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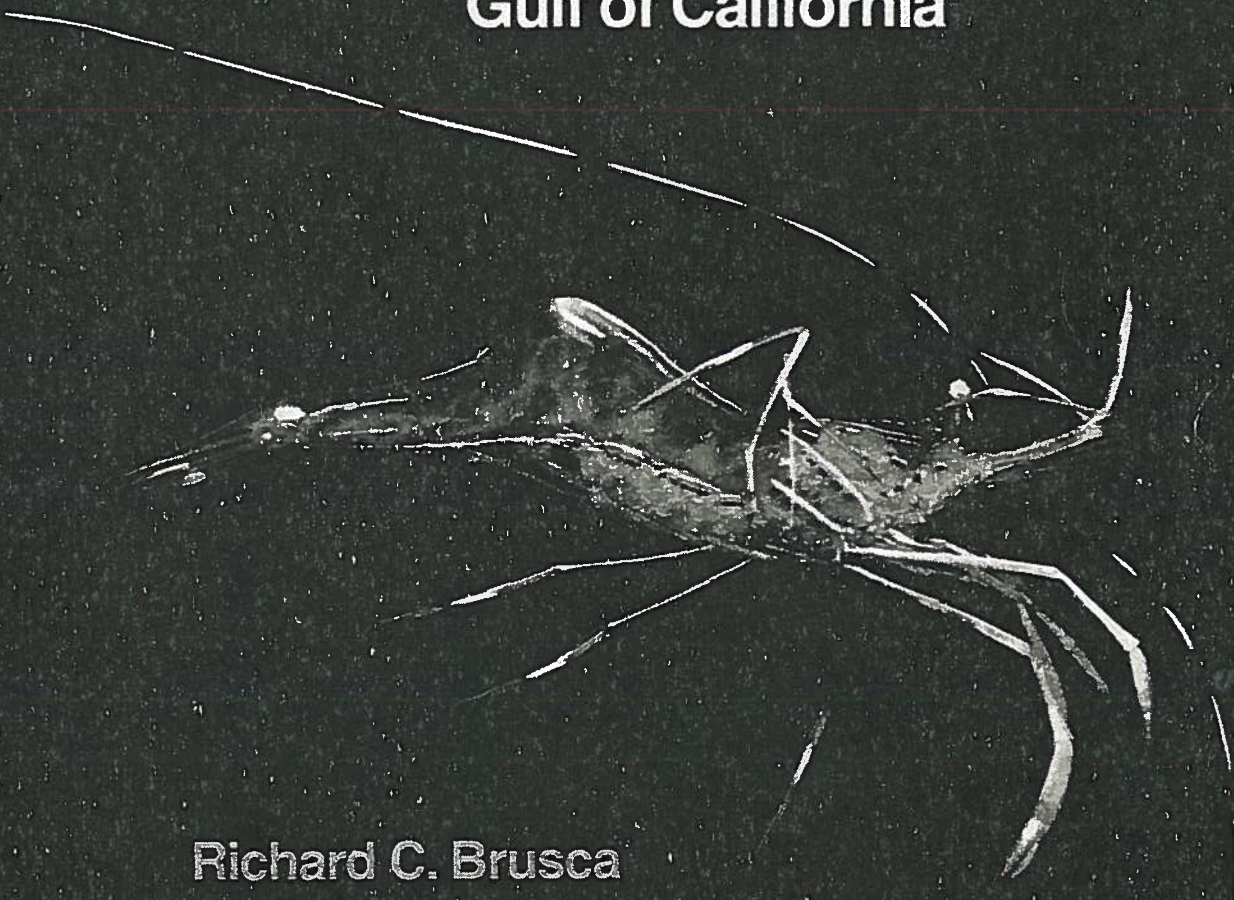

Richard C. Brusca

REVISED & EXPANDED ◦ SECOND EDITION

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Common Intertidal Invertebrates
of the Gulf of California

Common Intertidal Invertebrates of the Gulf of California

Revised and Expanded

SECOND EDITION

Richard C. Brusca

with contributed chapters by

William C. Banta
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About the Author

RICHARD C. BRUSCA has been a student of Pacific marine life since 1962. He has been traveling and studying in the Gulf of California since 1964 and served as resident director of the University of Arizona–University of Sonora Cooperative Marine Facility at Puerto Peñasco in Sonora, Mexico, from 1970 to 1972. His work in the tropical eastern Pacific has been supported by a wide variety of research grants and employments, and in 1975 he became Assistant Professor of Biology and Curator of Crustacea at the Allan Hancock Foundation, University of Southern California. The first edition of this Handbook was published in 1973, two years before Dr. Brusca was awarded his Ph.D. from the University of Arizona.

Second Edition

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TO ALEC AND CARLENE
AND TO
ANNA MARY

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PREFACE

The time is still far in the future when a tropical marine ecologist can identify the components of an ecosystem or a food chain from his handy pocket guide.

— Fenner A. Chace, Jr.
1969

The earth is presently experiencing the first waves of what some have termed the fifth worldwide ecosystem collapse (McConnaughey, 1974), equal in scope to those of the Paleocene, Triassic, Devonian, and Ordovician/late Cambrian periods. The present mass devastation of animal and plant species is being brought about almost solely by the efforts of man, largely through the destruction of natural environments. Literally tens of thousands of life forms will become extinct on this planet in the next 50–100 years, if present trends of population growth, urban expansion, and resource exploitation continue. The tropical and subtropical regions of the world are today experiencing the most rapid rate of growth. Unfortunately, these areas are the ones that are biologically most poorly understood, and we can expect animal and plant species there to be pushed into extinction daily, before they have even been named or described, much less their role in Earth's ecological drama determined. Although man is without doubt the most stubborn of all life forms, he is not a biologically separate entity on this small satellite of the sun. It would appear, however, that only as the current trends of growth and overexploitation threaten to steal our air and food, discolor our water and land, and finally disfigure our children will we be forced to awaken to the real oneness of life and our place in nature.

Today's worldwide phenomenon of urbanization is probably more menacing to natural communities than anything man has ever devised, with the possible exception of marine pollution practices. Increased urban development takes two forms: destruction of natural terrestrial habitats (timberland, chaparral, prairies, etc.) and the filling-in of coastal lagoons and bays (usually disguised under the Machiavellian phrase "land reclamation"). In bays and lagoons we are dealing with critically important and irreplaceable habitats. For example, Tampa Bay (Florida) by the early 1970s had already lost about 20 percent of its original water area to landfill, and San Francisco Bay (California) had lost about 35 percent. These losses reduced spawning areas for fishes and invertebrates, reduced overwintering regions for migrating water birds, changed local weather conditions, and made long-term alterations to local and offshore productivity. No estuaries or coastal lagoons have remained unaltered in California, and the loss of coastal lagoons along the shores of northwestern Mexico (primarily through agricultural efforts and the construction of boat marinas) has had drastic effects on the ecology of the Sea of Cortez.

Mexican-initiated investigations of Pacific tidelands resources and coastal management have been few. Decreasing fisheries yields and increasing pressure from conservation organizations in the United States have finally resulted in the establishment of several active Mexican national fisheries and oceanographic programs. These programs have been operated under the directorship of such Mexican governmental agencies as the National Institute of Fisheries (under the Secretary of Industry and Commerce); the Directorate of Aquaculture and General Directorate of Uses of Water and Prevention of Contamination (under the Secretary of Hydraulic Resources); the General Directorate of Maritime Works and General Directorate of Oceanography and Maritime Aids to Navigation (under the Secretary of the Navy); and the Center of Scientific

Investigations and Higher Education of Baja California (in conjunction with the National Council of Science and Technology). In addition, a number of Mexican schools have established active programs in marine research (see appendix B).

Like most developing countries, Mexico has approached the problem of preserving natural phenomena in a strictly pragmatic way. The dangers of this approach have been discussed by Snyder-Conn and Brusca (1977) in relation to the commercial shrimp fisheries of northwest Mexico. The natural response to decreased yield of this shellfish (due to overexploitation) was to build and operate more and larger boats and to decrease the mesh size of the shrimp nets. These methods resulted in a higher temporary yield, but, as might have been expected, the effect over time was a marked yearly decline of the shrimp population, and thus of fishery yield.

The destiny of the seas that border the coasts of all populated land masses, including Mexico, remains debatable. The isolated and fragile Sea of Cortez is especially endangered.

The initial thought of preparing a book such as this one came to me in 1964 when I first visited the Sea of Cortez. My thoughts grew and evolved until 1969 when Paul Dehnel introduced me to John Hendrickson, who had the imagination, faith, and ability to give me the means whereby I could get my notes and ideas into printed form. Originally I had hoped for a handbook that would be something of a Hegelian combination of *Light's Manual* and *Between Pacific Tides*—the two great Pacific coast standards which introduced so many of us to the seashore. My thinking was also greatly influenced in early years by the mystique of Ed Ricketts, the hegemonic polemics of Joel Hedgpeth, and the earlier writings of John Steinbeck. From 1969 to 1971 I spent twenty-four months in the field, collecting material, identifying specimens, mailing animals to specialists around the world, and keeping copious field notes. By the time deadlines approached for the first edition, I had come to realize that I was dealing with a fauna so poorly known that I was lucky to get a specimen identified to the species level, much less find any ecological data on it.

The 1973 edition of this Handbook was, however, a substantial beginning, one that has, I hope, proved helpful to biologists and other *aficionados* of the Vermillion Sea. Since that time I have been able to expand my field work to the most remote islands and regions of the Gulf and outer Baja California. In recent years I have had full use of the outstanding and invaluable collections of the Allan Hancock Foundation. Through the assistance of many fine people I have been able to collect many additional data on zonation, which are included (in part) in the introductory section of this edition. Many species still await names and descriptions, however, and the natural history of the tropical eastern Pacific invertebrate fauna will undoubtedly remain fertile ground for many generations of biologists co come.

One significant reason for the paucity of knowledge concerning the natural history of most marine animals has been the unfortunate trend, at least in this country, to turn students away from the complementary fields of systematics and field ecology and to encourage them to undertake strictly laboratory research. In addition, there has been a trend since 1950 or so to attempt to convert natural history into more of a "hard" science. It has rapidly become fashionable to place large amounts of expensive machinery and sophisticated mathematics between the reality of nature and the data one accepts as knowledge. The result is that it is becoming increasingly difficult for the working naturalist to publish a paper that conveys much in the way of qualitative or observational data, or any of the sense of wonder that he has gained during his research. In short, natural history is becoming unfashionable. Journal space has become so precious, scientific editors so rigid, and reviewers so influenced by faddism and "citation politics" (Fretwell, 1975), quantification of data, and concise style, that it is only in a vehicle such as this book that one can really point out or discuss the myriad associations that unfold between and among life and the inanimate environment. I sincerely hope that the observations, records, feelings, and speculations I have transferred from my field notes to these pages will serve to stimulate the reader to indulge his curiosity, as I have done mine.

I have continued in this edition to use the term "intertidal" as a noun and to refer to "this species color is...," rather than the technically more correct, but cumbersome, "individuals of this species are colored...." Vernacular names of animals found along the shores of the Sea of Cortez have been included when they are generally known, but most do not have common names, either in Spanish or English. The perils of using vernacular or local names are well known; I strongly encourage the reader to learn and to use the scientific names of the animals he examines.

This second edition of the Handbook discusses approximately 1,300 species of marine invertebrates, of which about 720 are illustrated, as well as a small number of plants and fishes. It presents the first scheme of intertidal zonation for the Gulf of California (and west Mexico in general). It is the second major stopping-off place along my passage through a region of many unknowns, a land of unrestrained beauty and depth, which represents a very large part of my life. I sincerely hope that this publication will stimulate others to continue or begin research in the Sea of Cortez; and, I will be grateful if the users of this edition continue to send me their reprints, criticisms, data, corrections, or ideas.

RICHARD C. BRUSCA

ACKNOWLEDGMENTS

A complete list of all the persons to whom I am indebted for assistance with this second edition would be far too large to include here. Over the years I have received countless letters containing data, specimens, reprints, and comments from intrepid Sea of Cortez travelers—naturalists, students, and scientists. To all of these fine, conscientious people I offer my most sincere gratitude and appreciation.

The writing of this Handbook would not have been possible without the efforts of a great many professional scientists, who have generously contributed their time and talents in identifying specimens, pointing out errors in my nomenclature or concepts, and reviewing the various manuscript chapters. This handbook is, in reality, a product of their cumulative knowledge (and that of their mentors). My small contribution lies only in the interpretation and synthesis of their words and thoughts, and in the production of whatever errors have been generated by that synthesis. These people are listed below and I ask forgiveness from those whose names might have slipped from my memory during the past few years.

Richard K. Allen (introductory materials as well as general inspiration); Donald P. Abbott (tunicates); Mary Needler Arai (anemones); Warren T. Atyeo (mites); Gerald J. Bakus (sponges); William C. Banta (bryozoans); J. Laurens Barnard (amphipods and introductory material); Thomas Biffar (ghost shrimp); James A. Blake (polychaetes); Thomas E. Bowman (isopods); Wynne Brown (noncrustacean arthropods); Gary J. Brusca (review of entire manuscript and peracarid vibrations); T. H. Bullock (acorn worms); Martin Burkenroad (ghost shrimp); Agustín Ayala Castañares (penaeid shrimp); Peter Castro (shrimp); Fenner A. Chace, Jr. (decapod Crustacea); C. Allan Child (pycnogonids); Kenneth Christenson (Collembola); Maureen E. Downey (echinoderms); Henry Dybas (Coleoptera); Isabel Pérez Farfante (shrimps); Kristain Fauchald (polychaetes); Eric Fisher (insects, especially asellid flies); Arthur Fontaine (echinoderms); Benjamin A. Foote (Diptera); Saul I. Frommer (introductory materials); John S. Garth (brachyurans); Donn Gorsline (introductory material, especially the physical history of the Gulf and Baja California); Janet Haig (anomuran crustaceans); Cadet Hand (cnidarians); Joel W. Hedgpeth (introductory material); Olga Hartman (polychaetes); Roy S. Houston (molluscs); Ernie Iverson (isopods); Gerald W. Kratz (mites); Jerry D. Kudenov (polychaetes); Vincent Lee (pseudoscorpions); R. B. Loomis (mites); Linda Yvonne Maluf (echinoderms); Raymond B. Manning (stomatopods); B. McDaniel (mites); John McKay (literature assistance); John Ljubenkov (cnidarians); Al R. Mead (molluscs as well as moral support); Ian Moore (*Endeodes* and staphylinids); William B. Muchmore (pseudoscorpions); Ann Muscat (echinoderms); William Newman (barnacles); Jim Norris (algae); Elliott Norse (portunid crabs); David L. Pawson (holothurians); Mary Ellen Pipin (literature assistance); John Polhemus (hemipteran section of Chapter 22); Fahmida Rafi (isopods); Donald J. Reish (polychaetes); Mary E. Rice (sipunculans and echiurans); Arnold Ross (barnacles); Vincent Roth (noncrustacean arthropods); Roger Seapy (intertidal zonation); Charles R. Smith (echinoderms); Elaine Snyder-Conn (hermit crabs as well as baby-sitting and Maguey spirits); Carl Stephan (Coleoptera); John S. Sumner (geology and physical history); Don Tuttle (insects); Barry Wallerstein (isopods); Andy Weaver (oniscoidean isopods); Mary Wicksten (shrimps); Richard [Bud] Winn (isopods, cumaceans and tanaids); Willis W.

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Special appreciation is here extended to David H. Montgomery, Arthur Fontaine, and Eugene Kozloff for offering me the finest of all my formal learning experiences; to Jerry Barnard, Lance Pape, Martin Burkenroad and Nick Yensen for massaging my mind and opening my eyes to new ways of looking at biological phenomena; and, to Lloyd T. Findley, Elaine Snyder-Conn, Dave Lindquist, John Foster, Chris Flanagan, Earl Segal, Matt Gilligan, Manuel Molles, Gary Hansen, Libbie Stull, Ray Wells, Dick Zimmerman, Richard Hammer, and Joe Franz for intellectual companionship both in the field and laboratory, and elsewhere.

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Acknowledgments are also extended to all of my fine former students from the University of Arizona, that worked with me from 1969 to 1975, especially Bud Winn, Mike McCollum, Mark Caldwell, Wynne Brown, and Wayne Crayton. Their boundless energies and tireless efforts contributed measurably to this book.

Sincere thanks are also offered to Waren Stauls, Dick and Dorothy Ingils, Agustín Cortez, Ramon Durazo, Mr. and Mrs. Richard Dwyer, Bill McClure, Lowell Hager, Ken Rinehart, Carolina de La Ranchita, and the owners and captains of all the fine Mexican ships that have been so kind to offer their services during the past few years.

Drawings from the first edition were done by Mr. Jerry Battagliotti; most of those for the second edition by Victoria Lawton; Teri Hoffman did figures 20.22, 20.37, 26.3 and 26.9; Wynne Brown did the illustrations for Chapters 22 and 23; and most of the isopod drawings are my efforts. The bulk of the typing was done by Ruth Toyama.

There is a very special category of deep and lasting gratitude for Margie Stinsen. I am indebted to her (and to Dennis Bostic) for giving me the opportunity to visit a great many of the Gulf and outer Baja islands, and remote regions of the Baja Peninsula. In addition Margie provided me with a wealth of new insight into Sonoran desert ecology, shore plant biology, cetacean natural history, and lava tube exploration. Also, in this special category are George and Kathy Staley, for assistance and companionship on the beaches of the Vermillion Sea and the shores of my soul.

I am deeply grateful to Marshall Townsend, Director of the University of Arizona Press, and the other members of his fine staff, for their professional handling of this book, particularly Marie Webner, for transforming my rough manuscript into publishable form. Special thanks are due Marshall, for recognizing and sincerely caring about my emotional concerns for the manuscript.

Lastly, and quite apart from all the other people who have given to me of their companionship and knowledge, is Anna Mary Mackey; best friend, unfailing partner, and field assistant *par excellence*. She kept me on the road when it seemed to disappear from view, and she carries the load, with a smile, when I grow weary. She is a part of me and a part of this book.

R. C. B.

How To Use This Handbook

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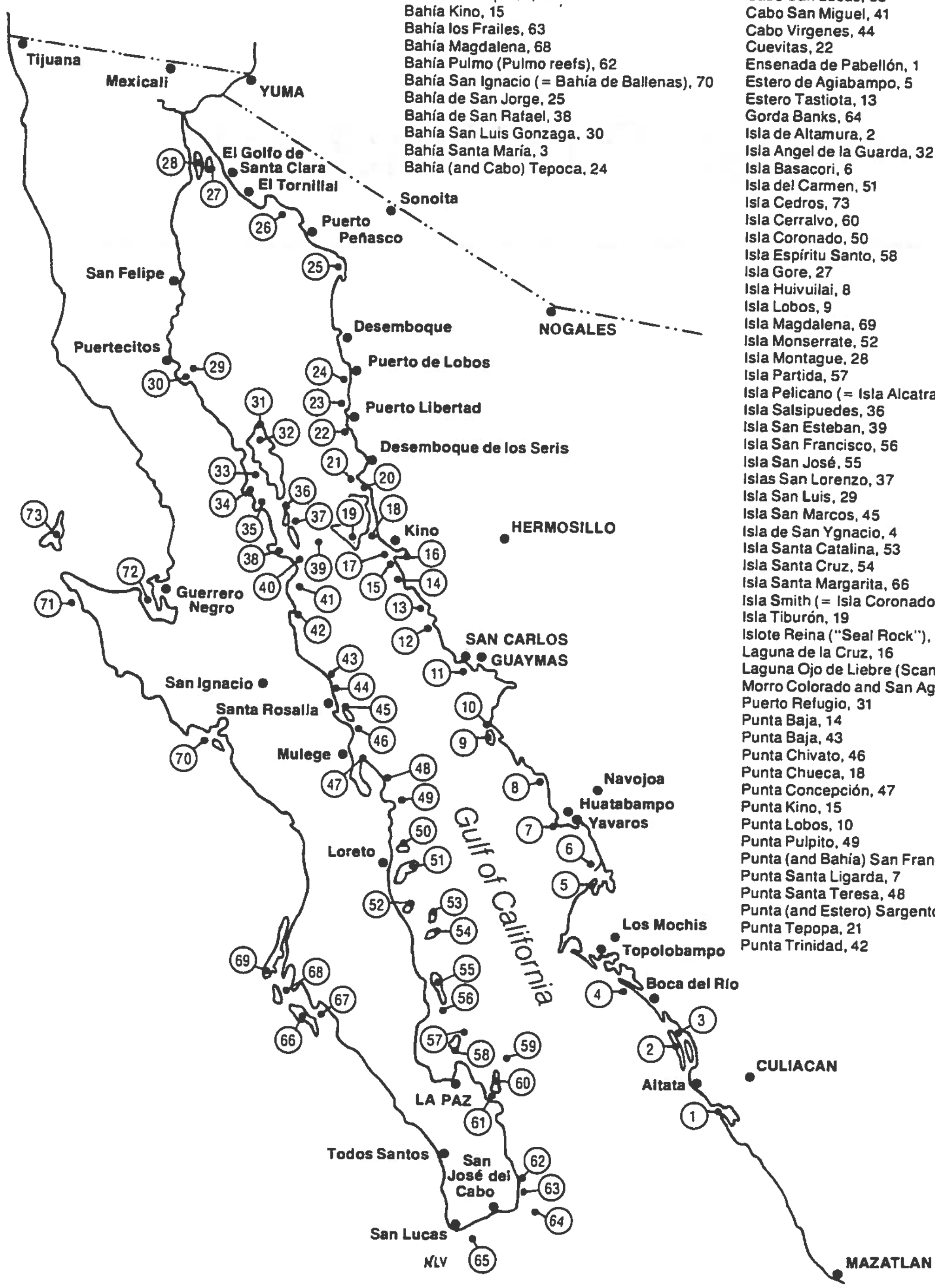


The key to this map is an alphabetical list of pertinent sites with locations numbered in consecutive order northward from the southernmost point on the mainland coast, then down the Baja California coastline and on around the tip of the peninsula. Locations are approximate.

HOW TO USE THIS HANDBOOK

Each major taxon of animals is treated as a chapter. For each group of animals treated, the following sections are presented: preservation, taxonomy, occurrence in the Gulf, dichotomous key, illustrations, species descriptions, and literature references. References for each major taxon are not, however, with the respective chapter but are found at the back of the handbook.

Taxonomic Scheme

The taxonomic scheme used for each group is taken from the most up-to-date and authoritative sources for that particular taxon. In many groups of animals, however, the systematics below the class level are unstable, and different workers often utliize different schemes of classification. In such cases, I have tried to use the classification of the last published monograph dealing with the animals of this particular region, or what I believe is a generally agreed upon taxonomy.

Keys

To use the keys, begin at couplet number one, with the animal to be identified in front of you. After reading each choice of the first couplet, decide which set of characters applies to the specimen you are identifying. Look at the number following the description fitting your animal, and go to the couplet with that number. Continue going from couplet to couplet, each time making the choice of which of the two sets of characters applies to your animal. Eventually you will reach a name instead of a number, and that is the name of your animal. You can now look up that name in the index, which will give you the page number of the description (which will be found in the section following the key). By comparing your animal to the species description, you can double-check the accuracy of your initial identification based on the key; never rely on the key alone for an identification.

The principal function of the keys is utility, and for this reason the keys are primarily artificial and not phyletic. That is, they are largely based on species characters alone, as opposed to characters of the higher taxa. In nearly all cases, key couplets apply equally well to all individuals of a population, regardless of sex or age. The choices are to be considered absolute and descriptive. The keys may be used either forward or backward (by using the numbers in parentheses that indicate the source of the couplet).

Definitions of terms used in the keys and in other sections of the handbook may be found either in the taxonomy section of the particular chapter or in the glossary. The keys have been, whenever possible, written from observations of the living animal. However, enough characters are given in almost all instances to identify an animal after it has been properly preserved. It is important to remember that an improperly preserved animal will often be impossible to identify, thus rendering it totally useless.

The animals included in the keys are primarily intertidal. I have, however, included the more common forms of shallow water subtidal invertebrates to make the handbook useful to skin and SCUBA divers.

Distribution Records

A great deal of effort has been made to present accurate distribution records for each species. Many of the ranges included in this handbook represent significant extensions of previously known distributions. These extensions are based primarily on the author's own collecting data.

Species Descriptions

Most of the species descriptions are based on a combination of the literature and observations of the live animal. The person's name following each species name indicates the author of that species (the person who first described the organism and gave the animal its specific name). Parentheses around the author's name indicate the species is now in a different genus than when originally described. When recent name changes have occurred or when an animal is commonly known by two or more names, I have included these synonymies in the species descriptions. Complete synonymies, however, have not been attempted for any taxon.

Anyone sincerely interested in biology, especially invertebrate zoology, should sooner or later take time to enjoy familiarizing himself with basic taxonomic procedures. A number of good texts are available for this purpose. Three particularly good books, included in the bibliography, are Cain (1960), Mayr (1969), and Ross (1974). Taxonomy is the study and practice of classifying animals (and plants). The primary objective of classification systems is to arrange life's myriad forms into a hierarchal system based on fundamental similarities that reflect their evolutionary relationships. The result is an ordered system of categories and subcategories that permits reliable information retrieval and illustrates the evolutionary history of the animal (or plant) kingdom. There are more than a million species of described plants and animals living today, 95 percent of which are invertebrates (and probably twice this number yet to be described). These figures alone underscore the importance of a sound, working knowledge of classification and taxonomy.

Literature References

The literature references for each group are not meant to be complete bibliographies but are designed to present the major works relating to the Gulf fauna. Occasionally a reference is included that deals with animals of a different region. The reason for this inclusion is that reference has been found to be a key taxonomic source for the entire group, or the paper contains an extensive bibliography, thereby making it a valuable source. Publications mentioned in a specific section of the handbook but not cited in the references for that section will be found in the introductory reference section. The Marine Sciences program of the University of Arizona has, since 1964, been printing annual compilations of student reports for their course in Marine Ecology. Although these reports are not printed in large enough quantities for general distribution, they have proven to be a valuable reference source for preliminary or baseline data and for research ideas.

References to Steinbeck and Ricketts throughout the text refer to John Steinbeck and Ed Ricketts, *Sea of Cortez*, Viking Press, New York, 1941. Anyone sincerely interested in the Gulf should have a copy of this remarkable book, a "leisurely journal of travel and research, with a scientific appendix on the marine animals of the Panamic Faunal Province." This book has been recently reprinted, in its entirety, by Paul P. Appel, 119 Library Lane, Mamaroneck, New York. References to Knudsen throughout the text refer to J. W. Knudsen, *Biological Techniques*, Harper & Row, New York, 1966. This book belongs on the shelf of every student of the life sciences. In it may be found formulas for preparing the preservatives, relaxants, fixatives, etc., mentioned in this handbook, as well as the techniques with which to apply them.

Terminology and Usage

When discussing ranges of the various species, I have used the phrases "northern Gulf" and "southern Gulf." For this handbook, "northern Gulf" includes any and all of the area above the midriff islands (Islas Angel de la Guarda and Tiburon), and "southern Gulf" includes any and all of the Gulf below these islands.

The name "Bahía Cholla" used throughout the handbook is one not usually found on maps of Sonora. It refers to a shoreline indentation above Puerto Peñasco that is actually a part of the much larger Bahía Lopez Collada. The latter is usually shown on maps as Bahía Adair, or as Adair Bay.

In an attempt to add a touch of familiarity to the text, where applicable I have briefly compared or mentioned certain animals from the shores of California, Oregon, and Washington. This will perhaps allow students from these regions to relate more directly to the overwhelming barrage of new animals they will encounter when visiting the Sea of Cortez.

Conservation of Beaches and Tidelands

Lastly, before progressing to the collecting and keying of the marine life of the Sea of Cortez, it becomes again necessary to remind everyone—teachers, students, and all visitors to the seashore—of the growing need for conservation and ecology-conscious explorations of the beaches and tidelands. Over the years, as interest in the sea has increased, so has our population, and an ever-increasing demand has been placed on the coastal regions of western America. The primary destroyers of tideland habitats have been the land "developers" and businesses that literally devastate a large piece of beach, replacing sand dunes and tidal flats with boat marinas, hamburger stands, and hotels—all things that could just as well have been built 1000 yards from the seafront. But, the people who use and love the seashore for its inherent beauty (and not its economic potential), and those of us who use the beaches as a natural outdoor laboratory, have also had drastic effects on many regions, by the all-too-simple act of picking up an attractive or interesting animal from a tidepool or, in some cases, picking up bucketfuls of these animals. The effects of these combined forces in southern California can be seen all too clearly and have been partly responsible for the passing of strict state laws forbidding the removal of any living organisms from that state's shoreline, without proper permits.

Mexico is just beginning to feel these same pressures. The most imminent threat to the littoral environments of the Gulf of California is the commercial tourist-oriented developments that drain the lush mangrove forests and esteros to replace them with boat docks, concrete retaining walls, and condominiums. Fortunately, "progress" of this sort is slower to evolve in Latin America, and so we still have time to halt much of it, or at least modify it, before it is too late and there is nothing left to save. As an individual you *do have* the power to become directly involved in saving and maintaining the beaches of Mexico. You can write letters. As trite as that may seem, it does work, probably much more so than most people realize. Write your congressmen, urging them to support any U.S.-Mexican policy that is environmentally conceived. Write letters to the Mexican Department of Tourism, in any large city, Mexico City in particular, telling them how you feel. You can write to the directors of the various marine stations (see appendix) along the coast of western Mexico, and even stop and visit them when you travel in that part of the country. Make them aware that their friendly neighbors to the north do indeed realize how they themselves waited until it was nearly too late to save their own beaches and seas, but you are certain the same mistakes won't be made in Mexico since they are still at the stage where good conscientious environmental policies can keep their beaches, shorelines, and seas as beautiful and rich as they are now. When you personally visit the beaches of Mexico, do so with a spirit of conservation; take only the specimens you need and return what you don't want alive. Remember: REPLACE YOUR OVERTURNED STONES AS YOU FOUND THEM. A special emphasis should be understood in this message for students of marine ecology, for the time has arrived when we must consider it part of our responsibility to man and his environment to do everything in our power to save the beaches and seas . . . and to spread the word. And right now is a good time to remind you that to collect animals legally anywhere in Mexico you need an official Mexican collecting permit, which may be obtained, in due time, from the Instituto Nacional de Pesca e Industrias Conexas, Departamento de Estudios Biológico Pesqueros, Mexico, D.F. To transport living or dead marine specimens across the border into the United States, you will need to show this permit to U.S. Customs agents.

Introduction

INTRODUCTION

1. The Physical Evolution of the Gulf of California

The earth's crust and uppermost mantle (collectively termed the lithosphere) is composed of about eight to ten very large plates or blocks (and a number of much smaller plates), which are bounded by ocean ridges, trenches, and faults. These 100-km-thick plates form and spread apart at the ridges, shear against each other along the faults paralleling the plate motion, and are eventually thrust under one another at their far edges (subduction zones) to be recycled, like a grand system of conveyor belts spread across our planet's surface. This phenomenon, the movement of the great masses of the earth's crust across the surface of the planet, is described by the study known as *plate tectonics*. It forms the basis of such major geophysical events as continental drift, sea-floor spreading, the formation of coastal and inland mountain ranges, much of the world's volcanic activity, and most of the world's great seismic disturbances (earthquakes). Almost all of the present shape and area of the oceans has been created by this process during the past 200 million years (or the last 5 percent of the recorded geologic history of the earth).

The physical history of Baja California and the origin of the Gulf of California is intimately tied to this process of plate tectonics. There is no need to explain the details of plate tectonics here, as numerous popular books and articles have been written on this subject in recent years (see bibliography). Of interest to us is one particular ridge in the floor of the east Pacific Ocean basin, the *East Pacific Rise*. Running the length of the center of this great rise is a rift valley, through which semiliquid material from the earth's mantle slowly wells up and out, wedging apart the older material. This new crustal material is drawn away from the rise, to the east and to the west, generating new seabed crustal material through the process of sea-floor spreading. The East Pacific Rise is bounded by two giant crustal plates or blocks. On the west is the *Pacific Plate* which is presently moving in a northwesterly direction with respect to the great *American Plate*, to the east of the rise.

Anderson (1972) has presented one of the most recent descriptions of the tectonic origin of the Gulf of California (and probably the most generally accepted at the time of this writing). Based on geomagnetic data, his description is as follows. At least 30 million years ago (Oligocene), one section of the East Pacific Rise came to intersect the North American continent, as the intervening plate (the Farallon Plate) was consumed by subduction. At this time a large section of western Mexico broke off to become welded to the Pacific Plate. This piece of land, over a period of about 5 million years, was rifted in a northwesterly direction and now forms much of west central California. As this portion of California was being carried away from Mexico by the Pacific Plate, a second segment of the rise intersected the west coast of Mexico and the above process was repeated, this time ripping a long, thin strip of continent off to form the Baja California peninsula. This latter process took place, according to Anderson, 4–6 million years ago (late Miocene). As magma from the upper mantle welled up into the rift, it formed a new rise that worked its way north into the widening Gulf. The peninsula of Baja California, as well as a large piece of southern California, is therefore now coupled with the Pacific Plate and continues to move northwest in respect to the rest of Mexico and North America in general, as the North Pacific basin slowly rotates in a counterclockwise direction.

Other authors have placed the origin of the Gulf of California at similar times, based on various types of data. Larson et al. (1968) placed the date of the opening of the deeper southern Gulf at 4–4.5 million years ago (on the basis of magnetic data).

Durham and Allison (1960), on the other hand, stated, "Throughout the Cenozoic period the boundaries of the Gulf expanded and contracted in harmony with submersion and emersion of the peninsula and adjacent areas on the eastern margin of the Pacific and with sedimentation at the mouth of the Colorado River. The peninsula of Baja California at times was restricted to a small northern area with its southern extent expressed in a series of islands. During times of emergence the peninsula expanded slightly to include areas beyond its present coasts." These authors also present a series of interesting maps illustrating the theoretical shape and location of the Gulf and Baja California through the Paleocene, Eocene, Oligocene, Miocene, and Pliocene.

Interestingly enough, paleontological data seem to indicate that the northern Gulf is older than the southern portion. Evidence indicates it was in existence (in some form) during the late Miocene (Larson et al., 1968). It has been postulated that the Gulf initially consisted of a narrow channel or very shallow southern Gulf leading up to the larger northern basin. The southern Gulf could then have arisen as a series of "offsets" or spreadings, initially moving from north to south.

At any rate, there is no question that the crest of the East Pacific Rise intersects the North American mainland very near the mouth of the Gulf of California. From there it extends south, continuing as a globe-circling oceanic ridge system. The rise disappears as such from the Gulf northward, where it is recognized as a complex system of transform faults, the most notorious being the San Andreas Fault, and finally reappears again in the north Pacific off Oregon in the form of the Gorda Rise and the Juan de Fuca Ridge.

The San Andreas Fault thus forms a boundary between the American Plate of crustal material and the Pacific Plate, separating Baja California and the southwestern part of California from the rest of North America. The Pacific Ocean and that part of California west of the San Andreas Fault are moving northwest in respect to the rest of the continent.

With the exception of the Malay Peninsula, Baja California forms the longest, most isolated peninsular area in the world. The peninsula itself extends over 1,100 km (700 miles), from a latitude of 32°N to below the Tropic of Cancer (just south of 23°N). Baja California alone has 3,218 km (2,000 miles) of shoreline and varies from about 241 km (150 miles) in width to only 48 km (30 miles) in width in the region of La Paz. Well over 3,900 km (2,400 miles) of North America's coastal deserts are confined to Baja California and Sonora, Mexico, most of which lie along the shores of the Gulf of California.

The Gulf is bordered on the west by the high mountains and pre- to mid-Cretaceous igneous and metamorphic rocks of the Baja California peninsula, consisting largely of granitic blocks. The entire Baja peninsula maintains an almost uninterrupted chain of mountains 1 to 3 km high. The presence of this long, high barrier contributes significantly toward producing a climate more continental than oceanic within the Gulf. On the east, the Gulf is bounded by the sedimentary and volcanic blankets of the coastal plains of Sonora and Sinaloa, which are largely covered by broad alluvial fans and deltas of sand and gravel. These are, in turn, covered in places by high sand dunes. The head of the Gulf is bordered by the Colorado River delta, which itself rests on older deltaic and lagoonal deposits and now serves to keep the waters of the Gulf from entering the low Imperial Valley and Salton Sea area of California. Much of the region around the northern Gulf consists of low-lying coastal plains, whose mud and salt flats bear sediment derived from the Colorado River. Records indicate that approximately 50 percent of the sediments brought into the Gulf (in former years) were derived from the Colorado River.

The lower two-thirds of the Gulf (below the midriff region, which is demarcated by Tiburon and Angel de la Guarda Islands) is a deep trough, which appears to be a rift between two continental blocks, separated by a crust of oceanic character. South of the midriff the central trough quickly descends to 2,400 m, then more gradually to depths of 3,600 m at 23°N. A few of the numerous basins in the southern Gulf plunge abruptly to depths of more than 3,000 m. These basins are described in Van Andel (1964). Three of the most remarkable are the Guaymas Basin, with depths to 2,180 m; the Farallon Basin, with depths of 3,520 m; and the Pescadero Basin, which plunges to 4,060 m. The upper third of the Gulf is more strongly affected by the deltaic deposits of the Colorado River and is much flatter and more shallow, averaging around 200 m in depth (60 percent of the northern Gulf is shallower than 200 m). Two deep basins (Salsipuedes and Delfin) lie between the peninsula and the islands of Angel de la Guarda and San Lorenzo and have maximum depths of 1650 and 800 m, respectively. Both are isolated from the deeper southern waters by a sill depth of 45 m. The ocean floor of the Gulf is also characterized by a high heat flow, which is related to the presence of the East Pacific Rise in this region.

A great variety of rock types occur along the shores of the Gulf of California, and numerous representatives of continental, oceanic, and mantle formations exist. Rhyolites, andesites, basalts, diabase, sandstone, and limestone are the most commonly encountered beach rock types. Most of the coastal limestone formations in the Gulf are of the Coquina limestone type. This is a porous material composed of shell fragments cemented together by calcite ($CaCO_3$). Coquina is typically found in warm climates where the evaporation rate is high. Excellent examples of this formation are the reefs in front of the marine station at Puerto Peñasco, Sonora, and at Coloraditos, 64 km (40 miles) south of San Felipe on Baja. The fossil shells comprising the Puerto Peñasco reef may be in the neighborhood of 2–6 million years old and the climate in this region may have been considerably warmer than it is at the present time.

The hardness of the rock formations making up the beach and intertidal regions directly influences the type and number of animals that can inhabit any particular shoreline. In general, the harder the rock, the less porous, or rugose, it is. Beaches composed of hard smooth rocks, like basalt and diabase, are often found to have a lower species richness than shorelines composed of softer sandstones, limestones, rhyolites, or the intrusive igneous rocks (such as granite or diorite). The reason for this sparsity is that there simply are not as many holes, cracks, and crevices available for the animals to take advantage of. In addition, smooth dark rocks will experience a considerably higher surface temperature during tidal exposure than will lighter colored, more rugose rocks, which will clearly influence the type of animals that can exist on these differing substrates. For example, along the Sonoran shore, species richness in the rocky intertidal is found to be very high at Puerto Peñasco, the Puerto Libertad area, and the San Carlos region, while it is considerably lower at Puerto Lobos and certain areas near Bahía Kino. The former regions have beaches composed of limestone, sandstone, and rhyolites while the latter have beaches composed of harder diabase and basalts. Certain animal types also show definite preferences for certain rock types. This is largely a reflection of the rock's hardness and surface texture. For example, the seastar *Heliaster* and numerous species of chitons and limpets prefer smooth hard rock surfaces and make attempts to locate on these types of rocks in preference to others in the same general area. Anemones, sponges, and many other invertebrates, on the other hand, show just the opposite preference.

The relationship of a rock formation to neighboring geological formations is also a matter for contemplation when studying the fauna of a particular region. For example, extrusive igneous materials such as rhyolite or andesite (as well as certain intrusive types such as granite) typically break down into clays and sand, eventually yielding large amounts of a material for tidal washes and sandy beaches. Basalt, on the other hand, is extremely high in calcium, and large calcium carbonate reefs (such as limestone and coral) often occur in basaltic areas, fed in part from the slow erosion of these deposits.

Solid rocky shores or shores composed of very large boulders are physically more stable than shores composed of smaller rocks or loose stones. One finds a direct correlation on these shores between stability of habitat and species richness. Loose cobble beaches have a very low species richness. Along the harder, more erosion-resistant shorelines cobble and shingle beaches are rare, since these are nearly always derived from high-erosion sources and subsequent reworking by wave action. Although shingle beaches are rare in the Gulf of California, a good example of this sort of biological shore-desert exists in the long stretch between Cabo Colonet and Bahía San Ramón, on the west coast of Baja.

The shores of the Sea of Cortez are largely protected from the heavy and continual wave shock seen on most exposed shores of western North America. However, brief but violent storms, known as "chubascos," and infrequent hurricanes do cause significant coastal damage on occasion. Likewise, many rocky regions are known to experience periodic (seasonal?) sand transport, completely burying local biota for periods of weeks or months.

The Imperial Valley is a structural continuation of the Gulf. It forms a trough whose land surface rests more than 402 m (250 feet) below sea level. The delta that separates the Sea of Cortez from this depressed trough is relatively flat and has a drainage divide only 10 m above mean sea level, but a thickness of over 6000 m of Pliocene to Recent sediments (Tarbet, 1951; Dibblee, 1954). Most of the deposits that have been examined in the northern Gulf are silt and clay of recent origins, although sediments of Miocene and Pliocene age have also been reported.

The recent history of the Salton Sea and the northern Gulf of California is an intriguing story. Briefly, it is as follows. Soon after its origin, the Gulf of California extended northward over the present Imperial and Coachella valleys to near San Gorgonio Pass, north of Palm Springs. The Colorado River was, at this time, emptying into the Gulf somewhere near the present site of Yuma, Arizona. As silt at the river mouth built up, perhaps aided by some geological uplifting, a massive delta began forming that eventually extended the entire width of the Gulf, closing it off to isolate the northern part as an ancient salt-water lake. The river alternated its flow between the northern basin and the open Gulf. At those times when the river receded from the northern basin, a salt evaporation pan formed, covering an area that would now include the cities of Mexicali, Brawley, and Indio. The lake had no outlet, and, like the Great Salt Lake of Utah, it dried up because its evaporation rate exceeded its influent. More recently the Colorado River again changed its course to begin dumping water into the dry lake bed instead of the gulf, refilling the basin to create the prehistoric Lake Cahuilla (or Lake LeConte). Paleontological evidence indicates this lake was initially fresh water but became progressively more saline as it dried up. Travelers cross the eastern fringe of the great Colorado River delta when driving south from

Mexicali to San Felipe. This drive is undoubtedly one of the most spectacular short trips available to southwest residents.

During this period, the lake probably drained into the Gulf via the great valley of the Rio Hardy. Finally, the Colorado River again changed its course to resume emptying directly into the Gulf. Lake Cahuilla dried up and remained dry until late 1905, when the river course was accidentally diverted toward the west to once again begin pouring water into the bed of Lake Cahuilla. This was the result of the construction of irrigation headworks to divert part of the Colorado's flow into the Imperial Valley by means of a long, level canal. The headworks were destroyed by floodwaters and the entire river began to flow down the canal instead of following its own channels to the Gulf. For two years the river emptied into the Imperial and Coachella valleys, finally being rediverted to its former course in 1907, when the break in the irrigation headworks was repaired. From this series of events came the no-outlet Salton Sea.

Sykes (1937) reported that in 1906 he observed the level of the Salton Sea rising at the rate of 10.16 cm (4 inches) per day, with a rapid advance of the water across the nearly level floor of the basin. After 1907 evaporation lowered the Salton Sea level, with a corresponding increase in salinity. More recently (since about 1948), the Sea has risen from irrigation drainage and salinity has decreased. The surface elevation of the Salton Sea fell from −61 m (−195 feet) in 1907 to −76 m (−250 feet) in 1925, and from 1925 to 1935 the level fluctuated between −76 m and −74 m (Walker, 1961). Recent estimates of future stabilization levels vary from −67 m (−220 feet) (Blaney, 1954) to −72 m (−235 feet) (Walker, 1961). It is of interest to note that the salinity of the Colorado River water at the head of the Alamo channel irrigation canal, prior to its destruction in 1905, was only 0.7 percent (Ross, 1914) and yet the Salton Sea had, by 1907, attained a salinity of 3.6 percent. The greater salinity of the Salton Sea in respect to the river was due to salts leached from the bottom deposits left by evaporation on previous occasions. The salinity of the Salton Sea remained below 1.5 percent until as recently as 1930, reached 4.04 percent in 1948, and fell to 3.07 percent in 1955. The present water source for the Salton Sea is largely via the All-American Canal, an irrigation tap off the Colorado River at Imperial Dam above Yuma.

Before the building of Hoover Dam (1935) and the advent of large-scale irrigation projects in the Imperial Valley, the effects of the Colorado River drainage could be seen in the Gulf as far south as La Paz. The average annual flow in the vicinity of Yuma for the years 1902 to 1934 was over 15 million acre-feet. In recent years, however, the flow of the river into the Gulf has been drastically and continually reduced. Thomson (1969) states that little river detritus has reached the Gulf of California in the last 55 to 60 years. The average annual river flow at the mouth for the years 1935 to 1965 has been reported as a little over 4 million acre-feet. In the early 1960s the annual discharge recorded at a station in El Maritimo, Mexico, was only 85,000 to 503,000 acre-feet, and by 1963 or 1964 it is unlikely any permanent surface water from the Colorado River was reaching the Gulf at all. The small amount that has reached the Gulf in recent years (by underground percolation and via the Rio Hardy system) has been extremely saline and polluted by agricultural pesticides and fertilizers from the United States and Mexico.

The origins of the numerous islands in the Gulf of California are complex, often based on independent structural events, not necessarily dependent upon each other, or on the primary movements of the peninsula itself. Most of the islands broke from the peninsula during the early history of Baja California. Islas Angel de la Guarda, San Lorenzo, and Salsipuedes may have been cut off along the same fault line that developed up to the Imperial Valley and gave rise to the San Andreas Fault. The Islas Las Tres Marías off the coast of Mazatlán, and Islas San Francisco near La Paz, and Isla Partida (in the midriff region) were probably all formed by volcanic upwellings, as were some of the other small islands of the Gulf.

At times during the past there existed a water connection between the Atlantic and Pacific oceans, across Central America, probably most recently in the region of Panama. Throughout the Tertiary Period, the North Equatorial Current of the Atlantic, aided by the ever present trade winds, funneled water through this island-studded land gap in middle America. The date of the last known opening of this water bridge has been placed at the Miocene (Keen, 1971) or the Pliocene (Simpson, 1950; McConnaughey, 1974; Rosenblatt, 1967), 2 to 5 million years ago. During this time a common flora and fauna was probably shared, to a greater or lesser extent, between the Caribbean and east Pacific regions. This so-called *Transisthmian Biota* is discussed in section three of this introduction.

The advent of two important new concepts in the fields of earth geology and biogeography, namely plate tectonics and generalized track theory, are having profound effects on our thinking in regards to historical geography and ecology. These two relatively new ways of looking at the history of life and events on earth may now be used to explain and elucidate the dynamics of one another. Such an effort has been recently made by Rosen (1975) in his excellent vicariance model of Caribbean biogeography.

TABLE 1
Major Global Events of Concern to the Gulf of California During the Last 225 Million Years

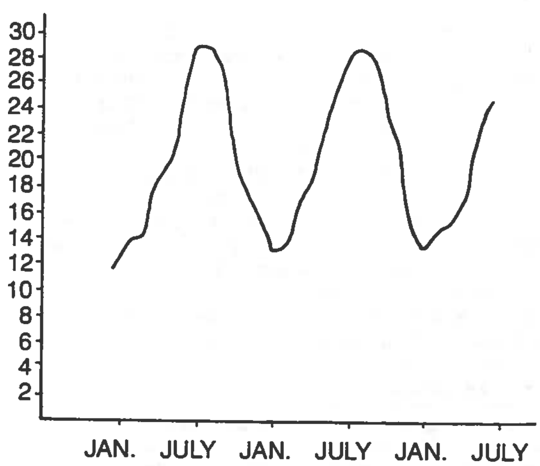
Millions of years ago	Era	Period	Epoch	Events
225	Mesozoic	Triassic		A single giant continent (Pangaea) and a single giant ocean (Panthalassa) exist on the earth. First appearance of stony (scleractinian) corals, and first records of diatoms. First mammals.
190		Jurassic		The supercontinent Pangaea begins to break up owing to the forces of plate tectonics. Diatom fauna begins to flourish. First birds.
136		Cretaceous		Pangaea has split into a northern (Laurasia) and a southern (Gondwanaland) land mass, separated by the Tethys Sea, which connects the Indo-Pacific with the eastern Atlantic oceans. 82% of earth's surface under water. North and South America are separated, creating a continuous belt of tropical seas around the world. Africa and South America separate (90–100 million years ago). End of Cretaceous marked by the greatest period of extinctions known; approximately ⅓ of all known families of animals disappear.
65	Cenozoic	Tertiary	Paleocene	North and South America attain what are essentially their present configurations.
54			Eocene	Diatoms have now become the dominant marine plant in the world's seas.
38			Oligocene	Portion of East Pacific Rise intersects west coast of America, tearing off a piece of Mexico and rafting it to northern California.
26			Miocene	Australia has been rafted to its present location and the formation of the Great Barrier Reef has begun. Somewhere here or in the Pliocene the Gulf of California forms as a portion of the East Pacific Rise again intersects the west coast of Mexico to tear off the Baja peninsula.
7			Pliocene	Antarctica reaches its present location, isolating the south polar region from thermal interchange with the world's oceans and initiating formation of the present antarctic ice cap, which lowers sea levels and augments a worldwide cooling trend both on land and in the sea. Arctic Ocean freezes over, further contributing to the development of a cooler world, with the tropics being restricted to a narrow belt near the equator. The Mediterranean basin becomes separated from the Atlantic and dries up, to become a hot, dry, below sea-level desert marked by salt basins and alkaline flats. Restoration of the Gibraltar sea connection ensues in the late Pliocene. Elevation of most of mainland Mexico (the Mexican Plateau). Panama seaway closes up as the American land bridge arises (2–5 million years ago). First manlike apes appear.
2.5		Quaternary	Pleistocene	A series of ice ages and interglacial periods sets in, moving thermal barriers alternately north and south across the Northern Hemisphere (we are presently in the fourth interglacial period). Estimates of lowered sea levels during various glacial periods range from 35 to 300 feet below present levels. The first true men appear: ***Homo erectus.*** Formation of the Red Sea (about 1 million years ago).

2. Water Temperatures and Salinities in the Gulf of California

Northern Gulf waters have been shown to be non-homogeneous, the presence of localized distributional patterns being common (Hendrickson, 1973). In general, shallow coastal and deltaic water temperatures are affected primarily by local air temperature and circulation (mixing). Sea-surface temperatures in deeper waters show considerably less variation through either the diurnal or seasonal atmospheric cycles.

There is a large, seasonal fluctuation in onshore sea surface temperature in the upper Gulf of California (above lat. 28°N). At Puerto Peñasco this annual fluctuation may exceed 18°C, while at Bahía de Los Angeles it may exceed 15°C. Onshore water temperatures at Puerto Peñasco may reach 30°–32°C (88°–91°F) in the summer and may drop to 10°–12°C (50°–53°F) in the winter, although the usual winter temperatures are around 13°–14°C. The intertidal region experiences an even greater range of temperatures because of periodic exposure to atmospheric conditions. Thomson and Lehner (1976) have recorded temperatures as high as 35.5°C, and as low as 4°C in small tidepools at Puerto Peñasco. Offshore sea-surface temperatures range from 17° to 30°C (monthly means); offshore temperatures, below 100 m, remain relatively constant throughout the northern Gulf, usually falling only 2°–5°C midway between the eastern and western shores. Near-shore (onshore) sea-surface temperatures for Puerto Peñasco, in the northern Gulf, are presented in the accompanying graph.

The northern Gulf periodically experiences exceptionally cold winters, where onshore water temperatures locally drop to 8° or 9°C (or less). When this happens, a massive die-off usually occurs, particularly in regard to certain macroscopic algae and the stenothermal tropical and subtropical fauna. During these periods littoral primary production is drastically reduced and overall species abundance falls, as eurythermal forms dominate the habitat. The occurrence of winter mortalities of tropical species in subtropical regions has been discussed by Kinne (1970), and for the Gulf of California specifically by Thomson and Lehner (1976). Indeed, most animal populations inhabiting strongly seasonal regions (like the northern Gulf of California) tend to be limited by winter temperatures. Many algae, on the other hand (as well as certain temperate-derived invertebrates, such as *Aplysia*), are limited more by the hot summer onshore water temperatures.



Graph. Monthly means of near-shore sea-surface temperatures at Puerto Peñasco, 1971–1973 (from Hendrickson, 1973)

Sea-surface temperatures in the southern Gulf (below lat. 28°N) exhibit less seasonal fluctuation than the waters of the northern Gulf. Onshore water temperatures drop to 17°–18°C (62°–65°F) in the winter, and rise to around 32°–35°C (90°–95°F) in the summer. Because of its warmer winter waters the southern Gulf is generally considered a tropical or subtropical habitat, as opposed to the northern Gulf, whose cold winter water temperatures and cooler summer temperatures in respect to the southern Gulf give it a more "temperate" climate. Offshore water temperatures, at varying depths, have been published by Robinson (1973), Hendrickson (1973), and Pacheco and Schwartzlose (1974). At 10 m depths most Gulf waters are warmer than those of Pacific Baja (at the same depth) from April to September; from October to March these temperatures are about the same.

Most of the Gulf of California acts as an evaporation basin, its surface salinities typically being 1–4 parts per thousand higher than the outer coast. The offshore salinity of the northern Gulf generally ranges from 35 to 36 parts per thousand. Onshore, or shallow water, salinities range from 36 to 39 parts per thousand. Lowest salinities occur in the winter months and highest salinities in the summer. Mean annual ranges vary from 1.3 to 2.5 parts per thousand locally (Hendrickson, 1973). The higher salinities common to the northern Gulf are partly a result of increased evaporation in this semi-isolated region. Roden (1964) stated that evaporation exceeds precipitation by approximately 250 cm/year in the northern Gulf, whereas evaporation over the entire Gulf approximates 5×10^9 cm^3/sec. The Sonoran and Sinaloan coasts generally experience greater rainfall than does the Baja coastline. In more recent years the increased salinity of the upper Gulf waters may also be, in part, attributable to the highly saline waters of the Colorado River that occasionally reach the Gulf by one means or another. Likewise, rare heavy rainfall in the northern Gulf will depress salinities up to 0.4 parts per thousand. In the southern Gulf (and below the 10-m level in the northern gulf) the salinity is nearer that of the open sea, approximately 35 to 36 parts per thousand.

Much of the mixing that exchanges northern Gulf water with that of the southern Gulf takes place over the Colorado delta region, where the warm hypersaline water from the numerous tidal channels or flats meets the cooler, less saline water moving up from the south. This produces a distinct tongue of low salinity water that moves northward up the Sonoran coast during the winter (Hendrickson, 1973). Hendrickson (1973) has hypothesized that the narrow trench running from Isla Pelicano to the northern end of Wagner Basin (in the northern Gulf) serves as a principal circulatory pathway for exchange of northern Gulf waters with those of the southern Gulf. He describes the process as one in which deep south-central Gulf water flows up the channel until forced to the surface by decreasing depth; convective mixing occurs over the channel and continues northward, while a general counterclockwise circulation tends to carry the surface waters derived from the extreme northern Gulf delta area southward along the coast of Baja California.

Of particular interest are the striking effects of the furious tidal currents and periodic strong winds of the Canal de las Ballenas (between Isla Angel de la Guarda and the Baja peninsula), and in the narrow passage between Islas San Lorenzo and San Esteban. These strong currents produce an enormous region of strong tidal mixing, resulting in abnormal temperatures at all depths, often depressed at the surface and elevated in subsurface waters (Hendrickson has recorded temperatures as high as 12°C at depths in excess of 500 m!). The turbulent mixing of cold deep water with warm surface waters produces occasional elevated temperatures throughout the Channel and has direct effects on the Baja coastline as far north as San Felipe, particularly during the summer when deep-derived nutrients are often injected onto this coastal system. One of the noticeable effects of this periodic enrichment is the good sport fishery present in that part of the Gulf, especially deep angling.

There exist, along the shores of Sonora and Sinaloa, a number of *negative estuaries*. A negative estuary, or 'estero,' is an estuary in which evaporation exceeds precipitation (or runoff). This creates a situation in which the salinity (and usually temperature) increases as one moves from the mouth toward the head of the estero. This effect is just the opposite of the one seen in a normal or *positive estuary*. Many of the esteros of western Mexico were probably positive estuaries at one time. Largely owing to the efforts of man and his modern agricultural practices few rivers now permanently flow into the Sea of Cortez (none do so in the state of Sonora). These esteros are similar to hypersaline lagoons in that the water temperature and salinities are well above that of the open sea beyond their mouths. In the summer months, during slack tide periods, temperatures in the shallow regions of these esteros often exceed 40°C (104°F) and salinities skyrocket to 40–70 parts per thousand. The backwaters of some of these lagoons have been used for commercial salt harvesting. A similar warming effect and salinity increase may be seen in the shallow turbid waters of the Colorado delta region, north of 31°4′N latitude.

Another feature of these Mexican esteros is their biological productivity, which, like most estuaries in the world, is quite high. Species diversity is often considerably higher than seen in temperate estuaries, especially in the more southern esteros that harbor lush mangrove forests. An investigation of Estero Soldado (near Guaymas), for example, revealed the existence of 354 species of macroscopic plants and animals (Brusca, unpublished). These shallow, highly productive regions also serve as nursery grounds for a number of species of commercially important fishes, shellfishes, and crustaceans, including the valuable penaeid shrimps upon which a large fishery is dependent throughout western Mexico (Snyder-Conn and Brusca, 1977). Unfortunately, it is these lovely and biologically important estero regions that are the first coastal areas to be ruined by man, and the effects of American tourism in Mexico can be increasingly seen along the Sonoran coast, as boat harbors now stand where lush mangrove forests once existed.

The northern Sonoran coast generally experiences prevailing northerly (i.e., wind direction is from the north) or northwesterly winds in the winter and prevailing southerly or southeasterly winds in the summer. In addition, offshore winds often prevail during the winter months, in contrast with prevailing onshore winds during the summer. Thomson and Lehner (1976) have commented that these seasonal tidal and wind patterns favor warm temperate species of tidepool fishes by limiting the potential for high temperatures in summer, while subjecting the cold-intolerant tropical fish species to critically depressed sea temperatures during the winter. These winter northerlies also induce significant upwellings on the lee side of many, if not most, Gulf islands and east coast capes, while the summer southerlies cause upwellings along the west (peninsular) coast. The result of these widespread upwellings is a nutrient rich basin with year-round localized plankton blooms. It was presumably those continuous blooms that originally provoked the explorer Francisco de Ulloa to christen the Gulf the "Vermillion Sea."

The work of Hendrickson (1973) suggests the following circulation pattern for the northern Gulf: In the summer the surface layers are warmed by ambient air temperatures in the shallow delta and coastal regions. These warm surface layers have a large sediment load, and, as they move away from these shallow regions and cool, their relatively greater density causes them to sink. This establishes a large summer convection cell which, under the influence of the Coriolis force, creates a general counterclockwise surface gyre, around a center of turbid downwelling water. A subsurface compensatory system exists that is the exact opposite of this surface system. Likewise, in the winter the delta and coastal water is refrigerated (to as much as 5° cooler than the water in the center of the upper Gulf) and thus dives beneath these latter waters. The effects of the Coriolis force now produce a system exactly opposite to that seen in the summer. Although this proposed model of a counterclockwise surface system in the summer and a clockwise surface system in the winter needs additional supportive evidence, it offers a resolution of Thompson's (1969) conflicting evidence (from summer data) that suggested a general net circulation clockwise but a coastal surface movement counterclockwise.

Between the waters of the California current and that of the Gulf of California a distinct density front has been observed to develop (Griffiths, 1965). It begins at Cabo San Lucas, where the cool, low salinity waters of California and west Baja meet the warm, high salinity waters of the Gulf. Surface water of increased salinity leaves the Gulf in the surface layer, while deeper (colder) water of lower salinity enters the Gulf beneath it. The exchange of water between the Gulf and the open Pacific is relatively low, on the order of 1 x 10^{12} cm^3/sec in each layer (Roden and Groves, 1959). In addition to tidal currents, wind driven circulation is responsible for a considerable amount of water exchange at the mouth of the Gulf. Under north or northwest winds the flow at the surface is out of the Gulf, with compensating flow into the Gulf at depth. With south or southeast winds there is a surface flow into the Gulf and an outward flow in subsurface layers. The overall evaporation loss in the Gulf results in a net inflow of ocean waters at the mouth.

3. Faunal Provinces and the Fauna of the Gulf of California

A faunal province has been defined by Schenck and Keen (1936) as a region populated by a distinctive assemblage of species. The uniqueness of this assemblage varies with the province and the specific animal groups used. Transition zones always exist between such general faunal assemblages, the width of these zones being different for each animal group examined. In other words, if the zoogeography of various groups of animals were to be studied, each being mapped individually, it may be found that each group would be represented by faunal zones with slightly different boundaries. In an attempt partly to resolve the ambiguities of faunal provinces Briggs (1974) established the following rule of thumb: if there is evidence that 10 percent or more of the species are endemic to a given area, it may be designated as a separate province. Other workers prefer to place this endemism level significantly higher, even as high as 40–50 percent, before recognition of a faunal province is made.

References to coastal faunal provinces are most commonly encountered when the literature pertaining to molluscs is reviewed. Much of the designation of these regions is based on molluscan distribution records, since the molluscs are probably better known than any other group of intertidal animals.

Numerous authors have broken the west coast of America up into provinces (or 'regions'), often differing from one another in terminology or degree of assemblage discrimination, but usually in general agreement with regards to the boundaries and relationships of the provinces. A review of several of these workers' schemes is presented below (see also Valentine, 1966, Brusca and Wallerstein, 1979, and papers by Schenck and Keen, 1936–1940).

Johnson and Snook (1967) considered the west coast of North America, north of Mexico, to consist of three faunal regions: the northern region, extending from Alaska to Oregon; the central region, ranging from Oregon to Point Conception (near Santa Barbara, California); and the southern region, from Point Conception to Mexico. McLean (1969) divides the west coast of North America into three regions also: the Oregonian, from southern Alaska to Point Conception; the Californian, from Point Conception to the southern tip of Baja California; and the Panamic, from the tip of Baja California southward. Abbott (1958) divides the west coast into five provinces (or four provinces and one subprovince): the Boreal, that portion of Alaska north of the Aleutian Islands; the Aleutian, from the Islands south to northern British Columbia; the Oregonian, from British Columbia to Point Conception; the Californian, from Point Conception to the Mexican border, and continuing offshore to the tip of Baja California; and the Panamic, ranging intertidally from the Mexican border and the head of the Gulf of California to South America. Newell's (1948) classic molluscan scheme is nearly identical to Abbott's, using four provinces as follows: Bering Province, Bering Strait to north end of Vancouver Island; Oregonian Province, north end of Vancouver Island to Point Conception; Californian Province, Point Conception to Cabo San Lucas; and, Panamic Province, from Cabo San Lucas south.

Steinbeck and Ricketts (1941) spoke of the Panamic Province, identifying its boundaries within rather narrow limits. They defined the southern limit as lat. 4°30'S, and the northern boundary as about lat. 23°N, near Cabo San Lucas, although they gave evidence of its northward extension to approximately lat. 28°N, near Isla de Cedros. Their collections, and other collections, indicate a small percentage of the Panamic fauna may be found as far north as Point Conception, California.

Dall (1909) described the Panamic marine province as extending from Lower California, including the Gulf of California, south to the Bay of Guayaquil, Ecuador. Keen (1971) describes the natural boundaries of the Panamic Province as Magdalena Bay in the north and Punta Aguja (Peru) in the south.

There appears to have developed some confusion surrounding the terminology of eastern Pacific zoogeographic regions. To clarify these terms: the term *east Pacific* (or *eastern Pacific*) refers to the entire length of the eastern shore of the Pacific Ocean, from Alaska to Chile. The term *Eastern Pacific Zoogeographic Region*, on the other hand, refers to that zoogeographic region ranging from the upper Gulf of California and the west coast of Baja California, south to the Gulf of Guayaquil, Peru. The Eastern Pacific Zoogeographic Region corresponds to what many authors have called the *Panamic Region* (McLean, 1969; Keen, 1971; Abbott, 1958; Steinbeck and Ricketts, 1941; Brusca, 1973). Unfortunately, some authors use the term east Pacific (or eastern Pacific) rather casually when they actually mean to imply the Eastern Pacific Zoogeographic Region.

Briggs (1974) felt the need to subdivide the Eastern Pacific Zoogeographic Region into several separate provinces, reserving the term *Panamic Province* for that area from Tangola-Tangola Bay (in the northern part of the Gulf of Tehuantepec, Mexico) to the Gulf of Guayaquil. That tropical-subtropical coastline north of Tangola-Tangola Bay (to the mouth of the Gulf of California) he refers to as the *Mexican Province*. The term "Panamic Region," as used in the species descriptions that follow, is synonymous with Briggs's "Eastern Pacific Zoogeographic Region."

Briggs concludes the Gulf of California to be a distinct warm-temperate province and *not* part of the Eastern Pacific Zoogeographic Province. He refers to the Gulf as the *Cortez Province* on the basis of the numerous reports of high endemism in this region. Yet, he goes on to state that the Gulf has relatively few species in common with the "San Diego Province" (that is, the Californian Province), that its "many endemic species were independently derived from tropical faunas to the south, and the rest of the fauna (with the exception of some warm-temperate invaders from the north) is comprised of eurythermic tropical species." Just what Briggs means to imply by the phrase "independently derived," or how he arrives at the conclusion a region should be considered to be "warm-temperate" when the only warm-temperate input has been "a few invaders from the north" and the remainder are tropical species, is not clear. The Gulf of California is, without a doubt, primarily tropical in origin and could be best considered, in its present sense, as subtropical. Like other subtropical regions of the world, its northernmost reaches (in the northern hemisphere) are populated by a watered-down tropical biota (consisting primarily of eurythermal tropical species), while its more southerly reaches gradually grade into a more typical tropical biota. Perhaps Briggs does not consider the existence of subtropical regions to be a reality. A visit to the Gulf of California will convince even a casual observer that the vast majority of organisms of this region are clearly tropical derived. It is unlikely that over 10–15 percent of the animal species occurring in the Gulf of California are represented by reproducing populations of temperate species. Warm-temperate regions, on the other hand, are comprised primarily of cool-temperate derived biota (originating to the north of their own latitudes). For a recent review of coastal zoogeography in the northeast Pacific, the reader is referred to Brusca and Wallerstein (1979).

There has also been some disagreement upon the placement of the northern limit of the Eastern Pacific Zoogeographic Region. Much of the confusion in this regard stems from the fact that along the Pacific coast of Baja there exist numerous bays, lagoons, and esteros that act as refugiums for the warm-water tropical and subtropical animals from the south, while the exposed rocky coastline between these lagoons harbors a distinctly more temperate-allied fauna. Adding still further confusion to the picture is the fact that as one moves south from the Mexican border, the common warm-temperate (Californian) species tend to be found farther offshore, becoming almost entirely absent near the southern tip of Baja California. This phenomenon is referred to as *submergence*. These cold water forms move into deeper water in the lower latitudes most likely to maintain a suitable environmental temperature. In addition, near-shore water temperatures are usually several degrees lower on the south coast of large headlands than on the northern coast, owing to upwelling phenomena.

Garth (1961), in his excellent discussion of brachyuran affinities and distributions in the Gulf, states, "The west coast of Baja California, at least in its northern portion, provides a continuum of habitat for north-temperate species found in the littoral zone of southern California south of Point Conception. This favorable environment for temperate species exists at least as far south as Punta Eugenio, opposite Isla de Cedros, and locally as far south as Punta Entrada, outside Magdalena Bay." Garth further notes, "It is also noticeable that when the Gulf of California range of these species is compared with their west coast of Baja California range, the southern limit in the Gulf of California is almost always farther north than on the open Pacific coast. This corresponds with what is known of temperatures in the region, as the outer coast is under a northerly current regime, with frequent upwelling, while the Gulf of California is cut off from northerly currents, with upwelling and associated phenomena modified by local conditions."

In regard to these phenomena I have spent some time studying the west coast of Baja California and tabulating faunal affinities at various places along the coast. As one moves south along the outer coast of Baja, the first place encountered having a higher percentage of tropical species than temperate species is Bahía Tortola (so-called Bahía San Bartolomé or Turtle Bay), just below Punta Eugenio. On the basis of extensive collections of littoral and subtidal invertebrates in this region (Brusca, 1975), it can be said that approximately 39 percent of the species are distinctly tropical and 21 percent temperate. In terms of overall biomass and abundance, however, the temperate forms are certainly more numerous than are the tropical forms. In other words, Bahía Tortola is probably the northernmost *significant* refugium for the more southern tropical fauna.

The next sizable lagoon south of Bahía Tortola is Bahía San Ignacio. This bay harbors a large and healthy mangrove forest (*Rhizophora mangle Avicennia germinans* and *Maytenus phyllanthoides*), and winter water temperatures here probably rarely drop below 17°C, the same as in the southern Gulf of California. There is no question as to the dominance of tropical species in this lagoon, in terms of both species number and individuals.

The next large bay south of this is Bahía Magdalena, a lush, semitropical system of large lagoons and enormous mangrove forests, harboring very few temperate species of invertebrates. Indeed, few temperate species exist south of Bahía Magdalena at all.

So, we see that the southwest coast of Baja California is an overlap or gradient zone between the warm water Eastern Pacific Zoogeographic Region and the cooler water Californian (warm-temperate) fauna. Alternating areas of protected warm waters and exposed colder water regions form a discontinuous gradient of these two faunas. This makes defining the boundary between these two regions difficult and somewhat arbitrary. The boundary might be established at Bahía de Sebastian Vizcaino (Scammon's Lagoon), which is the northernmost stronghold of much of the tropical eastern Pacific fauna, or at Bahía Tortola, which is the first place where the number of tropical species appears to outnumber the temperate species, and the giant kelp (*Macrocystis*) makes its last stand. The division might likewise be placed at Cabo San Lucas, where the California abalones finally cease to exist.

My studies and the above considerations indicate the logic of accepting the region between Punta Eugenio and Bahía Magdalena as the dividing region and of interpreting it as a zone of discontinuous overlapping transition between the cool Californian and warm tropical faunas. For workers who cannot accept this definition or find it unworkable for their own research, I suggest they consider Bahía San Ignacio as the arbitrary northern boundary of the Eastern Pacific Zoogeographic Region. For it is here that the naturalist first senses an unquestionably tropical environment. It is here that the first large mangrove stands appear and that the winter water temperatures approximate those of the southern Gulf of California. These arbitrary boundaries, of course, do not accommodate the species of tropical invertebrates that occur in southern California (such as the heart urchin, *Lovenia cordiformis;* the pale urchin, *Lytechinus pictus;* the fiddler crab, *Uca crenulata;* and others) or the temperate species that occur in the Gulf (the lined shore crab, *Pachygrapsus crassipes;* the long-fingered shrimp, *Betaeus longidactylus;* etc.).

The bibliographies supplied for each chapter provide numerous citations in which the origins and affinities of the fauna of the Gulf of California are discussed. In general, it is known that the fauna of the Gulf of California consists of representatives of three major zoogeographic regions: the Eastern Pacific Zoogeographic Region (Panamic Region of some authors); the Caribbean Region; and, the Californian Province (or the northeast Pacific Warm Temperate Region). In addition there exist in the Gulf a significant number of cosmopolitan and cosmotropical species and a surprisingly large number of species that appear to be restricted to the Gulf entirely. In time, however, it may be found that many of the supposed endemics actually range well beyond what is presently believed. I had always assumed, for example, that the sea star *Othilia tenuispina* was restricted to the upper Gulf of California, until I found it, in 1974, in Bahía Magdalena, on the west coast of Baja California, and then in 1975 in the region around Cabo San Lucas.

Excluding the insects, spiders, amphipods, and brachiopods from analysis (owing to incomplete knowledge of their distributions), the remaining 935 species of Gulf invertebrates treated in this Handbook may be classified as follows: Gulf of California endemics, 21 percent; eastern tropical Pacific species, 41 percent; temperate (northern) species, 18 percent [12 percent Californian; 6 percent Californian-Oregonian]; Indo-Pacific species, 1 percent; amphiAmerican species, 4 percent; cosmotropical and cosmopolitan species, 8 percent; species of uncertain affinity, 7 percent.

The tropical eastern Pacific fauna of the Gulf is primarily represented by those animals originating in Central and South America. Members of this group with which California students may be familiar include the sea porcupine, *Lovenia cordiformis;* the pale urchin, *Lytechinus pictus;* the brittle stars, *Ophiothrix spiculata* and *Ophioderma panamense;* the sand star, *Astropecten armatus;* the fiddler crab *Uca crenulata* (the only fiddler occurring along the Pacific shores of the United States); the polychaete *Diopatra splendidissima;* and the bland nemertine, *Lineus flavescens*. A number of the tropical east Pacific animals had their own origins in the Indo-Pacific region (the trans-Pacific fauna and its descendants), and a much larger percentage originated with the fauna of the transisthmian track, prior to the closing of the Panama seaway. In general, few species or genera of invertebrates have been able to cross the vast expanse of the southern Pacific Ocean (the "East Pacific Barrier" of Ekman, 1953) and survive to establish themselves in the tropical west Americas. Briggs (1961, 1967), Emerson (1967), and Rosenblatt and Walker (1963) have all stressed the fact that present-day Indo-Pacific faunal species and genera in the eastern tropical Pacific are largely restricted to offshore islands. One of the reasons these forms are so few in number on mainland shores is the absence of large coral formations there. Further discussion on coral reefs in this region may be found in Chapter 2.

The concept of a generalized transisthmian track has only recently been widely recognized (see Croizat, Nelson, and Rosen, 1974; Rosen, 1975); I hope it will be quickly accepted. Simply stated, this concept implies that, prior to the closing of the Panama seaway, there existed a large group of animals (and plants) whose distribution extended throughout both the tropical east Pacific and the tropical west Atlantic. This amphi-American biota [the "Panamanian Track" of Croizat et al. (1974), or the "Tertiary Caribbean Province" of Woodring (1966)] was the predecessor of many of the so-called twin, analog, or geminate species (species pairs) now recognized in the Caribbean and tropical eastern Pacific regions. Abele (1976) has indicated that, among the decapod Crustacea, about 45 percent of the extant species occurring in Panama are congeneric geminates. Reasonable estimates suggest that 5–40 percent of the tropical eastern Pacific invertebrate species may have Atlantic analogs (depending on the taxon examined), attesting to the close biological affinity of these regions. In addition, many invertebrate species are now represented in the Caribbean only as fossils, while still existing as extant populations in the east Pacific (Woodring, 1966, termed these species "Caribphiles," with "Paciphile" referring to the opposite situation). This picture of the origin of the Caribbean fauna in respect to the Gulf of California complements previous suggestions that the Caribbean species immigrated into the Pacific during the existence of the seaway, thence to evolve to the point where they are now recognized as distinct species. Considerable data have been presented dealing with the zoogeographic relationships of the Caribbean versus the east Pacific tropics. Much of it has been summarized by Jones (1972).

So, we see that in order to assign a zoogeographic "origin" to some of the animals living in the Gulf of California, we must first consider them to have been a part of the generalized Caribbean-tropical east Pacific fauna, and then, upon the closing of the Panama seaway, to have evolved in their own directions to become members of the Eastern Pacific Zoogeographic Region fauna. The opening of the Panama Canal has had little effect on the land barrier, owing to the continuous freshwater barrier of Gatun Lake.

The Californian fauna probably migrated to the Gulf by one or both of two possible ways. The first of these could have been a past water connection across the Baja California peninsula. Garth (1961) stated that there are three areas where this extinct water bridge can be shown to have possibly existed in the geological past: at the level of Llano de Magdalena; at the midpeninsular level below the Sierra Vizcaíno; or above the Sierra Vizcaíno, perhaps at the level of Laguna Ojo de Liebre (Scammons Lagoon). The second pathway the Californian fauna may have taken to the Gulf, and the most probable, would be by a southward displacement of present-day isotherms to move the colder temperate sea below the level of Cabo San Lucas, permitting immigration around the tip of Baja California and back up into the Gulf. The most recent large glaciation (the fourth Pleistocene ice age) occurred just 8,000 to 20,000 years ago, well after the Panama seaway had closed up. As a result of this phenomenon, a number of temperate species of animals are now "trapped" in the upper Gulf, where sea temperatures throughout most of the year are cooler than in the southern Gulf. For references to this temperate, disjunct fauna, see Durham and Allison (1960), Dawson (1960), Soule (1960), Garth (1960), Hubbs (1948), Walker (1960), and Brusca (1973, 1975). Not all of the Californian species possess this disjunct distribution, of course, and many live throughout the Gulf and around the tip of Baja north to California. Among the animals that display this disjunct distributional pattern are the crabs *Randallia ornata* and *Pyromaia tuberculata;* the shrimp *Betaeus longidactylus;* and numerous species of fish, such as the spotted rock bass *(Paralabrax maculatofasciatus)*, the opaleye *(Girella simplicidens)*, and the rock wrasse *(Halichoeres semicinctus)*. Other Californian animals living in the Gulf are *Pachygrapsus crassipes*, the lined shore crab; the barnacle *Chthamalus* *fissus;* the polyclad *Pseudostylochus burchami;* and the crab *Lophopanopeus frontalis*.

Another factor adding uniqueness to the Gulf of California–Baja California region is the phenomenon of insular species, encountered in the region of Cabo San Lucas. This littoral area is largely cut off and isolated from the mainland by deep water to the east and cold winter temperatures to the north. This means the Cabo San Lucas region is, in regard to its specialized fauna, somewhat of an island. Because of this, the area shares many tropical affinities, not with mainland Mexico, but with offshore islands such as Socorro, Clarion, and the Galápagos.

Garth (1955) stated that the intertidal regions of the upper Gulf of California, from Bahía Agua Verde on the west to Puerto San Carlos on the east, constitute in effect a Pacific Mediterranean region, of which the present communication with the ocean, unlike the Strait of Gibraltar, now lies in the tropics (referring to the region of Cabo San Lucas and Mazatlán). In general it could be said that the fauna of the northern Gulf constitutes a "diluted" tropical fauna, with the addition of a fair number of temperate and cosmopolitan species. Those tropical forms inhabiting the northern Gulf are generally more eurythermal than those of the southern Gulf. Likewise, much of this tropical fauna disappears from the littoral region of the northern Gulf during the colder winter months. Some of the animals may migrate to deeper water or more protected, warmer waters, while others apparently die off seasonally, to rely on spring (larval) recruitment from more southerly latitudes to reestablish their upper Gulf population. Most of the latter forms probably do not form "breeding" populations in the northern Gulf. The sea stars *Nidorellia armata* and *Oreaster occidentalis* may be examples of Gulf invertebrates that form nonbreeding populations in this region. Likewise, many types of invertebrates are known to be stenothermal in their spawning and young stages, but relatively eurythermal during the adult, nonreproductive periods. There are, no doubt, many such animals (of both tropical and temperate origin) in the northern Gulf. In this regard the upper Gulf, and in general the southern Gulf as well, may be considered a subtropical region. As one moves north from Bahía Tangola-Tangola the typical east Pacific tropical fauna becomes progressively more dilute or thinned-out.

Walker (1960) distinguishes four faunal areas in the Gulf, based on fish distributions, which he labels as: (1) the *upper Gulf*, extending north from Bahía San Francisco past the southern tip of Isla Tiburón; (2) the *central Gulf*, which includes the short length of shoreline from Bahía Kino to Guaymas on the eastern shore of the Gulf, and the much longer shoreline between Bahía San Francisquito and La Paz on the west side; (3) the *Cabo San Lucas area*, extending north from Cabo San Lucas to La Paz; and (4) the *southeastern Gulf*, from Guaymas south on the eastern shore of the Gulf. He includes a good discussion of each of these areas, particularly in regard to the fish populations of the Gulf. I do not, however, believe that the invertebrate faunas of these regions are distinct enough to warrant application of Walker's scheme to them.

The interesting phenomenon of ecological equivalence is strikingly seen in the Gulf. In fact, a student of the California intertidal zone can expect to find many of the same types of animals, in the same habitats, in the tidepools of the Gulf that he is familiar with along the Pacific shores of the United States. For instance: the common California rocky intertidal sea urchin, *Strongylocentrotus purpuratus*, is replaced in the Gulf rocky intertidal by the nearly identical *Echinometra vanbrunti;* the California mudflat crabs of the genus *Hemigrapsus* are replaced in the Gulf by similar-appearing mud crabs of the genus *Eurytium;* the ubiquitous California sea star *Pisaster* is represented in the Gulf by the equally ubiquitous sea star *Heliaster;* the mud snail, *Cerithidea californica*, by its near twin, *Cerithidea mazatlanica;* the sand dollar, *Dendraster excentricus*, by *Encope* and *Clypeaster*, and so on. Suffice it to say, the more one learns to know the animals of the seashore, the more one may predict a certain type of animal to be living in a certain habitat. The most conspicuous differences between these two regions are the lack of giant kelp (laminarians), goose barnacles, and large mussel beds in the Gulf, all three of which are familiar scenes to students of the west coast of the United States.

4. Habitats of the Gulf Intertidal

Hedgepeth (in Ricketts, Calvin, and Hedgepeth, 1968) stated that there are three principal factors influencing the [local] distribution of intertidal invertebrates: (1) amount of wave shock; (2) bottom type; and (3) tidal exposure. By varying the combinations and degree of these three factors, you can come up with just about every conceivable type of shoreline habitat, regardless of where you are, and expect to find approximately similar situations in any temperate or tropical sea of the world.

In addition to these three abiotic factors one must also consider temperature when examining an animal's local or overall distribution. As previously stated, the waters of the Gulf of California actually constitute two somewhat distinct thermal regimes: the upper Gulf (above the midriff islands), which has hot summer temperatures (similar to those found in the subtropics and tropics) but cold winter temperatures (similar to those found on the coast of California); and the southern Gulf, which has warm winter temperatures, similar to those found in subtropical regions throughout the world. The effects of these differences are partly to isolate certain animals in the upper Gulf while restricting certain others to the region below Islas Angel de la Guarda and Tiburón. It is only in the southern Gulf, for example, that you find such distinctly tropical sea stars as *Heliaster microbranchius* and *Acanthaster ellisii* (the east Pacific crown-of-thorns). The transition zone between these northern and southern Gulf thermal "provinces" may be thought of as occurring between Puerto de Lobos (30°20′N) and Bahía Kino (28°50′N). As might be expected, the extreme temperature variation in the northern Gulf has led to the establishment of a noticeable seasonality, seen in both the marine flora and fauna of that region. In the hot summers of the northern Gulf, certain temperate-allied animals completely disappear from the littoral region, including the common sea hare *Aplysia californica*, while during a cold winter such tropical species as the sea stars *Nidorellia armata* and *Oreaster occidentalis* disappear. In general, the animals of the northern Gulf represent a "watered-down" tropical fauna, consisting primarily of eurythermal tropical-subtropical species and a handful of warm temperate forms. This phenomenon was discussed in greater detail in the preceding section.

The effects of salinity variations in the Gulf of California are noticeable only in the negative estuaries (esteros) and lagoons of Sonora and Sinaloa, as discussed in part 2 of this introduction, and over the Colorado delta. Obviously only certain euryhaline animals and plants can manage to survive the extreme salinity variations found near the heads of these lagoons. Some animals that do live in such regions include fiddler crabs *(Uca)*, certain swimming crabs *(Callinectes bellicosus)*, ghost shrimps *(Callianassa)*, oysters *(Ostraea)*, certain snails *(Nerita, Cerithidea, Littorina,* and *Cerithium)*, barnacles, and certain fishes (such as gobies and mullet). More stenohaline species of invertebrates that establish temporary populations in these highly saline situations tend to be noticeably smaller in size than their open coast counterparts and probably do not breed there.

One of the most conspicuous differences that students will notice between the shores of North America and those of Mexico and Central America is the smaller size of the algae in the latter area. Especially noticeable is the absence of large brown kelps (Laminariales) that predominate on so much of America's temperate coast. Although the marine flora of the Gulf is exceedingly rich (334 species reported from the northern Gulf by Norris, 1976), species of three genera usually dominate (visually and by biomass): *Sargassum, Padina,* and *Colpomenia.*

The Gulf of California possesses a great diversity of shore types. The most conspicuous of these could be loosely grouped into rocky shores, sandy beaches, and tidal flats (mud or sand-mud flats of bays and estuaries). The most diverse of these areas, in terms of numbers of species, is the rocky shore. The high number of species present in this habitat is largely due to its stability and heterogeneity. For discussions of the general ecology of shoreline habitats on the Pacific coast of America, the reader is referred to references cited in the Preface, particularly McConnaughey (1974) and Ricketts, Calvin, and Hedgpeth (1968).

A brief description of a rocky shore fauna in the Gulf of California would go something like this. On the exposed surfaces of the rocks are vast numbers of barnacles *(Balanus, Chthamalus,* and *Tetraclita)*, coiled worm tubes *(Hydroides* and *Spirorbis)*, and snails *(Littorina, Nerita, Collisella* [formerly *Acmaea*], *Columbella* [formerly *Pyrene*], and *Acanthina)*. If the tide is low enough, we may also find the beautiful green coral *(Porites)*, sea anemones *(Bunodactis, Anthopleura, Bundosoma,* and *Phyllactis)*, and sea stars *(Othilia tenuispina, Phataria unifacialis,* and *Pharia pyramidata)*. In the crevices of the rocks are hidden the large crabs *(Eriphia* and *Grapsus)* and sea urchins *(Echinometra* and *Eucidaris)*. If we turn over one of the large rocks, vast numbers of small crustaceans scurry off it and into the water below. These are mostly amphipods, isopods, hermit crabs, shrimp *(Lysmata, Alpheus,* and *Synalpheus)*, and smaller porcelain crabs *(Petrolisthes* and *Pachycheles)*. Clinging to the bottom of the rock we can expect to find a multitude of animal types, from sponges *(Verongia, Geodia,* and *Haliclona)* to those distant relatives of man, the ascidians, who curiously are often difficult to tell apart from the lowly sponges. Also found clinging to the bottom of the rocks are sea cucumbers *(Neothyone, Pentamera,* and *Selenkothura)*, sea stars *(Heliaster* and *Pharia)*, small brittle stars *(Ophiothrix spiculata, Ophionereis annulata,* and *Ophiactis)*, flatworms *(Pseudoceros, Prosthiostomum,* and *Stylochoplana)*, the beautiful sea slugs or opisthobranchs *(Casella, Chromodoris, Pleurobranchus,* and *Aplysia)*, polychaete worms, porcelain crabs, a variety of gastropods and chitons, and some of the smaller true crabs *(Ala cornuta, Pilumnus,* and *Leptodius)*. In the pool left behind by our overturned stone we can find the large brittle stars *(Ophioderma* and *Ophiocoma)*; the ubiquitous fireworms *(Eurythoe* and *Notopygos)*, and other polychaetes; many of the small to medium sized crabs *(Pilumnus, Ala, Xanthodius, Geotice, Glyptoxanthus,* and *Leptodius)*: shrimp, including the pistol shrimp *(Alpheus)*; and small tidepool fish (mainly Gobiidae). If we were to pick up a handful of the sand from the place where the rock had been, we would find a large number of small crustaceans (amphipods and isopods), many different types of polychaete worms, probably a few peanut worms (sipunculans), and perhaps a burrowing anemone or two *(Metapeachia* or *Pachycerianthus).* Living in the interstitial material between and around the rocks is an interesting assemblage of animals, consisting largely of polychaete worms, including the beautiful fan worms *Sabella* and *Megalomma,* sea cucumbers *(Brandtothuria* and *Fossothuria),* amphipods, and sipunculids.

At first glance, this inventory may appear to exhaust our rocky shore habitat. But several interesting areas still remain to be explored. One of these is the rock itself. If the stone is hard, such as basalt, we need not bother to investigate it. But let us assume the rocks on this beach are of sedimentary nature, perhaps sandstone or limestone (as much of the rocky coastline of the Gulf is). By splitting the rock open (with a hammer or by dropping it on another rock), we will find it infested with a myriad of tubes and tunnels, whose principal inhabitants are sipunculans *(Themiste lissum),* boring clams *(Lithophaga),* polychaete worms, and holothurians. Another easily overlooked habitat is the mat of algae covering most of the rocks below the high tide zone. By careful examination of this material, or by rinsing it in a *mild* formalin solution (1–2 percent in fresh water) to chase out the inhabitants, we will find large numbers of amphipods, isopods, worms, and small crabs. One last habitat still remains to be explored—those large chunks of sponge underneath the rock that we just carefully restored to its original location. When the sponges are broken open, we find their interior resembles that of the soft rock we just cracked apart, a vast storehouse for small crabs, amphipods, brittle stars, and worms.

The vast expanses of large mud flats, perhaps more appropriately called *tidal flats,* of the Gulf are often overlooked by the student of the seashore. At first glance, these bleak, quiet, occasionally foul-smelling areas appear quite barren when one is used to the colorful and active habitats of the rocky coast. Upon close examination, however, these regions will reveal themselves as worthwhile collecting areas. Walking across the bay or estuary at low tide, we will almost invariably encounter the mud snails *Cerithidea mazatlanica, Cerithium stercusmuscarum, Natica chemnitzii,* and species of *Nassarius.* If the substrate has enough sand in it, we will find the olive shells *(Oliva* and *Olivella).* Many animals attach themselves to pebbles or shells exposed on the surface (or situated just below the surface) of these unconsolidated sediments. Clumps of compound ascidians and large chunks of sponge are often found on the sand-mud surface. Protruding from the ground or near the surface will often be the tubes of various polychaete worms *(Diopatra, Chaetopterus,* and *Arenicola)* and amphipods of the genus *Corophium.*

Just below the surface of the mud (or sandy mud), we may find a variety of polychaetes, the odd little acorn worms (enteropneusts), the ghost shrimps *Callianassa* and *Upogebia,* various isopods *(Ancinus, Cirolana, Excirolana),* and if luck is with us, the beautiful peanut worm *Sipunculus nudus.* Usually a number of small water channels will cut through a mud flat or bay, draining its upper reaches and often carrying water seaward even after the tide has begun moving in. These channels are good areas to look for cerianthid anemones and swimming crabs *(Portunus* and *Callinectes),* other invertebrates, and fish. If the tide is a very low one, and we were to walk all the way out to the water's edge or even wade in to our waists, we might be fortunate enough to come across a bed of sand dollars *(Encope, Mellita,* or *Clypeaster),* some gorgonian coral, and an occasional sea pen. On the way back in, if we were to stop and browse along the upper margin of the bay, where there are often large beds of algae, *Salicornia,* or marsh grass, we might find great colonies of fiddler crabs *(Uca)* and probably some of their predators, the larger crabs of the genus *Eurytium.* If we had taken a shovel along with us, we would have dug up large numbers of clams *(Chione, Protothaca, Tagelus,* and others*)* and would be well on our way to a delicious clam chowder.

In the central and southern Gulf, tidal flats and bays often have (at their heads) smaller, more enclosed and protected bodies of water, inhabited by the mangrove trees and their associated biota. These habitats are usually referred to as mangrove lagoons, mangrove swamps or mangrove forests. The mangrove forests of the Gulf and Baja California form a unique and exciting habitat that consists of several species of mangrove trees and a large number of associated plants and animals. The term "mangrove tree" actually refers to a group of halophytic plant species belonging to about twelve genera, in eight different families. The incredible similarity in structure and function of these phylogenetically unrelated plants is a classic example of evolutionary convergence (reflected in such unique adaptations as prop roots, pneumatophores, viviporous seeds, and a number of physiological modifications to saline environments). About ten species are found in the new world tropics and subtropics, while thirty-six have been reported from the Indo-West Pacific region (Lugo and Snedaker, 1974).

The mangrove regions of the Gulf and Baja California are especially unique in that they are nearly all found in "esteros," and not in true positive estuarine conditions. The concept of an "estero" has been discussed in section 2 of this introduction. The mangroves in these regions are all stunted, rarely over 2.5 m in height. This is probably a reflection of local climatic and physical conditions and has been referred to, in other regions, as scrub mangrove systems. These mangrove esteros are extremely productive regions and serve as highly efficient detritus and nutrient traps. Measurements of gross primary productivity in Florida mangrove habitats are on the order of 1.4–13.9 g C/m^2/day. There have been no published productivity data for Gulf mangrove habitats.

The most commonly encountered mangroves of northwestern Mexico are the Red Mangrove, *Rhizophora mangle* (mangle rojo or mangle colorado); the Black Mangrove, *Avicennia germinans* (mangle negro or mangle salada); and the White Mangrove, *Laguncularia racemosa*. Sweet Mangrove, *Maytenus phyllanthoides* (mangle dulce), is often encountered, more landward than the previously mentioned species. Mangle dulce, however, is not generally considered to be a "true" mangrove tree but more of a tropical coastal shrub.

Invertebrates typically associated with the mangrove vegetation include certain sponges *(Litaspongia* and *Ophlitaspongia);* an unidentified but very abundant brown anemone; oysters, especially *Ostrea columbiensis* and *O. palmula;* shipworms *(Teredo);* certain gastropods *(Littorina fasciata, Cerithium stercusmuscarum, Crepidula* spp., and *Crucibulum* spp.*);* barnacles *(Balanus pacificus* and *Chthamalus anisopoma);* several crabs *(Goniopsis pulchra, Tetragrapsus jouyi, Aratus pisonii, Pachygrapsus transversus,* and *Geograpsus lividus);* the brittle stars *Ophiothrix spiculata* and *Ophiactis simplex;* numerous species of ectoproct; and several types of compound and solitary tunicates, including *Ascidia* and *Aplidium*. In addition, the brightly colored, crablike spider *Gasteracantha elipsoides*, is often encountered in the vegetation (well above water line).

Nearly any tidal flat can be seen to have an anaerobic layer at some depth. The depth at which anaerobic conditions set in is determined by the amount of organic matter present, the particle size of the sediment, and the amount of wave action present. The depth at which this layer begins is marked by a distinct change in color to dark gray or black. Little animal life exists below this layer, although several species of polychaetes and crabs maintain living burrows within the anaerobic region, while feeding on the surface.

This still leaves the sandy beach unexplored. Hunting for animals in this habitat often leads to disappointment, and we may prefer to collect on the pure sand beaches while engaging in some other activity, such as swimming or picnicking. If our luck holds, we should find some of the scavenging ghost crabs *(Ocypode occidentalis)* burrowed above the water line. These crabs emerge from their burrows at night to feed on *Sargassum* and other jetsam washed ashore (thus exploiting a niche very similar to the one occupied by the numerous talitrid amphipods of temperate shores). If the tide is low and we have our shovel and some window screen or sieves, we might find mole crabs *(Emerita, Lepidopa,* or *Hippa),* the little clam *Donax punctatostriatus*, and surely a number of amphipods *(Paraphoxus, Hyale,* and *Megaluropos)* and isopods *(Excirolana braziliensis, Eurydice caudata).* If the tide is very low indeed, we could probably come upon some sand dollars, heart urchins, some of the large sand stars *(Astropecten, Luidia, Astrometis),* polychaetes *(Scolelepis agilis* and *Pisionidens indica),* and a few swimming crabs.

The foregoing account has mentioned only the most common inhabitants of the most common types of shorelines. The Gulf offers a number of other habitats, including wharf pilings, boat docks, and negative and positive estuaries. In each habitat, the animals can be seen to distribute themselves in relation to their particular needs. The animals that can cling tightly to the substrate will be found along wave-swept shores; the animals that cannot will be forced to live in quieter waters, and so on. One of the principal factors affecting the distribution of the intertidal animals is the degree of daily or monthly exposure during the low tides. This has led to the concept of intertidal zonation, which is discussed in the following section.

Parker's (1963) sizable publication has dealt with the ecology and community composition of many macroinvertebrates in the Gulf of California (particularly molluscs). Some of his computer-generated community assemblages appear questionable however, and discretion should be used in that regard. This publication also contains an excellent history of biological exploration in the Gulf, as well as numerous physical data.

5. The Tides and Intertidal Zonation in the Gulf of California

The upper Gulf of California has some of the largest tides to be found anywhere in the world (20 to 30 feet of vertical displacement). The earliest known tide records from the northern Gulf and the Colorado Delta region are those from Francisco de Ulloa, made in 1539 (Matthews, in Thomson, 1969). At the present time, there are four primary tide stations in the Gulf. These are at Guaymas, Topolobampo, La Paz, and Mazatlán. There are a total of fourteen tide stations on the west coast of Mexico.

No attempt will be made here to go into the physics and astrophysics of tides. The dynamics of tides have been amply explained in a great number of texts, and the reader is referred to the references for this section for information beyond what is given in this handbook. One of the most lucid accounts on the basics of this subject is Bascom's (1964) excellent description in his lovely little book, *Waves and Beaches*.

The tidal flow of the Gulf of California, and indeed that of nearly the entire Pacific coast of the Western

Hemisphere, is generally described as *semidiurnal* (or *semidaily*). These terms describe a tidal pattern of two high tides and two low tides each day. This pattern of highs and lows is associated with, and largely dependent upon, the phases of the moon (the relative position of the sun in respect to the moon and earth) and the height of the moon in relation to the celestial equator. The tides are also influenced to a lesser degree by the centrifugal force of the earth-moon system around the sun, the ocean basin topography, and that phenomenon known as *seiche*, or the inherent oscillations of large bodies of water. During the new and full moons the earth, moon, and sun are in an approximate straight line, and the tidal range is at its greatest as a result of the multiplying effect of the gravitational pull of these other two celestial bodies on the earth's seas. These periods of extreme high tides and extreme low tides are referred to as *spring tides*. During the quarters of the moon, when the sun and moon are at right angles to the earth, the tidal range is least, falling 10–30 percent below the average range, and this period is known as *neap tides*.

At Guaymas the tides are of fairly small amplitude, but at Puerto Peñasco the amplitude of all the tidal constituents is increased markedly over their values at Guaymas to produce a well-marked semimonthly inequality. The degree of inequality and the existence of semidiurnal tides is partly dependent also upon the natural period of oscillation of the body of water in question. Defant (1961) gives the natural period for the entire Gulf as 7.66 hours.

The exact nature of the tide-producing forces in the northern Gulf of California still demands documentation. It has been said there exists a standing wave that is in resonance with the astronomical forces, these combined factors accounting for the extreme high tides seen as one moves northward in the Gulf. The existence of this standing wave, and the exact time of the natural period (as well as its configuration and seasonal variations) are still largely matters of speculation. Current patterns in the Gulf also remain to be investigated and described, although J. R. Hendrickson (1973) and his co-workers have generated some preliminary data on currents in the upper Gulf (see part 2 of this introduction).

Unlike the northeastern coast of North America, whose two daily highs are usually approximately equal and whose two daily lows are also approximately equal, much of the Gulf of California (as on the west coast of the United States) experiences *irregular* or *mixed semidiurnal* tides, in which one daily high is much higher than the other high and one daily low is much lower than the other low. This irregularity is quite pronounced in the northern Gulf, but decreases in magnitude as one moves south. In the southern Gulf, the amplitude is small enough that it is often overcome by a given combination of the many interacting forces to produce periods of simple diurnal tides (one high and one low daily), these periods lasting a few days to a few weeks.

So, we have two low tides and two high tides occurring each day, and twice a month (during the full and new moons) developing into the very high highs and very low lows of the spring tides. The breadth of the beach that extends from the highest point the high tides cover, to the lowest point the low tides expose, is known as the *littoral* or *intertidal zone*. It is with this area that this handbook is primarily concerned. Below the low tide line lies the *subtidal* zone, accessible only by wading, diving, or trawling. Above the high tide line, in the narrow band where the winds and waves toss their salty spray, is the *splash* or *spray zone*. Above the spray zone is the vast expanse of the Sonoran desert. The lower limit of the intertidal zone is, biologically speaking, somewhat artificial, for most of the same plants and animals living below the 0-tide level are also found living in depths of 50–100 m.

For the sake of convenience, the intertidal zone, or more correctly the true tidal fluctuation, is classified quantitatively into a number of arbitrary divisions. In North America the unit of measurement used to divide the intertidal zone is feet. For example, in Puerto Peñasco the lowest low tide of the year is separated from the highest high tide of the year by about 24 feet of vertical displacement. In other words, if a pole were fixed in the water and observed daily, it would be found that the water level on the pole moves up and down about 24 feet throughout the year, between its highest point and its lowest point. In order to allow for long-term fluctuations in the level of the sea, we don't start measuring with 1 at the lowest point on the pole, or the lowest low tide, but rather compute a 0 point at a defined level between the extremes and call everything above this level a plus tide (e.g., +2 feet) and everything below it a minus tide (e.g., −2 feet). Thus, the actual, physical point of the 0-tide level may fluctuate from decade to decade as the level of the seas rise or fall and new calculations are made. The 0-tide level or "0 datum" (as used on the University of Arizona Tide Calendar for the Northern Gulf of California, 1968–79) is set at the mean (average) height of the low water of the spring tides, which is the conventional datum for Mexico and Central America. This means that the average of the lowest lows during the spring tides throughout the year is the 0-tide level. Thomson (1971) states, "Mean low water springs is defined as the mean of the low waters of the spring tides which occur a day or two after the moon is new or full." On U.S. tide charts, however, 0 datum is based on the mean of the lower of the two lows each day of the month (MLLW), thus incorporating neap-tide values as well as springs.

The vertical displacement of water along California shores is 7 to 12 feet, while in the northern Gulf of California it is 20–30 feet (in the Bay of Fundy, by comparison, the vertical displacement occasionally exceeds 50 feet, and on the east coast of the United States it is around 2 to 3 feet). The mixed semidiurnal tides of the northern Gulf have a fairly consistent pattern of the lows occurring early in the morning and late in the evening throughout the year. The southern Gulf exhibits much less tidal fluctuation, as the range of spring tides is only about 3 to 5 feet. The tidal range increases rapidly from Isla Tiburon north, reaching a maximum at the delta of the Colorado, where spring ranges of 30 feet are encountered. It must be remembered that these figures are for vertical displacement, up and down the pole we fixed in the sea bottom. When these vertical displacements are translated to horizontal displacements the figure increases as a factor of the slope. On a rocky shore with a good slope the tide may go out several hundred feet, while in a gently sloping bay or tidal flat, several miles will be uncovered as the tides retreat (in the northern Gulf). The Colorado delta tidal bore has been measured in excess of 10 knots.

Probably since the first naturalist took the time to carefully observe the seashore, it has been apparent to man that the intertidal zone could be divided not only quantitatively, by increments on a measuring stick, but qualitatively, by observing the organisms living in this area. Even a casual observer strolling down an exposed stretch of rocky intertidal beach will see these zones occurring one below the other. E. F. Ricketts' original studies of intertidal zonation on the Pacific Coast of California recognized four zones or regions in the intertidal. Most students of the west coast have become so familiar with this scheme that its concept and practical application are almost subconsciously applied and rarely questioned. Excellent, firsthand discussions of this and other zonational schemes are given by Ricketts, Calvin, and Hedgpeth (1968) in *Between Pacific Tides*, Stephenson and Stephenson (1972), Doty (1946 and 1957), Lewis (1964), Glynn (1966), Southward (1958), and Zenkevitch (1963).

It must be realized that the biology of the Gulf of California is poorly known, at best. Practically none of the invertebrate animals of this region have been examined in terms of their ecology, behavior, or physiology. Similarly, little work has been done on the phenomenon of intertidal zonation in regards to the Gulf of California. The only attempts to describe the zonational pattern of animals from this region are by Pickens (1970) and by Hendrickson and Brusca (1975). Pickens produced a mimeographed field guide to the common marine invertebrates of the Puerto Peñasco region, containing a two-page chart illustrating the zonation patterns of many common species, as envisioned at that time. Hendrickson and Brusca edited a collection of student research papers dealing with factors limiting the vertical distribution of nine species of key littoral invertebrates in the northern Gulf.

As a result of an overwhelming number of requests from users of the first edition of this handbook, as well as from other workers interested in the Sea of Cortez, I have attempted to formalize my notes and thoughts on zonation in the rocky intertidal of the northern Gulf. The result has been a zonational scheme not unlike that of Ricketts, Calvin, and Hedgpeth (1968). The data and concepts upon which I have based the following scheme have been collected by myself and Marine Ecology students at the University of Arizona; they have grown, changed, and matured over the past seven or eight years with the valued assistance of many people. Although they pertain only to the northern Gulf, and the region of Puerto Peñasco specifically, they may be used with caution in the southern Gulf also. Adjustments for tidal differences must, of course, be made.

One can understand the system of zonation given here, based purely on tidal levels (in feet). A somewhat more subtle comprehension may be obtained, however, by also considering the following tidal data characterizations.

HHHW	Highest higher high water. The highest level to which the tides ever reach. Also seen as EHWS (extreme high water springs).
MHW	Mean high water. The mean of all the high tides.
LLHW	Lowest lower high water. The highest level covered and uncovered at least twice each day.
HHLW	Highest higher low water. Approximately mean sea level.
MHLW	Mean higher low water. The mean of all the higher low waters.
MLLW	Mean lower low water. The mean of all the lower low waters (i.e., the mean of the lower of the two low tides of each day). This serves as 0 datum on most U.S. tide charts. On the University of Arizona Tide Calendar MLLW is about + 1 foot level.
LLLW	Lowest lower low water. The lowest level to which the tides recede. About − 6 feet in the northern Gulf of California. Below this is the subtidal or sublittoral region. Also seen as ELWS (extreme low water springs).

There are many other tidal data that can be computed for any given place, but these will suffice for our purposes as they correspond to the breaks seen between the faunal zones described below. It should be understood that the level of these tidal data will vary slightly from year to year. The effects of these small variations are as yet uncertain. These data are similar to but not conceptually the same as Doty's (1946) "critical tidal levels." The concept of "critical tidal levels" has recently been challenged (Connell, 1972; Underwood, 1978). Nevertheless, my observations indicate that the major breaks in faunal distribution in the littoral region of the northern Gulf *do* correspond to the "Tidal Levels" indicated in Table 2.

It should be understood that the ecology of the intertidal region, and the definition of its "zones" and zonation, are biological phenomena, based on distinct or dominant animals, plants, communities, and distributions. The application of tidal factors (or other physical parameters) to this scheme is secondary. Nevertheless, it is a fact that, in all but a few regions of the world, the rise and fall of the tides is the most important single factor governing life on the shore. It should also be realized that these changes in water level serve to generate a whole host of secondary phenomena which affect any particular animal's zonation pattern (i.e. fluctuations in temperature, salinity, oxygen availability, etc.).

As stated in the first edition of this handbook, I have found Ricketts' original scheme of zonation to be quite applicable for the upper Gulf of California. The only basic difference between the scheme presented below and that of *Between Pacific Tides* is the division between zones II and III. In the Gulf there seems to be a more distinct faunal break at LHHW (near the mean of the LLHW), than at the MHLW, as along California shores. This difference may be due to the greatly extended width of the intertidal zone in the northern Gulf, or perhaps it is a reflection of a more tropical shoreline. In this sense the following scheme is similar to that of Doty (1946 and 1957), who found mean sea level (near HHLW) to correspond to a distinct floral break between what is comparable to zones II and III.

Remember also that MLLW on the coast of California is used as 0-tide datum, while in the following system (being based on the 1975 University of Arizona Tide Calendar) MLLW is designated as the +1 foot level. My scheme of zonation is, like other schemes, based primarily on the vertical distribution of animals and plants in the rocky littoral region. Table 2 shows distribution of some of these organisms.

Zone I — The high intertidal zone; from above the highest high tides (HHHW), including the splash zone, to +15 feet (mean high water). This region is wet by only the spring tides, storm waves and spray.

Zone II — The upper midintertidal zone; +15 feet (mean high water) to +7 feet (LHHW; or the mean of the monthly LLHW, just above mean sea level). This region is alternately covered and exposed daily. Total monthly exposure time exceeds total coverage time.

Zone III — The lower midintertidal zone; +7 feet (LHHW) to +1 foot (MLLW). This region, like zone II, is alternately covered and exposed daily. Total mean monthly exposure time is less than total mean coverage time in this zone.

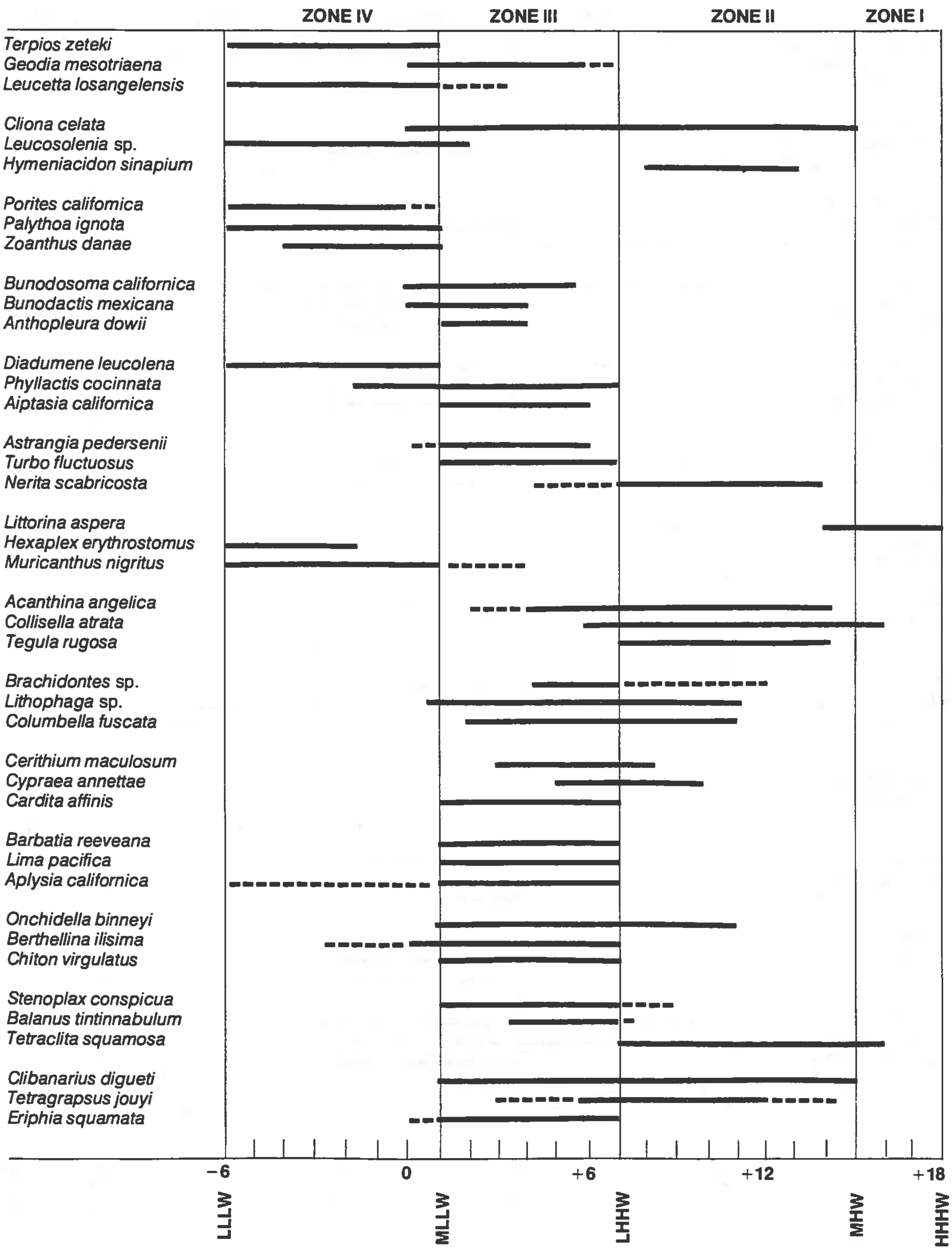
Zone IV — The low intertidal zone; +1 foot (MLLW) to −6 feet (LLLW). This region extends from the mean of the two daily low waters down to the lowest point on the beach uncovered by the receding tides.

Each of the zones described above tends to have one, or a few, animals that appear to dominate (at least visually) the exposed surface of the rocks. Thus, zone I could be called the "Blue-green algae–Periwinkle Zone"; zone II the "barnacle" or "*Tetraclita-Nerita* Zone"; zone III the "*Eriphia-Turbo* Zone"; and zone IV the "*Porites-Palythoa* Zone."

The animal life found above the highest tide line (in the spray zone or supralittoral region) subsists largely upon blue-green and cast-up algae (mostly *Sargassum*) and other jetsam. The fauna is largely terrestrial in nature and arthropods dominate the scene. Most of the animals described in Chapters 22 and 23 inhabit this upper portion of zone I and the reader is referred to these chapters for a more exhaustive treatment of life in the supralittoral region. Marine organisms inhabiting cracks and temporary pools in zone I are subjected to widely varying conditions. Water trapped in depressions in rocks quickly evaporates, subjecting the inhabitants to rapid and extreme salinity and temperature fluctuations. Conversely, the animals of this region are occasionally immersed in pure fresh water, from rain and runoff. There are several species of blue-green algae (Cyanophyta) and at least one species of lichen *(Umbilicaria?)* that manage to survive in this region, their presence giving the appearance of a black encrustation on the rocks. The most commonly encountered animals of zone I are the arthropods, including: mites, pseudoscorpions, various spiders, insects such as springtails, numerous flies, and (on sandy shores) rove, ground, and tiger beetles. Other invertebrates found here include the periwinkle *(Littorina aspera)* and the little mussel *Brachidontes* sp. Also found in this region are some animals that migrate up and down with the tides, always keeping on dry ground. These include the scavenging

Table 2

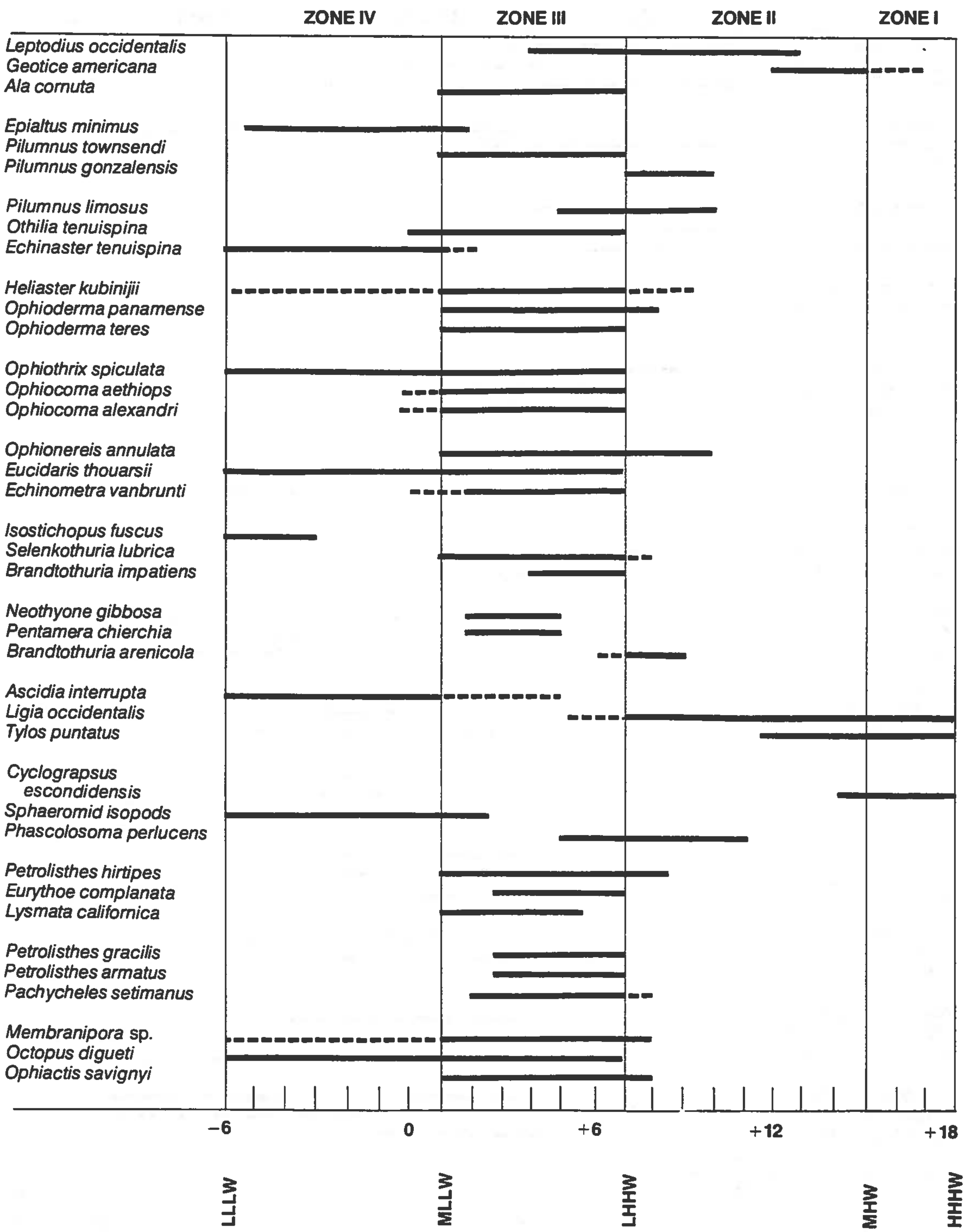
Vertical Distribution of Some Common Invertebrates in the Rocky Intertidal Areas of the Upper Gulf of California



(continued on following page)

Table 2 (continued)

Vertical Distribution of Some Common Invertebrates in the Rocky Intertidal Areas of the Upper Gulf of California



isopods *Ligia occidentalis* (on rocky shores) and *Tylos punctatus* (on sandy beaches), and the rare grapsoid crab *Cyclograpsus escondidensis*. Several members of the zone II fauna are occasionally encountered above the mean high water line also, in reduced numbers, such as the little grapsoid crab *Geotice americana*, the thatched barnacle *Tetraclita squamosa* and the limpet *Collisella atrata*. Zone I corresponds approximately to the "supralittoral fringe" of Stephenson's publications.

Zone II extends from mean high water to just above mean sea level. The animals typically found in this region include the Sonoran clingfish *(Tomicodon humeralis)*, certain gobioid fishes (such as *Gillichthys seta*), *Tetraclita squamosa*, *Nerita scabricosta*, *Tegula rugosa*, *Geotice americana*, *Tetragrapsus jouyi*, *Collisella atrata*, and various amphipods (including species of *Hyale* and *Ampithoe*). Algae found in zone II include *Valoniopsis pachynema*, *Enteromorpha* spp., *Ulva* sp., and *Padina mexicana*. Organisms more typically found in zone III that are occasionally found in zone II include the crabs *Leptodius occidentalis* and *Eriphia squamata*, the ubiquitous hermit crab *Clibanarius digueti*, certain species of *Ulva*, and (when *Tetraclita* is absent or sparse) the little acorn barnacles *Chthamalus* sp.

Zone III extends from LHHW to MLLW. The dominant animals of this region are: the tadpole clingfish *(Gobiesox pinniger)*, the snails *Turbo fluctuosus* and *Acanthina angelica*, the opisthobranchs *Aplysia californica* and *Onchidella binneyi*, the chiton *Chiton virgulatus*, the boring sponge *Cliona celata*, the hermit crab *Clibanarius digueti*, the crabs *Eriphia squamata* and *Leptodius occidentalis*, and the echinoderms *Heliaster kubinijii*, *Ophioderma panamense*, *Ophionereis annulata*, and *Selenkothuria lubrica*. Algae of Zone III include *Caulerpa*, *Codium*, *Padina durvillaei*, *Colpomenia*, *Dictyota*, *Ulva* and numerous red algae.

Zone IV, the low intertidal zone, extends from MLLW to LLLW. Starting at the +1 foot level, on a rocky shore in the Gulf, a distinct band of fauna begins to make its appearance. This fauna is perhaps best indicated by the first presence of the green coral *Porites californica* and the colonial sea anemone *Palythoa ignota*. It is primarily from this +1 foot level, and on down into the sublittoral zone, that the large predaceous gastropods *Muricanthus nigritus* (the black murex) and *Hexaplex erythrostomus* (the pink mouthed murex) occur, although juveniles may be found as high as zone III. Organisms in zone IV are nearly always covered by the sea. In temperate climates this is where the large brown seaweed begin, particularly the laminarians. In the tropics, however, *Sargassum* and the coralline algae are the predominant forms. Also abundant in zone IV are various nemertines *(Baseodiscus mexicanus* and *Baseodiscus punnetti)*, polychaete worms *(Megalomma* and *Spirobranchus)*, crabs *(Epialtus minimus*, *Epialtoides paradigmus*, *Stenorhynchus* spp. and *Podochela* spp.), echinoderms *(Isostichopus fuscus*, *Lovenia cordiformis*, heart urchins), and the solitary tuncate *Ascidia interrupta*.

It should be noted that on any given beach zonation may be distorted with regard to the tidal level owing to a number of factors. For instance, the tops of large boulders will have a fauna more characteristic of a zone higher up on the beach, since this region obviously gets exposed more often than the bottom of the rock, which reflects its actual level in the littoral zone. Also, an area exposed to a greater than normal degree of wave action will have its zones broadened and shifted upward. Also, a tidepool or drainage channel will have a fauna more characteristic of a lower tidal level as a result of prolonged submersion. The careful observer will notice that some animals, such as *Porites*, *Palythoa*, *Zoanthus*, *Diadumene*, etc., appear to show a distinct preference for constantly moving water. If one follows a swift-flowing drainage channel down the beach both *Porites* and *Palythoa* will be seen to make their appearance well above the actual +1 foot level. When onshore breezes are present, or the barometer is low, the tide may not fall as far as predicted; likewise, when offshore breezes are present or the barometer is high one can anticipate a lower tide than predicted.

The vertical distribution of many littoral invertebrates is limited by the availability of their preferred habitat. The chiton *Chiton virgulatus* and the sea cucumber *Selenkothuira lubrica*, for example, both seem to require boulders of a certain minimum size to live on and under. So, even though they could normally live as low as the +1 foot level, they should not be expected to occur there if their boulder habitat is missing. Of the factors controlling upper and lower limits of intertidal animals one often finds the upper limit to be set by such abiotic factors as habitat availability or exposure times, while the lower limits are often established by biotic factors, such as competition (for space or food) or predation. The sharpest zonation patterns seen are usually those produced by competition, predation, or both.

Most interpretations of ecological phenomena have centered around attempts to find a specific cause, using approaches that are, in essence, highly deterministic. It is in this light that some of the major (or at least the most popular) ecological hypotheses have been put forth in the last decade, including those dealing with species diversity and community dominance. However, the community ecologist who is used to performing experimental field studies on shores in temperate regions is usually at a loss when he experiences his first tropical coastline. The fact is that nowhere else on our watery world will he find the structure of natural communities to be at once so highly complex and yet so obviously under the influence of multiple random events. Indeed, it is this randomness, combined with the high species abundance of these regions, that tends to obliterate most traces of repetitive dominance patterns or predictable community structure. An observer recording a rocky shore strongly dominated by large *Aplysia* in March of one year may never witness these lumbering sea slugs in such numbers, at that beach, again—despite his repeated visits to the site. That is not to say that the presence of *certain* animals is not predictable. But of the total species known to inhabit the region, the *relative* predictability is quite low indeed. The numerically dominant species of invertebrates on any Gulf shoreline is under the overlapping and complex direction of a vast multitude of factors, including such things as breeding cycles, local seasonal or aberrant current regimes, larval dispersal, chance immigrations, normal and abnormal fluctuations in water temperature (and in some cases salinity), substrate movement, sand scouring, presence or absence of local competitors or predators, etc. It is my belief that these numerous cause-and-effect sequences, when combined with the adaptive relationships of the multitude of invertebrate species occurring in the Gulf of California, are so complex and multifaceted that local invertebrate community structure, at any one point in time and space, may be considered (mathematically) a random variable. Likewise, someone accustomed to sampling in the discrete "zones" or "invertebrate communities" of a temperate coastline (such as California's *Mytilus-Pollicipes* community) will be at a loss to identify such neat units of predictable structure in the Sea of Cortez and may find himself delineating scores of such communities, whose boundaries tend to become less and less discrete the more he recognizes and the more closely he examines them.

It is probable that tropical shorelines, for these very reasons, are *not* the best places to test modern deterministic hypotheses of community structure; they *are*, however, excellent places to look for new insights into the importance of randomness in structuring natural species groupings. This "random walk" effect on community composition in the Sea of Cortez appears to increase as one moves northward, into the upper Gulf. It is here that biological accommodation is most strongly suppressed by the twin (and complimentary) phenomena of randomness and physically controlled habitats.

6. Synopsis of Taxa Treated in the Handbook

PHYLUM PORIFERA

The sponges are a large, abundant group, well represented in the intertidal regions of the Gulf of California. Although they are the simplest of all multicelled organisms, they are a difficult group to describe because of the plasticity of their form. The majority of the littoral sponges grow as encrustations on various substrates, and the growth form of any two individuals is rarely identical—and often radically dissimilar. Sponges grow and proliferate in all directions, their eventual shape and size being the result of a multitude of varying environmental factors, both abiotic and biotic. The sponges found in intertidal regions usually appear as colorful growths on rocks, ranging from small, thin patches to massive shelves, several meters in length. A few are vaselike, and in these forms the general body plan is more easily seen. The calcareous and silicious sponges tend to display a more definable shape and size. The more common Demospongiae, however, rarely do. In calcareous sponges (such as *Leucetta* or *Leucosolenia*) or in certain Demospongiae (such as *Pseudosuberites*), the large excurrent pores (oscula) of the animal's filtering system can be easily seen. In other forms one must look more closely to see these small openings. The presence of these excurrent pores and the general spongy texture are the features that most easily distinguish sponges from the similar appearing sea pork (ascidians) in the field. Sponges feed by continually filtering the surrounding water for minute plants and animals and suspended organic detritus. Unicellular algae, protozoans, and bacteria probably all serve as vital food sources for sponges. It has been calculated that 1 cubic centimeter of sponge tissue (of *Leucandra*) filters around 20 liters of water daily. Few animals feed on sponges, probably because of their internal skeleton of spicules as well as their often unpleasant taste or habit of secreting mucus when injured. The animals that do include sponges in their diets include a few species of sea slugs (tectibranchs and "nudibranchs"), coral reef fishes, turtles, chitons, and gastropods. Possibly the most eminent danger a sponge faces in its adult life is to have its filtering system clogged with sediment. For this reason sponges are rarely found in muddy habitats and generally grow on the tops of rocks or other surfaces that are somewhat raised from the bottom itself. I have encountered only one sponge in the Gulf that could be considered useful as a "bath sponge." The group to which these commercial sponges belong (the keratose sponges) is poorly represented in the east Pacific. The scarcity of commercial sponges on the world market several decades ago stimulated the manufacture of artificial sponges made of cellulose and plastics, and it is to DuPont that ecologists perhaps owe a tip of the hat for the salvation of the Caribbean and Mediterranean "commercial" sponge fauna.

PHYLUM CNIDARIA

This large phylum includes three classes: anthozoans (sea anemones, gorgonians, sea pens, corals, etc.), hydrozoans (hydroids and hydromedusan jellyfish), and scyphozoans (the "true" jellyfish). The cnidarians are a highly diverse group of animals that illustrate a tendency toward colonization. Corals, hydroids, gorgonians, and alcyonarians are, in reality, little more than large colonies of miniature sea anemones. Many of the cnidarians display what is known as "alternation of generations." What this implies is that there is a polypoid phase ("anemone-like phase") that reproduces asexually, as well as a medusoid phase ("jellyfish-like phase"), that reproduces sexually. The hydroids are an example of cnidarians that have these two radically different forms in the life of a single individual. A species displaying more than one general body form is called a *polymorphic* species, and cnidarians have many representatives that display this phenomenon. The striking polymorphism seen in most hydroids is as bizarre as if a human being gave birth to a mushroom, and the mushroom in turn produced a human being.

One of the most characteristic features of this diverse phylum of animals is the presence of stinging cells, known as *nematocysts*. Nematocysts are most concentrated on the tentacles surrounding the mouth of hydroids, sea anemones, and jellyfishes. These specialized cells function either in piercing and poisoning or as "lassos" for trapping prey and for self-defense. Cnidarians are generally carnivorous, feeding on smaller animals they capture and carry to their mouths by use of the tentacles or, in some cases, ciliary tracts on their oral surface. Another trend seen in cnidarians is to form a symbiotic relationship with certain unicellular dinoflagellate protozoans and algae, the former referred to as zooxanthellae, the latter as zoochlorellae. The greenish or brown colors seen in many corals and sea anemones is due to these symbiotic partners. In many corals it has been shown that the cnidarian benefits by receiving oxygen and certain organic compounds (notably glycerol) produced by the zooxanthellae. The zooxanthellae benefit by receiving CO_2 and various nutrients from the coral (produced as by-products of the coral's normal metabolism). The presence of these symbionts has been shown to be necessary for the proper formation of coral reefs. The vast majority of the world's living coral reefs are only about 10,000 years old and are largely built on the tops of old Pleistocene reefs. Like the sponges, cnidarians are preyed upon by relatively few animals. No doubt the presence of their nematocysts plays a vital role in this regard. Some animals that do prey on cnidarians include certain sea slugs and pycnogonids (on hydroids and sea anemones), a few species of snails, especially the wentletraps (on gorgonians and sea anemones), certain echinoderms (on gorgonians and corals), and coral reef fishes (on corals).

PHYLUM CTENOPHORA

The comb jellies resemble jellyfish in form and habit, but they differ in a number of important ways. One of these is their means of locomotion, which in true jellyfish is effected by pulsations of the body, forcing water out from beneath the bell. The ctenophores, on the other hand, have eight rows of ciliary plates (called ctenes), the cilia of each plate beating in synchrony with the other plates, to rhythmically propel the little animal through the water. There are usually two long, thin tentacles arising from the sides of the body. These tentacles do not bear nematocysts, as in the Cnidaria, but sticky cells (colloblasts) that function in the capture of the prey. Ctenophores are strictly carnivorous, feeding largely on planktonic crustaceans and other small planktonic animals. The Ctenophora is a small group of animals, fewer than a hundred species having been described. Ctenophores normally occur in the open ocean, nearly all being planktonic. They have been included in this handbook because one species, *Pleurobrachia (bachei?)*, is occasionally found washed up on sandy beaches by storms at sea.

PHYLUM PLATYHELMINTHES

The phylum Platyhelminthes includes the parasitic tapeworms and flukes, as well as the largely free-living turbellarians. It is the latter group that is principally marine and draws our interest in this handbook. The flatworms are characterized by the presence of an incomplete gut, lacking an anus entirely. Nearly all are carnivores (although a few are known to feed on diatoms), and the majority are the larger forms belonging to the order Polycladida. Polyclads are abundant in the Gulf of California and are easily observed by turning tidepool rocks over and looking closely at their bottom side, a habitat favored by flatworms. They glide across the rock surface by means of microscopic cilia that cover their body, and some swim by graceful undulations of the body margin. Most have a distinctive pattern of eyespots at the anterior end and often along the sides of the body also.

PHYLUM NEMERTEA

The ribbon worms are similar to the flatworms in being soft-bodied, fragile, and covered with cilia. However, the nemerteans have a complete gut and are generally very long and slender and extremely contractile. A distinguishing feature of this phylum is their proboscis, an eversible device in or near the mouth, operating on a hydraulic-muscular system, that is thrown out to capture the worm's prey. Some have the tip of the proboscis armed with stylets, while others utilize a sticky mucoid substance to immobilize their victims. A large part of the diet of many ribbon worms consists of small polychaete worms. Nemerteans are in turn preyed upon by numerous larger invertebrates (especially crustaceans) and fishes.

PHYLUM ANNELIDA

This phylum consists of three general types, or classes: the earthworms, the leeches, and the marine polychaetes (class Polychaeta). It is, of course, the last group with which we are here concerned. Polychaetes comprise one of the most numerous of all marine invertebrate phyla. They are found in just about any habitat, nook, or cranny along the seashore and in the depths of the seas. Their most characteristic feature, and one that quickly separates them from the other worms in this environment, is their segmentation. The body is divided up into many identical, ringlike segments. In some cases certain segments are especially modified to serve particular functional needs. Polychaetes locomote by use of a complex set of body muscles and parapodia. The parapodia are reinforced flaps along the body wall that give support and leverage to the worm as he crawls, burrows, or swims about the sea. Many also use a hydraulic system of body fluids to extend various regions of their torso. This basic design of circular muscles (and contrasting longitudinal muscles) squeezing a portion of the body, forcing fluids up and into another region to distend it, is seen (in some form) in almost all invertebrate groups. It may be used for simple locomotion, prey capture, respiration, and a multitude of other functions. It represents one of nature's more clever and useful devices as is evidenced by its widespread use. Many of the polychaetes have evolved into a tube-building habit, and this sedentary life style has resulted in certain anatomical changes that are useful in distinguishing the different major groups.

PHYLUM MOLLUSCA

The molluscs are probably the best known group of invertebrates in the world. Their diversity and numbers of species are exceeded only by the arthropods. Included in this phylum are the snails, limpets, chitons, clams, tusk shells, octopods, and squid. This populous and widespread phylum is represented in nearly every environment known on earth and represents one of the best known groups in the fossil record, having left us traces of their ancestry from as long ago as 500 million years. As in most invertebrate phyla one quickly notices a particular feature or two about the group that stands out as being a "feature item" in the evolutionary energies of that group. With the molluscs it is obviously the shell, and it is primarily upon this highly variable character that the species of molluscs are still differentiated. Modern molluscan taxonomy has tended to place more and more emphasis on the radula also, which is a file-like feeding structure peculiar to the molluscs. Feeding strategies in this phylum run the gamut from voracious predators to placid suspension feeders, and from deposit feeders to saphrophytes. The feeding behaviors of the various families are discussed in the text. Molluscs are preyed upon by everything from other molluscs to fishes, and from crabs to sea stars. They constitute a major segment of the total energy and biomass available in almost any marine habitat, and the reader is encouraged to pursue his interest in this group of animals further. There are a great many fine texts and colorful books available on the natural history of this captivating invertebrate phylum.

PHYLUM ARTHROPODA

This extremely large, diverse, and important group of invertebrates includes the insects, spiders, mites and ticks (and their kind), scorpions (and their relatives), the horseshoe crabs, sea spiders, and the crustaceans. It is this last group, the class Crustacea, that is best represented, and contains the most number of species, in the marine world. One of the most obvious features that unites all these seemingly unrelated groups of arthropods is the fact that their body is composed, as in the phylum Polychaeta, of a repetitive series of segments, or body *somites*. In the crustaceans each of these body somites primitively bore a pair of appendages. The evolutionary history of these body appendages is a matter of great concern in tracing the history of the various groups and in devising a classification scheme for the crustaceans. The most obvious feature of the crustaceans that allies them as a group, in the mind of most seashore observers, is their hard exoskeleton and jointed appendages. A great deal of evolutionary energy has been spent by the crustaceans in this regard and the variety of function and design is a source of amazement and wonder to those who speculate on comparative and functional morphology. The 30,000 or so species of marine crustaceans are classified into a number of distinct groups. The ones treated in this handbook are described below.

Barnacles (subclass Cirripedia)

A group that, until 1830, was placed in the phylum Mollusca. They are sessile, attached to rocks and other hard surfaces, and encased in a hard calcareous shell. The shell is composed of a number of fused plates. Most barnacles are suspension feeders, capturing minute food particles from the surrounding medium by curling their cirri through the water (when covered by the waves or tides). Few animals are able to feed on barnacles, but some that can are certain predaceous snails (such as *Acanthina*), certain littoral fishes (clingfishes), and some sea stars (such as *Heliaster*).

Amphipods (order Amphipoda)

An extremely abundant group of shrimplike crustaceans. It would be hard to sample any portion of the intertidal zone without collecting at least a few of these animals along with anything else. They show a preference for clinging to and living among other animals and plants along the shore. Many are small, most being 5–20 mm in length, and characteristically flattened from side to side (compressed). There have been about 3600 species described in the world, but new ones are being named almost daily and many more are certain to be discovered in the future. There are three principal groups of amphipods. The hyperiids are largely oceanic, pelagic species. The caprellids are small, slender, sticklike animals that cling to other organisms in the intertidal region. The gammarids are the amphipods commonly collected in the intertidal zone and the only group covered in this text. Gammarid amphipods feed on small algae, invertebrates, and (primarily) detritus. Their sheer numbers make them an integral link in the food webs of most littoral communities, for they are consumed by a host of other animal types.

Isopods (order Isopoda)

Variously known as pill bugs, roly-poly bugs, sea slaters, rock lice, etc., the members of this order appear to be less common in the tropics than in the more temperate climates. They are distinguished from their close relatives, the amphipods, in being flattened from top to bottom (depressed). Isopods play a primary role in keeping beaches clean and recycling organic matter, being important scavengers on the world's seashores. The only group of crustaceans to successfully invade the land from the sea are the terrestrial isopods. Some members of this order are parasites on fishes throughout the world, others on various crustaceans, while still others destroy man's encroaching coastal structures by boring through and ruining docks, wharfs, and other unnatural fabrications. They are an interesting and extremely attractive group of Crustacea, noble and distinctive in all regards and worthy of considerably more interest and study than they have received in the past.

Mantis Shrimp (order Stomatopoda)

Dorsoventrally flattened, lobsterlike creatures, the stomatopods inhabit the shallow subtidal region and are only occasionally found in the intertidal zone. At first glance mantis shrimp resemble small crayfish, but a closer look reveals the presence of the greatly enlarged second thoracic appendages, the terminal article being turned back on itself and forming a heavy clublike structure or equipped with a knifelike, sharp, toothed edge. Stomatopods are generally lurking predators, often living in shallow burrows on the sea floor. They are often captured in bottom trawls, such as those used by the shrimp trawlers in the Gulf of California. They are also the namesake for a unique biological journal formerly published in Eureka, California.

True Shrimp (suborder Natantia)

This common group is probably easily recognized by almost everyone, particularly since some of its members afford us with such delectable culinary nutriment. Most shrimps collected in the marine littoral region belong to a group known as the cariid shrimps (section Caridea). They are small, 1 to 2 inches in length, and often quite colorful. The majority of the intertidal shrimps are scavengers, picking at bits of organic debris, algae, and minute invertebrates. The larger, offshore commercial shrimps (section Penaeidae) prefer to sit on the surface of sandy or sandy-mud bottoms, particularly during the night hours, when they feed. Knowledge of this behavior has allowed the shrimp fishermen of Mexico to establish a very efficient capture system, perhaps too efficient as it appears the yearly catch from this fishery is declining (Snyder-Conn and Brusca, 1977).

Lobster (section Palinura)

The Gulf of California has two types of Palinura, the spiney lobster *(Panulirus)* and the slipper lobster *(Evibacus)*. Earlier workers commonly placed the lobsters together with the ghost shrimps in a group known as the Macrura. This classification (and the taxon Macrura) was based largely on superficial similarities and is, in general, no longer adhered to. Lobsters in the east Pacific lack the large pincers (chelae) of the familiar east coast, or Maine, lobster. The highly spinose body and appendages do, however, afford the Pacific spiny lobsters an efficient means of protecting themselves from predators. Spiny lobsters are primarily subtropical and warm temperate forms, and they occur in their greatest numbers along the rocky shores and islands of Baja California.

Ghost Shrimp (superfamily Thalassinoidae)

This taxon includes the ghost or mud shrimp *(Callianassa* and *Upogebia)* and the spiny red thalassinid *Axius*. Ghost shrimp are generally found living in colonies on tidal flats, often in great numbers. Each species seems to prefer a particular tidal level and substrate type or particle size range, and colonies will sort themselves out on these bases on a tidal flat. Their bodies are typically colorless (or very pale) and soft. Most ghost shrimp feed by passing quantities of substrate through their gut, from which they extract organic sustenance. *Axius* is the exception to the rule as this elusive ghost shrimp is most commonly found living in burrows on hard clay or calcareous bedrock in the intertidal region. How *Axius* is able to dig its burrows in solid rock is a question that remains to be answered.

Porcelain Crabs (family Porcellanidae)

The porcelain crabs at first resemble the brachyuran crabs, but bear two, easily observed, distinct differences: the last pair of legs is greatly reduced and folded dorsally over the back, and the antennae arise on the outside of the eyes, as opposed to between the eyes in the brachyuran crabs. Porcelain crabs are especially common and abundant in tropical waters, and the Gulf of California is no exception, there being over forty species described from that region. The majority of the littoral porcellanids are suspension feeders, sitting quietly under the edge of a rock when the tide is up, filtering out small particulate matter with their setose mouth parts. Many have also been observed, on occasion, to pick about the substrate with the chelae in a manner reminiscent of brachyuran crabs or cariid shrimps. Porcelain crabs make up an important link in the food webs of shallow water environments by serving as prey items for numerous larger animals, including octopods, mantis shrimp, certain worms, and many species of fishes.

Hermit Crabs (superfamilies Paguroidea and Coenobitoidea)

These anomuran crabs have lost their hard abdominal exoskeleton and taken up the habit of living in empty mollusc shells for protection. Usually gastropod shells are utilized, but a few prefer other objects. In the Gulf of California one species lives in tusk shells (scaphopod molluscs) while several others are found, as adults, in homes composed of living sponge, tunicate, Bryozoa, or hydrocorals. Hermit crabs are some of the most familiar animals of the seashore and are well represented in the intertidal and shallow subtidal regions of the world. The hermits are important scavengers of the littoral realm, scampering about the rocks and tidal flats, picking up bits of organic debris, and generally helping to keep the place tidy. Some species have also been observed feeding on living algae or exhibiting a behavior that suggests they may occasionally filter feed in a manner reminiscent of the porcelain crabs.

Mole Crabs (superfamily Hippoidae)

The mole, or sand, crabs are members of a small group of anomuran crustaceans that are found burrowing in the sand of the intertidal and shallow subtidal zones. These curious crabs are rarely taken without a fair amount of digging and searching. Although there are many more species occurring along the sandy beaches of tropical west America, they are rarely found in such numbers here as are the two Californian species. The easiest way to capture mole crabs seems to be to dig down 6 to 18 inches into the sand with a quick stroke of the shovel, as a wave retreats. I have had most luck during the medium to high tides on beaches of a medium grain size.

The Regular Crabs (section Brachyura)

The brachyuran crabs are one of the most abundant and characteristic inhabitants of the intertidal region, as well as the shallow subtidal. They are found in their greatest numbers along rocky shorelines, although certain species do inhabit sandy beaches and tidal flats. Their abundance and diversity have led to behavioral and ecological specializations that allow them to be used as zonational markers and biological indicators for a number of natural phenomena. The vast majority of intertidal crabs are omnivores, feeding on organic detritus as well as on living animals and plants. The larger brachyurans are often quite predaceous, and the unwary collector will soon learn which of these species he can and cannot carelessly handle.

PHYLUM SIPUNCULA

The peanut worms represent a small phylum of unsegmented, rather seclusive worms, found in the intertidal region throughout the Gulf. Most species are only an inch or so long, brown in color, and resemble the kernel of a peanut when the eversible proboscis is drawn into the body (hence the common name). One exception is *Sipunculus nudus*, a large iridescent form found on tidal flats. Perhaps the most characteristic feature of the sipunculans is their retractable proboscis, bearing on its anterior end a ring of feeding tentacles. The peanut worms superficially resemble two other groups of worms, although all three are now considered to be separate phyla. These are the Priapula and Echiura. For nearly a hundred years these three phyla were considered to constitute a class of the Annelida known as the "Gephyrea." None of these three groups are, however, segmented, as are the annelids. Those sipunculans inhabiting rocky shores accumulate detritus with their tentacles, whereas burrowing forms are thought to pass quantities of sediment through the gut in order to extract organic matter. Sipunculans are probably preyed upon by few animals, owing to their secretive habits.

PHYLUM ECHIURA

The spoon worms are a small phylum of unsegmented, somewhat fleshy marine worms, found principally in burrows in sand and mud, or in rocky crevices of the intertidal. The sausage-shaped body has a flattened, spoon-shaped proboscis on its anterior end. This solid, grooved proboscis sits just anterior to the mouth and gave rise to the vernacular name of this group of unusual animals. Echiurans swallow large quantities of bottom sediment, particularly the lighter detrital material on the substrate surface. These worms are uncommon, and the seashore buff who finds one should take the time to carefully observe the animal in its natural habitat but not try to collect it unless necessary.

"PHYLUM" BRYOZOA

This group actually contains two distinct phyla, the Ectoprocta (the true Bryozoa) and the Entoprocta. However, for convenience they are often studied together (because of their similarity in appearance and habit). The bryozoans may form thin incrustations on rocks or other hard surfaces, or they may appear as short, bushlike branching colonies. A single colony is made up of many individual members, called zooids. Entoprocts are rarely encountered, and none are included in this handbook. The ectoprocts (or Bryozoa proper) are, however, fairly common, and numerous genera are discussed in this book. The ectoprocts constitute a very large and confusing phylum of animals, poorly studied, and for this reason it is a difficult and often confusing group to work with. Observation of living ectoprocts under a dissecting microscope is intriguing, as most species will be seen to bear specialized zooids known as aviculariae, which resemble miniscule bird's heads with giant, oversized beaks. The "beaks" of the aviculariae snap and grab at whatever passes within their reach and effectively prevent the larvae of other encrusting animals (sponges, other Bryozoa, etc.) from gaining a foothold atop the colony.

PHYLUM BRACHIOPODA

The lampshells are small, bivalved animals resembling pelecypods (clams) but having the shell halves (the valves) arranged dorsoventrally, as opposed to the right and left arrangement seen in the clams. They are nearly always subtidal and found attached by a short, fleshy peduncle (or pedicel). The Brachiopoda are a small group, rarely encountered. There are two classes: the Articulata, whose valves are hinged by interlocking teeth and sockets and whose stalk (pedicel) emerges through a hole in the ventral valve; and the Inarticulata, whose valves are not hinged but are held together by muscles. The pedicel in inarticulates may be long and used to retract the shell into a burrow in soft substrates, or it may be reduced or absent.

PHYLUM ECHINODERMATA

A large, abundant, and extremely diverse group of marine invertebrates. Four classes of echinoderms are treated in the handbook, as follows: Asteroidea, the sea stars; Ophiuriodea, the brittle or serpent stars; Echinoidea, the sand dollars, sea biscuits, and sea urchins; and Holothuroidea, the sea cucumbers. The unique feature of this entirely marine phylum is its water-vascular system, which serves to move the tube feet for locomotion and respiration as well as functioning in a number of other ways. The basic pentaradial (five "rayed") symmetry of most echinoderms is easily visible and, even in the elongate sea cucumbers, the tube feet are still quite often arranged in five distinct rows along the body.

PHYLUM HEMICHORDATA

A small group of wormlike marine animals that, until recently, had been considered a subphylum of the chordates. Only one of the two classes of hemichordates are considered in this handbook, the Enteropneusta or acorn worms. These worms inhabit shallow water, usually burrowing into the sand or mud substrate. Exposed tidal flats are occasionally dotted with the coiled castings of these small animals. This unique phylum shows affinities to both the echinoderms and the chordates, and the pelagic larvae of many bear a strong resemblance to the larvae of echinoderms. The adults, on the other hand, possess gill slits comparable to those seen in chordates.

PHYLUM CHORDATA

The chordates are characterized by three distinct features that are always present at some stage in their life: a notochord, pharyngeal gill clefts, and a tubular, dorsal nerve cord. The best known subphylum of the chordates is the Vertebrata, the vertebrate animals. The remaining members of the phylum lack a backbone and belong to one of two subphyla, the Urochordata or the Cephalochordata. The urochordates are represented in the littoral region by the ascidians, commonly known as "sea squirts." Ascidians are soft-bodied, sessile animals, usually found attached to rocks, shells, pilings, etc., in shallow water. Solitary forms ranging from minute to several inches in length occur, as do the more common colonial forms. The latter may appear as colorful encrustations on the undersides of rocks. They are all filter-feeding animals, making use of phytoplankton and small organic debris, which they strain from a current of water drawn into the branchial sac through the oral siphon. The current is generated by cilia lining the branchial stigmata, and the food particles are trapped in mucus secreted by the endostyle. This is a large group of very common animals that are difficult to work with, requiring a specialist for accurate species determinations. The ascidians of the Gulf are poorly known; only six genera are included here. The cephalochordates are represented in the Gulf by small, opaque, glassy fishlike creatures (popularly known as amphioxus) that dart in and out of the substrate on tidal flats and sandy embayments. They are difficult to observe but can be captured by careful screening or sieving procedures.

Common Intertidal Invertebrates of the Gulf of California

1

PORIFERA (Sponges)

Preservation: Sponges should be fixed in buffered 10 percent seawater formalin for 1 to 2 days, then transferred to 70 percent alcohol. Formalin should not be used for preservation of calcareous sponges, as it will eventually deteriorate the sponge spicules, which are required for proper identification. To prepare sponges for histological observations, fix them in seawater Bouin's solution or another similar fixative. A classical technique for freeing sponge spicules from their surrounding tissue for subsequent microscopic examination is to treat a small part of the specimen with sodium hypochlorite (or a chlorine bleach) until the spicules are free. The sample may then be examined "as is" or washed several times with water, centrifuging between washings to make certain that the minute spicules (e.g. microscleres) settle to the bottom. The water is finally replaced with 95 percent alcohol, and the suspension of spicules poured onto a slide and allowed to dry. Before examining under a microscope, a drop of xylene, glycerine, or other suitable mounting medium, and a cover slip, are placed on the spicules. Knudsen also describes simple techniques for preparation of slides for examination of sponge spicules and fibers. The key has been written, so far as possible, without relying on spicule morphology, which implies the need to use fresh material when identifications are being made.

Taxonomy: Field identification of sponges is difficult. Proper identification of species usually requires one or more laboratory procedures, such as: determining if the sponge is calcareous or siliceous (which is done by putting a drop of dilute acid on the sponge surface, a great deal of foaming and bubbling indicating a calcareous sponge, as the calcium carbonate spicules are dissolved by the acid); microscopic observation of spicules to determine type and size; and determination of body plan. Caution must be used when observing the action of an acid on a sponge, because if the specimen is attached to (or has embedded in it) substrate of a calcareous nature, this will also bubble when touched by the acid. Be careful to place the drop of acid directly (and only) on the sponge surface.

The taxonomy of this group is based largely on the spicule and sponge fiber anatomy and on embryology, which is impractical for field key usage. Accurate species determinations may be difficult (even for a specialist) because the fauna of this region is so poorly known. For these reasons, only the more common sponges of the Gulf are included in the following key. It is occasionally difficult to distinguish an encrusting sponge from some of the encrusting ascidians. Proper identification can almost always be made with the use of a microscope, but in the field the best way to be certain you are observing a sponge is to look for multiple excurrent openings (two or more oscula). Other less reliable, but *usually* satisfactory, methods include gently running your finger across the surface, feeling for the minute spicules that many sponges have protruding above the epidermis, giving a sponge a rough texture as opposed to the smooth slimy surface of an ascidian or encrusting bryozoan. Also, the compound ascidians usually have the individual members of the colony visible beneath the surface when the colony is broken open. It is important to keep good field notes on sponge characteristics before they are altered by preservation. Particularly significant characteristics include color, odor, oscular size and morphology, surface features, and general anatomy.

A new group of sponges, the sclerosponges (class Sclerospongia), is common to abundant at depths accessible to SCUBA, in the tropics. These sponges contain a coral-like, calcareous base, covered by a fleshy "skin" with siliceous spicules. Sclerospongia at first resemble corals, and they are best preserved in alcohol. None of these "coralline" sponges have yet been reported from the Gulf.

The sponges of the Gulf of California are poorly known. The systematics of this phylum in general have presented problems for students of the group for many years, and numerous taxonomic schemes and revisions have been presented. The general phylogeny and taxonomy of sponges are far from being settled. Although there exists a vast literature on Porifera in general, there is little on individual species. Significant work in sponge taxonomy has been published by Vosmaer (1882–86), Minchin (1900), Levi (1957), Hentschel (1923), de Laubenfels (1932; 1936a), and Bakus (1966). The paper by Bakus represents one of the first significant contributions to Pacific coast sponge taxonomy since de Laubenfels. One of the first really good keys to the central California sponges was constructed by Hartman, in the third edition of Light's Manual (Smith and Carlton, 1975). Significant work on sponges utilizing chemical taxonomy has been reviewed and summarized by Cimino et al. (1975). The following classification is based on Hartman (1958, 1975) and Levi (1957).

Sponges of the Gulf: There are probably more than a hundred species of sponges in the Gulf of California, most as yet undescribed. Steinbeck and Ricketts recorded fourteen species from the Gulf intertidal and concluded that the poriferan affinities of this region were closest to the Californian Province, less so to the West Indies fauna, and nearly lacking with the Panamic Province. Dickinson (1945) stated that the Demospongia are by far the dominant type of sponge in the Gulf intertidal (as is usually true wherever sponges are found) and that most of the sponge fauna of the Gulf probably arose as an "off-branching" from West Indies stock. This probably occurred, he said, in the late Miocene, when the sea channel across Central America was open. Recent evidence indicates the closing of the Panama seaway actually occurred closer to the late Pliocene, perhaps as recently as 2–5 million years ago. Dickinson further stated that this Gulf sponge fauna probably gave rise to the majority of the Californian sponge species, which, if true, could account for the Steinbeck and Ricketts findings of a close affinity between these two areas. I have, however, seen no other references to this latter relationship. According to Dickinson's data, regarding the northern Gulf, 58 percent of the sponges have tropical affinities and 28 percent have cool temperate affinities.

Within the intertidal zone, the majority of the sponges are found in the mid and low intertidal region, many extending into the subtidal. Some of the best sponge collecting can be done by skin or SCUBA diving beyond the lowest low tide line, where one often finds massive colonies or whole reefs of a species of sponge that may be represented in the intertidal as a mere patch encrusting on a rock ledge. In the intertidal zone, sponges may be found in permanent tidepools, crevices, and under rocks or ledges. The interior of a sponge often serves as a haven for vast numbers of smaller animals, such as amphipods, isopods, young crabs, polychaetes, shrimp, and brittle stars.

Symmetry and growth form in the sponges are strongly correlated with prevailing water currents and the depth at which they grow. Deep water forms tend to have regular, definite shapes while most intertidal species do not. Some exceptions to this rule are the "radially" symmetrical, dense sponges such as *Tethya* and *Craniella*. Bakus (1964) has also emphasized the importance of grazing reef fishes as controlling agents on sponge growth.

A lovely sponge not included in the keys is found subtidally, growing on the shells inhabited by a particular species of hermit crab. The larvae of this smooth brown sponge, probably *Suberites ficus*, apparently settle on the crab's shell and soon overgrow it (although it is conceivable that the sponge is deliberately placed on the shell by the hermit crab). The sponge is allowed to grow until it completely covers the original shell and, often, eventually dissolves it away entirely. The crab thus does away with the need to seek new and larger shells periodically as it grows, manicuring and maintaining the sponge commensal and keeping the aperture at just the proper dimensions.

KEY TO THE COMMON INTERTIDAL SPONGES

1 Sponge forms a thin encrusting growth on substrate (less than 15 mm thick) 2
-Sponge upright, a thick encrustation (20 or more mm thick) or hemispherical 13

2(1) Sponge bores in calcareous structures, especially shells, forming yellow or yellow-orange spots on substrate (fig. 1.3) ...... ***Cliona* spp.**
-Growth form not as above 3

3(2) External ostia visible to the naked eye 4
-External ostia not visible to the naked eye 12

4(3) Sponge yellow; skeleton composed entirely of spongin fiber, no spicules present .... ***Verongia aurea***
-Sponge not yellow (color variable); skeleton composed of spicules, usually with spongin fibers also 5

5(4) Sponge asconoid or leuconoid; spicules calcareous; sponge brittle and glassy; color white to cream 22
-Sponge leuconoid only; spicules not calcareous; sponge not brittle and glassy; color variable 6

6(5) Sponge red to orange 7
-Sponge lavender, brown or white 9

7(6) Sponge forms a thin, fragile film on substrate; common in mid intertidal zone; surface with a distinct pattern of grooves and channels .... ***Ophlitaspongia pennata***
-Sponge forms a thicker encrustation on substrate; rare in mid intertidal, generally occurring in low intertidal and subtidal; surface without the above pattern 8

8(7) Sponge emits a characteristic odor when crushed between the fingers; oscula very large .... ***Halichondria* sp.**
-Sponge odorless; oscula small to minute .... ***Tedania nigrescens***

9(6) Sponge white .... ***Hymeniacidon rugosus***
-Sponge lavender or brown 10

10(9) Ostia small but visible, not on raised collars or other elevations; exterior purple to pale brown .... **Sp. Undet.**
-Ostia larger, surrounded by distinct collars or in volcano-like elevations; exterior purple 11

11(10) Ostia surrounded by collars .... ***Adocia gellindra***
-Ostia mounted in tall, fingerlike projections or in volcano-like elevations .... ***Haliclona permollis***

12(3) Sponge smooth and even; sponge slate colored; sponge lacks spicules .... ***Halisarca* sp.**
-Sponge rough and irregular; sponge white; spicules present .... ***Hymenidacidon sinapium***

13(1) Sponge red, orange, or yellow 14
-Sponge not as above 18

14(13) Growth form with some symmetry, usually hemispherical, subspherical or ovate 15
-Growth form not as above, never with symmetry (amorphous) 17

15(14) Interior of sponge with tough fibers radiating out from central base 16
-Interior of sponge without radiating fibers (fig. 1.2) .... ***Pseudosuberites pseudos***

16(15) Surface warty; internal radiating fibers do not spiral .... ***Tethya aurantia***
-Surface not warty; internal radiating fibers tend to spiral out from the central base .... ***Craniella arb***

17(14) Sponge yellow with dark lavender patches, especially around the oscula; oscula usually mounted on tall, fingerlike projections; surface rough and rugose .... ***Verongia aurea***
-Sponge red or orange; oscula indistinct; surface generally smooth .... ***Tedania nigrescens***

18(13) Sponge forms a thick brown carpet on substrate surface (usually rocks); interior creamy yellow .... ***Terpios zeteki***
-Sponge does not form a thick brown carpet on substrate; interior whitish or same color as surface 19

19(18) Sponge with a stringy, rootlike holdfast; occurs on tidal flats (fig. 1.1) .... ***Tetilla mutabilis***
-Sponge not attached as above; occurs on rocks or other hard substrates 20

20(19) Sponge dark brown, purple or black externally, but pure white internally .... ***Geodia mesotriaena***
-Sponge color variable, but not as above 21

21(20) Sponge with long, sharp spicules that easily break off in the skin; spicules tetraxon only .... ***Stelletta estrella***
-Spicules not as above; spicules tetraxon, triaxon or monaxon 22

22(5, 21) Sponge forms a mass of convoluted folds and ridges; spicules vary greatly in size; sponge always white (fig. 1.5) .... ***Leucetta losangelensis***
-Sponge forms erect, fused, fingerlike processes; spicules all about the same size; sponge occasionally pink, but generally white (fig. 1.4) .... ***Leucosolenia* sp.**

CLASS DEMOSPONGIAE

Order Choristida

FAMILY GEODIIDAE

Geodia mesotriaena von Lendenfeld

When young this species is subspherical, but as it grows it spreads laterally into a massive cake, often forming very large colonies in the low intertidal and subtidal (at least to 30 m). There is a thick, tall spicule plush which is easily felt and rubbed off. The oscula are restricted to special pore areas (plates). The colorful cortex may often be thick and tough, difficult to cut through, even with a sharp knife. This may well be the commonest sponge of the Gulf intertidal. It is light or dark brown to purple externally (in extreme cases dirty white, or even charcoal black), and white or pale cream internally. The range is from southern Alaska to the Gulf of California. The internal chambers of this and many other sponges house a great number of small invertebrates. One piece of *Geodia*, approximately 15 by 15 cm, dissected by Mr. Dick Inglis at Puerto Peñasco, was found to have living in and on it over 100 different species of plants and animals, mostly amphipods, polychaete worms, and small crabs.

Order Choristida

FAMILY CRANIELLIDAE

Craniella arb (de Laubenfels)

A spherical to subspherical, orange to yellow sponge with an extremely fuzzy surface (hispid). This sponge greatly resembles *Tethya aurantia* in its growth form and even in the occasional appearance of what superficially would seem to be surface warts, but on closer examination are seen to be simply shallow irregularities. A cross section through the interior of this animal also reveals a strong similarity to *Tethya* in that both possess a thick outer cortex and tough, radiating internal fibers (actually spicule bundles). In *C. arb*, however, the fibers tend to spiral out from the center base of the sponge, whereas in *Tethya* they radiate straight out.

This radiating fiber phenomenon is not uncommon in sponges of the tetractinellid group (e.g., the orders Carnosa and Choristida), most of the genera with a thick and conspicuous cortex and these radiating fibers being placed in the order Choristida. The known range of this species is from central California to the Gulf of California. It is common throughout the Gulf, in the low intertidal and shallow subtidal (occasionally to depths of 25–30 m), and I have found it regularly at Puerto Refugio, the rocky mouth of Bahía Concepción, and numerous locations along the west coast of Baja. Hartman (1957) places this species in the genus *Tetilla* (and hence the family Tetillidae). The distinction between these two genera is based primarily on microsclere presence or absence. *Tetilla* lacks microscleres, whereas *Craniella* has them (in the form of sigmas). Hartman seems to feel this difference is unsufficient to warrant generic distinction.

FAMILY ANCORINIDAE

Stelletta estrella de Laubenfels

A subspherical, dirty white, cartilaginous sponge with a tough cortex. Growth forms range from small ovoid knobs to large cakes. This species has long, sharp spicules that easily break off in the skin and can irritate. Its range is from southern California to the Gulf of California. I have recorded this sponge only from Puerto Refugio in the Gulf. Hartman (1957) places this genus in the family Stellettidae.

Order Spirophorida

FAMILY TETILLIDAE

Tetilla mutabilis de Laubenfels

A species of *Tetilla*, tentatively assigned to *T. mutabilis*, has been found to be extremely common in the soft sediments of Laguna de la Cruz, near Bahía Kino. The sponge takes an erect brown growth form and stands attached to the mud by a bundle of rootlike filaments known as "anatriaenes." Most specimens are 5–20 mm wide and 20–70 mm tall. They are seldom dislodged but when they are, such as during severe storms, they tend to roll about over the mud flat surface, eventually accumulating in potholds or among the mangrove roots. *Tetilla mutabilis* is also known from southern California. Figure 1.1.

Order Myxospongida

FAMILY HALISARCIDAE

Halisarca sp.

A smooth sponge, entirely lacking both spicules and spongin. The skeletal support is derived from a very thick mesogleal layer. The dark encrustation it forms in the lower mid and low intertidal regions makes it almost indistinguishable from compound tunicates. This sponge is generally slate colored, and external ostia are rarely seen with the naked eye. Although the exact identity of this sponge is yet to be determined, Dr. G. J. Bakus has informed me that it is quite likely *Halisarca sacra* de Laubenfels. This is the so-called "slime sponge" of California waters, actually ranging at least from Washington state to southern California (and possibly into the Gulf of California). I have recorded *Halisarca* from throughout the Gulf, including the islands of the La Paz region and rocky shores of Puerto Peñasco. This

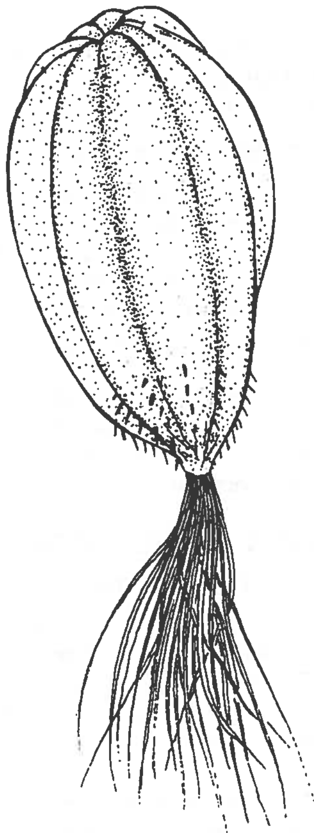


Fig. 1.1 *Tetilla mutabilis* (from Allen, 1976)

sponge was reported as *Chondrosia reniformis* in the first edition of this handbook, and it is perhaps also the *Chondrosia reniformis* that Steinbeck and Ricketts collected at the Bahía Pulmo reefs in 1940. The genus *Halisarca* is placed in the family Dendroceratidae by Hartman (1957).

Order Haplosclerida

FAMILY HALICLONIDAE

Haliclona (cf. *H. permollis* Bowerbank)

This sponge is a pale rose to vivid purple, soft and spongy to the touch, not at all slimy. Specimens living completely out of the sunlight, as under large boulders, usually have a more brownish to yellow-tan color. Most Gulf specimens have the regularly spaced oscula surrounded by volcano-shaped cones, 2 to 3 mm wide. This encrusting sponge is about 1 cm thick, and forms growths of flat sheets or meandering strands across the sides and undersurface of rocks. It is cosmopolitan in distribution and is one of the more common encrusting sponges of the California coast. Hartman (1957) claims that this species' name should be abandoned on our coast, as the supposedly cosmopolitan *H. permollis* is in need of critical reexamination. Actually, this entire genus is in need of critical reexamination. I have recorded this poriferan from rocky areas throughout the Gulf, especially where the water is clean and without excessive silt. Elvin (1976) found that the initiation of oogenesis in *H. permollis* (in Oregon) was closely related to increases in incident light, and secondarily to environmental temperatures. Development of the embryos was shown to be closely related to levels of particulate food supply.

FAMILY ADOCIIDAE

Adocia gellindra de Laubenfels

A thick encrusting form, 2 to 4 cm thick. This sponge is pale lavender with few oscula, all irregular in shape, often having raised collars. The surface is smooth. It ranges from central California to the Gulf of California.

Order Poecilosclerida

FAMILY TEDANIIDAE

Tedania nigrescens (Schmidt)

This common sponge varies from encrusting to massive and may or may not have visible oscula. The surface is generally smooth, unless damaged. It is characteristically bright red or orange. Another cosmopolitan species, ranging on our coast from the Gulf to the Galápagos Islands. There exists a very interesting group of minute bryozoans belonging to the genus *Loxosomella*. These elfin marine animals seem to show a particular liking for stagnant and polluted seawater, and also for living as commensals with certain sponges, particularly a species of tropical Atlantic *Tedania*, *T. ignis* (Duchassaing and Michelotti). Although not yet reported from the east Pacific, those bryozoan-sponge partnerships are known from just about everywhere else. One should, therefore, not be surprised to find a pale white fluff of *Loxosomella* on a sponge such as *Tedania nigrescens* in some backwater slough or boat harbor in the Gulf of California. San Carlos Bay marina, in fact, might be a very likely place to look for this association. Some workers place this genus in the family Myxillidae. A second species of thick, encrusting red sponge has been reported from the Gulf but not yet collected by the author. This species, *Axinella mexicana* de Laubenfels, resembles *Plocamia karykina* of the west coast of Baja and California and should be easily recognized by its ability to produce copious amounts of mucus when disturbed (as does *P. karykina*).

FAMILY CLATHRIIDAE

Ophlitaspongia pennata (Lambe)

Ophlitaspongia comprises another common but confusing genus of sponges whose members typically form thin reddish (or occasionally orange) encrustations on rock surfaces in the mid and low intertidal regions. Most of the original members of this taxon have been transferred to different genera, and de Laubenfels (1954) stated that he felt only four or five valid species of *Ophlitaspongia* remained described in the world. *Ophlitaspongia pennata* occurs commonly on rocks throughout the Gulf of California, forming bright patches in the mid and low intertidal zones. It is very thin, smooth, and fragile. This sponge is now known to range from Canada at least as far south as southern California and into the Gulf of California. It has characteristic oscula that are often star-shaped, and a pattern of stellate radiations or irregular grooves across the surface (representing the excurrent canals). Its color ranges from red-orange and orange-copper to (occasionally) a yellow-tan. Specimens placed in alcohol eventually turn a dull beige or lavender. One habit of *Ophlitaspongia* that makes it recognizable is the fact that it occurs in its greatest abundance in the mid intertidal zone, considerably higher up on the beach than any other red sponge commonly occurs. The pattern of canals or grooves on this sponge's surface is also seen in another red sponge, *Plocamia karykina* de Laubenfels (the so-called mucus sponge). *Plocamia*, however, is usually a much thicker sponge (5–25 mm thick) and has not been collected south of the central west coast of Baja California.

De Laubenfels erected the genus *Litaspongia* in 1954 to contain a group of sponges very similar to *Ophlitaspongia* but differing in the growth structure of the microscleres (spicules). G. J. Bakus has informed me that members of this new genus may also be distinguished by their branching growth form. I have found a member of *Litaspongia* growing on the roots of the Red Mangrove trees *(Rhizophora mangle)* in various esteros in the Gulf, and also in Bahía Magdalena, on the southwestern coast of Baja California.

Order Halichondrida

FAMILY HYMENIACIDONIDAE

Hymeniacidon sinapium de Laubenfels

A dull orange, yellowish green, or white sponge that forms a flat, thin encrustation on rock surfaces. On California shores, however, this species often grows to a thickness of 10–15 cm. The oscula are in numerous volcano-like elevations, often paired, giving the sponge surface a papillated appearance. It often encrusts small stones and empty shells in the lower mid intertidal zone, and ranges from central California to the Gulf of California. It has been recorded on California shores to depths of at least 5 m.

Hymeniacidon rugosus (Schmidt)

This white sponge is a thin encrusting form, usually about 1 cm thick and 6 cm square. The surface is fairly smooth but has numerous raised cones about 1 cm across at the base. This is a cosmopolitan species, occurring in the lower Gulf. There is a second species of encrusting white sponge that occurs in the Gulf intertidal, but its identification remains unknown. It differs from *Hymeniacidon rugosus* in being thinner (2–5 mm), smoother, and in having the oscula level with the sponge surface. It is quite similar to the California *Sigmadocia edaphus* (de Laubenfels).

FAMILY HALICHONDRIIDAE

Halichondria sp.

There is at least one species of this large and confusing genus of sponges that is fairly common in the Gulf of California. The members of this taxon are all very similar in appearance and more than 100 species have been described that still remain in this genus (many will certainly be synonymized, as future workers conduct more extensive studies on the group). They are usually red-orange or yellowish-brown in color and most even share a similar spicule morphology. The Gulf of California *Halichondria* is bright red-orange, amorphous, with a very irregular surface bearing large, scattered oscula. When it is crushed between the fingers a characteristic odor is detectable. Except for the color, this description fits that of *Halichondria panicea* (Pallas), a common cosmopolitan form known to range from Canada to Panama and the Galápagos Islands along our coastline, and the two are probably one and the same species. This species has usually been described as a temperate animal, despite its range. Color in the latter species is reported as ranging from orange to yellow and often greenish or pale brown. It is a fragile, soft sponge, forming amorphous encrustations 5–25 mm thick on rocky substrates or any hard surface.

Order Hadromerida

FAMILY SUBERITIDAE

Terpios zeteki (de Laubenfels)

A massive sponge forming a thick brown carpet over rocks, or occasionally resembling a mass of large, fused fingers. The surface is smooth, or occasionally lumpy. The exterior is chocolate brown, the interior a creamy yellow. Occasionally this sponge will have a distinct green hue due to a commensal alga. The oscula are large and obvious, 2 to 7 cm apart. It is reported from both sides of the Panama Canal and occurs throughout the Gulf of California in shallow subtidal and low intertidal regions. I have seen patches of rocks that are literally carpeted with *Terpios*, 1–6 cm thick and many square meters in area, in the Puerto Peñasco region (Norse Beach) and the Guaymas Region (Deer Island). Bryan (1973) reported on an undescribed species of *Terpios* from Guam, stating it grew an average of 23 mm per month (over a living colony of *Porites lutea*) and in some places encrusted the reef terrace for nearly a kilometer. See Plate 12.

Pseudosuberites pseudos Dickinson

A chocolate-brown, orange, or reddish sponge (occasionally yellow), with craters, pits, and cones evenly placed across the surface. The oscula are few in number, but large and obvious. Most colonies are about 10 by 12 cm across and 4 to 8 cm thick, are oval, and bear 3 to 4 large oscula, although I have found some colonies up to 40 cm in length and 15 cm in width. The species is easily recognized by its distinct cortex and large rounded growth form. It is usually found during minus tides, sitting free on the sand of an exposed bay or protected tidal flat, where it may have washed up from greater depths. Subtidally this sponge grows to massive heads, 0.5 to 1 m across, adding splendid color to the rocky outcroppings where it occurs. It may be restricted to the Gulf of California, where it is especially common at Bahía Cholla and in all of the numerous tidal inlets just north and south of Puerto Peñasco, and in Bahía Refugio. Figure 1.2.

FAMILY CLIONIDAE

Cliona celata Grant

This sponge may appear as a massive, vaselike structure, white or yellow in color, or more commonly as yellow patches in some calcareous structure that it is boring and living in. Apparently the older the sponge becomes, the more it loses its tendency to bore, and instead becomes free-living. Steinbeck and Ricketts reported it as an obvious and important feature of the lowest intertidal at Bahía de los Angeles. I have recorded it regularly throughout the Gulf. It is cosmopolitan in distribution. *Cliona* is one of a group of important marine animals that are key organisms in the recycling of calcium and carbonates in the littoral and benthic environment. The action of this sponge, boring clams (such as *Lithophaga*), certain worms, etc., begins the cycle that terminates with the eventual complete breakdown of a shell to release its chemical components back into the sea for use by other animals. Evidence of the presence of *Cliona* is easily seen by the number of shells one finds on the beach with their surface riddled with small round holes. Hopkins (1956) has demonstrated that the species of *Cliona* in a particular region can be used as ecological indicators of salinity regimes, owing to their specific tolerances to this environmental parameter. There are actually many species of *Cliona* in tropical waters, and there is no doubt that *C. celata* is but one among several of these boring sponges present in the Gulf of California. Figure 1.3 and Plate 3.

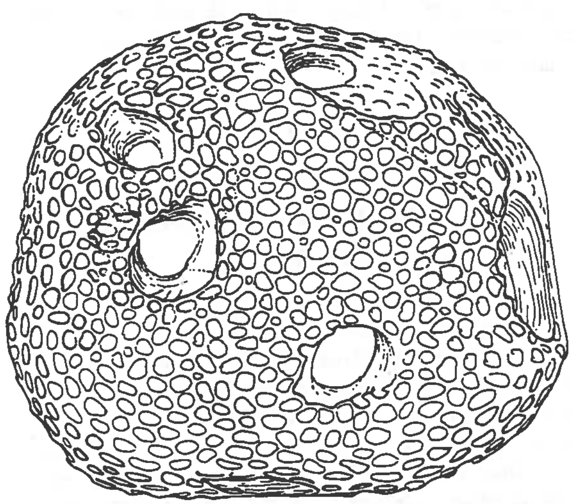


Fig. 1.2 *Pseudosuberites pseudos*

Fig. 1.3 *Cliona celata*
(from Allen, 1976)

FAMILY TETHYIDAE

Tethya aurantia (Pallas)

A cosmopolitan species of sponge, red to yellow-orange in color. The growth form is distinctive, usually more or less hemispherical, one to three inches across. The surface is pulpy and covered with raised, wartlike bumps. A cross section through the center of this poriferan reveals another distinct feature, a thick, contractile outer cortex (a few millimeters thick and occasionally tinged green with unicellular algae) and an internal structure of tough radiating fibers. *Tethya aurantia* attaches to rocks in the low intertidal and subtidal region, preferring crevices, the underside of rock ledges and vertical rock faces. Occasionally they send out short, fingerlike runners, resembling slime molds. This is part of a process called "budding" and is a form of asexual reproduction in this sponge. On the surface, it may appear similar to *Pseudosuberites pseudos*, but the latter generally has as many depressions or pits as it does warts and never grows in the distinctive hemispherical shape of *Tethya*. The only other sponge that may be confused with *Tethya aurantia* is *Craniella arb*, but in that species the fibers do not simply radiate out but spiral out from the center. I have recorded *T. aurantia* from numerous rocky regions of western Baja and throughout the Gulf. It seems to show a preference for clean, clear, protected rocky shores, such as Puerto Refugio, Bahía Bacochibampo, and Puerto Peñasco. See Plate 4.

Order Dictyoceratida

FAMILY SPONGIIDAE

Verongia aurea (Hyatt)

This cosmopolitan sponge has a variable and somewhat amorphous growth form. Littoral specimens typically form coarse-textured, spongy, yellow encrustations on rocks, while subtidal forms are best characterized by the presence of tall, thick, fingerlike projections, bearing a terminal osculum. The subtidal specimens are generally 7–15 cm across, occasionally larger, and found growing on rocky outcroppings to depths of 25 m. Their general color is yellowish with lavender patches, especially surrounding the oscula. Specimens have been found ranging from bright lemon yellow to dull yellow-orange or yellowish-green, with purple to blackish patches scattered across the surface. The cortex is fairly tough, especially for a keratose sponge. The interior of the tall projections forms a large continuation of the spongocoel, leading to the terminal osculum. The sponge turns dark purple, then black, when placed in alcohol. *Verongia aurea* is a very common animal throughout the shallow waters of the Gulf, and is especially common along the southwestern shores from Bahía Los Frailes to Bahía Concepción and Puerto Refugio. This animal lacks spicules, the skeleton being composed entirely of spongin fibers. This sponge is also common on California shores, where it is called the "sulfur sponge." Unfortunately most authors from that region still refer to it as *Verongia thiona*, a name long ago synonymized with *V. aurea*. A paper by Krejcarek et al. (1975) describes an interesting metabolite and the antimicrobial properties of this sponge. Reiswig (1973, 1974) has worked with a similar species of *Verongia (V. gigantea)* in the Caribbean. He found *Verongia gigantea* to have a water transport rate of approximately 190 cm^3 of water (per cm^3 of sponge) per hour. He found this sponge to be especially responsive to changes in various environmental conditions and further speculated that male sponges of this species may have higher pumping rates than do females, both sexes having a life expectancy of 50 to 100 years. See Plate 3.

Sp. Undet.

An unidentified species of Demospongiae has been found with some regularity along the Sonoran coast, from Puerto Peñasco to Bahía Kino. It resembles *Geodia* but is very smooth and slimy to the touch. The surface is purple to pale brown or tan, the interior cream-colored. The oscula are small but visible and fairly evenly spaced across the surface. The growth form of this sponge is such that it resembles a flowing organism (e.g., the pseudopodia of a giant amoeba) or perhaps colorful molasses. This bizarre growth form has led to its being described by certain students as a "purple glob of ooze on the rocks," a rather unscientific description but quite accurate. It forms a thin encrustation, 5–15 mm in thickness, in the lower mid and low intertidal zones, on ledges and underneath large rocks and boulders. The edges of this sponge are generally rounded or lobated.

CLASS CALCAREA

Order Leucosoleniida

FAMILY LEUCOSOLENIIDAE

Leucosolenia sp.

Members of this genus of sponges are typically small and white, with a fingerlike growth pattern. They are rather fragile and break easily. The development of the body form is on the primitive asconoid plan, and the spicules are always calcareous. Dickinson (1945) mentions only one species of this genus, *Leucosolenia irregularis* Jenkins, in the Gulf. Steinbeck and Ricketts also mention only one from the Gulf, *Leucosolenia coriacea* Montagu. Both of these species are cosmopolitan in distribution. Dickinson (1945) states of *L. irregularis* "... a small white sponge rather brittle to fragile in consistency. The shape of this sponge is not very symmetrical; in fact, it tends to be leafy." Specimens collected by the author, that have been assigned to this genus, range from dull or bright white to pale pink. There are so many species of this genus known throughout the world, and surely so many yet to be described, that it appears best to leave its identification at the generic level at this time, rather than make a guess at its specific identity. Figure 1.4.

Fig. 1.4 *Leucosolenia* sp.

Order Leucettida

FAMILY LEUCASCIDAE

Leucetta losangelensis de Laubenfels

Specimens of this calcareous sponge are usually quite amorphous. They form highly folded colonies that are nearly pure white. This is the most common calcareous sponge of the Gulf, and it ranks closely behind *Geodia* in abundance among all the intertidal sponges of the Gulf. It ranges from southern California into the Gulf, and usually occurs as an upright mass, several millimeters to several centimeters in diameter, from the lower mid intertidal to the shallow subtidal. I have found it to be most common in narrow crevices between large boulders, but it is also quite common on and under stones. The chambers of this sponge commonly house small annelids, amphipods, and isopods *(Paracerceis)*.

Burton (1963) calls this sponge *Leuconia barbata* (Duchassaing and Michelotti), in his revision of world Calcarea. Figure 1.5.

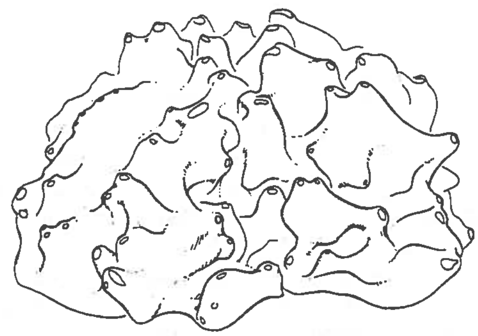


Fig. 1.5 *Leucetta losangelensis*

2

CNIDARIA (Sea Anemones, Corals, etc.)

Preservation: All of the cnidarians can be relaxed in magnesium chloride prior to preservation. The hydroids also will relax with menthol, the sea anemones with clove oil or chloretone, and the jellyfish with ethyl urethane or chloretone. Knudsen described a method for relaxing and fixing hydroids, in which hot Bouin's solution (50°C) is poured over fully expanded specimens, allowed to sit a few minutes, then poured off, to be replaced by a fresh solution of Bouin's for 30 more minutes. The hydroids are then subjected to a series of alcohol washes, beginning with a 30 percent solution and ending with 70 percent, in which they are preserved. Dr. Cadet Hand informs me he has had good success relaxing cnidarians with an isotonic solution of 7.5 percent $MgCl_2$ and seawater. Steinbeck and Ricketts (1941) recommended using cocaine or novocaine for relaxing sea anemones. Final preservation of the hydroids, sea anemones, and jellyfish can be in 5 percent formalin or 70 percent alcohol. The soft and stony corals should be preserved only in 70 percent alcohol.

Taxonomy: Classification of the Hydrozoa is based on a large number of morphological features of the medusae, zooids, and colony structure. The few morphological terms used in the key for this group can be found in the Glossary and in fig. 2.1. In general, the feeding polyps are referred to as gastrozooids (or hydranths), and the reproductive polyps as gonozooids (or gonangia). Unfortunately, the class Hydrozoa, especially the order Hydroida, has become plagued with double taxonomy. Many workers who have restricted their studies to the sessile, benthic stages of these creatures have placed species names on these polypoid stages, while other workers interested in the planktonic stages have placed entirely different names on the medusae of many of the same species. Only recently has extensive work begun to try to associate medusa with polyp and to give the animal a single species name (for an excellent example of this see Naumov, 1960). At first glance this double system of naming may appear cumbersome, but one should remember that it is quite often far better to have a name on an animal now, so that it can be identified and studied, even though you know that that name may well be changed some time in the future.

Classification of the sea anemones is based largely on body morphology, tentacle arrangement, nematocyst data, histology, and internal anatomy. The body of a typical sea anemone may be divided into three regions: the oral disk, the column, and the pedal disk. An effort to simplify the key as much as possible has resulted in the elimination of all specific anemone terminology beyond these areas.

Classification of the corals is based on growth form and skeletal anatomy. The classification of most corals has been in a state of constant revision for the past few decades. Hyman (1940) divides the class Anthozoa into two subclasses, putting the stony corals into subclass Zoantharia, order Madreporaria. Durham (1947) puts them into several orders, although the Gulf corals herein treated all fall into the order Scleractiniae. The skeleton of the coral colony as a whole is termed the *corallum*, of each polyp a *corallite*. The corallite consists of a cup with internal, vertical *septa* that rest on the *basal plate*. The wall of the cup is termed the *theca*. The inner ends of the septa are often fused to a central column called the *columella*.

The cnidarians form a large phylum of animals, displaying a great variety of body forms, but all possessing the same basic, radial-biradial symmetry. The entire phylum is treated in a single key to maximize utility. To facilitate rapid identification of specific groups, the various major taxa (class, order, etc.) are marked in the key in bold type. The conspicuous lack of published data on the Cnidaria in general makes it an extremely difficult group with which to work. A glance at the bibliography will reveal a noticeable lack of monographic material dealing with almost all of the group in this region, except the stony corals and hydroids.

The systematics used in this section are based on Fraser (1938a–c, 1948) for the hydroids, Durham (1947) and Durham and Barnard (1952) for the stony corals, Hyman (1940) and Carlgren (1951) for the sea anemones, and Hyman (1940) for the hydromedusae and gorgonians.

Cnidaria of the Gulf: The Cnidaria are well represented in the Gulf, especially in the subtidal, where an enormous number of species of hydroids, true corals, and gorgonians exist. Fraser (1948) reported 91 species of hydroids from the Gulf, from 23 different genera. Of these, 28 species in 11 genera are known to occur intertidally. The hydroid genera most often encountered in the Gulf intertidal are *Aglaophenia*, *Obelia*, *Plumularia*, *Sertularia*, and *Eudendrium*, although none of the hydroids could be considered abundant in the Gulf intertidal except perhaps *Aglaophenia*. In the intertidal zone, the phylum Cnidaria is represented principally by the sea anemones, and only occasionally will one encounter a sea pen, gorgonian, or hydroid.

The most often encountered anemones of the Gulf intertidal are probably *Bunodosoma*, *Aiptasia*, *Phyllactis*, and *Palythoa* on rocky coasts; and *Calamactis*, *Cerianthus*, and *Metapeachia* on the tidal flats. The rocky coastlines also harbor what is probably the only species of truly intertidal stony coral of the Gulf, *Porites californica*. During the lowest low tides a drained tidal flat may often expose living gorgonians and sea pens, although these and the majority of the corals are best collected with trawling and SCUBA gear, respectively. The actinian fauna (anemones) represented in the collections of the Ricketts-Steinbeck expedition were not worked up and published by Carlgren until 1951. This work still stands as the most significant contribution to the knowledge of these animals in this region.

The faunal affinities of the Gulf Cnidaria are largely tropical, although much more work needs to be done with this group throughout the eastern Pacific before the American fauna can be considered well known, especially the sea anemones and Alcyonaria. Many of the deep-water hydroids of the Gulf have ranges extended to both the temperate and tropical seas of America. Fraser (1938a) stated, "The hydroid fauna of the Gulf seems to be rather a mixture. While that of the west coast of Lower California is definitely northeast Pacific in type, that of the Gulf, if this collection is representative, is a mixture of species from the north and from the south, the latter related to those from the West Indian region," and (1938c), "When the Caribbean Sea was wide open to the Pacific, before the Panama land connection appeared, the hydroid fauna of the West Indian region must have been much similar to that of the contiguous part of the Pacific, since 85 species (out of the 119, 71 percent) in this list have been reported in the North Atlantic, mostly from the West Indian region or along the course of the Gulf Stream. These must all be old established species."

The true corals, on the other hand, are distinctly tropical in origin and affinity. Of the 11 genera of true corals reported from the Gulf by Durham (1947), four are cosmopolitan and seven are Indo-Pacific. Of the 21 species reported from the Gulf, 12 are unique to this region, while nine extend into the Panamic province. Of a combined total of 100 hermatypic scleractinian genera, the Atlantic and Pacific have in common only 6 (*Acropora*, *Cladocora*, *Favia*, *Madracis*, *Porites*, *Siderastrea*). Durham states the Gulf coral fauna probably originated in the Indo-Pacific, reaching the Gulf via the Panamic fauna; Porter (1972) is in agreement but comments that the generic-level similarity between the modern eastern Pacific fauna and Tertiary fossils of the same region suggests it is (at least in part) merely a relict of the old pan-tropical Tethyan fauna. For a discussion of zoogeographical affinities of the sea anemones, see Carlgren (1951).

The true jellyfish (Scyphozoa) typically inhabit the open sea and are not intertidal. These animals are therefore not included in the handbook, although two hydrozoan forms of floating coelenterates are included (*Physalia* and *Porpita*), as they are commonly blown into the intertidal by high winds at sea. Although not yet recorded from the Gulf proper, the colorful little sea pansy *Renilla amethystina* is fairly common on sandy shores and bays along west Baja.

KEY TO THE COMMON INTERTIDAL CNIDARIA

1	Animal free floating in sea (figs. 2.11–2.12)	2
	-Animal sessile or sedentary	3
2(1)	Animal flattened and disk-shaped, without a conspicuous float (fig. 2.11) .... ***Porpita***	
	-Animal not flattened and disk-shaped, with a large oval float (fig. 2.12) .... ***Physalia***	
3(1)	Animal colonial, in the form of featherlike plumes, or branching bushlike colonies, or erect stalks with secondary stems bearing zooids (Hydroids) (figs. 2.1–2.10)	4
	-Animal solitary or colonial, but without above forms, or, if featherlike, main stem is much broader than secondary branches (Corals, Sea Anemones, Alcyonaria)	8

Hydroids

4(3) Gastrozooids (hydranths) athecate, not encased in a chitinous outer covering (figs. 2.8–2.10) .... ***Eudendrium***
-Gastrozooids (hydranths) thecate, encased in a protective opaque outer covering 5

5(4) Hydrotheca (perisarc) with annulations or rings below polyp; colony unusually bushlike, up to several inches tall (figs. 2.1–2.4) .... ***Obelia***
-Hydrotheca without annulations; colony not bushlike, but in the form of a feather or small stalked rows of zooids 6

6(5) Polyps on both sides of branches; usually found growing on blades of algae or other plants .... ***Sertularia***
-Polyps on one side of branches only; rarely found growing on plants 7

7(6) Colony formed from clusters of featherlike branches; main stem stiff but flexible; hydrotheca close-set; colony brown to greenish-brown (fig. 2.7) .... ***Aglaophenia***
-Colony slender and not resembling a cluster of feathers; main stem flaccid, never stiff; hydrotheca set far apart; colony largely colorless (figs. 2.5–2.6) .... ***Plumularia***

8(3) Animal with 8 pinnate tentacles around mouth of each polyp; all colonial, but not encased in rigid, calcareous exoskeleton, rather without a skeleton or with a flexible skeleton (Alcyonaria: the sea pens, sea fans, sea pansies, and gorgonians) 9
-Animal with more than 8 tentacles surrounding the mouth of each polyp; tentacles not pinnate; animal solitary and without a rigid skeleton (sea anemones), or colonial with polyps embedded in hard, calcareous mass (true corals) 16

Alcyonarians

9(8) Polyps not embedded in a rigid matrix; body a single, flaccid stalk with leaflike folds bearing polyps (sea pens) (fig. 2.18) 10
-Polyps embedded in a rigid matrix; body a highly branched, rigid structure (gorgonians) (fig. 2.17) 11

10(9) Basal stalk (peduncle) of sea pen wide (8–35 mm thick) and pulpy or fleshy (fig. 2.18) .... ***Ptilosarcus* sp.**
-Basal stalk (peduncle) of sea pen narrow (2–8 mm thick) and stiff .... ***Stylatula* sp.**

11(9) Branches of colony intertwined, anastamosed, and fused to form a single, large fanlike structure (body lacelike) .... ***Gorgonia* spp.**
-Branches of colony do not anastomose and fuse as above (body treelike or bushlike) 12

12(11) Gorgonian orange or white 13
-Gorgonian red or red with yellow 14

13(12) Gorgonian white; branches taper to thin, narrow points .... ***Lophogorgia alba***
-Gorgonian orange; branches end in blunt points .... ***Eugorgia ampla***

14(12) Gorgonian red and yellow .... ***Eugorgia aurantica***
-Gorgonian pure red (or red with white polyps) 15

15(14) Surface smooth (but with numerous small holes where the polyps dwell); ends of branches blunt, not tapering to narrow points .... ***Psammogorgia arbuscula***
-Surface very bumpy and irregular; ends of most branches taper to thin, narrow points (fig. 2.17) .... ***Muricea californica***

16(8) Animals solitary, or, if colonial, *not* encased in a calcareous mass (sea anemones) 17
-Animal almost always colonial; always encased in a calcareous mass (true or stony corals) 34

Sea Anemones

17(16) Anemone always attached to a gastropod shell, inhabited by the snail or by a hermit crab 18
-Anemone not generally attached to gastropod shell 19

18(17) Gastropod shell inhabited by the snail; anemone with gray and white stripes on body .... ***Anthothoe carcinophila***
-Gastropod shell inhabited by a hermit crab; anemone not colored as above .... ***Calliactis variagatus***

19(17) Animal with a collar or serrated ruff below tentacular ring (ruff resembles a circle of short, fused tentacles) (fig. 2.15) 20
-Animal without a collar or serrated ruff as above 21

20(19) Column pink or white; tentacles without longitudinal brown stripes (fig. 2.15) .... ***Phyllactis cocinnata***
-Column orange; tentacles with brown, longitudinal stripes .... ***Phyllactis bradleyi***

21(19) Animal without a basal disk; usually found burrowing in sand or mud; entire column often in a mucus-lined tube 22
-Animal with a basal disk; usually found attached to rocks or other solid object; column exposed, or covered with adhering sand grains but not in a mucus-lined tube 27

22(21) Column white; with or without acontia 23
-Column gray, brown, or some other color, but not white; without acontia 25

23(22) 16 tentacles; siphonoglyph tubular and elevated, distinct from rest of oral disk and actinopharynx .... ***Metapeachia* sp.**
-More than 16 tentacles; siphonoglyph low and indistinct, not as above 24

24(23) Animal extremely thin and threadlike or wormlike .... ***Isarachnanthus panamensis***
-Animal elongate but stout, not threadlike or wormlike (fig. 2.13) .... ***Calamactis praelongus***

25(22) Anemone robust and living in a thick, heavy, mucus-lined tube; usually found in muddy or sandy-mud habitats, especially esteros and quiet lagoons .... ***Cerianthus* sp.**
-Anemone small and slender, living in a fragile mucus tube in which sand grains and shell fragments are loosely embedded; usually found under large rocks on sandy substrate or in fine or muddy sands 26

26(25) Tentacles with brown longitudinal stripes; column long .... ***Pachycerianthus insignis***
-Tentacles without longitudinal stripes, but occasionally with brown blotches; column short and stubby .... ***Pachycerianthus aestuari***

27(21) Anemones colonial, individuals fused at bases; tentacles very short and stout, leaving entire oral disk exposed (fig. 2.16) 28
-Anemones solitary, not fused at bases; tentacles usually long, partially or entirely obscuring oral disk 29

28(27) Tentacles brown; polyps usually over 20 mm long; mouth region brown or faintly green; oral disk brown or faintly green (fig. 2.16) .... ***Palythoa ignota***
-Tentacles green; polyps less than 20 mm long; mouth region yellowish; oral disk green .... ***Zoanthus danae***

29(27) Anemone small, column less than 13 mm in diameter; column without longitudinal rows of warts (verrucae) 30
-Anemone larger, column greater than 13 mm in diameter; column with numerous longitudinal rows of warts (verrucae) 32

30(29) Tentacles very thin and fine, banded; column not translucent .... ***Epizoanthus gabrieli***
-Tentacles stout, not banded; column often translucent 31

31(30) Column differentiated into two regions, an upper, delicate, thin-walled region and a lower, thick-walled portion; column yellowish brown .... ***Diadumene leucolena***
-Column not differentiated as above; column white to greenish brown .... ***Aiptasia californica***

32(29) Verrucae not adhesive (so that sand and bits of shell do not adhere to column); verrucae arranged in rows only near the pedal disk, becoming random over the majority of column; tentacles red, brown, or green, occasionally with yellow hashmarks around the mouth (fig. 2.14) .... ***Bunodosoma californica***
-Verrucae adhesive (sand and bits of shell usually adhering to column); verrucae in distinct rows entire length of column; tentacles green or transparent with white patches, without yellow hashmarks around the mouth 33

33(32) Tentacles green, without white patches; anemone usually over 40 mm tall; rows of warts on column close together; often a white, fusiform mark at the base of each inner tentacle .... ***Bunodactis mexicana***
-Tentacles transparent with white patches; anemone usually less than 30 mm tall; rows of warts widely spaced; without a white mark at the base of the inner tentacles .... ***Anthopleura dowii***

Stony Corals

34(16) Coral polyps (corallites) solitary or loosely joined at base only; 30 or more septa 35
-Coral polyps all joined into a rigid calcareous structure, tops of corallites more or less even with general surface of corallum; 25 or fewer septa 36

35(34) Corallum composed of 4–15 large and elongate corallites, each being 20–100 mm tall; color in life brilliant orange .... ***Tubastraea tenuilamellosa***
-Corallum composed of one to several small and stubby corallites, each being less than 15 mm tall; color in life variable (reds, purples, and browns predominate) .... ***Astrangia pedersenii***

36(34) Corallum growth form low and symmetrically rounded or lobated .... ***Cycloseris* spp.**
-Corallum growth form erect and branching or encrusting (asymmetrical) 37

37(36) Corallites interconnected by numerous meandering furrows and ridges covering the surface of the corallum .... ***Pavona gigantea***
-Growth form not as above, corallites independent from one another **38**

38(37) Colony encrusting; colony brilliant green .... ***Porites californica***
-Colony not encrusting, but erect and often branching; colony not brilliant green **39**

39(38) Colony broadly lobed, not distinctly branched; orifice of corallite irregular .... ***Porites nodulosa***
-Colony erect and highly branched, bushlike in its growth form; orifice of corallite rounded (fig. 2.17) .... ***Pocillopora elegans***

CLASS HYDROZOA

Order Hydroida

Suborder Calyptoblastea (Leptomedusae)

FAMILY CAMPANULARIIDAE

Obelia spp.

Members of this cosmopolitan genus grow in bushlike clusters and are usually more easily seen and more robust appearing than most other hydroids, even though they are often mistaken for clumps of algae or even overlooked entirely when covered with adhering mud and sediment, as they often are. The hydroid forms a branched colony growing from a creeping rootstalk. The feeding polyps have bell-shaped hydrotheca and are usually borne on short stalks. Members of this genus release free medusae that are flat and bear 12–16 tentacles. A number of workers have been drawn to speculate (in regard to the hydroids) that, since the medusae are the sexually reproducing forms, they should perhaps be considered as the adult stage; the polyps, being asexual, would therefore represent a highly specialized larval stage in the development of these animals. Evidence exists that favors both this and the opposing view, however. Fraser (1937, 1938a–c, 1939) reported three species of *Obelia* from the Gulf intertidal: *O. hyalina* Clarke, northern Gulf to Panama; *O. tenuis* Fraser, lower Gulf to Ecuador; and *O. plicata* Hincks, Alaska to Ecuador. Steinbeck and Ricketts reported *O. plicata* as a profusely branching form with tufts several inches long. Their record was from the Estero de la Luna, Sonora. They also reported the amphiamerican *O. dichotoma* (Linnaeus) from the back of a turtle in the same locale. *Obelia dichotoma* most commonly grows as a delicate whitish fuzz, only a few centimeters tall. It commonly prefers other animals and plants for attachment. A recent paper by Cornelius (1975) has reduced the number of world species of *Obelia* to just three: *O. bidentata; O. geniculata;* and *O. dichotoma*. By this treatment all three Gulf species are synonyms of *Obelia dichotoma*. *Obelia* plays host to a number of organisms that grow on or cling to its branches, including diatoms, protozoans, pycnogonids and caprellids, amphipods, and even other hydroids. A number of nudibranchs feed regularly on *Obelia* and other hydroids, the aeolid nudibranchs in particular. Figures 2.1–2.4.

FAMILY SERTULARIIDAE

Sertularia spp.

In this genus the feeding polyps are sessile, sitting right on the stalk, not held up on pedicels as in *Obelia*. The polyps are arranged in a definite pattern along the stem. Members of this genus do not produce free medusae. Specimens are frequently found attached to algae, especially broad-leafed forms (and also turtle grass). Fraser (1937, 1938a–c) reported three species from the Gulf intertidal: *S. desmoides* Torrey, northern California (at least) to the west coast of Mexico and southern Gulf of California; *S. exigua* Allman, southern California and the southern Gulf to Central America; and *S. stookeyi* Nutting, Baja California and the Gulf, south to Ecuador. Steinbeck and Ricketts reported *S. versluysi* Nutting from Cabo San Lucas. This latter identification may be questionable. The use of the generic name *Sertularia* has certain problems associated with it, for not all of Fraser's *Sertularia* species are still considered as belonging to that genus, many now being placed in the genus *Dynamena* Lamouroux 1812. In the latter genus individuals always have the hydrothecae oppositely arranged, and colonies always branch in a single plane. In *Sertularia sensu stricto* hydrothecae are never oppositely arranged, and branching may occur on any plane.

FAMILY PLUMULARIIDAE

Plumularia spp.

Members of this genus consist of colonies of pinnately arranged branches, arising from a central unbranched stalk. The hydrothecae have smooth margins, and the nematophores are movable. The gonangia are sac-shaped or bottle-shaped. Species of this genus occur regularly on *Sargassum* in the northern Gulf. Fraser (1937, 1938a–c) listed two species of *Plumularia* as occurring in the Gulf intertidal: *P. lagenifera* Allman, Alaska to Peru, a large, robust hydroid common to the low intertidal of California and Canada; and *P. sinuosa* Fraser, southern California to Panama and throughout the Gulf. Although Fraser (1938, 1949) gives no records of *P. setacea* (Ellis) from the Gulf intertidal, and I have not collected it there, it very likely ranges into the exposed littoral, as it does on the Pacific coast, and it is very common subtidally in the Gulf. *Plumularia setacea*

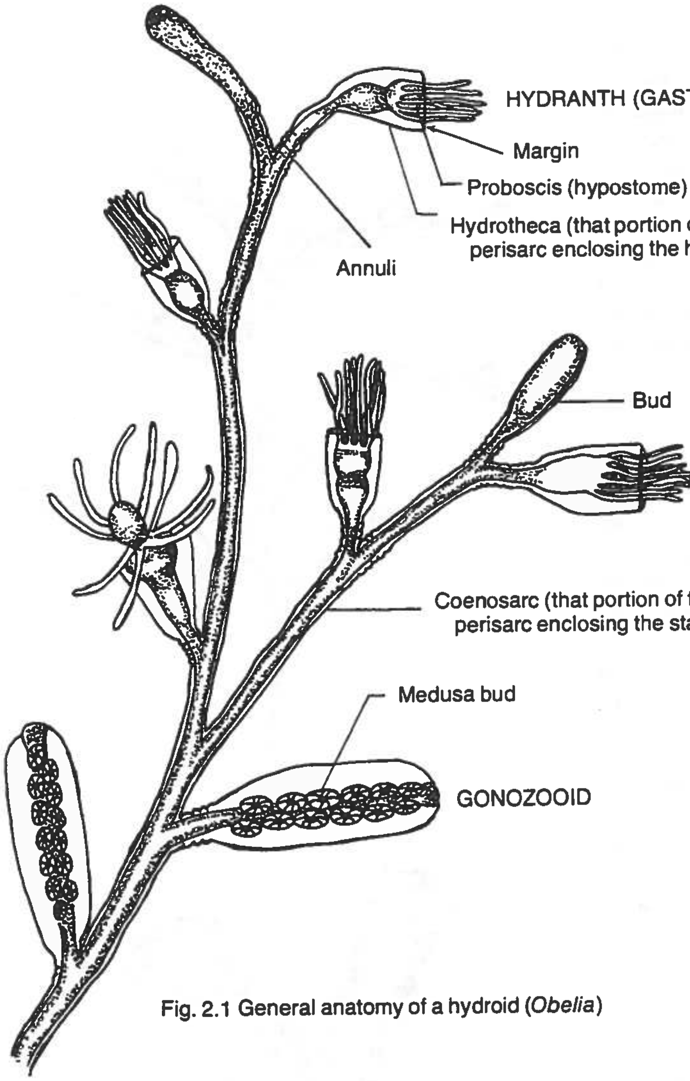


Fig. 2.1 General anatomy of a hydroid (*Obelia*)

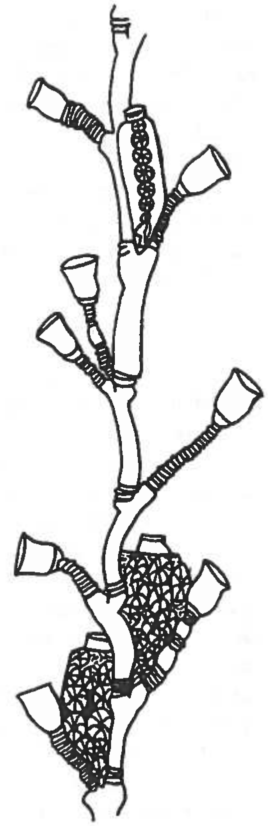


Fig. 2.3 *Obelia dichotoma*.
Portion of stem
with hydrothecae and gonangia
(after Defenbaugh and Hopkins, 1973).

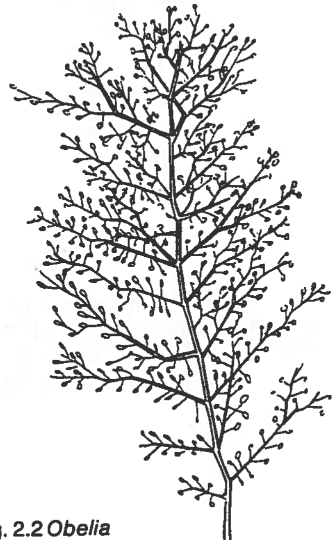


Fig. 2.2 *Obelia*
(from Allen, 1976)

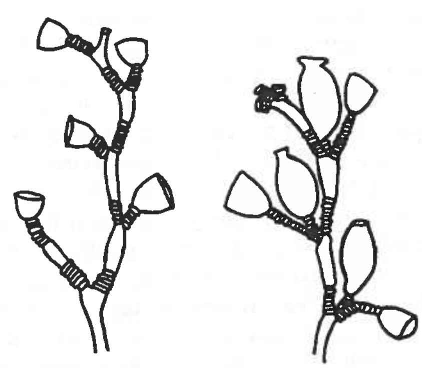


Fig. 2.4 *Obelia hyalina*.
Portions of colony with hydrothecae and gonangia
(after Defenbaugh and Hopkins, 1973).

is a common California and Atlantic plumularian. It is nearly transparent, and when viewed under water it seems to disappear. The delicate glasslike stalks are 5–20 mm tall. The hydrotheca are shallow and cup-shaped and the gonangia are bottle-shaped. It occurs as far north as Vancouver Island and possibly Alaska. This species does not release its medusae but retains them in a chamber until they have produced the larvae that will grow to form the new hydroid colonies. Hinton (1969) commented that this method of reproduction is common among hydroids living on wave-swept rocky shores, and may be an adaptation to keep the delicate medusae out of this dangerously turbulent region. Figures 2.5–2.6.

Aglaophenia spp.

This genus of "ostrich plume" hydroids is characterized by its featherlike growth form, sessile nematophores, hydrothecae-bearing tooth margins, and gonangia enclosed in a corbula formed by overlapping leaflike structures. Fraser (1937, 1938) reported four species of *Aglaophenia* from the Gulf intertidal: (1) *A. diegensis* Torrey, ranging from Alaska to Ecuador and throughout the Gulf. A delicate elongate form, solitary or occurring in clumps of a few stems. This may be the commonest intertidal hydroid of the Gulf. I have found large areas of the rocks in Bahía San Carlos and Coloraditos covered with this hydroid, from the subtidal up to about the 0-tide level, the stems attaining heights of 10 to 15 cm. It also occurs abundantly in the El Mogote region of La Paz. (2) *A. inconspicua* Torrey, from north of San Francisco to Isla de Cedros and in the northern Gulf. This is a common California ostrich-plume, small (usually about 3 to 5 cm tall), and often found growing on algae or broken shells. The polyp cup (hydrothecum) bears 9 teeth on its margin. The plumes are yellowish tan to light brown. (3) *A. pinguis* Fraser, southern California, Pacific coast of Baja California, and the lower Gulf. The polyp cups of this species also bear 9 teeth, but the median tooth is greatly reduced so as to give the appearance of only 8. Actually, the other teeth may occasionally be reduced also, giving the hydrothecum margin the appearance of a mere wavy line. (4) *A. propingua* Fraser is so far known only from Bahía Agua Verde in the Gulf and Ensenada on the outer side of Baja California. In this species the colonies stand to 12 cm high and may be slightly branched. The stem is dark brown and distinctly divided into internodes that are completely occupied by the hydrothecae, so that the margin of one hydrothecum practically touches the base of the next. The hydrothecae bear 9 very low, rounded teeth, the median tooth being the most acute. Members of this genus often have large numbers of caprellid amphipods clinging to the stems. Figure 2.7. See also Plate 12.

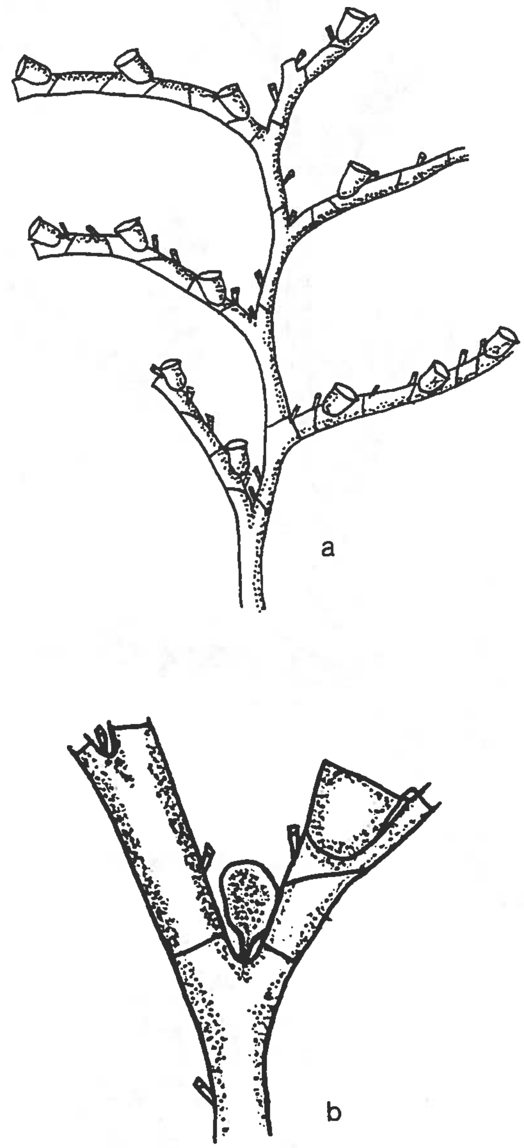


Fig. 2.5 *Plumularia sinuosa*.
(a) Portion of colony showing hydrocladia.
(b) Portion of stem and hydrocladium with gonangium (after Fraser, 1938, 1948).

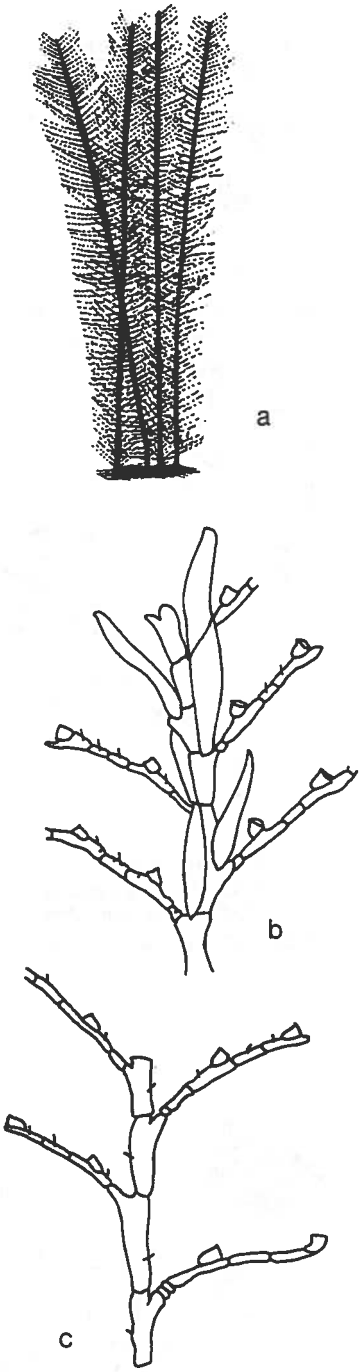


Fig. 2.6 *Plumularia setacea*. (a) Entire colony.
(b) Portion of colony with gonophores.
(c) Portion of colony showing hydrocladia and hydrothecae.

(Part a from Allen, 1976;
parts b and c after Defenbaugh and Hopkins, 1973.)

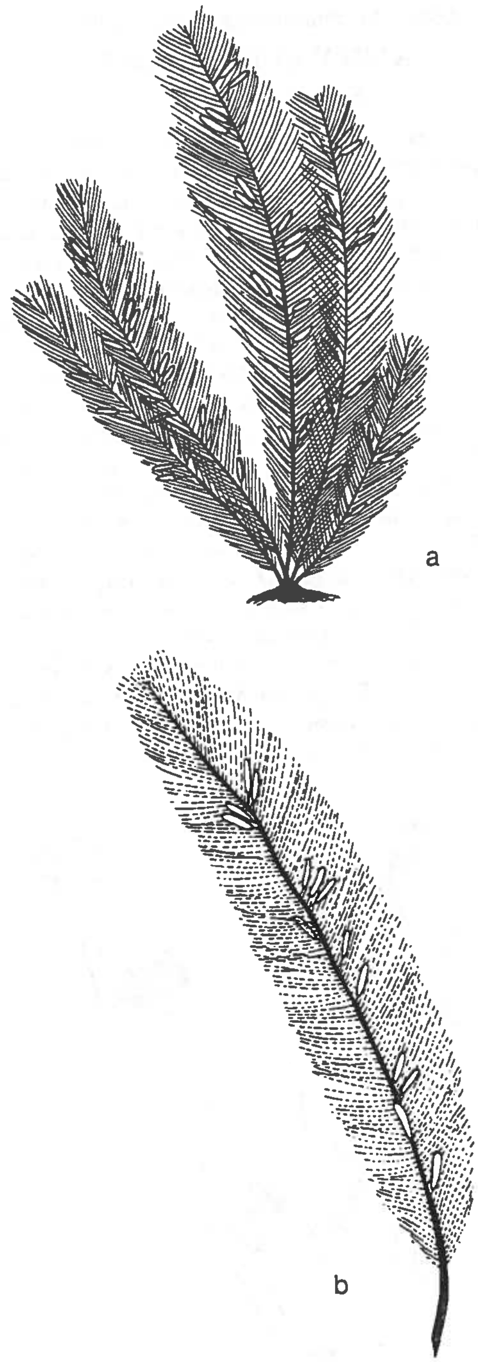


Fig. 2.7 *Aglaophenia*.
(a) Colony.
(b) Individual stalk.

Suborder Gymnoblastea (Anthomedusae)

FAMILY EUDENRIIDAE

Eudendrium spp.

Members of this genus form small colonies, resembling miniature flowering bushes. The branches of the colony take off in all directions, intertwining, as compared with the more upright growth form of *Obelia*. Even so, a thick growth of these hydroids can be easily mistaken for an alga. Close examination will reveal the flowerlike hydranths, usually borne at the tips of the secondary branches. The main stalks of many members of this genus are annulated. Members of the suborder Gymnoblastea differ from the Calyptoblastea in that they are without a perisarc around the hydranths and gonophores. Fraser (1937, 1938a–c) reported five species of *Eudendrium* from the Gulf intertidal: *E. cochleatum* Allman, Baja California, and the lower Gulf; *E. eximium* Allman, northern Gulf; *E. ramosum* (Linneaus), Alaska to Peru; *E. tenellum* Allman, northeast Pacific shores to Ecuador; and *E. tenue* A. Agassiz, southern California to Colombia. Members of this genus are seldom collected because of their small size, fragility, and scarcity. They do not produce medusae. I have identified *E. cochleatum* from the El Mogote region of La Paz. Figures 2.8–2.10.

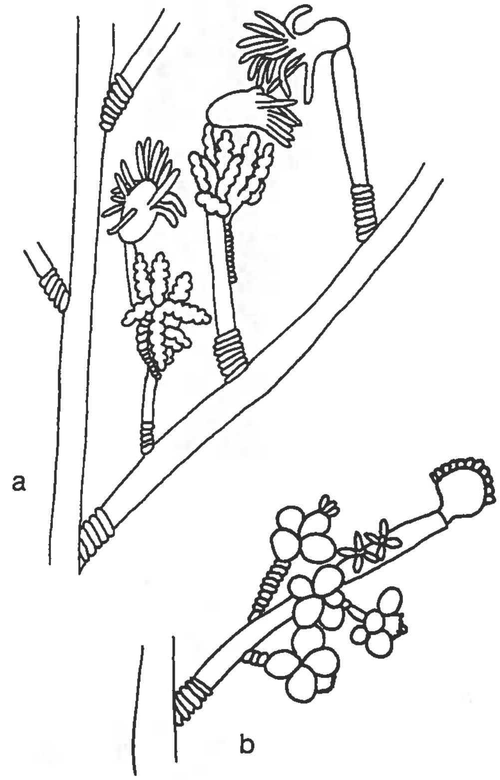


Fig. 2.9 *Eudendrium ramosum*.
(a) Portion of male colony.
(b) Portion of female colony.
(after Defenbaugh and Hopkins, 1973).

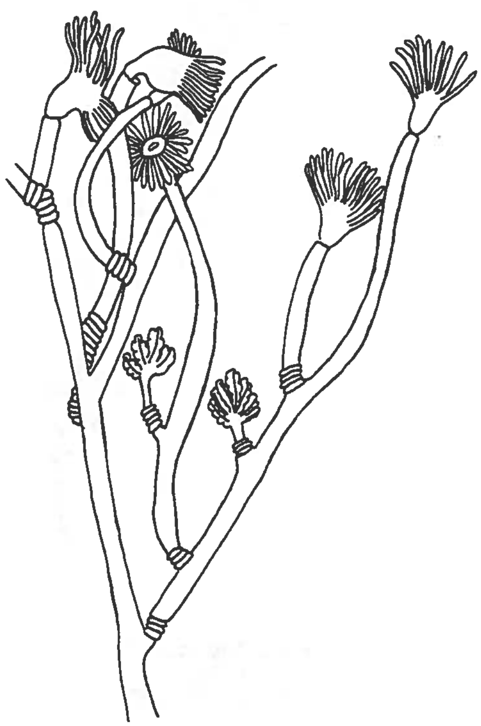


Fig. 2.8 *Eudendrium tenue*.
Portion of male colony
(after Defenbaugh and Hopkins, 1973).

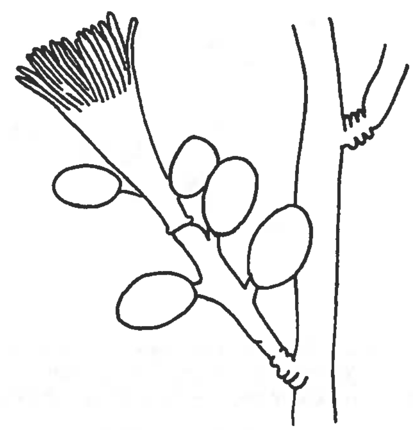


Fig. 2.10 *Eudendrium eximium*.
Portion of female colony
(after Defenbaugh and Hopkins, 1973).

Order Chondrophora

Porpita sp.

A small, disk-shaped, floating hydrozoan, blue to lemon colored, cosmopolitan in tropical and subtropical seas. The margin of the disk of *Porpita* is fringed with short, hollow, tentacle-like dactylozooids. The central gastrozooid possesses a true mouth and is surrounded by several cycles of gonozooids. The medusae are set free to discharge the sex cells (as in *Velella*, the north Pacific "by-the-wind sailor," or "purple sailor"), but the medusae apparently soon die because they cannot feed. I have collected this hydrozoan washed ashore at localities throughout the northern Gulf. The ontogeny and systematics of *Porpita* (and *Velella*) have long been debated. These animals have been, at various times, regarded as modified medusae, hydroid colonies related to siphonophores, and hydroid individuals. Most modern workers admit a close relationship with the sessile hydroids, and many place them in the separate order Chondrophora. A paper by Fields and Mackie (1971) describes them as being a single, large tubularian hydranth, floating upside down at the surface instead of being attached by a stalk to the bottom. Their classification of these two genera is as follows: order Anthomedusae; suborder Capitata; superfamily Tubularoidea; family Velellidae. Figure 2.11.

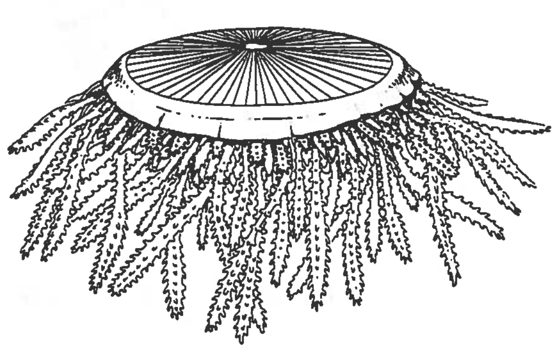


Fig. 2.11 *Porpita* sp.

Order Siphonophora

Suborder Physophorida

Physalia sp.

The infamous Portuguese man-of-war. This siphonophore, unlike most of its relatives, has no swimming bell with which to propel itself, but instead has an oval, saclike float that allows it to remain on the surface of the ocean to be blown about by sea breezes. The float appears to be filled primarily with carbon monoxide (CO), with traces of nitrogen, argon, and xenon. *Physalia* can deflate its float only enough to keep itself moist, not enough to sink below surface storm turbulence (although the crest of it is quite contractile) and, thus, is at the mercy of the ocean winds, which is the reason it is often found cast ashore after a stormy sea. Locomotion and dispersal in floating cnidarians has recently been reviewed by Mackie (in Muscatine and Lenhoff, 1974). A number of specialized polyps trail into the water from the underside of the float. These are several centimeters to several meters in length, depending on the type and the size of the individual. The specialized structures arise from a very short and inconspicuous "stem," which is in reality a budding coenosarc on the ventral surface of the float. Close examination (a microscope is not needed) will reveal clusters of attached medusae, tangles of long stinging tentacles (the dactylozooids) armed with nematocyst batteries, as well as the gastrozooids. A large, mature *Physalia* may be composed of several to 1000 or so separate individuals (polyps). The stinging tentacles contain strong longitudinal muscle fibers that can contract to pull trapped food items up to the mouths of the gastrozooids.

The beautiful bluish purple float of this dangerous jellyfish is a familiar sight (carefully avoided) in tropical and subtropical seas throughout the world. The sting from this creature is one of the strongest known among the cnidarians, rivaled only by that of the sea wasps (*Chironex* and other Cubomedusae). The exact nature of the toxin (called hypnotoxin by Hyman) is not known, but it is mainly composed of short-chain acidic proteins and is not formic acid as some authors have labeled it in the past. The MacGinities described an interesting and rather simple method of observing the discharge of cnidarian nematocysts (MacGinitie and MacGinitie, 1968, p. 121), and Knudsen (p.122) described several other methods of discharging and examining them. The study of nematocysts and nematocyst toxins is an interesting area of research, yet very little modem biochemically oriented work has been done in this field despite the potential to systematics. Lane (1960) stated that, in its crude form, the toxin of *Physalia* is about 75 percent as poisonous as the venom of a cobra and is likewise a neurotoxin. Despite this the small, colorful *Nomeus* fish lives out a happy life swimming amongst the tentacles of this deadly creature, feeding in part by nibbling off other fishes captured by the man-of-war. This commensal fish can apparently survive doses of the *Physalia* toxin 10 times that which it takes to kill a normal prey fish.

The early development of *Physalia* is possibly passed in deep water, as it has not yet been observed (Hyman, 1940). Members of this genus attain float lengths of 5 to 30 cm (2 to 12 inches), although I have never collected any from Gulf waters longer than 6 cm (2.5 inches). Lane (1960) speculated that the name of this animal probably originated with its resemblance to the lumbering but formidable galleons of the Portuguese

Navy, when that country reigned as a naval power. During the months of July, August, and September, these creatures are quite often cast ashore by summer winds throughout the Gulf.

There are three popular treatments for a man-of-war sting, all of which are applied directly to the skin as soon as possible: alcohol; various alkaline (basic) compounds, such as baking soda, crushed antacid tablets, and ammonia; and meat tenderizer. I have found meat tenderizer to be most effective, in particular those tenderizers containing the protein denaturing enzyme papain, derived from the papaya fruit. Although I've not heard of it being a remedy, I suspect rubbing a fresh papaya on the affected area would also give good results. Different people react in different ways to the sting of *Physalia;* natives of tropical coasts often build up a reasonable resistance to the toxin. Figure 2.12.

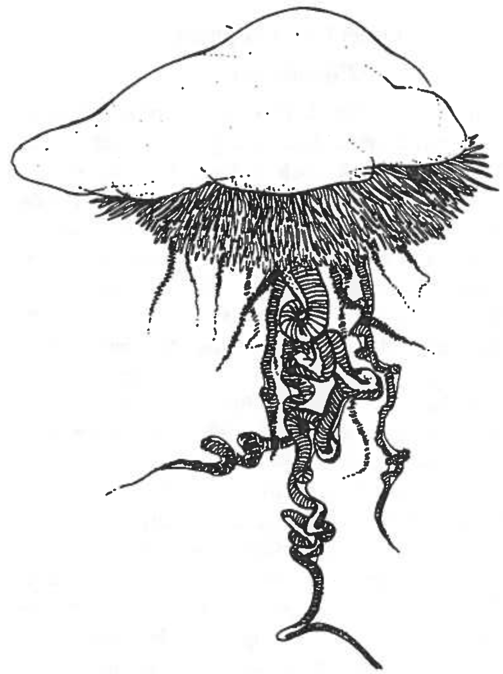


Fig. 2.12 *Physalia* sp.

CLASS ANTHOZOA

SUBCLASS ZOANTHARIA

Order Actiniaria (the true sea anemones)

Tribe Nynantheae

Subtribe Athenaria

FAMILY HALOCLAVIDAE

Metapeachia sp.

An elongate white anemone without a pedal disk and its corresponding basilar muscles. This anemone burrows into mud and muddy sand with its rounded aboral end, called a physa. It has 16 short, banded tentacles, and a single, tubular siphonglyph that is elevated above the level of the oral disk and actinopharynx. The tentacles are arranged in only two circles (cycles) around the mouth.

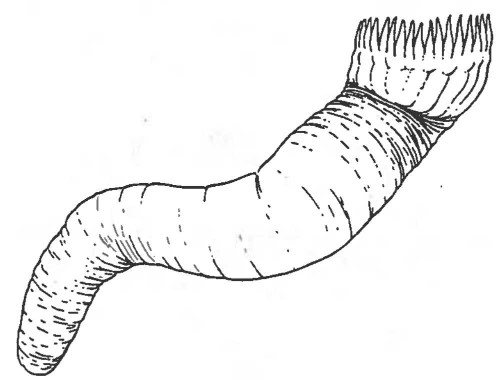


Fig. 2.13 *Calamactis praelongus*

FAMILY HALCAMPOIDIDAE

Calamactis praelongus Carlgren

Another elongate white anemone without a pedal disk (see *Metapeachia*) but possessing a well-developed physa. This species has around 24 tentacles, and its smooth column reaches lengths in excess of 50 mm. Members of the genus have only one siphonoglyph. *Calamactis praelongus* is found burrowing in mud and sand-mud bays. Pickens (1970) reported it as the most common anemone in Bahía Cholla. Figure 2.13.

Subtribe Endomyaria

FAMILY ACTINIIDAE

Bunodactis mexicana Carlgren

This species, as well as the following two species, of the family Actiniidae have the column covered with small round warts or verrucae. In *Bunodactis* and *Anthopleura* these warts are arranged in longitudinal rows between the septal attachments and are actually hollow projections of the body wall. They are provided with a special musculature and covered with a glandular adhesive epidermis, which allows the anemones to cover themselves with bits of shell and sand, probably an adaptation for physical protection against desiccation or predation. The tentacles of *Bunodactis* are olive green, occasionally reddish tipped, fairly long, and often number over 100. The column color is variable, but usually red, brown, or light green. There is often a white fusiform mark around the base of each inner tentacle. The polyps are large, the column reaching 50 to 60 mm in length. The tentacles are equally long. I have found this anemone to be especially common in the oyster lagoons of Isla Espíritu Santo, and on the submerged rocky shores of Isla San Pedro Nolasco (near Guaymas). See Plate 8.

Anthopleura dowii Verrill

This species resembles *Bunodactis* (above) but may be differentiated by the rows of verrucae, which are very close together in *Bunodactis* but widely spaced in *Anthopleura*, leaving portions of the column exposed between the rows of vesicles. *Anthopleura dowii* is also smaller than *Bunodactis*, and dark green or brown, the tentacles being a translucent green, spotted with white patches. The average specimen will have a column about 30 to 50 mm long, and tentacles 15 to 20 mm long. In large individuals, two broad siphonoglyphs are visible. This anemone is fairly common throughout western Mexico, also occurring in the Galápagos Islands.

Bunodosoma californica Carlgren

The column warts of this species, unlike the two species described above, are not adhesive; hence, this anemone will not be found covered with sand or bits of shell. The warts are arranged in rows only at the base of the column. In fact, only the first 3 to 4 vesicles are in distinct rows, the rest being dense and randomly placed over the column. The column is usually red or orange, but occasionally brown. The tentacles are red, brown, or green, and may number nearly 150. There is often a series of yellow hashmarks around the mouth. The well-developed pedal disk is narrower than the oral disk. This species is possibly the most abundant large anemone (oral disk 35–80 mm in width) of the Gulf. On the outer coast of Baja it ranges as far north as Bahía Magdalena. Figure 2.14.

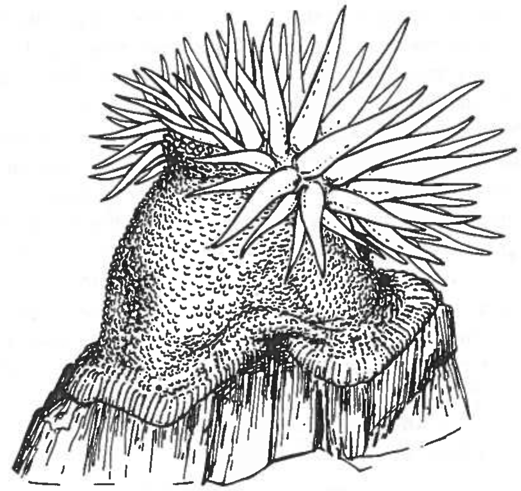


Fig. 2.14 *Bunodosoma californica*

FAMILY PHYLLACTIDAE

Phyllactis cocinnata (Drayton, in Dana, 1846)

Phyllactis cocinnata and the following species are quickly distinguished from all the other anemones treated here by the presence of a ruff or collar, resembling a circle of short fused tentacles, below the region of free tentacles. The true tentacles are short and set inside the ruff, very near the mouth, and usually number 40 or 48. This species is generally found attached to rocks in the mid and low intertidal by its well-developed pedal disk, usually burrowed into a deep crack or hole in the rock. It has unmarked tentacles and a pink or white column. The ruff bears numerous short filiform or dendritic appendages. The upper part of the column, below the ruff, is usually provided with 40 to 48 longitudinal rows of verrucae to which sand may adhere. This anemone is common throughout the Gulf, although often overlooked. Figure 2.15.

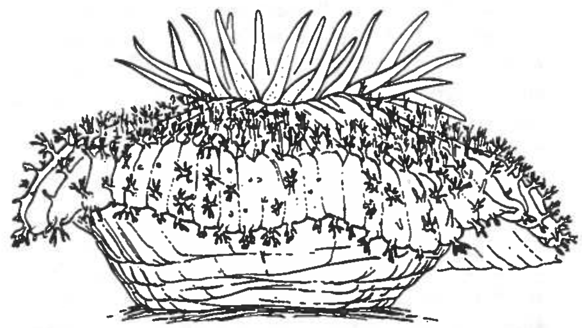


Fig. 2.15 *Phyllactis cocinnata*

Phyllactis bradleyi (Verrill)

This anemone greatly resembles the one above, differing principally in color, having orange longitudinal stripes on the column (fusing basally) and bluish to brown tentacles. The ruff and uppermost edge of the column are often tinged with blue flecks on a paler background. The verrucae of this species occupy only a small space below the ruff. The tentacles usually number 48. It is generally smaller than *Phyllactis cocinnata* and is not found attached to rocks but rather buried in the sand or sand-mud of tidal flats. Pickens (1970) stated that these may be two ecotypes of the same species. It is especially common in Bahía Cholla.

Subtribe Acontiaria

FAMILY DIADUMENIDAE

Diadumene leucolena (Verrill)

A very small anemone, often occurring in large numbers in low intertidal pools throughout the Gulf. It has a smooth, yellowish brown translucent column and many grayish brown tentacles. Unlike most anemones, *Diadumene* is reluctant to contract the body, even when disturbed. Fully expanded individuals are often seen draped across a rock surface during the low tide period.

The two regions of the column are not always obvious and are best seen in well-extended individuals as a definite contraction, or ring, around the middle. This anemone has acontia (as do all members of the subtribe Acontiaria). Members of the genus are known to reproduce by pedal laceration. This is a form of budding in which the basal disk breaks off one to many small pieces, each piece remaining attached to the substrate to grow into a new anemone and itself divide to form still more anemones. MacGinitie and MacGinitie (1968) give a good description and photograph of this process in *Diadumene* (pp. 139–40). The process can be quite easily seen if the anemone is kept in captivity long enough. *Diadumene leucolena* occurs also on the Atlantic coast of North America and has been reported from San Francisco Bay, California (Hand, 1955b).

FAMILY SAGARTIIDAE

Anthothoe carcinophila (Verrill)

This medium to small-sized anemone is normally found attached to the shells of living gastropods, usually mud-dwelling snails. It has many fine white tentacles, and longitudinal gray and white stripes on the column. Pickens (1970) reports this anemone from Bahía Cholla on the shells of the moon snails *Polinices* and *Natica*, and the auger and tower shells *Terebra* and *Turritella*. I have collected it also in shrimp trawls from 6 to 30 fathoms off Puerto Peñasco, San Felipe, and in El Golfo de Santa Clara, on the snails *Polinices*, *Hexaplex*, *Fusinus*, and *Terebra*. I have, only once, collected this anemone from a dead shell, a valve of the clam *Chione*, at El Golfo de Santa Clara. Carlgren also reports *Anthothoe panamensis* from the Gulf of California. Ross and others have discussed symbiotic associations between anemones and gastropods (see bibliography).

FAMILY HORMATHIIDAE

Calliactis variegata Verrill

An attractive sea anemone with bright pink acontia that are thrown out of the column with the slightest provocation. The pink acontia are so easily observed, in fact, that they serve as a ready field character to recognize this animal. *Calliactis variegata* is always found living on the shells inhabited by hermit crabs, usually *Dardanus sinistripes*. One to three anemones are generally found on the shell. It is usually collected on the smooth bottoms of large bays and esteros in the southern Gulf, and I have recorded it from Bahía Concepción, the Puerto Libertad area, and Bahía San Gabriel (on Isla Espíritu Santo). An excellent paper by Reimer (1973) discusses the feeding behavior of the widespread *C. polypus* (Forskal) (probably the same animal as *C. variegata*), and a series of works by Ross discuss the aspects of anemone-hermit crab partnerships (Ross, 1960–1975). There are at least four genera of sea anemones in the world that are known to have species found attached to hermit crab shells: *Calliactis*, *Adamsia*, *Paracalliactis* (family Hormathiidae); and *Isadamsia* (family Actiniidae).

FAMILY AIPTASIIDAE

Aiptasia californica Carlgren

A small anemone, usually found in large numbers (when present) circling the edges of tidepools in the low intertidal region. It is often translucent and may have iridescent patches on the column. The column and tentacles range from white to a dark or pale greenish brown. The column is fairly thin and the tentacles long.

Order Zoanthidea

(colonial and solitary "anemones")

Palythoa ignota Carlgren

This species and the following two belong to the small order Zoanthidea, whose members are mostly colonial forms, the individuals of the colony resembling the "true" anemones (order Actiniaria) but differing in the arrangement of the septa. A pedal disk is absent, and the aboral ends are united by basal stolons or a basal coenenchyma. All members of this order have only one siphonoglyph. The oral disk of *Palythoa ignota* bears a marginal circlet of very short tentacles, consisting of an exocoelic and an endocoelic cycle. The column epidermis is covered with a thick cuticle. The animal is light to dark brown in color, although the oral disk occasionally has a faint green tinge due to a symbiotic single-celled alga. The polyps are generally over 20 mm long and are set very close together. Colonies of these "anemones" occur in great masses in the low intertidal and subtidal, and they are occasionally found in permanent tidepools and drainage channels of the lower mid intertidal. *Palythoa ignota* is one of the commonest inhabitants of the rocky low intertidal of the northern Gulf. Cutress and Pequegnat (1960) and Carlgren (1951) report six species of *Palythoa* from the Gulf of California: *P. complanata* Carlgren; *P. ignota* Carlgren; *P. insignis* Carlgren; *P. pazi* Carlgren; *P. praelonga* Carlgren; and *P. rickettsi* Carlgren. Species recognition in this genus is a difficult and time-consuming task.

Caldwell (in Hendrickson and Brusca, 1975) found that the factors limiting the vertical distribution of *Palythoa ignota* (at Puerto Peñasco) were primarily physical (exposure time and substrate preference), although competition for space with brown algae (*Colpomenia sinuosa*, and others) probably exists at the lowest tidal levels. Figure 2.16 and Plate 3.

Epizoanthus gabrieli Carlgren

This is a small solitary zoanthid anemone, with many fine, banded tentacles. The column bears a very thick ectoderm (skin). The animal is found occasionally

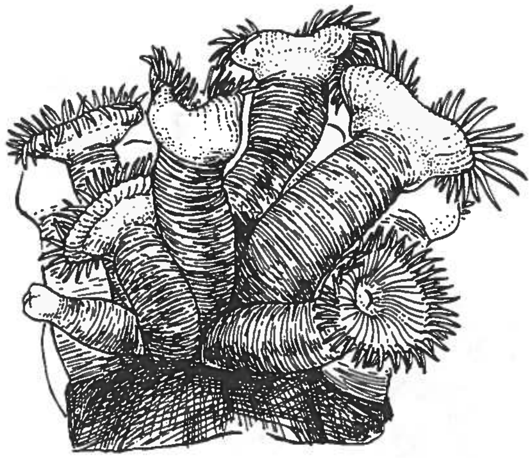


Fig. 2.16 *Palythoa ignota*

under rocks and ledges in the low intertidal. A second species of this genus, *E. californicum* Carlgren, has been reported from the La Paz area.

Zoanthus danae (LeConte)

This "anemone" is similar to *Palythoa* but smaller, with thinly set polyps, a bright green or blue-green oral disk and tentacles, and a somewhat yellowed mouth region. The polyps are rarely over 20 mm long. Students familiar with the Puget Sound fauna may at first mistake this species for the similar-appearing *Epizoanthus asper* of that region. Most members of the genus *Zoanthus* habitually grow on other animals, such as sponges, hydroids, corals, gorgonians, bryozoans, worm tubes, and shells inhabited by hermit crabs. I have found this species growing on the common sponge *Geodia*, and on rocks in the low intertidal throughout the Gulf. Its known range extends south to Panama and the Pearl Islands. A second species of this genus *(Z. depressum* Carlgren*)* has been reported from the Cabo San Lucas region.

Order Ceriantharia (anemone-like anthozoans)

Pachycerianthus spp.

This genus is characterized by its smooth, muscular, elongate body that lies buried in the sand with only the oral disk and slender, threadlike tentacles exposed. The aboral end is rounded, not flattened. The oral disk is provided with simple, slender tentacles arranged in two groups, the outer *marginal set* and the inner *oral set*. Each set may be arranged in one to four circles. Two distinguishing histological features of the cerianthids are the highly developed longitudinal epidermal muscle layer of the column (and its associated subepidermal nerve plexus), and the presence of an anal pore.

Cerianthids live in vertical, cylindrical cavities in the substrate, inside a case formed of a coherent slimy secretion in which are embedded sand grains, shed nematocysts, and bits of shell bound to the mucus-lined tube. When disturbed, the animals quickly draw themselves into the tube by contraction of the body musculature. The "anemone" extends itself by water intake through the siphonoglyph (as in the true anemones). These creatures exhibit a number of behavioral features adapting them to their particular mode of existence. They are geotactic—that is, they continually attempt to assume an upright position; they are strongly thigmotactic, with a strong "desire" for the body to remain in contact with some object (like the wall of their tube); and they are photonegative, retracting in strong light and directing the aboral end toward the region of weakest light intensity. There are at least two species of *Pachycerianthus* in the Gulf intertidal, *P. aestuari* (Torrey and Kleeberger) and *P. insignis* Carlgren. The former has a short stubby column and short tentacles, both splotched with brown or white. The latter has a long column and many long, thin tentacles, not blotched with brown (Pickens, 1970). The column of the latter species is dark gray, while the tentacles generally have longitudinal brown stripes.

Isarachnanthus panamensis

Another anemone-like cerianthid. This species is a thin, wormlike form that has great powers of contraction and extension. It is white, with medium length tentacles. Like *Pachycerianthus*, *Isarachnanthus* is commonly found in mud and sandy-mud substrates in the low intertidal zone of bays and tidal flats.

Cerianthus sp.

This is a burrowing, tube-building cerianthid "anemone" that is commonly found in the mangrove esteros along the shores of Sonora, Sinoloa, and Baja California Sur. It is easily overlooked as the body retreats very rapidly into its tube at the first sign of any local disturbance. As the tentacles are retracted into the burrow, however, they usually leave behind a distinctive "signature" of radiating lines in the mud. It is this "signature" that one must look for when on the trail of this elusive anemone. The tentacles are long and fragile, usually all bending in one direction with the current (pointing toward the mouth of the estero when the tide is ebbing, and toward the head of the estero as the tide flows). Tentacle spread is 5–15 cm. The body color is dark lavender, brown, or slate, occasionally with lighter markings on the column. The gray-black, mucus-lined tube of *Cerianthus* is an amazing product of mother nature. It was christened "sloppy guts" by the Ricketts and Steinbeck expedition. Running one's fingers down the inner walls of the tube reveals a pleasurable softness matched by only a few other products of nature; yet the tube is, at the same time, extremely tough and nearly impossible to tear. The lining of this tube (in cerianthids) is compounded, in part, by masses of embedded nematocysts (some discharged, others not). The biology of cnidarian nematocysts has recently been reviewed by Mariscal (in Muscatine and Lenhoff, 1974). The tubes go down quite deep, 10–60 cm, and a shovel is nearly always necessary to recover the animal itself. The body is smooth, cylindrical and very muscular, with a rounded aboral end that bears a distinctive terminal pore. The oral disk bears two groups of somewhat translucent tentacles, an outer marginal group and an inner oral group encircling (and concealing) the mouth, and they number over 100 in each group. The tentacles of the outer set often have pale brown bands, while those of the inner set generally do not. The tentacles also may occasionally bear a purplish color terminally. The genus is typically tropical and subtropical in distribution. There is a small commensal sipunculan worm that may occasionally be found living with this anemone in its tube, *Golfingia hespera* (see page 125). I have collected *Cerianthus* in Bahía Magdalena (on the west coast of Baja), Bahía San Everisto, in the El Mogote region near La Paz, and in numerous mangrove estuaries in Sonora and Sinaloa. Steinbeck and Ricketts reported what is likely to be this species from San Lucas cove, Puerto Escondido, Estero de la Luna, and El Mogote. It is perhaps the *Cerianthus* sp. reported from Ensenada by Ricketts, Calvin, and Hedgpeth in the fourth edition of *Between Pacific Tides* (p. 288).

Order Madreporaria (the true or stony corals)

FAMILY POCILLOPORIDAE

Pocillopora elegans Dana

The status of the species of *Pocillopora* in the eastern Pacific has been in a state of turmoil for many years, and good criteria are still lacking to assure the ordinary naturalist at which species he is really looking. Many name changes have taken place in the genus, largely owing to the variable nature of the characters classically used to differentiate and delimit the species. Squires (1959) briefly reviews some of the history of this group, in particular those species in the *P. elegans* complex. He concluded that *P. elegans* represents a widespread species on our coast that has been confused with or labeled *P. capitata* Verrill, *P. robusta* Verrill, and *P. damicornis* var. *cespitosa* Dana in past publications (including this handbook). Porter (1972), on the other hand, considered the majority of the *Pocillopora* varieties from west Panama to be forms of *P. capitata*. For our purposes it would probably be simplest to consider any member of this genus, encountered in the Gulf, to be *P. elegans*, at least tentatively (until a specialist can

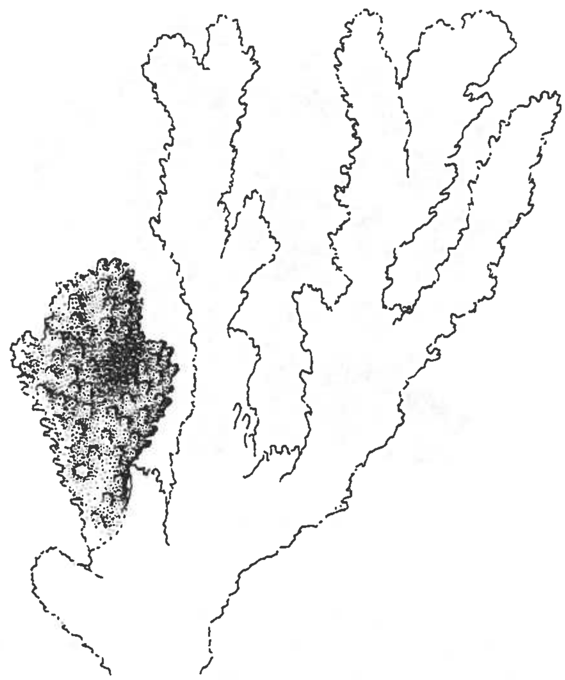


Fig. 2.17 *Pocillopora elegans*

examine it). *Pocillopora elegans* (fig. 2.17) is certainly the commonest species in the genus occurring in the Gulf of California, and the only reef-forming coral I have encountered in this region. This species is characterized by its inconspicuous or absent septa and columella, and its branching growth form. The surface is spinose and very rough to the touch. The corallites are small, circular, and deep. The corallum grows into large, massive, bushlike coral heads. This is the principal coral responsible for the Bahía Pulmo reefs which are the only true "coral reefs" in the Gulf (Brusca and Thomson, 1977). The color of *P. elegans* ranges from pale to dark brown, although locals often refer to it as "coral blanco" (no doubt referring to the dried skeleton). Pieces of this lovely coral are commonly seen in tourist shops throughout Mexico, usually dyed various odd colors and decorated with outlandish trinkets. This species ranges at least from the southern Gulf to Panama and the Galápagos Islands.

Excellent reviews of coral reefs in the eastern Pacific (and coral reefs in general) may be found in Squires (1959), Muscatine and Lenhoff (1974), Goreau (1963), Yonge (1963, 1973 and 1974), Glynn (1972, 1973, 1974, and 1976), Brusca and Thomson (1977), Stoddart (1969), and in *The Biology and Geology of Coral Reefs* (Academic Press). Coral reefs on the eastern shores of the Pacific (and Atlantic) ocean are few in number and tend to be isolated on scattered islands. The absence of a well developed hermatypic coral fauna in the eastern Pacific is generally attributed to three factors: the narrow (latitudinally confined) zone of prevailing, warm, tropical waters; the absence of suitable substrates; and the presence of large, freshwater rivers along these shores. No doubt all of these factors contribute to the absence of extensive coral development in this region. The east Pacific harbors approximately 103 species of stony corals (in 42 genera), while the west Pacific has over twice that number of species (in 68 genera). Most of the existing coral reefs in the world are comparatively young, and the El Pulmo Reefs are quite likely less than 10,000 years old. Evidence of past reefs are, however, plentiful throughout the Gulf. On the shores of Bahía San Gabriel, on Isla Espíritu Santo, there exists a massive bench of fossilized coral, nearly a meter thick. The sand of this bay is likewise composed entirely of disintegrated coral and is a stark bleached white that shines and reflects the bright light of the day so strongly as to make one dizzy if it is stared at too long. A fact of particular interest is that none of the Pleistocene coral species from the Gulf region have become extinct—all are still in existence today.

The increasing popularity of SCUBA diving has had the result of making coral reefs and other tropical habitats easily accessible to almost everyone with an interest. Unfortunately, many divers have not yet made that important transition in their thinking that gives one a subconscious sense of ecological awareness. Many fertile regions of the coast of Sonora and Baja are being ruined by divers that pick up nets full of shells or break off pieces of living coral. The Pulmo Reefs are especially susceptible, and repeated visits to that region will soon confirm one's suspicions that SCUBA divers are taking "trophy" coral heads, each time leaving behind several square feet of destroyed habitat. Yonge (1974) stated that "wide areas in the tropical Pacific and in the Caribbean are being scoured by SCUBA divers who are few in number and all too conspicuous in size and color." Ecological neglect is epitomized by the divers who strip the tropical subtidal regions of their populations of colorful animal life, especially taking corals and snails such as cones, cowries, and olives to sell in the shell collectors' market. I do not mean in any way to condemn all SCUBA diving, but I do suggest that it might best be used for observational or scientific purposes, not for plundering nature. Corals are particularly fragile animals and are susceptible to quick death from such environmental factors as excessive rain (or fresh water runoff) and petroleum pollution. The effects of the latter have been recently investigated by Reimer (1975), Birkeland et al. (unpublished), Grante (1970), Johannes (1972), Lewis (1971), and Straughan (1970).

FAMILY PORITIDAE

Porites californica Verrill

A beautiful, brilliant, emerald green coral that is found encrusting the rocks of the low intertidal and subtidal throughout the Gulf and as far south as Panama. The corallites are large, separated by porous walls. The columella is rudimentary, spongy, and quite often entirely absent. The encrustation reaches thicknesses of 70–130 mm, and the corallite diameter is about 1 mm. The calices are irregularly polygonal, usually about 0.5 mm in depth. The septa are in two sizes (cycles). This coarse hemispherical coral forms colonies several inches to nearly a foot across. It is not only the commonest intertidal coral in the Gulf, but usually the only one encountered without the aid of diving gear, the others being largely subtidal. Specimens living in deep water tend to lose (or never acquire) their chlorophyll-bearing, zooxanthellae partners. As a result the coral is a dirty yellow color in these regions. The genus *Porites* is circumtropical in distribution. Members of this genus comprise a significant portion of the interesting upper tertiary fossil coral formation found in the Imperial Valley of California.

Porites nodulosa Verrill

This coral is probably restricted to the extreme lower Gulf, and possibly to the La Paz–Cabo San Lucas insular fauna. Its corallum is subdivided into numerous small, crowded branches. The corallites are moderately large, shallow, and separated by thin, porous walls. There are usually 12 spinulose septa. The columella is poorly developed and the corallite diameter is 0.9 to 1.3 mm. This species has shallower calices, lower walls, and shorter pali than *P. californica* and is a coarsely branching form.

FAMILY ASTRANGIIDAE

Astrangia pedersenii Verrill

At first, this coral will appear to be a mass of isolated solitary corallites, somewhat resembling the California *Balanophyllia elegans* Verrill, but close examination will reveal the individuals are usually united at their bases to form a loose, encrusting colony. The individual polyps are minute, 3 to 4 mm across at their bases. There are 30 to 36 thin, unequal, narrow septa descending to the bottom of the corallite. The columella is narrow and papillose. Corallites are 2.5 to 6.5 mm high and 2.5 to 3.8 mm across. The skeleton of this species is a dull, green-brown color. This coral is probably restricted to the middle and lower Gulf and has been reported from La Paz and Guaymas. I have found it to be fairly common on the rocks of the Puerto Libertad to Guaymas region.

FAMILY DENDROPHYLLIIDAE

Tubastraea tenuilamellosa (Milne Edwards & Haime)

This beautiful coral is brilliant orange to red orange in life, the corallites growing quite separate from one another, fusing at their bases only. Typical specimens are composed of 5–10 corallites, each being 20–280 mm tall. These striking clumps of polyps form individual coralla on large rocks in the lowest intertidal regions and the subtidal of the southern Gulf, and range southward to Panama. The corallites are deep and circular, with fairly thin walls. The skeleton of dead specimens is a dirty, dark brown color. It has formerly been called *Dendrophyllia tenuilamellosa*. Members of the genus *Tubastraea* typically feed by use of the tentacles alone, whereas most other corals (especially the hermatypic forms) rely strongly on ciliary feeding techniques. Feeding by use of the tentacles alone is seen primarily in the solitary corals, and is considered by Yonge to represent the primitive condition. I have recorded this species at Isla Cerralvo, Isla Partida, Isla Espíritu Santo, and Isla San Ignacio Farallone in the Gulf. The latter locality is one of the most interesting islands in the Gulf. Its shores are steep, making SCUBA gear a necessity. The fauna of this island's rocky sublittoral coast is rich beyond belief and is composed of animals typically found in regions considerably north and south of its location, especially the more colorful, tropical types from Panama and parts of the insular fauna of the Cabo San Lucas region. See Plates 11 and 14.

FAMILY AGARICIIDAE

Pavona gigantea Verrill

A distinctive coral ranging from the southern Gulf south at least as far as Panama and the Galápogos Islands. This species is also known from the Pleistocene fossils of Isla Carmen. The corallum growth is massive, not branching, usually forming a robust, heavy columnar growth 2–15 cm tall and 1–9 cm wide. This coral is a fairly common component of the coral reefs at El Pulmo. Its distinctive surface markings, reminiscent of the brain corals, make this animal stand out clearly in underwater observations. The genus *Pavona*, like *Cycloseris*, *Pocillopora*, and *Tubastraea*, is essentially an Indo-Pacific taxon, not known to occur in the Atlantic Ocean. This absence of cogeners in the tropical Atlantic is of particular interest to zoogeographers, since nearly every other large group of eastern Pacific invertebrates have numerous elements that can be traced directly to a common west Atlantic–east Pacific faunal stock. (See introduction for a discussion of this relationship.) Members of the family Agariciidae are typically massive, the corallites lacking definite thecal walls. Glynn (1974b) has discussed a unique growth form of this coral (and several other species of corals in the region of Panama), termed coralliths, in which the coral forms an unattached, spherical colony that becomes quite mobile under the proper conditions.

FAMILY FUNGIIDAE

Cycloseris spp.

There are two species of this ornate solitary coral occurring in the Gulf of California, both being restricted to subtidal regions, primarily south of La Paz. *Cycloseris elegans* (Verrill) grows as thick, convex, rounded disks, with deep grooves and ridges radiating out from the center. The septa are rather thick and rounded, quite unequal, the six primaries being prominent and thickened at their inner ends. Septa of succeeding cycles are successively shorter and less elevated. The edges of the septa are usually crenulate or denticulate. Coralla range from 2 to 7 cm in diameter. Very large specimens lose some of the regular circular shape. *Cycloseris mexicana* Durham is a more lobated or fan-shaped species, with the deep grooves and ridges (septa) radiating out from a common basal region. This species lacks the thickened inner septal ends seen on the primary septa of *C. elegans*. I have collected *C. elegans* (see Plate 4) from the Pulmo Reefs, and it has been reported from the La Paz region to Panama and the Galápagos Islands, primarily on offshore islands. *Cycloseris mexicana* ranges from the southern Gulf to Panama and the Galápagos, and I have found it on the east coast of Isla Espíritu Santo.

SUBCLASS ALCYONARIA

Order Gorgonacea (the sea fans or gorgonians)

Suborder Holaxonia

FAMILY GORGONIIDAE

Muricea californica Aurivillius

A highly branched, brick red, purple, or occasionally brown gorgonian, with white or yellow-orange zooids. The numerous elevated polyp cones make the surface of the branches of this species very rough to the touch. The main stalks are thick, and often somewhat flattened, with a faint groove running along each flat side. The side branches are much thinner and taper to a thin, pointed end. This gorgonian attains heights of 20–80 cm, and it ranges as far north as southern California (Anacapa Island), where it represents one of the few members of this order in these cool northern waters. It is known to range south as far as Panama. I have recorded this gorgonian throughout the Gulf, as well as at Dana Point, Catalina Island, and Newport Bay in southern California, and all along the west coast of Baja California, where (in the north) it is often associated with the giant kelp *Macrocystis*. *Muricea* is an amphiamerican genus; however, no common species are shared between the Pacific and Atlantic oceans. The work of Kinzie (1973), Opresko (1973), and others indicates that gorgonians show variable degrees of habitat specificity, some being quite discreet in their preferences, others (like *Muricea californica*) being considerably less choosey. Research efforts by Theodor (1970) and others have shown that adjacent pairs of certain species of gorgonians may actually eliminate one another by some sort of chemical interplay. The colonies exchange chemical signals, after which metabolic activity in the smaller of the two neighbors ceases, and it undergoes dissolution due to its own lytic enzymes. Neither the signaling system nor the mechanism enabling one tissue to cause another to destroy itself has yet been explained. These sorts of systems hold great interest for cancer researchers. Figure 2.18.

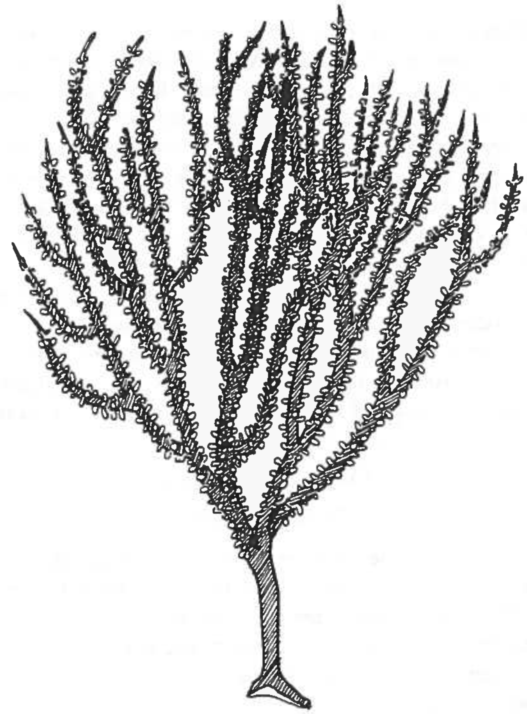


Fig. 2.18 *Muricea californica*

Psammogorgia arbuscula Verrill

A bright red gorgonian, with the stalks all growing straight upward. The branches are robust, thick, and blunt-tipped. Individuals may attain heights of 30 to 40 cm. Mexicans call this and most other species of gorgonians "Arbolitos del Mar." *Psammogorgia arbuscula* ranges from southern California to Panama.

Gorgonia spp.

Species of this amphiamerican genus generally have a growth pattern such that the branches all grow in one plane (or two, at 90° to each other), interlocking to form a flat latticework fan, resembling a doily or piece of colored crochet work. "Sea fans" encountered in the Gulf are generally 10 to 30 cm wide, and about the same height (although specimens tend to grow somewhat larger in deeper water). Farmer (1968) reported *Gorgonia adamsi* (Verrill), a purple sea fan, offshore at Puertecitos and "points south," and I have obtained this or a similar form from the shrimp trawlers at Puerto Peñasco (from 15 to 20 fathoms), and by SCUBA diving throughout the Gulf. Barham and Davies (1968) reported that the growth form of gorgonians is related to local currents. They found that the fans of *G. adamsi* (at Cabo San Lucas) are all oriented with the flat side directly facing into the prevailing current or surge, a phenomenon I have recorded in nearly all situations for most species of "sea fans." Cary (1914) and Birkeland (1975) found that the maximum size attained by *Gorgonia ventalina* (a Caribbean species) was controlled primarily by degree of local wave action. Gorgonians are usually most common where the currents are strong, or even violent. There appear to be two distinct species of *Gorgonia* in the Gulf, one with small, intricate latticework in the "fan," the other with a larger, more robust construction to the latticework. The latter form seems best to fit the description of *G. adamsi*.

Eugorgia ampla Verrill

A smooth-surfaced, orange, highly branched gorgonian, attaining heights of 40 to 50 cm. It is commonly brought up by shrimp trawlers in the northern Gulf.

Eugorgia aurantica Verrill

A beautiful red and yellow gorgonian, with short bumpy branches, all about the same diameter. This species, like most members of the genus *Gorgonia*, branches in only one plane, leaving the colony very flat and wide. This gorgonian ranges throughout the Gulf, and probably south beyond it. I also have a single record of it from Isla Cedros, on the central west coast of Baja California, and have seen it often south of there (Bahía Tortola, Bahía Magdalena, etc.).

Lophogorgia alba Duchassaing and Michelotti

A striking, pure white gorgonian, comprised of many tall, thin stalks that taper to narrow pointed ends. The surface of this species is fairly smooth to the touch. This lovely gorgonian lives on large submerged rocks throughout the Gulf of California. It seems to show more of a preference for calmer waters than do the other species of gorgonians. It is most commonly found growing as a solitary individual, 30–90 cm in height, in 5–25 m of water. The genus *Lophogorgia* is the only gorgonian genus to enjoy a worldwide distribution, occurring in both temperate and tropical seas. To my knowledge, however, there are no cosmopolitan, or even amphi-american, species. The gorgonian fauna of the eastern Pacific is in desperate need of some major taxonomic studies. Many species of gorgonians occur in the Gulf of California that simply have no name. I would guess at least 20 species remain to be described in this region. A good monographic work on this taxon would contribute immeasurably to our knowledge of the marine fauna of this region. Graduate students looking for research topics in taxonomy or tropical cnidarians might well consider investigating this large, interesting, and beautiful group of animals.

Order Pennatulacea

Ptilosarcus sp.

A subtidal sea pen, rarely seen except by SCUBA diving or unless it is picked up by a shrimp trawler, although Ljubenkov (personal communication) informs me that he has recorded it from the low intertidal of Puertecitos. The color ranges from yellow-orange to orange and red-orange, with paler, somewhat translucent leaflike structures along the upper half of the body. Fully expanded specimens are 3–10 cm wide and 20–30 cm tall, although the lower half of the body (the peduncle) is rarely seen as it is buried in the sediment. There is at least one species of this genus that is common in the Gulf, especially in the northern region, although I have also collected it off Isla Cerralvo, near La Paz. It prefers muddy sands and is a beautiful but difficult animal to capture alive and whole. Our Gulf form closely resembles *P. gurneyi* (Gray) and *P. undulatus*. The former is a common northwest species ranging at least from northern Canada to Washington state, and probably south. It has previously been reported as *P. quadrangulare* and *Leioptilus quadrangulare*. *Ptilosarcus gurneyi* is known to grow to lengths exceeding 50 cm (20 inches). *Ptilosarcus (=Leioptilus) undulatus* is a more southern species and quite likely is the one we are dealing with in the Gulf of California, although positive identification has not yet been possible. Figure 2.19.

The heavily muscularized peduncle (the basal "stem" of the animal) is able to pull the sea pen down into the sediment extremely fast, often more rapidly than the collector can move in his attempt to capture it. The incredible degree of expansion and contraction, especially of the rachis (the top part of the animal) is regulated by simple water pressure. The entire animal is referred to as the primary polyp, while the individual zooids on the rachis are called the secondary polyps. There are two basic types of secondary polyps, easily seen with a good hand lens. One is the feeding polyp (the autozooid), the other is the siphonozooid. It is the

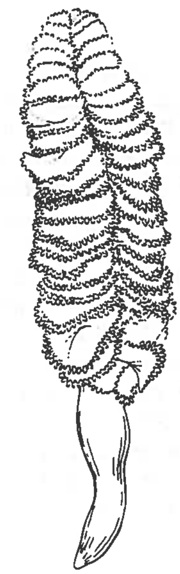


Fig. 2.19 *Ptilosarcus* sp.

siphonozooids that pump seawater into the animal to expand the entire primary polyp. These specialized siphonozooids are recognizable in that they lack the characteristic mesenteries and tentacles seen in the feeding autozooids. Birkeland (1974) provides a good description of the interactions between *P. gurneyi* and seven of its predators, in the Puget Sound region.

Stylatula sp.

Another subtidal sea pen, occasionally found exposed on a tidal flat during good spring tides. *Stylatula* is quite distinct from *Ptilosarcus* in being a very slender form, rarely more than 15 mm wide, even when fully expanded. Color in life is white, salmon or whitish-pink. The "leaves" of this species closely embrace the rachis and appear to be arranged in whorls around it. These animals often occur in large beds, consisting of several hundred individuals (each standing 0.3–0.6 m above the substrate), in 10–70 m of water. Like *Ptilosarcus*, *Stylatula* prefers a muddy sand sediment and tends to live where bottom currents are not too fierce. Our Gulf form resembles the Californian *S. elongata* (Gabb), and it is here tentatively assigned to that species. I have collected it at Bahía Cholla, Isla Partida, and in several Sonoran esteros, where solitary individuals may occasionally be found in the center of a mangrove channel. Sea pens are famous for the light shows they will put on when kept in the dark. Gentle prodding will induce a healthy captured specimen to display its lovely, bioluminescent capabilities. *Stylatula elongata* has been reported from as far north as central California. The bioluminescent properties of sea pens, and other cnidarians, has been reviewed by Morin (in Muscatine and Lenhoff, 1974).

3

CTENOPHORA (Comb Jellies)

The ctenophores, also known as comb jellies, constitute a small, entirely marine phylum; they resemble medusae in appearance. Ctenophores, however, lack the characteristic stinging cells (nematocysts) and oral tentacles of the true jellyfish. The ctenophores are represented in the Gulf of California by at least 3 genera. I have collected a species of *Beroë* off Isla Partida, near La Paz; *Pleurobrachia* sp. throughout the Gulf; and a form resembling *Bolinopsis* in Puerto Refugio (at the north end of Isla Angel de la Guarda). Ctenophores are planktonic animals, floating offshore in the sea. Only *Pleurobrachia* sp. is commonly found by shore collectors in our region, as this species has a propensity for being washed ashore, probably cast up on the beach by strong offshore winds. Like most oceanic and planktonic invertebrates that occasionally wash ashore, when they do they do so in large numbers. I've seen the sandy beaches of Kino, Puerto Peñasco, Yavaros, and Los Frailes coated with these silvery, shining, slippery spheres of *Pleurobrachia*. This is a small round ctenophore, resembling a clear, peeled, seedless grape, occasionally referred to by beachcombers as gooseberries or cat's eyes. The body is so transparent that the animals are difficult to see on the beach and nearly impossible to observe under water. Although the distribution of *Pleurobrachia bachei* A. Agassiz is given as boreal, ranging from Canada to San Diego (Hirota, 1974), our Gulf form appears identical to this temperate species, at least superficially. The general biology of *P. bachei* has been reviewed by Hirota (1974). It is 10–20 mm in diameter and nearly a perfect sphere. The comb plates are luminescent, and the tentacles (of which there are two) are up to 5 times as long as the diameter of the body and are fringed with pinnae which bear the colloblast cells. Colloblast cells are sticky "fishing" structures used to capture prey. Hirota found *P. bachei* to occur (in southern California) predominantly in the upper 15 meters of the water column during the day, and primarily at about 30 meters during the night hours. It will be noted that this pattern of vertical migration is just the opposite of that seen in the vast majority of planktonic organisms.

Although *P. bachei* is commonly infested with a parasitic amphipod *(Hyperoche mediterranea)* in California waters, I have not yet seen any crustacean symbionts associated with *Pleurobrachia* in the Gulf of California. *Pleurobrachia bachei* is a voracious carnivore, feeding primarily on small crustaceans, but also on floating fish eggs, invertebrate larvae and small arrow worms. The tentacles, bearing the colloblast cells, may actually be "fished" by maneuvers such as swirling the body in certain fashions. Once the prey has been captured it is swung to the mouth area by a rotating motion of the entire body, leaving the tentacles trailing behind to meet the mouth as it comes around. Figure 3.1.

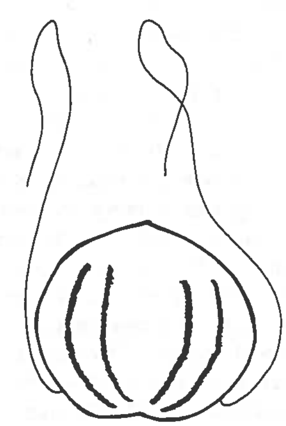


Fig. 3.1 *Pleurobrachia* sp.

4

PLATYHELMINTHES (Flatworms)

CLASS TURBELLARIA

Order Polycladida

Preservation: The flatworms are delicate animals, requiring special attention if one wishes to obtain good collections. They tear easily and must be lifted gently from the rocks or substrate with a thin knife blade or similar tool. They should be kept in a separate container during the collecting period, to prevent other animals from destroying them. If they are put into a container with empty shells or other material, they will often crawl into small holes and crevices, becoming inaccessible. Preliminary examination of the animal should be made as it crawls about in a watch glass, or other small container of seawater. This will allow you to make notes on color and body form. When the flatworm clings to the bottom of a dry watch glass or petri dish, the entire dish can usually be turned upside down under a dissecting microscope to observe the ventral surface. Careful taxonomic studies of the turbellarians require that they be mounted on slides, usually both as whole mounts and sections. Ideally, three or more individuals of each species should be collected, two for slides, and the others to be preserved in 5–10 percent formalin. However, preparation of both slides and preserved specimens requires proper fixation and relaxing. Knudsen lists a number of fixing and staining techniques for slide mounts. Preparation of serial sagittal sections of the copulatory apparatus is a method occasionally required but rarely attempted by anyone but the professional taxonomist. Relaxing for preservation may be done with chloretone, chloral hydrate, or menthol. Fixing for slide preparation may be done with F.A.A. (formal-acetic alcohol) or Gilson's fixative. Careful notes should always be made of live individuals, noting body form and color; presence or absence of ventral suckers, tentacles, and tubercles; and body size. Preserved animals will shrink and often curl up, making identification difficult or impossible, and dead individuals, if not preserved immediately, will begin deteriorating within hours.

Taxonomy: Although the phylum Platyhelminthes consists of three classes, only members of the class Turbellaria are generally free-living and collected commonly in the intertidal zone. Within this class, only the polyclads are abundant and large enough to be included in this handbook. The taxonomy of the group is based on a variety of anatomical features, mostly internal, requiring proper slide preparation for conclusive identification. Important external features include: presence or absence of ventral sucker and anterior tentacles; number and arrangement of eyespots; and general body form and size. The systematics used are taken from Hyman (1953). It is important to note that all color, size, and morphological characters used in the key are for live material only. Most people will find the flatworms nearly impossible to identify (by external characteristics alone) once they are preserved, and I strongly suggest these worms be collected sparingly, and returned *alive* to the seashore after they have been examined.

Polyclads of the Gulf: Hyman (1953), in her excellent monograph of the polyclad flatworms of the Pacific coast of North America, listed about 20 species known from the Gulf of California. Steinbeck and Ricketts (1941) recorded 7 to 12 species from the Gulf (unfortunately most of them were misidentified), noting *Alleena mexicana* (reported as *Latocestus* sp.), *Mexistylochus tuberculatus* (as *Stylochus* sp.), and *Pseudoceros mexicanus* (as *Pseudoceros* sp.) as the most frequently encountered flatworms of the intertidal zone. Hyman (1953) notes the following species as being common in the Gulf: *Alleena mexicana*, *Marcusia ernesti*, *Phaenocelis mexicana*, *Alloioplana sandiegensis*, and *Pseudoceros bajae*. I have found the following species to be common between Puerto Peñasco and Guaymas: *Mexistylochus tuberculatus*, *Prosthiostomum multicelis*, *Pseudoceros bajae*, and *Pseudoceros mexicanus*.

The various species of polyclads appear to be quite restricted in their distribution by factors of latitude, as most species have a very limited range. Hyman lists seven species limited to California and the Gulf of California, and nine species restricted to the Gulf itself. However, it is important to note that the marine flatworms, as a group, have been little studied in the field. Nearly all of the Gulf species of polyclads described by Hyman were collected by the MacGinities, Ricketts, or the Allan Hancock Expeditions. As more field work is accomplished, many of the present distributions for the various species will no doubt be greatly extended.

Flatworms are most readily found clinging to the undersides of rocks, or hidden in dense fronds of algae and in the crevices and holes of reefs and boulders.

KEY TO THE COMMON POLYCLAD FLATWORMS

1	Dorsal surface highly tuberculate	2
	-Dorsal surface not tuberculate	3
2(1)	Ventral surface with a small median sucker; dorsal tubercles brown with white specks; anterior margin of body folded up to form 2 marginal tentacles	***Thysanozoon* sp.**
	-Ventral sucker wanting; dorsal tubercles pale, often entirely white; without anterior, marginal tentacles. (fig. 4.2)	***Mexistylochus tuberculatus***
3(1)	Ventral surface with a small median sucker	4
	-Midventral sucker wanting	7
4(3)	Anterior margin folded to form 2 short tentacles; body obovate	5
	-Anterior margin without tentacles; body long and slender	6
5(4)	Lateral margins of body strongly ruffled; body brown, black or reddish purple, with a red-orange margin; white dorsal spots do not extend to body margins (fig. 4.8)	***Pseudoceros mexicanus***
	-Lateral margins of body without ruffles or with weak ruffles; body brown to black, without red margin; white dorsal spots extend to body margin	***Pseudoceros bajae***
6(4)	Body white or cream-colored, with black or brown spots (fig. 4.10)	***Enchiridium punctatum***
	-Body not as above, usually tan (fig. 4.9)	***Prosthiostomum multicelis***
7(3)	Possessing 2 short, anterior tentacles; body brown with brown or green patches, speckles or reticulations	8
	-Without anterior tentacles; body not as above	10
8(7)	Eyes in 2 lateral, anterior streaks; posterior end of body forms a blunt point; body tan with brown or green patches or speckles	***Alloioplana sandiegensis***
	-Eyes in a circular patch around the base of each tentacle, and a median patch between the tentacles; posterior end of body rounded; body tan with brown speckles or reticulations (or occasionally pure white)	9
9(8)	Lateral margins of body highly folded or ruffled; never pure white; body flaccid; length usually less than 25 mm	***Paraplanocera oligoglena***
	-Lateral margins of body not ruffled; occasionally pure white; body firm; length usually more than 25 mm	***Pseudostylochus burchami***
10(7)	Body unicolored tan or gray	11
	-Body rarely unicolored, usually olive, brown, black, or gray with white spots	13
11(10)	Body with eyes restricted to small clusters near the anterior end (figs. 4.6–4.7)	***Stylochoplana***
	-Body with or without anterior clusters of eyes, but always with marginal rows of eyes in anterior third of body	12
12(11)	Posterior end of body rounded, not tapering (fig. 4.1)	***Alleena mexicana***
	-Posterior end of body tapers to a blunt point (fig. 4.5)	***Phaenocelis mexicana***
13(10)	Margin highly ruffled; posterior end of body rounded; length to 40 mm (fig. 4.4)	***Marcusia ernesti***
	-Margin weakly ruffled; posterior end of body tapers to a blunt point; length to 80 mm (fig. 4.3)	***Mexistylochus levis***

CLASS TURBELLARIA

Order Polycladida

Suborder Acotylea

(polyclads without a sucker behind the female gonopore; tentacles, if present, of the nuchal type)

SECTION CRASPEDOMMATA

FAMILY LATOCESTIDAE

Alleena mexicana Hyman

A long, slender polyclad, to approximately 50 mm in length. The body is smooth and firm and tends to curl up when preserved. It is gray and has two groups of eyespots and a median band, both restricted to the anterior end. Steinbeck and Ricketts found some slate-colored specimens at Puerto Escondido and darker ones at Bahía de los Angeles and Guaymas (reported as *Latocestus* sp.). Hyman (1953) reports it from Puerto Peñasco and throughout the Gulf. This long, slender, uniform dark gray flatworm is one of the most common polyclads of the Gulf. Figure 4.1.

FAMILY STYLOCHIDAE

Mexistylochus tuberculatus Hyman

This is one of two Gulf polyclads bearing dorsal tubercles. It is oval and thick, about 30 mm long, and a pale brown color, the tubercles usually being nearly white. A band of marginal eyes almost completely encircles the body. This species is quite common in, and restricted to, the Gulf. It is reported as *Stylochus* sp. in Steinbeck and Ricketts. Figure 4.2.

Mexistylochus levis Hyman

A very large, thick polyclad, to 67 mm in length, tapering to a blunt point posteriorly. It is brown, spotted with white, and the eyes form a large fan at the anterior end, continuing as a complete margin around the body. I have found it only in the northern Gulf. Figure 4.3.

FAMILY CRYPTOCELIDAE

Marcusia ernesti Hyman

An elongate-oval form with rounded ends, and a body length to 35 mm. This species has ruffled margins and is black or gray, usually dotted with white spots. A marginal band of eyes completely encircles the body. Steinbeck and Ricketts reported it from Punta Marcial Reef and Plumo Reef (as *Stylochus* spp.), and Hyman (1953) reported it from Puerto Peñasco, Guaymas, and Clarion Island. Figure 4.4.

Phaenocelis mexicana Hyman

An elongate form, with a smooth margin and a body length to 26 mm, preserved. It is gray, with a few scattered eyespots anteriorly. Hyman (1953) reported it from Guaymas, Sinaloa, and southern California. Steinbeck and Ricketts reported it from Guaymas (as species reminiscent of the genus *Leptoplana*). Figure 4.5.

SECTION SCHEMATOMMATA

FAMILY LEPTOPLANIDAE

Stylochoplana panamensis (Plehn)

A thin, elongate to obovate form, tapering gradually posteriorly to a blunt point. This species is tan or gray and 30–50 mm long (approximately 22 mm long preserved). There are two patches of eyespots near the anterior end. Hyman (1953) reported the distribution of this species as southern California to the Gulf of Panama, including records from Guaymas. Figure 4.6.

Stylochoplana longipenis Hyman

A slender, elongate species with rounded ends, tapering slightly posteriorly. Very small, about 16 mm long (preserved). It is gray, and the eyes are similar to *S. panamensis*. Hyman (1953) recorded the distribution as southern California to the Gulf of California. Figure 4.7.

FAMILY PLANOCERIDAE

Alloioplana sandiegensis (Boone)

This species is oval, rounded anteriorly, slightly pointed posteriorly, is up to 20 mm long, and possesses a pair of nuchal tentacles. Boone's (1929) original description says it is a light tan with dark brown and olive green patches, or brown patches only; however, MacGinitie and MacGinitie (1968) describe it as brownish, speckled. Hyman (1953) stated that the figure of *Planocera burchami* in Johnston and Snook (Pl. 4, fig. 3) is actually *Alloioplana sandiegensis*, even though this watercolor is nearly pure white. The eyes are in a large cluster at the anterior end. It ranges from southern California at least to the Gulf of California.

Paraplanocera oligoglena (Schmarda)

This species is broadly oval, thin, with a ruffled margin. It is about 20 to 25 mm long and 15 to 20 mm wide. The nuchal tentacles are stout and conspicuous, and the body color is tan, speckled with dark brown. The eyes consist of a small girdle surrounding each tentacle. Hyman (1953) stated this species is "... probably cosmopolitan in tropical and subtropical waters." Steinbeck and Ricketts reported it as *Stylochus* (?) sp., from Bajío de Punta Marcial.

FAMILY CALLIOPLANIDAE

Pseudostylochus burchami (Heath & McGregor)

A firm, oval species, to 40 mm or more in length and 25 to 30 mm in width. It is one of the few species of polyclads from the Gulf with really conspicuous nuchal

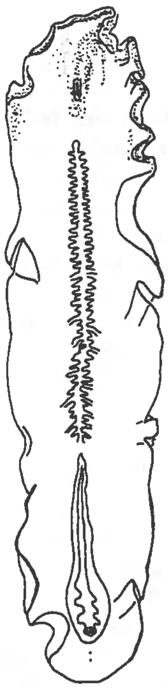


Fig. 4.1 *Alleena mexicana* (after Hyman, 1953)

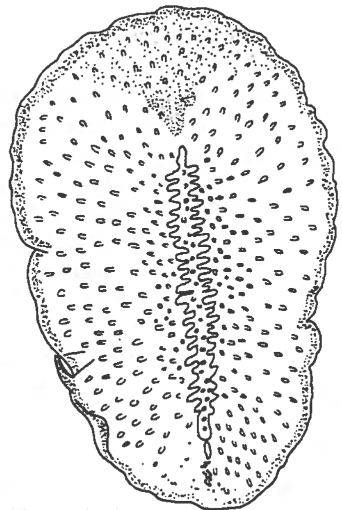


Fig. 4.2 *Mexistylochus tuberculatus* (after Hyman, 1953)

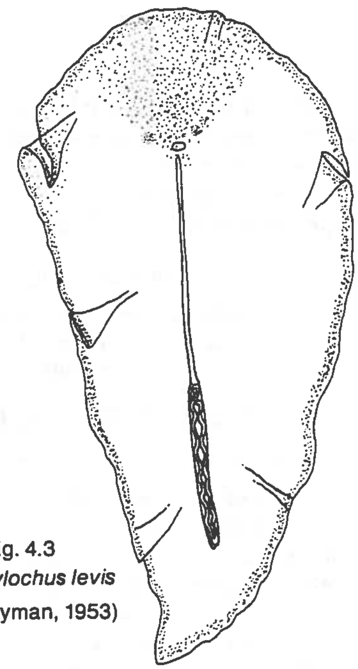


Fig. 4.3 *Mexistylochus levis* (after Hyman, 1953)

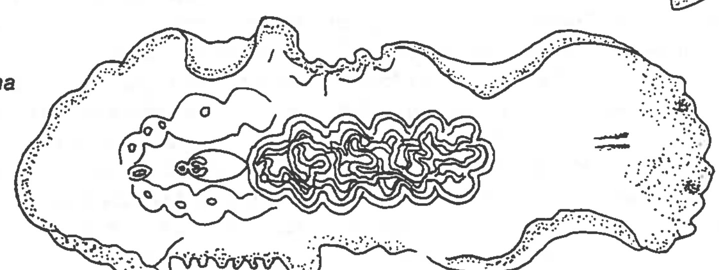


Fig. 4.4 *Marcusia ernesti* (after Hyman, 1953)

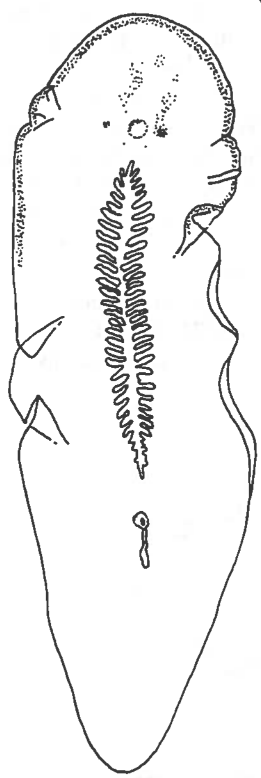


Fig. 4.5 *Phaenocelis mexicana* (after Hyman, 1953)

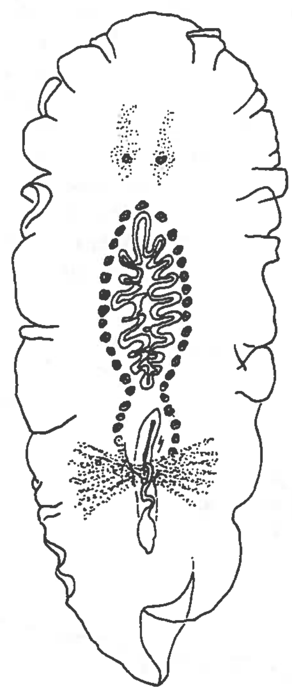


Fig. 4.6 *Stylochoplana panamensis* (after Hyman, 1953)

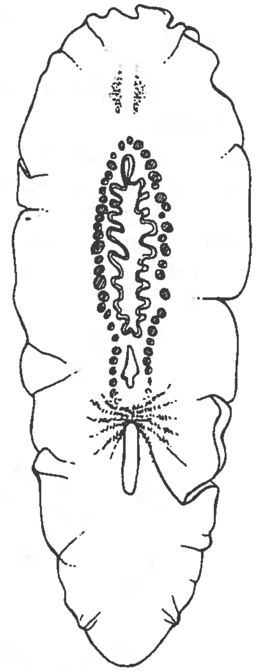


Fig. 4.7 *Stylochoplana longipenis* (after Hyman, 1953)

tentacles. The body is light brown, somewhat speckled or reticulated, and the eyes are restricted to small clusters near the tentacles. One of the most widely distributed species of polyclads on the west coast, known from Puget Sound to the Gulf of California.

Suborder Cotylea

(polyclads with a ventral sucker; tentacles, if present, formed by folds of the body margin)

FAMILY PSEUDOCERIDAE

Pseudoceros mexicanus Hyman

Described by Hyman (1953) from individuals sent to her by the MacGinities, collected at Puerto Peñasco. This is the "brown flatworm, over two inches in length" discussed in MacGinitie and MacGinitie (1968, p. 151). *Pseudoceros mexicanus* is a large, obovate form, tapering slightly posteriorly. It is thin, with strongly ruffled margins, and reaches nearly 100 mm in length and 40 mm in width. It is one of the three species of Gulf flatworms possessing anterior tentacles formed by folds of the body margin. The body is brown to dark purple or reddish purple, with a reddish orange margin. The dorsum has scattered white spots, but these spots do not extend all the way to the body margins. I have found this species in great abundance under rocks in the low intertidal throughout the northern Gulf. Its colorful body and wide swimming undulations make it one of the most beautiful animals of the Gulf intertidal, and a prized aquarium pet. Figure 4.8 and Plate 9.

Pseudoceros bajae Hyman

Another species described by Hyman (1953) from material sent to her by the MacGinities and Ricketts from Puerto Peñasco, Guaymas, and La Paz. This distinctive creature has marginal tentacles and a ventral sucker. It is tan to black, with white spots on the dorsum. It is obovate, tapering gradually posteriorly, and reaches lengths of 50 to 55 mm. It is distinguished from *Pseudoceros mexicanus* by its black color, lack of a red margin, smaller size, nonruffled margins, and the fact that the white dorsal spots extend all the way to the body margin. When placed in water *P. bajae* will crawl along the bottom to find the shelter of a rock's underside, while *P. mexicanus*, on the other hand, will usually swim rapidly through the water. This species is common throughout the Gulf, in the mid and low intertidal, where it may be found clinging very tightly to the undersides of rocks. Its ultrathin body is easily torn if one attempts to remove it from rock.

Thysanozoon sp.

This unusual flatworm appears to be an undescribed species of tropical Cotylea and represents the only member of the so-called "skirt dancer" worms in the Gulf. Individuals collected by the author have been small (20–30 mm long), obovate, and have a rounded posterior end. The dorsal surface is covered with dark brown to purple tubercles, on a pale background that is mottled white and purplish-brown. The body margins are reticulate, with white and lavender streaks. The dark tubercles often bear numerous, small, white specks, while the median tubercles are more yellowish. The anterior margin is thrown up into two large tentacles, typical of the family. There are two clusters of eyespots, one between the tentacles, and another immediately behind the tentacles. The pharynx is long and narrow, occupying the anterior third of the body. This species has been collected only at Puerto Peñasco, where it was found under rocks in the mid and low intertidal region. There appear to be at least two additional species of *Thysanozoon* on the California coast, one undescribed, the other described by Hyman (1953) as *T. californicum*. Hyman described this latter species from a single specimen sent to her by the MacGinities, collected in the intertidal of Corona del Mar, California, in 1933. The MacGinities noted its swimming behavior, characteristic of this and

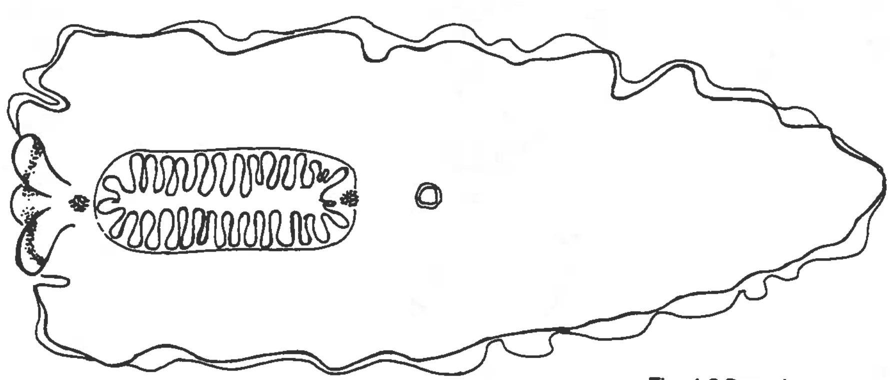


Fig. 4.8 *Pseudoceros mexicanus* (after Hyman, 1953)

other genera of polyclads, which consists of undulations of the lateral body margins (hence the European vernacular "skirt dancer"). Should the grand day arrive when the Pacific polyclad fauna is once again able to enjoy the efforts of a flatworm systematist, the presently undescribed species from that region (including perhaps this Gulf species) may prove to be polychromatic color variants of a single species of *Thysanozoon*. The genus is a small one, but cosmopolitan in distribution. The presence of the dorsal tubercles is, at the present time, the only character by which the genus is distinguished from other genera in the family. *Thysanozoon californicum* is periodically abundant at Santa Catalina Island, in southern California. One of the author's former students, Bruce Yurdin, made some preliminary studies on this worm (in 1977) and found its dorsal papillae capable of secreting a powerful acid that serves to deter would-be predators. This unique defense system allows this soft-bodied flatworm to crawl about exposed on rocky surfaces in 9 to 18 m (30 to 60 feet) of water on Catalina Island. See Plate 13.

FAMILY PROSTHIOSTOMIDAE

Prosthiostomum multicelis Hyman

A long, slender form, to about 30 mm, tapering to a blunt point posteriorly. The eyes are in two small medial rows anteriorly, and also along the anterior margin. Hyman (1953) reported the distribution of this species as southern California and the Gulf of California. The body is usually pale, with a tan overcast and slightly yellowed margins. Figure 4.9.

Enchiridium punctatum Hyman

A long, slender species, 40 or more mm in length and 8 to 10 mm in width. It is white or cream, covered with brown to black spots. It has two small clusters of anterior eyes, and marginal eyes that completely encircle the body. The distribution is southern California to the Gulf of California. Figure 4.10.

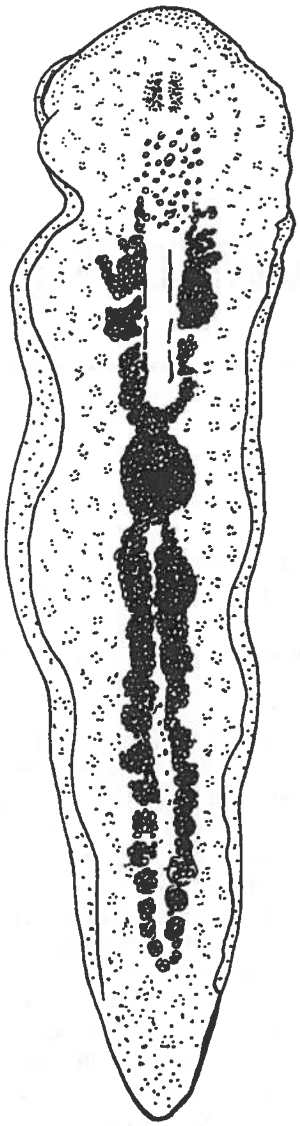


Fig. 4.10 *Enchiridium punctatum*
(after Hyman, 1953)

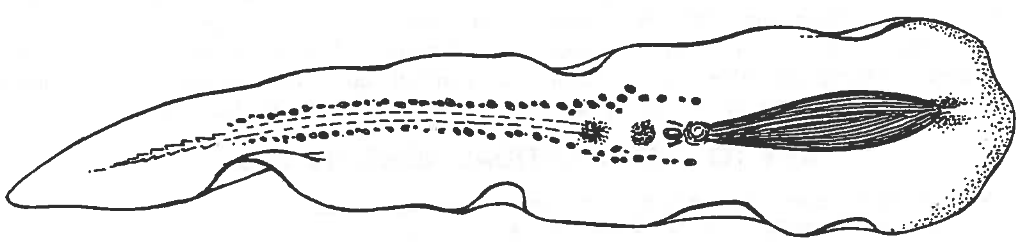


Fig. 4.9 *Prosthiostomum multicelis*
(after Hyman, 1953)

5

NEMERTEA (Ribbon Worms)

Preservation: Nemerteans are difficult to collect and preserve for several reasons: they usually secrete a slimy mucus substance that covers the animal and becomes opaque when placed in preservative; many species tend to fragment when picked up or even touched; most species will contract into a shriveled-up knot when placed in formalin or alcohol; and, they are relatively scarce in the first place. Specimens dropped randomly into a collecting bucket with other animals are rarely seen again, as they are chewed to pieces by other animals, or simply fragment their own bodies in response to the physical irritation. Proper narcotizing should be carried out, but, if materials are not available, an alternate but less effective method is that described for the holothurian echinoderms (see p. 417). Good narcotizing agents include chloretone, menthol, and Epsom salts. Buffered formalin in 5–10 percent solution is a good preservative for general collections, but, if critical taxonomic examinations are to be made, the hoplonemerteans should be preserved in alcohol to prevent deterioration of the calcareous stylets (hoplonemerteans are rarely encountered in the Gulf intertidal).

Taxonomy: Field identification of the nemerteans is somewhat restricted, because the taxa are separated on the basis of internal structure (position of brain, proboscis armature, body wall musculature, etc.). Fortunately, all of the common Gulf nemerteans belong to the order Heteronemertea, which are those ribbon worms without proboscis armature and with three layers of muscle in the body wall, the innermost being longitudinal muscle. Three species of hoplonemerteans are known to occur in the Gulf intertidal: *Paranemertes peregrina* Coe; *Oerstedia dorsalis* (Abildge); and *Zygonemerte virescens* (Verrill). They have not been included in the key because of their rarity. Characters used in the key include: the *caudal cirrus* (a little fleshy tail, visible under a dissecting microscope); a *proboscis sheath* (which requires dissection to examine); *ocelli* (visible with the naked eye, or under a low-power microscope, as rows of black dots along the lateral margins and on the head); body color; and body form. This treatment follows the systematic arrangement of Coe (1940 and 1944).

Nemerteans of the Gulf: Coe (1944) listed 14 species of ribbon worms from the Gulf intertidal. Steinbeck and Ricketts reported finding only one species in the Gulf, *Baseodiscus mexicanus*, which they concluded to be the most abundant and common Panamic nemertean of this region. The affinities of the Gulf nemertean fauna appear to be equally divided between the temperate species (6 of the above 14), and tropical or subtropical species (7 of the above 14).

Nemerteans are found under rocks and other stable objects, or buried in the sand and mud of bays and estuaries. They normally occur in the mid and low intertidal zones and shallow subtidal.

I have found *Baseodiscus mexicanus*, *B. delineatus*, *B. punnetti*, and *Lineus geniculatus* to be the most common nemerteans of the Gulf intertidal.

KEY TO THE INTERTIDAL NEMERTEANS

1	Head end with shallow, longitudinal slits—the cephalic grooves (Lineidae)	2
	-Head end without cephalic grooves (Baseodiscidae)	8
2(1)	Lateral edges of body folded back over dorsum to form a median, longitudinal groove	***Diplopleura vivesi***
	-Lateral edges of body not folded over dorsum as above	3

3(2)	Caudal cirrus present; ocelli minute or absent; proboscis sheath nearly as long as body	4
	-Caudal cirrus lacking; ocelli usually present and large; proboscis sheath much shorter than body	6
4(3)	Body soft; lateral margins of body not thinned and adapted for swimming	***Micrura wilsoni***
	-Body firm; lateral margins of body thinned and adapted for swimming	5
5(4)	Body with conspicuous longitudinal markings	***Cerebratulus lineolatus***
	-Body without conspicuous longitudinal markings	***Cerebratulus californiensis***
6(3)	Tip of head same color as remainder of body; body drab, without distinct markings	***Lineus flavescens***
	-Tip of head a different color than body; body with distinct markings	7
7(6)	Body green or brown, with numerous narrow white or yellow rings at irregular intervals; middle of head with a white ring (fig. 5.2)	***Lineus geniculatus***
	-Body dark brown or black, without pale rings as above; middle of head without a white ring	***Lineus pictifrons***
8(1)	Body with numerous transverse white rings (fig. 5.1)	***Baseodiscus mexicanus***
	-Body without transverse white rings	9
9(8)	Body gray with black or dark brown anastomosing longitudinal striations	***Baseodiscus delineatus***
	-Body pale brown, pink, red, lavender, or red-orange, without longitudinal striations as above	***Baseodiscus punnetti***

CLASS ANOPLA

Order Heteronemertea

FAMILY BASEODISCIDAE

Baseodiscus delineatus (Delle Chiaje)

This nemertean is easily recognized by its numerous, anastomosing, black or dark brown longitudinal lines. The head is broad and rounded, and capable of being withdrawn far into the body. This is one of the most widely distributed species of nemerteans, having been recorded from the Mediterranean, the South Pacific, the west coast of South America, and in subtropical North America on both sides of the continent. Coe (1940) reports a subspecies, *Baseodiscus delineatus curtus*, differing from the typical form in having small red or brown dots or larger mottlings, instead of the longitudinal lines. Both are reported from the Gulf of California. This may well be the most common ribbon worm of the Gulf intertidal.

Baseodiscus mexicanus (Burger)

A long (20 to 80 cm) and slender nemertean, moderately flattened dorsoventrally. The head is set off by annular constrictions. Small ocelli occur on the corners of the head. The body is firm, brownish green, brownish violet, or red, with numerous white rings encircling the body at irregular intervals. The head is usually bordered by a narrow white band. One of the most common and handsome nemerteans of the tropical Pacific coast, ranging from the Gulf of California to the Galápagos Islands, I have collected it at Isla Espíritu Santo, Mazatlán, Guaymas, Isla Tiburón, and La Paz. Figure 5.1.

Baseodiscus punnetti (Coe)

Dark brownish red to lavender or bright red-orange in color, with a broad truncate snout, tipped with white. The body is occasionally covered with a whitish bloom. The anterior region of the head often has a broad spot of slightly darker color, bordered by white. This species, and others of the genus, are without longitudinal cephalic grooves or a caudal cirrus. *Baseodiscus punnetti* has numerous small ocelli along the sides of the head. It is common among red algae, corallines, corals, and other growths of the intertidal zone. It ranges from central California to the Gulf of California. This species attains lengths of 60 cm, although most specimens range from 8 to 20 cm in length.

FAMILY LINEIDAE

Lineus pictifrons Coe

A dark brown or deep reddish nemertean, usually with pale yellow or white markings. The posterior end of this worm tends to be noticeably lighter in color than the rest of the body. The dorsal surface has numerous,

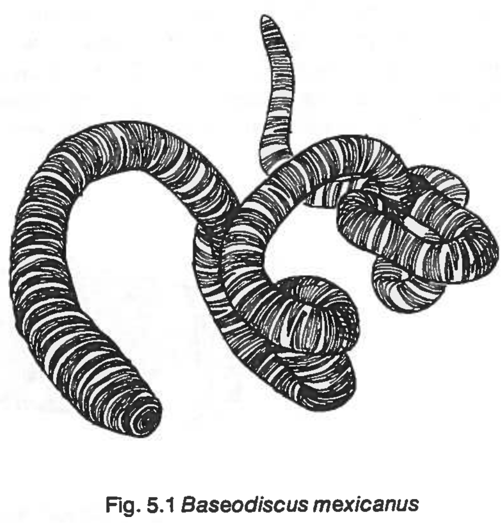


Fig. 5.1 *Baseodiscus mexicanus*

fine, longitudinal streaks, and occasional transverse streaks (or rings). The narrowed head has a thin white border. Individuals are somewhat flattened, have longitudinal cephalic slits, and are about 5–15 cm long. The body is soft, often with a velvety sheen, with the anterior and posterior ends more narrow than the middle. It lacks a caudal cirrus. This widespread species can be found in rocky habitats, among algae and kelp holdfasts, or in the mud bottoms of bays. It is known to occur from Puget Sound to the Gulf of California.

Lineus geniculatus (Delle Chiaje)

A green, lavender, or brown nemertean, with numerous narrow white or yellow rings at irregular intervals. A caudal cirrus is absent. The middle of the head is marked by a white ring. This species occurs in the rocky intertidal from the Gulf of California to Panama (also reported from the Mediterranean and Black seas and the west coast of Africa). *Lineus geniculatus* is reminiscent of *L. vegetus* of the California coast. Figure 5.2.

Lineus flavescens Coe

A rather bland, unmarked nemertean found in algae and other growths in the low intertidal of rocky shores or wharf pilings. The body is usually a pale yellow to red-orange, with a white longitudinal line down the back. The caudal cirrus is wanting. This species ranges from southern California, through the Gulf, and all along the lower west coast of Mexico. It, as well as many other nemerteans, seems to prefer living in entanglements of various species of red algae. *Lineus flavescens* is a small ribbon worm, generally less than 10 cm long.

Micrura wilsoni (Coe)

This nemertean is long and ribbonlike, with a very soft body, 4 to 15 cm in length. The caudal cirrus is minute and white, and the cephalic grooves are very long. The tip and usually the sides of the head are white, while the body is brown or blackish, lighter ventrally. Irregularly spaced transverse white lines often encircle the body. This species is found beneath rocks and on kelp holdfasts in the intertidal zone, and it has also been reported from sandy mud of bays. It ranges from central California to the Gulf of California.

Cerebratulus californiensis Coe

A highly variable species, ranging from dark brown or greenish brown in adults to gray, pink, red, yellow, or white with a brown head in juveniles. Age, sexual maturity, and substrate all affect the color. The nerve cords, and occasionally the muscle layers, are often a conspicuous diffuse red color. This species possesses deep longitudinal cephalic grooves and a caudal cirrus. The anterior region of the body is generally firm and stout, while the posterior portion is flattened and soft. These worms live in mud, sandy mud, or pure sand, mainly in the intertidal zones of bays and harbors. The proboscis of this ribbon worm, and most others discussed in this chapter, is extremely sticky; prey (primarily small annelids) are entrapped by means of this adhesive secretion. This species ranges from Puget Sound to the Gulf of California and may attain lengths of over 100 cm, although 5–25 cm is a more commonly recorded length. I have collected these worms most frequently at Topolobampo and Bahía Concepción.

Cerebratulus lineolatus Coe

A slender, pale gray nemertean with numerous fine, irregular, dark olive-brown longitudinal lines extending the length of the body, both above and below. The head is without distinct markings, and a caudal cirrus is present. This species lives in sandy mud in the low intertidal, from southern California to the Gulf of California, and has also been reported from Florida (Correa, 1961, 1964).

Diplopleura vivesi (Joubin)

This should be an easily recognized species because the lateral edges of the body are folded back over the dorsal surface to form a longitudinal groove in the dorsomedian line. It is reported to occur in fine sand near the low water line but is known from only a single specimen collected at La Paz.

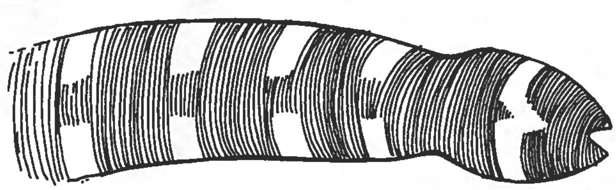


Fig. 5.2 *Lineus geniculatus*. (Head end only.)

6

ANNELIDA: POLYCHAETA (Bristleworms)

by Jerry D. Kudenov*

CLASS POLYCHAETA

Preservation: The primary concern in the preservation of polychaetous annelids is to produce undistorted specimens that can be regarded as morphologically representative of a particular species. If worms are placed directly into a fixative such as formalin, they immediately become contracted and nearly impossible to examine. Specimens must therefore be narcotized prior to preservation. Because there are so many undescribed polychaetes in the Gulf of California, improper fixing techniques are wasteful to both the collector and the taxonomist.

The following methods are recommended. First obtain a *fast-acting* narcotizing agent so that tissue deterioration is minimized. For instance, a 0.15 percent solution of propylene phenoxytol (Goldschmidt Chemical Corp., N.Y.) or a 0.5 percent solution of Finquel (MS-222, tricaine methonsulphonate; Ayerst Laboratories Inc., N.Y.) are rapid agents requiring only 15 minutes to narcotize specimens. The narcotizing fluid is added directly to the container with the worms. It is recommended that tube worms be removed from their tubes to allow for fully narcotized specimens. Two much less desirable techniques employ $MgSO_4.6H_2O$ (7.3 g per 100 ml distilled water) and isopropyl alcohol. In the latter technique, alcohol is added drop by drop into the container of worms until they are insensitive to external stimuli. The latter two techniques may take up to 6 hours, generally result in poorly preserved specimens, and are not recommended.

Once the specimens are motionless and insensitive to external stimuli, they may be placed into a fixative. One may simply decant the relaxing solution from the container and slowly add the fixative. Note that propylene phenoxytol can be saved and reused several times, while Finquel must be prepared fresh each time. Two recommended fixing solutions are 10 percent formalin and Bouin's fluid. Care must be taken with the latter because picric acid crystals are highly explosive upon impact. Bouin's fluid also dissolves calcareous materials, producing carbon dioxide. Make certain when preserving shell-boring worms, samples of coralline algae, and sediment containing shell fragments that your containers remain open for at least 24 hours. Otherwise the sudden release of carbon dioxide from a closed container can splatter Bouin's solution in many directions. In general, worms should remain in these fixatives for at least 24 hours, and a longer period of time will not harm them. Afterward, the fixing solution is decanted and saved (or the specimens removed with forceps), and 70 percent isopropyl alcohol is added to the container. After another 24- to 48-hour period, the alcohol becomes diluted by the residual fixative in the worms and should be discarded. Fresh alcohol is then added to the container. Alcohol should not be used to preserve worms because it tends to leave specimens soft and their appendages poorly defined.

A technique that I have yet to try combines the narcotizing and fixing agents into one solution called Steedman's solution. The stock solution contains 50 ml of full strength propylene phenoxytol, 500 ml of full strength formaldehyde, and 450 ml of full strength propylene glycol. Add 10 ml of the stock solution to 90 ml of distilled water to make a fixing solution. A narcotizing solution is made by adding 1 ml of the fixing solution to 99 ml of seawater. The advantage of Steedman's

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solution is that the animals initially react to the propylene phenoxytol and are gradually preserved in the process. There is very little, if any, deterioration of tissues when this solution is used.

A way to limit the bulkiness of jars is to purchase vials (or prescription tubes) into which specimens are placed. About 12 cotton-plugged vials can be placed into a pint-sized jar. Alcohol is added to both the vials and the jar to prevent the specimens from drying out.

Collecting techniques: It is difficult to collect a favorite group of animals to the exclusion of others. Some areas of the Gulf of California are still remote and difficult to visit. What a wasted effort it would be if only a particular family of animals were collected! I am advocating, of course, systematic (rather than indiscriminate) collecting techniques. For example, the algal mats at Puerto Peñasco abound with all kinds of small animals. It is relatively simple to scrape off sections of this mat and preserve everything in it. The samples can then be sorted in the lab and various phyla sent to specialists.

A final point is the collecting notes. These are as important as the specimens and should never be overlooked. The following information applies to all phyla. The notes should include the date of collection, time of day, location (in latitude and longitude), height in the intertidal (or subtidal depth), local habitat, color of specimens prior to preservation, animal associations (if any), method of capture, and collector's name. The notes should be written in indelible (waterproof) ink on good quality paper (high cotton content) and deposited directly into the jar or vial of specimens. It is also recommended that a field notebook be maintained in which all of the above information is duplicated.

Taxonomy: The major classes of the phylum Annelida are: Polychaeta (bristleworms), Oligochaeta (earthworms), and Achaeta or Hirudinea (leeches). The polychaetes are principally marine animals and represent the largest class of annelids, with over 10,000 described species. The other two classes are smaller, largely restricted to terrestrial and freshwater habitats, and altogether approximate 3,500 species. A characteristic feature of all annelids is the repetitious series of body parts called *segments*. All segments have basically the same internal and external morphology, and this condition is called *metamerism*.

The polychaetes are arbitrarily divided into two orders: the free-living (order Errantia) and the tube-dwelling (order Sedentaria) worms. Actually this classification represents a gradation of adaptations, because there are tube-dwelling errant and burrowing or free-living sedentary worms. Errant polychaetes may be considered to be the more primitive of the two orders and are partially characterized by having undifferentiated body parts and macrophagous feeding habits. Sedentary polychaetes, on the other hand, are typified by differentiated body regions and microphagous feeding habits. These two orders will be more fully defined following a discussion of their external morphology. An enlightening discussion on polychaete phylogeny is presented in Fauchald (1974b).

Although the present chapter is not intended to be a full treatment of polychaete systematics, its purpose is to discuss basic taxonomic criteria that are reflected in the diversity of form in polychaetes in the area studied. Descriptive terminology is minimized. For a more detailed treatment of the taxonomic characters used in polychaete systematics, the reader is referred to Day (1967). Introductions to the biology of polychaetes will be found in Dales (1967), Barnes (1969), and Clark (1969).

External morphology of polychaetes: The general shape of a polychaete's body ranges from a cylindrical to a flattened, elongate tube. For convenience, the body may be divided into three anatomical regions, consisting of the head, trunk, and tail. These are discussed below.

Head: The head consists of a region in front of the mouth (prostomium) and one or more fused segments around the mouth (peristomium). The prostomium often bears sensory appendages and eyes, while the peristomium is equipped with tentacles. Together the prostomium and peristomium display various degrees of development, ranging from a simple cone with or without tentacles to a dense or plumose array of filaments. The degree of head development is referred to as cephalization.

Figure 6.1 portrays diverse head types of nine errant families (Amphinomidae, Dorvilleidae, Glyceridae, Lysaretidae, Nereidae, Nephtyidae, Phyllodocidae, Polynoidae, Syllidae) and nine sedentary families (Ampharetidae, Capitellidae, Cirratulidae, Flabelligeridae, Maldanidae, Paraonidae, Pectinariidae, Sabellidae, Spionidae). One can readily observe the difference in head development (cephalization) between errant and sedentary polychaetes. Errant families generally have large, well developed heads with conspicuous antennae and eyes. Sedentary families generally have poorly developed heads with few, if any, antennae and eyes. For example, the prostomia of nereids (fig. 6.1e) and syllids (fig. 6.1i) each have two jointed palps. Palps are involved in tactile and chemosensory functions and generally originate from a region adjacent to the mouth. The palps of amphinomids (fig. 6.1a), polynoids (fig. 6.1h), dorvilleids (fig. 6.1b), and their allies are not jointed. The palps of sedentary polychaetes are generally grooved along one side and are used primarily for feeding. Such structures are present in cirratulids (fig. 6.1l), flabelligerids (fig. 6.1m), pectinariids (fig. 6.1p), spionids (fig. 6.1r), and their allies. They originate from the prostomium of cirratulids (Day, 1967) and sabellids, and from the peristomium in flabelligerids and spionids. The palps of errant and sedentary worms are not necessarily homologous structures.

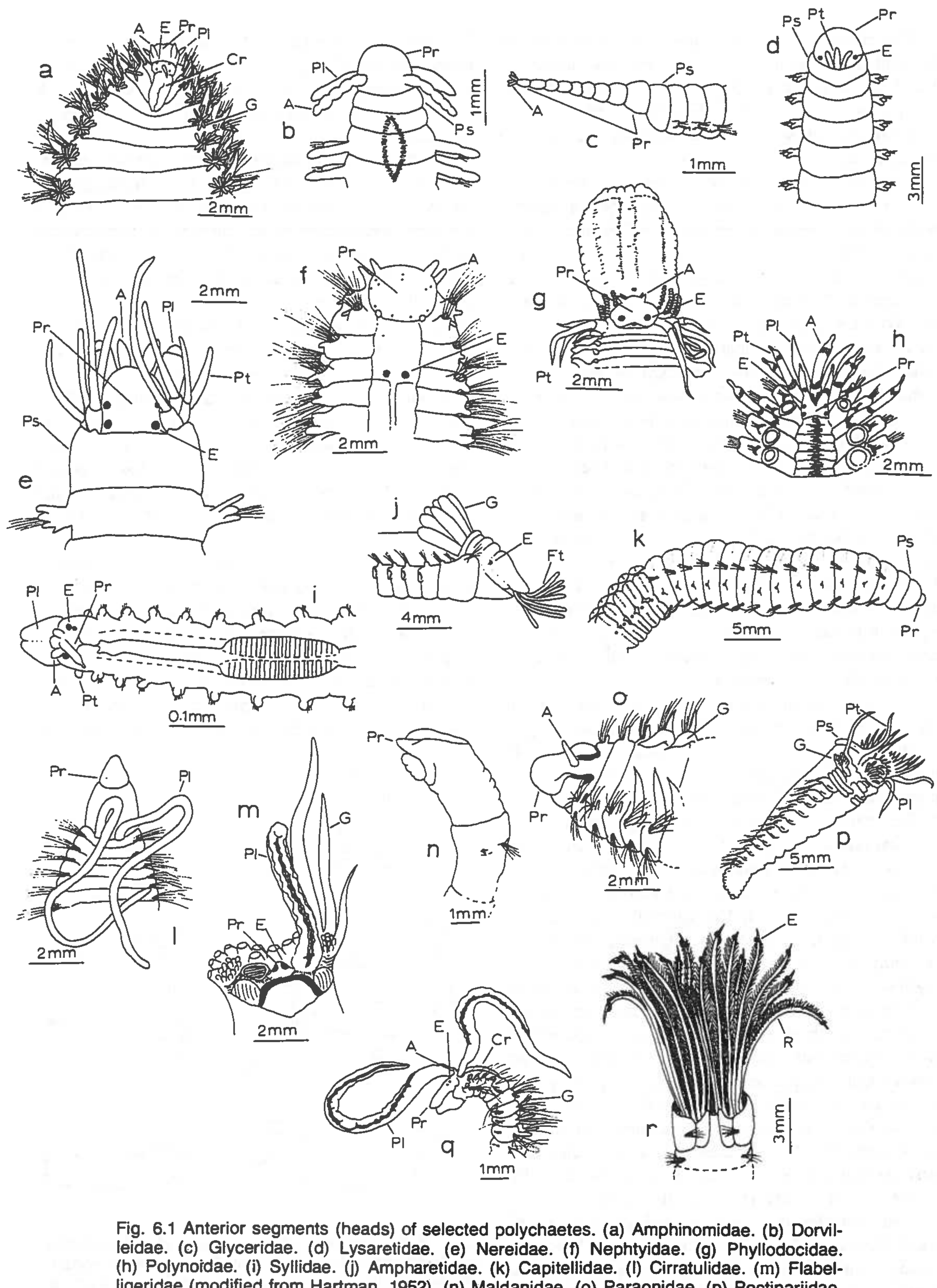

Fig. 6.1 Anterior segments (heads) of selected polychaetes. (a) Amphinomidae. (b) Dorvilleidae. (c) Glyceridae. (d) Lysaretidae. (e) Nereidae. (f) Nephtyidae. (g) Phyllodocidae. (h) Polynoïdae. (i) Syllidae. (j) Ampharetidae. (k) Capitellidae. (l) Cirratulidae. (m) Flabelligeridae (modified from Hartman, 1952). (n) Maldanidae. (o) Paraonidae. (p) Pectinariidae. (q) Sabellidae. (r) Spionidae. Cr, caruncle; E, eyes; Pl, palp; Pr, prostomium; Ps, peristomium; Pt, peristomial tentacle; R, radiole; A, antenna; Ft, feeding tentacle; G, gill.

Prostomial antennae are found in the amphinomids, dorvilleids, glycerids (fig. 6.1c), nereids, nephtyids (fig. 6.1f), phyllodocids (fig. 6.1g), polynoids, syllids, and paraonids (fig. 6.1o). The lateral processes of such families as spionids and scalibregmids are not true antennae.

Eyes are generally present in errant polychaetes, and often absent in sedentary ones. They are best developed in the Alciopidae, an errant family of pelagic, swimming worms. It is thought that alciopids actually form images with their compound eyes. Well developed eyes also occur on the branchial filaments (radioles) of sabellids. With few exceptions, polychaete eyes are of a type known as pigment-cups that function in the detection of light. Illustrations of polychaete eyes are presented by Barnes (1969). The presence or absence of eyes is important for the identification of some polychaetes.

Nuchal organs are present in most polychaetes and are best developed in predatory species. They can best be described as ciliated depressions that function in the detection of food. For example, they are present as ciliated patches behind the eyes of nereids; or they appear as pits or slits in the head region of ampharetids (fig. 6.1j), capitellids (fig. 6.1k), maldanids (fig. 6.1n), and their allies. The shape and length of the nuchal organs in maldanids, for example, are rather important taxonomically. Generally, however, nuchal organs are of low systematic importance.

The posterior margin of the prostomium is elaborated into a fleshy median lobe, called a caruncle, in amphinomids, spionids, and their allies. It supposedly functions in the detection of chemical gradients and is important in the systematics of these families.

Peristomial tentacles are typically present in errant polychaetes, although a few families such as the glycerids, goniadids, lumbrinerids, and arabellids generally lack them. Many authors refer to these processes as "peristomial cirri" or "peristomial antennae." To avoid confusion, all processes originating on the prostomium are called antennae, and those processes originating from parapodial lobes (to be discussed below) are called cirri. Peristomial tentacles may be long or short, smooth or ringed (beaded or annulated). A barrel-shaped base supports the tentacles in such families as the nereids and phyllodocids (fig. 6.1g), and the occipital antennae of onuphids (fig. 6.26a). This base is called a ceratophore, and its shape is of systematic importance. A few sedentary families also have peristomial processes which are used for feeding. For example, terebellids (fig. 6.47b) have numerous grooved tentacles that convey food particles to the mouth (Dales, 1955). The radioles of sabellids have already been mentioned. They also occur in a related family, called the Serpulidae. Radioles function in both feeding and respiration. Serpulids differ morphologically from sabellids in that they build calcareous tubes, and one of their radioles is usually modified into a plug (operculum) that is used to seal their tubes. A functionally homologous operculum is also present in sabellariids.

Proboscis: The structure of the proboscis and its accessory organs are of high systematic importance in the identification of many polychaetes. The proboscis is a feeding organ that is everted through the mouth and is defined as the eversible part of the gut. Fauchald (1977a) refers to the proboscis as an eversible *pharynx*. The proboscis (=pharynx) may be armed with chitinous jaws, or it may be unarmed. In the latter case, the proboscis is a thick muscular tube or a thin flexible sac. Some sedentary families lack a proboscis and feed using their palps. Dales (1962) examined the feeding organs of many polychaete families, and the reader is referred to his article for greater detail on the structure and function of the proboscis. Orrhage (1974) has criticized Dales's (1962) paper. For an excellent insight into the philosophy behind the scientific method, read Hesse (1974).

Some errant polychaetes, such as nereids, have a single pair of serrated jaws (fig. 6.2a, b), which are usually accompanied by many small chitinous processes called paragnaths. Paragnaths can be conical, bar-shaped, or comb-shaped (pectinate) in outline (fig. 6.2c–e) and are arranged in specific areas of the proboscis. Their distributions are important in the identification of nereid species. For example, figure 6.2 represents the

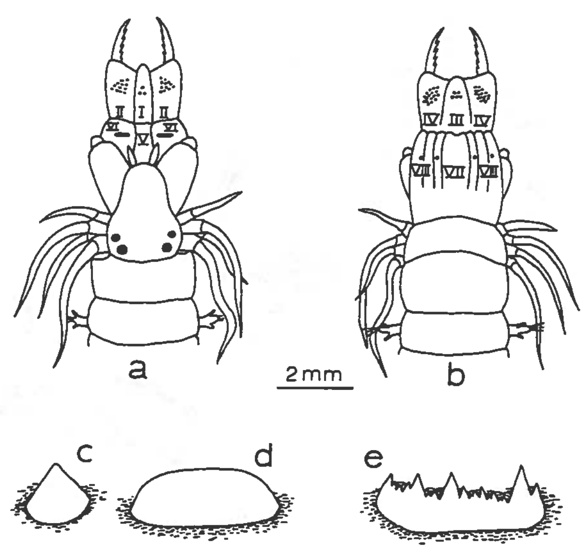

Fig. 6.2 An everted proboscis of a nereid polychaete. (a) Dorsal view. (b) Ventral view. (c) Conical paragnath. (d) Bar-shaped paragnath. (e) Pectinate (= comb-shaped) paragnath. I–VIII designate regions of paragnaths.

dorsal and ventral aspects of an everted nereid proboscis. It is divided into two parts: an oral ring and a maxillary ring. The oral ring is adjacent to the mouth when the proboscis is inverted, and just in front of the head when everted. The maxillary ring encircles the jaws. Each ring is divided into six areas, and numbered with Roman numerals. Paired areas of the proboscis are assigned even numerals (II, IV, VI, VIII); unpaired areas of the proboscis are given uneven numerals (I, III, V, VII). The proboscis shown in figure 6.2 is described thusly: proboscis with group I = 3, II = 12, III = 5, IV = 17, V = 0, VI = a single transverse bar, VII + VIII = a single row of 4. The type of paragnath is specified, as well as the pattern or outline in each region (i.e. triangular, elliptical, crescentic patch).

The superfamily Eunicea contains the errant families, such as the Eunicidae, Onuphidae, Lysaretidae, Lumbrineridae, Arabellidae, Dorvilleidae, and Iphitimidae, all of which have an elaborate jaw apparatus (fig. 6.3). This apparatus consists of a varying number of chitinous upper jaws (maxillae) and a lower jaw (mandible). There may be more than five pairs of maxillae but only a pair of mandibles. Each piece of the upper jaw is called a maxillary plate. Included in the upper jaws are pieces of chitin that support the plates, called maxillary carriers.

A dental formula using the symbol Mx is used to identify various maxillary plates. In the apparatus shown in figure 6.3, Mx I denotes the dorsal-most pair of plates, called the forceps; Mx II is the next and the largest pair, with around five or seven teeth on each plate; Mx III is represented only by a smaller left plate with six teeth; Mx IV, V, VI, etc., are represented by progressively smaller plates. The precise number of maxillary plates usually depends on the species. A dental formula can therefore be described for the apparatus shown in figure 6.3, as follows: Mx I = 1 + 1, Mx II = 7 + 5; Mx III = 6 + 0, Mx IV = 3 + 5. Arabic numerals denote the number of teeth in each plate. The features of the left plate are always given first. If the number of teeth on a particular plate is variable, the extremes are entered in parentheses [i.e., Mx II = (5–7) + (4–6)]. If a plate is absent, it is so indicated by a zero.

An exceedingly long proboscis exists in the families Glyceridae and Goniadidae. Glycerids have four black terminal jaws at the end of the everted proboscis (fig. 6.4a). Each jaw has a supportive element, called an aileron (fig. 6.4b). The size and shape of the support provides useful characters in glycerid identifications. In addition, the proboscis is equipped with many small papillar processes whose shape, size, and surface features are also important (fig. 6.4c).

Goniadids are similar to glycerids, and, in fact, some authors combine the two into a single family. Goniadids have a pair of large terminal jaws (macrognaths) and terminal dorsal and ventral arcs of smaller teeth (micrognaths) (fig. 6.4d). The proboscis is covered with characteristic chitinized processes, and a pair of structures at its base that look like a sergeant's military stripes, called chevrons, may be present.

Syllids have a rather more complex proboscis (fig. 6.1i; 6.5) than some other errant polychaetes because of the presence of an associated organ called a gizzard (proventriculus). Sphaerodorids also have a gizzard. The syllid proboscis, however, is chitin-lined, and generally has a median tooth that is thought to puncture other animals. The gizzard consists of well developed radial muscles and functions like a suction pump to extract body fluids from its prey. The location and number of these teeth are important characters in syllid identifications. For example, *Trypanosyllis* species have a number of terminal teeth distributed in the form of a king's crown (trepan).

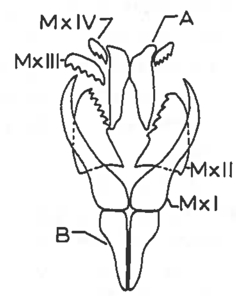

Fig. 6.3 An example of the jaws found in the Eunicea. A, Jaw supports; B, Mandibles; Mx I to Mx IV, Maxillary plates I to IV.

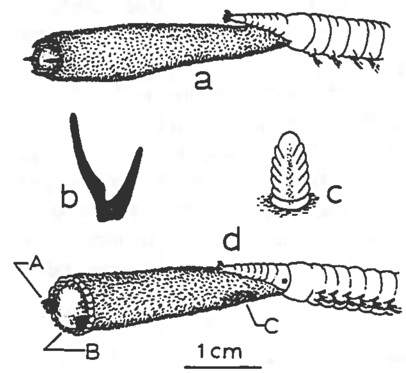

Fig. 6.4 Glyceridae and Goniadidae. (a) An everted glycerid proboscis showing the four terminal jaws. (b) A single jaw with support (aileron). (c) An example of a glycerid papilla from the proboscis. (d) An everted proboscis of a goniadid, showing the terminal jaws. A, large lateral jaw (macrognath); B, small tooth (micrognath); C, black sergeant's stripes (chevrons).

The proboscis of errant worms like phyllodocids, most hesionids, and pilargids is unarmed (fig. 6.6). Usually there are soft terminal papillae on the end of the feeding organ, plus rows of papillae on some region. For some families, the distribution of these papillae is an important species character.

The proboscis of sedentary polychaetes is usually thin, flexible, and unarmed. It is also ciliated and may have papillae in specific regions. Upon eversion, the feeding organ may appear saclike or branched in such families as orbiniids (fig. 6.32b) and opheliids, or it may appear as a bulbous or ciliated funnel like those found in capitellids, arenicolids, maldanids (fig. 6.7), and their allies.

Some tube worms like pectinariids, sabellids, and serpulids lack a proboscis. Pectinariids use thick chitinous setae (digging combs) to loosen the sediment, and short palps to ingest it. Feeding in sabellids and serpulids is discussed under "Feeding in Polychaetes."

Trunk: The body of polychaetes generally represents a linear series of morphologically similar segments. Errant polychaetes generally have similar body segments, while sedentary worms can have at least two and sometimes three distinct body regions. These body regions are called the thorax and abdomen and are obvious in such families as the orbiniids (fig. 6.32a), capitellids (fig. 6.42b), sabellids (fig. 6.49a), and serpulids (fig. 6.50a). Note that in the latter two families, the positions of the chitinous bristles (setae) in the thorax are inverted in the abdomen. This phenomenon is called setal inversion and is characteristic of sabellids and serpulids. In any case, the changes along the body axis in sedentary worms is usually exhibited by changes in the paired fleshy lobes, called parapodia. Various other external body features such as the number of segments, gills, types of setae, length, and sometimes color are used to distinguish between species. Basic external characters, such as parapodia, setal types, and body coverings, are discussed below.

Parapodia: Each segment generally has a pair of fleshy appendages (parapodia) which function in locomotion and to increase the surface area of the body for respiratory purposes. Some segments may totally lack parapodia and are referred to as being apodous. A parapodium may be well developed, or reduced to directly emergent bundles of setae on the sides of the body. It may have an upper lobe, called a notopodium, and a lower lobe, called a neuropodium. Two examples of parapodia are shown in figure 6.8. Each lobe generally has an elongate process called a cirrus. Parapodial cirri may be important in the identification of species, particularly for such families as the phyllodocids (fig. 6.8a). Additional lobes may be present, such as those found in nephtyids (fig. 6.8b). For example, the notopodial lobe is divided into three separate parts; a

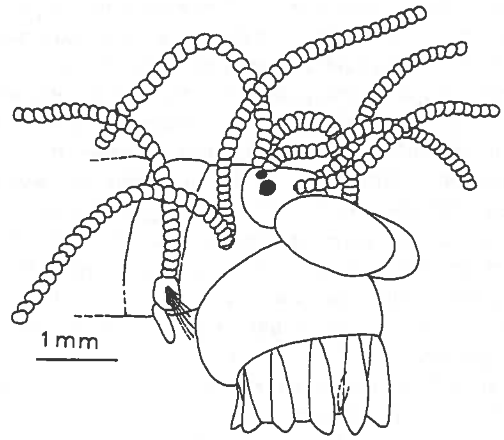

Fig. 6.5 An everted syllid proboscis, showing the median distal tooth, in lateral view.

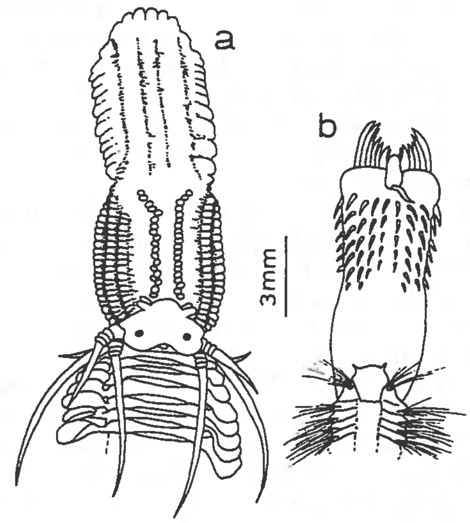

Fig. 6.6 The everted feeding organs of (a) a phyllodocid, and (b) a nephtyid, dorsal view.

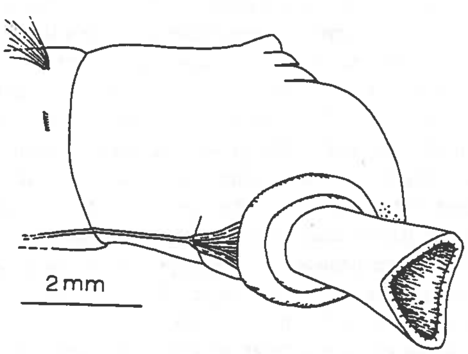

Fig. 6.7 The everted proboscis of a maldanid, lateral view.

central acicular lobe, a preacicular lobe, and a postacicular lobe. The shape of these lobes is important for species identifications of nephtyids.

Within a parapodium there may be one or two thick chitinous rods or spines called acicula. An aciculum supports the bundles of setae in each parapodium and confers rigidity to it. The acicular lobe of nephtyids is so named because it is equipped with an aciculum. Associated with acicula are groups or bundles of setae called fascicles. The setae in a notopodial fascicle are called notosetae; those in the neuropodia are called neurosetae. If a parapodium has a pair of acicula and a pair of fascicles, it is termed biramous; if only one aciculum and one fascicle are present, it is called uniramous (fig. 6.8a, b). Intermediate conditions may be present, particularly among such errant families as the hesionids, in which the notopodium exhibits various degrees of reduction. For example, the notopodium may be reduced to a dorsal cirrus with a few inconspicuous capillary notosetae and an internal aciculum.

Setae: Setae represent an important taxonomic criterion, and their size, shape, and number per fascicle are used extensively in polychaete systematics. Most setae are solid and consist of a chitin-protein complex secreted by specialized cells in the parapodia. The amphinomids and their allies, in contrast, have calcareous bristles which are glistening white, and very brittle to the touch.

There are two basic kinds of setae—simple and jointed. Generally, errant worms have both jointed and simple (not jointed) setae, and sedentary worms have simple setae. Although there are numerous types of setae, familiarity with the common types will facilitate the handling of keys in species identifications.

Basic kinds of simple setae include: capillary setae that are long and hairlike (fig. 6.9a); bilimbate setae, which are shaped like an oar, with a midriff (fig. 6.9b); limbate setae, having only a single blade (fig. 6.9c); sickle-shaped falcate setae (fig. 6.9d); and paleae or paleal setae, which are broad and flat (fig. 6.9e). Simple setae may also be hook-shaped, with tips that may have a single tooth, or two or three teeth (fig. 6.9f, g). In the latter case, if the tip of simple hooks has, for example, two teeth, it is called bifid; with three teeth, it is trifid. When the hook is not modified and the tip has a single point, it is often referred to as being distally entire. If a hook is surrounded by a clear membrane, it is called a hooded hook (fig. 6.9h, i). Another general type of seta that is characteristic of terebellids, ampharetids, sabellids, and serpulids, for example, is the uncinus (fig. 6.9j-l). Such setae may be shaped like a bird's beak (avicular) or be quadrangular in shape. In the latter case, one edge is toothed. Uncini are generally set very close together in one to many rows in a parapodium.

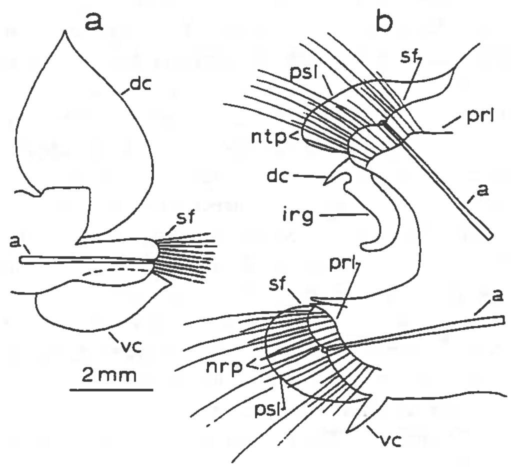

Fig. 6.8 Parapodia. (a) Uniramous phyllodocid parapodium. (b) Biramous nephtyid parapodium. a, aciculum; dc, dorsal cirrus; irg, interramal gill; nrp, neuropodium; ntp, notopodium; prl, preacicular (= presetal) lobe; psl, postacicular (= postsetal) lobe; sf, setal fascicle; vc, ventral cirrus.

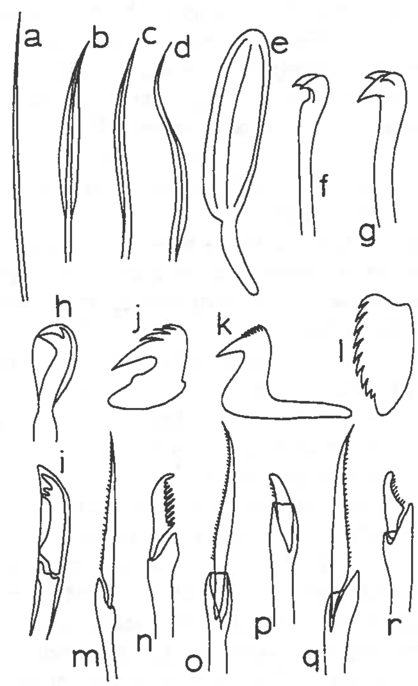

Fig. 6.9 Bristle or setal types. (a) Capillary. (b) Bilimbate. (c) Limbate. (d) Falcate. (e) Paleal seta. (f) Bifid hook. (g) Trifid hook. (h) Hooded hook. (i) Hooded hook. (j) Uncinus of a terebellid. (k) Uncinus of a sabellid. (l) Uncinus of a chaetopterid. (m) Jointed spiniger. (n) Jointed falciger. (o) Homogomph spiniger. (p) Homogomph falciger. (q) Heterogomph spiniger. (r) Heterogomph falciger. Approximate size, 0.1 to 0.5 mm.

Jointed setae may have numerous hinges such as those found in errant families like sigalionids and in sedentary families such as flabelligerids and acrocirrids. Most jointed setae, however, have a single hinge, and are typically found in errant polychaetes. They-have a proximal shaft and distal appendage. If the appendage tapers to a fine point, the setae is called a jointed spiniger (fig. 6.9m); if it terminates in a hook, it is referred to as a jointed falciger (fig. 6.9n). In nereid polychaetes, the hinge on the shaft may be symmetrical or asymmetrical. If the hinge is symmetrical, the seta is described as being homogomph; asymmetrical hinges are called heterogomph. Both falcigers and spinigers can be homogomph or heterogomph (fig. 6.9o-r).

Gills: Each segment may have one or more pairs of gills (branchiae). The gills are placed on the dorsolateral surface of most worms, although in some families the gills extend across the dorsal surface or may be parapodial. They are only rarely ventral. In such families as spionids and eunicids, the gills may be present on all body segments, or restricted to particular ones. Furthermore, the gills may be fused with the notopodial postsetal lobes (fig. 6.34b). They assume a variety of shapes, ranging from a simple lobe to an elaborately branching, comb-shaped or spiraled structure.

Nephridiopores: Opening at the base of, or between the parapodial lobes are small conical to cylindrical excretory pores called nephridiopores. They may be present on nearly all segments in errant worms and are generally confined to a few anterior segments in sedentary worms (fig. 6.10).

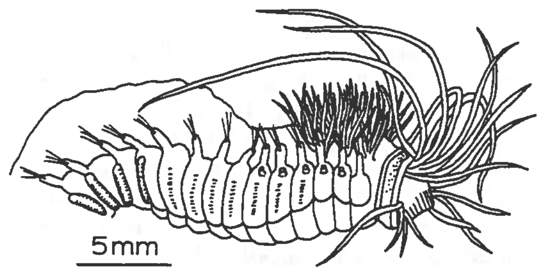

Fig. 6.10 Nephridiopores of a terebellid, lateral view.

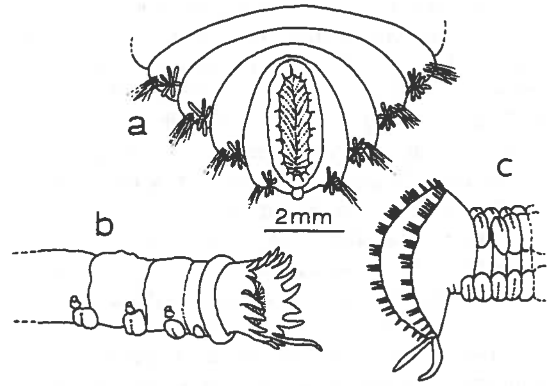

Fig. 6.11 Tails showing the pygidia of selected polychaetes. (a) Amphinomidae, dorsal view. (b) Maldanidae, lateral view. (c) Capitellidae, lateral view.

Scales: Occasionally the body is covered with scales (elytra). This is characteristic of errant worms belonging to such families as the Aphroditidae, Polynoidae, and Sigalionidae. The placement, size, and shape of these scales are important. In the aphroditids, however, these elytra are often obscured by long, silky notopodial setae that intertwine with one another to produce a feltlike layer on the dorsal surface. Their color and texture call to mind the hairs of a mouse. As a result, these worms are commonly called sea mice (fig. 6.12a).

Tail: The final section of the body is the tail (pygidium), which has a dorsal or terminal anus. Note that the pygidium is not a true segment because the segmental growth zone is located just in front of it. The pygidium may be truncate in shape or tapered; anal cirri and various types of setae may be present or absent. Generally speaking, the presence of the latter two characters is more important in the identification of sedentary than errant worms. Several kinds of tails are depicted in figure 6.11.

Techniques for examining polychaetes: In order to identify a species of polychaete, it is often necessary to dissect the proboscis and microscopically examine the setae. This can be tedious, if the worm is small. The proboscis can be exposed with a small, sharp scalpel. A dorsal median incision just behind the head is recommended for members of the superfamily Eunicea because the entire jaw apparatus can be examined without removing it from the worm. A ventral median incision, beginning from the mouth, is recommended for nereids with inverted proboscides. This incision need only cover a distance of two or three segments, and it can be held open for inspection by a pair of fine pointed forceps. A pair of iris scissors may be substituted for a scalpel. Syllids can be examined in several ways. Ideally these small worms will have everted their proboscides upon fixation. If not (and assuming one has a large number of well preserved specimens), it is possible to press a worm gently between a glass slide and a cover slip with forceps. The proboscis can then be examined through a microscope. If the body wall is pigmented, a dorsolateral incision is needed to expose the proboscis. Similar incisions (dorso- or ventromedian, dorsolateral, etc.) are required for other families of errant and sedentary worms whose feeding organs must be examined. Note that glycerids and phyllodocids, for example, have rather long feeding organs, and an incision may extend through tens of segments. In some species of glycerids, the proboscis may be one-third as long as the body! It is a shame to unnecessarily mutilate a specimen, and this can be minimized by using very sharp tools. One can keep his (or her) tools sharpened by purchasing a sharpening stone (available from most supply houses).

Usually both the parapodia and the setae must be examined at intervals along the body. A parapodium (with setae) can be obtained by pinching it off the body with a pair of fine-pointed forceps (such as jewelers' forceps). Two pairs of forceps are required for this operation, one of which is used to hold the specimen stationary. The parapodium is then placed on a glass slide with a drop of absolute alcohol, and properly oriented under a microscope. Once this is completed, a drop of mounting medium (Diaphane or CMC-9AF, available from Turtox, Chicago, Illinois), followed by a cover glass will produce a permanent slide. Label the slide using a diamond pen, and store it in a slide box for later reference. Finally, try to develop the habit of keeping detached parapodia and other body parts. Simply place the body part into a separate cotton-plugged capsule, with an appropriate identifying label, and place it in the same container holding the examined specimen.

Feeding in polychaetes: Polychaetes chiefly inhabit marine and estuarine environments in which they have evolved swimming, crawling, burrowing, and tube-dwelling modes of existence. Concomitant with habitat diversification has been the development of different feeding types. For simplicity, the two principal types of feeding in the Polychaeta can be said to be macrophagy and microphagy. Macrophagy involves the consumption of large, coarse pieces of plant and animal tissue. Microphagy, on the other hand, entails the ingestion of suspended or settled particulate matter (such as sediment and mud particles). Macrophagy, as defined here, can be considered characteristic of errant worms, whereas microphagy is found in sedentary ones. Admittedly the distinction is artificial because some nereids, for example, readily consume particulate matter.

Carnivorous feeding habits are typical of crawling errant worms like nereids and of burrowers like glycerids, lumbrinerids, and arabellids. A number of arabellids, however, are parasitic in the body cavity of ampharetids, at least as juveniles. The raptorial worms prey upon small invertebrates and even one another, and are aided in their task by powerful teeth and jaws. Syllids are thought to be raptorial feeders. Their denticles probably pierce the body of other invertebrates while the radial muscles in the gizzard (proventriculus) pump the body fluids into the gut. There are also herbivorous nereids and nephtyids that tear off pieces of algae with their jaws, while others will consume whatever foodstuffs are available.

Sedentary polychaetes generally exhibit microphagous methods of deposit, filter, and suspension feeding. Deposit feeding worms can be subdivided into direct and indirect deposit feeders. Arencolids, maldanids, opheliids, and their allies are examples of direct deposit feeders that actively ingest sediment for their food. Terebellids are examples of indirect deposit feeders that use their ciliated tentacles to glean particulate matter from the surface sediment and convey it to the mouth (Dales, 1955). An exquisite example of filter feeding is to be found in chaetopterids (Barnes, 1965). These tube worms force a current of water through a mucous net formed by the worm. Suspended material is captured in this net, which is periodically consumed while another net is being produced. Suspension feeding is found in the feather-duster worms (sabellids, serpulids). The cilia on the radioles and branchioles pull water into the branchial crown. The water is strained of food particles which become trapped in mucus produced by cells in the filaments of the crown. The food is then conveyed to a complex sorting region where food particles of a certain size are consumed; those of another size are used in tube construction; and those of a larger size are rejected (Bonar, 1972).

Reproduction in polychaetes: Generally, both errant and sedentary polychaetes have poorly developed gonads, and the gametes complete their development in the body cavity (coelom). Spermatozoa become fully matured in the coelomic cavity, while the female gametes (oocytes) usually develop to a stage just prior to full meiotic maturation. The gametes are usually spawned directly into seawater, where fertilization occurs. The oocytes complete the final stages of meiosis after they are spawned, and before or after sperm penetration. Once the oocyte is fertilized, it is properly called a zygote. The zygote undergoes cell cleavage and development while floating in seawater. The swimming larval stage present in most polychaetes is called a trochophore. The trochophore may be relatively small and observed to consume plankton at an early stage, in which case it is called planktotrophic. If the trochophore is relatively large and is not observed to consume food, it is most likely supplied with a yolky food supply upon which it subsists. Such a larva is referred to as being lecithotrophic. The larvae continue to grow while they are suspended in the water, and eventually can be identified to family and genus. The larvae settle from the plankton and undergo a metamorphosis in which they assume many adult features and lose many larval ones. The juveniles grow to adulthood (if they are not preyed upon or parasitized) and reproduce, thereby completing the life cycle. There are many variations of this generalized life cycle. Implicit in the above discussion is the point that male and female polychaetes exist as separate sexes. A few polychaetes are hermaphrodites, although self-fertilization of gametes is a rare event. Many worms brood or care for their young. One example is to be found in syllids that have their eggs attached directly to the outside of their bodies (fig. 6.20d). Some polychaetes also reproduce by budding. A classic example of artificial asexual reproduction is present in the cirratulid genus, *Dodecaceria* (fig. 6.38d). An individual middle segment is pinched off, which regenerates both a head and a tail. The detached head and tail pieces from the original segment grow to become two complete individuals. Members of this genus may be colonial, and thus it is possible to have all members of the colony of the same sex if they were derived from the same zygote. Upon sexual maturation, however, interbreeding within a sexual dimorphic colony can occur. The reader is referred to the following excellent reviews of polychaete reproductive biology: Clark, 1965; Clark and Olive, 1973; Schroeder and Hermans, 1975.

Zoogeography of polychaetes in the Gulf of California: Approximately 400 species of polychaetes are reported from the Gulf of California. In general terms, the polychaetes of the Gulf are a combination of Panamic, Caribbean, Indo-Pacific, temperate, cosmoplitan, and endemic species. The shallow water polychaete fauna (intertidal to a depth of 200 meters) exhibits strong affinities with warm water (subtropical and tropical) species. There is a decrease in the number of tropical and subtropical species as one travels from Cabo San Lucas to the delta of Río Colorado. Similar trends are reported for other invertebrate groups (Garth, 1961). The polychaete fauna beyond the continental shelf (greater than 200 meters) resembles generally that found in deep water around southern California and western Mexico (i.e. eastern Pacific) (Fauchald, 1972). There is an interesting anomaly, however. The polychaetes of the Salsipuedes Basin, located between Isla Angel de la Guardia and Baja California, exhibit strong affinities to cold temperate species. For example, 17 of 35 species taken from the basin have their centers of distribution along the Pacific coast of the United States. None of these 17 species has been collected south of Isla Cedros on the Pacific side of Baja California. Characteristic deep water families are poorly represented in the 1400+ meter deep Salsipuedes Basin (i.e. Onuphidae, Ampharetidae). Six species found in the basin typically occur in intertidal and shallow shelf depths. The latter point is partially explained by the fact that the strong tidal currents in the Canal de Ballenas enable the bottom waters in the basin to be well oxygenated. A tentative conclusion is that the polychaete fauna of the Salsipuedes basin represents a relict fauna of the time when the Gulf was cooler than it is now (Fauchald, 1972).

Definition of orders: Although various morphological characters presented below will overlap between the orders of polychaetes, a specimen can usually be correctly identified to order if it has a majority of the following characters:

1. Prostomium with sensory appendages and peristomial tentacles. The proboscis is usually muscular and may have jaws. Parapodia and parapodial cirri are well developed; parapodia with jointed setae. The body is not divided into different anatomical regions. Nephridiopores are usually located on all segments . . . . Errantia
2. Prostomium is reduced and usually lacks sensory appendages; peristomial tentacles are usually absent. The proboscis, when present, is unarmed and flexible. Parapodia and parapodial cirri are reduced; parapodia with simple setae. The body may be divided into at least two regions. Nephridiopores are usually restricted to a few anterior segments . . . . Sedentaria

Keys to selected Gulf polychaetes: The following keys (pp. 87–88, 106–07) are intended for use throughout the Gulf of California, and particaurly for the Sonoran coast, where the families selected are generally common and easily found. Many species that commonly occur throughout the Gulf have also been listed. Again, I emphasize the fact, as was done in the first edition, that there are over 80 known families of polychaetes in the world, of which 37 are included in the keys. The chances of finding both families and genera not covered in the keys are very good, although the major families are certainly listed in this chapter. Fauchald (1977a) has prepared a key to all polychaete families. It will be useful because the key can be used for specimens in all states of preservation (fragments, scaleworms without scales, phyllodocids without appendages, etc.). Reish (1968) provides a checklist of all the polychaete species known to that year; Fauchald (1972) also provides a checklist for deep water polychaetes. The polychaete literature for the Sea of Cortez is summarized by Kudenov (1975a). Additional references may be found in the bibliography. In the descriptions that follow the keys, recent references are cited, in which a more detailed account of a particular family or species may be obtained.

Glossary of selected terms: It seems unfortunate that the immense amount of terminology present in polychaete systematics necessitates a glossary, separate from that at the back of the handbook. I have tried to use terms throughout this chapter to minimize one's dependence upon this glossary and have even deleted a number of terms that were listed in the first edition. In any case, the terms used in the keys are defined in this glossary, and additional terminology can be found in Day (1967) and in Fauchald (1977a).

Abdomen. The posterior portion of the body, behind the thorax.

Aciculum (a). A thick chitinous rod conferring support to a setal fascicle.

Anal cirrus (i). An elongate process arising from the pygidium.

Annulate. Furnished with rings.
Antennae (a). Sensory processes of the prostomium.
Apodous. A segment without parapodia.
Asetigerous. A segment without setae.
Avicular seta. A seta with a bird-shaped beak.
Bidentate seta. A seta with two teeth.
Bifid. Diverging distally into two parts.
Bipinnate. Featherlike, with a main axis and a row of processes on each side.
Biramous. A parapodium with two bundles of setae and two acicula.
Branchiae. *See* Gills.
Caruncle. A sensory lobe of the prostomium.
Capillary seta. A simple, slender hairlike seta.
Ceratophore. A barrel-shaped basal portion of a tentacle or antenna.
Cirrus (i). A threadlike appendage.
Dentate. Toothed.
Distal. That part of a structure farthest away from its point of attachment.
Elytron (a). *See* Scale.
Entire. Applied to a continuous marginal edge lacking interruptions.
Falciger. A seta with a hooked tip.
Gills. Respiratory organs found on the body.
Gizzard. A barrel-shaped organ behind the proboscis of syllids.
Heterogomph. Pertaining to the uneven hinge joint of nereid setae.
Homogomph. Pertaining to the even hinge joint of nereid setae.
Hooded hook. The apex of a hook embedded in a clear chitinous matrix.
Hooks. A general term applied to setae with short shafts and recurved tips.
Inferior. The more ventral of two structures.
Jointed seta. A hinged seta with a shaft and a distal appendage.
Mandible. The lower jaw of the Eunicea.
Maxillae. The upper jaws of the Eunicea.
Neuropodium. The lower half of a biramous parapodium.
Neurosetae. The bristles associated with the neuropodium.
Notopodium. The upper half of a biramous parapodium.
Notosetae. The bristles associated with the notopodium.
Occipital. Pertaining to the posterior prostomial surface.
Operculum. Plug.
Palps. Sensory appendages of errant worms; feeding appendages of sedentary worms.
Papillate. Bearing many small conical processes.
Paragnaths. Chitinous processes on the proboscis of nereids.
Parapodia. Paired segmental locomotory appendages which usually bear setae.
Pectinate. Shaped like a comb.
Peristomium. The region behind the prostomium, and about the mouth.
Pharynx. *See* proboscis.
Proboscis. The eversible part of the gut.
Prostomium. The region in front of the mouth and peristomium.
Proventriculus. *See* Gizzard.
Proximal. That portion of a structure nearest its point of attachment.
Pygidium. The tail of a polychaete, bearing the anus.
Radioles. Bipinnate processes in the branchial crowns of sabellids and serpulids.
Scale. Flat plates found on the dorsal surface of scale-worms, also called elytra.
Sessile. Without a stalk.
Setae. Bristles produced by specialized cells in the parapodium.
Setiger. A segment bearing setae.
Spiniger. A jointed setae with a distally tapered appendage.
Superior. The dorsal-most of two structures.
Tentacle. A term applied to peristomial appendages.
Trifid. Diverging distally into three parts.
Tuberculate. Equipped with many fingerlike processes.
Tubicolous. Tube-dwelling.
Uncinus (i). Small quadrangular seta with one edge toothed.
Uniramous. A parapodium with a single lobe with setae.

KEYS TO SELECTED POLYCHAETE FAMILIES: ERRANTIA

1 Dorsal surface with scales (elytra) (fig. 6.13a) **2**
-Dorsal surface without scales **4**

2(1) Jointed neurosetae present (fig. 6.15a) .... **Sigalionidae**
-Jointed neurosetae absent **3**

3(2) Scales completely or partially covered with feltlike notosetae; a single median antenna on prostomium (fig. 6.12b) .... **Aphroditidae**
-Scales not covered with feltlike notosetae; prostomium always with three antennae (fig. 6.13b) .... **Polynoidae**

4(1) Caruncle present (fig. 6.17b) **5**
-Caruncle absent **6**

5(4) Notosetae resemble flat golden petals, arranged in transverse rows across dorsal surface (fig. 6.16a) .... **Chrysopetalidae**

	-Notosetae tubular, glistening white, arranged in circular tufts along the dorsolateral surface (fig. 6.17a)	**Amphinomidae**
6(4)	Prostomium with palps	**7**
	-Prostomium without palps	**12**
7(6)	Palps jointed (fig. 6.19a)	**8**
	-Palps not jointed (fig. 6.20a)	**9**
8(7)	Peristomial tentacles jointed; proboscis without paragnaths; notosetae, if present, are simple capillaries	**Hesionidae**
	-Peristomial tentacles smooth; proboscis with paragnaths; notosetae usually jointed (fig. 6.2)	**Nereidae**
9(7)	A cylindrical gizzard (proventriculus) present behind the proboscis (fig. 6.1i)	**Syllidae**
	-A gizzard absent	**10**
10(9)	Prostomium with two antennae; jaws as two to four arched rows of many small chitinous plates (fig. 6.31a)	**Dorvilleidae**
	-Prostomium with other than two antennae; jaws with three to six or seven plates	**11**
11(10)	Prostomium with five occipital antennae with ringed bases (ceratophore: fig. 6.26a)	**Onuphidae**
	-Prostomium with one, three or five antennae; ceratophores absent (fig. 6.27a)	**Eunicidae**
12(6)	Body covered with papillae (fig. 6.23); gizzard (proventriculus) present	**Sphaerodoridae**
	-Body smooth; gizzard absent	**13**
13(12)	Jaws present	**14**
	-Jaws absent	**19**
14(13)	Four or more pairs of jaws present	**15**
	-Only one or two pairs of jaws present	**17**
15(14)	Peristomium with three tentacles; first two segments with parapodia (fig. 6.28a)	**Lysaretidae**
	-Peristomium usually lacks tentacles; first two segments without parapodia (fig. 6.29a)	**16**
16(15)	Prostomium with eyes; all setae winged capillaries	**Arabellidae**
	-Prostomium without eyes; setae include winged capillaries and hooded hooks	**Lumbrineridae**
17(14)	Prostomium long, conical and ringed (annulated); body circular in section (fig. 6.4a)	**18**
	-Prostomium flattened, rounded to hexagonal in outline; body rectangular in section (fig. 6.22a)	**Nephtyidae**
18(17)	Proboscis with four black terminal jaws	**Glyceridae**
	-Proboscis with two large terminal jaws and one or two terminal arcs of smaller teeth (fig. 6.4d)	**Goniadidae**
19(13)	Dorsal cirri flattened, leaf-shaped (fig. 6.18b)	**Phyllodocidae**
	-Dorsal cirri cylindrical, jointed (fig. 6.19b)	**Hesionidae**

FAMILY APHRODITIDAE

The body is oblong and completely to partially covered with fine silklike setae (fig. 6.12a). The prostomium is globular, has a median antenna, facial tubercle, and 2 pairs of eyes (fig. 6.12b). Two pairs of peristomial tentacles are present. From 15 to 20 pairs of scales are present. Parapodia are biramous, and the neurosetae are characteristically arranged in 2 to 3 tiers in the neuropodia (fig. 6.12c). Pettibone (1966) reviews the characters of this family.

The aphroditids are generally subtidal polychaetes inhabiting muddy and silty bottoms. They are scavengers. A few species are known to live in kelp holdfasts. The thick layer of dorsal felt gives them a mouselike appearance; hence, the common name "sea mice." Sea mice are often obtained from shrimp trawlers.

Aphrodita mexicana Kudenov

This species was originally called *Aphrodita* sp. (Kudenov, 1973: 94–95). The body is elliptical, and measures about 73 mm long and 32 mm wide. There are 46 segments. The notosetal spines do not penetrate the felt layer. The median tentacle is reduced to a papilla on the prostomium. The notosetae are distally recurved (fig. 6.12d). The neurosetae have hairy tips. There are 2 superior neurosetae; 4 to 5 intermediate neurosetae; and 13 to 14 inferior ones. *A. mexicana* is known from the northern Gulf of California (Kudenov, 1975a).

Aphrodita sonorae Kudenov

This species is similar to *A. mexicana* in having the median antenna reduced to a tubercle. The notosetae of *A. sonorae*, however, penetrate the dorsal felt layer and are distally straight. This species is also known from the northern Gulf of California (Kudenov, 1975c).

Aphrodita refulgida Moore

The body is ovate, about 36 mm long and 18 mm wide. About 43 segments are present. Characteristic silky green lateral setae are present. The notosetae project through the felt and arch over the middle of the body. The superior level of neurosetae has 2 to 3 thick,

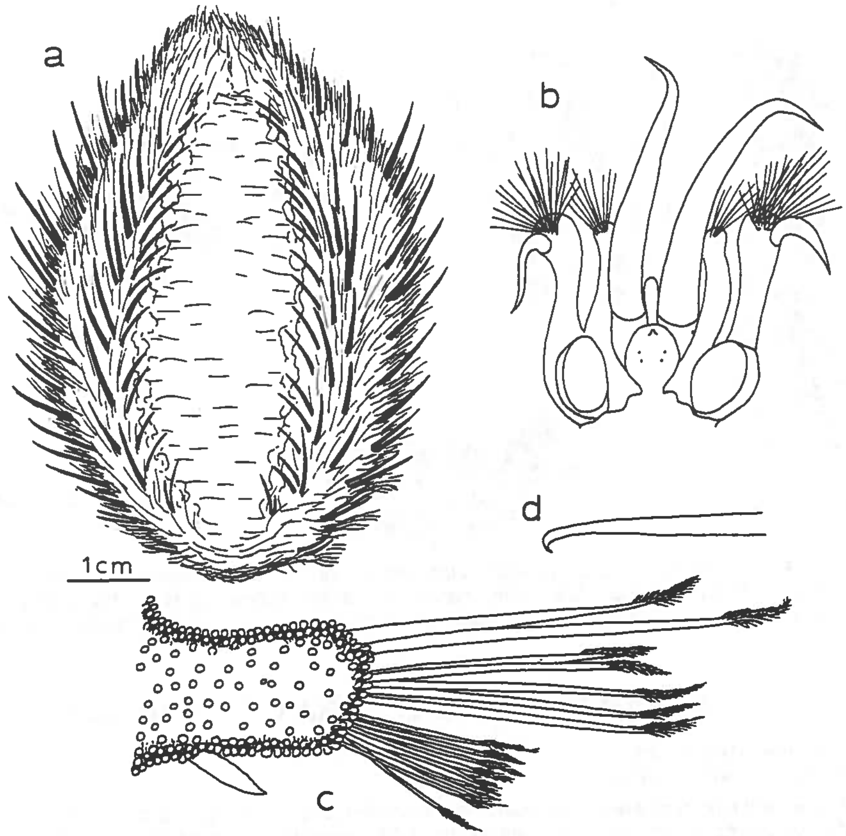

Fig. 6.12 Aphroditidae. (a) Entire worm, dorsal view. (b) Prostomium of *Aphrodita mexicana*, dorsal view. (c) Parapodium of *Aphrodita mexicana*, anterior view. (d) Notoseta of *Aphrodita mexicana*, lateral view.

dark brown spines; the intermediate level has 4 to 5 thinner, lighter brown spines; and the inferior tier has around 15 very slender, brownish-yellow setae. This species occurs south of Guaymas (Hartman, 1968; Kudenov, 1975a).

FAMILY POLYNOIDAE

The body is flattened and oval to elongate in outline (fig. 6.13a). The prostomium has 2 pairs of eyes, a median and 2 lateral antennae, and sometimes 2 lateral peaks (fig. 6.13b). Two pairs of peristomial tentacles are present. Elytra number from 12 to more than 40 pairs, occurring on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and on every third segment thereafter. The above sequence considers the peristomial segment as segment 1. Parapodia are biramous (fig. 6.13c), and all setae are simple. Notosetae are curved and have blunt to sharp tips (fig. 6.13d). Neurosetae are generally unidentate or bidentate (fig. 6.13e).

The arrangement of head structures is of prime importance in the identification of polynoid genera. For example, the median antenna can originate from the anterior to the posterior margin of the prostomium while the two lateral antennae can originate from the anterior margin to ventral surface of the prostomium. A possible combination of these features might be that the median antenna is anterodorsal in origin, and the laterals are terminal (i.e. continuous with the anterior prostomial margin). If lateral peaks are absent (fig. 6.13b), the genus is *Alentia*. Additional features must also be considered, such as the direction in which the bases of the lateral antennae are pointing in relation to the median antenna. All of this may at first sound burdensome, and a useful discussion of polynoid features and a key to many known polynoid genera will be found in Day (1967).

Polynoids are a rather abundant and diverse group of worms in the Sea of Cortez. They can be free-living, occurring under rocks, in crevices, or in algal mats; they also occur with other animals as commensals. For example, see *Lepidasthenia gigas*. Quite often, scale-worms are distinctively colored.

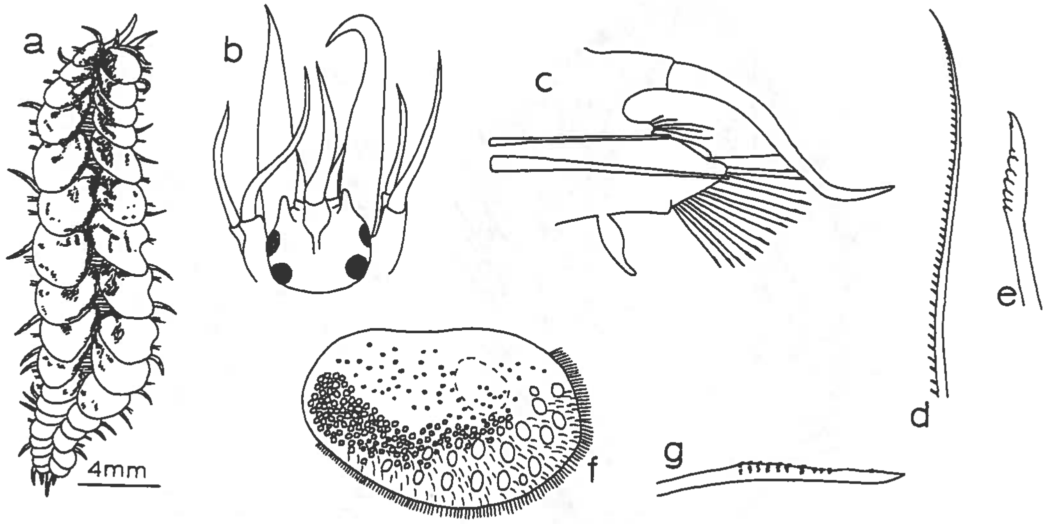

Fig. 6.13 Polynoidae. (a) Entire worm, *Halosydna*, dorsal view. (b) Head of *Harmothoe*, dorsal view. (c) Parapodium of *Malmgrenia hartmanae*, anterior view. (d) Notoseta of *Malmgrenia*. (e) Neuroseta of *Malmgrenia*. (f) Scale of *Harmothoe hirsuta*. (g) Neuroseta of *H. hirsuta*.

KEY TO SELECTED GENERA OF POLYNOIDS

1	Prostomium with peaks .... ***Harmothoe***	
	-Prostomium without peaks	2
2(1)	Median and lateral antennae terminal in origin (continuous with anterior prostomial margin)	3
	-Median antennae terminal; lateral antennae slightly ventral (their bases point toward base of median antenna) .... ***Malmgrenia***	
3(2)	Twelve pairs of scales present .... ***Lepidonotus***	
	-Fourteen or more pairs of scales present	4
4(3)	Eighteen to twenty-two pairs of scales present; notosetae present in all parapodia ...... ***Halosydna***	
	-Twenty-four or more pairs of scales present; notosetae generally absent .... ***Lepidasthenia***	

Harmothoe hirsuta Johnson

The body has around 40 segments and is 30 mm long and 6 mm wide. The 15 pairs of scales cover the dorsal surface. As the name implies, this species is rather hairy or shaggy in appearance. The elytra are thickly fringed and tuberculate and the body appendages (i.e. parapodial cirri) are covered by papillae. The scales have characteristic rows of yellow tubercles along the posterior margin (fig. 6.13f). Notosetae are thicker than the neurosetae. Neurosetae are bifid (fig. 6.13g). This species is known from Topolobampo, and its range is extended to Puerto Lobos, Sonora, where it occurs under low intertidal boulders (Rioja, 1947a; Hartman, 1968).

Halosydna brevisetosa Kinberg

The body is around 100 mm long and 11 to 12 mm wide. A total of 18 pairs of scales are present that completely cover the body. The scales vary from a mottled, fringed to tuberculate surface. The notopodia are reduced. The neuropodia are well developed, and the neurosetae are thick and unidentate (fig. 6.14a). This is a free-living species at Puerto Peñasco where it is brilliantly orange in color. It is a known commensal of starfish (Hartman, 1968).

Halosydna glabra Hartman

The body is 25 mm long, 7 mm wide, and has 25 segments. The elytra lack a marginal fringe. The first pair of scales is characteristic because two kinds of large tubercles are present: elongate yellow ones and stoutly conical white ones (fig. 6.14b). Many smaller tubercles are strewn over the entire surface. This species is reported from Bahía Concepción and Panama. It was collected from Isla Tiburón (Hartman, 1939).

Halosydna johnsoni (Darboux)

The 37 body segments are 48 mm long and 7 mm wide. The elytra are ear-shaped and marginally fringed. They are characteristically colored with alternating transverse bars of dark and light pigments. The neurosetae are thick and distally bifid (fig. 6.14c). *H. johnsoni* is free living or a commensal in the tubes of terebellids or certain snails. It occurs intertidally at San Felipe and Puerto Peñasco among basalt boulders (Berkeley and Berkeley, 1939).

Lepidonotus species 1

A small species, 10 mm long and 2 to 3 mm wide, with 30 segments. The prostomium is longer than wide. A median flap of tissue overhangs the posterior margin of the prostomium. The first 2 or 3 pairs of scales have tubercles with distal spines. An elytral fringe is absent, although a submarginal row of long tubercles conveys the false impression that a fringe is present. The notosetae are bipinnate (fig. 6.14d); the neurosetae are bidentate (fig. 6.14e). This species was collected from subtidal algal mats at Ensenada Perro and Punta Tormento, Isla Tiburón (Hartman, 1939).

Lepidasthenia gigas (Johnson)

A large worm, up to 230 mm long and 10 mm wide, with 90 segments and 44 pairs of scales (fig. 6.14f). Parapodia with neurosetae only, although the first 10 segments may have notosetae. The scales lack a fringe and are mottled with gray, yellow, and green. The superior neurosetae are thickest and are generally unidentate (fig. 6.14g). Other neurosetae are bidentate. This species is a commensal of a very large terebellid worm *(Thelepus* near *setosus)*. The present records are from southern Sonora and Isla Tiburón, and this species has been reported from San Felipe (Berkeley and Berkeley, 1939; Hartman, 1968).

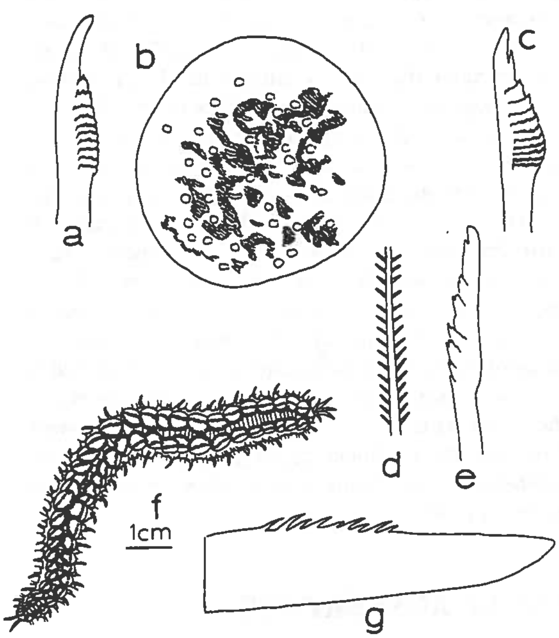

Fig. 6.14 Polynoidae. (a) Neuroseta of *Halosydna brevisetosa*. (b) Scale of *Halosydna glabra*, dorsal view. (c) Neuroseta of *Halosydna johnsoni*. (d) Notoseta of *Lepidonotus* sp. 1. (e) Neuroseta of *Lepidonotus* sp. 1. (f) Entire worm, *Lepidasthenia gigas*. (g) Neuroseta of *Lepidasthenia gigas*.

Malmgrenia hartmanae Kudenov

A small commensal species that is 6 mm long, around 2 mm wide and has 30 segments. There are 15 pairs of characteristically reticulate scales, which have small surface tubercles and lack a marginal fringe. The notosetae and neurosetae have characteristic transverse plates (fig. 6.13d, e). This species was found in the lateral setae of *Aphrodita sonorae* (Kudenov, 1975c).

FAMILY SIGALIONIDAE

The body is elongate and has numerous segments. The prostomium has four small eyes, and one to three antennae. Scales occur on every other segment anterior to segment 25, and on every segment posterior to segment 25. Dorsal cirri usually absent. The notosetae are simple spinose capillaries; the neurosetae are jointed falcigers with from one to many joints (fig. 6.15a, b).

Sigalionids occur in sandy to muddy sediments and are perhaps best known from subtidal localities in the Gulf of California. A recent review is presented by Pettibone (1971).

Thalenessa lewisii Berkeley and Berkeley

The body is around 150 mm long, 3 mm wide. The prostomium is rounded and has 2 pairs of inconspicuous eyes and 3 small conical antennae. The elytra have around 12 outer branching processes plus a submarginal row of single processes (fig. 6.15c, d). The notosetae are distally bidentate. *T. lewisii* occurs at several localities throughout the Gulf (Reish, 1968) and can be considered a Panamic species.

FAMILY CHRYSOPETALIDAE

The body is elongate and flattened (fig. 6.16a). The dorsal surface is covered with setae shaped like golden petals *(palaea)* (fig. 6.16b). The prostomium is often obscured by the setae. It is rounded, with 1 to 2 pairs of eyes, and a pair of palps. Parapodia are biramous, with notosetae distributed along the dorsal surface; neurosetae are jointed falcigers (Day, 1967).

Chrysopetalids are a warm water family, very common in the Sea of Cortez. They occur under basalt boulders in the low intertidal zones along the Sonoran coast.

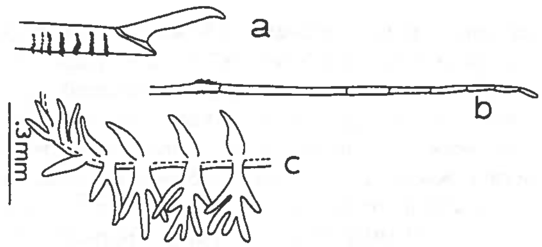

Fig. 6.15 (*above*) Sigalionidae. (a) Jointed neuroseta of *Psammolyce*. (b) Jointed neuroseta of *Sthenelais*. (c) Detail of scale of *Thalenessa lewisii*, from Berkeley and Berkeley, 1939.

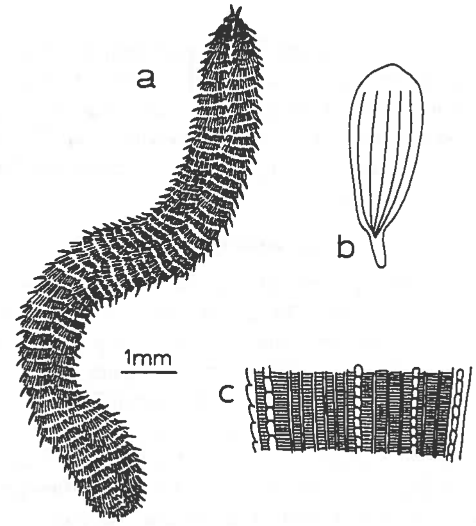

Fig. 6.16 (*right*) Chrysopetalidae. (a) Entire worm, *Chrysopetalum occidentale*. (b) Entire paleal seta of *Chrysopetalum occidentale*. (c) Detailed view of paleal seta of *Bhawania goodei*.

KEY TO SELECTED GENERA OF CHRYSOPETALIDS

1	Body elongate and covered by dark brown petal-shaped setae (palaea)	***Bhawania***	
	-Body short and covered by golden yellow palaea	***Chrysopetalum***	

Bhawania goodei Webster

The body is long and narrow, 50 to 60 mm long, and 2 to 3 mm wide. Each palaea has around 20 longitudinal ridges; 5 of these (2 outer and 3 inner rows) have blunt processes (fig. 6.16c). A female taken during December had a juvenile attached to its ventral surface (Kudenov, 1975a).

Chrysopetalum occidentale Johnson

A small fragile species that is 6 to 17 mm long and less than 1 mm wide, with 40 to 60 segments (fig. 6.16a). It fragments along intersegmental grooves if irritated. There are 2 kinds of notosetae: outer narrow bladed and inner broad bladed ones. The latter are most numerous (fig. 6.16b). This species is found among small serpulids on the bottom of boulders (Kudenov, 1975a).

FAMILY AMPHINOMIDAE

The body is usually short and stout but can be elongate (fig. 6.17a); it is trapezoidal to rectangular in section. The prostomium is often obscured by anterior segments and consists of an anterior and posterior lobe. The anterior lobe has a pair each of eyes, palps, and antennae; the posterior lobe has another pair of eyes, a median antenna, and a caruncle (fig. 6.17b). Parapodia are biramous (fig. 6.17c). Simple tubular, calcareous setae are present. Gills are bipinnate or bushy tufts.

Amphinomids are thought to feed on soft bodied animals (i.e. sponges, coral, ascidians), and they also ingest plant materials and sediment. They are often called *fireworms*, because of a poison associated with their detachable, brittle notosetae. Documented cases appear in the medical literature of people eventually losing toes and fingers as a result of stepping on or handling these worms. Actually they lost their appendages as a result of secondary infection. In any case, care should be exercised when turning over rocks or when collecting in the turbid water that results when a rock is overturned. Note also that amphinomids are generally timid worms. Literature on this family is summarized to that year by Kudenov (1974).

KEY TO SELECTED GENERA OF AMPHINOMIDS

1	Gills bipinnate	***Chloeia***	
	-Gills not bipinnate		**2**
2(1)	Gills generally restricted to anterior segments	***Pseudeurythoe***	
	-Gills present on nearly all segments		**3**
3(2)	Two pairs of dorsal cirri per segment	***Notopygos***	
	-One pair of dorsal cirri per segment		**4**
4(3)	Caruncle extends to setiger 4; body length around 100 to 400 mm	***Eurythoe***	
	-Caruncle extends to setiger 2; body length around 40 to 80 mm	***Pareurythoe***	

Chloeia entypa Chamberlin

The dorsal surface has one wide, reddish-brown longitudinal stripe that runs from head to tail. Posterior bifid notosetae are serrated on the side opposite the basal spur (fig. 6.17d). This common subtidal worm can be obtained from the shrimp trawlers at Puerto Peñasco. It is distributed from Ecuador northward to the Gulf and southern California (Treadwell, 1937).

Chloeia pinnata Moore

The body is colored fleshy-pink and is speckled with dark pigment. Pigmented stripes are absent. Posterior bifid notosetae are serrated on the same side as the basal spur (fig. 6.17e). This species occurs off southern California and the southern Gulf (Berkeley and Berkeley, 1939).

Chloeia viridis Schmarda

The dorsal surface has 3 longitudinal stripes on the anterior end of the body. Posterior bifid notosetae are smooth (fig. 6.17f). This species is common throughout the Gulf and has also been recorded from the Caribbean (Hartman, 1940).

Eurythoe complanata (Pallas)

The body is rectangular in cross section, and from 60 to 350 segments are present. The color in life ranges from a pinkish-gray to blue, with deep red gills. This species is the most abundant intertidal amphinomid in the Sea of Cortez, where it occurs under boulders. It is a highly gregarious, slow moving species that reproduces sexually and asexually (fig. 6.17g) during the summer months at Puerto Peñasco (Kudenov, 1974).

Notopygos ornata Grube

The body is oblong, about 50 to 70 mm long and 10 mm wide (fig. 6.17a). As the name implies, this species is ornately colored. The caruncle is conspicuous and rather long (fig. 6.17b). It is possible to float *N. ornata* like a raft by gently placing a specimen into a container of seawater. One can pick this species up by hand because harpoon notosetae are absent. Air bubbles become trapped in the setal fascicles. Such a phenomenon may be significant in terms of population recruitment and survival. Similar observations were made on juvenile specimens of *Eurythoe complanata*. *Notopygos ornata* is endemic to the Panamic Province (Hartman, 1940).

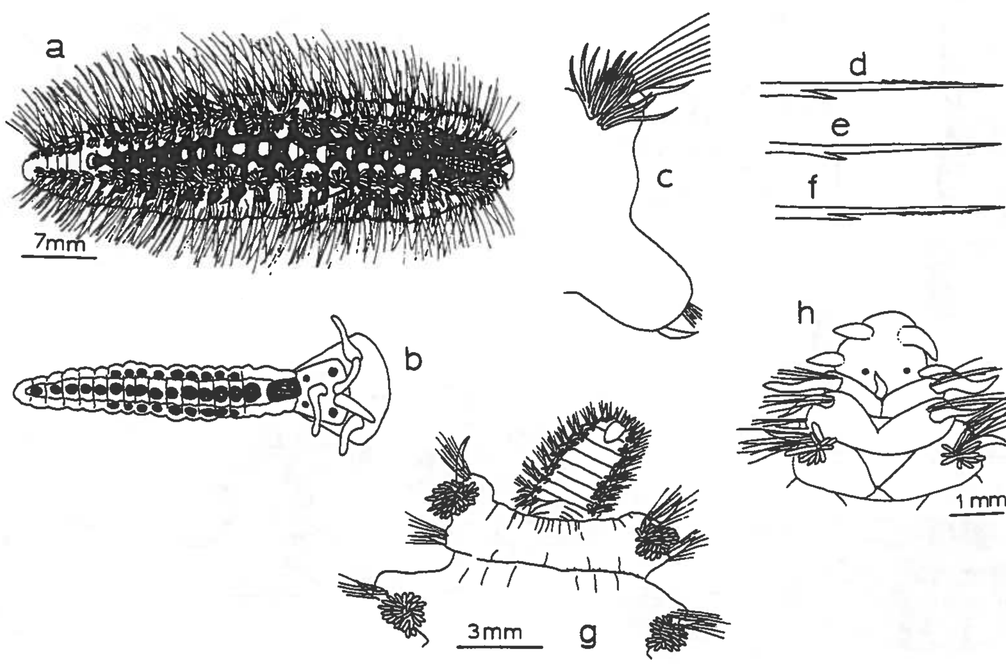

Fig. 6.17 Amphinomidae. (a) Entire worm, *Notopygos ornata*. (b) Head of *Notopygos ornata*. (c) Parapodium of *Pseudeurythoe tripunctata*, anterior view. (d) Notoseta of *Chloeia entypa*. (e) Notoseta of *Chloeia pinnata*. (f) Notoseta of *Chloeia viridis*. (g) Anterior regenerating segments of *Eurythoe complanata*. (h) Head of *Pseudeurythoe* sp. 1.

Pareurythoe californica (Johnson)

A small species superficially resembling *Eurythoe complanata* and distinguished from it by characters set out in the key. Around 50 to 80 segments are present. A useful discussion on this species will be found in Hartman (1940). *P. californica* is fairly common on the Pacific side of Baja California and southern California. It occurs at Bahía de los Angeles in the Gulf (Reish, 1968).

Pseudeurythoe tripunctata Kudenov

A large species around 155 mm long, 4 mm wide, with 175 segments. Gills are present from setiger 3. Characteristic forked notosetae are present on setigers 1 to 6, each with a knob at the junction of the spur and shaft. This species occurs in mangrove roots at Estero Soldado (Kudenov, 1975a).

Pseudeurythoe species 1

A small species up to 20 mm long, 2 to 3 mm wide, with around 50 segments. Caruncle often hidden under the fold of setiger 1 (fig. 6.17h). Gills are present from setiger 3 and are absent from posterior segments. Some neurosetae are very long and have a serrated edge and indistinct basal spur. The dorsal cirri of setiger 1 very large; all other cirri are reduced. This species was collected in sand, under mid intertidal rocks at Puerto Lobos, Sonora (Fauchald, 1972).

FAMILY PHYLLODOCIDAE

The body is long and narrow and distinctively colored. The prostomium is rounded to heart-shaped with a pair of eyes and 4 or 5 antennae (fig. 6.18a). The proboscis is cylindrical, unarmed, and has papillae. Two to four peristomial tentacles are present on the first three segments. Parapodia are reduced or absent on segments 1 to 3. Parapodia generally uniramous (fig. 6.18b). Characteristic leaf-shaped dorsal and ventral cirri are present. The setae are jointed spinigers.

The arrangements of the first 3 segments is important in phyllodocid systematics. For example, the segmental rings of these 3 segments are separate and distinct in *Protomystides;* the rings of segments 1 and 2 are dorsally fused in *Genetyllis* (fig. 6.18h). The shape of the peristomial tentacles is also important. An important review of phyllodocids was made by Uschakov (1972).

Phyllodocids are common in the Sea of Cortez, where they occur in various intertidal habitats ranging from sandflats and rocks to colonial animal assemblages.

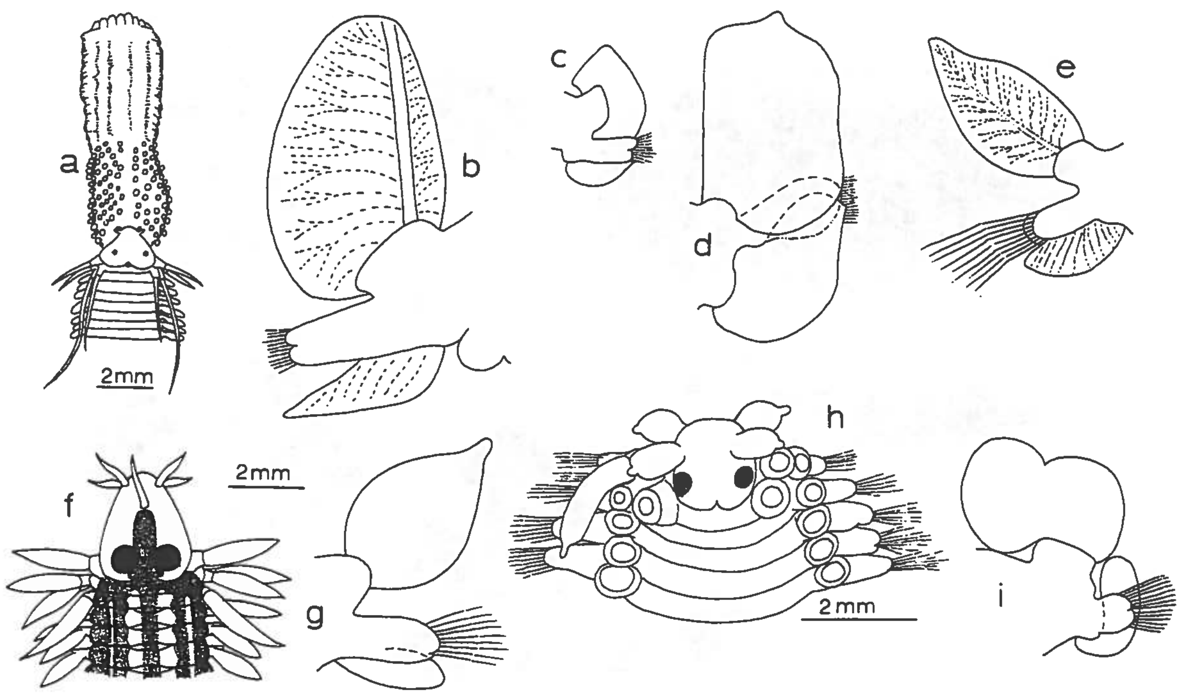

Fig. 6.18 Phyllodocidae. (a) Head of *Phyllodoce tuberculosa*. (b) Anterior parapodium of *Phyllodoce tuberculosa*. (c) Anterior parapodium of *Anaitides carolensis*. (d) Anterior parapodium of *Anaitides cortezi*. (e) Anterior parapodium of *Anaitides madierensis*. (f) Head of *Eulalia myriacyclum*. (g) Anterior parapodium of *Eumida sanguinea*. (h) Head of *Genetyllis* sp. 1. (i) Anterior parapodium of *Genetyllis* sp. 1.

KEY TO SELECTED GENERA OF PHYLLODOCIDS

1	Prostomium heart-shaped; a nuchal papilla present	2
	-Prostomium oblong; a nuchal papilla absent	***Genetyllis***
2(1)	Four prostomial antennae present	3
	-Five prostomial antennae present	4
3(2)	Base of proboscis with orderly rows of papillae	***Anaitides***
	-Base of proboscis with diffuse papillae	***Phyllodoce***
4(2)	Segments 1 to 3 dorsally distinct (the first pair of peristomial tentacles originate from segment 1)	***Eulalia***
	-Segments 1 and 2 dorsally fused (the first pair of peristomial tentacles appear to originate from prostomium)	***Eumida***

Anaitides carloensis Kudenov

This species was called *Anaitides* species 1 (Kudenov, 1973: 99–100, fig. 5.13a). The type specimen is a fragment, 44 mm long, with 85 segments. The proboscis has 12 proximal rows of papillae with 20 to 25 orange papillae per row. Anterior dorsal cirri are small and subrectangular (fig. 6.18c). This species is known from Bahía San Carlos (Kudenov, 1975a).

Anaitides cortezi Kudenov

This species was called *Anaitides* species 2 (Kudenov, 1973: 100, fig. 5.13b). The body is 154 mm long, 8 mm wide, and has over 300 segments. There are 12 proximal rows of papillae with 10 papillae per row. A single median papilla is present just in front of the prostomium. Anterior dorsal cirri are large and quadrangular (fig. 6.18d). This species is known from Bahía San Augustín (Kudenov, 1975a).

Anaitides multiseriata Rioja

A small species, 30 mm long, less than 2 mm wide, with 100 segments. This species has a characteristic pigment pattern shaped like an "H" on its prostomium. It occurs in sandy sediments and worm colonies at many Gulf localities, and is distributed from western Mexico to southern California (Rioja, 1941b).

Anaitides madeirensis (Langerhans)

The body is 70 mm long, 3 mm wide, and has 200 segments. There are 12 proximal rows of papillae with 6 to 11 papillae per row, plus a dorsomedian row with 5 to 6 papillae. Dorsal cirri are shaped like lance points, and all have pinnate venation (fig. 6.18e). This circumtropical species is common throughout the Gulf (Hartman, 1968).

Eulalia myriacyclum (Schmarda)

A very long, narrow species, 450 mm long, 1.5 to 5 mm wide, with over 400 segments (fig. 6.18f). Color in life is brilliant green, with 5 dark green dorsal longitudinal stripes, and 3 similarly colored ventral ones. The proboscis is diffusely papillate over its entire surface. This species secretes enormous quantities of mucus when disturbed. It occurs in mid intertidal rocky habitats at Puerto Peñasco, where it deposits circular green egg masses during January and February. *E. myriacyclum* is also found in the Caribbean (Rioja, 1962).

Eumida sanguinea (Oersted)

The body is up to 60 mm long, 1 to 2 mm wide, with up to 120 segments. The surface of the proboscis has low transverse ridges. The dorsal cirri are sharply pointed and shaped like broad leaves (fig. 6.18g). *E. sanguinea* is a cosmopolitan species, previously reported from La Paz, and collected at Punta Chueca, Sonora (Rioja, 1947a; Uschakov, 1972).

Genetyllis species 1

The body is short and broad, about 20 to 35 mm long, 4 to 5 mm wide, with 30 to 50 segments. Color in life is distinctive: cyan-blue body with yellow to yellow-green parapodia. The prostomial antennae are characteristic (fig. 6.18h). The dorsal cirri are bilobed, and the ventral cirri are J-shaped (fig. 6.18i). This species was collected from under large rocks in shallow subtidal depths at Bahía San Francisco, Sonora. Aggregations of 5 to 25 worms were embedded in mucus and silt (Uschakov, 1972). This is the first record of the genus from the Gulf.

Phyllodoce tuberculosa Kudenov

The body is 70 mm long, 3 mm wide, and has 200 segments. In life the body is green and the tentacles and cirri are opaque white. The proboscis has 11 oblique dorsolateral rows of papillae. The dorsal cirri of anterior segments have a thickened axis of tissue (fig. 6.18b). A characteristic inferior tubercle is present below the parapodia. This species is abundant on intertidal sandflats at El Golfo de Santa Clara and Estero Morua (Kudenov, 1975a).

FAMILY HESIONIDAE

The body is short, muscular, and has few segments. The prostomium is quadrangular, with 2 pairs of eyes, and generally a pair of jointed palps, and 2 or 3 antennae on the anterior margin (fig. 6.19a). Palps are absent in the genus *Hesione*. From 2 to 4 anterior segments are fused about the head such that 2 to 4 pairs of peristomial tentacles are present. Parapodia are primitively biramous and have reduced notopodia (fig. 6.19b). The notopodium is reduced to an aciculum and a few capillary setae, while the neuropodium is well developed and has jointed falcigers (fig. 6.19c).

Hesionids are active worms capable of rapid movements. They occur both as free-living species and commensals. One can usually find them under rocks, in animal colonies, or in the starfish *Heliaster kubinijii* (Day, 1967).

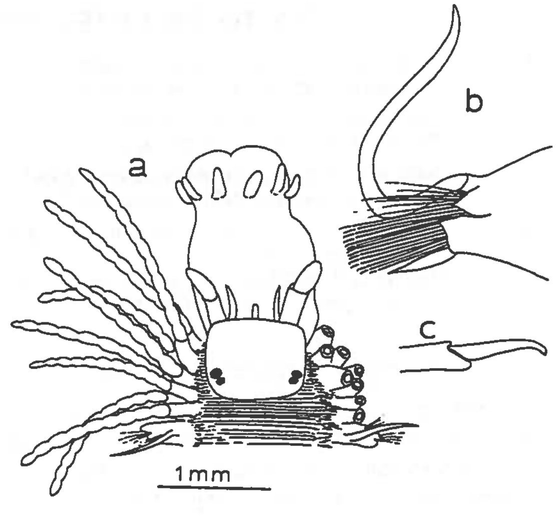

Fig. 6.19 (*right*) Hesionidae. (a) Head of *Gyptis* sp. 1. (b) Parapodium of *Gyptis* sp. 1, anterior view. (c) Jointed falciger of *Gyptis* sp. 1.

KEY TO SELECTED GENERA OF HESIONIDS

1 Eight pairs of peristomial tentacles present; jointed palps present or absent; two or three prostomial antennae 2
-Six pairs of peristomial tentacles; jointed palps present; three prostomial antennae .... ***Ophiodromus***

2(1) Palps present; three prostomial antennae .... ***Gyptis***
-Palps absent; two prostomial antennae .... ***Hesione***

Gyptis species 1

A small species, 5 to 23 mm long, 1 to 4 mm wide, with 30 to 40 setigers. Color in life is dark brown. The proboscis lacks jaws and is equipped with a circlet of papillae (fig. 6.19a). Parapodial cirri are smooth (fig. 6.19b). Neurosetae are unidentate, jointed falcigers (fig. 6.19c). This species is commonly associated with colonial tube worms under rocks, along the Sonoran coast, and is the first report of the genus from the Gulf (Day, 1967).

Hesione intertexta Grube

A species up to 50 mm long, 7 mm wide, with 16 parapodial segments. Color in life brownish to fleshy-pink with small dark spots scattered over the entire body. Notopodia reduced to dorsal cirri. Neurosetae are slightly bidentate. This species is common under rocks in the Gulf and is also known from the Philippines. Gravid individuals can be collected in June and July (Hartman, 1940).

Ophiodromus pugettensis (Johnson)

This species was called *Ophiodromus* sp. (Kudenov, 1973: 102). The body is 20 to 45 mm long, 3 to 5 mm wide, with 40 to 68 segments. The color is dark reddish-brown anteriorly and brick-red posteriorly. The neurosetae are jointed, bidentate falcigers. The species is known to be free living but has only been collected from the ambulacral grooves of the sun star *Heliaster kubinijii*, at Puerto Peñasco (Hartman, 1940, 1968).

FAMILY SYLLIDAE

Small and slender worms. The prostomium has 1 to 3 antennae, a pair of flat palps, and usually 2 pairs of eyes (fig. 6.20a). One or 2 pairs of peristomial tentacles are present. The proboscis has a chitinous pharynx with a median tooth or several terminal teeth, followed by a muscular, cylindrical gizzard (proventriculus) that consists of radial muscles. Parapodia each have a single bundle of setae and 1 or 2 acicula (fig. 6.20b). Dorsal cirri are present; ventral cirri may be absent. Cirri may be beaded or smooth to wrinkled, and may be cirriform, papilliform, or flask-shaped. Setae include simple bristles, hooks formed by the loss of a jointed appendage, and jointed falcigers and spinigers (fig. 6.20c).

Four subfamilies are recognized by the presence or absence of ventral cirri, the degree to which palps are fused along their inner margins (fig. 6.20e), and the presence of beaded or wrinkled dorsal cirri. It is necessary to examine most syllids under high magnification because they are generally less than 20 mm long. Important reviews are those of Imajima (1966a, 1966b, 1966c, 1966d, 1966e, 1967).

There is an alternation of sexual swimming and asexual crawling stages in many syllids. This is particularly true for autolytids. The crawling stage produces a stolon in posterior segments. The stolon may represent a linear series of small individuals in which heads, eyes, and tails are apparent. The individuals break off the stolon and become planktonic or free-swimming. Female buds are called a Saccocirrus and lack antennae and palps; male buds are called a Polybostrichus and have antennae and palps. These names were applied to these individuals before the reproductive cycle was fully understood and are now used as nouns. Syllid reproductive biology is rather interesting because of the diverse habits involved. A detailed review is available in Schroeder and Hermans (1975); introductions will be found in Pettibone (1963), Dales (1967), and Day (1967).

Syllids are far more abundant in the Sea of Cortez than the records indicate (9 species were reported in 1968). They occur in animal associations (i.e. sponges, ascidians, hydroids, bryozoa, other polychaetes), algal mats, and the upper layers of silty sediments.

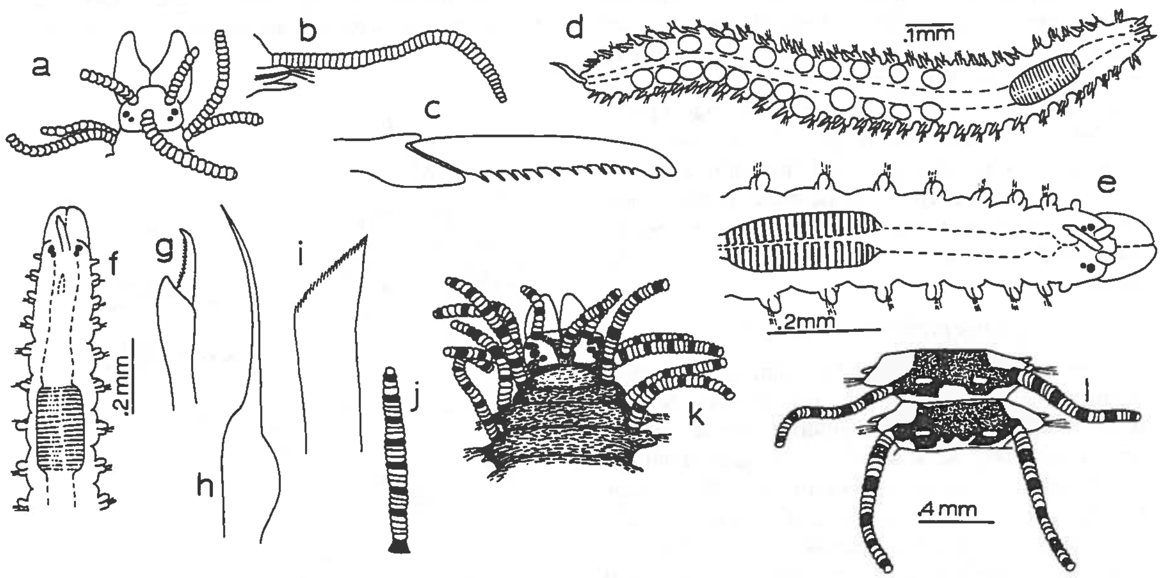

Fig. 6.20 Syllidae. (a) Head of *Typosyllis*. (b) Parapodium of *Typosyllis*, anterior view. (c) Jointed falciger of *Brania* sp 1. (d) Entire worm, *Brania* sp. 1. (e) Head of *Exogone* near *lourei*. (f) Head of *Spermosyllis* sp. 1. (g) Jointed falciger of *Spermosyllis* sp. 1. (h) Falsely jointed spiniger of *Spermosyllis* sp 1. (i) Spine of *Spermosyllis* sp. 1. (j) Dorsal cirrus of *Typosyllis* sp. 1. (k) Head of *Typosyllis* sp. 1. (l) Posterior segments of *Typosyllis* sp. 1.

KEY TO THE SUBFAMILIES OF THE SYLLIDS (from Imajima, 1966a)

1 Ventral cirri absent .... **Autolytinae**
-Ventral cirri present **2**

2(1) Body small, usually around 5 mm long; palps completely fused along their inner margin (fig. 6.20d) .... **Exogoninae**
-Body generally longer than 10 mm; palps completely free or only partially fused just in front of the prostomium (fig. 6.20a) **3**

3(2) Dorsal cirri appear as beads on a string .... **Syllinae**
-Dorsal cirri smooth or wrinkled; beading may be poorly defined .... **Eusyllinae**

KEY TO SELECTED GENERA OF EXOGONINS

1 One pair of peristomial tentacles present **2**
-Two pairs of peristomial tentacles present .... ***Brania***

2(1) Three prostomial antennae present .... ***Exogone***
-One prostomial antenna present .... ***Spermosyllis***

Brania species 1

A small species, 2 mm long, for 29 segments. The body is smooth. The gizzard is located between segments 3 and 7. The most predominant setal type is a long appendaged, bidentate jointed falciger (fig. 6.20c), each with about 20 processes on the cutting margin. Egg capsules are attached to the body (fig. 6.20d). Abundant in algal mats upon coquina platforms at Puerto Peñasco and Bahía Tepoca (Imajima, 1966a).

Exogone near *lourei* Berkeley and Berkeley

A small species, 7 mm long. The palps are fused and bluntly conical (fig. 6.20e). Peristomial tentacles are easily visible in dorsal view. Dorsal and ventral cirri resemble blunt papillae and are present in all parapodia. The setae are similar to *E. lourei* except that superior jointed spinigers and inferior jointed, unidentate falcigers occur in all segments, and that simple inferior spines are absent from posterior segments. *Exogone* near *lourei* is abundant in the intertidal algal mats on the boulders 2 km north of the estero at Punto Sargento, Sonora (Hartman, 1968).

Spermosyllis species 1

The body is 4 mm long and 0.2 mm wide. A single median antenna is present on the prostomium (fig. 6.20f). The dorsal cirri are papilliform; the ventral cirri are finger-shaped. Setae are of 3 kinds: jointed unidentate falcigers in anterior segments (fig. 6.20g); falsely jointed spinigers in all parapodia (fig. 6.20h); simple heavy spines in posterior parapodia (fig. 6.20i). This species was collected from low intertidal, sandy algal mats at Puerto Lobos, and is the first record of the genus in the Gulf (Day, 1967).

Typosyllis hyalina (Grube)

The body is 30 mm long and colored white in life. The median antenna is inserted on the center of the prostomium and has 12 beads. Long and short dorsal cirri alternate with one another. Short cirri with 6 beads; long cirri with 12. All setae are bidentate jointed falcigers. *T. hyalina* is a cosmopolitan species reported from intertidal algal mats, sponges, and clams. It is reported from La Paz and is commonly encountered along the Sonoran coast (Rioja, 1947a; Hartman, 1968).

Typosyllis species 1

The body is 15 mm long, 1 mm wide, and has 75 segments. All head and parapodial appendages have around 30 beads, with very characteristic pigmentation: two black beads alternate with every 3 or 4 white ones all along the appendage (fig. 6.20j). A fleshy flap is located behind the head (fig. 6.20k). The pigment pattern in preserved worms is slate gray on the anterior dorsal surface, and banded on posterior segments (fig. 6.20l). This species is common in sandy low intertidal algal mats along the Sonoran coast and on Isla Tiburón (Hartman, 1968).

FAMILY NEREIDAE

The body is elongate and cylindrical. The prostomium has 2 pairs of eyes, a pair of jointed palps, and usually a pair of frontal antennae (fig. 6.21a). The peristomium has 4 pairs of tentacles. The proboscis is equipped with a pair of serrated jaws; paragnaths are generally present. The first 2 segments with setae are uniramous; they are biramous thereafter (fig. 6.21b). The setae are simple or jointed. Jointed

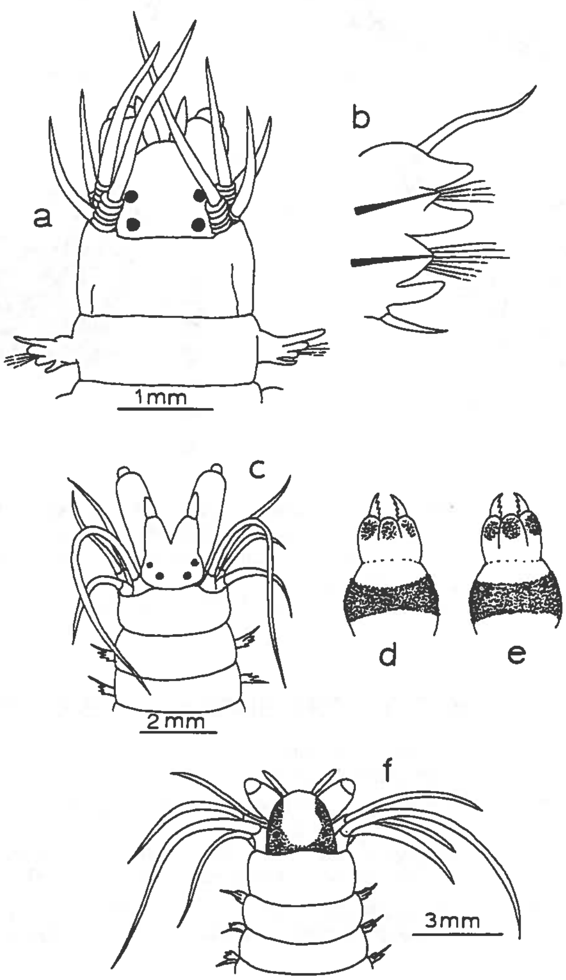

Fig. 6.21 Nereidae. (a) Head of *Perinereis* sp. 1. (b) Middle parapodium of *Platynereis dumerilii*. (c) Head of *Ceratonereis mirabilis*. (d, e) Proboscis of *Neanthes caudata*. (f) Head of *Platynereis bicanaliculata*.

setae include ordinary falcigers and spinigers plus even (homogomph) and uneven (heterogomph) hinged falcigers and spinigers.

Nereids inhabit rocky crevices, algae, sandflats, and are also associated with other animals. Members of this family undergo a remarkable morphological change as they begin to develop sexually. The tissues are enzymatically broken down and reconstructed. The end result is a heteronereis that is well adapted for swimming. At night heteronereids actively swim at the water's surface and spawn their gametes. The heteronereid usually dies after spawning (Schroeder and Hermans, 1975). One can watch this spectacular behavior from a dark pier at night by shining a bright light into the water.

KEY TO SELECTED GENERA OF NEREIDS

1	Paragnaths as cones	2
	-Paragnaths include cones plus transverse bars on group VI	***Perinereis***
	-Paragnaths as pectinate processes	***Platynereis***
2(1)	Paragnaths present on the oral and maxillary rings	3
	-Paragnaths present only on maxillary ring	***Ceratonereis***
3(2)	Notopodial falcigers present	***Nereis***
	-Notopodial falcigers absent	***Neanthes***

Ceratonereis mirabilis Kinberg

The body is about 30 mm long, with 50 segments. The prostomium has a characteristic median notch (fig. 6.21c). The maxillary ring has paragnaths in the following regions: I = 1; II = 7–8 cones; III = a patch of cones; IV = numerous small cones. Notopodia lack homogomph falcigers.

This species is common throughout the Gulf, where it is associated with algal mats. *C. mirabilis* occurs on both sides of tropical America (Hartman, 1968).

Neanthes caudata (delle Chiaje)

The body is 50 mm long and 3 mm wide, with 65 segments. The prostomium has 4 very large eyes. The maxillary and oral rings are characteristically encompassed by a dense, continuous band of paragnaths (fig. 6.21d, e). This species is reported from temperate seas and occurs at Puerto Peñasco (Kudenov, 1975a).

Nereis zonata Malmgren

The body is around 50 mm long with 75 segments. The prostomium is longer than wide. The proboscis has conical paragnaths as follows: I = 0–1; II = 2 or 3 rows; III = small transverse group; IV = oval patch; V = 0; VI = 6–10; VII and VIII = 2 bands of cones with 1 row of large cones nearest the maxillary ring and 1 row of smaller more numerous cones nearest the mouth. Posterior notopodial lobes not prolonged. This species is known from the central Gulf and from the southern Sonoran coast in rocky intertidal zones (Hartman, 1940, 1968).

Platynereis bicanaliculata (Baird)

The body is 70 mm long, 3 to 5 mm wide, with 100 segments. The prostomium is characteristically pigmented along the posterior margin (fig. 6.21f). Paragnaths are absent on regions I, II, and V; area III = elliptical patch of cones; IV = 7–10 rows of cones; VI = 2–3 rows of pectinate paragnaths; VII and VIII = 5 rows of pectinate and 2 lateral rows of conical paragnaths. Simple falcigers are present in the notopodia. This species occurs along the western coast of North America and is common in intertidal zones to 458 m in the Gulf (Fauchald, 1972).

Platynereis dumerilii (Audouin and M. Edwards)

The body is 60 mm long, 3 to 5 mm wide, with up to 95 segments. Posterior parapodia have typically prolonged notopodial lobes (fig. 6.21b). This is a cosmopolitan species previously unreported from the Gulf, where it was collected in shallow subtidal depths at Isla Tiburón (Hartman, 1968).

Perinereis species 1

The body is 68 mm long, 2 mm wide, with 105 segments. Anterior segments are about as long as wide (fig. 6.21a). The longest peristomial tentacle extends to setiger 2. Proboscis with paragnaths as follows: I = 4; II = 10; III = 20; IV = 17; V = 1; VI = 1 bar; VII and VIII = single row of 4 widely spaced cones. The superior notopodial lobe is prolonged in posterior segments (fig. 6.21d). Notosetae as homogomph spinigers; neurosetae include heterogomph spinigers and falcigers. This species was collected from the low intertidal sandflats south of the Seri Indian village at Punta Chueca (Hartman, 1968).

FAMILY NEPHTYIDAE

Worms with long rectangular bodies that are usually white in life. The prostomium is circular to hexagonal in outline (fig. 6.22a), with 4 to 6 antennae and sometimes a pair of deeply embedded eyes. The proboscis is muscular and has a pair of small conical jaws, terminal and subterminal papillae. The parapodia are biramous (fig. 6.8b). Each lobe of the parapodium is divided into 3 parts: the acicular lobe; preacicular (= presetal) lobe; and the postacicular (= postsetal) lobe. An interramal gill is present at the lower edge of the notopodium. The setae are simple, and there are two fascicles per parapodial lobe: a preacicular and a postacicular fascicle.

The shape of the 3 parapodial lobes, the prostomium, proboscis, and the segment from which the gills begin are important features in nephtyid systematics. Preacicular setae are barred (fig. 6.22b), and postacicular setae are toothed to varying degrees (fig. 6.22c).

Nephtyids are typical inhabitants of sandflats such as those found throughout the northern Sea of Cortez. They are active burrowers and swimmers and have characteristic sinusoidal movements (fig. 6.22d).

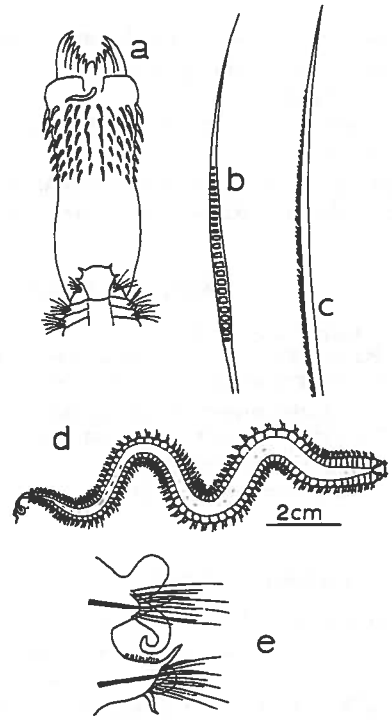

Fig. 6.22 (*right*) Nephtyidae. (a) Anterior segments of *Nephtys*. (b) Preacicular seta. (c) Postacicular seta. (d) Entire worm, *Nephtys* (modified from McIntosh, 1908). (e) Parapodium of *Aglaophamus dicirris*.

KEY TO SELECTED GENERA OF NEPHTYIDS

1 The gills are recurved inward, toward body .... ***Aglaophamus***
-The gills are recurved away from body .... ***Nephtys***

Aglaophamus dicirris Hartman

The body is around 40 mm long. Interramal gills begin from setiger 5. A cirrus is present on the upper edge of the neuropodium from setiger 14 to the end of the body (fig. 6.22e). This species is common in the Gulf and occurs on both sides of the Americas (Hartman, 1950).

Nephtys bilobatus Kudenov

This species was originally called *Nephtys* sp. (Kudenov, 1973: 106). The body is 100 mm long, 4 mm wide, and has over 120 segments. Gills begin from setiger 4. The upper edge of the neuropodium has a bilobed process from setigers 4 to 30. This species is known from sandflats in the northern Gulf (Kudenov, 1975a).

Nephtys magellanica Augener

The body is 40 mm long, 2 mm wide, and has 70 segments. Segment 1 is typically longer than any other segment. Gills are present from setiger 3. This species is distributed from the Straits of Magellan to southern California; it is common in the Gulf (Hartman, 1940; 1950).

Nephtys panamensis Monro

The body is 40 mm long and has 65 segments. The body has dark dorsal pigment bands and a midventral longitudinal stripe. Gills are present from segment 3. *N. panamensis* occurs in intertidal zones to depths of 97 meters in the Gulf and Panama (Hartman, 1940).

Nephtys singularis Hartman

The body is 40 mm long, and has 110 segments. Conspicuous postsetal lobes are present in middle body segments. Gills are present from setiger 4. The upper edge of setigers 4–30 have a single cirrus. This species is known from the northern and southern Gulf, and Guatamala (Hartman, 1950; Kudenov, 1975a).

Nephtys squamosa Ehlers

The body is 50 mm long, 3 mm wide, and has 117 segments. Gills are present from setiger 4 and nearly form complete loops by setiger 25. The dorsal surface has two, dorsolateral lobes per segment. These flat lobes make the species look very much like a scaleworm. This species is common throughout the Gulf and is distributed on both sides of the Americas as well as West Africa (Fauchald, 1972).

FAMILY SPHAERODORIDAE

A family of small worms. The body is covered with papillae and has few segments (fig. 6.23). The prostomium has 2 to 4 antennae. The proboscis lacks jaws but has a gizzard (proventriculus). The setae are jointed. The family is reviewed by Fauchald (1974a).

Sphaerodoridium species 1

A very small species, 2 mm long and 0.3 mm wide, with about 20 segments (fig. 6.23). Each segment has a dorsal transverse row of 8 to 10 large tubercles. This species was collected from the sandy algal mats in the low intertidal zone of Bahía Tepoca, Sonora (Fauchald, 1974a).

FAMILY GLYCERIDAE

The body is long, cylindrical, and tapered at both ends. The prostomium is conical, ringed, and has 4 distal antennae (fig. 6.4a). The proboscis has 4 black terminal jaws; each jaw has a lateral jaw support (aileron). There are also papillae strewn over the proboscis. Parapodia are either biramous or uniramous and have 1 or 2 presetal and postsetal lobes.

There are three genera in this family. Two are fairly common. The genus *Hemipodus* has uniramous parapodia; and the genus *Glycera* has biramous parapodia and more than 3 rings in the prostomium. Hartman (1940, 1950) provides useful information on the taxonomy of this family.

Glycerids are predatory, burrowing worms usually found in sandy and silty sediments. They are common in the northern Gulf.

Glycera americana Leidy

The body is up to 350 mm long, 13 mm wide, and has 300 biannulate segments. The prostomium has 8 to 10 rings. Parapodia have 2 pre- and 2 postsetal lobes of about equal size (fig. 6.24a). Branched, retractile gills present from setigers 14 to 18. This species occurs on both sides of the Americas and also occurs in New Zealand and Australia. It is common in the Gulf of California (Hartman, 1950) and can be found in sand among basalt boulders at Station Beach, Puerto Peñasco.

Glycera dibranchiata Ehlers

The body is up to 240 mm long, 8 mm wide, and has over 300 segments. The prostomium has 12–13 rings. The parapodia have 2 presetal and 2 postsetal lobes, with the upper presetal one the shortest. Two nonretractile gills are present per parapodium, with one gill on the upper and another gill on the lower edge of the parapodium (fig. 6.24b). This species is distributed on both sides of the Americas. It is common at El Golfo de Santa Clara and at Mazatlán (Hartman, 1940, 1950).

Glycera tesselata Grube

The body is 25 mm long and about 2 mm wide, with 100 segments. The prostomium has 12 to 14 rings and a pair of eyes. Parapodia with 2 presetal and 2 postsetal lobes (fig. 6.24c). Gills are absent. This is a circumtropical species commonly found in the Sea of Cortez (Hartman, 1950).

FAMILY GONIADIDAE

The body is long, cylindrical, and tapered at both ends. The prostomium is ringed, has 4 terminal antennae and a pair of eyes in the ring closest to the mouth. The proboscis has 2 large, terminal jaws (macrognaths) and a dorsal and/or ventral arc of smaller teeth (micrognaths); the surface of the proboscis has papillae and at the base may be black V-shaped bars called chevrons (fig. 6.25). The parapodia are uniramous anteriorly and biramous posteriorly. Sometimes the transition between the parapodia is abrupt, conveying the impression of 2 body regions; or it is gradual, in which case 3 body regions seem evident. Setae include capillaries and jointed falcigers and spinigers.

Goniadids occupy a similar role as glycerids, in that they are raptorial and often found in muddy sediments.

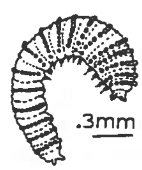

Fig. 6.23 Sphaerodoridae. Entire worm, *Sphaerodoridium* sp. 1.

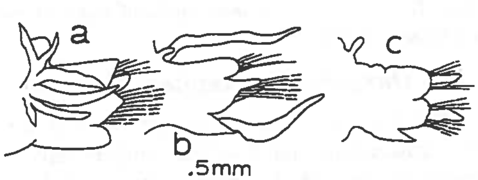

Fig. 6.24 Glyceridae. (a) Parapodium of *Glycera americana*. (b) Parapodium of *Glycera dibranchiata*. (c) Parapodium of *Glycera tesselata*.

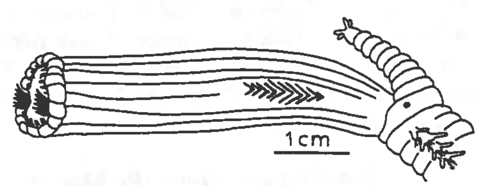

Fig. 6.25 Goniadidae. Head of *Glycinde* (modified from Hartman, 1950).

KEY TO SELECTED GENERA OF GONIADIDS

1	Black V-shaped sergeant's stripes (chevrons) present at base of proboscis; body divided into two regions	***Goniada***
	-Black V-shaped stripes absent; body divided into three regions	***Glycinde***

Glycinde armigera Moore

The body is up to 66 mm long with up to 144 segments. The prostomium has 8 to 9 rings. Three kinds of proboscideal processes are present. A pair of large terminal jaws and a dorsal arc of teeth present; a ventral arc is absent. The body has uniramous parapodia from setigers 1 to 30; transitional parapodia from setigers 31 to 60; biramous parapodia from setiger 61. The presetal notopodial lobes are heart-shaped. This species is distributed from Panama northward to southern California. It inhabits intertidal mudflats and has been taken at a depth of 1220 meters in Sal si Puedes basin (Reish, 1968; Fauchald, 1972).

Goniada littorea Hartman

The body is 70 mm long, less than 2 mm wide, and has 175 segments. The body is characteristically pigmented with 3 longitudinal rows of dark spots on both the dorsal and ventral surfaces. The prostomium has 8 to 9 rings. The transition between body regions occurs between setigers 36 to 44. This species occurs in low intertidal mudflats in southern California and is reported from Bahía de los Angeles (Reish, 1968; Hartman, 1968).

FAMILY ONUPHIDAE

The body is long and cylindrical. The prostomium has a pair of globular palps, 2 frontal antennae, and 5 occipital antennae with ringed ceratophores (fig. 6.26a). The peristomium lacks parapodia and has a pair of small tentacles, generally. Anterior setigers have conical ventral cirri which become padlike after setiger 5. Gills are simple filaments to elaborate spirals (fig. 6.26b). Parapodia are uniramous. Both simple and jointed setae are present. All onuphids are tube-dwellers.

Onuphids are thought to be scavengers that consume dead animals. These worms inhabit tough durable tubes to which shell fragments, sediment, and algae are attached. Onuphids are abundant in the northern Gulf. This family is best represented in very deep water (Hartman, 1944a; Fauchald, 1968).

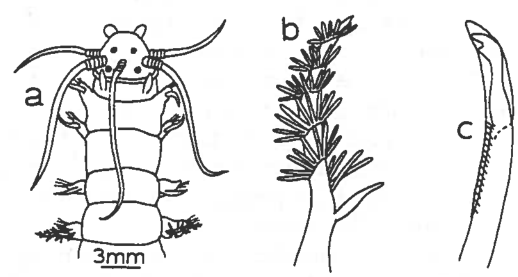

Fig. 6.26 Onuphidae. (a) Head of *Diopatra*. (b) Spiraled gill of *Diopatra*. (c) Hooded hook of *Diopatra splendidissima*.

KEY TO SELECTED GENERA OF ONUPHIDS

1	Peristomial tentacles present	2
	-Peristomial tentacles absent	***Hyalinoecia***
2(1)	Gills spiraled	***Diopatra***
	-Gills comb-shaped	***Onuphis***

Diopatra splendidissima Kinberg

Gills begin on setigers 4 or 5, and are strongly spiraled (fig. 6.26b). Ventral cirri are conical on setigers 1 through 4, and padlike thereafter. Can-opener-shaped bidentate, hooded hooks are present in anterior setigers (fig. 6.26c). This species is distributed from Ecuador northwards to southern California. It is common in the Gulf (Fauchald, 1968; Kudenov, 1975a).

Hyalinoecia juvenalis Moore

A small species, 20 mm long, less than 2 mm wide, with 35 segments. Simple gill filaments are present from setiger 19. Anterior hooded hooks are bidentate. The tube is glossy and transparent (hyaline). This species is common in shallow subtidal depths throughout the Gulf. It also occurs on both sides of tropical America (Fauchald, 1968).

Onuphis microcephala Hartman

The body is 120 mm long and has 250 segments. The prostomium and first few setigers have 5 to 6 reddish-brown, dorsal transverse stripes. Tubes are 40 cm long and 15 mm wide and are covered with fine white sand grains and pieces of shell. This species is common in low intertidal sandflats of Bahía Cholla. It is known also from southern California and the Gulf of Mexico (Fauchald, 1968).

FAMILY EUNICIDAE

The body is long and cylindrical. The prostomium has two cushionlike palps and 1, 3, or 5 antennae without ceratophores (fig. 6.27a). There are generally two anterior segments without parapodia, the second of which has a pair of dorsolateral tentacles. Gills are simple to comb-shaped (fig. 6.27b). Setae include simple and jointed falcigers and spinigers. An important feature is the color of the acicula (black or yellow) and the distribution of simple hooks located inferior to the acicula. The latter are called subacicular hooks (fig. 6.27b).

Eunicids have diversified into a variety of rocky, algal, and sandy habitats. All types of macrophagy occur in this family. Also found are the so-called palolo worms that swim to the water's surface to reproduce at precise times of the year (Fauchald, 1970).

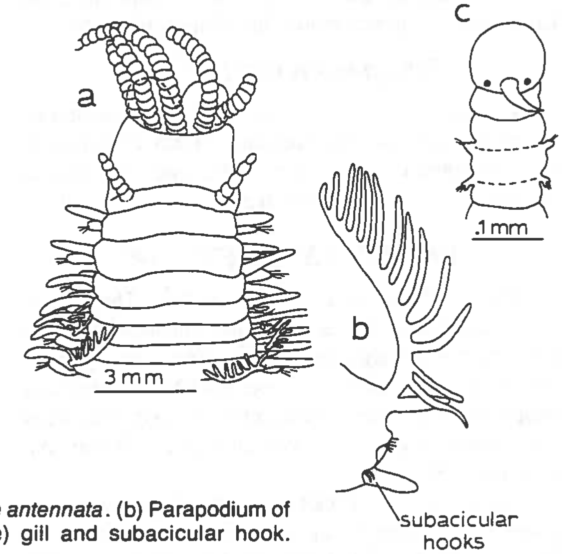

Fig. 6.27 (*right*). Eunicidae. (a) Head of *Eunice antennata*. (b) Parapodium of *Eunice* showing a comb-shaped (pectinate) gill and subacicular hook. (c) Head of *Nematonereis*.

KEY TO SELECTED GENERA OF EUNICIDS

1	Five antennae present	2
	-One antenna present	***Nematonereis***
2(1)	Peristomial tentacles present	3
	-Peristomial tentacles absent	***Marphysa***
3(2)	Gills first present on anterior segments	***Eunice***
	-Gills first present on posterior segments	***Palola***

Eunice antennata (Savigny)

The body is up to 100 mm long, and from 3 to 6 mm wide, with 130 segments. In life it is red and white, with middorsal spots on each segment. The prostomial antennae and peristomial tentacles appear beaded. Gills begin from setigers 4 to 6. Yellow acicula are present; subacicular hooks are trifid and begin from setigers 15 to 24. This species is ubiquitous in shallow warm water regions of the world and rather common in the Gulf (Fauchald, 1970).

Eunice aphroditois (Pallas)

The body is up to 200 mm long and 10 mm wide, with over 150 segments. Occipital antennae are short, with the median antenna having 7 beads. Acicula and subacicular hooks black and bidentate. The latter begin from setiger 35. Gills begin from setiger 6 or 7, and are comb-shaped with 40 branches per gill by setigers 20 to 22. *E. aphroditois* is a circumtropical species commonly encountered in the Gulf (Fauchald, 1970).

Eunice sonorae Fauchald

A large species, 345 mm long, 12 mm wide, with about 600 segments. Setiger 4 has a broad, white dorsal transverse bar. Other anterior segments are reddish. This species is known from Sonora in rocky intertidal zones (Fauchald, 1970; Kudenov, 1975a).

Marphysa sanguinea (Montagu)

The body is 220 mm long, 8 mm wide, and has 150 segments. In life the body is light pink to blood red. Gills begin from segment 30. Acicula and bidentate subacicular hooks are black. All jointed setae are spinigerous. This is a circumtropical species that is fairly common in intertidal mudflats in the Sea of Cortez (Fauchald, 1970).

Nematonereis unicornis (Grube)

The body is small, less than 30 mm long, and slender. The head has a single median antenna (fig. 6.27c). The maxillary formula is Mx I = 1 + 1; Mx II = 4 + 5; Mx III = 4 + 0; Mx IV = 4 + 6. This species is widespread in temperate and tropical seas and is reported from Bahía de los Angeles and collected from Isla Tiburón (Reish, 1968; Fauchald, 1970).

Palola paloloides (Moore)

A large species. The prostomium is bilobed, and 5 short, smooth antennae are present. Gills are absent from the first 100 to 150 segments. Right maxilla II has

2 large teeth plus a distal tooth. This species occurs in western Mexico and southern California in rocky habitats. It is common in the Gulf (Fauchald, 1970).

Palola siciliensis (Grube)

This species is almost identical to *Palola paloloides* except that right maxilla II has only 2 teeth. *P. siciliensis* is a circumtropical species recorded from the Sonoran coast in granitic rocky intertidal zones (Fauchald, 1970).

FAMILY LYSARETIDAE

Worms with long, cylindrical bodies. The prostomium lacks palps and has three small antennae along the posterior dorsal margin that may be hidden by a peristomial fold (fig. 6.28a). All segments have uniramous parapodia, with characteristic pre- and postsetal lobes and straplike dorsal cirri. Ventral cirri are absent. All setae are simple.

Lysaretids are basically a tropical family, represented in the Gulf by at least one species along the Sonoran coast where it occurs in sand among intertidal boulders (Fauchald, 1970).

Oenone fulgida (Savigny)

The body is up to 350 mm long. In life it is a brilliant reddish-orange. Bidentate subacicular hooks begin from setigers 14 to 24. Anterior parapodia have truncate presetal lobes and leaf-shaped postsetal lobes (fig. 6.28b); median and posterior parapodia with finger-shaped postsetal lobes. This is a circumtropical species, reported also from Japan. It occurs along the eastern coast of the Vermilion Sea (Fauchald, 1970).

FAMILY LUMBRINERIDAE

Polychaetes with long and narrowly cylindrical bodies. The prostomium generally lacks appendages and eyes; it is rounded to conically shaped (fig. 6.29a). Two anterior segments lack parapodia; the parapodia of other segments are uniramous (fig. 6.29b). Dorsal cirri are rudimentary, and ventral cirri are absent. Presetal and postsetal lobes are present. Simple capillaries and simple or jointed hooded hooks are present.

The following features are important: the presence of yellow or black acicula; development of pre- and postsetal lobes; dentation on Mx III and IV; and the distribution of hooks. Fauchald (1970) provides an excellent treatment of this family, reviewing all species known to that year. These worms are common throughout the Gulf and occur in sandflats, algae, and rocky intertidal habitats.

Lumbrineris erecta (Moore)

The body is 70 mm long, 1.5 mm wide, and has more than 130 segments. The prostomium is globular and midventrally grooved. Yellow acicula are present, and jointed hooks are absent. Simple hooded hooks begin from setiger 18. The postsetal lobes of posterior segments are prolonged. This species occurs in shallow waters throughout western Mexico (Fauchald, 1970).

Lumbrineris inflata Moore

A large species, 300 mm long, 5 mm wide, with over 300 uniannulate segments. Color in life is iridescent bronze to brown with dorsal transverse bands of dark pigment. The prostomium is rounded. Yellow acicula are present, and jointed hooks begin at setiger 1. Mx III = 3 + 3; Mx IV = 2 + 2. Postsetal lobes of posterior segments are prolonged. This species occurs in shallow waters throughout western Mexico (Fauchald, 1970).

Lumbrineris latreilli Audouin and M. Edwards

The body is about 100 mm long, 2 to 3 mm wide, and has about 100 segments. The body is reddish-brown in life. The prostomium is conical. Yellow acicula are present, and jointed hooded hooks begin from setiger 1. Mx III = 2 + 2; Mx IV = 1 + 1. Postsetal parapodial

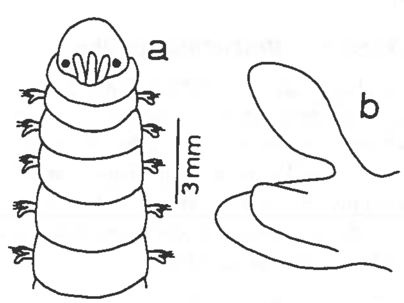

Fig. 6.28 Lysaretidae. (a) Head segments of *Oenone fulgida*. (b) Anterior parapodium of *Oenone fulgida* (modified from Fauchald, 1970).

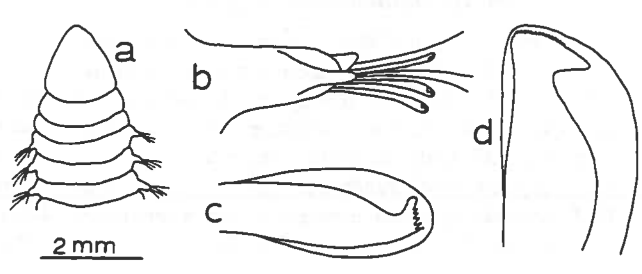

Fig. 6.29 Lumbrineridae. (a) Head of *Lumbrineris*. (b) Parapodium of *Lumbrineris*. (c) Hooded posterior hook of *Lumbrineris tetraura*. (d) Hooded posterior hook of *Lumbrineris zonata*. (Parts c and d modified from Fauchald, 1970.)

lobes are not prolonged. This species, as defined by Fauchald (1970), is distributed from southern California to western Mexico and the Gulf, where it occurs in intertidal and shallow water sediments.

Lumbrineris tetraura (Schmarda)

A large species, 150 mm long, with about 250 segments. The prostomium is broadly conical. Yellow acicula are present, and jointed hooks are absent. The postsetal lobes of posterior segments are prolonged. Posterior hooded hooks have a main fang and 5 smaller teeth in the crest (fig. 6.29c). This species may be distributed from Chile to southern California. It is found in rocky intertidal sediments along the Sonoran coast (Fauchald, 1970).

Lumbrineris zonata (Johnson)

The body may be 200 mm long with more than 200 segments. In life, it is reddish-orange to iridescent brown. The prostomium is bluntly conical. Yellow acicula are present, and jointed hooks are absent. Simple hooks are present from setiger 1. The postsetal lobes are not prolonged. Posterior hooks have a main fang with more than 15 smaller teeth in a single row (fig. 6.29d). This species occurs along the Pacific coast of North America and, in the northern Gulf, in intertidal sediments (Fauchald, 1970).

FAMILY ARABELLIDAE

Worms with long, cylindrical bodies. The prostomium is conical to rounded, and generally has eyes; appendages are absent (fig. 6.30a). Two anterior segments lack parapodia. Parapodia are uniramous. Dorsal cirri are rudimentary, and ventral cirri are absent. All setae are winged capillaries (fig. 6.30b); hooded hooks are absent.

Arabellids superficially resemble lumbrinerids. They are, perhaps, more specialized than lumbrinerids because a number of arabellids are known to be parasitic as larvae (Hartman, 1944a; Fauchald, 1970; Pettibone, 1963).

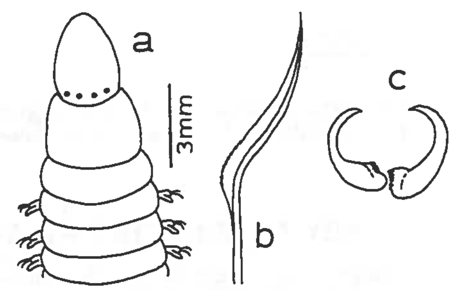

Fig. 6.30 Arabellidae. (a) Head of *Arabella iricolor*. (b) Winged capillary seta of *Arabella iricolor*. (c) Forceps (= Mx I) of *Drilonereis falcata*.

KEY TO SELECTED GENERA OF ARABELLIDS

1 Acicula penetrate acicular lobes .... ***Drilonereis***
-Acicula do not penetrate acicular lobes .... ***Arabella***

Arabella iricolor (Montagu)

The body may be up to 380 mm long, 5 mm wide, and have 300 segments. Most specimens from the northern Gulf are smaller. The prostomium is conical and has 4 eyes in a transverse row along the posterior border (fig. 6.30a). Parapodia have low presetal and conical postsetal lobes. It is common in the Gulf, where it occurs in intertidal sandflats along the eastern coast (Fauchald, 1970).

Drilonereis falcata Moore

This species is about 100 mm long, 1 mm wide, and has 200 segments. It is purplish-brown in life. The prostomium is oval and depressed. The basal portion of maxillae I is dentate (fig. 6.30c). The postsetal lobes of posterior parapodia are not prolonged. *D. falcata* is distributed from central California to western Mexico and is known from Topolobampo and Puerto Peñasco (Fauchald, 1970; Kudenov, 1975a).

FAMILY DORVILLEIDAE

Small worms with well developed appendages. The prostomium has a pair each of palps and antennae (fig. 6.31a). Two to four arcuate rows of maxillae are generally visible through the body wall. Each row has numerous toothed plates (fig. 6.31b). The first 2 segments lack parapodia and setae. Parapodia are uniramous (fig. 6.31c). Parapodial cirri may be well developed. Setae include capillaries, forked setae, and jointed falcigers (fig. 6.31d).

Dorvilleids are fairly common in the Gulf. They can readily be found in sand between rocks, coralline algae, and intertidal algal mats. An important review of the family was made by Jumars (1974).

Dorvillea species 1

A small species, known from an anterior fragment that is 12 mm long, 1.5 mm wide, and has 75 setigers. The prostomium is rounded, and the palps are flattened. The beaded antennae are about as long as the palps (fig. 6.31a). The peristomium is about as long as the first two setigers. Dorsal parapodial cirri are distally beaded; ventral cirri are blunt (fig. 6.31c). Capillary setae and bidentate jointed hooks (fig. 6.31d) are present; forked setae are absent. This species is known from Bahía San Francisco, Sonora, associated with the phyllodocid, *Genetyllis* species 1 (Jumars, 1974).

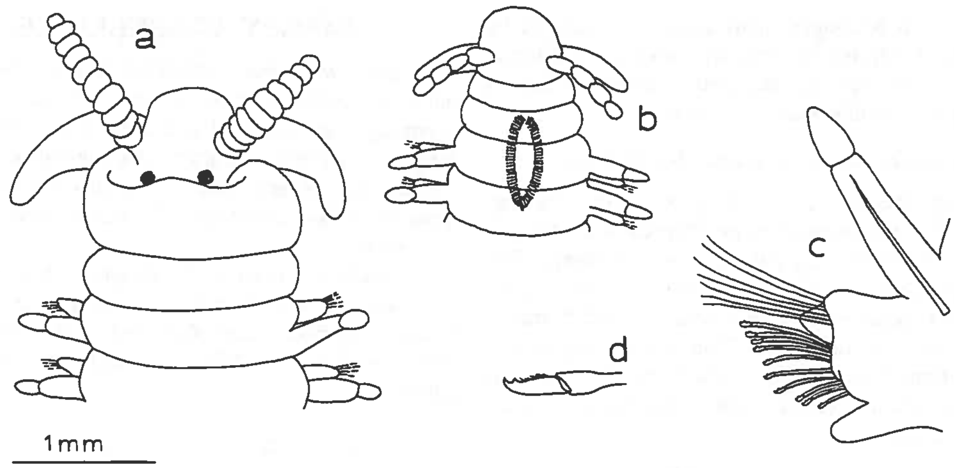

Fig. 6.31 Dorvilleidae. (a) Anterior segments of *Dorvillea* sp. 1. (b) Jaws found in dorvilleids. (c) Parapodium of *Dorvillea* sp. 1. (d) Bidentate jointed hook of *Dorvillea* sp. 1.

KEY TO SELECTED POLYCHAETE FAMILIES: SEDENTARIA

1	Changes in parapodia, setae and gills divide body into at least two regions (figs. 6.32a; 6.37a; 6.43a)	2
	-Body not divided into regions (fig. 6.41a)	16
2(1)	Simple thick spines present in setiger 4	**Chaetopteridae**
	-Simple thick spines absent from setiger 4	3
3(2)	Thoracic setae inverted in abdomen (setal inversion)	4
	-Thoracic setae not inverted in abdomen	5
4(3)	Tubes calcareous	**Serpulidae**
	-Tubes not calcareous	**Sabellidae**
5(3)	Notosetae present only on thorax (fig. 6.47a)	6
	-Notosetae present on thorax and abdomen (fig. 6.42d)	8
6(5)	Thoracic neurosetae as long spines (fig. 6.48b)	**Trichobranchidae**
	-Thoracic neurosetae as uncini (fig. 6.46b)	7
7(6)	Feeding tentacles located inside mouth (fig. 6.46a)	**Ampharetidae**
	-Feeding tentacles absent from mouth (present on collar about the head: fig. 6.47b)	**Terebellidae**
8(5)	Neurosetae as jointed falcigers (fig. 6.39c)	**Acrocirridae**
	-Neurosetae include simple falcigers	9
9(8)	A pair of palps present (fig. 6.35a)	10
	-Palps absent	13
10(9)	Prostomium spade-shaped; palps with papillae	**Magelonidae**
	-Prostomium rounded; palps grooved, lack papillae	11
11(10)	Caruncle present (fig. 6.36b)	12
	-Caruncle absent (fig. 6.38d)	**Cirratulidae**
12(11)	Hooded hooks present (fig. 6.34d)	**Spionidae**
	-Hooded hooks absent	**Poecilochaetidae**
13(9)	Dentate crested hooks present (fig. 6.42c)	14
	-Dentate crested hooks absent	15
14(13)	Hooks with hoods; body divided into two regions by parapodia	**Capitellidae**
	-Hooks without hoods; body divided into three regions by bushy gills	**Arenicolidae**
15(13)	Crenulate capillary setae present (fig. 6.32f); winged capillary setae absent	**Orbiniidae**
	-Crenulate capillary setae absent; winged capillary setae present (fig. 6.33b)	**Paraonidae**
16(1)	Notosetae with numerous joints (fig. 6.40c)	**Flabelligeridae**
	-Notosetae simple, not jointed	17

17(16) Gill filaments usually present above notopodia all along body; segments wider than long 18
-Gill filaments absent; segments longer than wide, appearing like bamboo canes 20

18(17) A midventral groove usually present; lateral eyespots may be present between midbody segments; palps absent .... **Opheliidae**
-A midventral groove absent; lateral eyespots absent; palps usually present 19

19(18) Caruncle present; hooded hooks present in neuropodia (fig. 6.34d) .... **Spionidae**
-Caruncle absent; hooks not hooded, usually present in neuropodia and notopodia (fig. 6.38f) .... **Cirratulidae**

20(17) Head with short, branching feeding processes (fig. 6.45b) .... **Oweniidae**
-Head without feeding processes (fig. 6.44e) .... **Maldanidae**

FAMILY ORBINIIDAE

The body is conspicuously divided into an anterior thorax and a posterior abdomen (fig. 6.32a). The prostomium is conical to truncate (fig. 6.32b); antennae are absent. The peristomium and sometimes the next segment lack setae. Parapodia are biramous. The notopodia have flat postsetal lobes (fig. 6.32c); neuropodia have collar-shaped postsetal lobes on the thorax. Notosetae and abdominal neurosetae are crenulate capillaries (fig. 6.32f). Thoracic neurosetae include acicular hooks (fig. 6.32d). Gills are simple filaments originating from the dorsal surface, between the parapodia, of thoracic and abdominal segments (fig. 6.32c).

Orbiniids are burrowing, deposit feeding polychaetes typically found in intertidal sand and mudflats. A review of the family was made by Hartman (1957).

KEY TO SELECTED GENERA OF ORBINIIDS

1 Prostomium blunt or square .... ***Naineris***
-Prostomium pointed and conical 2

2(1) Large spines in posterior thoacic neuropodia .... ***Phylo***
-Large spines absent from posterior thorax 3

3(2) Only crenulate capillaries in thoracic parapodia .... ***Haploscoloplos***
-Both crenulate capillaries and simple hooks present in thoracic parapodia .... ***Scoloplos***

Haploscoloplos ?fragilis (Verrill)

Known from an anterior fragment of 76 segments, which is about 20 mm long and 3 mm wide. The change from the thorax to abdomen is abrupt and occurs at segment 17. Gills are first present from segment 17. The postsetal lobes of thoracic parapodia are conspicuous. This identification is tentative because the specimen has finger-shaped notopodial and triangular neuropodial postsetal lobes. It otherwise agrees well with descriptions of *H. fragilis*, which has leaf-shaped lobes. *H. ?fragilis* occurs in the intertidal sandflats at Norse Beach (Hartman, 1957).

Naineris species 1

The body is short, 12 mm long, 1.5 mm wide, and has 80 setigers (fig. 6.32a). The prostomium is blunt (fig. 6.32b). The proboscis is branched. There are 13 thoracic setigers. Gills first present from setiger 13 and are well developed by setiger 14. Abdominal parapodia with a single postsetal notopodial and neuropodial lobe (fig. 6.32c). Hooks present in thoracic neuropodia (fig. 6.32d) and abdominal neuropodia (fig. 6.32e). Crenulate capillaries present in all fascicles (fig. 6.32f). This species was collected from a cobblestone beach 2 km north of Punto Sargento (Hartman, 1957).

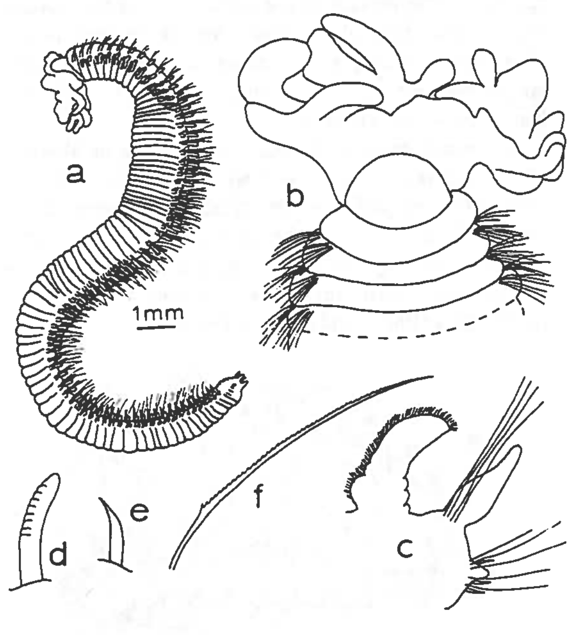

Fig. 6.32 Orbiniidae. *Naineris* sp. 1. (a) Entire worm. (b) Head and proboscis. (c) Parapodium. (d) Thoracic neurosetal hook. (e) Abdominal neurosetal hook. (f) Crenulate capillary seta.

Phylo felix Kinberg

The body is up to 120 mm long, 4 mm wide, with over 120 segments. Characteristic spines are present in the posterior thorax, as well as continuous ventral transverse rows of papillae. The thorax has 16 to 18 segments. This species is distributed on both sides of the Americas, and occurs at Bahía de los Angeles and in the intertidal sandflats at Punto Sargento, Sonora (Hartman, 1968).

Scoloplos ?chevalieri (Fauvel)

There are 21 to 22 thoracic segments. The gills are simple and not branched. The postsetal notopodial lobes are entire and not branched. Thoracic neuropodia have both crenulate capillaries and smooth hooks in a regular arrangement. *S. chevalieri* is known from west Africa, and the identification is considered doubtful because of the remoteness of the two localities. The present record is from Bahía Cholla (Hartman, 1957; Kudenov, 1975b).

FAMILY PARAONIDAE

Small, narrow worms, superficially resembling orbiniids. The prostomium is conical and has a pair of nuchal pits, a pair of eyes and sometimes a median antenna (fig. 6.33a). The peristomium is fused to the prostomium and is usually not visible dorsally. Parapodia are biramous and poorly developed. Smooth winged capillary setae present in the notopodia and neuropodia (fig. 6.33b). Specialized hooks may be present in the notopodia or neuropodia of abdominal segments. Gills are simple and begin from setigers 4 to 18, and may continue over the entire body.

Important features include the presence or absence of the median antenna, and whether hooks occur in abdominal notopodia or neuropodia. Paraonids occur commonly in the algal mats at Station Beach, Puerto Peñasco. Although no species are presented here, keys to genera and useful reviews will be found in Hartman (1957), Day (1967), and Strelzov (1972).

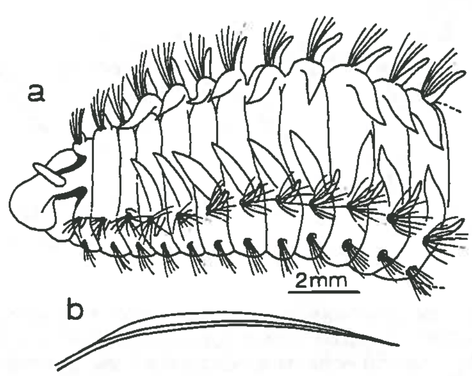

Fig. 6.33 Paraonidae. (a) Head of *Aricidea*. (b) Winged capillary seta.

FAMILY SPIONIDAE

Worms with flattened bodies (fig. 6.34a). The prostomium is rounded or pointed and may have lateral lobes which are not true antennae. A pair of long, ciliated palps is present on the peristomium. A caruncle is usually present. The parapodia are biramous (fig. 6.34b). Setae include winged capillaries, and hooded hooks (fig. 6.34d) in both the notopodia and neuropodia, and setiger 5 of the *Polydora* complex has thick spines. Gills are present on the dorsal surface, next to the notopodium; they may be fused to the postsetal notopodial lobes. The pygidium is terminal and variable in shape (fig. 6.34c; Rioja, 1943b). A revision of the genera was made by Blake and Kudenov (1978).

Spionids use their palps to gather food from the sediment or the water column. They occur in a variety of habitats, ranging from sandflats and oyster shells to wharf pilings and boat hulls. Spionid tubes form dense carpetlike mats in the high intertidal sandflats of Bahía Cholla. Spionids of the *Polydora-Boccardia* complex reproduce by depositing their eggs inside their tubes. The larvae hatch at the three-setiger stage and usually leave the tube to take up a swimming existence (Blake, 1969; Blake and Woodwick, 1972).

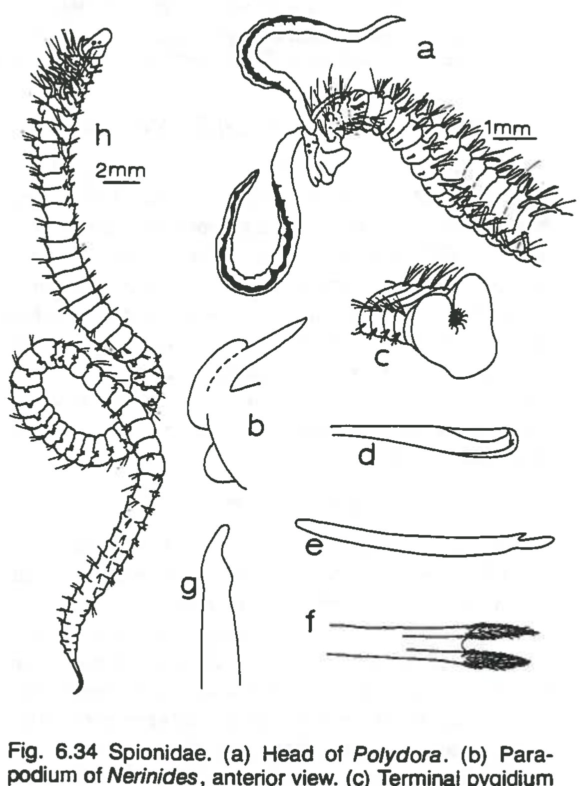

Fig. 6.34 Spionidae. (a) Head of *Polydora*. (b) Parapodium of *Nerinides*, anterior view. (c) Terminal pygidium of *Polydora*. (d) Hooded hook of *Malacoceros*. (e) Distally notched spine of *Polydora ligni*. (f) Brush top seta of setiger 5 from *Polydora ligni*. (g) Distally excavate spine of *Polydora socialis*. (h) Entire worm of *Prionospio*.

KEY TO SELECTED GENERA OF SPIONIDS

1	Setiger 5 with thick spines	***Polydora***
	-Setiger 5 without thick spines	**2**
2(1)	Gills present on nearly all segments, partly fused to postsetal notopodial lobes	**3**
	-Gills present only on anterior segments, not fused to postsetal notopodial lobes	**4**
3(2)	Gills from setiger 1; prostomium with lateral peaks	***Malacoceros***
	-Gills from setiger 2, prostomium without peaks	***Scolelepis***
4(2)	Less than twelve pairs of gills present (fig. 6.34h)	***Prionospio***
	-More than twelve pairs of gills present	***Laonice***

Laonice cirrata (Sars)

The body is up to 100 mm long, 5 mm wide, and has 150 segments. The color in life is reddish brown. The prostomium is T-shaped and blunt. Gills are present from setigers 2 to 50. Hooded hooks are bidentate. *L. cirrata* is a cosmopolitan species reported from Bahía de los Angeles, and collected from the low intertidal sandflats at Punto Sargento, Sonora (Hartman, 1969).

Scolelepis squamata (Müller)

The body is 50 mm long, 2 mm wide, and has over 130 segments. The body is light green. The prostomium is prolonged and very narrowly conical. Gills are present from setiger 2 and are fused to the postsetal notopodial lobe (fig. 6.34b). Hooded bidentate hooks are present in the neuropodia from setiger 30. This species occurs in southern California, and Bahía de los Angeles (Reish, 1968; Hartman, 1969).

Malacoceros indicus (Fauvel)

This species was called *Scolelepis indicus* (Kudenov, 1973: 117, fig. 5.23g, h). The body is 60 mm long, 1.5 mm wide, with numerous segments. Neuropodia with bidentate to tridentate hooded hooks (fig. 6.34d). This species occurs in warm waters in the Indian Ocean and off western Mexico, as well as in the Caribbean. It is known from Bahía San Carlos (Kudenov, 1975b).

Polydora ligni Webster

The body is 25 mm long and 1 mm wide. The setae of setiger 5 are brush-top spines alternating with distally notched ones (fig. 6.34e, f). Characteristic hooks are present in the notopodia of posterior segments. *P. ligni* occurs on wharf pilings, ship hulls, and sandflats. It is distributed on both sides of North America and is commonly encountered in the Gulf (Rioja, 1943b; Hartman, 1969).

Polydora nuchalis Woodwick

The body is 20 mm long and 1 mm wide, with 110 segments. Setiger 1 lacks notosetae, and a characteristic papilla is present on the prostomium. *P. nuchalis* occurs in southern California and the northern Gulf (Woodwick, 1953; Kudenov, 1975b).

Polydora socialis (Schmarda)

The body is around 30 mm long, 1 mm wide, with 50 segments. The prostomium is bilobed, and the caruncle extends to setiger 4. Setiger 5 is longer than any other segment and has thick brown, distally excavate spines (fig. 6.34g). This species is known from the eastern Pacific and is commonly encountered in the Gulf (Hartman, 1969).

Polydora wobberi Light

The body is 27 mm long and has 134 segments. The falcate spines of setiger 5 are distally excavate. A characteristic web connects the gills from setiger 12. *P. wobberi* bores into the gorgonian *Lophogorgia* sp., and occurs in Bahía de San Francisquito (Light, 1970).

Prionospio cirrifera Wirén

A small free-living species, 35 mm long with about 80 segments. From 6 to 11 cirriform gills are present, beginning from setiger 2. The postsetal notopodial lobes of setigers 1 to 5 are leaf-shaped. This species is widespread in temperate seas and is reported from Bahía de los Angeles, and has been collected from low intertidal sandflats at Punta Chueca, Sonora (Hartman, 1969).

FAMILY MAGELONIDAE

Long slender worms with the body divided into an anterior thorax of 9 setigers, and a posterior abdomen of numerous setigers. The prostomium is shaped like a spade (fig. 6.35a). The palps are papillate. Gills are

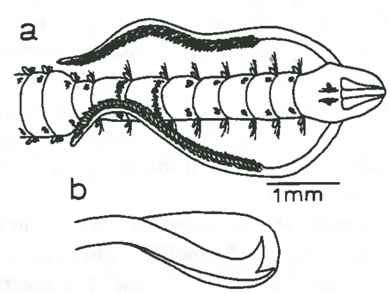

Fig. 6.35 Magelonidae. (a) Anterior segments of *Magelona californica* (modified from Hartman, 1944b). (b) Hooded hook of *Magelona*.

absent. Parapodia are biramous. Capillary setae are present in setigers 1 through 8 and sometimes also 9. Setiger 9 may have hooded hooks. All abdominal segments have hooded hooks (fig. 6.35b).

Important reviews of the family are those of Jones (1963, 1971). Magelonids occur in intertidal sandflats, usually several centimeters below the surface.

Magelona californica Hartman

A small species around 30 mm long with 100 segments. The prostomium is rounded anteriorly and lacks lateral processes. Setiger 9 has capillary setae only. Abdominal hooded hooks are bidentate. This species occurs in southern California and in Bahía de los Angeles; it was collected from muddy intertidal flats in the estero at Punto Sargento, Sonora (Hartman, 1969).

FAMILY POECILOCHAETIDAE

The body is divided into 3 regions by the shape of the dorsal cirri (fig. 6.36a). The prostomium is rounded and has 2 pairs of eyes (fig. 6.36b). The peristomium is reduced. The dorsal lip of the mouth has a median projection. A pair of very long, grooved palps is present. Setae are simple, with acicular hooks in setigers 2 through 4, and spines in middle body segments. Members of this family occur from intertidal to slope depths along western Mexico (Fauchald, 1972).

Poecilochaetus near *johnsoni* Hartman

A small species about 30 mm long, 3 mm wide, with over 150 segments. The prostomium is rounded and has a caruncle extending to setigers 6 or 7 (fig. 6.36b). Acicular hooks are present in each neuropodium of setigers 2 and 3. This species is very near *P. johnsoni* but differs in size, shape of posterior dorsal cirri, and habitat. *P.* near *johnsoni* constructs tubes on the bottom of boulders in the low intertidal zones along the Sonoran coast (Fauchald, 1972).

FAMILY CHAETOPTERIDAE

Chaetopterids are long worms, with bodies arbitrarily divided into three regions. Two long or short grooved palps are present at the base of the mouth (fig. 6.37a). Anterior segments are uniramous, and setiger 4 has thick spines (fig. 6.37b). The middle body region has biramous parapodia with simple capillaries and characteristic uncini (fig. 6.37c). Posterior body segments are also biramous, and the notopodia may have from one to three lobes.

These worms are tube-dwellers whose tubes are tough, leathery, or parchmentlike. They are efficient filter feeders (Barnes, 1965). The family is reviewed by various authors, and a summary of characters is given by Kudenov (1975b).

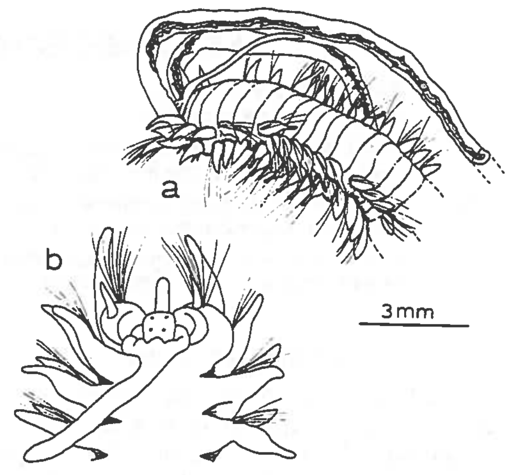

Fig. 6.36 Poecilochaetidae. (a) Anterior segments of *Poecilochaetus*. (b) Head of *Poecilochaetus* near *johnsoni*.

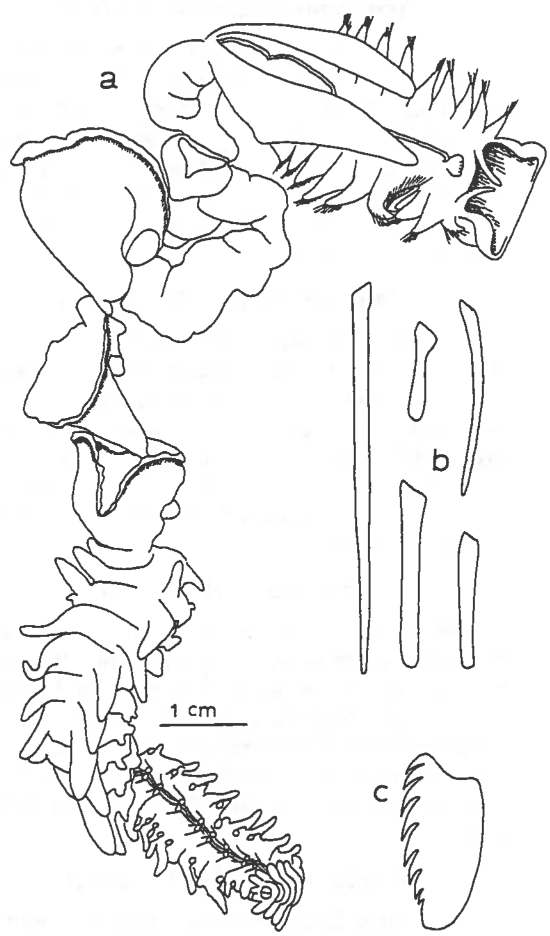

Fig. 6.37 Chaetopteridae. (a) Entire worm, *Chaetopterus variopedatus*. (b) Cutting spines from setiger 4 of chaetopterids (from Kudenov, 1975b). (c) Uncinus.

KEY TO SELECTED GENERA OF CHAETOPTERIDS

1	Tube clear, ringed and not branched .... ***Spiochaetopterus***	
	-Tube often encrusted with debris, not ringed	2
2(1)	Tube U-shaped .... ***Chaetopterus***	
	-Tube vertical or J-shaped .... ***Mesochaetopterus***	

Chaetopterus variopedatus (Renier)

This species can be 250 mm long and 25 mm wide (fig. 6.37a). The anterior region is brown, the middle region green, and the posterior region yellow. It is a cosmopolitan species, common in the Gulf. Commensal crabs can occur in the tubes (Kudenov and Haig, 1974; Kudenov, 1975b).

Mesochaetopterus alipes Monro

A large species up to 285 mm long and 10 mm wide. In life, the color of the anterior region is white to light brown and the posterior region is greenish. The first body region has 11 segments; the second has 3; the last has 68. *M. alipes* is known from Panama and Sonora. Gravid females were collected during August (Kudenov, 1975b).

Mesochaetopterus mexicana Kudenov

This species was called *Mesochaetopterus* sp. (Kudenov, 1973:118). The body is over 100 mm long and is 5 mm wide. There are 13 anterior segments; segment 14 is the largest. Cup-shaped depressions are present on setigers 14 to 17. This species is known from Bahía Cholla (Kudenov, 1975b).

Spiochaetopterus costarum monroi Gitay

This species was called *Spiochaetopterus* sp. (Kudenov, 1973:118). The anterior region has 9 to 10 setigers; the middle region has more than 30; posterior region with numerous setigers and finger-shaped notopodial lobes. This species is common in low and mid intertidal sandflats along the Sonoran coast where it is easily recognized by its opaque, ringed tube (Gitay, 1969).

FAMILY CIRRATULIDAE

Worms with cylindrical bodies and many segments (fig. 6.38a). Both ends of the body are tapered. The prostomium is rounded to conical. A pair of palps may be inserted on the posterior margin of the prostomium (fig. 6.38b), or there is a transverse dorsal band of tentacles (fig. 6.38c). Parapodia are biramous, and the lobes are rudimentary to absent. Simple capillary setae and acicular hooks are present in the parapodia. Gills are usually located on the body, just above the notopodium.

Cirratulids are deposit feeding polychaetes that inhabit sediments between rocks or under them. Usually they are associated with black, characteristically odorous sediments. They can be detected by their exposed red gill filaments that wave about the top of the sediment (Day, 1967).

KEY TO SELECTED GENERA OF CIRRATULIDS

1	A pair of large palps present	2
	-Palps absent; numerous grooved tentacles present	4
2(1)	Two to eight pairs of gills limited to anterior setigers .... ***Dodecaceria***	
	-More than ten pairs of gills present along the entire body	3
3(2)	Only capillary setae present .... ***Tharyx***	
	-Capillary setae and acicular hooks present .... ***Caulleriella***	
4(1)	Gills occur anterior to grooved tentacles .... ***Cirriformia***	
	-Gills occur on same segment as grooved tentacles .... ***Cirratulus***	

Caulleriella alata (Southern)

A small species up to 25 mm long, 0.2 mm wide, with up to 100 segments. The prostomium is triangular and has a pair of deeply embedded eyes (fig. 6.38b). Bidentate acicular spines are present in the neuropodium of setiger 1 and the notopodium of setiger 21. *C. alata* is known from temperate waters; it is reported from Bahía de los Angeles and collected from Isla Tiburón in silty sand (Reish, 1968; Hartman, 1969).

Cirratulus cirratus spectabilis (Kinberg)

A small species up to 50 mm long, 4 mm wide, with around 100 segments. The prostomium is circular anteriorly. Ten pairs of dorsal tentacles are present on setiger 1. Neurosetal spines are first present around setiger 20; notosetal spines first present from setiger 30. This species is reported from Acapulco and the southern Gulf in sand among rocky intertidal zones. It is reported also from California to Alaska (Hartman, 1969).

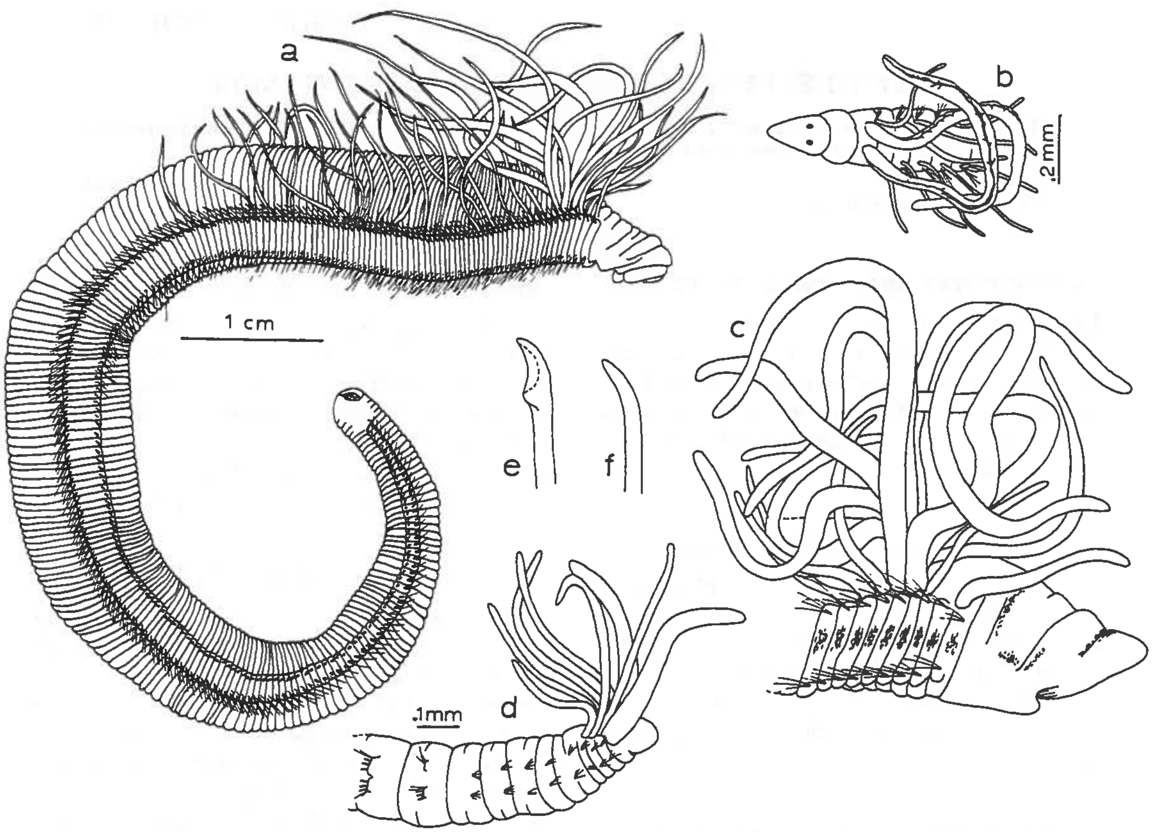

Fig. 6.38 Cirratulidae. (a) Entire worm, *Cirriformia*. (b) Head of *Caulleriella alata*. (c) Head of *Cirriformia*. (d) Head of *Dodecaceria* sp. 1., lateral view. (e) Hook of *Dodecaceria* sp. 1. (f) Acicular spine of *Cirriformia*.

Cirriformia luxuriosa (Moore)

The body is around 80 mm long, 5 to 6 mm wide, with 200 to 300 segments. The prostomium is a rounded triangle shape and has about 4 or 5 rings. Gills begin from setiger 1. A dense tuft of tentacles, numbering from 15 to 25 pairs, is present on setiger 4. Dark acicular spines (fig. 6.38f) are present in the neuropodia of setigers 30 to 35, and in the notopodia of setigers 50 to 55. Gills of posterior segments are closer to one another than they are to the parapodia. This species is commonly found in reduced black sand along the southern Sonoran coast. It occurs from California to western Mexico (Hartman, 1969).

Cirriformia near *luxuriosa*

The species is 50 mm long, 3 mm wide, and has 250 to 300 segments. It is reddish-brown in life, with red gills and black spines. From 12 to 15 pairs of tentacles are present on the dorsal surface of setiger 4. Neurosetal hooks first present from setiger 1; notosetal hooks present from setigers 35 to 37. This species occurs among granitic rocks in sand at Norse Beach, Puerto Peñasco (Hartman, 1969).

Cirriformia species 1

An extremely common cirratulid along the Sonoran coast. It is 25 to 30 mm long, 1 to 2 mm wide, with 55 to 60 segments. Color in life is reddish, with green tentacles and red gills. The prostomium is triangular and has 4 rings; it is as long as the first 7 setigers. A transverse row of tentacles is present on the dorsal surface of setiger 4, with 7 pairs of tentacles. All filaments are about one-half the length of the body. Neurosetal spines are present from setigers 9 to 10; notopodial spines are present from setigers 42 to 48. This species occurs in fine sediment among boulders (Hartman, 1969).

Dodecaceria species 1

A small species about 10 mm long, 0.2 mm wide with 50 segments. A pair of palps is present on the rounded prostomium (fig. 6.38d). A pair of gills is present on each of segments 3 through 5. The gills are as long as the palps and one-third as wide. Distally excavate acicular spines are first present from setigers 9 in the neuropodia and 10 in the notopodia (fig. 6.38e). This species was found inside an empty snail shell taken from coralline algae at Isla Tiburón, directly opposite Punta Chueca, in shallow depths (Hartman, 1969).

Tharyx ?parvus Berkeley

A small species that is up to 15 mm long, 0.5 mm wide, with 200 to 300 segments. A characteristic mid-dorsal reddish-brown stripe is present on the anterior third of the body. A pair of palps is present on setiger 1. This species is distributed along the Pacific coast of North America and occurs in Bahía de los Angeles. The identity of this species was questioned by Hartman as a valid record for the Gulf (Reish, 1968).

FAMILY ACROCIRRIDAE

Small worms with cylindrical to semicircular bodies. The prostomium is rounded and has a median dorsoventral ridge anteriorly. A pair of palps is present on the anterior margin of the head; they are grooved, and the grooves face the ventral surface (fig. 6.39a). There are 13 thoracic segments, generally; and numerous abdominal segments. Parapodia are biramous and usually poorly developed. Notosetae are finely jointed capillaries; neurosetae are jointed falcigers (fig. 6.39c) that face posteriorly in the thorax and face anteriorly in the abdomen. Segment 14 may be modified and have acicular hooks. Four pairs of gills are present on segments 2 to 5.

Acrocirrids are a group of free-living worms that were allied by most authors to the cirratulids. Most now agree that they are more closely related to flabelligerids. Little is known about the biology of this family which was erected by Banse (1969).

Acrocirrus incisa Kudenov

The body is 27 mm long, over 1 mm wide, and has 90 segments. In life the body is green; the palps are brownish-green; the gills are orange to reddish-green. Well developed parapodial lobes are present from segments 7 to 41; the parapodia are typically incised (fig. 6.39b). Notosetae and neurosetae are present from segment 4. Acicular hooks are present in the neuropodium of segment 14. This species occurs along the Sonoran coast in rocky low intertidal habitats. It usually attaches itself to the leeward sides of flat rocks (Kudenov, 1975b).

FAMILY FLABELLIGERIDAE

The body is cylindrical and has few segments. The prostomium is poorly defined and is usually retracted into a membranous sheath. Gills and a pair of palps are present near the prostomium (fig. 6.40a). The setae of setigers 1 through 4 are very long and have numerous joints (fig. 6.40c). These setae usually surround the head region forming what is called a cephalic cage. Parapodia are biramous and usually reduced to bundles of setae on the sides of the body. Notosetae are jointed capillaries; neurosetae are simple to jointed falcigers. The body is usually covered with large epidermal papillae (fig. 6.40b).

Flabelligerids are surface deposit feeders found under rocks in silty sand at Puerto Lobos and in rock platforms at Puerto Libertad (Hartman, 1969).

Piromis americana Monro

The setae of setigers 2 to 3 or 4 are prolonged anteriorly, forming the cephalic cage (fig. 6.40b). There are around 60 setigers present; the body is 40 mm long and 6 mm wide. Numerous small gill filaments are attached to a tonguelike membrane. Neurosetae are simple, unidentate hooks from setigers 6 or 7 (fig. 6.40d). Characteristic longitudinal rows of papillae are present on the ventral surface. *P. americana* is known from Panama and California. This is the first record of the species in the Gulf from Puerto Lobos (Hartman, 1969).

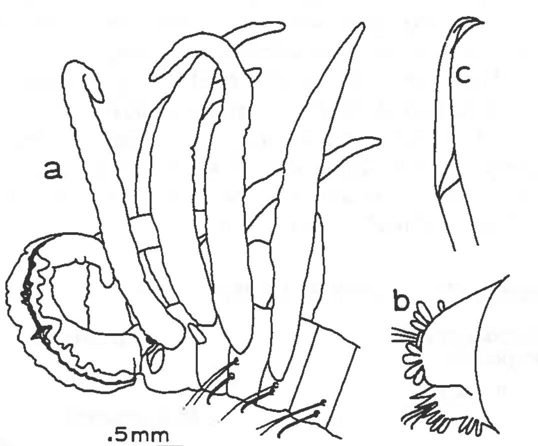

Fig. 6.39 Acrocirridae. (a) Anterior segments of *Macrochaeta* (from Kudenov, 1976). (b) Parapodium of *Acrocirrus incisa*, anterior view. (c) Jointed neurosetal falciger.

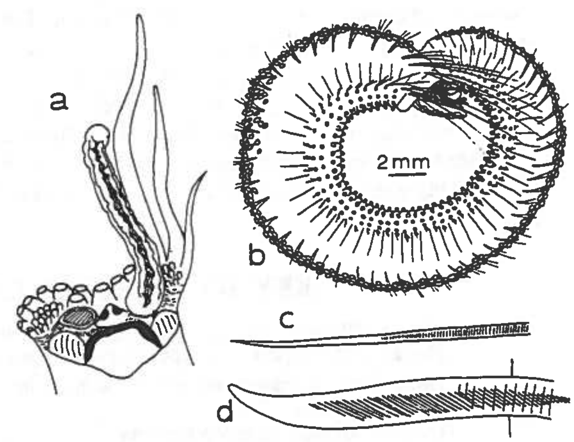

Fig. 6.40 Flabelligeridae. (a) Exposed head of *Pherusa* (from Hartman, 1952). (b) Entire worm, *Piromis americana*. (c) Notoseta of *Piromis americana*. (d) Neurosetal falciger of *Piromis americana*.

FAMILY OPHELIIDAE

Worms with fusiform to grublike bodies and few body segments (fig. 6.41a). The prostomium is conical and lacks appendages. The midventral surface is often grooved. Parapodia are biramous and poorly developed; dorsal and ventral cirri are usually absent. Gills are simple filaments when present. Lateral eyespots may be present between successive parapodia of middle body segments (fig. 6.41b). The pygidium is elongate and usually has anal cirri. All setae are simple capillaries.

Opheliids are deposit feeders that live in sandflats or sandy intertidal algal mats along the Sonoran coast.

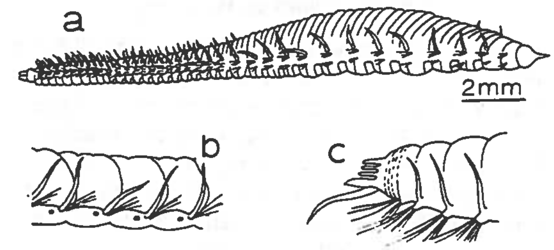

Fig. 6.41 Opheliidae. (a) Entire worm, *Travisia fusiformis*. (b) Lateral eyespots of *Armandia*. (c) Pygidium of *Armandia bioculata*, lateral view.

KEY TO SELECTED GENERA OF OPHELIIDS

1	Body midventrally grooved; eyespots present between parapodia of midbody segments	2
	-Body not generally grooved; eyespots absent .... ***Travisia***	
2(1)	Gills present .... ***Armandia***	
	-Gills absent .... ***Polyophthalmus***	

Armandia bioculata Hartman

A small species, 20 mm long and less than 2 mm wide, with 29 setigers. The prostomium is conical and has a pair of deep-set lateral eyes. A total of 27 pairs of gills are present, beginning from setiger 2. Eleven pairs of lateral eyespots are present from setigers 6/7 to 16/17. The pygidium has 5 short and 2 long papillae, plus a longer one placed inside the dorsal collar (fig. 6.41c). *A. bioculata* occurs in California and western Mexico. It is fairly common in the northern Gulf in sandy and silty sediments (Hartman, 1969).

Polyophthalmus pictus (Dujardin)

A small species up to 25 mm long with 27 to 28 biannulate segments. A pattern of brown markings is present on the dorsal surface. The prostomium is rounded, and eyespots are present. Gills are absent. Lateral eyespots are present generally from setigers 7 to 21; the limits are variable. The pygidium is small, and a few anal cirri are present. *P. pictus* is a circumtropical species collected from Ensenada Perro, Isla Tiburón, associated with coralline algae in shallow subtidal depths. This is the first record of the species in the Gulf (Hartman, 1969).

Travisia fusiformis Kudenov

This species was called *Travisia* sp. (Kudenov, 1973: 120–121, fig. 5.26). The body is long and fusiform, 22 mm long and 2 mm wide, with 35 to 36 segments (fig. 6.41a). Gills are present from setiger 2. The body is covered by small processes. The species is present throughout the sandy intertidal regions of Bahía Cholla (Kudenov, 1975b).

FAMILY CAPITELLIDAE

Polychaetes that are earthwormlike in appearance. The body is long and narrowly cylindrical (fig. 6.42a) and divided into an anterior thorax and a posterior abdomen. The transition between these two regions may be poorly defined. Gills may be present in the abdomen. Parapodia are biramous. Capillaries and hooded hooks or spines may be present in the thorax; hooded crested hooks are present in the abdomen (fig. 6.42c).

These worms are found in nearly every conceivable intertidal habitat, ranging from black unoxidized sediment to pieces of rotting mangroves. There are many capitellids in the Gulf, some of which readily fragment when handled. A useful review of generic characters will be found in Hartman (1947a).

KEY TO SELECTED GENERA OF CAPITELLIDS

1	Thorax with nine setigers; setae first present from the peristomium .... ***Capitella***	
	-Thorax of more than nine setigers; setae absent from peristomium	2
2(1)	Ten thoracic setigers (setigers 1–4 with capillaries; setigers 5–10 with hooks) .... ***Mediomastus***	
	-Thorax with more than ten setigers	3
3(2)	Thorax with eleven setigers with capillaries only .... ***Notomastus***	
	-Thorax with more than eleven setigers	4
4(3)	Thorax with twelve setigers; abdominal gills may be present .... ***Leiochrides***	
	-Thorax with thirteen setigers; abdominal gills present .... ***Dasybranchus***	

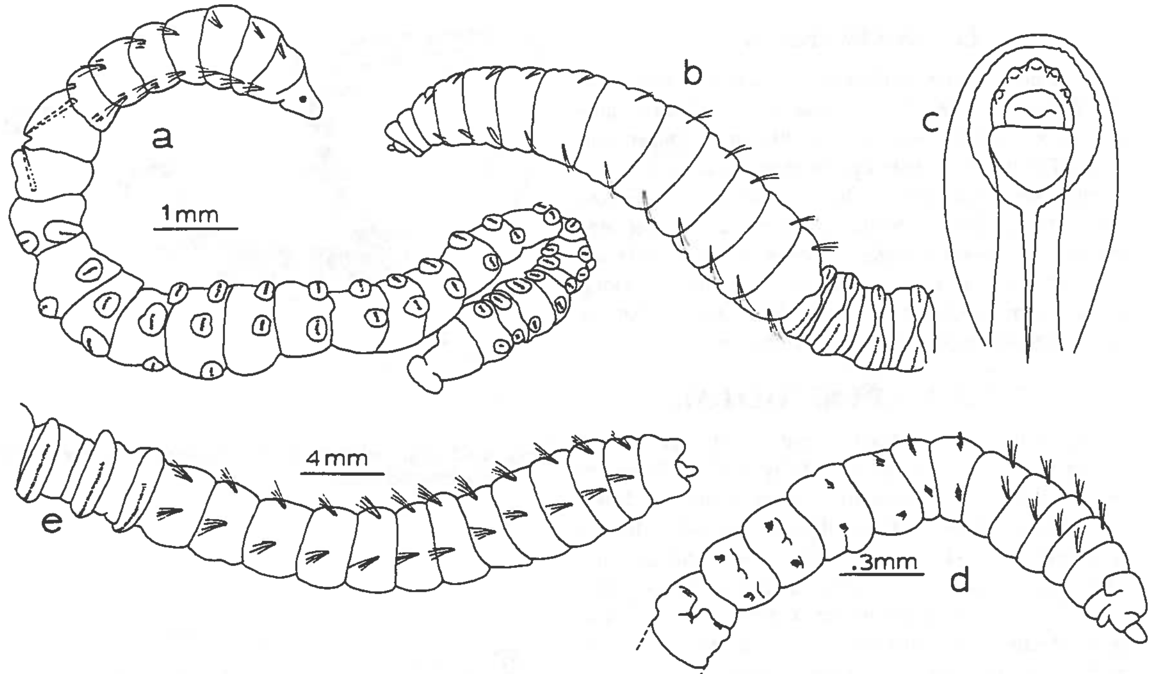

Fig. 6.42 Capitellidae. (a) Entire worm, *Capitella capitata* subspecies 1. (b) Anterior segments of *Notomastus sonorae*. (c) Abdominal hooded hook of *Dasybranchus parplatyceps*. (d) Head of *Mediomastus* sp. 1. (e) Anterior segments of *Leiochrides* sp. 1.

Capitella capitata subspecies 1

A small worm, similar to *Capitella capitata ovincola* Hartman in that setigers 1 to 4 have capillary setae; and setigers 5 to 7 have both capillaries and hooks (fig. 6.42a). *C. capitella ovincola* has abdominal hooded hooks with a main fang and a single transverse row of 5 small teeth; *C. capitella* subspecies 1 has a main fang with 3 transverse rows of alternating teeth. This subspecies is common in the algal mats on the coquina platforms at Bahía Tepoca (Hartman, 1947a).

Dasybranchus platyceps Hartman

The body is up to 100 mm long, with 180 segments. Thoracic segments with capillary setae only. Gills are present from segment 27. Abdominal crested hooded hooks have a main fang, a secondary fang, and an upper transverse row of 3 small teeth (fig. 6.42c). This species is known from an unspecified locality of the Sonoran coast (Hartman, 1947a).

Dasybranchus parplatyceps Kudenov

A species similar to *Dasybranchus platyceps*. Consistent differences exist between the two species. One difference is the fact that 5 small teeth are present in the upper transverse row of abdominal crested hooks. *D. parplatyceps* occurs in sand beneath basalt boulders at Puerto Peñasco (Kudenov, 1975b).

Notomastus sonorae Kudenov

This species was called *Notomastus* sp. (Kudenov, 1973: 122). Setigers 1 to 4 each with 3 rings; setigers 5 and 6 are five ringed; setigers 7 to 11 are 4 ringed. Fleshy ridges connect the abdominal notopodia to the neuropodia (fig. 6.42b). This species is known from the high intertidal sandflats among conglomerate boulders in Bahía Cholla (Kudenov, 1975b).

Notomastus tenuis Moore

A very small, slender, red colored worm that easily breaks when spadefuls of sediment are overturned. Setiger 1 has notosetae and lacks neurosetae. Abdominal crested hooks have a main fang and a transverse row of 4 to 5 smaller teeth. *N. tenuis* is known from the Pacific coast of North America. In the Gulf it is reported from Bahía de los Angeles and Bahía Cholla (Kudenov, 1975b).

Mediomastus species 1

The body is 12 mm long, 0.3 mm wide, and has over 110 segments. The prostomium is finger-shaped (fig. 6.42d). The transition from the thorax to the abdomen is distinct. Posterior abdominal segments are bell-shaped. This species occurs in low intertidal sandflats at Puerto Lobos (Hartman, 1947a).

Leiochrides species 1

The body is longer than 60 mm and has more than 110 segments. The 12 thoracic segments all have capillary setae. Anterior segments are two times longer than wide. The transition between the thorax and abdomen is abrupt. Segmental collars that are incomplete middorsally connect the parapodia of anterior abdominal segments. The superior edges of posterior neuropodia are produced into entire gills. This species is common along the southern Sonoran coast in mid intertidal sandflats of protected esteros (Hartman, 1947a). Fig. 6.42e.

FAMILY ARENICOLIDAE

Polychaetes with fairly large bodies, generally. Segments are superficially ringed (fig. 6.43a). There are relatively few body segments. The prostomium is small and lacks appendages. The proboscis is an eversible sac. The body is divided into three regions: an anterior setigerous section without gills; middle setigerous section with gills; posterior region without both setae and gills. Parapodia are biramous, with capillary notosetae and dentate neurosetal hooks (fig. 6.43b).

Arenicolids inhabit subtidal and low intertidal sandflats in the Gulf. During the period from 1972 to 1974, the marine lab at Puerto Peñasco had a continuous culture of arenicolids living in a small holding pond.

Arenicola glasselli Berkeley and Berkeley

Commonly called lugworms, this species is up to 110 mm long and has 16 setigers. Ten pairs of bushy gills are present from segments 7 to 16. Nephridial openings are present on setigers 5 to 11. *A. glasselli* is closely related to *A. caroledna;* this relationship is discussed by Kudenov (1975b). As presently defined, *A. glasselli* is known from San Felipe, the Sonoran coast, Brazil, and Senegal (Wells, 1962).

FAMILY MALDANIDAE

Polychaetes with cylindrical bodies and few segments (fig. 6.44a). The head is usually truncate and platelike; a margin is usually present about the plate. Parapodia are biramous and poorly developed. Capillary notosetae are present; neurosetae are either acicular hooks or dentate crested hooks (fig. 6.44b, c). The pygidium is usually truncate and may be shaped like a cone, funnel, or flattened oblique plate; anal cirri are usually present, one of which may be long and midventral (fig. 6.44d).

The number of body segments, the distribution of acicular spines, and the shape of the head and tail are important characters in maldanid identifications. Maldanids look very much like bamboo canes. As a result their common name is *bamboo worm.* They are common in sandflats throughout the Gulf (Day, 1967).

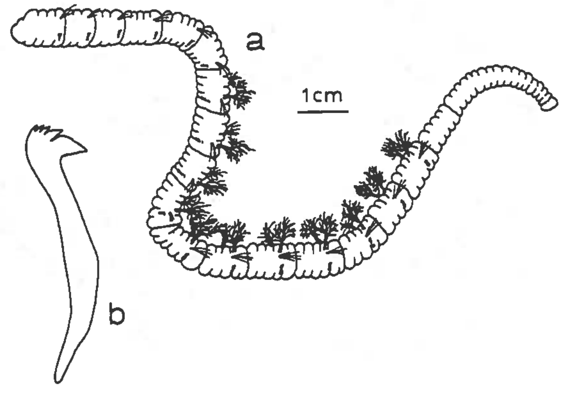

Fig. 6.43 Arenicolidae. (a) Entire worm, *Arenicola*. (b) Dentate crested hook.

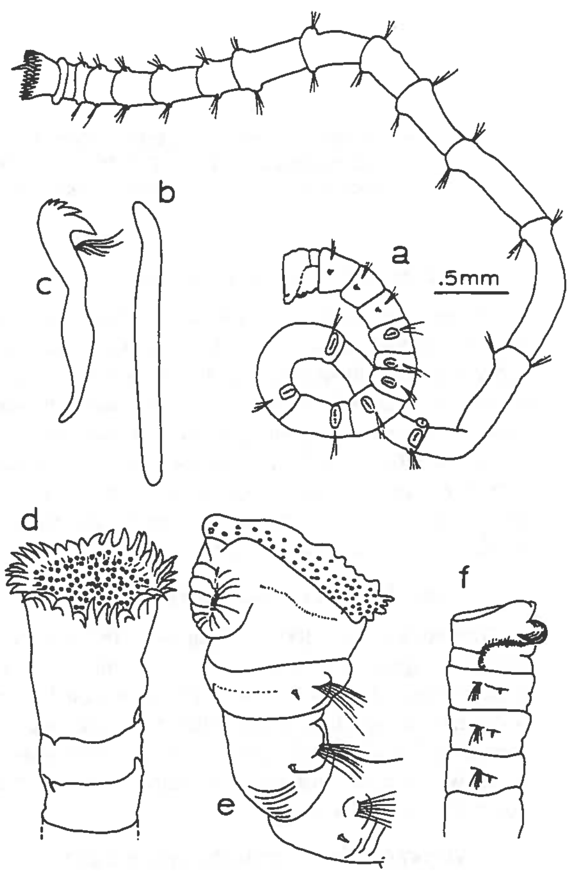

Fig. 6.44 Maldanidae. (a) Entire worm, *Heteroclymene* species 1. (b) Acicular hook. (c) Dentate crested hook. (d) Pygidium of *Euclymene papillata*. (e) Head of *Euclymene papillata*. (f) Head of *Heteroclymene* sp. 1, showing the lateral glandular folds in front of setiger 1.

KEY TO SELECTED GENERA OF MALDANIDS

1	Neurosetae of the first three setigers resemble those of other segments .... ***Axiothella***	
	-Neurosetae of the first three or four setigers different from those posteriorly	2
2(1)	Pygidium with a long midventral anal cirrus	3
	-Pygidium without a long midventral cirrus .... ***Isocirrus***	
3(2)	Acicular spines in first four setigers; up to 100 segments present	4
	-Acicular spines in first three setigers; less than 30 segments present .... ***Euclymene***	
4(3)	Lateral glandular fold present in front of setiger 1 .... ***Heteroclymene***	
	-Lateral glandular fold absent from setiger 1 .... ***Proclymene***	

Axiothella rubrocincta (Johnson)

The body is up to 60 mm long, 1 mm wide, with 21 segments. In life the body can be red with green parapodia, or green with red parapodia. There are 18 segments with setae, and 2 or 3 preanal segments without setae. There are 18 to 30 alternating long and short anal cirri, one of which is distinctly midventral. This species is known from the Pacific coast of North America and is common in the low intertidal sandflats in the northern Gulf (Hartman, 1969).

Euclymene papillata Berkeley and Berkeley

The body is 85 mm long, 2 to 3 mm wide, with 21 segments. In life the body is reddish anteriorly and pink posteriorly. There are 19 segments with setae and 2 preanal segments without setae. Acicular spines are present in setigers 1 to 3. Dense papillation is present on the head plate and inside the pygidium (fig. 6.44d, e). This worm is common under rocks in mid intertidal zones, where its sandy U-shaped tube is often attached to the rock (Berkeley and Berkeley, 1939).

Heteroclymene species 1

The body is over 9 mm long and about 0.2 mm wide, with more than 10 segments. The pygidium is terminal, with 18 cirri of alternating long and short lengths; a midventral anal cirrus present. The species is commonly encountered in the algal mats on the coquina platform at Bahía Tepoca (fig. 6.44f) (Hartman, 1969).

Isocirrus species 1

The body is 40 mm long, 0.3 mm wide, and has 28 setigers. All segments have setae. Acicular spines present in neuropodia of setigers 1 to 3. Pygidium terminal, and all anal cirri of equal length. This species is common in the estero at Punto Sargento, Sonora (Hartman, 1969).

Proclymene species 1

About 100 segments are present. Acicular spines are present in the neuropodia of setigers 1 to 4. The nuchal grooves are curved. Posterior segments are bell-shaped. It is difficult to collect intact worms because their vertical tubes penetrate a dense shell layer in Bahía Cholla, thus impeding digging efforts. The species occurs in the upper mid intertidal zone quite near the establishment at Bahía Cholla (Day, 1967).

FAMILY OWENIIDAE

Worms with a small, cylindrical body and few segments (fig. 6.45a). The prostomium is fused to the peristomium; antennae are absent. The terminal mouth is surrounded by a feeding membrane (fig. 6.45b). Parapodia are biramous and poorly developed; capillary notosetae and distally bifid neurosetal hooks are present (fig. 6.45c). Anal cirri are absent (Day, 1967).

Oweniids are common in the Gulf. Their tight fitting tubes are characteristically durable and appear to have been constructed by a stone mason (fig. 6.45d).

Owenia collaris Hartman

The body is up to 100 mm long. The color in life is green. The thorax has 3 short segments, each with capillary setae. Anterior abdominal segments are long and gradually decrease in length posteriorly. A thick glandular collar is present along the dorsal anterior margin, just below the feeding tentacles. *O. collaris* is known from the Pacific coast of North America. It occurs in sandflats in the northern Gulf (Hartman, 1969).

Owenia fusiformis (delle Chiaje)

A species similar to *Owenia collaris* except that a dorsal collar is absent and the neurosetae are shaped

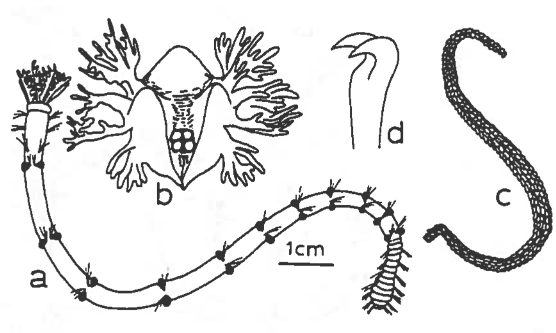

Fig. 6.45 Oweniidae. (a) Entire worm, *Owenia*. (b) The mouth and feeding tentacles of *Owenia*. (c) Tube of *Owenia*. (d) Bifid neurosetal hook.

differently. Additional differences are listed by Hartman (1969). *O. fusiformis* is a cosmopolitan species collected from low intertidal, sandy algal mats at Puerto Lobos.

FAMILY AMPHARETIDAE

The body is divided into an anterior thorax and a posterior abdomen. The latter region has numerous segments. Numerous retractile feeding tentacles are present inside the mouth. They may be smooth or covered with small papillae. From 2 to 4 pairs of gills are present on segments 3 and 4; usually the gills of the latter two segments are coalesced to lie in a straight line across the dorsal surface of segment 3 (fig. 6.46a). Thoracic segments have notopodial capillaries and neuropodial uncini (fig. 6.46b). Abdominal segments have uncini only. Note that the notosetae of segment 3 may be developed into conspicuous spines called palaea.

Ampharetids are surface deposit feeders that are best represented in deep water (Fauchald, 1972). Although no species are presented here, a few have been collected all along the Sonoran coast. A useful introduction to this family is found in Day (1967) and Fauchald (1977a).

FAMILY TEREBELLIDAE

The body is divided into an anterior thorax and a posterior abdomen (fig. 6.47a). These worms are very similar in appearance to ampharetids. Terebellids, however, lack retractile mouth tentacles; their feeding tentacles are located on a dorsal collar about the head (fig. 6.47b). Note that these tentacles are not retractile. There are 2 to 3 pairs of gills located on segments 2 through 4. The thorax has biramous parapodia with capillary notosetae and uncini in the neuropodia; the abdomen has uncini only.

Important characters in the identification of terebellids are, for example, the shape of the head, gills, and uncini, plus the number of thoracic segments and gills. A dental formula is used to describe the teeth of an uncinus. The uncinus in figure 6.47c is described thusly: MF:2:3; where MF is the largest tooth (= main fang) surmounted by 2 intermediate sized teeth and 3 smaller ones. The uncini are variable, so that the formula may indicate this (i.e. MF:2–3:0–4). The regular features used to identify many terebellids are almost worthless when applied to the subfamily Polycirrinae. Members of this group are partly characterized by the absence of gills; it is best to examine them when they are alive (Day, 1967).

Terebellids are commonly encountered in the Gulf where they occur in sand under rocks, coquina platforms, mudflats, algal mats, *Zostera* beds, and mangroves. Terebellids, like ampharetids, are surface deposit feeders.

KEY TO SELECTED GENERA OF TEREBELLIDS

1	Gills present	2
	-Gills absent (subfamily Polycirrinae) .... ***Polycirrus***	
2(1)	Branched gills present (subfamily Amphitritinae)	3
	-Simple gill tufts, not branched (subfamily Thelepinae)	4
3(2)	Fleshy flaps present on segments 2 to 4; notosetae distally smooth .... ***Pista***	
	-Fleshy flaps absent; notosetae with spinose tips .... ***Terebella***	
4(2)	Notosetae from first gill bearing segment; uncini from setiger 4 .... ***Streblosoma***	
	-Notosetae from second gill bearing segment; uncini from setiger 3 .... ***Thelepus***	

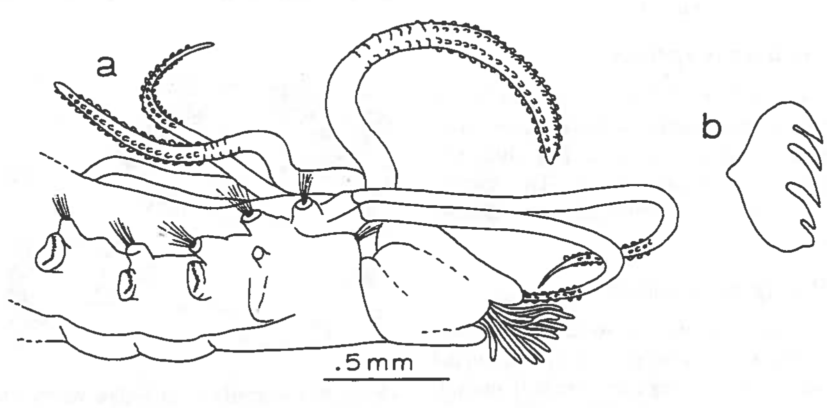

Fig. 6.46 Ampharetidae. (a) Anterior segments of *Samythella*. (b) Thoracic uncinus.

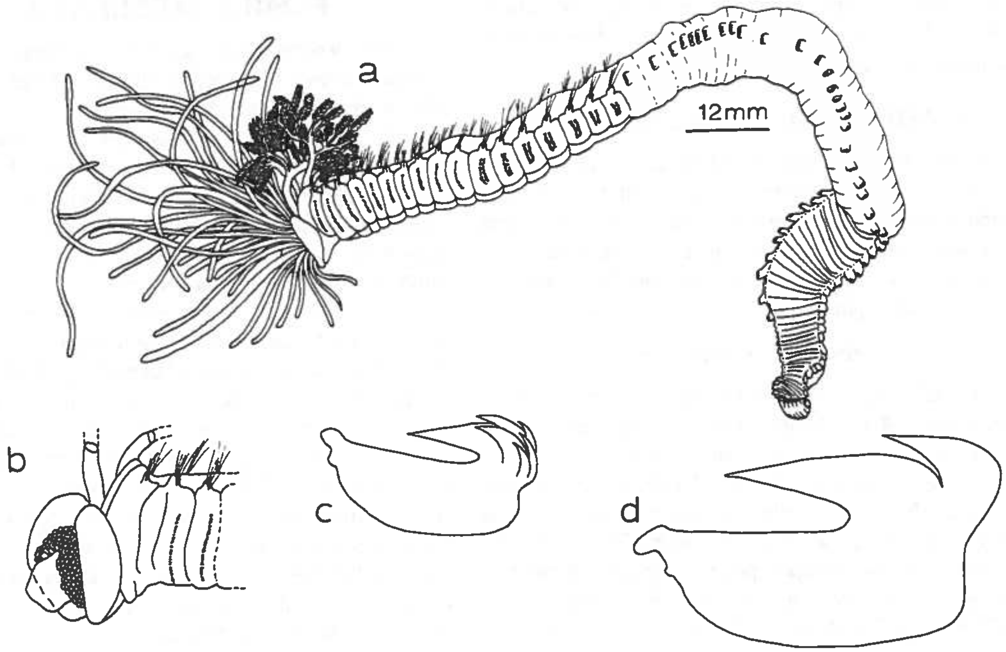

Fig. 6.47 Terebellidae. (a) Entire worm, *Thelepus*. (b) Detail of head region of *Thelepus* near *setosus*. (c) Thoracic neurosetal uncinus. (d) Uncinus of *Streblosoma uncinatus*.

Pista elongata Moore

The body is around 100 mm long, 4 mm wide, and has 130 segments. Thoracic segments number 17. Three pairs of gills are present. Fleshy lateral lobes from segment 3 project forward and obscure the head. A distinguishing feature is the elongated body. *P. elongata* is reported from southern California; it occurs at El Mogote and Punta Chueca in the Gulf where, at the latter locality, it was collected from a mid intertidal sandflat (Hartman, 1969).

Polycirrus species 1

A small red species around 14 mm long without tentacles, and 20 mm long with them. The body is 0.5 mm wide and has 45 to 50 segments. The head is totally obscured by numerous feeding tentacles. Notosetae and neurosetae are present, and it requires a microscope and patience to determine their distribution. Notosetae are present from segments 3 to 13; neurosetae are present from setiger 7. This species may approach *Polycirrus perplexus* Moore. It is difficult to establish the species identity because, "As currently known, the genus is confused, (and) the specific characters are so variable that distinction is not possible" (Hartman, 1969:629). This species (?) occurs in rocky intertidal regions, between rocks; it does not form tubes.

Terebella californica Moore

The body is up to 80 mm long, 3 mm wide, and is light red with deep red gills. There are 23 to 26 thoracic segments. Ventral plates *(scutes)* are present on the first 16 segments. Two pairs of bushy gills are present on segments 2 and 3. This species was collected from the rocky low intertidal zones of Puerto Peñasco (Hartman, 1969).

Thelepus near *setosus* (Quatrefages)

A very large, impressive species that was originally called *Thelepus setosus* (Kudenov, 1973:128). The body is up to 150 mm long, 12 to 15 mm wide, with about 130 segments. The thorax has about 50 segments. Three pairs of clustered, cirriform gills are present. Nephridial papillae are present on setigers 3 through 5. Uncini have a main fang surmounted by two denticles. This species is common in shallow subtidal and low intertidal depths in the northern Gulf. Previous records of *T. setosus* probably represent this species. A commensal polynoid, *Lepidasthenia gigas*, is often found in the tubes of this terebellid (Hartman, 1969) (fig. 6.47a, b).

Streblosoma uncinatus Kudenov

A small species that is 33 mm long, 3 mm wide, and has 62 segments. The thorax has over 50 segments. Thoracic uncini are characteristically set in U-shaped rows from setigers 15 to 56; the dental formula is MF:2:0–1 (fig. 6.47d) (Kudenov, 1975b). It is common along the Sonoran coast.

FAMILY TRICHOBRANCHIDAE

Worms very similar in appearance to terebellids and ampharetids. They differ, in part, in having long thoracic spines in the neuropodia; these are absent from the other families (fig. 6.48a, b). Members of this family occur in various types of sediments and are present in practically all depths.

Terebellides stroemii Sars

A small species in the Gulf, around 25 mm long; it can be over 100 mm long in cool temperate waters. Gills are characteristically 4-lobed and appear like the pages of a closed book (fig. 6.48a). There are 18 thoracic segments. Notosetae begin from segment 3; neurosetae from setiger 6 as long shafted hooks (fig. 6.48b). *T. stroemii* is a cosmopolitan species taken from Bahía San Carlos and from slope and basin depths throughout the Gulf (Berkeley and Berkeley, 1939; Fauchald, 1972).

FAMILY SABELLIDAE

These worms are recognized by the presence of the branchial crown that circumscribes and hides the mouth (fig. 6.49a). Each long filament of the crown is called a radiole, and the lateral processes are called branchioles. The collar about the base of the crown may have 2 or 4 lobes (fig. 6.49b). The body is divided into an anterior thorax and a posterior abdomen. Thoracic neuropodia may have one or two parallel rows of setae. The setal bundles of the thorax are inverted on the abdomen. Thoracic notosetae and abdominal neurosetae are variously shaped capillaries; thoracic neurosetae and abdominal notosetae are beaked uncini (fig. 6.49c).

Sabellids are abundant in the Gulf and are easily recognized by their brilliantly colored branchial crowns. These worms are commonly called feather dusters for obvious reasons. They occur in a variety of habitats, ranging from sandflats, sponges, and corals to sand-filled crevices in and among rocky areas (Day, 1967). Two subfamilies are recognized by the presence of one or two rows of thoracic neurosetae. A third subfamily occurs in clear gelatinous tubes.

KEY TO SELECTED GENERA OF SABELLIDS

1	Thorax with two parallel rows of neurosetae; worms generally large (subfamily Sabellinae)	2
	-Thorax with one row of neurosetae; worms generally small (subfamily Fabriciinae)	4
2(1)	Collar setae set in a straight row .... ***Hypsicomus***	
	-Collar setae set in a tuft	3
3(2)	Branchial crown inrolled dorsally; terminal eyes absent from radioles .... ***Bispira***	
	-Branchial crown semicircular; terminal eyes present on radioles .... ***Megalomma***	
4(1)	Radioles united by a membrane for most of their length .... ***Chone***	
	-Radioles not united by a membrane	5
5(4)	Thoracic neurosetae long shafted, beaked hooks .... ***Fabrisabella***	
	-Thoracic neurosetae long acicular hooks .... ***Fabricia***	

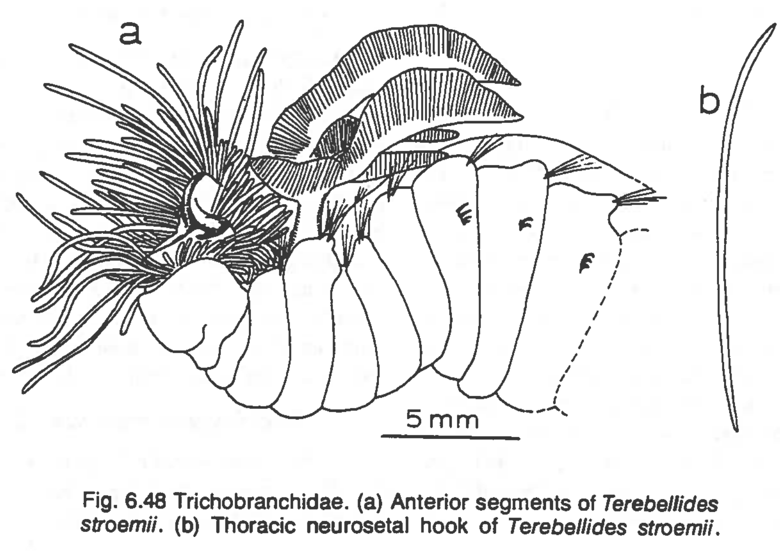

Fig. 6.48 Trichobranchidae. (a) Anterior segments of *Terebellides stroemii*. (b) Thoracic neurosetal hook of *Terebellides stroemii*.

Bispira rugosa monterea Monro

This species was called *Bispira* sp. (Kudenov, 1973:130). The body is 50 mm long, 8 mm wide, and has 100 segments. The branchial crown is characteristically banded orange and bluish-white. The tubes are smooth. This species is known from Panama and the Gulf of California (Kudenov, 1975b).

Chone mollis (Bush)

A small species, 40 mm long, less than 3 mm wide, and with 60 segments. There are 8 thoracic segments. A characteristic glandular band encircles segment 2. The neurosetae are long shafted spines. *C. mollis* was collected from the reef at Bahía Cholla in fine sand. The species is known from the Pacific Coast of North America (Hartman, 1969).

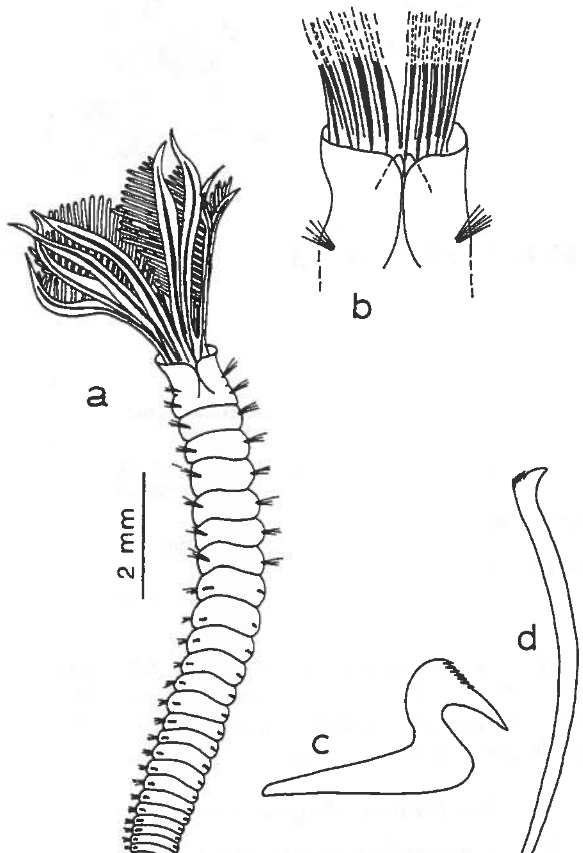

Fig. 6.49 Sabellidae. (a) Entire worm, *Fabrisabella* sp. 1. (b) Collar of *Fabrisabella* sp. 1., dorsal view. (c) Beaked (avicular) uncinus. (d) Long-handled hook of *Fabrisabella* sp. 1.

Fabricia limnicola Hartman

A small species, up to 7 mm long, with 8 thoracic and 3 abdominal segments. A collar is present. Two pairs of dark eyes are present, one at the base of the crown and one at the pygidium. This species is known from California. It occurs in the Gulf among sandy algal mats along the Sonoran coast and at Bahía de los Angeles (Reish, 1968; Hartman, 1969).

Fabrisabella species 1

A small species up to 10 mm long, of which the crown is 2 to 3 mm. Eight thoracic and 23 abdominal segments are present (fig. 6.49a). Eight pairs of radioles are present. Thoracic uncini beak-shaped and long-handled (fig. 6.49d). This species is rather abundant in the algal mats on the coquina platforms at Bahía Tépoca and other similar habitats along the Sonoran coast. This is the first record of the genus in the Gulf (Hartman, 1969).

Hypsicomus phaeotaenia (Schmarda)

The body is 50 to 60 mm long and has 8 thoracic setigers. This species characteristically occurs in coral heads of *Porites californica*. The branchial crown is black to deep purple and a similarly colored midventral stripe is also present on the body. The tubes are hyaline and brown in color. This is a widespread tropical and temperate species frequently encountered along the southern Sonoran coast and southern Gulf burrowing in coral (Day, 1967).

Megalomma splendida (Moore)

This species was called *Megalomma* sp. (Kudenov, 1973:129). It is around 50 mm long, 6 mm wide, and has 120 segments. The first segment has only bilimbate capillary setae. The branchial crown is variably colored from purple to brownish-orange; the tubes are coarsely textured. *M. splendida* deposits egg masses during the summer months at Puerto Peñasco; it is common in the Gulf and is distributed from California to western Mexico (Fauchald, 1972; Kudenov, 1975b).

FAMILY SERPULIDAE

Serpulids construct and inhabit white calcareous tubes that are sometimes red in color. They have branchial crowns similar to those described for sabellids (fig. 6.50a). The serpulid crown differs because a radiole is usually modified into a plug (operculum) that is used to seal the tube. The thorax has from 3 to 8 segments and is usually set off from the numerous abdominal segments by a thoracic collar (fig. 6.50a). A pair of setal bundles is usually present on the collar, which are capillary setae only. Their presence or absence and the shape of the collar setae are important characters in serpulid taxonomy. The abdomen exhibits setal inversion, similar to that described for sabellids. Thoracic notosetae and abdominal neurosetae are capillaries; thoracic neurosetae and abdominal notosetae are uncini (fig. 6.50c).

Serpulids are divided into three subfamilies, one of which is the Spirorbinae. These are very small worms (ca. 2 mm long) inhabiting spirally coiled tubes (fig. 6.50d). If the tube is viewed from above, it may coil in a clockwise (sinistral) or an anticlockwise (dextral) direction. The body is secondarily modified after the larvae settles such that the adult's body is not bilaterally symmetrical. Spirorbids are the subject of intensive worldwide research by such authors as Baily-Brock, Knight-Jones, and Vine. These small worms are best preserved in 5 percent buffered formalin. In many cases it is now necessary to send spirorbids to specialists because scanning electron microscopy is generally required to identify spirorbid species.

Serpulids are common throughout the Gulf where they occur on solid firm surfaces such as rocks, shells, *Zostera*, *Sargassum*, mangroves, boat hulls, and wharfs. A useful discussion will be found in Day (1967).

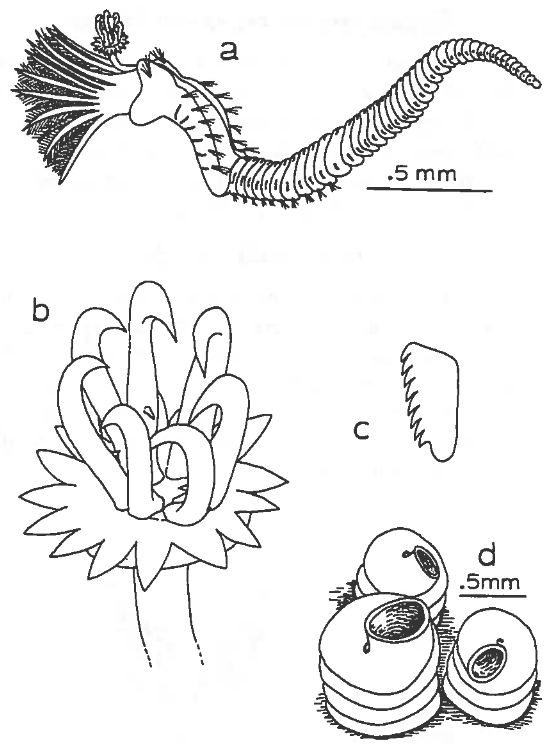

Fig. 6.50 (*right*) Serpulidae. (a) Entire animal, *Eupomatus recurvispina*. (b) Detail of operculum of *Eupomatus recurvispina*. (c) Uncinus. (d) Tubes of *Spirorbis*.

KEY TO SELECTED GENERA OF SERPULIDS

1	Body asymmetrical .... ***Spirorbis***	
	-Body symmetrical	2
2(1)	Operculum present	3
	-Operculum absent or poorly developed	5
3(2)	Opercular stalk with paired lateral processes .... ***Spirobranchus***	
	-Opercular stalk without processes	4
4(3)	Opercular spines with lateral processes .... ***Hydroides***	
	-Opercular spines without lateral processes .... ***Eupomatus***	
5(2)	Collar setae with basal processes; worms form clusters of delicate corallike tubes .... ***Filograna***	
	-Collar setae without basal processes; worms generally solitary; tubes mostly unattached .... ***Protula***	

Eupomatus recurvispina (Rioja)

This species was called *Eupomatus* sp. (Kudenov, 1973:130). The operculum has 2 disks: the lower disk has 18 marginal processes; the upper disk has 7 large spines (fig. 6.50b). This species is endemic to the Gulf of California (Rioja, 1942a).

Filograna implexa Berkeley

A small gregarious species that is 4 mm long and with 30 segments. An operculum is present, although regenerating individuals lack one. When present, the operculum is clam-shaped. *F. implexa* is reported from numerous worldwide areas; it was called *Salmacina dysteri*. A discussion of the synonymy is found in Day (1967). This species is common in low intertidal rocky habitats along the Sonoran coast.

Hydroides crucigera Mörch

A small species that has basal spurs on the collar setae. The operculum has 2 disks: the lower one has 38 simple pointed marginal processes; the upper one has 7 distal spines, each with paired lateral processes located just below the middle part of the spine. This is a Panamic species, commonly encountered in the Gulf (Rioja, 1944b).

Protula tubularia balboensis Monro

A species up to 25 or 35 mm long. An operculum is absent. In life it is brilliantly colored orange to red. Small tubercles are present on the outer base of each radiole. This species is known from Panama and the Sonoran coast (Monro, 1933; Kudenov, 1975b).

Spirobranchus giganteus (Pallas)

A large species around 120 mm long with over 200 segments. The tube is cylindrical and is usually colored with a red middorsal stripe. The body is generally bluish in color. The calcareous operculum has from 2 to 4 antlerlike processes. This is a tropical species which is reported from the coral reef at Cabo Pulmo (Day, 1967).

Spirorbis (Dexiospira) marioni (Caullery and Mesnil)

A small species with 3 thoracic segments and 15 to 20 abdominal ones. The tube is coiled anticlockwise, when viewed from above, and has a median crest. This is a Panamic species occurring throughout the Gulf of California, on basalt boulders (Bush, 1904; Rioja 1942b).

7

SIPUNCULA (Peanut Worms)

Preservation: Sipunculans will invariably retract their introvert when removed from the substrate and must be relaxed prior to preservation. Narcotizing may be with magnesium sulfate, menthol, alcohol, or by the putrid water method described for the holothurians. Preservation should be in 80 percent alcohol or 7 percent buffered formalin, the formalin preserving the color better than alcohol. Steinbeck and Ricketts stated that these worms are especially sensitive to metals and their salts and will retract the introvert when in contact with even small amounts of these compounds during relaxing procedures.

Taxonomy: The taxonomy of the Sipuncula, or peanut worms, is based primarily on internal anatomy, tentacle arrangement, and the position and morphology of the body papillae and introvert hooks. There has only recently been a generally accepted arrangement of the genera into higher taxa (Stephen and Edmonds, 1972). Fisher (1952) and Edmonds (1955, 1956) recognize 13 genera. Fisher used the name *Golfingia* Lankester in place of *Phascolosoma* and replaced *Physcosoma* Selenka with *Phascolosoma* Leuckart, in order to conform to the rules of zoological nomenclature. The following classification follows this arrangement and the classification of Stephen and Edmonds.

Sipunculans of the Gulf: Compared with most regions of the world, the sipunculan fauna of North America is relatively sparse. *Phascolosoma agassizii* is the dominant intertidal form from Alaska to central California and extends into the Gulf of California with less frequency. *Phascolosoma puntarenae* is the dominant species from the lower Gulf of California to Panama. *Sipunculus nudus* is somewhat of an offshore form, cosmopolitan in the bays and estuaries of the world and fairly common in the Gulf. Steinbeck and Ricketts reported six species of sipunculans from the Gulf and found *Golfingia hespera* (reported as *Phascolosoma hesperum*) and *Physcosoma* sp. to be the most common peanut worms of this region. I have found *Themiste lissum* and *Phascolosoma perlucens* to be the most common species in the upper Gulf.

Sipunculans may be found buried just below the surface on sandy beaches, mainly under large rocks in the mid and low intertidal. Some species commonly inhabit sponges; at least one *(T. lissum)* may be found burrowed into sedimentary rocks and conglomerate reefs.

KEY TO THE INTERTIDAL SIPUNCULANS

1 Oral tentacles bushy and conspicuous when extended 2
-Oral tentacles smaller and fingerlike, not bushy when extended 4

2(1) Middle third of body (except for the ventral region) with furry or fuzzy appearance; oral tentacles arise from 7 to 10 roots .... ***Xenosiphon branchiatum***
-Body not as above; oral tentacles arise from 4, 8, or more than 10 roots 3

3(2) Oral tentacles arise from 4 or 8 roots; body smooth and devoid of papillae; small (length of trunk and introvert 25–35 mm); tentacles surround mouth (fig. 7.2) .... ***Themiste lissum***
-Oral tentacles arise from more than 10 roots (the tentacular crown is thrown into numerous folds to accommodate the large number of tentacles, usually 50 or more); body with numerous papillae; medium to large (length of trunk and introvert 45–60 mm); tentacles dorsal to mouth .... ***Phascolosoma antillarum***

4(1) Body small and threadlike; introvert extremely filamentous and wrinkled; usually commensal in burrow of annelid or burrowing sea anemone .... ***Golfingia hespera***
-Body not small and threadlike; introvert not as above; free-living **5**

5(4) Skin with rectangular cross-hatchings; length of trunk and introvert about 120–300 mm; occur primarily on tidal flats (fig. 7.1) .... ***Sipunculus nudus***
-Skin not as above; length of trunk and introvert 25–170 mm; occur primarily on rocky shores **6**

6(5) Body long and slender, about 5 by 160 mm when extended; body covered with small mammiform glands surmounted by a minute papilla .... ***Phascolosoma rickettsi***
-Body shorter and more stout, usually 25–90 mm in length (rarely to 150 mm); body not covered with mammiform glands as above **7**

7(6) Introvert usually without brown bands; subepidermal, longitudinal muscle bands conspicuous; introvert with numerous, prominent, pointed papillae on dorsal surface (fig. 7.4) .... ***Phascolosoma perlucens***
-Introvert with numerous brown bands; longitudinal muscle bands not conspicuous; introvert without enlarged, conspicuous papillae as above **8**

8(7) Introvert with 25 to over 100 rings of hooks; length of body and introvert 30–70 mm .... ***Phascolosoma puntarenae***
-Introvert with 15–25 rings of hooks; length of body and introvert 60–150 mm (fig. 7.3) .... ***Phascolosoma agassizii***

FAMILY SIPUNCULIDAE

Sipunculus nudus (Linnaeus)

This is one of the best-known and most widely distributed peanut worms in the world. *Sipunculus nudus* is eurythermal, nearly cosmopolitan, in all but the coldest seas. The skin appears longitudinally ribbed, usually crosshatched to form numerous small rectangles, owing to the underlying bundles of muscle bands. The introvert is short and bears numerous scalelike papillae, which are somewhat triangular and have the tips pointing away from the mouth, closing together to overlap like the shingles of a roof. The tentacles of the introvert are fingerlike processes, borne on a horseshoe-shaped tentacular fold that encircles the mouth, and are usually difficult to observe. The skin is white or flesh colored and shines with a pearly iridescence when alive. Most individuals are about 100 mm long when extended (a subtidal form reported from Pacific Grove, California, was 300 mm long). This species is commonly found in the sandy mud of sloughs, estuaries, or bays, the largest colonies being subtidal. They feed by passing quantities of bottom sediment through their gut, much as the earthworms do, to extract organic matter. This species is recorded from Brazil north to the Carolinas, Europe, the Indian Ocean, and the western shores of the Pacific. On the west coast of America it is known from central California to Panama, and throughout the Gulf of California. *Sipunculus nudus* (as well as *P. agassizii*) belong to a group of peanut worms having two distinct larval stages, a trochophore and then a pelagosphera larva. The latter bears an attaching organ on the posterior end to facilitate settlement out of the water column. Figure 7.1.

Xenosiphon branchiatum (Fisher)

A large peanut worm (to 420 mm in length) with a small introvert (20–30 mm long), the latter being covered with scalelike squamiform papillae which increase in size anteriorly. The body is distinctively marked with a furry epidermis across the middle 1/3 of the trunk. This "fuzz" is actually many closely packed, slender, pointed papilliform outgrowths of the cuticle. The oral tentacles are composed of numerous small, grooved, foliate elements, arranged in about 7 distinct groups, radiating from around the mouth. This is a southern Gulf form known from La Paz, Panama, and Ecuador. There are only about three known species of this genus in the world.

FAMILY GOLFINGIIDAE

Golfingia hespera (Chamberlin)

This unique sipunculan is a very thin, wrinkled, wormlike animal that is found commensally in the tubes of burrowing sea anemones *(Cerianthus, Edwardsiella)*, polychaetes *(Mesochaetopterus)*, and brachiopods

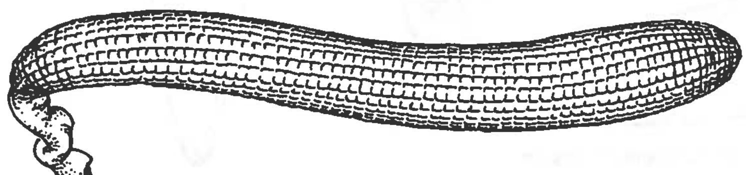

Fig. 7.1 *Sipunculus nudus*

(Glottidia). The introvert is exceedingly long and slender, up to eight times the trunk length, and usually randomly coiled or twisted when extended. The introvert bears numerous rings of minute hooks. When the long introvert is retracted, it entirely fills the body cavity with its irregular coils, displacing the viscera. The body wall is translucent, a bleached brown or yellow color. The body tapers to a point posteriorly and bears numerous short, ovoid, or cylindrical papillae. There is a very small tentacular crown. The length of the trunk and introvert combined is 100 to 140 mm. This species has been previously reported as *Phascolosoma hespera*. Its range is from southern California to the lower Gulf of California. I have found it in great abundance living in the parchment tubes of *Mesochaetopterus mexicanus* near Puerto Peñasco. This is the largest known genus of sipunculans, with close to 100 species having already been described worldwide.

Themiste lissum (Fisher)

A very small sipunculan with a short, tan body, and a short, thick introvert. It is devoid of visible spines and papillae on both trunk and introvert. The tentacles are large and profusely branched, making it easy to identify among the other short-tentacled species of the Gulf. The tentacles arise from four (or eight) thick basal tentacles. The introvert is about one-fourth the body length, and the anterior third of it forms a smooth, translucent collar, while the rest is whitish and crowded with minute convex glands, not easily seen. This species is known only from the intertidal zone of the Gulf of California, where it is usually found burrowed into clay, limestone, or other soft rock. *Themiste lissum* is rarely seen unless one hacks away at these substrates, whereupon a broken chunk of rock will often reveal great masses of these worms in their narrow burrows. This species has recently been placed in the genus *Themiste* and was known for many years as *Dendrostomum lissum*. There is no experimental evidence that links the supposed boring activities of sipunculans to a specific organ or structure. Structures that have been speculatively associated with boring are: hooks and spines of the introvert, cuticular papillae with associated epidermal glands, anterior and posterior horny shields, and anterior calcareous shields. Rice (1969) suggested the rigid trunk papillae and thickened posterior shield, coupled with secretory products of the numerous epidermal glands, appear to be the most likely devices to be used by these worms for their boring activities. Figure 7.2.

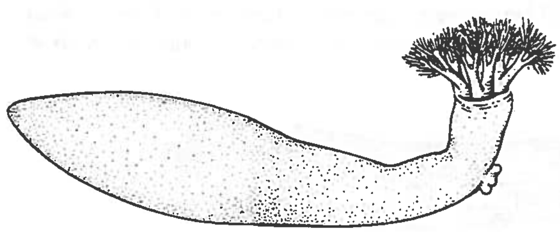

Fig. 7.2 *Themiste lissum*

FAMILY PHASCOLOSOMATIDAE

Phascolosoma agassizii Keferstein

A good-sized peanut worm with 24 or less short, digitiform tentacles arranged in a crescent pattern dorsal to the mouth. The introvert has 15 to 25 rings of tiny hooks anteriorly, is long (more than half the length of the trunk), and marked by irregular transverse bands of dark brown. The trunk is bluntly pointed posteriorly, and rough to the touch, owing to the numerous convex or conical skin papillae that are a darker brown than the general skin tone. The body wall varies from slightly translucent to opaque, and the skin color from pinkish gray, greenish tan, or yellowish gray to brown. Quite often, the trunk and introvert may be spotted with black, brown, or purple. The length of an extended animal is 60 to 150 mm. This is a dominant sipunculan of the intertidal zone in many regions, having adapted itself to a variety of habitats from the midtide zone to over 100 fathoms. In the intertidal zone, it may be found under rocks in sand or mud, in kelp holdfasts, or in rocky crevices filled with mud. In California, it is almost invariably found in the large mussel beds of *Mytilus californianus*, and in southern California it is quite common in the massive colonies of the tube-building polychaete worm *Phragmatopoma*, and also in association with terebellid polychaetes. This species has been previously reported as *Phymosoma agassizii*, *Golfingia agassizii*, and *Physcosoma japonicum*. Its range includes Alaska to San Quintín, Baja California, and the Gulf of California. It is recorded from temperate and tropical waters of both hemispheres. Figure 7.3.

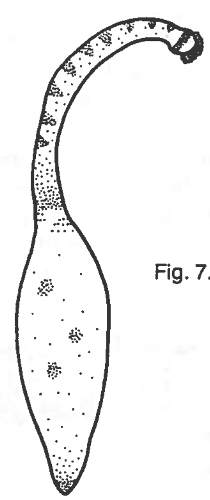

Fig. 7.3 *Phascolosoma agassizii*

Phascolosoma puntarena Grube

A small- to medium-sized sipunculan (to about 70 mm), similar to *Phascolosoma agassizii* but with slightly longer papillae, especially on the dorsal surface of the introvert. The introvert has transverse bands of brown and bears 24 tentacles. The hooks of the introvert are borne in 25 to 100 or more rings. Some workers consider this species to be a variant of *P. agassizii*, but Fisher (1952) considers it more closely related to the tropical form, *P. nigrescens (P. agassizii* is a temperate, cold water species). Fisher also notes that the name *P. puntarena* has 7 years' priority over *P. agassizii*, should synonymy be considered. This species has been previously reported as *Sipunculus puntarenae* and *Physcosoma agassizii*. It ranges from the Gulf of California to Panama.

Phascolosoma perlucens Baird

A medium-sized, slender species with a dorsal, preanal area of conspicuously enlarged, dark brown, sharp tubercles, and a similar area of tubercles at the posterior end. The introvert bears about 16 to 21 rings of small hooks, sharply bent apically, and usually has some dark brown patches on the dorsal surface. There are about 12 to 15 tentacles, usually olive colored. This species resembles *Sipunculus nudus* in having longitudinal muscle bands visible through the body wall. The body is highly papillated, and when extended is 40 to 70 mm long. The introvert is a dark brown to purple. The species is recorded from the Philippines and the general Indo-Pacific region and the Gulf of California, where it occurs under stones in the mid intertidal zone. It was formerly known as *Phascolosoma dentigerum*. Figure 7.4.

Phascolosoma antillarum Grube & Oersted

A medium-sized, robust *Phascolosoma* with a brown trunk bearing numerous low, convex papillae that become large and crowded at the posterior end, and again in the anal region. The introvert is set off by its pale cream color, being about one-third the trunk length. There are no hooks on the introvert. This is one of two sipunculans of the Gulf that have long, conspicuous, and highly branched tentacles, the other being *Themiste lissum*. These two species are easily distinguished, because the latter is smooth and without papillae, while *Phascolosoma antillarum* is highly papillated. There are 50 to 200 oral tentacles, and the tentacular disk is thrown into a number of folds to accommodate this great number of feeding appendages. Extended length is about 50 to 60 mm. This species is reported from the lower Gulf of California to Chile and Hawaii, and on the east coast from the West Indies to Brazil.

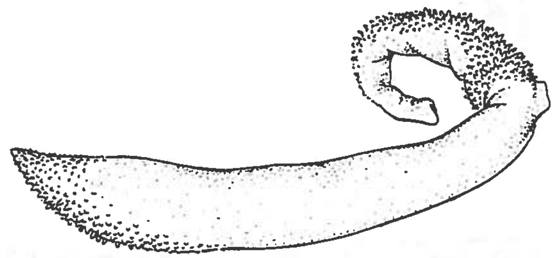

Fig. 7.4 *Phascolosoma perlucens*

Phascolosoma rickettsi (Fisher)

A slender sipunculan, somewhat reminiscent of a *Golfingia* and having a very long introvert, comprising about 3/4 of the total length in expanded individuals. The oral tentacles are small, filiform, and very numerous. The body of this worm is extremely thin, and individuals whose total length reaches 170 mm may have a trunk width of only 4–5 mm. The body is covered with many small, evenly spaced, mammiform glands, surmounted by a more or less evident cylindrical papilla. The introvert bears approximately 35 circles of minute, slender hooks, so closely packed that they overlap and touch one another. The holotype, upon which Fisher based the original description, was collected by Ed Ricketts at Isla Espíritu Santo, in the southern Gulf. It has not been reported since.

8

ECHIURA (Spoon Worms)

Preservation: The spoon worms should be narcotized prior to preservation to prevent contraction of the proboscis. Knudsen gave the following technique, recommended by the *British Museum Collector's Guide* (1954): Place the specimens in finger bowls containing seawater and sprinkle liberally with menthol crystals after they are fully expanded. After an hour or two, begin to introduce, drop by drop, enough alcohol to make a 10 percent solution. Preservation may be in 5 percent formalin or 80 percent alcohol.

Taxonomy: The echiurans resemble the sipunculans (peanut worms) but lack proboscis tentacles and possess a terminal anus, as opposed to the midbody or anteriorly placed anus of the latter. The body is usually sausage-shaped, with a solid, extensible proboscis just anterior to the mouth. The shape of this contracted proboscis has given the group the common name of "spoon worms." A ring of posterior setae usually is found near the anus, and a pair of small hooked setae is usually located behind the mouth. The systematics used in this handbook are from Fisher (1946). Fisher reported only three species of echiurans from the Gulf of California, all three of which are known to occur intertidally. Fisher stated, "Echiuroids are burrowers in mud or sand, where they fashion more or less permanent tunnels. Sometimes they live under rocks; sometimes in mud-filled mollusc shells or sand-dollar tests, which afford some protection; or they inhabit the rock galleries excavated by boring clams. Their food consists of organic material contained in the mud, which they swallow in large quantities, or of lighter organic detritus selected by the usually long proboscis. In the same species from different localities the intestinal pellets vary with the character of the bottom. One genus *(Urechis)* has very specialized feeding habits and uses only finely divided material, including bacteria. It is probable that any small organism living in the surface film of mud will be eaten by echiuroids."

KEY TO THE ECHIURA

1 Width of extended proboscis, at base, nearly equal to length; body length usually less than 20 mm; longitudinal muscle bands not present (fig. 8.1) . . . . ***Thalassema steinbecki***

-Extended proboscis much longer than width; body usually greater than 30 mm in length; longitudinal muscle bands present and visible through epidermis 2

2(1) Body translucent; longitudinal muscle bands weakly defined; 8 longitudinal muscle bands . . . . ***Listriolobus pelodes***

-Body not translucent (or translucent in midregion only); longitudinal muscle bands distinct, at least in anterior half of body; 16 to 17 longitudinal muscle bands (fig. 8.2) . . . . ***Ochetostoma edax***

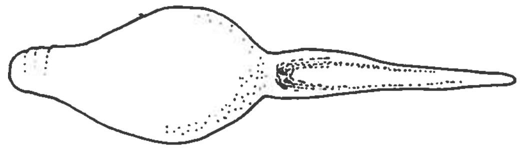

Fig. 8.1 *Thalassema steinbecki*

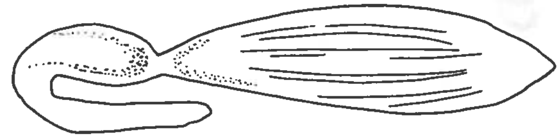

Fig. 8.2 *Ochetostoma edax*

Order Echiuroinea

FAMILY ECHIURIDAE

Thalassema steinbecki Fisher

A small spoon worm, with a body length of about 12 mm and a proboscis of about the same length. The body is slightly translucent, but not transparent as in *Listriolobus pelodes*. The proboscis is very broad at the base, as wide as the entire length of the extended structure, which is ribbonlike distally. *Thalassema* does not possess differentiated muscle bands, as do the other two species of spoon worms reported from the Gulf. Dr. W. K. Fisher named this species after John Steinbeck, who sent him a single specimen found burrowed in the sandy mud, collected by himself and E. F. Ricketts, near La Paz. Other records for this species are from 10 fathoms off Isla Cerralvo (just south of La Paz), and farther south to Ecuador. It has been collected both intertidally and at depths of up to 165 fathoms. I have not collected this species in the Gulf. Figure 8.1.

Listriolobus pelodes Fisher

A highly transparent species, with the proboscis much longer than wide, quite ribbonlike when extended. The body reaches at least 60 mm in length. The body wall is marked by eight weakly defined muscle bands. The proboscis is yellow-orange, elongate, soft, and easily detached. The body is gray-violet with greenish raised specks. When fully extended, the proboscis length slightly exceeds the body length. Dr. Fisher reported this species from numerous localities in central and southern California, Los Frailes near the southern end of Baja California, and in the upper end of the Gulf of California in 5 to 120 fathoms. I have collected what may be this species at Bahía San Everisto on the east coast of Baja California, at approximately lat. 24°50′N, in December, 1971.

Ochetostoma edax Fisher

Probably the most common species of intertidal spoon worm in the Gulf, *Ochetostoma edax* is opaque only occasionally in the midregion of the body. The proboscis is longer than it is wide, and the body is 25 to 65 mm long. This species has 16 to 17 distinct grayish muscle bands, merging into a continuous sheet posteriorly. The body color is generally rose to lavender, often covered with whitish papillae. The proboscis is about one-fourth the body length. Fisher reported that *O. edax* feeds upon the sand or coarser material in which it lives, and does not mold its excrement into definite fecal pellets. He reported the type locality as Bahía Pichalingue (near La Paz) and listed records from Isla Coronado, Isla Espíritu Santo, and Isla Angel de la Guarda, all in the Gulf. I have collected this species in large numbers at Puerto Libertad and Bahía San Everisto on the east coast of Baja California, at approximately lat. 24°50′N. This particular little bay, which is opposite Isla San José, proved to be one of the richest collecting sites I found in the Gulf. Unfortunately it is only easily accessible by boat, or perhaps I should say fortunately, as this is probably one of the reasons it possessed such a grand fauna. Figure 8.2.

9

MOLLUSCA

by Roy S. Houston*

The best-known group of invertebrates in the Gulf of California is the Mollusca. The richness and diversity of this group is exemplified by the more than 3,300 species described from the Panamic region, of which a majority occur in the Gulf.

It is virtually impossible to treat this phylum fully in the present handbook. Therefore, in keeping with the title, only the more common species are included. Owing to the overwhelming number of species of molluscs, I have chosen a more abbreviated style than that found in the other chapters of this treatise. About 261 species are treated, nearly all are illustrated, and identifications should be made using these figures and the species diagnoses.

If the reader wishes to pursue this subject further, he may refer to Keen (1971), which is the most recent and authoritative work on molluscs of this region. Keen and Coan (1974), Olsson (1961), Morris (1966), and Marcus and Marcus (1967) are also useful in the identification of members of this phylum in the Gulf of California.

Taxonomy: The taxonomy of genera and species is at this time based primarily on shell and radulae characteristics. The higher taxa, however, are separated by differences in internal anatomy, in addition to differences in shell structure. Measurements given for the molluscs in this chapter represent the longest recorded size, unless otherwise stated. We are indebted to Keen (1971) for the photographs in this chapter. In addition, we are grateful to Richard K. Allen for permission to use certain drawings from his handbook of "Common Intertidal Invertebrates of Southern California."

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Preservation: If a mollusc is to be used for dissection or histological study, it is imperative that the soft parts be relaxed before fixation. If this is not done, the animal will become contracted and severely distorted when placed in a fixative. If only the shell is desired, the animal may be boiled for 5 minutes, and the soft parts removed from the shell with a dissecting needle.

There are numerous ways to narcotize molluscs. The following methods are most widely used because they are quite successful, and the chemicals are easily obtained. These procedures are taken in part from Russell (1963).

Narcotizing agents:

1. Alcohol, 70 percent, added slowly to seawater containing the animal.
   a) *Chromodoris*
   b) *Natica*
2. 3 percent alcoholized seawater solution.
   a) Polyplacophora
   b) Prosobranchiata
   c) Opisthobranchiata
   d) Scaphopoda
3. Chloral hydrate—crystals dropped directly into water containing the animal, or animals placed directly into a 10 to 15 percent solution.
   a) *Aplysia*
   b) Polyplacophora
   c) Octopoda
   d) Scaphopoda
   e) *Berthellina*
4. Chloroform—added slowly.
   a) Pelecypoda
5. Formalin, 10 percent, added slowly to seawater containing animal until it has relaxed.
   a) Nudibranchiata

6. Magnesium sulfate, 20 to 30 percent solution—added slowly to seawater containing animal until it has relaxed.
   a) Nudibranchiata
   b) Pelecypoda
7. Propylene phenoxytol—shake 5 ml of propylene phenoxytol into 20 ml of seawater. Add this to a small quantity of seawater containing the animal (do not let the emulsion directly touch the animal).
   a) Molluscs with siphons
8. Fresh water—submerge the animal in boiling water.
   a) Pulmonata

Fixative:

1. Bouin's solution—best general fixative for all molluscs. Place the animal in Bouin's fluid for 24 to 48 hours.

Storage:

1. 70 percent alcohol for all molluscs.

Molluscs of the Gulf: The molluscs are comprised of seven living classes. These groups are classified according to anatomical differences in their foot, gills, alimentary systems, genital tract, and shell. Evolutionarily the molluscs have radiated into many species occupying numerous habitats. Members of all living classes are found in the ocean. However, only two classes (pelecypods and gastropods) have invaded fresh waters. The gastropods also occur on land.

Class Monoplacophora: This is a primitive group that is found in deep water. There are but a few living species. However, they are well represented in the fossil record. The shell is limpetlike with the apex recurved anteriorly. Internally there are five to six pairs of muscle scars. In addition, the gonads, gills, and kidneys are segmentally arranged. The foot is broad and flat, and the head is reduced. Very little is known about their biology; however, it appears that they have separate sexes. *Neopilina galatheae* Lemche occurs in deep waters (3500–3800 m) from Cabo San Lucas to Costa Rica.

Class Aplacophora: These are deep water vermiform molluscs without a shell. By some authors they are placed with the chitons in the class Amphineura. It is believed they feed on organic material in bottom sediments. *Alexandromenia agassizi* Heath occurs in depths of around 850 m off the Revillagigedo Islands, south of the Gulf of California.

Class Polyplacophora: Commonly known as chitons, these molluscs are characterized by having a shell composed of eight interlocking dorsal plates. In addition, there is a thick girdle holding the shell in place. The foot is broad and flat, and the reduced head lacks eyes and tentacles. The presence of the large foot greatly reduces the size of the mantle cavity. Hence, the gills are divided into a series of small leaflets that extend the entire length of the animal. Sexes are separate, with the male gametes being shed into the water. Fertilization occurs in the mantle cavity of females. Brooding occurs in some species. Most species of chitons are herbivorous and can be observed scraping algae off rocks by use of the radula. (Figs. 9.228 to 9.238.)

Class Pelecypoda: The pelecypods or bivalves have a shell composed of two valves which enclose the soft parts. These valves have an articulating hinge that is held in place by a tough chitinous ligament. In addition, one or two large, strong, adductor muscles prevent the valves from gaping.

Those species living in sand or mud are provided with a large foot modified for digging or plowing; as opposed to attached forms which have a much reduced foot.

The posterior region of the mantle is modified into tubular extensions or simply openings in the edge which function as siphons. The ventral siphon brings water and food particles into the mantle cavity while the dorsal one expels water and waste material. In the mantle cavity water passes over the gills for respiration. In addition, food particles are trapped in the gills and are passed to the mouth via ciliary currents.

Most bivalves have separate sexes and shed their gametes into the surrounding water. Fertilization is external resulting in free swimming larvae which later settle to the bottom and develop into young adults. Some species of oysters and clams are protandrous hermaphrodites, having a male phase followed by a female phase. Fresh water clams produce a glochidia larva which is parasitic on the gills of fish until it drops off and settles to the bottom, where it develops into a juvenile clam. (Figs. 9.1 to 9.66.)

Class Gastropoda: This is the largest class of living molluscs, with over 80,000 described species. In most species the shell is coiled; however, in the limpets the coiling has been lost in the adult. Some families have lost the shell completely.

They have a well developed head with tentacles and eyes. Most gastropods have a feeding organ called a radula which has many teeth modified for rasping or tearing food.

The reproductive systems are highly varied in this group. They range from a simple gonad to extremely complex systems with numerous accessory organs. During embryonic development a process known as "torsion" occurs, where many of the internal organs twist 180 degrees so they rest toward the anterior region of the animal.

The gastropods are divided into three subclasses: the Prosobranchiata is exemplified by having full torsion in the adult. Within this subclass there are three orders.

The Archaeogastropoda are characterized by having paired internal organs and radulae with many teeth. Most of these snails are herbivorous. The orders Mesogastropoda and Neogastropoda have lost their right internal organs and have radulae specialized for an omnivorous or carnivorous diet. In addition, they have an extensible proboscis. The subclass Opisthobranchiata exhibits various degrees of detorsion. Furthermore, the shell may be external, internal, reduced, or absent depending upon the group. These include the sea hares and sea slugs. The subclass Pulmonata includes the land snails and slugs. They have a specialized mantle cavity which functions as a "lung." In addition, they lack an operculum and most forms are herbivorous. Comments on the ecology and behavior of *Collisella* spp. have been taken from Yensen (1973). (Figs. 9.67 to 9.227.)

Class Scaphopoda: The scaphopods, commonly referred to as the tusk shells, are characterized by having a tubular shell open at both ends. They live in the mud or sand with the posterior (small) end extending above the surface. Anteriorly they have a conical foot projecting into the sand. Specialized feeding structures called captacula capture small organisms and pass them to the mouth. Tusk shells have lost both gills and heart, and gas exchange occurs across the mantle while blood is circulated with the aid of pumping vessels. The sexes are separate with external fertilization. (Figs. 9.239 to 9.244.)

Class Cephalopoda: This group is probably the most spectacular of all the molluscs, for they include the squids and octopods. Anatomically they are the most advanced invertebrates in that they possess well developed eyes and a complex brain (often enclosed in a cartilaginous brain case). Furthermore, they demonstrate learning capabilities and color vision. All cephalopods are predatory and have tentacles which surround the mouth, which is armed with a strong beak. This structure is designed for tearing prey into small pieces. Internally is a radula for further mastication.

The sexes are separate and development is direct, in that the veliger larval stage is absent, juveniles developing directly from the yolk-filled eggs.

Cephalopods are fast swimmers, propelling themselves by expelling water from their mantle cavity by way of a siphon.

Unfortunately the cephalopods appear to be a dying group, in evolutionary terms, for the number of species has decreased over the past few million years. This has been attributed to their over-specialization.

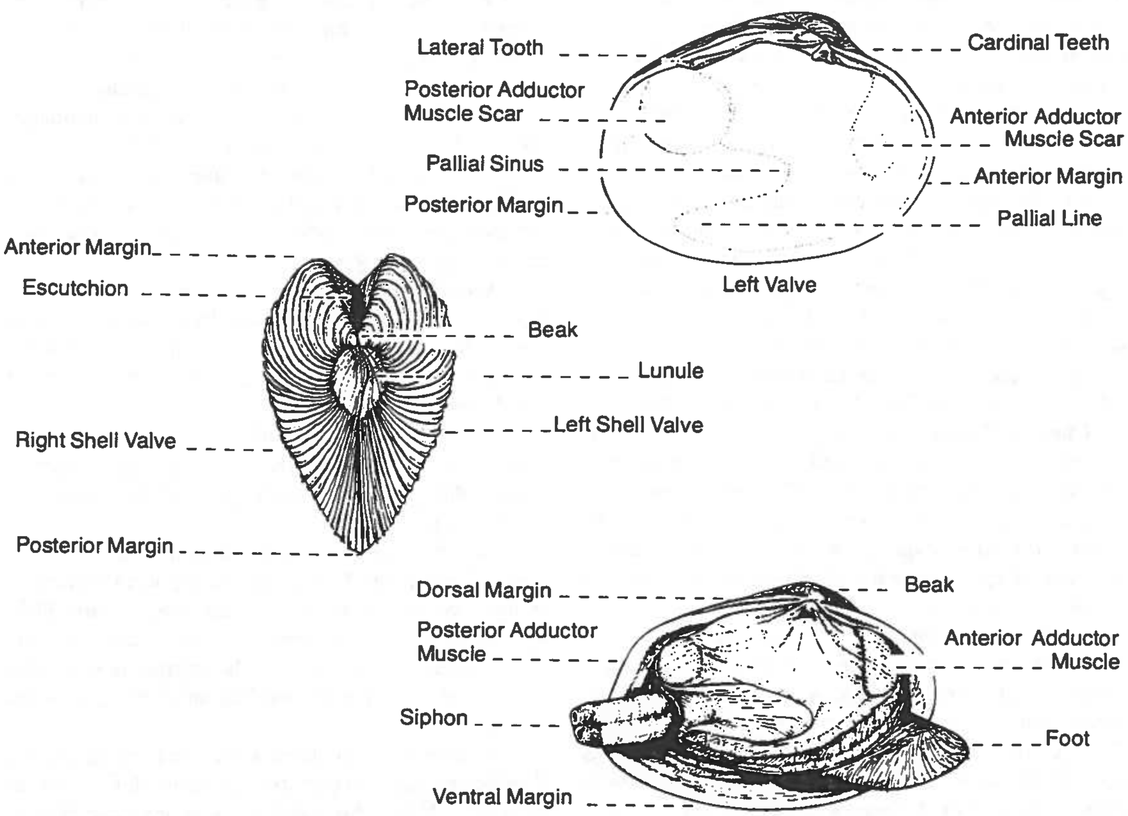


Fig. 9.1 General pelecypod morphology
(from Allen, 1976)

CLASS PELECYPODA

SUBCLASS PTERIOMORPHA

Order Arcoida

FAMILY ARCIDAE (ark shells)

The arks are characterized by having shells with long toxodont hinges, with the ligament occurring in grooves. The pallial line is continuous and connects the two equal-sized muscle scars. Some of the intertidal species are attached to rocks by a byssus.

Arca mutabilis (Sowerby, 1833) (Fig. 9.2)

Shell characteristics: Light brown with a hairy periostracum; variable shape; long ligamental area; steep ridge separates posterior from central regions.

Measurements: Length, 35 mm; height, 20 mm; diameter, 18 mm.

Habitat: Low intertidal zone, under rocks.

Distribution: Bahía Magdalena and throughout the Gulf, south to Ecuador.

Arca pacifica (Sowerby) (Fig. 9.3)

Shell characteristics: Shape variable, irregular sculpture; locally known as "pata de yegua."

Measurements: Length, 110 mm; height, 60 mm.

Habitat: Intertidally to deep water.

Distribution: Scammon's Lagoon, Baja California, and throughout the Gulf, south to Peru.

Barbatia reeveana (Orbigny) (Fig. 9.4)

Shell characteristics: Large; coarsely reticulate; shell often distorted from growing between rocks; white with a dark brown periostracum.

Measurements: Length, 82 mm; height, 45 mm.

Habitat: Tidal flats, lagoons, and rock-mud interfaces; mid intertidal to depths of 120 m.

Distribution: Manuela Lagoon (Baja) and throughout the Gulf, south to Peru.

Barbatia illota (Sowerby) (Fig. 9.5)

Shell characteristics: Gray to ivory with a dark periostracum that forms fine hairs.

Measurements: Length, 35 mm; height, 24 mm.

Habitat: Low intertidal of tidal flats and offshore to at least 70 m; also along rock-mud interfaces; commonly dredged in central and southern Gulf.

Distribution: Central Gulf to Peru; not uncommon in Bahía de los Angeles and Bahía Concepción.

Anadara tuberculosa (Sowerby, 1833) (Fig. 9.6)

Shell characteristics: Thick, ovate with 33–37 ribs, anterior ribs have tubercles.

Measurements: Length, 50 mm; height, 40 mm; diameter, 35 mm.

Habitat: Primarily in mangrove esteros.

Distribution: Ballenas Lagoon, Baja California and throughout the Gulf, south to Peru.

Remarks: An important food item to both ancestral peoples and modern coastal dwellers; known locally as "pata de mula."

Anadara grandis (Broderip and Sowerby) (Fig. 9.7)

Shell characteristics: Large, white with dark brown periostracum; about 26 ribs.

Measurements: Length, 100 mm; height, 70 mm.

Habitat: In sand, intertidally and in shallow water.

Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Anadara multicostata (Sowerby, 1833) (Fig. 9.8)

Shell characteristics: Left valve overlaps the right; 31–36 ribs; quadrate.

Measurements: Length, 55 mm; height, 48 mm; diameter, 45 mm.

Habitat: On sandbars, offshore.

Distribution: Newport Bay, California; along Baja California, and throughout the Gulf, south to Panama and the Galápagos Islands; also known from the upper Pleistocene of San Diego, California.

FAMILY NOETIIDAE

Robust shells, generally ovate to trigonal. The hinge teeth are radial, the anterior series somewhat longer than the posterior series.

Noetia reversa (Sowerby) (Fig. 9.9)

Shell characteristics: Equal valves, extremely prominent beaks that lean posteriorly.

Measurements: Length, 35 mm; height, 35 mm.

Habitat: Subtidal in mud.

Distribution: Point Conception (uncommon) and the central Gulf, south to Peru.

FAMILY GLYCYMERIDAE (bittersweet shells)

Bittersweets have toxodont hinges in which the teeth are bent. In addition, the hinge plate is curved and the shell is extremely symmetric. It is very difficult to differentiate between the anterior and posterior regions in these bivalves. The glycymerids generally occur just offshore in shallow water. Moreover, the valves are relatively common in beach drift.

Glycymeris gigantea (Reeve) (Fig. 9.10)

Shell characteristics: Smooth white, with red zigzag radial lines. About 30 hinge teeth.

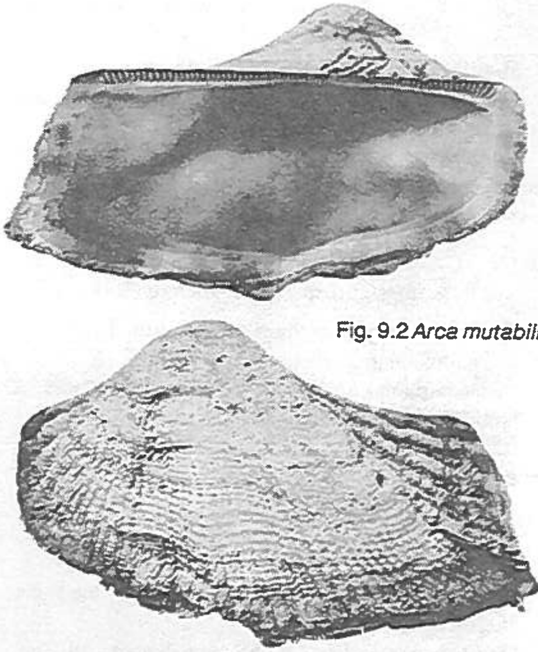


Fig. 9.2 *Arca mutabilis*

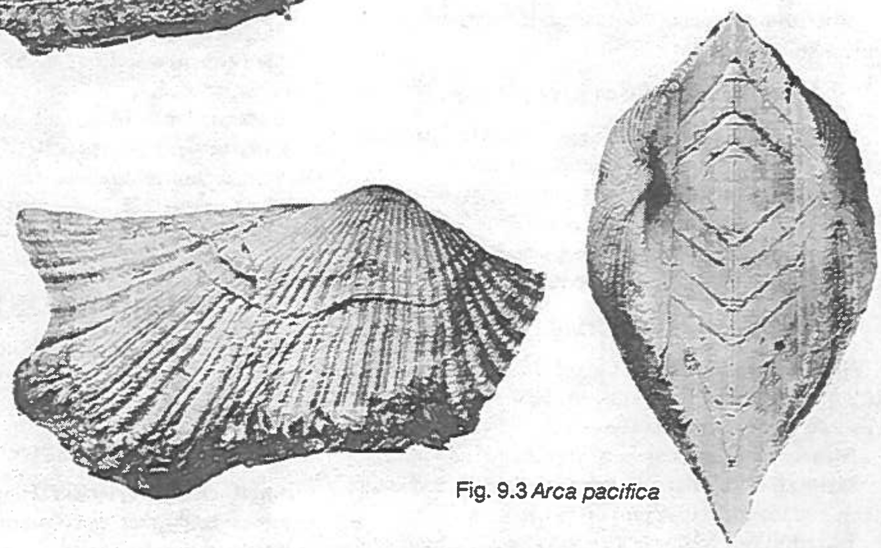


Fig. 9.3 *Arca pacifica*

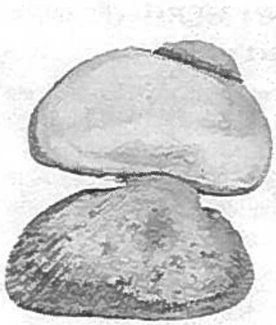


Fig. 9.5 *Barbatia illota*

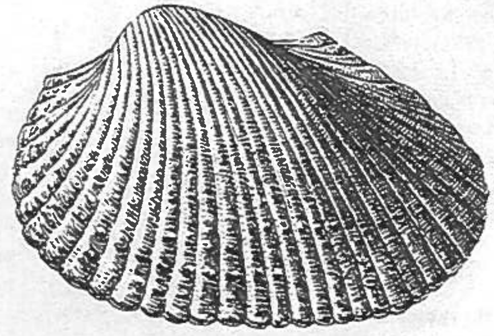


Fig. 9.6 *Anadara tuberculosa*

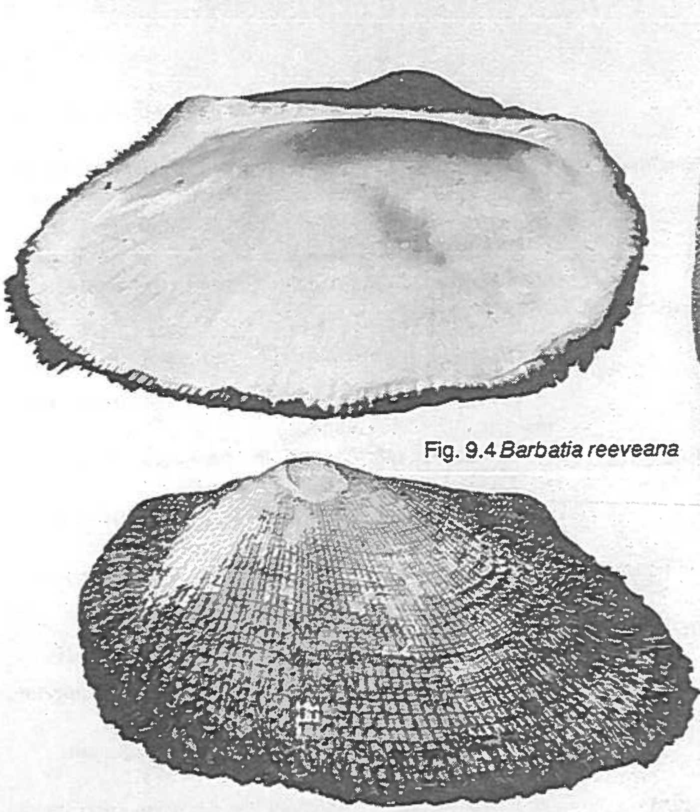


Fig. 9.4 *Barbatia reeveana*

Fig. 9.7 *Anadara grandis*

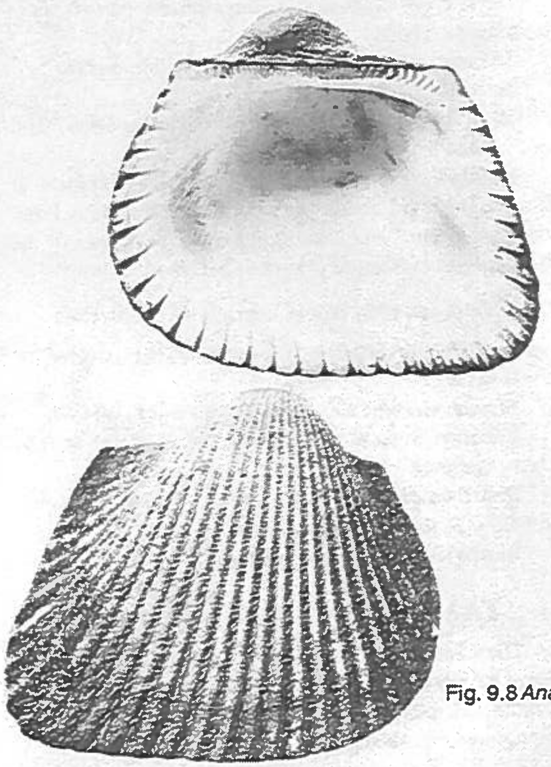


Fig. 9.8 *Anadara multicosta*

Measurements: Length, 110 mm.
Habitat: Subtidal in muddy sand.
Distribution: Bahía Magdalena and throughout the Gulf.

Glycymeris maculata (Broderip, 1832) (Fig. 9.11)

Shell characteristics: White with small brown spots; smaller than *G. gigantea*.
Measurements: Length, 30 mm; height, 25 mm; diameter, 20 mm.
Habitat: Intertidally in sand.
Distribution: Northern Gulf south to Peru.

Glycymeris multicostata (Sowerby, 1833) (Fig. 9.12)

Shell characteristics: Gray, mottled with brown; 35–40 ribs fragmented at the ends.
Measurements: Length, 30 mm; height, 30 mm; diameter, 20 mm.
Habitat: Subtidally, in sand.
Distribution: Gulf of California to Ecuador.

Order Mytiloidea

FAMILY MYTILIDAE (mussels)

There are many species of mussels, occupying a wide variety of habitats. Some species are attached to rocks and pilings by a byssus, while others occur on mud flats. Moreover, other species are burrowers in rocks or shells. Mussels are sessile and tend to aggregate in large masses. They serve as food for a wide variety of predators, such as sea stars and predatory snails. Like many bivalves, mussels are filter feeders that extract microorganisms from the water. At certain times of the year (in many areas) there are large numbers of toxic dinoflagellate protozoans in the water. These microorganisms are filtered out by mussels and the toxin concentrated in their tissues. Mussels that have concentrated these products are unsafe to eat. The large mussels and mussel beds so common to California shores (the genus *Mytilus*) do not occur in the tropical east Pacific.

Brachidontes semilaevis (Menke) (Fig. 9.13)

Shell characteristics: Dorsal surface purple to brown, ventral surface yellow to green; one to three large teeth in the hinge; ventral side of shell smooth.
Measurements: Length, 10 mm.
Habitat: Intertidal zone, on rocks and algae.
Distribution: Throughout the Gulf of California, south to Peru.

Mytella guyanensis (Lamarck) (Fig. 9.14)

Shell characteristics: Green to black; interior white with purple on the muscle scar; concentric lines on posterior region; anterior retractor scar behind umbo; anterior adductor scar along anterior margin.
Measurements: Length, 50 mm; width, 25 mm; diameter, 20 mm.
Habitat: In sandy mud, attached to shells and rocks, on the bases of mangrove roots (where they are often referred to locally as "Choro de mangle").
Distribution: Throughout the Gulf of California, south to Peru. In the Atlantic Ocean from Venezuela to Brazil.

Lithophaga spatiosa (Carpenter) (Fig. 9.15)

Shell characteristics: Large, wide and covered with many rows of fine nodules.
Measurements: Length, 65 mm; width, 25 mm.
Habitat: Intertidal to shallow water.
Distribution: Northern Gulf of California to Ecuador.
Remarks: This species is commonly found boring into oyster shells *(Pinctada* and *Ostrea)*.

Lithophaga aristata (Dillwyn) (Fig. 9.16)

Shell characteristics: Elongate valves with anterior regions flattened and twisted around each other.
Measurements: Length, 30 mm; width, 10 mm.
Habitat: Intertidal.
Distribution: Throughout the world in subtropical and tropical waters.
Remarks: This species commonly bores into rocks or shells of other molluscs.

Modiolus capax (Conrad) (Fig. 9.17)

Shell characteristics: Orange-brown periostracum with serrated hairs.
Measurements: Length, 75 mm; width, 30 mm.
Habitat: Intertidally on rocks.
Distribution: Northern California to Peru, and throughout the Gulf of California.
Remarks: This mussel is extremely common at Cholla Bay and Bahía de Los Angeles, where large numbers occur half buried in the mud. Mexicans of the Baja peninsula often refer to this species as "Choro."

Modiolus rectus (Conrad) (Fig. 9.18)

Shell characteristics: Bluish-white shell covered by a yellowish-brown periostracum.
Measurements: Length, 118 mm; width, 40 mm.
Habitat: Burrow in mud with the posterior margin above the surface.
Distribution: Vancouver Island, British Columbia to Bahía Concepción, Gulf of California.
Remarks: Uncommon in the Gulf.

FAMILY PINNIDAE (pen shells)

These shells are extremely fragile and occur in protected bays buried in the sand or mud, or occasionally on a protected rocky shore. The shells are triangular with the pointed end anchored in the substrate by a byssus.

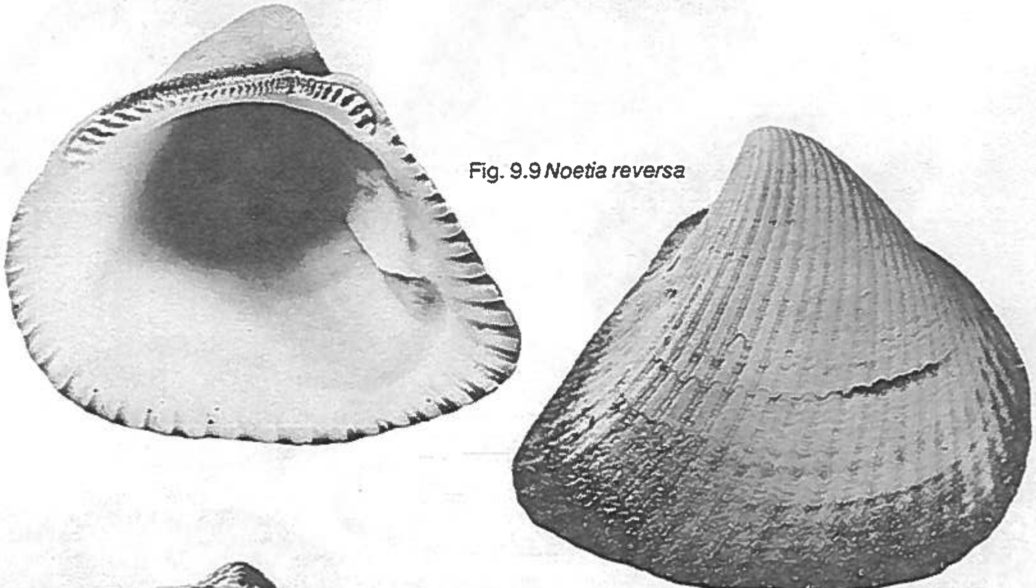


Fig. 9.9 *Noetia reversa*

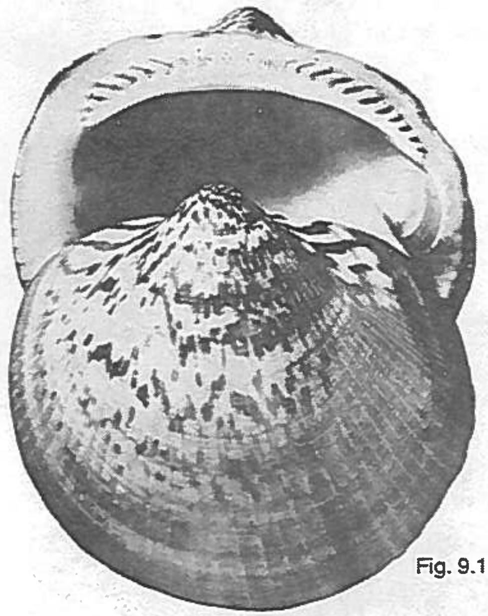


Fig. 9.10 *Glycymeris gigantea*

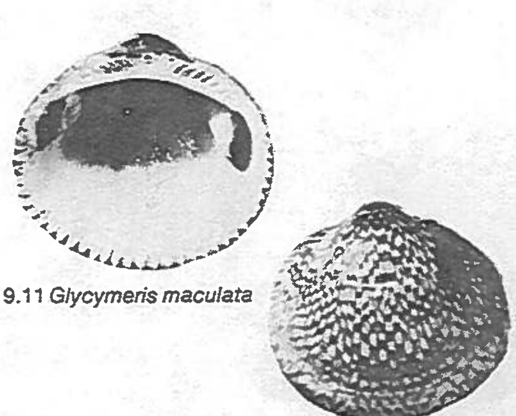


Fig. 9.11 *Glycymeris maculata*

Fig. 9.12 *Glycymeris multicostata*

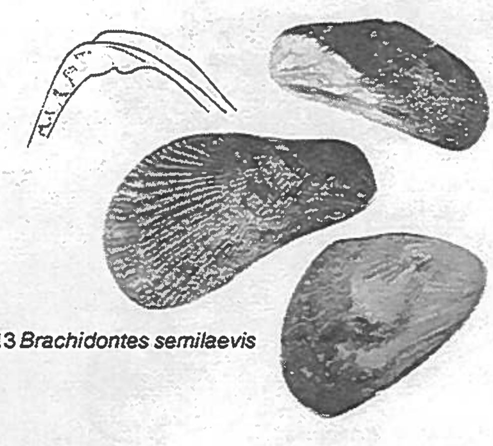


Fig. 9.13 *Brachidontes semilaevis*

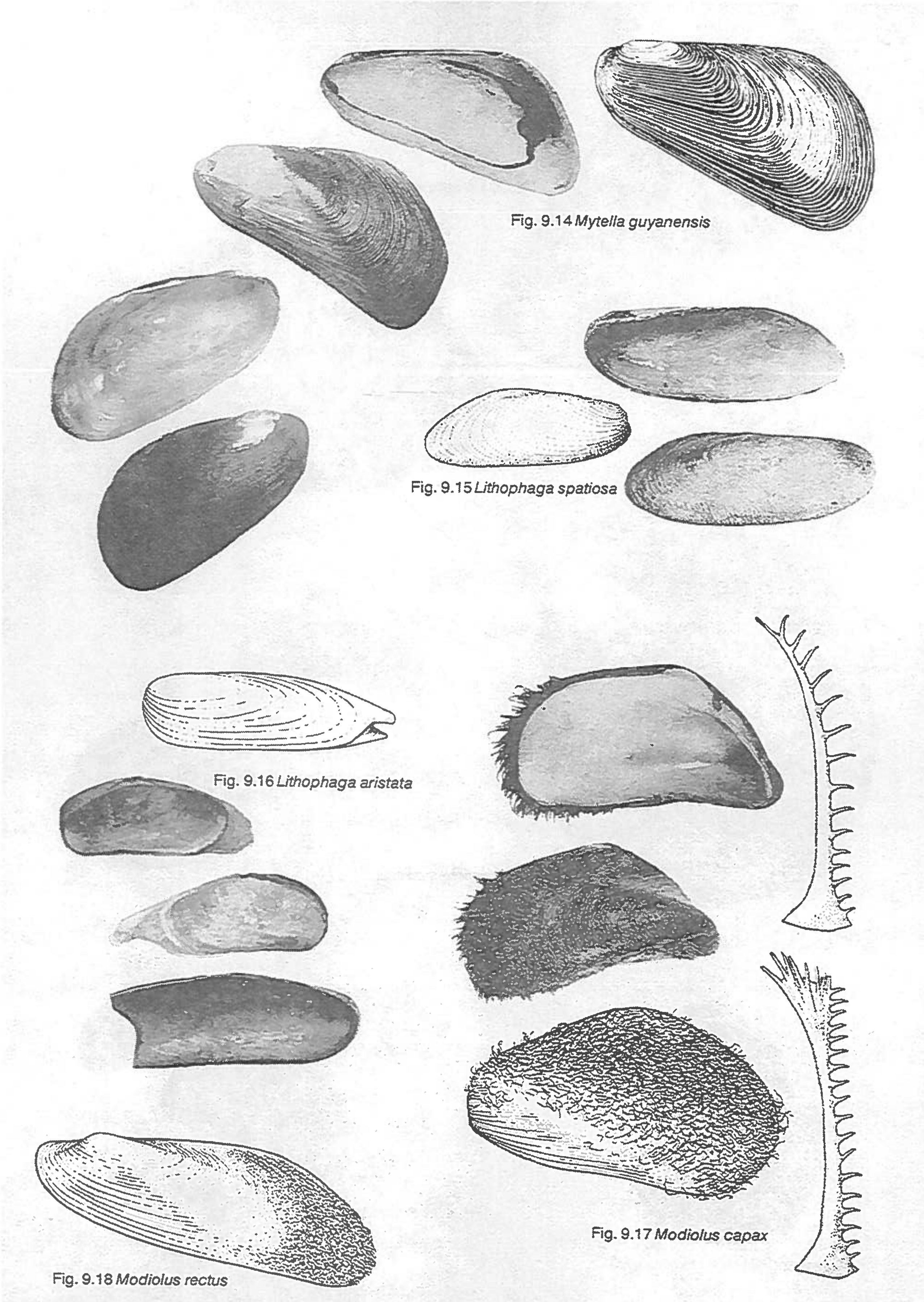


Fig. 9.14 *Mytella guyanensis*

Fig. 9.15 *Lithophaga spatiosa*

Fig. 9.16 *Lithophaga aristata*

Fig. 9.17 *Modiolus capax*

Fig. 9.18 *Modiolus rectus*

Pinna rugosa (Sowerby) (Fig. 9.19)

Shell characteristics: Large, spiny on the outside, 8 rows of tubular spines; spines become eroded in older specimens; known locally as "hacha larga."

Measurements: Length, 190 mm; width, 90 mm.

Habitat: Intertidal in sand or between rocks.

Distribution: Southern Baja California and throughout the Gulf, south to Panama.

Atrina tuberculosa (Sowerby) (Fig. 9.20)

Shell characteristics: Brown to black; convex with short thick spines.

Measurements: Length, 210 mm; width, 130 mm; diameter, 40 mm.

Habitat: At low tide and offshore on mudflats.

Distribution: Throughout the gulf, south to Panama.

Remarks: An important food source in certain localities; often referred to as "hacha china."

Order Pterioida

FAMILY PTERIIDAE

The shells of this family are characterized by having winglike projections at the hinge. In some species the posterior projection is much longer than the anterior one. A byssal indentation is present just below the hinge in the right valve. Adults appear to have only one muscle scar, but in reality they have two, although the anterior adductor is highly reduced.

Pteria sterna (Gould) (Fig. 9.21)

Shell characteristics: Brown outside with a beautiful nacreous-blue interior; hairy periostracum; thin, delicate with a large anterior wing and short posterior wing.

Measurements: Length about 100 mm; height, 80 mm.

Habitat: On mud flats, intertidally and offshore.

Distribution: Baja California and throughout the Gulf, south to Peru.

Remarks: This species apparently used to be much more common in the Gulf than it now is. One often encounters massive piles of shells along deserted beaches of Baja, where natives have decimated local populations in search of pearls. It is known locally as "concha nácar" or "pega-pega."

Pinctada mazatlanica (Hanley) (Fig. 9.22)

Shell characteristics: Shell heavier and darker than *Pteria;* periostracum strongly fluted.

Measurements: Length, 100–125 mm.

Habitat: Low intertidal and shallow subtidal; muddy bays and mud-rock areas.

Distribution: Lower west Baja coast and throughout Gulf, south to Peru.

Remarks: Like *Pteria sterna* this species has been strongly depleated locally due to pearl fishermen. Young specimens are not uncommonly found attached to the shells of *Pinna rugosa*. The commensal shrimp *Pontonia margarita* is commonly found in the pallial sinus of this clam.

FAMILY ISOGNOMONIDAE

Hinge with multiple ligamental grooves but lacking hinge teeth; shell with a single central muscle scar; pallial line broken into small pits; interior nacreous.

Isognomon janus Carpenter (Fig. 9.23)

Shell characteristics: Strongly elongate; 7–9 pits along hinge margin; light tan to brown; locally referred to as "*hojarasca*," a pleasantly descriptive name.

Measurements: Length, 30 mm; height, 80 mm; diameter 7 mm.

Habitat: Tidal flats and mud-rock intertidal regions and offshore in very shallow water.

Distribution: Lower west coast of Baja and throughout the Gulf, south at least to Oaxaca.

FAMILY OSTREIDAE (oysters)

Oysters, in many ways, are similar in structure to the scallops. Both groups have a central ligament. However, it is much larger in the oysters. In addition, both exhibit a centrally located muscle scar. The ribbing in oysters is irregular, unlike that of the pectins. Since one valve is cemented to the substrate, mature oyster shells tend to be deformed or distorted. Variability in the position of the muscle scar, color, size, and shape of the ligament and shell are distinguishing characteristics of different species. The lower (left) valve is generally larger and deeper, while the upper valve is often flattened.

Ostrea conchaphilia (Carpenter) (Fig. 9.24)

Shell characteristics: Thin, circular, and flat, with radiating bands of brown, purple, or orange. Narrow ligament, small teeth about one-third of the distance between the hinge and ventral margin.

Measurements: Length, 50 mm.

Habitat: Intertidal and offshore cemented to rocks.

Distribution: Southern California and throughout the Gulf, south to Panama.

Remarks: As the name implies, this species is commonly found attached to the shells of other molluscs, especially members of the families Pinnidae and Pteriidae.

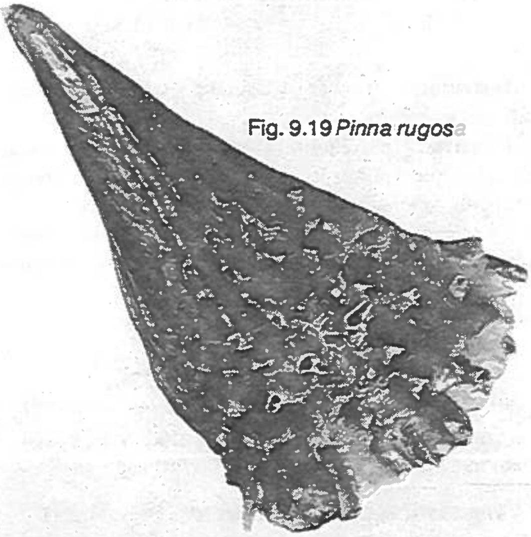


Fig. 9.19 *Pinna rugosa*

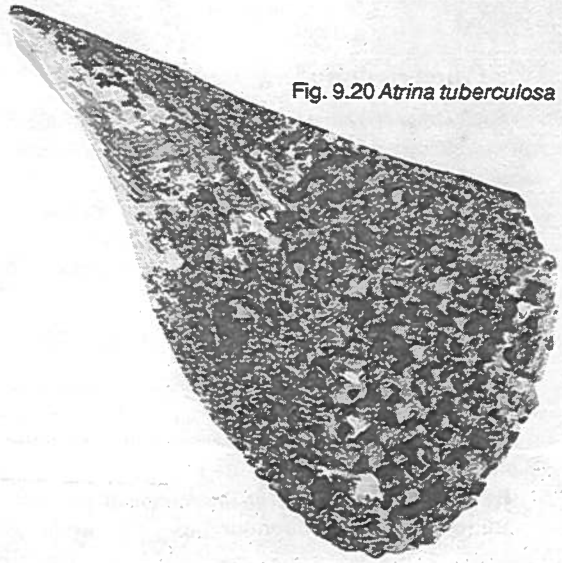


Fig. 9.20 *Atrina tuberculosa*

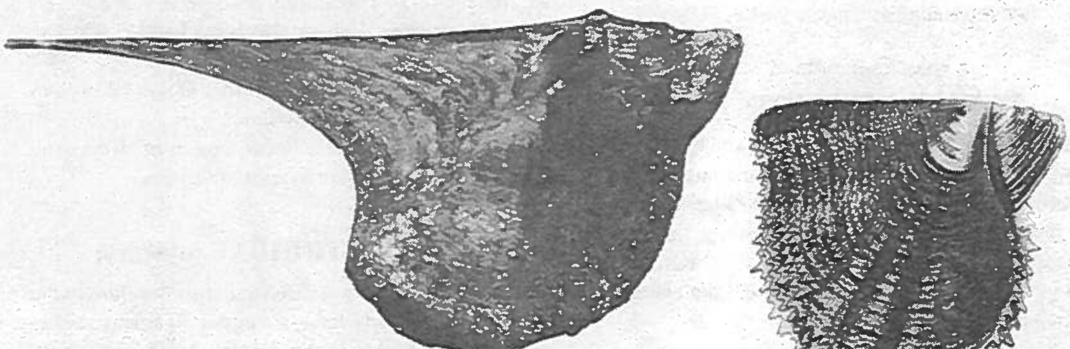


Fig. 9.21 *Pteria sterna*

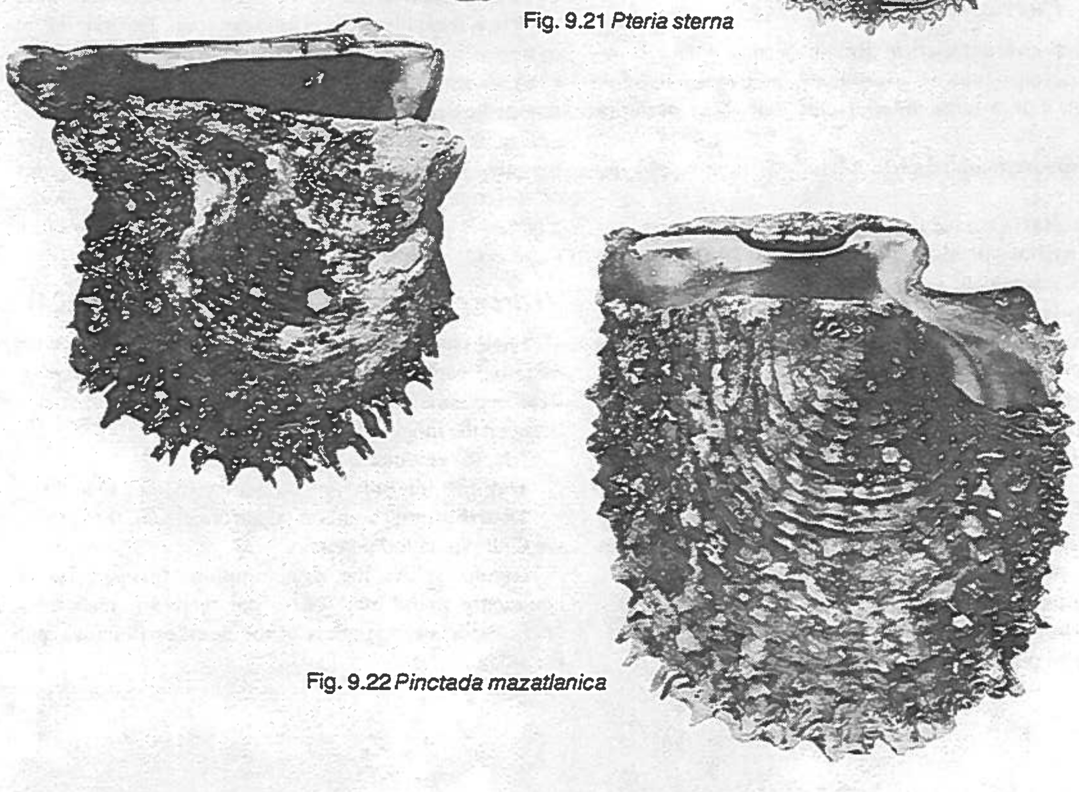


Fig. 9.22 *Pinctada mazatlanica*

Ostrea palmula Carpenter (Fig. 9.25)

Shell characteristics: Dull white to light blue; upper valve very flat to concave; lower with fan-shaped margins; a highly variable species.

Measurements: Diameter, 50–70 mm.

Habitat: Intertidal, on rocks and mangrove roots.

Distribution: Pacific coast of lower Baja California, throughout the Gulf to Equador.

Ostrea columbiensis Hanley (Fig. 9.26)

Shell characteristics: White with a wavy purple margin; adductor scar kidney-shaped; upper valve often rayed with purple or yellow.

Measurements: Length, 75 mm.

Habitat: On rocks and mangrove roots; common in mangrove swamps.

Distribution: Lower Baja south to Chile.

Remarks: Commonly eaten by locals.

FAMILY PECTINIDAE (scallops)

The scallops comprise a large number of species occurring throughout the world. Many are extremely colorful and have shells with complex, intricate patterns. A few are intertidal; however, most species occur in shallow and deep water. The shell is generally round with regular radiating ribs. In the hinge region there are projecting wings. Scallops swim by jet propulsion, in that they force water out of their mantle cavity in regular spurts. In addition, they have numerous photoreceptors ("eyes") located along the mantle edge. In many cases these "eyes," or ocelli, are bright blue.

Argopecten circularis (Sowerby) (Fig. 9.27)

Shell characteristics: Color variable, white to orange or purple, some individuals striped or mottled; both valves convex with about 21 ribs.

Measurements: Length, 45 mm.

Habitat: Extreme low tide zone and offshore, in sand.

Distribution: Throughout the Gulf of California and lower Baja California, south to Peru; also known from the upper Pleistocene of San Diego, California.

Remarks: Popularly known as "almeja catalina voladora" because of its locomotory behavior, which consists of snapping the valves together to expel water and jet through the environment.

Leptopecten tumbezensis (Orbigny) (Fig. 9.28)

Shell characteristics: Variable in color; left valve red to black with tiny white specks. Right valve yellowish with dark rays near the posterior margin. Fourteen to fifteen ribs, with interspaces just as wide.

Measurements: Diameter, 30 mm.

Habitat: Offshore in sand.

Distribution: The Gulf of California to Peru.

FAMILY SPONDYLIDAE (spiny oysters)

The spiny oysters are similar to the pectins in having a centrally located hinge ligament. However, they are missing the byssal gape in the right valve. They have an irregular shell like the oysters because of their attachment to hard substrates.

Spondylus calcifer Carpenter (Fig. 9.29)

Shell characteristics: Dark red outside with a wide purple band on the inside margin; many regularly spaced spines cover the outer surface.

Measurements: Diameter up to 150 mm.

Habitat: Extreme low tide and offshore, on rocks.

Distribution: Throughout the Gulf of California, south to Ecuador.

Remarks: The shells are usually perforated with numerous boring organisms, such as, worms, sponges, and other molluscs. This is the largest of the American *Spondylus*, adults attaining weights of over 3 lbs. It is occasionally referred to as "el concha burro," owing to its size and weight.

Spondylus princeps unicolor Sowerby (Fig. 9.30)

Shell characteristics: Colorful; bright red to orange to white. Covered with large curved spines; attachment scars small to absent.

Measurements: Diameter, 150 mm.

Habitat: On rocks, intertidally to shallow water.

Distribution: Throughout the Gulf of California and Baja California Sur, to southern Mexico.

Remarks: Very common off La Paz, Baja California; often seen in shell shops.

FAMILY LIMIDAE (file shells)

File shells or swimming clams look much like the pectins, except the shell is oval or oblong in shape. These animals, like the scallops, swim by forcing water out of their mantle cavity. The fringed mantle edge, which is so apparent when the animal is moving about, makes these bivalves beautiful and fascinating creatures to observe.

Lima pacifica Orbigny (Fig. 9.31)

Shell characteristics: Long and narrow, dull texture, and ivory white.

Measurements: Length, 35 mm; width; 12 mm.

Habitat: Intertidally under rocks.

Distribution: Northern Gulf of California to Peru.

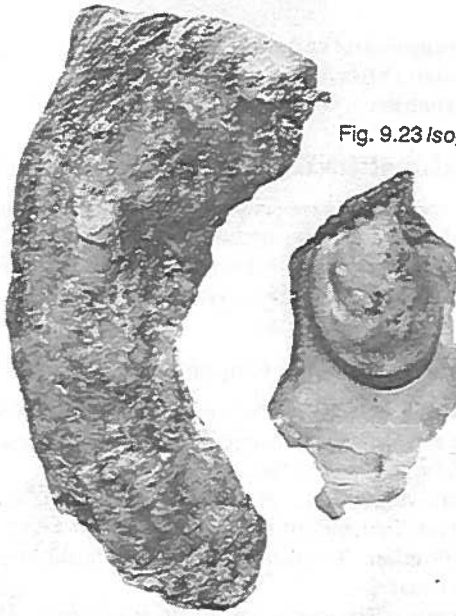


Fig. 9.23 *Isognomon janus*

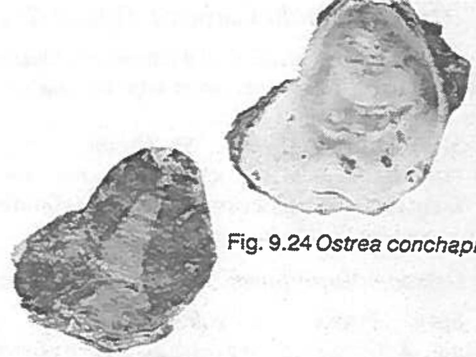


Fig. 9.24 *Ostrea conchaphilia*

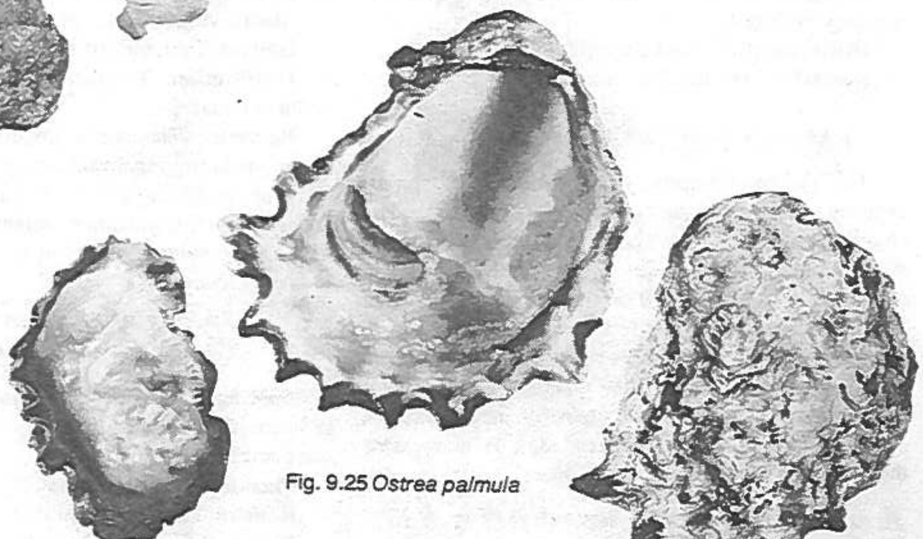


Fig. 9.25 *Ostrea palmula*

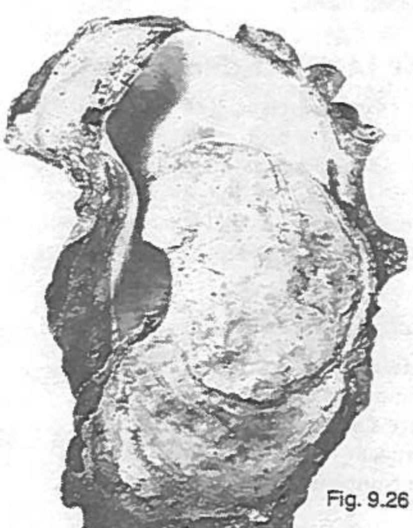


Fig. 9.26 *Ostrea columbiensis*

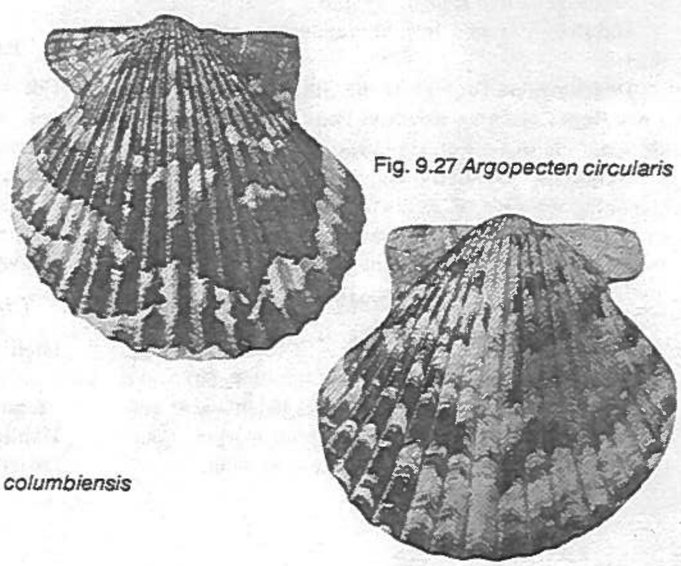


Fig. 9.27 *Argopecten circularis*

FAMILY ANOMIIDAE (jingle shells)

These animals attach to hard surfaces, as the oysters do. However, they utilize a byssus instead of directly cementing their shell. The bottom valve exhibits a large hole through which the byssus projects. This opening is formed after the byssal apparatus is completed. Jingle shells are highly irregular in form; however, these irregularities are sometimes symmetric with respect to both valves.

Anomia adamas (Gray) (Fig. 9.32)

Shell characteristics: Color variable; white to orange; considered by some to be a color variant of *A. peruviana*.

Measurements: Diameter, 40 mm.

Habitat: Intertidally on rocks.

Distribution: Gulf of California to Central America.

Anomia peruviana Orbigny (Fig. 9.33)

Shell characteristics: Highly variable in growth form; when growing on another shell usually very thin and translucent, when growing on a rock generally heavier and darker; bluish-green with a nacreous interior.

Measurements: Length, 45 mm; width, 35 mm; diameter, 9 mm.

Habitat: Intertidal and offshore on rocks or other shells.

Distribution: Central California to Peru, throughout Gulf.

Remarks: The Seri Indians of the Sonoran coast of west Mexico occasionally use these lustrous shells in their necklaces.

SUBCLASS HETERODONTA

Order Veneroidea

FAMILY CARDITIDAE

The shell has external ligaments and distinct radial ribs. The anterior cardinal tooth is reduced, while the posterior is long and well defined. In addition, the lateral hinge teeth are short.

Cardita affinis Sowerby (Fig. 9.34)

Shell characteristics: Light brown; elongate, length about twice as long as width; 15 or more ribs.

Measurements: Length, 45 mm.

Habitat: Intertidal zone, on and between rocks.

Distribution: Northern Gulf of California.

FAMILY CHAMIDAE

This family is highly variable with respect to growth form and coloration. These bivalves are attached to the substrate like oysters. The shells serve as a habitat for different species of boring organisms. Because of their highly variable morphology, they are extremely difficult to identify.

Chama mexicana Carpenter (Fig. 9.35)

Shell characteristics: Exterior light brown, pink around anterior muscle scar; two rows of long white spines, among numerous smaller ones. Spines break off in older specimens.

Measurements: Length, 90 mm.

Habitat: Intertidally on rocks.

Distribution: Possibly restricted to the Gulf of California.

Pseudochama inermis (Dall) (Fig. 9.36)

Shell characteristics: White inside and out except for a stripe of purple or brown on the unattached valve; attached valve smooth and covered with a tough yellowish periostracum.

Measurements: Length, 55 mm.

Habitat: Intertidal, on rocks.

Distribution: Gulf of California to Oaxaca.

Remarks: Uncommon; Keen states this species may be a variant of *P. panamensis*.

Pseudochama janus (Reeve) (Fig. 9.37)

Shell characteristics: Whitish to yellow with radiating brown lines.

Measurements: Length to 50 mm.

Habitat: Intertidal, on rocks.

Distribution: Throughout the Gulf, south to the Galápagos Islands.

FAMILY CARDIIDAE (cockles)

Unlike many bivalves, the cockles (or heart cockles) have shell sculptures which are generally constant. These features make them easy to identify. The two large adductor muscle scars are almost equal in size. The foot is strong and slender, which makes them rapid and efficient burrowers. Cockles are good eating and serve as an important food source in many regions of the world.

Trachycardium consors (Sowerby) (Fig. 9.38)

Shell characteristics: Pink to light yellow; inside red to flesh color; 30–34 heavy ribs covered with imbricated spines.

Measurements: Length, 65 mm; height, 50 mm; diameter, 50 mm.

Habitat: Intertidal, on tidal flats, and in shallow subtidal.

Distribution: Northern Gulf of California, south to Ecuador and the Galápagos Islands.

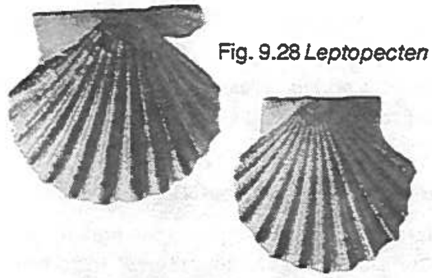


Fig. 9.28 *Leptopecten tumbezensis*

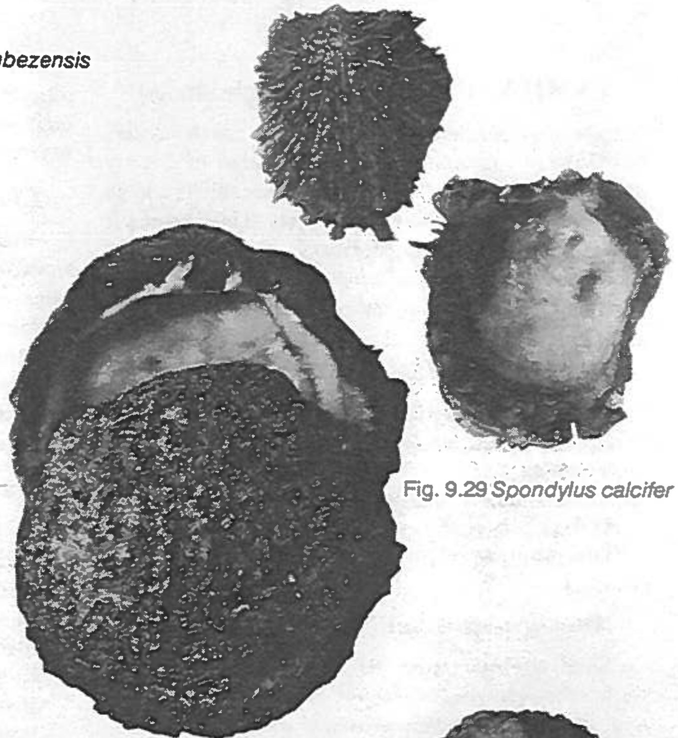


Fig. 9.29 *Spondylus calcifer*

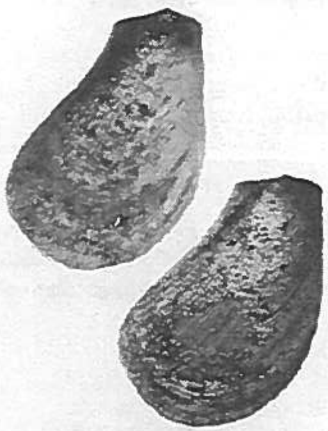


Fig. 9.31 *Lima pacifica*

Fig. 9.32 *Anomia adamas*

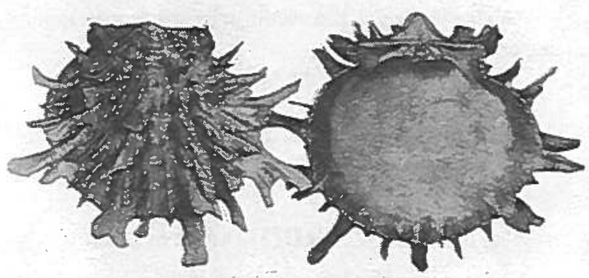


Fig. 9.30 *Spondylus princeps unicolor*

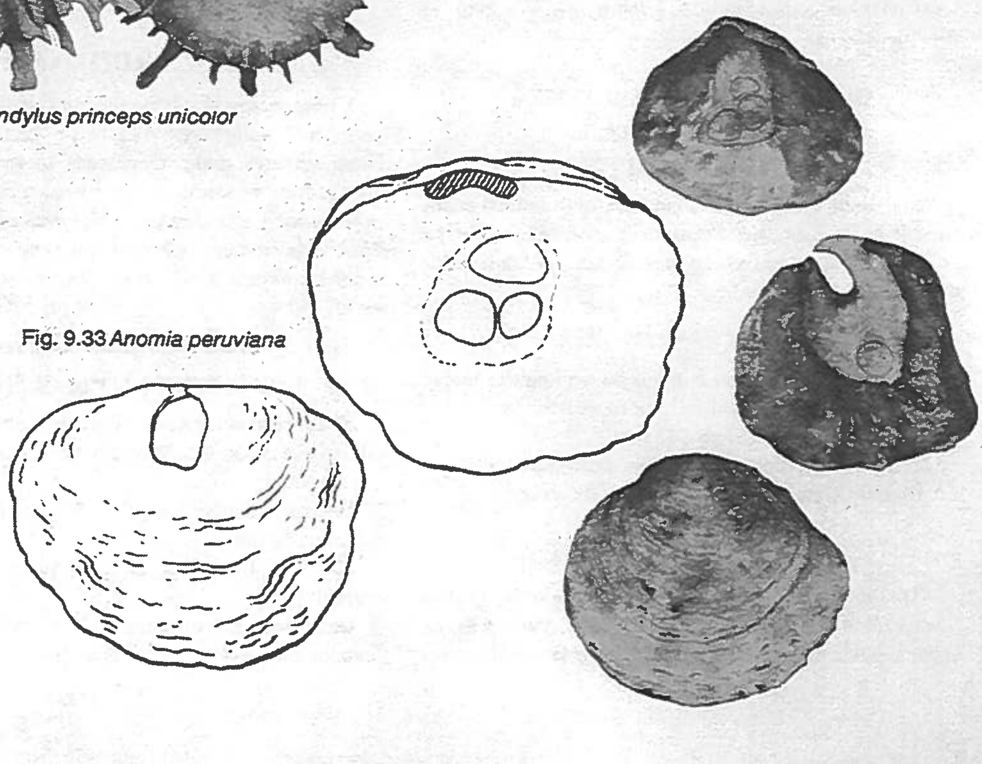


Fig. 9.33 *Anomia peruviana*

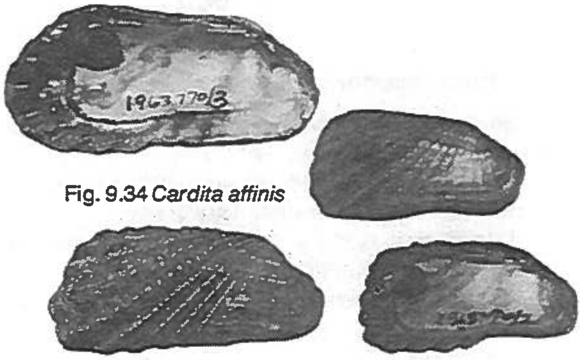


Fig. 9.34 *Cardita affinis*

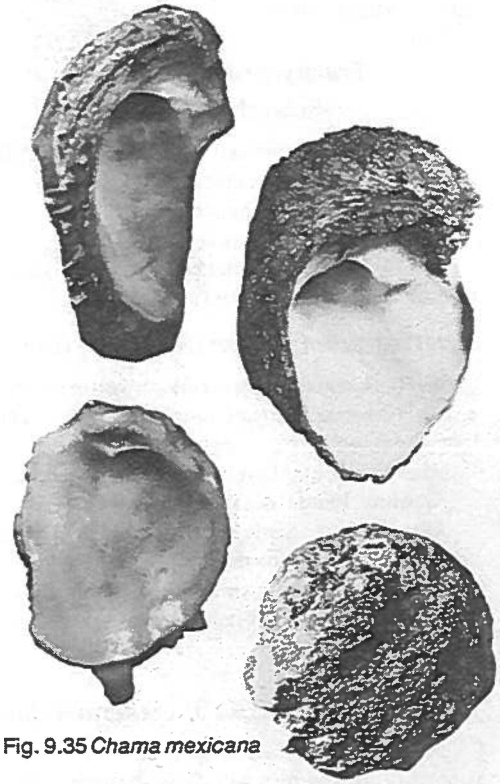


Fig. 9.35 *Chama mexicana*

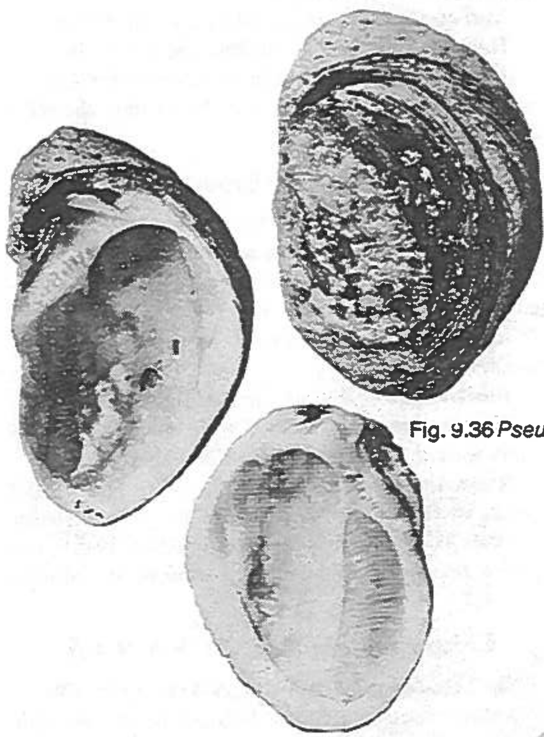


Fig. 9.36 *Pseudochama inermis*

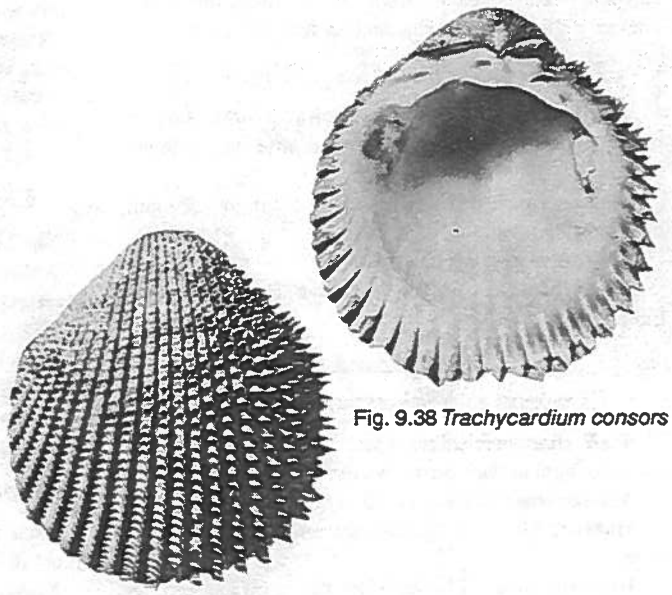


Fig. 9.38 *Trachycardium consors*

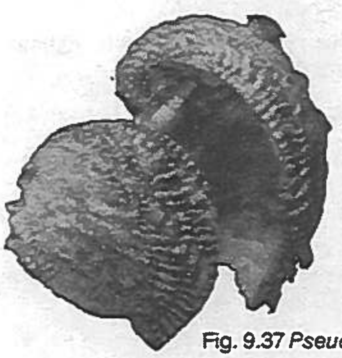


Fig. 9.37 *Pseudochama janus*

Trachycardium panamense (Sowerby) (Fig. 9.39)

Shell characteristics: Large, heavy with flattened triangular ribs. White with green.

Measurements: Diameter up to 100 mm.

Habitat: On mud flats at low tide.

Distribution: The outer coast of Baja California and throughout the Gulf, at least to Costa Rica.

Laevicardium elatum (Sowerby) (Fig. 9.40)

Shell characteristics: Yellow with a smooth, light brown periostracum; interior is white; ribs extremely light and smooth; large species.

Measurements: Length, 140 mm.

Habitat: Intertidally on muddy sand.

Distribution: Southern California and throughout the Gulf, south to Panama.

Remarks: Rather common on mud flats at San Felipe. The local inhabitants utilize this species as an important food source.

FAMILY VENERIDAE (venus clams)

The venus clams are considered to be the most advanced of all the bivalves. They comprise the largest family and have many colorful and diverse forms. The porcelaneous shell can be ovate to heart-shaped. All types of sculpturing exist and the beaks occur in front of the midline. The hinge is characterized by having three cardinal teeth in each valve. In addition, there is a marked pallial sinus which can be extremely deep.

Tivela byronensis (Gray) (Fig. 9.41)

Shell characteristics: Red to brown with a smooth brown periostracum, beaks with dark blue spot; inflated valves.

Measurements: Length, 60 mm; height, 55 mm; diameter, 35 mm.

Habitat: On sandy beaches.

Distribution: Throughout the Gulf, south to Ecuador.

Tivela planulata (Broderip and Sowerby) (Fig. 9.42)

Shell characteristics: Flat, triagonal, with wide radiating light to dark brown bands.

Measurements: Length, 50 mm; width, 40 mm.

Habitat: On sandy beaches from low tide to shallow water.

Distribution: Throughout the gulf, south to Ecuador.

Remarks: This species resembles the Pacific pismo clam *T. stultorum*, although it is much smaller.

Pitar lupanaria (Lesson) (Fig. 9.43)

Shell characteristics: White, tinged with violet. A row of long, slender spines.

Measurements: Length, 50 mm; width, 40 mm.

Habitat: In sand at low tide and offshore.

Distribution: Common, especially in the central and southern Gulf of California.

Remarks: Extremely common in beach drift in many areas.

Dosinia dunkeri (Philippi) (Fig. 9.44)

Shell characteristics: Valves flat and round, appear as saucers. Fine, regular, concentric lines on external surface. Pallial sinus angular.

Measurements: Length, 60 mm; width, 55 mm.

Habitat: On mud flats offshore and at low tide.

Distribution: Abundant in northern Gulf of California, especially at San Felipe and Cholla Bay, and south to Peru.

Chione californiensis (Broderip) (Fig. 9.45)

Shell characteristics: White with brown specks; coarse; widely separated concentric ribs and lamellae, the latter becoming flattened toward the shell edge partially to cover interspaces.

Measurements: Length, 65 mm; height, 65 mm; diameter, 35 mm.

Habitat: Low tide mark, on mud flats, and offshore.

Distribution: Southern California, along Baja California and throughout the Gulf to Panama.

Remarks: Common in beach drift. The various species of *Protothoca* and *Chione* are often collected by locals in mud and sand under intertidal rocks, and for this reason are commonly referred to as "almejas piedras."

Chione tumens (Verrill) (Fig. 9.46)

Shell characteristics: White; 6–8 concentric ribs.

Measurements: Length, 50 mm; height, 45 mm; diameter, 43 mm.

Habitat: On mud flats and offshore.

Distribution: Throughout the Gulf and lower west coast of Baja California.

Remarks: This species is extremely common in beach drift at Puerto Peñasco.

Chione undatella (Sowerby) (Fig. 9.47)

Shell characteristics: Similar to *C. californiensis*, except the ribs are not as widely separated.

Measurements: Length, 55 mm; height, 50 mm; diameter, 48 mm.

Habitat: On sandy beaches and offshore to 100 m.

Distribution: Southern California to Peru.

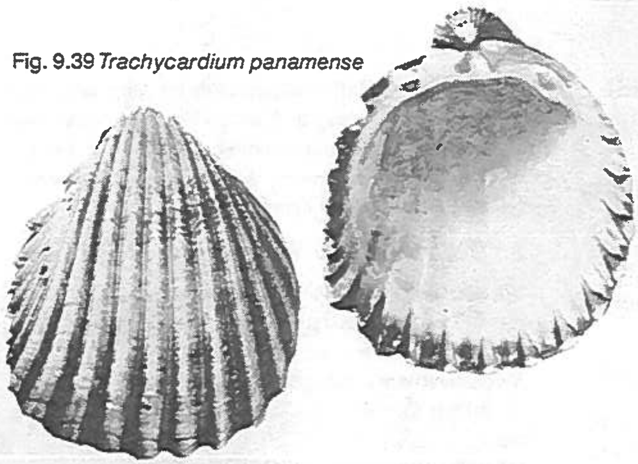


Fig. 9.39 *Trachycardium panamense*

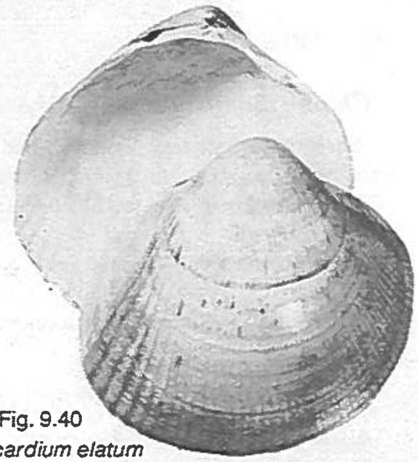


Fig. 9.40
Laevicardium elatum

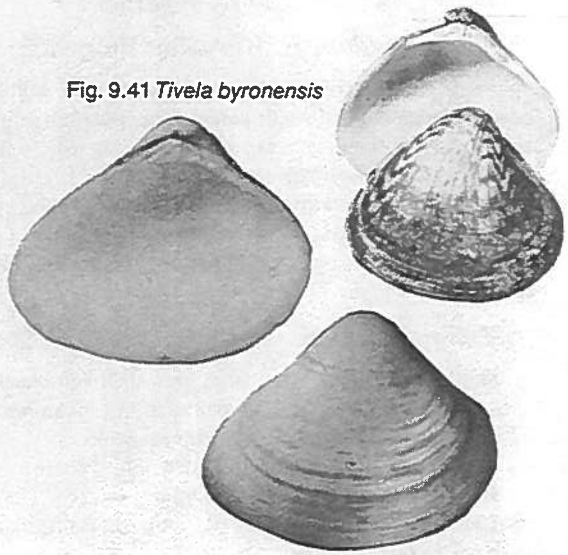


Fig. 9.41 *Tivela byronensis*

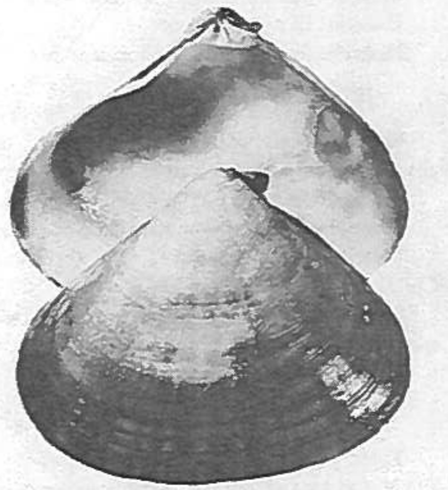


Fig. 9.42 *Tivela planulata*

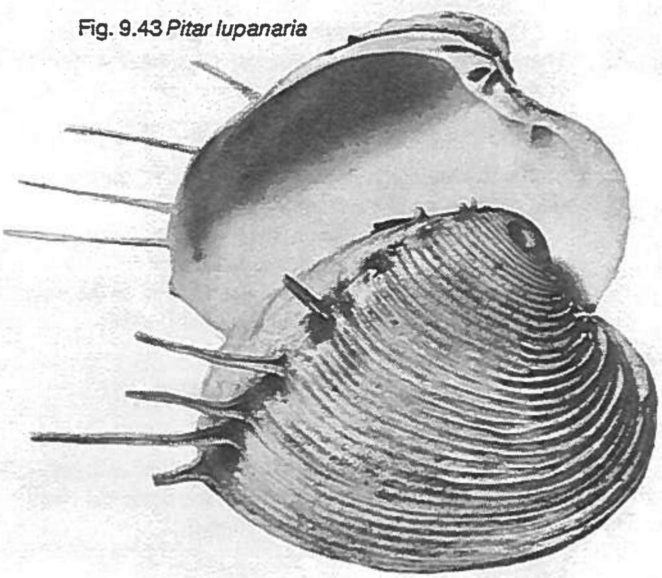


Fig. 9.43 *Pitar lupanaria*

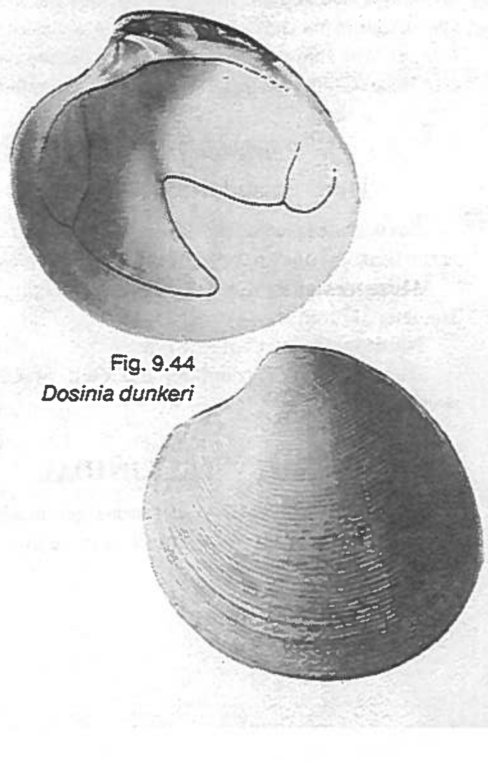


Fig. 9.44
Dosinia dunkeri

Chione fluctifraga (Sowerby) (Fig. 9.48)

Shell characteristics: Gray to white, inside is blue; smooth concentric ribs; distinct radial striations.

Measurements: Length, 50 mm; height, 45 mm; diameter, 35 mm.

Habitat: Intertidally in mud; very common in mangrove esteros.

Distribution: Southern California to the Gulf of California.

Chione amathusia (Philippi) (Fig. 9.49)

Shell characteristics: Extremely variable, fine sculpture. Large primary ribs interspersed by fine secondary ribs. Strong concentric lamellae.

Measurements: Length, 40 mm; width, 35 mm.

Habitat: In sand, offshore.

Distribution: Gulf of California to Peru.

Protothaca grata (Say) (Fig. 9.50)

Shell characteristics: Color highly variable, generally white with complex purple to black patterns.

Measurements: Length, 40 mm; width, 35 mm.

Habitat: Intertidally on mud flats and offshore.

Distribution: Northern Gulf of California south to Chile.

Remarks: A very abundant and wide ranging species. Used locally as food source.

FAMILY PETRICOLIDAE

These clams differ from the venerids by lacking a lunule and having only two cardinal teeth in the right valve. In addition, there are no lateral teeth. These bivalves are remarkable because they dig into various substrates and remain there throughout their adult life. On occasion the larvae will settle in a preformed burrow, and the shape of the adult shell will then conform to that hole. Clams of this family are often referred to as "nestling clams."

Petricola lucasana Hertlein and Strong (Fig. 9.51)

Shell characteristics: White overall with red areas at the beaks; round shape with short pallial sinus.

Measurements: Length, 25 mm; height, 25 mm; diameter, 17 mm.

Habitat: On rocks at low tide.

Distribution: Throughout the Gulf of California, south to Oaxaca.

FAMILY TELLINIDAE

The tellens are small to medium-sized marine clams that generally burrow into soft bottom sediments. The hinge bears two small cardinal teeth on each valve and the pallial sinus is deep and wide. This is a very large and complex family represented in the Gulf by the genera *Tellina*, *Florimetis*, *Macoma*, *Psammotreta*, *Strigilla*, *Tellidora*, and *Temnoconcha*.

Tellina macneilii Dall (Fig. 9.52)

Shell characteristics: Small, flattened, and smooth; posterior end somewhat truncate; color deep rose, slightly zoned, paler toward basal margin.

Measurements: Length, 11.5 mm; height, 7.3 mm.

Habitat: On mud flats and offshore to considerable depths.

Distribution: Central Gulf to Costa Rica.

Tellina simulans C. B. Adams (Fig. 9.53)

Shell characteristics: Smooth and lustrous with a beautiful rose-colored shell; pallial sinus does not quite reach anterior adductor scar; somewhat trigonal, with strong concentric sculpturing.

Measurements: Length, 45 mm; height, 27 mm.

Habitat: On tidal flats and soft bottoms offshore.

Distribution: Lower west Baja and throughout the Gulf, south to Peru.

Tellina ochracea Carpenter (Fig. 9.54)

Shell characteristics: A large, thin shell with much weaker concentric sculpturing than seen in *T. simulans*. White or pale yellow; color stronger near beaks.

Measurements: Length, 38 mm; height, 28 mm.

Habitat: On tidal flats and offshore.

Distribution: Throughout the Gulf of California, and possibly restricted to it.

FAMILY DONACIDAE (bean clams)

The shells are generally small, triagonal, and sturdy. There are two cardinal teeth in the hinge flanked by one or more laterals. The external ligament is on a platform.

Donax punctatostriatus (Hanley) (Fig. 9.55)

Shell characteristics: Brown exterior, purple inside. Numerous fine radiating ribs.

Measurements: Length, 40 mm; width, 20 mm.

Habitat: In muddy sand, shallow water.

Distribution: From Laguna San Ignacio on the west coast of Baja California, through the Gulf to Peru.

FAMILY PSAMMOBIIDAE

The shells have a large, well-defined pallial sinus; valves are unequal and gape at the posterior end; hinge ligament raised on a platform, as in the donacids; small lateral hinge teeth and two cardinal teeth.

Fig. 9.45 *Chione californiensis*

Fig. 9.46 *Chione tumens*

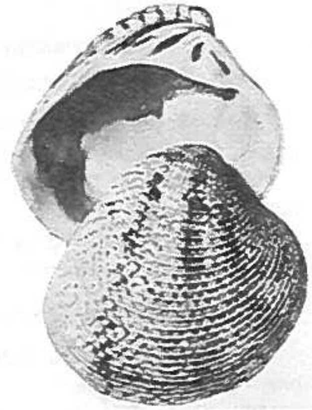


Fig. 9.47 *Chione undatella*

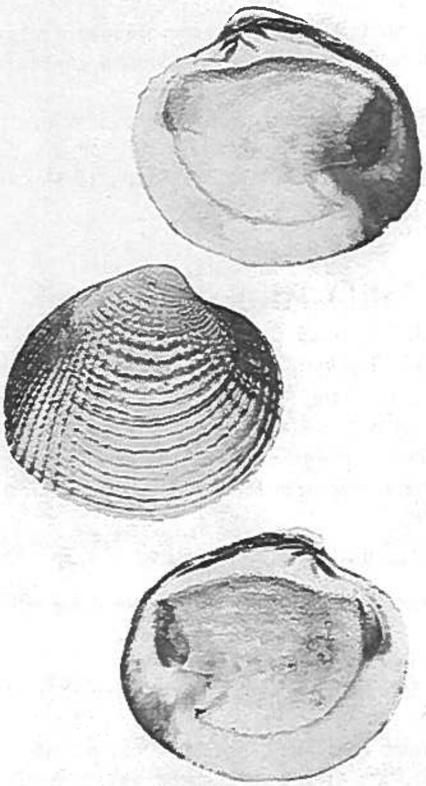


Fig. 9.48 *Chione fluctifraga*

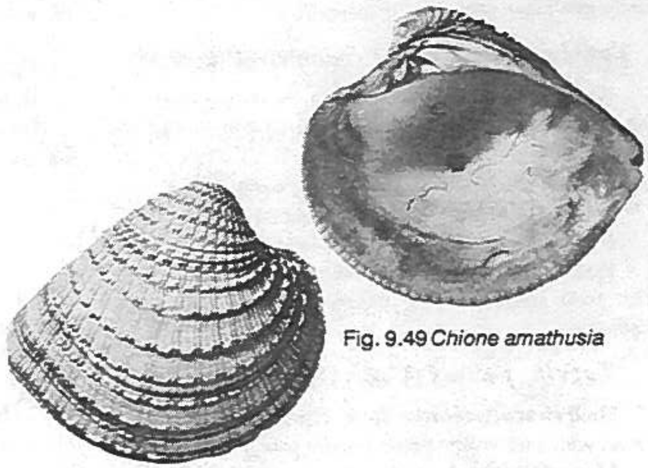


Fig. 9.49 *Chione amathusia*

Fig. 9.50 *Protothaca grata*

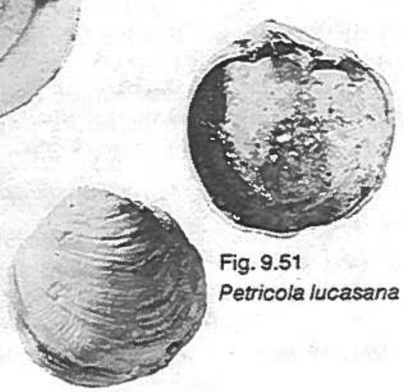


Fig. 9.51
Petricola lucasana

Sanguinolaria tellinoides A. Adams (Fig. 9.56)

Shell characteristics: Bright pink to purple intermixed, with dark and light colored concentric bands.

Measurements: Length, 80 mm; height, 50 mm; diameter, 25 mm.

Habitat: On sandy beaches and offshore.

Distribution: Southern Gulf to Ecuador.

Gari maxima (Deshayes) (Fig. 9.57)

Shell characteristics: Yellowish-white, rayed with brownish pink or purple.

Measurements: Length, 55 mm; height, 33 mm.

Habitat: Intertidal on mud flats.

Distribution: Gulf of California to Colombia.

FAMILY SOLECURTIDAE (Jacknife and razor clams)

The shells are oblong or rectangular to cylindrical, and more than twice as long as wide.

Tagelus affinis (C. B. Adams) (Fig. 9.58)

Shell characteristics: White with a yellowish-brown periostracum. Pallial sinus more than half the length of the shell.

Measurements: Length, 50 mm; width, 20 mm.

Habitat: On mud flats, intertidal and offshore.

Distribution: Gulf of California to Peru.

Remarks: This jacknife clam serves as an important food source for the swimming crab, *Callinectes bellicosus*.

Tagelus politus (Carpenter) (Fig. 9.59)

Shell characteristics: Thin, almost translucent, and rayed with dark violet; periostracum glossy.

Measurements: Length, 35 mm; height, 13 mm.

Habitat: On mud flats, intertidal and offshore.

Distribution: Gulf of California to Panama.

FAMILY SEMELIDAE

The main characteristics of this family are the wide rounded pallial sinus, and the hinge ligament which is partially enclosed in the hinge plate. The lateral teeth are well-defined in both right and left valves. The oval to round valves are either smooth or have fine concentric sculpturing.

Semele jovis (Reeve) (Fig. 9.60)

Shell characteristics: Pink with red beaks and a light band centrally located in the umbo; fine, numerous concentric ribs; interior rose and white.

Measurements: Length, 50 mm; height, 45 mm; diameter, 19 mm.

Habitat: Low intertidal zone in muddy sand.

Distribution: Throughout the central and southern Gulf, to Panama.

Semele guaymasensis Pilsbry and Lowe (Fig. 9.61)

Shell characteristics: Light buff, faintly mottled or rayed with violet; dorsal borders dark purple.

Measurements: Length, 19 mm; height, 15 mm.

Habitat: Primarily offshore on soft bottoms.

Distribution: Throughout the Gulf of California, and possibly restricted to it.

FAMILY SOLENIDAE

Beaks terminal or nearly so; hinge with only one tooth in either valve; siphons fused; foot modified for rapid digging in sand.

Solen rosaceus Carpenter (Fig. 9.62)

Shell characteristics: Straight and somewhat tubular with the beak and hinge nearly terminal; umbones pale rose.

Measurements: Length, 75 mm; height, 11 mm.

Habitat: Tidal flats and offshore on soft bottoms.

Distribution: Santa Barbara, California, to Mazatlán; sporadically throughout the Gulf.

Order Myoida

FAMILY PHOLADIDAE

The pholads or rock piddocks burrow into rock, shells, or wood. The boring is accomplished by rotating the shell against the sides of the burrow, and secondarily by the action of seawater on the exposed surfaces of the tube. The family is complex and difficult to work with, and nine genera have been reported from the tropical eastern Pacific.

Pholas chiloensis Molina (Fig. 9.63)

Shell characteristics: Large, thin, white; somewhat elongate.

Measurements: Length, 125 mm.

Habitat: Burrowing into soft stone, especially clays and limestones.

Distribution: Throughout the Gulf, south to Chile.

Remarks: Rarely found alive; shells fairly common locally in beach drift.

Martesia striata (Linnaeus) (Fig. 9.64)

Shell characteristics: Beaks present; pear-shaped.

Measurements: Length, 35 mm.

Habitat: Burrowing into wood, especially pilings, drift logs and mangrove roots.

Distribution: Circumtropical; throughout the Gulf, south to Peru.

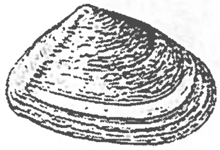
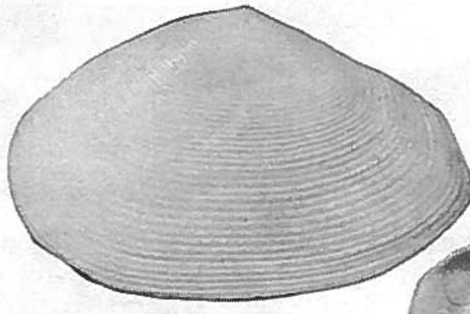


Fig. 9.52 *Tellina macneilii*



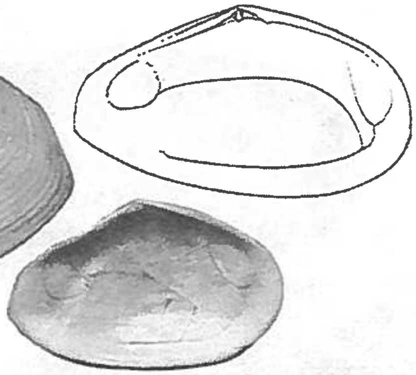
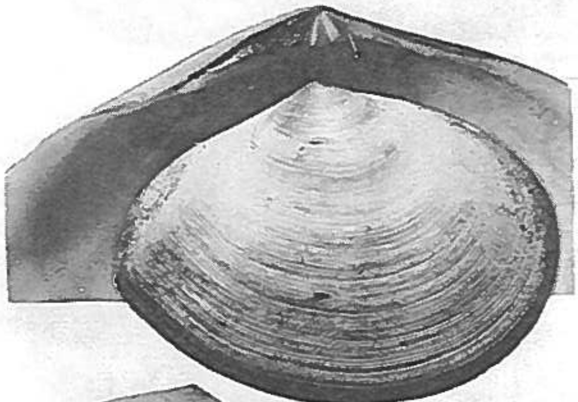


Fig. 9.53 *Tellina simulans*



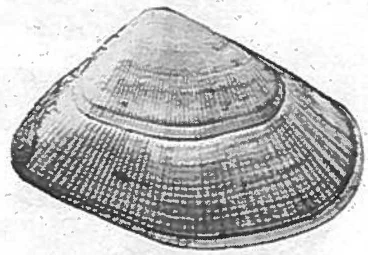
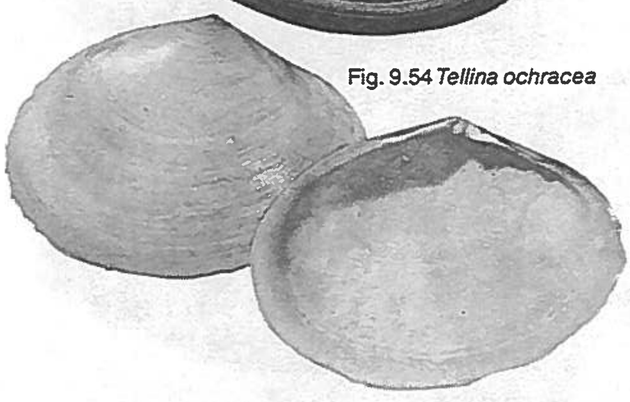


Fig. 9.55 *Donax punctatostriatus*

Fig. 9.54 *Tellina ochracea*



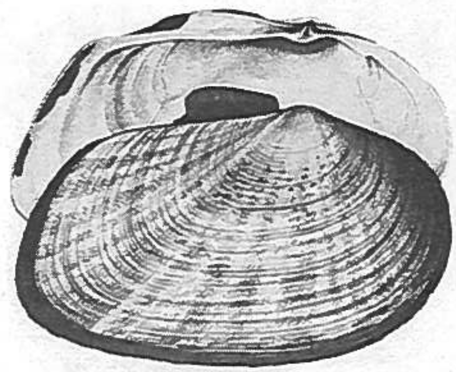
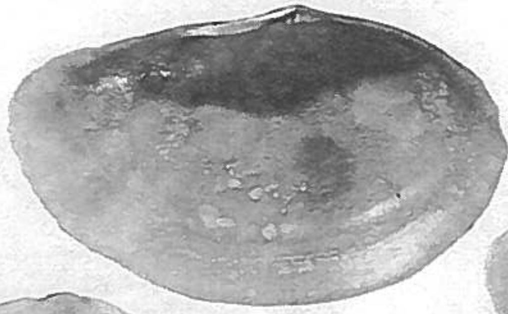


Fig. 9.57 *Gari maxima*



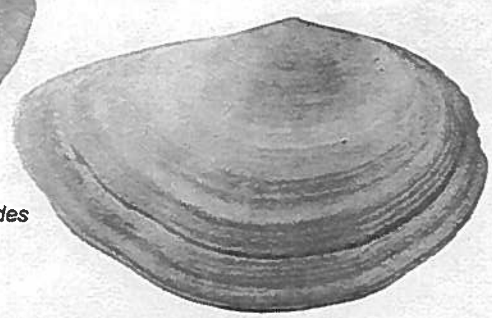


Fig. 9.56 *Sanguinolaria tellinoides*

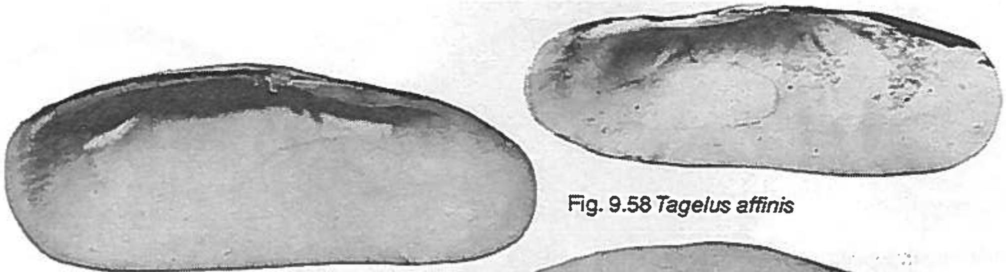


Fig. 9.58 *Tagelus affinis*

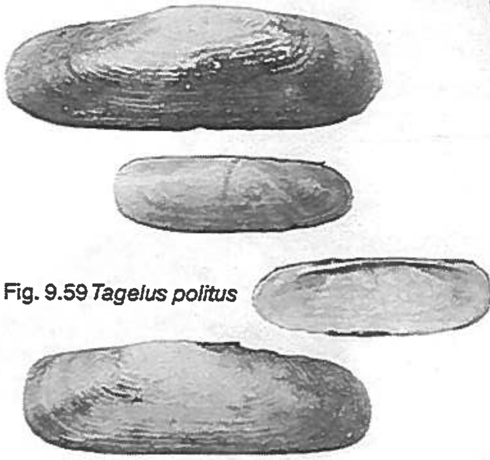


Fig. 9.59 *Tagelus politus*

Fig. 9.60 *Semele jovis*

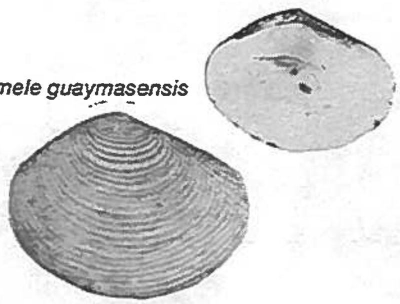
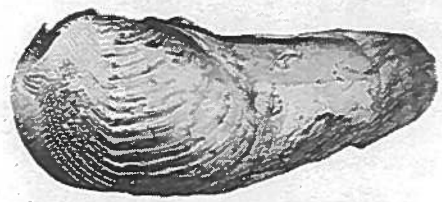


Fig. 9.61 *Semele guaymasensis*



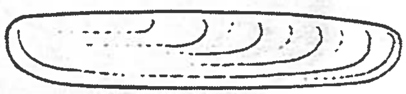


Fig. 9.62 *Solen rosaceus*

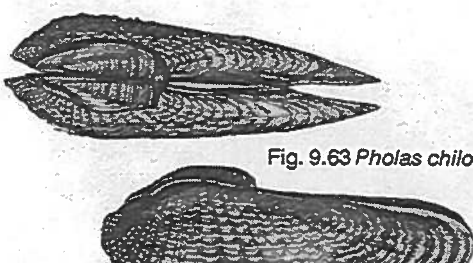


Fig. 9.63 *Pholas chiloensis*

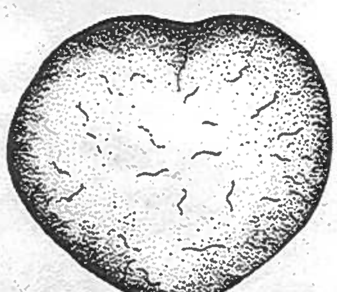


Fig. 9.64 *Martesia striata*

FAMILY TEREDINIDAE (shipworms)

The shipworms have a reduced shell that is modified anteriorly for boring into wood pilings and other substrates. The shell is located at the anterior end of a long soft body which is enclosed by the burrow. At the posterior end are the long siphons, with hard calcareous tips. These are utilized for circulation of water within the burrow. In addition, these siphon tips can effectively close off the opening for protection.

Bankia gouldi (Bartsch) (Fig. 9.65)

Shell characteristics: Light brown with elongated pallets.

Measurements: Length, 10 mm.

Habitat: In mangrove roots.

Distribution: Throughout mangrove esteros along Sonora and Sinaloa; also in the Caribbean.

CLASS GASTROPODA
SUBCLASS PROSOBRANCHIATA
Order Archaeogastropoda

The archaeogastropods are considered to be the most primitive (earliest evolved) of all the prosobranch gastropods. Nearly all are generalized herbivores, browsing on small algae. Included here are the limpets, top shells (*Tegula*, etc.), turbins (*Turbo*, etc.), and others. Figure 9.66 depicts general gastropod morphology.

FAMILY FISSURELLIDAE (Keyhole limpets)

Keyhole limpets are striking because of the opening at the apex of the shell. In addition, the shape of the callus, position of the anal opening, and the shape of the muscle scars characterize the different groups. Internally, the pallial organs are double and the rectum runs through the ventricle. Trochophore and veliger larvae are free swimming.

Diodora digueti (Mabille) (Fig. 9.67)

Shell characteristics: Sides slightly convex, oval or circular orifice; white color with dark rays; internal callus with gray border.

Measurements: Length, 25 mm; width, 14 mm; height, 8 mm.

Habitat: Mid intertidal zone on rocks.

Distribution: San Ignacio Lagoon, Baja California, and throughout the Gulf to Equador.

Remarks: Similar to *Diadora inaequalis* but larger.

Diodora inaequalis (Sowerby) (Fig. 9.68)

Shell characteristics: Smooth margin, radiating dark and light bands originating from apex. Sculptured with fine radial ribs. Orifice tends to be tripartite, broad in the middle and constricted at both ends.

Measurements: Length, 30 mm; width, 18 mm; height, 10 mm.

Habitat: Intertidally under rocks.

Distribution: Throughout the Gulf, south to Galápagos Islands.

Remarks: Living specimens have a conspicuous bright orange mantle.

Diodora saturnalis (Carpenter) (Fig. 9.69)

Shell characteristics: Thick, broad and with coarse marginal crenulations; orifice about one-third the distance back from the anterior margin, small, slotlike and three-lobed in larger specimens.

Measurements: Length, 24 mm; width, 17 mm.

Habitat: Intertidal on rocks; not uncommon on rocky shores of protected bays and coves.

Distribution: Lower west Baja and throughout the Gulf, south to the Galápagos Islands.

FAMILY ACMAEIDAE (limpets)

These are the true limpets. This is an extremely complex group consisting of many variable species. They are characterized by having a horseshoe-shaped muscle scar and a conical shell. The coiling of the shell has been completely lost, even during development. Internally they have only a single ctenidium. Limpets are generally restricted to the intertidal zone, where they inhabit rocks, seaweeds, or other molluscs' shells. They feed on algae which they scrape off the substrate with their radula. Some species of limpets exhibit "homing" behavior in that they always return to the exact same spot after feeding. Acmaeids have a free-swimming trochophore larva. An excellent review of the limpets and limpetlike gastropods of the Gulf of California, including keys and ecology, may be found in Yensen (1973).

Collisella atrata (Carpenter) (Fig. 9.70)

Shell characteristics: Roughly sculptured margin and apex; white primary ribs interspaced with black; inside is white to yellowish gray with a checkered margin.

Measurements: Length, 45 mm; width, 40 mm; height, 15 mm.

Habitat: On rocks in mid littoral.

Distribution: Bahía Magdalena, west coast of Baja California, and through the Gulf to Mazatlán.

Remarks: Often with attached plants or animals on the shell; exhibits a homing behavior; occasionally with symbiotic flatworms in the mantle cavity (Yensen, 1973).

Collisella dalliana (Pilsbry) (Fig. 9.71)

Shell characteristics: Low; numerous fine, beaded radiating ribs; many small white flecks scattered about the surface; interior bluish-white, often with a brownish central stain.

Measurements: Length, 50 mm; width, 30 mm; height, 7 mm.

Habitat: On rocks at mid tide.

Distribution: Common in the northern Gulf of California.

Remarks: This species resembles *C. limatula* of southern California. It is one of the largest limpets in the Gulf. A nocturnal grazer.

Collisella acutapex (Berry) (Fig. 9.72)

Shell characteristics: Rather small and variable, generally with an elevated apex and 15–20 prominent whitish ribs that project at the margin; ribs irregular and undulating; interior white, although external brown color usually shows through.

Measurements: Length, 16 mm; width, 13 mm; height, 7 mm.

Habitat: On rocks at mid tide.

Distribution: Throughout the Gulf of California and possibly restricted to it.

Remarks: Forages during high tide and has strong homing behavior; strongly resembles the barnacle *Tetraclita stactilifera;* preyed upon by certain littoral fishes, especially the clingfish *Tomicodon boehlkei* (Yensen, 1973).

Collisella stanfordiana (Berry) (Fig. 9.73)

Shell characteristics: Thin and flat; numerous large white to yellow blotches covering exterior; interior turquoise.

Measurements: Length, 30 mm; width, 24 mm; height, 10 mm.

Habitat: On rocks, especially basaltic boulders, in the littoral.

Distribution: In the northern and central Gulf of California.

Remarks: This limpet is similar to *C. dalliana* except it has a turquoise interior. In addition, the apex is nearer the anterior margin. In the evening individuals are exposed and may be observed feeding. However, during the day they disappear underneath the rocks. A weak homing behavior appears to exist. A symbiotic flatworm has been recorded from the mantle cavity (Yensen, 1973).

Collisella strigatella (Carpenter) (Fig. 9.74)

Shell characteristics: Black with irregular white V-shaped patterns extending to the margin; surface smooth with eroded apex; internal surface bluish-white with irregular brown patterns near the center.

Measurements: Length, 25 mm; width, 22 mm; height, 10 mm.

Habitat: On rocks and protected areas in the mid intertidal zone.

Distribution: British Columbia to Cabo San Lucas, and throughout the southern Gulf of California.

Collisella turveri (Hertlein and Strong) (Fig. 9.75)

Shell characteristics: Thin, nearly flat; with 10 to 14 radial ribs extending to the margin; peripheral regions marked with a crisscross network of fine brown lines on white surface; interior is light blue with brownish lines near center.

Measurements: Length, 21 mm; width, 17 mm; height, 5 mm.

Habitat: High and mid intertidal zones, on rocks.

Distribution: A gulf of California endemic.

Remarks: Populations at San Felipe are not as flat and have narrower ribs. They have been assigned subspecific status by Hertlein (1958), *C. turveri fayae.* A specific homing behavior exists.

Collisella strongiana (Hertlein) (Fig. 9.76)

Shell characteristics: Small; off white to black, with irregular brown and white radial bands; surface rarely eroded; interior tinted bluish-white, radial bands of outside visible through shell; margin irregular.

Measurements: Length, 10–17 mm; width, 7–14 mm; height, 1–4 mm.

Habitat: On rocks in the mid intertidal zone.

Distribution: Throughout the Gulf of Califomia.

Remarks: Has a strong homing behavior and has been recorded exhibiting a rather unique mantle defense behavior in response to *Heliaster kubinjii* and *Morula ferruginosa* (Yensen, 1973).

Scurria mesoleuca (Menke) (Fig. 9.77)

Shell characteristics: Exterior highly variable, usually mottled with reddish-brown and olive maculae; with fine radial ribbing; interior bluish-green, checkered brown and white at the margin.

Measurements: Length, 35 mm; width, 28 mm; height, 8 mm.

Habitat: In protected rocky intertidal regions.

Distribution: Southern Gulf of California to the Galápagos Islands; common at Cabo San Lucas.

Remarks: This species closely resembles *Collisella stanfordiana;* however, the presence of a branchial cordon places it in the Genus *Scurria.* This genus is best developed on the west coast of South America (in the Peruvian Province).

FAMILY TROCHIDAE (top shells)

The shells are top-shaped with round apertures. Many species have an open umbilicus. The round operculum is composed of chitin and sculptured with concentric lines. The mantle cavity has only one ctenidium; however, the other pallial organs are paired. Like other herbivorous gastropods, they possess a rhipidoglossan radula, which is adapted for scraping algae off rocks.

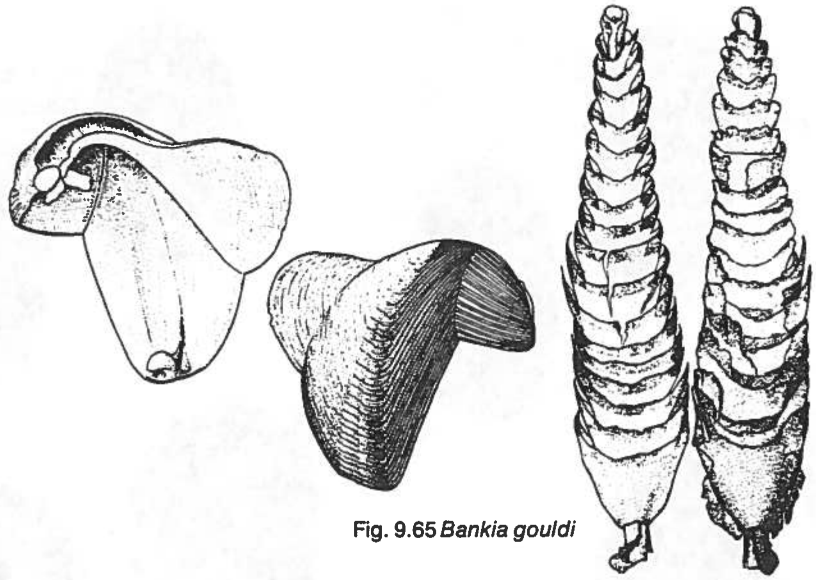


Fig. 9.65 *Bankia gouldi*

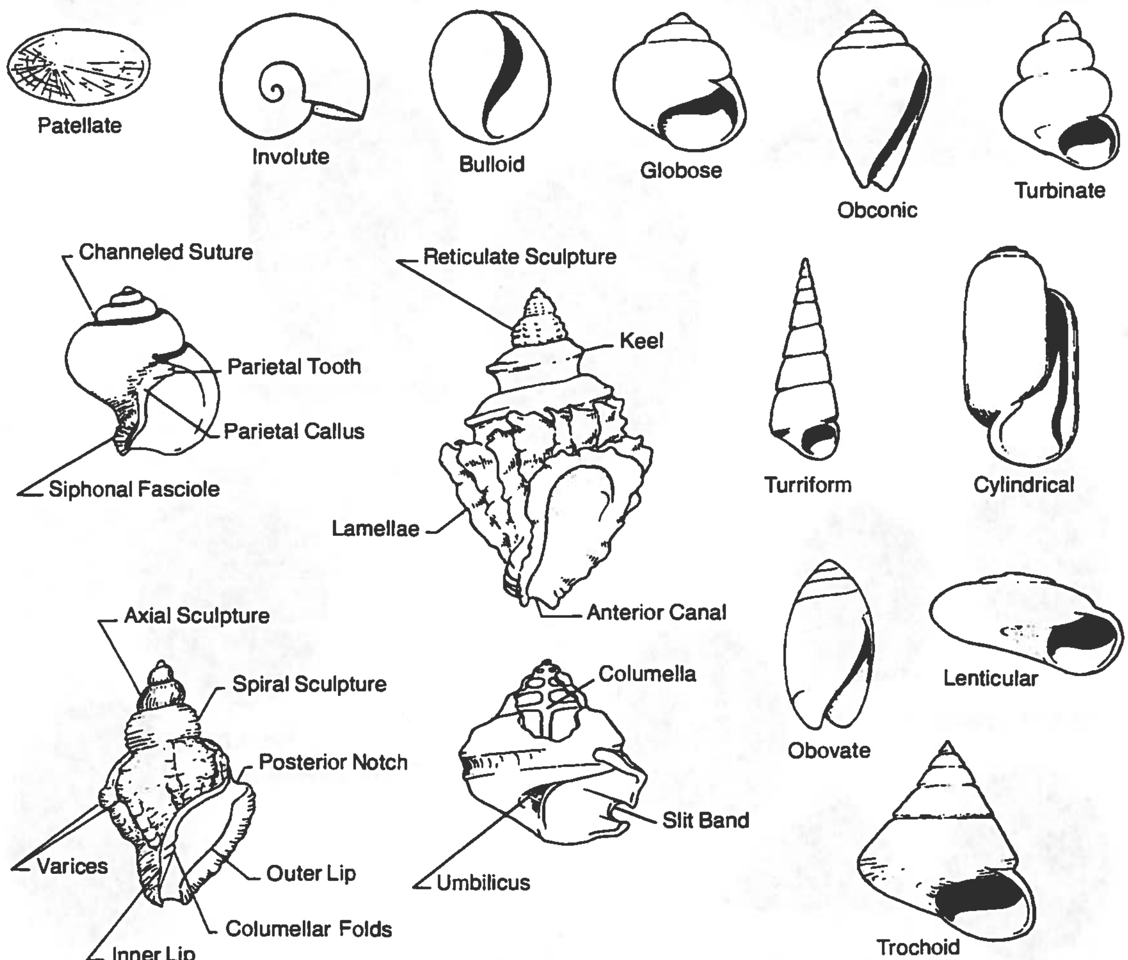


Fig. 9.66 General gastropod morphology

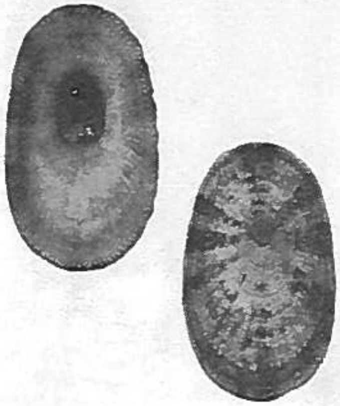


Fig. 9.67 *Diodora digueti*

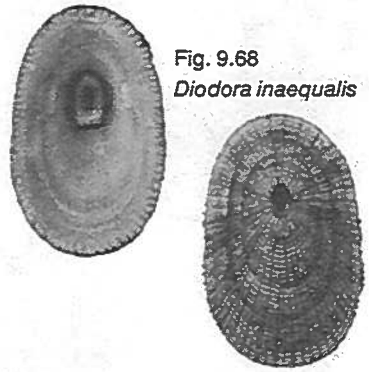


Fig. 9.68 *Diodora inaequalis*

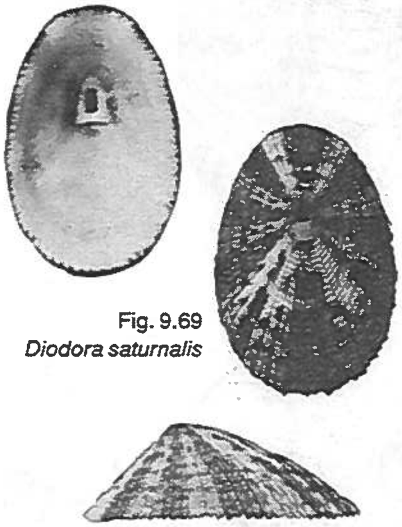


Fig. 9.69 *Diodora saturnalis*

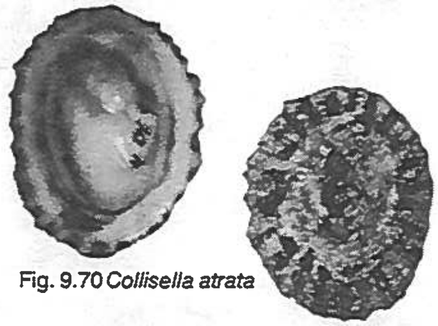


Fig. 9.70 *Collisella atrata*

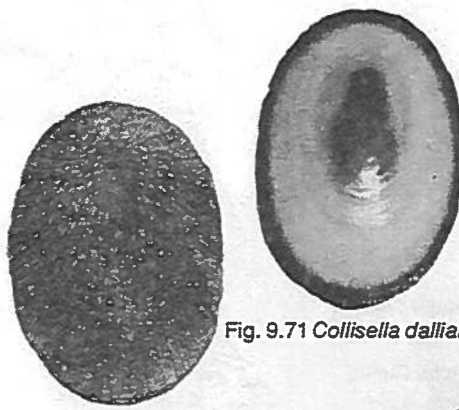


Fig. 9.71 *Collisella dalliana*

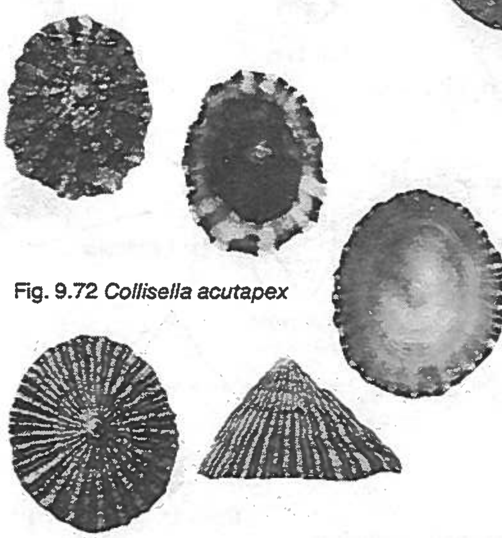


Fig. 9.72 *Collisella acutapex*


Fig. 9.73 *Collisella stanfordiana*

Calliostoma marshalli Lowe (Fig. 9.78)

Shell characteristics: Tan to light yellow; with distinct reddish-brown spiral beads.

Measurements: Height, 15 mm; diameter, 13 mm.

Habitat: In sandy mud at low tide and offshore.

Distribution: Common in the northern Gulf of California, especially in the San Felipe region; less common in southern Gulf.

Calliostoma nepheloide Dall (Fig. 9.79)

Shell characteristics: Olive brown marked with darker flammules; flat-sided whorls and finely beaded spiral cords.

Measurements: Height, 25 mm; diameter, 22 mm.

Habitat: In sandy mud at low tide, especially in esteros and mangrove lagoons.

Distribution: Lower west Baja and central Gulf, south to Mazatlán.

Tegula corteziana McLean (Fig. 9.80)

Shell characteristics: Gray-brown with deep spiral sculpturing; one columellar tooth; greenish unbilicus.

Measurements: Height, 12 mm; diameter, 13 mm.

Habitat: Common under rocks at low tide.

Distribution: A Gulf of California endemic.

Tegula rugosa (A. Adams) (Fig. 9.81)

Shell characteristics: Large; heavy; dull brown in color. Extremely thick with irregular sculpturing on the whorls.

Measurements: Diameter, 33 mm; height, 36 mm.

Habitat: Under rocks and in crevices in the high and mid intertidal.

Distribution: Common (and endemic to) the Gulf of California; probably the most abundant *Tegula* of the Gulf.

Tegula felipensis McLean (Fig. 9.82)

Shell characteristics: Green with brown axial bands; strong spiral ribbing; distinct keel on body whorl; umbilicus green; strong basal ribs.

Measurements: Height, 15 mm; diameter, 17 mm.

Habitat: Under rocks in the high and mid intertidal zones.

Distribution: Extremely common in the San Felipe and Coloradito regions of the northern Gulf; appears to be a northern Gulf endemic.

Tegula mariana Dall (Fig. 9.83)

Shell characteristics: Light brown to gray and mottled with dark and light areas; spiral sculpture variable; green umbilicus; smooth basal region.

Measurements: Height, 14 mm; diameter, 8 mm.

Habitat: Intertidally under rocks.

Distribution: This species extremely common at Puerto Peñasco, extending south to Guaymas and La Paz; reappearing again in Panama.

FAMILY TURBINIDAE

Robust, turbinate or top-shaped shells of relatively few whorls. The aperture is rounded and internally nacreous. The operculum is calcareous and heavy.

Turbo fluctuosus Wood (Fig. 9.84)

Shell characteristics: Color variable, ranging from bright orange to dark green. Strong spiral sculpturing with evenly spaced nodules just below the suture.

Measurements: Diameter, 70 mm; height, 60 mm.

Habitat: Rocky lower mid intertidal.

Distribution: Common throughout the Gulf of California, to Ecuador and Peru.

Remarks: The operculum, commonly referred to as a "cat's eye," is sought by collectors for making jewelry. This turban is best observed at night when it moves about in tidepools grazing on algae. *Turbo fluctuosus* is one of the most abundant rocky shore gastropods of the Gulf.

Astraea olivacea (Wood) (Fig. 9.85)

Shell characteristics: Green to brown; fibrous periostracum; bright red spot around umbilicus; single spiral rib on the base.

Measurements: Height, 55 mm; diameter, 65 mm.

Habitat: On rocks at low tide, extending offshore to shallow depths.

Distribution: Southern Gulf of California to Oaxaca, Mexico.

Remarks: The foot of this, and several other species of *Astraea*, are occasionally dried into a type of "jerky" and eaten locally. The flavor and texture leave a bit to be desired.

Astraea unguis (Wood) (Fig. 9.86)

Shell characteristics: Brown with long hooked blunt spines around the margin; several spiral ribs on light colored base; outer lip extends more than one-half the circumference of the body whorl.

Measurements: Height, 55 mm; diameter, 60 mm.

Habitat: Low intertidal and offshore, on rocks.

Distribution: Common from Guaymas south to Acapulco; uncommon in Ecuador.

FAMILY NERITIDAE (nerites)

The nerites have shells that are low spired and globular. Since the spire is almost nonexistent, the animal utilizes the inner surface by resorbing the walls of the inner whorls. This is an unusual strategy in the Prosobranchiata; however, it is common in the pulmonate gastropods. The inner lip is toothed and thickened as a callus. The operculum has an apophysis that fits under the edge of the columella. This insures a secure closure when the animal retracts into the shell. This is an excellent adaptation for minimizing water loss, for these snails inhabit the mid and high intertidal zone. Some of the tropical species have a bright red inner lip and are commonly called "bleeding tooth shells."

Nerita scabricosta Lamark (Fig. 9.87)

Shell characteristics: Large, gray to black with strong spiral ribs.

Measurements: Diameter, 40 mm; height, 45 mm.

Habitat: On rocks at high tide levels.

Distribution: Outer coast of Baja California, through the Gulf to Ecuador; very common; preliminary observations indicate the snail increases in size as one moves south in the Gulf.

Nerita funiculata Menke (Fig. 9.88)

Shell characteristics: Small, irregular nodules on the callus; short spire.

Measurements: Diameter, 15 mm; height, 10 mm.

Habitat: On rocks at high tide levels.

Distribution: Baja California, throughout the Gulf to Peru.

Remarks: This species occurs in tremendous numbers at Puerto Peñasco. In fact, it tends to be gregarious, comprising clumps of up to several hundred individuals.

Theodoxus luteofasciatus Miller (Fig. 9.89)

Shell characteristics: Small, polished with variable pattern of lines and dots; aperture brown with gold-brown callus.

Measurements: Height, 12 mm; diameter, 11 mm.

Habitat: High tide mark on mud flats, salt marshes, and mangrove esteros.

Distribution: Throughout the Gulf of California to Peru.

Remarks: This is one of the most highly polymorphic, and colorful species in the Panamic region.

Order Mesogastropoda

The mesogastropods are primarily herbivorous, but a few are carnivores. The carnivores can generally be recognized by the presence of an anterior notch on the aperture. Some are parasitic. Herbivores include periwinkles *(Littorina)*, turrids *(Turritella)*, tube snails (many are mucus-net suspension feeders), horn shells *(Cerithium, Cerithidea)*, Strombs *(Strombus)*, cup-and-saucer and slipper limpets, etc. Carnivores include the moon snails *(Polinices, Natica)*, and others.

FAMILY LITTORINIDAE (periwinkles)

The periwinkles comprise a very common group of marine gastropods—worldwide in distribution. There are many species, of which the majority are intertidal. In fact, some species occur in the supralittoral zone, which is affected only by periodic wave splash. Here they can be observed in cracks and crannies feeding upon the blue-green algae. It is hypothesied that periwinkles were the ancestors of the present-day land snails. They have a scaly, chitinous operculum which closes off the aperture to minimize water loss. In addition, these snails are known to excrete high amounts of uric acid in order to retain metabolic water.

Littorina aspera (Philippi) (Fig. 9.90)

Shell characteristics: Extremely polymorphic, generally white with axial banding. Sculptured with coarse spiral ribs.

Measurements: Diameter, 10 mm; height, 15 mm.

Habitat: On rocks at high tide levels.

Distribution: Bahía Magdalena, Pacific coast of Baja California, and throughout the Gulf of California to Ecuador or Peru.

Littorina fasciata Gray (Fig. 9.91)

Shell characteristics: Golden brown with numerous oblique axial bands.

Measurements: Height, 30 mm; diameter, 25 mm.

Habitat: On rocks at high tide levels.

Distribution: Magdalena Bay, Baja California, throughout the Gulf to Ecuador.

Remarks: One of the largest species of *Littorina*.

Littorina modesta Philippi (Fig. 9.92)

Shell characteristics: White, dotted with reddish-brown; aperture orange-brown within; columella broad and somewhat excavated.

Measurements: Height, 16 mm; diameter, 10 mm.

Habitat: On rocks at high tide levels.

Distribution: Both coasts of Baja California and throughout the Gulf, south to Ecuador. Fairly common along the Sonoran coast between Guaymas and Puerto Lobos.

FAMILY ARCHITECTONICIDAE (sundials)

The sundials have a top-shaped shell with a low spire. The sculpturing consists mainly of spiral lines with evenly spaced beads. The chitinous operculum has a protrusion extending into the foot. As colorful and popular as they are, the biology of these snails is virtually unknown.

Fig. 9.74 *Collisella strigatella*

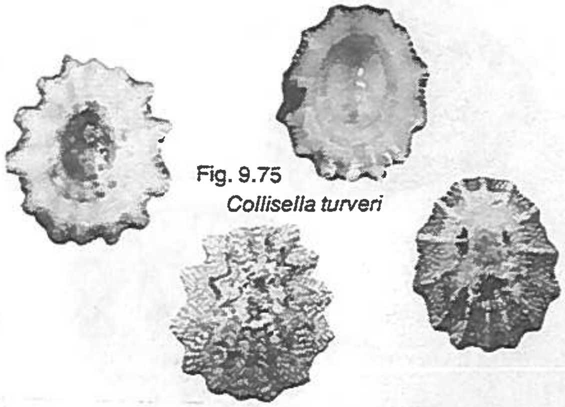


Fig. 9.75 *Collisella turveri*

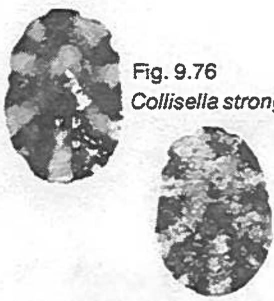


Fig. 9.76 *Collisella strongiana*

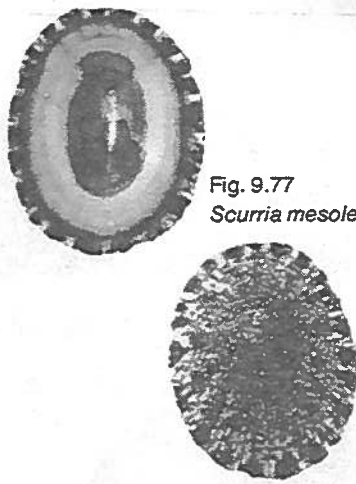


Fig. 9.77 *Scurria mesoleuca*

Fig. 9.78 *Calliostoma marshalli*

Fig. 9.79 *Calliostoma nepheloide*

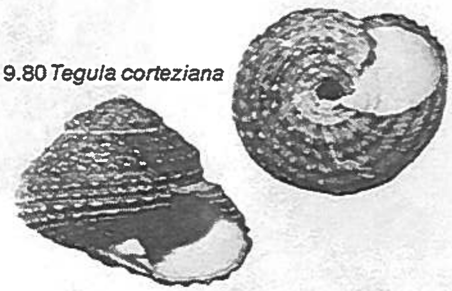


Fig. 9.80 *Tegula corteziana*

Fig. 9.81 *Tegula rugosa*

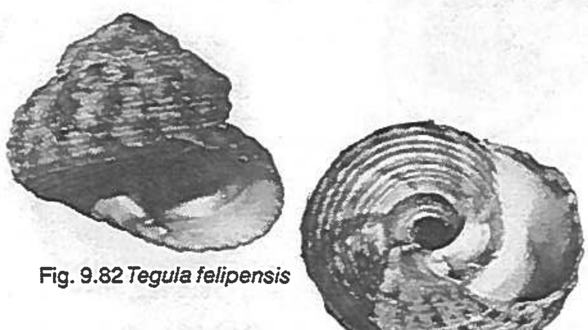


Fig. 9.82 *Tegula felipensis*

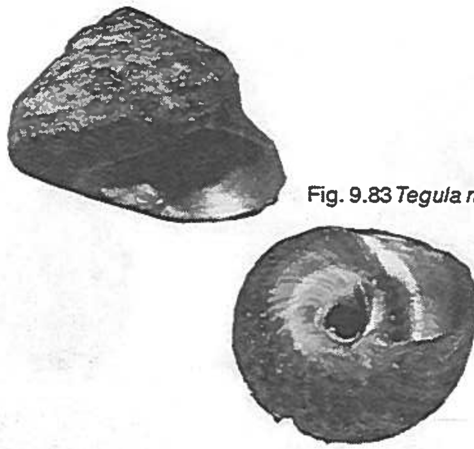


Fig. 9.83 *Tegula mariana*

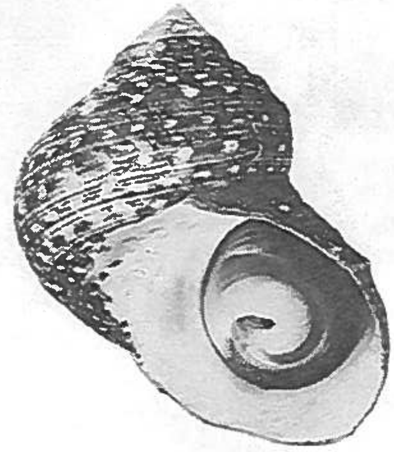


Fig. 9.84 *Turbo fluctuosus*

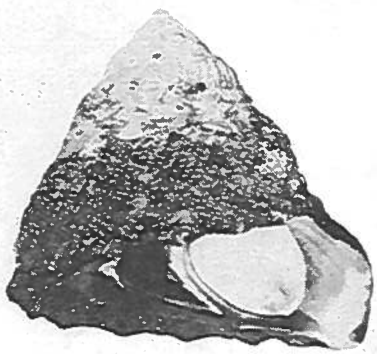


Fig. 9.86 *Astraea unguis*

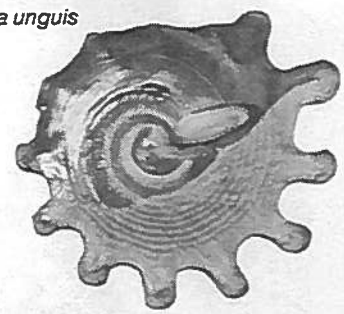


Fig. 9.85 *Astraea olivacea*

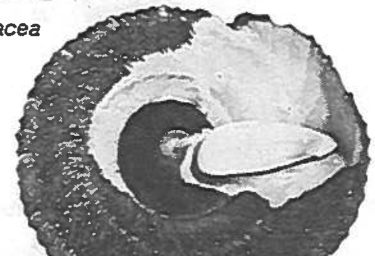


Fig. 9.87 *Nerita scabricosta*

Fig. 9.88 *Nerita funiculata*

Fig. 9.89 *Theodoxus luteofasciatus*

Architectonia nobilis Röding (Fig. 9.93)

Shell characteristics: Gray to tan with light-brown spotted bands.

Measurements: Height, 15 mm; diameter, 30 mm.

Habitat: On mud flats to shallow water.

Distribution: Throughout the Gulf of California and lower west coast of Baja, south to Peru.

Remarks: This species also can be found along the eastern and western Atlantic coasts.

FAMILY TURRITELLIDAE (tower shells)

In general, tower shells are long with slender spires. Since these snails are detritus feeders, they usually occur in mud or sand. However, a few species are found in rocky habitats. The shells are either smooth with deep sutures, or deeply sculptured with spiral ribs. The operculum is chitinous with concentric bands.

Turritella anactor Berry (Fig. 9.94)

Shell characteristics: Yellow with purplish-brown lines; whorls concave with a keel just below the surface.

Measurements: Height, 120 mm; diameter, 30 mm.

Habitat: Intertidally in sandy mud.

Distribution: Northern Gulf of California.

Remarks: Rather common near San Felipe, Baja California.

Turritella gonostoma Valenciennes (Fig. 9.95)

Shell characteristics: Gray to purple with white blotches; slight sculpturing to almost smooth whorls; sutures slight.

Measurements: Height, 115 mm; diameter, 20 mm.

Habitat: Intertidally in mud or sandy mud.

Distribution: Throughout the Gulf of California, south to Ecuador.

Remarks: This species is especially common in the low tide zone of Bahía Cholla, Sonora, Mexico.

Turritella leucostoma (Valenciennes) (Fig. 9.96)

Shell characteristics: Color variable, red to brown with a mottled appearance; sutures deep.

Measurements: Diameter, 20 mm; height, 120 mm.

Habitat: On rocks and mud flats, intertidally to 40 m.

Distribution: Both coasts of Baja, throughout the Gulf and south to Panama.

Remarks: Large populations of this species occur at low tide on mud flats of Bahía Cholla, Sonora, Mexico.

Vermicularia pellucida eburnea (Reeve) (Fig. 9.97)

Shell characteristics: White, thin; with irregular coils; distinct apex.

Measurements: Length about 50 mm; diameter of tube, 10 mm.

Habitat: Intertidally; cemented to small rocks.

Distribution: Gulf of California to Peru.

FAMILY VERMETIDAE (worm shells)

These snails are often mistaken for tube-inhabiting polychaete annelids. They appear as irregular tubes cemented to rocks and shells. One distinct difference between vermetids and polychaetes is that the worm snails have a four-layered shell that is shiny inside and originates as a tightly coiled protoconch. On the other hand, the polychaetes have a two-layered shell that is dull inside and which originates as a single tubular chamber. Another group of gastropods, the vermicularias, a subfamily of the turritellids, is often confused with the vermetids. In the vermetids the adult whorls occur at right angles to the protoconch, whereas, in the vermicularias the shell is initially tightly coiled, then, as it grows, the adult whorls become lax and unwound (see *Vermicularia pellucida eburnea*).

Vermetus indentatus (Carpenter) (Fig. 9.98)

Shell characteristics: Brown to black with strong longitudinal lines; heavily beaded; irregular coiling.

Measurements: Length, 20 mm; diameter of tube, 3 mm.

Habitat: Mid intertidal zone on rocks and shells.

Distribution: Gulf of California to Mazatlán, Mexico.

Tripsycha tripsycha (Pilsbry and Lowe) (Fig. 9.99)

Shell characteristics: White to tan; coiling in the form of a hollow cone.

Measurements: Length, 70 mm; greatest diameter, 10 mm.

Habitat: Cemented to rocks in mid and low intertidal zones.

Distribution: Along the west coast of Mexico from Puerto Peñasco to Mazatlán.

Remarks: Individuals tend not to entangle like other worm snails. In fact, when two or more settle near each other they grow in opposite directions.

Serpulorbis margaritaceus (Chenu, *ex* Rousseau MS) (Fig. 9.100)

Shell characteristics: Tube brown, coiled in a flat spiral or straight; spiral ribs with rough scales.

Measurements: Diameter of large coil, 70 mm; diameter of tube, 10 mm.

Habitat: Intertidally on rocks or shells.

Distribution: Gulf of California to southern Mexico.

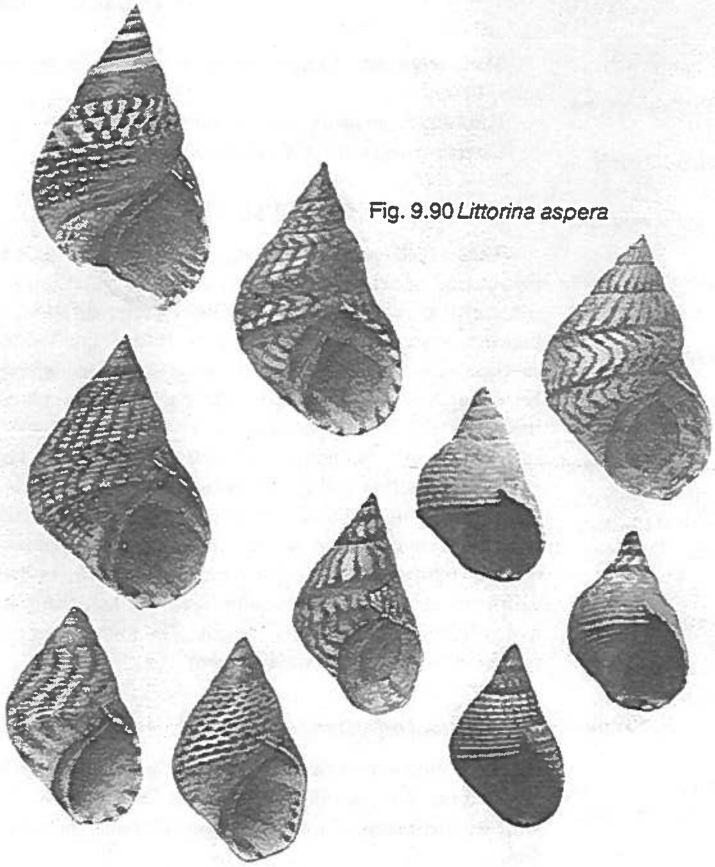


Fig. 9.90 *Littorina aspera*

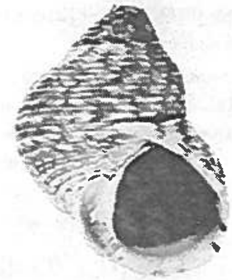


Fig. 9.91 *Littorina fasciata*

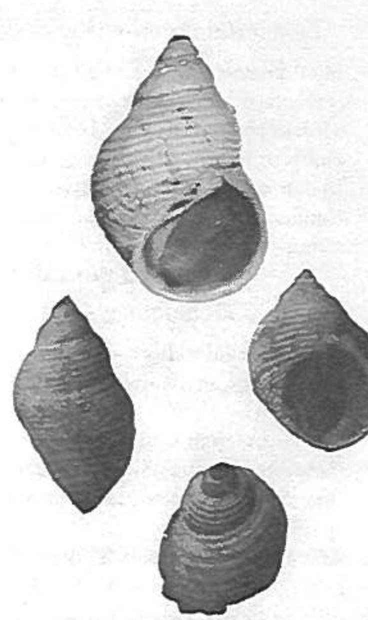


Fig. 9.92 *Littorina modesta*

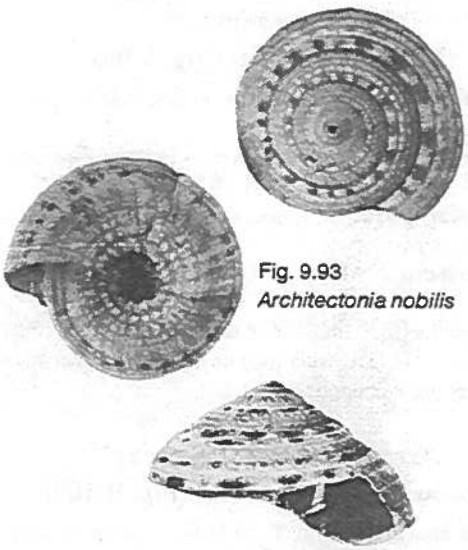


Fig. 9.93
Architectonia nobilis

Fig. 9.94 *Turritella anactor*

Fig. 9.95 *Turritella gonostoma*

Fig. 9.96 *Turritella leucostoma*

Fig. 9.97 *Vermicularia pellucida eburnea*

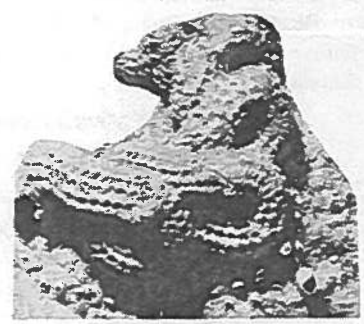


Fig. 9.98 *Vermetus indentatus*

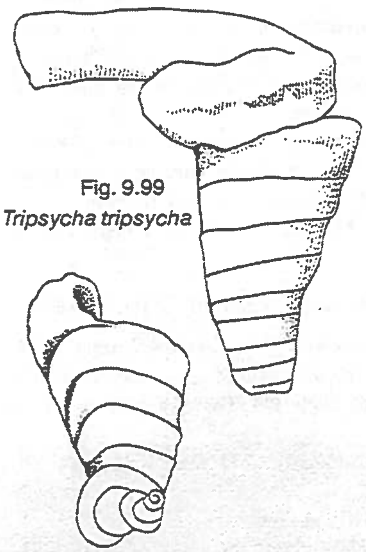


Fig. 9.99 *Tripsycha tripsycha*

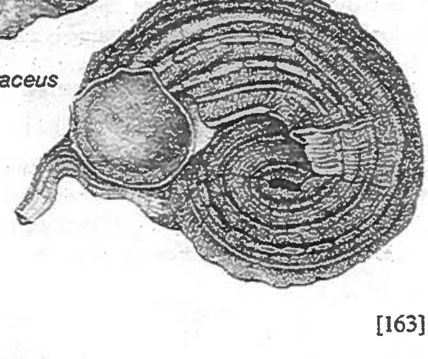


Fig. 9.100 *Serpulorbis margaritaceus*

FAMILY CERITHIIDAE (ceriths)

The sculptured shell is tower-shaped with several whorls and a short anterior canal. Reproductive system is open and the larval stages are free swimming.

Cerithium maculosum Kiener (Fig. 9.101)

Shell characteristics: Gray with brown and white dots; slender spire; numerous nodes just below the suture.

Measurements: Height, 45 mm; diameter, 20 mm.

Habitat: In sand pockets between rocks in the middle and low intertidal zones.

Distribution: Bahía Magdalena and throughout the Gulf of California to Mazatlán and the Tres Marías Islands.

Cerithium stercusmuscarum (Valenciennes) (Fig. 9.102)

Shell characteristics: Dark brown to black, speckled with small white dots. Row of nodules just below the suture.

Measurements: Diameter, 10 mm; height, 25 mm.

Habitat: On mud flats; especially common in esteros.

Distribution: Bahía San Ignacio (west Baja), through the Gulf, to Peru.

Remarks: This species is extremely common, especially on mud flats in the northern Gulf, where they can be observed piled on top of one another, in gigantic clumps, wherever a semihard substrate is available.

Liocerithium judithae Keen (Fig. 9.103)

Shell characteristics: Green to dark gray; slender; whorls with deeply sculptured spiral grooves; the upper 2 or 3 cords of each whorl light and marked with regularly spaced black spots; aperture oval with an anterior notch lacking the anterior canal.

Measurements: Height, 22 mm; diameter, 6 mm.

Habitat: Mid intertidal zone, under rocks.

Distribution: Bahía Magdalena and throughout the Gulf; very common.

FAMILY POTAMIDIDAE (horn shells)

The horn shells are brown to black in color with heavy axial sculpturing. The anterior canal is highly reduced or absent, and the operculum is subcircular.

Cerithidia mazatlanica (Carpenter) (Fig. 9.104)

Shell characteristics: Dark brown to black, sculptured with a network of axial and spiral ribs.

Measurements: Diameter, 10 mm; height, 25 mm.

Habitat: In salt marshes, on mud.

Distribution: Lower west coast of Baja and throughout the Gulf, south to Panama.

Remarks: Large populations occur in esteros, similar to those of *C. californica* along the Pacific coast. Berry (1956c) has suggested a pale version of *C. mazatlanica* (occurring in the northern Gulf) represents a distinct species: *C. albonodosa* Gould and Carpenter.

FAMILY STROMBIDAE (conchs)

The conchs are both biologically and aesthetically pleasing. They include a wide variety of forms, including the famous queen conch of the Caribbean, *Strombus gigas*. Instead of gliding along like other gastropods, they have a narrow foot specialized in leaping or hopping. In addition, they have a long narrow aperture which is notched at the anterior end. Most species are herbivorous; however, some feed on echinoderms, notably sea stars or urchins.

Strombus gracilior Sowerby (Fig. 9.105)

Shell characteristics: Yellowish-white, outer lip may be orange, but not always. Spire, tall with nodes just below the suture. Periostracum thin and shiny.

Measurements: Width, 45 mm; length, 75 mm.

Habitat: On sand flats, mud-sand lagoons, and offshore.

Distribution: Gulf of California to Peru.

Strombus granulatus Swainson (Fig. 9.106)

Shell characteristics: Color variable, generally brown dots on a whitish background; smooth periostracum; distinct nodes on both body whorl and spire; inside of outer lip granulated.

Measurements: Height, 45 mm; diameter, 35 mm.

Habitat: Intertidally in sandy mud or where rocks are embedded in soft substrates; offshore to 75 m.

Distribution: Northern Gulf of California to Ecuador.

Strombus galeatus Swainson (Fig. 9.107)

Shell characteristics: White with a brown spire; dark brown periostracum; aperture is orange with a crenulated outer lip; outer lip often reduced or highly eroded.

Measurements: Height, 200 mm; diameter, 130 mm.

Habitat: Subtidally in sand.

Distribution: Throughout the Gulf of California, south to Ecuador.

Remarks: This species is most likely the largest eastern Pacific gastropod. Because of its large size, it serves as an important local food source. Large piles of these shells are often found along the shores of western Mexico. This species is known locally as "caracol burro."

Fig. 9.101
Cerithium maculosum

Fig. 9.102 *Cerithium stercusmuscarum*

Fig. 9.103
Liocerithium judithae

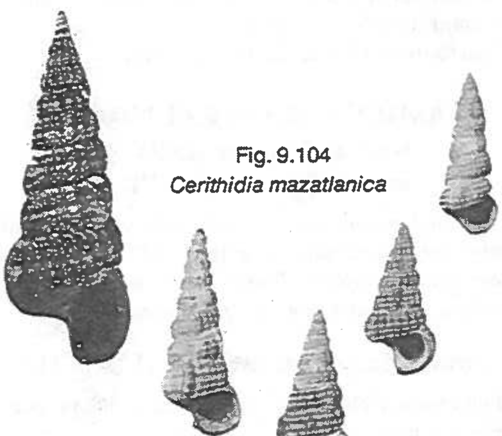


Fig. 9.104
Cerithidia mazatlanica

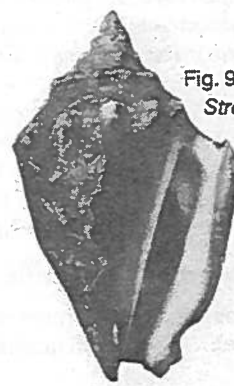


Fig. 9.105
Strombus gracilior

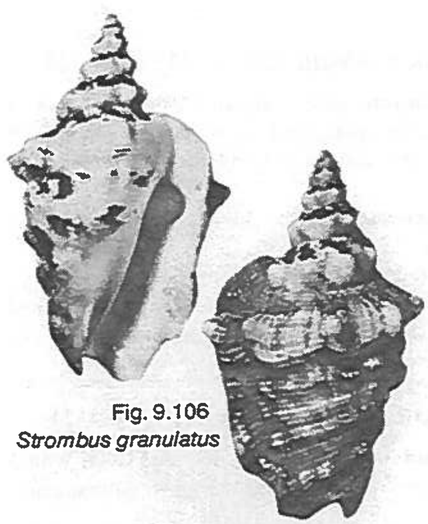


Fig. 9.106
Strombus granulatus

Fig. 9.107 *Strombus galeatus*

FAMILY JANTHINIDAE

Individuals of this family are widely distributed because they are pelagic. They secrete air bubbles which are contained in a mucous envelope. This mechanism allows them to float on the surface and be transported by oceanic currents. The shell is low spired. Janthinids exhibit the phenomenon of countershading by having a shell that is purple on top and white underneath. This coloration functions as a protective mechanism, reducing the chances of being seen by predators below. Most janthinids are hermaphroditic and produce free swimming veliger larvae.

Janthina janthina (Linnaeus) (Fig. 9.108)

Shell characteristics: Purple on the dorsal region and white to lavender ventrally; low spired.

Measurements: Height, 10 mm; diameter, 35 mm.

Habitat: Pelagic.

Distribution: Throughout the tropical and subtropical waters of the Pacific and Atlantic oceans.

Remarks: During certain times of the year currents and storm winds carry large numbers of these snails to deposit them on various beaches throughout the Gulf.

Janthina prolongata Blainville (Fig. 9.109)

Shell characteristics: Aperture relatively large; columella twisted; sutures well marked; very similar to *J. janthina*.

Measurements: Height, 25 mm; diameter, 22 mm.

Habitat: Pelagic.

Distribution: Throughout the tropical and subtropical waters of the Pacific and Atlantic oceans. Not uncommon in the Gulf.

FAMILY EULIMIDAE

This family consists of snails which are parasitic or commensals on other invertebrates. Most individuals are small, usually 3 to 5 mm in length. The shell is tower-shaped, smooth with a shiny surface.

Turveria encopendema Berry (Fig. 9.110)

Shell characteristics: White with a brown colored stripe just below the suture; oval–conic in shape.

Measurements: Height, 4 mm; diameter, 1.5 mm.

Habitat: On the sand dollars *Encope grandis* and *Encope micropora*.

Distribution: Common in the northern Gulf of California.

FAMILY HIPPONICIDAE (horse-hoof limpets)

The shell is generally thick and cap-shaped. The spiral coiling has been lost in the adult, while the apex usually leans toward the posterior end. Since the muscle scar is horseshoe-shaped, these snails are commonly referred to as horse-hoof limpets.

Hipponix pilosus (Deshayes) (Fig. 9.111)

Shell characteristics: Dark brown; yellow-brown periostracum with rows of fine filiments interspersed by distinct radial ribs.

Measurements: Height, 11 mm; diameter, 23 mm.

Habitat: Mid intertidal zone, on rocks.

Distribution: Throughout the Gulf of California, south to Ecuador.

Hipponix panamensis C. B. Adams (Fig. 9.112)

Shell characteristics: A low conical form with the apex near the posterior margin; surface with many close-set lamellae; dirty white; highly variable in overall shape.

Measurements: Diameter, 25 mm; height, 11 mm.

Habitat: Intertidal, on rocks.

Distribution: Gulf of California to Peru.

FAMILY CALYPTRAEIDAE (cup and saucer shells and "slipper limpets")

The calyptraeids have a shell that is conical to slipper-shaped. Internally there is a shelf used for attachment to the soft parts. These snails are protandrous hermaphrodites, and they have free-swimming veligers.

Calyptraea mamillaris Broderip (Fig. 9.113)

Shell characteristics: White, conical, smooth; purple or brown spire.

Measurements: Diameter, 35 mm; height, 15 mm.

Habitat: Mud flats, attached to rocks and shells; less common in rocky intertidal.

Distribution: Bahía Magdalena, through the Gulf to Peru.

Crepidula aculeata (Gmelin) (Fig. 9.114)

Shell characteristics: Brown externally; interior may have brown spots; deck is white and notched on sides and center; surface is spiny with apex curved to one side.

Measurements: Length, 20 mm; width, 15 mm; height, 6 mm.

Habitat: Intertidally, on rocks or shells.

Distribution: Widespread through California and the Gulf of California, south to Chile; also reported in the Caribbean and west Pacific.

Crepidula striolata Menke (Fig. 9.115)

Shell characteristics: White, low and ovate with a few fine ribs on dorsum; apex is marginal; periostracum is dull yellow.

Measurements: Length, 28 mm; width, 20 mm; height, 7 mm.

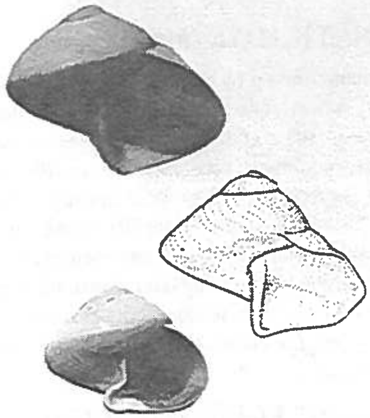


Fig. 9.108 *Janthina janthina*

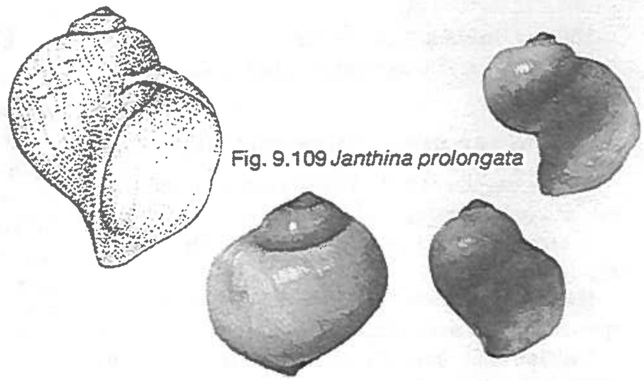


Fig. 9.109 *Janthina prolongata*

Fig. 9.111 *Hipponix pilosus*

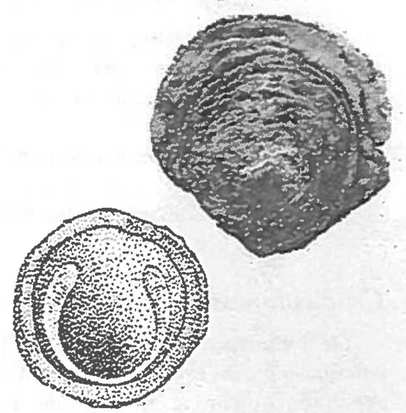


Fig. 9.112 *Hipponix panamensis*

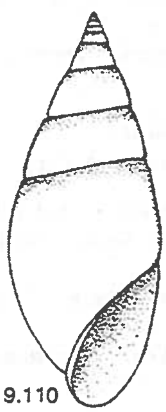


Fig. 9.110
Turveria encopendema

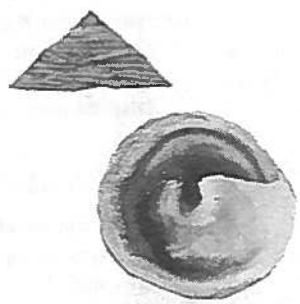


Fig. 9.113 *Calyptraea mamillaris*

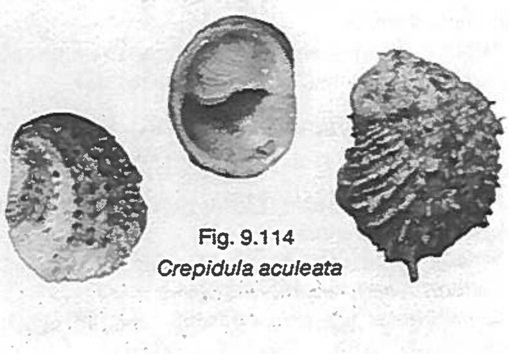


Fig. 9.114
Crepidula aculeata

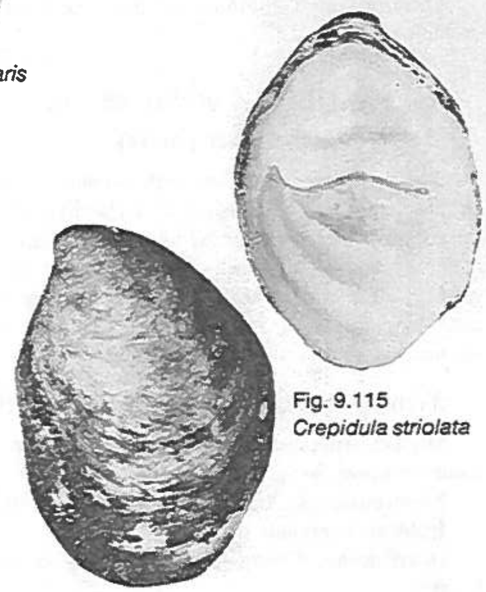


Fig. 9.115
Crepidula striolata

Habitat: Intertidally under rocks.
Distribution: Throughout the Gulf of California to Panama.

Crepidula excavata (Broderip) (Fig. 9.116)

Shell characteristics: Yellowish-brown with dark spots and/or brown strips.
Measurements: Length, 33 mm; width, 24 mm; height, 12 mm.
Habitat: Generally found attached to other shells, especially moon snails; intertidal.
Distribution: Baja California and throughout the Gulf, south to Panama.

Crucibulum spinosum (Sowerby) (Fig. 9.117)

Shell characteristics: Brownish-white; recurved apex; rough sculpture with many rows of spines; internal cup is white and attached at one side, as well as at the apex.
Measurements: Diameter, 30 mm; height, 10 mm.
Habitat: Intertidally on rocks and shells.
Distribution: California, south through the Gulf to Chile.

Crucibulum scutellatum (Wood) (Fig. 9.118)

Shell characteristics: Variable in shape and color but usually brownish with coarse radial ribbing and light concentric sculpturing. Internal cup attached along one side as well as at the apex.
Measurements: Diameter, 50 mm; height, 7.5 mm.
Habitat: On stones and dead shells intertidally and offshore; especially common on large tidal flats and bays.
Distribution: California and throughout the Gulf, south to Chile.

FAMILY XENOPHORIDAE (carrier shells)

The shells are cap-shaped with flat-sided whorls. In addition, they are equipped with a clawlike, chitinous operculum. These animals are interesting because many gather up bits of shells and sand and attach them to the growing edge of the whorl. The operculum and foot are used in conjunction to facilitate a leaping mode of locomotion, similar to the Strombidae.

Xenophora robusta Verrill (Fig. 9.119)

Shell characteristics: White; brown aperture; operculum is brown, ovate, and horny.
Measurements: Height, 60 mm; diameter, 100 mm.
Habitat: Subtidally in sand.
Distribution: Central and lower Gulf to southern Mexico.

FAMILY NATICIDAE (moon snails)

The shell is characterized by its short spire and extremely large body whorl. The aperture is round at the bottom, tapering to an angle at the top. These snails are highly carnivorous, and their diet consists mostly of bivalves or other gastropods. They bore through the shell of their prey by making a nearly perfect round hole with their radula. When completed they can then extend their proboscis through the opening and consume the flesh. During the reproductive season females deposit their eggs in the shape of a collar, which is a matrix of eggs, sand, and mucus.

Natica chemnitzii Pfeiffer (Fig. 9.120)

Shell characteristics: Gray to grayish-yellow, 4 to 5 bands of pointed markings. Operculum smooth and white.
Measurements: Diameter, 30 mm; height, 30 mm.
Habitat: Intertidally on mud flats.
Distribution: Bahía Magdalena and throughout the Gulf of California to Peru.

Polinices bifasciatus (Griffith and Pidgeon) (Fig. 9.121)

Shell characteristics: Light brown to dull yellow or brown, with two distinct white bands; umbilicus partially obscured by a brown callus.
Measurements: Height, 45 mm; diameter, 37 mm.
Habitat: On tidal flats.
Distribution: Throughout the Gulf of California to Panama.

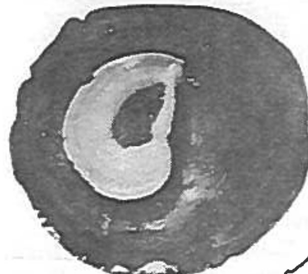
Polinices uber (Valenciennes) (Fig. 9.122)

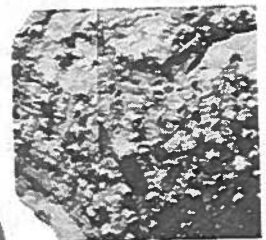
Shell characteristics: A somewhat variable form typically possessing a strong, high spire; umbilical opening only slightly closed.
Measurements: Height, 20 mm; diameter, 18 mm; exceptionally large specimens have been recorded to diameters of 42 mm.
Habitat: Intertidally and offshore on sand and sand-mud substrates.
Distribution: Central west Baja (Scammon's Lagoon) and throughout the Gulf, south to Peru.

Polinices recluzianus (Deshayus) (Fig. 9.123)

Shell characteristics: Tan to brown on a whitish background; callus entirely white.
Measurements: Height, 55 mm; diameter, 50 mm.
Habitat: Intertidally on sandy mud.
Distribution: Southern California and throughout the Gulf of California to Tres Marías Islands.
Remarks: Locally abundant on tidal flats harboring large clam populations (upon which this moon snail feeds), such as Bahía de Los Angeles.

Fig. 9.116 *Crepidula excavata*





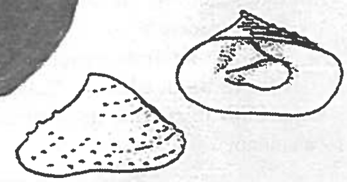
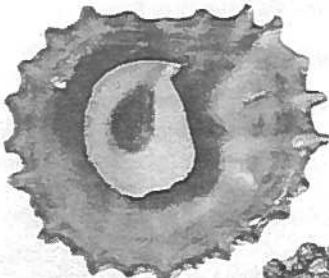


Fig. 9.117
Crucibulum spinosum



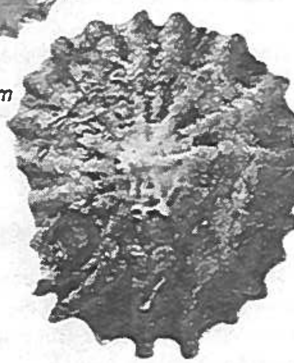


Fig. 9.118
Crucibulum scutellatum

Fig. 9.120
Natica chemnitzii

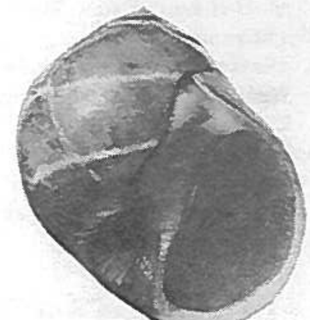
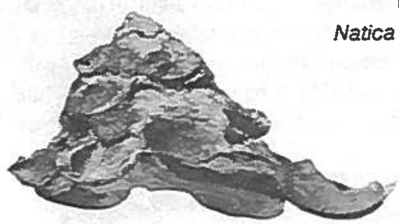
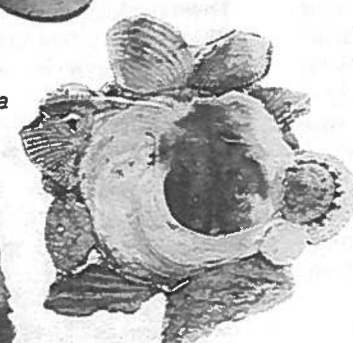


Fig. 9.121
Polinices bifasciatus





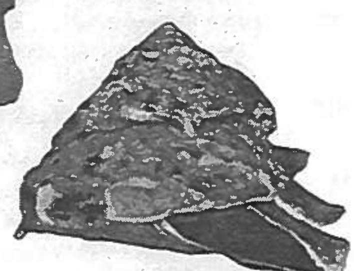


Fig. 9.119 *Xenophora robusta*

Fig. 9.122 *Polinices uber*

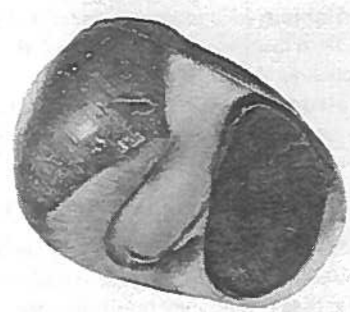


Fig. 9.123 *Polinices recluzianus*

FAMILY TRIVIIDAE (coffee beans)

Members of this group have oval shells with low spires, which, in some species, is hidden in the adult. The aperture runs the entire length of the shell. There are usually strong ribs which lie perpendicular to the aperture.

Trivia californiana (Gray) (Fig. 9.124)

Shell characteristics: Dark pink to purple or brown with strong ribbing; anterior and posterior ends blunt; ribs interspaced by granules.

Measurements: Length about 10 mm.

Habitat: Intertidal zone, under rocks.

Distribution: Central California, Pacific coast of Baja California and throughout the Gulf, south to Acapulco.

Trivia solandri (Sowerby, *ex* Gray MS) (Fig. 9.125)

Shell characteristics: Brown with fewer ribs than *T. californiana*.

Measurements: Length, 16 mm.

Habitat: Middle and low intertidal, under rocks.

Distribution: Southern California and throughout the Gulf, south to Peru.

Remarks: Young specimens have poorly developed ribbing, becoming stronger as the animal matures. Common in beach drift.

FAMILY CYPRAEIDAE (cowries)

The shells of adults are cylindrical with the outer lip turned in toward the aperture. In addition, both lips are lined with rows of denticles or teeth. In living individuals the mantle, when extended, completely covers the shell. The periostracum is absent in this group of gastropods, leaving the beautiful and highly polished shell exposed. Figure 9.126 depicts cypraeid morphology.

Cypraea annettae Dall (Fig. 9.127)

Shell characteristics: Brown on blue, with many spots on dorsal surface. Ventral surface tan to brown, with white teeth.

Measurements: Length, 40 mm; width, 25 mm.

Habitat: Mid intertidal; under rocks.

Distribution: Pacific coast of Baja California and throughout the Gulf.

Remarks: During the summer months females of this species deposit bright purple egg capsules in large clumps on the undersides of rocks.

Cypraea arabicula (Lamarck) (Fig. 9.128)

Shell characteristics: Dorsal surface green to turquoise, spotted with brown; dorsal region is bumped, while base is flat; numerous fine, sharp aperture teeth.

Measurements: Length, 25 mm; width, 15 mm.

Habitat: Intertidal; under rocks.

Distribution: Central Gulf, south to Peru.

Cypraea cervinetta Kiener (Fig. 9.129)

Shell characteristics: Yellowish-brown dorsal surface with numerous gray dots near the margins; base pale, often with a brown spot; internally it is purple with brown apertural teeth; juveniles are banded.

Measurements: Length, 35 to 110 mm; width to 50 mm.

Habitat: Under rocks in the low intertidal zone.

Distribution: Northern Gulf of California to Peru.

Remarks: During the summer months individuals deposit bright purple egg capsules on the underside of rocks.

FAMILY OVULIDAE (egg shells)

The shell is similar to the coweries except there are no color bands or spots, and the spire curves outward. These snails are often predators on coelenterates, which they tend to mimic in color.

Simnia aequalis (Sowerby) (Fig. 9.130)

Shell characteristics: Varies from white to lavender or pink, the anterior and posterior ends often being yellow or orange; dorsum smooth or finely striate with transverse ridges. Individuals have been found on white gorgonians having a mantle that is white with pale orange spots.

Measurements: Length, 22 mm.

Habitat: On gorgonians and possibly free-living.

Distribution: Monterey, California, through the Gulf of California and south to Panama and the Galápagos Islands.

Jenneria pustulata (Lightfoot) (Fig. 9.131)

Shell characteristics: Dorsal surface covered with bright orange pustules which are surrounded by black rings; base is brown with apertural teeth extending to the margins; purple interior; a distinctive and unmistakable snail.

Measurements: Length, 25 mm; width, 15 mm.

Habitat: Rocky intertidal and subtidal and associated with large corals.

Distribution: Gulf of California to Ecuador.

FAMILY TONNIDAE (tuns)

The shell is large, thin, and blotted with wide smooth spiral sculpturing. Furthermore, the body whorl is extremely large with a reflected outer lip containing dentacles on its inner surface. There is no operculum in members of this family.

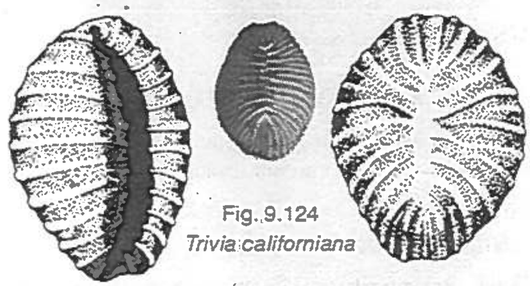


Fig. 9.124
Trivia californiana

Fig. 9.125
Trivia solandri

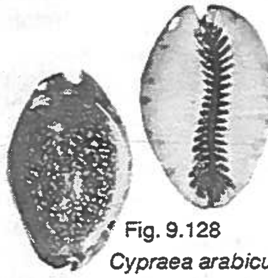


Fig. 9.128
Cypraea arabicula

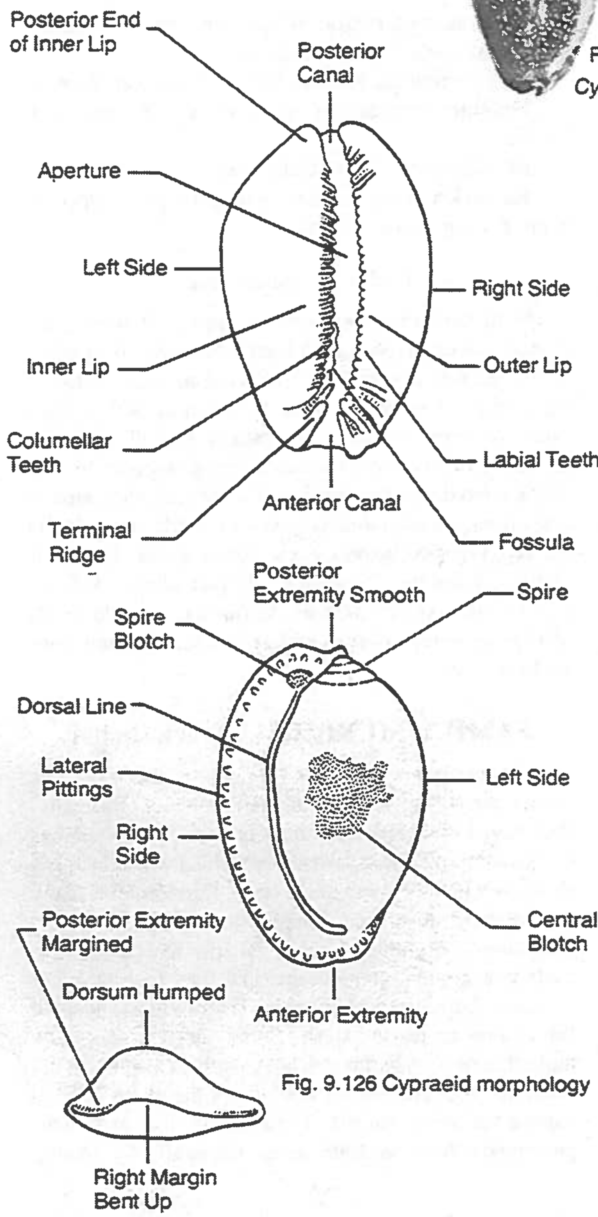


Fig. 9.126 Cypraeid morphology

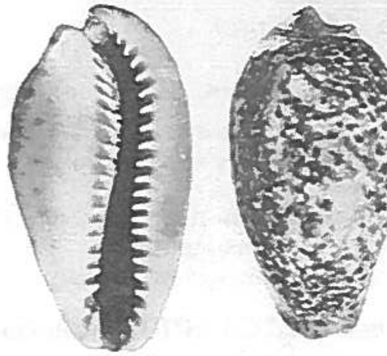


Fig. 9.127 *Cypraea annettae*

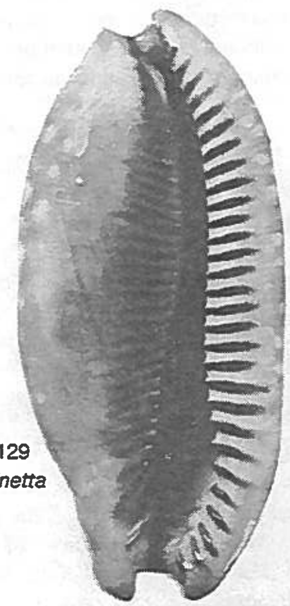


Fig. 9.129
Cypraea cervinetta

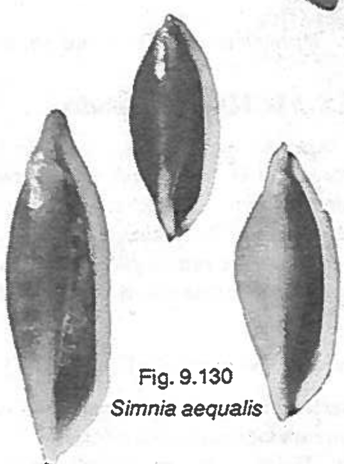


Fig. 9.130
Simnia aequalis

Fig. 9.131
Jenneria pustulata

Malea ringens (Swainson) (Fig. 9.132)

Shell characteristics: Large; white with faint yellow spots; thin periostracum; outer lip reflected and toothed.

Measurements: Height, 150–240 mm.

Habitat: Subtidally in sand.

Distribution: Northern Gulf to Peru.

FAMILY CASSIDIDAE (helmet shells)

Helmet shells are heavy with a shiny porcelaneous texture. The spire is medium to short, and the inner lip is covered by a wide flat callus. In some species this callus is smooth, while in others it contains thick, evenly spaced ribs. The operculum is in the shape of a semicircle and has radial striations. These snails are active predators, often feeding on sea urchins.

Cassis coarctata Sowerby (Fig. 9.133)

Shell characteristics: White with spotted, yellowish, spiral bands; low spire, outer lip not reflected; aperture posteriorly contracted.

Measurements: Height, 50 mm; diameter, 28 mm.

Habitat: In sandy mud at low tide.

Distribution: Throughout the Gulf to Ecuador.

Remarks: This species is relatively common in beach drift; often abundant at Bahía Cholla.

Cassis centiquadrata (Valenciennes) (Fig. 9.134)

Shell characteristics: White with regular spiral ribs and pale brown blotches; callus granular.

Measurements: Height, 55 mm; diameter, 35 mm.

Habitat: On sand flats at lowest tide level and offshore.

Distribution: Throughout the Gulf and south to Peru.

FAMILY FICIDAE (fig shells)

The shell is thin and more or less pear- or fig-shaped. The body whorl is large, with an enormous aperture. Sculpturing is light with distinct spiral lines. The operculum is wanting. A striking feature is the enormous foot upon which the animal glides. Moreover, there is a conspicuous mantle that covers the shell when the animal is extended.

Ficus ventricosa (Sowerby) (Fig. 9.135)

Shell characteristics: Tan to gray; spiral ridges with brown dots; aperture smooth and bluish inside.

Measurements: Height, 100 mm; diameter, 50 mm.

Habitat: Offshore in sand.

Distribution: Bahía Magdalena and throughout the Gulf of California to Peru.

Remarks: Large numbers of these snails are dredged up by shrimp fishermen and sold to tourists.

FAMILY BURSIDAE

Spire bluntly pointed; sculpture nodose; whorls laterally compressed; anterior canal slotlike, with a thickened edge.

Bursa caelata (Broderip) (Fig. 9.136)

Shell characteristics: Brown with spiral rows of dark colored nodes; aperture whitish.

Measurements: Height, 50 mm; diameter, 30 mm.

Habitat: Rocky intertidal and shallow subtidal; in corals.

Distribution: Gulf of California and west Baja, south to Peru.

Bursa sonorana Berry (Fig. 9.137)

Shell characteristics: White with a brown band and some brown staining; nodes sharp.

Measurements: Height, 100 mm; diameter, 62 mm.

Habitat: Subtidal; primarily on soft benthic sediments.

Distribution: Gulf of California.

Remarks: Very similar, and perhaps conspecific with, *B. californica* (Hinds).

Order Neogastropoda

With few exceptions these highly evolved gastropods are carnivores, or at least saprophagous in habit. Their feeding strategies are reflected in their anatomy, especially the radula. In some that feed on soft animals (such as coral polyps) the radula has disappeared entirely. Members of this order, being carnivorous, are characterized by the presence of a long inhalant siphon and corresponding anterior canal or notch. Included in the neogastropod taxon are: the murex shells; dye shells *(Thais, Acanthina, Purpura);* basket shells *(Solenosteira);* mud snails such as *Nassarius;* spindle shells *(Fusinus);* olives *(Oliva* and *Olivella);* and the cone shells *(Conus).*

FAMILY MURICIDAE (rock shells)

Commonly known as the rock shells, species in this family are highly variable in shell structure. Basically, they have evenly spaced varices or periodic thickenings of the outer lip. These varices are formed when there is a slowdown in the growth of the shell. Furthermore, many species have developed complex and beautiful spines, projections, or nodes. Muricids are, like most neogastropod groups, carnivorous, and they feed on other molluscs, barnacles and mussels. Their radula is adapted for cutting or tearing flesh. Some species, especially those that feed on barnacles, have evolved a spine on the outer lip. This enables the snail to pry the plates apart to expose the living animal. These snails, like most neogastropods, have separate sexes. Generally the mating

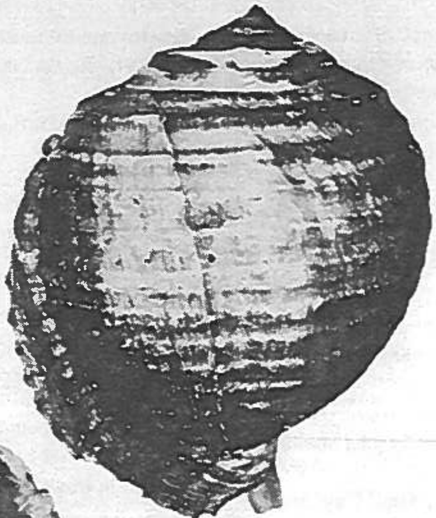


Fig. 9.132 *Malea ringens*

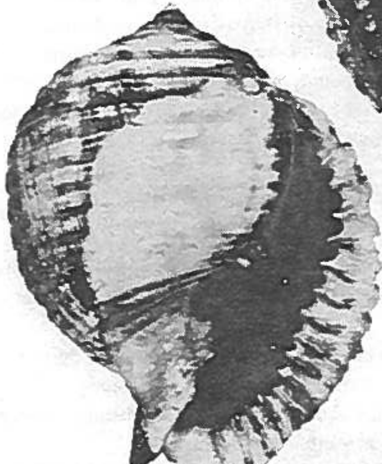


Fig. 9.133 *Cassis coarctata*

Fig. 9.134
Cassis centiquadrata

Fig. 9.137
Bursa sonorana

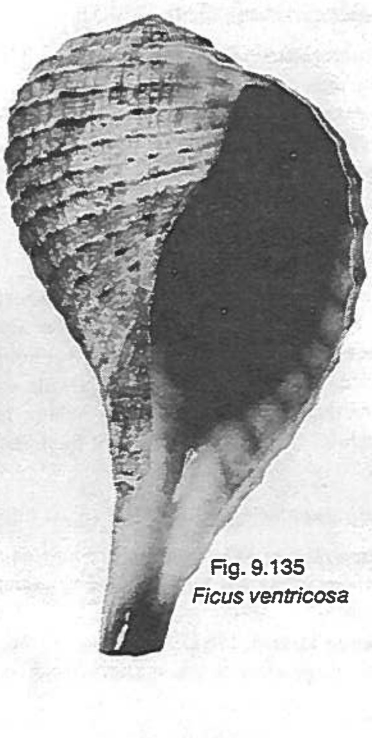


Fig. 9.135
Ficus ventricosa

Fig. 9.136 *Bursa caelata*

pairs copulate and fertilization is internal. Females deposit attractive and sometimes intricate egg capsules on and under rocks. In many species the free swimming veliger stage is suppressed and development occurs entirely within the egg capsule. These larvae then metamorphose into juvenile snails which hatch out of the capsule.

Murex elenensis Dall (Fig. 9.138)

Shell characteristics: White to yellow; short knobby spines on whorl, long spines on anterior canal; inside of aperture light purple; occasionally referred to as the "caracol alacran."

Measurements: Length up to 80 mm.

Habitat: Low intertidal zone, on rocks, and shallow subtidal.

Distribution: Scammon's Lagoon, Baja California and throughout the Gulf, south to Ecuador.

Hexaplex erythrostomus (Swainson) (Fig. 9.139)

Shell characteristics: Dull white outside, bright glossy pink inside.

Measurements: Diameter, 55 mm; height, 100 mm.

Habitat: On rocks, low intertidal and offshore.

Distribution: Throughout the Gulf of California, south to Peru.

Remarks: Large numbers are dredged up by shrimp fishermen and sold to tourists; common; egg capsules triangular or tongue-shaped.

Hexaplex regius (Swainson) (Fig. 9.140)

Shell characteristics: White with pink aperture; brown to black columellar lip; reflected varices are doubled; whorls with well-defined brown streaks between the varices.

Measurements: Length, 120 mm.

Habitat: On mud flats at low tide levels and offshore.

Distribution: Southern Gulf of California to Peru.

Muricanthus nigritus (Philippi) (Fig. 9.141)

Shell characteristics: Color, off-white, with dark brown to black spines.

Measurements: Length, to 150 mm.

Habitat: On rocks and mud flats, low intertidal and shallow subtidal.

Distribution: Endemic to the Gulf of California; common in the north.

Remarks: Commonly observed feeding on bivalves, and occasionally on other gastropods.

Muricanthus princeps (Broderip) (Fig. 9.142)

Shell characteristics: Whitish background with brownish tipped spines; 5–8 varices.

Measurements: Length, 120 mm.

Habitat: Rocky bottoms; lowest intertidal region and offshore.

Distribution: Gulf of California to Peru; uncommon north of Guaymas.

Pterynotus macleani Emerson and D'Attilio (Fig. 9.143)

Shell characteristics: Wide, thin, and fragile; pinkish-gray with brown blotches.

Measurements: Length, 30 mm; width, 23 mm.

Habitat: Primarily offshore to depths of 45 m.

Distribution: Central-southern Gulf to Panama.

Remarks: Although reported as uncommon, this shell is often found by SCUBA divers and is occasionally present in trawl samples.

Eupleura muriciformes (Broderip) (Fig. 9.144)

Shell characteristics: White to dark gray; extremely variable shape; body whorl triangular with large spines at shoulder.

Measurements: Length, 35 mm; diameter, 25 mm.

Habitat: On rocks intertidally and offshore.

Distribution: Central west Baja and throughout the Gulf of California, south to Ecuador.

Remarks: This species is especially common at Estero Soldado, Guaymas, Mexico, where it feeds on *Cerithium*.

Pteropurpura erinaceoides (Valenciennes) (Fig. 9.145)

Shell characteristics: Pale brown, covered with scales; strong varices.

Measurements: Length, 50 mm; diameter, 27 mm.

Habitat: Rocky low intertidal.

Distribution: Southern California and throughout the Gulf of California.

FAMILY CORALLIOPHILIDAE

This is an extremely variable family with respect to shell sculpture. Some species have a very spinose shell, whereas in others it is nodose. Interestingly enough, they all feed on corals and assume a near sessile existence. Owing to their specialized feeding habits, they have lost the radula. Little is known about their reproductive biology.

Coralliophila macleani Shasky (Fig. 9.146)

Shell characteristics: White; globose body whorl; variable sculpture; outer lip flanged and crenulate; yellow operculum.

Measurements: Height, 20 mm; diameter, 12 mm.

Habitat: On gorgonians in low intertidal and shallow subtidal.

Fig. 9.138
Murex elenensis

Fig. 9.139
Hexaplex erythrostomus

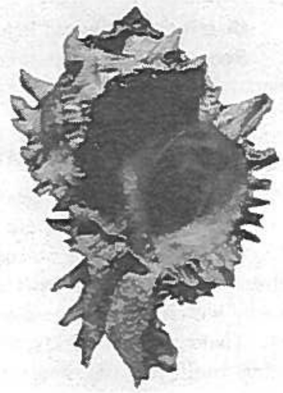


Fig. 9.140 *Hexaplex regius*

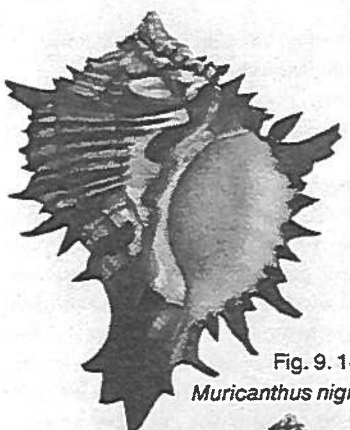
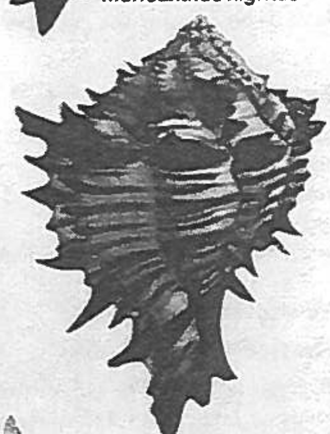


Fig. 9. 141
Muricanthus nigritus



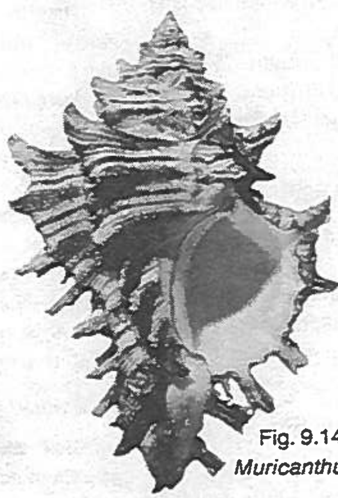


Fig. 9.142
Muricanthus princeps

Fig. 9.143 *Pterynotus macleani*

Fig. 9.146
Coralliophila macleani

Fig. 9.144 *Eupleura muriciformes*

Fig. 9.145
Pteropurpura erinaceoides

Distribution: Puerto Peñasco, Sonora, to Mazatlán.
Remarks: Common at Bahía Cholla, on gorgonian reef at extreme low tide.

FAMILY THAIDIDAE

These gastropods possess thick evenly spaced nobs on the spire. The anterior canal is well defined but short. The spines and varices, so characteristic of muricids, are absent in members of this family. The operculum is horny with a shiny ridge along the interior of the outer lip. Thaids, like muricids, are carnivorous and feed on other molluscs and small crustaceans. They have a rachiglossan type radula and accessory salivary glands. The hypobranchial gland secretes a purple substance which is used by some people as a dye. They reproduce in the same manner as the muricids, and their egg capsules are quite similar.

Thais biserialis (Blainville) (Fig. 9.147)

Shell characteristics: Gray; rough sculpture; sometimes with bright orange aperture, often with black dots near the upper inner margin.
Measurements: Diameter, 50 mm; height, 75 mm.
Habitat: Intertidally on rocks and offshore.
Distribution: Central west Baja California and throughout the Gulf, south to Chile.

Thais speciosa (Valenciennes) (Fig. 9.148)

Shell characteristics: White with brown spots on the spiral bands; yellow aperture.
Measurements: Height, 35 mm; diameter, 28 mm.
Habitat: Mid intertidal zone, under rocks.
Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Thais kiosquiformis (Duclos) (Fig. 9.149)

Shell characteristics: Gray to brown, marked with white; aperture brown or brown-and-white banded; suture frilled.
Measurements: Length, 43 mm; diameter, 26 mm.
Habitat: Primarily found in mangrove lagoons; in rocky areas with abundant sediment.
Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.
Remarks: A common form in mangrove lagoons, where it feeds on *Ostrea*. Many species of *Thais* and *Purpura* are known to drill holes through the shells of other molluscs, especially oysters and mussels, in order to feed upon them. Many are also known to be predators on various barnacles.

Acanthina angelica Oldroyd (Fig. 9.150)

Shell characteristics: Dull gray; high spire with large nodes below the suture; large spine on outer aperture, purple within.
Measurements: Diameter, 20 mm; height, 40 mm.
Habitat: On rocks in mid intertidal zone.
Distribution: Gulf of California.
Remarks: Extremely common at Puerto Peñasco, Sonora, Mexico. Individuals are gregarious, often occurring in large clumps while feeding on barnacles. The apertural spine possibly is used to pry open the opercular plates of acorn barnacles.

Acanthina tyrianthina Berry (Fig. 9.151)

Shell characteristics: Gray, checkered with dark brown; interior tawny brown.
Measurements: Height, 27 mm; diameter, 18 mm.
Habitat: Rocky intertidal.
Distribution: Bahía Tortola (central west Baja) to the southern Gulf of California.

Purpura pansa Gould (Fig. 9.152)

Shell characteristics: Dark gray with a bright salmon aperture.
Measurements: Height, 100 mm; width, 45 mm.
Habitat: Rocky mid intertidal.
Distribution: Bahía Magdalena and through the central and southern Gulf to Colombia and the Galápagos Islands.
Remarks: This snail (as well as most others in this family) exudes a viscous, milky-white secretion when handled roughly. After a few minutes of exposure to the air, the secretion turns purple and emits a sulfurous odor. This purple dye used to be extracted and utilized as such by many groups in the Old World (as well as the Central American Amerinds), and the generic name *Purpura* was originally given to these snails on this basis. It is thought to be useful to the gastropod in subduing its prey.

Morula ferruginosa (Reeve) (Fig. 9.153)

Shell characteristics: Dark gray to black; large, prominent nodules; tall spire; aperture blue to brown.
Measurements: Diameter, 5 mm; height, 12 mm.
Habitat: Intertidally under rocks.
Distribution: Bahía Magdalena and throughout the Gulf.

Neorapana tuberculata (Sowerby) (Fig. 9.154)

Shell characteristics: Brown to tan; relatively high spire; strong nodes on body whorl and spire; inside of aperture pinkish-orange; tooth on outer lip.
Measurements: Height, 50 mm; diameter, 40 mm.
Habitat: On rocks in mid intertidal zone.
Distribution: Throughout the Gulf of California.

Neorapana muricata (Broderip) (Fig. 9.155)

Shell characteristics: Yellowish-brown; aperture pinkish; spire low; similar to *N. tuberculata* but with a lower spire and with the first rib not being broken up into nodes.

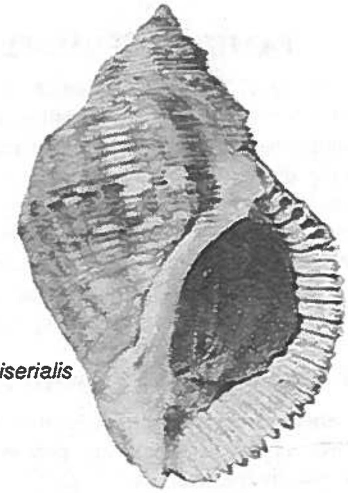


Fig. 9.147 *Thais biserialis*

Fig. 9.148 *Thais speciosa*

Fig. 9.149 *Thais kiosquiformis*

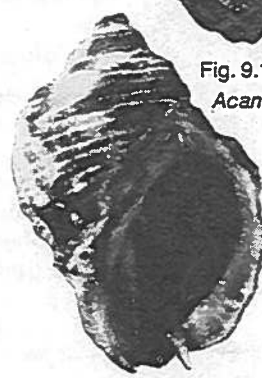


Fig. 9.151 *Acanthina tyrianthina*

Fig. 9.150 *Acanthina angelica*

Fig. 9.152 *Purpura pansa*

Fig. 9.153 *Morula ferruginosa*

Fig. 9.155 *Neorapana muricata*

Fig. 9.154 *Neorapana tuberculata*

Measurements: Height, 50–100 mm; diameter, 50–70 mm.

Habitat: Rocky intertidal and shallow subtidal; coral heads.

Distribution: Central Gulf to Ecuador.

FAMILY BUCCINIDAE (whelks)

The shell is tall and somewhat conical, usually with heavy axial and spiral sculpturing. The operculum is chitinous. There is a ventral pedal gland on the foot; however, there is no accessory boring organ. Buccinids are generally scavengers or saprophytes and they can often be seen feeding on dead fish and invertebrates. They have a proboscis with a rachiglossan type radula. There is no accessory salivary gland and the esophageal gland is rather small. The stomach is simple, lacking a crystalline style, and the axial gland is absent. The nervous system is more concentrated than in the muricids or thaids. Moreover, their genitalia are generally closed and complex. The egg capsules are horny and the veliger stage is sometimes suppressed.

Cantharus elegans (Griffith and Pidgeon, *ex* Gray MS) (Fig. 9.156)

Shell characteristics: Brown with white nodes; strong spiral ribbing; rather long siphonal fasciole; fibrous periostracum.

Measurements: Height, 45 mm; diameter, 22 mm.

Habitat: Intertidally, on rocks.

Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Solenosteira capitanea Berry (Fig. 9.157)

Shell characteristics: Tan to brown, fuzzy periostracum; distinct shoulders; large; robust; inner and outer lips white.

Measurements: Height, 60 mm; diameter, 35 mm.

Habitat: On mud flats at low tide.

Distribution: So far reported only from the northern Gulf of California.

Remarks: Often large populations of hermit crabs inhabit empty shells of this species.

Solenosteira macrospira Berry (Fig. 9.158)

Shell characteristics: Similar to *S. capitanea* but smaller and with a more pronounced siphonal fasciole; shoulders more rounded.

Measurements: Height, 45 mm; diameter, 30 mm.

Habitat: Intertidally on mud flats.

Distribution: Northern Gulf of California.

Remarks: During the spawning season, females deposit egg capsules on the shells of males. In many instances the shell is completely obscured by capsules.

FAMILY COLUMBELLIDAE

The shell is small to medium in size and either smooth or sculptured. Columbellids are generally herbivorous with a rachioglossan type radula modified for tearing off bits of seaweed. Their nervous system is concentrated, and their reproductive system is closed. In some species the females have the ability to ingest spermatozoa within their pericardial cavity. The egg capsules are small and usually attached to seaweeds. The veliger can be free swimming or suppressed.

Columbella fuscata Sowerby (Fig. 9.159)

Shell characteristics: Reddish-brown, with triangular markings below the suture; periostracum light green to brown; purple aperture.

Measurements: Diameter, 10 mm; height, 20 mm.

Habitat: Mid tide line under rocks and in tidepools.

Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Columbella major Sowerby (Fig. 9.160)

Shell characteristics: Similar to *C. strombiformis* except the periostracum has a spiral sculpture only at the shoulder; zigzag marking extremely variable; shoulder of outer lip more defined.

Measurements: Height, 25 mm; diameter, 15 mm.

Habitat: Low intertidal zone between rocks.

Distribution: Southern Gulf of California to Peru.

Columbella strombiformis Lamarck (Fig. 9.161)

Shell characteristics: Large body whorl with extended shoulder; reddish-brown; zigzag spiral lines; brown periostracum; orange outer lip.

Measurements: Diameter, 15 mm; height, 30 mm.

Habitat: Low-tide line under rocks.

Distribution: Gulf of California to Peru.

Anachis coronata (Sowerby) (Fig. 9.162)

Shell characteristics: Color variable, tan to yellow with irregular brown lines.

Measurements: Diameter, 6 mm; height, 14 mm.

Habitat: Intertidally under rocks.

Distribution: Pacific coast of Baja California and throughout the Gulf to Panama.

Anachis nigricans (Sowerby) (Fig. 9.163)

Shell characteristics: Black to dark brown; granules just below suture; small.

Measurements: Height, 7 mm; diameter, 2 mm.

Habitat: Under rocks in mid intertidal zone.

Distribution: Gulf of California to Panama.

Fig. 9.156
Cantharus elegans

Fig. 9.157
Solenosteira capitanea

Fig. 9.158
Solenosteira macrospira

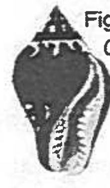


Fig. 9.159
Columbella fuscata

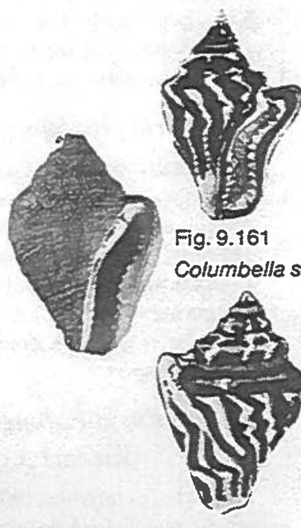


Fig. 9.161
Columbella strombiformis

Fig. 9.162
Anachis coronata

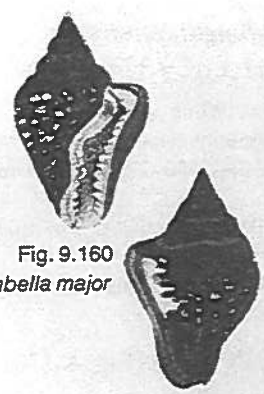


Fig. 9.160
Columbella major

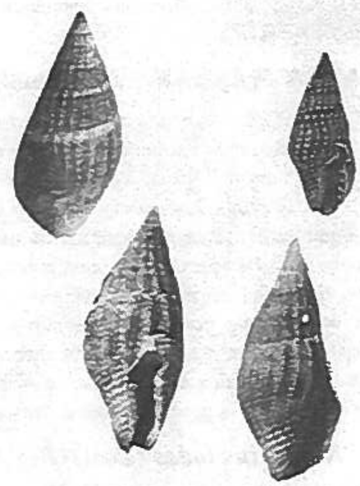


Fig. 9.163 *Anachis nigricans*

Anachis sanfelipensis Lowe (Fig. 9.164)

Shell characteristics: Yellow to tan; strong dark axial sculpturing; long and slender spire.

Measurements: Diameter, 9 mm; height, 20 mm.

Habitat: Under rocks, mid to low intertidal.

Distribution: Northern Gulf of California.

Anachis varia (Sowerby) (Fig. 9.165)

Shell characteristics: Dark brown to black; strong axial ribs; light banding at the suture.

Measurements: Diameter, 10 mm; height, 20 mm.

Habitat: Intertidally under rocks.

Distribution: Sonoran coast of Mexico, south to Panama.

Mitrella guttata (Sowerby) (Fig. 9.166)

Shell characteristics: Glossy; dark brown; covered with light spots. Protoconch usually broken off.

Measurements: Diameter, 4 mm; height, 14 mm.

Habitat: Under rocks at mid-tide line.

Distribution: Bahía Magdalena and throughout the Gulf to Panama.

FAMILY MELONGENIDAE

The shells are pear-shaped with an extremely large body whorl and small spire. The biology of these snails is virtually unknown.

Melongena patula (Broderip and Sowerby) (Fig. 9.167)

Shell characteristics: Reddish-brown with yellow or white bands. Smooth columella; dark brown periostracum.

Measurements: Height, 60–250 mm.

Habitat: On mud flats.

Distribution: Gulf of California to Panama.

Remarks: This is the only species of melongenid in the tropical east Pacific.

FAMILY NASSARIIDAE (basket whelks)

The shell of nassariids is small to medium in size, with a characteristic reticulate sculpture pattern. The siphons are long and the bilobed foot leaves well defined tracks in the mud. Posteriorly the foot is divided into two tentacles of which the function is unknown. These saprophytic scavengers can be seen in large masses feeding on dead and decaying animal tissue. When turned over, their strong pedal muscles allow them to right themselves in a split second. Their reproductive system is closed and females deposit vase-shaped egg capsules. The veliger larva is generally free swimming.

Nassarius iodes (Dall) (Fig. 9.168)

Shell characteristics: White, with a purple band in middle of the body whorl; well-developed callus.

Measurements: Diameter, 5 mm; height, 8 mm.

Habitat: On tidal flats and in esteros.

Distribution: Endemic to the Gulf of California.

Nassarius moestus (Hinds) (Fig. 9.169)

Shell characteristics: Tan to brown, maroon aperture; callus thin; lightly sculptured with many small beads on spire.

Measurements: Diameter, 9 mm; height, 15 mm.

Habitat: On tidal flats.

Distribution: Throughout the Gulf of California (and possibly restricted to it).

Remarks: Extremely common at San Felipe and Bahía Cholla, where it is sympatric with *N. tiarula*.

Nassarius tiarula (Kiener) (Fig. 9.170)

Shell characteristics: Yellowish-white; thick callus; broad dark band around spire; large nodes on the shoulder.

Measurements: Diameter, 10 mm; height, 15 mm.

Habitat: On muddy tidal flats.

Distribution: Gulf of California to Panama.

FAMILY FASCIOLARIDAE

These snails have a shell with a high spire and a very long anterior canal. The operculum is chitinous and teardrop shaped. The radula is of the rachiglossan type. Little is known about the biology of this group.

Fasciolaria princeps Sowerby (Fig. 9.171)

Shell characteristics: Large; orange to brown; dark brown periostracum; orange columella and aperture.

Measurements: Height, 150–300 mm.

Habitat: Offshore on sand.

Distribution: Gulf of California to Peru.

Remarks: The foot and mantle of this species is striking, for it is bright orange or red with iridescent lavender-blue spots.

Fusinus dupetitthouarsi (Kiener) (Fig. 9.172)

Shell characteristics: White with greenish periostracum; extremely long anterior canal.

Measurements: Height, 150–250 mm; diameter, 50 mm.

Habitat: On mud flats and sand at low tide and offshore.

Distribution: Pacific coast of Baja California and throughout the Gulf, south to Ecuador.

Fusinus felipensis Lowe (Fig. 9.173)

Shell characteristics: Brown; aperture purple; 10–11 axial ribs.

Measurements: Height, 19 mm; diameter, 8 mm.

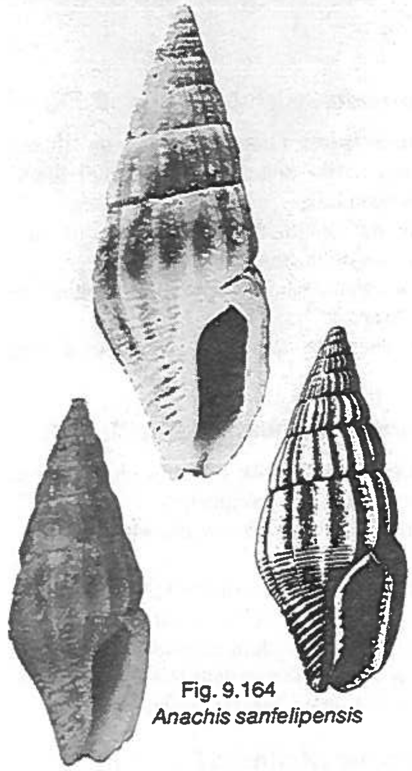


Fig. 9.164
Anachis sanfelipensis

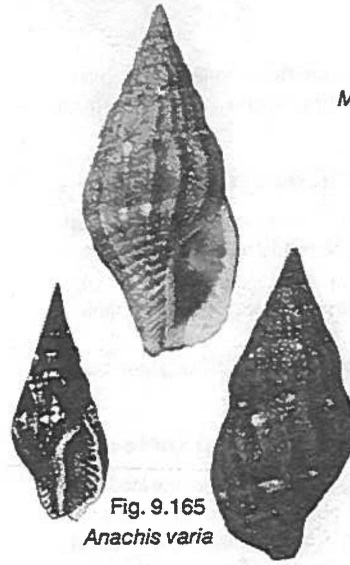


Fig. 9.165
Anachis varia

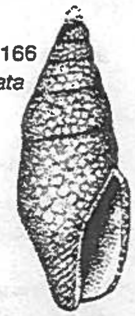


Fig. 9.166
Mitrella guttata

Fig. 9.167
Melongena patula

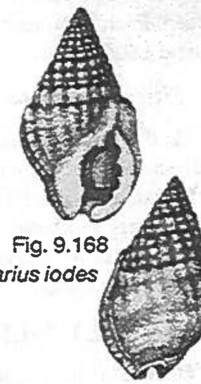


Fig. 9.168
Nassarius iodes

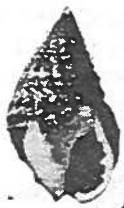


Fig. 9.169
Nassarius moestus

Fig. 9.170
Nassarius tiarula

Fig. 9.171
Fasciolaria princeps

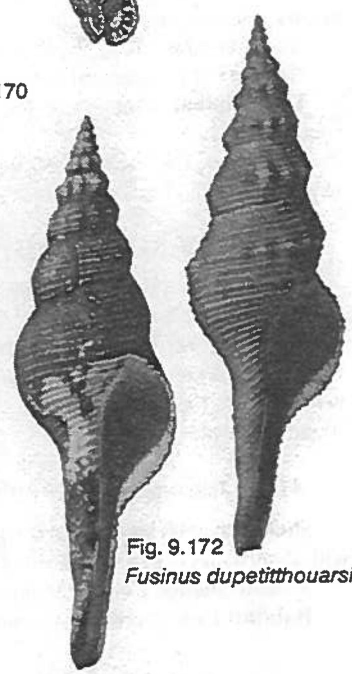


Fig. 9.172
Fusinus dupetitthouarsi

Habitat: Middle to low intertidal zone, under rocks.

Distribution: San Felipe region of the Gulf of California.

Fusinus ambustus (Gould) (Fig. 9.174)

Shell characteristics: Yellowish, shaded with brown, especially between the axial ribs, of which there are 8 to 11.

Measurements: Height, 45 mm; diameter, 18 mm.

Habitat: Mud flats.

Distribution: Throughout the Gulf but more common in the southern region.

FAMILY HARPIDAE (harp shells)

Beautiful, shiny shells, rhythmically decorated with ribs and delicate scalloped patterns in browns and reds. The aperture is wide, with a notch rather than a canal, and in most species with a brightly colored callus area. There is no operculum. The harps are widespread in the western Pacific but represented by a single species in the tropical east Pacific.

Harpa crenata Swainson (Fig. 9.175)

Shell characteristics: Grayish, with inconspicuous axial ribs and fine brownish lines.

Measurements: Height, 82 mm; diameter, 52 mm.

Habitat: Soft bottoms, offshore.

Distribution: Bahía Magdalena and the southern Gulf, south to Colombia.

FAMILY OLIVIDAE (olive shells)

The olivids have a polished shell which is obconic in design. The mantle edge is large and completely covers the shell when it is extended. They have long siphons and a mantle filament, of which the function is unknown. Olivids are carnivorous and feed on other molluscs. Their reproductive system is closed, and females lay small, jellylike capsules which are attached to the sand. The veliger is usually free swimming.

Olivella dama (Wood, *ex* Mawe MS) (Fig. 9.176)

Shell characteristics: White with a purple apex and brown zigzag patterns; highly polished.

Measurements: Diameter, 9 mm; height, 20 mm.

Habitat: Intertidally in sandy mud.

Distribution: Throughout the Gulf of California.

Olivella fletcherae Berry (Fig. 9.177)

Shell characteristics: White with two brown wavy bands; columellar area with 6–7 folds.

Measurements: Length, 10 mm; diameter, 4 mm.

Habitat: Intertidally in sand.

Distribution: Northern and central Gulf of California.

Oliva incrassata (Lightfoot) (Fig. 9.178)

Shell characteristics: Gray to brown with delicate, wavy, pink lines on the columella; body whorl thick, humped above the middle.

Measurements: Length, 60 mm; diameter, 30 mm.

Habitat: In sand at the low tide mark.

Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Remarks: The foot has brown spots on a light background.

Oliva porphyria (Linnaeus) (Fig. 9.179)

Shell characteristics: Dark brown with numerous tan zigzag patterns; siphonal fasciole tinged with violet.

Measurements: Length, 90 mm; diameter, 45 mm.

Habitat: Offshore in sand.

Distribution: Gulf of California to Panama.

Remarks: This is one of the most beautiful and sought after shells in the western hemisphere; the "tent olive." There is some evidence that this olive is occasionally eaten by the slipper lobster, *Evibacus*.

Oliva spicata (Roding) (Fig. 9.180)

Shell characteristics: Color variable, generally greenish-brown with brown dots; high spire.

Measurements: Diameter, 20 mm; height, 45 mm.

Habitat: In sandy mud at low tide.

Distribution: Gulf of California to Panama.

Agaronia testacea (Lamarck) (Fig. 9.181)

Shell characteristics: Light blue to yellow with brownish zigzag axial lines; brown apex; white columella; aperture purple within.

Measurements: Length, 45 mm; diameter, 15 mm.

Habitat: High intertidal zone, in sand.

Distribution: Throughout the Gulf of California, south to Peru.

Remarks: The colorful foot is white with pale blue to gray flecks.

FAMILY MITRIDAE (miter shells)

Snails of this family have brightly colored fusiform shells and have been the pride of shell collectors for many years. Deep columellar folds on the inner lip are the most striking feature of this group. Miters are carnivorous and have a toxoglossan type radula, like that found in cones.

Mitra fultoni E. A. Smith (Fig. 9.182)

Shell characteristics: Black; regular spiral channels with evenly spaced pits; two distinct columellar folds.

Measurements: Length, 35 mm; diameter, 10 mm.

Habitat: Low intertidal zone, under rocks.


Fig. 9.173
Fusinus felipensis

Fig. 9.174
Fusinus ambustus


Fig. 9.175
Harpa crenata

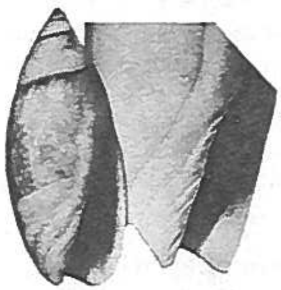


Fig. 9.176 *Olivella dama*

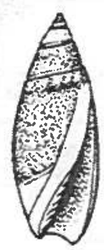



Fig. 9.177
Olivella fletcherae

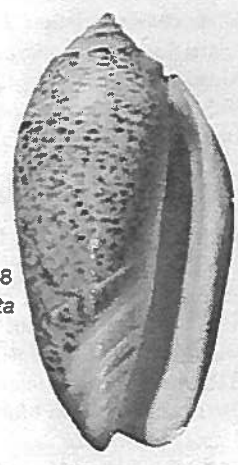


Fig. 9.178
Oliva incrassata

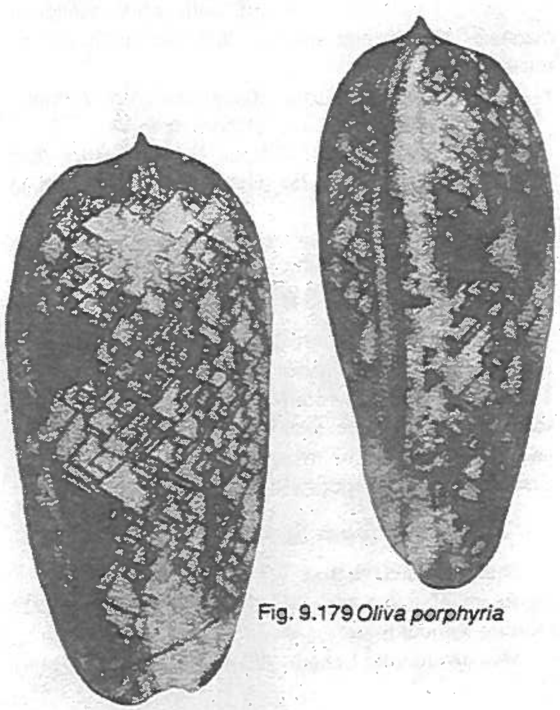


Fig. 9.179 *Oliva porphyria*

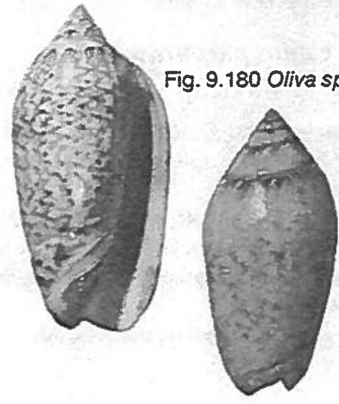


Fig. 9.180 *Oliva spicata*

Distribution: Outer coast of Baja California and throughout the Gulf.

Remarks: This species closely resembles *Mitra idae* which occurs off Southern California.

Subcancilla directa (Berry) (Fig. 9.183)

Shell characteristics: White with dark brown periostracum; strong spiral ribbing; sharp columellar folds.

Measurements: Length, 35 mm; diameter, 10 mm.

Habitat: Offshore in sand.

Distribution: Northern Gulf of California to Guaymas, Mexico.

FAMILY CONIDAE (cone shells)

The shell is conical with an extremely short spire. In many species there are nodes around the shoulder of the body whorl. The operculum may be present or wanting. These snails have attracted much interest because of their specialized feeding structures. They are equipped with poison glands and harpoonlike radulae which they inject into their prey. Except for feeding, their biology is not well known.

Conus princeps Linnaeus (Fig. 9.184)

Shell characteristics: Orange to pink with many dark axial lines; dark periostracum with spiral lines.

Measurements: Diameter, 30 mm; height, 50 mm.

Habitat: Intertidally, under rocks.

Distribution: Gulf of California to Ecuador.

Conus brunneus Wood (Fig. 9.185)

Shell characteristics: Dark brown, with darker revolving lines and white blotches on the spire or in a central band; spire low, mostly eroded; with well-developed coronations on the body whorl.

Measurements: Diameter, 37 mm; height, 56 mm.

Habitat: Rocky low intertidal and offshore.

Distribution: Bahía Magdalena and throughout the Gulf, south to Ecuador.

Remarks: Especially common in beach drift.

Conus purpurascens Sowerby, *ex* Broderip MS (Fig. 9.186)

Shell characteristics: Color variable; consisting of brown lines or bands of purple-brown and violet; thick hairy periostracum.

Measurements: Length, 45 mm; diameter, 25 mm.

Habitat: Intertidally on rocks and in tide pools.

Distribution: Bahía Magdalena and throughout the Gulf, south to Ecuador.

Remarks: This cone feeds on tidepool fish.

Conus regularis Sowerby (Fig. 9.187)

Shell characteristics: White background with brown spots and purple axial lines; purple aperture; spire either low or high.

Measurements: Length, 55 mm; diameter, 30 mm.

Habitat: In sandy mud, intertidally and offshore.

Distribution: Bahía Magdalena and throughout the Gulf, south at least to Panama.

Conus perplexus Sowerby (Fig. 9.188)

Shell characteristics: White to yellow, with variable spiral rows of dots and dashes; aperture blue to purple; thin light periostracum.

Measurements: Diameter, 15 mm; height, 25 mm.

Habitat: Intertidally and offshore, on sand.

Distribution: Bahía Magdalena and throughout the Gulf, to Ecuador.

Conus ximenes Gray (Fig. 9.189)

Shell characteristics: Cream colored, with numerous evenly spaced spiral rows of small brown dots; purple aperture; rather high spire.

Measurements: Length, 45 mm; diameter, 22 mm.

Habitat: Intertidally and offshore, in sandy mud.

Distribution: Throughout the Gulf of California, south at least to Panama.

Conus dalli Stearns (Fig. 9.190)

Shell characteristics: Complex color pattern of browns and yellows, mixed in with white triangular markings; light orange aperture; thin transparent periostracum.

Measurements: Length, 50 mm; diameter, 27 mm.

Habitat: Intertidally and offshore on rocks.

Distribution: Midriff Islands (Islas Tiburón and Angel de la Guarda), throughout the southern Gulf to Panama.

Remarks: This species feeds on other molluscs.

FAMILY TEREBRIDAE (auger shells)

The augers are extremely long, slender shells with many whorls. The anterior canal is wide and short. These are sometimes colorful species with strong axial sculpturing. They are carnivorous and, like the cones and miters, they have toxoglossate feeding structures. The majority of the species in this group are subtidal.

Terebra strigata Sowerby (Fig. 9.191)

Shell characteristics: White with brown to black zigzag axial lines; body whorl rather long; elongate aperture without folds.

Measurements: Length, 120 mm; diameter, 40 mm.

Fig. 9.181 *Agaronia testacea*

Fig. 9.182 *Mitra fultoni*

Fig. 9.183 *Subcancilla directa*

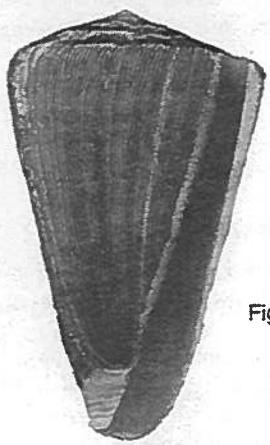


Fig. 9.184 *Conus princeps*

Fig. 9.185 *Conus brunneus*

Fig. 9.186 *Conus purpurascens*

Fig. 9.187 *Conus regularis*

Fig. 9.188 *Conus perplexus*

Habitat: Intertidally and offshore on rocks.

Distribution: Gulf of California to Galápagos Islands.

Terebra ornata Gray (Fig. 9.192)

Shell characteristics: Stubby shell, beige with squarish brown spots; columella recurved with two plications, the anterior one forming a sharp ridge.

Measurements: Length, 80 mm; diameter, 20 mm.

Habitat: Intertidal and subtidally to depths of 85 m.

Distribution: Central Gulf to the Galápagos Islands.

Terebra variegata Gray (Fig. 9.193)

Shell characteristics: Reddish-brown with thick bands just below the suture; strong spiral lines.

Measurements: Length, 85 mm; diameter, 20 mm.

Habitat: In sandy mud at low tide mark and offshore.

Distribution: Bahía Magdalena and throughout the Gulf, south to Ecuador.

FAMILY TURRIDAE (turrid shells)

Turrids have a fusiform shell with variable sculpturing. The most distinct characteristic of the shell is the presence of a posterior notch on the outer lip. This group also possesses a toxoglossan feeding apparatus. They apparently feed on small polychaetes and other molluscs. Their reproductive systems are similar in structure to the muricids and thaids. Moreover, the veliger stage is generally suppressed.

Knefastia tuberculifera (Broderip and Sowerby) (Fig. 9.194)

Shell characteristics: Orange under a dark green periostracum; spiral sculpturing coarse with evenly spaced nodes on each whorl.

Measurements: Length, 65 mm; diameter, 25 mm.

Habitat: Rocky low intertidal and offshore to 50 m.

Distribution: Northern Gulf of California to Jalisco, Mexico.

Crassispira pluto Pilsbry and Lowe (Fig. 9.195)

Shell characteristics: Black; thin axial and spiral lines with evenly spaced nodes.

Measurements: Diameter, 7 mm; height, 19 mm.

Habitat: Under rocks in low intertidal.

Distribution: Gulf of California.

Crassispira incrassata (Sowerby) (Fig. 9.196)

Shell characteristics: Shell surface glossy black; aperture and parietal callus pad whitish; lip edge crenulate, thickened by a swollen rib.

Measurements: Height, 40 mm.

Habitat: Low intertidal and offshore to 35 m on sandy bottoms.

Distribution: Throughout the Gulf, south to Ecuador.

Crassispira maura (Sowerby) (Fig. 9.197)

Shell characteristics: Brown with a dark periostracum; axial ribs nodular on the spire and slanting obliquely on the base.

Measurements: Height, 70 mm; diameter, 17 mm.

Habitat: Mainly offshore, on sandy and muddy bottoms to 55 m.

Distribution: Central Gulf of California to Ecuador.

Crassispira unicolor (Sowerby) (Fig. 9.198)

Shell characteristics: Yellowish-brown under a dark periostracum; axial ribs sinuous; spiral sculpture consisting of fine striae on the base; subsutural beading prominent.

Measurements: Height, 24 mm; diameter, 9 mm.

Habitat: In sandy areas near rocks at low tide and offshore to 20 m.

Distribution: Throughout the Gulf to Ecuador.

Crassispira discors (Sowerby) (Fig. 9.199)

Shell characteristics: With a prominent yellow subsutural cord; axial and spiral ribs forming tubercles at intersections.

Measurements: Height, 21 mm; diameter, 8 mm.

Habitat: On rocky shores and gravel bottoms from the low intertidal to depths of 30 m.

Distribution: Central Gulf to Ecuador.

Crassispira kluthi E. K. Jordan (Fig. 9.200)

Shell characteristics: Glossy black; shoulder smooth except for a faint subsutural cord; periphery weakly noded; base with fine spiral striae.

Measurements: Height, 16 mm; diameter, 6 mm.

Habitat: On mud and sand flats, low intertidal to 50 m.

Distribution: Throughout the Gulf to Ecuador.

Crassispira appressa (Carpenter) (Fig. 9.201)

Shell characteristics: Strong axial ribbing; peripheral nodes elongate; subsutural cord swollen and nodular; often with orange or whitish markings on the nodes and tubercles.

Measurements: Height, 15 mm; diameter, 5 mm.

Habitat: Rocky low intertidal and offshore.

Distribution: Throughout the Gulf of California and the Tres Marías Islands.

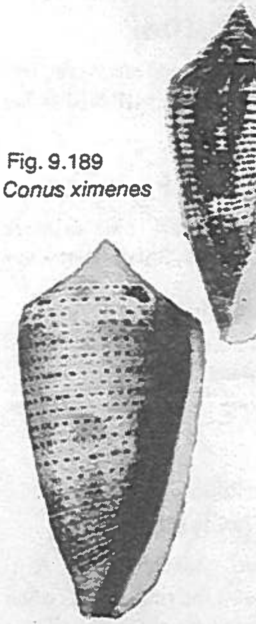


Fig. 9.189
Conus ximenes

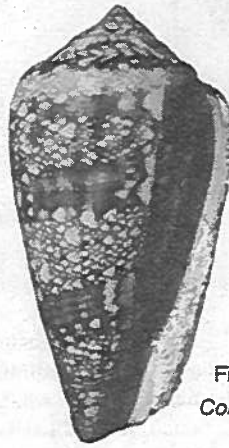


Fig. 9.190
Conus dalli

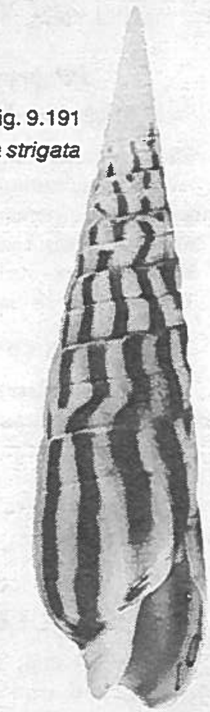


Fig. 9.191
Terebra strigata

Fig. 9.192
Terebra ornata

Fig. 9.193
Terebra variegata

Fig. 9.194
Knefastia tuberculifera

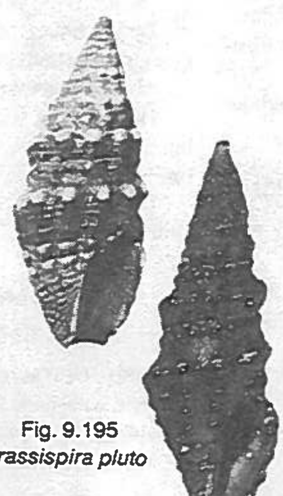


Fig. 9.195
Crassispira pluto

Fig. 9.196
Crassispira incrassata

Pilsbryspira nymphia (Pilsbry and Lowe) (Fig. 9.202)

Shell characteristics: Dark gray with white evenly spaced nodes; subsutural bands and base of nodes bright orange; surface covered with fine striations.

Measurements: Length, 20 mm; diameter, 8 mm.

Habitat: Rocky intertidal.

Distribution: Throughout the Gulf of California.

SUBCLASS OPISTHOBRANCHIATA

Most opisthobranchs have undergone detorsion and the tendency is toward shell loss and bilateral symmetry. When shells are present they are generally thin, bubble-like, scalelike, or consist of small remnants embedded in the animal's dorsal tissues. Most are carnivores and some are parasites.

Order Cephalaspidea

FAMILY BULLIDAE (bubble shells)

The shell is thin, fragile, and bubble-shaped. In addition, there is a smooth callus lining the columella. When the animal retracts it is unable to withdraw entirely into the shell.

Bulla punctulata A. Adams in Sowerby (Fig. 9.203)

Shell characteristics: Similar to *B. gouldiana* but smaller.

Measurements: Length, 25 mm; diameter, 15 mm.

Habitat: On soft bottoms below low tide mark.

Distribution: Bahía Magdalena and throughout the Gulf, south to Peru.

Bulla gouldiana Pilsbry (Fig. 9.204)

Shell characteristics: Pink to tan with black spots; light brown periostracum.

Measurements: Length, 55 mm; diameter, 35 mm.

Habitat: On tidal flats, in salt marshes, and in mangrove esteros.

Distribution: Southern California and throughout the Gulf of California, south to Ecuador.

Haminoea vesicula (Gould) (Fig. 9.205)

Shell characteristics: Grayish-yellow; smooth with a broadly oval to truncate outline.

Measurements: Length, 20 mm; diameter, 13 mm.

Habitat: Tidal flats, salt marshes, and mangrove esteros.

Distribution: Alaska to the southern end of the Gulf of California.

Remarks: *H. vesicula* is here considered synonymous with *H. angelensis*.

FAMILY AGLAJIDAE

These opisthobranchs are voracious carnivores (often on other sea slugs) and have an internal shell in the form of a flat spiral.

Navanax inermis (Cooper) (Fig. 9.206)

Body characteristics: Animal dark blue to black with thin peripheral red and blue lines. Small white spots cover the entire surface.

Measurements: Length, 60–225 mm.

Habitat: Intertidal under and between rocks, especially where sediments accumulate.

Distribution: Monterey Bay, California, and the northern Gulf of California.

Order Anaspida

FAMILY APLYSIIDAE (sea hares)

The shell is internal and thin. Members of this family are called "sea hares" because the rhinophores often give the appearance of ears, like those of a rabbit. Their coloration varies from solid brown to green, to a mixture of both.

Aplysia vaccaria Winkler, 1955 (Fig. 9.207)

Body characteristics: Large; dark purple; some individuals have white spots.

Measurements: Length, generally to 225 mm.

Habitat: Low intertidal zone, under rocks and in tide pools; offshore.

Distribution: Southern California to Bahía de Los Angeles.

Remarks: This is probably the largest opisthobranch known, for subtidal specimens have been collected which measure 750 mm in length.

Aplysia californica Cooper (Fig. 9.208)

Body characteristics: Animal mottled brown with green streaks and spots.

Measurements: Length to 150 mm.

Habitat: In tidepools and under rocks; primarily intertidal; occasionally embedded in mud on tidal flats (probably accidental).

Distribution: Northern California to the northern Gulf of California.

Stylocheilus longicauda (Quoy and Gaimard) (Fig. 9.209)

Body characteristics: Light brown background covered with dark brown streaks; bright blue eye spots surrounded by orange; prominent papillae.

Measurements: Length to 50 mm.

Fig. 9.197
Crassispira maura

Fig. 9.198
Crassispira unicolor

Fig. 9.199
Crassispira discors

Fig. 9.200
Crassispira kluthi

Fig. 9.201
Crassispira appressa

Fig. 9.202
Pilsbryspira nymphia

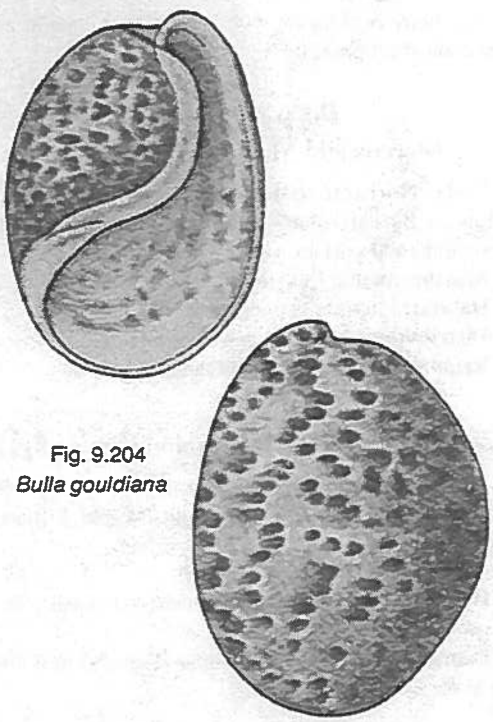


Fig. 9.204
Bulla gouldiana

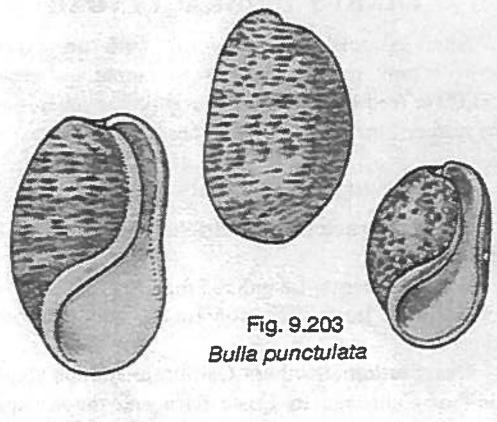


Fig. 9.203
Bulla punctulata

Fig. 9.205
Haminoea vesicula

Habitat: Intertidally on rocks and in mangrove esteros..

Distribution: Throughout the Gulf of California, west to tropical Indo-Pacific region, including Hawaii.

Order Notaspidea

FAMILY PLEUROBRANCHIDAE

Shell partially or entirely covered by the mantle, thin and kidney-shaped; animals fairly large, usually robust.

Pleurobranchus areolatus (Mörch, 1863)

Body characteristics: Brown background, covered with white, red, and yellow spots; numerous dorsal tubercles and bumps.

Measurements: Length, 75 mm.

Habitat: Rocky mid and low intertidal.

Distribution: Throughout the Gulf and south to Panama; Caribbean.

Remarks: The "cottony sea slug."

Berthellina ilisima Marcus and Marcus

Body characteristics: Bright uniform orange.

Measurements: Length, 60 mm.

Habitat: Intertidally under rocks.

Distribution: Bahía Tortola (W. Baja) and through the Gulf of California.

Remarks: The "apricot slug." Undoubtedly a derivative of the nearly identical *B. engeli* of the Caribbean region.

FAMILY UMBRACULIDAE

Shell platelike to conical, with an external periostracum; radula broad, with numerous teeth (to 150,000); feed by grazing on microscopic organisms on the surface film of sponges or other sessile objects.

Tylodina fungina Gabb (Fig. 9.210)

Body characteristics: Bright yellow; oval; long antennae.

Measurements: Length, 35 mm.

Habitat: Intertidally, on rocks, and offshore to 25 m.

Distribution: Southern California and the southern Gulf of California to Costa Rica and the Galápagos Islands.

Remarks: Usually found on yellow sponges.

Order Sacoglossa

FAMILY JULIDAE

"Bivalved" sea slugs, one valve with a spiral coiling, the other developing from a lobe at the left side of the aperture and hinged along the columellar margin.

Berthelinia chloris (Dall) (Fig. 9.211)

Body characteristics: Small; translucent green; periostracum nearly transparent.

Measurements: Length, 6–9 mm.

Habitat: Usually found on green algae, especially the fernlike *Caulerpa*.

Distribution: Southern Baja and the southern end of the Gulf.

FAMILY ELYSIIDAE

Elysiids generally have very long tentacles, a narrow foot, and a flattened body, fringed with fleshy appendages.

Tridachiella diomedea (Bergh) (Plate 2)

Body characteristics: Yellow-green to gray ground color with diffuse black spots peripherally; body margins with blue, purple, and orange markings; highly colorful.

Measurements: Length to 35 mm.

Habitat: Rocky mid intertidal to about 15 m.

Distribution: Gulf of California to Panama.

Remarks: The "Mexican (or Spanish) dancer" nudibranch.

Order Nudibranchia

FAMILY DORIDIDAE

The body is elongate with a papillated dorsum and retractable rhinophores.

Doris pickensi
Marcus and Marcus (Fig. 9.212)

Body characteristics: White; translucent or yellowish border; many white papillae on dorsum; rhinophores and gills are yellow.

Measurements: Length, 25 mm.

Habitat: Intertidally under rocks.

Distribution: Northern and central Gulf.

Remarks: "Picken's nudibranch."

Rostanga pulchra MacFarland (Fig. 9.213)

Body characteristics: Uniform pink to red; rhinophores composed of vertical lamellae and a finger-shaped apical projection.

Measurements: Length, 30 mm.

Habitat: Rocky mid and low intertidal; usually on a red sponge.

Distribution: British Columbia (Canada) to Chile; rare in the Gulf of California.

Fig. 9.206 *Navanax inermis*

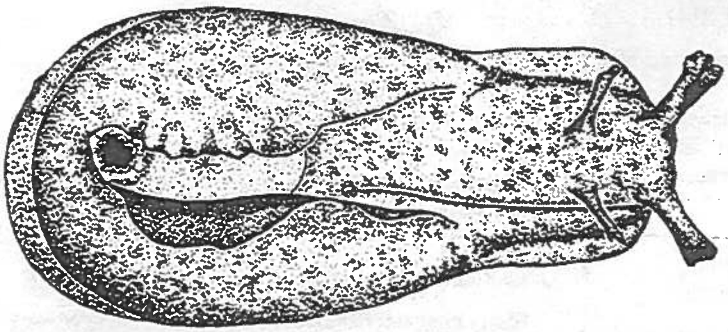


Fig. 9.207 *Aplysia vaccaria*

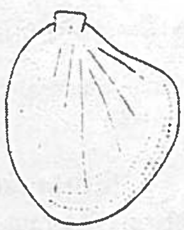
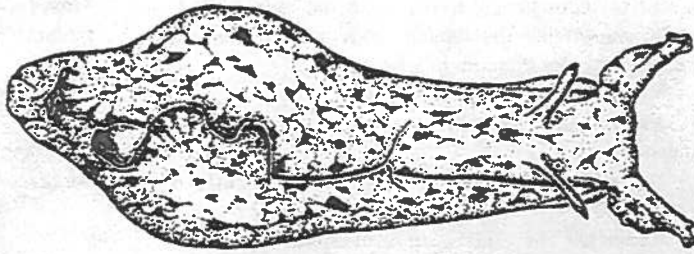



Fig. 9.208 *Aplysia californica*

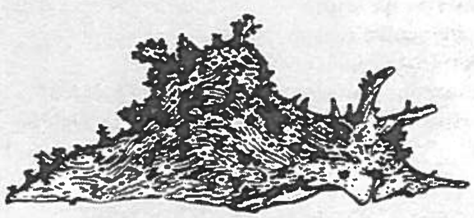


Fig. 9.209 *Stylocheilus longicauda*

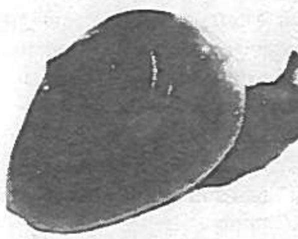


Fig. 9.211 *Berthelinia chloris*

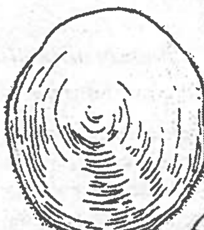
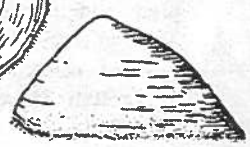



Fig. 9.210 *Tylodina fungina*

FAMILY CHROMODORIDIDAE

These sea slugs are characterized by their radular structure. The lateral teeth are short and cuspate, while the central tooth is reduced.

Chromodoris banksi sonora Marcus and Marcus (Fig. 9.214)

Body characteristics: White with brown and black dots of varying size (and occasionally a few cream colored or orange spots). A narrow orange stripe runs around the entire body margin. The tips of the rhinophores and gills are rimmed with orange.

Measurements: Length, 30 mm.

Habitat: In tidepools and under rocks.

Distribution: Northern Gulf of California.

Remarks: The "salt 'n pepper nudibranch."

Chromodoris banksi banksi Farmer

Body characteristics: Same as *C. banksi sonora* except for consistent differences in the radula. In *C. banksi sonora* the first lateral tooth is denticulate, as opposed to a smooth tooth in this species.

Measurements: Length, 40 mm.

Habitat: Intertidally on *Sargassum* and rocks, and in tidepools.

Distribution: Northern and central Gulf of California.

Remarks: The "salt 'n pepper nudibranch."

Chromodoris norrisi Farmer (Fig. 9.215 and Plate 1)

Body characteristics: White; rhinophores and gills orange at the ends; dorsal surface with alternating yellowish and purple dots; quite similar to *C. banksi* in general appearance.

Measurements: Length, 65 mm.

Habitat: Intertidally on rocks and seaweed.

Distribution: Pacific coast of Baja California and throughout the Gulf of California.

Remarks: "Norris's nudibranch."

Chromodoris sedna (Marcus and Marcus)

Body characteristics: White; three colored strips bordering the foot: inner, off white; middle, red; outer, yellow; rhinophores and gills red-tipped.

Measurements: Length, 45 mm.

Habitat: In tidepools and under rocks; offshore to 20 m.

Distribution: Gulf of California, south to Nayarit.

Hypselodoris californiensis (Bergh) (Fig. 9.216)

Body characteristics: Dark blue, with bright yellow spots and iridescent sky-blue stripes.

Measurements: Length, 70 mm.

Habitat: Rocky low intertidal and subtidal to 15 m.

Distribution: Central California, along the west coast of Baja California, and throughout the Gulf of California, south to Jalisco.

Cadlina evelinae Marcus

Body characteristics: White with numerous large or small bright red to orange spots.

Measurements: Length, 30 mm.

Habitat: Rocky low intertidal and shallow subtidal.

Distribution: Both coasts of Baja California; western Atlantic.

Diaulula sandiegensis (Cooper) (Fig. 9.217)

Body characteristics: Ground color white to brown; scattered darker rings, especially along sides of notum; body gritty to the touch.

Measurements: Length, 75 mm.

Habitat: Rocky mid and low intertidal and shallow subtidal.

Distribution: Japan and Alaska, south to the Gulf of California.

Remarks: Known to feed extensively on sponges, including *Haliclona*.

Tayuva ketos Marcus and Marcus (Fig. 9.218)

Body characteristics: White to tan, mottled with brown spots; brown rhinophores; many small tubercles on dorsum; body very firm.

Measurements: Length, 50 mm.

Habitat: In tidepools and under rocks.

Distribution: Northern Sonoran coast of Mexico.

Remarks: Strongly resembles a compound tunicate on a rock.

FAMILY GYMNODORIDIDAE

In contrast to the dorids, the gymnodorids have a smooth elongated body with retractable rhinophores, and short tentacles.

Nembrotha eliora Marcus and Marcus (Fig. 9.219)

Body characteristics: Bright yellow to greenish-black with longitudinal turquoise stripes bordered in black; gills centrally located on the back.

Measurements: Length, 45 mm.

Habitat: Under rocks in low intertidal and shallow subtidal.

Distribution: Northern Gulf of California.

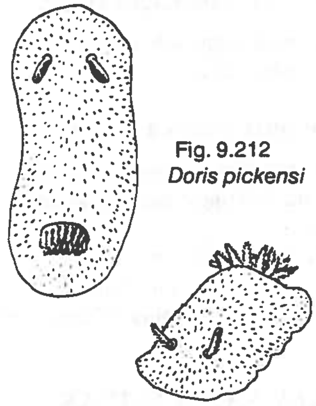


Fig. 9.212 *Doris pickensi*

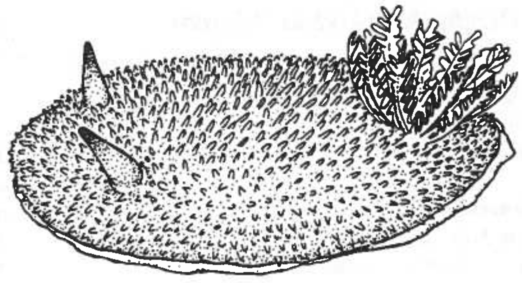


Fig. 9.213 *Rostanga pulchra*

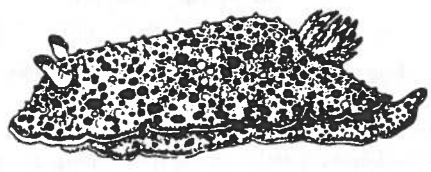


Fig. 9.214 *Chromodoris banksi sonora*

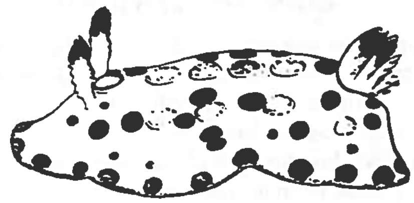


Fig. 9.215 *Chromodoris norrisi*

Fig. 9.216 *Hypselodoris californiensis*

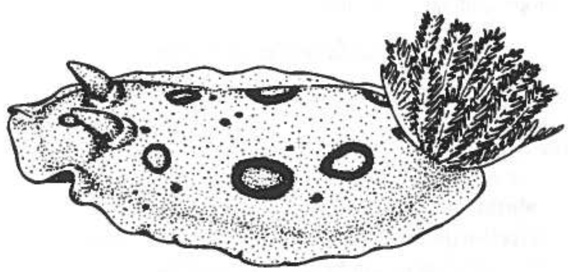


Fig. 9.217 *Diaulula sandiegensis*

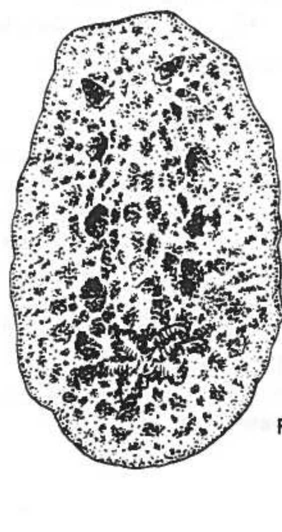


Fig. 9.218 *Tayuva ketos*

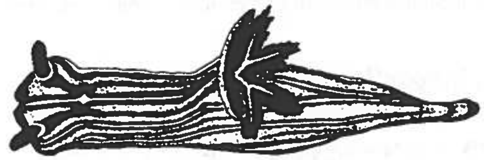


Fig. 9.219 *Nembrotha eliora*

FAMILY DENDRODORIDIDAE

Dendrodoris krebsii (Morch)

Body characteristics: Black with a red lateral margin; tips of rhinophores and gills white.

Measurements: Length, 45 mm.

Habitat: Rocky mid and low intertidal and shallow subtidal.

Distribution: Bahía Tortola, through the Gulf of California to Jalisco; uncommon on outer Baja coast.

Remarks: "Krebs's nudibranch."

FAMILY TETHYIDAE

Anterior end greatly expanded, more or less fringed.

Melibe leonina (Gould)

Body characteristics: Pale yellowish, translucent, with small yellow spots; large oral hood; digestive gland can be seen inside as brownish threads.

Measurements: Length, 90 mm.

Habitat: Intertidally on *Sargassum* and other algae; often found on floating algae, offshore.

Distribution: Alaska, south to the Gulf of California.

FAMILY ARMINIDAE

Without appendages on the notum; frontal veil well developed, lobed at the sides.

Armina californica (Cooper)

Body characteristics: Gray to black; many white longitudinal fleshy ridges running along the dorsal surface.

Measurements: Length, 100 mm.

Habitat: In sandy mud at low tide, to 80 m.

Distribution: British Columbia (Canada) to Panama; common in San Felipe region of Gulf.

FAMILY ANTIOPELLIDAE

With numerous elongate spindle-shaped dorsal papillae around the margin of the notum; long cerata on body.

Antiopella barbarensis (Cooper)

Body characteristics: White to translucent with extremely long cerata, tipped in brilliant red or blue. A raised crest lies between the rhinophores.

Measurements: Length, 40–70 mm.

Habitat: Variable; rocky low intertidal (on protected shores), tidal flats, and boat docks and pilings.

Distribution: British Columbia (Canada) south to the Gulf of California; not uncommon at Bahía Cholla.

FAMILY FLABELLINIDAE

Body elongate, with numerous cerata; radula with large central teeth, smaller laterals.

Flabellinopsis iodinea (Cooper)

Body characteristics: Bright lavender with reddish-orange cerata covering entire dorsal surface; tips of rhinophore white.

Measurements: Length, 65 mm.

Habitat: Rocky low intertidal to 30 m.

Distribution: British Columbia (Canada) to the Gulf of California.

FAMILY FACELINIDAE

Body long and slender; cerata simple and arranged in transverse rows; radula uniserial.

Hermissenda crassicornis (Eschscholtz, in Rathke) (Fig. 9.220)

Body characteristics: Translucent white with a variable color pattern; cerata usually green interiorly, with reds, browns, and blacks exteriorly; an orange stripe begins anterior to the rhinophores and passes between them to widen into a diamond between the first cerata group.

Measurements: Length, 60 mm.

Habitat: Rocky mid and low intertidal and shallow subtidal; often taken from hydroids and bryozoans.

Distribution: Alaska to the Gulf of California.

Order Gymnophila

FAMILY ONCHIDIIDAE

These opisthobranchs are characterized by having retractable tentacles with eyes at the tips, an oval body, and numerous dorsal papillae.

Onchidella binneyi Stearns (Fig. 9.221 and Plate 9)

Body characteristics: Charcoal gray with a long narrow foot.

Measurements: Length, 30 mm.

Habitat: Rocky high and mid intertidal; prefer large boulders; rarely appear to avoid direct sunlight.

Distribution: Northern Gulf of California.

Remarks: An excellent discussion of the genus *Onchidella* may be found in Watson, 1925.

Onchidella hildae (Hoffman) (Fig. 9.222)

Body characteristics: Gray to brownish or greenish-white; foot very narrow (1/4 body width).

Measurements: Length, 25 mm.

Habitat: Rocky high and mid intertidal; prefer large boulders; rarely appear to avoid direct sunlight.

Distribution: Throughout the Gulf, south to Ecuador; common along the southern Sonora coast.

Remarks: This opisthobranch has an interesting defense reaction. When disturbed, the animal contracts the body strongly, forcing out a milky blue fluid along the edges of the mantle. It is apparently a rather distasteful chemical.

Hoffmannola hansi Marcus and Marcus (Fig. 9.223)

Body characteristics: Dark brown to black with lighter blotches around the low flat warts of the dorsum; body with a very tough epidermis; short brown antennae.

Measurements: Length, 50 mm.

Habitat: Rocky intertidal.

Distribution: Central Gulf of California.

SUBCLASS PULMONATA

Order Basommatophora

FAMILY MELAMPIDAE

The shell is obconic with a short spire and denticles on the outer lip of the aperture (in some species they occur on the inner lip as well).

Melampus olivaceus Carpenter (Fig. 9.224)

Shell characteristics: Brown with white spiral bands; dark green periostracum; outer lip ridged with teeth at the ends.

Measurements: Diameter, 10 mm; height, 17 mm.

Habitat: In bays and esteros at high tide line.

Distribution: Southern California and throughout the Gulf.

Remarks: Shells often common in beach drift.

Marinula rhoadsi Pilsbry (Fig. 9.225)

Shell characteristics: Yellowish-brown with dark band around body whorl.

Measurements: Diameter, 6 mm; height, 10 mm.

Habitat: In bays above high tide line.

Distribution: Northern end of the Gulf of California.

FAMILY SIPHONARIIDAE (false limpets)

The shell is low and cap-shaped with a siphonal canal on the right side. These pulmonates occur intertidally in subtropical and tropical waters.

Siphonaria maura Sowerby (Fig. 9.226)

Shell characteristics: Dirty white; shape variable from low to high capped; deeply sculptured with radial ribs.

Measurements: Length, 25 mm; width, 15 mm.

Habitat: Rocky high and mid intertidal.

Distribution: Gulf of California to Ecuador.

CLASS POLYPLACOPHORA (chitons)

Order Chitonida

FAMILY CHITONIDAE

The dorsal plates of these chitons have well defined notches or cuts on the bottom surfaces of the insertion teeth.

Chiton stokesii Broderip (Fig. 9.227)

Shell characteristics: Dark brown with white at the middle; beaded lattice work sculpture in the lateral regions; inside light blue.

Measurements: Length, 50–100 mm.

Habitat: On exposed surfaces in rocky intertidal.

Distribution: Gulf of California to Ecuador.

Chiton virgulatus Sowerby (Fig. 9.228)

Shell characteristics: Elongate; olive brown at edge, green in center; inside turquoise; girdle with alternating dark and light bands.

Measurements: Length, 65 mm.

Habitat: Intertidal, on and under rocks.

Distribution: Bahía Magdalena, west coast of Baja California, to the northern region of the Gulf of California.

FAMILY ACANTHOCHITONIDAE

Generally, the anterior valve has five notches, a setose girdle covers or obscures the plates, and the insertion plates are rather sharp.

Acanthochitona exquisita (Pilsbry) (Fig. 9.229)

Shell characteristics: Dark olive; largely covered by girdle; girdle with green, pink, or gold hairs; inside blue.

Measurements: Length, 35 mm; width, 15 mm.

Habitat: Mid intertidal, under rocks in sandy mud.

Distribution: Central and southern Gulf of California.

Acanthochitona avicula (Carpenter) (Fig. 9.230)

Shell characteristics: Greenish-gray with spots and flecks of black and dark green; occasionally entirely

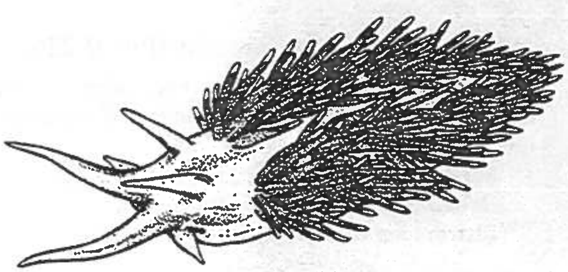


Fig. 9.220
Hermissenda crassicornis

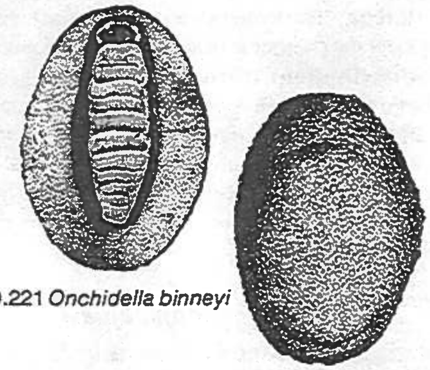


Fig. 9.221 *Onchidella binneyi*

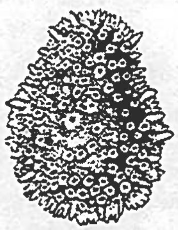


Fig. 9.222
Onchidella hildae

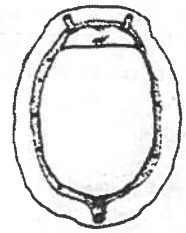


Fig. 9.223 *Hoffmannola hansi*

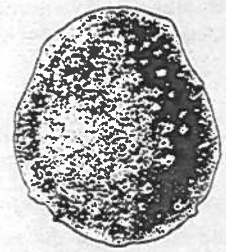


Fig. 9.225
Marinula rhoadsi

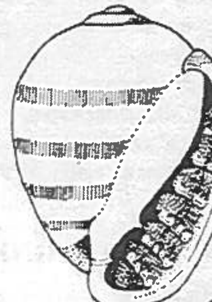


Fig. 9.224
Melampus olivaceus

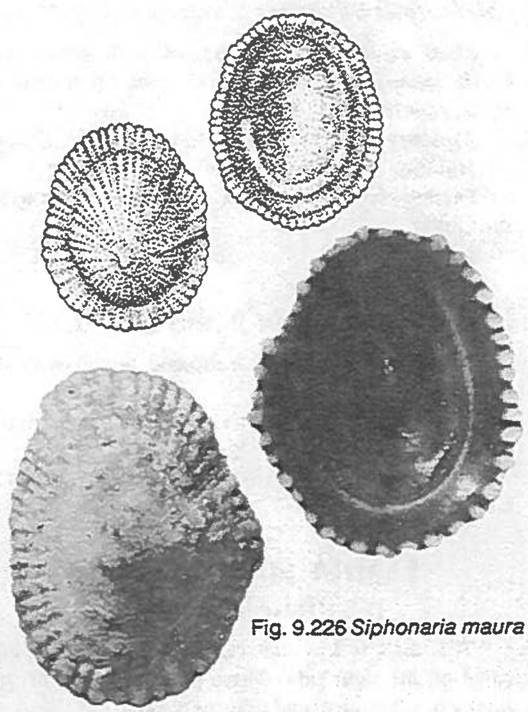


Fig. 9.226 *Siphonaria maura*

Fig. 9.227
Chiton stokesii

black or red-orange; girdle spines large, occurring only on outer three-quarters of girdle.

Measurements: Length, 20 mm.

Habitat: Rocky low intertidal and shallow subtidal.

Distribution: Southern California to southern Mexico; throughout the Gulf.

FAMILY ISCHNOCHITONIDAE

Insertion plates on all valves; posterior valve ladened with well developed teeth; girdle usually scaley.

Radsiella tridentata Pilsbry (Fig. 9.231)

Shell characteristics: Variable, green to black with numerous spots, speckles, or lines of black; plates with fine granular markings; central area with longitudinal lines; radial regions with V-shaped lines.

Measurements: Length, 25 mm.

Habitat: On rocks intertidally.

Distribution: Central and southern Gulf.

Stenoplax conspicua sonorana Berry (Fig. 9.232)

Shell characteristics: Green, sharp coarse sculpture; inside pink with blue spot; anterior valve with 13 slits, medial valves with 2 to 4, posterior valve with 12 slits: girdle with spines.

Measurements: Length, 50 mm; width, 20 mm.

Habitat: Rocky intertidal.

Distribution: Northern and central Gulf.

Stenoplax magdalenensis (Hinds) (Fig. 9.233)

Shell characteristics: Brown to green; central areas with longitudinal sculpturing; radial regions deeply engraved with bumpy ridges; flat girdle with curved scales.

Measurements: Length, 50–100 mm.

Habitat: Rocky mid intertidal.

Distribution: Central Pacific coast of Baja California to the head of the Gulf.

Callistochiton gabbi Pilsbry (Fig. 9.234)

Shell characteristics: Central areas light brown, lateral regions greenish-brown; anterior valve has 9 slits, posterior, 8.

Measurements: Length, 15 mm; width, 10 mm.

Habitat: Rocky intertidal.

Distribution: Gulf of California and outer Baja coast.

Lepidozona clathrata (Reeve) (Fig. 9.235)

Shell characteristics: Grayish-brown with a distinct reddish ridge; alternating gray and brown bands along the girdle; valves heavily sculptured and beaded.

Measurements: Length, 30–50 mm.

Habitat: Rocky intertidal.

Distribution: Northern Gulf of California.

Lepidozona serrata (Carpenter) (Fig. 9.236)

Shell characteristics: Variable color, mixtures of green, gray, brown, and red; variable radial sculpture; central regions with longitudinal and transverse striations.

Measurements: Length, 10–15 mm.

Habitat: Rocky intertidal.

Distribution: Central and southern Gulf.

Lepidozona subtilis Berry (Fig. 9.237)

Shell characteristics: Variable color, mixtures of brown, black, white, orange, and green; ribs on central area; beads on radial areas.

Measurements: Length, 15 mm.

Habitat: Rocky intertidal.

Distribution: Northern and central Gulf.

CLASS SCAPHOPODA
FAMILY DENTALIIDAE

Shell is tusk-shaped with the larger diameter at the oral end. The exterior surface can be sculptured or smooth.

Dentalium neohexagonum Sharp and Pilsbry (Fig. 9.238)

Shell characteristics: White with six sides.

Measurements: Length, 30 mm.

Habitat: In sand, low intertidal and offshore to 250 m.

Distribution: Central California to the northern Gulf of California.

Dentalium oerstedii Mörch (Fig. 9.239)

Shell characteristics: Finely sculptured ridges along the shell length.

Measurements: Length, 50 mm; diameter at aperture, 4 mm.

Habitat: In sand, low intertidal and offshore to 145 m.

Distribution: Puerto Peñasco to Ecuador.

Dentalium quadrangulare Sowerby (Fig. 9.240)

Shell characteristics: White; numerous longitudinal ribs in the middle part of shell; four sides when viewed in cross section.

Measurements: Length, 20 mm.

Habitat: In sand, low intertidal and offshore to 37 m.

Distribution: Throughout the Gulf of California to Ecuador.

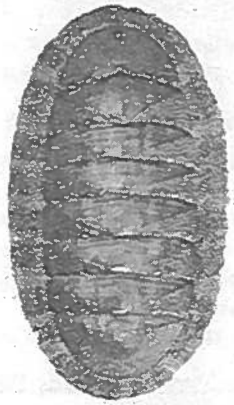


Fig. 9.228
Chiton virgulatus

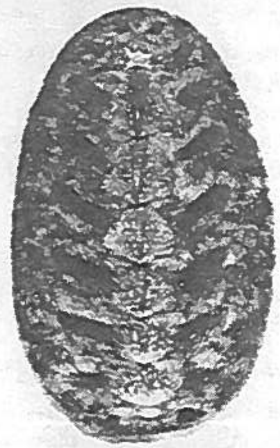


Fig. 9.229
Acanthochitona exquisita

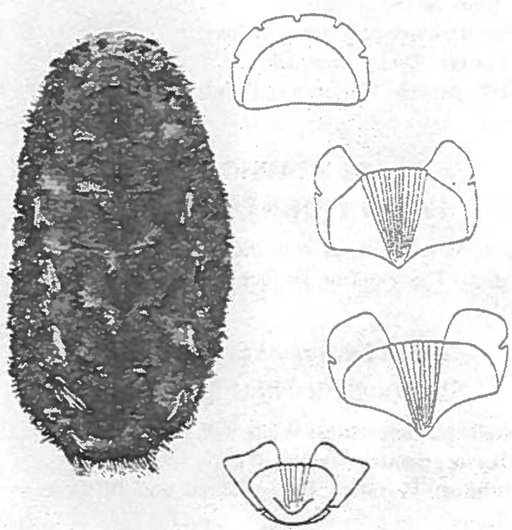


Fig. 9.230 *Acanthochitona avicula*

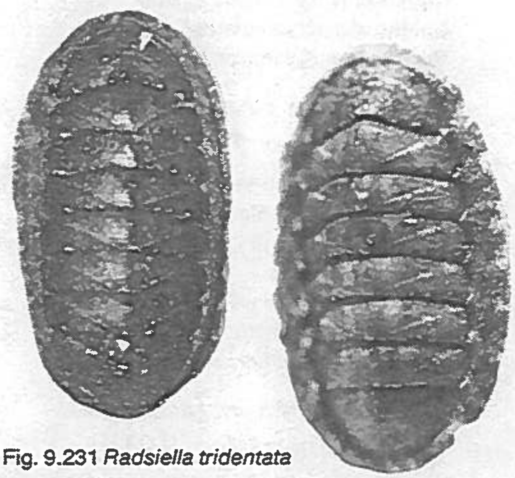


Fig. 9.231 *Radsiella tridentata*

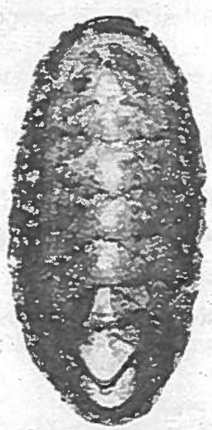


Fig. 9.232 *Stenoplax conspicua sonorana*

Fig. 9.233
Stenoplax magdalenensis

Fig. 9.234
Callistochiton gabbi

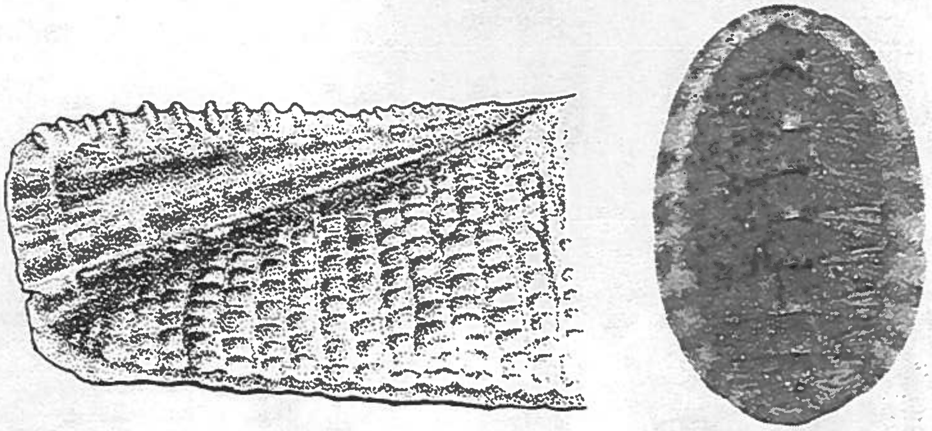


Fig. 9.235 *Lepidozona clathrata*

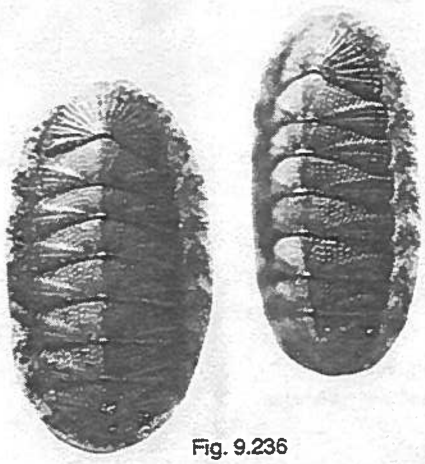


Fig. 9.236
Lepidozona serrata

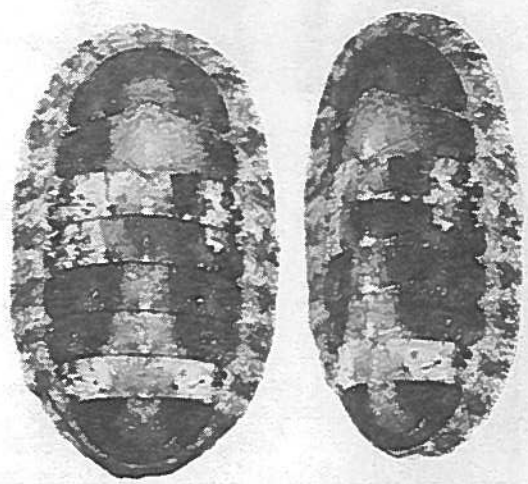


Fig. 9.237 *Lepidozona subtilis*

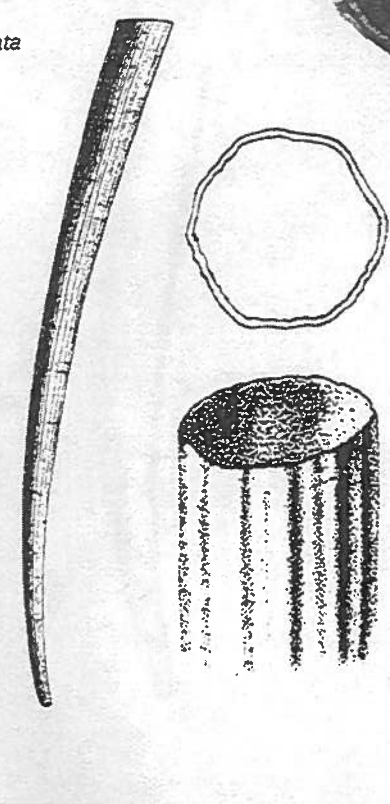


Fig. 9.238 *Dentalium neohexagonum*

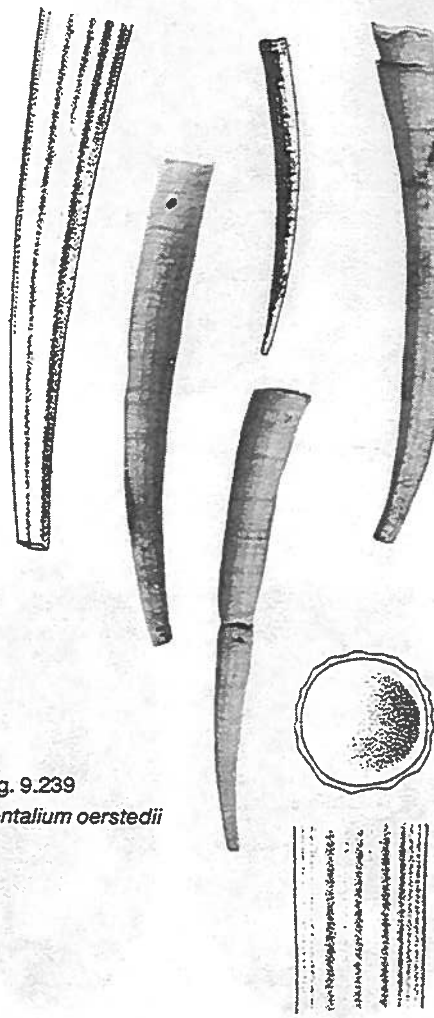


Fig. 9.239
Dentalium oerstedii

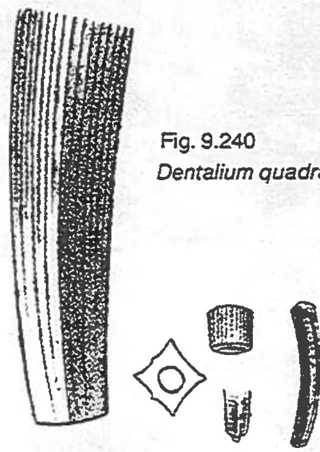


Fig. 9.240
Dentalium quadrangulare

Fig. 9.242
Fustiaria splendida

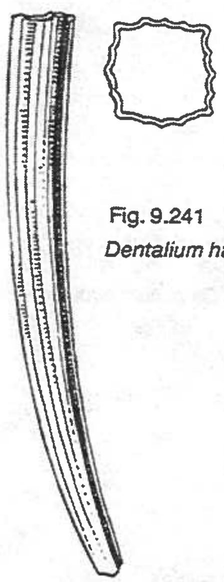


Fig. 9.241
Dentalium hancocki

Fig. 9.243
Cadulus fusiformis

Dentalium hancocki Emerson (Fig. 9.241)

Shell characteristics: Strongly quadrate in cross section, with scalloped sides; numerous pits in the grooves between the major ribs.

Measurements: Length, 14 mm.

Habitat: In sand, shallow subtidal to 40 m.

Distribution: Bahía Magdalena and throughout the Gulf, south to Colima, Mexico.

Fustiaria splendida (Sowerby) (Fig. 9.242)

Shell characteristics: Finely sculptured circular lines; no longitudinal ribs; apical orifice with a notch.

Measurements: Length, 45 mm.

Habitat: Intertidally and offshore in coarse sand, to 110 m.

Distribution: Puerto Peñasco to Ecuador.

FAMILY SIPHONODENTALIIDAE

Moderately to strongly curved, slightly tapering; circular in cross section; apex large, usually cut into lobes.

Cadulus fusiformis Pilsbry and Sharp (Fig. 9.243)

Shell characteristics: Slightly arched; robust; widest beyond anterior orifice.

Measurements: Length, 10 mm.

Habitat: Sandy shallow subtidal to 365 m.

Distribution: Central California to the Gulf of California.

CLASS CEPHALOPODA

by F. G. Hochberg*

The cephalopod fauna of the Gulf of California is one of the richest in the world. The following short section deals only with the octopods but will serve to indicate that, although some systematic details are known, very little information is available concerning the distribution and biology of these animals in the Gulf.

The key and corresponding descriptive text present suites of characters which must be used in species identification. The dorsal mantle length (DML) is a standard measurement taken on the dorsal surface from the tip of the body to a point midway between the eyes. This, in combination with arm length, will provide an indication of general body proportions. Color, color patterns and markings (i.e. ocelli) may be helpful and should be noted if the animal is observed alive. The proportions of the length of the modified tip to the total length of the hectocotylized arm of the male, and the size of the eggs laid by the female are good characters to use in separating species of the genus *Octopus*. The presence and location of enlarged suckers and counts of the number of lamellae per gill also are extremely useful in making correct specific determinations.

If it is desirable to keep an octopus alive for experimentation, it may be narcotized with any number of substances (ethyl alcohol, dripped into seawater containing the octopus, works the best). Measurements and gill counts can be made on the relaxed animal during the ensuing few minutes. When the animal is returned to fresh seawater it will quickly recover.

Animals to be preserved should first be killed in freshwater. When dead, the mucus must be removed by stroking with the hand, which also straightens out the arms. Next fix in 10 percent buffered formalin for a few hours to several days depending on the size of the octopus. Be sure to use a container that is large enough so the animals lie flat and straight. Finally, wash in freshwater and then preserve in 70 percent ethyl alcohol or 45 percent isopropyl alcohol for long-term storage.

Fourteen species of octopods are presently known from the Gulf of California. Of these, two are undescribed. In the genus *Octopus*, many of the species occurring in the Gulf are dwarfs, typically measuring less than 30 mm DML. Several species are endemic to the Gulf, among these are *O. alecto*, *O. fitchi*, *O. penicillifer*, and perhaps *O. digueti* and *O. hubbsorum*. *Octopus bimaculatus* and *O. rubescens* both occur along the California coast as well as in the Gulf. One species, *O. veligero*, appears to be restricted to the region around Cabo San Lucas. The ranges of *O. chierchiae* and *Argonauta cornutus* extend southward into the Panamic province. Both *A. nouryi* and *A. pacificus* are widespread in the equatorial Pacific ranging from southern California to Peru as well as throughout the Gulf. Additional distributional and biological information on octopods recovered or observed in the Gulf would be most helpful in expanding our knowledge of this most interesting and important group.

KEY TO THE OCTOPODA

1 Single row of suckers along each arm; small muscular papillae (cirri) present along each arm; fins present; found only in deep water (below 1000 m) ..... ***Opisthoteuthis* sp. nov.**

-Double row of suckers along each arm; cirri and fins absent; pelagic or shallow water benthic forms **2**

*Curator of Invertebrate Zoology, Santa Barbara Museum of Natural History.

2(1) Pelagic octopods (often washed ashore); marked sexual dimorphism (females large, dorsal arms with large membranous and glandular expansions which secrete a paper-thin, involutely coiled shell, used as a flotation device and brood chamber for the eggs; males tiny, third left arm hectocotylized, enveloped in a special sac, whole arm autotomous) . . . . ***Argonauta* spp.**

-Benthic octopods; sexes similar in size, not markedly dimorphic; calcareous shell not secreted by female; hectocotylized arm of male on right side, not encased in a sac, not autotomous **3**

3(2) Dorsal mantle length of mature individuals often exceeding 75 mm; hectocotylus inconspicuous, less than 2 percent arm length; color dark gray, olive, or black **4**

-Dorsal mantle length less than 75 mm; hectocotylus large, greater than 5 percent arm length; color light, often reddish or with conspicuous transverse bands or spots **5**

4(3) With conspicuous eyelike spots (ocelli), one below each eye near bases of arms 2 and 3; enlarged suckers on arms 2 and 3 of mature males . . . . . . ***Octopus bimaculatus***

-Without ocelli; no enlarged suckers on arms of either sex . . . . ***Octopus hubbsorum***

5(3) Dorsal mantle length 50–75 mm; shallow subtidal forms **6**

-Dorsal mantle length less than 50 mm; intertidal forms **7**

6(5) Arms less than 3 times body length; ventral arms webbed to tips; hectocotylus fleshy, 5 percent arm length; no enlarged suckers on arms of either sex; gills large, with 30–34 lamellae/gill . . . . ***Octopus veligero***

-Arms 3–4 times body length; ventral arms not webbed; hectocotylus 10 percent arm length; enlarged suckers on all arms of male only; gills medium, with 22–26 lamellae/gill . . . . ***Octopus rubescens***

7(5) Arms long and snakelike, 5–6 times body length, easily detached; hectocotylus conspicuous but small, 2 percent arm length; with 12–14 lamellae/gill . . . . ***Octopus alecto***

-Arms short, 2–3 times body length; hectocotylus not small; gills with lamellae counts other than above **8**

8(7) With a conspicuous spotted or banded color pattern; tips of arms brushlike (with elongate nonfunctional suckers) **9**

-Without a conspicuous color pattern; arms without brushlike tips **10**

9(8) Dark transverse bands around body and arms, outlined in green-yellow; dorsal mantle length 30–40 mm; hectocotylus 8 percent arm length . . . . ***Octopus chierchiae***

-Dark spots on body and along arms; dorsal mantle length less than 30 mm; hectocotylus 10 percent arm length . . . . ***Octopus penicillifer***

10(8) Commonly found in rocky intertidal areas; dorsal mantle length 20–30 mm; hectocotylus 9–12 percent arm length, ligula lanceolate; enlarged suckers on all arms of both sexes; with 10–12 lamellae/gill; eggs small, 5–6 by 2–2.5 mm; body surface smooth (WARNING: This species bites) . . . . ***Octopus fitchi***

-Commonly inhabits large gastropod or bivalve shells in sandy intertidal areas; dorsal mantle length 40–50 mm; hectocotylus 6–8 percent arm length, ligula spatulate; enlarged suckers on all arms of male only; with 14–16 lamellae/gill; eggs 9–10 by 3–3.5 mm; body surface granulate or papillate . . . . ***Octopus digueti***

Order Octopoda

Suborder Cirrata

FAMILY OPISTHOTEUTHIDAE

All members of the suborder Cirrata bear fins on the body and lack a radula. The arms bear muscular papillae (cirrata) which alternate with a single row of suckers. They are primarily benthic and most often occur in deep water (generally below 1000 m).

Opisthoteuthis Verrill

A single specimen of the genus has been recovered from a deep basin in the lower half of the Gulf. Its exact status is presently being worked out, but in all probability it represents a new species.

Suborder Incirrata

FAMILY ARGONAUTIDAE

The argonauts resemble typical octopods. The body is short and rounded; they lack fins and cirri but possess a radula and biserial rows of suckers along the arms. This group is epipelagic throughout their life cycle. The sexes are distinctly dimorphic. Females are large, and the first arms bear a wide membrane with which they secrete a paper thin calcareous shell which serves as an egg chamber. The name "paper nautilus" has been applied by laymen to this fragile, involutely coiled shell. Males are tiny and lack a shell. The third left arm is hectocotylized. It is retained in a special pouch until maturity and is then capable of being detached.

Argonauta Linnaeus

Three species of *Argonauta* have been reported from the Gulf of California. Since none are found alive in the intertidal, I have included reference only to the genus in the key. Little or no information is available as to the precise distribution of each species in the Gulf. Only rarely are these animals encountered in the pelagic environment; most often "shells" are picked up on beaches following storms. See Keen (1971) for illustrations of the "shells" of these three species.

Argonauta cornutus has been found from Panama to Puerto Escondido on the east coast of the Gulf. Both *A. nouryi* and *A. pacificus* are widespread in the equatorial Pacific ranging from Peru to southern California and throughout the Gulf of California.

FAMILY OCTOPODIDAE

The octopods are bottom dwelling cephalopods which live from the intertidal zone to moderate depths. The sexes are similar in size and morphology. The female does not produce an egg chamber but lays its eggs under stones or inside objects such as bottles, cans, or empty shells. In the male the third right arm is hectocotylized and is not capable of being detached. An ink sac is present in the genus *Octopus*.

Octopus alecto Berry

Body rounded; dorsal mantle length 20–30 mm; color of living animal not known; no ocelli; arms heavy and snakelike, 5 to 6 times body length; enlarged suckers on second arms of male only; hectocotylus minute, 1/50 arm length; 12–14 lamellae per gill; egg size and habits of the young unknown.

This unique species is easily recognized by the long, snaky arms which detach easily upon handling. Very little is known about the biology of this species, nor has the distribution been well worked out. It appears to be endemic to the upper Gulf, where it is occasionally seen in the rocky intertidal at San Felipe and from Puerto Peñasco to Guaymas along the Sonoran coast.

Octopus bimaculatus (Verrill)

Body pyriform; dorsal mantle length of mature individuals 70–180 mm; color variable, generally dark gray, brown, red, or olive mottled with black above, lighter below; with conspicuous ocelli (eyelike spots), one below each eye near bases of arms 2 and 3; arms 4 to 5 times body length; adult males with 1 to 2 specialized enlarged suckers on arms 2 and 3; hectocotylus minute, 1/50 arm length; 14–20 lamellae per gill; eggs small (2–4 by 1–1.5 mm), laid in large clusters, the stalks twisted into long cords; larvae briefly planktonic before settling to bottom.

The presence of eyelike ocelli makes this species easy to recognize in the field. *Octopus bimaculatus* is found in the intertidal in rocky areas from Puerto Peñasco and San Felipe in the upper Gulf to La Paz in the lower Gulf. It is also known to occur in the intertidal and offshore in rocky areas to depths of 50 m from Point Conception, California, to Punta Santa Eugenia, Baja California, and on all the California islands.

Octopus chierchiae Jatta

Body rounded; dorsal mantle length 30–40 mm; conspicuous dark transverse bands on body outlined in light greenish-yellow; no ocelli; arms short, 2 times body length; no enlarged suckers; nonfunctional, elongate, papillaelike suckers on tips of all arms of male only; hectocotylus 1/13 arm length; 16–18 lamellae per gill; eggs large and striated (size unknown); young dermersal after hatching.

This small, transversely banded octopus is known throughout the tropical eastern Pacific from Panama to the Gulf of California. Records of capture in the Gulf, though incomplete, indicate that it is to be found in the intertidal and shallow subtidal along both coasts in the lower Gulf.

Octopus digueti Perrier and Rocheburne

Body rounded; dorsal mantle length 40–60 mm; color in life light buff or tan; no ocelli; arms 2 to 2.5 times body length; several suckers enlarged on all arms of male only; hectocotylus 1/12 arm length; 14–16 lamellae per gill; eggs medium size (9–10 by 3–3.5 mm), attached singly inside large shells; young probably demersal after hatching.

This small octopus is probably related to *O. fitchi*. In contrast, however, it normally is found living in the intertidal on sand-mud flats in empty shells of large bivalves (i.e. *Pecten, Megapitaria, Doscina)* or gastropods (i.e. *Muricanthus*). In the Gulf it is known to range from San Felipe to La Paz along the Baja coast and from Puerto Peñasco to Mazatlán along the coast of Mexico.

Octopus fitchi Berry

Body elongate-ovoid; dorsal mantle length 20–30 mm; color reddish to wood brown above, lighter below; no ocelli; arms 2.5 to 3 times body length; with 1–2 enlarged suckers on all arms of both sexes; hectocotylus about 1/10 arm length; 10–12 lamellae per gill; eggs small (5 by 2 mm), attached singly to undersides of rocks; planktonic larval stage.

Octopus fitchi is endemic to the upper gulf. It is the most commonly encountered octopus in the rocky intertidal, especially at San Felipe and Puerto Peñasco. Berry also reports it from the Salton Sea. This small octopus has a reputation for biting and should be handled with care since some people may be allergic to the salivary toxins.

Octopus hubbsorum Berry

Body rounded to ovate; dorsal mantle length 50–70 mm; color dark slaty gray when live; no ocelli; arms stout and muscular, 3 to 4 times body length; no enlarged suckers; hectocotylus minute, 1/50 arm length; number of lamellae per gill unknown; egg size and habits of young unknown.

This octopus superficially resembles *O. bimaculatus*, but its robust and powerful body and the lack of ocelli are sufficient to distinguish the two. Very little is known about the biology or distribution of this species. It has been collected near Guaymas and at Cabo San Lucas. It probably occupies the intertidal and shallow subtidal of the lower half of the Gulf.

Octopus penicillifer Berry

Body ovate, pointed posteriorly; dorsal mantle length 30–40 mm; color reddish-brown with conspicuous dark spots scattered over body and along arms; no ocelli; arms short, 2 to 2.5 times body length; no enlarged suckers; tips of arms in male brushlike, with nonfunctional, papillaelike suckers; hectocotylus 1/10 arm length; number of gill lamellae unknown; egg size and habits of young unknown.

Though similar to *O. chierchiae*, this small octopus can be distinguished by the spotted, instead of banded color pattern. So far it has been recorded only from the shallow subtidal off Punta Arena at the tip of Baja California and from a reef off Estero Soldado, Sonora, Mexico. If this species proves to be the same as *Octopus stictochrus* which Voss described in 1971, then the range may be extended to Panama.

Octopus rubescens Berry

Body rounded to ovoid; dorsal mantle length 50–100 mm; color dull red to reddish-brown, often mottled with white; no ocelli; arms 3 to 4 times body length; sixth pair of suckers enlarged on all but ventral arms of male only; hectocotylus conspicuous, 1/10 arm length; 22–26 lamellae per gill; eggs small (3–4 by 1.5–2 mm), capsules with stalks twisted into cords and attached in long strings; larvae planktonic.

Octopus rubescens is the commonest octopus in the eastern Pacific, ranging from Alaska to Scammon's Lagoon, Baja California. It is trawled offshore on sand-mud bottoms to depths of 200 m and may occasionally be found under stones in the low intertidal. In the Gulf it has been trawled off Guaymas only. This species is known to bite when handled or disturbed.

Octopus veligero Berry

Body rounded to ovate; dorsal mantle length 50–70 mm; skin rugose, color mottled red-brown, metallic gold and silver around eyes and along sides of head; no ocelli; arms less than 3 times body length, webbed to the tips ventrally; no enlarged suckers; hectocotylus minute, fleshy, 1/20 arm length; large, plumelike gills, 30–34 lamellae per gill; eggs small (size unknown); larvae planktonic.

Octopus veligero is distinguished by the short arms, webbed to the tips ventrally, and by the large gills. This species has been trawled at depths up to 200 m off Cabo San Lucas and off the outer Baja coast north to San Juanico. In the Gulf, small planktonic octopods attributed to this species have been taken off La Paz.

COLOR PLATES

PLATE 1

Chromodoris norrisi

PLATE 2

Tridachiella diomedea
Petrolisthes armatus

PLATE 3

Verongia aurea
Cliona celata
Squilla tiburonensis, with *Palythoa ignota* and *Echinometra vanbrunti*

PLATE 4

Acanthaster ellisii
Tethya aurantia
Cycloseris elegans

PLATE 5

Periclimenes lucasi
Gnathophyllum panamense

PLATE 6

Toxopneustes roseus, with pedicellariae extended
Toxopneustes roseus, with pedicellariae retracted

PLATE 7

Nidorellia armata
Sand dollars: *Mellita longifissa, Encope grandis, Encope micropora*

PLATE 8

Ophiocoma aethiops
Echinometra vanbrunti and *Bunodactis mexicana*

PLATE 9

Onchidella binneyi, with *Chiton vigulatus*
Pseudoceros mexicanus

PLATE 10

Aplidium (species A)
Aplidium pellucidum ?

PLATE 11

Pylopagurus varians, with *Tubastraea tenuilamellosa* and *Hippoporidra* sp.

PLATE 12

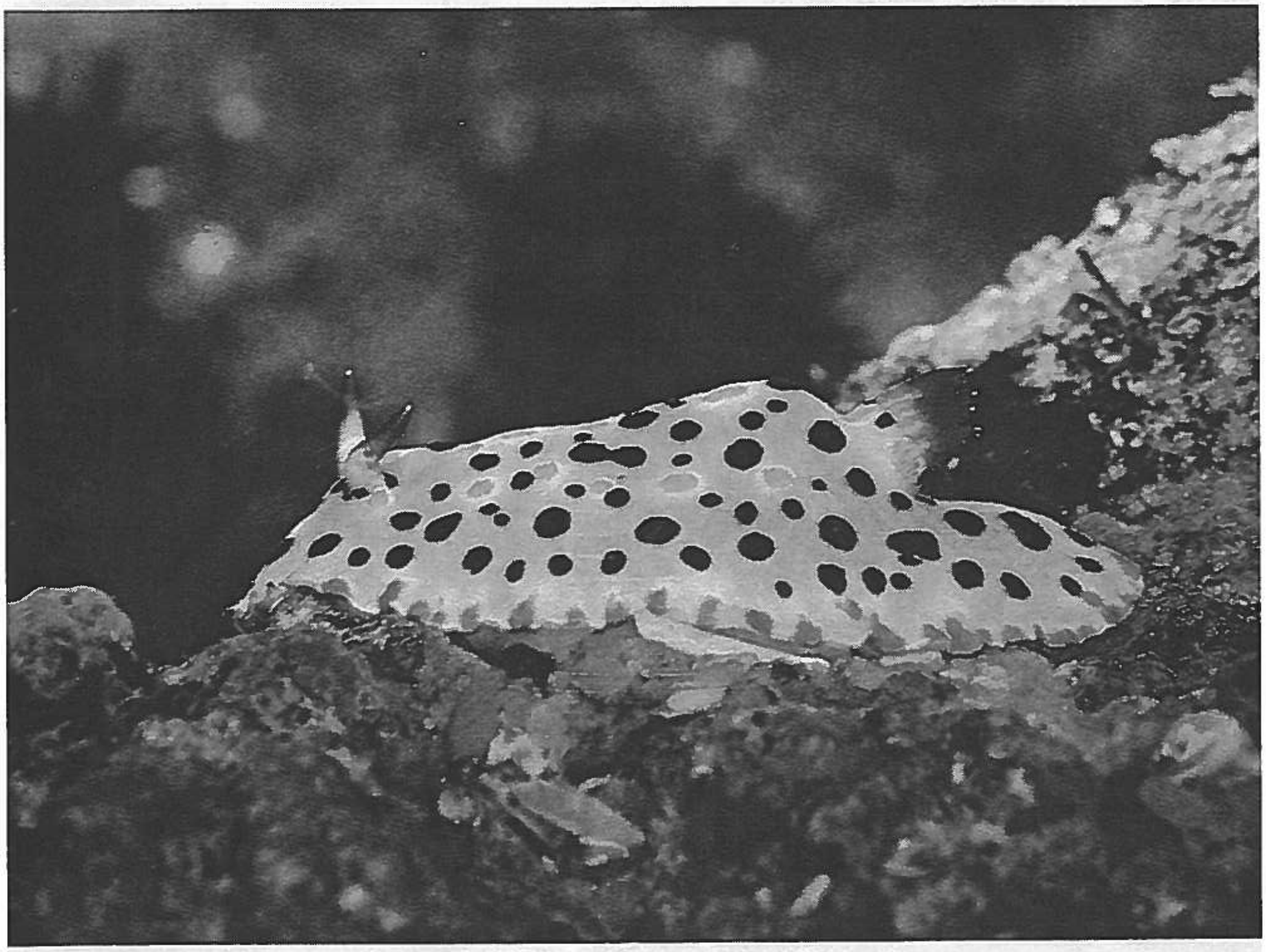
Terpios zeteki, with *Aglaophenia*
Linckia columbiae

PLATE 13

Axius vivesi
Thysanozoon sp., with *Tetraclita stalactifera*
Euapta godeffroyi

PLATE 14

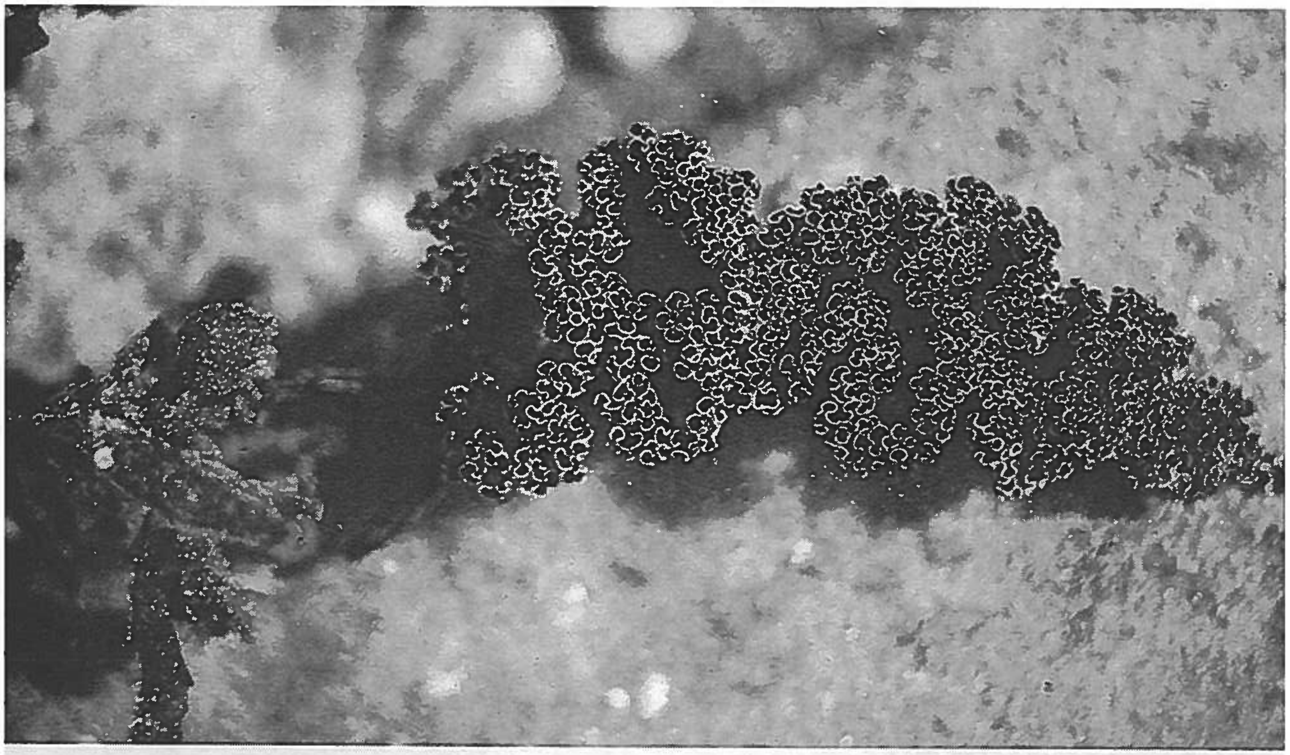
Clypeaster testudinarus
Eucidaris thouarsii, *Tubastraea tenuilamellosa* and *Jenneria pustulata*



Alex Kerstitch

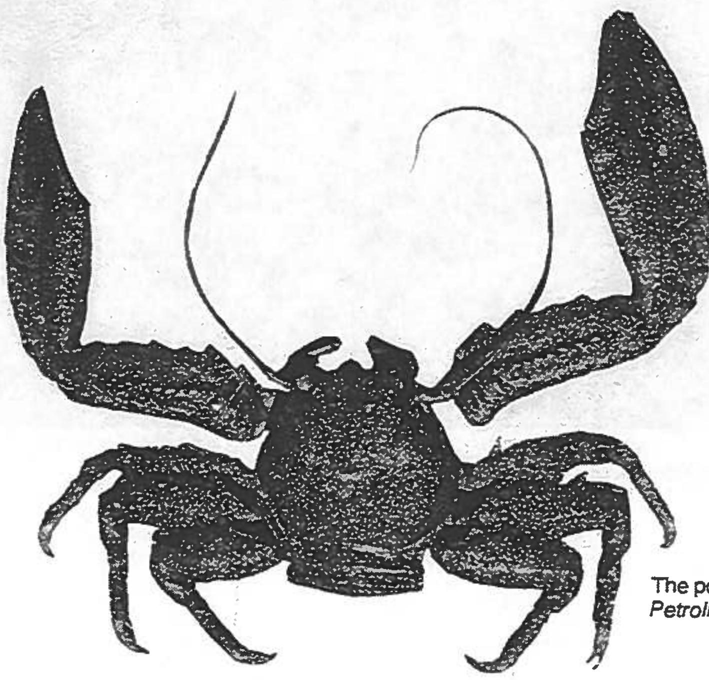
"Norris's nudibranch," *Chromodoris norrisi*.

PLATE 1



The "Mexican dancer," *Tridachiella diomedea*, approaching a small clump of Sargassum.

Roy Vail



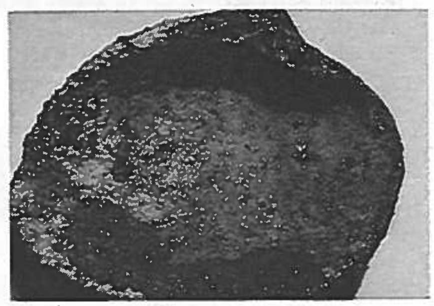
The porcelanid crab *Petrolisthes armatus*.

R. Brusca

PLATE 2

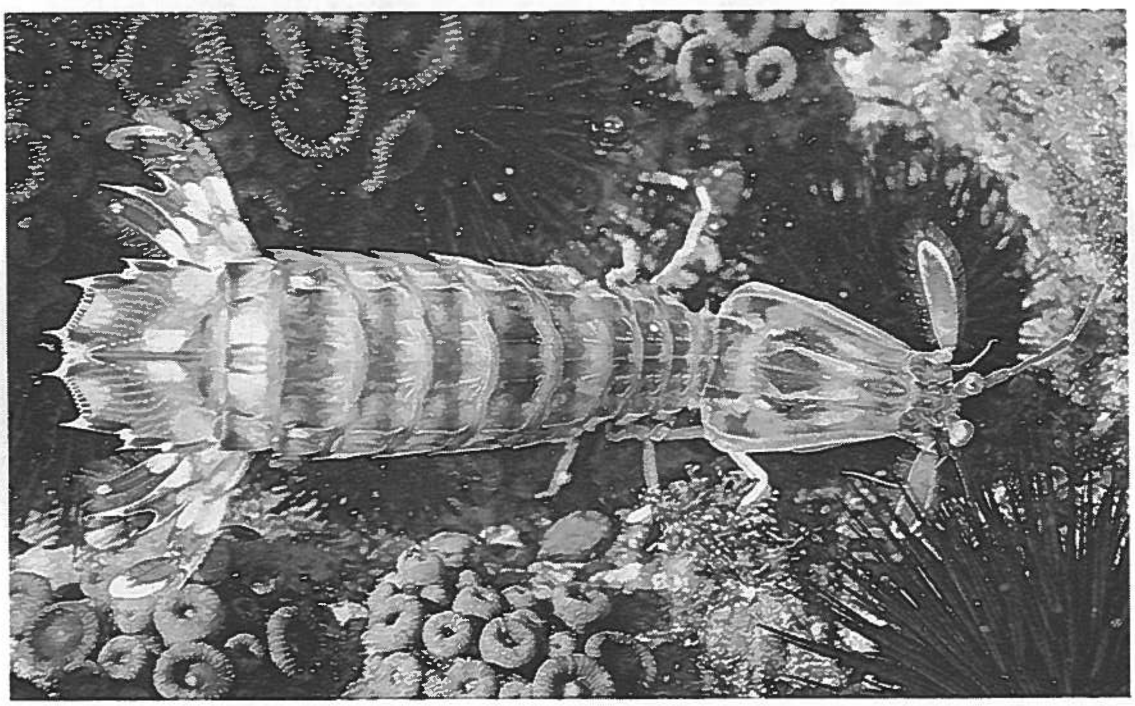
The cosmopolitan sponge *Verongia aurea;* subtidal growth form.

R. Brusca



The boring sponge *Cliona celata*, living in and upon a clam valve.

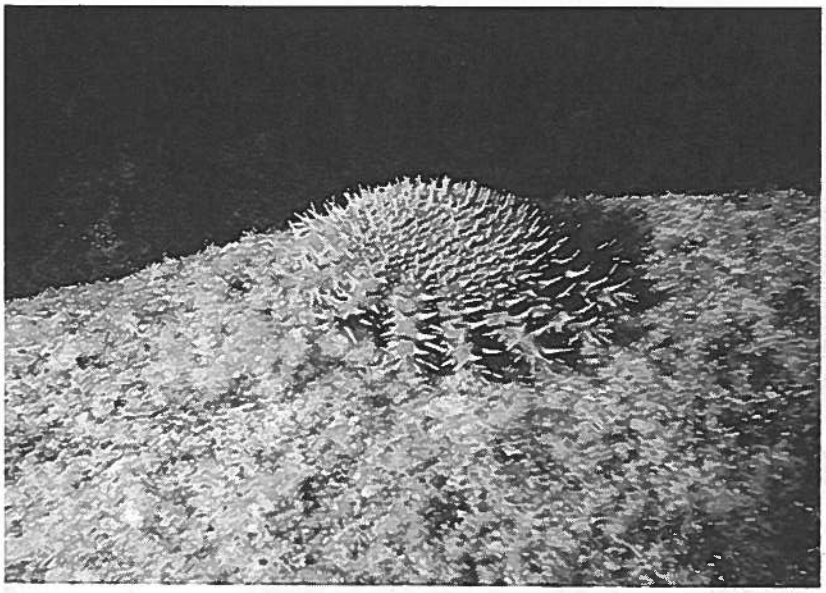
R. Brusca



Alex Kerstitch

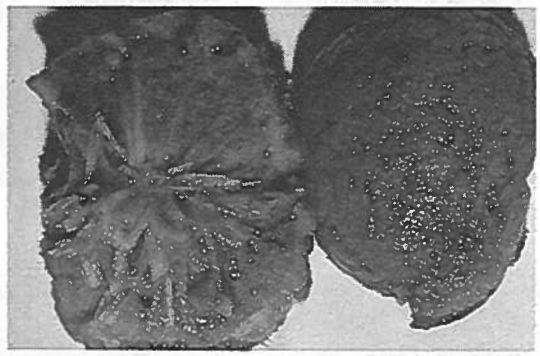
The mantis shrimp *Squilla tiburonensis*, photographed on a bed of colonial "anemones" (*Palythoa ignota*) and urchins *Echinometra vanbrunti*.

PLATE 3



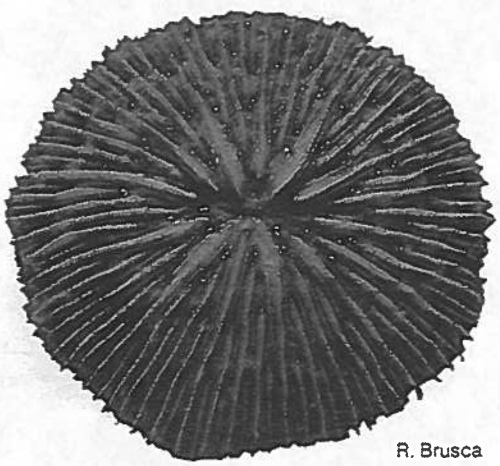
Alex Kerstitch

The eastern Pacific Crown-of-Thorns seastar, *Acanthaster ellisii*, photographed at a depth of 10 m on algal turf.



R. Brusca

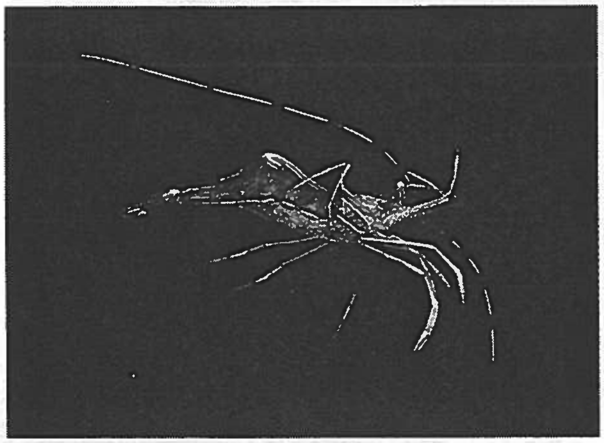
Tethya aurantia, a cosmopolitan Demospongiae with a distinctive color and growth form; internal and external views.



R. Brusca

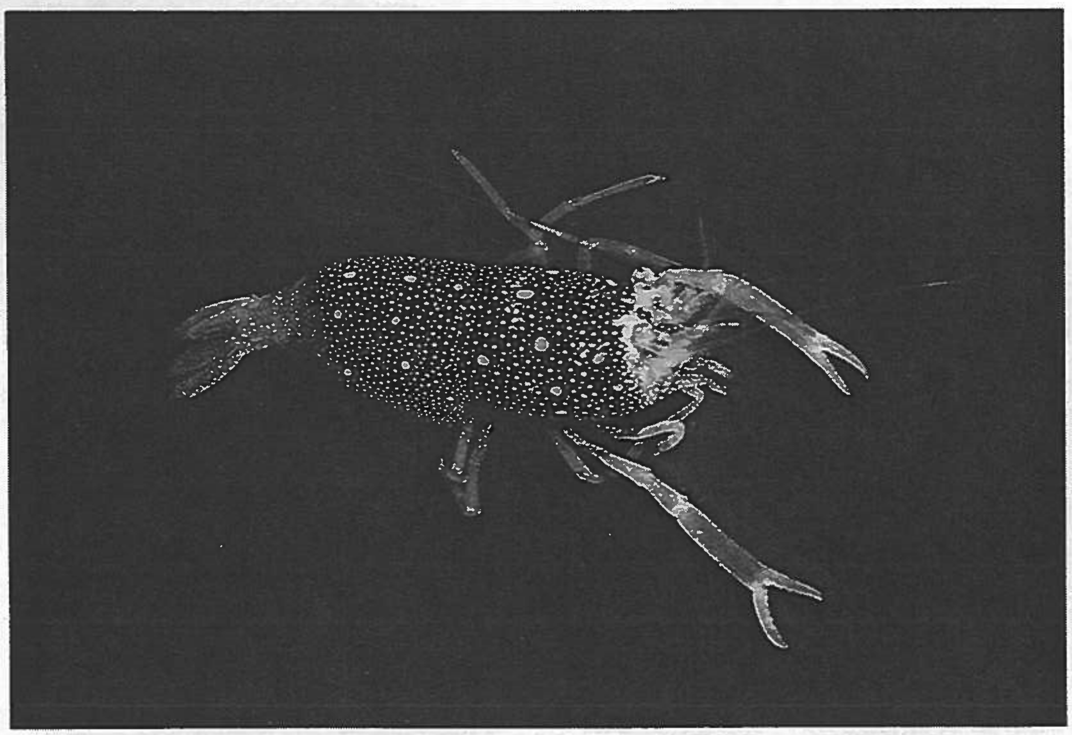
The fungiid coral *Cycloseris elegans*, from the southern Gulf.

PLATE 4



The colorful pontoniid shrimp
Periclimenes lucasi.

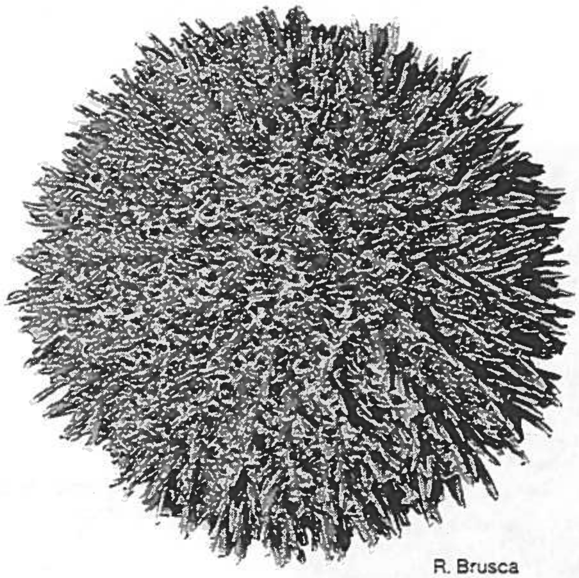
Alex Kerstitch



Alex Kerstitch

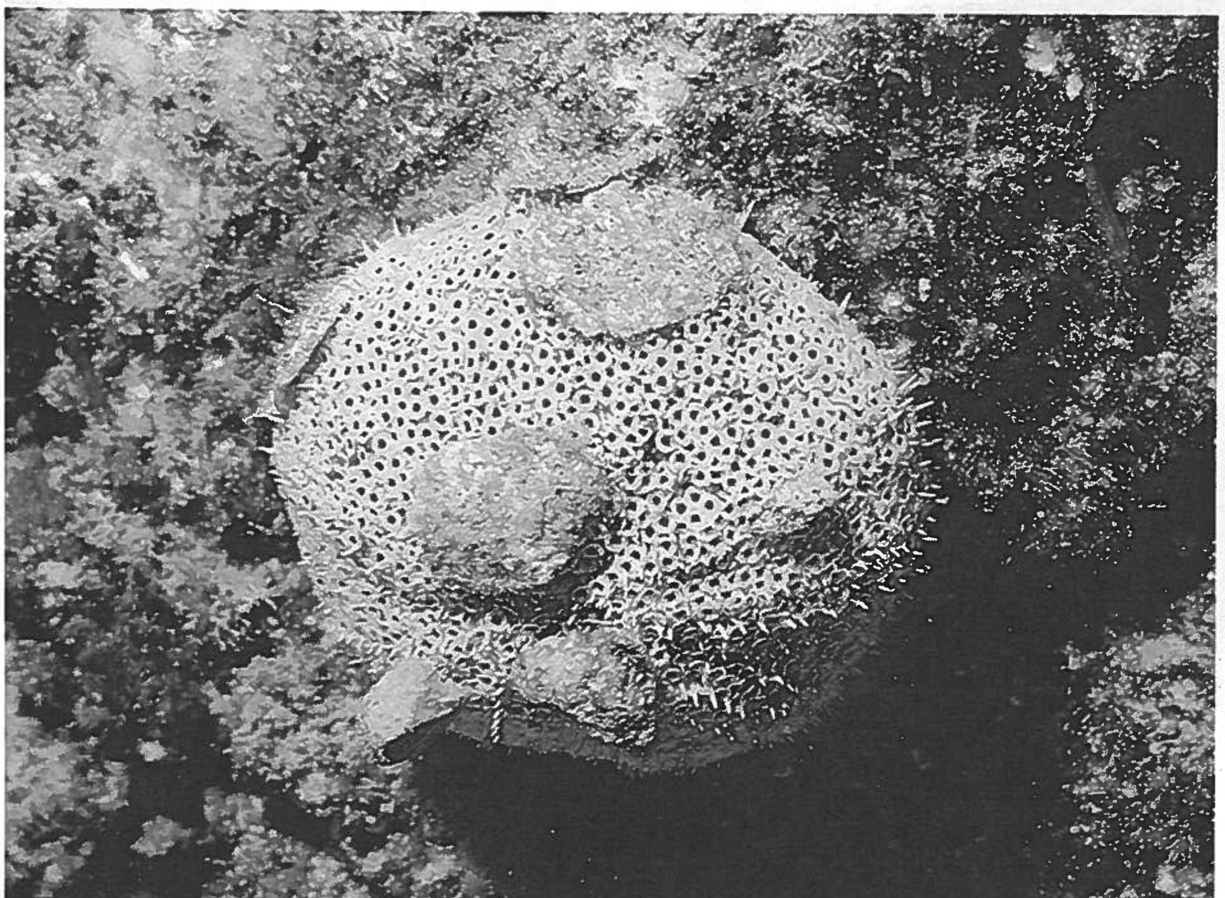
The cariid shrimp *Gnathophyllum panamense* (the "barrel shrimp").

PLATE 5



The central and southern Gulf sea urchin *Toxopneustes roseus*, with the pedicellariae extended.

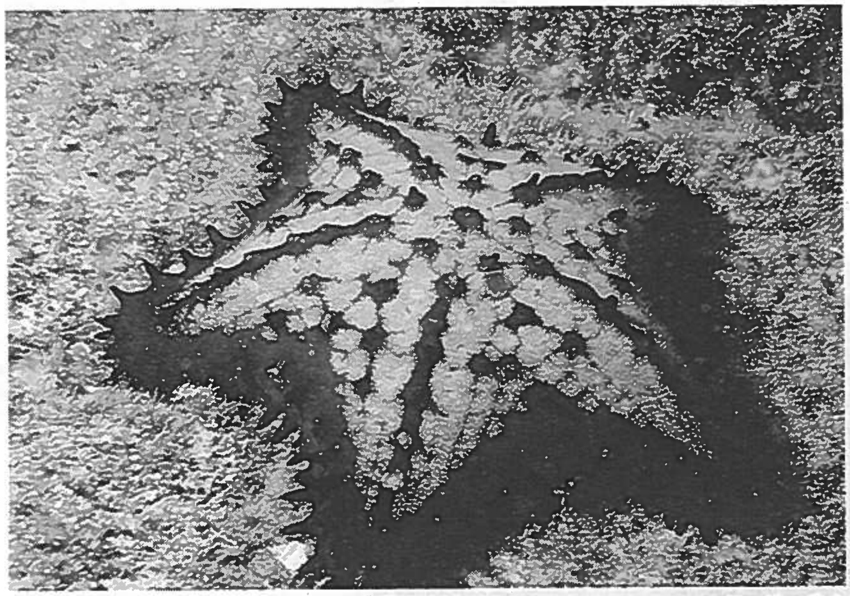
R. Brusca



Alex Kerstitch

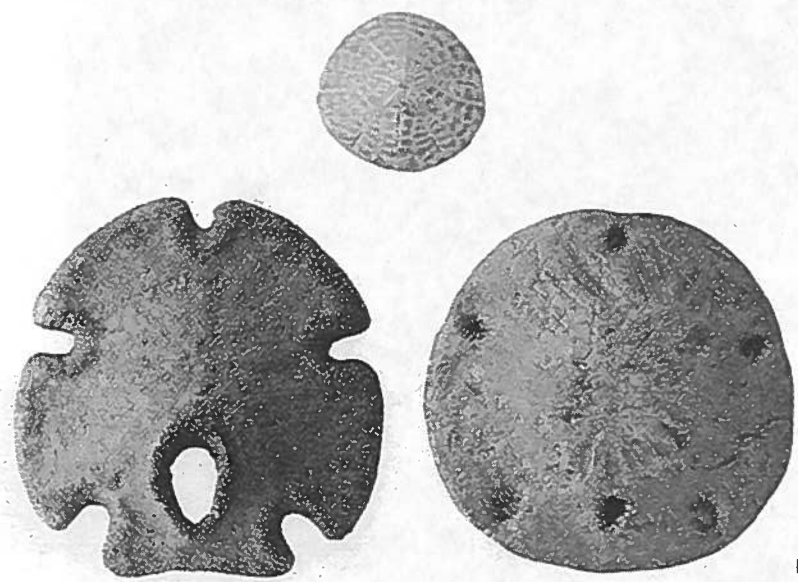
Toxopneustes roseus (as above) with the pedicellariae largely retracted, revealing the short spines.

PLATE 6



Alex Kerstitch

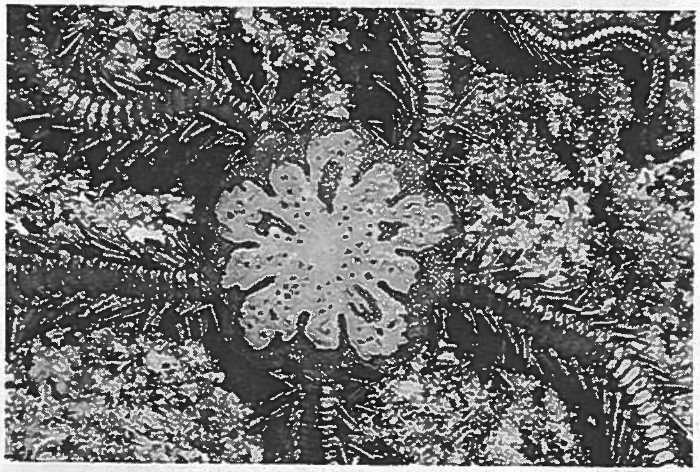
The seastar *Nidorellia armata*, photographed at a depth of 20 m.



R. Brusca

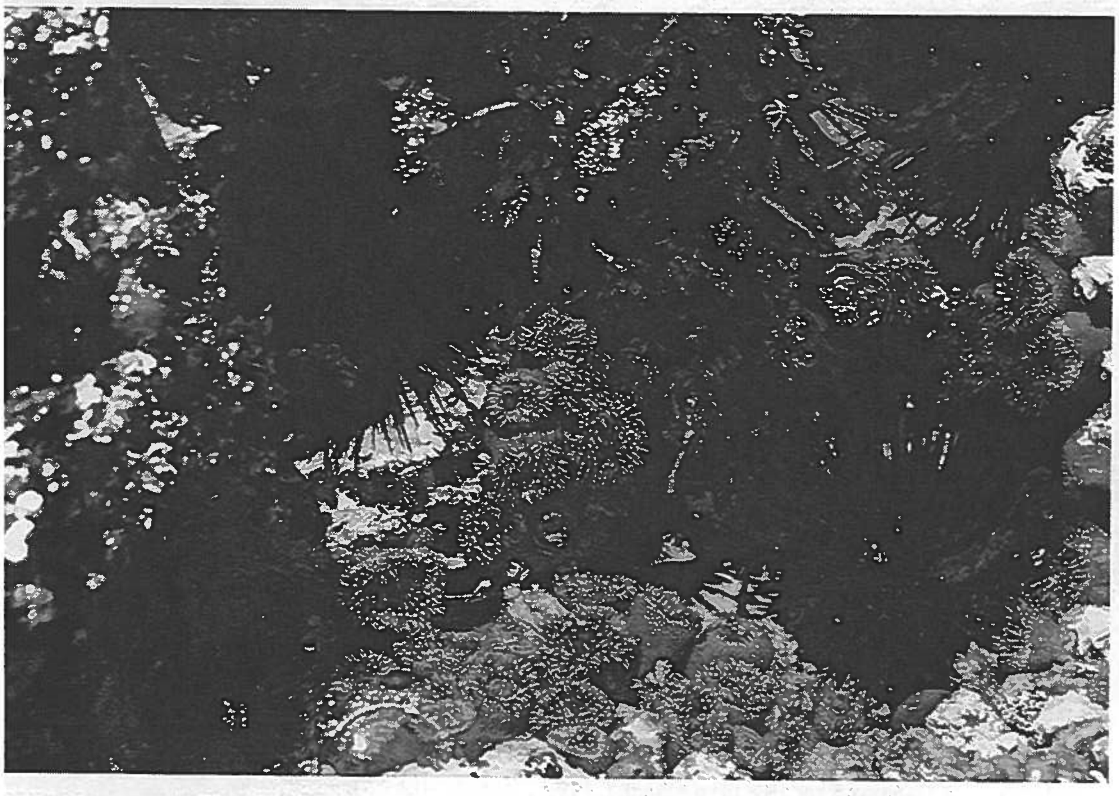
Three common Gulf sand dollars:
Mellita longifissa (top), *Encope grandis* (left), and *Encope micropora* (right).

PLATE 7



Ophiocoma aethiops,
the largest brittle star in the Gulf.
This individual possesses a
common color aberration on the disc.

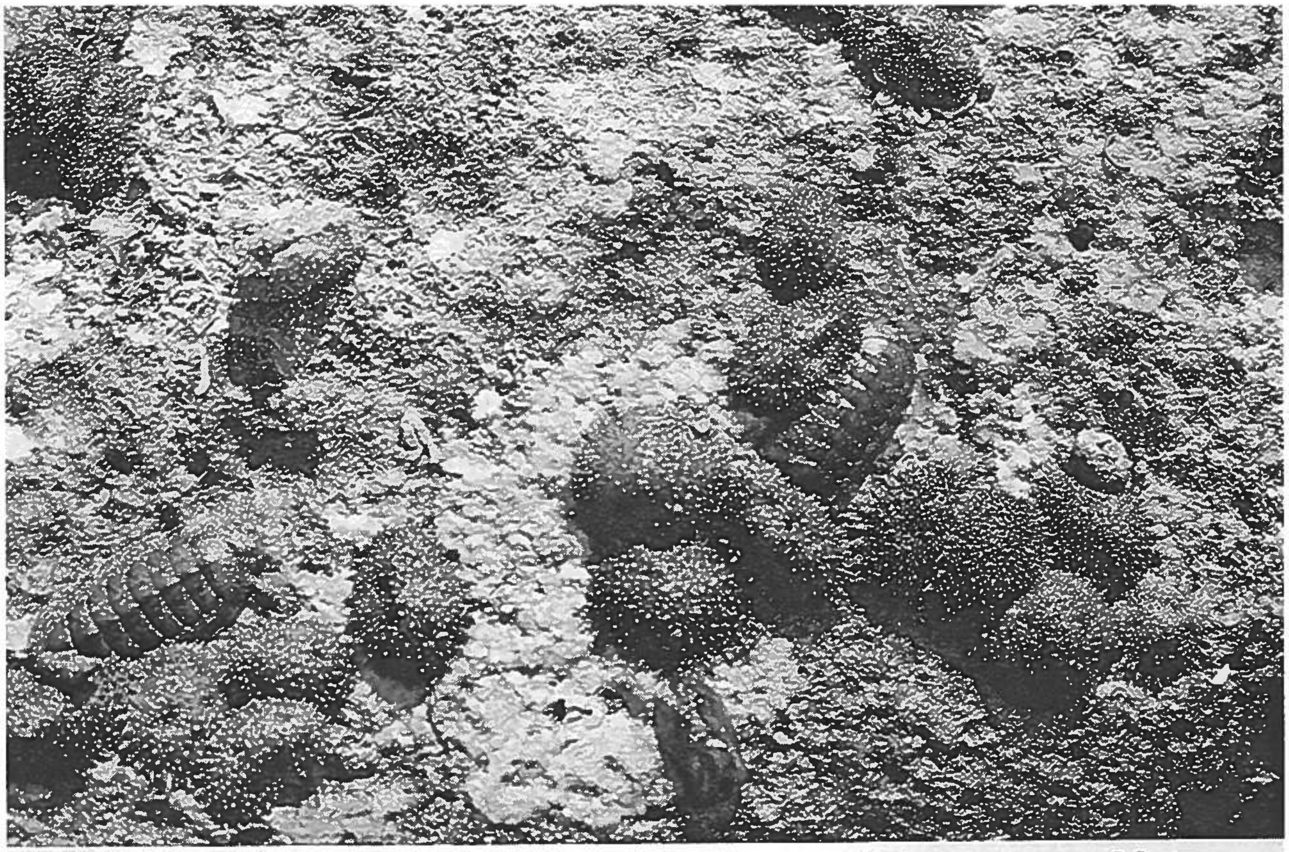
R. Brusca



R. Brusca

Two common tidepool inhabitants of the Sea of Cortez,
Echinometra vanbrunti (urchins) and *Bunodactis mexicana* (anemones).

PLATE 8



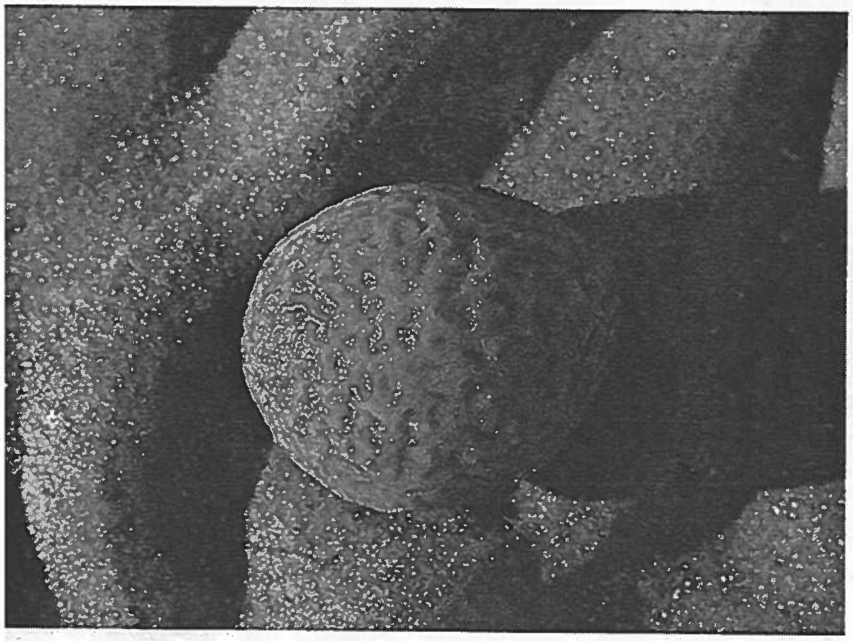
R. Brusca

The gymnophilid opisthobranch *Onchidella binneyi*, with the common Gulf chiton, *Chiton virgulatus*.

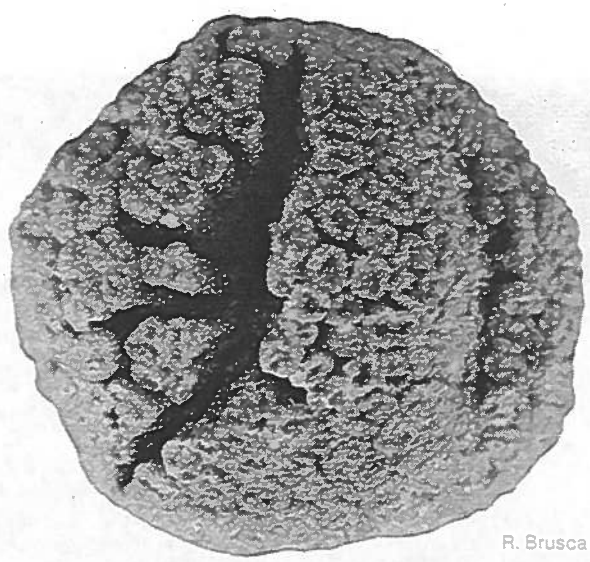
The common Gulf polyclad flatworm, *Pseudoceros mexicanus*.

Roy Vail

PLATE 9

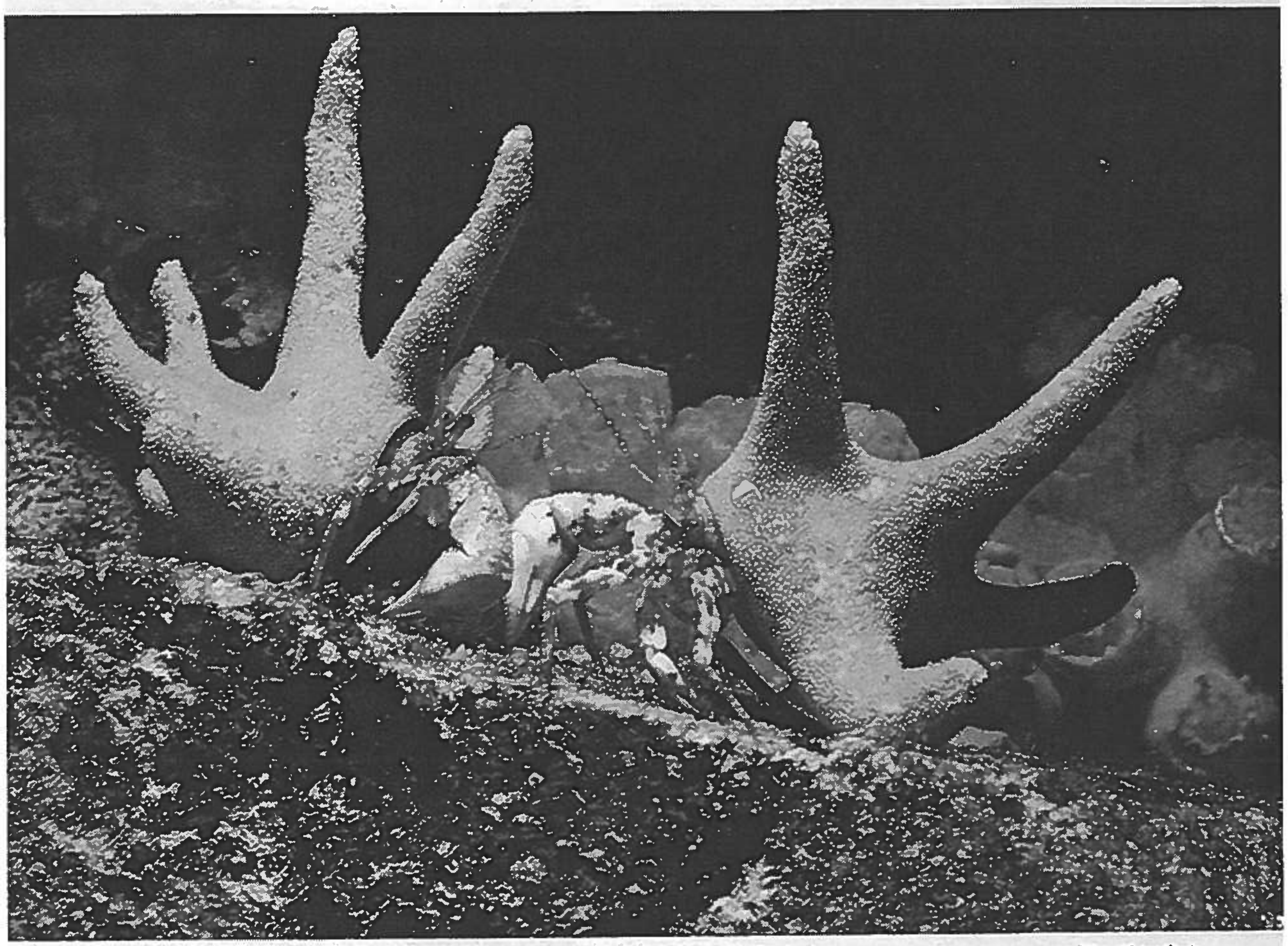


The common tunicate *Aplidium* (species "A" of this text).



A tidal flat tunicate (*Aplidium pellucidum* ?).

PLATE 10



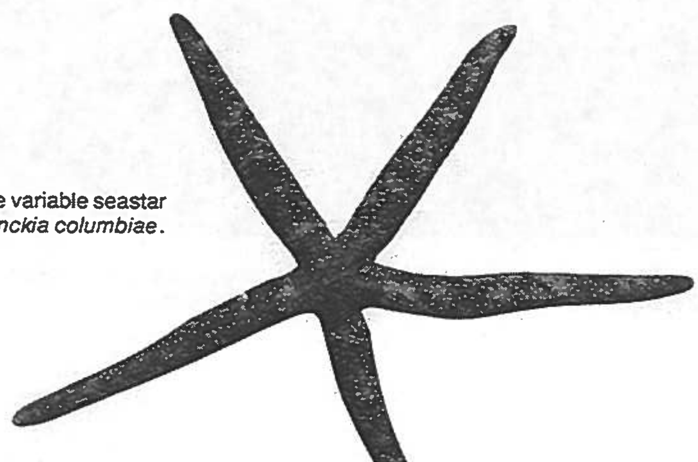
Alex Kerstitch

The unique hermit crab *Pylopagurus varians* in its home of staghorn hydrocoral (*Hippoporidra* sp. ?)
The orange coral in the background is *Tubastraea tenuilamellosa*.

PLATE 11

Roy Vail

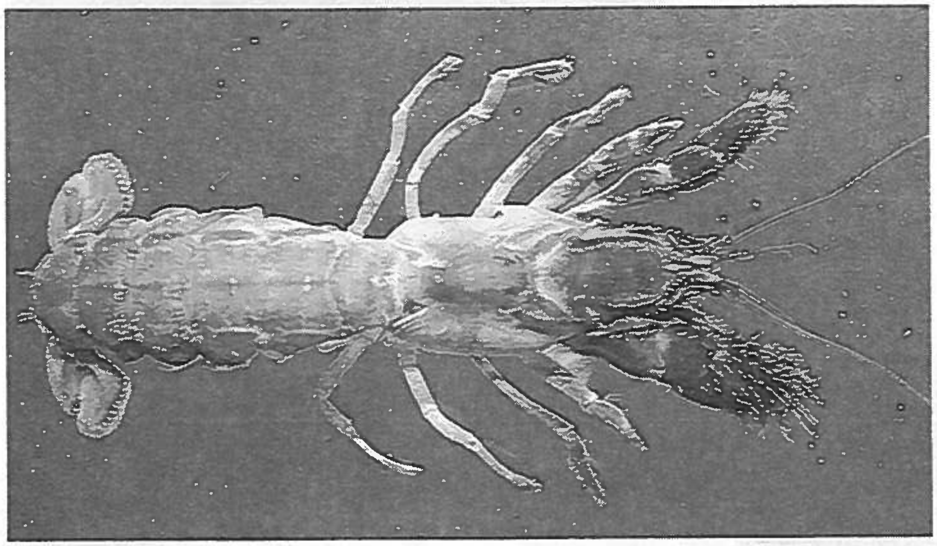
The brown, carpet-forming sponge *Terpios zeteki*,
with several clumps of hydroid (*Aglaophenia*) growing out of it.



The variable seastar
Linckia columbiae.

R. Brusca

PLATE 12

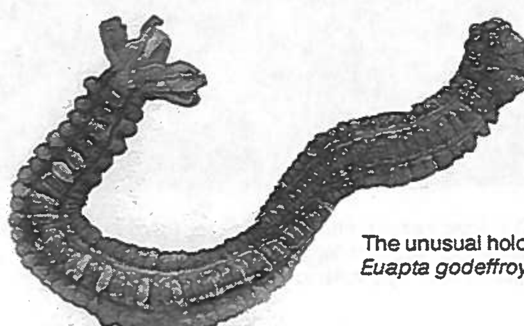


Alex Kerstitch

The unusual thalassinid shrimp *Axius vivesi*.

Alex Kerstitch

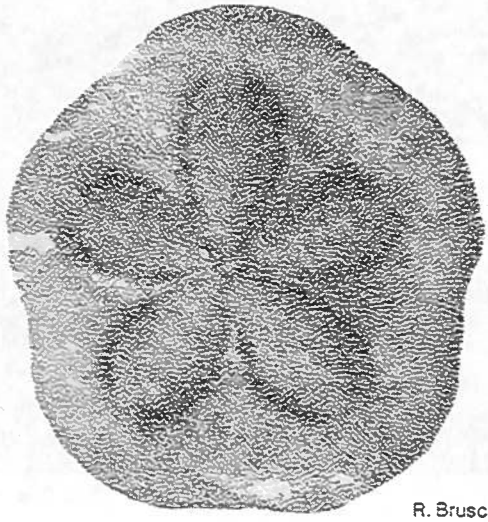
The polyclad flatworm, *Thysanozoon* sp., with the barnacle *Tetraclita stalactifera*.



The unusual holothurian *Euapta godeffroyi*.

R. Brusca

PLATE 13



The giant sea bisquit
Clypeaster testudinarius.

R. Brusca

The common Gulf slate pencil urchin *Eucidaris thouarsii* and the orange coral *Tubastraea tenuilamellosa*.
The unique ovulid, *Jenneria pustulata*, is seen in the foreground.

Alex Kerstitch

PLATE 14

10

Introduction to the Phylum
ARTHROPODA: CRUSTACEA
Cirrepedia (Barnacles)

General preservation: Most large crustaceans can autotomize their legs, but rarely do so if handled gently. However, if too many crabs or other large crustaceans are put into the same container for any length of time, they tend to fight and will break off appendages (as well as destroy other fragile specimens near them). Smaller forms, such as certain isopods and shrimps, and the spider crabs are especially fragile and tend to autotomize appendages more readily than do the larger crustaceans. Most marine crustaceans (except shrimp) should be killed by slowly adding fresh water to their seawater container, or simply by allowing the standing seawater to become putrid. Epsom salts (magnesium sulfate) or menthol crystals may be used to relax the animals if the above methods are undesirable. Knudsen describes various methods of preparing specimens for display and study. Crustaceans always should be preserved in 70 to 80 percent alcohol, and color notes should always be made prior to preservation.

General taxonomy: The Crustacea are a very large class of arthropods (over 30,000 recent species) with a traumatic taxonomic life of name changings and taxa revisions. Such a history of name changes and revisions is primarily a reflection of two things: (1) the size of the taxon, and (2) the incomplete knowledge of its systematics and biology. Although some groups are now reaching the stage where they are fairly well known and understood, at least in North America (most brachyuran and porcelanid crabs, barnacles, mantis shrimps), many remain poorly known (mysids, isopods, amphipods, tanaids, cumaceans, hermit crabs, etc.). By poorly known I mean to imply that many species still need to be named and described, and those species that have been described need to be more fully understood in terms of their whole biology. The deeper water forms are especially poorly known. It is only through the efforts of professional, full-time systematists that these animals will become known, and it is largely through their efforts that the biology will be studied. It is a shame that more institutions have not seen fit to make systematic chairs available for this needed research. This becomes strikingly evident in the tropics, where coastal populations and unrestrained development are accelerating faster than anywhere else in the world—yet, these are the very regions most poorly known to science at this time. One cannot help but wonder how many species of shallow-water, tropical, marine invertebrates and fishes will become extinct before ever having been described, or their role in the ecology of the environment elucidated. Owing to its large number of species, many taxonomic categories are used to delimit phylogenetic affinities within the Crustacea (such as super-, sub-, and infraorder; section, tribe; etc.). The following taxonomic scheme is derived largely from Schmitt (1965), Kaestner (1970), and Moore (1969) and is followed throughout the sections dealing with the Crustacea.

Class Crustacea
- Subclass Cephalocarida
- Subclass Branchiopoda
- Subclass Ostracoda
- Subclass Mystacocarida
- Subclass Copepoda
- Subclass Branchiura
- Subclass Cirripedia
  - *Order Thoracica
  - Order Acrothoracica
  - Order Ascothoracica
  - Order Rhizocephala
- Subclass Malacostraca
  - Series Leptostraca
    - Order Nebaliacea

*Described in this handbook.

Series Eumalacostraca
Superorder Syncarida
Superorder Pancarida
Superorder Peracarida
Order Spelaeogriphacea
Order Mysidacea
Order Cumacea
Order Tanaidacea
*Order Amphipoda
*Order Isopoda
Superorder Hoplocarida
*Order Stomatopoda
Superorder Eucarida
Order Euphausiacea
Order Decapoda
Suborder Natantia
*Section Panaeidea
*Section Caridea
Section Stenopodidea
Suborder Reptantia
Section Astacura
Superfamily Nephropoidea
*Superfamily Thalassinoidea
*Section Palinura
Section Anomura
*Superfamily Galatheoidea
Family Porcellanidae
Family Galatheidae
*Superfamily Paguroidea
*Superfamily Hippoidea
*Superfamily Coenobitoidea
*Section Brachyura

Specific taxonomies of the various groups of Crustacea are discussed in their respective sections.

Since much of the literature includes information about the Anomura and Brachyura within single papers, cross-checking literature references for these groups is recommended.

Crustaceans of the Gulf: Crustaceans are well represented in the Gulf of California, as they are along almost any seashore of the world. The most conspicuous members of this group, in the intertidal zone, are the barnacles (Cirripedia) and crabs (Brachyura and Anomura). There are many species of amphipods and isopods inhabiting the Gulf littoral, but they are less frequently encountered by the general observer, owing to their small size and specific habitats. Collecting these small creatures usually requires meticulous examination of sand and mud samples, algae beds, and other microhabitats. The true shrimp (Natantia) are common and abundant but difficult to catch, resulting in few good, available collections. The mantis shrimp (Stomatopoda) are rarely encountered intertidally. These curious creatures are most easily obtained by sampling beyond the low tide level with trawls and dredges.

Other Crustacea from the Gulf intertidal, rarely encountered, include: the sand or stone lobsters (Scyllaridae), such as *Evibacus princeps*, which live in the subtidal but may occasionally wash ashore after a bad storm; the mysids, many copepods and the euphausiids, which are largely planktonic and must be captured with a fine mesh net; and the ostracods, copepods, tanaids and cumaceans, those small, odd crustaceans that live half buried in the sandy-mud or mud substrate, often of estuaries and bays. One occasionally finds a mole crab or sand crab (Hippoidea) buried in the sand above or near the water line. These little anomuran crabs are filter feeders, lying just beneath the sand surface and extending their densely fringed antennae into the water as the waves alternately cover and expose them. A pelagic galatheid crab not treated in the keys is *Pleuroncodes planipes* Stimpson, occasionally referred to as "pelagic rock lobsters" or "lobster krill." It has been reported washed ashore in vast numbers throughout its range: Monterey, California (1859, 1960); Isla Espíritu Santo (1940); La Paz (1940); Punta Belcher (1964); Bahía de los Angeles (no date); and I have found it washed ashore, at different times, literally throughout the Gulf, below the midriff region, as well as along the lower west coast of Baja California. In the open sea these creatures probably serve as an important food source for turtles, whales, and fish. Enormous schools of these crabs are often encountered and one member of a Russian exploratory expedition estimated a school's size at 200 billion individuals (totaling about 300 thousand tons). The range of *P. planipes* is given by Haig et al. (1970) as Baja California and the northern Gulf to about 250 km south of Cabo San Lucas, its occurrence on Californian shores being limited to years when the ocean water is unusually warm in that region. These galatheids are often called "scarlet lobsterettes," a very descriptive name.

KEY TO THE MAJOR GROUPS OF INTERTIDAL CRUSTACEA

1 Animal volcano-shaped; enclosed in a series of 4 or 6 heavy calcareous plates; attached to substrate by a broad base (the barnacles) (figs. 10.1 to 10.3) .... **Subclass Cirripedia** (p. 207)

-Animal not volcano-shaped; exoskeleton soft to hard, but not encased in plates as above; free-living, not attached to substrate (crabs, shrimp, etc.) .... **Subclass Malacostraca 2**

*Described in this handbook.

2(1) Body sticklike and greatly reduced (abdomen vestigial); body usually less than 20 mm long (Caprellids) (fig. 11.2) .... **Order Amphipoda** (Suborder Caprellidea)
-Body not sticklike and greatly reduced (abdomen not vestigial); body often greater than 20 mm long **3**

3(2) Carapace lacking **4**
-Carapace present **5**

4(3) Animal compressed, laterally (side to side) (figs. 11.3 to 11.13) .... **Order Amphipoda** (p. 214)
-Animal depressed, dorso-ventrally (top to bottom) (figs. 12.1 to 12.31) .... **Order Isopoda** (p. 220)

5(3) Carapace short, not covering the last 3 to 4 thoracic segments; second thoracic appendages modified to form large, mantislike, raptorial claws (the mantis shrimps) (figs. 13.1–13.13) .... **Order Stomatopoda** (p. 241)
-Carapace completely covering thorax; second thoracic appendages not as above **6**

6(5) Body more or less laterally compressed; first abdominal segment equal to or larger than more posterior segments; pleopods always present and well-developed, used for swimming (shrimp) (figs. 14.1 to 14.13) ... **Suborder Natantia** (p. 248)
-Body not laterally compressed, usually dorsoventrally depressed; first abdominal segment distinctly smaller than more posterior segments; pleopods absent, or if present anterior pair reduced and not adapted for swimming (crabs, lobsters, and burrowing or mud shrimp) .... **Suborder Reptantia** **7**

7(6) Abdomen folded under thorax, or reduced and asymmetrical; uropods and telson absent or reduced **8**
-Abdomen extended and well-developed; large uropods and telson **11**

8(7) Abdomen reduced and tightly flexed beneath thorax; fifth legs not greatly reduced, plainly visible; eyes usually lateral to antennae (regular crabs) (figs. 20.1 to 20.47) .... **Section Brachyura** (p. 292)
-Abdomen reduced and folded under thorax *or* abdomen asymmetrical, soft and twisted (as in hermit crabs); fifth legs reduced and turned upward, often appearing absent; eyes median to antennae; (mole crabs, hermit crabs, porcelain crabs) .... **Section Anomura** **9**

9(8) Animal occupying a mollusc shell (usually a gastropod shell); abdomen soft, without chitinous exoskeleton; abdomen extended and asymmetrical (hermit crabs) (figs. 18.1–18.12) .... **Superfamily Paguroidea** (p. 275)
-Animal not occupying a mollusc shell; abdomen hard, with chitinous exoskeleton; abdomen folded under thorax; abdomen symmetrical **10**

10(9) First legs with pincers (chelipeds); body usually crablike; carapace rarely inflated, or highly convex; rostrum often present; rarely found burrowing in sand (porcelain crabs) (figs. 17.1 to 17.17) .... **Family Porcellanidae** (p. 262)
-First legs with or without pincers; body not crablike; carapace inflated and highly convex; rostrum never present; found burrowing in sand, often high up on beach (mole or sand crabs) (figs. 19.1 to 19.9) **Superfamily Hippoidea** (p. 286)

11(7) First pair of legs chelate (ghost or mud shrimp) (figs. 15.1–15.2) .... **Superfamily Thalassinoidea** (p. 258)
-First pair of legs not chelate (lobsters) (fig. 16.1) .... **Section Palinura** (p. 260)

CIRRIPEDIA (Barnacles)

Preservation: Barnacles may be fixed in buffered 10 percent formalin but should be preserved in 70 percent alcohol. To preserve specimens with the cirri extended, it is necessary to narcotize expanded individuals with chloretone or menthol.

Taxonomy: Most of the New World barnacles were described in Darwin's (1851, 1854) classic monographs. In these works he described and classified all the living, as well as fossil, barnacles known at that time. It was truly an amazing undertaking. Since that time, studies on American barnacles have extended ranges, established new species and subspecies, isolated new taxonomic characters, elucidated phylogenetic trends, and described many important ecological relationships. The taxonomy of this group is based principally on the number and morphology of the calcareous plates, the morphology of the mouth parts and cirri, and the site of attachment to the substrate. The following paragraph briefly describes structures a student may need to recognize when using the key to the barnacles.

The armor (shell) of barnacles consists of calcareous *plates* connected by an interlocking mechanism, or by fusion. Each plate has three parts: a median triangular area, the *paries* (pl. parietes); and two lateral wings, called *radii* when they overlap adjacent plates and *alae* when they are overlapped by adjacent plates. The membranous or calcareous plate upon which the barnacle rests is the *basis*. Barnacles primitively have eight plates. The one farthest from the head is the keellike *carina* (usually the tallest plate); the one opposite the carina is the *rostrum;* the two *carinolaterals* flank the carina; two *rostrolaterals* flank the rostrum; and last are the middle compartments, referred to as the *laterals*. The sessile littoral barnacles found in the Gulf may have a shell composed of either six or four wall plates, depending on whether or not some plates are fused or lost. In *Balanus* the rostrolaterals are fused with the rostrum, while in *Chthamalus* the carinolaterals are lacking altogether, giving individuals of these two genera only six plates. Further, in *Chthamalus* both end plates of the shell wall (rostrum and carina) are overlapped by the adjacent plates, while in *Balanus* one of the end plates (rostrum) overlaps its adjacent plates. In *Tetraclita* the rostrolaterals are fused with the rostrum and the carinolaterals are absent, giving it four plates.

The most significant recent work on cirripeds is a revision of the balanomorph barnacles by Newman and Ross (1976). The classification used here is taken from that monograph.

Barnacles of the Gulf: There are two great divisions of the barnacles: the acorn barnacles (Balanomorpha), and the goose or stalked barnacles (Lepadomorpha). The vast majority of the intertidal barnacles of the Gulf of California are balanomorphs (belonging to the order Thoracica, suborder Balanomorpha). These are the only barnacles treated in the following key. In addition to these littoral acorn barnacles, pieces of wood or pumice occasionally wash ashore covered with goose barnacles of the genus *Lepas* (fig. 10.1); certain fishes, portunid crabs, and cymothoid isopods *(Nerocila)* occasionally have the purple-striped barnacle *Conchoderma virgatum* attached to their outer surface; and sea turtles are often found inhabited by the large white *Chelonibia testudinaria* (Linnaeus). Henry (1960) reported the tropical goose barnacle *Pollicipes elegans* lesson from the Gulf, but I have found this species to be exceedingly rare north of Manzanillo. These goose barnacles are prepared in a tasty dish known as *percebes*, in Costa Rica.

Cornwall (in Steinbeck and Ricketts) reported 10 species (or infraspecific forms) of barnacles from the Gulf and concluded that the majority of the Gulf fauna in this class was of Panamic origin, with a few unique species and a few species showing affinities with the Californian Province. Combining the range extensions of Steinbeck and Ricketts with the geographic distributions given by Pilsbry (1916), who reported 4 species from the Gulf, we find that approximately 44 percent of the Gulf species (or subspecies) may be associated with the Panamic fauna, 22 percent show affinities to the Californian fauna, and 33 percent are apparently unique

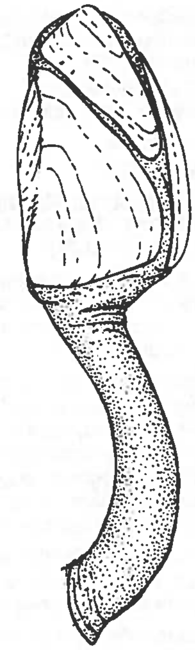


Fig. 10.1 *Lepas* sp.
(from Allen, 1976)

to the Gulf. These figures are approximations, since many barnacles are carried freely on ships' hulls to ports around the world, thereby making zoogeographic studies of this group extremely difficult. There are, in fact, several species known only from ship bottoms!

Ross (1962) stated that the barnacle fauna of the Gulf of California is predominantly tropical east Pacific (Panamic) in its affinities, with infiltrations of some more northern, southern, and cosmopolitan elements. Of the 27 species (or varieties) of Pacific Mexican balanomorphs treated by Ross, 9 were endemic to western Mexico (33 percent), 5 ranged north to California (19 percent), 5 were cosmopolitan (19 percent), and 8 were widespread Panamic forms (29 percent). He further commented that the tropical cirripeds of western Mexico show little or no affinity to those of the Indo-western Pacific region, either at present or in the fossil record. This is in contrast to the more northern, temperate western American forms, which do show strong affinities to the temperate west Pacific fauna.

The majority of the Panamic barnacle fauna probably originated as a facet of the generalized transisthmian track (Caribbean–east Pacific), and Ross (1962) has shown that 29.6 percent of the living barnacles of western Mexico also occur in the west Atlantic fauna. Although this trend is seen in nearly every animal group of this region (to greater or lesser degrees), in most, evolution has proceeded at a pace fast enough to produce differences that constitute distinct species recognition. Does this imply that the barnacles, as a group, tend to have a more conservative evolutionary rate, or a slower mutation rate, in the New World tropics, than other invertebrate taxa? Dr. J. Laurens Barnard of the Smithsonian Institution has an excellent way of describing the gradual (or not so gradual) steps necessary in an evolving population. He refers to each significant step as an "evolutionary increment." Increments of significant size and temporal duration can cause a group or population to undergo evolutionary changes quite apart from its parent stock or, in other words, proceed to speciate. The closing of the Panama seaway (cessation of the trans-isthmian track) during the Pliocene represents a powerful evolutionary force of this type, splitting literally thousands of populations (or potentially interbreeding groups) in two. The independent evolution of the two separate groups, or populations, is called "vicariance" (Croizat, Nelson and Rosen, 1974). Smaller evolutionary increments, perhaps temperature fluctuations, competition or predator effects, pollution, etc., can accumulate to eventually result in the same phenomenon. One wonders if the evolutionary increments required by cirripeds are not perhaps of a grander scale than those that affect other groups of invertebrates. On the other hand, this high percentage of amphi-American cirripeds may also reflect the particular approach that classical barnacle taxonomists have used over the past few decades.

Barnacles are found attached to rocks, wharf pilings, mollusc shells, crustacean exoskeletons, and other hard surfaces, from the splash zone (*Tetraclita* and *Chthamalus*) to the mid intertidal (most *Balanus* and *Chthamalus*), and to a lesser extent in the low intertidal. All of the Gulf barnacles are relatively small, especially compared with the 12- to 15-cm giant *Balanus nubilus* Darwin of the Pacific northwest, or *Balanus psittacus* (Molina) of Chile and Peru, both large enough to be eaten, the latter being harvested commercially for this purpose. *Balanus nubilus* is also known from Pleistocene and Pliocene deposits of Baja California.

KEY TO THE COMMON BARNACLES

1	Plates of shell appear fused and indistinguishable externally; plates with deep, vertical striations; shell composed of 4 plates (visible internally) (fig. 10.3)	***Tetraclita* spp.**
	-Plates of shell visible externally; plates smooth, or with weak striations; shell composed of 6 plates	**2**
2(1)	Shell white or gray	**3**
	-Majority of shell with red or purple markings	**5**
3(2)	Both end plates of shell wall (rostrum and carina) overlapped by adjacent plates; walls solid; opercular plates darker than wall	**4**
	-Only one end plate of shell wall (carina) overlapped by adjacent plates; walls tubiferous; opercular plates usually same color as wall	***Balanus improvisus***
4(3)	Base of shell star-shaped; shell usually covered by an olive-brown periostracum; small, 1–7 mm wide	***Chthamalus anisopoma***
	-Base of shell evenly rounded; shell usually dingy white; larger, 6–9 mm wide (fig. 10.2)	***Chthamalus fissus***
5(2)	Barnacle commensal on stony coral (particularly *Porites californica*); shell strongly ribbed	***Armatobalanus durhami***
	-Not commensal on stony coral; shell unribbed or weakly ribbed	**6**
6(5)	Barnacle commensal on octocorals (particularly gorgonians); shell elongated along carinorostral axis, carina higher and longer than other plates	***Conopea galeata***
	-Barnacle not commensal on octocorals; shell not as above	**7**
7(6)	Orifice diamond-shaped or ovate	**8**
	-Orifice trigonal or pentagonal	**9**
8(7)	Orifice usually diamond-shaped; commonly found attached to crustacean exoskeletons; width at base 10–30 mm	***Balanus pacificus***
	-Orifice never diamond-shaped; rarely found attached to crustacean exoskeletons; width at base 20–60 mm (fig. 10.4)	***Megabalanus* spp.**
9(7)	Edges of orifice form strong, tall teeth; parietes smooth (may appear wavy due to variations in color intensity)	***Balanus eyerdami***
	-Edges of orifice form weak teeth; parietes with weak ribs or striae	**10**
10(9)	Exterior of scutum marked by one or more longitudinal rows of pits; radii pale pink or white	***Balanus trigonus***
	-Exterior of scutum marked by simple transverse growth lines, without pits; radii always white	***Balanus amphitrite***

Order Thoracica

Suborder Balanomorpha

SUPERFAMILY CHTHAMALOIDEA
FAMILY CHTHAMALIDAE
SUBFAMILY CHTHAMALINAE
Chthamalus fissus Darwin

This and the following species have both end plates (rostrum and carina) overlapped by the adjacent plates. The laterals lack deep ribs, and all of the walls are solid. The orifice is ovate, occasionally subapical. The radii are extremely narrow. This species is white to dingy gray (occasionally with an olive-brown hue), with a circular base. It is a small barnacle (6 to 9 mm in diameter) that usually occurs in great colonies on rocks and pilings from the splash zone to the upper mid intertidal. It occurs from central California to the Gulf of California, and with *Tetraclita* is one of the most commonly encountered barnacles of the Gulf. Numerous authors have stated or implied that this and other species of *Chthamalus* have become restricted to the high intertidal zone because of their inability to compete with the faster growing *Tetraclita* and *Balanus* (Barnes and Barnes, 1959; Connell, 1961; Coe and Allen, 1937; Ross, 1962; Stephenson and Stephenson, 1972). Physiological work by Barnes and Barnes (1959) has shown that barnacles occurring in the high intertidal zone have a lowered metabolic rate, which is one adaptation to that habitat. Figure 10.2.

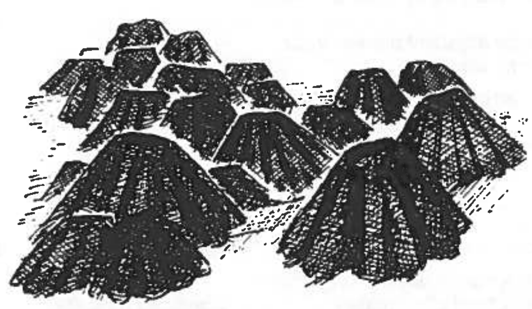


Fig. 10.2 *Chthamalus fissus* (from Allen, 1976)

Chthamalus anisopoma Pilsbry

A very small barnacle that superficially resembles *C. fissus* but may be distinguished by the strongly ribbed parietes, long elliptical orifice (oval in *C. fissus*), and star-shaped base. The growth form is a depressed cone, and the shell is ivory white, though generally covered with an olive-brown to olive-green cuticle. Radii are present but poorly developed. *Chthamalus anisopoma* occurs throughout the Gulf but is not known to occur south of Cabo San Lucas. Like *C. fissus* it prefers the high intertidal zone and has been found attached to *Tetraclita*. Size ranges from 1 to 7 mm in width.

SUPERFAMILY CORONULOIDEA
FAMILY TETRACLITIDAE
Tetraclita spp.

A widely distributed and well known genus, with two species (each consisting of several recognized forms), on the Pacific coast of North America. Members of this genus are typically large and conical, with the base diameter reaching 25–50 mm. It has only four wall plates instead of the usual six. The plate junctions are usually indistinguishable externally, and so the entire animal appears to be of a single plate.

Tetraclita is found in the higher mid intertidal zone on exposed rocks, usually well above the *Balanus* zone, and is probably the most commonly encountered barnacle in the Gulf. Tetraclitids occur worldwide in tropical, subtropical, and temperate seas. Students familiar with the more solitary California species will be impressed by the gregariousness of those in the Gulf, which often entirely cover large rocks and reefs, to a thickness of several individuals. Because of their heavy striations, tetraclitids are often called the "thatched barnacles." Colors range from dull brick red to gray or white. It has been shown that most barnacles typically inhabiting these higher intertidal regions do not do so because of preference alone. In fact, many grow faster and are more active if given greater submergence times. They are, however, often restricted to higher zones by biotic factors, such as predation and substrate competition. In certain localities, where these predators and competitors are absent, some species of barnacles may be found living at considerably lower levels on a rocky beach. Whether or not this is the case with *Tetraclita* has not yet been shown in the Gulf of California.

The three subspecies of *Tetraclita* known to occur on the Pacific coast of Mexico are: *T. stalactifera stalactifera* (Lamarck), Gulf of California to southern Mexico, and west Atlantic (South Carolina to southern Brazil); *T. stalactifera confinis* Pilsbry, Gulf of California only; and *T. squamosa rubescens* Darwin, central California to Cabo San Lucas (not reported from the Gulf). All are locally referred to as *el broma marina*. As can be seen by the above ranges, only *Tetraclita stalactifera* is presently known from the Gulf of California. (*T. stalactifera* was formerly regarded as a subspecies of *T. squamosa*.) The two subspecies can be differentiated by their color, *confinis* having a light gray or blue-gray shell, the nominate form (*stalactifera*) having a creamy white to slate black shell. *Tetraclita stalactifera confinis* is also known from the Pleistocene of the Puerto Peñasco (Sonora) region. Figure 10.3.

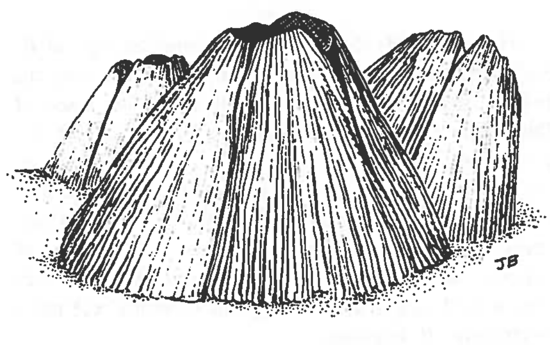


Fig. 10.3 *Tetraclita* sp.
(from Allen, 1976)

SUPERFAMILY BALANOIDEA
FAMILY ARCHAEOBALANIDAE
SUBFAMILY ARCHAEOBALANINAE
Armatobalanus (Hexacrevsia) durhami (Zullo)

This barnacle is a coral epizoan on *Porites californica*. The shell is low, conic, and spreading, and the color is usually a pink to pale violet. The surface is ornamented by numerous low ribs that usually extend well beyond the shell circumference. The barnacle is visibly divided into six unequal sections, and the orifice is usually diamond-shaped. *Armatobalanus durhami* is generally found overgrown by the host coral to varying degrees, often obliterating the sutures and radii. The opercular valves (of living specimens) are covered with a purple-black membrane, both inside and out. This barnacle has been collected from the mid-Gulf as far south as the Tres Marías Islands but may possibly range as far as Panama, as does the host coral. It has also been reported on *Porites californica* from Pliocene and Pleistocene deposits in the Gulf of California. This species was formerly known as *Balanus durhami*. The association appears to be one of commensalism, rather than parasitism.

Conopea galeata (Linnaeus)

The shell of this barnacle is usually elongated along the carinorostral axis, with the carina decidedly higher than the other compartments. In most cases the barnacle is overgrown by the gorgonian host to which it is attached. If the shells are cleaned, the parietes are seen to be smooth and pink or dark red. The radii are broad and slightly sunken. The basis is also elongated along the carinorostral axis. In general, most gorgonians (and other octocorals) live below the low tide mark, thus establishing *Conopea galeata* as a subtidal species. It was recorded by the "Albatross" at depths of 540 m. This barnacle is known to range throughout the Gulf, north as far as southern California and south to the Galápagos. It also occurs on the Atlantic coast of North America, from South Carolina, through the Gulf of Mexico to Venezuela. This species was formerly known as *Balanus galeatus*.

FAMILY BALANIDAE
Balanus eyerdami Henry

The growth form in this barnacle is conic to cylindrical, with the color varying from red to lavender or purple. The orifice is large, trigonal, and deeply toothed. The parietes are generally smooth, although they may have a wavy appearance due to variations of the color intensity. Concentric growth lines are visible under magnification. The radii are moderately broad, transversely striate, glossy, and rather deeply sunken. The radii and alae are usually dark. This barnacle normally attains heights of 20–40 mm but approaches 60–70 mm when the basis is lengthened. Like most other barnacles this one is not infrequently found attached to shells. The most distinctive field characters are the combination of size, color, and the deeply toothed orifice. Henry (1960) stated this species represents a Pacific form of *Balanus spongicola*, a common barnacle occurring throughout the Atlantic and Indian oceans. *Balanus eyerdami* is presently known only from the Gulf of California, having been recorded from Guaymas, Isla San Diego, and the south side of Isla Tiburón, from shore to 85 m. It has been found most commonly offshore, on various shells.

Balanus amphitrite Darwin

This is another widely distributed and well-known species of acorn barnacle, containing numerous subspecies. In this species, the base is calcareous and tubiferous (and the parietes are also permeated by tubes). The parietes are purplish-blue to red with white lines, and the radii are a drab white. The base diameter may reach 25 mm, but it is usually much less. The species superficially resembles *M. californicus;* however, it may be distinguished by its hidden alae, the paries and radius being the only exposed section of the plate. It is found in tropical, subtropical, and warm temperate seas of the world. Henry and McLaughlin (1975) have recently published a treatise on the barnacles of the *Balanus amphitrite* complex.

Two subspecies occur in the Gulf of California, *B. amphitrite inexpectatus* Pilsbry and *B. amphitrite amphitrite* Darwin. The former ranges from western Baja and the Gulf to Ecuador, the latter is cosmopolitan in warm and temperate seas. *B. amphitrite inexpectatus* attains diameters of 17 mm and heights of 10 mm; it attaches to rocks but is also commonly found attached to shells, especially those of oysters. The orifice is diamond-shaped or trigonal. *Balanus amphitrite amphitrite* has a slightly toothed, trigonal orifice, and a low conic growth form. The apex of the rostrum is recurved. This subspecies occurs on rocks, primarily below the low tide level, commonly down to 10 feet or so. It is a euryhaline barnacle, having a salinity tolerance range of 16–50 parts per thousand, and is common in shallow bays and lagoons and is also known to occur in the highly saline regions of the Suez Canal. This may well be the subspecies referred to by Carlton (in Smith and Carlton, 1975:18).

A form of *Balanus amphitrite* also occurs in abundance in the Salton Sea of California. Rogers (1949) described it as *Balanus amphitrite saltonensis*. It was likely introduced many years ago from the Gulf of California or the coast of California, and it greatly resembles *B. amphitrite inexpectatus*. It occurs in all parts of the Sea, apparently having found near-optimal growing conditions there. It differs from *B. a. inexpectatus* in being smaller and having a slightly different growth form, wherein the sides are nearly parallel and the orifice is about the same size as the base. This particular type of morphological change is not uncommon where barnacles grow in extremely crowded conditions, and Linsley and Carpelan (1961) have shown that this barnacle assumes a more conical shape when grown in laboratory conditions. The shell is generally much thinner and lighter than in the oceanic forms. Shells are washed up on the beaches of the Salton Sea in great numbers, to be disarticulated and eroded by water and wave action, forming a sort of coarse calcareous sand. The result of this phenomenon has been to alter certain parts of the shoreline, changing it from mud to a shell-sand beach, the crushed barnacles being several feet thick in some areas.

Balanus pacificus Pilsbry

In this species the parietes are weakly ribbed (occasionally smooth), with pink to purple stripes. This barnacle is strongly conical, with a thin, flat base, and a maximum diameter of around 20–25 mm. It shows a preference for settling on other animals, as well as rocks, and is not uncommon on shells and crustacean exoskeletons, particularly crab legs. Two subspecies are known from the Gulf of California. *Balanus pacificus pacificus* Pilsbry ranges from southern California to Chile. It has a diamond-shaped to ovate orifice, the parietes tend to be smooth, and the radii are broad, with the summits forming angles of 45 degrees or less with the base. The opercular valves are tinted wine red both inside and out near the apices. *Balanus pacificus mexicanus* Henry occurs in the lower Baja California–Mazatlán region. Larger specimens are steeply conic with small ovate orifices, and most have longitudinal striae on some of the parietes. The radii vary in width from moderate to narrow. Large specimens reach 18 mm in diameter and 13 mm in height.

Hurley (1973) discussed the general biology of *B. pacificus* but apparently did not differentiate between the two subspecies that are sympatric along the coast of Baja. She stated that *B. pacificus* fits many of the criteria of a fugitive species: it has a tendency to occur on small ephemeral objects in the sand rather than in established multi-species communities on large rock surfaces; it shows a high fecundity; it has an early age of maturity; and, it breeds continuously throughout the year (in her study area). In these regards it greatly resembles its congener *B. trigonus*.

Balanus trigonus Darwin

The growth form is a low cone, the orifice characteristically trigonal, although it is occasionally pentagonal. The parietes are ornamented with weak ribs or striae, and the radii are broad, transversely striate, and glossy. The general color is purplish-red, although the radii tend to be pale pink or white. The basal diameter is 10–25 mm. This barnacle may be found on almost any inanimate object in the sea, including octocorals, stony corals, crustaceans, and stones. It rarely occurs above the mean low tide mark and has been recorded to depths of 3000 m. This is a short-lived, cosmopolitan, opportunistic species, common on ships' bottoms. In Japan it commonly settles on the carapace of various crabs. It typically occurs in large clusters, but it may also be solitary. Ayling (1976) has described the orientation strategies of this barnacle, which orientates itself at right angles to the axis of wave-surge movement. This allows the animal to swivel the cirral net 90° in either direction to take advantage of both the advancing and the retreating surge flows. In a constant current regime the cirri beat with the current flow, not against it (the reverse strategy of most littoral barnacles).

Balanus improvisus Darwin

This is a small, uncommon barnacle, usually around 9 by 12 mm, with a white shell that is often covered with a dull yellow epidermis. The orifice is somewhat pentagonal and moderately toothed. *Balanus improvisus* is a euryhaline Atlantic species that has been introduced to our coast, probably by hitchhiking on ships' bottoms or on the Virginia oyster *(Crassostrea virginica)*. This oyster has been repeatedly introduced to the west coast of America since 1869. The occurrence of *B. improvisus* in the eastern Pacific is patchy, but it has been recorded from various localities in Oregon and California and by Cornwall (in Steinbeck and Ricketts) from the Gulf of California. It seems to prefer brackish water of bays and estuaries, where it grows on shells, pilings, and other objects, in the low intertidal and subtidal. It is a common species throughout the entire north Atlantic, Caribbean, Red Sea, and Indian Ocean regions, particularly in estuarine habitats. The planktonic larvae of this barnacle have been reported in waters where the salinity is as low as 2 parts per thousand, and it is the only barnacle that survives the brackish Gulfs of Finland and Bothnia.

Megabalanus spp.

This genus of acorn barnacle is one of the best known in the world. Numerous species have been described, several of them known only from ship bottoms.

Members of this genus are easily recognized by their large size (10 to 50 mm in basal diameter) and red, or purple, and white vertical striations. The parietes are permeated by tubes, as are the radii, which are well developed. The parietes and alae of each plate are exposed and easily visible. The shell base is nearly circular, while the wall plates form a conical to elongate (or tubular) shell. Members of this genus are common inhabitants of ship bottoms, wharf pilings, and rocks in the low and mid intertidal zone.

Two species probably occur in the Gulf, *Megabalanus californicus* (Pilsbry) (formerly *Balanus tintinnabulum californicus) and M. peninsularis* (Pilsbry). The former ranges from San Francisco, California, to the Gulf, the latter from the southern Gulf to Acapulco. *Megabalanus peninsularis* is an intertidal form, while *M. californicus* seems to occur primarily near the low water mark and off shore. Coe and Allen (1937) found that the critical temperature below which the spawning of the latter species is inhibited is approximately 16°C and that their long spawning period may result in two complete generations in a single calendar year in certain regions. This form is known from Pleistocene deposits throughout Baja California. Both of these species were formerly considered as subspecies of *Balanus tintinnabulum*. There is a third species known to occur from Mazatlán south to Panama, *Megabalanus coccopoma* (Darwin), although Jordan and Hertlein (1926) recorded it from Pliocene deposits at Turtle Bay, Baja California. Figure 10.4.

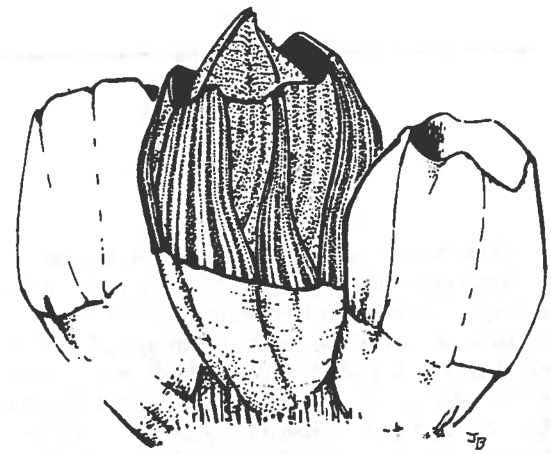


Fig. 10.4 *Megabalanus* sp.
(from Allen, 1976)

11

ARTHROPODA: CRUSTACEA
Amphipoda (Amphipods)

Preservation: See general preservation, Crustacea.

Taxonomy: The taxonomy of this group is based principally on the external anatomy (figs. 11.1 and 11.2), in particular that of the various appendages. Owing to the overwhelming number of amphipods, both in individuals and species, and their generally small size, the taxonomy and identification of this group have become largely a matter for specialists. For this reason, Dr. J. Laurens Barnard, one of the world's foremost amphipod experts, was called upon. He graciously agreed to write the following on amphipod identification, as well as the taxonomic key.

"Identification requires patience and careful microscopic technique. The following key is designed so that only a few operations are required. The key fits mainly the upper half of the Gulf and deals with the rocky intertidal gammarideans only. To properly use the key the following items will be needed: high quality compound and dissecting microscopes, glass slides and cover slips, glycerine, needles, fine jeweler's forceps, and depression slides. If depression slides are not available to mount the thick body parts, use flat slides with pins or sand grains to hold the cover slip above the animal parts. Do not attempt, at first, to identify one isolated amphipod. Rather, collect several hundred and sort out many similarly appearing ones. This will give you a *series* to work with, allowing comparisons and making identification easier.

"Cut off the last three body segments in one piece and place them in a drop of glycerine on a glass slide and cover with a clean cover slip. Be sure that the top of the last three segments points upwards. Examine this with a compound microscope, locating *uropod 3* and the *telson*. The structure of these plus general observations of the body under the dissecting scope will provide most of the data to use the key.

"The mount of the posterior end of the body is the most important observation. These last three body segments are known collectively as the *urosome* and bear three pairs of *uropods* and a single telson. Identify uropods 1 to 2 so as to eliminate them from your search for uropod 3 and the telson. Usually uropod 3 is large and easily seen, but in three genera *(Heterophlias, Corophium,* and *Podocerus)* it is very small, and one

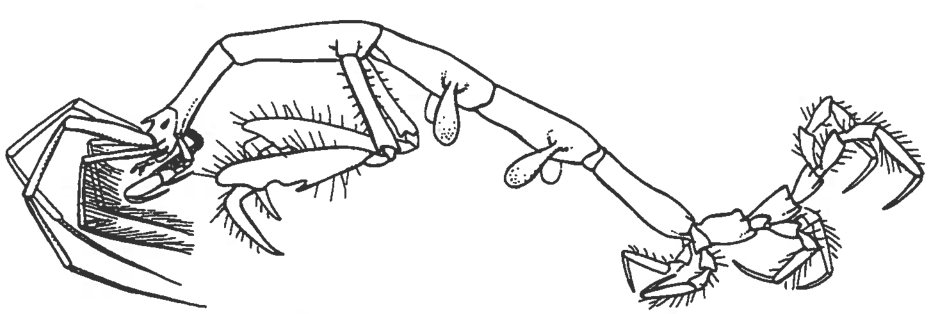


Fig. 11.1 A caprellid amphipod
(from Allen, 1926)

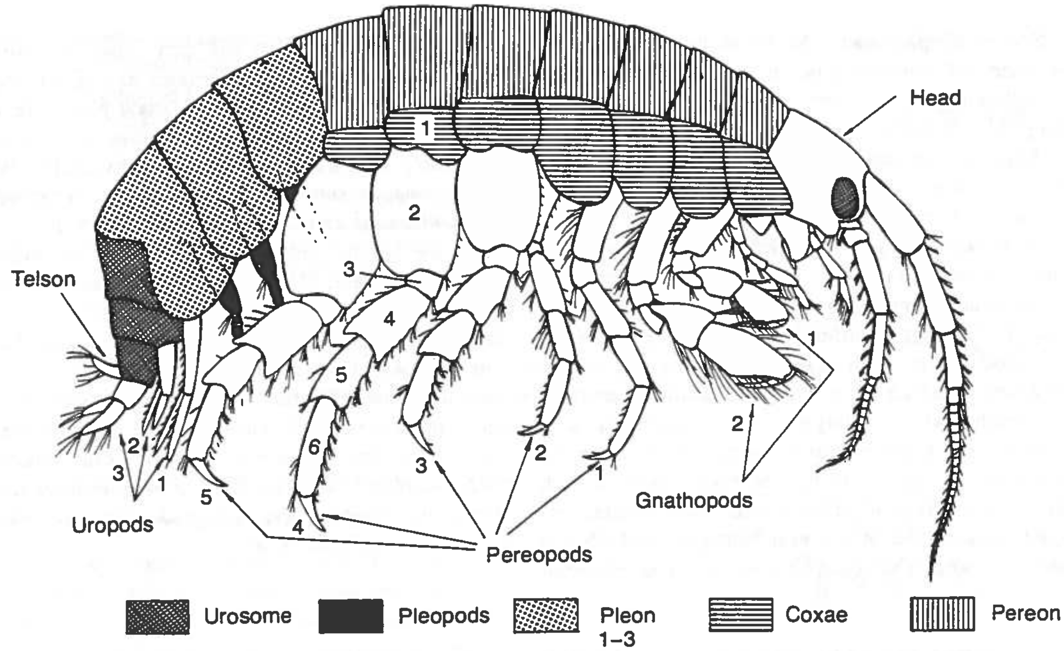


Fig. 11.2 Amphipod morphology
(modified from Barnard, 1969b)

may have to overturn the urosome and observe it from a ventral view. In this case, it will appear as a small flap below the telson. If no definite third uropod is found, discard the specimen, as all amphipods in this key have a third uropod. Several genera, especially *Pontogeneia*, tend to lose the third uropod during collecting and transporting of specimens. The telson is always symmetrical but is occasionally damaged, one half being lost. This can be confusing and misleading, as the damaged telson then appears to be uncleft (formed of only one lobe).

"You may need to examine *antenna 1* to find the *accessory* (secondary)*flagellum*. This lies on the medial and distal end of article 3 of the first antenna (antenna 1). It may be large and visible under the dissecting scope, or it may be small, making it necessary to mount the antenna on a glycerine slide and search it out. If the specimen has broken antennae, do not attempt identification. The *rostrum* may be seen by depressing the antennae with a pin while holding the amphipod with forceps. In some cases you will need to observe the rostrum from the top view *(Heterophlias)*, but in others, when the *mandibular palp* needs to be seen, it can be observed under the dissecting scope by searching beneath antenna 2 where it joins the head. The palp is a long, flexible setose appendage. Do not confuse this with the *maxillipeds*, those larger mouth parts covering the entire mouth field.

"If one is to deal with the amphipods effectively, one must become a serious student of their taxonomy. If one is making a biological survey of communities and a casual amphipod is collected (a few specimens only), it is scarcely worthwhile trying to identify these, or even have an expert deal with them. Amphipods are so abundant and diverse that a lone record or two of a few broken specimens is virtually worthless. Time rather should be spent dealing with vast quantities of specimens. When submitting specimens to an expert, one should ensure that they be well-preserved, in clean preservative and placed in a small glass vial, stoppered with cotton, this small vial then placed in a larger vial or jar and stoppered. A paper label should be enclosed in the large vial but not in the small vial with the amphipods. Large paper labels ruin specimens by rubbing off appendages. The label should be small and bear a code number. In the letter sent to the expert, the full collection data should be keyed to the code numbers in the vials. Do not enclose large labels in the vials as these are a nuisance to the expert. Always be certain to obtain permission from the specialist before sending him the material.

"The following key is carried only to genus, as species have not yet been fully studied in the Gulf. For a double check of your identifications, you may also utilize the keys to genera in Barnard (1969b). Most of the literature of the Gulf amphipods may be found in Barnard (1969a), but identifications to species remain difficult because of poor descriptions, misidentifications, and sparsity of illustrations in the literature."

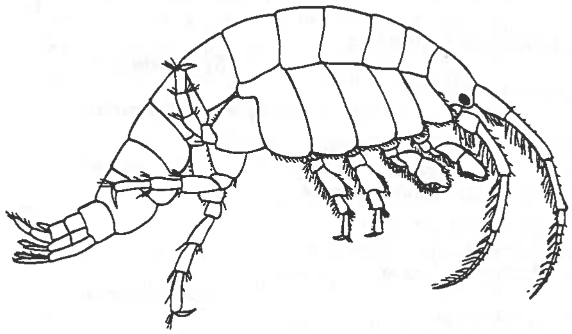


Fig. 11.6 *Photis* sp.
(from Barnard 1969b)

Gammaropsis Liljeborg

Accessory flagellum 3- or more articulate; article 3 of antenna 1 equal to or longer than article 1; gnathopods subchelate; uropod 3 biramous, rami equal to each other, variable in length, generally equal to or longer than peduncle.

FAMILY AMPITHOIDAE

Ampithoe Leach

Antenna 1 lacking accessory flagellum; mandible with palp; gnathopods large, subchelate, gnathopod 2 equal to or larger than 1; article 6 of pereopods 3 to 5 scarcely widened apically, rarely prehensile; outer ramus of uropod 3 with two hooks. There is a large green species of this genus that occurs throughout the upper Gulf. Figure 11.7.

FAMILY AORIDAE

Lembos Bate

Article 3 of antenna 1 shorter than article 1, accessory flagellum present; male gnathopod 1 subchelate, with articles 4 to 5 lacking teeth, article 6 not narrower but usually longer than 5, female gnathopod 1 subchelate; male gnathopod 2 subchelate, with article 5 longest, poorly setose on anterior edge; rami of uropod 3 equal, longer than peduncle.

FAMILY LEUCOTHOIDAE

Leucothoe Leach

Coxa 2 at least as long as broad, rounded ventrally and anteriorly, coxa 1 not concealed; mandibular palp 3-articulate; outer plate of maxilliped reaching less than halfway along palp article 1. Figures 11.8 and 11.9.

FAMILY OEDICEROTIDAE

Synchelidium Sars

Cutting edge of mandible projecting, toothed, molar small, conical, with apical spine, unringed; inner lobes of lower lip flat but separate; gnathopods dissimilar, gnathopod 1 subchelate, stout, article 5 forming a lobe guarding article 6, gnathopod 2 slender, chelate, article 5 unproduced; uropod 2 reaching end of uropod 3. Figures 11.10 and 11.11.

FAMILY AMPHILOCHIDAE

A large family (17 genera) of amphipods, represented in the Gulf by a number of species. Accessory flagellum absent; coxa 1 very small, partially hidden by following coxae; rostrum conspicuous; coxae 3 to 4 enlarged, either overlapping or, when immensely enlarged, with contiguous margins abutting; uropod 2 shortened; uropod 3 biramous, peduncle elongate; telson entire in all but one genus, often elongate and triangular, also short and linguiform.

FAMILY TALITROIDEA

Hyale Rathke

Article 4 of maxillipedal palp unguiform; gnathopods subchelate in both sexes, male gnathopod 2 larger than 1, article 5 not projecting between articles 4 and 6, female gnathopod 2 like gnathopod 1; uropod 3 lacking inner ramus; telson cleft. One occasionally finds hugh colonies of these amphipods burrowed into the sand above the daily high water line, their presence indicated by thousands of small, slightly elevated holes in the sand. At night they are active, emerging from their burrows to scavenge the beach wrack. They appear to feed largely on cast-up algae, especially *sargassum*. Figure 11.12.

FAMILY EUSIRIDAE

Pontogeneia Boeck

Accessory flagellum absent; gnathopods not eusirid, article 5 not lobate, slightly longer than article 6; pereopods 3 to 5 with articles 4 to 6 each not longer than article 2, article 4 slender; outer lobes of lower lip not broadly separated. Figure 11.13.

FAMILY GAMMARIDAE

Elasmopus Costa

Accessory flagellum three or more, occasionally 2-articulate; lower lip with inner lobes; gnathopods normal; uropod 3 variable in length, rami equal, rectangular, outer 1-articulate; telson deeply cleft; urosome occasionally with dorsal teeth; palp article 3 of mandible falcate, stout.

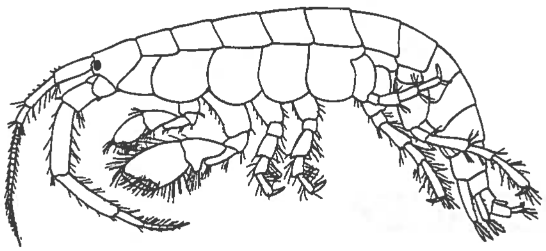


Fig. 11.7 *Ampithoe* sp.
(from Barnard 1969b)

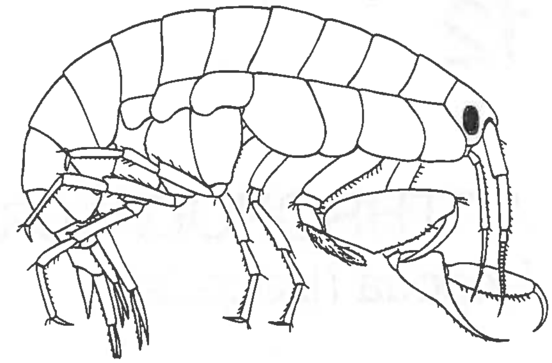


Fig. 11.8 *Leucothoe* sp.
(from Barnard 1969b)

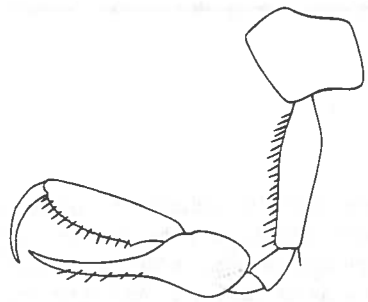


Fig. 11.9 *Leucothoe* sp., gnathopod 1
(from Barnard 1969b)

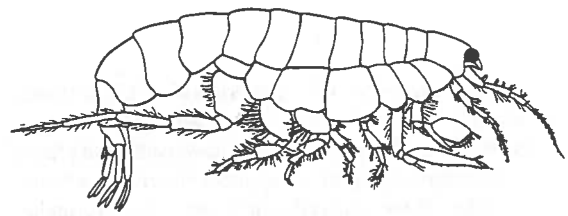


Fig. 11.10 *Synchelidium* sp.
(from Barnard 1969b)

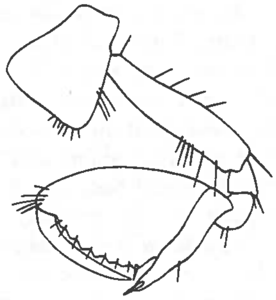


Fig. 11.11 *Synchelidium* sp., gnathopod 1
(from Barnard 1969b)

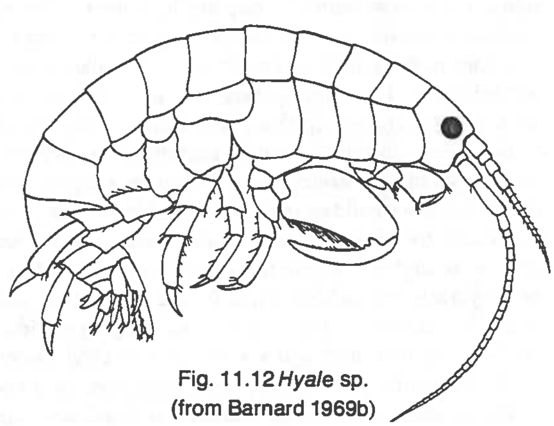


Fig. 11.12 *Hyale* sp.
(from Barnard 1969b)

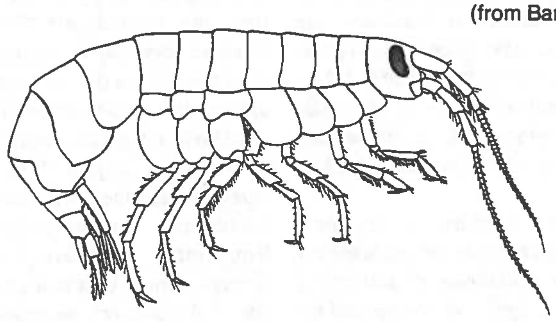


Fig. 11.13 *Pontogeneia* sp.
(from Barnard 1969b)

12

ARTHROPODA: CRUSTACEA
Isopoda (Isopods)

Preservation: Most isopods should be killed (fixed) by placing them in 15 percent formalin for a few seconds. After death, the specimens are washed and placed in a 70 percent solution of alcohol (preferably ethanol) for storage. If the material is left too long in formalin, the exoskeleton begins to decalcify and the muscles and tendons have a tendency to stiffen, making it difficult to manipulate or dissect the animal during later observations. Like most animals, isopods lose their color in alcohol; however, color is rarely used as a taxonomic character in this group, and most are a rather bland color to begin with. For some species, in a few groups (such as anthurids) chromatophore patterns have been shown to be reliable features to aid in identification. For this reason, should a distinct color pattern be evident, descriptive notes should be made prior to preservation. It is important that these, and any small crustaceans, not be allowed to dry out. Should this occur, your material can be rehydrated by soaking it in a 0.5 percent solution of trisodium phosphate for 1–2 days (or in polyethylene glycol), and then thoroughly washing it in clean water before transferring back to alcohol. Fragile species, such as *Ligia*, some of the small anthurids and asellotes, the interstitial forms, arcturids, etc., should be relaxed prior to killing. This can be accomplished by use of a 1 percent solution of chloretone, added slowly to the small container housing the specimen. Lack of immediate response to physical prodding indicates the isopod is relaxed and ready to be fixed.

Taxonomy: Isopods form one order of the superorder Peracarida, which is that group of crustaceans characterized (in part) by the possession of a thoracic brood pouch for the developing eggs and young, and by the absence of a carapace (or possession of a reduced carapace). They are generally considered to be phylogenetically the most advanced group of peracarids (the peracarids also include the amphipods, mysids, cumaceans, tanaids, and the rare Spelaeogriphacea). Although not included in this edition of the handbook (owing to rarity and inadequate understanding) cumaceans (*Cumella* sp.) and tanaids (*Anatanais* sp. and *Leptochelia* sp.) do occur in small numbers in the Gulf intertidal. The isopods are distinguished from all other peracarid groups by the following combination of characters: sessile eyes, dorsoventrally depressed body, an abdominal heart, 5 pairs of lamellate pleopods, a single pair of uropods, and usually 7 distinct thoracic segments, each with a pair of subsimilar, nonchelate, uniramous legs. Needless to say, occasional exceptions to some of these features can be found within the group.

The generalized isopod body plan is diagramed in figure 12.1. As can be seen, the body is divided into three regions: the *cephalon* (head), the *pereon* (thorax), and the *pleon* (abdomen). The head bears the following sets of paired appendages, from anterior to posterior: *antennae one* (often called the antennules or inner antennae); *antennae two;* the *mandibles;* the first and second *maxillae;* and the *maxillipeds*. The maxillipeds (as the name implies) are actually derived from the first thoracic appendages, whose body somite became fused with the head in the evolutionary past of this group. The appendages of the head are illustrated in fig. 12.2.

The free thoracic region is referred to as the *pereon*, its segments as *pereonites*. The paired legs of each pereonite are the *pereopods*. In all groups except the Gnathiidae, the genus *Colathura*, and some of the Bopyridae, there are 7 pairs of pereopods. The pereopods may be ambulatory, subchelate, or "prehensile." Ambulatory pereopods are simple, not strongly recurved, and used primarily for walking. "Prehensile" pereopods have the terminal article, the *dactyl*, strongly developed and recurved, to be used for clinging or

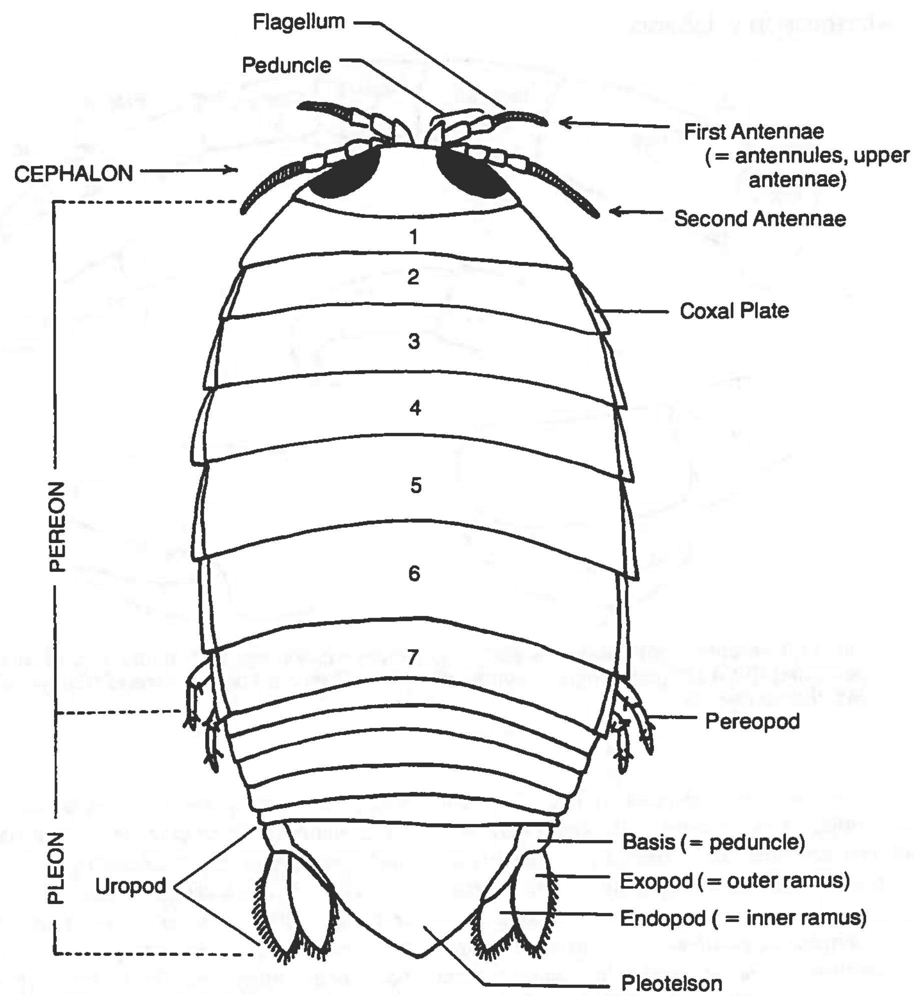


Fig. 12.1 General anatomy of an isopod

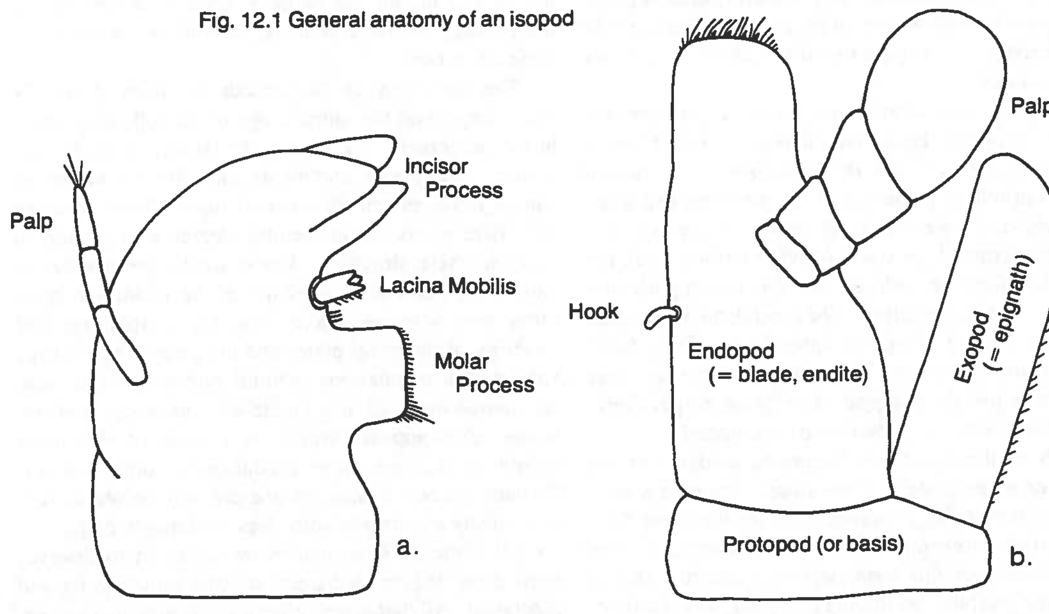


Fig. 12.2 Head appendages in isopods. (a) Mandible. (b) Maxilliped.

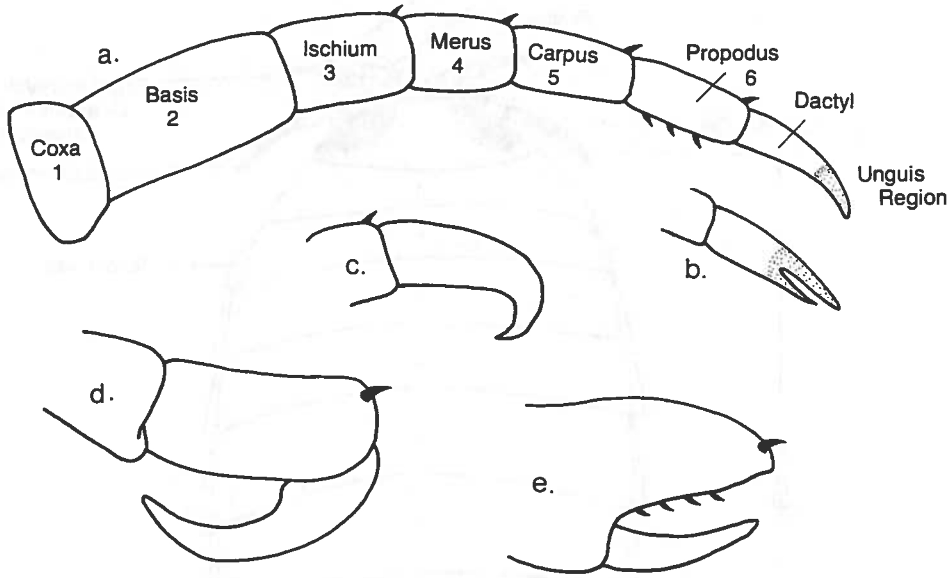


Fig. 12.3 Perepod (leg) types in isopods. (a) Simple walking leg, with simple unguis (uniunguiculate). (b) A bifurcate unguis (biunguiculate). (c) Recurved or "prehensile" dactyl. (d, e) Subchelate dactyls.

grasping. Pereopods are illustrated in fig. 12.3. The basal-most article of the pereopods (the coxa) may form two important structures. It develops an outward expansion that folds up to fuse (completely or only in part) with the lateral margin of its respective pereonite. This structure is termed the *coxal plate* (incorrectly referred to as an "epimere" in some works). In females several coxae also expand medially, forming thin lamellar plates covering the ventral surface of the pereon. These are the *oostegites*, which form the brood pouch, or *marsupium* of lady isopods.

The abdomen is referred to as the *pleon*, its segments being the *pleonites*. Each pleonite bears a pair of lamellate appendages termed the *pleopods*. The isopod abdomen primitively consists of six pleonites and a terminal telson. However, in all groups except the anthurids the terminal, or sixth, pleonite is fused with the telson, thus forming a *pleotelson*. The anus opens subterminally on the pleotelson. The pleotelson bears a pair of *uropods*, representing the appendages of the fused sixth abdominal segment. Each uropod bears an inner and outer ramus, the *endopod* and *exopod*, respectively, arising from the *basis* (= peduncle or protopod).

Much of the frustration beginning students of the Isopoda experience stems from sloppy use of the morphological terminology as reflected in the literature. One particularly good example is the term "prehensile." The strict definition of this term implies a structure that is adapted for grasping or clinging. As such, this is a functional term; this definition, when applied to a real appendage, allows for a variety of interpretations (but not, perhaps, the variety that one actually encounters in the literature.) Three other terms that have been variously interpreted are "subchelate," "segment," and "article." These, and other important terms, are defined in the glossary of this text; it is strongly recommended that students using the arthropod sections of this handbook, or any other literature, be thoroughly familiar with the correct definitions of terms used in describing the morphology of these animals, as well as variations on these definitions.

The taxonomy of the Isopoda has been classically based largely on the morphology of the following structures: pereopods, pleopods, pleotelson, uropods, antennae, coxal plates, and mouth parts. Recent studies on isopod development and natural history have revealed that there exists a considerable degree of variation in many of these structures. For example: the number of antennal articles and the shape of the pleotelson quite often vary with age and/or sex; the morphology and visibility of the coxal plates and the general body shape vary within populations (natural polymorphism); and, the morphology of the pleotelson, uropods, and antennae often appear variable in a series of specimens owing to damage from predation or other causes. Perhaps the best characters one can rely on not to vary excessively are the pleopods, legs, and mouth parts.

All of the above structures are quite easy to observe, even those requiring dissections (the mouth parts and pleopods). All that is needed is a dissecting microscope, two pairs of good forceps (jeweler's forceps are excellent), and a thin probe (an insect pin stuck through the eraser end of a pencil makes an excellent probe for microscopic work). If you prefer to mount an appendage on a slide, do so in alcohol or glycerine, and, when finished with your observations, replace it in alcohol. I do not recommend the use of commercial mounting media as they make manipulation of the appendages difficult, lack long-lasting optical clarity, and do not preserve crustacean material properly. Keep the appendages in small vials (labeled), stoppered with cotton, in the same jar with the specimen from which they came. In most cases stains are not required and a good transmitted light will bring out all of the features, right down to the hairs and spines of the maxillipeds. If a stain is needed, borax carmen stain is good, as the material can be destained in alcohol until the proper color is attained for best observation.

Isopods of the Gulf: The isopod crustacean fauna of the Gulf of California is poorly known. Steinbeck and Ricketts reported 12 species from this region, of which 5 range from the Gulf northward and none have strictly Panamic affinities. Some of their identifications, however, remain questionable. Ohmart (1964) reported 8 species from the upper Gulf, in the region of Puerto Peñasco. Schultz (1969) reported only four species with distributions in the Gulf *(Codonophilus gilberti, Codonophilus gaudichaudii, Rocinela aries*, and *Rocinela tuberculosa)*. Hansen (1897) recorded 2 species from the 1891 "Albatross" expedition to the Gulf of California *(Rocinela laticauda* and *Pseudione galacanthae)*. Brusca (1977, 1978a, and 1979) has reported 5 species of Cymothoidae from the Gulf, and Brusca and Wallerstein (1977, 1979) reported 11 species of Valvifera from this region. Bowman (1977) reported 10 species from the collections of the 1938 "Presidential Cruise." Of the 42 species of isopods (*Cirolana californiensis* not included) treated in this handbook: 12 (29 percent) are temperate in origin; 11 (27 percent) eastern Pacific tropical; 3 (6.5 percent) amphiamerican; 13 (31 percent) are presently known only from the Gulf; and 3 (6.5 percent) are widespread throughout both the Californian and Cortez provinces. The systematics and biology of the tropical east Pacific isopod fauna are presently being studied by the author of this handbook and his students. These studies include a series of familial monographs on the Gulf of California isopod fauna. At the time of this writing the family Idoteidae had been published, and the families Excorallanidae, Cirolanidae, Aegiidae and Cymothoidae were in preparation. Specimens sent to the author for study will be appreciated.

The following key allows one to distinguish between all nine suborders of isopods known from throughout the world: Epicaridea, Anthuridea, Valvifera, Flabellifera, Oniscidea, Gnathiidea, Microcerberidea, Asellota, and Phreatoicidea. Only the first five of these are presently well represented in my collections and discussed in this chapter. Pennak (1958) described a member of the suborder Microcerberidea *(Microcerberus mexicanus)* from a beach near Acapulco (including this group in the family Anthuridae). There have been no subsequent records of this species. The phreatoicids are known only from the Australian region.

Following the key to the suborders are keys to the Gulf of California genera in each of these taxa. Unfortunately the fauna of this region is still so poorly known that the keys must remain, for this edition, at the generic level.

KEY TO THE SUBORDERS OF ISOPODS (OF THE WORLD)

1 Parasitic on crustaceans; female much larger than male and with slightly to highly distorted bilateral symmetry; pereopods present, absent or reduced (fig. 12.29) .... **Epicaridea** (page 238)
-Not parasitic on crustaceans; females subequal or larger than males, but with strong bilateral symmetry; pereopods always well developed 2

2(1) Body with only 5 free pereonites and 5 pairs of pereopods; 2 pairs of maxillipeds (the second pair being the flattened pylopods) .... **Gnathiidea**
-Body with 7 free pereonites and 6–7 pairs of pereopods; 1 pair of maxillipeds 3

3(2) Body more or less compressed (flattened side to side, as in the gammarid amphipods); fresh water (known only from the Australian-New Zealand region) .... **Phreatoicidea**
-Body depressed or tubular; marine, estuarine, fresh water, or terrestrial 4

4(3) Primarily terrestrial; first pair of antennae rudimentary (fig. 12.30) .... **Oniscidea** (page 238)
-Primarily aquatic; first pair of antennae not rudimentary (but may be quite short) 5

5(4) Uropods modified into a pair of covers folded under the abdomen and covering the pleopods (figs. 12.19–12.28) .... **Valvifera** (page 235)
-Uropods not as above (lateral or terminal) 6

6(5) Body elongate, length greater than 6 times width; body tends to be tubular 7
-Body not elongate, length less than 4 times width; body depressed 8

7(6) Length usually greater than 4 mm; uropods folded up and partially over the telson (figs. 12.19–12.20) .... **Anthuridae** (page 233)

-Length usually less than 3 mm; uropods not as above; minute interstitial forms .... **Microcerberidea**

8(6) Uropods lateral, hinged at sides of pleotelson to form a "tail fan"; first or second pleopods never form operculate covers for remaining pleopods (figs. 12.4–12.18) .... **Flabellifera** (page 224)

-Uropods terminal (hinged on posterior margin of pleotelson), minute and usually styliform; first or second pleopods often modified into thin opercular plates covering remaining pleopods .... **Asellota**

KEY TO THE GENERA OF THE SUBORDER FLABELLIFERA

1 Pleon composed of 3 or less visible free segments, plus the pleotelson 2

-Pleon composed of 4–5 free segments, plus the pleotelson 5

2(1) Pleon composed of a single free segment, plus the pleotelson; body ovate in cross section (dorsum strongly convex); cephalon free (family Sphaeromatidae) 3

-Pleon composed of 3 free segments, plus the pleotelson; body strongly depressed, flat in cross section; cephalon fused medially with pereonite one (family Serolidae) .... ***Serolis***

3(2) Uropods uniramous, only a long endopod present (fig. 12.4); first pair pereopods subchelate; posterior border of pleotelson never deeply notched .... ***Ancinus***

-Uropod biramous, the small exopod being present and fused with the basis; first pair pereopods not subchelate; posterior border of pleotelson often notched 4

4(3) Exopod of uropods capable of sliding under endopod; both rami of uropods similar; exopod of pleopod 3 of 1–2 articles .... ***"Dynamenella"***

-Exopod of uropods not capable of sliding under endopod; exopod and endopod (of males) markedly different; exopod of pleopod 3 always of 2 articles (figs. 12.5–12.8) .... ***Paracerceis***

5(1) Uropods greatly reduced, with small clawlike exopod; body less than 3 mm in length; burrowing in wood or algal holdfasts (family Limnoridae) .... ***Limnoria***

-Uropods normal, both exopod and endopod flattened; body usually greater than 3 mm in length; not found burrowing in wood or algae 6

6(5) All pereopods prehensile (family Cymothoidae) 7

-No pereopods, or just anterior pereopods prehensile 10

7(6) Border between cephalon and pereon trisinuate; cephalon never deeply immersed in pereon (fig. 12.14) .... ***Nerocila***

-Border between cephalon and pereon never trisinuate; cephalon more or less deeply immersed in pereon 8

8(7) Basal articles of antennae 1 dilated and touching (fig. 12.17) .... ***Codonophilus***

-Basal articles of antennae 1 not dilated and touching 9

9(8) Pleon abruptly narrower than pereon, throughout its length (fig. 12.18) .... ***Cymothoa***

-Pleon not abruptly narrower than pereon, forming a continuous convex body margin with it (figs. 12.15–12.16) .... ***Lironeca***

10(6) Mandibles without a lacina mobilis and molar process; middle article of maxillipedal palp greatly elongated; maxilla 1 with outer lobe forming a single, large, robust, recurved spine; anterior pereopods prehensile (family Excorallanidae) .... ***Excorallana***

-Mandibles with a lacina mobilis and molar process; articles of maxillipedal palp subequal in length; maxilla 1 not as above; anterior pereopods ambulatory or prehensile 11

11(10) Anterior pereopods strongly prehensile; maxillipedal palp of 2 OR 5 articles (family Aegidae) .... ***Rocinela***

-Anterior pereopods not prehensile, OR only weakly prehensile; maxillipedal palp with 4–5 articles (family Cirolanidae) 12

12(11) Front of head with a spatulate process that bisects the sets of antennae; antenna 2 with 4 peduncular articles .... ***Excirolana***

-Front of head not as above; antenna 2 with 4–5 peduncular articles 13

13(12) Basal articles of antennae 1 thin and very close together, exiting from the head straight forward, the second articles then forming right angles to extend the antennae laterally; peduncle of antenna 2 of 4 articles; basis of uropod with inner angle produced OR not markedly produced .... ***Eurydice***

-Basal articles of antennae 1 normal, not as above; peduncle of antenna 2 of 5 articles; basis of uropod always with inner angle markedly produced .... ***Cirolana***

FAMILY SPHAEROMATIDAE

Pleonites largely fused, usually with partial suture lines evident; body shortened, length usually not over 2 times width; endopod of uropods rigidly fused with peduncle; sexual dimorphism often marked.

Members of this large family of isopods differ markedly from all other marine forms in several regards. One is their ability to roll up into a ball (like the terrestrial pill bugs or sow bugs). Another is that the fertilized eggs are often withdrawn into invaginations on the ventral surface of the pereon and are thus not free in the marsupium as in other groups. Males of species in this family often have the exopod of the uropods greatly elongated and extended posteriorly. The body of many sphaeromatids is spiny or strongly tuberculate.

Sphaeromatids are common intertidal and shallow water forms, generally rather small (about 4–10 mm in length), and many are good swimmers. The pereopods of the swimming species are well supplied with long natatory setae. Sphaeromatids are especially common under rocks and in association with other organisms, such as encrusting sponges and bryozoans.

The systematics of this group is in need of reexamination and generic revisions. Many of the genera are poorly understood and difficult to discriminate among. A good summary of Hansen's (1905) treatment of the Sphaeromatidae may be found in Menzies and Glynn (1968).

Genus *Ancinus* Milne Edwards

A distinctive genus of sphaeromatids, in which the first pereopod is subchelate and the second (in males) prehensile (or at least strongly recurved). The uropod is reduced to a single, long styliform process, and the second pleopod forms an operculate covering over the remaining pleopods (at first resembling the abdomen of a valviferan isopod).

The systematics of this genus are presently in a state of confusion. There have been 4 species described from the west coast of America: *A. granulatus* Holmes and Gay, *A. daltonae* Menzies and Barnard, *A. seticomvus* Trask, and *A. panamensis* Glynn and Glynn. The first 3 are known only from California, while the last has been recorded from Panama and Colombia. The taxonomic status of these 4 species, plus the 2 species known from the Atlantic [*A. brasiliensis* Lemos de Castro and *A. depressus* (Say)] is still being debated, and the reader is referred to the following publications for a complete review of this New World genus: Lemos de Castro, 1959, 1969; Loyola e Silva, 1963, 1967, 1971; Schultz, 1973; Glynn and Glynn, 1974). Schultz (1973) reduced *A. seticomvus* to a junior synonym of *A. granulatus*.

A species of *Ancinus* that appears to be somewhat intermediate between *A. panamensis* and *A. granulatus*

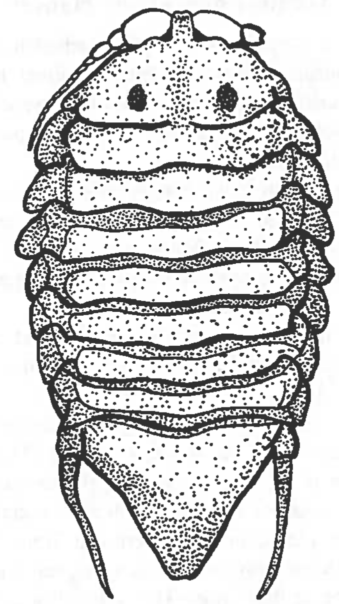


Fig. 12.4 *Ancinus* sp.

occurs in the shallow, tidal flat pools left behind by the retreating tides in the northern Gulf of California. It is a small white isopod, 3–6 mm in length (fig. 12.4). It may be found by carefully running one's finger through the fine sand sediment in these pools, which generally induces the animal to emerge and swim about in the shallow water for a few seconds. The sediment from the pools can also be sieved or screened if such apparatus is available.

Genus "*Dynamenella*"

This genus is placed in quotation marks because reliable taxonomic characters for distinguishing species of the very similar genera *Dynamenella* and *Dynamenopsis* in North American forms are not known. Steinbeck and Ricketts reported an unidentified species of *Dynamenella* from the Gulf of California, and Schultz (1969) reported four species of this genus from the west coast of North America in general, including *D. dianae* Menzies from Bahía de San Quintin and *D. glabra* (Richardson) and *D. benedicti* (Richardson) from Monterey Bay, California. Glynn (1968) described *Dynamenella josephi* and *D. setosa* from Panama. I have collected what appears to be *Dynamenella benedicti* from tidepools at Puerto Peñasco, and two additional species in the north-central Gulf region. Whether or not these actually represent 3 distinct species or are morphological variations of a single species is a problem that remains to be solved. One of these "new" species also appears very similar to *D. dianae*.

Genus *Paracerceis* Hansen

Apex of pleotelson strongly notched in males and with a ventral, somewhat tubular channel in females; exopod of uropods in males about twice the length of the endopod (subequal in females); dorsum of pleon usually with ornamentation.

This genus has had a complicated taxonomic history related, in part, to the pronounced sexual dimorphism seen in most species. Males are generally strikingly ornate with the uropodal exopod developed into an extremely long caudal process and with a complex pleotelson incision, variously notched and carved. In addition there is evidence that morphological variation with age occurs.

I have recorded two species of *Paracerceis* from the Gulf of California: *Paracerceis sculpta* (Holmes) and *Paracerceis* sp. (a new species, as yet undescribed). The former has been found in the north and central Gulf and is also known to occur in southern California. The latter I have collected only on Isla San Esteban and Isla San Pedro in the central Gulf. The possibility of these two forms being ecological varieties or ecotypes of *Paracerceis sculpta* is raised by this unusual distribution and presents still another problem that needs investigating in this part of the Pacific.

Paracerceis sculpta (figs. 12.5–12.6) and *Paracerceis* sp. (figs. 12.7–12.8) are often found living in the chambers of calcareous sponges such as *Leucetta* and *Leucosolenia*, in the intertidal zone. Occasionally a single male and female will be found paired and occupying an individual chamber in a sponge. Because of the confusion that surrounds many members of this genus, I have provided illustrations of both the males and the females of these two isopods, from which they can be differentiated. This genus was referred to by Richardson (1905a) as *Cilicaea*.

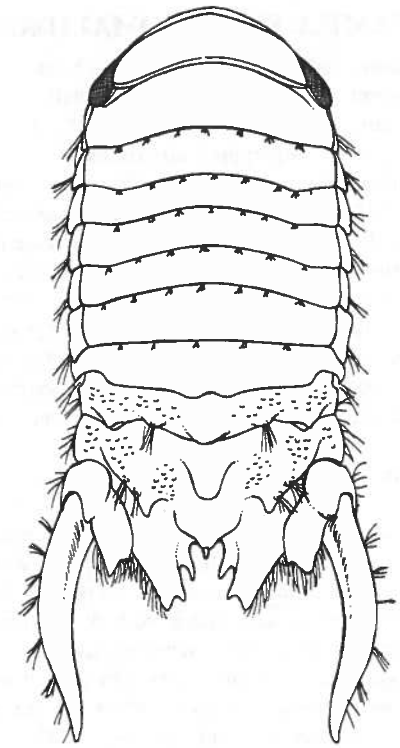


Fig. 12.5 *Paracerceis sculpta*, male

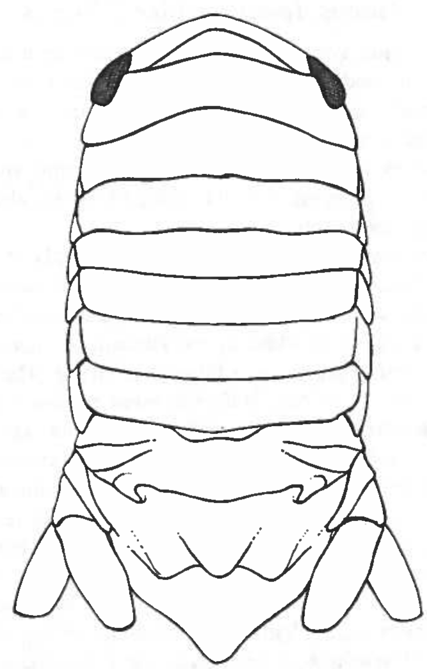


Fig. 12.6 *Paracerceis sculpta*, female

FAMILY CIROLANIDAE

The body is sleek and evenly contoured, with distinct coxal plates on pereonites 2–7; the pereopods are usually ambulatory, although the first 3 pairs often tend toward a prehensile form; the pleon is usually comprised of 5 distinct pleonites, plus the pleotelson; the uropods are well developed and form a distinct tail fan with the pleotelson; both pleotelson and uropods typically bear marginal setae and/or spines; the peduncle of antenna 2 is of 4 or 5 distinct articles; the palp of the mandible is of 3 articles; the palp of the maxilliped is of 4 or 5 subequal articles; and, the mandible possesses a well developed lacina mobilis and molar process.

The majority of the cirolanids are free living, predaceous or meat-eating scavengers. Some burrow in sand or live under rocks; others spend the majority of their lives in the algal and animal turfs of hard substrates, mussel beds, and algae holdfasts. Nearly all seem to enter the water column at times, some doing so on a regular basis (e.g. *Eurydice*). In this regard most are graceful swimmers, well supplied with appendage setae to aid in this function. They are easily captured by baiting with dead fish on or in the substrate, in the intertidal and shallow subtidal regions.

Cirolanids are strong biters, and swimmers in tropical and warm temperate seas will commonly feel the sharp bite of one of these isopods that has emerged from hiding to take a meal from passing prey (in this case the swimmer). Three easily distinguished genera are known from Pacific North America, *Cirolana*, *Excirolana*, and *Eurydice*.

Genus *Excirolana* Richardson

Head with a frontal, spatulate process, produced anteriorly to separate the basal articles of the antennae, and dilated distally (fig. 12.9); uropods and pleotelson furnished with long setae; rami of uropods with marginal spines (except in the Malaysian *E. kumari*); pleopods with both branches long and slender.

A small genus of quite distinctive isopods; the long spatulate head process setting them apart from all other genera. There seems to be but one species of *Excirolana* in the Gulf, *E. braziliensis* Richardson. It occurs in great numbers and is undoubtedly an important animal in the ecology of the sandy beaches of this region. This little pale to brown isopod lives buried beneath the sand on nearly every beach I've visited in the Gulf, from El Golfo de Santa Clara to La Paz. It has two rather different and distinct feeding behaviors. The first occurs during the high tides. The isopod patiently waits for the tide to begin to flow above the approximate +1 foot level, whereupon it emerges from its seclusion to swim freely about in the water column, seeking a passing fish. When a prey fish is located, the isopod grabs ahold and rides about for a few minutes while taking its meal. The mandibles are powerful and strongly fitted for chewing and

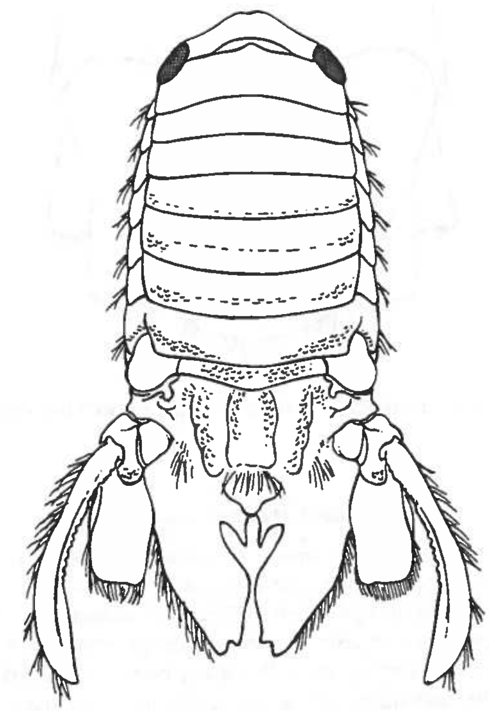


Fig. 12.7 *Paracerceis* sp., male

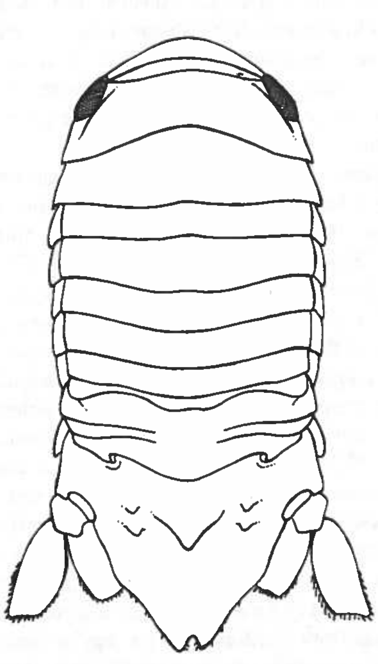


Fig. 12.8 *Paracerceis* sp., female

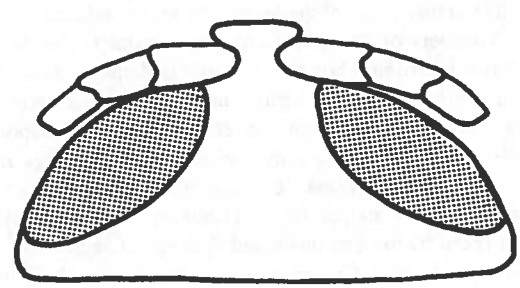


Fig. 12.9 *Excirolana braziliensis*.
Head (note spatulate frontal process).

biting (not sucking). One easy way to capture this animal is simply to stand quietly in about 4 feet of water on a sandy beach at high tide and wait for it to find you, which it does with great tenacity, seemingly able to seek out places on one's body where the skin is particularly thin for its attack. The other feeding behavior occurs primarily during the low tides, when this isopod becomes an important beach scavenger. A dead fish washed ashore on a sandy beach, from the lower mid intertidal on down, will quickly be reduced to a mere skeleton as literally thousands of these crustaceans emerge from the sand to consume the refuse. The scavenging behavior can become quite bothersome when one is sitting on the beach attempting to sort through a fish collection from a seine haul.

Excirolana braziliensis occurs in the Caribbean Sea also, and Glynn et al. (1975) have reviewed its distribution and habitat, stating that it is a wide-ranging species on tropical, subtropical and temperate American beaches. The reproductive and molting cycles of a similar excirolanid, *E. chiltoni*, have been studied by Klapow (1970, 1972).

The younger growth stages of *E. braziliensis* were described by Bott (1954) and Schuster (1954) as new species (*Cirolana koepckei* and *Cirolana salvadorensis*, respectively), and Dexter (1972) misidentified it as the similar *Cirolana maya* Ives. This last species is also an amphiamerican form (known from both coasts of America) but appears to be strictly tropical in distribution.

Members of the genus *Excirolana* are ovoviviparous, maintaining the eggs and developing embryos in the paired oviducts of the female, which function as uteri. The reduced oostegites in this genus function as a genital operculum, rather than as a brood pouch.

Genus *Eurydice* Leach

Peduncle of second antenna of 4 articles; first antennae with basal articles touching and extended straight in front, at right angles to the remainder of the antenna; pleon of five segments plus pleotelson; uropods with plumose setae; uropods generally ventral to pleon and with the inner angle of the basis very little produced.

Members of this genus are very similar to those of the genus *Cirolana* but may be quickly distinguished by their unusual antennal arrangement (described above) and the weakly produced inner angle of the uropod basis. I have recovered only one species of *Eurydice* in the Gulf of California, *E. caudata* Richardson, described from Catalina Island (California) in 1899 and later taken by the Steinbeck and Ricketts expedition and the Presidential Cruise of 1938 from the Gulf of California south to Ecuador. This little isopod is an active swimmer, and I have found it to be a common crustacean, attracted to night lights hung from ships, throughout the entire Gulf. It is easily recognized by its strongly truncate uropods and pleotelson (fig. 12.10).

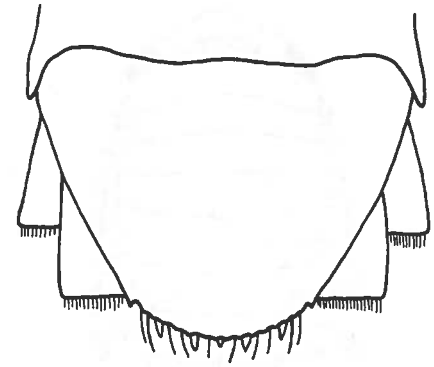


Fig. 12.10 *Eurydice caudata*. Pleotelson, with uropods.

Genus *Cirolana* Leach

First peduncular article of antenna 1 normal (not projecting outward at right angles to the remainder of the antenna, as in *Eurydice*); peduncle of antenna 2 of 5 articles; basis of uropoda with inner angle strongly produced; 5 pleonites, the fifth usually being considerably smaller than the preceding 4 (and with its lateral margins generally covered by pleonite 4).

The cirolanids are common and abundant in almost all shallow water marine habitats. Certain predaceous species are occasionally referred to as parasites, no doubt because they are often found attached to a swimming fish. This is incorrect, however, as these predatory isopods cling to a passing fish only long enough to take a meal, then swim away (a behavior seen also in *Excirolana braziliensis*). At least three species of *Cirolana* occur in the Gulf but only two of these have yet been described.

Cirolana parva Hansen is a cosmopolitan species first described from our coast as *Cirolana diminuta* (Menzies, 1962, from Bahía San Quintin on the outer coast of Baja). It occurs throughout the Gulf and is characterized by the following features: eyes well developed; antenna 1 with 7–12 flagellar articles; antenna 2 with 22–29 flagellar articles; maxillipedal endite small, with 2 coupling hooks; pleotelson triangular, with plumose marginal setae and 8 marginal spines; rami of uropods with serrate margins and a deep apical notch. (See fig. 12.11.) This species ranges, on our coast, from Point Conception to west central Mexico, and probably further south. It shows a predilection for coral crevices, sponge interstices and algal turfs, and has been collected at depths ranging from the low intertidal to 145 m.

Cirolana californiensis Schultz is a subtidal species that ranges from California all the way to South America. It is most commonly collected in deep trenches and offshore basins, but I have taken it in shallower depths in the southern Gulf. It is blind (without eyes, or if eyes are present they lack pigmentation), with 8–12 flagellar

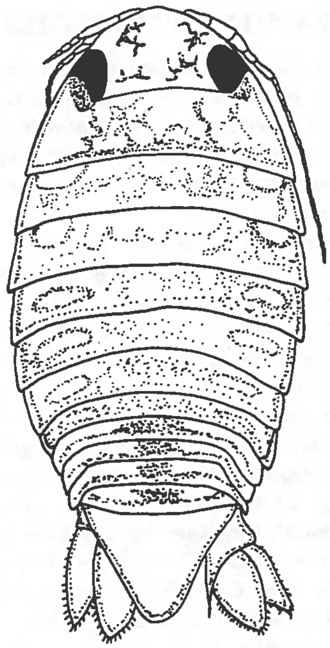


Fig. 12.11 *Cirolana parva* (after Menzies, 1962)

articles in the first antenna, 10–21 in the second, and the pleotelson bears 8–12 small marginal spines and long plumose setae. The uropods are smooth and lack the distinctive apical notch of *C. parva*.

FAMILY EXCORALLANIDAE

The Excorallanidae is monogeneric, the single genus *Excorallana* thus having the same characters as its family: mandibles without lacina mobilis or molar process; incisor elongated; maxillipedal palp of 5 articles, middle article elongated; maxilla 1 with apex of outer lobe (exopod) with a single, large, stout, recurved spine; eyes usually well developed, often contiguous, or nearly so; pleonite 1 generally obscured by pereonite 7; dorsum of body often with tubercles, carinae or setae.

Excorallana Stebbing

Two species of *Excorallana* occur in the Gulf, one of which is named and described, the other not. *Excorallana kathyae* Menzies is easily recognized by the fact that the entire dorsum of its body is covered with long, golden setae, particularly in the posterior region. In addition, all of the pleonites bear denticles on their posterior margins, while pleonites 3–5 have large, paired, median tubercles. This species occurs from Point Conception (California) south to central west Baja, and is encountered only infrequently in the Gulf of California. The second, and undescribed species of *Excorallana*, bears a morphology equally as distinctive as that of *E. kathyae*. The cephalon is strongly tuberculate and the front is thrust out and upward to form a large, thin, anterior shield. I've collected this unusual beast throughout the Gulf, but never in large numbers.

FAMILY AEGIDAE

Large, cirolanidlike isopods with well developed eyes and well defined coxal plates; peduncle of both pairs of antennae stout and well defined; pleopods and pleotelson with plumose setae; pereopods 1–3 prehensile, pereopods 4–7 ambulatory; distal article of palp of maxilliped with stout, recurved spines; pleon of 4–5 segments (plus the pleotelson).

Members of the family Aegidae are active predators on fish, which may be classified as "temporary parasites." They cling tenaciously to their "host fish" while taking a meal, but are not known to display much host specificity. Members of this family may be thought of as representative of an evolutionary stage between the free living, predaceous cirolanids and the truly parasitic cymothoid isopods. Only a single genus is so far known from the Gulf.

Genus *Rocinela* Leach

Maxillipedal palp of 2 articles; pereopods 1–3 with inside margin of propodus expanded and armed with stout setae or hooks; body strongly depressed.

Schultz (1969) reported three species of *Rocinela* as occurring in the Gulf of California: *R. tuberculosa* Richardson (fig. 12.13), *R. signata* Schioedte and Meinert (fig. 12.12), and *R. laticauda* Hansen. *R. aries* was made a junior synonym of *R. signata* by Menzies and Glynn (1968). I have collected *R. tuberculosa* throughout the Gulf and around to Scammon's Lagoon, on the west coast of Baja California. There is another form of *Rocinela* occasionally found in the northern Gulf, which appears to lack the minute tubercles or punctae seen on *Rocinela tuberculosa*. Whether this represents a new species or simply a variety of the latter is not known at this time. The two appear similar in all other respects. The four species of *Rocinela* known from this region can be differentiated by the following key:

1	Pleotelson wide, as wide as cephalon .... ***R. laticauda***	
	-Pleotelson narrower than cephalon	2
2	All 5 pleonites distinct (fig. 12.12) .... ***R. signata***	
	-Only 4 pleonites distinct	3
3	Dorsal surface with minute punctae (fig. 12.13) .... ***R. tuberculosa***	
	-Dorsal surface without punctae .... ***R. sp.***	

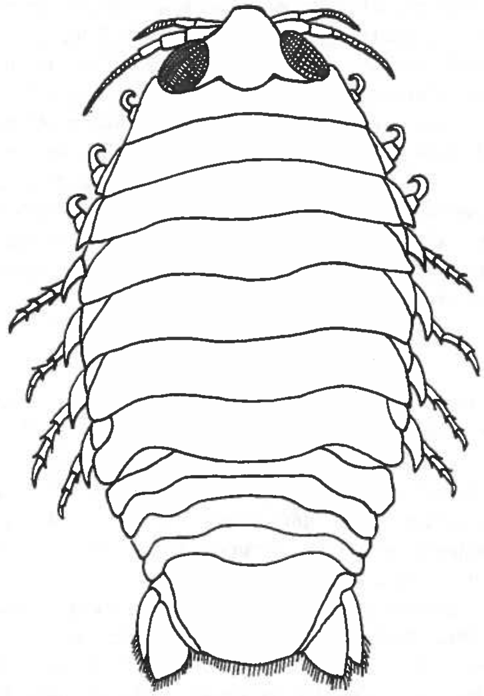


Fig. 12.12 *Rocinela aries*

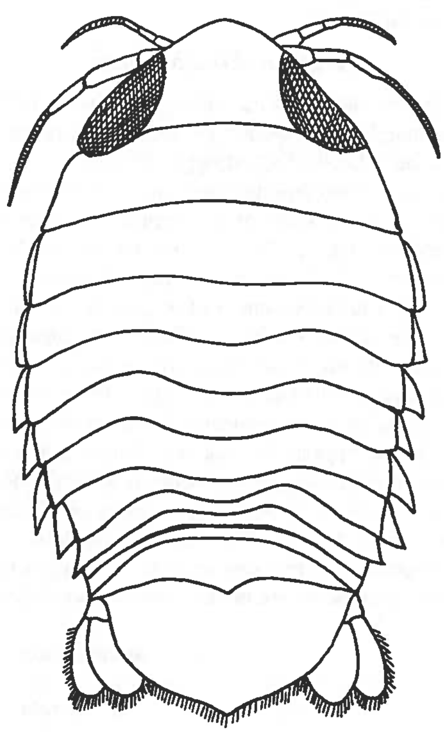


Fig. 12.13 *Rocinela tuberculosa*

FAMILY CYMOTHOIDAE

Body cirolanidlike; all pereopods prehensile; maxillipedal palp of two articles, terminal article with 1 to several stout clawlike setae; antennae reduced, not elongate, and without a clear distinction between the peduncle and flagellum; pleopods (of adults) without setae; external symbionts of fishes.

The cymothoid isopods are generally described as being parasites on fishes and certain invertebrates. They are not, however, always parasitic, and it is unlikely any are natural parasites of anything other than fish. The family is quite large, over 100 species having been described worldwide. In the eastern Pacific nine genera have been reported, as follows: *Lironeca*, *Irona*, *Codonophilus*, *Nerocila*, *Cymothoa*, *Anilocra*, *Idusa*, *Braga*, and *Aegathoa*. The existence of members of the genus *Braga* in the eastern Pacific is questionable, as this is a tropical, freshwater genus known from the east coast of South America. Boone's (1918) record of *Braga occidentalis* from California therefore remains questionable. Likewise, Richardon's (1904) single record and description of *Idusa carinata* from Panama remains in need of further documentation. Lastly, the genus *Aegathoa* is now known to be a polyphyletic group, composed of juveniles of other genera of cymothoids. This reduces the number of assuredly valid east Pacific genera to six (*Lironeca*, *Codonophilus*, *Cymothoa*, *Irona*, *Anilocra*, and *Nerocila*). Of these six evidence is accumulating from my own investigations that members of the last named genus are indeed parasites, while in the other genera it may eventually be shown that it is only the males that should be considered as true parasites, the females more properly being regarded as commensals. Host specificity appears to be fairly high for some species (e.g. *Codonophilus gilberti*) but quite low for others (e.g. *Nerocila californica*). Further discussion on these topics may be found in the generic descriptions that follow.

The cymothoids are some of the largest isopods (reaching 60 mm in length) and are one of the most interesting of all the crustacean families. They greatly resemble members of the family Aegidae and are quite likely descended from an ancestral form related to that taxon of "temporary" parasites. One of the most striking features of the family Cymothoidae is their sex reversal, known as protandric hermaphrodism. As the name implies, juveniles first mature as males, and later in their life reverse sex to become functional females. Brusca (1978a) has shown that this sex reversal takes place in *Nerocila californica* in a single molt, and it is likely that most, if not all, eastern Pacific cymothoids do likewise (at least superficially). Isopods generally molt in two stages: first a split forms in the cuticle between the 4th and 5th pereonite; then the posterior half of the body is molted; several hours later the anterior half is finally molted. It has been said that the strategy behind this molting pattern is to allow copulation to take place at the time when the female is molting, while the chitin of the posterior half of the body is still soft and before the oostegites form to cover the oviducts. In the cymothoids, this molting behavior results in the unique phenomenon of intermolt-intersex individuals, wherein the broad posterior region is female in character, but the narrow anterior region is still male.

For more details on this interesting group of isopods the reader is referred to Brusca (1977, 1978a, b) and other references in the bibliography.

Genus *Nerocila* Leach

Head posteriorly produced into three lobes; first pair of antennae often almost contiguous at base; mandibular palp of three articles; posterolateral angles of most pereonites produced; body often with three dark, longitudinal stripes on the dorsum; pleonites well developed.

Only a single species of *Nerocila* has been reported from the west coast of America, *N. californica* Schioedte and Meinert, known to range from southern California, throughout the Gulf and south to Peru (fig. 12.14). This handsome isopod clings tenaciously to the surface of various fishes, including the following: surfperch, leather jack, anchovy, flounder, and mullet. It will also cling tenaciously to you, should you allow one to crawl from a captured fish onto your hand or arm. The recurved (prehensile) dactyl articles of the legs and hooked setae of the maxillipeds serve to hold this animal firmly in place upon its host. The usual place of attachment is near the base of a fin, and in heavily infested regions many of the host fishes mentioned above will show definite signs of damage and skin erosion due to *Nerocila californica*. Brusca (1978) has shown that this species undergoes 2–3 molts as a male, then reverses sex to live through 3–4 molts as a female. Copulation has never been witnessed in this animal and the behavioral mechanisms involved remain a mystery, although the act is presumably consummated on the host fish itself. It will be noticed that all of the hosts listed above belong to one or both of two distinct ecological categories: schooling fishes and/or bottom (demersal) fishes. Both of these types of fish have behaviors that would clearly aid in the spread of an infestation of this parasite. One of the characteristic features of *N. californica* is the lateral expansion of pleonites 1 and 2. There exists, in the Gulf of California, another type of *Nerocila*, lacking these lateral expansions. Whether this represents a new species or not is still being studied. All too often, in the past, taxonomists have been too quick to publish names and brief descriptions of what they wanted to consider as a new species, only to find later that it represented a morphological variation of an already well known animal.

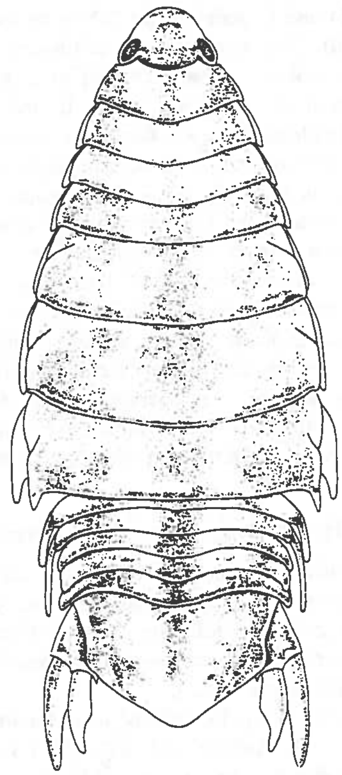


Fig. 12.14 *Nerocila californica*, female

Genus *Lironeca* Leach

Body suboval, often twisted slightly to one side or another; head deeply immersed into first pereonite; first pair of antennae widely separated at base; pleon not much narrower than pereon, except for pleonites 1 and 2, which may be narrow and immersed in pereon.

Of the 15 species of *Lironeca* described from the New World, 4 have been reported from the east Pacific. The species of this genus, known from the east Pacific, show few morphological differences between one another. As in most genera of cymothoids, the characters I have found to be most reliable are those of the abdomen (pleotelson, uropods, and pleopods). Members of this genus, and the following two genera of cymothoids, are characterized by having parasitic males that attach to the gill rakers and filaments of their host fishes, feeding on them. The females, however, appear primarily to be commensals, living in the throat of the host fish and not feeding at all (or feeding only very infrequently). One of the most interesting behaviors to witness is the release of the young by the female. An occasional angler or trawler will be fortunate to capture an ovigerous female in the process of pouring the newly hatched young out through the host fish's gill cavity. Two species of *Lironeca* occur in the Gulf of California: *L. convexa* Richardson (fig. 12.15) and *L. panamensis* Schioedte and Meinert (fig. 12.16). The two may be distinguished by the pleotelson, which is wider than long in *L. panamensis* but not so in *L. convexa*. (Also, if one wishes to examine the pleopods he will find that *L. convexa* has an accessory lobe on the endopod of pleopods 1 and 2, whereas *L. panamensis* does not). *Lironeca convexa* ranges from southern California to Ecuador and has been reported from pompano and the Pacific bumper. *Lironeca panamensis* ranges from northern Baja California (both coasts) to Panama. Its host fish is not known. Recent studies by the author strongly suggest that *L. panamensis* actually represents southern populations of *L. vulgaris*, a temperate species known from Oregon to northern Baja California. Hosts of the latter include various surfperches, rockfish, and the Pacific sand dab.

Genus *Codonophilus* Haswell

Head more or less deeply set into first pereonite; first pair of antennae dilated, contiguous at the base (basal articles of peduncle touching); pleon immersed in pereon, abruptly narrower than pereon; pereopods 4–7 with carinae on basis.

This genus is usually referred to under the generic title of *Meinertia* Stebbing. Hale (1926), however, has pointed out that the latter name is a junior synonym of *Codonophilus*. *Codonophilus* is one of the more poorly known genera of Cymothoidae, and there has been no real work on this group since Stebbing (in the 19th century) first proposed its generic status (as *Meinertia*). This genus is represented in the New World by just 4 species, 2 of which occur on the west coast: *C. gaudichaudii* (Milne Edwards) and *C. gilberti* (Richardson). These 2 isopods may be distinguished by examining the bases of the last 4 pairs of legs, which bear a high carina in *C. gaudichaudii* but do not in *C. gilberti* (fig. 12.17). The former is known to range from upper Baja California (west coast) to Chile, including the Galápagos Islands. I have not yet collected it in the Gulf of California, although I suspect it probably occurs in the southern region. Its host fishes are members of the fast swimming, schooling jacks and tuna, and it has been reported from pompano, bonito, and jacks. *Codonophilus gilberti* ranges from upper Baja California (both coasts) to Mazatlán. Although there have been no records south of Mazatlán, one should not be surprised to find that it ranges considerably beyond that locality. *Codonophilus gilberti* is so far known to be host specific for mullet *(Mugil hospes)*.

Genus *Cymothoa* Fabricius

Caphalon more or less deeply immersed into pereon; first pair of antennae widely separated at base; pleon deeply immersed into pereon, much shorter and distinct from pereon; pleonites increase in length and width from anterior to posterior; pleotelson quadrate.

Like *Codonophilus*, the genus *Cymothoa* is poorly known. There has been little said about the biology of members of this taxon since it was first proposed in 1793. There have been no New World species described in this century. Although 20 or so species are known

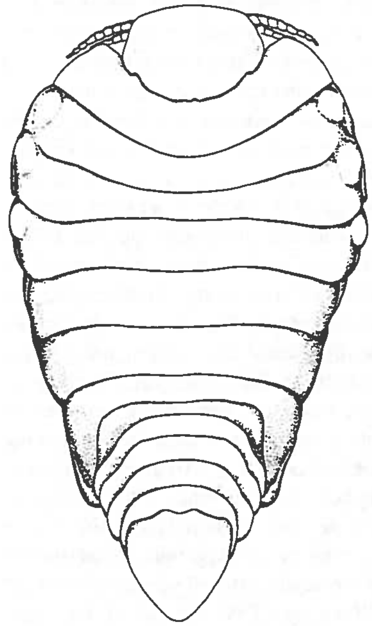


Fig. 12.15 *Lironeca convexa*, female

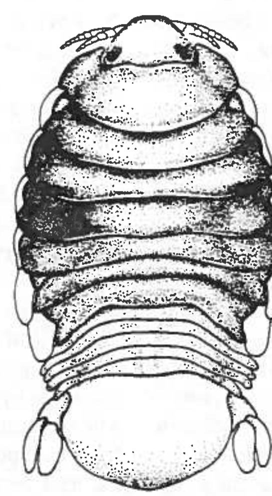


Fig. 12.16 *Lironeca panamensis*, female

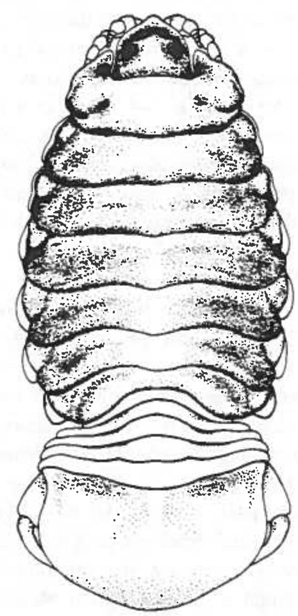


Fig. 12.17 *Codonophilus gilberti*, female

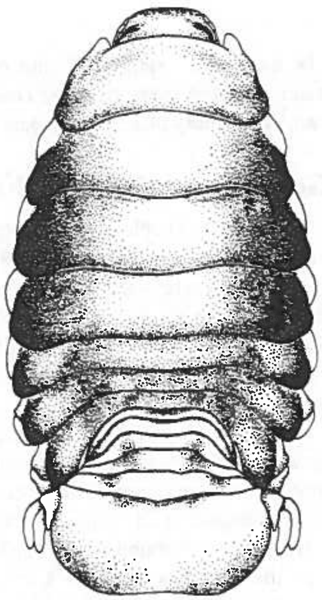


Fig. 12.18 *Cymothoa exigua*, female

worldwide, only 5 have been reported from North America, 2 of which occur in the east Pacific: *C. exigua* Schioedte and Meinert (fig. 12.18) and *C. recta* Dana. The former ranges from the upper Gulf of California south to Panama and the Galápagos Islands. *Cymothoa recta* has been reported only from Hawaii, and its host is not known. *Cymothoa exigua* occurs commonly in grunts *(Orthopristis reddingi)* at least in the northern part of its range. I have witnessed otter trawls, in the northern Gulf of California, that contained literally thousands of grunts, over three-fourths of them infested with this isopod.

FAMILY LIMNORIDAE

The limnorids are minute, wood- and algae-burrowing isopods, characterized by the following combination of characters: antennae separated at base, not contiguous, with scale on antenna 1; mandible lacking lacina mobilis and molar process; peni consisting of a pair of elongate plates which articulate with the body; coxal plates present on pereonites 2–7; uropodal branches tubular or clawlike, not expanded and flattened; pleon of 5 distinct somites plus a large semicircular pleotelson.

Members of this family are often called "gribbles" and are divided into two genera: *Limnoria* Leach and *Paralimnoria* Menzies. *Limnoria* is further divided into two subgenera, *Limnoria* (containing only wood-boring species), and *Phycolimnoria* (containing only algal-boring species). Only the genus *Limnoria* is known from western North America. The gribbles are often considered the most important isopod group in terms of human economy, in that they account for millions of dollars in damage to wooden marine structures annually. In terms of the overall economy of the sea, and its shallow water food webs, they aid in the initial breakdown of dead and dying woody materials. Limnorids not only burrow into wood but actually ingest it, producing their own cellulase enzymes to digest the material. Seasonal migrations are known for several species. The principal predators of these isopods appear to be worms, both polychaetes and turbellarians.

I have recovered only one species of *Limnoria* from the Gulf, an undescribed form that burrows into red mangrove trees in the esteros along the Sonoran coast.

FAMILY SEROLIDAE

Members of this unusual family are characterized by the following combination of characters: body wide and flattened, dorsum strongly depressed; cephalon united medially with pereonite 1; both antennae with multi-articulate flagellum; pereonite 7 usually not visible in dorsal view; pereopods 1 and 2 subchelate in male; pereopod 1 only subchelate in female; pleon of 3 dorsally visible segments, plus the pleotelson; pleopods 4 and 5 large, indurated and operculiform; pleopods 1–3 normal, smaller than the fourth and fifth.

This family is widely distributed on shallow and deep sea bottoms and is especially abundant in the Southern Hemisphere and Antarctica. Only a single species, *Serolis carinata* Lockington, occurs in the Gulf of California, and ranges north to southern California. It has been collected in the low intertidal and to depths of 75 m. It appears to be quite uncommon south of Punta Banda on outer Baja.

KEY TO THE GENERA OF THE SUBORDER ANTHURIDEA

1 With 6 pereonites and 6 pairs of pereopods .... ***Califanthura***
-With 7 pereonites and 7 pairs of pereopods 2

2(1) Without eyes .... ***Cortezura***
-With eyes 3

3(2) Segments of pleon usually distinct and completely separated from one another; with a tooth on palm of pereopod 1; apex of maxillipedal palp pointed; pereonites with diffuse chromatophore pattern .... ***Paranthura***
-Segments of pleon not distinctly separated, often indicated by lateral suture lines or dorsal furrows; without a tooth on palm of pereopod 1; apex of maxillipedal palp rounded; pereonites with distinct chromatophore pattern .... ***Mesanthura***

FAMILY ANTHURIDAE

Small to medium-sized, elongate, subcylindrical isopods; maxillipedal palp of 0–5 articles; 6 or 7 pereonites; pereopod 1 often strongly subchelate, remaining pereopods subchelate to ambulatory; occasionally with lateral grooves or ridges along the edges of the pereonites; uropods arise laterally to curl up and partly over top of telson; usually with long, nonplumose setae on the uropods and telson; statocysts frequently present in telson; sixth pleonite not fused with telson as in other isopods (free telson); sexual dimorphism not uncommon, particularly with regards to the antennae, which may be greatly enlarged and setose in males. Species with piercing and sucking mouthparts have pointed maxillipeds with a palp of only a few articles. Species with biting and chewing mouthparts usually have a more rounded maxilliped and a palp of 1 to 5 articles.

Most anthurids live in tubular burrows they construct in the sediment (or occasionally in the tube of another animal), although many are also known from encrusting organisms, such as matted algae, hydroids, bryozoans, worm tubes, sponges, etc. They are quite different from all other isopods in the possession of an extremely elongate body and the peculiar configuration of the uropods. These features, as well as the presence of a statocyst in many species, are taken to be adaptations to their burrowing or tube-dwelling habit. Burbanck (1974) and others have demonstrated that most, if not all, members of this family can undergo a transition from female to male at some point in their life. The maxillipeds are quite distinctive between the genera in this family and can usually be used to differentiate these taxa.

Anthurids have so far proven to be rather uncommon in the Gulf of California, although 4 genera are represented in my collections. They are perhaps not so uncommon as it would appear, for the small size and fragile bodies make these animals difficult to find and capture. They are well worth the search however, for the chromatophore patterns and sculpturing of some species is a beautiful sight when viewed through a dissecting microscope. The basic treatise on this group of isopods was produced by Dr. K. Barnard (1925), who, it is said, carried out the majority of his observations with only a 10X hand lens, thus attesting to the belief that good biology is, indeed, primarily the product of careful hard work. Work on this family has been plagued by what appears to be excessive "splitting," and of the 7 described species reported from the west coast of North America, each is presently placed in a separate genus.

Genus *Califanthura* Schultz

Pereon with only 6 visible segments (pereonite 7 being minute and hidden between pereonite 6 and pleonite 1); only 6 pairs of pereopods; first antenna with 4 articles (the terminal being the only flagellar article); antenna 2 with 5 articles; mouth parts generally modified for piercing and sucking; maxillipedal palp of 3 articles. This genus was formerly called *Colanthura*.

This is a monotypic genus, containing only the species *C. squamosissima* Menzies. Although this small species (under 6 mm in length) has been reported as a California "coastal shelf" species, recovered in 18–19 m of water, I have found it in tidepools and on *Sargassum* in the northern Gulf of California (fig. 12.19). *Califanthura* may be recognized by its small eyes, vestigial seventh pereonite, flattened telson (lacking statocysts), and triarticulate maxillipedal palp (fig. 12.19).

Genus *Cortezura* Schultz

This genus was recently proposed by Schultz (1977) based on specimens collected at Puertocitos (on the west coast of the Gulf) by Deborah M. Dexter, an ecologist of sandy beaches. The exact type locality is questionable, however, as Schultz describes the beach as being near Puerto Peñasco (on the east coast of the Gulf), and hence named this new species *Cortezura penascoensis*. The genus and species are characterized by the following combination of characters: chewing mouthparts; no eyes; 6 conspicuous pleonites; medial projection of cephalon as long as anterolateral projections; first pereopods subchelate; first pleopods operculate; flagellum of antenna 1 of 2 articles; flagellum of antenna 2 of 1 article; maxillipedal palp with 3 free articles. Although Schultz described this species as lacking statocysts, these structures are in fact present (in the telson).

Cortezura is very similar to the California genus *Bathura*, also a monotypic group. Both genera are blind, have statocysts, and are very similar in overall appearance. I have collected *Cortezura penascoensis* throughout the northern Gulf of California.

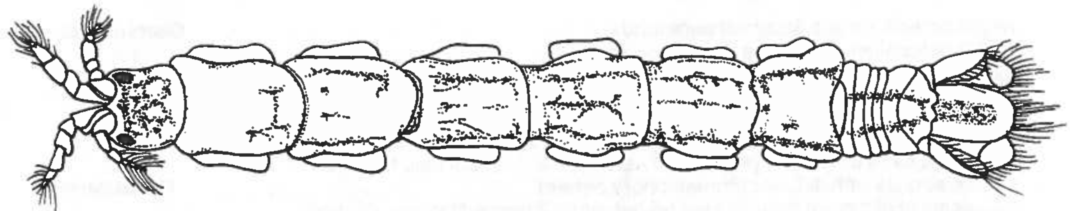


Fig. 12.19 *Califanthura squamosissima* (after Menzies, 1951)

Genus *Paranthura* Bate and Westwood

A heterogeneous assemblage of small anthurids; antenna 1 with multiarticulate flagellum; antenna 2 with rudimentary flagellum of a single article; without statocysts; maxillipedal palp of 3 articles.

Paranthura elegans Menzies is fairly common throughout the Gulf, particularly in the rocky low intertidal and in algal mats. Adults are 8 to 15 mm long, very pale in color, and bear conspicuous pleonal segments. This species was formerly known from Marin County, California, to Bahía San Quintín, on the upper west coast of Baja. In California waters it has been reported from shallow water to depths of 55 m. It is easily overlooked because of its small size.

Genus *Mesanthura* Barnard

Pereon with distinctive pigment patterns and without dorsal pits; pleon short, sutures absent or extremely short; antenna 1 of male with brushlike flagellum; antenna 1 of female with flagellum of 2 articles; antenna 2 with flagellum of 2–4 articles; maxilliped and mandible both with palp of 3 articles; pereopod 1 with sixth article dorsally excavate; pereopods 2–3 with sixth article cylindrical; exopod of uropods apically notched, folding down over telson; female with only 4 pairs of oostegites.

I have found but one species of *Mesanthura* in the Gulf so far. It closely resembles *Mesanthura occidentalis* Menzies and Barnard (known from southern California and the outer coast of Baja), but differs in color pattern, shape of the pleon and uropods, and a few other features. It is about 20 mm long, quite attractive, and has been collected from algal mats in the rocky intertidal region of the northern Gulf (fig. 12.20).

One cannot help but speculate on the origin of what appears to be a Gulf of California endemic form, such as this species of *Mesanthura*. There are only 2 species of *Mesanthura* described from North America (Schultz, 1969): *M. occidentalis*, a Pacific warm temperate species, and *M. pulchra*, an Atlantic Caribbean species. From which of these species did our new Gulf form originate? Did it reach the Gulf of California through the Panama seaway, or did it move into the Gulf around the tip of Baja California, possibly during the last glacial period?

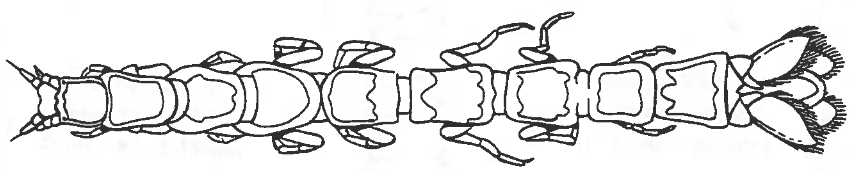


Fig. 12.20 *Mesanthura* sp.

KEY TO THE GENERA OF THE SUBORDER VALVIFERA

1	Pleon composed of 3 distinct segments; flagellum of antenna 2 multiarticulate (figs. 12.21–12.25)	***Idotea***
	-Pleon composed of a single segment; flagellum of antenna 2 multiarticulate OR reduced to a single article (figs. 12.26–12.28)	2
2(1)	Flagellum of antenna 2 multiarticulate (fig. 12.26)	***Colidotea***
	-Flagellum of antenna 2 reduced to a single article	3
3(2)	Coxal plates dorsally visible only on pereonites 6–7; lateral margins of pleon smooth and gently convex; pleon with an anterior partial suture line, indicating a single fused segment (fig. 12.27)	***Eusymmerus***
	-Coxal plates dorsally visible on pereonites 2–7; lateral margins of pleon straight or expanded posteriorly; pleon with or without a partial suture line anteriorly (fig. 12.28)	***Erichsonella***

FAMILY IDOTEIDAE

Valviferan isopods with the body generally somewhat depressed; ovate, oblong, or elongate; first pair of antennae usually shorter than second pair; flagellum of antenna 1 usually of a single article; mouth appendages well developed, primarily of the chewing and biting type; maxillipedal palp of 3–5 articles; pereopods ambulatory, more or less similar, anteriormost ones occasionally subchelate; pleon composed of 1–3 free pleonites; pleotelson well defined; uropods operculate, usually uniramous. The oral appendages of this family have been discussed in detail by Collinge (1918).

Idoteids are rarely encountered in large numbers, and most are retiring, secretive animals. They usually live somewhat solitary lives, clinging quietly to various algae during the day and moving about during the night. They are omnivorous and are known to feed largely on seaweeds, but also on dead and decaying fish and other animal material, and small invertebrates. Most are crawlers and clingers, but some are known to be good swimmers. The seaweed clingers have powerful legs with enlarged dactyls for grasping the algal leaves and stems. Certain species show a preference for specific habitats, such as a particular alga or a mussel bed assemblage. Most idoteids seem to prefer clean clear water; some, however, are known to inhabit the oxygen deficient mud of bay sediments, where sulfur bacteria thrive (*Idotea neglecta* Sars, in Europe, for example). Remarks on the ecology of this family may be found in Kjennerud (1950), Bate and Westwood (1868), Matzdorff (1883), Rauschenplat (1901), Collinge (1918), Wahrberg (1930), Elmhirst (1946) and Dollfus (1895).

The idoteid isopods of the Gulf of California are presently being studied by Brusca and Wallerstein (1977, and manuscripts in preparation).

Genus *Idotea* Fabricius

Eyes lateral; maxillipedal palp composed of 4 or 5 articles; pleon composed of 2 segments, plus the pleotelson (a third pleonite is represented by a pair of lateral incisions only); antenna 1 with a rudimentary flagellum; antenna 2 with a multiarticulate flagellum; pereopods 1–7 ambulatory and similar.

This genus is composed of two subgenera, the distinguishing characteristic between the two being the number of articles present on the palp of the maxilliped. Members of the subgenus *Idotea* have palps composed of four articles, while species of the subgenus *Pentidotea* have palps consisting of five articles. It has been shown, however, that certain species of *Pentidotea* can have only four articles to the maxillipedal palps when young, these palps later differentiating into five articles (Menzies and Waidzunas, 1948). Brusca and Wallerstein (1977) reported five species of this genus from the Gulf of California, although none have been encountered in large numbers. They may be distinguished by the following key, and by figures 12.21–12.25.

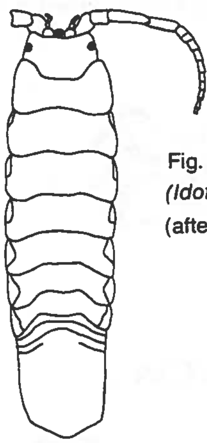


Fig. 12.21 *Idotea (Idotea) urotoma* (after Menzies, 1951)

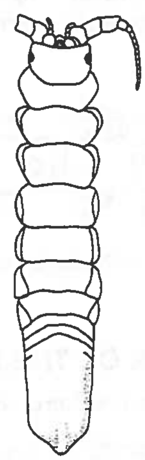


Fig. 12.22 *Idotea (Pentidotea) aculeata* (after Menzies, 1951)

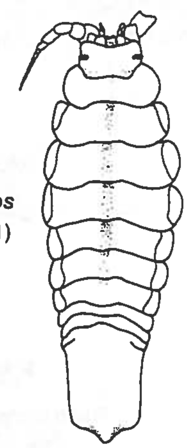


Fig. 12.23 *Idotea (Pentidotea) stenops* (after Menzies, 1951)

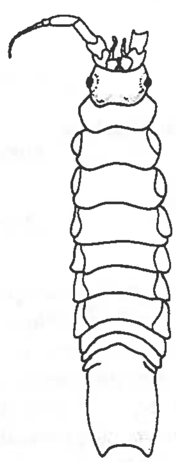


Fig. 12.24 *Idotea (Pentidotea) resecata* (after Menzies, 1951)

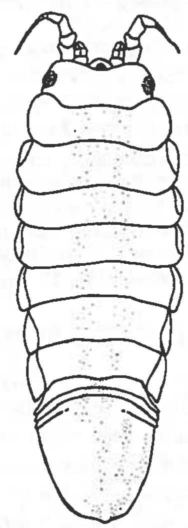


Fig. 12.25 *Idotea (Pentidotea) wosnesenskii* (after Menzies, 1951)

KEY TO THE SPECIES OF IDOTEA

1	Maxillipedal palp of 4 articles .... ***I. (Idotea) urotoma* Stimpson**	
	-Maxillipedal palp of 5 articles	**2**
2(1)	Eyes transversely (dorsoventrally) elongate; apex of frontal process with median notch; maxilliped with 1, 2, or 3 coupling hooks .... ***I. (Pentidotea) stenops* Benedict**	
	-Eyes oval or reniform; apex of frontal process entire or slightly concave; maxilliped with 1 coupling hook	**3**
3(2)	Posterior border of pleotelson strongly concave; frontal process narrow and pointed, extended beyond frontal lamina 1 .... ***I. (Pentidotea) resecata* Stimpson**	
	-Posterior border of pleotelson convex, with small median lobe; frontal process blunt or widely angular, not extended beyond margin of frontal lamina 1	**4**
4(3)	Pleonite 1 with acute lateral borders; eyes reniform; pereopod 7 with distinct tufts of setae on articles 4–6 .... ***I. (Pentidotea) wosnesenskii* Brandt**	
	-Pleonite 1 without acute lateral borders; eyes circular; pereopod 7 without tufts of setae on articles 4–6 .... ***I. (Pentidotea) aculeata* (Stafford)**	

Idotea stenops, *I. urotoma*, and *I. resecata* appear to be wide ranging forms, the first being known from as far north as Oregon; *I. urotoma* from Puget Sound; and, *I. resecata* ranging all the way to Alaska. The appearance of *I. wosnesenskii* in the Gulf may be an anomaly, as its previously known range is Alaska to San Francisco Bay.

Genus *Colidotea* Richardson

Pleon composed of a single segment, with a pair of anterolateral suture lines indicating a single coalesced segment; flagellum of antenna 2 multiarticulate; coxal plates of pereonites more or less coalesced with their segments; maxillipedal palp of 4 articles.

The genus *Colidotea* was erected by Richardson based upon Benedict's *Idotea rostrata* (now *Colidotea rostrata*), a California species that lives on echinoids. The genus remained monotypic for 35 years, until Miller described *Colidotea edmondsoni* (1940) from Hawaii. There now exists, in the Gulf of California, a third species in this genus, *C. findleyi* (fig. 12.26), recently described by Brusca and Wallerstein (1977).

I have recorded *Colidotea findleyi* from the rocky intertidal of Punta Eugenio and Isla Guadalupe (on the outer coast of Baja) and from the upper Gulf to Bahía Kino. It is a medium sized isopod, 5–20 mm in length, and occurs in the low intertidal, in association with *Sargassum*. The isopod clings tenaciously to these algae and is identical to it in color. This cryptic habitat is enjoyed by numerous small invertebrates, and the patient observer will be well rewarded should he spend an hour or so carefully picking through the fronds of *Sargassum* on Gulf seashores. In addition to *Colidotea* will be found the anthurid isopods *Cortezura* and *Mesanthura*, the valviferan isopod *Erichsonella*, various spider crabs (many of which are decorators), pycnogonids, amphipods, caprellids, hydroids, sponges, and tunicates.

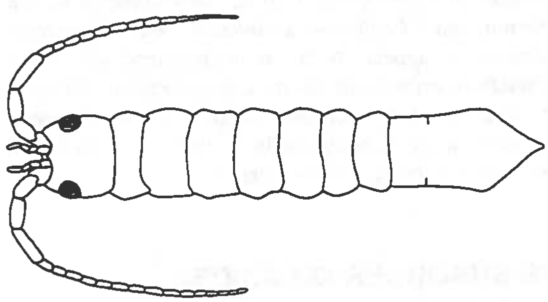


Fig. 12.26 *Colidotea findleyi*

Genus *Eusymmerus* Richardson

Body evenly convex; eyes ovate, located on extreme lateral edge of cephalon; maxillipedal palp of 4 articles; pleon composed of a single segment, with lateral suture lines indicating a second, fused segment; antennae 1 and 2 with flagellum of a single article; pereopods 1–7 ambulatory, terminating in a reflexed dactyl with a bifid unguis; coxal plates dorsally visible only on pereonites 6–7.

Richardson (1899) erected the monotypic genus *Eusymmerus* based on a single specimen from the west coast of Baja (collected by the *Albatross* expedition), naming it *Eusymmerus antennatus* (fig. 12.27). This species may now be considered as a subtropical form, ranging at least from the central outer coast of Baja to Acapulco, and throughout the lower Gulf. Perhaps the most striking features of this little isopod are its smooth, evenly convex body margins and the extreme lateral eyes (incorrectly figured as dorsal by Richardson). Ecologically this isopod appears to have adapted to a number of quite different habitats. I have recorded it from shore to depths of 30 feet, and from exposed rocky headlands as well as quiet, mud-bottomed lagoons.

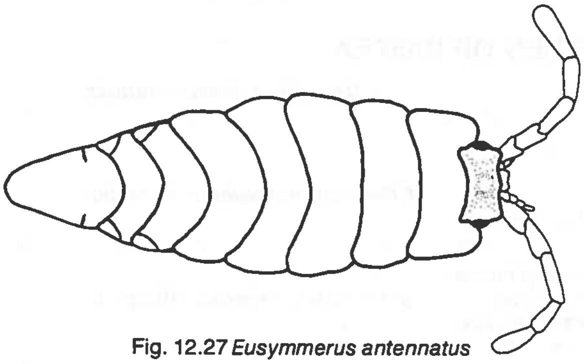


Fig. 12.27 *Eusymmerus antennatus*

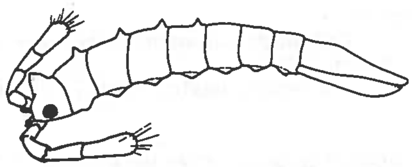


Fig. 12.28 *Erichsonella cortezi*

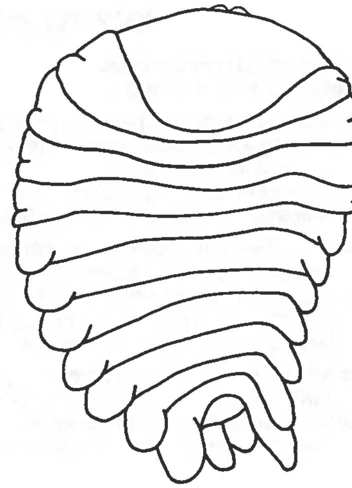


Fig. 12.29 *Pseudione galacanthae*, a parasite on galatheid crabs

Genus *Erichsonella* Benedict (in Richardson)

Eyes lateral; maxillipedal palp composed of 4 articles; antenna 1 with a rudimentary flagellum; antenna 2 with a single clavate, flagellar article; pereopods 1–7 ambulatory, terminating in a bifid unguis; pleon composed of a single segment (occasionally with indications of a partly coalesced anterior segment).

There have been five species described in this small genus, two of which occur on the coast of California; *E. crenulata* (Menzies) and *E. pseudoculata* Boone. A third species has been found in the northern Gulf of California: *E. cortezi* Brusca and Wallerstein. It is similar to *E. crenulata* but differs in having large tubercles on the posterior margin of pereonites 1–4, and in having large, spinelike tubercles on pereopods 2–7. The Gulf species is most commonly found intertidally, associated with *Sargassum* (fig. 12.28).

Suborder Epicaridea
(= Bopyroidea)

The epicarideans are a group of entirely parasitic isopods, infesting other species of crustaceans. The general biology of the majority of the species is not known, or is poorly known at best. The taxonomy of several groups is, to a certain extent, dubious. Males and females are generally quite different in appearance, the males usually being considerably smaller than the females and bearing a fair degree of symmetry. There are four families of Epicaridea reported from North America, as follows: Bopyridae (parasites on various decapods); Cryptoniscidae (parasites on various malacostracans, including other isopods); Dajidae (parasites primarily on euphausids and mysids); and, Entoniscidae (parasites on brachyuran and porcellanid crabs). The family Bopyridae is by far the largest group of epicaridean isopods.

Only a single species in this suborder has been reported from the Gulf of California, *Pseudione galacanthae* Hansen (fig. 12.29). It was reported from the branchial cavity of the galatheid crab *Galacantha diomediae parvispina*. Oddly enough, it has also been reported from *Munida quadrispina*, from the state of Washington. It is probable that this latter record is in error. *Pseudione galacanthae* is a member of the family Bopyridae. Dr. Elaine Snyder-Conn has found a second species of bopyrid isopod to be fairly common on the hermit crabs *Paguristes anahuachis* and *Clibanarius digueti*. It appears to be an undescribed species of *Pseudione* also. In the Puerto Libertad region of Sonora I have found the common tidepool shrimp *Lysmata californica* to be occasionally infested by still another species of bopyrid, as yet unidentified.

KEY TO THE GENERA OF THE SUBORDER ONISCIDEA

1 Uropods operculate, covering pleopods; able to roll up into a ball; lives on sandy beaches .... ***Tylos***
-Uropods terminal; not able to roll up into a ball; lives on rocky beaches .... ***Ligia***

FAMILY TYLIDAE

A monotypic family, consisting of the single genus *Tylos*.

Genus *Tylos* Latreille

Antenna one of 1 or 2 articles; 4 pairs of pleopods, each of a single lamella only; uropods operculate, with the exopod reduced and situated apically; abdomen with 5 pleonites, plus the pleotelson. Figure 12.30.

The members of this group occur littorally but are completely terrestrial animals, found on the seacoasts of warm and warm-temperate regions of the world. All are very much alike in general appearance and usually difficult to distinguish from one another. The body is strongy arched and capable of being rolled up into a ball. The general surface is granulated and scantily pigmented, usually bearing scattered, short, stiff (microscopic) hairs. Perhaps the most distinctive feature of this genus is the ventral, operculate uropods, similar to those seen in the marine valviferan isopods. Members of the genus occupy the same tidal level as do the species of *Ligia* but prefer sandy beaches as opposed to the rocky shores on which *Ligia* is encountered. *Tylos* bury themselves in the sand, emerging in the evenings to feed, at low tide, on cast up detritus. The combined efforts of *Tylos*, *Ligia*, and *Excirolana* no doubt account for the majority of the beach scavenging that keeps the shores of the Sea of Cortez clean and fresh, not allowing debris such as dead fish and algae to accumulate in large quantities. A large windrow of *Sargassum*, cast ashore on a sand beach, will support literally tens of thousands of *Tylos*. After studying the activity cycles of *T. punctatus* on the outer coast of Baja California, Hamner et al. (1968, 1969) have concluded that this isopod navigates primarily by recognition of the slope of the beach; it moves downhill when the sand is dry, and uphill when the sand is wet. This is said to facilitate both feeding (on freshly uncovered detritus), as well as return to the high tide line ahead of the oncoming tides.

Although *Tylos latreilli* Audouin and Savigny was reported from the Gulf by Ohmart (1964) and Mulaik (1960), this is actually an Atlantic species, and it is *Tylos punctatus* Holmes and Gay that keeps the beaches of the Sea of Cortez clean. Van Name (1924) also reported *T. latreilli* from the Galápagos Islands but later (1936) stated he was in error and described these Galápagan forms as a new species *(T. insularis* Van Name, now considered to be a subspecies of *T. punctatus)*. *Tylos latreilli* is a trans-Atlantic species, also known from European shores. *Tylos punctatus* ranges from San Diego, California, all along the sandy shores of Baja, and throughout the Gulf of California; but, the southern extent of its distribution is not yet known. There is no question but that these two species of *Tylos* are very cosely related, probably stemming from a common ancestor of the preglacial Panama seaway fauna, like so many other Atlantic-Pacific species pairs appear to have done (see Introduction). Those intrepid beachcombers that walk the sandy shores of the Sea of Cortez are forewarned that an idle rest on the shore, particularly around sunset, will often present portions of one's anatomy that can tempt *Tylos* beyond restraint (the mandibles are formidable). Hamner et al. (1968, 1969) have investigated the general behavior and life history of *Tylos punctatus*, on the shores of west Baja. They concluded this isopod was capable of navigating up (when the substrate is wet) and down (when the substrate is dry) the beach by orientation to slopes as small as 1°.

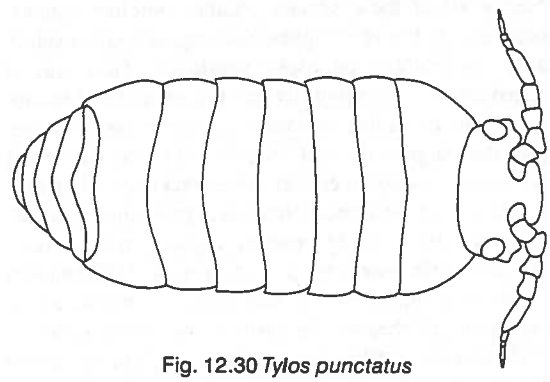


Fig. 12.30 *Tylos punctatus*

FAMILY LIGIIDAE

Body oval or elliptical, with more or less loosely articulated segments; second antennae very long, with flagellum of many articles; one or both branches of uropods long and styliform; palp of maxilliped of 5 articles; outer branch of pleopods without trachae. Two genera: *Ligia*, a semi-terrestrial group inhabiting marine shorelines; and *Ligidium*, a freshwater genus.

Genus *Ligia* Fabricius

Body robust, oval, and rather loosely articulated; front rounded; eyes large, first pair of antennae rudimentary, of 3 small articles; second pair of antennae long and multiarticulate; pereon tapers evenly into pleon; basis of uropods not produced at the inner angle, rami styliform; pleotelson broad, usually produced into short posterolateral spines; mandibles without palps.

Members of this genus are commonly referred to as rock lice or shore lice, and in Mexico they are often descriptively called "cucarachas del mar." It is not known whether the littoral habit of *Ligia* is primitive or recently acquired. The legs are, as in most terrestrial isopods, well specialized for rapid locomotion on land.

The genus *Ligia* is speciose, and Van Name reported 14 species from North America alone (1936).

Nearly all of these species inhabit shoreline regions, occurring in the very highest tide region and the splash zone, particularly on rocky substrates. They are, as stated above, very rapid runners and are difficult to capture. The two most important predators on *Ligia* are probably large crabs and seagulls. The one way that I have found it easy to collect these quickly crawling critters is to wait for a good highwater spring tide, at which time they will often be crowded together in great numbers above the waterline. If the proper location is chosen (such as a large, vertical rock face, a breakwater, or dock pilings), they can be easily scooped into a collecting bucket by the hundreds. There would be no reason for taking such large numbers, of course, unless one wished to do some comparative morphology or developmental research on a population.

There are probably 3 species of *Ligia* occurring in the Gulf of California. *Ligia occidentalis* Dana occurs throughout the Gulf (north as far as central California and south at least to the Islas Tres Marías). *Ligia exotica* Roux occurs only in the extreme southern Gulf, becoming especially common at the latitude of La Paz and Mazatlán but ranging farther north on the various islands. This latter species is quite probably of old world origin but has, since the advent of sailing vessels, become a cosmopolitan form. On our coast it has been reported only sporadically from California to Chile. The ability of any one particular species of terrestrial isopod (or semimarine) isopod, *L. exotica* for example, to distribute itself, presumably on ship's bottoms, worldwide, may well be related to its ability to withstand submersion in salt water (and fresh water) for greater lengths of time than other related isopods (*Ligia occidentalis*, for example). Indeed, I have noticed much more of a predilection toward periodic submersion in *L. exotica* than in *L. occidentalis*. An investigation into this aspect of *Ligia*'s comparative behavioral physiology, at different latitudes, might be an excellent topic for a graduate thesis or other research problem. Ondo and Mori (1956) have published some data in this regard for *L. exotica*.

The third species that has been reported from the Gulf is *Ligia baudiniana* Milne-Edwards, a species more typical of Caribbean waters. I have not yet collected this isopod from the shores of the Sea of Cortez. The following key can be used to differentiate these very similar species.

1 Merus and carpus of male pereopod 1 lined with numerous marginal spinelike setae; appendix masculinum with a fleshy apical stylet; terminal region of propus of male first pereopod normal; antenna 2 never extended beyond posterior margin of pleon .... ***L. baudiniana***

-Merus and carpus of male pereopod 1 with only a few scattered spinelike setae; appendix masculinum not as above; terminal region of propus of male first pereopod with a lateral extension toward dactylus; antenna 2 may or may not extend beyond posterior border of pleon 2

2(1) Antenna 2 reaching beyond pereon and often (in males) beyond pleon; uropoda at least 2/3 body length; body very loosely articulated .... ***L. exotica***

-Antenna 2 never extended beyond pereon; uropoda about 1/2 body length; body not as loosely articulated .... ***L. occidentalis***

It might be noted that, owing to the existence of a very old description of a megalops stage of a crab (Weber, 1795) that bore the generic name *Ligia*, this genus was (for a short period around the turn of the century) called *Ligyda*. This unusual synonomy was discovered by the famous carcinologist Mary Rathbun (1904). Van Name (1936) later reinstated the name *Ligia* in a manner befitting the practical taxonomist that he was. In 1926 Verhoeff split the genus *Ligia* into 4 different genera *(Geoligia, Megaligia, Nesoligia* and *Ligyda)*. Again, it was Van Name who, just 10 years later reduced these to subgeneric status, thus pointing out the overindulgence in Verhoeff's attempt at fragmenting this obviously coherent group of crustaceans. This is an example of what is known as "excessive splitting," a practice that has usually proved to mask the natural evolutionary affinities of closely related animal or plant groups. Fortunately, it appears to be a practice that is growing rather uncommon among modern workers.

The integument of *Ligia* is fairly permeable to water, thus allowing for the process of evaporative cooling, which is of special significance along the desert shores of the Gulf. Continued evaporation of body water leads to increased blood concentration and pleopod dessication, and eventually these "cucarachas del mar" must replenish their bodily fluids. This they can do by either oral or anal drinking. The latter process involves dilation of the rectum and antiperistalic movements which transport water to the gut for absorption. Figure 12.31.

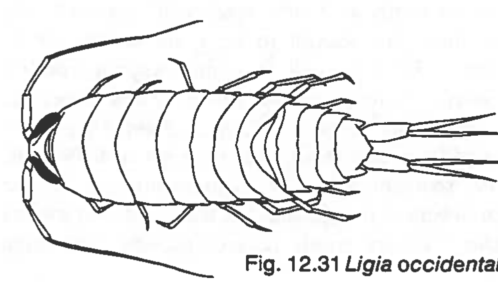


Fig. 12.31 *Ligia occidentalis*

13

ARTHROPODA: CRUSTACEA
Stomatopoda (Mantis Shrimp)

Preservation: See general Crustacea section.

Taxonomy: The taxonomy of stomatopods is based primarily upon the morphology of the maxillipeds and ornamentation of the exoskeleton. These unique crustaceans are quite distinctively marked with various spines, ridges, and grooves, which allow them to be more easily identified than many other groups of crustaceans. The keys and descriptions in this handbook are largely based on Schmitt (1940) and Manning (1963, 1968, 1969a, b, and 1971a, b).

Until recently all stomatopods had been assigned to only a few genera in a single family (family Squillidae). During the last 10 years or so, Dr. R. Manning (of the Smithsonian Institution) and other workers have been able to rearrange this bizarre group of crustaceans into more realistic phylogenetic groupings (see bibliography for references). The result has been a dramatic increase in the numbers of taxa in this crustacean order.

Stomatopods of the Gulf: These shrimplike crustaceans are called "mantis shrimp" because the second thoracic appendages (maxillipeds) are greatly enlarged, the terminal segment being turned back to fit into the one above it (like a knife fits into its handle), forming a strong raptorial claw. This arrangement gives the creature the general appearance of a seagoing praying mantis. There are only three pairs of walking legs. The abdomen is elongate and depressed, and bears five pairs of flattened swimming appendages that serve the dual purpose of locomotion and respiratory structures. Figures 13.1 and 13.2 identify structures used in the following key.

Most mantis shrimp live in burrows or holes, or in crevices among rocks. One of the best sources of material for this group (and many others) is the shrimp fleet operating out of many Mexican ports. I have recovered three species of stomatopods from the shrimp trawlers at Puerto Peñasco (*Squilla bigelowi* Schmitt, *Squilla mantoidea* Bigelow, and *Squilla tiburonensis* Schmitt), and two additional species from the southern Gulf, in shallow water by SCUBA diving (*Gonodactylus stanschi* Schmitt and *Gonodactylus oerstedii* Hansen). Mantis shrimps are just about completely restricted to the subtidal region and are not commonly collected by any simple means.

Approximately 42 species of mantis shrimps have been recorded from the tropical east Pacific, 16 of which occur in the Gulf of California (and are included in this handbook).

KEY TO THE SPECIES OF MANTIS SHRIMPS

1 Raptorial dactylus inflated at base; merus with ventral groove hollowed out for reception of propodus for not more than 3/4 of its length; articulation between merus and ischium of raptorial leg situated at a point anterior to the proximal end of the merus, which consequently extends backward considerably beyond the joint (genus *Gonodactylus*) (figs. 13.9–13.10) 2

-Raptorial dactylus not inflated at base; merus grooved inferiorly for the reception of the propodus throughout its length; articulation between merus and ischium of raptorial leg terminal 4

2(1) Telson with upper surface more or less spinulose (armed with spines, spinules or prickles) .... ***Gonodactylus stanschi***

-Telson without spines or spinules on upper surface (except occasionally a small point or "bead" on the posterior end of the median and intermediate carinae) 3

3(2) Telson with intermediate marginal teeth not widely set off from submedians; intermediate denticles set at or posteriorly to level of intermediate tooth (fig. 13.10) .... ***Gonodactylus zacae***
-Telson with intermediate marginal teeth distinct and intermediate denticles recessed anteriorly (fig. 13.9) .... ***Gonodactylus oerstedii***

4(1) Carapace with well marked carinae; first 5 abdominal somites with longitudinal carinae 5
-Carapace without carinae; first 5 abdominal somites without longitudinal carinae 9

5(4) Submedian teeth of telson with movable apices; dactylus of raptorial claw with 4–5 teeth (fig. 13.3) .... ***Schmittius polita***
-Submedian teeth of telson with fixed apices; dactylus of raptorial claw with 5–7 teeth (usually 6) 6

6(5) Prelateral lobe or angle of telson present and spined (fig. 13.5) .... ***Squilla bigelowi***
-Prelateral lobe of telson margin absent or, if present, not spined 7

7(6) Of submedian carinae on the abdomen, only those of segment 6 are posteriorly spined (fig. 13.7) .... ***Squilla tiburonensis***
-Submedian carinae of abdominal segments 5–6 (or 4–6) posteriorly spined 8

8(7) Submedian carinae of abdominal segments 5–6 posteriorly spined; lateral spine of thoracic segment 5 curved forward; cornea set more or less transversely on eyestalk (fig. 13.4) .... ***Squilla biformis***
-Submedian carinae of abdominal segments 4–6 posteriorly spined; lateral spine of thoracic segment 5 directly laterally, not markedly turned or inclined forward; cornea set very obliquely on eyestalk (fig. 13.6) .... ***Squilla panamensis***

9(4) Abdomen depressed, noticeably flattened; telson without true or definite median carinae (except Eurysquilla veleronis) 10
-Abdomen usually compressed, rarely noticeably flattened; telson with a well-marked, usually sharp, median carina 14

10(9) Carapace with marginal carinae present on posterior portion of lateral plates; telson with a sharp crest (fig. 13.8) .... ***Eurysquilla veleronis***
-Carapace without trace of carinae; telson without a sharp crest 11

11(10) Telson without a transverse row of posteriorly directed dorsal spines above or anterior to the posterior margin; lacking movable submedian teeth on telson (fig. 13.12) .... ***Lysiosquilla desaussurei***
-Telson with a transverse row of dorsal spines, in addition to those of the posterior margin; generally with movable submedian teeth on telson 12

12(11) Transverse row of dorsal spines on telson number more than 18 (fig. 13.11) .... ***Nannosquilla californiensis***
-Transverse row of dorsal spines on telson numbers less than 18 13

13(14) Raptorial claw with 8 teeth (counting terminal tooth) (fig. 13.13) .... ***Acanthosquilla digueti***
-Raptorial claw with 4 teeth (counting terminal tooth) .... ***Heterosquilla mccullochae***

14(9) Raptorial claw unarmed except for the terminal tooth .... ***Hemisquilla ensigera***
-Raptorial claw with 3 teeth, counting the terminal tooth .... ***Pseudosquillopsis marmorata***

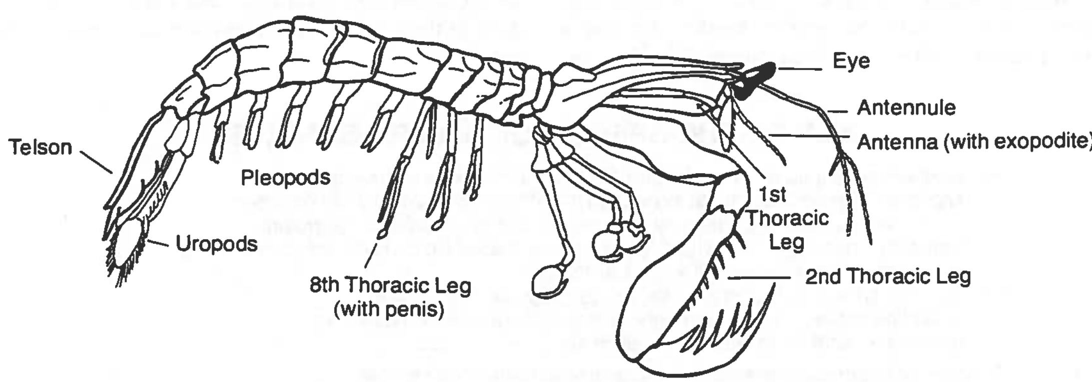


Fig. 13.1a General morphology of a stomatopod. Lateral view.

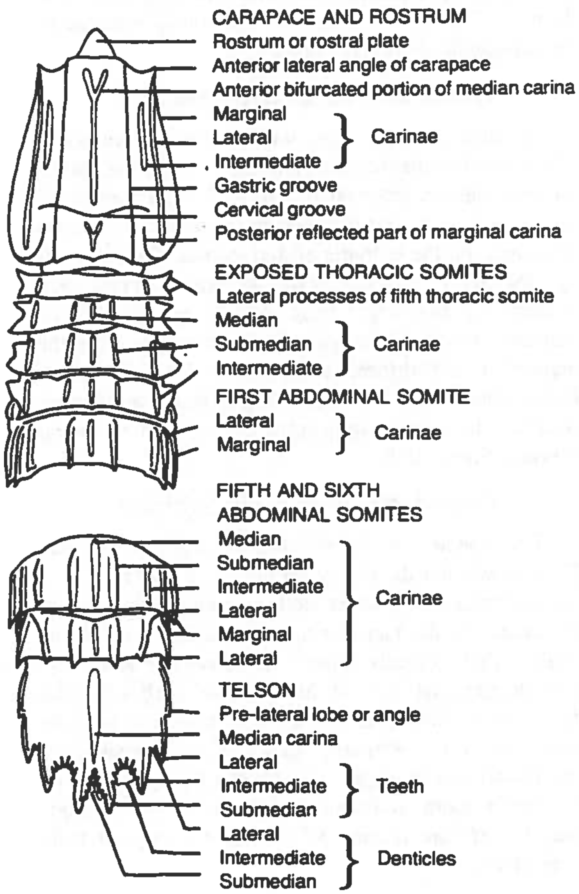


Fig. 13.1b General morphology of a stomatopod. Dorsal view.

FAMILY SQUILLIDAE

Schmittius polita (Bigelow)

A Californian species reaching lengths of 60 mm. The body is highly polished and the dactylus of the raptorial claw bears 4–5 teeth. The telson of this species has two pairs of strong lateral spines and a single pair of movable posterior spines. It ranges from Monterey Bay, California, to Baja California and the lower Gulf, but the bulk of the distribution lies between Point Conception and central Baja California. This species has been recovered from depths of 12–185 m. Figure 13.3.

Squilla biformis Bigelow

A strictly deep water tropical species of stomatopod, ranging from the extreme southern Gulf (La Paz region) south to Panama. The telson of males bear 3 pairs of short marginal spines and a weak posterior crenulation; the telson of females bear 4 pairs of short marginal spines and a strong posterior crenulation. *Squilla biformis* has been reported from depths of 28–518 m. Figure 13.4.

Squilla bigelowi Schmitt

The raptorial claw of this species bears 5–6 dactyl teeth and the telson has 4 pairs of marginal teeth and a crenulate posterior margin. The adult length averages 65–100 mm. This species has been recovered from depths of 6–150 m, from the upper Gulf of California to Cabo San Lucas (and probably south to Central America). Manning (1962) reported the occurrence of an abnormal female from Cabo Lobos (in the Gulf of California) in which the 6th and 7th thoracic segments were fused. Figure 13.5.

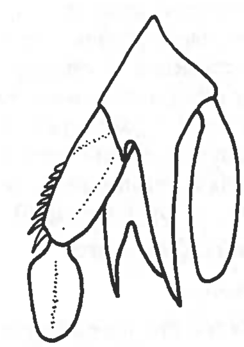


Fig. 13.2 *Squilla* sp., uropod

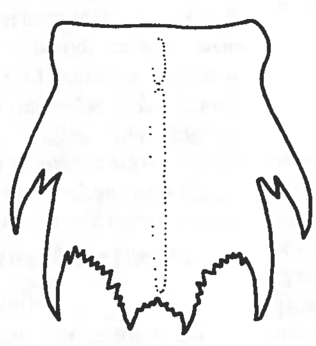


Fig. 13.3 *Schmittius polita*, telson (after Schmitt, 1940)

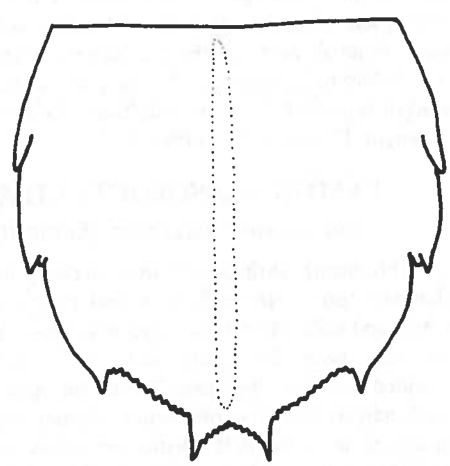


Fig. 13.4 *Squilla biformis*, telson (after Schmitt, 1940)

Squilla mantoidea Bigelow

This is a southern Panamic tropical mantis shrimp that has been reported from the Gulf of California but once (Brusca, 1973). This may have been an accidental occurrence or perhaps this species is simply rare this far north. It is distinguished by the following combination of characters: Cornea of eye strongly bilobed; carapace narrow anteriorly; dactylus of claw with 6 strong teeth; 5 epipods present; rostral plate with a median carina; and median carina of carapace with an anterior bifurcation. This species may range from the Gulf of California south, at least as far as Peru.

Squilla panamensis Bigelow

A small to medium-sized mantis shrimp, known from Mazatlán south to Peru. The adult length of this species ranges from 40 to 105 mm. The lateral margins of the telson bear 3 pairs of spines, the anteriormost of which is rounded rather than acute. The posterior margin of the telson is very strongly emarginate and bears a single set of median spines. A distinctly formed pair of dark-colored crescents or arcs of small circles occur on either side of the proximal end of the median carina of the telson. The carapace is rough, pitted, and finely eroded, so that when dry it is rather dull in comparison with most other members of this genus. This species has been recovered from depths of 13–100 m. Figure 13.6.

Squilla tiburonensis Schmitt

This appears to be an endemic species, known only from the Gulf of California, where it has been reported from Isla Angel de la Guarda, Isla Espíritu Santo, and Bahía Santa Inés. *Squilla tiburonensis* is similar to *S. panamensis* but may be distinguished by its different color markings; basally on the telson, instead of a dark crescent on either side of the median carina, there is a dark, more or less squarish area. There are also a pair of these squarish areas on the middorsum of the 2nd and 5th abdominal segments. This species has been recovered in depths of 15–33 m. Adults are about 60–85 mm in length. Figure 13.7 and Plate 3.

FAMILY GONODACTYLIDAE

Eurysquilla veleronis (Schmitt)

This mantis shrimp is characterized by its extreme flattened form, trianguliform rostral plate (wider than long), and wide telson (also wider than long). The raptorial claw bears 7–8 dactyl teeth and a well-marked rounded lobe near the base. The telson bears a strong, well-marked median carina with a rounded crest ending in a short spine. There is a distinctive, black, subcircular spot with a light colored longitudinal band through the middle, ornamenting each posterolateral angle of the 6th abdominal segment. *Eurysquilla veleronis* ranges from the upper Gulf of California to Panama, and has been recovered from depths of 10–100 m. It appears to be a rather small species, recorded lengths ranging from 35 to 40 mm. This species has been previously reported as *Pseudosquilla veleronis*. Figure 13.8.

Gonodactylus oerstedii Hansen

A rather small species, with an olive-green body. The telson has distinct marginal teeth, while the marginal denticles are recessed anteriorly. The carinae of the telson are largely unarmed, except for an occasional lobe or spinule on the extreme posterior end. The embryology and larval stages of this species have been described in detail by Manning (1963c) and Manning and Provenzano (1963). In the east Pacific it ranges from the upper Gulf of California to Ecuador, while it is known from Bermuda and North Carolina to Brazil in the west Atlantic. It is most frequently encountered in island habitats. Figure 13.9.

Gonodactylus stanschi Schmitt

This species of mantis shrimp closely resembles *G. oerstedii* but differs by the unarmed and relatively inconspicuous knob under the hinder end of the median carina and by the fact that the intermediate carina normally ends in a single spine. The submedian and intermediate marginal teeth of the telson are well separated by a distinct notch, as are the corresponding teeth in specimens of *G. oerstedii*. Adults of this species average 10–40 mm in length. It is known from the Gulf of California south to Bahía Tangola-Tangola, Mexico, and the offshore islands of the Isla Isabela and Islas Tres Marías.

Gonodactylus zacae Manning

Another small species of *Gonodactylus* that may be quickly distinguished from *G. oerstedii* by its color, being a uniform reddish as opposed to the greenish color usually seen in *G. oerstedii*. In addition to the color, *G. zacae* may be distinguished by the following combination of characters: anterolateral angles of rostral plate acute but broadly rounded; 6th abdominal somite with 6 long carinae (a generic character); telson longer than broad or subequal, deeply emarginate on posterior margin. This species is the Pacific counterpart of *Gonodactylus bredini*, a common west Atlantic form. It ranges from the Gulf of California to Panama, and is the most common east Pacific *Gonodactylus*. Figure 13.10.

Hemisquilla ensigera californiensis Stephenson

This tropical east Pacific form is but one evolutionary unit of a wide-ranging species. Stephenson (1967) recognized 3 distinct Pacific populations of *Hemisquilla ensigera*, designating them as subspecies. This was

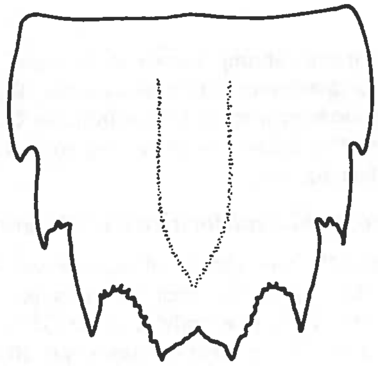


Fig. 13.5 *Squilla bigelowi*, telson (after Schmitt, 1940)

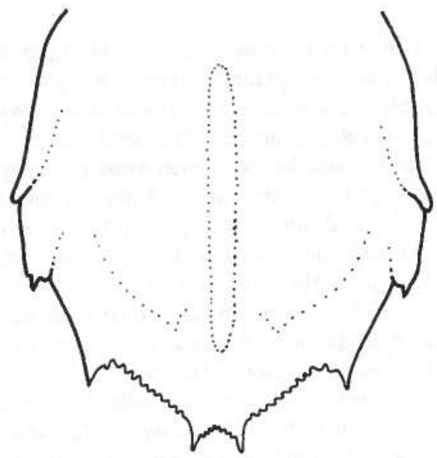


Fig. 13.6 *Squilla panamensis*, telson (after Schmitt, 1940)

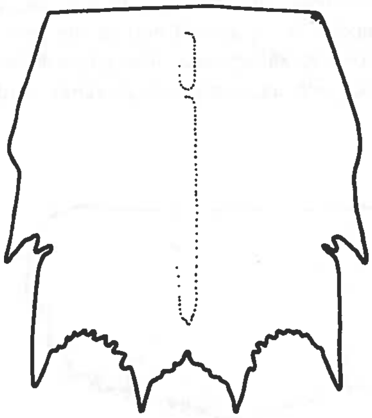


Fig. 13.7 *Squilla tiburonensis*, telson (after Schmitt, 1940)

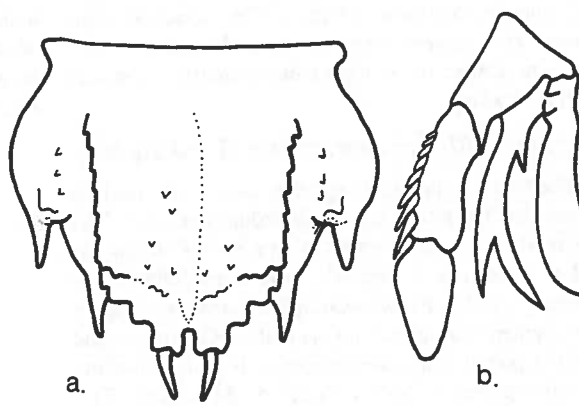


Fig. 13.8 *Eurysquilla veleronis*. (a) Telson. (b) Uropod. (After Schmitt, 1940.)

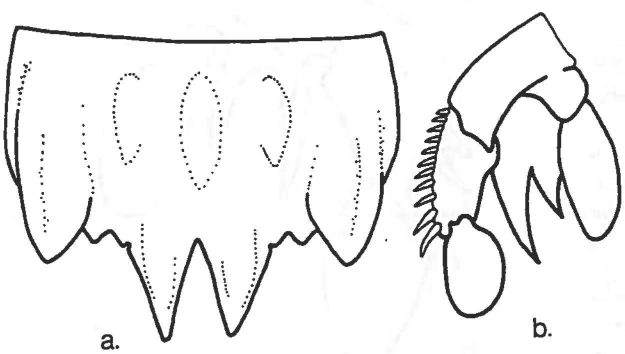


Fig. 13.9 *Gonodactylus oerstedii*. (a) Telson. (b) Uropod. (After Schmitt, 1940.)

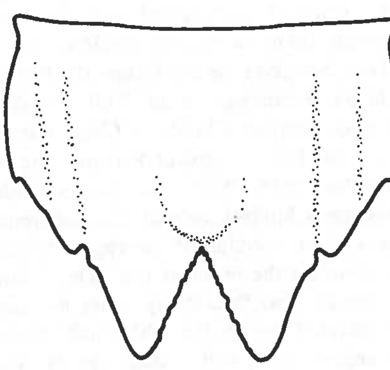


Fig. 13.10 *Gonodactylus zacae*, telson (after Manning, 1971)

based not only on morphological data but upon their apparent isolated geographic ranges. As with most closely related taxa a certain degree of morphological overlap exists and Manning (1971b) noted that: "... all of the characters used by Stephenson overlap broadly; in spite of this, as he pointed out, the Chilean population appears to be as distinct from the Californian as it is from the Australasian. Although the recognition of three subspecies is probably sound on a biological basis, the broad overlap of characters makes it difficult at best to identify a single specimen to the subspecific level on any basis other than geography." This mantis shrimp may be quickly distinguished from most other Gulf species by the absence of teeth on the raptorial claw and the brightly colored, purple to lavender uropods. Adult specimens range from 85 to 105 mm in length. *Hemisquilla ensigera californiensis* ranges from southern California and the Gulf of California south to Panama (including the offshore islands). The nominate subspecies, *H. ensigera ensigera*, is restricted in distribution to Chile; *H. ensigera australiensis* occurs in Australian waters.

Pseudosquillopsis marmorata (Lockington)

The first 5 abdominal segments of this species lack carinae and the telson lacks submedian denticles. The postlarval and juvenile stages of this mantis shrimp, as well as the similar *P. lessonii*, have been described by Manning (1969a). *Pseudosquillopsis marmorata* ranges from southern California into the Gulf of California, and is also reported from the Galápagos Islands. Manning (1971b) reported it from a depth of 64 meters. This species has been referred to as *Squilla marmorata* in past publications.

FAMILY LYSIOSQUILLIDAE

Heterosquilla mccullochae (Schmitt)

This unusual stomatopod was, for many years, known only from the original specimen (the holotype), which was dredged from a coralline algal bottom in 15 m off Isla San Francisco, in the Gulf. It has since been found to occur from Florida to Costa Rica in the Atlantic, on the Pacific coast of Panama, and in the Indo-west Pacific region. This species has a smooth carapace, and obscurely bilobed corneas set transversely on the eyestalks. The dactylus of the raptorial claw bears 4 teeth, including the terminal one. The abdominal segments are all smooth dorsally, with the posterolateral angles rounded (except the 6th, which has the posterolateral angles armed with a sharp spine). The telson is slightly better than twice as wide as long and strongly spined. Light to dark oval spots occur across the dorsal surface of the body. This species has been previously reported as *Lysiosquilla mccullochae*. The only other species of mantis shrimp known to be strictly trans-Pacific in its distribution is *Clorida mauiana* (Bigelow). This is an uncommon form, known from the Gulf only from Puerto Escondido (26–33 m), and not included in the key (Manning, ms.).

Nannosquilla californiensis (Manning)

A seemingly rare species of stomatopod, known only from the original specimen (the holotype). It was described from Puerto Escondido, in the Gulf, from a depth of 13 m. The original specimen was 20 mm in length and had small, subglobular corneas. The rostral plate is much wider than long, with the anterolateral angles acute. The carapace is smooth, short, and without carinae, and the antennal scale is small, not as long as the rostral plate. The raptorial claw is small, the dactylus being armed with 8 teeth, and the outer margin bearing a deep notch at the base, followed by a broad lobe. The abdomen is smooth, being spined only at the posterolateral corners of the 6th segment. The telson is twice as wide as long, with an emarginate posterior border. Figure 13.11.

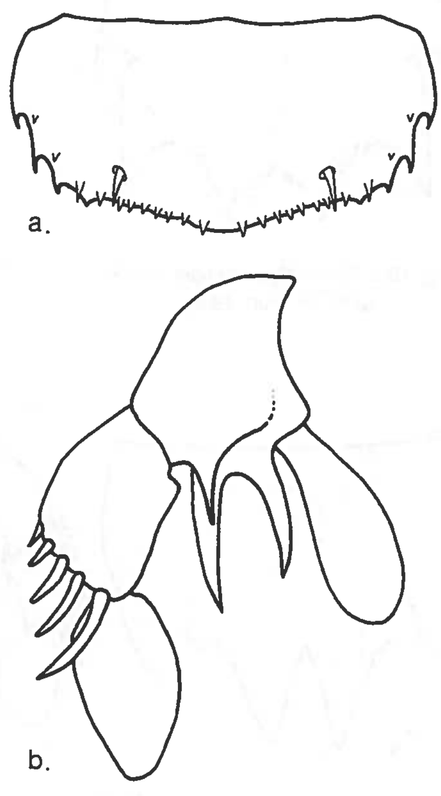


Fig. 13.11 *Nannosquilla californiensis*. (a) Telson. (b) Uropod. (After Manning, 1961.)

Lysiosquilla desaussurei Stimpson

The dactylus of the raptorial claw of this species bears 12 strong teeth, the rostral plate is cordiform, wider than long, with a median carina, and the antennal scale is slender, the length being over 3 times the width. The overall color pattern is barred (as in most *Lysiosquilla*). The body segments each bear a broad, dark, anterior band and a narrower posterior line. The dorsal surface of the telson has median and submedian black spots and the antennal scale is outlined in black. Adult *Lysiosquilla desaussurei* average 65–90 mm in length. This mantis shrimp ranges from Mazatlán to Peru (plus a single record from San José del Cabo, Baja) and has been recovered by use of night lights hung off the sides of ships. This species was known from only the original description, from Mazatlán (1857) until it was recovered by the "Zaca" expedition of the New York Zoological Society, under the directorship of William Beebe (Manning, 1971b). Figure 13.12.

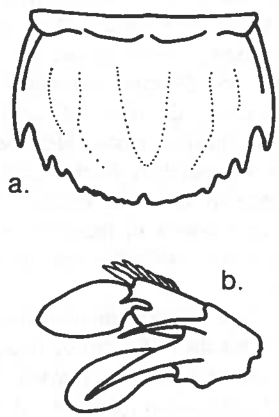


Fig. 13.12 *Lysiosquilla desaussurei*. (a) Telson. (b) Uropod. (After Manning, 1961.)

Acanthosquilla digueti (Coutière)

A small mantis shrimp, adults ranging from 20 to 30 mm in length. The dactyls of the raptorial claw are armed with 6–8 teeth, the cornea of the eye is subglobular, and the telson is strongly spined (with numerous marginal spines and a row of 5 dorsal spines). The carapace bears distinct pigment spots similar in color and pattern to those of the dorsal elytra of the polynoid scale worm that shares this mantis shrimp's habitat. *Acanthosquilla digueti* lives commensally in the tube of the acorn worm *Balanoglossus*, sharing its home with the polychaete annelid *Lepidasthenia digueti* Gravier. Such symbionts as these, which inhabit the tube (or other abode) of other animals, are termed inquiline species. *Acanthosquilla digueti* is known to range from the southern Gulf at least as far south as Panama, and on the Atlantic coast from Florida to Brazil. Figure 13.13.

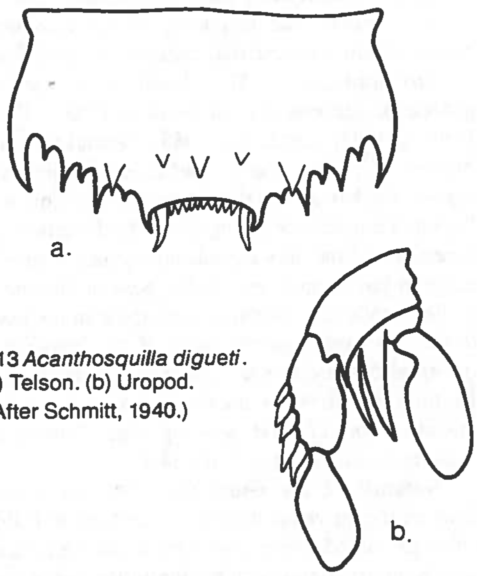


Fig. 13.13 *Acanthosquilla digueti*. (a) Telson. (b) Uropod. (After Schmitt, 1940.)

14

ARTHROPODA: CRUSTACEA
Natantia (True Shrimp)

Preservation: See general Crustacea section.

Taxonomy: The taxonomy of the true shrimp is based primarily on external features of the carapace and various appendages. The classification used in this handbook follows that of Schmitt (1921, 1935) and Holthuis (1951, 1952, and 1955). Because of the large number of poorly known species of shrimp from this region, the key is largely to genus only. For extensive keys to the species of the true shrimp, the serious student is referred to the above publications and to other references in this section, especially those of Holthuis (1947 to 1955). Mention of the hepatic spine in the key refers to the short spine on the sides of the carapace, about one-third of the distance back from the head. Note that the third maxilliped is often very long and can easily be mistaken for the first walking leg. General shrimp anatomy is illustrated in figure 14.1.

Natantia of the Gulf: Very little work has been done on the intertidal shrimps of the Gulf of California, although the Mexican government does encourage research on the commercial shrimp of the genus *Penaeus*. Members of this group are, however, rarely found in the intertidal, although immature individuals are occasionally collected in bays and estuaries. Castro (1966) stated (in regard to the species he studied) that the shrimp of the Gulf of California have strong Californian affinities. Of the nine species of known specific status he discussed, five were Californian forms, two Panamic, one Indo-Pacific, and one was previously known only from the west Atlantic. Steinbeck and Ricketts reported 13 species of shrimp from the Gulf and found the fauna to be well distributed between Panamic and Californian forms. There are 39 species of shrimp discussed in this chapter, presumably representing roughly the 39 most commonly encountered shrimp of the Gulf. Of these: 22 (56 percent) are members of the tropical eastern Pacific fauna only; 7 (18 percent) are members of the Californian fauna; and 10 (26 percent) are Gulf endemics. In addition 5 species are components of the present transisthmian faunal element, 1 is trans-Pacific and 1 is circumtropical in distribution.

The shrimp most often encountered in the intertidal zone of the Gulf are the pistol shrimp (snapping shrimp) of the genera *Alpheus* and *Synalpheus*, and the red-striped shrimp *Lysmata californica*. A recently discovered, unidentified species of the genus *Thor* is apparently quite rare and has not been included in the following key.

Shrimp are most easily captured by the use of a hand net in large tidepools, a push net on sea grass habitats, or by overturning large stones and grabbing them by hand. The subtidal shrimp can be retrieved from the shrimp trawls, which are actually small otter trawls and are good sources of many invertebrates. Shrimp fleets operate out of most large cities on the west coast of mainland Mexico.

KEY TO THE GENERA OF INTERTIDAL NATANTIA

1 Lateral portions of second abdominal pleura expanded to overlap the first abdominal pleura; mainly intertidal (fig. 14.1) 2

-Lateral portions of second abdominal pleura not as above; mainly subtidal .... **Family Penaeidae** (see page 254)

2(1)	Wrists of second legs undivided	3
	-Wrists of second legs divided (multiarticulate)	7
3(2)	Posterior margin of telson with 3–4 pairs of spines	4
	-Posterior margin of telson with 2 pairs of spines (fig. 14.2)	***Palaemon***
4(3)	Hepatic spine absent	5
	-Hepatic spine present	6
5(4)	Rostrum with teeth	***Gnathophyllum***
	-Rostrum without teeth (figs. 14.5–14.7)	***Pontonia***
6(4)	Supraorbital spine present; mandible with a palp (fig. 14.8)	***Palaemonella***
	-Supraorbital spine absent; mandible without a palp (figs. 14.3–14.4)	***Periclimenes***
7(2)	First legs much larger than others; eyes covered by carapace; rostrum small or wanting	8
	-First legs not much larger than others; eyes not covered by carapace; rostrum prominent	10
8(7)	Rostrum entirely wanting; front not spined (fig. 14.10)	***Betaeus***
	-Small rostrum present; front with or without lateral spines	9
9(8)	Large cheliped laterally compressed; epipods present on first 2–4 pairs of pereopods; front of carapace with or without lateral spines (fig. 14.9)	***Alpheus***
	-Large cheliped not laterally compressed, but rounded; epipods not present on any pereopods; front of carapace with lateral spines	***Synalpheus***
10(7)	Carpus of second pair of legs of 3 articles (fig. 14.12)	***Hippolyte***
	-Carpus of second pair of legs with more than 10 articles (fig. 14.11)	***Lysmata***

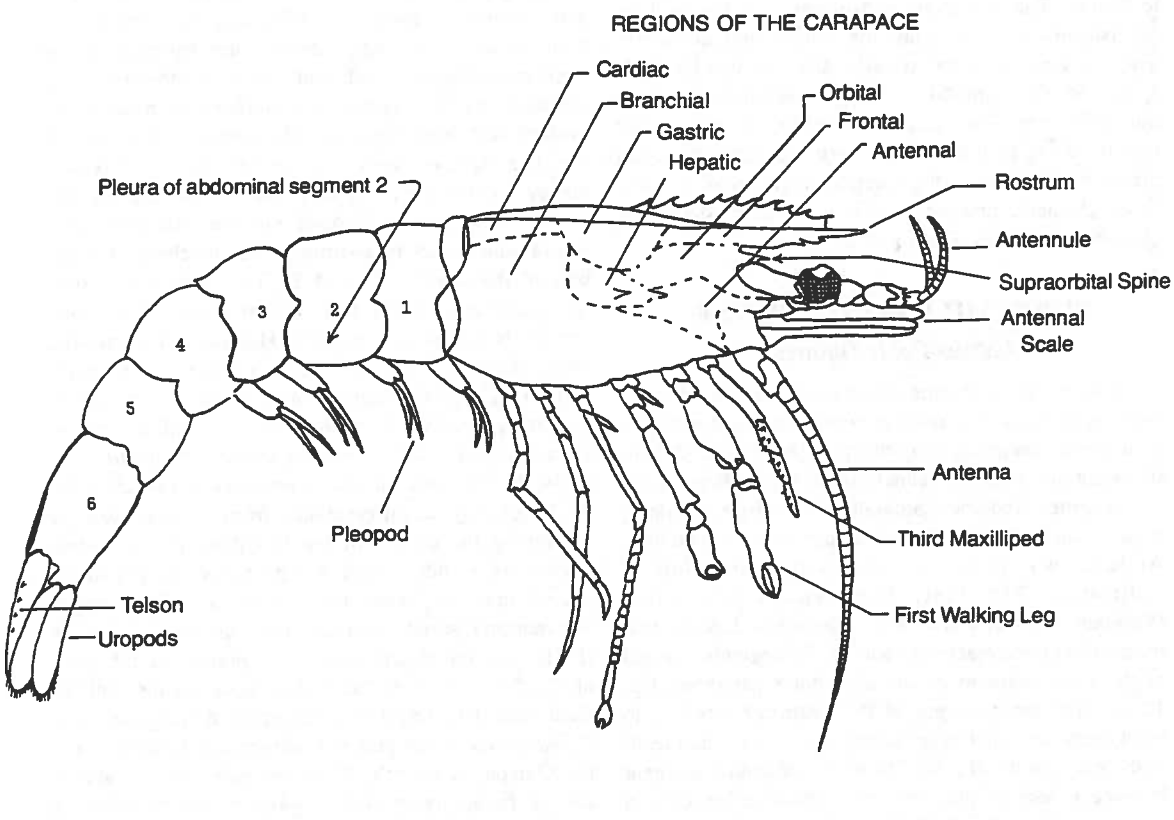


Fig. 14.1 General anatomy of a shrimp
(after Word and Charwat, 1974)

SECTION CARIDEA

FAMILY PALAEMONIDAE

SUBFAMILY PALAEMONINAE

Genus *Palaemon*

This genus is characterized by the following set of characters: rostrum well-developed, toothed; carapace smooth, with antennal and branchiostegal spines; telson with two pairs of dorsal and two pairs of posterior spines; posterior margin of telson pointed; two feathered setae between the inner posterior spines. Holthuis (1952) reported five species from the west coast of the Americas, of which only one, *Palaemon ritteri* Holmes, is known to occur in the Gulf. This species ranges from southern California to Peru, including the Gulf of California. Steinbeck and Ricketts recorded it from the midriff islands, and Holthuis (1952) reported it from Bahía de Agua Verde, Isla San Francisco, and Cabo San Lucas. *P. ritteri* is a brightly colored tidepool shrimp resembling the "broken-back" shrimps of California shores. The rostrum is long and bears 7 to 8 dorsal teeth, one or two of which are behind the orbit, and 3 prominent ventral teeth. The length of this species is about 20 to 40 mm. The shrimp are translucent, with longitudinal reddish-brown lines along the thorax and abdomen. There is a red spot, and occasionally two smaller black spots, on each uropod. I have collected this species throughout the Gulf, usually in tidepools, where they tend to aggregate under large rocks. Reynolds (in press) places this species in the category of facultative (part-time) cleaners, and he discusses its nonhost-specific cleaning tendencies. Figure 14.2.

SUBFAMILY PONTONIINAE

Genus *Periclimenes*

A large genus, distinguished by the following combination of characters: rostrum compressed and provided with teeth; carapace smooth, may be provided with supraorbital (rarely), antennal (usually), and hepatic (always) spines; abdomen generally with all the segments broadly rounded (pleura); second legs stronger than first. At least two species are known from the Gulf of California. The first, *Periclimenes infraspinis* (Rathbun), formerly *Urocaris infraspinis*, has the rostrum straight and reaching about to the beginning or end of the third segment of the antennular peduncle (fig. 14.3). The upper margin of the rostrum bears five to eight teeth, and the lower margin one or two small teeth in the extreme distal part. The sixth abdominal segment is twice as long as the fifth, and somewhat longer than the telson. The telson has two pairs of dorsal spines, and the posterior margin bears three pairs. According to Chace (1937), the color in life is semitranslucent, pale brown. This species ranges from southern California to Costa Rica and the Galápagos, as well as being reported from the lower Gulf of California. The second species, *Periclimenes lucasi* Chace, ranges from Baja California and the central Gulf to Panama, and is especially common in the extreme southern portion of Baja California, around Cabo Pulmo and Cabo San Lucas. This species has the rostrum failing to reach the end of the antennular peduncle (fig. 14.4). The upper margin of the rostrum is convex and bears 8 to 9 teeth, the lower margin 1 to 3 teeth near the apex. The sixth abdominal segment is about the same length as the telson. The sure way to distinguish these two species is to examine the dactylus (last article) of the last three pairs of legs—in *P. lucasi* the dactyli are simple, while in *P. infraspinis* they are biunguiculate. *Periclimenes lucasi* is a colorful little shrimp, the appendages being banded with a striking pattern of blue and yellow. It is a common commensal of corals, cerianthid anemones and other invertebrates. See Plate 5.

Genus *Pontonia*

This is another large genus of shrimp, with three species reported from the Gulf by Holthuis (1951). The genus is distinguished by the following set of characters: body dorsoventrally depressed; rostrum depressed, when teeth present, very small and few in number (1 to 2); carapace smooth, hepatic, and supraorbital spines never present; last three legs with bifid dactylus. The first of the three species reported from the Gulf is *Pontonia pinnae* Lockington, characterized by its strongly depressed and flattened rostrum, and the sixth abdominal pleura which ends in a strong spine, reaching over the base of the uropods (fig. 14.5). This shrimp is a common commensal on the hatchet clam, *Pinna*. The second species is *Pontonia longispina* Holthuis, characterized by its depressed and somewhat down-curved rostrum, and large, well-developed dorsal spines on the telson (the dorsal spines of *P. pinnae* are very small and inconspicuous) (fig. 14.6). The last species, *Pontonia margarita* Smith, also has the down-curved rostrum (fig. 14.7) but may be differentiated from *P. longispina* by examining the dactyli of the last three pairs of legs. These are slender, with the posterior margin about straight in *P. longispina*, but very broad, with the posterior margin distinctly convex, in *P. margarita*. Holthuis (1951) lists the distribution of *P. pinnae* as the Gulf of California to Panama; *P. longispina* as the Gulf of California (Isla Angel de la Guarda and Guaymas); and *P. margarita* as the gulf of California to Colombia and the Galápagos Islands. *Pontonia margarita* is almost always found living commensally in the pearl oyster *Pinctada mazatlanica* (Hanley), and I have recovered it from this clam all along the shores of southeastern Baja California.

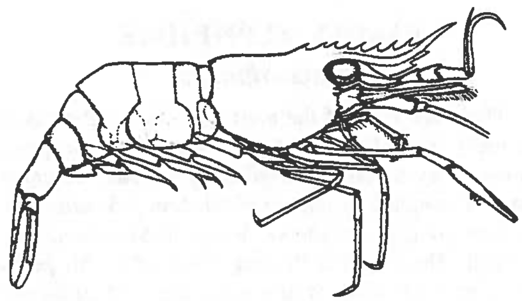


Fig. 14.2 *Palaemon ritteri*
(from Word and Charwat, 1976)

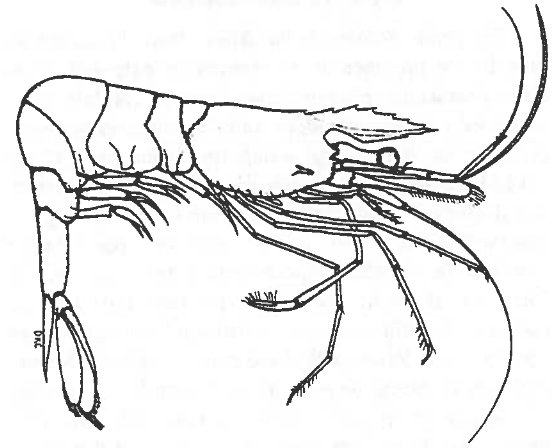


Fig. 14.3 *Periclimenes infraspinis*
(from Word and Charwat, 1976)

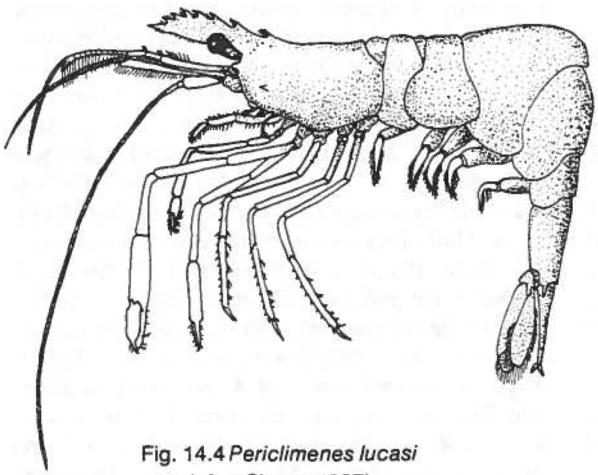


Fig. 14.4 *Periclimenes lucasi*
(after Chace, 1937)

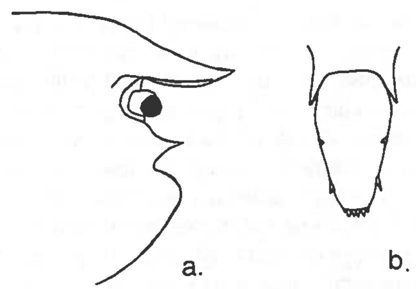


Fig. 14.5 *Pontonia pinnae*.
(a) Anterior region. (b) Telson.
(After Holthuis, 1951.)

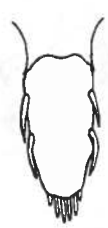


Fig. 14.6 *Pontonia longispina*, telson
(after Holthuis, 1951)

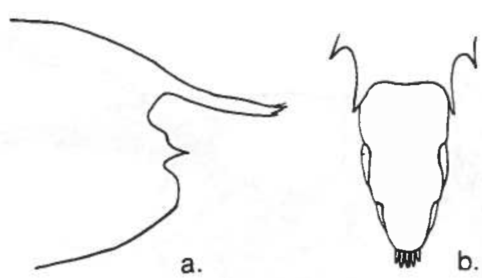


Fig. 14.7 *Pontonia margarita*.
(a) Anterior region. (b) Telson.
(After Holthuis, 1951.)

Genus *Palaemonella*

The genus *Palaemonella* differs from *Periclimenes* only by the presence of its mandibular palp and a few other characters. *Palaemonella holmesi* (Nobili) (formerly *Periclimenes tenuipes* and *Periclimenes holmesi*) occurs in shallow coastal waters from southern California to Ecuador, including the entire Gulf of California. It is distinguished as follows: rostrum straight or slightly upturned at the tip; six to nine teeth on upper margin (two situated on the carapace behind the orbit), two to four ventral teeth; abdomen with first four pleurae rounded, the fifth ending in a small acute point; posterior margin of the telson with three pairs of spines, the median spine being very long and slender. The size of this species is about 10 to 24 mm, the color pale brown (fig. 14.8). The only other species of this genus reported by Holthuis from the Americas is *Palaemonella asymmetrica* Holthuis, known only from the Galápagos Islands.

FAMILY GNATHOPHYLLIDAE

Genus *Gnathophyllum*

Gnathophyllum panamense Faxon is a short, stocky, little shrimp, 10–30 mm in length, with a somewhat reduced abdomen. Its shape has led to the adoption of the vernacular name "Barrel Shrimp" by certain groups of students. *Gnathophyllum panamense* is usually encountered below the lowest tide level, in 5–50 feet of water. This gaily colored Lilliputian is often observed by SCUBA divers and is characteristically found sitting atop a sponge or coral head, where its brilliant hues and color patterns cause it to stand out regardless of the habitat in which it may be encountered. The bizarre color patterns displayed by species of this warm water genus have attracted the attention of many w rkers, and *G. panamense* is often brought back from the Gulf by aquarium fans for display purposes. Unfortunately this shrimp is quite fragile and rarely survives such attempts. *Gnathophyllum panamense* occurs throughout the Gulf of California (and south at least to Panama) but is uncommon north of the Midriff Islands. See Plate 5.

FAMILY ALPHEIDAE

Genus *Alpheus*

These are some of the most common inhabitants of the rocky intertidal of the Gulf. Members of the genus *Alpheus* may be distinguished from the other common genus of snapping shrimp, or pistol shrimp, *Synalpheus*, by their compressed chelae, which in *Synalpheus* are rounded. The length of the large cheliped in this genus often exceeds that of the carapace and abdomen combined (fig. 14.9). There are at least 8 or 9 species of *Alpheus* known from the Gulf, three of which (*A. clamator* Lockington, *A. californiensis* Holmes, and *A. bellimanus* Lockington) are common California forms, known from the tidepools of southern California and both sides of Baja California. *A. clamator* is reported by Schmitt (1921) as ranging from San Francisco, California, to Cabo San Lucas; *A bellimanus* ranges from central California, around Baja and north to the Arena Bank region; *A. californiensis* ranges from southern California to the Gulf. *A. malleator* (Dana) is reported by Steinbeck and Ricketts as occurring from Ecuador to the Gulf, where they report it from Bahía Plumo, and *A. lottini* Guerin is reported by Steinbeck and Ricketts (as *A. ventrosus*) and by Chace (1962) as ranging throughout the Indo-Pacific, Hawaiian Islands, and the Gulf of California, where they also reported it from Bahía Plumo. I have collected six species of *Alpheus* in the gulf, including *A. californiensis* (which appears to be especially common in the northern region). In addition I have the following records: from Topolobampo, *A. californiensis* and *A. normanni* Kingsley; from Guaymas, *Alpheus* sp. (near *A. heterochaelis* Say) and *A. panamensis* Kingsley; and from Puerto Peñasco, *A. paracrinitus* Miers, *A. californiensis*, and *Alpheus* sp. (near *A. heterochaelis* Say).

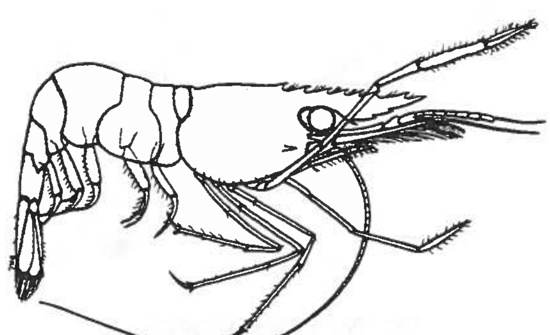


Fig. 14.8 *Palaemonella holmesi* (from Word and Charwat, 1976)

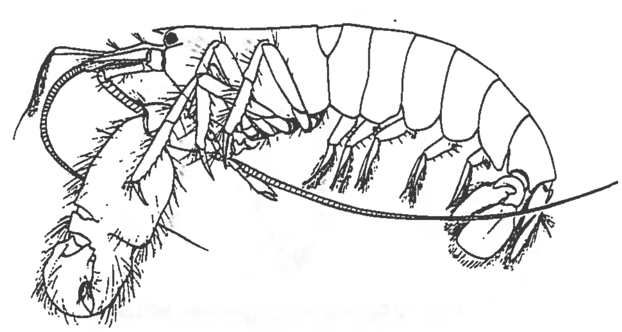


Fig. 14.9 *Alpheus* sp.

Both the male and female members of this genus have the single enlarged cheliped, and both have the eyes hidden under the opaque carapace. One need not see these curious creatures to be aware of their presence, for the sharp crack of their cheliped can be heard a good distance away. The sound is made by the shrimp's snapping its dactyl against the fixed finger of the large cheliped, the rapid impact being made possible by a trigger device at the joint. It is an odd experience to be walking along a reef at low tide, in the evening when the sea is calm and the air is still, and suddenly hear a chorus of loud reports resounding from the rocks below your feet. A curious phenomenon of these shrimp is that, when the large cheliped is pulled off, the new one will usually be formed, during the next molt, on the opposite hand. Molting can, in fact, often be induced in these animals by removing the large cheliped. Once it is removed, the shrimp will shed in about five weeks (MacGinitie and MacGinitie, 1968). In the aquarium, these shrimp can be induced to snap by agitating the water near their burrows. A number of functions probably can be assigned to the snapping device, but one that has been observed is the shrimp's ability to stun small fish for subsequent dining. I have yet to witness this function myself, although I have seen these shrimp use the large cheliped to quickly grab a morsel of food drifting by in the water. The large number of retorts one often hears during the low tide periods suggest that perhaps there is some social function to these curious animals' noise-making device.

Genus *Synalpheus*

Numerous species of this genus are present in the Gulf intertidal. The most common one in the northern Gulf (and probably occurring throughout the Gulf) is *Synalpheus lockingtoni* Coutiere, characterized by having the rostrum longer than the lateral spines of the anterior carapace margin, and the second joint of the antennules longer than the third. The body of this species is 15 to 30 mm long, and pale green. *S. lockingtoni* is also known from southern California and Baja California. I have collected this and one other species of *Synalpheus* in the Gulf, the other being an undescribed species from Topolobampo. Steinbeck and Ricketts reported at least 4 additional species of this genus, all from the southern Gulf: *S. digueti* Coutiere, *S. sanlucasi* Coutiere, *S. townsendi mexicanus* Coutiere, and *S. apioceros sanjosei* Coutiere (?). Coutiere (1909) reported *S. sanlucasi* from Cabo San Lucas, *S. digueti* from the west coast of Baja California to Ecuador, and *S. goodei* from Baja California.

Genus *Betaeus*

A common genus in the warm temperate waters of western North America, whose members are quickly recognized by the unusual morphology of the chelipeds, in which the hand is inverted, allowing the finger to articulate ventrally, instead of lateral or dorsal as in most other shrimps. Members of this genus also lack a distinct rostrum on the carapace. Only one species of this genus has been found in the Gulf, *Betaeus longidactylus* Lockington (the "long-fingered" shrimp). This little crustacean reaches a maximum length of about 40 mm. It is green to olive or blue-green in color, the chelae often taking on a strong bluish hue. The legs are usually reddish. The chelipeds are subequal, long and narrow, with the fingers longer than the palms. The carapace is slightly projected anteriorly, like a "sun visor." *Betaeus longidactylus* occurs in tidepools, among and under rocks, in eelgrass beds, and in southern California has been reported from the burrows of the ghost shrimp *Upogebia pugettensis* and the "fat innkeeper," *Urechis caupo* (an echiurid worm). Shrimps of this genus are often found living in pairs, one female and one male. Its range is from central California (Elkhorn Slough) to the Mexican border, reappearing again in the upper Gulf of California. It is by far most abundant in the Los Angeles to San Diego region, and is quite uncommon in the Gulf. I have recorded this shrimp only occasionally in the Sea of Cortez, always between Puerto Peñasco and Puerto Lobos (on the Sonoran shore). Schmitt (1924) reported it from Bahía Tepoca (=Puerto Lobos) and Word and Charwat (1976) reported it from the rocky intertidal of Bahía de los Angeles. Figure 14.10.

A similar shrimp occurs in the southern California–west Baja region, *B. ensenadensis* Glassell, and is a common commensal in the burrows of ghost shrimps *Callianassa* and *Upogebia*.

FAMILY HIPPOLYTIDAE

Genus *Lysmata*

Probably several species of *Lysmata* are in the Gulf. The most common of these is the red and white striped shrimp common to southern California tidepools, *Lysmata californica* (Stimpson) (formerly *Hippolysmata californica* Stimpson). These beautiful shrimp are found

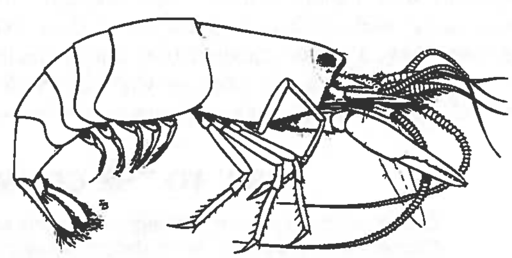


Fig. 14.10 *Betaeus longidactylus* (from Allen, 1976)

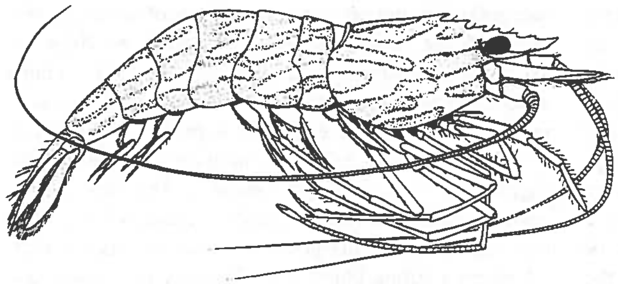


Fig. 14.11 *Lysmata californica*

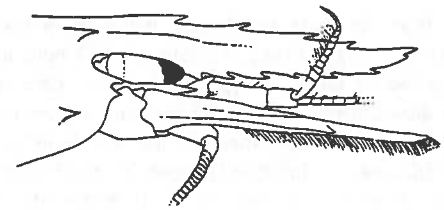


Fig. 14.12 *Hippolyte californiensis*. Anterior region (after Chace, 1951)

clinging to the underside of coarse boulders in the mid and low intertidal, often in large numbers. They may be picked off the rocks with relative ease, but once in the water they are nearly impossible to capture, as they swim backward with great speed and agility. Limbaugh et al. (1961), and others have shown that these shrimp are facultative cleaners of fish, aiding in the removal of external parasites, although this behavior has rarely been seen by the author in the Gulf of California. In California they are known to be cleaners of a number of fishes, including the California moray eel, garibaldi, and even spiny lobster. These colorful little shrimp make excellent aquarium pets, as they are hardy and attractive, coming out in the evenings to dart about and feed. Figure 14.11.

L. californica is characterized by its translucent red body with longitudinal white or pale pink stripes (or vice versa), and the 6 to 7 dorsal and 3 to 4 ventral teeth of the slender rostrum. The second pair of legs is very long and slender, the merus being divided into about 20 segments. In most individuals, the telson and third maxillipeds are dark mahogany. The body length often exceeds 50 mm. The range of this species is from San Simeon, California, to La Paz, on both sides of Baja California, and on the east side of the Gulf at least as far south as Bahía Kino. Limbaugh et al. also reported this shrimp from Guadalupe Island. A second species, *Lysmata* sp. (?), has been collected at various points in the northern Gulf and probably represents a new species. It is characterized by a small rostrum of variable length. In specimens with a short rostrum (about two-thirds the length of the eye), there is a minute dorsal spine. All individuals have a cluster of about 7 fine, ventral bristles on the rostrum. The body is opaque with dark brown spots. Castro (1966) reported a maximum length for this undescribed species of 23 mm in a gravid female. This species may be restricted to the tidepools of the northern Gulf. Dr. Fenner A. Chace, Jr. has informed me that, based on Castro's description alone, he suspects this *Lysmata* to be in fact a member of the recently proposed genus *Ambidexter* (family Processidae). A third species has been collected only at Guaymas. It is nearly identical to *L. californica* but lacks the characteristic stripes of the latter.

Genus *Hippolyte*

I have not collected any representatives of this genus in the Gulf. However, Chace (1951) reported *H. californiensis* Holmes as ranging from Bodega Bay, California, to the Gulf of California, and Schmitt (1924) reported it from Isla Patos in the Gulf. This species is green and abounds in the eelgrass beds of northern California. The rostrum has 3 to 5 dorsal and 3 to 5 ventral teeth. The shrimp upon which these records were based (in the Gulf) may eventually prove to be a new, undescribed species of *Hippolyte*. Figure 14.12.

SECTION (OR TRIBE) PENAEIDEA

FAMILY PENAEIDAE

Members of the family Penaeidae are recognized by their robust body form, well developed (usually toothed) rostrum, and biramous antennules. They form the basis of the large and important commercial shrimp fishing industry of Mexico. Although this fishery relies primarily on members of the genus *Penaeus*, four other genera are known to occur in the Gulf of California. Dr. Mary K. Wicksten (Allan Hancock Foundation) has provided us with the following artificial key to these taxa, from this region.

KEY TO THE COMMON PENAEID SHRIMPS

1	Dorsal carina present on all segments of the abdomen .... ***Sicyonia***	
	-Dorsal carina present only on abdominal segments 4–6	**2**
2(1)	Rostrum with teeth on ventral margin .... ***Penaeus***	
	-Rostrum without teeth on ventral margin	**3**

3(2) Carapace with postorbital spine and easily seen cervical groove; antennae much longer than body .... ***Solenocera mutator***
-Carapace without postorbital spine; cervical groove indistinct; antennae same length as (or shorter than) body 4
4(3) Rostrum shorter than eye .... ***Trachypenaeus brevisuturae***
-Rostrum longer than eye 5
5(4) Rostrum with 7–10 widely spaced dorsal teeth; cornea of eye less than 1/2 length of rostrum .... ***Trachypenaeus pacificus***
-Rostrum with 9–10 crowded dorsal teeth; cornea of eye 1/2 length of rostrum, or more .... ***Metapenaeopsis mineri***

Genus *Penaeus*

Members of this genus are the large commercial shrimp collected subtidally by shrimp trawlers. They are rarely found in the intertidal zone, although young specimens often occur in large numbers in many of the esteros of Sonora and Sinaloa. There are four principal species that make up the bulk of the west Mexican shrimp fishery. *Penaeus californiensis* Holmes (the "brown" or "khaki" shrimp), *P. stylirostris* Stimpson (the "blue" shrimp), *P. vannamei* Boone (the "white" shrimp), and *P. brevirostris* Kingsley.

Penaeus stylirostris is a white to pale blue shrimp, ranging from 150 to 200 mm in length when mature. The rostrum usually bears 8–9 dorsal teeth (maximum range of 5–10) and 4–5 ventral teeth (maximum range of 3–8). Three of the dorsal rostral teeth sit on the carapace proper. This species ranges from the upper Gulf of California to Peru.

Penaeus californiensis is a light brown to reddish-brown shrimp, ranging from 150 to 200 mm in length when mature. The rostrum has 8–11 dorsal teeth and 2–3 ventral teeth. Four of the dorsal rostral teeth sit on the carapace proper. This species ranges from San Francisco, California, to Peru. Figure 14.13.

Penaeus brevirostris is 140 to 190 mm in length when mature. The rostrum bears 9–11 dorsal teeth (maximum range of 8–12) and 2 ventral teeth (maximum range 1–3). Four of the dorsal rostral teeth sit on the carapace proper. This species ranges from the central Gulf (northern Sinaloa) to Peru and the Galápagos Islands.

Penaeus vannamei is smaller than the other three species of penaeids, being only 100–150 mm in length when mature. The rostrum bears 9–10 dorsal teeth and 2 ventral teeth. Four of the dorsal rostral teeth sit on the carapace proper. This species ranges from the southern Gulf at least as far south as Panama. This shrimp is the Pacific analog of *Penaeus setiferus*, a commercially important west Atlantic species.

The fisheries history and population dynamics of these commercial shrimps has been discussed by Snyder and Brusca (1977). The industry has been an active and salient economic influence in Mexico since at least 1935 and has been intensive since 1940. In addition, the Japanese were engaged in concentrated shrimp fishing in the Gulf during the early years. In the northern Gulf shrimp catches consist mainly of *P. californiensis* and *P. stylirostris*, while *P. stylirostris* and *P. vannamei*

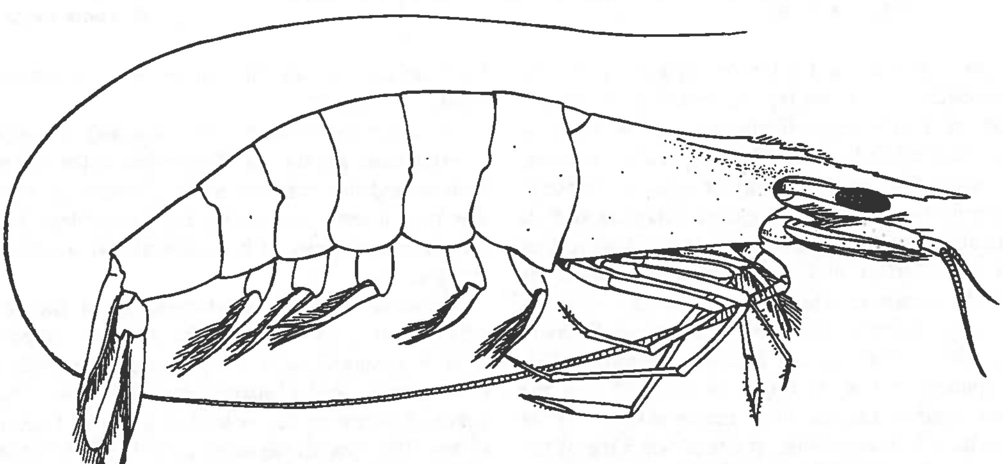


Fig. 14.13 *Penaeus californiensis*

predominate in southern Gulf catches. In 1974 over 850 shrimp trawlers operated out of Mazatlán, Yavaros, Topolobampo, Guaymas, Santa Cruz, San Felipe, and Puerto Peñasco (key ports in the Gulf of California). These authors have presented evidence that the shrimp fishery of western Mexico is in real need of increased management and that without it this vital resource may be expected to continue to decline dramatically.

Species of this genus (as well as *Sicyonia*) are known to enter the coastal esteros of west Mexico in the mysis stage. Once in the quiet waters of these warm lagoons they develop through the postlarval stage into juveniles. The juveniles (25–30 mm in length) then leave the esteros and migrate out to sea. The use of these unique habitats as nursery grounds is not uncommon and many important game fishes follow a similar behavior. Obviously, these penaeids must be considered as a euryhaline/eurythermal group, withstanding salinities of 33–40 parts per thousand and a temperature range of at least 15 centigrade degrees during their lifetime. Experimental work on these commercial shrimps indicates that temperature and kinds of available food are the prime controlling parameters of growth rate (as might be expected).

Genus *Sicyonia*

These shrimps are usually brought up with *Penaeus* in shrimp trawls dragged across the seafloor in 10 to 40 fathoms. In the northern Gulf they also have been collected at very low tide in large, sandy bays. There are at least 6 species in the Gulf. They may be distinguished by the following notes and key, provided by Dr. Mary K. Wicksten (Allan Hancock Foundation). Positive identification requires examination of the reproductive structures and the concerned naturalist is referred to Burkenroad's (1934, 1938) papers for further information.

KEY TO THE SPECIES OF *SICYONIA*

1	Three teeth on carapace posterior to rostrum	2
	-Two teeth on carapace posterior to rostrum	4
2(1)	Dorsal carina of second abdominal segment notched at junction of transverse sulci	***Sicyonia disparri***
	-Dorsal carina of second abdominal segment not notched at junction of transverse sulci	3
3(2)	Rostrum with 1–2 teeth; rostrum 11–25 percent of carapace length; rostrum horizontal or to 30° angle to carapace	***Sicyonia penicillata***
	-Rostrum with 3 teeth; rostrum 26 percent of carapace length; rostrum at 35° angle to carapace	***Sicyonia disedwardsi***
4(1)	Rostrum with bifurcate tip; carina of carapace low	***Sicyonia disdorsalis***
	-Rostrum with trifurcate tip; carina of carapace high, at least posterior to last tooth	5
5(4)	Rostrum with 2 teeth posterior to apex; rostrum length equals 37 percent carapace length	***Sicyonia aliaffinis***
	-Rostrum with 3–4 teeth posterior to apex; rostrum length equals 25 percent carapace length	***Sicyonia picta***

Sicyonia penicillata Lockington appears to be the commonest *Sicyonia* in the region, occurring throughout the gulf and in the warm water bays of west Baja, as far north as Scammon's Lagoon. The carapace has a strong, raised carina. The anterior carapace tooth lies close to the posterior rostral tooth; the second carapace tooth is considerably higher than the anterior tooth. This species usually has a distinct, dark, brownish-purple spot on the side of the carapace, which has led to its vernacular name "target shrimp." Members of the genus *Sicyonia* are also often referred to as "Japanese shrimps." This name apparently has its origin in the fact that the Japanese used to harvest them commercially (in the Gulf) in the 1930s and 1940s, at a time when the Mexican fleets were concerned only with the larger meatier species of *Penaeus*. Owing to the excessive decline in catch in recent years, Mexican shrimpers now take *Sicyonia* also, selling them mixed with the smaller size classes of *Penaeus*.

Sicyonia disedwardsi (Burkenroad) is similar to *S. penicillata* but smaller. The carina of the carapace is high behind the posterior tooth, decreasing anteriorly. The pleonic sulci are shallow and incomplete. *Sicyonia disedwardsi* appears to be a central and southern Gulf species.

Sicyonia disparri (Burkenroad) has the rostrum extended at a 35° angle to the carapace proper. The anterior carapace tooth lies close to the middle tooth, never anterior to the hepatic spine. The telson often has a pair of mobile spines as well as a pair of fixed lateral spines. This species has been found in 30–35 fathoms at Bahías Gonzaga and Santa Inés.

Sicyonia aliaffinis (Burkenroad) has the carapace carina elevated between the teeth. The anterior carapace tooth lies well behind the posterior rostral tooth, barely in front of the hepatic spine. The posterior carapace tooth is high. It has been collected off Isla Angel de la Guarda in 51–54 fathoms. An undescribed species of *Sicyonia*, resembling *S. aliaffinis* but with a tuberculate abdomen, has been taken at Arena Bank.

In *Sicyonia picta* Faxon the carapace carina remains high posterior to the last tooth, and the first tooth lies anterior to the hepatic spine. The carapace is setose and marked with a distinct ring on the branchial region. It has been taken at Bahías Gonzaga and Los Angeles in 17–23 fathoms.

Sicyonia disdorsalis (Burkenroad) has a low carapace carina, with the anterior tooth smaller than the posterior tooth, and in front of the hepatic spine. It has been taken south of Isla Tiburón, in 2–16 fathoms. *Sicyonia ingentis* (Burkenroad) occurs along the west coast of Baja and may eventually be reported from the Gulf proper. It resembles *S. disdorsalis* but is larger and possesses fixed lateral spines on the telson (which *S. disdorsalis* lacks).

Genus *Solenocera*

Solenocera mutator Burkenroad is a small shrimp with 6 dorsal rostral teeth (rarely 5 or 7) and a heavily setose ventral rostral margin. The epigastric spine is in line with the hepatic spine. This species is found along both coasts of Baja California (and rarely in southern California) south at least to Panama, in 1–100 fathoms.

Genus *Metapenaeopsis*

Metapenaeopsis mineri (Burkenroad) is a very small shrimp, the carapace rarely exceeding 11 mm in length. The carapace is setose (in fresh specimens), and the epigastric spine lies posterior to the hepatic spine. The rostrum is setose along the ventral margin and the telson has 3 pairs of mobile lateral spines. *Metapenaeopsis mineri* occurs along the lower west coast of Baja and throughout the Gulf, in 2–63 fathoms.

Genus *Trachypenaeus*

Trachypenaeus brevisuturae Burkenroad is a small species, the largest adults reaching about 60 mm in length. The epigastric spine is slightly anterior to the hepatic spine and the carapace has a short longitudinal suture. Fresh specimens retain a soft pubescence on the carapace. The telson has 4 pairs of mobile lateral spines. This species is known from both coasts of Baja, south at least to El Salvador. It has been collected at depths from 3 to 35 fathoms. *Trachypenaeus pacificus* Burkenroad is another small shrimp, with a longitudinal carapace suture extending to the hepatic spine. The hepatic spine is in line with the epigastric spine, and the rostrum is slightly arched along the dorsal surface, over the eye. The telson bears 0–4 pairs of mobile lateral spines. This species ranges from the central Gulf south at least as far as Panama, and has been collected in depths of 1–24 fathoms.

15

ARTHROPODA: CRUSTACEA
Thalassinoidea (Ghost Shrimp)

Preservation: See general Crustacea section.

Taxonomy and occurrence in the Gulf: The Gulf thalassinoids resemble very small spiny lobsters except that the first pair of legs is chelate, and the body is often soft and unpigmented as opposed to the rigid, colorful body of the regular lobsters. The rostrum is sometimes well developed, and the tail fan is always well developed. At least three genera of thalassinoids occur in the Gulf intertidal: *Axius*, *Callianassa*, and *Upogebia*. The Gulf thalassinoid fauna is still awaiting critical examination. There are many undescribed and probably endemic species.

FAMILY AXIIDAE

Axius (Neaxius) vivesi (Bouvier) is a hard-bodied, well-pigmented, reddish species resembling a small crayfish. It was first described by Bouvier in 1895 from a unique specimen collected by M. Diguet in La Paz. It was later described more fully by J. G. DeMan (1925a). The only published records since these descriptions are those of Steinbeck and Ricketts, who stated they found it in abundance east of La Paz in burrows in the gravelly mud flats, under and around the (mostly) dead heads of the coral *Porites*, and of Westervelt (1967), who reported it from Puerto Peñasco, living in burrows in the rocky reef. I have found *Axius* to be present but not abundant at Puerto Peñasco and Bahía Cholla, where it lives in burrows and holes in the granite and Coquina reefs. I have also found it in great abundance at Bahía San Everisto (northeast of La Paz) living in mud burrows under rocks, and in the Cabo San Lucas region. The length and complexity of the burrows, coupled with the nature of the reef rock, make this animal especially difficult to capture, which is no doubt one reason it has been so rarely reported in the literature. Martin Burkenroad has visited the Puerto Peñasco–Bahía Cholla area and had considerable success in capturing *Axius* by enticing them out of their burrows with a bit of fresh meat (such as crushed snails) and then quickly spearing them with a small harpoon. See Plate 13.

FAMILY CALLIANASSIDAE (ghost shrimp)

Ghost shrimp are found burrowing in muddy and sandy-mud bays and tidal flats, or occasionally along protected coastlines where rocks are imbedded in a soft substrate. They build elaborate burrows, often with one entrance under the edge of a large rock, and other entrances several feet away. Two genera of callianassid ghost shrimp occur in the Gulf: *Callianassa* and *Upogebia*.

Callianassa spp.

A genus of ghost shrimps similar to *Upogebia* (below) but with a less firm body and with the males possessing unequal chelae (the larger one being nearly as long as the body itself). Members of this genus, from the Gulf, are white to pinkish-red, and are found in the same general habitat as *Upogebia*. At least three species of *Callianassa* occur in the Gulf: *C. seilacheri*, *C. rochei*, and *C. uncinata*—and possibly a fourth, the common California form *C. californiensis* (fig. 15.1).

Ghost shrimps utilize both deposit feeding and suspension feeding techniques, although deposit feeding appears to be the preferred mode in most species. Some species have been reported as turning over 30 inches of sediment every 240 days. The presence of a colony of ghost shrimps on a tidal flat is easily discerned by the large number of uneven, but closely spaced, holes on the sediment surface. Most of the holes are surrounded by a shallow mound of mud. An individual ghost shrimp constructs a complex array of burrows and tunnels, usually having several openings on the surface. It would appear that in areas of greater disturbance (unconsolidated or muddy sediments, high populations of skates and rays, excessive burrowing activity of swimming crabs, etc.) individual shrimps' burrows tend to have more surface openings than in areas of less disturbance.

Ghost shrimp often harbor a number of commensal and ectoparasitic animals in their burrows with them. The following animals have been found living with *C. californiensis* Dana on the Pacific coast of the United States: *Clevelandia ios* (the arrow goby); *Typhlogobius californiensis* (the blind goby); *Scleroplax granulata*, *Pinnixa franciscana*, and *P. schmitti* (pea crabs); *Hesperone complanata* (a scale worm); *Betaeus complanta*, usually a male and a female (shrimp); *Cryptomya californica* (a small clam); and the ectoparasitic copepods *Hemicyclops callianassae*, *H. thysanotus* and *Clausidium vancouverense*. Members of the same or similar genera and species may be expected to be found living in the burrows of other species of ghost shrimp. I have collected *Callianassa uncinata* Milne-Edwards throughout the northern Gulf. This ghost shrimp ranges south all the way to Chile. In the southern extent of its range it is often parasitized by 2 small isopods, *Ionella agassizi* Bonnier and *Ione ovata* Shiino 1964. Neither of these isopods has been reported from the Gulf of California.

Upogebia spp.

Members of this genus of ghost shrimp are found burrowing in soft mud, under rocks, or at the base of mangrove roots. They build an elaborate burrow, up to about 1 m in length, with numerous side branches and turnarounds. The chelae are approximately equal in size in both sexes, and the body is generally more rigid than in *Callianassa*. Careful collectors will often find one male and one female *Upogebia* inhabiting each burrow, plus a host of small commensals (see *Callianassa*). There are at least two species of *Upogebia* known from the Gulf of California, *Upogebia pugettensis* (the "blue mud shrimp") and *U. rugosa*. The former ranges from Alaska to La Paz, on both sides of the Gulf. In California, *U. pugettensis* often harbors a parasitic isopod, *Phyllodurus abdominalis;* however, this parasite has not yet been recorded from the Gulf of California. *Upogebia pugettensis* often constructs a Y-shaped burrow, with 2 openings on the surface of the substratum. Many members of this genus tend to feed on plankton and suspended detritus, as opposed to extracting food out of the mud (deposit feeding), as is more commonly done in the genus *Callianassa*. Ghost shrimps of this genus are commonly recovered from the stomachs of the little gobioid fish *Gillichthys mirabilis*, which apparently feeds regularly on *Upogebia*. Figure 15.2.

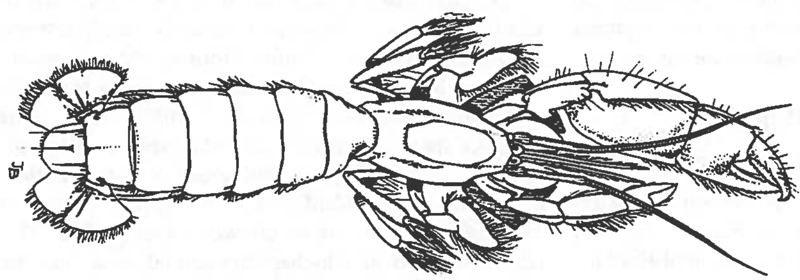


Fig. 15.1 *Callianassa californiensis* (from Allen, 1976)

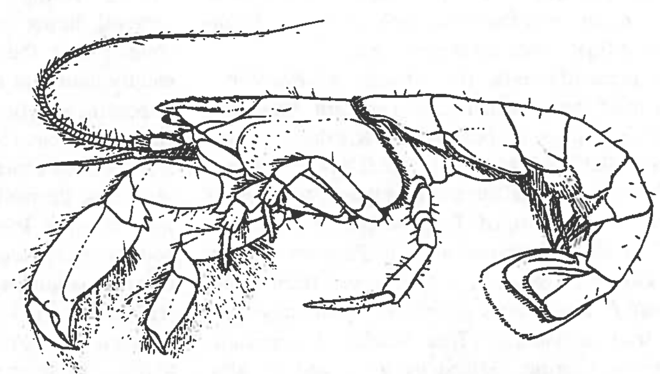


Fig. 15.2 *Upogebia pugettensis* (from Allen, 1976)

16

ARTHROPODA: CRUSTACEA
Palinura (Lobsters)

Preservation: Lobsters should be preserved in alcohol, although they may be air-dried subsequent to fixing in formalin. Storing specimens in the dried condition is intended for display purposes only and should not be done if the animals are to be maintained as reference or systematic collections.

Taxonomy: See Chapter 10.

Lobsters of the Gulf: Two genera of lobsters are commonly seen in the Gulf of California, the spiny lobster *(Panulirus)* and the slipper lobster *(Evibacus)*. Both are subtidal forms, the latter occasionally being picked up by shrimp trawlers. Spiny lobsters are best captured with the aid of SCUBA gear or by use of lobster traps.

FAMILY PALINURIDAE
Panulirus inflatus (Bouvier)

The history and systematics of the spiny lobsters (family Palinuridae) of the eastern Pacific has been much confused for many years. It was not until Holthuis and Villalobos (1962) reviewed the very similar species *Panulirus gracilis* and *Panulirus inflatus* that a definitive light was finally shed on this problem.

There presently exist five species of *Panulirus* described from the eastern Pacific (western America), distributed as follows: *P. interruptus* (Randall), central California to Bahía Magdalena (outer Baja); *P. inflatus* (Bouvier), Bahía Magdalena and throughout the Gulf of California to the Gulf of Tehuantepec; *P. gracilis* Streets, Gulf of Tehuantepec south to Peru (plus a few southern Gulf records and a single record from Bahía Magdalena); *P. penicillatus* (Olivier), known only from offshore tropical islands (Tres Marías, Clipperton, Revillagigedo, Clarion, Galápagos, etc.); and, *P. pascuensis* Reed, known only from Easter Island.

Panulirus penicillatus is a trans-Pacific species, distributed through south Africa, the Red Sea, and the Indian Ocean, but being entirely insular in the eastern Pacific. Occasional references have been made in the literature to *P. ornatus* (Fabricius). This species is, however, strictly an Indo-Pacific form, not found in the waters of mainland America. In most cases. it appears that the authors were referring to *P. gracilis*.

As can be seen from the above summary of spiny lobster distributions, only *Panulirus inflatus (or rarely P. gracilis)* can be expected to occur in the Gulf of California proper. *Panulirus inflatus* is locally referred to as the "Blue" or "Caribe" lobster and is generally the one obtained in markets and restaurants along the coasts of Sonora and Sinaloa. In *P. inflatus* most of the carapace spines are orange with white spots, while in *P. gracilis* they are uniformly dark green or blue. *Panulirus interruptus*, the "California" or "Red" lobster, is taken in large numbers on the west coast of Baja. This latter species is of a higher commercial value than the "Blue," owing to its greater abdominal size and better survival during transit. *Panulirus gracilis* is rarely encountered on the domestic market although it is sufficiently abundant in the Galápagos to be of commercial importance. Migrations of *Panulirus argus* (a west Atlantic species) for several miles have been reported by a number of observers. The members of the migrating mass link themselves together, head to tail, forming a long chain of lobsters that slowly walk across the sea bottom, each following the member in front and all ultimately dependent on the primary, leading lobster (Herrnkind, 1970). Several excellent articles on the ecology of the Atlantic spiny lobster *(P. argus)* may be found in Earle and Lavenberg (1975). Preliminary work by Baez (unpublished as of this writing) suggests the larvae of *P. gracilis* migrate offshore to develop, then back inshore to settle and metamorphose into adults. Figure 16.1.

FAMILY SCYLLARIDAE

Evibacus princeps Smith

Variously known as the slipper, sand, flat, or boot lobster. This curious decapod has a very hard, flat carapace, that extends laterally beyond the margin of the body proper, like thin serrated wings. The abdomen can be tightly flexed under the thorax. There are five pairs of walking legs and no chelipeds. This strange lobster lives subtidally on sandy bottoms and is occasionally picked up by the Gulf shrimp trawlers in their otter trawls, or washed ashore during a storm. It is prized for its delicious meat but is relatively scarce. There may be a second species of flat lobster known from the Gulf, which is much larger and more laterally compressed. The Mexican shrimpers call these sand lobsters, "langosta de arena" or "zapatera." The range is given by Rathbun (1910) as La Paz to Peru; however, Steinbeck and Ricketts reported it from Guaymas, in the central Gulf, and I have collections from the Puerto Peñasco area, in the upper Gulf.

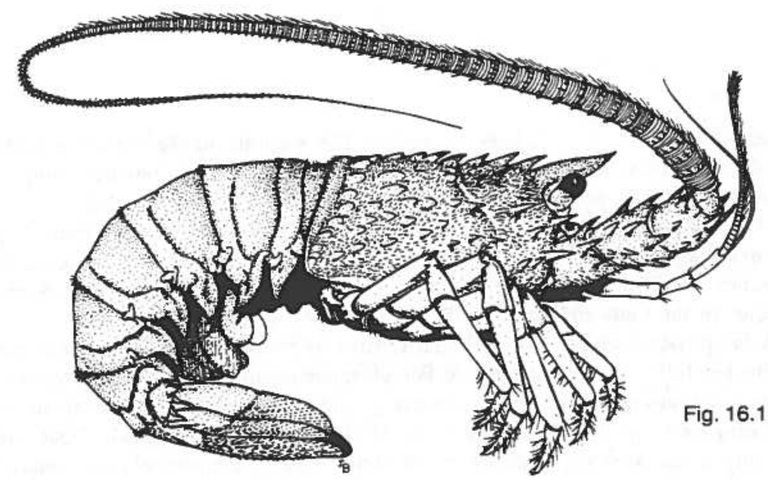


Fig. 16.1 *Panulirus* sp., the spiny lobster

17

ARTHROPODA: CRUSTACEA
Porcellanidae (Porcelain Crabs)

Preservation: See Brachyuran section.

Taxonomy: The only group of galatheoids commonly encountered in the Gulf intertidal are the porcelain crabs (Porcellanidae). The taxonomy of the porcellanids is based primarily on external features of the carapace, legs, antennae, and abdomen. The main features used to distinguish the species of the Gulf are carapace and cheliped structures. A brief discussion of some of the structures mentioned in the key follows.

Epibranchial spines: The carapace of crabs may be divided into various areas, corresponding to the internal anatomy, and usually visible externally as elevated regions, demarcated by shallow grooves. For the purpose of this key, the only zone necessary to recognize is the epibranchial region, which is that area from the lateral margin of the carapace (about midway from anterior to posterior) to an area about even with a line extending directly back from the eye. This is roughly the two anterolateral quarters of the carapace. The importance of this region is whether or not it possesses small spines (the epibranchial spines), and if so, how many. The spines are usually entirely dorsal, but they may occasionally be formed as lateral projections of the carapace.

Piliferous striations: The carapace of some porcelain crabs has numerous shallow, transverse depressions, each lined with a row of short, stiff setae. The setae are usually microscopic.

Cheliped characters: The first segment behind the manus (the manus is the claw portion of the cheliped) is the carpus. The important characters of the carpus are its length-to-width ratio and the number of spines it has along the anterior or inside (leading) margin. Whenever the terms "manus" and "carpus" are used in the key, they refer to the first leg (chelipeds).

Telson: The telson of porcelain crabs is regarded as that portion of the abdomen that consists of articulating plates or pieces. The majority of the porcelain crabs have 7 free plates in the telson, but a few have only 5.

See fig. 20.1 for remaining crab morphology.

The systematics used in this handbook are from Haig (1960), and many of the key couplets are extracted or modified from her excellent monograph of the eastern Pacific Porcellanidae.

Porcelain crabs of the Gulf: There are about ten genera of Porcellanidae common to the Gulf intertidal. The dominant genera are *Petrolisthes* (with about 18 species in the Gulf) and *Pachycheles* (with about five species in the Gulf). The most commonly encountered species throughout the Gulf are the little hairy-clawed *Pachycheles setimanus* (with unequal chelae), the smooth-clawed *Petrolisthes armatus*, *Petrolisthes crenulatus*, and *Petrolisthes gracilis* (with subequal chelae), and the hairy-clawed *Petrolisthes hirthipes* (with subequal chelae). In the northern Gulf *Petrolisthes sanfelipensis* is quite abundant, while in the southern Gulf *Petrolisthes nigrunguiculatus* is often encountered.

Many of the porcelain crabs of the Gulf are unique to this region and are found nowhere outside the Gulf of California. The vast majority of the Porcellanidae of this region, however, have Panamic affinities. In fact, not one of the crabs treated in this section is known to occur north of Mexico. Westervelt (1967) stated that 42 percent of the anomurans (porcellanids and pagurids) he studied from the Puerto Peñasco region were endemics and 46 percent were Panamic.

Most porcelain crabs are found clinging to the undersides of rocks in the mid and low intertidal zones, or hiding in the crevices and chambers of coral and sponge. Some species are commensal on hermit crabs *(Porcellana paguriconviva* and *Porcellana cancrisocialis)* or gorgonian coral *(Orthochela pumila*, etc.). Three species in the key superficially resemble the mole crabs (family Hippidae). They are: *Euceramus transversilineatus*, *Minyocerus kirki*, and *Ulloaia perpusillia*. These three species may be readily distinguished from the true mole crabs by the presence of pincers on the first legs (chelipeds), whereas most mole crabs are without pincers.

Several of the species included in the key are rare or uncommon in the Gulf. These forms are listed below with a note of explanation as to their rarity, and are marked with an asterisk in the key.

Orthochela pumila: Commensal on gorgonian coral; largely subtidal; only Gulf record is from Mazatlán.
Petrolisthes glasselli: Usually associated with coral; largely subtidal; not reported north of La Paz.
Petrolisthes lewisi: Rarely encountered.
Petrolisthes nobilii: Not reported north of La Paz.
Petrolisthes tonsorius: Known only from the mouth of the Gulf (Cabo San Lucas).
Pachycheles spinidactylus: Only Gulf record is Cabo San Lucas.
Heteroporcellana corbicola: Known only from Roca Consag, northern Gulf, at 10 to 25 fathoms.
Megalobrachium erosum: Subtidal (5 to 25 fathoms).
Minyocerus kirki: Commensal on sea stars, primarily restricted to the genus *Luidia*, and mainly subtidal.
Ulloaia perpusillia: Known only from three localities: Puerto Peñasco, Costa Rica, and Panama.
Polyonyx nitidus and *P. quadriungulatus:* Uncommon and largely subtidal. Often commensal in tube of *Chaetopterus*, the polychaete worm.

The hairy little lithode crab *Hapalogaster cavicauda* Stimpson (family Lithodidae) strongly resembles the porcelain crabs, although it is actually more closely related to the hermit crabs. This lithode has been reported in the Gulf only from the Guaymas area (Brusca and Haig, 1972). Its appearance in these warm waters appears to be quite unusual and I have not recorded it from the Gulf since this original citation.

KEY TO THE PORCELLANID CRABS

1 Carapace longer than broad 2
-Carapace length equal to, or less than, width 8

2(1) Chelipeds normally held more or less straight out in front of carapace; lateral margins of carapace with a series of about 12 to 15 minute, close-set spinules; always commensal on gorgonian coral .... ***Orthochela pumila****
-Chelipeds normally bent sharply at articulation of carpus and manus, with manus directed inward; lateral margins of carapace without numerous close-set spinules; rarely commensal on gorgonian coral 3

3(2) Antennae minute and rudimentary, the total length less than or barely exceeding the width of the eye; commensal on sea stars (fig. 17.16) .... ***Minyocerus kirki****
-Antennae not minute, rather large and easily seen, length much greater than width of eye; not commensal on sea stars 4

4(3) Chelae unequal in size; manus tuberculate; carapace and legs very rough, with numerous large ridges and furrows .... ***Ulloaia perpusillia****
-Chelae subequal; manus not tuberculate; carapace and legs relatively smooth, not as above 5

5(4) Carapace 1.5 times as long as broad (or more); a large, orbitlike concavity on anterolateral margin; usually found burrowing through sand .... ***Euceramus transversillineatus***
-Carapace not 1.5 times as long as broad; no orbitlike concavity on anterolateral margin; usually found clinging to rocks or in coral or sponge 6

6(5) Telson of abdomen with 5 plates; fingers of chelae opening vertically; carpus without spines or a large lobe on the anterior margin; probably not commensal with hermit crabs (fig. 17.14) .... ***Heteroporcellana corbicola****
-Telson of abdomen with 7 plates; fingers of chelae opening horizontally (or oblique); carpus with a single spine or lobe on the anterior margin; usually commensal on hermit crabs 7

7(6) Carapace with 2 to 3 epibranchial spinues; carpus with a spine-tipped lobe on anterior margin; manus with long marginal hairs; carapace yellow to orange, with red and blue spots (fig. 17.13) .... ***Porcellana cancrisocialis***
-Carapace with no epibranchial spines; carpus without a spine on the anterior margin but with a large lobe; manus without long, marginal hairs; carapace lavender with orange strips .... ***Porcellana paguriconviva***

8(1) Chelae subequal in size 9
-Chelae unequal in size 34

*Rare or unusual in the Gulf.

9(8) Basal segment of antennae large, produced forward, and broadly in contact with anterior margin of carapace, leaving movable segments far removed from orbit; chelipeds stout; length of carpus never 2 times width 10
-Basal segment of antennae short, not strongly produced forward to meet anterior margin of carapace, leaving movable segments with free access to orbit; chelipeds usually (but not always) thin and flat; length of carpus usually 2 times width 15

10(9) Telson of abdomen with 5 plates 11
-Telson of abdomen with 7 plates 12

11(10) Carapace and legs covered with small, shallow pits; legs without stiff, marginal setae; carpus with 1 spine on anterior margin (fig. 17.15) ... ***Megalobrachium garthi***
-Carapace and legs not covered with small pits, but covered with numerous tubercles; legs with stiff, marginal setae; carpus with 3 to 4 spines on anterior margin .... ***Megalobrachium tuberculipes***

12(10) Dactylus of walking legs ending in 2 or more large, strong, fixed spines (fig. 17.17); carapace markedly broader than long; front nearly transverse in dorsal view .... ***Polyonyx* spp.**
-Dactylus of walking legs ending in a single spine, often with accessory movable spinules on posterior margin; carapace not markedly broader than long; front variable 13

13(12) Carapace and chelipeds heavily eroded and pitted; not known to occur intertidally .... ***Megalobrachium erosum****
-Carapace and chelipeds smooth to rough, but not heavily eroded and pitted; intertidal or subtidal 14

14(13) Carpus with a narrow, blunt spine on proximal third of anterior margin and often with several small blunt spines beyond this .... ***Megalobrachium sinuimanus***
-Carpus without spines, or at most with a slight projection at anteroproximal angle .... ***Megalobrachium smithi***

15(9) Anterior margin of walking legs spined; epibranchial spine(s) present 16
-Anterior margin of walking legs without spines; epibranchial spines absent 24

16(15) Carapace with distinct transverse piliferous striations or grooves, interrupted at grooves defining the various body regions 17
-Carapace smooth to rough, but without transverse striations as above 21

17(16) Length of carpus 2 times width; manus often with distinct tubercles; carpus with 3 to 5 spines on anterior margin 18
-Length of carpus less than 2 times width; manus without distinct tubercles; carpus with 4 to 6 spines on anterior margin 20

18(17) Manus and walking legs with a fringe of very long setae (fig. 17.6) .... ***Petrolisthes hirtipes***
-Manus and walking legs without a fringe of long setae 19

19(18) Anterolateral area of carapace with a group of spines in addition to usual epibranchial spine; carpus with 3 to 5 simple spines on the anterior margin .... ***Petrolisthes sanfelipensis***
-No spines on dorsal surface of carapace, other than a single epibranchial spine; carpus with 3 *serrated* spines on anterior margin (fig. 17.3) ..... ***Petrolisthes edwardsii***

20(17) Two epibranchial spines; carapace length 4 to 11 mm (fig. 17.4) .... ***Petrolisthes glasselli****
-One epibranchial spine; carapace length 3 to 6 mm .... ***Petrolisthes polymitus***

21(16) Length of carpus less than 2 times width; anterior margin of carpus with 4 to 6 spines .... ***Petrolisthes haigae***
-Length of carpus 2 or more times width; anterior margin of carpus with 3 to 6 spines 22

22(21) Anterior margin of carpus with 4 to 6 spines; spines of carpus broad and close-set (fig. 17.7) .... ***Petrolisthes hirtispinosus***
-Anterior margin of carpus with 3 to 4 spines; spines of carpus low and wide-set 23

23(22) Epibranchial spine distinct; no short pubescence on outer margin of ventral surface of manus; carapace nearly as wide across mid-region as posteriorly (fig. 17.1) .... ***Petrolisthes armatus***
-Epibranchial spine absent or vestigial; ventral surface of manus with a narrow band of short pubescence along outer margin; carapace widest posterior to mid region (fig. 17.10) .... ***Petrolisthes nobilii****

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*Rare or unusual in the Gulf.

24(15) Epibranchial spines small and vestigial or entirely lacking; anterior margin of walking legs spined (fig. 17.10) .... ***Petrolisthes nobilii****
-Epibranchial spines always absent; anterior margin of walking legs without spines 25

25(24) Merus of walking legs nodulate on anterior margin; carpus of females with 5 to 8 very small spines on anterior margin; carpus of male unarmed; carpus over 2.5 times as long as broad .... ***Petrolisthes tiburonensis***
-Merus of walking legs without nodules on anterior margin; carpus of females with 0 to 4 spines on anterior margin; carpus of male armed or unarmed; length of carpus variable 26

26(25) Carpus not armed with strong teeth or tubercles 27
-Carpus with strong teeth or tubercles on anterior margin 29

27(26) Carpus over twice as long as wide (fig. 17.5) .... ***Petrolisthes gracilis***
-Carpus twice as long as wide or less than twice as long as wide 28

28(27) Margin of carapace, between eyes, forms a narrow, rounded projection; length of carpus nearly 2 times width; occasionally with a single spine on anterior margin of carpus; length of carapace 3 to 12 mm (fig. 17.9) .... ***Petrolisthes tonsorius****
-Margin of carapace, between eyes, forms a wide, V-shaped projection; length of carpus much less than 2 times width; often with a row of very small granules on anterior margin of carpus; length of carapace 3 to 6 mm .... ***Petrolisthes schmitti***

29(26) Manus with a thick fringe of hair on outer margin; fingers dissimilar in the two chelae; carpus with wide-set, conical tubercles on the anterior margin 30
-Manus without a thick fringe of hair; fingers not distinctly dissimilar in the two chelae; carpus with strong teeth on anterior margin 31

30(29) Tips of chelae red-orange; epibranchial area often with a tubercle or 1 or 2 minute spinules; manus with numerous denticles; posterior margin of merus of walking legs 1–2 with 2 to 3 distal spines; carapace covered with short, transverse plications (fig. 17.6) .... ***Petrolisthes hirtipes***
-Tips of chelae not red-orange; epibranchial area never with a tubercle or spines; manus with few or no denticles; posterior margin of merus of walking legs 1–2 without spines; carapace nearly smooth, not as above .... ***Petrolisthes nigrunguiculatus***

31(29) Telson of abdomen with 5 plates; outer orbital angle produced into a distinct tooth .... ***Petrolisthes hians***
-Telson of abdomen with 7 plates; outer orbital angle not strongly produced 32

32(31) Manus with 2 longitudinal crests on dorsal surface, and a heavy, rounded crest along the outer margin (fig. 17.8) .... ***Petrolisthes lewisi****
-Manus without 2 dorsal crests, and without a heavy rounded crest along the outer margin 33

33(32) Anterior margin of carapace forms a 3-lobed shelf between eyes; carapace covered with minute granules and/or short plications; carpus about 1.5 times as long as wide; carpus with 3 or 4 spines on anterior margin; a large, rust-colored crab; length of carapace 3 to 14 mm (fig. 17.2) .... ***Petrolisthes crenulatus***
-Anterior margin of carapace forms a straight shelf, not 3-lobed; carapace nearly smooth, not as above; carpus less than 1.5 times as long as wide; carpus with 3 spines on anterior margin, not as above; length of carapace 3 to 7 mm .... ***Petrolisthes ortmanni***

34(8) Telson of abdomen with 5 plates 35
-Telson of abdomen with 7 plates 36

35(34) Carpus with 0 to 3 spines on anterior margin; carapace devoid of visible hair; manus without setae .... ***Pachycheles biocellatus***
-Carpus with 4 to 5 spines on anterior margin; carapace with numerous, fine setae; manus lightly setaceous .... ***Pachycheles marcortezensis***

36(34) Carapace with a distinct tuft of hairs on front, or surface covered with distinct hairs 37
-Carapace devoid of hairs (or at most with traces scarcely visible under magnification) (fig. 17.11) .... ***Pachycheles setimanus***

37(36) Front with a distinct tuft of hair; carpus with 3 to 4 spines on anterior margin (fig. 17.12) .... ***Pachycheles spinidactylus****
-Front without a distinct tuft of hair; carpus with 2 to 3 spines on anterior margin .... ***Pachycheles panamensis***

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*Rare or unusual in the Gulf.

SUPERFAMILY GALATHEOIDEA
FAMILY PORCELLANIDAE
Orthochela pumila Glassell

A small and rather strange-looking porcelain crab with very large, heavy chelipeds, with the manus held straight out in front of the carapace instead of folded inward, as in most crabs. The chelipeds are unequal in size, the largest being about 2.5 times the carapace length. The chelipeds are without hair, the carpus lacks spines on the anterior margin, and the palm is longer than the fingers. The fingers open vertically and bear a short pubescence in the gape. The carapace is nearly 1.5 times as long as broad and has a large, projecting median lobe. The lateral margins have 12 to 15 spinules but lack epibranchial spines. The color of this crab is variable. It has been recorded as yellow, with red lines and blotches; solid purple; blotched red and yellow; brown with white spots; and white with rust-colored spots. However, it seems that the crab will always match perfectly the color of the gorgonian coral upon which it is living. It has seven abdominal plates, and the carapace is about 2 to 4 mm long. *Orthochela pumila* is relatively uncommon and is an obligatory commensal on gorgonian coral, restricting its habitat to the subtidal and the lowest of low tides. Its range is reported as Bahía San Hipolito on the outer Baja California coast, and Mazatlán on the mainland, south to Ecuador.

Petrolisthes armatus (Gibbes)

A very common crab of the Gulf. The carapace is pale brown to olive-black, occasionally with green markings, occasionally pubescent (but usually smooth and naked), and bearing a single epibranchial spine. The carpus of the cheliped is 2–2.5 times as long as wide, usually naked, and armed with 3 to 4 teeth along the anterior margin. The manus is usually naked, although young individuals often have some setae. The gape of the fingers is pubescent. This species is about 4 to 15 mm long and is common under stones in the mid and high intertidal. It has been reported in mangrove beds, coral, sponge, oyster, and mussel beds, and under rocks from both the Atlantic and Pacific oceans. On our coast, it ranges from the upper Gulf to Peru and the Galápagos Islands. Feeding methods in the porcellanids which have been observed and recorded by a number of authors, are generally described as "cast-net" feeding, wherein the enlarged and highly setose third maxillipeds are waved through the water to collect plankton and are then brought in to be cleaned off by the second maxillipeds. Westervelt (1967) has a good discussion of porcellanid and pagurid feeding methods and has recorded observations on *Petrolisthes armatus* and 10 other species of porcelain crabs. Figure 17.1 and Plate 2.

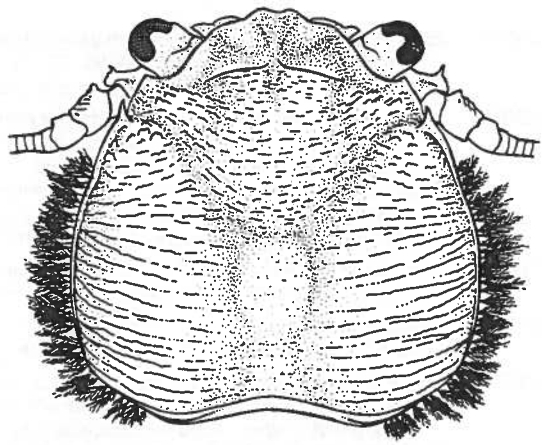

Fig. 17.1 *Petrolisthes armatus* carapace

Petrolisthes crenulatus Lockington

A common species of crab throughout the Gulf. The carapace is covered with short plications, lacks epibranchial spines, and is about 3 to 14 mm long. The front is trilobate and often bears long plumose hairs. The carpus of the cheliped is about 1.5 times as long as wide, with 3 to 4 teeth on the anterior margin. The manus has long plumose hairs, and the gape of the fingers bears a thick pubescence. A large and robust species, easily recognized by its dull white carapace, covered with many rust-colored blotches and large teeth on the inner margin of the carpus. The fingers are entirely red, and the eyes are bright green. This species is common from Bahía Magdalena and the upper Gulf to Mazatlán and Islas Tres Marías. It usually is found under stones in the low intertidal, but is also known to occur in coral heads. Figure 17.2.

Petrolisthes edwardsii (Saussure)

This species is uncommon in the Gulf. The carapace is botched with pink or red and has strong, transverse, piliferous striations and a single epibranchial spine. The carpus of the cheliped is about two times as long as wide and is armed with three denticulate spines on the anterior margin. The manus is broad and covered with tubercles (as is the carpus) and a few proximal spines. The fingers bear a short pubescence. This is a large species, reaching about 16 mm in length. *Petrolisthes edwardsii* occurs under rocks and in coral from Bahía Santa María on the outer Baja California coast, and the upper Gulf, to Ecuador and the Galápagos Islands. It has been recorded from the intertidal, as well as to depths of 20 fathoms. Figure 17.3.

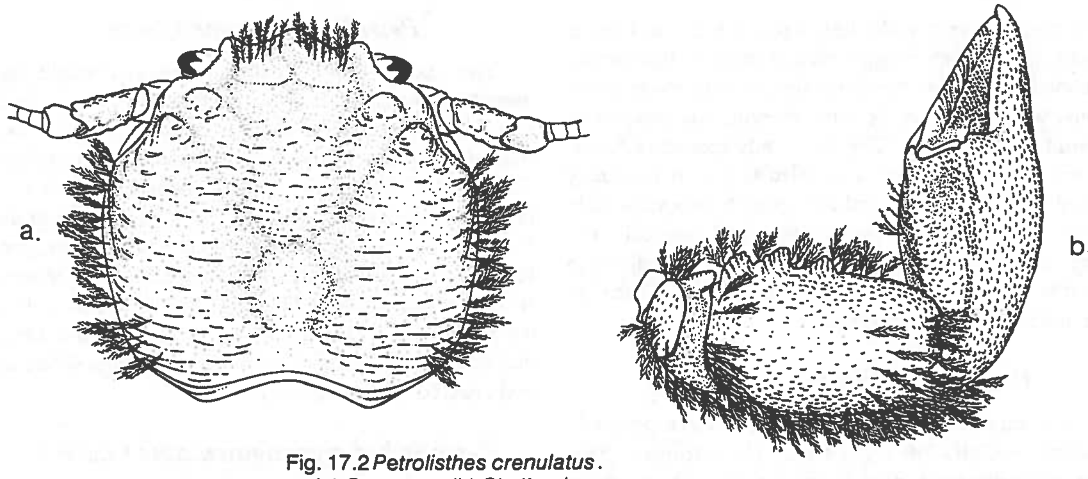

Fig. 17.2 *Petrolisthes crenulatus*.
(a) Carapace. (b) Cheliped.

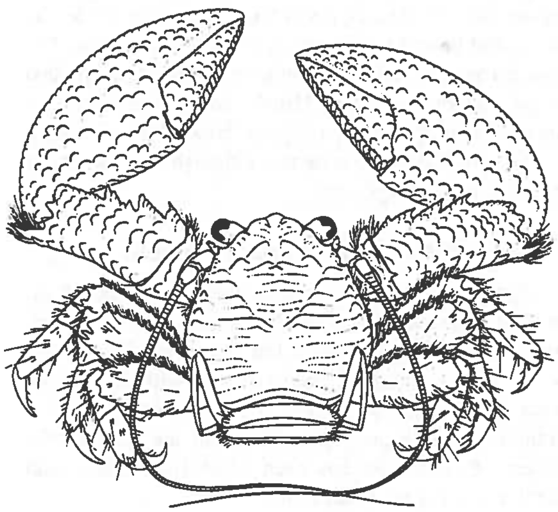

Fig. 17.3 *Petrolisthes edwardsii*

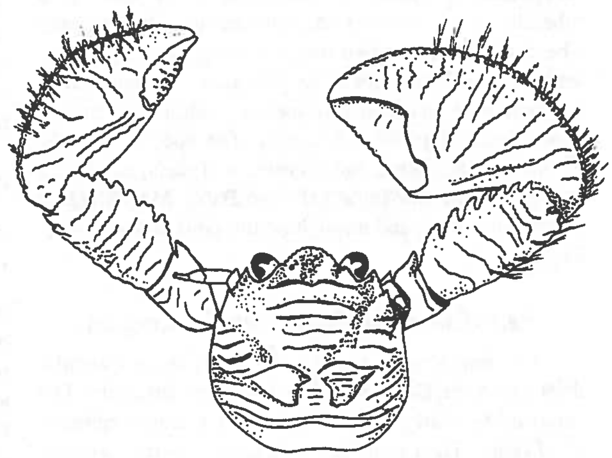

Fig. 17.4 *Petrolisthes glasselli*
(after Haig, 1957)

Petrolisthes glasselli Haig

This species is uncommon in the Gulf. The carapace is 4 to 11 mm long and covered with transverse, piliferous striations. It is the only member of this genus in the Gulf with two epibranchial spines. The carpus of the chelipeds is less than twice as long as wide, with four to five teeth along the anterior margin. The manus is broad, with a few flattened tubercles and occasionally a fringe of hairs. The fingers do not bear a pubescence. Records indicate this species is usually (but not always) associated with corals (*Pocillopora* and *Pavona*), and ranges from the mouth of the Gulf (Cabo San Lucas) south to Colombia and the Galápagos and other offshore islands. Figure 17.4.

Petrolisthes gracilis Stimpson

A common species in the Gulf. The carapace is about 3 to 11 mm long, bluish-green with white spots, nearly smooth, and lacks an epibranchial spine. The carpus is 2.5 to three times as long as wide, and without spines along the anterior margin. The manus is long and slender, with no hairs. This species is found under stones from the upper Gulf and Bahía Magdalena as far south as Bahía Tangola-Tangola, Mexico. Figure 17.5.

Petrolisthes hians Nobili

The carapace of this species is about 2 to 6 mm long, rough anteriorly and smooth posteriorly, and lacks an epibranchial spine. The chelipeds are short and stout.

The carpus is very wide, less than 1.5 times as long as broad, the anterior margin bearing three to four broad, rounded teeth. The manus is covered with rough plications, with a crest on the outer margin, and completely devoid of pubescence. This is the only species of *Petrolisthes* in the Gulf with a 5-plated telson. It is usually found associated with coral and sponge, or occasionally under stones, in the low intertidal and subtidal. The range is reported as Guaymas to Ecuador, in addition to records from Bahía Magdalena and Punta Tosca on the outer Baja California coast.

Petrolisthes hirtipes Lockington

A common and easily recognized brown porcelain crab of the Gulf. The legs all bear a long fringe of hair, and the chelae have many large tubercles. The carapace is about 3 to 11 mm long, finely plicate and lightly tuberculate, and lacks an epibranchial spine (although a tubercle or one to two small spinules may be present). The carpus is about two times as long as wide, with a series of small tubercles in the proximal half. The manus is tuberculate and highly setaceous, with a short pubescence in the gape of the fingers. The species is fairly common under stones and in crevices of reefs, coral, and sponges in the low intertidal from Bahía Magdalena to Cabo San Lucas, and throughout the Gulf of California. Figure 17.6.

Petrolisthes hirtispinosus Lockington

A common form, found under rocks in the intertidal throughout the Gulf (and probably restricted to it). The carapace is nearly smooth and bears a single epibranchial spine. The carpus is a little over two times as long as wide, the anterior margin with four to six serrate-edged spines. The manus has a longitudinal crest of flattened granules, a short fringe of hairs (easily rubbed off), and a short pubescence in the gape of the fingers. The carapace is light red, mottled with yellow and white, and the length is 2 to 13 mm. Figure 17.7.

Petrolisthes lewisi (Glassell)

A rare species in the Gulf. The carapace is nearly smooth, lacks epibranchial spines, and is about 3 to 6 mm long. The carpus is about 1.5 times as long as wide, and bears three to four spines on the anterior margin. The manus has three heavy crests, defined by deep grooves. The gape of the fingers has a short pubescence. Miss Janet Haig informs me the range of the Gulf subspecies *P. lewisi lewisi* is Isla del Carmen, Gulf of California to Bahía Tangola-Tangola, Mexico. Another subspecies, *P. lewisi austrinus*, is reported from Nicaragua to Ecuador. Figure 17.8.

Petrolisthes haigae Chace

This species has a smooth carapace, a single epibranchial spine, and is 3 to 13 mm long. The carpus is less than two times as long as wide, and bears four (occasionally five to six) spines on the anterior margin. The manus is granular, with a longitudinal crest of larger, flattened granules extending from the base of the fingers. This species is rarely found under stones, preferring to hide in the interstices of coral *(Porcillopora)*. Its range is recorded as Guaymas to Ecuador as well as the Galápagos and other offshore islands. Until 1962, this species was known as *Petrolisthes marginatus*, an east coast form that it closely resembles.

Petrolisthes nigrunguiculatus Glassell

This crab has a smooth carapace, about 3 to 10 mm long, without an epibranchial spine, and is mottled with brown and red. The carpus is about two times as long as wide, and bears four spines on the anterior margin. The manus has a thick fringe of hair on the outer margin and in the gape of the fingers. Usually found under stones in the intertidal, the known range of this species suggests it is a Gulf of California endemic, although a single record from Colombia does exist.

Petrolisthes ortmanni Nobili

Petrolisthes ortmanni ranges from the central Gulf, to Peru. The carapace is nearly smooth, without an epibranchial spine, and is about 3 to 7 mm long. The carpus is less than 1.5 times as long as wide, with three broad teeth on the anterior margin. The manus is smooth to granular, with a thick pubescence in the gape of the fingers. *P. ortmanni* has been taken from stones and coral in the low intertidal zone.

Petrolisthes polymitus Glassell

An uncommon species, with the carapace bearing distinct, transverse, piliferous striations and a single epibranchial spine. The carapace is about 3 to 6 mm in length. The carpus is about 1.5 times as long as wide, with four to five broad, serrated spines on the anterior margin. The manus and fingers have flattened rugae and granules covering the surface with a row of spines and scattered hairs on the outer margin. This species ranges from the southern Gulf to Ecuador and the Galápagos Islands, and occurs under rocks and in coral and sponges.

Petrolisthes sanfelipensis Glassell

A common species with a bright pink or red carapace, 3 to 11 mm long, having distinct, transverse, piliferous striations on the dorsal surface, and a cluster

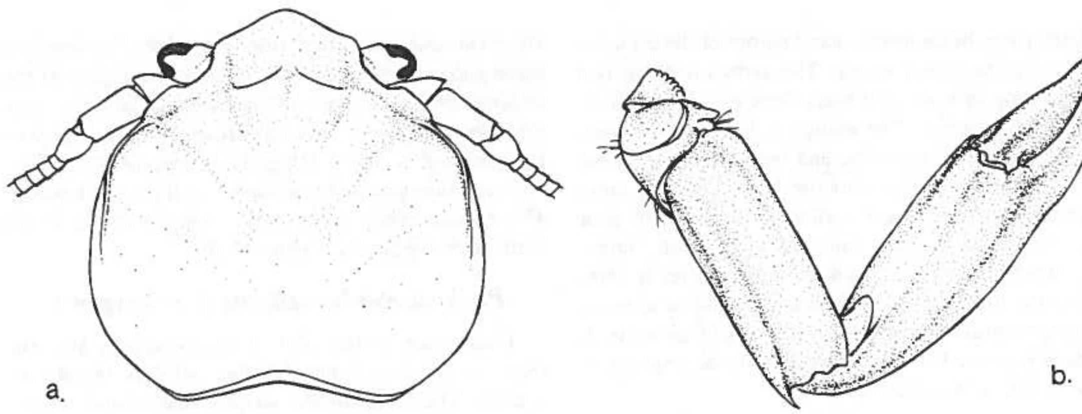

Fig. 17.5 *Petrolisthes gracilis*.
(a) Carapace. (b) Cheliped.

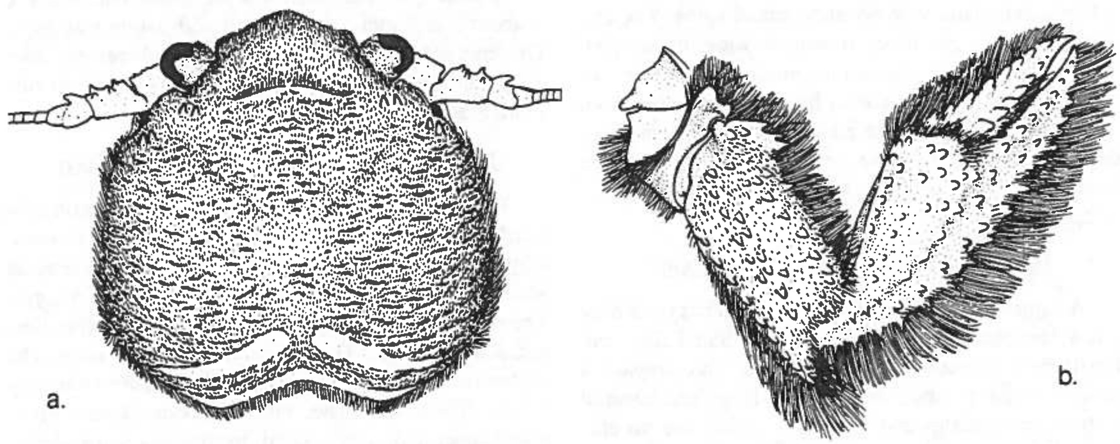

Fig. 17.6 *Petrolisthes hirtipes*.
(a) Carapace. (b) Cheliped.

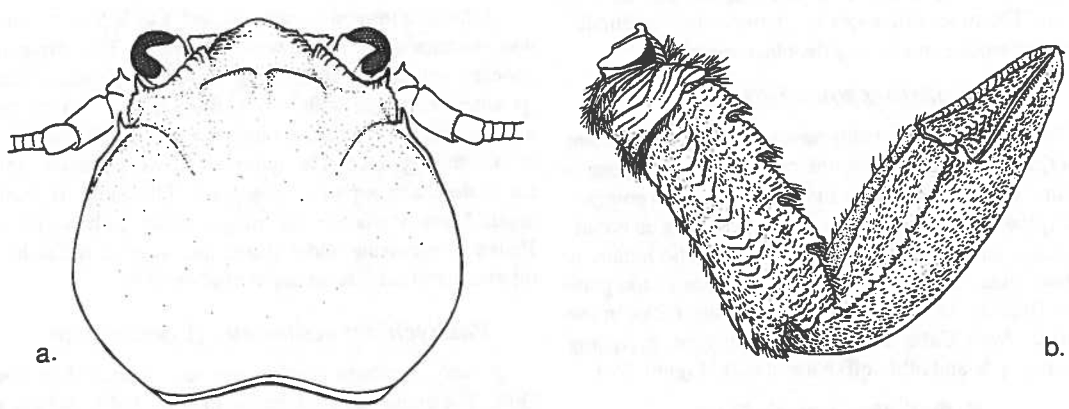

Fig. 17.7 *Petrolisthes hirtispinosus*.
(a) Carapace. (b) Cheliped.

of short spines in the anterolateral corner of the carapace (near the epibranchial spine). The carpus is about two times as long as wide, and bears three to four spines on the anterior margin. The manus is long and slender, covered with small granules, and bears a row of spines and a fringe of scattered plumose hairs along the outer margin. The fingers bear a short pubescence in their gape. The color in these crabs becomes greatly intensified when preserved in alcohol. This species is common in the low tide zone under rocks, and in sponges and gorgonian coral throughout the Gulf of California. It has been reported from as far north as Punta Pequeña on the west side of Baja California.

Petrolisthes schmitti Glassell

An uncommon species, reported only from a few locations in the upper Gulf of California. The carapace is finely granulate, with no epibranchial spine. The carpus is less than two times as long as wide, the anterior margin possessing numerous enlarged granules or spinules. The manus is somewhat swollen on the dorsal surface, with several large granules and a smooth crest, defined by a broad groove near the outer margin. The fingers bear a thick tuft of pubescence in the gape. The carapace is about 3 to 6 mm long.

Petrolisthes tiburonensis Glassell

A somewhat uncommon species, reported from only a few localities, all in the Gulf, from San Felipe and Puerto Peñasco south to Punta Trinidad. The carapace is chocolate-brown, about 6 to 12 mm long, and covered with rough granules and plications. There are no epibranchial spines. This species shows a great deal of sexual dimorphism. The carpus in males is over three times as long as broad, in females about 2.5 times as long as broad. The carpus in males is unarmed, but in females there are about five spinules on the anterior margin. The manus in males is unarmed, but in females bears numerous spines along the outer margin.

Petrolisthes tonsorius Haig

The only records of this species from the Gulf are from Cabo San Lucas (near the mouth). The carapace is smooth, about 3 to 12 mm long, and lacks an epibranchial spine. The carpus is 1.5–2 times as long as broad, and lacks spines on the anterior margin. The manus is without setae, except for a fine pubescence in the gape of the fingers. This species is found under rocks in the intertidal from Cabo San Lucas to Ecuador, including the Galápagos and other offshore islands. Figure 17.9.

Petrolisthes nobilii Haig

An unusual porcelain crab in which the epibranchial spine is either vestigial or absent, although its position is generally marked by a distinct notch. The carpus is about two and a half times as long as wide. The manus is broad and curved on the outer margin. The merus of the walking legs bears a row of spines on the anterior margin. The carapace is about as broad as long or slightly broader, and is naked or lightly pubescent. The chelipeds are subequal and also naked or lightly pubescent. This species occurs intertidally, from the mouth of the Gulf south to Ecuador. Figure 17.10.

Pachycheles biocellatus (Lockington)

Uncommon in the Gulf. The carapace is smooth, about as broad as long in males, slightly broader in females. The chelipeds are unequal, and devoid of hair. The carpus is less than two times as long as broad and has 0–3 lobed spines on the anterior margin. The manus is smooth, without hair. The abdomen of this species has only 5 plates, and the males lack pleopods. The carapace is about 3 to 7 mm long, and red with white markings. This crab is found under rocks and in coral crevices from the lower Gulf, south to Ecuador, including most offshore islands.

Pachycheles marcortezensis Glassell

This species is rare intertidally, not uncommon subtidally, about 3 to 5 mm long, with the carapace covered with setae. The carpus is less than two times as long as wide, and has four to five spines on the anterior margin. The manus has four longitudinal rows of small granules, and scattered setae. The fingers are devoid of setae. The chelae are barely unequal in size. The abdomen has only 5 free plates, and males lack pleopods. This crab is found under rocks and in coral, from Bahía Santa María, on the west coast of Baja California, and Isla Angel de la Guarda south to Arena Bank.

Pachycheles panamensis Faxon

A fairly common species, about 3 to 8.5 mm long, with the carapace covered with short setae. The carpus is covered with short rugae, or granules, and short setae, its anterior margin with two to three teeth. The manus and fingers are unequal on the two chelipeds, and covered with long setae. The abdomen has seven plates, and the males have a pair of pleopods. The range is from Bahía Santa María and the middle of the Gulf, south to Ecuador, occurring under stones and in coral in the low intertidal and subtidal to depth of about 8 m.

Pachycheles setimanus (Lockington)

A very common crab in the low intertidal of the Gulf. The chelipeds are unequal in size, and both bear a very heavy tuft of soft, long, brown setae. The carapace is smooth, without hair, and small (about 3 to 8 mm long). The carpus is less than twice as long as broad, and bears three teeth on the anterior margin. The gape of the

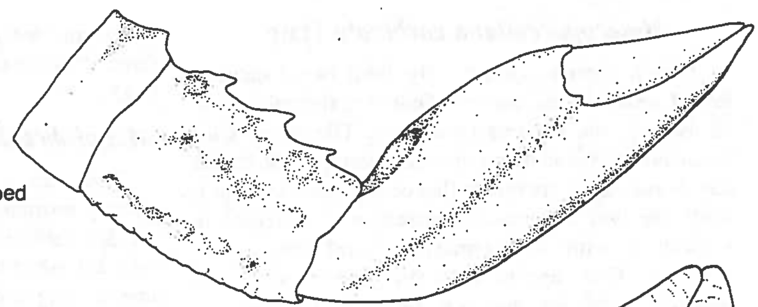

Fig. 17.8 *Petrolisthes lewisi*, cheliped (after Haig, 1960)

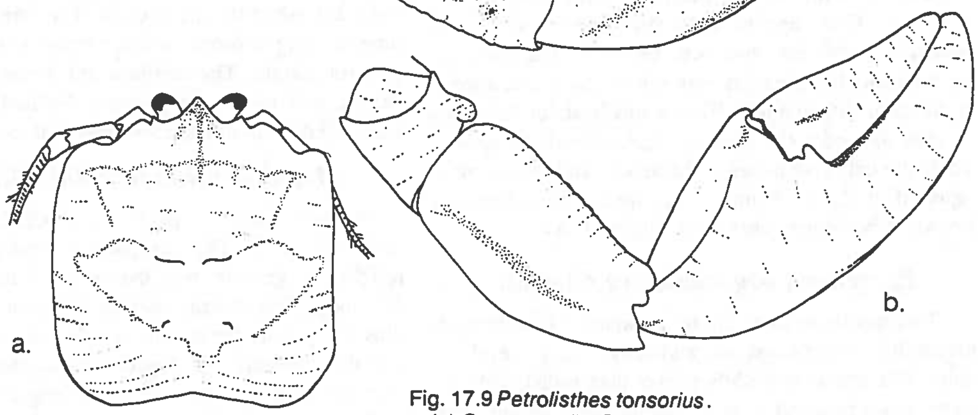

Fig. 17.9 *Petrolisthes tonsorius*. (a) Carapace. (b) Cheliped. (After Haig, 1960.)

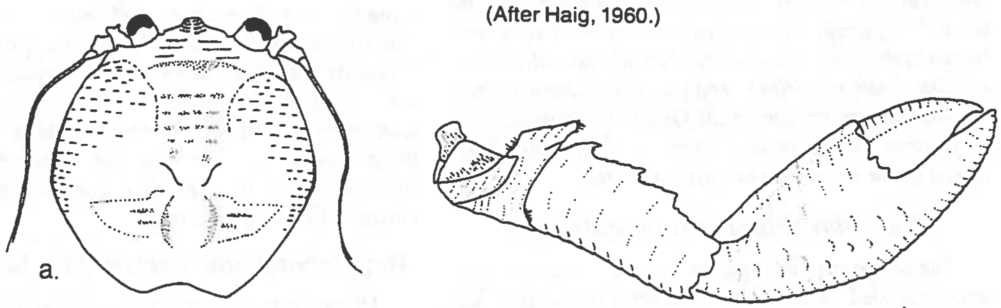

Fig. 17.10 *Petrolisthes nobilii*. (a) Carapace. (b) Cheliped. (After Haig, 1960.)

fingers is without pubescence. The abdomen is 7-plated and males have one pair of pleopods. This is a dull white to pale tan crab, common under large stones throughout the Gulf (and apparently restricted to it). Figure 17.11.

Pachycheles spinidactylus Haig

This species has a tuft of hair on the front of the carapace, and is about 3 to 8 mm long. The chelipeds are unequal in size, and the carpus is covered with small, conical tubercles with tufts of long, stiff, setae surrounded by clumps of long, plumose hairs. The manus is similar to the carpus. The telson is 7-plated in the males (which lack pleopods), but only 5-, or incompletely 7-, plated in the females. This species ranges from the mouth of the Gulf (Cabo San Lucas) to Colombia (also reported from Bahía Santa María on the west coast of Baja California). Figure 17.12.

Porcellana cancrisocialis Glassell

The carapace is about 2 to 7 mm long, naked or covered with long hair, with two to three epibranchial spinules. The dorsal surface is orange to yellow, with red and blue spots. The carpus is less than 1.5 times as long as broad, and bears a large lobe with a single spine on the inside margin. The manus has long hair on its margin. The anterior margin of the carapace has three large spines between the eyes. There are 7 plates to the telson. This species is free-living, or commensal with hermit crabs. It has been found from the upper Gulf and Bahía San Juanico (on the outer Baja coast) south to Peru. I have found it to be a common commensal on *Petrochirus californiensis* in the northern Gulf. A single hermit crab may often be host to six to ten of these beautiful little crabs. It is also occasionally reported from *Dardanus sinistripes*. Figure 17.13.

Heteroporcellana corbicola Haig

A rare species, known only from two localities, Roca Consag, in the northern Gulf of California (20 to 50 meters), and Panama (intertidal). The single Gulf specimen was found living in association with the basket star *Astrocaneum spinosum* (hence the specific name), while the two Panama specimens were collected in association with an ahermatypic coral *(Phyllangia dispersa)*. These are the only three specimens of this uncommon crab that have been reported. The carapace has a tuft of plumose hairs between the eyes, and a spine at the epibranchial angle. The carpus is about 1.5 times as long as wide, the anterior margin without spines. There are only five plates in the telson, and the length is reported as 2.4 to 6 mm. This species was formerly known as *Porcellana corbicola*. Figure 17.14.

Porcellana paguriconviva Glassell

This species has a nearly flat carapace, lavender with longitudinal orange stripes, and faint transverse plications. The carpus is slightly longer than broad, with no teeth, but a rounded lobe on the anterior margin. The chelipeds are smooth, with little or no setae, and the telson is 7-plated. The species is commensal with large hermit crabs *(Aniculus elegans, Petrochirus californiensis, Dardanus sinistripes,* and *Paguristes digueti)*. It is known to occur throughout the Gulf of California, south to Panama. There is also a record from Bahía Magdalena on the west coast of Baja California.

Megalobrachium erosum (Glassell)

The carapace of this species is about 2 to 6 mm long, heavily eroded, with strong, transverse ridges and shallow pits. The chelipeds are large, slightly unequal, and naked or covered with a light pubescence. The carpus is about 1.5 times as long as broad, with a single, low tooth on the anterior margin. The manus bears longitudinal rows of pits, and the telson is 7-plated. This species ranges from Isla Angel de la Guarda to La Paz (it has also been recorded from Punta Malarrimo to Bahía Magdalena on the west coast of Baja California), and is known from the subtidal only, from 10–50 m.

Megalobrachium garthi Haig

This species resembles *Megalobrachium erosum* but has a more rounded carapace. Carapace and chelipeds are covered with small, shallow pits (microscopic) and scattered hair. The carpus is about 1.5 times as long as broad, with a narrow blunt tooth, or lobe, on the anterior margin. The manus bears three longitudinal crests, defined by broad grooves. The gape of the fingers is without pubescence. The telson of this species has only 5 free plates. The carapace length is 2 to 8 mm. This species ranges from the middle of the Gulf to Colombia. There are also records from Punto Tosca and Bahía Santa María on the west coast of Baja California. Figure 17.15.

Megalobrachium sinuimanus (Lockington)

This crab is not uncommon in the Gulf but is apparently restricted to it. The carapace is nearly smooth, rounded, covered with fine granules, about 2 to 6 mm long, and white to buff in color. The carpus is about 1.5 times as long as broad, with a narrow, blunt tooth on the anterior margin. The carapace and chelae are practically devoid of hair, and the telson is 7-plated. Found under stones and in coral in the low intertidal and subtidal.

Megalobrachium smithi (Glassell)

A fairly common species in the Gulf, and probably restricted to it. The carapace is nearly pure white, roughened, granular near the margins, and about 4 to 8 mm long. The chelae, walking legs and carapace margins are usually tinted with a pale gray-lavender color, and the antennae are ringed with lavender and white. The carpus is about 1.5 times as long as broad, and is without spines on the anterior margin. The manus is flattened with four crests, defined by broad grooves. The fingers are devoid of pubescence, and the telson is 7-plated. Individuals are found under rocks in the mid to low intertidal. The behavior of this little crab differs from most porcellanids in that it tends to sit quietly on the bottom of an overturned rock, rather than to scurry off quickly into the water. It also tends to occur in small clusters of 3–10 individuals.

Megalobrachium tuberculipes (Lockington)

This species has a gray carapace, with a dark median blotch, and is covered with tubercles. It is an unusually small crab, rarely over 4 mm long. The carpus is less than 1.5 times as long as wide, has a single large spine and two to three smaller denticles along the anterior margin. The chelipeds are tuberculate, and the manus, carpus, and carapace all bear numerous bands of long hair. The overall appearance of this crab is that of a bumpy, rough, hairy creature. The telson is 5-plated. These crabs are found on sponge-incrusted sea fans, or on the sponges themselves, subtidally, and occasionally in the low tide zone. They range from Bahía Hipolito on the west coast of Baja California and the upper Gulf south to Ecuador.

Euceramus transversilineatus (Lockington)

This curious creature resembles a mole crab but has small chelipeds and weak pincers. The carapace is about 1.5 times as long as broad, with distinct transverse striations, and is convex, about 5 to 12 mm long. The dorsal surface is pink to buff, with red to brown striations. The chelipeds are covered with long, scattered setae, hooked

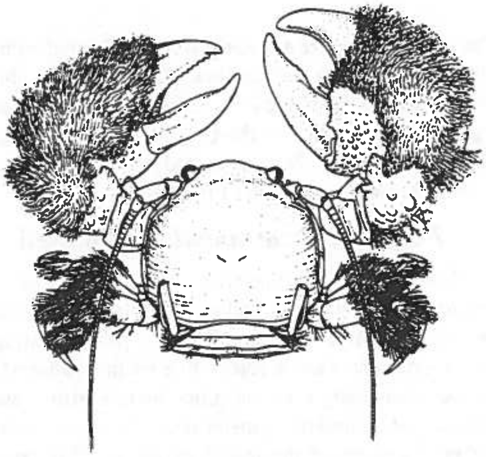

Fig. 17.11 *Pachycheles setimanus*

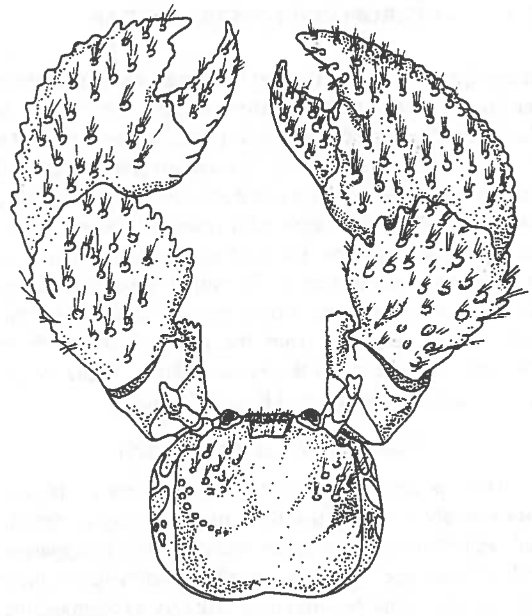

Fig. 17.12 *Pachycheles spinidactylus* (after Haig, 1957)

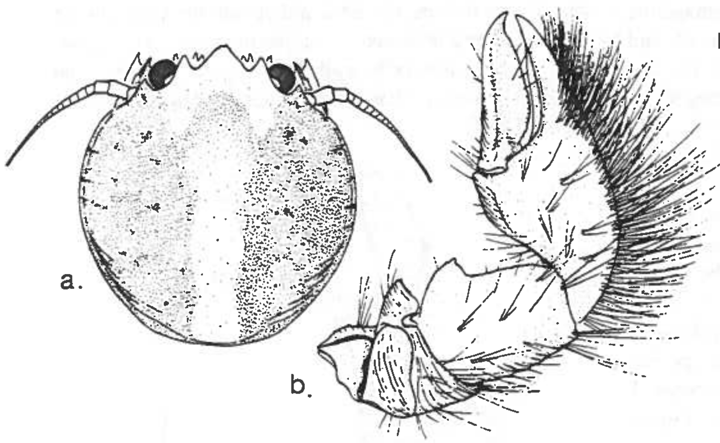

Fig. 17.13 *Porcellana cancrisocialis*
(a) Carapace. (b) Cheliped.

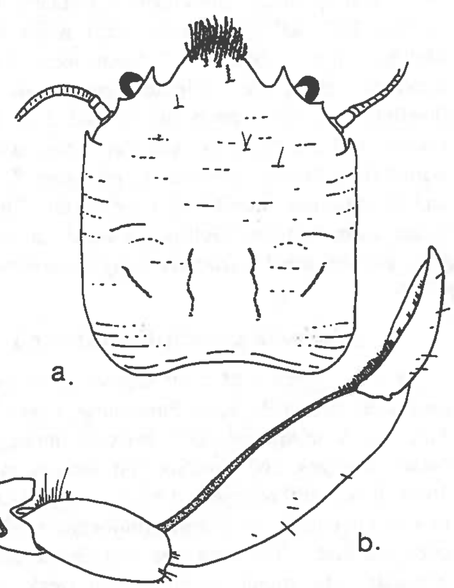

Fig. 17.14 *Heteroporcellana corbicola*.
(a) Carapace. (b) Cheliped.
(After Haig, 1960.)

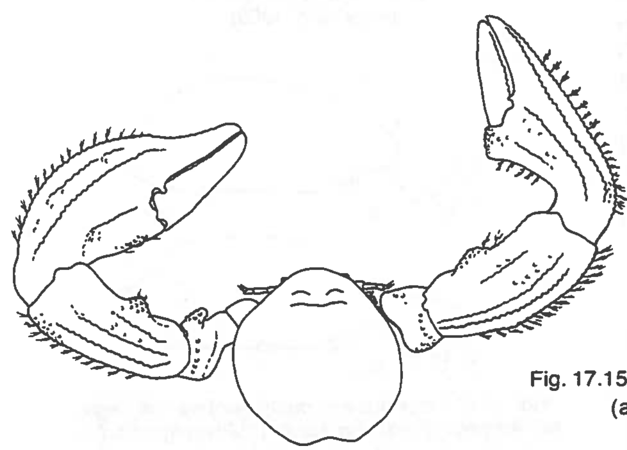

Fig. 17.15 *Megalobrachium garthi* (after Haig, 1957)

at the tips. The carpus is short and stout, with one to four narrow spines on the anterior margin. The telson is 7-plated. These crabs are found buried in the sand in the low intertidal and subtidally. Westervelt (1967) collected this little crab from the tube of *Pachycerianthus insignis*, and Glassell (1938a) reported it from gorgonians. Westervelt commented that the feeding position of this crab is with the posterior part of the body buried in sand and the eyes, antennae, and mouth parts protruding into the water. The range is from the upper Gulf south to Panama. (There are also records from Bahía Magdalena, on the west coast of Baja California).

Minyocerus kirki Glassell

This species also resembles a mole crab, with the carapace about one and a third times as long as broad, and highly convex. It is easily recognized by its apparent lack of antennae, which are actually rudimentary, their total length being less than, or scarcely exceeding, the width of the eye. The chelipeds are subequal, small, and have a long narrow manus (much longer than the fingers). The carpus is short and stout, with a strong spine at about the center of the anterior margin, often followed by several spinules. The telson is 7-plated. The dorsal surface is usually greenish, with white or yellow blotches, and is about 2 to 5.5 mm long. These small porcelain crabs are obligate-commensals on sand-dwelling sea stars, primarily restricted to the genus *Luidia*, and nearly always subtidal. They have been reported from *Luidia columbia*, *L. phragma*, *L. foliolata*, and at least one species of serpent star. This species ranges from the upper Gulf of California to Nicaragua. I have also recorded it from *Astropecten armatus*. Figure 17.16.

Ulloaia perpusillia Glassell

A rare species of crab known from only three localities; Puerto Peñasco; Puntarenas, Costa Rica; and Panama. A strange species, it is found among gorgonian corals, sponges, and bryozoa from the low intertidal to 16 m. It is easily recognized by its elongate carapace (3 to 4 mm in length), and large protuberances and setae all over the body. The carapace and chelae are roughly granular. The manus is small and weak, with long plumose hairs. The carpus is slightly longer than wide, and armed on the anterior margin with a median lobe or broad tooth. The gape of the fingers has a long tuft of plumose hairs.

Polyonyx nitidus Lockington

The carapace is broader than long, smooth or lightly plicate, nearly oval, and lacks epibranchial spines. The chelae are smooth, slightly unequal in size, and have a fringe of long setae along the outer margin. The carpus is 1.4–1.8 times as long as broad, and without spines. The walking legs are all nearly smooth, fringed with fine plumose hair along the margins. The carapace is about 4 to 15 mm long. Its range is from the upper Gulf, south to Panama. Although all of the Gulf records of this species are free-living, the Panama record was as a commensal in the tube of *Chaetopterus*. Figure 17.17.

Polyonyx quadriungulatus Glassell

This little crab is nearly identical to *Polyonyx nitidus*, differing in the following ways: (1) *P. nitidus* has, in addition to the 3 posterodistal movable spinules on the propodus (and a fourth one on the midregion of the posterior margin of the propodus), a fifth movable spinule just behind the 3 distal ones. (2) spinules on the posterior margin of the merus of the walking legs are stronger in *P. nitidus*. The telson of both of these crabs is composed of 7 plates. *Polyonyx quadriungulatus* is now known from offshore islands of southern California south down the coast of Baja and up into the Gulf, all the way to Puerto Peñasco; a rather unusual distribution. This crab is regularly collected in the tubes of the polychaete worm *Chaetopterus variopedatus* (Renier). Figure 17.17.

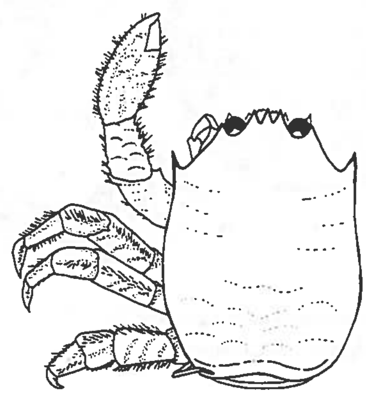

Fig. 17.16 *Minyocerus kirki* (after Haig, 1960)

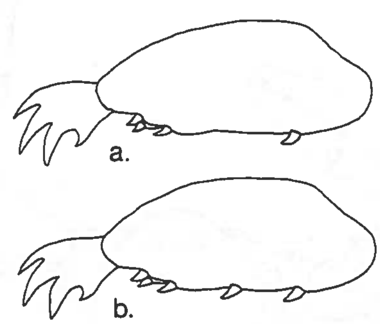

Fig. 17.17 Propodus and dactylus of walking legs. (a) *Polyonyx quadriungulatus*. (b) *Polyonyx nitidus*. (After Haig, 1960.)

18

ARTHROPODA: CRUSTACEA
Paguroidea and Coenobitoidea (Hermit Crabs)

by Elaine Snyder-Conn*

Collection and identification: Several individuals of each species should be examined before attempting an identification, since it takes several molts for individuals with damaged chelipeds to regenerate these appendages to the proper relative sizes. Live color notes of the chelipeds, walking legs, carapace, antennae, antennules, eyestalks, and corneas are invaluable in proper identification. Also important are the substrate type, depth, location, and date. The collector should also take note of the many inquilinous, epiphytic, epizoic, and other commensal associations of a species. Amphipods, porcellanid crabs, polynoid worms, and even tiny hermit crabs may emerge from a shell, while anemones, bryozoans, sponges, hydrocorals, serpulid worms, barnacles, and limpets may utilize the shell exterior.

Preservation: Hermit crabs should be preserved in alcohol with their shell. The eviction of the hermit crab is necessary but does not always follow preservation. Several methods are recommended depending on the fit of the hermit crab within its shell, when it is retracted. If the hermit crab is large for its shell or if it can be easily seen at the mouth when it retracts into the shell, it can usually be removed with forceps after preservation. When the fit of the hermit crab within the shell allows the hermit crab to go sight unseen, several not-so-delicate solutions are available. Most hermit crabs will evacuate their shells when heated to 40°C in seawater. The shell tip may also be heated with a match or Bunsen burner, but this may result in a fried (not freed) hermit crab. Many hermit crabs can be evicted by placing them in a bottle of seawater and shaking intermittently, but vigorously, or by placing them in seawater with a small amount of formalin. If the shell is delicate, its tip may be cut off and then the hermit crab can be prodded out from the rear. Otherwise one may resort to finesse with the hammer, chipping away at the shell mouth until the hermit crab is sufficiently exposed. Slow, carefully applied pressure in a good vise has also been found to be a reliable technique to crack open certain types of shells.

Taxonomy: The approximation of the outer maxillipeds, the relative sizes, shapes and orientations of the chelae, the number and placement of the pleopods on the male and female and the spination of the carapace, eye scales, antennal acicles (scales at the outer bases of the antennae), and various segments of the chelipeds and walking legs are some principal anatomical features used in the taxonomic identification of hermit crabs. However, the key presented here is oriented toward the amateur and is largely superficial, utilizing easily recognized characters such as color. The serious researcher, if confronted with problems, should consult Benedict (1892), Glassell (1937, 1938b), Haig, Hopkins, and Scanland (1970), and Ball and Haig (1974).

Hermit crabs of the Gulf: Twenty-four hermit crabs *(congrejos ermitaños)* from the Gulf of California are included in the key and descriptions which follow. I have attempted to include all known Gulf littoral hermit crabs and also locally common or widely distributed sublittoral hermit crabs. However, it should be emphasized that in certain areas of the Gulf, notably between Guaymas and Mazatlán and also the northernmost portion of the Gulf around the Colorado River delta, collections have been scant. Likewise, sublittoral collections except in such areas as Gorda Bank, Arena Bank, and Bahía Santa Inéz, have been sporadic.

The observation of hermit crabs in shallow water, especially in tidepools, can be rewarding. Much of their activity (including aggression, courtship, and mating) is

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highly ritualized. Dr. Brian Hazlett (1965, 1966, 1968a, 1968b, 1969, 1972) of the University of Michigan has analyzed many postures and repertoires of different species in numerous journal articles. Also, of interest is the shell exchanging behavior necessitated by continued growth of a hermit crab. Usually a larger hermit crab dominates a smaller one with a more desirable shell. After some poking at the subdominant hermit crab and much clapping of shells together, the smaller hermit crab will usually evacuate its shell, allowing the larger crab to "try it on for size" before making a final decision. These shell exchanges are split-second affairs in nature and may be observed only by undivided attentiveness. Shell exchange has been studied by a number of researchers, but prominent among them is Dr. Ernst Reese (1962, 1963, 1969) of the University of Hawaii.

KEY TO THE HERMIT CRABS

1	Peduncle (supportive basal segments) of antennule approximately 5 times the length of the eyestalk; antennular flagellum truncated at tip, rather than ending in a filament; eyestalks laterally compressed; semiterrestrial land hermit crab. Coenobitidae (fig. 18.1)	***Coenobita compressus***
	-Not as above	**2**
2(1)	Chelae (claws) of distinctly different size; right chela always larger; outer maxillipeds widely spaced at bases; hermit crabs small to medium-sized (in Gulf) Paguridae	**3**
	-Chelae usually equal or subequal in size or left chela distinctly larger than right (except for *Petrochirus californiensis* with larger right chela); outer maxillipeds adjacent at their bases; hermit crabs small to large in size. Diogenidae	**10**
3(2)	Right chela forms a broad "operculum" sealing the shell entrance when the hermit crab is retreated	**4**
	-Right chela larger than left, but not operculate	**7**
4(3)	Walking legs with longitudinal stripes overlying diffuse broad bands	***Pylopagurus californiensis***
	-Walking legs banded horizontally, but without stripes	**5**
5(4)	Hermit crab typically occupying a staghorned hydrocoral which may partially or completely obscure the earlier gastropod shell	***Pylopagurus varians***
	-Hermit crab usually occupying a gastropod shell	**6**
6(5)	Major chela a solid black (with a white tip); walking legs banded on all segments with brown, tan, white and faint blue	***Pylopagurus roseus***
	-Major chela a blotched brown except on fingers; minor chela and walking legs with broad wavy brown bands superimposed on white or pale orange areas	***Pylopagurus venustus***
7(3)	Major chela considerably longer than minor chela; eyestalks short and stout with corneas expanded	**8**
	-Major chela only slightly longer and larger than minor chela; eyestalks not as above but expanded at base (slightly)	***Pagurus lepidus***
8(7)	Hard part of carapace subequal in length and width or slightly longer than wide; dactyls of walking legs longitudinally grooved on both sides (fig. 18.11)	***Pagurus albus***
	-Hard part of carapace distinctly wider than long; dactyls of walking legs without grooves	**9**
9(8)	Major chela 2-1/2 to 3 times as long as wide; minor chela barely reaching the base of the major chela (fig. 18.12)	***Pagurus gladius***
	-Major chela about 2 times as long as wide; minor chela reaching the proximal portion of the dactyl of the major chela	***Pagurus smithi***
10(2)	Left chela much larger than right	**12**
	-Not as above	**11**
11(10)	Right chela larger than left (fig. 18.10)	***Petrochirus californiensis***
	-Chelae equal or subequal	**14**
12(10)	Major chela tuberculate and hairy; tips of fingers corneous (fig. 18.6)	***Dardanus sinistripes***
	-Major chela smooth (or microscopically granulate) and hairless; tips of fingers calcareous	**13**
13(12)	Walking legs bright reddish-orange; dactyls solid reddish-orange; chelipeds an olive to black color with reddish-orange margins (fig. 18.3)	***Calcinus californiensis***

-Walking legs reddish-black to black with orange and black bands on dactyls; chelipeds black to reddish-black with orange and white margins, the latter not highly visible .... ***Calcinus explorator***

14(11) Antennae short, usually not reaching tips of the fingers of the chelae 15
-Antennae not short, usually reaching or exceeding the tips of the fingers of the chelae 20

15(14) Antennae with comblike setae; eyestalks each with two dark dorsal stripes .... ***Isocheles pacificus***
-Antennae nude or setose (but not comblike); eyestalks not as above 16

16(15) Dark blue spot (reddish in alcohol) on the inside of the merus (arm) of the chelipeds; rostrum undeveloped; eye scales contiguous .... ***Paguristes* sp.**
-Not as above 17

17(16) Chelae slender, almost twice as long as wide (fig. 18.7) .... ***Paguristes anahuacus***
-Chelae wide, less than twice (usually 1-1/2 times or less) as long as wide 18

18(17) Heavy spines on the upper surface of the chelae; eye scales toothed on inner and outer margins with approximately eight teeth; rostrum subequal to laterals .... ***Paguristes bakeri***
-Not as above, rostrum exceeding laterals in length 19

19(18) Inner margin of carpus of chelae with heavy spines; hard part of carapace approximately as wide as long; hermit crab generally red (fig. 18.8) .... ***Paguristes digueti***
-Inner margin of carpus not heavily spined; hard part of carapace longer than wide; hermit crab generally orange (fig. 18.9) .... ***Paguristes sanguinimanus***

20(14) Carapace with strong grooves; chelipeds and walking legs with strong grooved rings (fig. 18.2) .... ***Aniculus elegans***
-No strong grooves on carapace or rings on chelipeds and walking legs 21

21(20) Small dark red hermit crab; antennae and antennules bright red 22
-Not as above 23

22(21) Walking legs and chelipeds uniformly red or olive (fig. 18.4) .... ***Clibanarius digueti***
-As above, but dactyls of the walking legs white .... ***Clibanarius albidigitus***

23(21) Fingers of the chelae open horizontally; walking legs with longitudinal dark (blackish) and light (yellowish) stripes on each segment (fig. 18.5) .... ***Clibanarius panamensis***
-Fingers of the chelae open obliquely; irregular pale blotches over a generally brown background on the carapace, eyestalks, chelipeds, and walking legs .... ***Trizopagurus magnificus***

SUPERFAMILY COENOBITOIDEA
FAMILY COENOBITIDAE
Coenobita compressus H. Milne-Edwards

This semiterrestrial hermit crab is distributed from the central Gulf to Peru and has also been recorded on western Baja (Ball, 1972). In the Gulf, it has been found from Santa Rosalia to Cabo San Lucas along Baja and from Guaymas to Mazatlán, (where it is quite abundant), along mainland Mexico. Brusca (1973) noted hordes also near the Jergens' Plantation, north of Mazatlán, moving across beaches and up coconut groves during hot summer months.

This medium to large-sized nocturnal crab, when not a nuisance to campers, is most intriguing in its habits. Occurring mostly along sandy beaches, it is apparently omnivorous, eating anything from dead or molting crabs to cacao on plantations. When active it scavenges by olfaction, following foods downwind (Glassell, 1937; Ball, 1972). Although terrestrial, it remains fairly close to the sea in order to renew its water supply and also to breed and release the pelagic larvae. During the day, unless in a moist area, *C. compressus* retreats to cool underledges, caves, and burrows under rocks and drift. It is even found in trees, especially around mangrove swamps.

This hermit crab immediately strikes one as different from other hermit crabs in appearance as well (fig. 18.1). The antennular peduncles are quite long, so that the antennules approach the antennae in length. The chelae are held vertically, and the left one is much stouter. When retreated into its shell, all its appendages are observed to be drawn in parallel to one another. The body color varies from cream to dirty gray-brown.

This hermit crab is apparently limited in its local distribution by the availability of shells. Ball (1972) notes that often shells such as *Turbo*, *Thais*, *Acanthina*, and *Nerita*, have been recycled so many times that the columella is missing. In northward distribution, *C. compressus* seems limited by cold winter temperatures. Several returned to a terrarium in Tucson succumbed during midwinter.

FAMILY DIOGENIDAE

Aniculus elegans Stimpson

This medium to large hermit crab is widely distributed in the sublittoral, from outer Baja and throughout the Gulf from San Carlos south to Ecuador. It typically is found between 5 and 24 meters on a variety of substrates including rocks, gravel, and *Pocillopora* coral (Ball and Haig, 1974). Small aggregations of the hermit crab are not uncommon.

This rather hairy species is also distinguished by possessing deep red groovelike markings contrasting with the pink to orange coloration of the body. The carapace is strongly grooved, and the chelipeds and walking legs possess strong grooved rings. Splotches of dark red also occur on the carapace and legs, which are irregularly banded with red. The antennae are reddish brown. The eyestalks are tan to brown, and the corneas are dark brown to black. The body hairs are red to golden in color (fig. 18.2).

The porcelain crab *Porcellana paguriconviva* is sometimes a resident of this hermit crab's shell, although this association has not been noted in the Gulf of California proper. According to Ball and Haig, the shells of this hermit crab are often large in relation to their occupants.

Calcinus californiensis Bouvier

Calcinus californiensis is perhaps the most attractive of the Gulf hermit crabs with its contrasting bright orange-red and dark green-black colors. This small to medium-sized hermit crab typically occurs on rocky or coral substrates from the central Gulf to Acapulco and also on outer Baja and Isla Clipperton. In the central Gulf it is often found between 3 and 7 meters depth, but proceeding south it is found in tidepools at Cabo Pulmo. *Calcinus californiensis* also seems to occur at depths of 3 meters or more on islands, where sea temperatures may be more moderate than on adjacent mainland coasts. According to Ball and Haig (1974), this species occurs from the lower intertidal zone to 3 meters depth near Acapulco. This pattern reveals a common trend among tropical marine species, which tend to prefer more shallow waters in the lower latitudes but submerge as they proceed into more temperate regions.

The left chela is quite large, flattened, and oriented obliquely outward. Although appearing smooth, fine granulations may be seen under a microscope. The inside of the fingers of both chelae are white, roughly toothed, and lightly setaceous. The carapace and chelae are dark green to black but margined with bright orange-red. The walking legs are solid orange-red with black tips, and the antennae are orange. (In *C. explorator* the walking legs are black.) The long, slender, green eyestalks have a white distal band which precedes the black cornea. This distal band is rather broad, also distinguishing this species from *C. explorator* (fig. 18.3).

Often large numbers of this rather gregarious hermit crab may be found together. This species also appears to occupy a wide variety of shells.

Calcinus explorator Boone

This small to medium-sized hermit crab occupies the rocky intertidal habitat. It has been reported from the islands of Tres Marías, Isabel, Galápagos, Cocos, Revillagigedos, and Clipperton, as well as Colombia. It also occurs on mainland Mexico, at Bahía Tenacatita, Jalisco. I have collected this species in large numbers only at Cabo Pulmo, Baja. This northward extension of range is additional support for the view of Garth (1960) that southern Baja is strongly "insular" in character.

At Cabo Pulmo, *Calcinus explorator* co-occurred with *Calcinus californiensis* and *Clibanarius digueti* in tidepools. It may be distinguished from *C. californiensis* by its black walking legs, banded on the dactyls with orange (*C. californiensis* has solid reddish-orange walking legs). *Calcinus explorator* occupies a large variety of shells. It proved to be rather active when uncovered from rocks, where it gregariously rests.

Clibanarius albidigitus Nobili

This small intertidal hermit crab is reported mostly in areas south of the Gulf, from El Salvador to Peru.

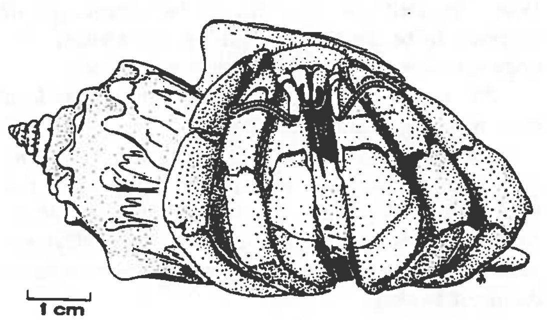

Fig. 18.1 *Coenobita compressus*

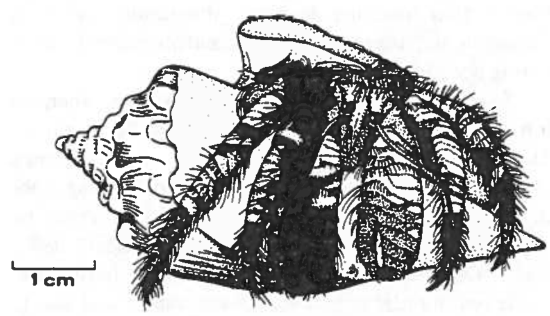

Fig. 18.2 *Aniculus elegans*

However, Janet Haig has informed me that there are several unpublished records from Guaymas. I have also collected one specimen in the upper Gulf, at Puerto Peñasco. This specimen was located in a hermit crab cluster of *Clibanarius digueti* under a rock in the mid intertidal zone. Recently, several other specimens have been taken on tide flats nearby.

Although quite similar to *C. digueti*, this hermit crab may be distinguished by the pronounced white sides of the dactyls of the walking legs and by the mottled gray-black abdomen as opposed to the reddish-brown abdomen of *C. digueti*. The eyestalks of *C. albidigitus* also appear to be comparatively longer and more tapered. Otherwise, size, coloration, clustering behavior, and distribution in the intertidal are strikingly similar.

Clibanarius digueti Bouvier

This small species is the most common intertidal hermit crab throughout the Gulf of California. It has also been collected on the lower coast of outer Baja, at Bahía de Magdalena. It is usually distributed higher, in the mid and upper intertidal zones, than any other Gulf species. Although most abundant on rocky substrates, *C. digueti* has also been collected in sandy shore habitats with rock outcrops or shell debris, and also in mangrove swamps.

When exposed at low tide, this hermit crab clusters in groups of up to 700 individuals under boulders or, especially after storms, on rock surfaces. When the tide waters are ebbing or flooding, individuals disperse onto substrate surfaces to scavenge and filter feed. Then at high tide individuals may again be found under boulders.

This species is usually red in appearance but also has an unexplained olive color phase. Expanded chromatophores superimpose a light blue speckling over the chelipeds and walking legs. The antennae and antennules are bright red to orange. The carapace is tan to gray (fig. 18.4).

The breeding season of this species is from April through September. During April, May and June coupling is very commonly observed. Courtship is entertaining since the male must often give chase. Over a 12-hour or so period the smaller female is rotated, jiggled, tickled, and finally seduced.

C. digueti occupies a variety of shells: no less than 30 species at Puerto Peñasco, Sonora, Mexico. I have found only one parasite on *Clibanarius digueti*, the isopod *Pseudione* sp. (identified by Richard C. Brusca). A very small male is attached to the female isopod, located on the anterior, dorsal side of the abdomen.

Clibanarius panamensis Stimpson

This medium-sized hermit crab occurs in protected bays and esteros on sand to mud substrates. It is typically found in shallow water, less than 3 meters in depth, and may even be found out of water. This hermit crab is distributed from Cholla Bay in the northern Gulf to Peru and also occurs on the outer Baja coast.

In appearance, *C. panamensis* is readily identified by the equal sized, hoof-shaped fingers of the chelae and by its color pattern. The walking legs and chelipeds possess longitudinal stripes on each segment. These stripes are alternately yellow and black. Eyestalks are a solid cream to brown with a very faint, incomplete, light brown stripe on each dorsal surface. The antennae are a uniform light olive color and are nonsetaceous. White spots may be evident on the chelipeds and walking legs (fig. 18.5).

I have never found this hermit crab in very large numbers. Judging from the ill-repair of its shells, low densities may result from shell limitations. *Clibanarius panamensis* occurs in the shells of *Turbo*, *Turitella*, *Fusinus*, and *Solenosteira*, and undoubtedly others.

Dardanus sinistripes (Stimpson)

This slow and retiring, medium-sized hermit crab is recorded from Isla Tiburón in the central Gulf to Peru and also occurs on outer Baja. It may be locally abundant on sand or gravel substrates from 2 to 5 meters, but also has been found much deeper, to 110 meters. Apparently there is some confusion as to whether or not two different species may both currently be involved under this name (Biffar and Provenzano, 1972), and so the serious researcher should keep pace with future studies.

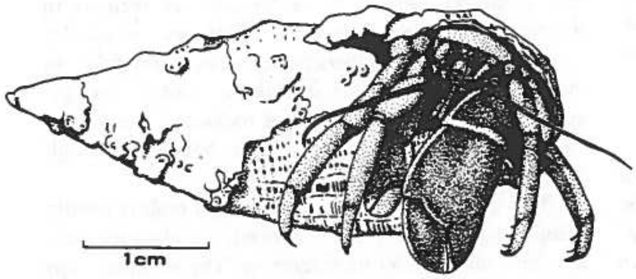

Fig. 18.3 *Calcinus californiensis*

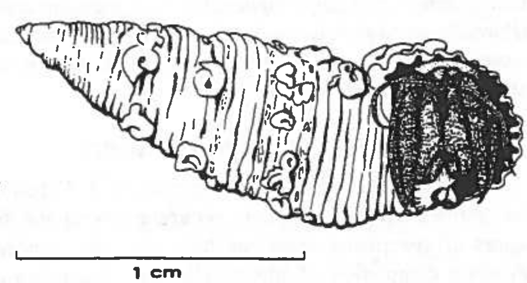

Fig. 18.4 *Clibanarius digueti*

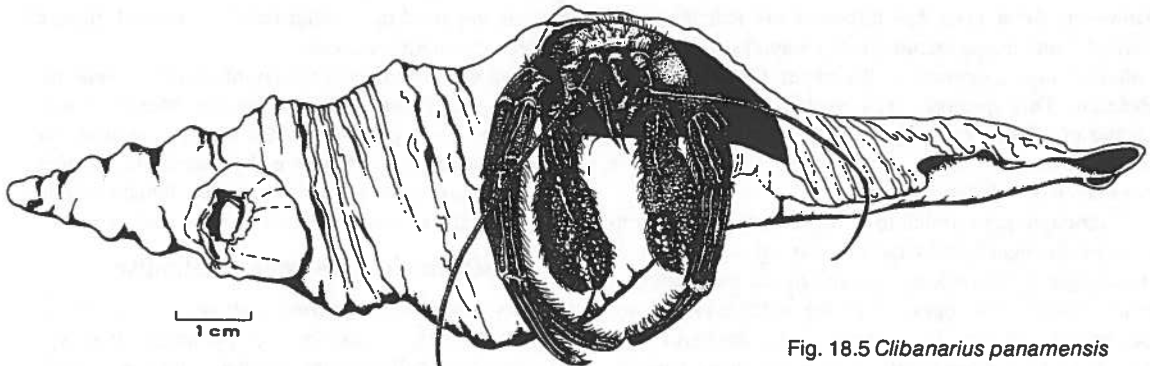

Fig. 18.5 *Clibanarius panamensis*

This hermit crab is brownish-gray (or salmon) with a reddish tinge. Dark red markings appear at the joints of the chelae and walking legs, which possess white tubercles. Both the nonsetaceous antennae and the antennules are a dull solid orange in color. The eyestalks are faintly banded with both a medial and a proximal band. The gray corneas are traversed by a curved medial dark bar and are tufted with approximately eight setae on the dorsal surface. Reddish-brown hairs lightly cover exposed body regions. In addition to the distinct coloration, the difference in size and shape of the chelipeds should identify this species. The left chela is over twice as large and rather stout, while the right chela is slender and distinctly spooned. Both chelae are held obliquely (fig. 18.6).

Characteristically, *D. sinistripes* maintains an anemone on its shell, tentatively identified by Dr. Peter Pickens and Mr. Charles Cutress as *Calliactis polypus* (= *C. variagata*). This species actively transplants its anemone(s) from its previous shell to its new one. In an aquarium I have seen a large individual trade shells with a smaller one and also transplant its original anemone, leaving the smaller hermit crab with both a smaller shell and destitute of its anemone. This habit of carrying anemones may incidentally account for the unusually large shells sometimes utilized by these accomplished weight lifters.

In addition to anemones, sponges and hydroids (*Hydractinia* sp.) seem to find favorable habitats on the shell exterior, and polynoid annelids and porcelain crabs (*Porcellana paguriconviva*), as well as polyclad flatworms, may be inquilinous or commensal within the shell (Ball and Haig 1974).

Isocheles pacificus (Bouvier)

The genus *Isocheles* is being revised by J. Forest of the Musée National d'Histoire Naturelle (Paris) and the status of specimens described here may be changed. Pending completion of this revision, it is not known whether the Gulf specimens identified by Westervelt (1967) are actually *I. pacificus* (originally described from Paita, Peru) or a close relative.

In addition to specimens from Cholla Bay, Janet Haig has noted records of *Isocheles* from Coronados Island, San Ignacio Bay, Point Piaxtla, south of San Felipe, and Topolobampo, as well as outer Baja. (Some specimens from the latter locality may be *I. pilosus*.)

Members of the genus *Isocheles* may be identified by the horizontal, equal-sized, acuminate chelipeds and by the short antennae with comblike setae. *Isocheles pacificus* is a small hermit crab, tan to white, with two dark dorsal stripes on each eyestalk, and a setaceous carapace. It occurs in the lower intertidal to sublittoral zones on sandy substrates. It is not uncommon at Cholla Bay.

An interesting burrowing habit may make this hermit crab inconspicuous to the observer, despite the possible presence of large colonies.

Paguristes anahuacus Glassell

This small species is perhaps the second most abundant littoral hermit crab in the Gulf of California rocky habitats. I have noted this species at almost every rocky shore habitat in which I have looked from Puerto Peñasco to Guaymas and from Loreto to Isla Cerralvo. Its littoral zonation pattern is distinctive. While *C. digueti* occupies the upper to lower mid intertidal areas, *P. anahuacus*, with some overlap, occurs from the lower mid intertidal zone to the sublittoral, as well as in tidepools. It is gregarious in its habits and can usually be located in large numbers under rocks at low tide. As the tides ebb and flow, *P. anahuacus*, like *C. digueti*, appears on the upper surfaces of rocks to feed. I have found ovigerous females from March through September.

This generally cream-colored hermit crab is readily identified by its very hairy fringed, equal-sized, acuminate chelae and by its coloration. The antennae, tips of the antennular flagella and 2nd and 3rd maxillipeds are china blue in color. White ringlike markings occur at the joints of the maxillipeds. The corneas are black and a dark medial band plus a wide crimson proximal band occur on the eyestalks interspaced by cream coloration. In young, the eyes and eyestalks are china blue, however. The antennae are quite short (fig. 18.7).

It should be noted by the serious worker that closely related species complexes of this genus have recently been documented in the western Atlantic (McLaughlin and Provenzano, 1974a, b) and are likely to exist also in the Gulf and vicinity. Janet Haig now feels that the species reported as *P. anahuacus* for outer Baja (Haig, Hopkins, and Scanland, 1970) is instead a closely allied species, and she also recognizes several additional allies within the Gulf, which she hopes to describe in the near future.

Paguristes bakeri Holmes

This small to medium-sized hermit crab occurs from San Francisco, California, to outer Baja, and into the Gulf of California as far north as Punta Baja (north of Guaymas). Although most common in deeper waters (40 to 232 meters), it has also been collected in cold shallow waters. *Paguristes bakeri* is apparently associated with a sandy substrate.

In alcohol, the carapace is pinkish-white with orange-red flecks on the surface. The eyestalks are red (or white dorsally and carmine ventrally). The chelipeds and legs are buff with corneus brown spines and straw yellow setae. The rostrum is subequal to the laterals. The hard carapace is longer than wide. The eyestalks are long, straight, and slender. About eight teeth rim the eye scales. The antennae are lightly ciliated. The chelae are broad and laterally convex, and possess heavy spines on the upper surface.

According to Glassell (1937), this hermit crab is quite active. It seems to prefer heavy shells such as *Polinices*.

Paguristes digueti Bouvier

This medium-sized hermit crab is apparently affiliated with sandy bottoms in sublittoral habitats, from 13 to 60 meters. It has so far been reported only along the east coast of Baja from Santa Rosalia to Arena Bank. However, Janet Haig notes several unpublished records south to Ecuador, and also from Magdalena Bay.

In appearance, *P. digueti* closely resembles *P. sanguinimanus*. It is differentiated from the latter by the three conical spines on the inner carpal margin, by the antennal acicle which extends two-thirds the length of the eyestalk, and by the bifid tip of the eye scales. Its color in alcohol is a pinkish-white speckled with a rich red. The hands are a dark red. The corneas are blue and the eyestalks are red (fig. 18.8).

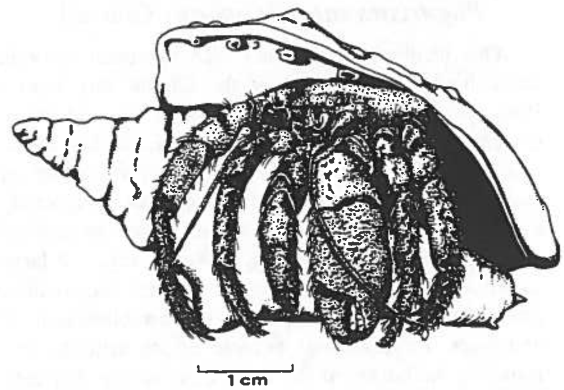

Fig. 18.6 *Dardanus sinistripes*

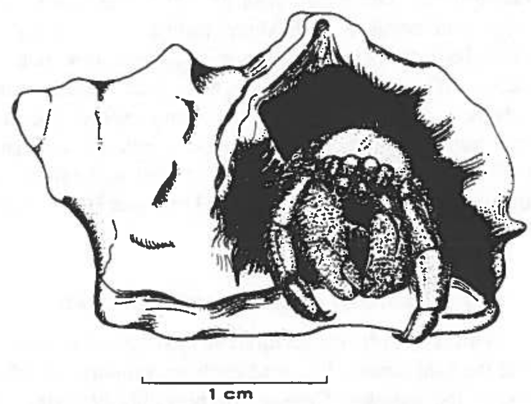

Fig. 18.7 *Paguristes anahuacus*

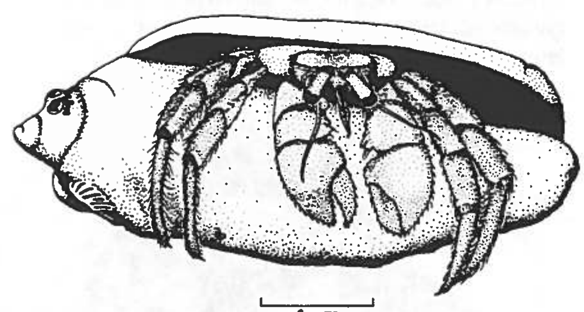

Fig. 18.8 *Paguristes digueti*

Paguristes sanguinimanus Glassell

This medium-sized hermit crab has been reported from the lower intertidal of the Cholla Bay–Puerto Peñasco area in the northern Gulf. It also occurs at Conception Bay, Gonzaga, Isla Carmen, Isla San Jorge, and Isla Tiburón. Here, this species occurs mostly on sand flats, although it is also collected in rocky/sandy areas. However, Dr. Manuel Molles, studying subtidal model patch reefs in the Guaymas area, reported large subtidal clusters of this species at his reefs shortly after their construction. Later, with the establishment of octopuses, these clusters became empty artifacts surrounding the homes of the octopuses, presumably easy victims of predation.

This species is easily recognized by its bright blue eyes and the bright orange color of the legs, chelipeds, mouthparts, and eyestalks. The carapace and legs have white spots, often ringed with red, on the orange background. The equal-sized chelipeds are heavy and wide and covered with sharp pointed, light-colored tubercles interspersed with short setae and some pubescences. The walking legs are also stout, rugose, and setaceous. The rostrum is distinct and exceeds the lateral teeth in length. The eyestalks, which are long and cylindrical, are turned slightly outward and tufted on the dorsal surface (fig. 18.9). This species may be easily confused with *P. digueti*.

Petrochirus californiensis Bouvier

This large, retiring hermit crab inhabits sand, gravel, and mud substrates. It is frequently encountered in bays and at the mouths of esteros (hypersaline estuaries) in rather shallow water, especially in the winter and early spring. However, it has also been taken at considerable depths, 48 meters in one location. It is therefore not unexpected that this species is widely distributed from Ecuador to the northern Gulf, and on outer Baja. As one collects at greater depths, specimens tend to become larger. The average carapace length is 24–50 mm.

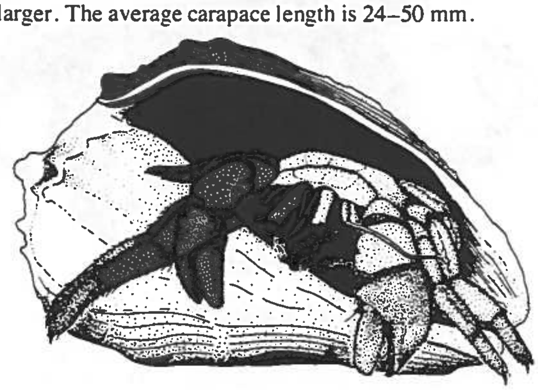

Fig. 18.9 *Paguristes sanguinimanus*

Petrochirus californiensis has impressive heavy, rough claws, the right one being slightly larger. In color, the chelipeds are reddish-purple with white cutting edges and tips on the dactyls. The antennae are nonsetose and banded with reddish-brown and white segments. The dactyls of the walking legs are reddish-brown with numerous hairs of similar color along the edges. The eyestalks are also reddish-brown, but a white band precedes the corneas (fig. 18.10).

This hermit crab often harbors a number of commensals within and on its shells. In the Gulf, pairs of *Porcellana cancrisocialis* are not uncommon. I have also taken specimens with anemones, as yet unidentified, in tow. Ball and Haig (1974) also list another porcellanid crab, several flatworms, and polychaete worms as "in-house" residents. Shells that are typically inhabited by this species include *Strombus, Muricanthus, Fasciolaria, Murex*, and *Hexaplex*.

Trizopagurus magnificus (Bouvier)

This medium-sized hermit crab appears to be restricted to the southern portion of the Gulf. It ranges southward to Ecuador, the Galápagos, Malpelo Island off Colombia, and also on southwestern Baja. It occurs from the intertidal to about 9 meters depth on rocky substrates and wedged into *Pocillopora* coral (Ball and Haig, 1974). It is apparently somewhat gregarious, with groups of 7–8 not uncommon.

This species is immediately identified by its equal-sized, hoofed chelipeds, which open obliquely, and by its generally blotched appearance. Striking, large irregular white to orange blotches occur on the carapace, chelipeds, walking legs, eyestalks, and proximal segments of the antennules, which are otherwise brown. The corneas are red. The eyestalks, slightly expanded at the bases, are long and slender. Long setae are present on the chelipeds, legs, and carapace.

According to Ball and Haig, this species feeds on algae which it scrapes from rocks with both chelipeds. It occurs in a variety of shells.

SUPERFAMILY PAGUROIDEA
FAMILY PAGURIDAE
Pagurus albus (Benedict)

Had *P. albus* been the first hermit crab to be collected, the common name "hermit crab" would never have gained acceptance. A live *P. albus*, although small in size, is both fast and feisty. An individual can scurry across a sand substrate rapidly enough to pose collecting difficulties sometimes. This species is associated with sandy bottoms from Puerto Peñasco in the northern Gulf to Estero de la Luna and Bahía Santa Inéz in the south-central Gulf. Although typical of tidal flats, it is also not uncommon to a depth of 5-1/2 meters.

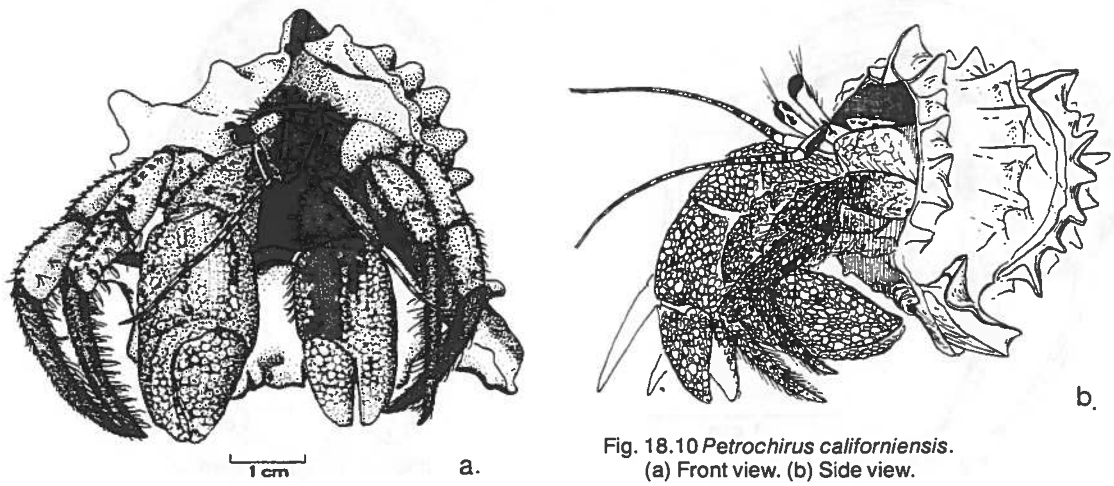

Fig. 18.10 *Petrochirus californiensis.* (a) Front view. (b) Side view.

In addition to its aggressive behavior, for which a friend has dubbed his aquarium pet "Ahab," this species can be identified by its pinkish-cream color, which adapts this hermit well to camouflage on sandy bottoms. Very light diffuse, brown, oblique banding can be seen on the walking legs and major chela. The eyestalks are white, but the centers of the corneas are dark. The eyestalks are rather short and stout and bulge distally. The walking legs also appear adapted to a sandy bottom. They are long, exceeding the lengths of the chelae, and tapering (fig. 18.11).

This hermit crab is often found without companions and seems to live a rather solitary life. At ebb tide it is usually found close to the receding water mark. It is frequently an inhabitant of *Polinices* and *Natica* shells.

Pagurus gladius (Benedict)

This small to medium-sized species had previously been reported only at depths of 36 to 91 meters in the Gulf. However, Haig, Hopkins, and Scanland (1970) listed this species in a paper dealing with shallow water fauna of southwestern Baja. In the northern Gulf, too, this species has been trawled from much more shallow depths. Its distribution is from the Gulf of California to Ecuador.

The carapace is orange to red and lightly speckled with pale green. The abdomen is slightly lighter in color. The chelae are pinkish-buff with a light purplish tinge and speckled with pale brown and red small blotches. Eyestalks are pale orange and eyes are dark green to black. The walking legs are pale gray with two orange bands and a bright red band on the merus (not distinct in all specimens) and vague red or purple bands on the propodus. The entire ventral side of the hermit crab is pinkish-buff except on the frontal portion, which is scarlet red. The eyestalks in this species are very stout and flattened. Spines, tubercles, and granulations occur on most segments of the chelipeds and walking legs. On the carpus of the walking legs, these spines may have 2–3 points (fig. 18.12).

Characteristic of this hermit crab is its small shell which often does not cover the carapace. According to Glassell (1937), the shell is partially disintegrated by the action of bryozoans or polyps. This unidentified polypoid growth forms a large, flexible, spiral home for the crab.

Pagurus lepidus (Bouvier)

The average size of this species is probably smaller than that of any other Gulf species (the carapace length is on the order of 3.8 mm). *Pagurus lepidus* is quite common in the lower intertidal and the sublittoral (to 40 meters). Within the intertidal it is most frequent in rocky areas with residual water, such as tidepools, where it is often the dominant species. Here it is often observed clinging to vegetation such as *Sargassum* spp. *Pagurus lepidus* has been recorded at Puerto Peñasco and throughout the Gulf, from Isla Clipperton (?), and from 550 kilometers up the outer Baja peninsula, at Bahía de San Hipolito.

Characteristic of this crab is the fairly slender, larger, right chela which is oriented horizontally in contrast to the oblique orientation of the left chela. Another prominent feature of live specimens is the black longitudinal stripes arranged in bands on each segment of the walking legs. These bands alternate with white or pinkish areas. The antennae are also banded with about three white segments. Because *Pagurus lepidus* may actually consist of several closely allied species (Haig, Hopkins, and Scanland, 1970), the researcher should exercise caution in his studies. Janet Haig has suggested that three or four species of this complex exist in shallow Gulf water.

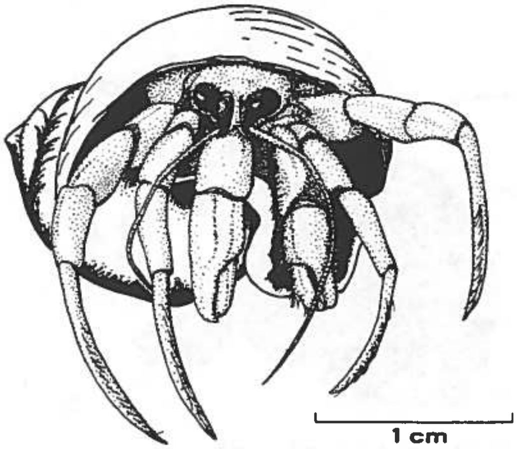

Fig. 18.11 *Pagurus albus*

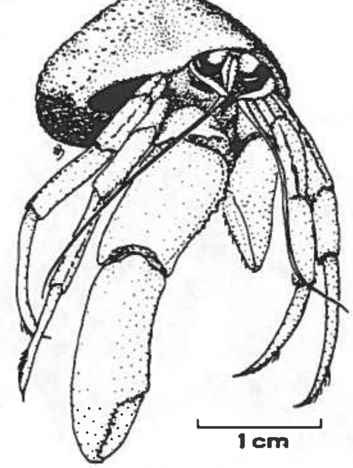

Fig. 18.12 *Pagurus gladius*

Pagurus galapagensis also occurs in the Gulf but is uncommon. It differs from *P. lepidus* by having long slender eyestalks not dilated at the corneas, by spination occurring on dactyl, propodus, and carpus of the minor chela and first pair of walking legs, and by possessing only a single spine on each eye scale.

In the intertidal zone *P. lepidus* exhibits similar behavior to *C. digueti*. When exposed at low tide, individuals retreat to moist crevices, but as the tides ebb and flood individuals apparently filter-feed, occupying the upper surfaces of rocks and algae. *Pagurus lepidus* seems to breed over a wide period, at least from January through July.

Pagurus smithi (Benedict)

A medium-sized hermit crab, *Pagurus smithi* is apparently concentrated in sublittoral waters from depths of 32 to 70 meters. It is, however, widely distributed from Estero de Tastiota (north of Guaymas) to Punta Piaxtla (north of Mazatlán) and from Bahía Santa Inéz on south-central Baja to Boca de Santo Domingo, 350 km north of Cabo San Lucas, on outer Baja.

In alcohol, the carapace, ambulatory legs, and eyestalks are buff. The carpus, manus, and chelae are light orange and the palms of the chelae and dactyls are white. The eyestalks of *P. smithi* are short and stout and expanded at the corneas. Spines cover the merus, carpus, hands, and dactyls of the chelipeds. The carpal and propodal joints of the walking legs are spined, as are the ventral surfaces of the dactyls. The upper surfaces of both hands are covered with flattened plates or tubercles.

Pylopagurus roseus (Benedict)

This small, colorful hermit crab is apparently a "fugitive" species in the intertidal zone, occurring sporadically in tidepools and under rocks in the mid and lower intertidal. It also occurs sublittorally to a depth of at least 8 meters. The distribution reported in the literature is for only two areas, the Bahía Adair–Norse Beach area (near Cholla Bay in the northern Gulf), and outer Baja. I have also collected *P. roseus* at San Carlos, Isla San Pedro, Ensenada de los Muertos, and Isla Cerralvo. Although never found in abundance, when one individual is encountered, several others are likely to be found nearby.

The large, flat, major chela acts as an operculum allowing this hermit crab (and others of its genus) to seal its shell against intruders. The major cheliped is black, except near the tip which is usually white. Large rose-red colored eyes (corneas) identify this crab at a glance. Segments of the walking legs are each banded sequentially with black, white, light blue, tan, and dark brown. The antennae are banded brown and white.

Although *P. roseus* is lithe in its movements, it is particularly delicate and should be collected and contained with care. *Pylopagurus roseus* appears to breed in the winter. I have collected ovigerous (berried) females from January to late March.

Pylopagurus varians (Benedict)

Although this small species is typical of deeper sublittoral waters, to 183 meters, it has been located in water as shallow as 6 meters (Ball and Haig, 1974). I have included this species because it is noticed by divers and also commonly appears in trawl nets. The distribution is from the northern Gulf (just above the midriff) to Panama, and also on outer Baja. Collections of this hermit crab are often made in a mixed sand and rock habitat.

Pylopagurus varians has an operculate major (right) chela used for sealing its "shell." The "shell" is typically composed of a white or tan staghorned hydrocoral which has chemically eroded away the original gastropod shell. The manner of growth of the hydrocoral is frequently such that, if turned upside down, the hermit crab may not be able to turn erect again. Against this disadvantage is the advantage of apparently not requiring a change of shells, for the hydrocoral continues to grow at the mouth of the shell. At the mouth, it is neatly manicured by the hermit crab to fit its size requirements.

In appearance, this species is differentiated from most other species of *Pylopagurus* by the red and white mottling of the minor cheliped and the merus of the major cheliped, by the reddish-brown to orange major chela, by the bright orange corneas, and by the reddish-brown walking legs with white areas at the distal end of each segment. See Plate 11.

Another species, *P. cervicornis*, also lives in a shell covered by staghorn hydrocoral but is generally restricted to deeper water (see Walton, 1954). This species may be distinguished by microscopic examination of the telson, which is denticulated on the general margin rather than just on the sides of the notch, and by the slender spines on the opercular face of the chelae which are vertically directed rather than anteriorly directed and basally constricted.

Pylopagurus venustus (Bouvier)

To date, this species has been reported only from La Paz in the southern Gulf, on the outer Baja coast, and at Ecuador, but this seemingly disjunct distribution suggests a wider occurrence. *Pylopagurus venustus* is a sublittoral species which closely resembles *P. californiensis*.

This species can be distinguished by its brown, wavy bands on the merus, carpus, propodus, and dactyls of the walking legs and minor cheliped. Also, *P. venustus* has many forward directed spines on the carpus of the major chela, a feature absent in *P. californiensis*. The segments of the major cheliped are irregularly blotched and are diffusely brown, except for the fingers and lateral extensions of the chelae.

Pylopagurus californiensis (Benedict)

This hermit crab is apparently a cold water lover, showing a pattern of increasing total vertical range as one proceeds north. At Panama it is found at 121 meters while on the Californian coast it is most common on subtidal rocks and rubble (to 55 meters), but it may even be collected at low tide. It has also been collected in the cold waters of the Galápagos Islands at 4-1/2 meters. In the Gulf of California it has been recorded at Arena Bank, Santa Inéz Bay, La Paz, Cabeza Ballena, and Isla Angel de la Guarda on the Baja side, and at Cholla Bay south to Cabo Tepoca and Isabel Island off mainland Mexico.

Characteristics of this species include the operculate right chela, with its orange and white (or blue) spots. The walking legs have orange to red stripes superimposed on broad transverse bands of white and pale orange. The eyestalks are also orange with a broad, proximal, white ring. The antennae are banded with reddish-brown and tan.

19

ARTHROPODA: CRUSTACEA
Superfamily Hippoidea: Families Hippidae and Albuneidae (Mole and Sand Crabs)

by Janet Haig*

Preservation: See general preservation, Crustacea.

Taxonomy: The superfamily Hippoidea is divided into two families, Hippidae and Albuneidae. Hippoids live buried in sandy or gravelly substrate, and the taxonomy is based chiefly on morphological features (including carapace, eyestalks, antennules, antennae, legs, and telson) that show adaptations to this mode of life. For an excellent discussion of some of these adaptations see Snodgrass (1952). Miers (1878) gave a general account of the classification. Students who are interested in consulting the earlier literature on the superfamily should be cautioned about a confusion of nomenclature that involves the two most common genera in the Hippidae: *Emerita* was frequently called *Hippa* and the genus to which the latter name is now applied was known as *Remipes*. The following key includes the characters that most easily separate the families and the four genera (*Emerita, Hippa, Albunea,* and *Lepidopa*) represented in the Gulf.

Mole and sand crabs of the Gulf: Nine species are known to occur in the Gulf of California. Their affinities are largely tropical. One species is known from the Gulf only; one is restricted to the southern end of the Baja California peninsula; five range southward along the tropical portion of the west American coast, and one of these also occurs throughout the tropical Indo-west Pacific. The other two species are temperate forms of the outer coast but have also been recorded from the upper part of the Gulf.

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The family Hippidae includes only three genera of which two, *Emerita* and *Hippa*, are represented in the eastern Pacific by two species each; all four of these species occur in the Gulf. They lie buried just under the surface of the sand, sometimes in large aggregations, and are fairly easy to observe while feeding, even though their color usually matches that of the substrate. Weymouth and Richardson (1912) and others have described the feeding behavior of *Emerita analoga* from the California coast, and Seilacher (1961) discussed feeding of *E. rathbunae* in Central America. These animals live in the shifting sand of wave-swept beaches, in the area washed by the waves; they bury themselves near the surface, facing seaward with only the inner antennae (held together to form a breathing tube) and eyes out of the sand. When a wave has broken and is draining off the beach, the long, feathery outer antennae protrude from the substrate and, extending forward and outward, form a filter in which small suspended food particles are caught and then carried to the mouthparts. Since this type of behavior is adapted to conditions of heavy surf and strong currents, it is reasonable to suppose that the animals might react somewhat differently in the quieter waters of the Gulf, probably in the manner described by Efford (1966) for *E. analoga* in the laboratory. Efford found that when a slow current of water was passed over these crabs they fed by partly (to almost completely) emerging from the sand, with the outer antennae held upward or curved backward over the body.

Hippa has small outer antennae which are not adapted as a filtering apparatus as in *Emerita*. It grasps small organisms or pieces of animal matter with its nonchelate first pair of legs (apparently somewhat like a man eating with chopsticks) and carries the food to the mouthparts. In Hawaii, *H. pacifica* has been observed feeding selectively on *Physalia* (Portuguese man-of-war) in the surf zone by seizing the coelenterates as they are washed in to shore and pulling them beneath the sand.

In most *Emerita*, including the two eastern Pacific species, females are considerably larger than males. Efford (1967) attributed this to neoteny (males reaching sexual maturity at small size). However, there is growing evidence that the phenomenon is due to protandric hermaphroditism (males changing into females). For a discussion see Barnes and Wenner (1968) and Wenner (1973). Wenner found no evidence for sex reversal in *Hippa*.

Of several genera in the family Albuneidae, only *Albunea* and *Lepidopa* occur in the Gulf of California. *Albunea lucasia* is the only member of its genus to be reported from the eastern Pacific. *Lepidopa* is represented in the eastern Pacific by 11 species, and 4 of them have been found in the Gulf. A few other *Lepidopa* species, known to occur in Mexico south of the Gulf, might turn up there sooner or later. Efford's (1971) revision of genus *Lepidopa* should be consulted for the identification of Gulf material that does not definitely fit any of the species treated in this handbook.

Albuneids are often deeply buried in the sand, with the inner antennae (antennules) held together to form a very efficient breathing tube. They do not form large aggregations as do the Hippidae. Because of this, they are frequently difficult to see and only randomly collected. *Albunea* and *Lepidopa* are found at low tide levels where they have been taken by digging or seining. They also occur subtidally and have sometimes been dredged in rather deep water. Little is known of their habits. Benedict (1904) suggested that the inner antennae of *Albunea* and *Lepidopa* might be involved in feeding. In a study of the hippoids of Madagascar, Thomassin (1969) discussed filter-feeding in *Albunea*. The inner antennae play a major role in this, just as the outer antennae do in *Emerita*. They are very long and feathery (2 or 3 times the carapace length in *Albunea*), and they collect coarse food particles in suspension which are then scraped off with the mouthparts. The food-gathering mechanism may be the same in *Lepidopa*, whose antennules are similar in structure and even longer (up to 5 times the carapace length).

KEY TO THE MOLE AND SAND CRABS

1 Carapace oval, strongly convex, with lateral expansions covering legs; first pair of legs nonchelate: family Hippidae 2
-Carapace subquadrangular, more or less flattened, without lateral expansions covering legs; first pair of legs chelate or subchelate: family Albuneidae 5

2(1) Flagellum of outer antennae very long; distal article of first pair of legs oval and lamellate: genus *Emerita* 3
-Flagellum of outer antennae short, consisting of only a few articles; distal article of first pair of legs styliform: genus *Hippa* 4

3(2) Transverse crenulations of carapace close-set, crossing entire posteromedian part of carapace (fig. 19.1) .... ***Emerita rathbunae***
-Transverse crenulations of carapace rather wide-set, lacking on a smooth median area at posterior end of carapace (fig. 19.2) .... ***Emerita analoga***

4(2) Frontal margin of carapace with 2 rounded lobes between eyestalks; lateral carapace margins with a submarginal row of shallow pits (fig. 19.3) .... ***Hippa pacifica***
-Frontal margin of carapace with a broad triangular lobe between eyestalks; lateral carapace margins with a broad band of oblique striations (fig. 19.4) .... ***Hippa strigillata***

5(1) Frontal margin of carapace with a median concavity flanked on either side by a row of spines: genus *Albunea* (fig. 19.5) .... ***Albunea lucasia***
-Frontal margin of carapace with a median lobe: genus *Lepidopa* 6

6(5) Median lobe of frontal carapace margin with a spine 7
-No spine on median lobe of frontal margin 8

7(6) Eyestalks squarish (fig. 19.6) .... ***Lepidopa mearnsi***
-Eyestalks ovoid, longer than wide (fig. 19.7) .... ***Lepidopa esposa***

8(6) Median lobe of frontal margin low, not well developed; submarginal groove on posterior part of carapace follows about halfway along median concavity (fig. 19.8) .... ***Lepidopa myops***
-Median lobe of frontal margin well developed; submarginal groove on posterior part of carapace stops near base of median concavity (fig. 19.9) .... ***Lepidopa californica***

SUPERFAMILY HIPPOIDEA
FAMILY HIPPIDAE (mole crabs)
Emerita rathbunae Schmitt

This species is reported from Bahía San Francisquito and La Paz on the Baja side of the Gulf; the northernmost Sonora record I know is from Bahía Kino (specimens in the Allan Hancock Foundation). Carapace lengths up to 44 mm for females and 8 mm for males are recorded. Knight (1967) studied the larval development of the species in the laboratory; she recognized larvae from zooplankton as far north as Bahía San Francisquito and Isla Tiburon in the Gulf, and from a number of offshore localities to the south and east of Cabo San Lucas. A nearshore plankton sample containing several developmental stages of *E. rathbunae* was taken just south of Bahía Magdalena, suggesting the possibility (not yet proved) that these larvae were hatched locally and that populations of the species may occur in the sandy beaches of outer Baja between Bahía Magdalena and Cabo San Lucas (Knight, 1967). *E. rathbunae*, which has also been cited in the literature as *Emerita* (or *Hippa*) *emerita*, is characterized by the close-set crenulations, rough to the touch, that cross the entire posteromedian part of the carapace, and by the presence of a short groove at the posterior end of the carapace close to and paralleling each lateral margin. It ranges from Bahía San Francisquito and Bahía Kino to Iquique in northern Chile, and Efford (1969, 1976) cited records from the Galápagos Islands. Abele (1976) reported it as the dominant species on sandy beaches in west Panamá. Figure 19.1.

Emerita analoga (Stimpson)

A temperate species with a discontinuous distribution, *E. analoga* is recorded from Kodiak Island, Alaska, to Bahía Magdalena on the outer coast of Baja California, and from Paita, Peru, to the Strait of Magellan, with an isolated population at Caleta Falso (False Bay), Argentina. *E. rathbunae* was thought to be the only representative of the genus *Emerita* in the intervening tropical region, until Knight (1967) reported *analoga*-like larvae from plankton samples taken in the Gulf of California. Since these were found at a time of year when currents would be unlikely to carry them into the Gulf from breeding populations on the outer Baja coast, Knight speculated that either *E. analoga* or a close relative might be established in the Gulf. Not long afterward a population of *E. analoga* was recorded from Bahía San Francisquito (Efford, 1969), and it was subsequently reported from Estero de Tastiota and Bahía Kino (Efford, 1976). Seven small specimens of *E. analoga* were collected at Estero de Tastiota by Dr. Peter E. Pickens of the University of Arizona and are deposited in the Allan Hancock Foundation; the carapace of the largest, a fully mature female, is a little under 12 mm long. In this species there is a smooth area on the posteromedian part of the carapace, the crenulations of which are more wide-set than in *E. rathbunae*; and the groove at the posterior end of the carapace near the lateral margin is concealed beneath the overlapping second abdominal segment. Figure 19.2.

Hippa pacifica (Dana)

This mole crab ranges throughout the tropical and subtropical Indian and Pacific oceans, on intertidal beaches and occasionally at moderate depths. The carapace may reach a length of about 30 mm. The species has been reported several times in the eastern Pacific under the names *Remipes testudinarius* and *Remipes* (or *Hippa*) *denticulatifrons*. It has been found in the Gulf at La Paz, Los Frailes, and Cabo San Lucas on the Baja side, and on the Sonoran coast from El Sahuaral (near Morro Colorado) southward. This *Hippa* has 2 rounded lobes on the anterior margin of the carapace

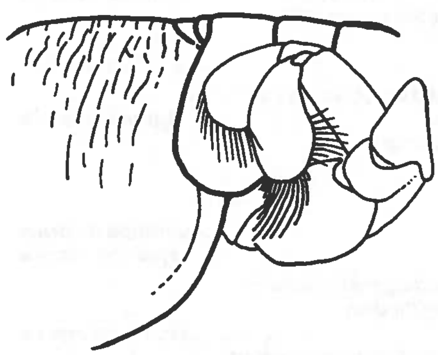

Fig. 19.1 *Emerita rathbunae*. Lateral view showing posterolateral sulcus of carapace.

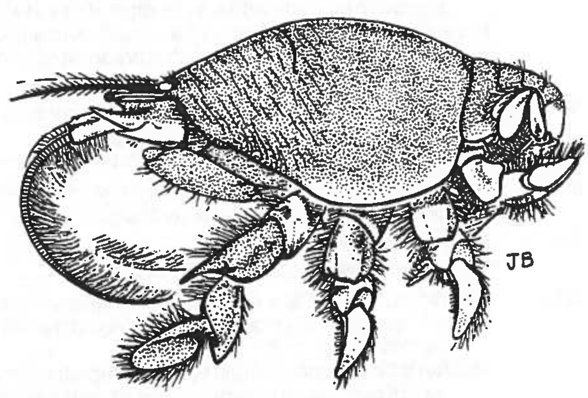

Fig. 19.2 *Emerita analoga* (from Allen, 1976)

between the eyes, normally 2 articles in the flagellum of the outer antennae, and a row of about 30–40 shallow pits along each lateral carapace margin. In the eastern Pacific it is known from a few mainland localities from the Sonoran coast of the Gulf to at least as far south as Panama, but in general its distribution here, as elsewhere, is insular (Efford, 1973); it occurs on offshore islands including the Revillagigedos, Clipperton, Cocos, and the Galápagos, as well as on the southern part of the Baja California peninsula with its "insular" characteristics (Garth, 1961). Wenner (1977) has studied the general ecology of this species and concluded that they rely primarily on animal matter washed ashore by wind-driven surface waters for food. In addition, reproductive seasonality (in terms of egg production) was concluded to be a direct result of food availability (rather than changes in temperature or photo period). Figure 19.3.

Hippa strigillata (Stimpson)

This species, with a carapace length to about 25 mm, has been reported in the Gulf only from Los Frailes and Cabo San Lucas, near the tip of the Baja California peninsula. It has a broad median lobe on the anterior margin of the carapace, and a series of oblique striations along each lateral carapace margin; this striated area is very broad in its posterior half, where it occupies about one-fourth of the carapace width. The species is known from several Mexican localities to the south of the Gulf and from just north of La Libertad, El Salvador. Figure 19.4.

FAMILY ALBUNEIDAE (sand crabs)

Albunea lucasia Saussure

Steinbeck and Ricketts (1941) found this species at "San Lucas Cove" (Cabo San Lucas) burrowing in sand of the intertidal beach; the "Velero III" and "Velero IV" of the Allan Hancock Foundation dredged it north of Punta Lobos (near Guaymas) in 25 fathoms and northeast of Cabo San Lucas in 10 fathoms. Its carapace may reach a length of 25 mm. It can be readily recognized by the eyes which are over twice as long as wide and conical in shape, with a distinct terminal cornea; and by the frontal margin of the carapace which bears 8–11 spines on either side of a median concavity. The recorded range is Cabo San Lucas and Punta Lobos south to Panama, and I have seen specimens from Ecuador and Peru. Figure 19.5.

Lepidopa mearnsi Benedict

This sand crab, with a carapace length to about 10 mm, has been found intertidally in the upper part of the Gulf. Westervelt (1967) reported specimens from Norse Beach, collected 4 to 7 cm below the surface of fine sand at lowest tide levels. I have seen material from Bahía Cholla from shore collections of Thomas A. and Beatrice L. Burch. Recognition characters include the squarish eye scales and the median rostral spine. According to Westervelt, the color is "white, with a

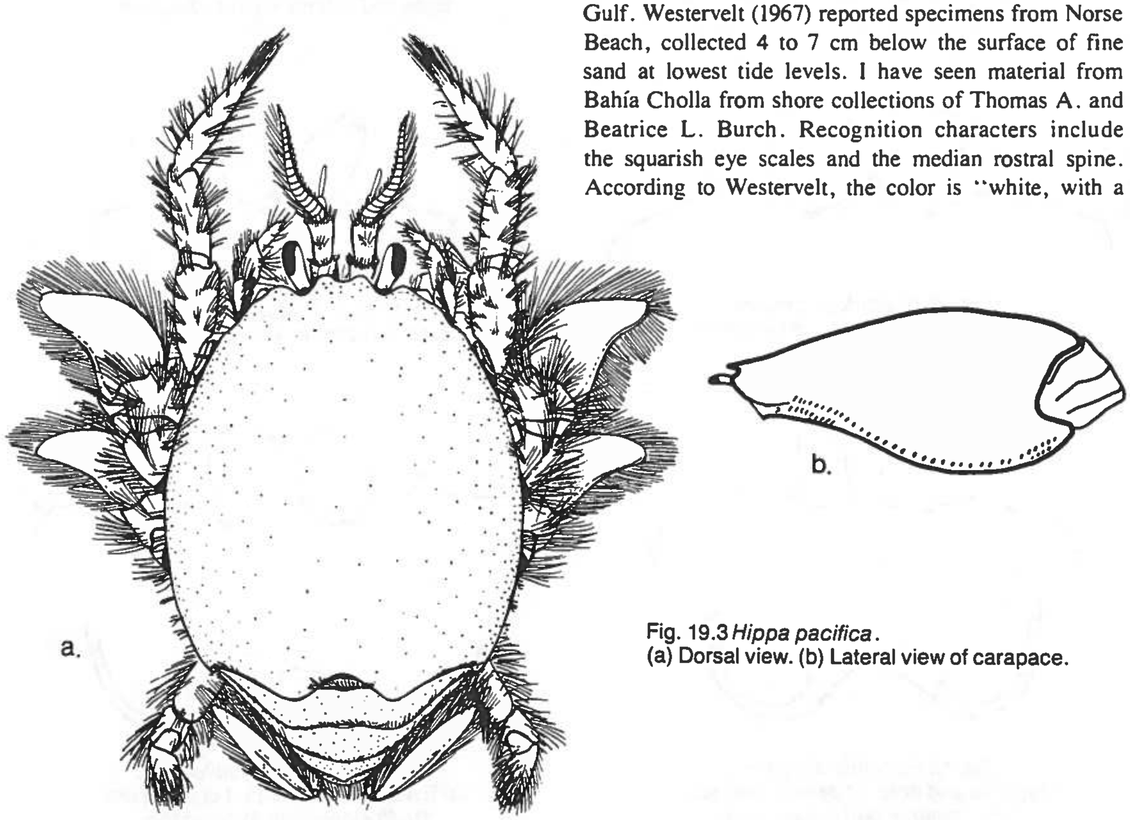

Fig. 19.3 *Hippa pacifica*.
(a) Dorsal view. (b) Lateral view of carapace.

dark brown spot at the posterior end of the thorax, and at the anterior end of abdomen in a mid dorsal position. Some light iridescent pink color is present on the propodus of the chelipeds." Aside from those noted above there are only a very few records for the species, from southern Mexico to Costa Rica. Figure 19.6.

Lepidopa esposa Efford

Until 1975 the only known specimen of this species was the holotype from Bahía de La Paz; in that year additional material was found on two separate occasions in the upper Gulf of California by personnel from the University of Arizona. Two small specimens were collected at Bahía la Cholla by Paul Werst and Mark Tashiro. On that day the tide was about −4 feet; the crabs were taken separately with a spade and seive at about the −3 foot tide level, a short distance ahead of the returning water front, on flats of fine muddy sand. Two weeks later a 2-hour search for more material was made in the same location, but without success. Later in the same year a specimen with the carapace 11.5 mm long (the largest on record) was collected at Norse Beach by Elaine Snyder-Conn. This species resembles *Lepidopa mearnsi* in having a median rostral spine, but differs from it in the rounded and more elongate eye scales. Figure 19.7.

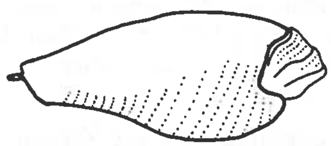

Fig. 19.4 *Hippa strigillata*.
Lateral view of carapace.

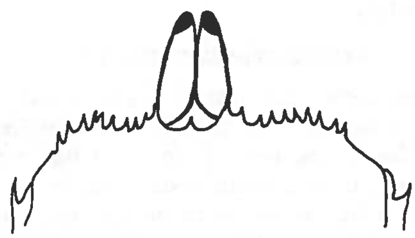

Fig. 19.5 *Albunea lucasia*.
Eyes and anterior part of carapace.

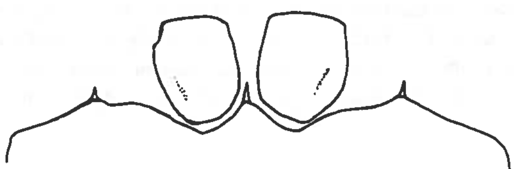

Fig. 19.6 *Lepidopa mearnsi*.
Eyes and anterior part of carapace.

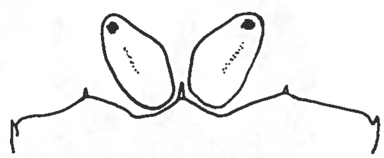

Fig. 19.7 *Lepidopa esposa*.
Eyes and anterior part of carapace.

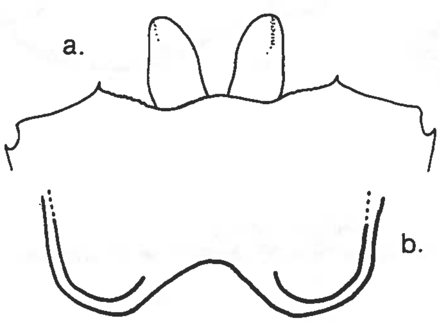

Fig. 19.8 *Lepidopa myops*.
(a) Eyes and anterior part of carapace.
(b) Posterior part of carapace.

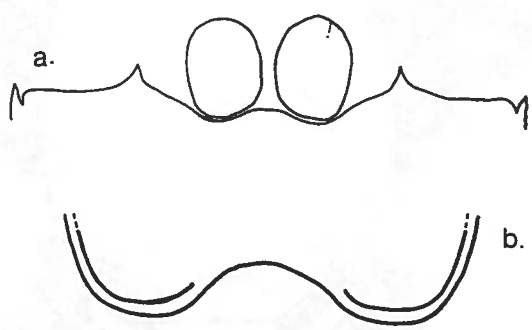

Fig. 19.9 *Lepidopa californica*.
(a) Eyes and anterior part of carapace.
(b) Posterior part of carapace.

Lepidopa myops Stimpson

For many years the name *myops* was applied to the Californian population of *Lepidopa*; Efford (1971) showed this to be a distinct species and renamed it *L. californica*. *L. myops*, as restricted by Efford, is known to occur only around the southern end of the Baja California peninsula. The carapace reaches a length of nearly 11 mm. The Allan Hancock Foundation has material dredged by the "Velero III" and "Velero IV" on sand bottoms in 10–25 fathoms. In a description of the larval development of *L. californica* (as *L. myops*), Knight (1970) noted that zoeal larval stages of a second species of the genus have been found in the plankton of coastal waters of southern California and outer Baja south to Bahía Magdalena, being particularly abundant in the area of Bahía Sebastián Vizcaíno. This form, which Knight designated as "species B," is perhaps *L. myops*. Adults of *L. myops*, however, are recorded only from Cabo San Lucas and the area immediately to the northeast of it, as well as from Bahía Santa María on the lower west coast of Baja California. Figure 19.8.

Lepidopa californica Efford

This species, which was identified with *Lepidopa myops* prior to Efford's (1971) revision of the genus, is found along the California coast from Monterey Bay to San Diego on sheltered sand beaches at low tide levels, and is known subtidally to a depth of 13 fathoms. Recorded carapace lengths are 12 mm for males and 18 mm for females. The larval development was worked out in the laboratory by Knight (1970, as *L. myops*), who also recorded larvae of the species in the plankton from southern California south to Bahía Magdalena. Efford (1971) reported a single specimen dredged by the "Velero III" off Isla Angel de la Guarda in 62–76 fathoms. This is the only recorded occurrence in the Gulf, but the species may yet be encountered there along shore or in shallower subtidal waters. *L. californica* and *L. myops* are quite similar in appearance, with their rounded eye scales and lack of a spine on the median (rostral) lobe of the frontal margin of the carapace; they can be distinguished by the characters illustrated and given in the key. Figure 19.9.

20

ARTHROPODA: CRUSTACEA
Brachyura (Regular Crabs)

Preservation: The regular crabs should be preserved in 75 percent alcohol, as formalin will deteriorate the calcareous exoskeleton. Care should be taken not to break off the appendages when handling individuals; however, narcotizing is generally not necessary. The larger brachyurans may be left in the preservative, or removed (after several days) and air-dried. Dried specimens do, however, become quite brittle and must be handled with care. Since alcohol tends to bleach the color from the exoskeleton, color notes should always be taken prior to preservation.

Taxonomy: The classification of the brachyuran crabs is based on a large series of taxonomic characters. The majority of these characters are external, morphological features of the carapace and appendages. The use of the male's first pleopod as an important taxonomic character has resulted in the discovery of many significant taxonomic relationships among the higher taxa of this group. Fig. 20.1 will aid the user of this handbook in locating specific anatomical parts of his specimen mentioned in the key. References to the manus, arm, or palm refer to the chelipeds, and not the walking legs, unless otherwise designated. When the number of anterolateral spines on the carapace is given, that number includes the outer orbital spine. The systematics used in this handbook are from Rathbun (1918–1937) and Garth (1958, 1966) (see Arthropod section for further taxonomy).

Brachyurans of the Gulf: Glassel (1934a) listed 197 species of regular crabs from the Gulf. Steinbeck and Ricketts collected 54 species (mainly intertidal). Rathbun (1918–1937) described over 200 brachyurans from this region, while Garth (1960) reported 230 species from the Gulf. This large number of species makes the Gulf an extraordinarily rich collecting ground for students of the regular crabs. The author has found 67 species of intertidal and shallow water brachyurans common enough in the Gulf to be included in the key that follows.

The Gulf of California possesses an especially rich fauna of swimming and fiddler crabs. Garth and Stephenson (1966) reported 17 species of Portunidae, and Crane (1975) reported 7 species of fiddlers from the Gulf. By comparison, the Pacific coast of North America north of Mexico has but one fiddler *(Uca crenulata)*, and only two swimming crabs *(Portunus xantusii* and *Callinectes arcuatus)*, all restricted to southern California. The Gulf pea crab fauna (Pinnotheridae) is not well-known, although Rathbun (1918) reported five genera, and Glassell (1934–1936) later reported 18 species he had found to be endemic to the Gulf. Because of the great variety and numbers of species known to occur in the Gulf, the key includes only the most common species of intertidal and shallow water crabs, mainly those collected by the author himself. The serious student of the Brachyura is referred to Rathbun's monumental series published by the United States National Museum (1918, 1925, 1930, and 1937), and the excellent monographs by Garth (1958), Garth and Stephenson (1966), and Crane (1975). Dr. Garth is undoubtedly the foremost living authority on the Pacific Brachyura, and students of this group are eagerly awaiting further volumes of his *Brachyura of the Pacific Coast of America*.

The most commonly observed large crab of the rocky shores of the lower Gulf is probably the famous Sally Lightfoot crab, *Grapsus grapsus*, while in the upper Gulf *Eriphia squamata* emerges as the most commonly encountered large crab. Of the small to medium-sized crabs (those usually found under rocks), *Leptodius occidentalis, Tetragrapsus jouyi, Ala cornuta, Goetice americanus*, and the hairy crabs of the genus *Pilumnus* are most common to the Gulf intertidal. Sandy beaches, bays, and estuaries are inhabited by the swimming crabs, of which *Callinectes bellicosus* and *Portunus xantusii* are most often collected. Also, high on sandy beaches throughout the central and southern Gulf are the fascinating ghost crabs *Ocypode occidentalis* and the uncommon scavenging crabs *Cyclograpsus escondidensis*. In mud and sandy-mud bays, the fiddlers abound. Several species are common in the northern Gulf: *Uca musica*, *Uca crenulata*, *Uca latimanus*, and *Uca princeps;* while in the southern Gulf *Uca macrodactylus*, *Uca princeps*, and *Uca vocator* appear to be the most common fiddlers. The masking crabs are represented in the Gulf intertidal principally by *Ala cornuta* and *Podochela hemphilli*. Of the species of spider crabs included in the key, only six of the genera *(Ala, Podochela, Pitho, Thoe, Epialtoides,* and *Epialtus)* are commonly found intertidally, the others being uncommon in the intertidal zone and most easily collected by skin diving or by sorting through the catch of the shrimp trawlers. The common kelp crabs of the Pacific coast of the United States *(Pugettia)* are largely replaced in the Gulf by the smaller *Sargassum* crabs: *Epialtus minimus*, *Acanthonyx petiveri*, *Podochela* spp., *Eucinetops lucasi*, *Inachoides laevis*, *Pitho picteti*, and *Epialtoides paradigmus*. It should be kept in mind that almost any crab common to the low intertidal zone will also be found subtidally, at least in depths that make SCUBA collecting profitable.

Although not included in the key, the giant land crab *Cardisoma crassum* Smith has been consistently found near the small fishing village of Boca del Río, Sinaloa, and at San José del Cabo, on the peninsular side. These large, red-white-and-blue crabs dig burrows in the dry mud from half a kilometer to several kilometers inland, along the banks of the rivers. The burrows are deep (150–200 cm) but easily spotted by the large mound of dried mud that the crab deposits above the entrance. Anyone visiting the mouth of the Sinaloa River will be missing a beautiful sight if he doesn't travel up river to observe these crabs.

The majority of the brachyuran fauna of the Gulf has its affinities with the Panamic Province. Of the 230 species of true crabs reported from the Gulf by Garth (1960), 131, or 52 percent, were considered by him to be Panamic, while 80 (32 percent) were considered indigenous to the Gulf, and 19 (8 percent) represented northern forms. The occurrence of littoral species from the Californian Province is rare. The familiar *Pachygrapsus crassipes* of the Pacific coast of North America is reported only sporadically, between Puerto Peñasco and Guaymas. It is likely that these members of the colder water Californian fauna often occur in deeper water and must be collected subtidally, except in the colder winter months when they may move into the intertidal in the northern Gulf. The trend of colder water animals occurring deeper as one moves south (in the Northern Hemisphere) is often seen on the west coast of

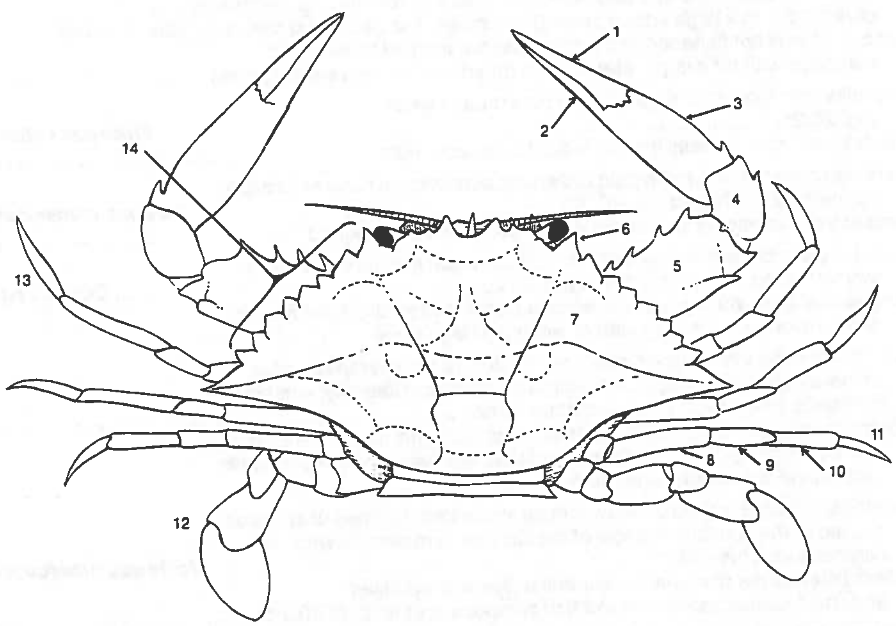

Fig. 20.1 General brachyuran crab morphology (after Rathbun, 1918). (1) Movable finger. (2) Fixed finger. (3) Manus (palm, hand). (4) Carpus (wrist). (5) Merus (arm). (6) Outer orbital spine. (7) Anterolateral or epibranchial region. (8) Merus (of walking leg). (9) Carpus (of walking leg). (10) Propodite (of walking leg). (11) Dactylus (of walking leg). (12) Last walking leg. (13) First walking leg. (14) Anterolateral spines.

the United States and Baja California (see Introduction). The vast majority of Californian or temperate forms are restricted to the colder northern third of the Gulf, disappearing in the southern Gulf and on around Cabo San Lucas, to reappear midway up the west coast of Baja California. Some southern California–northern Baja Californian brachyura found in the Gulf include *Randallia ornata*, *Lophopanopeus frontalis*, and *Cancer amphioetus*. Previously published reports of *Hemigrapsus* from the Gulf are probably in error (see p. 301).

Motile marine invertebrates, generally speaking, utilize four distinct modes of escape from their predators. By placing oneself in the role of "predator" these four techniques can be demonstrated particularly clearly with brachyuran crabs. They may be observed to be as follows:

1. Speed and agility; literally outrunning or dodging a predator; seen in most of the grapsoid crabs and Ocypodidae (*Grapsus grapsus*, *Geograpsus lividus*, *Pachygrapsus crassipes*, *Ocypode occidentalis*, etc.).
2. Concealment; by use of cryptic coloration, attachment of other organisms to the body, and/or cessation of body movements ("playing dead"); seen in many of the smaller crabs and the spider crabs (*Ala cornuta*, *Pilumnus limosus*, *Glyptoxanthus meandricus*, etc.).
3. Fighting back; out and out aggression; seen in many territorial species and certain crabs with broad, heavy chelae (*Eriphia squamata*, *Callinectes bellicosus*, etc.).
4. Chemical defenses; the use of distasteful or toxic chemical substances (not yet shown in any Gulf crabs, but known to occur in brachyurans in other regions; Garth 1971, 1975).

Adequate Spanish names for the brachyuran crabs are lacking. In general, small crabs are referred to as "*cangrejos*," while the larger portunids are called "*jaivas*"; red crabs are often called "*cangrejos rojos*," white crabs "*cangrejos blancos*," etc.

KEY TO THE COMMON INTERTIDAL BRACHYURAN CRABS

1 Small crabs, carapace width usually less than 15 mm; eyes reduced; carapace usually membranous and with reduced pigmentation; commensal in worm tubes, in holothurians, and on sand dollars (the pea crabs) 63
-Larger crabs, carapace width usually greater than 10 mm; eyes not reduced; carapace not membranous, usually well-pigmented; free-living, or occasionally commensal in sponges 2

2(1) Last pair of legs flattened and paddlelike, with the tips rounded for swimming; carapace with a large lateral spine (Portunidae, the swimming crabs) (fig. 20.18–20.23) 3
-Last pair of legs not flattened and paddlelike, but pointed for walking; carapace without a large lateral spine (often with several small spines) 10

3(2) Eyestalks very long, one-third or more of carapace width (fig. 20.21) .... ***Euphylax robustus***
-Eyestalks short, much less than one-third carapace width 4

4(3) Entire carapace covered with pale red spots; supraorbital fissures broadly opened and V-shaped (fig. 20.22) .... ***Arenaeus mexicanus***
-Carapace not as above; supraorbital fissures not broadly opened 5

5(4) Anterolateral teeth alternately large and small; distal margin of merus of swimming leg with a large spine (fig. 20.23) .... ***Cronius ruber***
-Anterolateral teeth not distinctly alternating large and small; distal margin of merus of swimming leg with or without a large spine 6

6(5) Abdomen of male triangular-shaped (fig. 20.20b); anteroexternal angle of merus of third maxillipeds not strongly produced laterally; wrist of chelipeds with a large inner and outer spine 7
-Abdomen of male ⊥-shaped (fig. 20.19b); anteroexternal angle of merus of third maxillipeds strongly produced laterally; wrist of chellipeds with outer spine but without inner spine 9

7(6) Posterodistal border of merus of swimming legs without spines or spinules; a spine at the postlateral angle of the carapace; maximum width of carapace less than 35 mm .... ***Portunus tuberculatus***
-Posterodistal border of merus of swimming legs with spinules and 0 to 1 spines; maximum width of carapace greater than 40 mm 8

8(7) Posterodistal border of merus of swimming legs with spinules but no spines; length of wrist and manus combined less than twice carapace length (fig. 20.20) .... ***Portunus xantusii***
-Posterodistal border of merus of swimming legs with spinules and one spine; length of wrist and manus combined 2 to 3 times carapace length .... ***Portunus asper***

9(6) Median pair of frontal teeth low and rudimentary, often entirely absent (fig. 20.19a); length of largest lateral spine of carapace usually equaling 1/12 (.06 to .08 percent) carapace width; carapace remarkably smooth, lines of granules visible but barely perceptible to the touch; maximum carapace width 155 mm (fig. 20.19) .... ***Callinectes bellicosus***

-Median pair of frontal teeth well-developed, about half length of outer pair (fig. 20.18b); length of largest lateral spine of carapace usually equaling 1/7 to 1/10 (.10 to .14 percent) carapace width; carapace not as smooth, lines and scattered granules both visible and quite evident to the touch; maximum carapace width 120 mm (fig. 20.18) .... ***Callinectes arcuatus***

10(2) Manus of one cheliped, in males, more than 3 times longer than opposing manus (*Uca*, the fiddler crabs) (fig. 20.14–20.17) **11**

-Manus of opposing chelipeds subequal in both males and females **17**

11(10) Anterior margin of carapace between eyestalks wide, greater than 1/10 greatest width of carapace; carapace width 5–35 mm **12**

-Anterior margin of carapace between eyestalks narrow and spatuliform, less than 1/10 greatest width of carapace; carapace width 20–50 mm (fig. 20.17) .... ***Uca princeps***

12(11) Gape between fingers of small chela wide, tips of chela only touching **13**

-Gape between fingers of small chela much narrower, much more than just tips of chela touching **14**

13(12) Finger of major chela shorter than manus (palm); no oblique stridulating ridge on palm (but with a row of denticles near base of fingers); width of adults 10–15 mm (fig. 20.15) .... ***Uca latimanus***

-Finger of major chela longer than manus; with oblique stridulating ridges on palm; width of adults 6–11 mm .... ***Uca musica***

14(12) Base of chelae red underneath; anterior part of side margins of carapace straight or nearly so, continuing backward with an angular turn; small chela with gape moderate, about equal to width of adjacent part of dactyl (or slightly less) (fig. 20.14) .... ***Uca crenulata***

-Base of chelae not red underneath; anterior part of side margins of carapace convex, curving gradually backward; small chela with gape more narrow **15**

15(14) Eyestalks long, eyes reaching anterolateral corners of carapace; carapace less than 15 mm wide; length of fingers subequal to length of palm .... ***Uca galapagensis***

-Eyestalks shorter, eyes not quite reaching anterolateral corners of carapace; carapace usually greater than 15 mm wide; length of fingers much greater than length of palm **16**

16(15) Anterior margin of carapace, between base of eyestalks, at least 1/3 width of entire anterior margin of carapace; oblique tuberculate ridge of palm vestigial; carapace with scattered setation (fig. 20.16) ...... ***Uca vocator ecuadoriensis***

-Anterior margin of carapace, between base of eyestalks, less than 1/3 width of entire anterior margin of carapace; oblique tuberculate ridge of palm strong; carapace without setae .... ***Uca brevifrons***

17(10) Length of carapace, including rostrum, greater than width **18**

-Length of carapace less than width **34**

18(17) Carapace length subequal to rostral length; length of walking legs greater than 2 times carapace length (fig. 20.36) .... ***Stenorhynchus debilis***

-Carapace length greater than rostral length; length of walking legs more or less than 2 times carapace length **19**

19(18) Rostrum absent; posterior region of carapace with 4 large holes .... ***Speleophorus digueti***

-Rostrum present (may be minute); carapace without large holes as above **20**

20(19) Rostrum bifid (split into two distinct points) **21**

-Rostrum not bifid **29**

21(20) Larger crabs, length greater than 25 mm (fig. 20.43) .... ***Stenocionops angusta***

-Smaller crabs, length less than 25 mm **22**

22(21) Carapace without dorsal setation; chelae bright red .... ***Thoe sulcata sulcata***

-Carapace with dorsal setation; chelae not bright red **23**

23(22) Chelipeds about same length as first walking legs **24**

-Chelipeds distinctly longer than first walking legs **25**

24(23) Carapace with 6 very large anterolateral spines; tips of chelipeds extend slightly beyond tips of first walking legs; carapace suboval; scattered body setae .... ***Pitho picteti***

-Carapace without 6 large anterolateral spines; tips of first walking legs extend slightly beyond tips of chelipeds; carapace triangular; body very hairy .... ***Herbstia pubescens***

25(24) Tips of chelae dark; maximum body length 15 mm .... ***Eucinetops lucasi***
-Tips of chelae pale; maximum body length 25 mm **26**

26(25) Merus (arm) of cheliped does not extend beyond tip of rostrum .... ***Microphrys platysoma***
-Merus (arm) of cheliped does extend beyond tip of rostrum **27**

27(26) Dorsal surface of carapace nearly flat; first walking legs about same length as second (fig. 20.40) .... ***Herbstia camptacantha***
-Dorsal surface of carapace inflated; first walking legs much longer than second **28**

28(27) Carapace covered with thick carpet of short brown hair; rostrum bifid only at apex (fig. 20.41) .... ***Libinia mexicana***
-Carapace not as above, only slightly setaceous; rostrum bifid entire length .... ***Microphrys brachialis***

29(20) First walking legs 2–2-1/2 times carapace length **30**
-First walking legs shorter, less than 2 times carapace length **31**

30(29) Propodus of walking legs spinulose (fig. 20.37) .... ***Podochela latimanus***
-Propodus of walking legs not spinulose .... ***Podochela hemphilli***

31(29) Chelae extend beyond tips of first walking legs **32**
-Chelae do not extend beyond tips of first walking legs **33**

32(31) Merus long, extended beyond tip of rostrum; male with 5 free abdominal segments; small, total length 6–11 mm (fig. 20.39) .... ***Epialtoides paradigmus***
-Merus shorter, not extending to tip of rostrum; male with 6 free abdominal segments; larger, total length 10–21 mm (fig. 20.38) .... ***Epialtus minimus***

33(31) Small, length 3–11 mm; walking legs 2–4 subequal .... ***Inachoides laevis***
-Larger, length 18–22 mm; walking legs 1–4 diminishing in length posteriorly .... ***Pyromaia tuberculata mexicana***

34(17) Crab with a distinct rostrum; crab regularly "masks" itself with attached organisms (algae, sponge, bryozoa, hydroids, etc.) (fig. 20.42) .... ***Ala cornuta***
-Without a rostrum, or with a minute, indistinct rostrum; crab may or may not mask itself as above **35**

35(34) Dorsal surface of carapace and legs covered with bright yellow circles, bordered by reddish-brown or orange (fig. 20.45) .... ***Hepatus lineatus***
-Dorsal surface of carapace and legs not colored as above **36**

36(35) Chelae covered with large, oval tubercles **37**
-Chelae not covered with large, oval tubercles **38**

37(36) Carapace highly setaceous; last pair of legs reduced and folded anteriorly on back; crab carries empty pelecypod valve on back; carapace unicolored tan (fig. 20.47) .... ***Hypoconcha lowei***
-Carapace not setaceous; last pair of legs not as above; without pelecypod valve; carapace mottled (fig. 20.24) .... ***Eriphia squamata***

38(36) Dorsal surface of carapace setaceous (setae may be very short, requiring close examination) **39**
-Dorsal surface of carapace not setaceous **45**

39(38) Carapace entirely covered by living ascidian or sponge (fig. 20.46b); fifth leg modified and folded anteriorly on back for holding ascidian or sponge (fig. 20.46a) .... ***Dromidia larraburei***
-Carapace not covered by a living ascidian or sponge (although small bits of sponge and algae may be lodged on the back); fifth legs not as above **40**

40(39) Carapace triangular; minute, bifid rostrum present .... ***Mithrax denticulatus***
-Carapace rectangular, square, or oval; rostrum absent **41**

41(40) Fingers of walking legs with 6 distinct longitudinal rows of dark setae (fig. 20.11) .... ***Sesarma sulcatum***
-Fingers of walking legs not as above **42**

42(41) Fingers of manus white; carapace and legs deeply eroded with patterned vermiculations, giving the crab a spongy appearance; dorsal setae small and inconspicuous (fig. 20.27) .... ***Glyptoxanthus meandricus***
-Fingers of manus black or dark; carapace and legs not as above; dorsal setae conspicuous **43**

43(42) Carapace visible beneath dorsal setae; dorsal surface red to purple 44
-Carapace not visible beneath dorsal setae; dorsal surface tan (fig. 20.31) .... ***Pilumnus limosus***

44(43) Body setae long and stiff; anterolateral margins of carapace with 4 long sharp spines (including outer orbital spine); abdomen mottled with reddish-purple (fig. 20.32) .... ***Pilumnus townsendi***
-Body setae short and soft; anterolateral margins of carapace with 4–5 short, blunt spines (including outer orbital spine); abdomen unicolored (fig. 20.30) .... ***Pilumnus gonzalensis***

45(38) Carapace distinctly triangular; posterior area of carapace with 2 large holes (fig. 20.44) .... ***Speleophorus schmitti***
-Carapace oval or quadrate; carapace without large posterior holes as above 46

46(45) Carapace entirely covered with many coarse granules; eyestalks extremely long; anterolateral margin of carapace forming a single large spine; in burrows on sandy beaches, well above water line (fig. 20.13) .... ***Ocypode occidentalis***
-Carapace not covered with many coarse granules; eyestalks normal; anterolateral margin of carapace forming no spines *or* 2 or more spines; not inhabiting burrows as above 47

47(46) Anterolateral corners of carapace rounded, not forming spines 48
-Anterolateral corners of carapace forming 2 or more blunt or pointed spines 51

48(47) Bright red-orange crabs inhabiting high intertidal zone of sandy beaches; small, maximum carapace width 15 mm (fig. 20.7) .... ***Cyclograpsus escondidensis***
-Color and habitat not as above; larger, carapace width 20–70 mm 49

49(48) Chelae with several longitudinal rows of large denticles; 4th abdominal segment of male with 2 large tubercles .... ***Hepatus kossmanni***
-Chelae without rows of denticles (or with very small denticles); 4th abdominal segment of male without 2 large tubercles 50

50(49) Carapace covered with small pits; small crabs, usually less than 30 mm wide; chelae black (fig. 20.34) .... ***Xanthodius hebes***
-Carapace smooth; large crabs, usually more than 30 mm wide; chelae white to pale (fig. 20.12) .... ***Gecarcinus quadratus***

51(47) Fingers of manus black or dark brown 52
-Fingers of manus white or pale (at least distal third of fingers) 54

52(51) Anterolateral margin of carapace forming 4–5 blunt or pointed spines 53
-Anterolateral margin of carapace forming 1–2 blunt or pointed spines (fig. 20.33) .... ***Trapezia ferruginea***

53(52) Front of carapace, between eyes, forming 2 humped, elevated flanges; anterolateral teeth acute; sides of body very hairy (fig. 20.28) .... ***Leptodius occidentalis***
-Front of carapace, between eyes, forming 2 flat, unelevated flanges; anterolateral teeth flat (except for posteriormost tooth); sides of body lightly pubescent (fig. 20.25) .... ***Eurytium affine***

54(51) Anterolateral margin of carapace forming a single spine, the outer orbital spine; chelae with a small patch of stiff black setae (fig. 20.10) .... ***Aratus pisonii***
-Anterolateral margin of carapace forming 2 or more spines (including outer orbital spine); chelae without a small patch of stiff black setae 55

55(54) Walking legs with long, heavy black setae; upper surface of chelae highly denticulate (fig. 20.3) .... ***Goniopsis pulchra***
-Walking legs without long, black setae; upper surface of chelae generally not highly denticulate 56

56(55) Anterolateral margins of carapace form 3 or more pointed or blunt spines (including outer orbital spine) 57
-Anterolateral margins of carapace form 2 spines (including outer orbital spine) 60

57(56) Width of carapace (in adults), between eyes, much less than 1/2 greatest width of carapace; carapace ovate; outer orbital angle not forming a sharp spine 58
-Width of carapace (in adults), between eyes, more than 1/2 greatest width of carapace; carapace square or rectangular; outer orbital angle forming a sharp spine 59

58(57) Fingers of chelae white on tips only; walking leg 1 shorter than legs 2–3 (fig. 20.29) .... ***Panopeus purpureus***
-Fingers of chelae entirely white; walking leg 1 subequal to legs 2–3 (fig. 20.26) .... ***Eurytium albidigitum***

59(57) Fourth (last) walking leg shorter than preceding legs; carapace rectangular, width greater than length; last (3rd) spine on lateral margin of carapace smaller than previous spines, but not minute (fig. 20.9) .... ***Tetragrapsus jouyi***
-Fourth (last) walking leg as long as, or longer than, preceding legs; carapace nearly square, length subequal to width; last (3rd) spine on lateral margin of carapace minute (fig. 20.8) .... ***Goetice americanus***

60(57) Width of carapace, between eyes, less than 1/2 greatest width of carapace; manus with numerous spines or tubercles **61**
-Width of carapace, between eyes, greater than 1/2 greatest width of carapace; manus without numerous spines or tubercles **62**

61(60) Third pair walking legs longest; manus with several longitudinal rows of small denticles; lateral margins of carapace highly convex; anterior margin of carapace folding down at a sharp angle (90°) between eyes; fingers with broad spooned tips (fig. 20.4) .... ***Grapsus grapsus***
-Second pair walking legs longest; manus with small denticles, but not arranged in rows as above; lateral margins of carapace straight, or nearly so; anterior margin of carapace folding down at slight angle (20° to 40°) between eyes; fingers acute, not spooned (fig. 20.2) .... ***Geograpsus lividus***

62(60) Distal end of merus of last 2 pairs of legs with numerous marginal spines; carapace dark red, occasionally with purple blotches; carapace width 10–17 mm (fig. 20.6) .... ***Pachygrapsus transversus***
-Distal end of merus of last 2 pairs of legs without marginal spines; carapace dark red with green lines and spots; carapace width 25–50 mm (fig. 20.5) .... ***Pachygrapsus crassipes***

63(1) Ischium of external maxillipeds fused with merus to form a single piece, which lies obliquely or transversely **64**
-Ischium not fused with merus, lying longitudinally or slightly obliquely **66**

64(63) Dactylus of first 3 pairs of walking legs bifurcate, with a long outer finger and a short inner finger; carapace subpentagonal; usually commensal on sand dollars .... ***Dissodactylus* spp.**
-Dactylus of first 3 pairs of walking legs not bifurcate; carapace not subpentagonal; never commensal on sand dollars **65**

65(64) Carapace much wider than long; legs diminish in length from first to last (fig. 20.35) .... ***Parapinnixa* spp.**
-Carapace longer than wide; legs not diminishing in length from first to last .... ***Pinnotheres* spp.**

66(63) Third pair of legs longest .... ***Pinnixa* spp.**
-Second pair of legs longest .... ***Tetrias* spp.**

Subtribe Brachygnatha

SUPERFAMILY BRACHYRHYNCHA (grapsoid and cancroid crabs)

FAMILY GRAPSIDAE

Geograpsus lividus (H. Milne-Edwards)

A yellowish-red crab, with lines or patches of darker red or purple on the carapace. The width is about 25 to 35 mm. This species is found on both coasts of America, living among loose stones and rocks in the high tide and splash zones. On the west coast, it ranges from the central Gulf to Chile and the Galápagos Islands, and on the east coast from Florida to Brazil. I have collected it in the central and southern Gulf, living among the roots of mangrove trees at Topolobampo, and on the rocky shores of Cabo San Lucas, Bahía Kino, and Isla Partida. Crane (1947) remarked that this crab was principally a carnivore, and Boone (1927) gave the following excerpt from William Beebe's book, *Galápagos—World's End*, "Everything about them was broad and flat and thin as tissue, and it needed all one's attention to catch one, for they could slip between closed fingers and into the merest crack of a crevice, like magic. When cornered, they gave up all attempt at escape and waved their claws valiantly and even rushed forward to attack a finger." Figure 20.2.

Goniopsis pulchra (Lockington)

This species is the Pacific analog of the only other member of the genus in the western hemisphere, *Goniopsis cruentata*, which lives in the same habitat on the east coast of America. *Goniopsis pulchra* is brown or reddish, with purple variegations, similar to *Geograpsus*, but with slimmer legs and stouter claws. The carapace of adult *G. pulchra* is about 35 to 45 mm wide. This crab is abundant in mangrove swamps, in estuaries (even where the water is quite fresh), and on roots and along tree trunks in damp, humid areas throughout the mid and southern Gulf. It often builds horizontal or

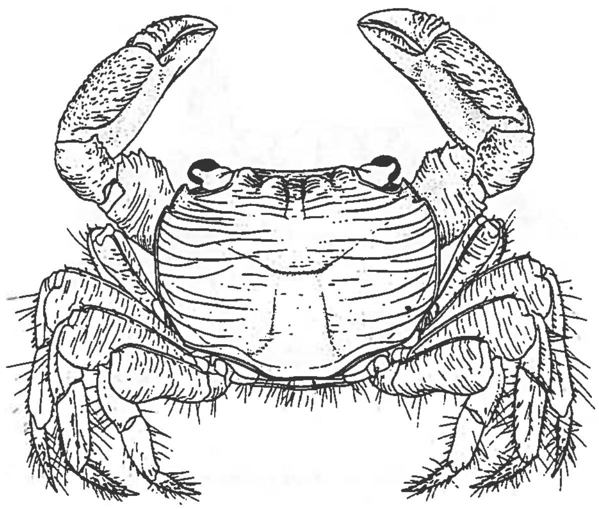

Fig. 20.2 *Geograpsus lividus*

slanted burrows into the mud banks of estuaries or lagoons. It is also occasionally found among the rocks of the high tide zones, usually where the rocks are imbedded in a muddy substrate. *Goniopsis* prefers to remain very near the water, rarely wandering about the rocks as does *Grapsus grapsus*. It ranges from Bahía Magdalena and the mid Gulf to Peru. I have collected it from Bahía Kino south and on most rocky shorelines or mangrove swamps between Santa Rosalia and Cabo San Lucas. Figure 20.3.

Grapsus grapsus (Linnaeus)

The famous Sally Lightfoot crab is one of the most common rocky shore inhabitants of the lower Gulf intertidal, whose abundance is reflected in its scientific name (literally, Crab crab). *Grapsus grapsus* is variegated deep red and pale green, or occasionally solid red. The carapace is usually 40 to 90 mm in width. The fingers are spoonshaped, and the front of the carapace is strongly vertical. Sally Lightfoot is a very agile crab, preferring the continual wave shock of the low splash zone of exposed outer coasts, although it often follows the water line down as the tide recedes. Most of the preferred habitats of this crab occur on rugged, rocky points, often inaccessible by roads. It scampers about the rocks, being knocked into the sea by the waves and climbing quickly back onto the nearest exposed rock. Sally Lightfoot seems to prefer a diet of algae although, like so many animals, it will alter its eating habits in response to changes in the environment. It has been seen feeding at various times on a number of small invertebrate types. Boone (1927) mentioned members of the Galápagos Islands population of *Grapsus grapsus* catching and feeding on the ticks of the iguanid lizards. Crane (1947) stated that these crabs occasionally catch and eat martins, and are preyed upon in turn by nocturnal raccoons, birds, and other predators. In the Gulf it would appear that shorebirds are the principal predators.

In spite of their numbers, these attractive crabs are very difficult to capture. John Steinbeck said of them in *Sea of Cortez*, "They seem to be able to run in any of four directions; but more than this, perhaps because of their rapid reaction time, they appear to read the mind of their hunter. They escape the long-handled net, anticipating from what direction it is coming. If you walk slowly, they move slowly ahead of you in droves. If you hurry, they hurry. When you plunge at them, they seem to disappear in little puffs of blue smoke. . . . It is impossible to creep up on them. Man reacts peculiarly but consistently in his relationship with Sally Lightfoot. His tendency eventually is to scream curses, to hurl himself at them, and to come up foaming with rage and bruised all over his chest."

Had Mr. Steinbeck done his collecting during the dark of the night, he may have had better luck with Ms. Lightfoot, for these crabs occasionally "sleep" on the rocks well above the water line, often becoming so inactive they can be picked up by hand. Dr. J. Hedgpeth has informed me that he has observed Ms. Lightfoot sitting submerged on the bottom of tidepools on warm days (in the Galápagos Islands). Yet their antics prompted Hans Sloane, as long ago as 1725, to christen the Jamaican members of this species "Mardi Gras" crabs *(Natural History of Jamaica)*. One of the most colorful accounts of these acrobats I have read can be found in Boone (1927). A passage from William Beebe's *Galápagos —World's End* is especially apropos: "Lying flat on the gentle slope of a huge cube, twenty feet each way, I watched the waving tentacles of anemones far below me. Suddenly a scarlet curtain swept across the whole face of the rock as an army of crabs skittered into view. . . . These hosts of Sally Lightfoots were the most brilliant spots of color above water in these islands, putting to shame the dull drab hues of the terrestrial organisms and hinting of the glories of colourful animal life beneath the surface of the sea."

Grapsus grapsus is widely distributed in tropical and subtropical America and Africa. On the west coast, it ranges from Isla Cedros and the middle of the Gulf to the Galápagos Islands and Chile. I have found it regularly, in small numbers, from Puerto Libertad south and in abundance at Mazatlán and on all rocky points south of Santa Rosalia in Baja California, including all the southern islands of the Gulf. Knudsen (1968) described the molting behavior of *Grapsus tenuicrustatus*, from the Marshall Islands, demonstrating it to be a land molter with a somewhat unusual technique of leaving its exuvia. Figure 20.4.

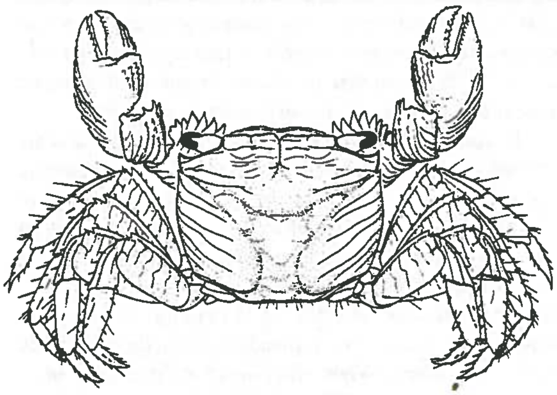

Fig. 20.3 *Goniopsis pulchra*

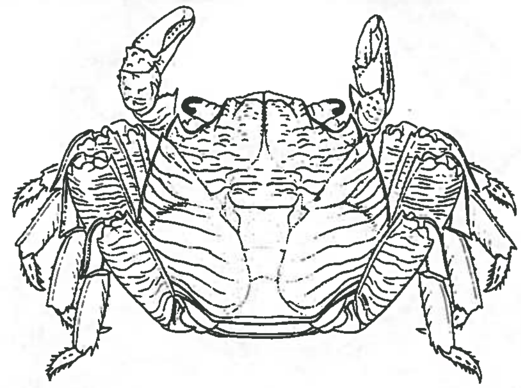

Fig. 20.4 *Grapsus grapsus*

Pachygrapsus crassipes Randall

The "striped shore crab" is one of the most common rocky shore inhabitants of the California and Oregon coasts but is rarely encountered in the Gulf. Dr. John S. Garth considers the records of this crab from Chile and the Galápagos Islands as doubtful, although it does occur in Japan and Korea. This species bears a dark red or reddish-green carapace with transverse green lines. The carapace is about 40 to 75 mm wide and the chelae are strong, marked with deep red and purple veining. Students of the California coast will recognize *Pachygrapsus* as an inhabitant of their high and mid intertidal zones, and in the Gulf I have found it from the splash zone to the lower mid intertidal. Until the summer of 1975 I had collected only one individual of this species in the Gulf, from Guaymas. However, in June of that year I found numerous individuals, including gravid females, from Puerto Lobos to Guaymas. One gravid female from the Guaymas area (Playa Venetia) carried an egg mass that was 9.1 percent of its body weight (wet weight). Dr. T. H. Bullock informs me he has seen crabs of this species on the rocks of Bahía Cholla in past years. I have also collected this crab along the outer coast of Baja at least as far south as Bahía Tortola, and it would appear to be an extremely eurythermal, wide ranging brachyuran. Although this crab, like its congener below, is primarily an herbivore, it has also been recorded as a part-time scavenger. Figure 20.5.

Pachygrapsus transversus (Gibbes)

A small to medium-sized crab, resembling a darker and smaller version of its big brother, *Pachygrapsus crassipes*. Adults average 10–20 mm in width. There are two anterolateral teeth (including the outer orbital tooth) as in *P. crassipes*, and the carapace is transversed by fine furrows or depressions. The sides are more strongly convergent posteriorly than in *P. crassipes*. *Pachygrapsus transversus* is found among stones and the roots of mangrove trees on both coasts of North America, as well as on Oriental shores. It has also been found on coral outcroppings, sandy beaches, and even far out at sea, clinging to floating clumps of *Sargassum* in the North Atlantic. Its range on the west coast of America is from California and the Gulf to Peru and the Galápagos Islands. I have collected it throughout the central and southern Gulf, and at Topolobampo it lives in great numbers in the mud and stones and throughout the mangrove swamps. Crane (1937a) stated these little crabs are preyed upon by the tidepool blennies and gobies. *Pachygrapsus transversus* is primarily herbivorous. Lebour (1944) described the first zoeal stage, this being very similar to that of *Planes*, a genus that is morphologically nearly identical to *Pachygrapsus*. Chace (1951) described some of the biology of *Pachygrapsus marinus*, a species that is very closely related to *P. transversus* but living among the floating seaweeds of the Sargasso Sea. Figure 20.6.

Cyclograpsus escondidensis Rathbun

A small grapsoid crab, at first resembling one of the "cancer crabs" because of its smooth, oval, bright red-orange carapace. The carapace lacks spines (except for the outer orbital spine) and is slightly wider than long, large males averaging 9 by 12 mm. The walking legs have small patches of soft brown hair near the tip (on the inner side of the propodus). The chelipeds of the males are noticeably fatter than those of the females.

This handsome little crab is of particular interest for two reasons, the first being its rarity. It has seldom been reported since its original description by Glassel (1933). I have found it only in the central Gulf region, at Playa Venetia (about 50 km north of Guaymas) and Bahía San

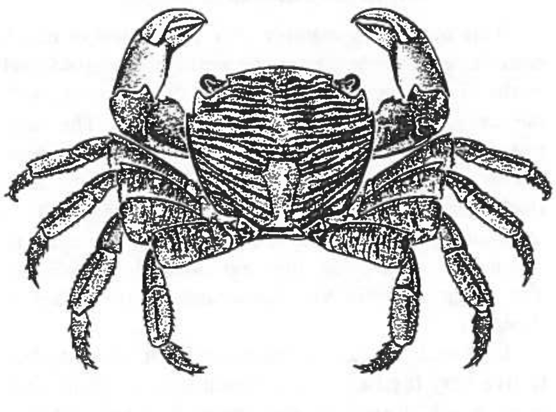

Fig. 20.5 *Pachygrapsus crassipes*

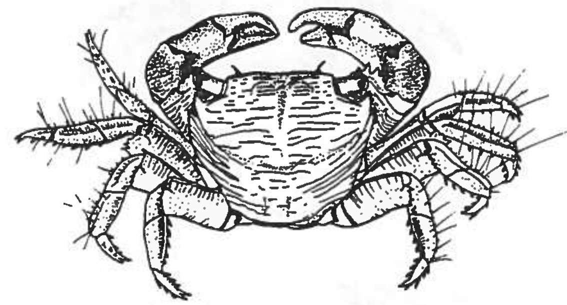

Fig. 20.6 *Pachygrapsus transversus* (after Christiansen, 1969)

Francisco (about 13 km north of Guaymas). It was originally described from Puerto Escondido, just south of Loreto, on the Baja Peninsula. Secondly, it apparently occurs only in the high intertidal region, well above the level where most all other Gulf brachyurans occur. It seems to prefer beaches of small cobble to large-grained sand. *Cyclograpsus escondidensis* is a beach scavenger, sharing its habitat with the large isopod *Ligia*, and I have found these two crustaceans together, sharing meals of dead fish that have been washed ashore. *Cyclograpsus escondidensis* may be a Gulf of California endemic, although its uncommonness suggests it may eventually be discovered in southern Mexico and/or its offshore islands. Figure 20.7.

Goetice americanus Rathbun

A small to medium-sized grapsoid crab, strongly resembling *Hemigrapsus oregonensis* of the Pacific coast of the United States, with which it has been confused a number of times. In fact, *H. oregonensis* does not occur south of Punta Banda (Ensenada) on the outer coast of Baja California. Reports of this latter species from the Gulf of California may be considered as having likely been *Goetice americanus*.

The carapace of *G. americanus* is just barely wider than long, average sized adults ranging from 12 to 20 mm in width. Chelipeds in the male are very heavy and equal, with a large tuft of soft brown hair on the inner side. Chelipeds of females are smaller and equal. There is considerable variation in individuals from any one locality, both in carapace coloring (mottling) and cheliped shape. The carapace has two strong anterolateral teeth (counting the outer orbital tooth) and a single, weak mediolateral tooth.

This crab is known from the central outer coast of Baja (Bahía Tortola or "Turtle Bay") and from the upper and central Gulf of California. It is fairly common on beaches where boulders are embedded in coarse sand. *Goetice americanus*, like numerous other Gulf of California invertebrates, may be considered an "essentially endemic" species, its occurrence outside the Gulf being uncommon or restricted to the warm-water refugia of west Baja's coastal lagoons. Figure 20.8.

Tetragrapsus jouyi (Rathbun)

A small species of crab, abundant throughout the Gulf, although often overlooked, possibly because of its small size and nondescript appearance. The carapace is dark and nearly square, slightly broader than long, with 3 sharp anterolateral spines (including the outer orbital spine). The legs are slender and setaceous. The chelae are equal, but larger in males than in females. Rathbun (1930) stated this species is rare and known from only the type locality of Guaymas. However, I have found *Tetragrapsus jouyi* to be common under stones in bays and other quiet waters from Puerto Peñasco to Mazatlán, Islas Espíritu Santo and San Francisco, and La Paz. At Bahía Kino in 1971, nearly every rock turned over had a handful of these little crabs half-buried in the sand under it. It appears to be more common in the southern Gulf than in the north. Figure 20.9.

Aratus pisonii (Milne-Edwards)

This is a curious little crab, with the sides of the carapace converging strongly posteriorly. Its most distinctive feature is perhaps the long tufts of stiff, black bristles on each cheliped. The carapace is mostly smooth and dark, mottled red-brown-green. The legs are reddish. The carapace is about 20 to 25 mm wide. *Aratus* occurs frequently in mangrove swamps and among rocks in estuaries from the lower Gulf to Panama. Figure 20.10.

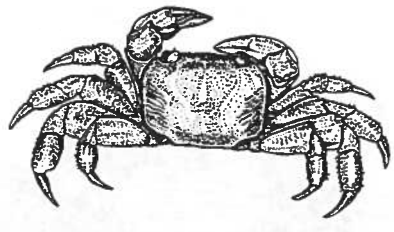

Fig. 20.7 *Cyclograpsus escondidensis* (after Glassell, 1933)

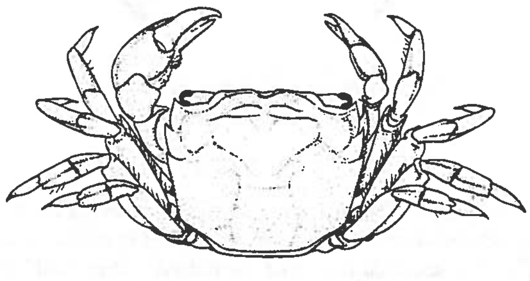

Fig. 20.8 *Goetice americanus*

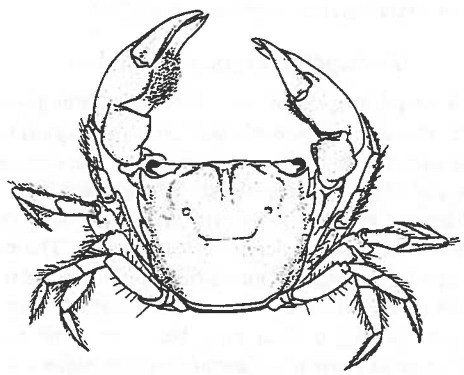

Fig. 20.9 *Tetragrapsus jouyi*

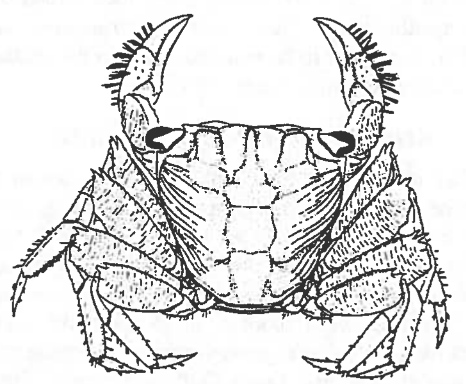

Fig. 20.10 *Aratus pisonii*

Sesarma sulcatum Smith

This is the only member of a large genus of marsh crabs (at least ten species on the west coast) I have found in the Gulf. It is a large crab, 40 to 50 mm wide, with the carapace somewhat grooved and pitted. The carapace and broad, flat legs are very hairy. The anterolateral margins of the carapace form two sharp teeth (including the outer orbital tooth) and occasionally a series of minute teeth behind these. The chelae are oval and heavy in the male, thin and small in the females. The range is Bahía Magdalena and Puerto Lobos to Panama.

Like most species of this genus *S. sulcatum* prefers to live very high up in the littoral region. Crabs such as these, which spend a great deal of their time exposed and out of the water, tend to have greatly reduced gill areas, per unit gram of body weight (e.g. *Ocypode*, *Gecarcinus*, etc.). This is often compensated for by an increased vascularization of the lower region of the carapace, to form a sort of "primitive lung." Figure 20.11.

FAMILY GECARCINIDAE

Gecarcinus quadratus Saussure

One of the smallest members of its genus, this crab inhabits the upper shores of estuaries, mud flats, and mangrove swamps. The carapace is about 45 to 60 mm wide, smooth, with a central depression. The dorsal surface is brown, with a reddish-purple, median blotch. The eyes are on short stalks, near the center of the anterior margin of the carapace. This species ranges from the upper Gulf to Colombia, where it has been reported from both the Pacific and Atlantic oceans. I have collected it at Puerto Peñasco, Guaymas, and Mazatlán. Figure 20.12.

FAMILY OCYPODIDAE
(ghost crabs and fiddler crabs)

Ocypode occidentalis Stimpson

One of the darkest members of a genus that is usually a light sandy color to blend with its background, *Ocypode occidentalis*, the Gulf ghost crab, is still difficult to see on a sandy beach. This crab has slightly unequal chelae, long heavy eyestalks, and little coarse tubercles all over the carapace. When pursued, *Ocypode* runs rapidly across the beach to the soft, dry sand, where it will dive into its burrow to escape capture. Contrary to popular belief, the ghost crabs cannot burrow in the sand faster than a person can dig. They are easy to catch by simply following their burrow down as you dig them up. The size is quite variable, because the same beach may harbor several generations. Usually there are two to three size groups, or generations, on a beach. The larger crabs may reach 150 mm in width. Smaller individuals

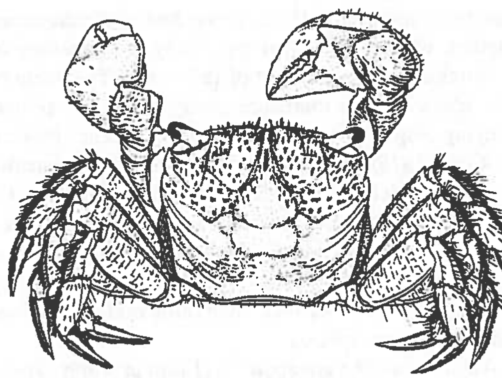

Fig. 20.11 *Sesarma sulcatum*

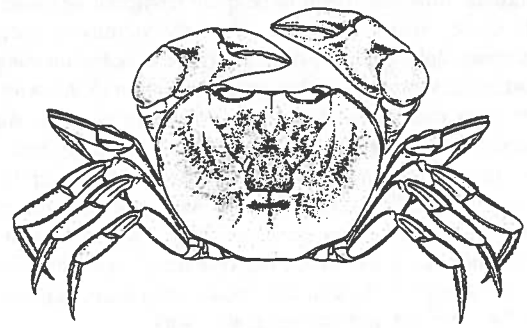

Fig. 20.12 *Gecarcinus quadratus*

seem to fall into 35–45 mm and 15–20 mm categories. Larger individuals tend to live higher up on the beach. Ghost crabs range from the upper Gulf and the west coast of Baja California to Peru. I have found them to be common inhabitants of nearly every stretch of sandy beach in the Gulf, south of Puerto Lobos.

Considerable work has been published on the behavior of ghost crabs, although almost none dealing with *O. occidentalis* itself (see papers by Barrass, Crane, Daumer et al., Fellows, George and Knott, Griffin, Horch, Hughes, Lighter, Little, Rao, and Cowles). *Ocypode occidentalis* is an omnivorous macroscavenger, emerging at sunset to feed along the drift line or swash zone of the sandy beaches upon which it lives. Other species of *Ocypode*, however, are microorganic detritus feeders, like fiddler crabs, or predators. All members of the genus appear to have developed some degree of territoriality and homing behavior. Research suggests that homing behavior is strongest in areas of lower relative densities. Although *O. occidentalis* appears to restrict its activity to nocturnal periods, other species are known to be diurnal or active in both daytime and nighttime periods. Some species appear to be capable of actually shifting their activity periods from nocturnal to diurnal patterns, to compensate for seasonal temperature regimes. Like most species of the related genus *Uca*, many ghost crabs avoid periods of high winds or unusually low air temperatures, preferring to remain secreted in their burrows until more favorable conditions return. M. Crase and B. Wallerstein tell of enjoying the company of these crabs in their coastal Baja camps during the evening meal, when moths fly into the camp lanterns and fall to earth, making easy prey for *O. occidentalis*. Figure 20.13.

Uca brevifrons (Stimpson)

A medium-sized fiddler crab, with short eyestalks and very thin fingers on the large cheliped. Crabs of this species often wander inland several miles in woody areas and have even been found in fresh water. The carapace is about 30 mm wide. *Uca brevifrons* occurs from the southern Gulf to Panama.

Uca crenulata (Lockington)

This is probably the most common fiddler of the Gulf of California. It is a small species, with fairly long eyestalks, and a smooth cheliped that has two rows of small denticles at the base of the fixed finger. The carapace is about 15–20 mm wide and 10–12 mm long. This fiddler (and almost all others) prefers estuaries and sand-mud flats where it burrows well into the high intertidal zone, and, when possible, among vegetation (where surface temperatures are cooler than in exposed areas). *Uca crenulata* occurs on both coasts of America. On the west coast, it ranges from southern California and throughout the Gulf, south to the Mexican state of Jalisco. *U. crenulata* will often be a different color when collected at different times of the day. The reason for this is that *Uca* possesses several types of pigment-bearing cells, or chromatophores, in its body (red, black, etc.), and can vary the presence of each to alter its appearance. This species, and perhaps most species of fiddler crabs, have both a tidal and a diurnal rhythm in their color phases (Bates, 1966). The red and black chromatophores will become more or less concentrated according to the tide level and time of day. The daily dispersion of melanin in *U. pugnax* occurs on a time cycle that allows it to occur about 50 minutes later each day, in other words, following a semidiurnal tide cycle.

Wallace (1967) found that excessive crowding in *U. crenulata* inhibits the normal burrowing behavior at high tide. Straw (1967) reported from a behavioral study of several unidentified species of *Uca* from the northern Gulf that females and young males apparently have no permanent residence. They burrow at high tide but abandon the burrow at low tide to wander about in search of food or mating areas, not returning to their old burrows when the tide waters again return. Male fiddlers, however, seem to be quite territorial and readily chase other males away from the vicinity of their burrows. Johnson and Snook (1955) reported witnessing battles between males that ended in one crab throwing the other over his back a distance of a foot or more. An excellent summary of the fascinating field of claw-waving and sound production behavior is given by Crane (1941, 1975). In her recent monograph (1975) on the fiddler crabs, Jocelyn Crane has presented a summary of what is known on the systematics and behavior of the species of *Uca* in the world, and serious students of the brachyura are referred to this work.

There exists a subspecies of *Uca crenulata* known as *Uca crenulata coloradensis* (Rathbun). Formerly regarded as a full species, it was reduced to the subspecific rank by Crane in 1975. It is distinguished from the nominate subspecies *(U. crenulata crenulata)* by only minor differences. It has been reported from the head of the Gulf as well as the Guaymas region, and is known to occur in certain fresh water wells near the coast. Figure 20.14.

Uca musica Rathbun

Uca musica is a small fiddler crab that resembles *U. crenulata*, but with pink or lavender coloration at the cheliped base (as opposed to the brick red of the latter).

One of the most outstanding structural characteristics of this species is its distinctive, alleged stridulating mechanism. This consists of parallel striations on the manus and a row of tubercles on the first walking legs. The functioning of this device has not yet, however, been documented. An outstanding behavioral feature of *Uca musica* is the predilection of males to construct perfectly symmetrical towers or obelisks near the entrances to their burrows. These consist of packed mud, square or rectangular at the base, and rising 30–40 mm up in a slight, gentle arch to a pointed apex. One's first view of a tidal flat covered with these strange little towers is quite a treat. I shall never forget my first encounter with them. It was on a very still and foggy afternoon in a small estero in northern Sonora. I first saw them upon my approach to a beached and abandoned freighter, whose master had apparently been unaware of the extreme tides in this part of the world. The obelisks stood like a million miniature sentry towers all around the dying ship—a somewhat surrealistic scene. Powers and Cole (1976) have shown that fiddler crab burrow temperatures decrease rapidly with depth (about 0.5°C/cm); the burrows thus provide a significant heat refugium for certain species. They also found that the hooded burrows of *U. virens* (a Gulf of Mexico species) were significantly warmer than nonhooded burrows made by the same species.

Adult *U. musica* are about 7–11 mm in width. There are two subspecies: *U. musica musica* and *U. musica terpsichores*. The former ranges from the upper Gulf and the central west coast of Baja to southern Mexico; the latter from Central America to Peru.

Uca latimanus (Rathbun)

A small species (width, 10–15 mm), with a finely granulate carapace. The large cheliped is short and stout, the fingers being broad and flat and shorter than the palm. The third to sixth segments of the male abdomen are fused, though vestiges of the sutures remain. This species ranges from the upper Gulf to Ecuador. I have collected it only at Puerto Peñasco and Estero Sargento (near Punta Tepopa). Figure 20.15.

Uca galapagensis (Milne-Edwards and Lucas)

A small fiddler crab, with fairly long eyestalks and a tuberculate cheliped. The carapace tapers strongly posteriorly and is about 12 mm wide. This species has been collected in the mud of mangrove swamps in the lower Gulf, where it is often found in large hordes. This is the species reported in the first edition of this handbook as *Uca macrodactylus;* the specific name has been recently suppressed (see Crane, 1975), and older records of that species may belong to a number of different valid species.

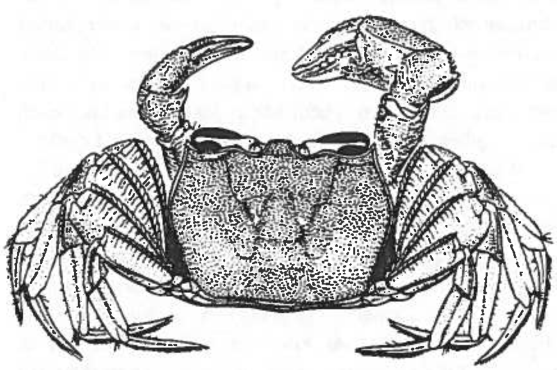

Fig. 20.13 *Ocypode occidentalis*

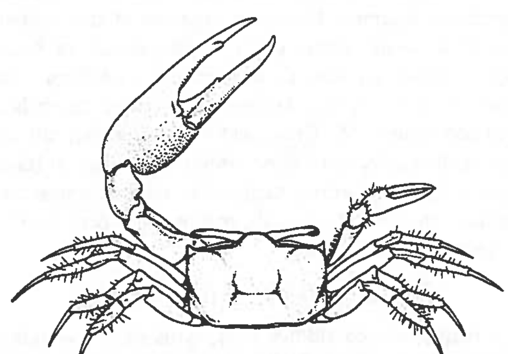

Fig. 20.14 *Uca crenulata*

Uca vocator ecuadoriensis Maccagno

A medium-sized fiddler, 20 to 35 mm wide, with long eyestalks and slightly roughened chelae. This subspecies prefers estuaries, digging holes in the mud, or living under stones. It has been reported to construct chimneys at the burrow opening (Venezuela), but I have not recorded that behavior in the Gulf. *Uca vocator ecuadoriensis* ranges from the lower Gulf to Peru. The nominate form of this species *(Uca vocator vocator)* ranges from central Mexico to Brazil, in the west Atlantic. The eastern Pacific subspecies was previously reported as *Uca mordax* (a western Atlantic species). Figure 20.16.

Uca princeps (Smith)

A large fiddler with long eyestalks and a pale to dark blue or smokey blue carapace, bearing a faint veinlike pattern in the lateral regions. It inhabits salt marshes and estuaries but is occasionally found under rocks in the upper regions of muddy tidal flats. The carapace is usually 30–50 mm wide. Its range is from the upper Gulf of California and the west coast of Baja California to Peru. It has been found to be especially common in the southern Gulf, where I have seen mass emergences of thousands of these crabs from their burrows on mud flats near the small fishing villages of Boca del Río, Yavaros, and others.

Crane (1975) proposed 2 subspecies for *Uca princeps: Uca princeps princeps* and *Uca princeps monilifera*. The latter had been formerly regarded as a full species. The nominate subspecies is distributed throughout the entire range, while the *monilifera* form is said to be restricted to the Gulf region. The two are differentiated on the basis of some rather minor morphological differences, in particular the small tubercles on the chelae, which are said to extend all the way to the fingers in *U.p. princeps* (but are restricted to the base of the manus in *U.p. monilifera*). Figure 20.17.

FAMILY PORTUNIDAE (swimming crabs)

Callinectes arcuatus Ordway

The lateral spines on this species are very long and pointed and the arms of the chelae usually have 3 to 4 long spines on the inside margin. The carapace is very convex and finely granulate, especially in the median region. The width of the carapace on adults is 100 to 170 mm, but young individuals are commonly found whose carapaces are 40 to 80 mm wide. This species is common from southern California and the upper Gulf to Peru. It is often confused with *Callinectes bellicosus* (below). Two morphological features that may be used to tell these two swimmers apart are the long ridge of shallow denticles on the inside of the manus of *C.*

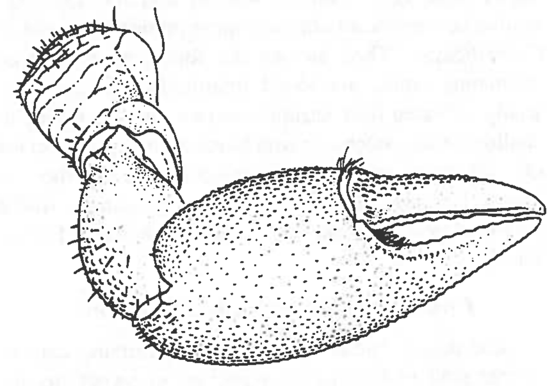

Fig. 20.15 *Uca latimanus*, large cheliped of male

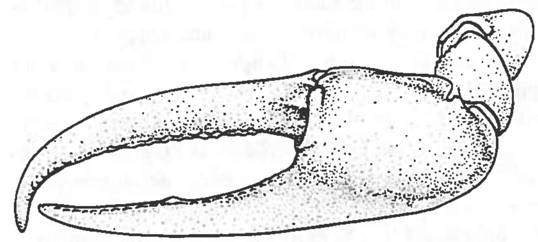

Fig. 20.16 *Uca vocator ecuadoriensis*, large cheliped of male

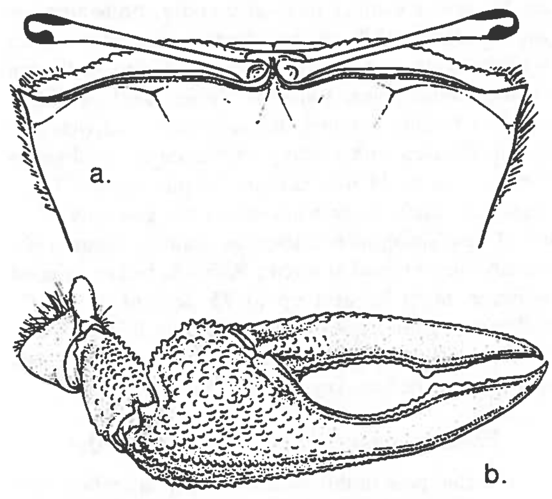

Fig. 20.17 *Uca princeps*.
(a) Anterior of carapace.
(b) Large cheliped of male.

arcuatus, and the length of the carapace spines between the eyes (see key). Also, the walking legs of *C. arcuatus* tend to be a noticeably deeper, more intense blue than in *C. bellicosus*. This, and all the following species of swimming crabs, are found intertidally but are most easily collected from shrimp trawlers, by skin diving in shallow sandy waters, or with beach seines. The species of *Callinectes* in the Gulf are especially common in coastal lagoons, esteros, and mangrove swamps, where they tend to accumulate in the drainage channels. Figure 20.18.

Callinectes bellicosus (Stimpson)

The largest lateral spine of this swimming crab is shorter than in *Callinectes arcuatus*, in respect to the body width. The carapace is evenly convex, and the arm (= merus) of the chelipeds usually has 3 to 4 long spines on the inside margin. This and *C. arcuatus* are very common crabs in the Gulf, frequently found in shallow water over sandy bottoms of bays and lagoons. *C. bellicosus* ranges from San Diego, California, and the upper Gulf as far south as Mazatlán, and possibly farther, and is the most commonly encountered swimming crab of the Gulf intertidal. It commonly buries itself in the sand until only the eyes and antennae are visible, forming incurrent and excurrent water channels to supply the gills. I have found immature individuals, 1 to 3 cm wide, buried as deep as 50 cm on an exposed tidal flat. It is not unusual to find males and females "in copula," where the female (on the bottom) has recently molted and does not yet possess a hard exoskeleton. Copulation at this particular time in the female's life might serve a distinct survival purpose, protecting her from predators while she is especially susceptible. This is a very aggressive species and has been seen feeding on clams, fiddler crabs, and small fishes. Jenkins (1966) reported finding a rather old and sickly individual at Puerto Peñasco with a heavy infestation of small goose barnacles (6 to 18 mm tall) in the gill region. These barnacles appear to be members of the genus *Octolasmis*. I have since found numerous healthy, mature individuals thus infected at Puerto Peñasco; in fact, a good estimate might suggest up to 75 percent of the *C. bellicosus* of this region is infected with this barnacle. Williams (1974) reports a Pleistocene record for this species from the Los Angeles area. Figure 20.19.

Portunus asper (A. Milne-Edwards)

The chelipeds of this swimming crab are robust, and the posterodistal border of the merus of the fifth leg is serrated and has a single spine. This is a large species, the males reaching nearly 100 mm across the carapace. The anterior border of the arm has 4 to 5 spines, the distal spine being well separated from the others. The inner spine of the wrist is well developed. The manus and wrist are elongate, making the cheliped of the males over three times as long as the carapace. The dorsal surface is covered with a very short pubescence. This species is synonymous with *Portunus panamensis*, and ranges from the mid Gulf of California (Canjame, Sonora) to Chile.

Portunus tuberculatus (Stimpson)

A small swimming crab, with the posterodistal border of the merus of the swimming legs without spines or spinules. The carapace is usually 10–30 mm wide, light brown, and marbled with black. The base of the lateral spines is often tinged with red. The posterolateral corner

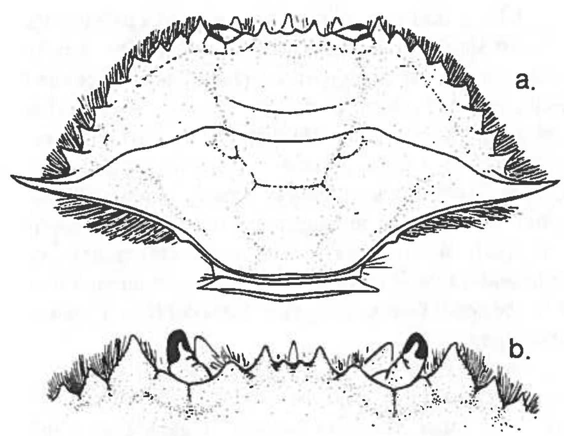

Fig. 20.18 *Callinectes arcuatus*.
(a) Carapace. (b) Anterior region of carapace.

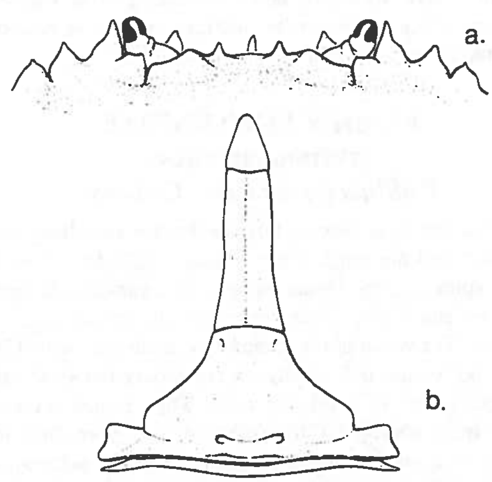

Fig. 20.19 *Callinectes bellicosus*.
(a) Anterior region of carapace.
(b) Abdomen of male.

of the carapace is spinous, and the entire carapace is covered with rows of small, elevated tubercles. The anterior border of the arm has four spines, the distal spine being well separated from the others. The inner and outer spines of the wrist are both well developed. This swimmer ranges from the mid-Gulf to Ecuador and the Galápagos Islands and is largely subtidal.

Portunus xantusii (Stimpson)

This species represents a complex assemblage of three subspecies. Through the examination of over 3,500 specimens, and the statistical methods applied by Stephenson (Stephenson, 1965; Garth and Stephenson, 1966), these workers were able to resolve the complex relationship of what now consists of one species with three subspecies (and over eight synonyms). It is comforting to the practical naturalist to see a group of nearly identical animals competently placed together in what appears to be a natural phylogenetic scheme, as opposed to being split up and given three or four or even five different species names that tend to disguise their natural affinities and confuse students. The three subspecies of *Portunus xantusii* are *P. x. xantusii* (Stimpson), *P. x. minimus* Rathbun (= *P. pichilinquei*), and *P. x. affinis* (Faxon). The posterodistal border of the merus of the swimming legs of this species has spinules but no spines. The inner spine of the wrist is short, and the posterolateral corner of the carapace is rounded. The width of the carapace and length of the last anterolateral tooth are variable and serve as a partial basis for distinguishing the subspecies. The arm has four to six spines on the anterior border, occasionally more in very large specimens. The three subspecies are nearly allopatric, with only a slight overlap in distribution. *P. x. xantusii* is the only one occurring north of Bahía Magdalena on the west coast of Baja California, extending from Santa Barbara, California, to Cabo San Lucas (also reported from Bahías Concepción and Agua Verde in the Gulf); *P. x. minimus* is the common form in the Gulf, ranging from El Golfo de Santa Clara to Cabo San Lucas; and *P. x. affinis* is the southern form, ranging from Cabo San Lucas to Ecuador [reported also from Isla Isabel in the Gulf (Garth, 1960)]. The carapace of *P. x. xantusii* is approximately 8–73 mm wide, that of *P. x. minimus* about 13–43 mm wide, and that of *P. x. affinis* about 11–54 mm wide. Swimming crabs of this species captured north of Cabo San Lucas in the Gulf of California will probably be *P. x. minimus*. Figure 20.20.

Euphylax robustus A. Milne-Edwards

This interesting and distinctive swimming crab has extremely long eyestalks, the eyes placed at or near the anterolateral corners of the carapace. The chelipeds are robust and the carapace is dull, not polished as in most of the swimming crabs. The arms have three well developed spines on the anterior margin, and the wrist has a well developed spine on the inner and outer sides. The carapace is usually 30–60 mm wide, gray with tinges of blue-green, and with only four anterolateral spines, the second from the front being much shorter than the others. This species ranges from El Golfo de Santa Clara, at the head of the Gulf, to Peru. I have collected it in abundance from shrimp trawlers at Puerto Peñasco. Figure 20.21.

Arenaeus mexicanus (Gerstaecker)

The most beautiful swimming crab of the Gulf, and one of the most attractive crabs I have ever seen, this swimmer has the carapace covered with pale red or pink circles having white to pale green centers. The background color is a pale reddish-brown. The coloring is nearly identical to that of the box crab, *Hepatus*

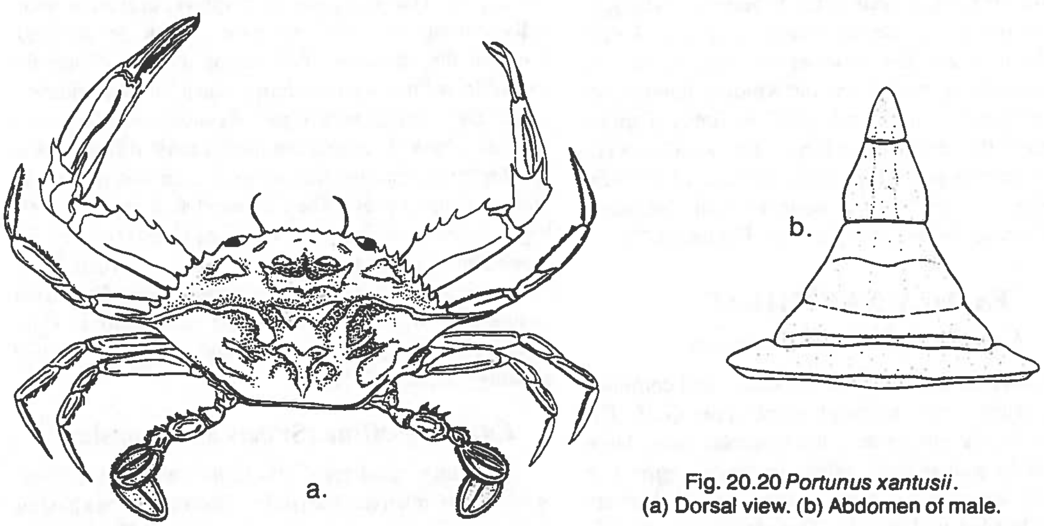

Fig. 20.20 *Portunus xantusii*.
(a) Dorsal view. (b) Abdomen of male.

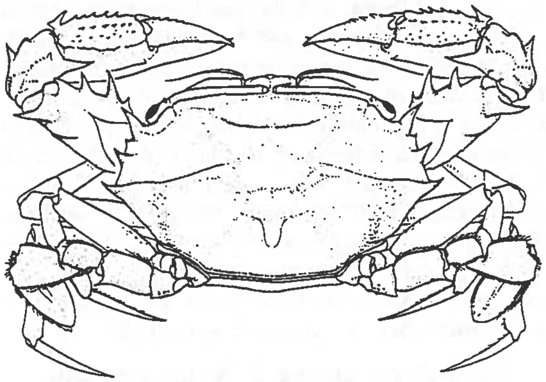

Fig. 20.21 *Euphylax robustus*

lineatus. There are six to eight anterolateral teeth. The chelae are stout, and the wrist has a short outer spine or tubercle. This species ranges from Bahía Magdalena and the mid-Gulf to Peru. I have collected it only at Huatabampito (near Yavaros, Sonora). *Arenaeus mexicanus* seems to prefer living offshore from open, sandy beaches. Figure 20.22.

Cronius ruber (Lamarck)

An attractive swimming crab, with a dark carapace and purplish-red to purplish-blue shading on the back and legs. The swimmerets are rust-colored, and the entire carapace is covered with transverse rows of thick, short setae. The outer surface of the wrist has three strong spines, and the posterior border of the merus of the swimming leg has a very strong spine. The chelae are heavily spined, darkest near the tips, but white on the extreme tip. The carapace is about 15–80 mm wide. The anterolateral spines are alternately large and small, the second, fourth, and sixth being the shorter. This species ranges from the upper Gulf to Chile and the Galápagos Islands. It also occurs on the Atlantic seacoast. I have collected it in several feet of water over sand at low tide in Bahías Cholla, Concepción, and Kino. In February of 1974 I collected a single individual in Bahía Tortola, well north of this crab's usual range. This small bay is a warm water refugium for many species of tropical invertebrates that get carried north of their "regular" distributional range (see introduction). Figure 20.23.

FAMILY XANTHIDAE

Eriphia squamata Stimpson

This is one of the most common crabs, and dominant animals, of the rocky intertidal of the upper Gulf. The chelae are highly tuberculate, the tubercles being large and round to oval-shaped, pilose on the margin. The carapace is dark green or gray, mottled, and the legs are generally banded with black. The carapace is usually 30–55 mm wide. Students familiar with the Californian fauna might at first glance mistake this crab for *Paraxanthias taylori*, common in similar habitats in southern California. *Eriphia squamata* occurs in great numbers in the lower midintertidal zone of rocky shores in the northern Gulf, and less frequently in the southern Gulf. It commonly hides in holes or crevices during the day but emerges at night to forage for food. It has been seen grazing on algae and detritus, as well as attacking smaller crabs and worms. Crane (1947) examined the stomachs of numerous individuals and found they had been feeding primarily on small worms, crustacea, and algae. This hardy crab is also said to be a fairly common inhabitant of mangrove swamps, where its carnivorous tendencies should be most easily seen. I have not, however, recorded it from that habitat.

Eriphia squamata ranges from the upper Gulf to Ecuador and the Galápagos Islands, but I have rarely found it south of Topolobampo and Bahía San Luis Gonzaga in the Gulf. Individuals of this species appear to be quite territorial, defending their territory by claw-waving gestures reminiscent of *Uca*, or by actual attacks. Tidepool gobies commonly occur around *Eriphia* when it is feeding on algae. Apparently the crab dislodges a good deal of detritus and other foodstuffs for the small fish to feed on as they dart in and out between the crab's chelae to snatch food floating in the water near the crab's mouth. The crab appears to be oblivious to the fish. Stomach analyses have revealed that the algae *Valoniopsis pachynema* is one of the most common food items of *Eriphia* in the region of Puerto Peñasco. A study by Beumer (1966) revealed that the upper lethal temperature for this species is about 40° to 44°C, while the lower lethal temperature is about 0°C (population from Puerto Peñasco). Fabbiani (1972) reported the unusual occurrence of this crab from the coast of Venezuela. That *E. squamata* displays, at least periodically, strong territorial behavior cannot be doubted. Even in the aquarium these crabs quickly divide the available habitat up into fairly equal-sized territories, which they defend with vigor. Reynolds and Reynolds (in press) have discussed the interoceanic differences in the degree of coadaptation of species in this genus and their gastropod prey. They contend that the relatively high degree of predator-prey coadaptation in *E. squamata* (and certain species of *Nerita*) would allow these species to quickly out-compete their Caribbean analogs, or siblings, should these taxa become sympatric (e.g., should the sea level Panama Canal become a reality). Figure 20.24.

Eurytium affine (Streets and Kingsley)

A medium-sized crab, 20–40 mm wide, closely resembling its relative, *Eurytium albidigitum*, but having much darker claws and a flatter carapace. The teeth of

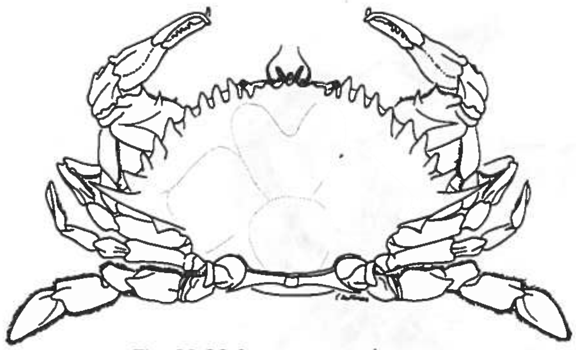

Fig. 20.22 *Arenaeus mexicanus*

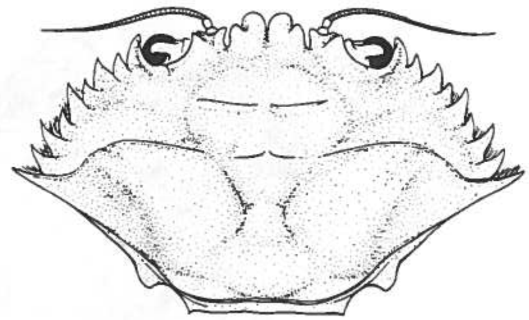

Fig. 20.23 *Cronius ruber*, carapace

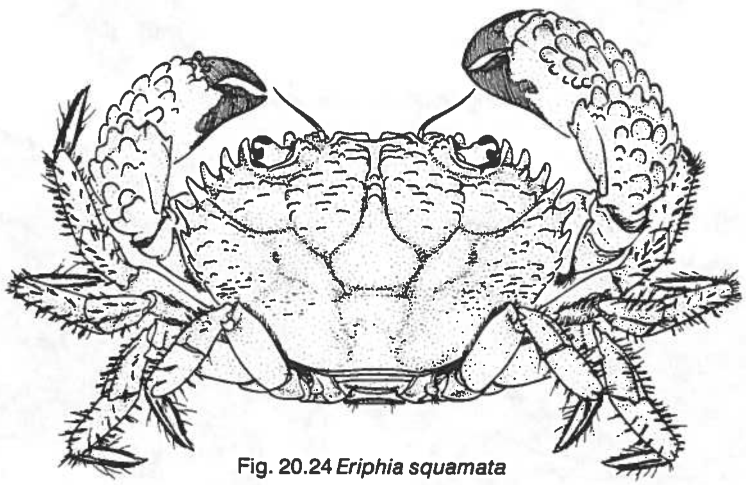

Fig. 20.24 *Eriphia squamata*

the anterolateral margin are flattened anteriorly but become pointed toward the rear. The carapace is a mottled red-blue-green-tan. The chelae are slightly unequal in size. This species is quite common throughout the Gulf intertidal zone, in quite muddy bays, usually under stones. Its range is from the upper Gulf and west coast of Baja California as far south as Manzanillo (possibly to Ecuador), reappearing again in the Galápagos Islands. Figure 20.25.

Eurytium albidigitum Rathbun

A medium to large crab with a mottled blue-gray carapace, usually with white spots. The carapace is nearly 1.5 times as broad as long. This species is common in mud flats and estuaries where it burrows into the mud, or keeps well under the rocks in the high tide zone. *Eurytium albidigitum* is a scavenger and a carnivore. It is carnivorous on small fiddler crabs and is especially common where there is abundant vegetation. It has been found consistently throughout the upper Gulf but is not known to occur below San Felipe and Desemboque sur. Figure 20.26.

Glyptoxanthus meandricus (Lockington)

This easily distinguished crab has the surface of its carapace and legs highly vermiculated with deep furrows, ridges, and pits. It is a small to medium-sized crab, 25–35 mm wide, pale, usually variegated with yellow and carmine. It lives under large stones in the low intertidal, and is common throughout the Gulf, at least as far south as Guaymas and the midriff islands. *Glyptoxanthus meandricus* was synonymized with *G. labyrinthicus* in 1930 by Rathbun, but removed from synonomy in 1939 by Garth. Two young albinos were collected at Puerto Libertad in the summer of 1975. Figure 20.27.

Leptodius occidentalis (Stimpson)

One of the commonest crabs of the upper and lower midintertidal throughout the Gulf. This species has a varicolored carapace, mottled with gray, brown, white, violet, or greenish-red, often with one to three darker patches (usually red) medially. The carapace often turns brilliant red-orange after preservation in alcohol. The palm of the chelae is light, but the fingers are dark

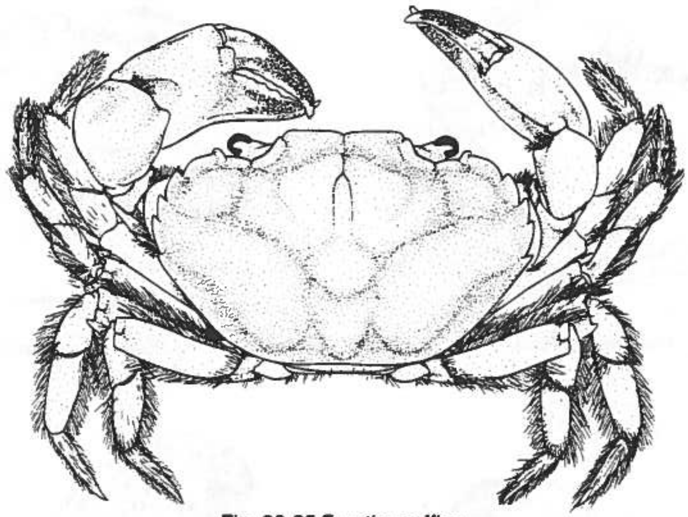

Fig. 20.25 *Eurytium affine*

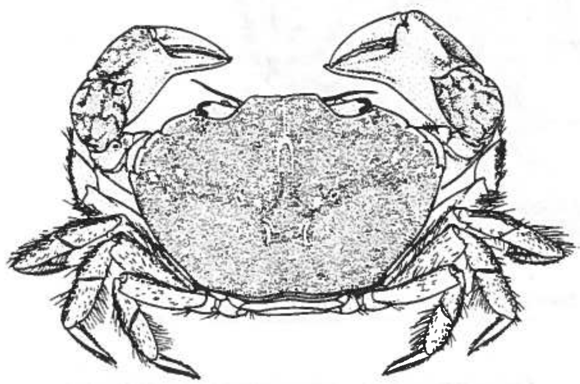

Fig. 20.26 *Eurytium albidigitum*

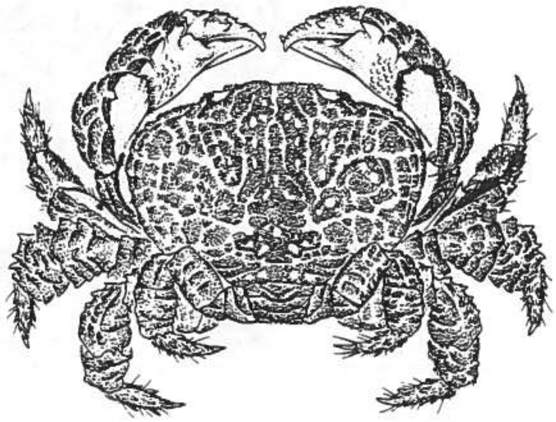

Fig. 20.27 *Glyptoxanthus meandricus*

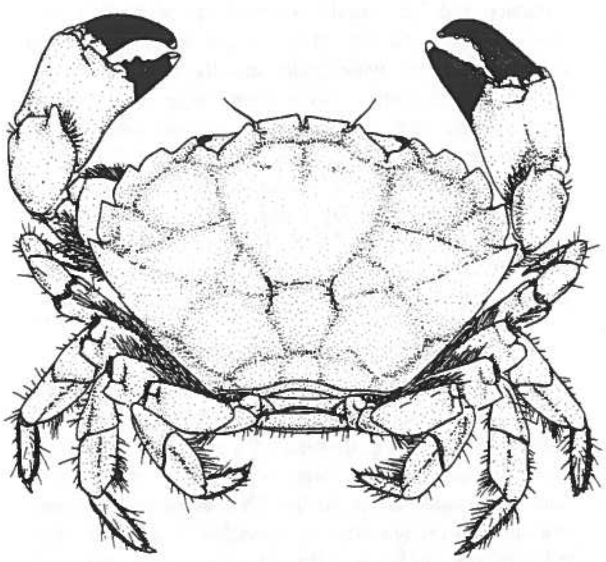

Fig. 20.28 *Leptodius occidentalis*

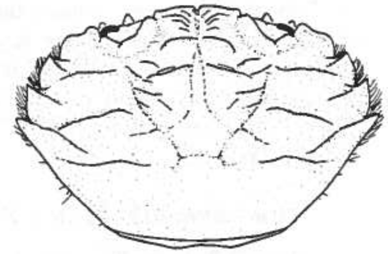

Fig. 20.29 *Panopeus purpureus*, carapace

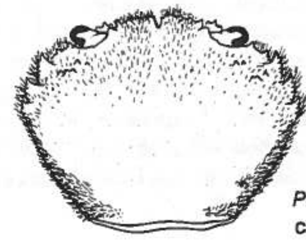

Fig. 20.30
Pilumnus gonzalensis,
carapace

brown to black. There is a distinguishing bilobed flange between the eyes, each lobe being dorsally convex. The sides of the body and the base of the legs are very hairy. The carapace is 25–45 mm wide, but juveniles are often found to be no more than 1 or 2 cm in width. Juveniles of this and several other species of crabs are commonly encountered living in the algal turf of large stones and in the pores of thick sponges like *Geodia*, *Leucetta*, and *Leucosolenia*. This crab is common among rocks and in mangrove swamps throughout the Gulf, south as far as Manzanillo, reappearing again in the Galápagos Islands. Figure 20.28.

Panopeus purpureus Lockington

A medium-sized crab, 20–50 mm wide, closely resembling its cousin *Leptodius occidentalis*. Both of these species, as well as *Eurytium affine* and *Xanthodius hebes*, have the anterior margin of the carapace, between the eyes, more or less extended to form an indented flange or protrusion. There are four fairly strong anterolateral teeth on the mottled red or brown carapace of *Panopeus*. The fingers of the chelae are brown, with white on the tips. This species ranges from the upper Gulf to Peru, preferring much the same habitat as *Eurytium affine*, and is a predator-scavenger. I have often found the two species living together in the lower Gulf. Figure 20.29.

Pilumnus gonzalensis Rathbun

The most common hairy crab of the Gulf intertidal. It has short setae on the dorsal surface, spread thinly so as to leave the reddish-purple carapace visible below. The carapace is flat, 15–20 mm wide, with five anterolateral spines, the first two being quite small. This species ranges throughout the Gulf of California to Tenacatita and may be found at nearly every rocky point in the Gulf. The crabs avoid strong light, spending the daytime hours secreted in holes or crevices among the rocks. They become active during the night and twilight periods, when they emerge to scavenge over the nearby area, or simply to sit in one place and capture food drifting by in the water. *Pilumnus gonzalensis* shows a distinct preference for drainage channels in rocky habitats, where they are exposed to a nearly constant flow of well-oxygenated, detritus-laden water. Figure 20.30.

Pilumnus limosus Smith

The smallest and least common of the hairy crabs of the Gulf intertidal. This species has the carapace completely obscured by the short, thick, setae that form a soft, velvety-tan carpet across the dorsal surface. There are four anterolateral spines. The upper and outer surfaces of both palms are rough and hairy. The carapace is 10–15 mm wide. This species ranges from the upper Gulf to Peru, but I have rarely seen it below Bahía Kino. Figure 20.31.

Pilumnus townsendi Rathbun

The second most common of the three hairy crabs of the Gulf intertidal. This species has a carapace width of 15–35 mm. There are four anterolateral spines on the carapace. Less than half of the outer surface of the palm is smooth. The chelae have numerous stiff black-and-brown setae, and are covered with sharp spines. The carapace setation is of two types, a long stiff type and a shorter softer type. The dorsal setae are not so thick as to obscure the purple carapace below. This species lives under rocks in the lower mid intertidal from the upper Gulf to Bahía Manzanillo. Students of the California seashore might at first mistake this species for the similar appearing *P. spinohirsutus*, whose range is from southern California to lower Baja California, but it has one less anterolateral spine. Figure 20.32.

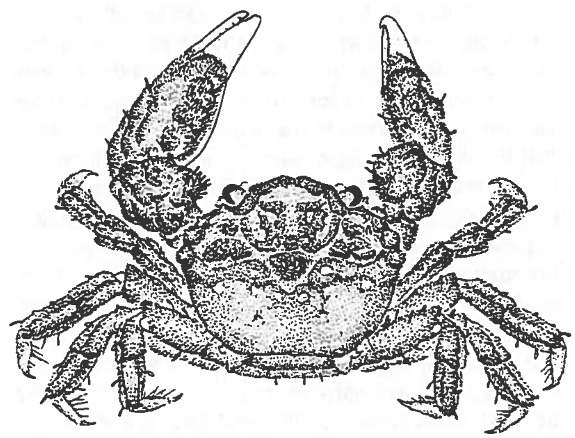

Fig. 20.31 *Pilumnus limosus*

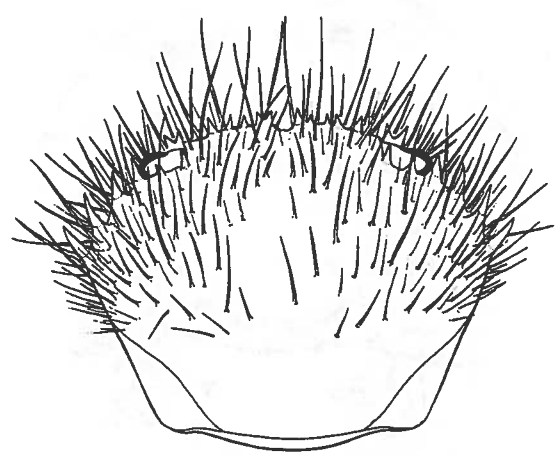

Fig. 20.32 *Pilumnus townsendi*, carapace

Trapezia ferruginea Latreille

All species of *Trapezia* are obligate symbionts of scleractinian corals, and many are known to feed on coral mucus. A total of 23 species are included in Serène's provisional key (1969). *Trapezia ferruginea* is a shiny little red to orange crab, either unicolored or with a few dark patches on the carapace, and with brown to gray fingers on the chelae. As the crab matures, the chelae turn progressively darker, although never becoming black. The chelae are very large for the size of the body. The carapace is only 10 to 20 mm wide. This species is barely included in the Gulf fauna. It ranges from the extreme lower Gulf (Bahía Pulmo) to Colombia and the Galápagos Islands, and also occurs in the Indo-Pacific region and the Red Sea. I have collected it at Cabo San Lucas, Los Frailes, and Bahía Pulmo, where it was a commensal with the coral *Pocillopora elegans* (along with several other species of decopod crustaceans, including the crabs *Mithrax sinensis* and *Daira americana*). Crane (1947) mentioned this species as found commonly in coral heads of *Porcillopora*, often one male and one female in a chamber. Crane also noted that the shrimp *Crangon ventrosus* is often found living in the coral with *Trapezia*, probably mimicking the crab's color. Garth (1974) points out that coral inhabiting crabs (corallicolous crabs) have been known from the tropical east Pacific since the middle of the nineteenth century. Described originally as new species, they have increasingly been found identical with Indo-west Pacific species; in fact, with few exceptions, corallicolous crabs and shrimps are the only trans-Pacific decapod crustaceans. Garth concluded that these decapod coral commensals have succeeded where free-living species have failed because, once found, the coral community provides the habitat to which they are pre-adapted. Castro (1976) gives a good review of coral associated brachyuran crabs. Figure 20.33.

Xanthodes hebes Stimpson

This attractive little crab has an almost perfectly oval carapace, 20–35 mm wide. The color is a dull orange to red, occasionally tinged with green. The carapace has no anterolateral teeth, and the fingers of the chelae are black. Close examination of the carapace and chelipeds will reveal them to be highly punctate. This species ranges from the central Gulf (and Bahía Magdalena on the outer coast of Baja California) to Isla de María Madre (off the Nayarit coast). I have collected it at Puerto Lobos, Guaymas, and on rocky points through the southeastern Gulf. Although this species was synonymized with *X. sternberghi* by Crane, Guinot preferred to leave it as a valid species (even though the two appear to intergrade south of the Gulf). Figure 20.34.

FAMILY PINNOTHERIDAE
(the pea crabs)

Pinnotheres Latreille

The members of this genus of pea crabs are commensal in pelecypods and occasionally gastropods, tunicates, annelids, and sea urchins. The majority of the taxonomy of this genus is based on characters of mature females, the males being much smaller and usually free-living. At least six species are known from the Gulf of California.

Parapinnixa Holmes

This genus is known only from North America, Mexico, and the Galápagos Islands. The single species reported from the Gulf [*P. nitida* (Lockington)] is known only from the original description, the type of which has since been destroyed. Figure 20.35.

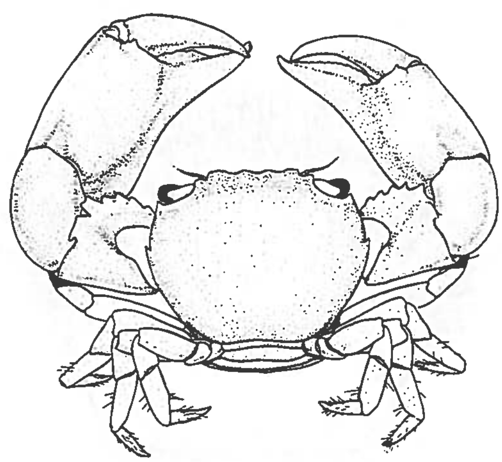

Fig. 20.33 *Trapezia ferruginea*

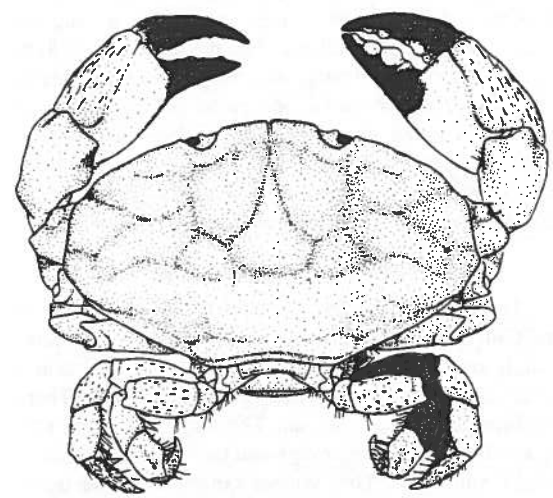

Fig. 20.34 *Xanthodes hebes*

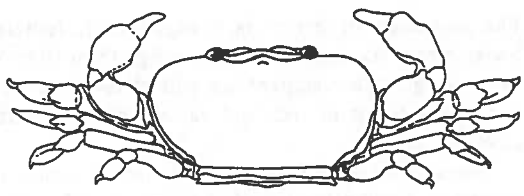

Fig. 20.35 *Parapinnixa* sp.

Pinnixa White

A very large genus of pea crabs, living commensally in mollusc and annelid tubes and burrows, in the cloaca and rectum of holothurians, and freely in mud burrows. Only one or two species have been reported from the Gulf.

Tetrias Rathbun

A small genus of pea crabs known mainly from the Indo-Pacific region, with a few species occurring in the eastern Pacific. Only one or two species have been reported from the Gulf.

Dissodactylus Smith

A small genus of pea crabs with a subpentagonal carapace, minute eyes, and a bifurcate dactylus on the first three pairs of walking legs. This genus is restricted to America. Its members are commonly found clinging to the outside of sand dollars and sea urchins with their bifurcate fingers. The sand dollars *Encope grandis* and *Encope micropora* in the northern Gulf usually have these little commensal crabs clinging to the spines in the lunules and food grooves (*D. nitidus* Smith).

SUPERFAMILY OXYRHYNCHA (spider crabs)
FAMILY MAJIDAE
SUBFAMILY INACHINAE
Stenorhynchus debilis (Smith)

This "arrow crab" has a smooth, triangular carapace, long, thin legs, and a long slender rostrum that is cylindrical and as long as, or longer than, the remainder of the carapace. The rostrum is armed with short pointed spines. This beautiful fragile crab is bright green in life, with the lateral portions of the back and legs covered with yellow streaks and a soft, gray pubescence. The fingers of the chelae are reddish. The width of the carapace is usually 10–15 mm. The body, with its long rostrum and rounded margins, greatly resembles a giant teardrop. This species is mainly subtidal, usually being collected with SCUBA gear or from shrimp trawls, but may occasionally be found intertidally during the lowest minus tides. *Stenorhynchus debilis* ranges from the upper Gulf to Chile and the Galápagos Islands. I have collected it throughout the Gulf, from the low intertidal (associated with *Sargassum*) to depths of 50 m. Barr (1975) discussed the ecology of *S. seticornis*, a west Atlantic species. Figure 20.36.

Inachoides laevis Stimpson

Another very small spider crab, commonly found associated with the *Sargassum* fauna, but also being found on muddy or sandy bottoms (especially where large amounts of shell fragments exist), from the low intertidal to depths of 100 m. The carapace is strongly triangular, extended anteriorly and grading into the rostrum. The first pair of walking legs is considerably longer than the others, while the remaining three pairs are essentially subequal. The carapace is fairly smooth, with only a few scattered tubercles, but hidden beneath a heavy layer of soft, fine hairs. The chelipeds of the male are heavy and globular, giving the first set of legs a rather pendulous appearance upon close inspection. The soft pubescence gives this crab a brown color, usually with a yellow-green hue. Lengths of adults range from 3 to 11 mm. *Inachoides laevis* ranges throughout the Gulf, and from the central outer coast of Baja, south to Ecuador.

Pyromaia tuberculata mexicana Rathbun

A small to medium-sized spider crab (length 18–22 mm) with a strongly triangular, inflated carapace and long, thin walking legs. The chelipeds are fat and larger in the male than the female. The carapace is covered with a fine pubescence as well as numerous denticles of varying size, 3–4 medial ones being larger than the others and being in a line from anterior to posterior. The

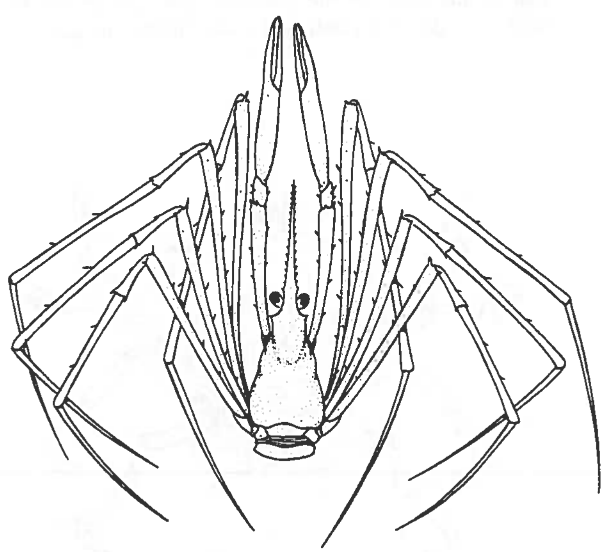

Fig. 20.36 *Stenorhynchus debilis*

rostrum is a single spine of varying length. The walking legs diminish in length from anterior to posterior. *Pyromaia tuberculata* is a wide ranging species, having been reported from central California to Colombia. Garth (1958) separated the species into two distinct subspecies, based on certain morphological characters and their distributions, restricting the subspecies *P. t. mexicana* to the Gulf of California. This is primarily a subtidal species, occurring in depths of 10 to 150 m.

Podochela latimanus (Rathbun)

Another small to medium-sized spider crab with a triangular, elongate carapace. This crab strongly resembles its congener *Podochela hemphilli* but may be distinguished by close examination of the propodus of the first walking legs, which is spinulose in this species but unarmed in *P. hemphilli*. *Podochela latimanus* is a common member of the *Sargassum* fauna throughout the Gulf (while *P. hemphilli* appears not to be) but has also been recorded from other habitats, from shore to depths of just over 61 m. Distribution records indicate this crab is a Gulf of California endemic species. Figure 20.37.

Podochela hemphilli (Lockington)

A small to medium-sized spider crab with extremely long legs. The body is strongly triangular, produced anteriorly, and the rostrum is fairly long. Long hairs cover most of the body and legs, making close examination somewhat difficult. Likewise, strands of algae, bryozoa, and other matter cling to the body. The first walking legs are extremely elongated (2-1/2 times the body length), much longer than the chelae or other walking legs, which decrease in length posteriorly. The eyes are on fairly long stalks and protrude laterally just behind the base of the rostrum. The chelae are robust in males but small and quite slender in females. The abdomen of males is 6-segmented; females 5-segmented. Average sized adults range from 10 to 30 mm in length. The carapace is a pale olive-brown with two lateral bands of red, and various patches of red across the surface.

These crabs have been reported from a variety of substrates, ranging from mud and sand to rocks, from the shore to depths of over 150 m. Unlike *Podochela latimanus*, however, I have not found this spider crab among the fauna generally associated with *Sargassum* in the intertidal region. It ranges from central California and throughout the Gulf south at least as far as Panama.

Eucinetops lucasi Stimpson

A hairy little spider crab found on rocky shores, usually clinging to *Sargassum* or other large algae. *Eucinetops lucasi* is quite small, adults usually averaging around 7–9 mm wide and 10–14 mm long. The carapace bears scattered patches of recurved spines or bristles that serve, as in many other species of spider crabs, to hold camouflaging material on the back. The eyestalks are quite long, as are the rostral horns. There is a large postorbital spine, and the walking legs are gradually shorter from anterior to posterior. *Eucinetops lucasi* has been reported only from the Gulf, from Puerto Peñasco to Cabo San Lucas. I have recovered it among the *Sargassum*-inhabiting fauna of Puerto Peñasco and Guaymas.

SUBFAMILY ACANTHONYCHINAE

Epialtus minimus Lockington

A small majid crab with an elongate, flattened, and bifurcate rostrum in the males, but a shorter, rounded, and more truncate rostrum in females. The carapace is 10–15 mm wide and forms two large anterolateral lobes.

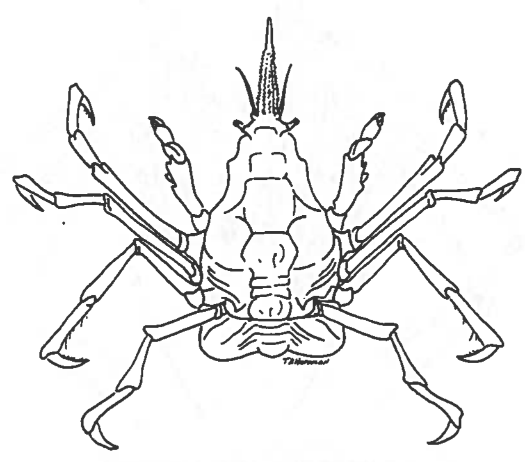

Fig. 20.37 *Podochela latimanus*. Gravid female with distended abdomen.

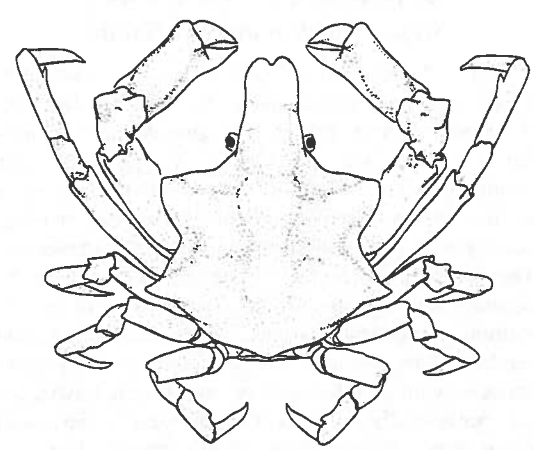

Fig. 20.38 *Epialtus minimus*

The dorsal surface is reddish-yellow, occasionally spotted with brown, with three backward-pointing tubercles in the gastric region. The chelae of the males are massive, the meri grossly enlarged and tuberculate. This species is commonly found clinging to bunches of *Sargassum*, especially where this seaweed forms large beds or mats. It ranges from Laguna Ojo de Liebre (Scammon's Lagoon) and throughout the Gulf, south at least as far as Acapulco. Figure 20.38.

Epialtoides paradigmus Garth

A small majid crab, resembling *Epialtus* but with longer chelae, larger processes on the carapace, and five instead of six free abdominal segments in the males. The rostrum is emarginate, but not highly bifurcate. The dorsal surface is brown to red as in *Epialtus*, but usually differs from the latter in the presence of a large, drab yellow blotch in the mid region. The chelae are massive in the males, but partly obscured by the large anterolateral projections of the carapace. This species ranges throughout the Gulf to somewhere south of Mazatlán. Figure 20.39.

SUBFAMILY PISINAE

Herbstia camptacantha (Stimpson)

This is primarily a subtidal form, occasionally found on rocks or coral heads in the low intertidal, or by diving. The carapace is about 15 to 25 mm wide, triangular-shaped, and covered with short spines. The legs bear many heavy marginal spines, and the chelipeds are long and thin. This spider crab ranges throughout the Gulf, and down the west coast of Mexico at least as far as the state of Oaxaca. I have collected it at Puerto Peñasco, where it is often brought up in the shrimp trawls, and at Playa Venetia (near Guaymas) in 1 m of water on algae-covered rocks. Figure 20.40.

Herbstia pubescens Stimpson

An intriguing little spider crab with a somewhat trigonal carapace. The legs and body are covered with long brown hairs that give this crab the appearance of a seagoing fuzz ball. The rostrum is quite short, and the chelipeds are rather slender and elongate (and bright red-orange in alcohol). The chelipeds and first walking legs are about the same length, and the legs get progressively shorter posteriorly. Adults average 10–20 mm in length. This crab is a common inhabitant of coral heads *(Pocillopora)* to depths of 10 m but has also been found on rocky shores in the low intertidal zone. It ranges from the central Gulf of California at least as far south as Panama.

Libinia mexicana Rathbun

An odd-looking crab with an inflated, oval carapace, and a long tubular rostrum. The carapace is 50 to 65 mm long, bears a short brown pubescence, and has six large dorsal spines in a row down the middle, plus numerous other spines on both sides of this median row. The chelae are white and much longer than the first walking legs, which are in turn longer than the second. This crab is largely endemic to the Gulf. It is common subtidally from El Golfo de Santa Clara to Bahía de San Ignacio in northern Sinaloa and possibly further south. I have collected it at El Golfo and Puerto Peñasco, from shrimp trawlers and with SCUBA gear. *Libinia mexicana* could easily be confused with the similar appearing *L. setosa*, a cognate species, but the former is restricted to the Gulf, while the latter occurs on the west coast of Baja California. Figure 20.41.

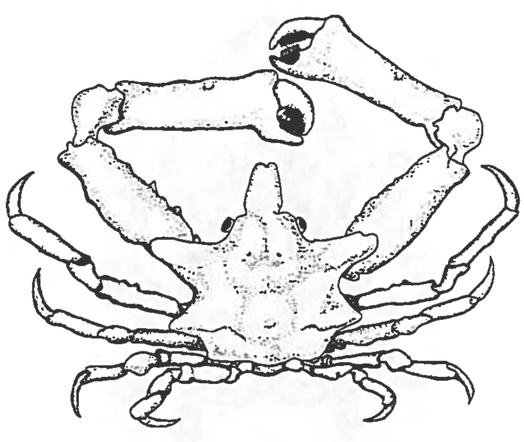

Fig. 20.39 *Epialtoides paradigmus* (after Garth, 1958)

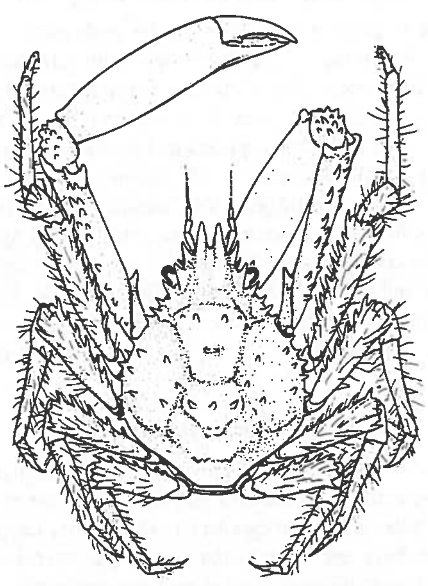

Fig. 20.40 *Herbstia camptacantha*

SUBFAMILY MITHRACINAE

Ala cornuta (Stimpson)

The most commonly encountered Gulf masking crab, and one of the commonest small to medium-sized crabs of the low intertidal, on rocky beaches throughout the Gulf. The carapace is 20–55 mm wide, moderately triangular, and has seven to nine tufts of stiff setae or bristles on the dorsal surface. There are also numerous tufts along the margins of the legs and carapace. The carapace is pale olive, or dull yellow-brown to pale red, often with small dark patches. The dorsal surface is usually covered with small bits of algae and sponge, and occasionally a solitary anemone or some compound ascidian. This material is placed there by the crab, enmeshed in the stiff bristles of the carapace. When *Ala* is kept in an aquarium and deprived of natural material for camouflage, it will substitute with almost anything you give it, including paper, bread, and hamburger! The rostrum is one-fourth to one-fifth the length of the remainder of the carapace. The chelipeds are tuberculate and slender, a little longer than the first pair of walking legs. When the carapace is scraped clean, you can see four to five very large spines along the anterolateral margins. When threatened, *Ala* shows no defense behavior other than increasing the strength of its hold on the substrate. When picked up, the crab remains perfectly still, and with its carapace covered with miscellaneous tidepool organisms it resembles a small overgrown rock or clump of algae. The main food appears to be algae. *Ala* is common throughout the Gulf and ranges as far south as Peru. I have collected it at nearly every rocky point in the Gulf. Figure 20.42.

Stenocionops angusta (Lockington)

This is another species of spider crab only rarely encountered in the intertidal, but occurring subtidally to at least 30 fathoms. The body is strongly inflated, triangular, and about 20–40 mm wide. Garth (1958) reported all the collections of this species he has seen from sand, shell, or coralline bottoms. The chelae are long and slender, with black fingers. The carapace is similar to *Herbstia* in being covered with numerous short spines set on elevated regions. This species occurs throughout the Gulf and on the west coast of Baja California. I have collected it subtidally and among rocks, in a meter or so of water during minus tides, at Puerto Peñasco. Figure 20.43.

Mithrax denticulatus Bell

A lovely little spider crab with a broad, subtriangular carapace, at first resembling a grapsoid crab more than a typical spider crab. The carapace is about 1-1/2 times as broad as long and bears numerous large anterolateral spines. The rostrum is very short, inconspicuous, and bifid. The chelipeds are only slightly longer than the

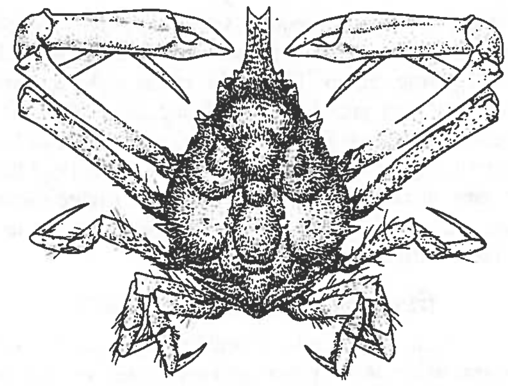

Fig. 20.41 *Libinia mexicana*

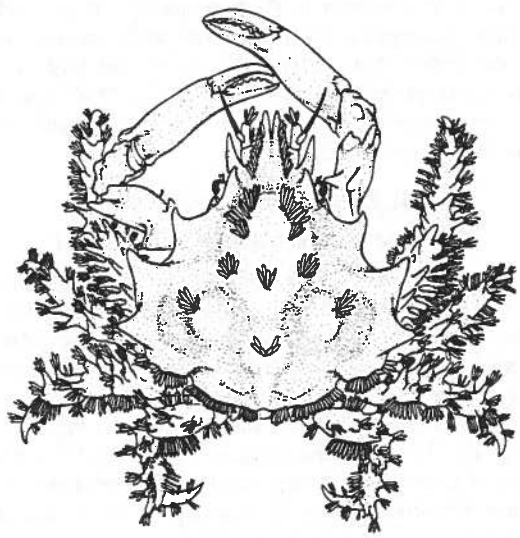

Fig. 20.42 *Ala cornuta*

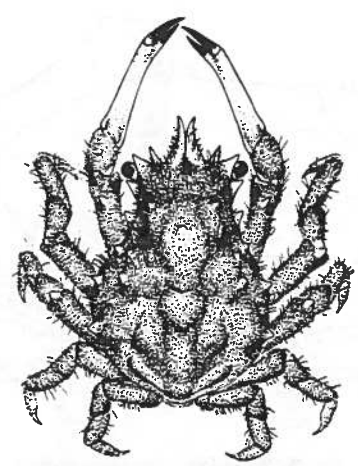

Fig. 20.43 *Stenocionops angusta*

first walking legs; the legs decreasing in length posteriorly. There are 5 anterolateral spines, the second and third being blunt, the first (outer orbital), fourth, and fifth being acute. The carapace and chelipeds are mottled brown and olive green. Although the legs are quite hairy, the carapace itself is relatively naked, but bears numerous deep grooves and depressions. Adults range from 5 to 15 mm in length. This species is largely intertidal, on rocky shores, although it may commonly be found in shallow subtidal depths by SCUBA divers. It ranges from the central Gulf of California to Ecuador. One of the best collecting techniques for taking these small spider crabs, and other small crustaceans, is by rinsing large rocks in fresh water or a dilute formalin solution (2–3 percent) for a few minutes. Most of the mobile inhabitants are stimulated to abandon the rock and may be later retrieved from the rinse solution. One VERY IMPORTANT procedure to remember when using this technique is to return the rinsed rocks to standing water, preferably the surf zone, so that the animals and plants left on the rock do not suffer undue hardships while awaiting the returning tide waters.

Thoe sulcata sulcata Stimpson

A small, yellowish-brown majid crab, with reddish chelae and a triagonal carapace. The walking legs are somewhat flattened and bear lateral rows of "fringe hair" on either side. The chelae are stout, but thin fingered. The legs decrease in length posteriorly, the fourth walking legs being quite short. The carapace is without obvious setation, although it is strongly marked with various pits and depressions. Adults average 5–17 mm in length. *Thoe sulcata* is primarily an intertidal species, although it is not uncommonly found associated with coral in shallow subtidal depths (to about 5 m). The nominate subspecies *T. sulcata sulcata* ranges from the central Gulf to southern Mexico, while the more southerly subspecies (*T. sulcata panamensis* Nobili) ranges from northern Central America to Ecuador.

Microphrys platysoma (Stimpson)

A small majid crab, never over 20 mm in length. The carapace is distinctly triangular in shape, with a short, robust, bifid rostrum. The carapace is strongly tuberculate and spinose, with 3 anterolateral spines, plus an additional 2 spines between the eye and the rostrum. The chelipeds are longer than the first walking legs, the latter diminishing in length posteriorly. These crabs are good maskers, attaching growths of bryozoans, hydroids, or algae (especially coralline algae) to their backs and legs, making them nearly impossible to spot in their natural habitat. The chelipeds are quite distinctive, however, being creamy white mottled with red, and with a distinct band of red across the base of the fingers. *Microphrys platysoma* lives in tidepools and under stones in the lower intertidal zone and on sand-rock bottoms and in coral heads subtidally to depths of 75 m. This species ranges from the upper Gulf to Panama and offshore islands of the tropical east Pacific, including the Galápagos.

Microphrys brachialis Rathbun

Another small to medium-sized *Microphrys* with a strongly triangular carapace which is formed into 4 distinct, swollen, dorsal inflations (and covered with numerous tubercles and short spines). As in the other species of *Microphrys* the rostrum is bifid and there are two strong spines between it and the eye (one being the inner orbital spine). *Microphrys brachialis*, however, is a larger, more robust crab than *M. platysoma*, with a longer rostrum and chelipeds. It also lacks the 3 strong anterolateral spines of *M. platysoma*. The first walking legs extend only to the base of the manus of the long cheliped. The walking legs progressively decrease in length posteriorly. Chelipeds of males are about 1-1/3 times the carapace length; those of females are about the same length, or shorter, than the carapace. Average sized adults are 15–23 mm in length. In contrast to *M. platysoma* this species rarely occurs intertidally, being most common in 30–300 fathoms of water, on rocks, mud, and sand, particularly where there is some algal growth. This is a common species in shrimp hauls, picked up by the otter trawls of Mexican shrimp boats. It ranges from the central Gulf and Bahía Magdalena to Ecuador. I have collected it intertidally only once, at Puerto Libertad.

SUBFAMILY OPHTHALMIINAE

Pitho picteti (Saussure)

A small spider crab with an oval, strongly spinose carapace. There are 6 strong anterolateral spines and scattered body setae. The cheliped is scarcely longer than the first walking leg and the rostrum is short and notched. The abdomen (of males) is composed of 7 segments. Walking legs decrease just slightly in length posteriorly. The general color is whitish with a few pale brown patches. The chelae are mottled dark yellow-green and white, the fingers fading to tan distally. Adults are 6–22 mm in length.

This handsome crab is a common inhabitant of the *Sargassum* community throughout the Gulf, although it has also been reported from other habitats. It occurs from the low intertidal zone to depths of over 61 m, and ranges from the lower outer coast of Baja, and the upper Gulf, at least to Panama. Like so many of the smaller crustaceans (indeed, the invertebrates in general) their true beauty can scarcely be appreciated without examination under a dissecting microscope or good hand lens, and the true lover of sea life should by all means not neglect this observational technique.

Subtribe Oxystomata (oxystomatous crabs)

FAMILY LEUCOSIIDAE

Speloeophorus schmitti Glassell

Members of this unusual genus have large orifices in the posterior region of the carapace. Two species are common in the Gulf. *Speloeophorus schmitti* has two large holes, invisible from the dorsal view, and a triangular carapace that is much broader than long, the width being about 30–40 mm. This crab is found throughout the Gulf of California subtidally and in the low intertidal. I have collected it at San Felipe, Puerto Peñasco, and Puerto Libertad. Figure 20.44.

Speloeophorus digueti (Bouvier)

This species has four large posterior orifices, two that are visible from the dorsal view and two that are hidden. The carapace is roughly pentagonal, 5–20 mm wide, and longer than broad. This crab probably does not occur intertidally. Its range is given as the Gulf of California and the west coast of Baja California to Panama. I have not collected this species.

FAMILY CALAPPIDAE

Hepatus lineatus Rathbun

This is certainly one of the most beautiful crabs of the Gulf. It has a narrow, high carapace, strongly arched, with the height equal to about one-third the width. The dorsal surface is 20–80 mm wide, covered with yellow to orange spots, and encircled by reddish-purple lines. These crabs occasionally decorate their already attractive carapace with sea anemones of the family Sagartiidae. This crab is found in the low intertidal and subtidal, often buried under a few centimeters of sand. At certain times of the year, it is possibly the most commonly encountered brachyuran in the shrimp trawls of the northern Gulf. Its range is from the upper Gulf and the west coast of Baja California to La Paz and possibly farther south. I have collected it throughout the northern Gulf and in Bahía Magdalena, in sandy bays at low tide and from shrimp trawls. Figure 20.45.

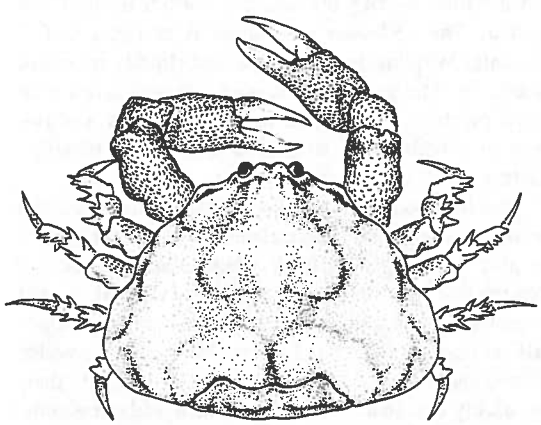

Fig. 20.44 *Speloeophorus schmitti*

Hepatus kossmanni Neumann

This species has the carapace covered with narrow stripes of dull red, making it nearly as attractive as *Hepatus lineatus*. However, this species loses most of its color in preservation, whereas *H. lineatus*, for some reason, retains most of its color. There are two large tubercles on the fourth abdominal segment of the male. The carapace is usually 60–70 mm wide. The species occurs in the low intertidal and subtidal, from the upper Gulf to Ecuador. I have collected it only at El Golfo de Santa Clara.

Subtribe Dromiacea (sponge crabs)

SUPERFAMILY DROMIOIDEA

FAMILY DROMIIDAE

Dromidia larraburei Rathbun

Members of this genus usually carry a sponge, a compound ascidian, or occasionally a sea anemone on their backs for concealment. The fifth legs are reduced and highly modified for this purpose, being folded anteriorly on the back. This is a medium-sized crab, 20–45 mm wide, with numerous small, ball-shaped tubercles

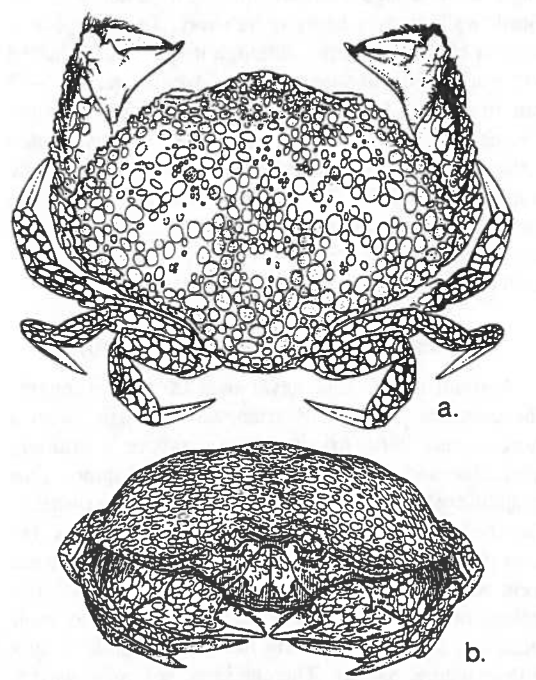

Fig. 20.45 *Hepatus lineatus*.
(a) Dorsal view. (b) Anterior view.

on the upper surface of the palm. The carapace is tan and highly pilose. *D. larraburei* ranges from Monterey, California, to Peru and the Galápagos Islands. I have collected specimens subtidally and in the lowest intertidal at Puertecitos (with a large, living sponge on the back), and Puerto Peñasco (carrying various species of compound ascidian). These are fascinating crabs to keep in the aquarium. When they are deprived of their natural camouflage they will utilize nearly anything of the correct size, from pieces of algal fronds they cut up, to pieces of newspaper. Figure 20.46.

Hypoconcha lowei Rathbun

A very hairy crab, 30–60 mm wide, that carries an empty pelecypod shell on its back by the use of its modified last pair of legs. The chelae are covered with numerous large, white, oval denticles. It is common in the Gulf, often brought up in the otter trawls of shrimp fishermen, but also encountered in the low intertidal, especially when SCUBA diving. Its range is from the upper Gulf to Ecuador. I have collected it in abundance throughout the upper Gulf, from shore to 80 m. Figure 20.47.

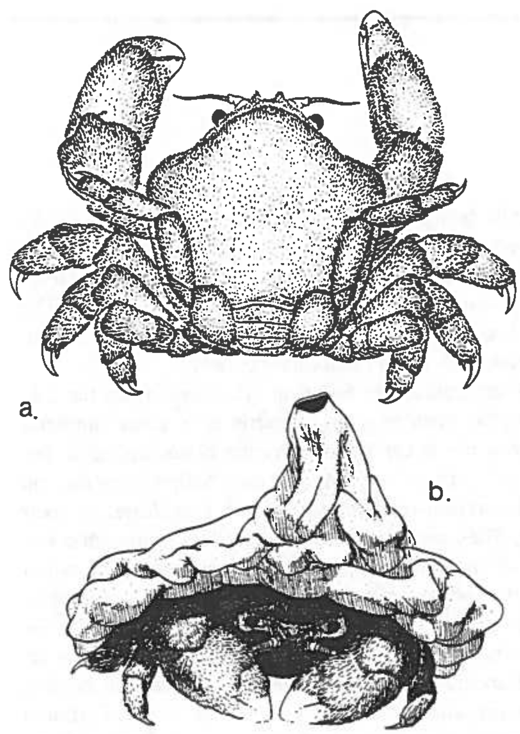

Fig. 20.46 *Dromidia larraburei*.
(a) Dorsal view, with sponge removed.
(b) Anterior view, with sponge in place.

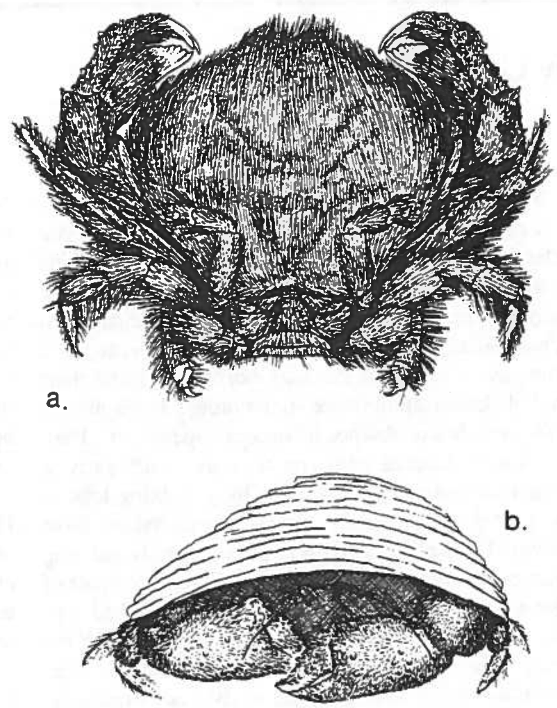

Fig. 20.47 *Hypoconcha lowei*.
(a) Dorsal view with shell removed.
(b) Anterior view, with shell in place.

21

ARTHROPODA: PYCNOGONIDA (Sea Spiders)

by C. Allan Child*

Preservation: See general Crustacea section.

Taxonomy: The Pycnogonida, or "sea spiders" are a class of arthropods only distantly related to arachnids on the one side and to Crustacea on the other. They are distinct from both in lacking biramous appendages, a cephalothorax, and a prominent abdomen. Pycnogonid taxonomy is based on external morphology, and their familial classification (there are no orders) relies mainly on the presence or absence of various appendages. They have a very reduced body, no separate mouth parts, a chitinous exoskeleton, and eight long walking legs (a few species have ten and two Antarctic species have twelve). The walking legs carry the sex glands and long diverticula of the gut. Besides the legs, there is a pair of shorter egg-carrying legs beneath the body called ovigers, to which the male cements eggs received from the female. The reduced body consists of a cephalic segment plus three (sometimes four or five) additional segments. The posterior segment bears a small tuberclelike abdomen having no known function other than to carry the anus at its tip. The cephalic segment bears the nonsegmented proboscis which is sometimes quite large in relation to the body, and from two to four pairs of appendages. The first are the chelifores, which may be chelate as in *Nymphon*, or missing altogether as in *Pycnogonum*, and are situated above the proboscis. The second pair is the palpi, carried laterally to the proboscis. These are missing in some genera. The third pair is the ovigers, from which are derived several diagnostic characters and which may be missing or reduced in females of several genera. A dorsal eye tubercle is also situated on the cephalic segment and bears four simple eyes. The first pair of legs is also attached to the cephalic segment with another pair attached to each subsequent body segment. The legs are composed of eight articles: three coxae, a femur, two tibiae, and a tarsus and propodus making up the "ankle and foot." The propodus carries a claw at the tip which may or may not be flanked by a pair of auxiliary claws.

Pycnogonids are found in all oceans from the tide line to the deep trenches, sometimes in great numbers, but they are not often seen by the casual collector because they are usually tiny and their bodies often take on the coloration of their habitat and sometimes of their food. They are mainly bottom dwellers, although a few are bathypelagic, and they feed by sucking the juices out of soft bodied animals such as bryozoans, hydroids, coelenterates, and tunicates. The male usually carries newly hatched larvae around with him, but the larvae of some species have been found as parasites in bivalve molluscs and hydroids. The life history of almost all species is unknown. The eggs and young of one whole family have never been found (or at least never identified).

Sea spiders are most readily collected by the following methods. Algal substrate with its associated hydroid and bryozoan colonies can be washed at the shore in a bucket of dilute formalin, or the algae can be picked up in mats or scraped from rocks and examined under a low power microscope in the laboratory. One of the best sources for specimens is in scrapings from submerged rocks, pilings, or boat bottoms that have been in the water for a long time. Almost all littoral pycnogonids are tiny or at least small enough to require the use of a dissecting microscope for identification. A specialist is often the only one who can differentiate between species, but the generic data presented below should provide enough information for collectors to identify the few known Gulf forms.

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Pycnogonids of the Gulf: There has been only one paper written dealing with the pycnogonid fauna of the Gulf of California, and the few that have been written concerning the west coast of Central America mainly describe the deeper water forms. The pycnogonids of northwest Mexico and the Gulf represent an extension of some of the better known California fauna, with one or two exceptions. Hilton (1942) lists six species from the Gulf and outer Baja California; Stock (1955) lists four species, primarily from Panama; and an occasional specimen will be listed for Central America in papers on California and Pacific pycnogonids. Too little is known about Gulf pycnogonids to conjecture about membership in faunal provinces, but at least one, *Tanystylum intermedium*, crosses several faunal zones in its distribution. A forthcoming paper by the author of this chapter lists only one new species for the Gulf of California and only a few new range extensions for California species. Intensive collecting for benthic microfauna along these vast and beautiful, but difficult to reach, shores will probably double the number of pycnogonid records for the Gulf and perhaps add more new species to the list of Gulf pycnogonids.

KEY TO THE COMMON PYCNOGONID GENERA

1	Chelifores or palps (or both) present	2
	-Chelifores and palps absent; stout body and short legs; ovigers small only in male (fig. 21.6)	***Pycnogonum***
2(1)	Palps present; ovigers in both sexes	3
	-Palps absent; ovigers only in male (fig. 21.3)	***Anoplodactylus***
3(2)	Chelifores with functional fingers; palps of 5 or less articles	4
	-Fingers of chelifores atrophied or missing in adults; palps of 6 or more articles	5
4(3)	Male palps of 4 articles, female palps absent; ovigers without terminal claw; foot without auxiliary claws; occur subtidally (fig. 21.2)	***Anoropallene***
	-Palps of 5 articles in both sexes; ovigers with serrate terminal claw; foot with large auxiliary claws (fig. 21.1)	***Nymphon***
5(3)	Chelifores long, without functional fingers; palps of 9 articles	6
	-Chelifores reduced to 2-segmented knobs, much shorter than proboscis; palps of 7 articles; body disc-shaped, stout (fig. 21.5)	***Tanystylum***
6(5)	Legs very spinose, without tall tubercles; ovigers of 9 articles (fig. 21.4)	***Ammothella***
	-Legs and midline of body with tall tubercles bearing setae; ovigers of 10 articles	***Nymphopsis***

FAMILY NYMPHONIDAE

Nymphon Fabricius

The family Nymphonidae is composed of 6 genera, including both 10- and 12-legged forms, but all genera except *Nymphon* are represented by only a few to a single species. Indeed, the genus *Nymphon* is the largest among the pycnogonids, with over 120 known species. The genus is characterized by well developed chelae fingers, usually with many teethlike spines, which persist in the adult and overhang in front of the proboscis. The ovigers are also well developed in adults, composed of 10 articles and a terminal claw. They are carried by both sexes. Clearly, in a genus of this size, the species of *Nymphon* are often quite closely related and in most the differences are so minute as to demand critical examination of dissected parts under a compound microscope. The 4 terminal articles of the oviger are curved into the shape of a shepherd's crook. These articles are armed within with featherlike spines, and the crook is used by this genus and several others as a Greek strigilis, or body scraper, to clean their long thin legs and other appendages of accumulated debris. The use of the single serrate claw at the end of the strigilis remains unknown.

The *Nymphon* body is usually long, segmented, and thin enough to appear as though composed of coalesced leg roots instead of a functional trunk. The 2 terminal articles of each leg, called the tarsus and propodus, also serve as characters for taxonomic differentiation. The genus has been separated into 2 groups by several authors, based on the presence or absence of propodal auxiliary claws. This character is not sufficient in itself to separate the huge group into two genera. The propodus is usually a fairly straight article in *Nymphon*, without a heel, and like all pycnogonids, it bears at least one terminal claw. The terminal claw may be flanked by the two auxiliary claws which are shorter than the main claw and have no known function.

There is possibly only one species to be found in the shallow waters of the Gulf. This is a new species from Puerto Peñasco, to be described shortly. The only other species known from the Gulf, *Nymphon pixellae* Scott, has been found only in waters deeper than 18 meters. It has a tarsus much longer than the propodus, whereas the new species of *Nymphon* has a tarsus shorter than the propodus. Figure 21.1.

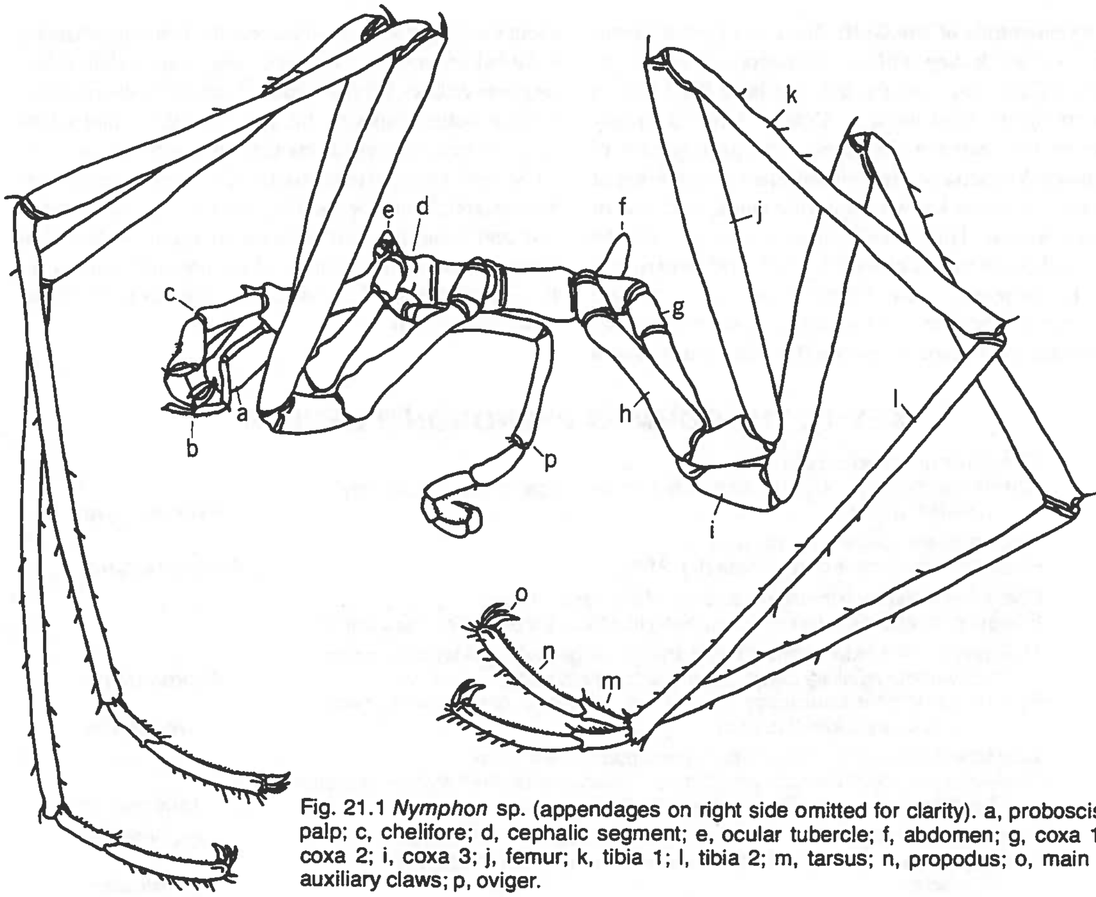

Fig. 21.1 *Nymphon* sp. (appendages on right side omitted for clarity). a, proboscis; b, palp; c, chelifore; d, cephalic segment; e, ocular tubercle; f, abdomen; g, coxa 1; h, coxa 2; i, coxa 3; j, femur; k, tibia 1; l, tibia 2; m, tarsus; n, propodus; o, main and auxiliary claws; p, oviger.

FAMILY CALLIPALLENIDAE
Anoropallene Stock

The family Callipallenidae, unlike the Nymphonidae, contains a wealth of genera. Twenty genera are currently recognized, 17 of which have less than 10 species each, with the remaining 3 containing the majority of the 156 species in the family. The family is in a state of chaos and in need of revision. Some species are probably not valid and perhaps even one or more genera will fall when more specimens are available for a thorough comparison to be made. The Callipallenidae are characterized by differences in their chelifores and palps, and sometimes by peculiar shapes taken by the proboscis. The chelifores, composed of a scape and the chela, may have a scape of one or two articles and have a functional chela. The palps may be absent altogether in some genera, or represented by a knob of a single article in others, and may be composed of up to 4 distinct articles in still other genera. The ovigers are found on both sexes and always have 10 articles but may or may not have the terminal claw. The terminal articles form a strigilis in most but not all genera.

The genus *Anoropallene*, unlike the previous genus *Nymphon*, lacks a terminal oviger claw and has palps of four articles only in the male, instead of both sexes. The chelae are large, functional, and armed with a few teeth. The male's fifth oviger article has a conspicuous setose knob on one side of the distal end. This article is shorter in the female oviger and lacks the knob. The 3 known species of this genus are differentiated by length of their body segments, presence or absence of body and leg tubercles and auxiliary claws, and the shape of propodus and oviger articles. The abdomen of all three species is very short and placed low between the last leg processes so as to be almost hidden from view.

The single species known from the Gulf, *Anoropallene palpida* (Hilton), has been taken along the southern California coast in several localities. It was later described as *A. crenispina* Stock, from the Guatemala coast and as *A. heterodenta* (Hilton), from Bahía Santa Maria, Sinaloa, Mexico. These are all the same species. Specimens have been taken as far up the Gulf as Guaymas, and *A. palpida* appears to be fairly common in several shallow localities along the Panama coast. Figure 21.2.

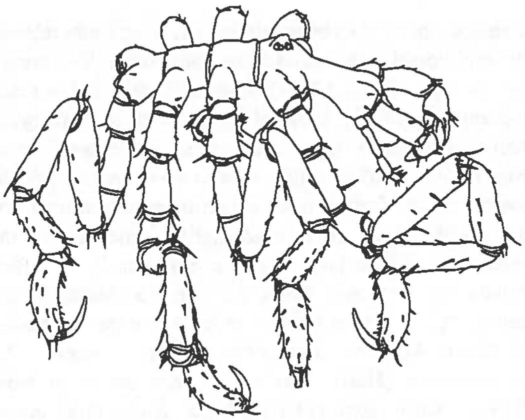

Fig. 21.2 *Anoropallene palpida*
(left appendages removed for clarity)

FAMILY PHOXICHILIDIIDAE

Anoplodactylus Wilson

Unlike the Callipallenidae, there are only 4 genera in this family, but the genus *Anoplodactylus* contains a bewildering variety of over 70 species. This family is characterized by the complete lack of ovigers in females, lack of palps in either sex (although some forms have a small bud or knob where a palp would usually appear), a cephalic segment that extends forward in varying lengths out over the proboscis carrying the ocular tubercle well forward, and small but functional chelae with or without teeth. The ovigers vary from 5 to 9 articles in the family, but *Anoplodactylus* has ovigers of 6 articles, although in two species the last two have coalesced into one. Most species have very small to minute auxiliary claws, but at least 10 species are without auxiliaries at all. The abdomen is conspicuous and erect in this genus. Males have one, although sometimes several, dorsal femoral cement gland with which they cement eggs together on their ovigers after receiving them from the female. As with all pycnogonids, the eggs are fertilized externally. These cement glands have taxonomic importance in separating various species in groups that otherwise look almost alike. Species recognition is also based on characters available in other genera and families, such as the presence or absence of tubercles, setae, spines, and the relative lengths of body and appendage segments.

Only one species, *Anoplodactylus viridintestinalis* (Cole), has been found in the Gulf, but at least 2 more, *A. erectus* Cole and *A. portus* Calman, have been found both to the north and south of the Gulf. More intensive collecting for these small forms will probably turn up these 2 and possibly other species in Gulf waters. Hilton (1942) lists 4 additional species from the southern California coast, and there are at least 6 other species of *Anoplodactylus* found on the Pacific coast of Panama. The coast of Central America has been poorly collected, which reflects on our knowledge of many groups of invertebrate animals.

Anoplodactylus viridintestinalis is one of the smallest pycnogonids to be found in the Gulf. It measures only about 5 mm in its usual flexed condition when found in clumps of algae. As its name states, it assumes the green coloration of its algal habitat and is quite difficult to see unless it is on a different colored substrate. Examination for small species such as this one should be done using a low power microscope, or they will be lost to any but the sharpest eyes. This species is unlike most other *Anoplodactylus* in that it has a compact body with an oval shape. Most others have tenuous bodies with the legs implanted further apart. It has large brown eyes, but the whole animal is so small that these are difficult to see except under higher magnification. This species and, indeed, members of the genus and family are not known to use the oviger as a cleaning appendage, and the terminal articles are only slightly curved and armed with a few simple setae instead of the many comb spines of *Nymphon* and *Anoropallene*. Figure 21.3.

FAMILY AMMOTHEIDAE

Ammothella Verrill

A more heterogeneous group of genera would be hard to find among invertebrate groups than those assigned to this family. The family Ammotheidae has been a catchall for many years and is in need of a good sorting out. There are 27 genera currently recognized, and there have been many other generic synonyms introduced and discarded under the ammotheid umbrella. The family is characterized by specimens having ovigers of 9 or 10 articles in both sexes, chela that are usually functional in juveniles, but atrophied with loss of the fingers in adults, and palps of 4–10 articles. There may or may not be auxiliary claws, depending on the genus. Three genera are known from the Gulf.

Ammothella has long chelifores of 3 articles, with the chelae reduced to knobs in adults. The palps and ovigers are of 9 articles, and the ovigers have one or two comb spines on the terminal articles which are not usually curved into the shepherd's crook shape. The body and appendages are long and thin and usually retain quite a bit of detritus in the long spines and setae that clothe the specimens. Various species of *Ammothella* have club-shaped or blunt hollow tube spines which are used to differentiate many species.

The only species found in the Gulf has been *Ammothella spinifera* Cole. Other species, such as *A. biunguiculata* and *A. tuberculata* may be present but are known thus far from the California coast and more distant localities. *Ammothella spinifera* has a very long ocular tubercle and abdomen, and its body and appendages are armed with many tubular and pointed spines. The propodus has 3 large heel spines and auxiliary claws almost as long as the main claw. With the legs extended, members of this species measure about 8 mm across and are often overlooked among the debris in the bottom of a sorting dish. Figure 21.4.

Nymphopsis Haswell

This genus is represented in the Gulf by *Nymphopsis duodorsospinosa* Hilton, an easily recognized species which is much larger and more robust than *Ammothella*.

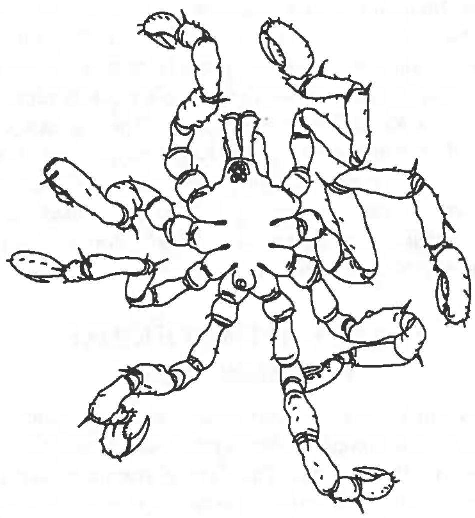

Fig. 21.3 *Anoplodactylus viridintestinalis*

The body of *N. duodorsospinosa* has 2 long tubercles on the mid dorsal surface and many spiny tubercles dorsally on the legs. These tubercles usually catch detritus and the animal must be brushed lightly with a small brush before the closely spaced tubercles can be seen. *Nymphopsis* is specifically like a large *Ammothella*, but the ovigers of the former have an extra or tenth article and the chelifores are more club-shaped. The size of the specimens and the large tubercles serve easily to differentiate the 2 species. There are only 13 species in this genus, but 2 of them have been found on the west coast of North America. The other western species is *N. spinosissima* (Hall), which has been collected from Washington to southern California. It has three dorsal body tubercles instead of two. *Nymphopsis duodorsospinosa* is found also on the southeast coast of the United States and in the Galápagos Islands. It has been collected in littoral algae at Puerto Peñasco, and further south in the Gulf at Bahía San Francisquito and Isla Espíritu Santo. It is known to range as far south as Panama, where it is quite common.

Tanystylum Miers

This is another large genus of pycnogonids with two species found in the Gulf. At least three other species: *Tanystylum duospinum*, *T. tubirostrum*, and *T. oculospinosum*, have been collected on the west coast of Mexico, but only *T. intermedium* and a new species soon to be described have been taken in the Gulf of California. The first was collected at Puerto Peñasco on intertidal ascidians, and the new species was collected at

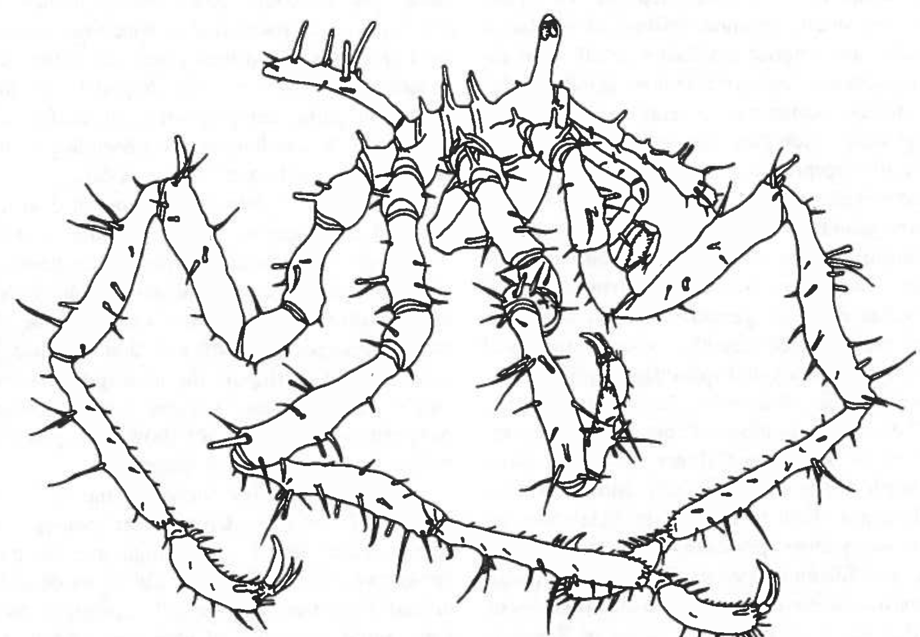

Fig. 21.4 *Ammothella spinifera*

La Paz in algal washings. Species of this genus are tiny and are characterized by a very compact disc-shaped body, ovigers of 10 articles that are noticeably smaller in the female, palps that range from 4 to 7 articles, and short fat legs. The genus has chelifores usually reduced to rounded stumps much shorter than the proboscis, but in *T. intermedium* and one or two other species, the chelifores are of 2 articles with the chelae reduced to round knobs. The palp of this species is composed of 7 articles, but is sometimes found with 6, as the last 2 articles are occasionally coalesced into one. This species is atypical in another character. The proboscis of most *Tanystylum* species is very large in diameter at the base and tapers off to a thinner blunt tip or sometimes even a thin tube. In *T. intermedium* the proboscis has a thin base, flares out to a greater diameter in the middle, and has a gradually decreasing diameter toward the rounded tip. Its legs are also longer and thinner than the typical species. The first coxa of each leg has 3–4 dorsolateral tubercles with spines, as have many *Tanystylum* species. The oviger has one or two comb spines on the terminal articles and is usually curved into the strigilis shape. Whether or not it is used for cleaning is unknown. All known species of this genus have fairly long auxiliary claws. The range of *T. intermedium* is from southern California to as far south as Chile. It is sometimes very common in littoral communities and has been found in large numbers in several places on the Pacific coast of Panama. Since all of the species of this genus are tiny, hydroids, bryozoans, algal mats, and other sessile growth should be examined carefully under a dissecting microscope if these as well as most other littoral pycnogonids are to be found. The typical color of live *Tanystylum* and most other littoral pycnogonids is white or straw color, making them blend into the background of most shallow habitats. Figure 21.5.

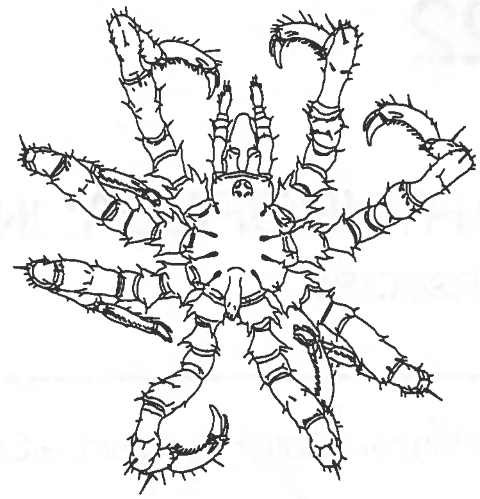

Fig. 21.5 *Tanystylum intermedium*

FAMILY PYCNOGONIDAE

Pycnogonum Brünnich

This is probably the most easily recognized pycnogonid genus and includes the first described species (1762) in this class. Its members have no chelifores or palps and the large proboscis is carried straight out in front. They have short thick legs, the ocular tubercle is often low with large, well defined eyes, and the abdomen is carried horizontally between the juncture of the last pair of legs. Some species have large humps or tubercles on the median dorsal surface at the posterior of each segment. Only the male has ovigers, which are quite small and composed of 4–9 articles with a large terminal claw. They do not serve to clean the appendages but only to carry the eggs, which usually consist of a single mass rather than two or several. Several species have been discovered with the males lacking ovigers, but none of these occur in the Gulf. Species of

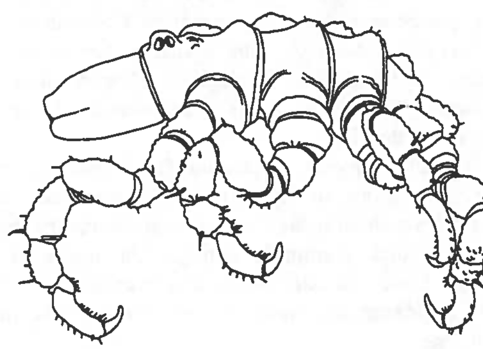

Fig. 21.6 *Pycnogonum stearnsi*

Pycnogonum are often straw colored, but some are variously colored from mustard to chocolate when freshly preserved or live. Quite a few species have their integument reticulated in a pretty checkered pattern with the reticulation lines of a lighter color than the base color. Unfortunately, the only member of this genus found so far in the Gulf of California, *Pycnogonum stearnsi* Ives, has a smooth integument without reticulations (fig. 21.6). It is common in southern California, occurring on the sides and bases of anemones and hydroids such as *Anthopleura* and *Aglaophenia*, in tide pools and shallows. To our knowledge, it ranges as far south as the state of Oaxaca, Mexico, and has been found at Puerto Peñasco in algae and on tunicates. There are four other species found on the west coast of North America: *P. rickettsi*, *P. reticulatum*, *P. cessaci*, and *P. panamum*. Of these four, only *P. cessaci* is not reticulated. These species have been found in localities further south than the Gulf, except *P. rickettsi*, which appears to be an endemic California species. It is probable that at least one of these species will be found in the Gulf as two of them have wide distributions in tropical habitats.

22

ARTHROPODA: INSECTA
(Insects)

by Vincent Roth* and Wynne Brown†

Insects are characterized by their three pairs of legs, paired antennae, and, except for Collembola, one or two pairs of wings. The immature forms are six-legged with antennae, or legless (Hymenoptera and Diptera). The latter usually bear pseudopods on the abdominal sternites.

The class Insecta constitutes the largest and most diversified group in the animal kingdom. They have invaded almost all habitats on earth in abundance, being found in such seemingly inhospitable places as hot springs, brine and alkali pools, and in crude petroleum. It is surprising that more are not found in the intertidal zone.

Over ninety species have been recorded from the narrow strip of land constituting the intertidal or littoral zone of the Gulf of California. A few of the supralittoral zone insects, especially ants, enter this area to forage. The silverfish, *Allacrotelsa spinulata* (Packard), is common at the upper fringe in drifting sand but is also found inland. There are also accidentals and strays which drift in on the winds, fly to lights on the beach, are washed ashore, or otherwise wander in. Those insects that are confined to the littoral zone, however, are referred to as obligates.

The distributions given below likely represent only a portion of the actual distribution. It should be remembered that very little collecting has been done in the Gulf, and the majority of the following records are from Puerto Peñasco south to Kino (the Sonora coast). Undoubtedly many of the species will be found on both sides of the Gulf when adequate collections are finally made.

A series of papers published by the California Academy of Sciences, entitled "Proceedings on the Expedition of the California Academy of Sciences to the Gulf of California in 1921" included mostly insect species collected inland off the various anchorages, and very few from the intertidal zone.

Only five orders of insects have been found in the Gulf littoral zone: the primitive and wingless Collembola, the Hemiptera, Coleoptera, Diptera, and Hymenoptera. The following characterizations of the families refer only to species found on the Gulf of California.

A GLOSSARY OF SPECIALIZED INSECT TERMINOLOGY

Apterous. Without wings.
Arista. A large seta arising on the side of the third antennal segment of many flies.
Collophore. A ventral tube projecting from the first abdominal segment of some collembola.
Costal vein (costa). The first vein (the anterior edge) of the fly wing.
Deutonymph. The third instar of a mite.
Elytra. The hardened front wings of beetles.
Filiform. Describes antennae of uniform thickness (generally thin).
Furcula. A bifid appendage on the apex of the abdomen of some collembola.
Halter. The reduced knoblike hind wings of flies.
Hypognathous. Describes a head and mouthparts directed downward.
Prognathus. Describes a head and mouthparts directed forward.
Pronotum. The dorsal surface of the prothorax.
Pseudopods. False, unsegmented legs; roughened ridges on the abdominal sternites of fly larvae.
Style. Terminal antennal segment when long and tapered to a point.
Urogomphi. Paired segmented or solid terminal abdominal processes on beetle larvae.
Venation. The pattern of veins in an insect wing.

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KEY TO THE INSECT ORDERS

1	Wingless	2
	-Winged	8
2(1)	Antennae usually conspicuous, sometimes concealed; adults or nymphs	3
	-Antennae minute, inconspicuous; larvae only	6
3(2)	Mouthparts short, for chewing or lapping	4
	-Mouthparts long, slender and tubelike for sucking	**Hemiptera**
4(3)	Abdomen broadly joined at thorax	5
	-Abdomen constricted, wasplike	**Hymenoptera**
5(4)	Females larviform; antennae 10-segmented	**Diptera**
	-Adults not larviform; antennae 4-segmented (fig. 22.1–22.3)	**Collembola**
6(2)	Larvae lacking segmented legs	7
	-Larvae with three pairs of segmented legs (fig. 22.18)	**Coleoptera**
7(6)	Larvae free-living	**Diptera**
	-Larvae parasitic, usually within the host	**Hymenoptera**
8(1)	Outer wings hardened, sclerotized	9
	-Outer wings membranous	10
9(8)	Chewing mouthparts; outer wings without veins, not membranous at tips; outer wings not overlapping at tip (figs. 22.9–22.25)	**Coleoptera**
	-Sucking-piercing mouthparts (tubelike); outer wings with veins, membranous at tips; outer wings overlapping at tip (figs. 22.4–22.8)	**Hemiptera**
10(8)	Two pairs of wings; abdomen constricted at thorax (figs. 22.36–22.37)	**Hymenoptera**
	-One pair of wings; abdomen broadly joined at thorax (figs. 22.26–22.35)	**Diptera**

Order Collembola (springtails)

The order Collembola consists of minute to small (0.9 to 2.3 mm), primitive, wingless insects with simple metamorphosis. Immature forms have the same appearance as the adults. The species of Isotomidae and Entomobryiidae (but not the Poduridae) bear a furcula on the apex of the abdomen. It is the bifid spring, usually folded under the abdomen, which gives the springtail its name and enables it to jump when threatened. The first abdominal segment bears a collophore or ventral tube. The head is referred to as prognathous or hypognathus, depending on whether the mouthparts are directed forward or downward. They are usually found in damp areas where they feed upon organic debris or dead animals.

The body is covered with various types of hairs and/or scales and a waxy secretion which repels water. Specimens will not wet and will even float on alcohol (they cannot be picked up with a damp camel's hair brush which works well with other small insects). An aspirator works best for capturing springtails.

KEY TO THE SPECIES OF COLLEMBOLA

1	Furcula absent; antennae shorter than head, stout. (family Poduridae) (fig. 22.1)	2
	-Furcula present; antennae usually longer than the head, slender	3
2(1)	Abdomen cylindrical with two short spines on tip; length around 2.2 mm (possibly an undescribed genus) tribe Anuridini	
	-Abdomen flattened, with a rough texture and without spines on tip; length 0.9 mm or less	***Anurida* sp. and *Friesea* sp.**
3(1)	Abdominal segment IV longer than III (family Entomobryiidae) (fig. 22.2)	4
	-Abdominal segments III and IV subequal (family Isotomidae) (fig. 22.3)	5
4(3)	Eyes large	***Seira fulva***
	-Eyes reduced, minute	***Pseudosinella* sp.**
5(3)	Antennae twice as long as head	***Isotoma maritima***
	-Antennae as long as or slightly longer than head	***Archisotoma besselsi***

FAMILY PODURIDAE

The podurids can be recognized by the absence of a furcula and the very short, stout antennae. They are slow moving, usually dark gray in color, with equal-sized thoracic and abdominal segments. Specimens probably representing a new genus of the Anuridini (fig. 22.1) have been collected under large algae-covered boulders resting on fine gravel and on rocky reefs in the lower intertidal zone. This species is 2.2 mm in length, whereas the other two members of this family known from the Gulf are less than 1 mm long. One specimen of *Anurida* sp. has been collected from rotting seaweed and *Friesea* sp. has been collected off algae-covered rocks.

FAMILY ENTOMOBRYIIDAE

The entomobryiids are characterized by having abdominal segment IV distinctly longer than III, a furcula on the apex of the abdomen and relatively long antennae. Two species are known from the Sonoran side of the Gulf. *Seira fulva* Scott (fig. 22.2) was originally described from Magdalena Island, on the Pacific side of Baja California Sur. This is a common species, found under rocks and wrack and on sand, moving ahead of the tide. *Pseudosinella* sp. has been collected from the algae-covered rhyolite reefs at Punta Cirio.

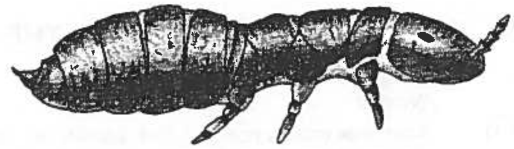


Fig. 22.1 Poduridae: *Anurida* sp.

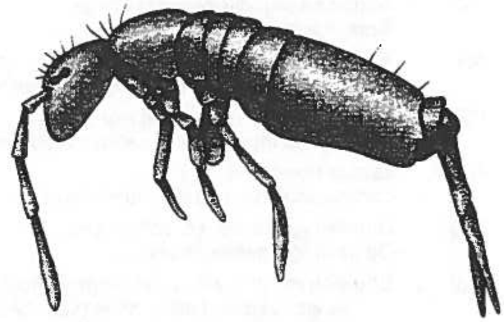


Fig. 22.2 Entomobryiidae: *Seira fulva*

FAMILY ISOTOMIDAE

Isotomids are characterized by the presence of a furcula, nearly equal-sized abdominal segments III and IV and relatively short antennae. A cosmopolitan species, *Isotoma maritima* Tullberg was tentatively identified from Punta Cuevas, Sonora. It is a pale form, about 1.3 mm in length. It has been collected from under rocks which are daily immersed. *Archisotoma besselsi* Packard (fig. 22.3) is another cosmopolitan species, bluish-gray in color and usually ranging to 1 mm in length. It is one of the most common species on the Sonoran coast and is found in rotting algae.

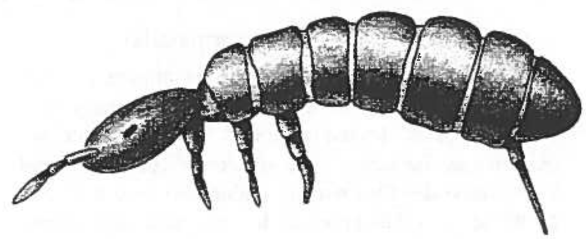


Fig. 22.3 Isotomidae: *Archisotoma besselsi*

Order Hemiptera (true bugs)

True bugs are characterized by their sucking mouth parts (in the form of a 3–4 segmented beak), 4-segmented antennae (except Corixidae), and overlapping anterior wings with the basal part thickened and the apical part membranous.

KEY TO THE FAMILIES OF HEMIPTERA

1	Antennae longer than head	2
	-Antennae shorter than head, concealed (fig. 22.4)	**Corixidae**
2(1)	Hind coxae small, conical or cylindrical, less than 1/4 width of the abdomen; wing membrane, when present, without veins	3
	-Hind coxae large, transverse, half the width of the abdomen (figs. 22.7–22.8)	**Saldidae**
3(2)	Claws of all legs inserted at tips of tarsi (fig. 22.6)	**Mesoveliidae**
	-Claws of all legs inserted before tips of tarsi (fig. 22.5)	**Gerridae**

FAMILY CORIXIDAE (water boatmen)

The water boatmen are recognized by their concealed antennae, scooplike front tarsus, and oarlike hind legs, which are usually held at right angles to the body.

The widespread algavorous and ooze-feeding species, *Trichocorixa reticulata* (Guerin-Meneville) (fig. 22.4) has been collected in the delta region of the Gulf (Polhemus and Hendrickson, 1974) from a plankton tow. It is known from both coasts of Baja into South America, and west across the Pacific Ocean to China.

FAMILY GERRIDAE (water striders)

Water striders are easily recognized, as they skate across the surface of quiet waters, by their long and slender hind two pairs of legs. The first pair of legs is stout and used for support. The second pair is longest. The thorax is slightly wider than the abdomen.

Two genera and three species of gerrids are found in the Gulf.

KEY TO THE GENERA OF GERRIDAE

Tibia and first tarsal segment of middle leg with a fringe of long hairs;
color silvery gray .... ***Halobates***
-Tibia and first tarsal segment of middle leg without a fringe of long hairs;
color brown and yellow .... ***Rheumatobates***

Rheumatobates aestuarius Polhemus (fig. 22.5) is a peculiar insect recorded from the quiet waters of mangroves in Bahía San Carlos, Bahía La Paz, and on Isla San José. The male of this species is 3.2 mm in length, lacks wings, has enlarged antennae and modified hind legs. The female lacks these modifications. Most specimens have been found closely associated with *Rhizophora mangle*, the Red Mangrove.

Two species of *Halobates* inhabit the Gulf, and either may be found in the intertidal zone or on shore after storms, although they usually skate on open water away from shore. *H. micans* Eschscholtz has the intermediate femur about one and one-half times as long as the posterior femur, whereas in *H. sobrinus* White the intermediate femur is only about one and one-fifth times as long as the posterior. *Halobates* are the only insects that have managed to colonize the truly open oceans and to complete their entire life cycle there.

FAMILY MESOVELIIDAE
(water treaders)

The water treaders are similar to the Gerridae in habits. They differ from them in having all three pairs of legs slender, the third pair being the longest. The tarsal claws are apical, and the tarsal tip is not divided.

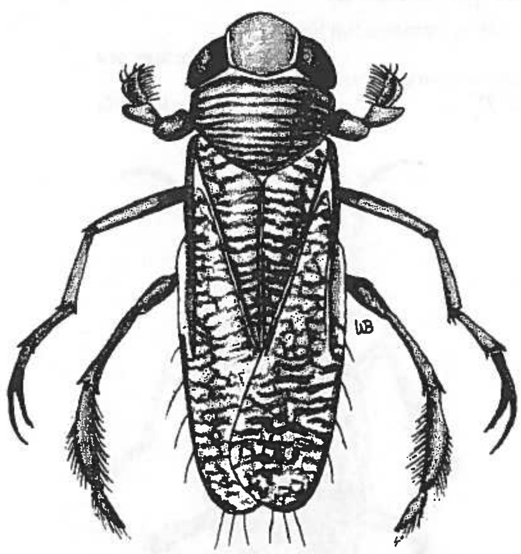


Fig. 22.4 Corixidae: *Trichocorixa reticulata* (modified from Usinger, 1968)

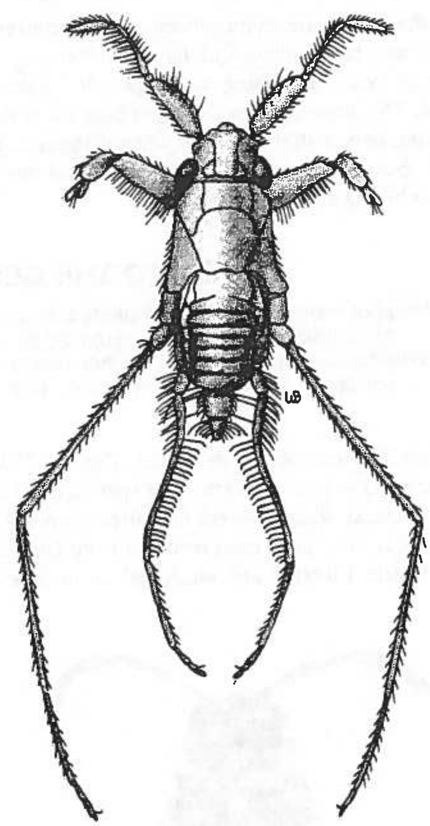


Fig. 22.5 Gerridae: *Rheumatobates aestuarius* (modified from Polhemus 1969)

KEY TO THE GENERA OF MESOVELIIDAE

Eyes small, about 1/4 the head length; head not strongly sloping ahead of eyes;
length of head greater than length of thorax (viewed from above) .... ***Speovelia***
-Eyes larger, 1/3 or more of head length; head strongly sloping ahead of eyes;
length of head less than length of thorax (viewed from above) (fig. 22.6) .... ***Mesovelia***

Mesovelia mulsanti White (fig. 22.6) is slightly larger (over 3 mm in length) than *Speovelia mexicana*. It is widely distributed throughout the Western Hemisphere and west to Hawaii. It has been collected on quiet waters, both fresh and salt, where it may be seen running rapidly over the surface from one patch of vegetation to the next. Occurring in all land areas around the Gulf, it has been found in coastal marshes at Mazatlán.

Speovelia mexicana Polhemus is a smaller species (2.6 mm. in length) known by an apterous male and a few nymphs from Bahía Concepción, and an apterous female from Guaymas. They were collected from the surface of a tide pool under an overhang and at night on an open pool (Polhemus, 1975).

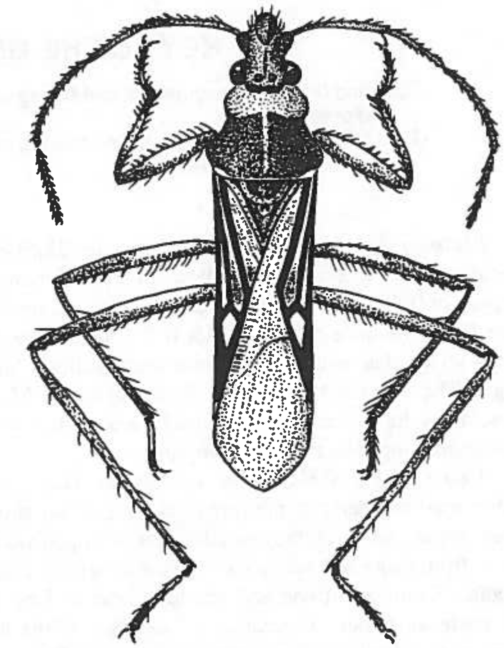


Fig. 22.6 Mesoveliidae: *Mesovelia mulsanti* (modified from Usinger, 1968)

FAMILY SALIDIDAE (shore bugs)

The shore bugs are characterized by their conspicuous antennae, broad abdomen, large hind coxae, and 3–5 looped veins (enclosing as many cells) near the wing tips. The shore species flit about near the water's edge, flying only a short distance when disturbed. The intertidal species may be seen running over the surface of rocks or hiding among the crevices.

KEY TO THE GENERA OF SALDIDAE

Posterior margin of pronotum indented; wing membrane clearly demarcated from basal (thickened) half of wing (fig. 22.8) .... ***Pentacora***

-Posterior margin of pronotum not indented, at most straight; wing membrane not clearly demarcated from basal half of wing (fig. 22.7) .... ***Enalosalda***

Enalosalda mexicana (Van Duzee) (fig. 22.7) is a small species, 3–4 mm in length. This species is usually captured on rocky shores, where it is often abundant on the wet rocks. They have been recorded from Guaymas north to Puerto Libertad and on Angel de la Guardia Island.

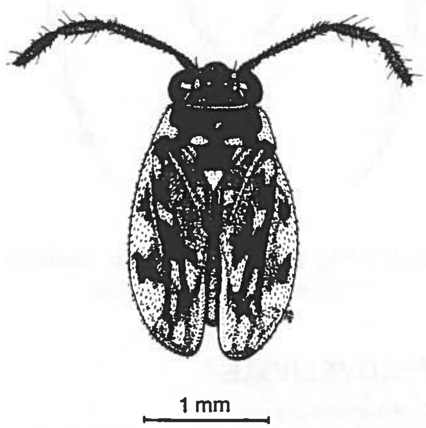


Fig. 22.7 Saldidae: *Enalosalda mexicana* (from Polhemus, in press)

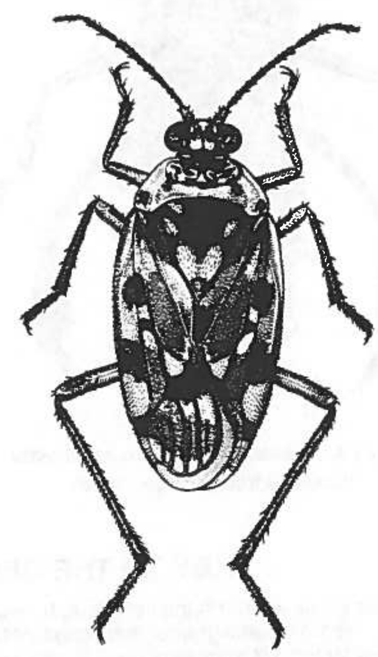


Fig. 22.8 Saldidae: *Pentacora signoreti* (from Usinger, 1968)

Pentacora signoreti Guerin-Meneville (fig. 22.8) can be separated from the following species by its large size (to 6 mm) and by the presence of thorns on the side of the pronotum. It has been reported from Loreto, Mulegé, and Bahía San Everisto on the west side of the Gulf. This is a widespread species, known from Canada south along both sides of America to southern Yucatán and Costa Rica.

Pentacora sphacelata (Uhler) lacks thorns on the side of the pronotum. It has been reported from the beach at Loreto and San José Island on salt flats (Van Duzee, 1923). It is also widespread on the east coast of America, from Texas south to Costa Rica, and has been reported from the Galápagos Islands.

Order Coleoptera (beetles)

The order Coleoptera contains the largest number of species in the class Insecta, but relatively few have exploited the intertidal zone. They are characterized by their hardened outer wing covers (the elytra) and chewing mouthparts. Their larvae are six-legged with a sclerotized head capsule, and usually with a pair of terminal abdominal appendages (urogomphi) or a single sclerotized process.

The majority of the beetles are found in the wrack on sandy beaches and are never or seldom submerged. A few, however, are found on algae-covered rock and are submerged daily.

KEY TO THE FAMILIES OF COLEOPTERA

1	Abdomen covered by elytra, one or occasionally two segments exposed	2
	-Abdomen with at least 3, and usually all abdominal segments exposed	8
2(1)	Small to minute beetles, less than 5 mm in length	3
	-Larger beetles, 5.5–18 mm in length	7
3(2)	Small beetles, 2–5 mm in length	4
	-Minute beetles, less than a millimeter in length	**Ptiliidae**
4(3)	One abdominal tergite exposed (rarely two), penultimate tergite usually membranous; antennae and head exposed, conspicuous	5
	-Two abdominal tergites exposed, both sclerotized; antennae and head usually concealed; body compact, polished, with striae and/or punctuations (fig. 22.13)	**Histeridae**
5(4)	Anterior legs modified or dilated distally; head not constricted behind eyes (fig. 22.25b)	6
	-Anterior legs slender; head strongly constricted behind eyes (fig. 22.24)	**Anthicidae**
6(5)	Less than 4 mm in length; tibiae of hind legs slender, smooth	**Carabidae**
	-More than 4.5 mm in length; tibiae of hind legs stout, dilated, with short spines (fig. 22.25)	**Tenebrionidae**
7(2)	Head narrower than thorax; legs short and stout; body black to brown (fig. 22.25)	**Tenebrionidae**
	-Head broader than thorax; legs long and slender; body colorfully patterned (figs. 22.9–22.10)	**Cicindelidae**
8(1)	Basal abdominal tergites membranous, not exposed (figs. 22.15–22.18); abdomen much wider than thorax; head red-orange	**Melyridae**
	-All abdominal tergites sclerotized and exposed (figs. 22.19–22.23); abdomen about same width as thorax; head usually black or brown	**Staphylinidae**

FAMILY CICINDELIDAE (tiger beetles)

The tiger beetles are large insects (7–18 mm in length), often metallic colored and with distinctive elytral patterns. They have large, conspicuous, toothed mandibles, large bulbous eyes protruding laterally from the head, a narrowed thorax and long, slender legs (figs. 22.9 and 22.10). The larvae live in vertical burrows in damp soil, have a flattened head and two or three pairs of hooks on the fifth abdominal tergite.

Sixteen species and subspecies have been recorded from the beaches of the Gulf (Cazier, 1954) and, although they are not strictly intertidal, they prefer this habitat and may be considered opportunists, moving in and out with the tides. The species of *Cicindela* known from the Gulf are as follows:

C. californica californica Ménétries. Southern half of Baja California. Fig. 22.10a.

C. c. brevihamata Horn. Bahía Kino south to Sinaloa. Fig. 22.10b.

C. c. mojavi Cazier. Northern end of the Gulf, south to Bahía Cholla and San Felipe. Fig. 22.10c.

C. carthagena carthgena Dejean. South of Bahía Kino to Guaymas. Fig. 22.10d.

C. c. collossea Horn. Baja California and the islands near Bahía Kino Fig. 22.9.

C. latesignata parkeri Cazier. Bahía Cholla. Fig. 22.10e.

C. lemniscata leminscata Le Conte. Guaymas (Empalme). Fig. 22.10f.

C. l. rebaptista Vaurie. Baja California, Gulf shores, Texas and Chihuahua. Fig. 22.10g.

C. macrocnema kino Cazier. Bahía Kino. Fig. 22.10h.
C. m. macrocnema Chaudoir. Bahía Kino and south. Fig. 22.10i.
C. rockefelleri Cazier. Bahía Cholla. Fig. 22.10j.
C. sinaloae digueti Horn. Tiburón Island and the Gulf side of Baja California. Fig. 22.10k.
C. s. schrammeli Cazier. North end of the Gulf, south to Bahía Cholla and San Felipe. Fig. 22.10l.
C. s. sinaloae Bates. Bahía Kino and south. Fig. 22.10m.
C. tenuisignata Le Conte. Sandy margins of estuaries, Cochare Beach, Empalme. Fig. 22.10n.
C. trifasciata ascendens Le Conte. Eastern shores of the Gulf, south of Bahía Kino. Fig. 22.10o.

These predatory beetles prey on insects and probably amphipods. *Cicindela macrocnema kino* has been seen attempting to catch amphipods on the beach at Bahía Kino. *Cicindela sinaloae schrammeli* has been collected six miles from land at night where it was landing on the water surface, feeding upon arrow worms (Hendrickson, personal communication).

FAMILY CARABIDAE (ground beetles)

The ground beetles can be recognized by their polished brown or black coloration, 11-segmented filiform antennae, constricted thorax, five-segmented hind tarsi, and active habits. The larvae are similar to those of rove beetles, with paired urogomphi. Two genera are represented in the Gulf.

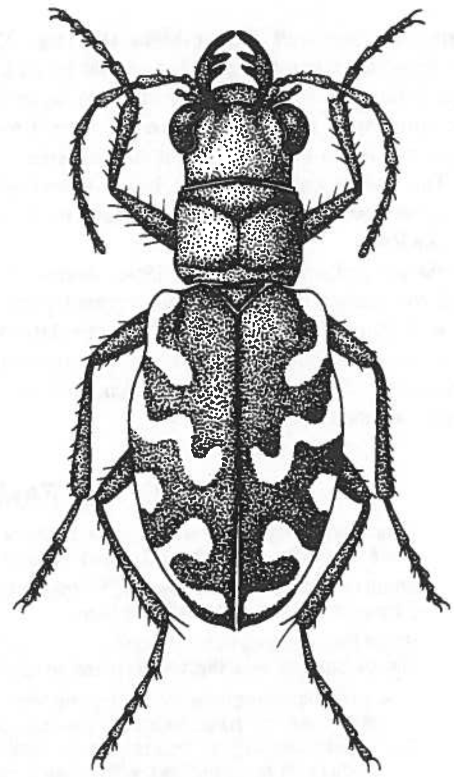


Fig. 22.9 Cicindelidae: *Cicindela carthagena collossea* (modified from Cazier, 1954)

KEY TO THE GENERA OF CARABIDAE

Length 2.5 mm; front tibia with one or no large distal spines (fig. 22.11b); with an antennae cleaning brush on the front tibia (fig. 22.11b); elytral suture recurved at tip (fig. 22.11a); abdomen broadly joined to thorax .... ***Tachys***
-Length, 3.5–4.0 mm; front tibia with two long distal spines (fig. 22.12b); without cleaning brush (fig. 22.12b); elytral suture straight (fig. 22.12a); abdomen petiolate .... ***Dyschirius***

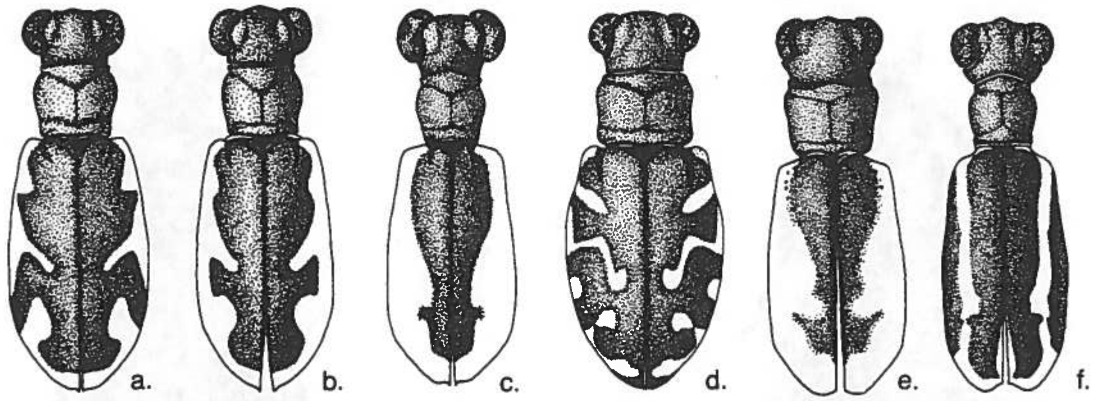
Tachys (fig. 22.11) has a flattened, convex thorax that is less constricted posteriorly than the thorax of *Dyschirius*. It is represented by five or six species on the northeastern shores of the Gulf. *Tachys corax* Le Conte was reported by Evans (1968) from rock crevices at the upper level of the barnacle-algae zone. Three species have been collected in wrack, one from mud flats at low tide, and one from barnacles. This genus is being revised at the present time.

Dyschirius sp. has a nearly globose thorax, strongly constricted behind (fig. 22.12). *Dyschirius marinus* (Le Conte) is known from the California coast where it is found on wet sand. Others are found in burrows in sandy or clay soil, often in connection with the staphylinid, *Bledius* (Arnett, 1971). The single unidentified species recorded from the Gulf was found on mud flats at Punta Tepoca.

FAMILY HISTERIDAE

These predatory insects are distinguished by the following set of characters: short, hard, black or brown, polished, compact bodies; concealed clubbed, elbowed antennae; spined tarsal segments; and exposed, large, heavily sclerotized distal two abdominal tergites.

There are a few genera which are confined to sandy beaches, where they are almost always found in association with dead and rotting animals or in the wrack zone among rotting seaweed. A similar group of insects, the dermestids (family Dermestidae), are occasionally found among rotting animal life on sandy beaches. They are more elongate than histerids and are covered with fine hairs, often with a grayish pile below.



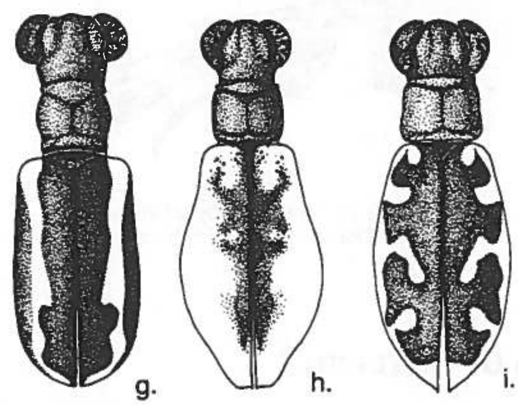
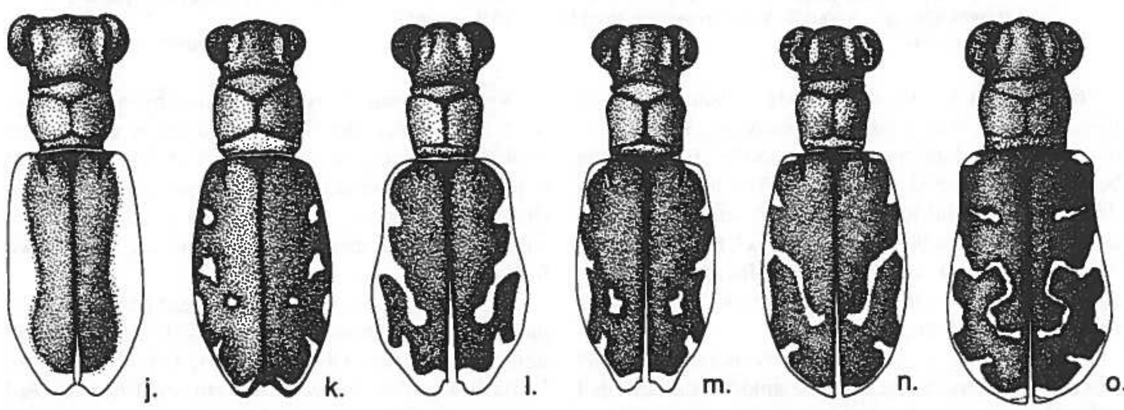


Fig. 22.10 Cicindelidae. *Cicindela* of the Gulf (modified from Cazier, 1948 and 1954)

a. *Cicindela californica californica*
b. *Cicindela californica brevihamata*
c. *Cicindela californica mojavi*
d. *Cicindela carthagena carthagena*
e. *Cicindela latesignata parkeri*
f. *Cicindela lemniscata lemniscata*
g. *Cicindela lemniscata rebaptista*
h. *Cicindela macrocnema kino*
i. *Cicindela macrocnema macrocnema*
j. *Cicindela rockefelleri*
k. *Cicindela sinaloae digueti*
l. *Cicindela sinaloae schrammeli*
m. *Cicindela sinaloae sinaloae*
n. *Cicindela tenuisignata*
o. *Cicindela trifasciata ascendens*



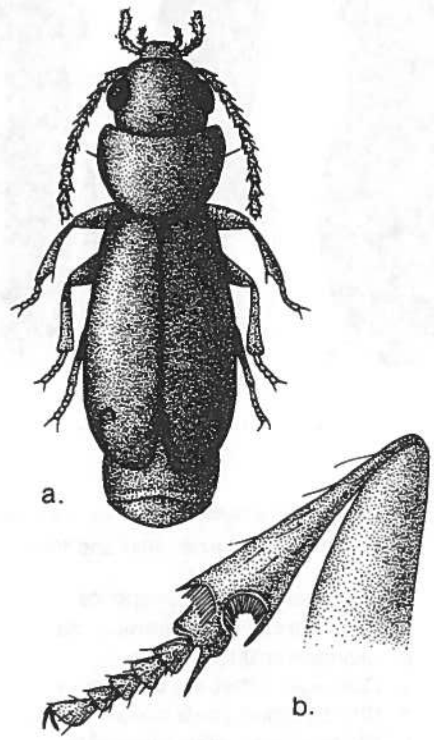


Fig. 22.11 Carabidae: *Tachys* sp.
(a) Dorsal view. (b) Front tibia.

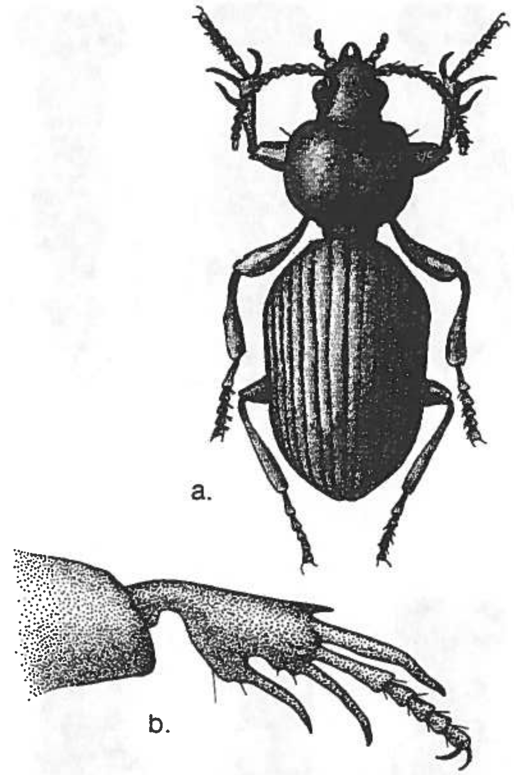


Fig. 22.12 Carabidae: *Dyschirius* sp.
(a) Dorsal view. (b) Front tibia.

KEY TO THE GENERA OF HISTERIDAE

More than 2.5 mm in length 2
-Less than 2 mm in length .... ***Halacritus***

2(1) Hind femur 2 times as long as wide; tibia strongly dilated, densely tuberculate; thorax polished, elytra punctate 3
-Hind femur 3 times as long as wide; tibia slightly enlarged at tip, smooth; thorax and elytra strongly punctate around edges .... ***Xerosaprinus***

3(2) Large species, about 6 mm in length; front tibia with two large, dull, lateral teeth (or processes) at tip .... ***Neopachylopus***
-Smaller species, about 3–4 mm in length; front tibia with 3–4 small teeth (fig. 22.13) .... ***Baeckmanicolus***

Baeckmanicolus sp. (fig. 22.13) is about 3.5 mm in length, brown, with a polished thorax and a single line of punctations along the posterior border. Each elytron bears four striae and punctations. The hind tibiae are dilated distally and tuberculate. This species has been taken on the shores of Sonora at Bahía Cholla on a dead octopus and from under wrack at Bahía Kino. This genus is also known from the Atlantic and Pacific sandy coastal shores (Arnett, 1971).

Halacritus sp. is characterized by its small size, the absence of elytral striae and the smooth slender hind tibiae. It was collected from under seaweed at Punta Cirio.

Neopachylopus sp. is characterized by its large size, stout tuberculate, and dilated hind tibiae and by the spatuliform process on the underside of the last segment of the middle and hind tarsi. It is known only from Bahía Cholla, where it was collected from under a dead octopus. Two other species in this genus are also known from Pacific shores.

Xerosaprinus sp. is a medium-sized beetle, densely punctate on the thorax and elytra with a smooth hind tibia which is only slightly dilated. It is known from Bahía San Carlos, where it was collected from a dead and decaying fish.

FAMILY PTILIIDAE
(feather-winged beetles)

These microscopic (about 0.6–0.8 mm in length), usually black beetles are characterized by their small size, slightly clubbed antennae, and the barlike hind wing with a fringe of hairs (fig. 22.14). Only one species (of the genus *Actidium*) is known from the upper end of the Gulf, on the Sonoran shore. Other species are known from intertidal zones in Florida where they have been taken from decaying kelp (Dybas, personal communication) and from the Pacific side of Baja California. They are cryptic and barely discernible as they crawl over wet barnacles or along rock crevices.

FAMILY MELYRIDAE
(soft-winged flower beetles)

The melyrids are represented by the genus *Endeodes* in the Gulf. They are characterized by their small size (2.5–4.8 mm), barely serrate antennae, short elytra (figs. 22.15–22.17), membranous abdominal tergites, and blue to black and orange-red coloration. Their red larvae (fig. 22.18) are more or less flattened with a fused bifid abdominal process on the last segment.

The predatory adults and larvae are found on beaches, under debris, or on rocky shores and algae-covered reefs. Five of the nine known species are found on the Gulf, while the others are known from the Pacific beaches of Baja California north to British Columbia (Moore and Legner, 1975).

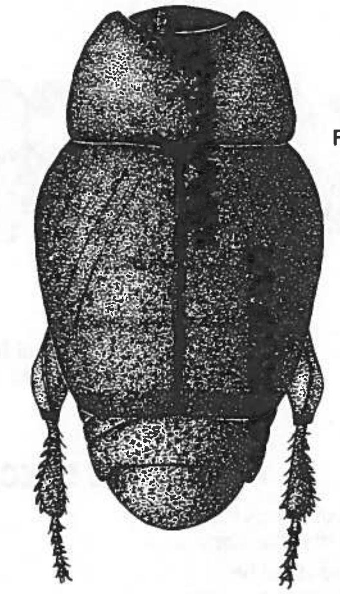


Fig. 22.13. Histeridae: *Baeckmanicolus* sp.

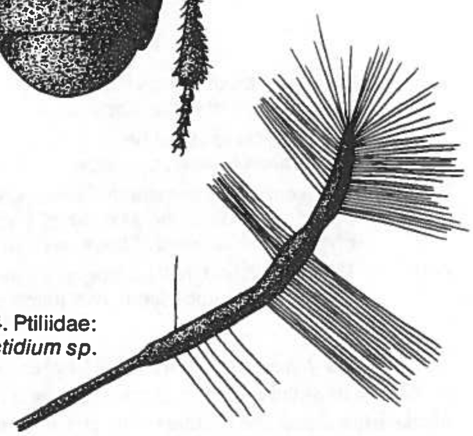


Fig. 22.14. Ptiliidae: wing of *Actidium sp.*

Fig. 22.15 Melyridae: *Endeodes rothi*

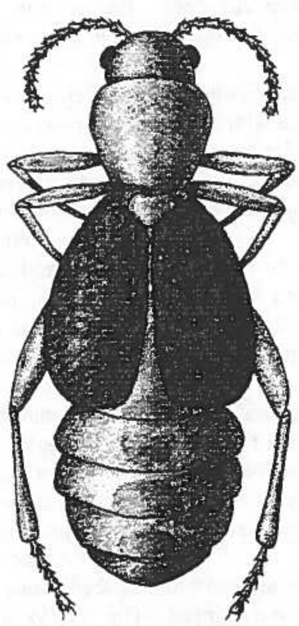


Fig. 22.16 Melyridae: *Endeodes sonorensis*

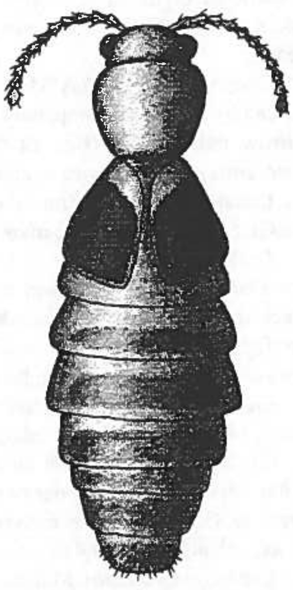


Fig. 22.17 Melyridae: *Endeodes intermedius*

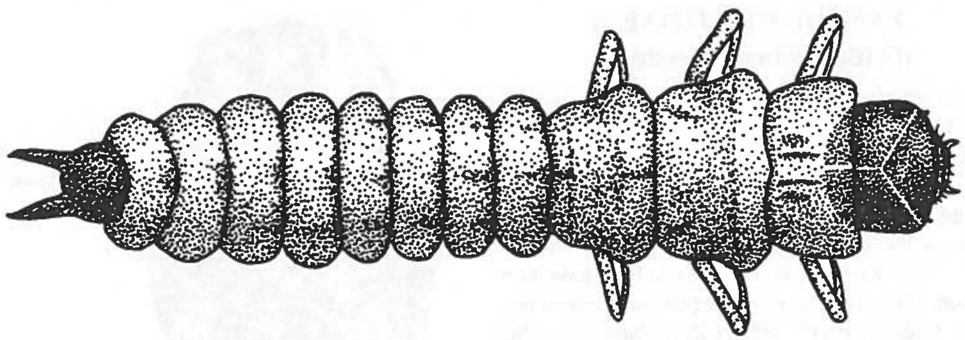


Fig. 22.18 Melyridae: *Endeodes* sp., larva

KEY TO THE SPECIES OF ENDEODES

1 Distal portion of elytra yellow to red 2
-Distal portion of elytra black 4

2(1) Elytra yellow to red at base 3
-Elytra black at base, tip yellow .... ***E. terminalis***

3(2) Elytra conjointly constricted dorsoventrally at base, with sparse but long setae (one-third as long as width of elytra); large (4.8 mm) (fig. 22.15) .... ***E. rothi***
-Elytra not constricted at base, with short pubescence; small (2.5–3 mm) .... ***E. fasciatus***

4(1) Thorax polished, half as long as elytra (fig. 22.16) .... ***E. sonorensis***
-Thorax rough, pubescent, two-thirds as long as elytra (fig. 22.17) .... ***E. intermedius***

Endeodes fasciatus Moore and Legner is characterized by its small size (2.5–3 mm) and by a transverse black stripe across the middle of the elytra, similar to *E. rothi* but with the basal half reddish. It also lacks the constricted elytra of *E. rothi*. This species has been taken at Punta Cirio, from seaweed on a boulder-strewn beach.

Endeodes intermedius Moore and Legner is characterized by its almost completely black elytra with only a narrow reddish rim (fig. 22.17). It is similar to *E. sonorensis*, but the elytra is about two-thirds as long as the thorax. It is known from the northeastern shores of the Gulf, on algae-covered rhyolite.

Endeodes rothi Moore and Legner is the largest of the *Endeodes* (4.8 mm) and bears a broad transverse black stripe on the elytra, bounded by a reddish base and tip (fig. 22.15). It has been collected at Punta Cirio from seaweed on a boulder-strewn beach.

Endeodes sonorensis Moore is recognized by its short, black elytra, and is reddish only at the base (fig. 22.16). The elytra are about twice as long as the thorax. It has been found on the northeastern shore of the Gulf south to Guaymas. This melyrid occurs on wet sand, rocks, and algae-covered rhyolite.

Endeodes terminalis Marshall can be separated from other species found in the Gulf by its black elytra, tipped with red. It is the only species recorded from the western side of the Gulf (at Puertecitos).

FAMILY STAPHYLINIDAE (rove beetles)

Rove beetles constitute the most speciose family of beetles in the intertidal zone of the Gulf. Unfortunately little is known about them, and most are represented by undescribed genera and species. They are characterized by their short elytra, exposed and sclerotized abdominal segments, and by their linear shape, the abdomen being about as wide as the head and thorax combined. They are active beetles and tend to fly readily when disturbed. The larvae are found in the same habitats as the adults and are similar in form. They have a sclerotized head capsule and thoracic tergites, but the abdominal tergites are membranous. The ninth larval abdominal segment bears a pair of urogomphi, and the tenth segment is elongated and used as a proleg.

The rove beetles of the Sonoran beaches may be divided into three groups, based upon their habitats: (1) the obligates, associated with rocky shores and large boulders which are inundated daily or twice daily by the sea; (2) the wrack species, associated with rotting seaweed; and (3) the salt and mud flat species.

The most conspicuous of the first group is an undescribed genus and species of the subtribe Bolitocharina (fig. 22.19). It is tan to light brown in color, slow moving, 3.5–5.4 mm long, has a dense pilose covering on the abdomen, and lacks hind wings. Its larva has a short dorsal process on the 8th abdominal tergite. This nocturnal species is found only at low tide on algae-covered rhyolite rocks or under boulders in company with chitons, sea cucumbers, bryozoa, and starfish. It is found from Punta Cirio to Punta Cuevas. Three other species of obligate rove beetles are found in this same rocky habitat: *Carpelimus* sp., a minute (1.0–1.6 mm) black beetle; a representative of an undescribed genus (fig. 22.20), 2.4–3.0 mm long with an orange head and thorax; and *Bryothinusa rothi* Moore and Legner, 1.5 mm in length, reddish with a darker abdominal patch. A fifth species, *Cameronium sonorensis* Moore, was taken from cracks in the rocks in the intertidal zone at Bahía San Carlos.

Rove beetles associated with wrack are most common, eight species having been found in rotting seaweed and debris, generally on sandy beaches. They include the following forms.

Cafius sulcicollis Le Conte (fig. 22.21) is the largest (6.0–7.5 mm) and one of the commonest of the beetles at Punta Cirio. Their flights by the thousands along the Pacific coast are well known (Leech and Moore, 1971), and these have been observed on the Sonoran shores of the Gulf (Roth and Brown, personal observation). They and their larvae are common in piles of rotting seaweed (Moore, 1975). Adults can be recognized by their large size and the two distinct lines of punctations on the thorax.

Aleochara arenaria Casey (fig. 22.22) is a medium sized (2.4–5.5 mm) rove beetle, black with orange-brown legs and a light central spot (that is darker laterally and anteriorly) on the elytra. This species is more common on rotting animal matter but is also found in decomposing seaweed. It has been collected at Punta Cirio south to Punta Chueca.

Other species collected in the wrack are: *Scopaeus* sp. and *Halorhadinus* n. sp. from Puerto Peñasco; *Thinobius* sp. from Tastiota; and representatives of three undescribed genera from the upper Sonoran coast.

The sand, alkali, and mud flat species are mostly widespread inhabitants of saline environments, both inland and on the coast. Most are algavorous. They include: *Bledius jacobinus* Le Conte, from Bahía Kino (and also Arizona); *B. ferratus* Le Conte, from southwestern United States to Sonora and islands in the Gulf; *Microbledius forcipatus* (Le Conte), with distinct ocular horns from Punta Sargento and especially distributed along the rivers of the Southwest extending onto the beaches of Sonora and Sinaloa; *Psammobledius punctatissimus* (Le Conte), from Bahía San Carlos south to Ecuador, the West Indies, and Florida (Herman, 1972); and an undescribed species (fig. 22.23) of *Psammobledius*. The last species has been found at Punta Sargento, burrowing just under the surface of the mud flats. Its presence is indicated by raised bits of mud (frass); when this frass is blown away, the subsurface tunnels, as well as the larvae and beetles, become visible.

The mud flat species are characterized by their projecting mandibles, bearing one or two dull teeth.

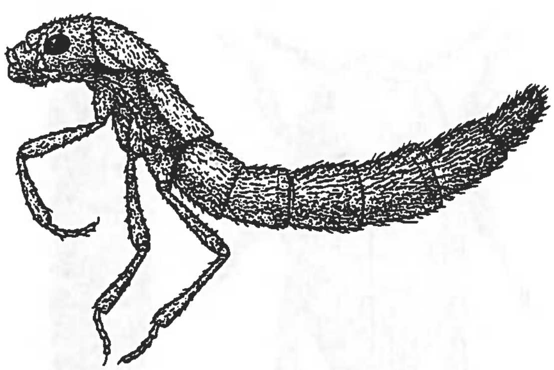


Fig. 22.19 Staphylinidae: undescribed genus no. 1

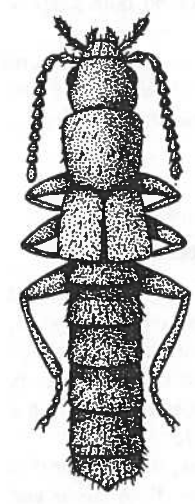


Fig. 22.20 Staphylinidae: undescribed genus no. 2

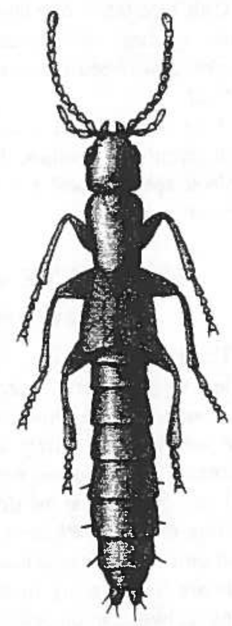


Fig. 22.21 Staphylinidae: *Cafius sulcicollis*

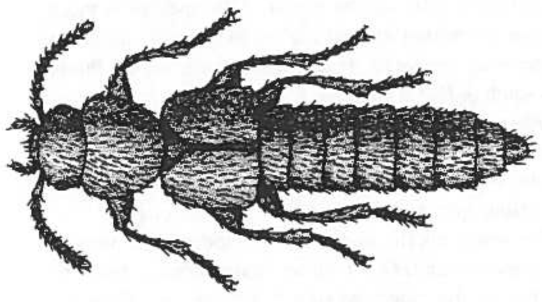


Fig. 22.22 Staphylinidae: *Aleochara arenaria*

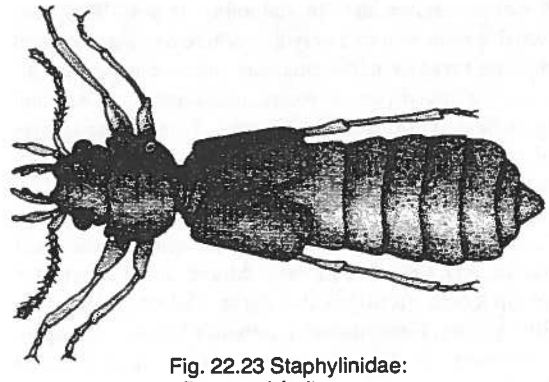


Fig. 22.23 Staphylinidae: *Psammobledius* n. sp.

KEY TO THE GENERA OF MUD FLAT INHABITING ROVE BEETLES

1 Tarsi 3-segmented; less than 4 mm in length 2
-Tarsi 4-segmented; 4–8 mm in length .... ***Bledius***

2(1) Thorax with a lateral ridge; ocular horns absent; two dull mandibular teeth; 2.6–3.7 mm in length .... ***Psammobledius***
-Thorax lacking a lateral ridge; ocular horns usually present; one dull mandibular tooth; 1.7–2.6 mm in length .... ***Microbledius***

FAMILY ANTHICIDAE (antlike flower beetles)

The anthicids are small predatory beetles (2.5–3.0 mm in length), with strong constrictions between the head and thorax (fig. 22.24) and with slender legs. Only one species, *Anthicus custoidiae* Werner, is known from the Gulf intertidal zone (fig. 22.24). It is an unmarked, orange species, very common under dry, partially decomposed seaweed on sandy beaches on both sides of the Gulf.

Two supralittoral species are occasionally found on the Sonoran beaches, *Vacusus infernus* (La Ferté) (a black species) and *Formicillo munda* Le Conte, a checkered species.

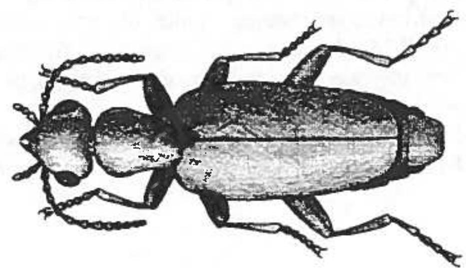


Fig. 22.24 Anthicidae: *Anthicus custoidiae*

FAMILY TENEBRIONIDAE (darkling ground beetles)

The tenebrionids are dull black or brown colored beetles, with filiform antennae, 4-segmented hind tarsi, and slow deliberate movements. Their larvae are called false wireworms. They are cylindrical and heavily sclerotized, with the last segment ridged dorsally with a short upturned spur at the tip (fig. 22.25b).

Only the genus *Phaleria* (including three species) is found on the sandy beaches of Sonora. Both larvae and adults are found in dry to slightly damp sand under dry rotting seaweed upon which they feed. The adults are characterized by their broadly oval, convex bodies (fig. 22.25a), short legs, and dilated tibiae which are covered with short blunt spurs no longer than twice their width.

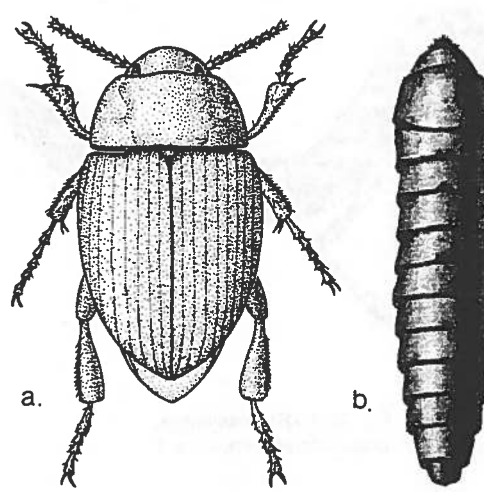


Fig. 22.25 Tenebrionidae: *Phaleria lata* (a) Adult. (b) Larva.

KEY TO THE SPECIES OF PHALERIA

1 Moderate sized beetles 4.5–7.0 mm in length; eyes separated below by less than width of eye 2
-Large beetles, 9–10 mm in length; eyes separate below by almost twice the width of the eyes .... ***P. lata***

2 Smaller beetles, 4.5–5.5 mm in length; usually with elytral markings; eyes barely separated below by 1/5th width of eye .... ***P. debilis***
-Larger beetles 6.5–7.0 mm in length; without elytral markings; eyes separated below by 1/2 the width of an eye .... ***P. pilifera***

Phaleria debilis Le Conte is found on the coast of Sonora south to Jalisco.

Phaleria lata Blaisdell (fig. 22.25) is also found on the coast of Sonora and from Isla San Luis and Bahía San Luis Gonzaga in Baja California Norte.

Phaleria pilifera Le Conte, another Sonoran species, is also known from Isla Tiburon and Baja California Norte.

Order Diptera (flies)

Flies are characterized by their single pair of wings and the presence of a pair of halters (knobbed appendages representing the vestiges of reduced hind wings). The larvae are legless. The order is divided into the following groups: (1) the Nematocera, having many segmented antennae, larvae with head capsules, and mandibles working horizontally which include the Chironomidae and Ceratopogonidae; (2) the Brachycera with two or three antennal segments and an apical style, and larvae with a less developed head capsule and mouth hooks moving vertically which include the Asilidae, Dolichopodidae, and Empididae; and (3) the Cyclorrhapha with three antennal segments and an arista, larvae with no head capsule, and mouth hooks moving ventrally. These include the remaining flies.

Adult dipterans are the most common and active insects in the intertidal zone, some taking advantage of moist sand (*Lissoteles* spp.) or mud flats (*Thinophilus* spp.), most being associated with decomposing seaweed (*Tethina*, *Coelopina*, *Canaceoides*, *Fucellia* and *Leptocera*), and a few being found on wet rocks at the water's edge (*Aphrosylus*, *Thalassomya*, and *Clunio*). The females of *Clunio* species are wingless and are confined to this area. Most of the dipterous larvae are found in wrack, but several are found on algae and barnacle-covered rocks.

KEY TO THE FAMILIES OF ADULT DIPTERA

1 Winged flies **2**
-Wingless flies .... (in part) **Chironomidae**

2(1) Antennae with 3 short, stout segments terminated by a slender segment (the style) (fig. 22.28) or a stiff bristle (the arista) (figs. 22.29, 22.31, 22.32) **3**
-Antennae long and slender with 7–13 segments, not terminated by an arista or style (figs. 22.26–22.27) **16**

3(2) Basic color orange-brown to black **4**
-Basic color metallic green or purple, especially on side of the thorax .... **Dolichopodidae**

4(3) Head not depressed between eyes; abdomen stout, about as long as thorax; wing length less than 6 mm **5**
-Head depressed between eyes above; abdomen slender, about twice as long as thorax; wing length 6 mm or more (fig. 22.28) .... **Asilidae**

5(4) Head, thorax, and abdomen setose **6**
-Head, thorax, and abdomen smooth, lacking setae (*Lipochaeta slossonae* Coquillett) **Ephydridae**

6(5) Wings average more than 3 mm in length (use several adults of both sexes where possible) **7**
-Wings average less than 3 mm in length **11**

7(6) Distal segment of antenna rectangular, twice as long as wide (fig. 22.34) **8**
-Distal segment of antenna globular (fig. 22.31) **9**

8(7) Cross vein *m* twice as long as distance from posterior edge of vein to edge of wing .... **Anthomyiidae**
-Cross vein *m* as long as distance from posterior edge of vein to edge of wing (fig. 22.35) .... **Muscidae**

9(7) Length of wing 1.7–3.4 mm; costal vein broken (fig. 22.33) **10**
-Length of wing 3.5–4.5 mm; costal vein unbroken .... **Coelopidae**

10(9) Hind femora slender, barely larger than tibia .... **Canaceidae**
-Hind femora swollen, distinctly larger than tibia .... **Tethinidae**

11(6) Wing length less than 2 mm **12**
-Wing length 2–3 mm **15**

12(11) Eyes widely separated (fig. 22.32a) 13
-Eyes almost contiguous (fig. 22.29) .... **Empididae**

13(12) Antennae directed forward on front of head; posterior wing veins reach border of wing (fig. 22.33) 14
-Antennae directed laterally; posterior wing veins short, not reaching border of wing (fig. 22.32b) .... **Sphaeroceridae**

14(13) Male genitalia exposed; costal vein broken once (fig. 22.33); abdomen with 6–7 visible segments .... **Canaceidae**
-Male genitalia retracted; costal vein broken twice; abdomen with 5 visible segments .... **Ephydridae**

15(11) Hind femora much stouter than tibiae .... **Tethinidae**
-Hind femora slender, similar to tibia .... **Canaceidae**

16(2) Wing length, 2–3 mm; antennae with 7–10 segments .... **Chironomidae**
-Wing length 0.8–1.2 mm; antennae with 13 segments .... **Ceratopogonidae**

FAMILY CERATOPOGONIDAE (biting midges)

Biting midges, known also as "Punkies" or "No-See-Ums" are tiny stout flies (0.9–1.34 mm wing length), with piercing mouthparts, 14-segmented antennae, and a tiny head on a humped-back thorax. Only the two anterior wing veins are distinct. Adults are active day and night over algae-covered rocks and along the beaches and can be quite bothersome to man. The larvae are herbivorous, feeding on algae and diatoms, living on algae-covered rocks and in mangrove swamps (Wirth, in press).

Four species of *Dasyhelea* are known from the Gulf. More than one species are often found in the same collections.

KEY TO SPECIES OF DASYHELEA

1 Halter infuscated, gray-brown or with markings 2
-Halter pale .... ***D. bajensis***

2(1) Halter bicolored 3
-Halter infuscated .... ***D. griseola***

3(2) Halter stem brownish, knob whitish .... ***D. calvescens***
-Halter pale, base of knob dark .... ***D. sonorensis***

Dasyhelea bajensis Wirth. Collected from an emergence trap in mangroves in Isla San José; also recorded from California and Sinaloa.

Dasyhelea calvescens Macfie. Known from Puerto de Lobos and on the tip of Baja California as well as Panama and the Hawaiian Islands.

Dasyhelea griseola Wirth. This species was swept from mangroves on Isla San José. It is also known from Trinidad and Panama.

Dasyhelea sonorensis Wirth. Collected on the Sonoran coast among holes in pitted algae-covered rock. It is also known from the tip of Baja California.

FAMILY CHIRONOMIDAE (midges)

Midges of this family are similar to the Ceratopogonidae but have fewer antennal segments (7–11), lack piercing mouth parts, have longer legs and a more slender abdomen. Their wing venation is inconspicuous, simple, without cross veins. The larva has a head capsule and a terminal "pseudopod."

KEY TO THE GENERA OF CHIRONOMIDAE

Wing length, 1.2 mm; female wingless; male genitalia large, 1/3 the length of the abdomen (fig. 22.26) .... ***Clunio***
-Wing length, 2.6–3.2 mm; females winged; male genitalia small, about 1/7 length of the abdomen (fig. 22.27) .... ***Thalassomya***

Clunio n. sp. (fig. 22.26) is a peculiar midge. The females are wingless and live in the algae-covered pitted rhyolite. The males are winged, with a humped thorax extending over the head, stout legs (shorter than the body), and with large genitalia, about as long as the thorax. They are seen flitting over the tide pools and algae, usually in the splash zone. Taking the females from among the algae, males grasp them with their large genitalia and fly off with them. The larvae live among algae on wave-splashed rocks. This species is known from both sides of the Gulf from Punta Cirio and Bahía Cholla to San José de Cabo.

Thalassomya pilipes Edward (fig. 22.27) is a larger species, more like the typical midge. It runs about actively over wet rocks at night or is attracted to lights on the rocky beaches. Its legs are long, the hind legs about two and a half times as long as the body. The larvae live in silken tubes among the algae encrusted rocks. This is a wide-spread species found on both sides of the Gulf and in the Galápagos and Revillagigedo Islands.

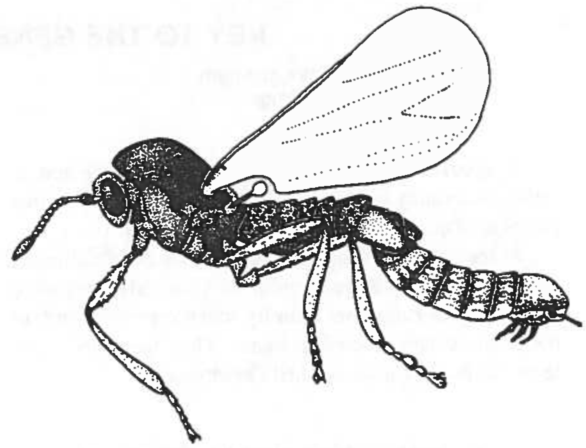


Fig. 22.26 Chironomidae: *Clunio* n. sp. Male and wingless female in copula.

FAMILY ASILIDAE (robber flies)

Robber flies are the largest flies (6–9 mm in length) one encounters in the intertidal zone. Adults are characterized by their bearded faces, three-segmented antennae with a terminal style, depressed area between the widely spaced eyes, and an elongated abdomen. Asilids are predatory, generally diurnal solitary species. Littoral species fly about on wet sandy beaches and are often seen resting on the sand or "sunning themselves." *Lissoteles aquilonius* Martin (fig. 22.28) has also been collected in fairly large numbers by using night lights.

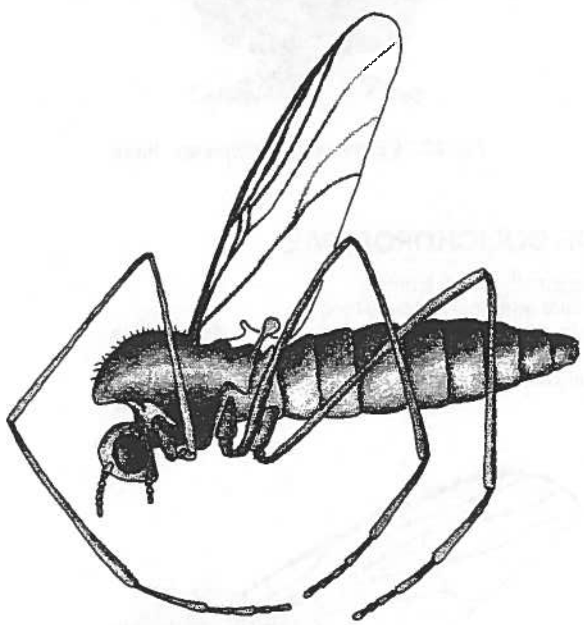


Fig. 22.27 Chironomidae: *Thalassomya pilipes*

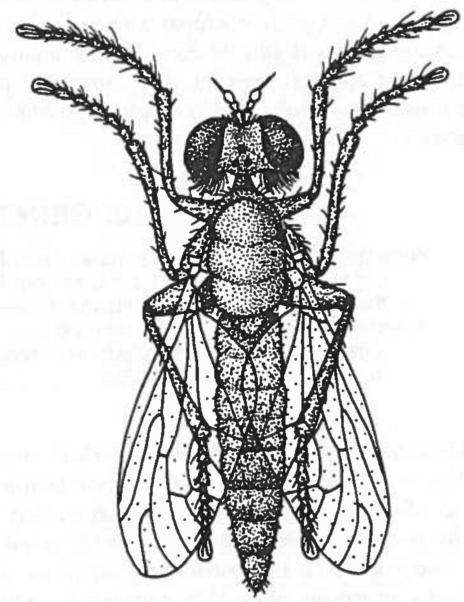


Fig. 22.28 Asilidae: *Lissoteles aquilonius*

KEY TO THE SPECIES OF LISSOTELES

All tibiae black or dark reddish-brown .... *L. vanduzeei*
-Basal half or more of tibiae yellow, usually with black apices (fig. 22.28) .... *L. aquilonius*

Lissoteles aquilonius Martin is known from both sides of the upper Gulf, south to Nayarit (fig. 22.28).

Lissoteles vanduzeei Cole is known from the southern half of Baja California, from Bahía de Los Angeles to Punta Conejo on the Pacific coast.

FAMILY EMPIDIDAE (dance flies)

The empidids are tiny flies, distinguished by the following set of characters: wing lengths of 1.3–2.0 mm; venation reduced to five veins (all reaching the edge of the wing), with no cross veins; with an unbroken costa; with contiguous eyes (or nearly contiguous eyes), and piercing mouthparts; and with the third antennal segment terminated by a style.

KEY TO THE GENERA OF EMPIDIDAE

Wings 1.3–1.5 mm in length .... ***Stilpon***
-Wings 2.0 mm in length .... ***Chersodromia***

A species of *Chersodromia* has been collected at lights on a sandy beach at Punta Chueca. Species of this genus are known from beaches of both coasts.

A species of *Stilpon* (fig. 22.29) has been collected from algae-covered rocks and from seaweed. They have a tendency to run rather than fly when disturbed and do not seem to be attracted to lights. They have been collected at Punta Cuevas and El Desemboque.

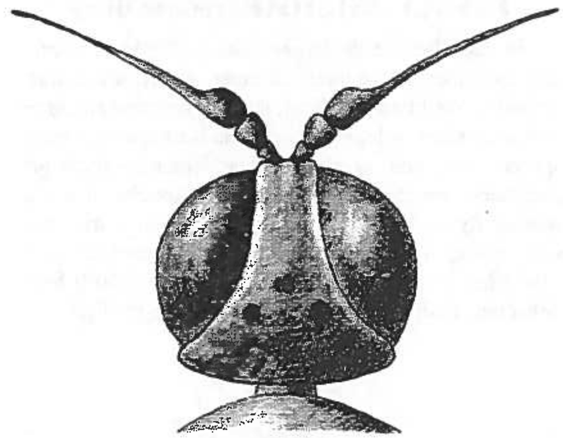


Fig. 22.29 Empididae: *Stilpon* sp., head

FAMILY DOLICHOPODIDAE
(long-headed flies)

The dolichopodids are usually recognized by their metallic colors, their long heads, and slender, unspined legs. *Aphrosylus* might be confused with canaceid flies, but they are usually larger, the costal vein is unbroken, and the third antennal segment tapers to a dull point rather than being globular. Both the larvae and adults are predaceous.

KEY TO THE GENERA OF DOLICHOPODIDAE

Wing length 3.0–3.5 mm; body metallic purple, occasionally with a touch of green on the sides of the thorax; legs black; third antennal segment longer than wide, tapering to a point and terminated by a style .... ***Aphrosylus***
-Wing length 4.5–5.0 mm; body metallic green with a tinge of red and yellow; legs yellow; third antennal segment about as long as wide, with an arista arising at the base (fig. 22.30) .... ***Thinophilus***

Aphrosylus fumipennis Van Duzee adults swarm over algae-covered rocks at the water's edge at all times. They occasionally are found on wrack. Larvae may be found living on algae-encrusted rocks. They have mouth hooks, pseudopods on most abdominal segments, and four fleshy processes posteriorly forming a circular depression. Adults have been collected from Isla San Esteban in the northwestern part of the Gulf and from Puerto Peñasco south to Bahía Kino.

Thinophilus longiventris Van Duzee (fig. 22.30) is a solitary fly with clear wings, found on the mud flats at Punta Sargento. It has also been recorded from Bahía Tepoca and "Bahía Gonzales" (probably Bahía San Luis Gonzaga, Baja California, Norte).

Thinophilus mexicanus Van Duzee is recorded from the same localities but no habitat is given. It differs from *T. longiventris* by having a clouded spot on the cross vein and on the middle of the last section of the fourth vein, and the hind tibia is all yellow rather than with a blackish ring at the base.

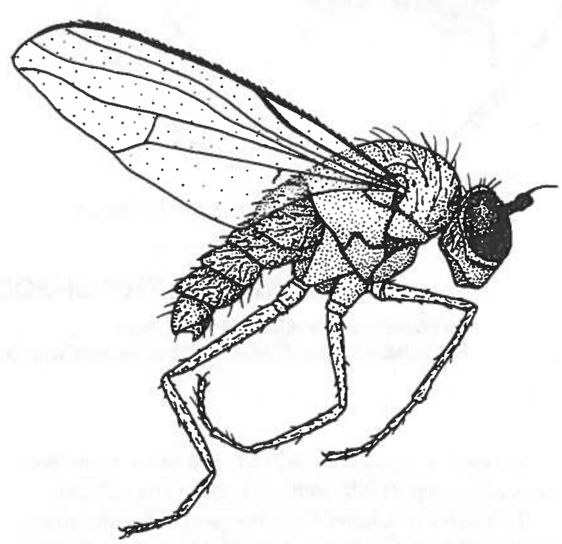


Fig. 22.30 Dolichopodidae: *Thinophilus longiventris*

FAMILY COELOPIDAE (seaweed flies)

Representatives of this family are found in many parts of the world, their larvae living in rotting seaweed. They are recognized by their deeply concave face in which partially lies the globular 3rd antennal segment, stout and spiny legs, spiny abdomen (some spines longer than the length of the tergite), and the unbroken costal wing vein (which is similar to the muscoid wing pattern illustrated in figure 22.35). The wings of the adults range from 2.7 to 5.3 mm in length, most being in the 4-mm range. Members of this family are similar to *Tethina* but are usually larger, and the cross vein *m* is longer than the distance of it to the posterior edge of the wing.

There is but a single species in this family recorded from the Gulf, *Coelopina anomala* Cole (fig. 22.31). This fly is often abundant on freshly stranded algae. In the early morning they are very active over the wet seaweed, constantly flicking their wings. They disappear as soon as the wrack dries. The abdomen is often covered with relatively large deutonymphs of the mite, *Thinoseius* sp., probably *T. spinosus* (Willman) (family Eviphididae).

This fly is common on the upper Sonoran coast south to El Desemboque, and on the northern Baja coast south to Isla Angel de la Guardia.

FAMILY SPHAEROCERIDAE

The only representative of this family found in the Gulf is an undescribed species of *Leptocera* (subgenus *Thoracochaeta*). It is characterized by its small size (wing length 0.9–1.8 mm), widely spaced eyes, laterally directed antennae with a long arista (fig. 22.32a), and short, lapping mouthparts. The costal margin of the wing is broken, and the venation is reduced to four longitudinal veins, the posterior two being short, not reaching the edge of the wing (fig. 22.32b).

These flies are extremely abundant at times, swarming out of rotting seaweed when disturbed. They have been found from Puerto Libertad south to Tastiota.

FAMILY TETHINIDAE

Most of the tethinid genera are confined to seashores and alkaline areas. Only the genus *Tethina* is found in the Gulf. It is characterized by its globular third antennal segment, muscoid-like wing venation, and broken costal wing vein. This genus is similar to *Coelopina* but is usually smaller, the face is less concave, and cross vein *m* is much shorter than its distance to the posterior edge of the wing.

Tethina spinulosa Cole is a small species with a wing length of 2.2–3.2 mm. This species has been found to be abundant, at times, in deep piles of wet, decomposing seaweed. Pale white mite larvae, hypopi of *Myianoetus* sp. (Anoetidae) are often found on the abdomen of this fly. *Tethina spinulosa* has been reported from southern California, Baja California, and along the Sonoran coast between Puerto de Lobos and El Desemboque.

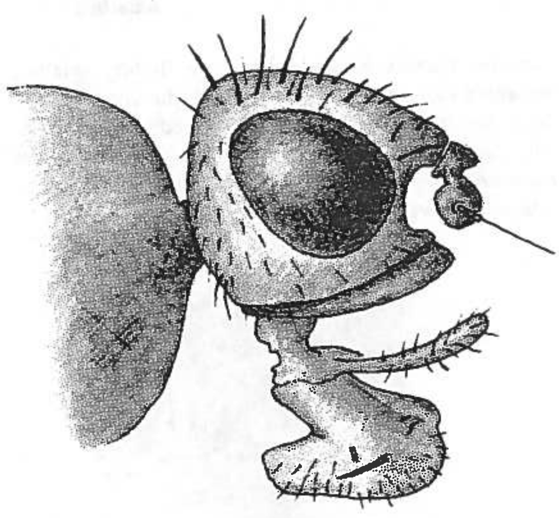


Fig. 22.31 Coelopidae: *Coelopina anomala*, head

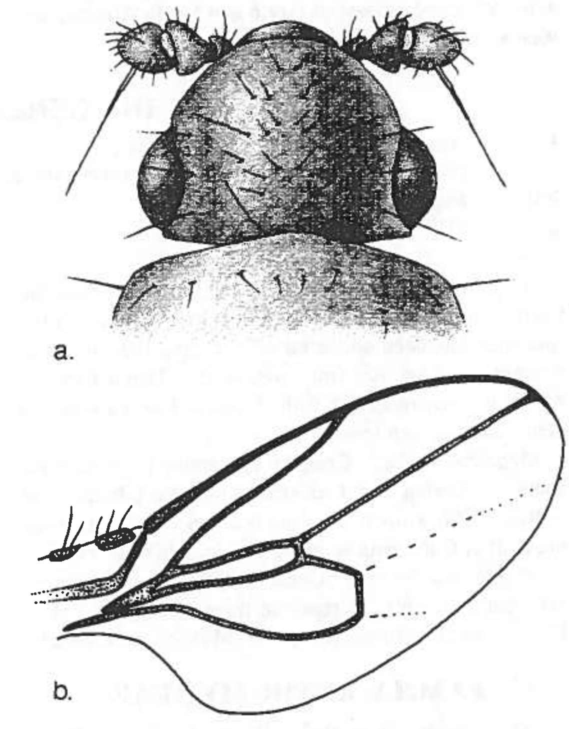


Fig. 22.32 Sphaeroceridae: *Leptocera* sp. (a) Head. (b) Wing.

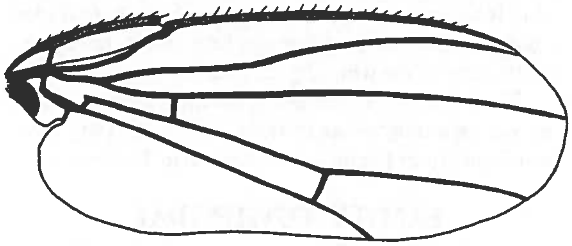


Fig. 22.33 Canaceidae: *Canaceoides* sp., wing

FAMILY CANACEIDAE (beach flies)

The beach flies are black with red eyes, all relatively small, with a wing length of 1.6–3.4 mm and a broken costal vein (fig. 22.33). The third antennal segment is large and globular with an arista; the legs are slender, and the abdomen is seven-segmented. The species of this family are separated by details in the male and female genitalia (Wirth, 1969). The larvae feed on algae on the wave-splashed rocks. The adults fly in swarms over wave-washed rocks and the adjacent sand and wrack.

The genus *Canaceoides* is represented in the Gulf by six of the ten known species. Other species are found along the Pacific coast of North and South America and west to the Hawaiian Islands (Wirth, 1969).

Canaceoides angulatus Wirth. This widespread species is found in swarms on wet sandy beaches and algae-covered granite rocks. It has been recorded from both sides of the Gulf, the Galápagos Islands, Hawaii, and Peru.

Canaceoides scutellatus Wirth is known only from Isla Ildefonso.

Canaceoides setosus Wirth is known from the southern part of Baja California and adjacent islands.

Canaceoides spinosus Wirth is known only from the southern tip of Baja California.

Canaceoides tenuistylus Wirth has been recorded from Isla San Francisco and Isla Partida.

Canaceoides n. sp. (fig. 22.33) is known from Punta Cirio south to Bahía San Carlos. It has been collected in association with *C. angulatus* Wirth.

FAMILY EPHYDRIDAE (shoreflies)

The ephydrids are characterized mainly by their small size, a very large oral cavity, and the once or twice broken costal vein. They differ from the quite similar canaceid flies by having five visible abdominal segments. There should be many more ephydrids recorded from the beaches of the Gulf, and no doubt many new species will be described from this region when more extensive collections are made and worked up. Some specimens have been collected but are as yet unidentified. Shoreflies are characteristically solitary species.

KEY TO THE GENERA OF EPHYDRIDAE

1	Head, thorax, and abdomen setose	2
	-Head, thorax, and abdomen bare, lacking setae	***Lipochaeta***
2(1)	Middle tibia with dorsal bristles	***Paralimna***
	-Middle tibia lacking dorsal bristles	***Mosillus***

Lipochaeta slossonae Coquillett is found on both the Pacific and Atlantic coasts, in saline habitats. One specimen has been collected off the mud flats at Punta Sargento and another from wet sand at Bahía Kino. It has also been recorded from Loreto, Isla Partida (on kelp), and Isla San José.

Mosillus tibialis Cresson is known from Canada south to Florida and California, the West Indies and Ecuador. It is known from the beaches on both sides of the Gulf of California south to Mulegé and Guaymas.

Paralimna decipiens Loew is recorded as "neotropical" but has also been reported from Michigan, Texas, Florida, and California (as well as Mulegé and Loreto).

FAMILY ANTHOMYIIDAE

The anthomyiids of the Gulf are large flies (4.3–6.0 mm wing length), with a muscoid type of wing, an unbroken costal vein and an elongate rectangular third antennal segment (fig. 22.34). They are similar to *Tetramerinx* (family Muscidae) but are slightly smaller, brownish rather than black, and with the cross vein *m* being half its length from the posterior edge of the wing. The family is represented in the Gulf by the genus *Fucellia*, which is well known along the Pacific shores where they swarm over rotting seaweed.

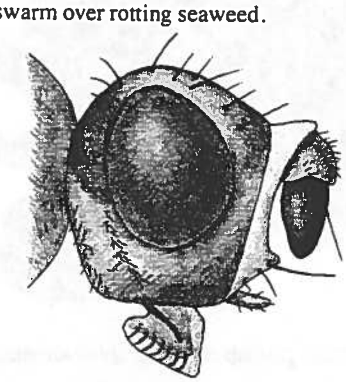


Fig. 22.34 Anthomyiidae: *Fucellia tergina*, head

KEY TO THE SPECIES OF FUCELLIA

Femora black except for tip (femur I at least dusky in some females) (fig. 22.34) .... *F. tergina*
-Femora orange .... *F. rejecta*

Fucellia rejecta Aldrich is known from Oregon, California, and the northern Sonoran coast, where its larvae feed on the eggs of the grunion, a fish that spawns on wet sandy beaches (Cole, 1969).

Fucellia tergina (Zetterstedt) is one of the commonest flies on the sandy beaches from Puerto de Lobos to Bahía Kino (fig. 22.34). Its larvae are found in wrack. The adults are common on wet sandy beaches, algae-covered rocks, and wrack. Deutonymphs of the mite *Thinoseius* sp. [*T. spinosus* (Willman)?] are often attached to the abdomen.

FAMILY MUSCIDAE

The muscids are large, bulky, black flies (wing length, 5.5–6.0 mm), with red eyes, a rectangular third antennal segment, and typical muscoid wing venation (fig. 22.35) with an unbroken costal vein. They are similar to *Fucellia*, an anthomyiid of similar size and shape. The family is represented in the Gulf by the single genus *Tetramerinx* (= *Phyllogaster*).

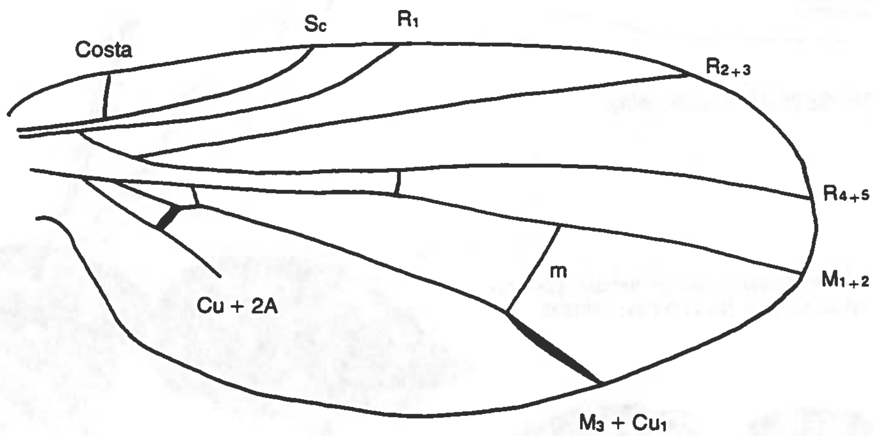


Fig. 22.35 Muscidae: *Tetramerinx* sp., wing

KEY TO THE SPECIES OF TETRAMERINX

Tibia black; antennal arista plumose, hairs much longer than diameter of arista .... *T. longispinus*
-Tibia orange; antennal arista not plumose, with short hairs as long as diameter of arista .... *T. inermis*

Tetramerinx inermis (Stein) has been collected off the mud flats at Punta Sargento where it is quite wary, keeping some distance from an approaching collector. It is also known from the coasts of Washington to California.

Tetramerinx longispinus (Malloch) has also been found on the mud flats at Punta Sargento, as well as wet sandy beaches at Punta Chueca.

Order Hymenoptera (wasps and ants)

The Hymenoptera of the intertidal zone consist of minute parasites whose hosts are insect eggs, larvae, and pupae. They are characterized by their small size, long antennae, and four pairs of wings (usually) with reduced venation.

Eight species of microhymenoptera have been collected in the intertidal zone. Most are represented by only a specimen or two and remain unidentified. They may have strayed in, but more likely most of them are parasites of insects inhabiting rotting seaweed. Until they are identified, or their habits known, they must remain unlisted.

Several species of ants have been collected on the sandy beaches. These are opportunists, foraging in from above the supralittoral zone. One commonly finds *Solenopsis xyloni* McCook, an orange ant with a black abdomen, and more than one species of the larger reddish harvester ant, *Pogonomyrmex*.

FAMILY BRACONIDAE

One small (1.5 mm), black unidentified species (fig. 22.36) of this hymenopteran family has been found to be common at Bahía San Carlos, Sonora. These braconids were observed walking about on algae-covered rocks which are covered during the high spring tides.

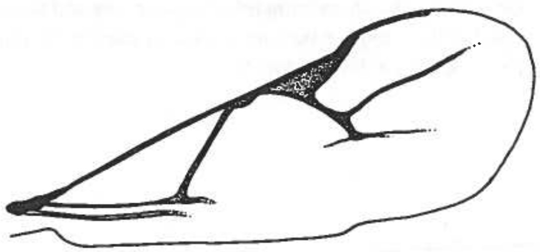
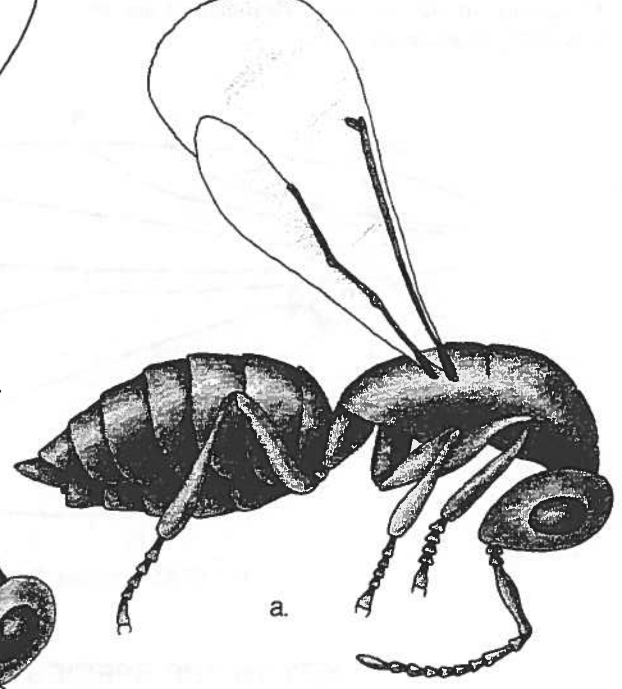


Fig. 22.36 Braconidae, wing

FAMILY PTEROMALIDAE

Another small (1.0–1.5 mm), black wasp (fig. 22.37) identified as an undescribed genus and species of the subfamily Spalanginae. Males are winged, but the females have reduced wings or are apterous. This species was found at Punta Cuevas, Sonora, crawling about on closely cropped (1/4 inch high) green algae mixed with tiny barnacles *(Chthamalus)*, at low tide in the sunny afternoon. The winged forms showed no tendency to fly, even when disturbed by collecting. The dolichopodid fly larvae, *Aphrosylus fumipennis* Van Duzee, were common among the algae and may be the host of this parasite.



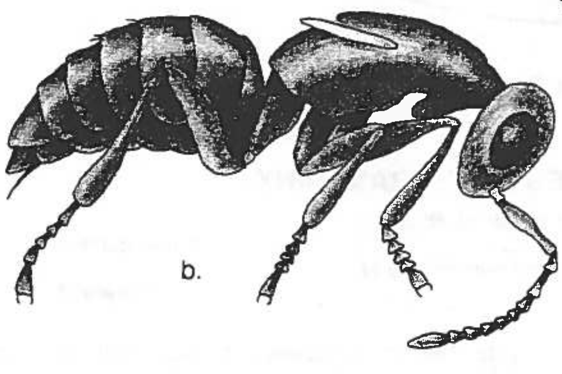


Fig. 22.37 Pteromalidae: new genus and species. (a) Winged male. (b) Wingless female.

23

ARTHROPODA: ARACHNIDA
(Mites, Spiders, and Scorpions)

by Vincent Roth* and Wynne Brown†

The Arachnida of the intertidal zone include a diverse assemblage of forms ranging from microscopic mites a few hundred micrometers in length to relatively large scorpions, 40 mm or more in length. This class is characterized by the absence of antennae and the presence of four pairs of legs (except mite larvae which have three pairs), chelicerae, and a pair of palpi. Most of these animals are predators, with the exception of some species of mites. They are all killed and preserved in 75 percent alcohol.

A GLOSSARY OF SPECIALIZED ARACHNID TERMINOLOGY

Calamistrum. A series of curved spines on the dorsolateral edge of metatarsus IV on cribellate spiders.

Chelicerae. The first pair of appendages of the arachnid head.

Claw Tufts. Bunches of hairs, often spatulate on the tarsal tips of two-clawed spiders.

Endites. Paired mouthparts lateral to the labium, usually rectangular.

Gnathosoma. The anterior part of the mite body bearing the mouthparts.

Hypopi (us). A specialized second nymphal stage of mites.

Idiosoma. The posterior part of a mite bearing the legs.

Pectines. Basal comblike abdominal appendages of scorpions.

Pedipalps. First pair of appendages anterior to the legs.

Phoretic. Said of animals attached to another and being carried from one place to another.

Retromargin. Opposite the promargin of the chelicerae, the posterior, usually toothed area adjacent to the claw.

Sclerotized. A hardening or thickening of the body wall.

Spinnerets. The three pairs of appendages at the apex of the spider abdomen through which silk is spun.

Telson. The last segment (stinger) of the scorpion's "tail."

KEY TO ARACHNIDA

1	Small to minute arachnids, less than 15 mm in length; caudal appendages, if present, minute	2
	-Large arachnids, 30 mm or more in length, including the caudal appendage	**Scorpionida**
2(1)	Abdomen lacking spinnerets at tip; pedipalp chelate; *or,* minute, species less than 2 mm in length	3
	-Abdomen with spinnerets at tip; pedipalps not chelate, simple or modified in adult males to a sperm transfer organ (figs. 23.10–23.13); over 2 mm in length	**Araneae (Spiders)**
3(2)	Minute arachnids, usually 2 mm or less in length; usually not flattened; with inconspicuous pedipalps (figs. 23.2–23.6)	**Acari (Mites)**
	-Small arachnids, over 2 mm in length; flattened; with large chelate pedipalps (fig. 23.1)	**Pseudoscorpionida**

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Order Scorpionida (scorpions)

Scorpions are a group of generally homogenous species characterized by their enlarged chelate pedipalps, broadly joined abdomen, long cauda (tail) terminated by a telson (sting), and with comblike pectines attached to the second abdominal sternite. These normally nocturnal arachnids are usually found in dry and hot regions of the world, although many are found in damp soil and even in caves. Along the shores of the Sea of Cortez they are commonly found on sand dunes and rocky supralittoral zones. All are predaceous, feeding mostly on ground-dwelling arthropods.

Two diurnal species of *Vaejovis* have been collected in the littoral zone of the Gulf. On a coarse gravel beach near Bahía de Los Angeles, Baja California Norte, scorpions have been seen moving at midday through the interstices of the gravel as the tide advanced. Two of these scorpions were seen feeding upon isopods (Roth, unpublished data). Williams (1971) found small scorpions on the beach of Isla Danzante in the Gulf, where they were stalking small insects in the fresh beach litter. They were active for about an hour during the hottest part of the afternoon.

Order Pseudoscorpionida (pseudoscorpions)

Pseudoscorpions are small (2.0–5.8 mm), flattened, scorpionlike arachnids characterized by their broadly attached abdomen, large chelate pedipalps, and the absence of a caudal appendage. They are usually found under leaf litter, under stones, in burrows or animal nests, and in caves where they prey on tiny arthropods. Species known from the littoral zone are found under wrack on sandy shores and under boulders or in crevices on rocky beaches. Recently Lee (1972) completed a thesis (unpublished) on littoral pseudoscorpions of the Gulf of California, and the following key is modified from his thesis.

KEY TO THE FAMILIES OF PSEUDOSCORPIONIDA

1 Tarsi of all legs similar; venom apparatus usually present in at least one chelal finger 2
-Tarsus of first leg with one segment, tarsus of fourth leg subdivided to form two segments; chelal fingers without venom apparatus .... **Chthoniidae**

2(1) Tarsi of all legs divided 3
-Tarsi of all legs not divided .... **Chernetidae**

3(2) Carapace more or less quadrangular, not triangular; pleural membrane of abdomen smoothly plicate; abdomen more or less parallel sided 4
-Carapace manifestly triangular; pleural membrane of abdomen wrinkled-rugose; abdomen subovate or globose .... **Garypidae**

4(3) Sides of carapace parallel sided; fixed finger of chela with 11 or 12 tactile setae; venom apparatus in fixed finger of chela only .... **Menthidae**
-Sides of carapace slightly diverging posteriorly; fixed finger with normally 8 tactile setae; venom apparatus in both chelal fingers .... **Olpiidae**

FAMILY CHERNETIDAE

Dinocheirus carminis (Chamberlin) is known from islands in the Gulf and adjacent areas, where it was collected from under drifted seaweed, stones, and debris along rocky beaches (Chamberlin, 1923) and from the underside of algae-covered boulders in the lower intertidal zone (Roth and Brown, unpublished data).

FAMILY CHTHONIIDAE

Paraliochthonius johnstoni (Chamberlin) is known from various islands in the Gulf and adjacent shores of Baja California. It was found under rocks regularly inundated by the sea (Lee, 1972).

FAMILY GARYPIDAE

The largest of the pseudoscorpions occur in this family, and all that are found in the Gulf belong to the genus *Garypus*. Members of this genus have broad, flattened abdomens and a narrow head, the whole appearance being teardrop-shaped (fig. 23.1).

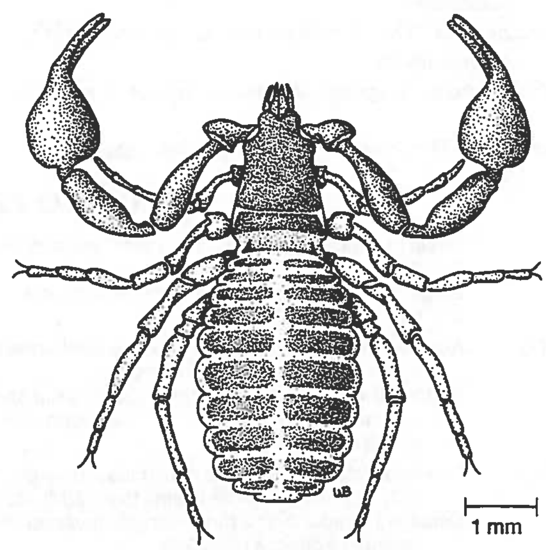


Fig. 23.1 *Garypus sini*, a pseudoscorpion (from Roth and Brown, in press)

Garypus sini Chamberlin and *G. pallidus* Chamberlin have been collected from various islands in the Gulf and adjacent shores of Baja California and Sonora. They are found under stones or drift along rocky or sandy beaches in dome or thimble-shaped nests made from silk and sand grains (Chamberlin, 1923). Specimens of *G. sini* have also been collected from under dried seaweed on the coast of Sonora (Roth and Brown, unpublished data). Perhaps this species is the same as the one reported by Evans (1968) from crevices in rocks at Bahía San Carlos, Sonora. Lee (1972) also describes a new species in his thesis from islands on the north end of the Gulf from under decaying algae.

FAMILY MENTHIDAE

Menthus lindahli (Chamberlin) was collected from under stones along a rocky beach in Sonora, but it does not appear to be confined to this habitat (Lee, 1972). *Menthus rossi* (Chamberlin) is found both in the littoral and supralittoral zones on a number of the islands in the Gulf and adjacent shores (it is also found inland).

FAMILY OLPIIDAE

One beach-dwelling pseudoscorpion of this family, *Serianus litoralis* (Chamberlin), was collected from "under a stone on beach" on Monserrate Island (Chamberlin, 1923), and one specimen was collected near Mazatlán, Sinaloa (Lee, 1972).

Order Acari (mites)

Intertidal mites are usually minute, and on the basis of size alone most can be separated from other intertidal arachnids. The largest species are slightly over 2 mm in length but most of them are less than 1 mm, and the six-legged larvae range down to 100 micrometers or less. Adult mites consist of two parts, the broadly joined abdomen (idiosoma) and the gnathosoma which includes the mouthparts, pedipalps, and the usually chelate chelicerae.

The mite population of the Gulf has been only lightly sampled. Most of the larger and more conspicuous species have been collected, but there are undoubtedly many more minute species. Specialized collecting techniques include using very fine nets, screening sand and gravel, and washing algae from rocks and decanting the residue.

Marine mites are known from a great number of habitats: some are free-living in the oceans, some are found in the interstitial spaces of littoral sand, and many are on algae-covered rocks or in crevices. They are predators, scavengers, algavores, and a few species are parasitic on marine vertebrates and invertebrates.

KEY TO THE LARGER AND MORE COMMON MITE FAMILIES

1	Body flattened, with a dorsal shield (figs. 23.4–23.5)	2
	-Body globose, without a dorsal shield (figs. 23.2, 23.3, 23.6)	3
2(1)	First two pairs of legs separated from posterior two pairs	**Rhodacaridae**
	-All legs equally separated	**Eviphididae**
3(1)	Tarsus I slender; body without velvetlike vestiture	4
	-Tarsus I dilated; body with velvetlike vestiture (fig. 23.3)	**Erythraeidae**
4(3)	Small mites 1.0 mm or less in length; occasionally red; idiosoma bulbous	5
	-Large mites 2.0 mm in length; always brilliant red; abdomen broad posteriorly, tapering to the long chelicerae (fig. 23.2)	**Bdellidae**
5(4)	Posterior femora not swollen	6
	-Posterior femora swollen	**Eupodidae**
6(5)	Pale yellow to green mites, less than 1 mm in length; eye spots absent	7
	-Red-orange mites, 1 mm in length; eye spots conspicuous, broadly spaced (fig. 23.6)	**Teneriffidae**
7(6)	Free-living mites	**Acaridae, Halacaridae, Hyadesiidae**
	-Parasitic or phoretic, attached to abdomen of tethinid flies	**Anoetidae**

FAMILY ACARIDAE

Caloglyphus sp. is a short-legged, heavily sclerotized mite about as long as broad (0.95 mm). It was collected at night on granite rock among barnacles at Punta Cuevas.

FAMILY ANOETIDAE (slime mites)

The hypopi (a tiny, 160–175 mm, second nymphal stage) of *Myianoetus* sp. have been frequently collected from the abdomen of the tethinid fly *Tethina spinulosa* Cole, a common inhabitant of the decaying wrack on the upper Sonoran coast.

FAMILY BDELLIDAE (snout mites)

The bdellids are characterized by their pear-shaped bodies and sharp gnathosoma (fig. 23.2). The only species in the Gulf, *Neomolgus littoralis* (Linn.), is a bright red, active mite, 2.2 mm or less in length. The palpi are twice as long as the chelicerae and slender. It differs from the only other large mites (Erythraeidae) by the absence of a velvetlike vestiture and by lacking a dilated tarsus. This predatory mite is found on algae-covered reefs and boulders up into the barnacle zone and is active during both day and night. This cosmopolitan species is the commonest mite of the upper Sonoran coast. We have records from Puerto Peñasco south to Bahía Kino.

FAMILY ERYTHRAEIDAE

This family is represented by one unidentified, very common, conspicuous, large (1.6 mm) red mite. It is often seen moving actively over wet rocks at low tide and on algae-covered, pitted rhyolite, and among barnacles of the genus *Tetraclita*. Like other members of the family, it is covered with a velvetlike vestiture and is distinguished by the slightly constricted body, the extrusible chelicerae, a palpal thumb-claw, dilated tarsi on legs I, and the front two pairs of legs widely separated from the posterior two pairs (fig. 23.3). The larvae of various members of this family are known to parasitize arthropods. Collections of this mite have been made from Puerto Peñasco south to Bahía Kino.

FAMILY EUPODIDAE

Eupodes sp. is a small (0.5 mm) whitish mite, characterized by its swollen hind femora and the anteriorly swollen idiosoma. It is found in clusters on algae-covered rocks. When disturbed, these mites become very active and appear to jump. They have been collected from Coloraditos south to Bahía San Carlos. Another *Eupodes*, *E. halophilus* Halbert, is known from the lower intertidal zone in England.

FAMILY EVIPHIDIDAE

Thinoseius sp. [*T. spinosus* (Willman)?] is a brownish mite about 1.45 mm in length and is similar to *Hydrogamasus* of the Rhodacaridae. It has a dorsal shield (fig. 23.4) but lacks the ventral abdominal plate, and its legs are closely grouped. They have been found under seaweed on Gulf shores, and deutonymphs are commonly found on the abdomen of the agromyzid fly *Fucellia tergina* Zett and the coelopid fly *Coelopina anomala* Cole. It is known from Punta Chueca. Other species of *Thinoseius* are common in rotting seaweed in England, New Zealand, and other parts of the world. *Thinoseius brevisternalis* (Canaris), the Pacific Kelp Mite, is known from the Pacific coast of America.

FAMILY HALACARIDAE

There are probably many species of these mites in the Gulf region; however, we have collected only two

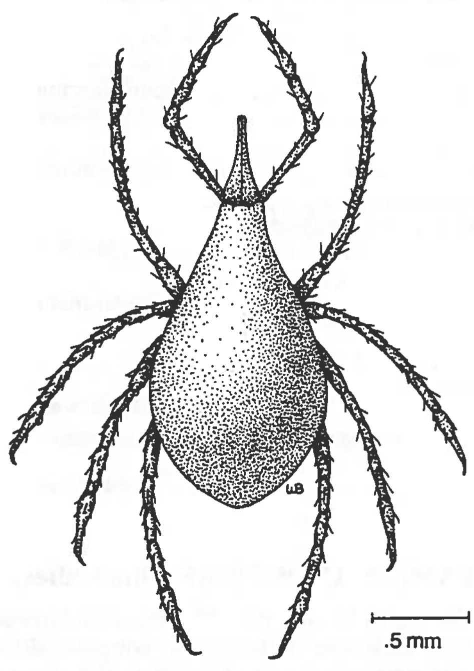


Fig. 23.2 *Neomolgus littoralis*, a bdellid mite (from Roth and Brown, in press)

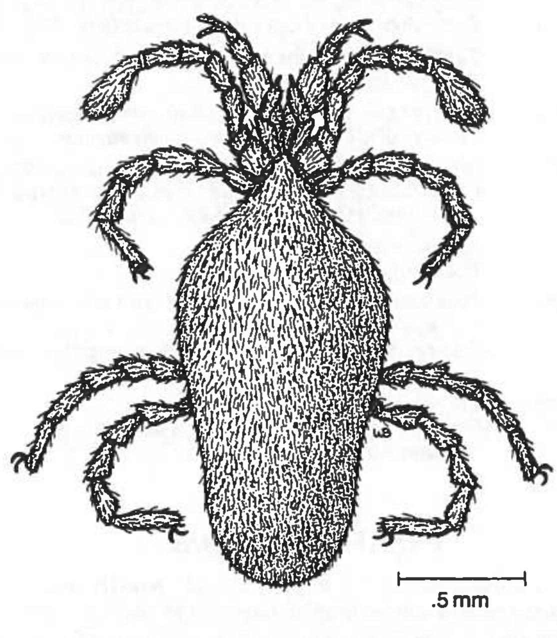


Fig. 23.3 A erythraeid mite (from Roth and Brown, in press)

and these remain unidentified. Scrapings from algae-covered rocks at Coloradítos produced a tiny (0.3 mm) green mite of the genus *Rhombognathus*. This mite had petiolate claws, short swollen gnathosoma, and a broad polished venter. An unidentified larva (0.92 mm) with transverse rows of slender setae was collected at the same type of habitat at Punta Cuevas and Punta Cirio.

FAMILY HYADESIIDAE

Representatives of *Hyadesia* sp. were collected from scrapings from algae-covered rocks at Coloraditos. These tiny (0.3 mm) mites were mottled green with yellow gnathosoma and legs, single clawed, with long abdominal setae (half as long as the body).

FAMILY PACHYGNATHIDAE

An unidentified species of this average sized (650 μm) mite has been found at Coloraditos and Punta Cirio. It is white with relatively broad chelicerae and a bulbous body with rows of short blunt setae across the idiosoma. This slow-moving pachygnathid was found on the bottom side of boulders along with chitons, sea cucumbers, and starfish.

FAMILY RHODACARIDAE

Hydrogamasus sp. is a large species, 1.2 mm long, with a polished orange-tan dorsal shield (fig. 23.5). The legs are stout, and the two anterior pairs are widely separated from the posterior pairs by a polished sternum and a ventral abdominal plate separated by a transverse membrane. These mites are found on the undersurface of large, algae-covered, granitic boulders embedded in coarse sand among chitons, sea cucumbers, and starfish. They have been collected at low tide, between Punta Cirio and Punta Cuevas. *H. littoralis* (G. and R. Canestrini) is known from crevices in the intertidal zone in England.

FAMILY TENERIFFIDAE

The family Teneriffidae is characterized by its two pairs of widely spaced eyes (fig. 23.6), and is represented in the Gulf by an undescribed species. It is about 1.0 mm in length, red to orange in color, with very conspicuous, broadly spaced eye spots on a broad, almost rectangular body. The body tapers abruptly in front of the eye spots to the chelicerae. The legs are about as long as the body and very spiny. These common predatory mites are usually found on algae-covered pitted rocks, among barnacles, and on the sand adjacent to these rocky shores. They are active day and night from Bahía Kino north to Punta Cirio.

Order Araneae (spiders)

Spiders found in the intertidal zone of the Gulf are relatively small, ranging down to 2.3 mm in length. The wolf spider *Arctosa serii* Roth and Brown, however, reaches 12 mm. Spiders are distinguished from all other

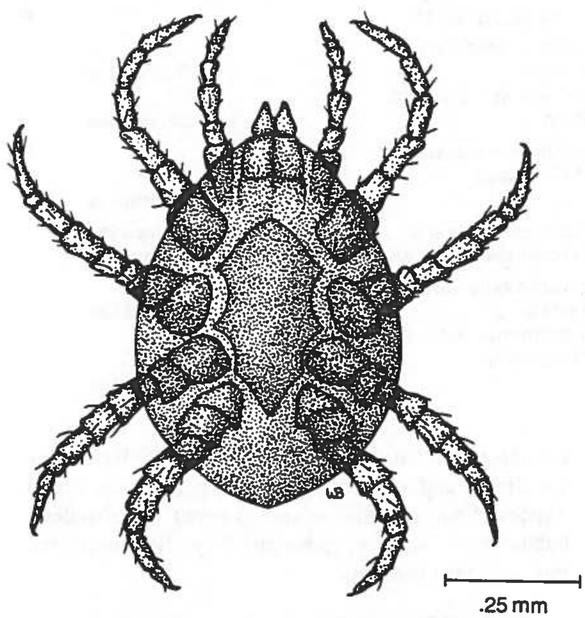


Fig. 23.4 *Thinoseius* sp., an eviphidid mite (from Roth and Brown, in press)

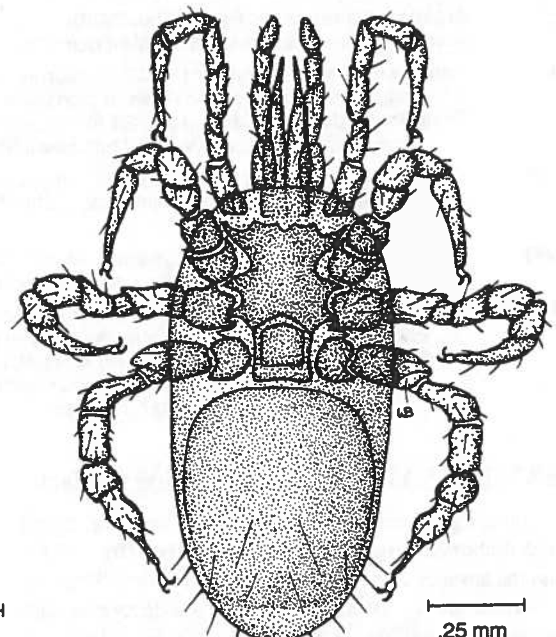


Fig. 23.5 *Hydrogamasus* sp., a rhodacarid mite (from Roth and Brown, in press)

arachnids by having two body parts, the cephalothorax and the petiolate abdomen, the latter bearing a compact group of six spinnerets. The palpi of the female is simple, that of the male enlarged and modified into sperm transfer organs.

All spiders are predators, capturing almost any small arthropod they can subdue, although many have preferences. Many are wanderers and occasionally will be found moving down from the supralittoral zone to forage on the beach. The species listed in the Clubionidae, Gnaphosidae, and Salticidae may or may not be confined to the beach, but the other species are. One common spider that lives in the mangroves and is never submerged is the spiny abdomened orb-weaver, *Gasteracantha cancriformis* (Linn.), well known to the Seri Indians as "Spider Rich One." It hangs from large orb webs among the mangrove trees and, because of its brilliant red and yellow coloration, is frequently commented upon.

Intertidal spiders can be collected by turning rocks and debris on the beach or by collecting at night using a head lamp. A set of blunt tweezers is best for capturing fast moving spiders, and by dampening the tips with alcohol the smaller species can easily be picked up.

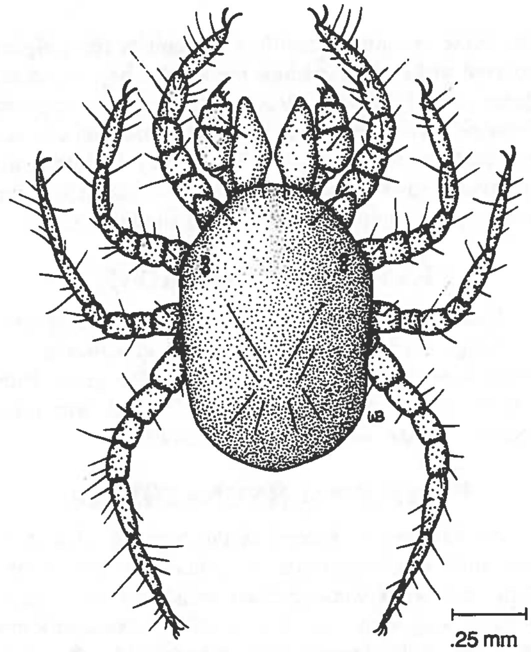


Fig. 23.6 *Teneriffia* sp., a teneriffid mite (from Roth and Brown, in press)

KEY TO THE FAMILIES OF SPIDERS

1	All eyes small and similar in size (fig. 23.13)	2
	-One pair of eyes large (1.25 to 2 times as large as others), projecting forward (figs. 23.8, 23.9)	3
2(1)	Anterior spinnerets contiguous (fig. 23.10)	4
	-Anterior spinnerets separated by their diameter or more (fig. 23.11)	6
3(1)	Anterior median eyes largest (fig. 23.8); diurnal jumping spiders from drift, sandy beaches, and rocks at high water mark	**Salticidae**
	-Posterior median eyes largest (fig. 23.9); nocturnal wolf spiders from sandy beaches, often in vertical burrows in sand	**Lycosidae**
4(2)	Cribellum and calamistrum absent; web filmy, sheetlike, or absent	5
	-Cribellum and calamistrum present (figs. 23.14–23.15); web ladderlike (fig. 23.16)	**Dictynidae**
5(4)	Legs and thorax pale yellow; legs stout; usually found under wrack	**Clubionidae**
	-Legs and thorax orange; legs thin; usually found in cavities under boulders	**Erigonidae**
6(5)	Chelicerae small, vertical (fig. 23.18); retromargin with single carina; endites rounded ectally; usually found under wrack	**Gnaphosidae**
	-Chelicerae large (fig. 23.12), projecting forward; retromargin with six or seven large teeth; endites straight and notched ectally; usually found at night among barnacles	**Desidae**

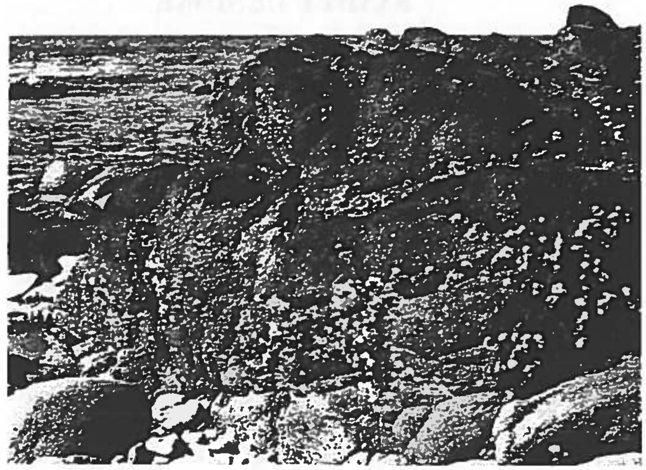
FAMILY SALTICIDAE (jumping spiders)

Jumping spiders are characterized by their broad cephalothorax, large anterior median eyes (fig. 23.8), and the absence of notches on their trochanters. They are a colorful group, the males of which are decorated with bright colors and fringes of hairs on the palpi or legs.

Several species of *Pellenes* have been collected from shores of the Gulf (Chamberlin, 1924) including *P. ammophilus* Chamberlin (from Isla Ceralbo and Isla San Francisco), *P. polius* Chamberlin (from Isla Santa Catalina), and one unidentified species from Punta Tepoça, Sonora. Little is known about these spiders' habits in the Gulf, but apparently they often invade the intertidal zone regularly.

FAMILY LYCOSIDAE (wolf spiders)

Wolf spiders are distinguished from all other littoral spiders by the large posterior median eyes (fig. 23.9)



A B

Fig. 23.7 Boulder-strewn beaches on the coast of Sonora. (A) Teneriffid, bdellid, thrombidiid, and erythaeid mites are found on the reef in the background. Rhodacarid and pachygnathid mites and erigonid spiders are found under the largest boulders. (B) The habitat of the spiders *Paratheuma* and *Dictyna*.

and notched trochanters. One species of wolf spider, *Arctosa serii* Roth and Brown, appears to be confined to the sandy intertidal zone on both sides of the Gulf. *Arctosa littoralis* (Hentz), with similar habits on the Atlantic coast, may inhabit this zone also, as there are records from inland Baja California and from some coastal localities. *Arctosa serii* is pale yellow, with a slightly darker thorax and legs, and a darker irregular abdominal pattern over the heart region. This spider makes 15- to 20-cm burrows along the drift line of sandy beaches, emerging at night, sometimes remaining in the mouth of its burrow and often resting nearby. They can easily be found by using a head lamp to spot the reflection of their eyes as one walks along the beach. The spiders remain in their burrows when the tide covers them, emerging at low tide to feed upon amphipods and *Phaleria* sp., a darkling ground beetle of sandy beaches (Brown, in preparation). Occasionally, *Lycosa anteleucana* Montgomery (with black venters) will stray onto the beach. These are fairly large spiders, 10–12 mm in length.

FAMILY CLUBIONIDAE

Clubionids are not distinctive spiders. They have relatively stout legs, are two-clawed with claw tufts, bear compactly arranged spinnerets (fig. 23.10) and similar sized eyes in two rows, and lack a cribellum and calamistrum. They are represented in the Gulf by an undescribed species of the genus *Tixcocoba*, of the subfamily Clubioninae. This pale yellow spider is about 5 mm long, with stout chelicerae and relatively stout legs. It is a wandering spider, living under wrack on rocky beaches at Punta Tepoca.

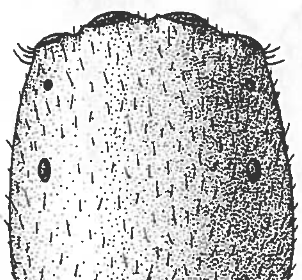


Fig. 23.8 Eyes of a salticid spider (from Roth and Brown, in press)

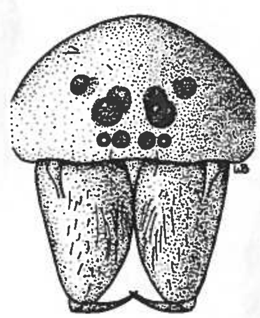


Fig. 23.9 Eyes of a lycosid spider (from Roth and Brown, in press)

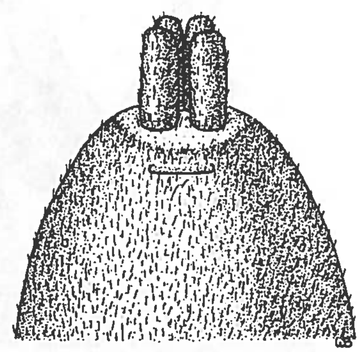


Fig. 23.10 Contiguous spinnerets of members of the family Clubionidae (from Roth and Brown, in press)

FAMILY DESIDAE

The desids are characterized by their large projecting chelicerae (fig. 23.12) and widely spaced spinnerets (fig. 23.11) (wider than those of gnaphosids), and a slightly advanced tracheal spiracle. This family contains the well-known marine spiders of the genus *Desis*, found in tropical waters from western Africa to the Galápagos Islands. On the Sonoran shores of the Gulf there is a species in the related genus *Paratheuma*, *P. interaesta* (Roth and Brown; Platnick, 1977). This is a moderate sized spider, 4.6–5.8 mm in length (fig. 23.13). This nocturnal spider lives along rocky shores in the intertidal zone and emerges from its retreat after dusk during low tides. During the day they have been found in empty barnacle shells. They feed upon flies, especially dolichopodids, which are commonly found along the water's edge, but have refused isopods (Roth and Brown, 1975). They have been found from Puerto Peñasco south to Punta Cuevas.

FAMILY DICTYNIDAE

Dictynids are characterized by the presence of a cribellum and calamistrum (figs. 23.14–23.15), and are the only cribellate spiders found in the intertidal zone of the Gulf. Only one species is found in this region, *Dictyna mineata* Banks, a small spider ranging from 2.5 to 4.3 mm in length with brownish-orange thorax and legs and a dark gray abdomen. It makes its retreat in rock crevices and empty barnacle (*Tetraclita*) shells on vertical or almost vertical surfaces. The spider lives in the upper half of the barnacle where it forms small (4.5–5.5 mm in diameter), lens-shaped cocoons. There are usually several cocoons in a shell, each containing 15–19 eggs. At night, and when its retreat is not submerged, this spider emerges and spins a horizontal ladderlike web that extends from the mouth of the opening to an adjacent point 15 or 20 cm (or more) away with guide lines extending outward, crisscrossed with vertical supporting webs (fig. 23.16). The spider is often seen feeding on dolichopodid flies, common on the wave-washed rocks. It is found from Guaymas north to Punta Peñasco.

FAMILY ERIGONIDAE (dwarf spiders)

The erigonids are recognized by their small size, slender legs without spines (fig. 23.17), similar sized eyes in two rows, compactly arranged spinnerets, and the absence of a cribellum and calamistrum. Most are found in litter, some in swamps, and a few in the littoral zone. In the Gulf there is one undescribed species of *Erigone*, representing the smallest of our littoral spiders (2.3–2.6 mm long). The males of this species have distinctive short spurs on the outer side of the palpal femur and the front of the chelicerae. *Erigone* is found in air pockets in depressions under large boulders in company with chitons, sea cucumbers, bryozoa, and starfish, where they build filmy webs. They have been found from Punta Lobos south to Punta Cuevas, and at Coloraditos (on the east coast of Baja California Norte).

FAMILY GNAPHOSIDAE

Gnaphosids are usually recognized by their active habits (for they are often seen dashing across the substrate), by their oblong or slanted posterior median eyes, small chelicerae (fig. 23.18), and widely separated spinnerets. They can be separated from all other intertidal spiders by the rounded lateral edges of the endites.

Two species are found on the shores of the Gulf, *Gnaphosa maritima* Platnick and Shadab, recorded from near Bahía de los Angeles, Baja California Norte; and *G. synthetica* Chamberlin from Isla San Luís, Isla Tiburón, and the shores of Sonora. These spiders range from 5 to 8.5 mm in length and are light tan in color. They both have been collected on gravelly beaches, and *G. synthetica* is especially common under wrack, living with certain isopods and amphipods (Platnick and Shadab, 1975; Roth and Brown, unpublished data).

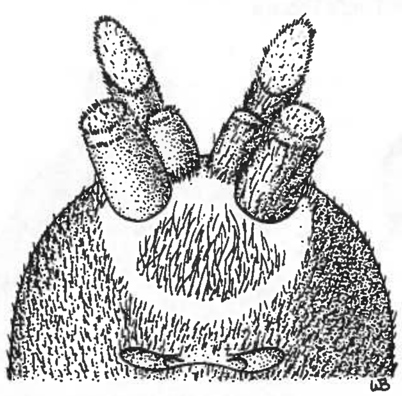


Fig. 23.11 Separated spinnerets of members of the family Desidae, *Paratheuma interaesta* (from Roth and Brown, in press)

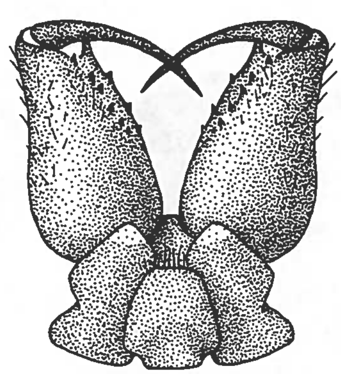


Fig. 23.12 Chelicerae of *Paratheuma interaesta*, with toothed retromargin

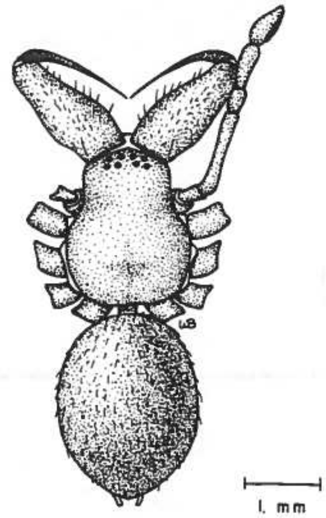


Fig. 23.13 *Paratheuma interaesta*, male
(from Roth and Brown, in press)

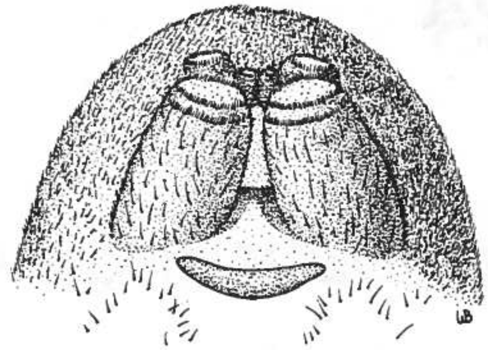


Fig. 23.14 Cribellum of a dictynid spider
(from Roth and Brown, in press)

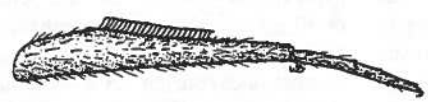


Fig. 23.15 Calamistrum of a dictynid spider
(from Roth and Brown, in press)

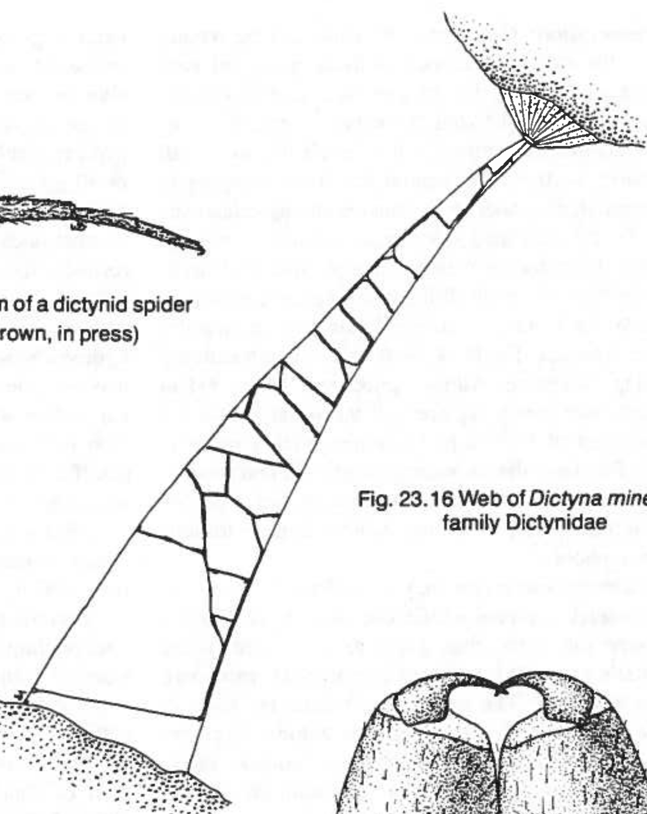


Fig. 23.16 Web of *Dictyna mineata*,
family Dictynidae

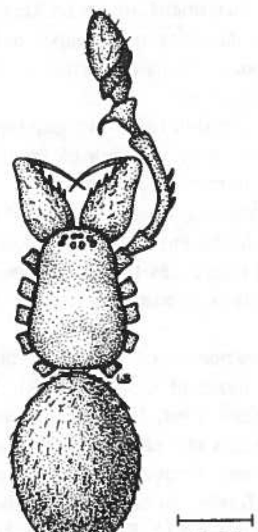


Fig. 23.17 *Erigone* sp., male,
family Erigonidae
(from Roth and Brown, in press)

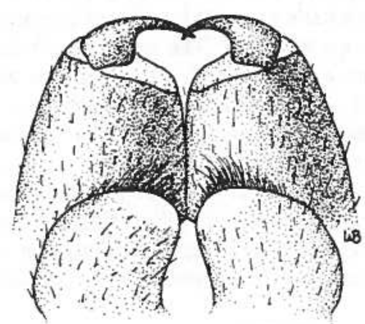


Fig. 23.18 Chelicerae
of a gnaphosid spider

24

BRYOZOA (Moss Animals)

by William C. Banta*

Preservation: Calcareous Bryozoa can be readily dried in the sun and wrapped in tissue paper for easy transport and storage, but this involves loss of noncalcareous forms and destroys the value of specimens for all but taxonomic purposes. It is preferred to fix all material in 5–10 percent neutral formalin, changing to 70 percent alcohol later to prevent dissolving calcareous parts. To fix expanded specimens, cocaine is perhaps best, but chlorotone or menthol crystals also work well. Float crystals in a small dish containing the animals, in the shade, for 1–4 hours; fixing is then done in formalin or gluteraldehyde. Dr. R. S. Boardman recommends the following procedure: Allow lophophores to expand in seawater, then gently replace half the water with a 7.5 w/w solution of $MgCl_2$ in tap water, adding more as needed. Fix when the animals no longer respond to probing (an hour or so). Store in 70 percent alcohol in bottles filled to the top to prevent mechanical damage to delicate lophophores.

Calcareous specimens may be soaked 2–3 hours in laundry bleach (aqueous KOCl; potassium hypochlorite) to remove soft parts, then glued to slides with white carpenter's glue or placed in paleontologists' cardboard "foram mounts." The latter are preferred but take up more space. Mount an unbleached colony fragment next to the bleached one to preserve cuticular parts. Bleached, dry specimens may be dyed with ink applied with a brush to increase contrast.

Calcified bryozoans may be stained (Harris's hematoxylin works well) and mounted in balsam. Since noncalcified forms usually collapse in xylene, most require gentle impregnation. After staining, transfer to 3 percent glycerine in a petri dish; allow the water to evaporate and mount in glycerine jelly. Calcified forms may be decalcified in acid fixers (Bouin's, Zenker's, Gilson's); formalin-fixed material can be decalcified in 5 percent trichloracetic acid or 2 percent acetic acid in 70 or 80 percent alcohol, and embedded in glycerine jelly. J. Soule (1963:21) recommends this procedure for ctenostomes boring in calcareous shells: decalcify formalin-fixed shells in 5 percent trichloracetic acid, stain in 10 percent azocarmine or safranin in 70 percent alcohol, dehydrate and mount in synthetic hydrocarbon-soluble resins such as Permount. Permount may become opaque with age and should be ringed with nail polish when dry if specimens are to be kept more than five years. Tough cuticular parts make ordinary paraffin sections disappointing; methacrylate or epoxy embedding methods are preferred.

Most bryozoan identification requires a good-quality binocular dissecting microscope with a high magnification (x 50 at least) to see minute details.

Taxonomy: The Bryozoa are here considered a distinct phylum, unrelated to the entoprocts. A good summary of arguments and references to the controversies over the name of the phylum is found in J. and D. Soule (1968).

Major taxonomic treatments of Bryozoa from the Gulf of California are those of Osburn (1950, 1952, 1953), J. Soule (1953, 1959, 1961, 1963), and J. and D. Soule (1964). Osburn treats the entire eastern Pacific, and Soule and Soule covered Scammon's Lagoon on the west coast of Baja California, an area related zoogeographically to the northern Gulf (J. Soule, 1963:2). Although there have been other papers on Gulf bryozoans, these are scattered, narrow in scope, and of less value to the generalist. Beginners interested in bryozoan

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morphology, physiology, and ecology will find Hyman (1959), Soule et al. (1975), and Ryland (1971) most valuable.

Bryozoans have the unfortunate reputation among zoologists of being difficult to work with. I think this is due more to the unfamiliar terminology than to anything else. Zoologists don't complain nearly so much about identifying mammals, arthropods, or molluscs, even though there are more specialized names for structures in these groups than for bryozoans (Schopf et al., 1975)! Maybe students are bamboozled by bryozoans because they are unfamiliar with the names of parts because the Bryozoa are so badly neglected in zoology courses. The Bryozoa are often stuffed away in chapters like "lesser lights" or "minor coelomates"—perhaps because textbook authors find them hard to write about, because they are also unfamiliar with the terminology. The result is a self-perpetuating circle of neglect.

Bryozoans *have* been neglected. Large parts of the intertidal and especially subtidal of the Gulf of California are dominated by bryozoans like *Antropora, Watersipora*, and *Schizoporella*. J. Soule (1963) reports 160 species from the Gulf, but that is probably a conservative underestimation because new species keep turning up almost anywhere one looks closely. Besides, bryozoans are not well studied, and most bryozoan taxonomists may fairly be called "lumpers." A "splitter" turned loose in the group might well increase the number of species astronomically. If diversity or biomass means anything, bryozoans should be as carefully studied as, say, echinoderms and coelenterates.

No attempt has been made in this chapter to divide the Bryozoa into major taxa below the level of "order," because they are in a state of rapid change. In general, the arrangement of species follows that of Osburn and Soule. The species included tend to be weighted toward the ascophoran cheilostomes because of my own interest. The key is mostly artificial and weighted heavily toward easily seen characters, and terminology has been kept as simple as possible. The most frequently used terms are illustrated in figure 24.1.

Because of the variability of bryozoans and because the taxonomy of many groups is poorly understood, exact identifications require careful study of many primary literature sources, a good deal of experience, and often reference to type specimens. Furthermore, many new species undoubtedly lurk in the Gulf of California. This chapter is intended as a semipopular account of the most common or conspicuous forms and only 108 species are treated herein. The descriptions are necessarily abbreviated and rely heavily on illustrations, usually copied from drawings of specimens taken far from the Gulf of California. If bryozoan determinations are to be used for any serious taxonomic or zoogeographical purposes, readers are urged to bolster their determinations by referring to the references cited or to send their specimens to a specialist.

Acknowledgments: This account is based on my own work in the northern Gulf of California and, heavily, on the fine works of R. C. Osburn, J. F. Soule, and D. F. Soule. In many cases, particularly where Gulf species do not occur to the north, the descriptions are taken from these authors and rewritten to be more understandable to nonspecialists. John and Dorothy Soule and Dr. A. H. Cheetham deserve special thanks for reading the manuscript and for their less direct help a thousand times before. Woljie Lee typed the manuscript, and Carol Cohen helped with six illustrations. Lee Crist, Marcia Loeb, and Daniel Goldy tried out the key and made many helpful suggestions.

GLOSSARY OF SPECIAL TERMINOLOGY FOR BRYOZOA

Aperture. The opening through which the lophophore (feeding organ) is protruded. (The term is used elsewhere by some authors as the uncalcified part of the frontal wall in some anascan cheilostomes.) See fig. 24.1.

Ascopore. See ascus.

Ascus. In cheilostomes, a cuticular sac underneath the frontal wall which opens to the outside through part of the aperture or through a special pore, the ascopore.

Autozoid. The feeding individual in a colony, equipped with a functional lophophore.

Avicularium. In cheilostomes, a structure (probably a heterozoid) with a modified operculum, called a mandible, closing like a jaw on the rostrum. The function is unknown, possibly defensive.

Basal. The rough equivalent of dorsal; the side attached to the substrate. Opposite of frontal. See fig. 24.1.

Distal. The rough equivalent of anterior; the direction of budding, from the center to the edge of the colony; opposite of proximal. See fig. 24.1.

Frontal. The rough equivalent of ventral; the side away from the substrate. Opposite of basal. See fig. 24.1.

Heterozoid. A modified individual in a colony; a zoid other than a feeding zoid (autozoid), derived during evolution from an autozoid.

Hinge tooth. Calcareous projections into the aperture of cheilostome bryozoans on which the operculum pivots. See fig. 24.1.

Mandible. In cheilostomes, the movable cuticular "jaw" of an avicularium. See fig. 24.1.

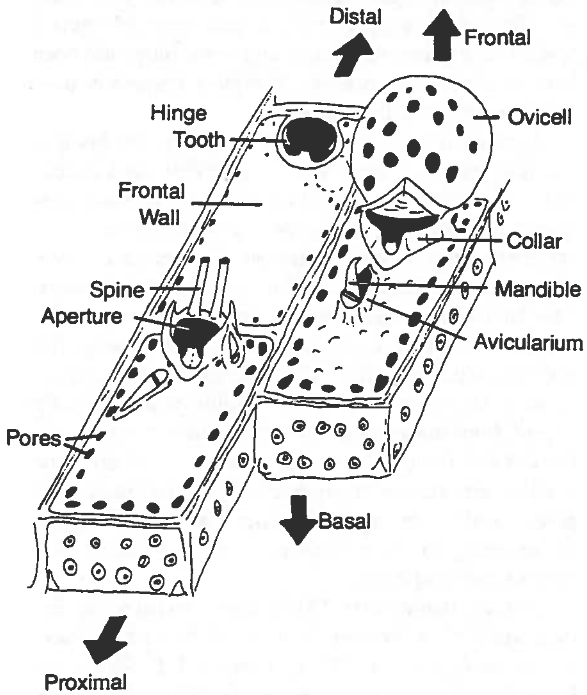


Fig. 24.1 Three zoids of the ascophoran cheilostome *Parasmittina*, to show the most commonly used terms (modified from D. Soule, 1973)

Oecium. Brood chambers formed from the entire body of fertile zoids in cyclostome and a few cheilostome Bryozoa (used by some authors as a synonym of ovicell).

Operculum. In cheilostomes, a cuticular (rarely calcified) flap of body wall which closes the aperture, like a little trapdoor.

Ovicell. Brood chambers in most cheilostome Bryozoa. See fig. 24.1.

Peristome. A calcareous collar around the aperture, or a tube bearing the aperture at the tip.

Proximal. The rough equivalent of posterior; the direction opposite of budding, from the center to the margin of the colony; opposite of distal. See Fig. 24.1.

Quincunx. The lacelike arrangement of zoids in most colonies. Resembles "running bond" or "standard bond" in brickwork. See fig. 24.1.

Rostrum. In cheilostomes, the reinforced base of an avicularium on which the mandible (jaw) closes.

Spine. In cheilostomes, hollow, tubular, often calcified projections from zoid margins, especially near the aperture. Distinguished from knobs and spikes of calcium carbonate, which are solid, not hollow. See fig. 24.1.

Vibraculum. In cheilostomes, an aviculariumlike heterozoid with a long whiplike "setum" movable in more than one plane.

Zoid. In colonial animals, the individual in a colony. See also autozoid, heterozoid. Also spelled zooid.

KEY TO THE COMMON BRYOZOA

1 Colony flaccid, flexible; uncalcified or lightly calcified; no macroscopic parts brittle; colorless, brownish, purplish, or white 2

-Colony brittle; encrusting (lacy or crusty), or erect with at least some macroscopic parts that break with pressure; any color 10

2(1) Colony creeping; zoids inconspicuous individually, forming disorganized brown mats, borings in shells, or inconspicuous; colonies with tubular autozoids arising from a stolon smaller in diameter than autozoids; aperture squared, no operculum; includes most ctenostomes 3

-Colony erect and conspicuous; colorless, yellow, or brown; autozoids arise from each other or from a stolon larger in diameter than autozoids; cellularine cheilostomes and some ctenostomes 6

3(2) Boring in shells .... **The calcium-penetrating Bryozoa** (p. 369)

-Not boring shells 4

4(3) Gizzard present, recognized as a cluster of scores of tiny polygonal retractile teeth in the gut .... ***Bowerbankia gracilis*** (p. 367)

-No gizzard 5

5(4) Autozoids erect with a thin, tapering proximal part attached to the stolon .... ***Walkeria tuberosa*** (p. 369)

-Proximal parts of autozoids attached to the substrate; erect; parts not thinned proximally .... ***Nolella stipata*** (p. 367)

6(2) Totally uncalcified; autozoids tubular in shape, arising from a stolon; colorless or brown; no parts crushable; colony mostly collapses when dry or removed from water; erect ctenostomes 7

-Lightly calcified; whitish; zoids (but not whole colonies) can be crushed individually with a dissecting needle; zoids retain much of their shape when dry; autozoids tubular, box-shaped, or otherwise, arising from each other; most cellularine cheilostomes **8**

7(6) Autozoids form a helix along the stolon .... ***Amathia* spp.** (p. 367)
-Autozoids arise in rows or clusters, not in a helix .... ***Zoobotryon verticillatum*** (p. 369)

8(6) Colonies purplish; no avicularia; no spines; ovicells large, spherical, whitish .... ***Bugula neritina*** (p. 375)
-Colony color otherwise; avicularia present; usually with spines; ovicells variable **9**

9(8) Colony colorless or yellowish; avicularia stalked .. ***Bugula californica*** **[and other species]** (p. 375)
-Avicularia not stalked; vibracula present; colony usually orange when live, tan when preserved .... ***Scrupocellaria* spp.** (p. 375)

10(1) Zoids widely separated in uniserial branching rows; colony creeping on algae or hard substrates, inconspicuous **11**
-Colony otherwise **15**

11(10) Aperture perfectly circular, on a long or short tube, finely perforated, but not annulated or swollen terminally (also see first part of couplet 12) .... ***Stomatopora granulata*** (p. 366)
-Aperture slitlike or with a proximal notch, not circular; operculum present **12**

12(11) A long or short tube extending vertically from the substrate at the distal end of the attached part (tube is annulated, finely perforate, with a terminal swelling and slitlike aperture); lightly calcified (if the vertical tube is broken off, it may resemble *Stomatopora,* couplet 11) .... ***Aetea* spp.** (p. 369)
-Autozoids entirely attached to the substrate (no erect parts extending vertically from the substrate) **13**

13(12) Spines abundant; most of frontal (upper) surface uncalcified, covered by a thin membrane; aperture covered by a crescent-shaped or hemicircular operculum continuous with the thin frontal membrane .... ***Membranipora* spp.** (p. 371)
-No spines; frontal wall calcified, with radial growth rings; aperture with a V-shaped proximal notch (*Hippothoa*) **14**

14(13) Proximal thinned part of autozoid shorter than rest of autozoid .... ***Hippothoa divaricata*** (p. 378)
-Proximal thinned part longer than rest of autozoid .... ***Hippothoa distans*** (p. 378)

15(10) Colony erect, lacy, stony; with regularly arranged oval holes about 1 mm long; orange when live .... ***Phidolipora labiata*** (p. 390)
-Colony otherwise **16**

16(15) Colony shaped like a cup or shallow cone; on sand, not permanently attached to a substrate; 2 mm to 2 cm in diameter .... ***Cupuladria canariensis*** (p. 373)
-Colony otherwise **17**

17(16) Colony erect, branching, with cuticular joints so that brittle calcareous parts (internodes) are connected by flexible intervals **18**
-Colony otherwise **19**

18(17) Autozoids tubular or nearly so, finely perforated on all sides; aperture nearly circular; swollen fertile zoids (oecia) present; no avicularia or ovicells .... **Crisiids** (p. 366)
-Autozoids rectangular, lacy, with a shallow proximal apertural notch; large spherical ovicells; a pair of large holes proximal and lateral to the aperture; large avicularia scattered among autozoids .... ***Thalamoporella californica*** (p. 373)

19(17) More than half the frontal surface of autozoids uncalcified; aperture covered by a hemicircular or crescent-shaped operculum at the distal end of the zoid; spines usually present around the edge of the zoid; usually encrusting, lacy in appearance **20**
-Most or all the frontal surface except the aperture calcified; aperture, spines, and colony form variable **30**

20(19) Autozoids rectangular, usually with knobs at corners or paired at one end; 3/4 or more of frontal surface uncalcified; colorless, white, or pale buff; no ovicells or avicularia (some membraniporids) **21**

-Autozoids rectangular through oval to polygonal; knobs absent; spines, ovicells, avicularia, color, and frontal calcification variable 23

21(20) Knobs prominent, white, about as wide as the aperture; spines absent .... ***Membranipora tuberculata*** (p. 369)

-Knobs smaller or absent; spines present or absent 22

22(21) Delicate chitinous spinules on the thin frontal membrane covering the autozoids; no spines .... ***Membranipora arborescens*** (p. 369)

-No delicate spinules on the frontal membrane; spines present or absent .... ***Membranipora* spp.** (p. 371)

23(20) Very large avicularia borne on short stalks; a few hollow spines and ovicells; walls thin, lightly calcified; encrusting on hard substrates .... ***Sessibugula translucens*** (p. 375)

-Avicularia, if present, not as above; spines, ovicells, calcification and colony habit variable 24

24(23) Spines absent; on hard substrates 25

-Spines present, surrounding zoids, on hard substrates or algae 26

25(24) Margins of autozoids scalloped or crenulated; zoids all of about the same size; no avicularia; ovicells (absent on some colonies) prominent, circular .... ***Alderina smitti*** (p. 371)

-Zoid margins granular, not scalloped; zoids variable in size, grading into avicularia with semicircular mandibles; colonies many-layered, white or pink to purple; no prominent ovicells .... ***Antropora tincta*** (p. 371)

26(24) Spines independent only in young zoids, fusing together into a porous shield over the frontal membrane in older zoids *(Membraniporella)* 27

-Spines seldom or never fused together, never forming firm shield 28

27(26) Spines fail to fuse completely, especially in the midline, even in old zoids .... ***Membraniporella baueri*** (p. 375)

-Spines invariably fuse completely, even in the midline .... ***Membraniporella aragoi*** (p. 375)

28(26) Autozoids widely separated, connected by calcareous tubules; avicularia with rounded mandibles replace autozoids in places; ovicells conspicuous when present .... ***Retevirgula* spp.** (p. 371)

-Autozoids closer together; avicularia inconspicuous, resembling spines with slightly enlarged ends; ovicells inconspicuous; brownish encrustations, mostly on shells *(Cauloramphus)* 29

29(28) Autozoids average about 0.55 mm long, their walls in contact with those of neighbors .... ***Cauloramphus spiniferum*** (p. 371)

-Autozoids smaller, about 0.45 mm long; autozoids slightly separated [Species of *Alderina, Hincksina,* and others, may key out here but are absent or uncommon in the Gulf of California; see Osburn (1950).] .... ***Cauloramphus brunnea*** (p. 371)

30(19) Autozoids tubular in shape, the apertures circular; no operculum (check very young zoids at colony tips for opercula); no spines, ovicells, or avicularia; embryos brooded in swollen zoids (oecia, gonozoids), sometimes inconspicuous or absent; most Cyclostomata. [If you go wrong at this step of the key, see first part of couplet 50] 31

-Autozoids otherwise; if tubular, there is an operculum visible in very young zoids; spines, ovicells, and avicularia variably present; gonozoids occur in very few species; most Cheilostomata 34

31(30) Colony erect, massive, branching; tan or yellowish to white; apertures 0.3 mm or less in diameter, with polygonal edges, arranged in honeycomblike clusters; other colony surfaces finely perforated .... ***Fasciculipora pacifica*** (p. 366)

-Colony encrusting; white or pale bluish to purplish; apertures less than 0.15 mm in diameter 32

32(31) Colonies encrusting, mostly circular; autozoid apertures project from the colony surface on long or short tubes, fused in clusters which form radial rows, making colonies resemble little corals; membrane-covered polygonal kenozoids between autozoid clusters (the lichenoporids) 33

-Colony fan-shaped or irregular in outline; autozoid apertures on long tubes, fused together or independent; no obvious kenozoids between autozoid clusters .... ***Tubulipora* sp.** (p. 366)

33(32) Colony massive, spreading; many stellate radial clusters of autozoid apertures per colony; kenozoids between autozoids (cancelli) partly but not entirely closed by a calcareous diaphragm; on hard substrates .... ***Disporella californica*** (p. 367)

-Colony usually circular, delicate; usually with only one or two radial autozoid clusters per colony; kenozoids not partly closed by a diaphragm, either open or completely closed .... ***Lichenopora* spp.** (p. 366)

34(30) Frontal wall formed of fused marginal spines which leave traces of their origin in the calcium carbonate; pores arranged in radial rows over the frontal wall, or near the center of the wall and teardrop-shaped, the points directed medially; encrusting .... the **cribrilinids** (p. 375)

-Frontal wall otherwise; colony encrusting or erect **35**

35(34) Frontal wall nearly flat; depressed slightly below the surrounding edge of the frontal wall; evenly perforated with fine pores or imperforate, never with marginal pores alone; operculum crescent-shaped, without a definite proximal border, blending into the thin frontal membrane (except *Micropora,* 36, with a hemicircular operculum); encrusting, usually one-layered (many anascans) **36**

-Frontal wall otherwise, usually convex frontally; pores variable; operculum with a more or less definite proximal border; encrusting or erect (most ascophorans) **41**

36(35) Aperture hemicircular; frontal wall bordered by a ridge ending lateral to the aperture at a pore on each side .... ***Micropora coriacea inarmata*** (p. 373)

-Aperture crescent-shaped, continuous proximally with a thin cuticular frontal membrane; calcareous frontal wall stops proximal to the aperture (the part covered by the operculum), forming a hole larger than the aperture—the false aperture, or opesium; lateral ridges otherwise or absent **37**

37(36) Large holes (opesiules) present, lateral and proximal to the opesium (false aperture); large pointed avicularia replace autozoids in places; encrusting or erect (*Thalamoporella*) **38**

-Opesiules absent; opesium entire or notched proximolaterally **39**

38(37) Colony encrusting and lacy, or erect with club-shaped parts connected by cuticular joints; avicularium rostrum (the calcareous part underlying the mandible) complete distally, not notched .... ***Thalamoporella californica*** (p. 373)

-Colony encrusting or forming erect 2-layered fronds; avicularium rostrum notched distally .... ***Thalamoporella gothica*** (p. 373)

39(37) False aperture (opesium) hemicircular .... ***Mollia patellaria*** (p. 373)

-Opesium not hemicircular **40**

40(39) Opesium 3-cornered, like a cloverleaf; avicularia present .... ***Floridina antiqua*** (p. 371)

-Opesium not shaped like a cloverleaf; no avicularia .... ***Labioporella sinuosa*** (p. 373)

41(35) Frontal wall without pores, ringed transversely by growth lines; aperture skull-shaped (round distally with a U- or V-shaped proximal notch); white; encrusting; zoids of several sizes; ovicelled zoids with altered aperture (*Celleporella*) **42**

-Frontal wall with at least a few pores, almost never with transverse growth lines; aperture, colony habit, color, zoid sizes, and ovicelled zoids variable **44**

42(41) Colony at first one-layered, becoming many-layered; angle between operculum and substrate tilted about 20 degrees; ovicells with numerous pores .... ***Celleporella hyalina*** (p. 378)

-Colony one-layered at all times; angle between operculum and substrate 45 degrees or more; ovicell imperforate or with marginal pores **43**

43(42) Operculum almost perpendicular to the substrate; frontal wall strongly ribbed between growth lines, sometimes forming prominent knobs (umbos); on algae .... ***Celleporella cornuta*** (p. 378)

-Operculum at about 45 degrees to substrate; frontal wall ribbed, but not so strongly; no umbos; on algae .... ***Celleporella santacruzana*** (p. 378)

44(41) Ascopore present, recognized as a central kidney-shaped (rarely circular) hole, larger than others, in the frontal wall or as a single plate (in the same place) with numerous fine pores; aperture semicircular with a straight proximal border; encrusting; one-layered 45
-No ascopore; aperture, colony, and habit variable 49

45(44) Colony dark; gray, black, or blue-black; only marginal pores present; autozoids polygonal in shape; a large avicularium between aperture and ascopore, rarely absent .... ***Reptadonella violacea*** (p. 390)
-Colony buff, tan, or pale yellow; numerous fine pores over most of frontal wall; avicularia otherwise or absent (the microporellids) 46

46(45) No avicularia; at least a few pores present between aperture and ascopore .... ***Fenestrulina malusi*** (p. 386)
-Avicularia proximal and lateral to the aperture with pointed or spinelike mandibles; no pores between aperture and ascopore (*Microporella*) 47

47(46) Ascopore oval, covered by a finely perforated calcareous plate .... ***Microporella cribosa*** (p. 386)
-Ascopore crescent-shaped, not covered by a perforated plate 48

48(46) Ovicell nearly as broad as the zoid bearing it, finely perforated by inconspicuous pores; avicularia single, sometimes paired; autozoids about 0.5 mm long .... ***Microporella ciliata*** (p. 386)
-Ovicell narrower than the zoid bearing it, perforated by prominent central pores; avicularia paired, sometimes single; autozoids about 0.65 mm long .... ***Microporella californica*** (p. 386)

49(44) Frontal wall evenly perforated by pores, although there may be a small imperforate area just proximal to the aperture or an imperforate collar around the aperture, sometimes long. In some species, pores are small and it may be necessary to treat colonies in KOCl, dry, and dye them with ink and a brush. This step is tricky; if you go wrong in the key, return here 50
-Frontal wall perforated only at the margin of the zoid, a third or more of the central part of the frontal wall imperforate; avicularia almost always present 82

50(49) Apertures of autozoids surrounded by a high calcareous imperforate collar bearing one or two avicularia enclosed in the collar or at its tip (also see first part of couplet 87) 51
-Calcareous collar absent or poorly developed; avicularia, if present, otherwise 57

51(50) Two avicularia at the tip of the calcareous collar (*Lagenipora*) 52
-One avicularium on the proximal side at the end of the collar or enclosed within it, sometimes hard to see (some *Smittina*) 56

52(51) Colony erect, branching, stony 53
-Colony encrusting 54

53(52) Young autozoids at growing tip of the colony about 0.7 mm long (also see second part of couplet 91) .... ***Lagenipora punctulata*** (p. 394)
-Young autozoids 0.5 mm long or less .... ***Lagenipora mexicana*** (p. 394)

54(52) Collar around aperture long, ribbed longitudinally and/or frilly, with calcareous spinules projecting from the end; young autozoids (before peristome formation) 0.5 mm long .... ***Lagenipora spinulosa*** (p. 394)
-Collar not conspicuously ridged longitudinally, the end not frilled, no spinules; young autozoids average more than 0.5 mm long 55

55(54) Collar shorter than aperture length; avicularia distal to the middle of the aperture; young autozoids about 0.7 mm long .... ***Lagenipora lacunosa*** (p. 394)
-Collar usually longer than aperture length; avicularia at the middle or proximal to the middle of the aperture; young autozoids about 0.6 mm long .... ***Lagenipora hippocrepis*** (p. 394)

56(51) Autozoids about 0.7 mm long; on a few zoids where avicularia are absent, the collar is circular, not notched proximally .... ***Smittina landsborovi*** (p. 388)
-Autozoids large, up to 1 mm long; collar notched proximally even when avicularia are absent on a few zoids .... ***Smittina maccullochae*** (p. 388)

57(50) Aperture rounded distally, but with a shallow or deep median V- or U-shaped proximal notch narrower than the rest of the aperture 58
-Aperture without a proximal notch, circular, concave proximally, shaped like an 8, or otherwise 75

58(50) Aperture notched proximolaterally as well as proximally; frontal finely perforated 59
-Aperture not notched proximolaterally; frontal with fine to coarse perforations 60

59(58) Spines at borders of zoids; paired avicularia with long, thin mandibles .... ***Crepidacantha poissoni*** (p. 394)
-No spines; no avicularia; a minute zoid with a tiny aperture distal to each autozoid .... ***Trypostega venusta*** (p. 380)

60(58) Colony black, a red fringe when alive; encrusting or forming erect 2-layered fronds (also see *Watersipora*, p. 392) .... ***Uscia mexicana*** (p. 392)
-Colony not black, usually colorless, buff or orange; mostly encrusting, sometimes erect 61

61(60) Avicularia present on at least some zoids on the colony (search well over many zoids and also be sure they really are avicularia with mandibles and not just empty holes) 62
-No avicularia 70

62(61) Avicularia in the midline just proximal to the aperture, mandibles directed proximally or distally (also see second part of couplet 51) 63
-Avicularia not in the midline, mandible directed variously, seldom consistently 64

63(62) An occasional, rare, giant spoon-shaped avicularium with a mandible larger than the aperture replaces the normally small avicularia .... ***Codonellina anatina*** (p. 384)
-No giant spoon-shaped avicularia .... ***Schizomavella auriculata*** (p. 384)

64(62) Ovicell imperforate, with a central area with radial striations, gradually becoming partly or wholly engulfed in secondary calcification 65
-Ovicell usually perforated by numerous pores, without a central area with radial striations; secondary calcification variable 66

65(64) Proximal apertural notch distinct, V-shaped or a definite U-shape .... ***Schizoporella cornuta*** (p. 382) or ***Stephanosella vitrea*** (p. 386)
-Proximal notch shallower, a vague U, blending more gently into the rest of the aperture .... ***Schizoporella dissimilis*** (p. 383)

66(64) Ovicell gigantic, as big as an autozoid, obscuring the aperture of the fertile zoid; proximal apertural notch V-shaped or slitlike .... ***Stylopoma spongites*** (p. 384)
-Ovicell smaller than an autozoid, fertile zoid aperture visible; apertural notch variable 67

67(66) Ovicell closed by the operculum 68
-Ovicell aperture remains open when the aperture of the fertile zoid is closed (*Schizoporella*) 69

68(67) Two, sometimes one, avicularium next to the aperture; young zoids with 3 spines .... ***Escharina vulgaris*** (p. 384)
-One, rarely two, avicularia near the aperture; young zoids with 6 spines .... ***Hippomonavella longirostrata*** (p.386)

69(67) Very young autozoids at outermost colony margins with about two thin spines, soon lost; usually one-layered .... ***Schizoporella occidentalae*** (p.382)
-No spines, even on young zoids; colony usually massive, many-layered .... ***Schizoporella "unicornis"*** (p. 382)

70(61) Spines present around the aperture, especially in young zoids; ovicell imperforate; a calcareous crescent-shaped ridge proximal to the aperture; encrusting, one-layered .... ***Arthropoma circinata*** (p. 384)
-No spines, even in young zoids; ovicell perforated or absent; without a crescent-shaped ridge, as above; knobs or spikes present or absent; colony habit various 71

71(70) No ovicells (ovicells very rare); a pair of small shining dots on the operculum at the junction of the proximal apertural notch to the rest of the aperture (also see first part of couplet 73) .... ***Watersipora cucullata*** (p. 392)
-Ovicells present, but sometimes uncommon or partly submerged in secondary calcification of the frontal wall 72

72(71) Ovicell aperture closed by the operculum 73
-Ovicell aperture remains open when the operculum of the fertile zoid is closed 74

73(72) Proximal apertural notch vague, broadly U-shaped; aperture often surrounded by a very low, circular, calcareous collar with knobs, like a crude pearl necklace (also see first part of couplet 71) .... ***Dakaria sertata*** (p. 383)
-Proximal apertural notch U-shaped; apertural collar less prominent, seldom beaded (also see first part of couplet 71) .... ***Dakaria ordinata*** (p. 384)

74(72) Pores of frontal wall and ovicell star-shaped .... ***Schizoporella trichotoma*** (p. 382)
-Pores not star-shaped .... ***Schizoporella inarmata*** (p. 382)

75(57) Aperture circular or nearly so; usually with hinge teeth slightly proximal to middle of aperture 76
-Aperture not circular; proximal apertural border concave, the same shape and size as the distal part, or otherwise 79

76(75) Autozoids hexagonal, the aperture in the middle, surrounded by calcareous spikes; rare avicularia .... ***Cigclisula porosa*** (p. 396)
-Autozoids not hexagonal, aperture near distal end of zoid; no avicularia 77

77(76) Ovicells imperforate, radially ridged, much wider than an autozoid; zoids thinly calcified, delicate, coarsely perforated; a small pore on a low knob just proximal to the aperture .... ***Hippodiplosia insculpta*** (p. 384)
-Ovicells perforated or absent 78

78(77) Encrusting or erect with hollow branches; autozoids large, over 1 mm long; no hinge teeth; lightly calcified, delicate .... ***Cyclicopora longipora*** (p. 380)
-Encrusting, usually many-layered; autozoids smaller, about 0.6 mm long; hinge teeth prominent; heavily calcified (also see first parts of couplets 73 and 81) .... ***Dakaria sertata*** (p. 383)

79(75) Colony black, a red fringe when alive; aperture concave proximally; a pair of shining dots on the operculum .... ***Watersipora arcuata*** (p. 390)
-Colony color otherwise; aperture wider or as wide proximally as distally, not concave proximally; no dots on operculum 80

80(79) A pair of small avicularia, with rounded mandibles, lateral to the aperture; ovicells coarsely perforate (if you go wrong here, see second part of couplet 46) .... ***Hippopetraliella magna*** (p. 380)
-Giant avicularia among autozoids (also see third part of this couplet) .... ***Anexochona anchorata*** (p. 392)
-Avicularia absent or rare, proximal to the aperture; ovicells rare, perforated, absent, or not obvious (seemingly absent) 81

81(80) Colony red or purple, at least when dry or preserved, the color persisting even after KOCl-treatment; aperture oval, with prominent hinge teeth and calcareous lapetts lateral to the aperture; autozoids about 0.75 mm long; ovicells rare, perforate .... ***Cycloperiella rosacea*** (p. 380)
-Colony color pale, not red or purple, white when KOCl-treated; aperture shaped like an 8, with lateral calcareous indentations; autozoids about 0.55 mm long; no obvious ovicells .... ***Hippopodinella adpressa*** (p. 390)

82(49) Avicularia absent (search carefully, tilting the colony if necessary, to look down into the aperture) 83
-Avicularia present, usually conspicuous, sometimes hidden 84

83(49) Autozoids large, 0.75 mm; collar around aperture formed of spines ...... ***Escharella major*** (p. 388)
-Autozoids smaller, 0.5 mm long or less; calcareous apertural collar, if present not formed of spines (probably a rare colony or colony part which lacks avicularia; see second part of couplet 82) 84

84(82) Median avicularia just proximal to the midline (other avicularia may occur elsewhere in some species); mandibles directed proximally or distally; encrusting 85
-Avicularia otherwise; colony variable 88

85(84) Ovicell with a central, finely perforated area; numerous marginal pores (*Smittoidea*) 86
-Ovicell imperforate, less than 10 marginal pores (*Porella*) 87

86(85) Avicularium enclosed in calcareous collar surrounding the aperture .... ***Smittoidea prolifica*** (p. 388)
-Avicularium well proximal to aperture, not in contact with the calcareous collar .... ***Smittoidea reticulata*** (p.388)

87(85) Ovicell with a central depression .... ***Porella rogickae*** (p. 388)
-Ovicell smooth on top, no depression .... ***Porella porifera*** (p. 386)

88(84) Aperture surrounded by a high calcareous collar, usually with a proximal notch; operculum soon obscured by the collar, visible only in young zoids; secondary layers of irregularly arranged autozoids produced by frontal budding (sometimes a difficult step; return here if you go wrong in the key) 89
-Distinct calcareous collar absent; if the aperture becomes obscured, it does so only by great thickening of the frontal wall; frontal budding present or absent; ovicell imperforate 92

89(84) Aperture of young zoids, before collar formation, with a proximal calcareous shelf (lyrula) and proximolateral hinge teeth projecting into the round aperture (*Parasmittina*) 90
-Aperture of young zoids with a distinct proximal notch 91

90(89) Many autozoids with large avicularia proximal and lateral to the aperture with their mandibles directed proximally .... ***Parasmittina crosslandi*** (p. 388)
-Large avicularia with proximally directed mandibles rare; many zoids with large avicularia near the aperture with their mandibles ascending the collar, directed distally and medially .... ***Parasmittina californica*** (p. 388)

91(89) Edge of the aperture of very young zoids seen to be finely beaded or serrated; a large avicularium proximal and lateral to the aperture, its mandible directed laterally, soon obscured by the calcareous collar and thickening frontal wall; ovicell imperforate, quickly embedded (also see couplet 95) .... ***Rhynchozoon* spp.** (p. 390)
-Edge of aperture not serrated; avicularia paired on rounded projections above and to the side of the aperture, mandibles rounded; ovicell perforated in a radial pattern (also see first part of couplet 51) .... ***Celleporina costazi*** (p. 396)

92(88) Aperture (visible in very young zoids) with a distinct notch in the proximal border; hinge teeth inconspicuous or absent; giant avicularia, larger than autozoid apertures, common 93
-Aperture straight or slightly curved proximally, or nearly circular; distinct hinge teeth 94

93(92) Giant avicularia spoon-shaped, wider distally than proximally; ovicells coarsely perforate; colonies usually erect, with cylindrical branches; white or buff .... ***Schismopora anatina*** (p. 394)
-Giant avicularia oval in shape, the mandibles usually darkened in a shovel-shaped pattern; ovicells imperforate; colony encrusting, nodular; tan to dark brown, the color due to cuticular parts .... ***Celleporaria brunnea*** (p. 396)

94(88) Aperture circular or nearly so, located near the center of a nearly hexagonal autozoid; frontal wall with numerous vertical calcareous spikes; avicularia occasional, sometimes rare; no spines .... ***Cigclisula porosa*** (p. 396)
-Aperture with a straight or gently convex proximal border located near the distal end of the zoid; calcareous spikes, if present, mostly proximal or lateral to the aperture. Avicularia common, rarely absent; spines present on aperture of very young zoids 95

95(94) Young zoids have 8–13 marginal pores, 2–4 apertural spines; some avicularia occasionally larger than autozoid apertures; young zoids about 0.3 mm long .... ***Hippoporella gorgonensis*** (p. 384)
-Young zoids with less than 10 marginal pores, about 6 apertural spines; avicularia never much larger than aperture; young zoids about 0.5 mm long (also see couplet 91) .... ***Aimulosia uvulifera*** (p. 386)

CLASS GYMNOLAEMATA

All marine Bryozoa and a few fresh water representatives. Calcified or noncalcified with a circular lophopore, no epistome and no distinct somatic body wall muscle layers.

SUBCLASS STENOLAEMATA

Calcified Bryozoa without an operculum.

Order Cyclostomata

All recent stenolaemate Bryozoa.

Stomatopora granulata (Milne-Edwards)

A probably primitive cyclostome bryozoan forming inconspicuous, colorless, uniserial encrustations on shells and stones. Young autozoids finely perforated by numerous pseudopores; older ones lack pores. Autozoids vary greatly in length (0.4–1.0 mm) and vary from a nearly tubular shape to pyriform (pear-shaped, with the swelling around the aperture). Distal parts of autozoids (peristomes) are erect from the substrate. Peristomes vary in length from stubby collars to sizable tubes. Oecia resemble swollen autozoids with more numerous pores. Its aperture is borne on a peristome somewhat shorter than those of autozoids. Widely distributed in cool temperature to tropical waters. Figure 24.2.

Tubulipora spp.

A large group of encrusting and erect cyclostome bryozoans with fanshaped lobes consisting of groups of zoecia adherent to one another (adnate). The distal ends of the zoecia sometimes project independently, forming "peristomes." Oecia are generally swollen and perforated by numerous pores smaller than the usual pseudopores on autozoids. *Tubulipora tuba* (Gabb and Horn) is the largest common Gulf of California species. It is found on rocks, shells, and especially algae. They are usually bluish, retaining their color when dry, at least for a time. The oecium's aperture (oeciostome) is compressed, arising next to an autozoid aperture from the swollen, minutely perforate oecium. Autozoids are fused distally in groups of 2–25, and measure about 120 μm wide. *Tubulipora pacifica* Robertson is a smaller, more delicate white species most common on algae. Autozoids are about 120 μm in diameter, projecting as single peristomes near the center of the colony but clustered into groups marginally. The apertures are clustered in rough radial rows, giving a corallike appearance. The ovicell is like that of *T. tuba*, but the distal end of the oeciostome is only adjacent to an autozoid peristome, not fused to it. Both species are common in temperate to tropical eastern Pacific Seas; *T. tuba* apparently is restricted in the Gulf of California to the northern end (J. Soule, 1963:6). Figure 24.3.

Fasciculipora pacifica Osburn

A frequently massive bryozoan whose erect colonies may reach 5 or 10 cm in height, resembling a small whitish brain coral. The branches start from an encrusting base, expanding by addition of new tubular zoecia, branching as they broaden. Autozoid apertures open distally; that is, at the tips of branches; they average about 0.3 mm in diameter. Apertures are polygonal in shape, crowded by their neighbors. New autozoids are added at the growing distal tips, looking like small autozoids centered on walls between larger autozoids (see McKinney, 1975:72). Oecia resemble autozoids except that they are larger in diameter. A common species in the Gulf of California (Soule 1963:8). Figure 24.4.

CRISIIDS

An abundant group of erect branching cyclostomes with flexible joints. Crisiids form algalike white or yellowish tufts an inch or more in height. As in almost all cyclostomes, autozoids are cylindrical, and totally lack opercula. Brooding is accomplished in swollen zoids (gonozoids) which convincingly look like very pregnant autozoids. *Filicrisia franciscana* (Robertson) is recognizable because of its dark yellow or black joints (fig. 24.5). *Crisia operculata* Robertson has thicker branches, and an ovicell with a little hood over the oeciostome (fig. 24.6).

Lichenopora spp.

This is a difficult genus of conspicuous and beautiful bryozoans, common throughout the Gulf of California. Serious students should refer to primary literature for species determinations.

Lichenoporids are generally disc-shaped, often with a radial or stellate arrangement of zoid clusters, making the colony superficially resemble a small solitary scleractinean coral. Most are pale yellow in color. They most often occur on shells or rocks, but they may also grow locally in vast numbers on algae.

The autozoids are tubular, horizontal, and adnate (stuck together) to one another for most of their length. Apertures are mostly borne on short extensions (peristomes) which may or may not be adnate to each other. Autozoid peristomes tend to group into radial clusters, hence the stellate, corallike appearance. The radial groups may be uniserial (that is, each group consisting of one radial row of peristomes), biserial (two rows of peristomes) or multiserial (several rows). The radial groups may branch. The part of the colony between radial groups is filled in with "cancelli," a type of kenozoid. Cancelli look like smaller (sometimes larger) autozoid apertures without peristomes. They sometimes are partly occluded by calcareous covers ("diaphragms"). Oecia (brood chambers) are sometimes inconspicuous and frequently absent, even on large colonies. They occur near centers of colonies and are covered by cancelli. The oeciostome (oecium aperture) is frequently borne on a flared or trumpet-shaped peristome, a little larger than autozoid peristomes. The oeciostome may be adnate to autozoid peristomes.

Apertures and cancelli of many lichenoporids contain "pinhead spicules." These minute calcareous projections protrude from calcareous walls into the coelomic cavity. Curiously, they do not interfere with lophophores even when they are abundant in autozoids; the function is unknown.

Three species of *Lichenopora* are fairly common in the Gulf of California. *L. buskiana* Canu and Bassler and *L. novae-zelandiae* (Busk) are similar (figs. 24.7 and 24.8). Both are mostly circular, generally a centimeter or less in diameter. Both have trumpet-shaped oeciostomes, with autozoid apertures measuring about 0.75 mm in diameter. *L. buskiana* has mostly biserial radial clusters of peristomes which radiate from the colony center. Cancelli are about the same diameter as autozoids; they generally have numerous pinhead spicules and are often closed by an imperforate calcareous diaphragm. An abundant species in California and the Gulf of California. *L. novae-zelandiae* (Busk) has more or less uniserial radial peristome clusters. Cancelli are quite variable in size, from much smaller to somewhat larger than autozoid apertures. Pinhead spicules in cancelli are common; cancelli are sometimes occluded by a calcareous diaphragm perforated by numerous tiny pores. Widely distributed warm water Pacific species. *Lichenopora intricata* is more distinct (fig. 24.9). Colonies are large (up to 4 cm) and rarely circular because they are generally made up of a complex of subcolonies. Each subcolony is recognized by a separate stellate cluster of radial peristomial clusters with cancelli between them. Each ray of peristomes may be uniserial, biserial, multiserial, or may blend into other rays. Peristomes are about 0.11 mm in diameter, often drawn out into a pointed calcareous spike, sometimes paired. Cancelli are circular, resembling in size and shape autozoids without peristomes. Pinhead spicules are rare. Oecia are near centers of subcolonies. They are large, perforated by tiny pores and are covered by shallow polygonal cancelli somewhat larger than normal cancelli. The oeciostome is tubular or slightly flared, short, and resembles an autozoid peristome. *L. intricata* is abundant in Baja California and the Gulf of California. D. and J. Soule (1964) point out that the identity of Japanese and New Zealand specimens with eastern Pacific forms remains questionable.

Disporella californica (d'Orbigny)

See the discussion of *Lichenopora* spp. for general morphology. *Disporella* generally resembles the genus *Lichenopora* except that cancelli tend to be thicker-walled and are frequently incompletely closed by a calcareous diaphragm which grows inward from the walls (of the cancelli), leaving a circular pore at the center. Osburn (1953) records 9 eastern Pacific species; *D. californica* is so far the only one known in the Gulf of California.

D. californica resembles *L. novae-zelandiae* in having uniserial rays (clusters of autozoid peristomes), but subcolonies like those of *L. intricata* are sometimes formed. Cancelli are larger than autozoid apertures when formed, but are slowly reduced in size as diaphragms seal them over. Ovicells tend to be formed between autozoid peristome rays; the oeciostome is short, slightly flared, not adnate to peristomes.

D. californica is a subtropical to tropical species of the eastern Pacific and appears to be most abundant in the Gulf of California. Figure 24.10.

SUBCLASS EURYSTOMATA

Calcified gymnolaemates with an operculum; or uncalcified, with or without an operculum.

Order Ctenostomata

The uncalcified ctenostomes without an operculum.

Nolella stipata Gosse

An inconspicuous ctenostome growing from creeping stolons attached to hard substrates. When autozoids are crowded together it may resemble *Bowerbankia gracilis*, but *Nolella* lacks the gizzard present in *Bowerbankia*. It is distinguished from *Walkeria tuberosa* by lacking a thinned basal stalk to the autozoids and by not dropping off old autozoids from the stolon as they age. Circumglobal in warm waters. Figure 24.11.

Bowerbankia gracilis Leidy

This ctenostome forms brownish clusters or mats on many substrates. Autozoids may exceed a millimeter in length, arising from a creeping, branching stolon. A conspicuous gizzard is present. The taxonomy of this genus is complex (Prenant and Bobin, 1956), and other species may be involved. *B. gracilis* is usually considered cosmopolitan in distribution. Figure 24.12.

Amathia spp.

A distinctive and widely distributed group of erect, branching brownish ctenostome bryozoans found throughout temperate and tropical water. Gizzards are present.

There is a central, thick, branching stolon with autozoids arranged in a characteristic helix along the stolon. J. Soule (1963) records three species in the Gulf of California. *A. convoluta* (Lamouroux) has large autozoids (about 0.75 mm long), which are connate (stuck

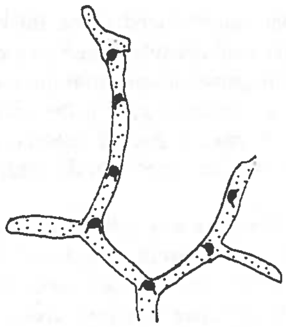


Fig. 24.2 *Stomatopora granulata* (after Osburn, 1953)

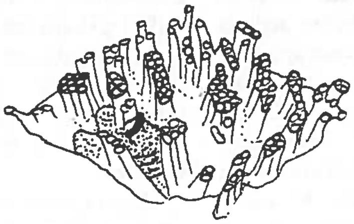


Fig. 24.3 *Tubulipora tuba* (after Osburn, 1953)

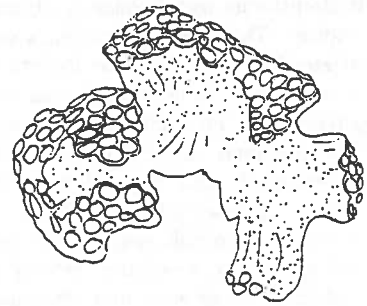


Fig. 24.4 *Fasciculipora pacifica* (after Osburn, 1953)

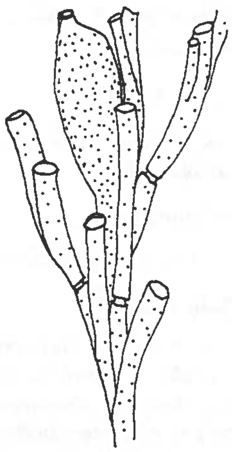


Fig. 24.5 *Filicrisia franciscana* (after Osburn, 1953)

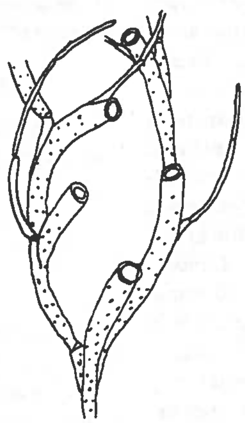


Fig. 24.6 *Crisidia cornuta* (after Osburn, 1953)

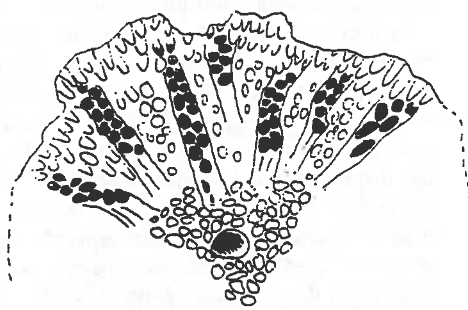


Fig. 24.7 *Lichenopora buskiana* (after Osburn, 1953)

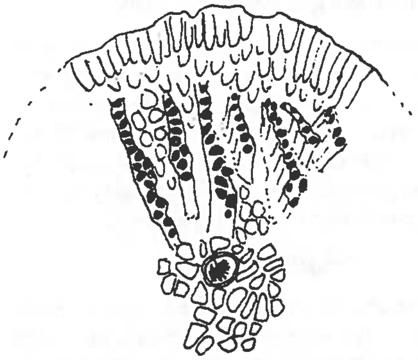


Fig. 24.8 *Lichenopora novae-zelandiae* (after Osburn, 1953)

Fig. 24.9 *Lichenopora intricata* (after Osburn, 1953)

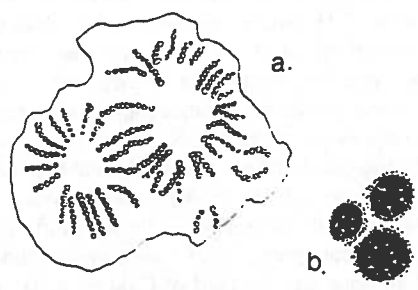


Fig. 24.10 *Lichenopora californica*. (a) A Colony a little larger than life size. (b) Three cancelli magnified to show pinhead spicules. (After Osburn, 1953.)

together) throughout their length. *A. vidovici* (Heller) has autozoids about 0.4 mm long which are connate only at the base. *A. distans* Busk (fig. 24.13) closely resembles *A. vidovici*, but the branches tend more to creep along the substrate. Detailed descriptions are found in J. Soule (1953:740) and Prenant and Bobin (1956:283).

Zoobotryon verticillatum (della Chiaje)

This species resembles *Amathia*, but the autozoids are not arranged in helical rows, and the colonies are pale yellowish to colorless, whereas *Amathia* colonies are more brownish. A common and widely distributed species in calm subtropical and tropical waters. It has a well-defined and conspicuous gizzard (toothed grinding apparatus in the gut). It is easily cultivated and has been used in some fine experimental work (Zirpolo, 1933; Bullivant, 1967). Although this is primarily a subtidal form it is often found washed into tidal flats, where it may accumulate in channels and depressions. It is also found, occasionally in enormous numbers, attached to dock pilings below the low water line. Figure 24.14.

Walkeria tuberosa Heller

An inconspicuous tiny ctenostome sometimes abundant, especially on algae. Autozoids about 0.5 mm long originate in clusters from a branching stolon adherent to the substrate. The basal part of each zoid is slender, with a stalk attaching it to the stolon. No gizzard is present. Autozoids are shed like leaves as they die and are replaced by new zoids elsewhere on the colony. A related species, *Bantariella cooki*, is known from northwestern Baja California. A widely distributed warm water species commonly known under the name of *Valkeria*. Figure 24.15.

CALCIUM-PENETRATING BRYOZOANS

These peculiar animals bore into shells throughout the world and are known from as far back as the Middle Ordovician. Most are ctenostomes, but one genus, *Penetrantia*, is regarded by Soule to be a strongly modified cheilostome (see Voigt and Soule, 1973). Bryozoa are known also to bore in wood (Jebram, 1969) and *Cephalodiscus* coenecia (J. Soule, 1968). Living (recent) calcium-penetrating bryozoans can be properly studied only after decalcification and staining (see preservation section), but they can be recognized by their delicate tracings left on shells. Species found in the Gulf of California include *Terebripora comma* Soule (fig. 24.16), *Immergentia californica* Silén (fig. 24.17), *Penetrantia densa* Silén (Soule, 1963), and *Spathipora* (J. Soule and D. Soule, unpublished).

Order Cheilostomata

Bryozoa with an operculum, or a 'trap-door' closure to the aperture. Mostly calcified, some lightly calcified, a few possibly uncalcified.

ANASCAN CHEILOSTOMES

A heterogeneous group of cheilostomes without an ascus.

Aetea spp.

This is a small group of probably primitive cheilostomes found throughout the world in shallow waters. The base of the colony is creeping and uniserial to biserial (like the oldest fossil cheilostomes). A "stalk" and "head" arise from where one would expect an aperture. The annulated (ringed) stalk and creeping basal part of the colony harbor the polypide when it is retracted. The opesium and aperture, with a small operculum, are born on the "head." There is a small setigerous collar, recalling ctenostomes. All *Aetea* species are calcified, but the calcification may be light. "Ovicells" are saclike protrusions near (or from) the aperture but seem to be very rare. Mawatari (1973) discusses the taxonomy of Pacific species. Figure 24.18.

Membranipora tuberculata (Bosc)

An encrusting, lacy colony with zoids arranged like brickwork ("in quincunx"). Zoids possess a largely membraneous frontal surface, underlain by a narrow cryptocyst. There are two large tubercles at the proximal end of each zoid. The operculum is visible as a semicircular yellowish line at the distal end of the zoid. Colonies are colorless to pale yellow, usually encrusting algae, only very rarely on shell or rock. There are no spines or obvious polymorphs.

M. tuberculata is widely distributed throughout the Atlantic and eastern Pacific but is less common in the tropics, possibly because of the scarcity of large macroscopic algae. Figure 24.19.

Membranipora arborescens (Canu and Bassler)

One- to many-layered tan encrustations on shells. Autozoids are rectangular, surrounded by a distinct brown line. There is a large uncalcified frontal area, the opesium or false aperture. A granular calcareous rim and calcareous spinules projecting into the false aperture, under a delicate cuticular frontal membrane. The operculum is crescent-shaped, continuous with the frontal membrane. The frontal membrane has many tiny cuticular projections or "spinules" on the surface. No spines or avicularia are present. Also called *Conopeum commensale* Kirkpatrick and Metzelaar, and probably

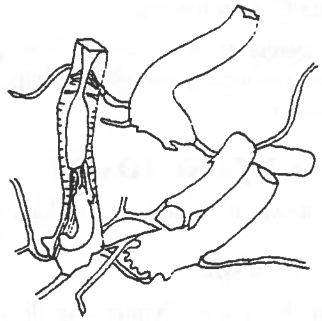


Fig. 24.11 *Nolella stipata* (after J. Soule, 1953)

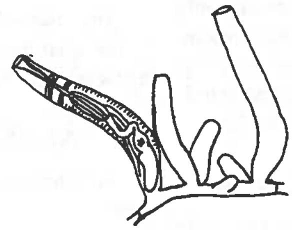


Fig. 24.12 *Bowerbankia gracilis* (after J. Soule, 1953)

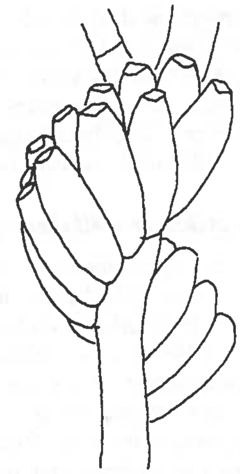


Fig. 24.13 *Amathia distans* (after J. Soule, 1953)

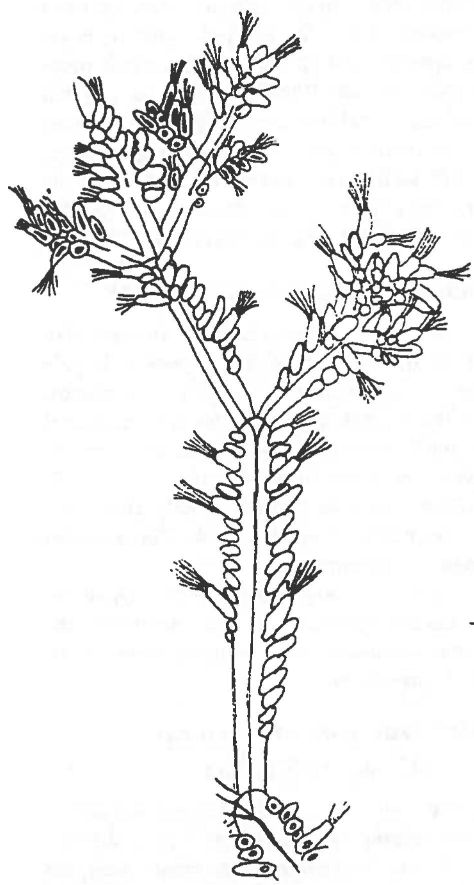


Fig. 24.14 *Zoobotryon verticillatum* (after Prenant and Bobin, 1959)

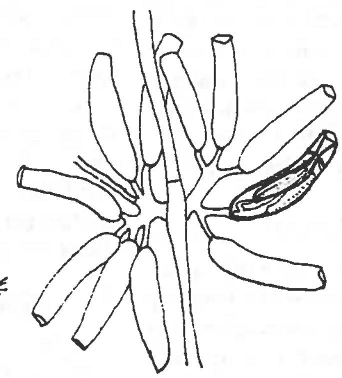


Fig. 24.15 *Walkeria tuberosa* (after J. Soule, 1953)

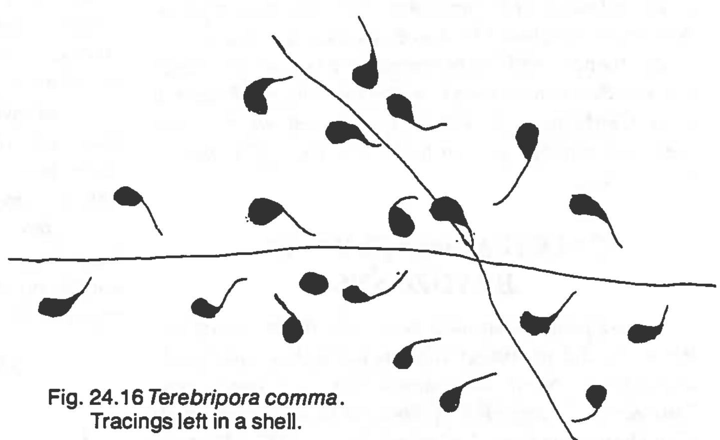


Fig. 24.16 *Terebripora comma*. Tracings left in a shell. (After Prenant and Bobin, 1959.)

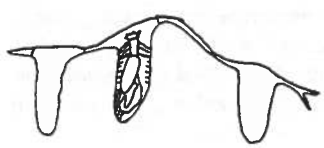


Fig. 24.17 *Immergentia californica* (after J. Soule, 1953)

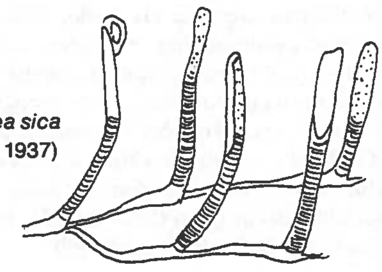


Fig. 24.18 *Aetea sica* (after Marcus, 1937)

frequently confused under other names. The membraniporids are difficult to identify and tend to grade into one another ("rassenkreis"). Cook (1968) does a valiant job of trying to sort them out but doesn't claim success. Other similar species occur; *M. arborescens* and its close relatives are circumglobal in warm temperate and tropical waters. Figure 24.20.

Membranipora spp.

A confusing species complex of one or many species without tiny cuticular spinules on the thin frontal membrane and with small or no knobs at the autozoid borders. Spines are sometimes present. No ovicells or avicularia are present. See also the discussion of *M. tuberculata* and *M. arborescens*. A nearly cosmopolitan species complex in shallow waters; most abundant in temperate to tropical waters. Figure 24.21.

Antropora tincta (Hastings)

One of the most abundant and characteristic encrusting bryozoans in the Gulf of California. It frequently occurs on shells of hermit crabs, forming a pinkish encrustation; it may form exposed white calcareous mats in some intertidal areas. Near Bahía de Los Angeles rocks may be cemented together by this species to form a "paar." Nodules the size of hens' eggs are occasionally formed in deeper water. Old colonies may form spikes or branching spires of 5 to 10 cm in length.

Colonies are many-layered, formed by repeated overgrowth of old layers by new ones. The colony surface may be marked by papillae, probably representing excurrent water outlets when polypides are feeding, although this has not been observed in this species.

Autozoids are about a half millimeter long and nearly hexagonal in shape. They vary greatly in size and seem almost to grade into the numerous interzoecial avicularia with semicircular mandibles. There is a heavy, granulated cryptocyst; spines are lacking. Ovicells are inconspicuous dilations of the distal wall of fertile autozoids.

A. tincta is a common warm-water species from Point Conception, California, south. In California, it is especially characteristic on *Kelletia* shells inhabited by the gastropod *Holopagurus*. Figure 24.22.

Cauloramphus spiniferum (Johnson)

A one-layered, flat, encrusting colony common on shells from the Gulf of Alaska to Chile and from the coasts of England and France. The brownish or grayish autozoids have a broad membranous opesium surrounded by a dozen or so stout spines. The avicularia are inconspicuous spikes with a bulge at the outer end. Ovicells are present but difficult to see, forming an inconspicuous distal bulge. The zoids are large compared to *C. brunnea (next), about 0.55 mm long.*

Cauloramphus is thought by Silén, Jebram, and others to be a primitive cheilostome; the avicularia are thought primitive because they resemble spines, which are in turn homologized to primitive autozoids because of their position. Polypides of California specimens have 15 (13–17) tentacles. Figure 24.23.

Cauloramphus brunnea (Canu and Bassler)

This species is a little smaller than *C. spiniferum* (0.45 mm long), variable in color, and the autozoids are separated more widely from each other. Common on shells. Figure 24.24.

Alderina smitti Osburn

A very common Gulf species forming large brown encrustations on hard substrates. Autozoids are oval or egg-shaped, often broader proximally than distally. They measure about 0.5 mm long. No spines or avicularia are present. The edges of the autozoids (mostly cryptocystal) are crenulated or frilly-looking and roughened by tubercles. Ovicells are large, imperforate, hemispherical, and about 0.3 mm wide. A widely distributed warm water species, elsewhere confused with *A. irregularis*. Atlantic specimens of *A. smitti* differ in detail from Pacific specimens, and several species may be involved. Figure 24.25.

Retevirgula spp.

Encrusting calcareous cheilostomes with autozoids surrounded by numerous hollow spines. Autozoids are not usually crowded close together but are separated from each other by short calcareous tubules, about 6 per zoid. Avicularia are interzoecial; that is, they occupy the same positions as autozoids in the colony. The opesium is large, with the spines bending over the delicate frontal membrane. Ovicells are conspicuous, with a single central perforation. J. Soule (1959) recorded four Gulf species. Three are common eastern Pacific warm water species; the fourth, *R. osburni* Soule, is known only from Isla Coronado in the Gulf of California. Figure 24.26.

Floridina antiqua (Smitt)

An encrusting species forming light yellow colonies on shells. The opesium is strongly restricted by a large knobby cryptocyst. The opesium is 3-cornered, like a clover leaf. Zoids are a little less than 0.5 mm long. Avicularia are a little shorter than, and scattered among, autozoids (interzoecial or vicarious). Their mandibles are symmetrical, with a membranous part on each side (this type of avicularium is sometimes called an onychocellarium). No spines or ovicells are present.

The two proximal notches in the cryptocyst are for the passage of parietal muscles which depress the frontal

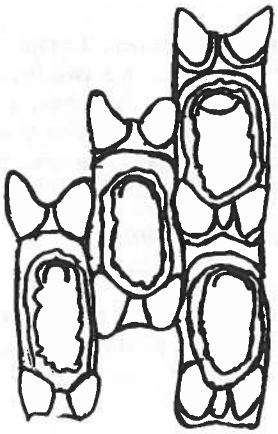


Fig. 24.19 *Membranipora tuberculata* (after Moyano, 1966)

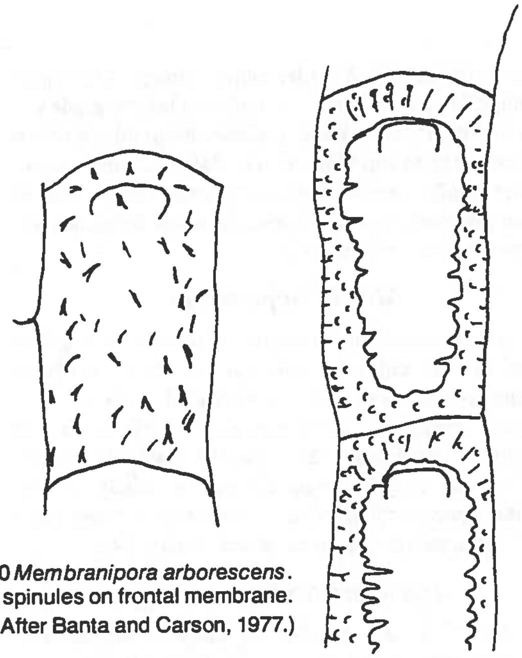


Fig. 24.20 *Membranipora arborescens*. Figure on left shows cuticular spinules on frontal membrane. (After Banta and Carson, 1977.)

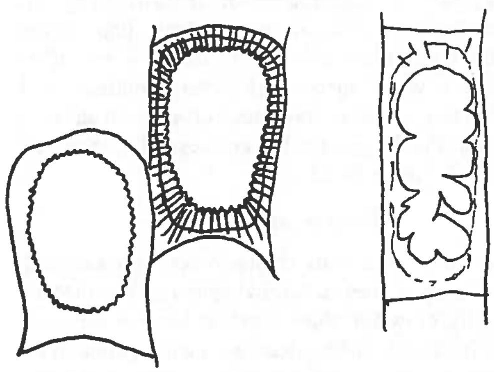


Fig. 24.21 *Membranipora* spp. (after Osburn, 1950)

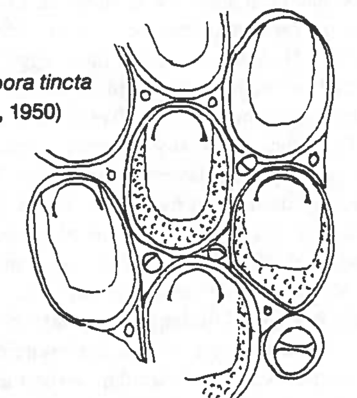


Fig. 24.22 *Antropora tincta* (after Osburn, 1950)

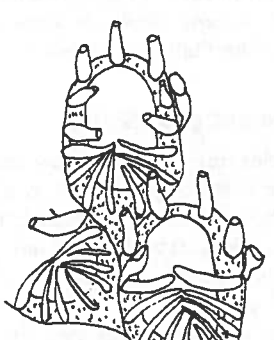


Fig. 24.23 *Cauloramphus spiniferum* (after Osburn, 1950)

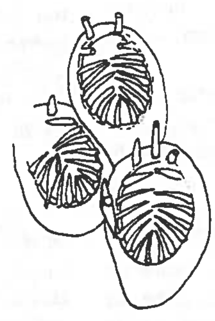


Fig. 24.24 *Cauloramphus brunnea* (after Osburn, 1950)

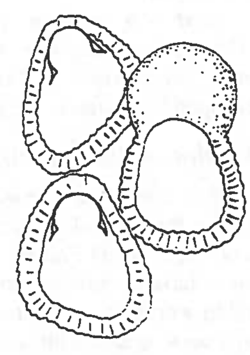


Fig. 24.25 *Alderina smitti* (after Osburn, 1950)

membrane, extruding the polypide. A warm temperate and tropical species of the Caribbean and Pacific. Figure 24.27.

Mollia patellaria (Moll)

An inconspicuous, loosely encrusting species. The small autozoids (0.4 mm long) have a perforated (cryptocystal) frontal shield, which occupies about two-thirds of the frontal side. No spines or avicularia are present. Each autozoid is raised slightly above the substrate by 6–8 basal (backside) hollow calcareous tubules, a characteristic feature. A widely distributed species in warm waters; not uncommon in the northern Gulf of California. Figure 24.28.

Micropora coriacea inarmata Soule

An encrusting species not uncommon on shells. The frontal wall is flat, minutely perforate, and delicately granulated. The aperture is hemicircular; the ovicell is conspicuous, globular, and imperforate. In other subspecies a large avicularium is found distal to autozoids. The unarmed subspecies is apparently restricted to the Gulf of California (J. Soule, 1959). Figure 24.29.

Labioporella sinuosa Osburn

An attractive, encrusting cheilostome with regularly arranged rectangular autozoids. No ovicells, spines, or avicularia are present. The flat frontal wall (a cryptocyst) is perforated by numerous tiny pores. The proximal and lateral ends of the false aperture dip down to insert on the basal wall. A widely distributed warm water species. Figure 24.30.

Thalamoporella californica Levinsen

An abundant and conspicuous lower California species with two main growth forms: lacey unilaminar encrustations and erect jointed colonies with clubshaped segments ("internodes").

Encrusting colonies are found mostly on algae, rarely on shells, as colorless to yellowish sheets with conspicuous autozoids arranged in neat quincunx, so that the mats are distinctly lacelike and quite pretty, especially under low magnification. The mats closely encrust the substrate; I have not seen frondose or frilly colonies like those of *T. gothica*. Erect colonies are cylindrical clubs interconnected with each other by brownish cuticular joints. The joints are formed by parts of autozoids remaining uncalcified. The clubs, or internodes, are formed of 6 to 12 (rarely more) autozoid rows, each trying to grow back-to-back against the others. Erect colonies arise from encrusting bases and probably also by fragmentation of other erect colonies. The colonies may form huge masses, nearly a meter in diameter, and may be encountered rolling back and forth in the subtidal (especially in the kelp beds of California) or washed ashore by the tide. Autozoids are medium-sized, about 0.6 mm long, provided with a skull-shaped false aperture and two large perforations (opesiules) just behind the aperture on a perforated cryptocystal frontal wall. Parietal muscles, whose contractions depress the diaphranous frontal membrane, pass through the opesiules; opesiules are characteristic of the Coilostega and Pseudostega.

Avicularia are interzoecial, that is, they "replace" autozoids in the budding pattern; they characteristically replace the first autozoid at the beginning of a new zoid row. Avicularia are about as long as autozoids but narrower; the mandible occupies about two-thirds of the avicularium's length and is bullet-shaped in outline, with two strong sclerites (cuticular reinforcements) running longitudinally near the middle. The distal border of the rostrum (the calcareous part underlying the mandible) is complete, with no notch.

Ovicells are uncommon but often abundant on individual colonies. They are huge, up to 0.5 mm in diameter, with a keeled seam running up the middle. The coelomic fluid is filled with odd calcareous spicules called "calipers"; the function is unknown.

T. californica is a characteristic eastern Pacific species, ranging from California to Chile. It can be difficult to distinguish from *T. gothica*, and it is possible that the two species intergrade. Figure 24.31.

Thalamoporella gothica (Busk)

Like *T. californica* with the following differences: colonies encrusting or rising up into frills or fronds; erect branching cylindrical colonies are never formed; autozoids usually longer (0.8 mm or more), but sizes may overlap with *T. californica;* avicularia proportionately a little shorter (see illustrations); and the tip of the avicularium rostrum is notched. There are other differences (see J. Soule, 1959). Figure 24.32.

Cupuladria canariensis (Busk)

One of comparatively small number of bryozoans found living free on soft sandy sublittoral bottoms. The colonies are 10–40 mm in diameter and shaped like a shallow cone. The autozoids resemble a stony *Membranipora,* but the cryptocyst may be large in some specimens. Distal to each autozoid is a large vibraculum, a zoid polymorph with a whiplike "seta." *Cupuladria* is one of the few bryozoans in which the function of vibracula is known: they remove sand from the colony and prevent it from becoming buried in the shifting sand bottom. The underside of the colony is provided with odd kenozoids. Lagaaij (1963) discusses this species in detail, especially its history and distribution. Håkansson (1973) discusses its morphology. Widely distributed in the tropics and subtropics. Figure 24.33.

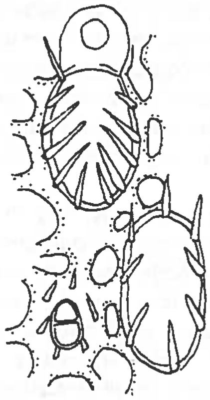


Fig. 24.26 *Retevirgula tubulata*
(after Osburn, 1950)

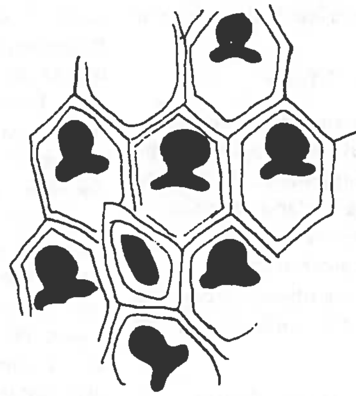


Fig. 24.27 *Floridina antiqua*
(after Smitt, 1873)

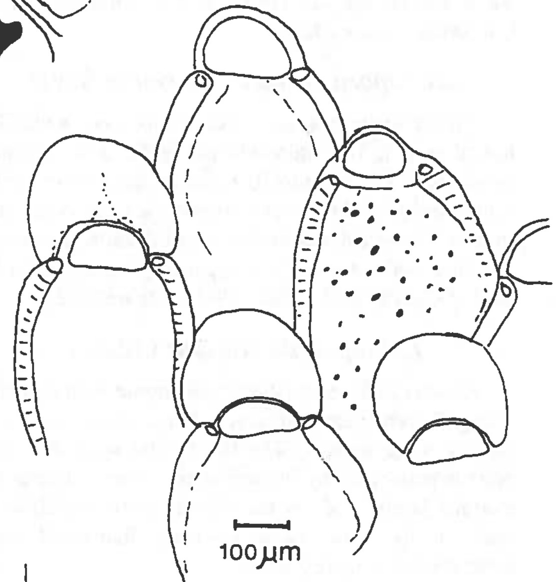


Fig. 24.29 *Micropora coriacea inarmata*
(after J. Soule 1959)

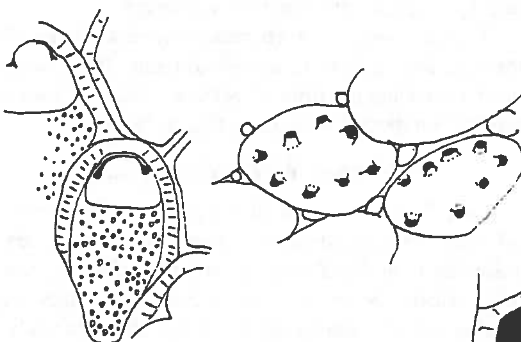


Fig. 24.28 *Mollia patellaria*.
Autozoids and basal view of
autozoids to show basal tubules.
(After Osburn, 1950.)

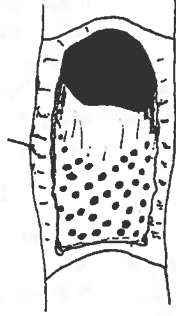
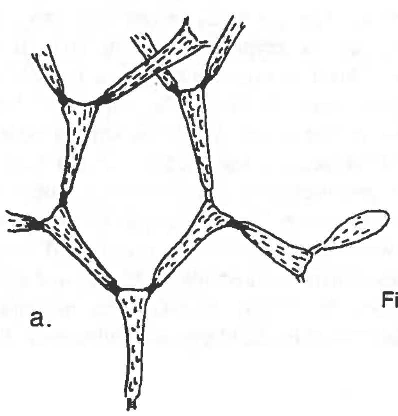


Fig. 24.30 *Labioporella sinuosa*
(after Osburn, 1950)



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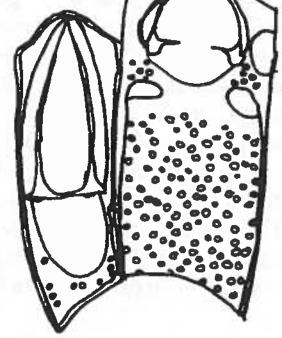


Fig. 24.31 *Thalamoporella californica*.
(a) An erect colony fragment,
about life size.
(b) An avicularium and autozoid.
(After Osburn, 1950.)

A less common cup-shaped ascophoran cheilostome, *Mamillopopora cupula* Smitt, occurs in the Gulf of California. It has heavily calcified zoids with rounded apertures, heavy hinge teeth, and numerous large avicularia.

Scrupocellaria spp.

A diverse and abundant group of "cellularine" (*Bugula*-like) bryozoans with several known representatives in the Gulf. Colonies are bushlike, flexible, and usually yellowish to brownish in color. Branches are biserial; that is, composed of two rows of autozoids. Avicularia are abundant, varying in size from minute to giants as large as autozoids, and they may be lateral or frontal in position. Vibracula with long whiplike setae are common on the basal (back) side of branches. The wide opesium is surrounded by numerous spines. One spine is normally developed into a flattened shield ("scutum") which covers the delicate frontal membrane. The scutum may be barely flattened, or developed into a branching shield with many sharp points. Ovicells are conspicuous, located at distal ends of autozoids; they may or may not be perforated by pores. Refer to Osburn (1950:131). Figure 24.34.

Bugula neritina (Linnaeus)

Colonies bushy (erect and branching), pale to dark reddish-brown or purplish. Autozoids are moderate-sized, but large for branching cellularine cheilostomes (about 0.75 mm). They are arranged biserially (in two rows) along the branch segments (internodes) with 5–15 pairs of zoids per branch. Autozoids all face in the same direction, toward the inside of branches. The outer distal angle of each zoid is extended into a blunt triangular point. There are no spines, avicularia, or vibracula; the basal surface is plain, marked only by divisions between zoids. Stolons are uncommon, but occasionally are produced basally, helping attach the colony. Ovicells are almost spherical, whitish, and conspicuous. They are about 0.4 mm in diameter and are usually fairly well calcified, causing them to look like a string of white beads along the darker colony. The tentacles are numerous (20 or more), long, snakelike, and pigmented like the rest of the animal.

Color and lack of avicularia and spines characterize this species well, although paler colonies sometimes are found. It can be confused with *B. minima* (Waters), but this species is smaller (autozoid length about 0.5 mm), lighter in color, and has avicularia at the proximal ends of many zoids.

B. neritina is a fairly common intertidal species in the Gulf of California. It is worldwide in distribution, occurring especially in harbors where it may be a fouling pest. It is a commonly studied species with a considerable literature (see Prenant and Bobin, 1966). Figure 24.35.

Bugula californica Robertson

One of three colorless or yellowish *Bugula* species in the Gulf with conspicuous stalked avicularia. Refer to the illustrations for identification. Figure 24.36.

Sessibugula translucens Osburn

This species forms thin, delicate encrustations on hard substrates. The broad opesium is surrounded by numerous hollow spines (some branching) which bend over it. Huge stalked avicularia with blunt or pointed mandibles are present. Ovicells are imperforate, delicately marked with radial lines. Known from Costa Rica, the Galápagos, and the Gulf of California (J. Soule, 1959). *Sessibugula* is likely to be confused only with species of *Beania*, represented in the Gulf by 3 species (J. Soule, 1959). In these species, autozoids are widely separated, connected to each other by narrow tubules, not crowded together as in *S. translucens*. Figure 24.37.

CRIBRILINIDS

A diverse family of mostly encrusting cheilostomes with numerous spines bent over the frontal membrane. The spines are characteristically fused together to form a sizable frontal shield ("pericyst") over the delicate frontal wall.

In the most primitive genus, *Membraniporella*, the spines are often incompletely fused, especially at the outer edge of colonies, so that young zoids resemble a *Chaperiella* or *Cauloramphus*. In *Membraniporella baueri* Soule (fig. 24.38), spines are stout, solid, and branching; ovicells are solid-looking, imperforate, with a "mucro" (point) on the top. The frontal shield is normally incomplete; spines fail to fuse in the midline. No avicularia are present. It is restricted to the Gulf of California and is apparently rare. *M. aragoi pacifica* Osburn is similar to *M. baueri*, but complete frontal shields invariably form. It is a warm temperate and tropical eastern Pacific subspecies (fig. 24.39).

Species of *Cribrilaria*, which also go under the names *Colletosia*, *Cribrilina*, and *Puellina*, have almost completely fused sets of numerous spines, and forming autozoids at colony edges are never seen to have lateral independent separated spines like *Membraniporella*, which they generally resemble. The aperture is ringed with stubby spines. Ovicells are prominent, imperforate, and often keeled longitudinally. Avicularia are interzoecial (that is, occupying the same place in the colony as autozoids). Most species have small autozoids, less than 0.5 mm long; many do not exceed 0.4 mm. Two species are common in the Gulf: *C. radiata* (Moll), with pointed avicularia (fig. 24.40), and *C. flabellifera* (Kirkpatrick), with blunt or spoon-shaped avicularia. Both are widely distributed, with *C. flabellifera* preferring more tropical seas (see J. Soule, 1959:47).

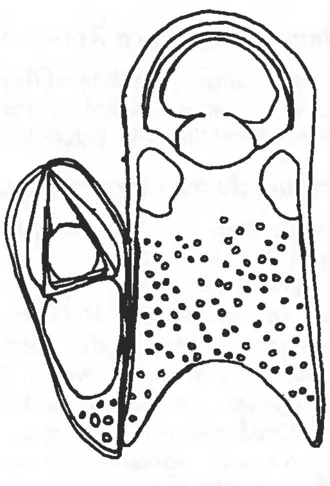


Fig. 24.32 *Thalamoporella gothica*
(after Osburn, 1950)

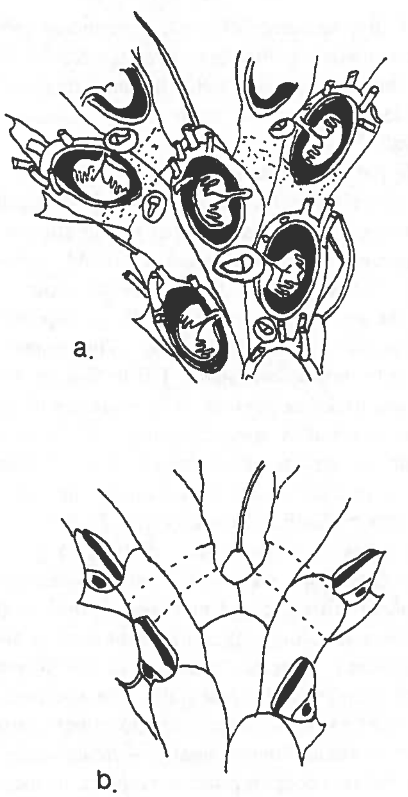


Fig. 24.34 *Scrupocellaria mexicana*.
(a) Frontal view.
(b) Basal view.
(After Osburn, 1950.)

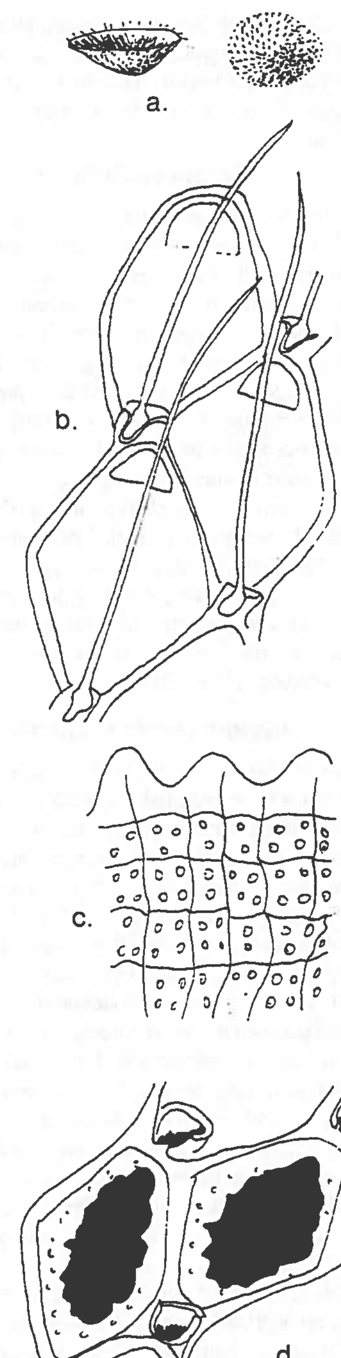


Fig. 24.33 *Cupuladria* sp.
(a) Two colonies about life size.
(b) Three autozoids with vibracula.
(c) The colony from the basal side.
(d) Two KOCl-treated zoids.
(After Norman, 1909.)

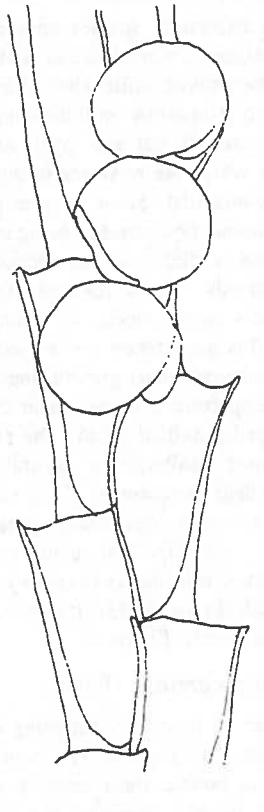


Fig. 24.35 *Bugula neritina*
(after Maturo, 1966)

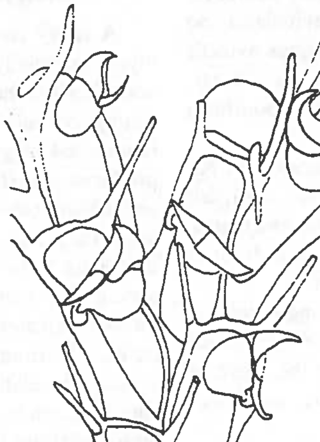


Fig. 24.36 *Bugula californica*
(after Osburn, 1950)

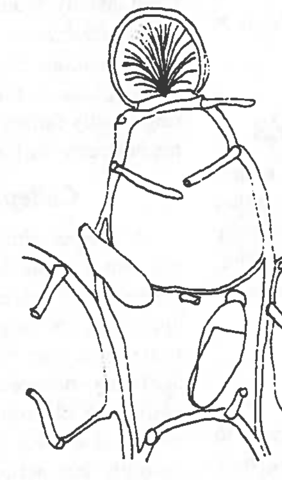


Fig. 24.37 *Sessibugula translucens*
(after Osburn, 1950)

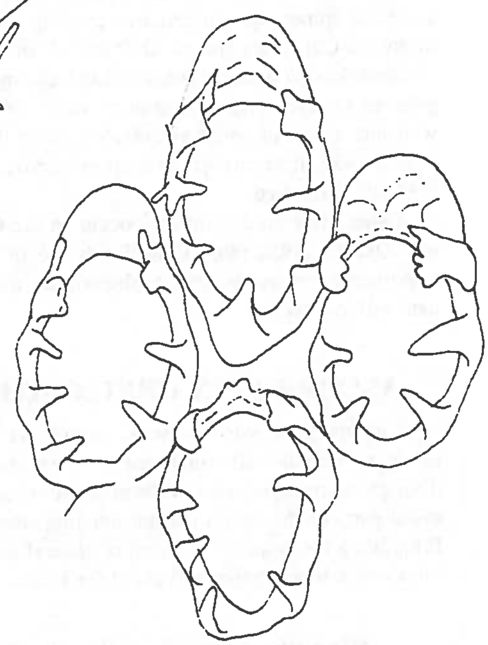


Fig. 24.38 *Membraniporella baueri*
(after J. Soule 1959)

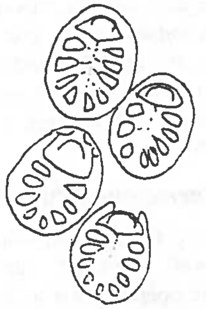


Fig. 24.39 *Membraniporella aragoi pacifica*
(after Osburn, 1950)

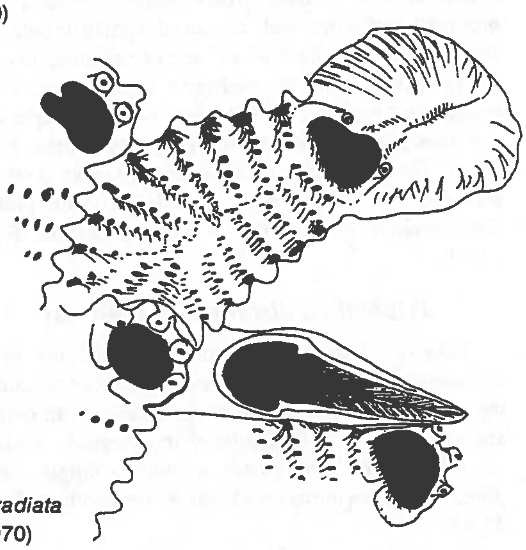


Fig. 24.40 *Cribrilaria radiata*
(after Harmelin, 1970)

Reginella mucronata (Canu and Bassler) resembles species of *Cribrilaria*, but there are no avicularia, no spines around the aperture, and the conspicuous ovicells are perforated by numerous scattered pores (fig. 24.41). It is common, but apparently limited to southern California and Baja California.

Figularia hilli Osburn resembles *R. mucronata*, but there are only 8 or so pores in the frontal wall, all occluded by brownish cuticle. There are no avicularia, apertural spines, or obvious ovicells (fig. 24.42). It is limited to California and the Gulf of California.

Bellulopora bellula (Osburn) has radiating pores and grooves on the ovicell resembling those of the frontal wall and a pair of small avicularia next to the aperture (fig. 24.43). It occurs in the eastern Pacific, as well as the Gulf of Mexico.

Other cribrilinids probably occur in the Gulf. Consult Osburn (1950:188). Cribrilinids are of theoretical importance because some ascophorans are thought to be derived from them.

ASCOPHORAN CHEILOSTOMES

Cheilostomes with an ascus; a cuticular sac underneath the frontal wall which opens to the outside either through the proximal part of the aperture (very rarely the distal part) or through a special opening, the ascopore. Probably a heterogeneous group of several evolutionary lines which independently evolved the ascus.

Hippothoa divaricata Lamouroux

An inconspicuous creeping ascophoran attached to shells and stones. Autozoids are uniserial; that is, they form isolated strings (rows) of zoids; the zoid rows frequently branch. Zoids are oval or mummy-shaped. If the proximal end is thinned into an elongated tubule, it is shorter than the length of the rest of the zoid. Ovicells are prominent, smooth, perforate, or imperforate. The frontal wall is glassy when young, turning opaque later; it is marked by a series of transverse growth lines, but no pores. The aperture is rounded distally, with a shallow proximal notch. No spines or avicularia are present. Cosmopolitan in temperate to tropical oceans. Figure 24.44.

Hippothoa distans MacGillivray

Like *H. divaricata*, but the proximal ends of the autozoids are drawn out into threadlike tubules connecting autozoids in the same zoid row. Zoids with ovicells are sometimes a little smaller than autozoids. Ovicells are prominent, imperforate, or with a single central pore, sometimes borne on a knob. Cosmopolitan. Figure 24.45.

Celleporella hyalina (Linnaeus)

A fairly common encrusting species on rocks and algae, especially red algae. Colonies are at first glassy and colorless, becoming opaque white when older. Very young colonies are one-layered and monomorphic (composed only of autozoids), but new layers are soon produced superficially which are mixtures of autozoids and heterozoids (nonautozoids). Some species of *Celleporella* are unusual among bryozoans in being sexually dioecious: autozoids are sterile; male and female zoids are smaller than autozoids. Males resemble tiny autozoids; females possess large ovicells with numerous pores. The frontal wall is imperforate and ridged transversely by relatively inconspicuous growth lines (compare *C. cornuta*). The aperture is hemicircular distally, with a shallow U-shaped proximal notch. The plane of the operculum is not quite parallel to the substrate but is tilted distally about 20 degrees (compare *C. cornuta* and *C. santacruzana*). No spines or avicularia are present.

C. hyalina is nearly cosmopolitan, being common from Alaska to southern California and possibly occurring locally farther south (Pinter, 1973). It may occur in the northern Gulf of California. Figure 24.46.

Celleporella cornuta (Busk)

A species similar to *C. hyalina*, encrusting red algae, but with the following differences. The frontal wall is heavily ribbed, even umbonate, transversely at growth lines. The operculum is almost perpendicular to the substrate at the very distal end of autozoids. The aperture is distinctly notched proximally, more so than in *C. hyalina*. Male zoids are narrower, but often almost as long as autozoids (0.4 mm). The ovicell is imperforate centrally but peripheral "pores" (possibly zoid buds) appear at the edges. The colonies are always one-layered, never forming secondary layers. Not known from the Gulf of California, but abundant and possibly endemic to California. Finding it in the Gulf would not be unexpected and would be of great interest; hence its inclusion here. Figure 24.47.

Celleporella santacruzana (Pinter)

A very similar species to *C. cornuta*, with these differences. The frontal wall is ribbed, but not as strongly as *C. cornuta*. The operculum is at about 45 degrees to the substrate. The aperture is strongly notched, sometimes V-shaped, the upper edges of the notch being squared. Male zoids are slightly shorter (0.3 mm) than autozoids (0.35 mm). The ovicell is imperforate or perforated centrally by a few pores. Colonies are always one-layered. So far known only from southern California, and only recently recognized as a species. Good descriptions of *C. santacruzana*, *C. cornuta*, and *C. hyalina* are found in Pinter (1973:438). Figure 24.48.

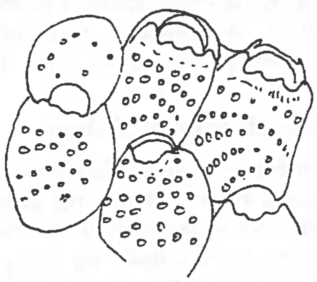


Fig. 24.41 *Reginella mucronata* (after Osburn, 1950)

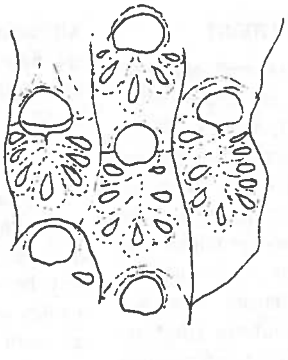


Fig. 24.42 *Figularia hilli* (after Osburn, 1950)

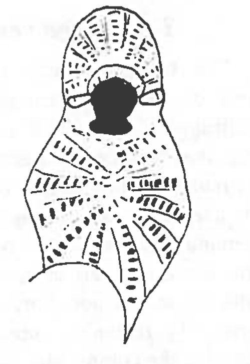


Fig. 24.43 *Belluloporo bellula* (after Osburn, 1950)

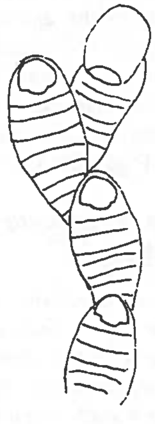


Fig. 24.44 *Hippothoa divaricata* (after Osburn, 1952)

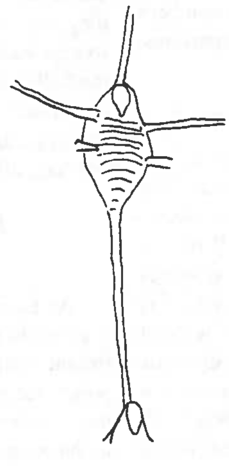


Fig. 24.45 *Hippothoa distans* (after Osburn, 1952)

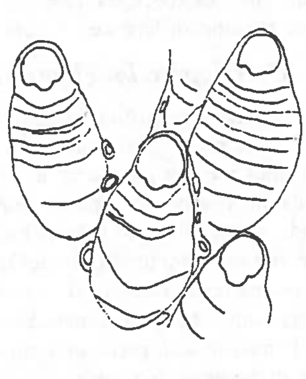


Fig. 24.46 *Celleporella hyalina* (after Osburn, 1952)

Fig. 24.47 *Celleporella cornuta* (after Osburn, 1952)

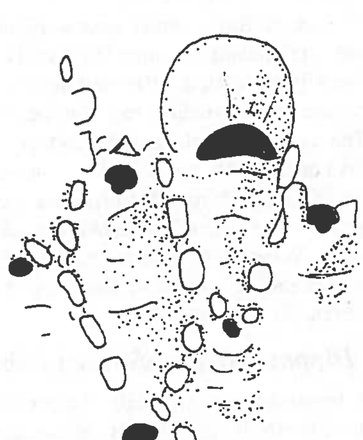


Fig. 24.48 *Celleporella* (?) *santacruzana* (after Woollacott, 1971)

Trypostega venusta (Norman)

This bryozoan forms tan, single-layered encrustations on subtidal hard substrates, especially other cheilostomes. Autozoids are rhomboid, about 0.45 mm long, the frontal perforated with tiny pores. The aperture is circular distally, deeply notched proximally, with two tiny lateral notches, giving it a characteristic shape. The operculum is brown and not planer: the proximal part joins the distal part at an obtuse angle. "Zoeciules," probably sexual polymorphs, are diagnostic. They superficially resemble interzoidal avicularia (that is, placed in the colony pattern like autozoids) and measure about 0.1 mm long. Their apertures are minute, brown, and circular. Ovicells are mere bulges in the colony surface distal to some zoids. It is common in tropical waters; occasionally in temperate seas. A related species, *T. claviculata* (Hincks), is found in southern California. Its zoeciules have keyhole-shaped apertures; there are other differences. Figure 24.49.

Cyclicopora longipora (MacGillivray)

Generally encrusting, sometimes forming erect, hollow branches, slightly flattened, 1–3 mm wide. The branches are not jointed as in *Thalamoporella*. Autozoids are nearly rectangular, monomorphic (all of one kind), and large (up to 1.2 mm long). The frontal wall is thin and delicate, uniformly perforated. The aperture is almost perfectly circular, 0.24 mm in diameter, without hinge teeth. The operculum is delicate and thin. Ovicells are hemispherical, perforated, prominent, and about 0.4 mm in diameter. No spines or avicularia are present. A tropical or subtropical Pacific species; occasional in the southern Gulf of California. Figure 24.50.

Hippopetraliella magna (d'Orbigny)

This species forms small encrustations on shells. Autozoids are rectangular, rounded distally. The frontal wall is heavily perforated, often roughened by secondary calcification; in old colonies zoid outlines all but disappear. The aperture is elongated, slightly wider proximally than distally. No hinge teeth are present. A pair of small avicularia, with rounded mandibles, are lateral to the aperture. The ovicell is coarsely perforate, partly submerged. Warm temperate to tropical in the Pacific and Indian oceans. Also known under the name *Petralia japonica* (Busk). Figure 24.51.

Hippopodina californica Osburn

This bryozoan encrusts shells. Autozoids are coarse, large (to 0.8 mm long), distinct, and rectangular. The frontal wall is rough, perforated by large pores. The aperture is rounded with a broad proximal notch and strong hinge teeth; operculum heavy, brown. No spines or avicularia are present. Ovicells are round, 0.45 mm wide, becoming embedded by secondary calcification. All features are best seen in young autozoids before they are heavily calcified. Worldwide in warm waters. Common in the southern and middle Gulf. Figure 24.52.

Cycloperiella rosacea Osburn

A red or reddish-purple encrusting species, the color infiltrating the skeleton as well as the living parts. Because the color is known only in preserved specimens, it may be very different when animals are living. Autozoids are large (0.75 by 0.50 mm), rhomboidal, swollen, with a coarsely perforated frontal wall. The aperture is rounded distally and proximally, with straight sides; cardelles are present. The sides of the aperture may be formed into lappets, larger on zoids with ovicells. A knob (umbo) may be proximal to the aperture. Avicularia are sporadic, frequently absent; when present, they are proximal and lateral to the aperture on the frontal wall, with pointed mandibles directed obliquely medially. Ovicells are uncommon, prominent, evenly perforated, and continuous with the apertural lappets. Subtropical to tropical in the Atlantic and Pacific; common all through the Gulf. Figure 24.53.

Hippopleurifera mucronata Canu and Bassler

An encrusting species orange to red when preserved. Autozoids are oval and large (to 0.8 mm long). The frontal wall is coarse, perforated at the edges by large pores; the pores are usually separated by ridges which may converge medially to form a knob or spike proximal to the aperture. The aperture is rounded distally, straight laterally, with a V-shaped notch and strong hinge teeth. It is surrounded by about 6 short hollow spines, 4 when an ovicell is present. Avicularia may occur; when present, they are just proximal and lateral to the aperture on the frontal wall, the small red mandibles pointed distally and medially. A warm water Atlantic and Pacific species. Don't confuse it with schizoporellids. Figure 24.54.

THE SCHIZOPORELLIDS

This is a large, diverse, common group of ascophoran cheilostomes with many representatives in the Gulf. It is a difficult group, even for experienced specialists, because the species are maddeningly variable and tend to form complex clines. They are mostly encrusting species, frequently red or orange in life, becoming brownish when dry. All have autozoids with uniformly perforated frontal walls, and most have apertures with prominent hinge teeth and round distal parts and proximal V-shaped or U-shaped notches. Small avicularia with pointed mandibles are frequent, but absent in some species and sometimes absent in some colonies of species possessing avicularia. Ovicells are

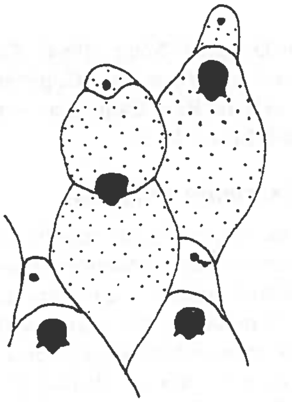


Fig. 24.49 *Trypostega venusta* (after Osburn, 1952)

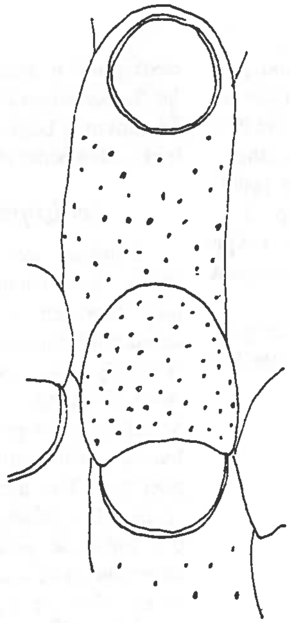


Fig. 24.50 *Cyclicopora longipora* (after Osburn, 1952)

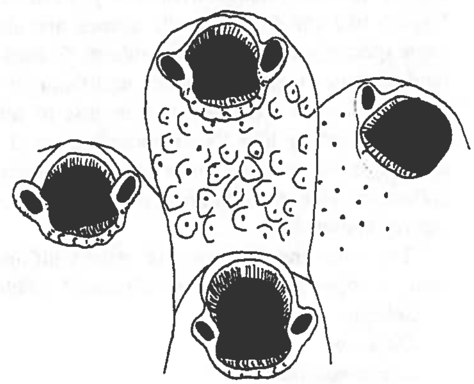


Fig. 24.51 *Hippopetraliella magna* (after Osburn, 1952)

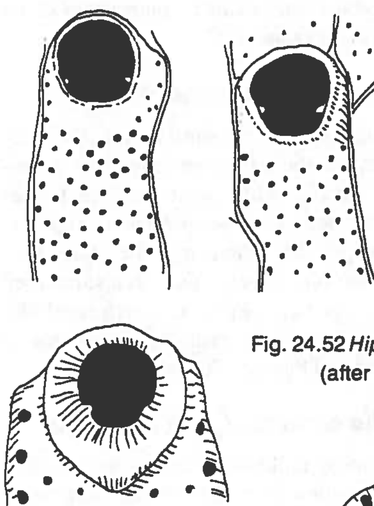


Fig. 24.52 *Hippopodina californica* (after Osburn, 1952)

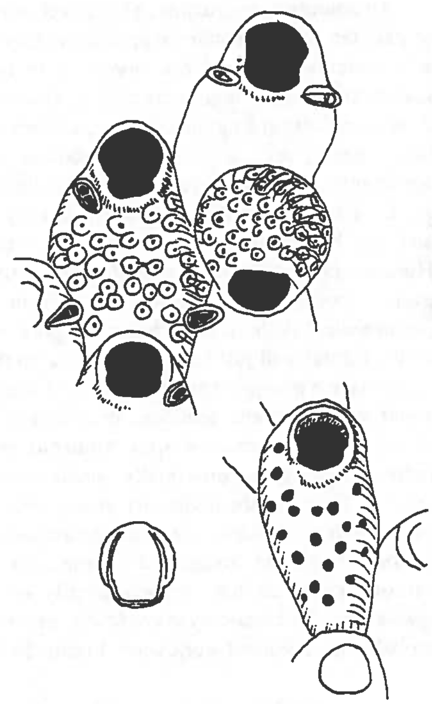


Fig. 24.53 *Cycloperiella rosacea* (after Osburn, 1952)

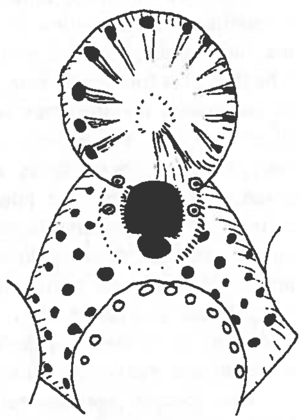


Fig. 24.54 *Hippopleurifera mucronata* (after Osburn, 1952)

usually present, characteristically prominent and perforated like the frontal wall. Spines are abundant in some species, rare or absent in others. Colonies are unilaminar (one-layered) in some, multilaminar in others. Most beginners will find it safe just to label specimens something like "schizoporellid, sp. 1, sp. 2... etc." Precise determinations require reference to type collections and are sometimes impossible at our present state of knowledge.

The following genera occur in the Gulf and are generally ascribed to the Schizoporellidae (J. Soule, 1961):

Schizoporella
Dakaria
Schizomavella
Arthropoma
Escharina
Stylopoma
Gemelliporidra
Hippodiplosia

Schizoporella "unicornis" (Johnston)

An abundant, encrusting, pale violet through orange to pale tan, multilaminar ascophoran cheilostome. Several species probably are involved in the Gulf of California; none of them may be identical to the "true" *S. unicornis* from England. Young, unilaminar colonies have square, rectangular, or rhomboidal zoids which sometimes become covered by secondary layers of zoids. The frontal wall is swollen, evenly perforated, and may bear a knob or spike proximal to the aperture. Hollow spines are never present around the aperture, even in young zoids; if spines are present, suspect *S. occidentalae*. At least some autozoids possess avicularia on the frontal wall just behind and lateral to the aperture. Zoids have a pointed mandible, directed laterally, that is about as long as the aperture. If avicularia are totally absent, suspect *Darkaria* spp. Autozoid apertures are round notch (sinus) proximally; small hinge teeth are present. Ovicells are frequently absent over whole colonies. When present, they are prominent, globular, perforated like the frontal wall, sometimes with a calcareous knob on top. A supposedly cosmopolitan species, but the taxonomy is confused, and many species probably are involved worldwide. Figure 24.55.

Schizoporella occidentalae D. Soule and J. Soule

A mostly unilaminar encrusting species on rocks and shells which generally resembles *S. "unicornis,"* with these differences. The colonies are colorless or pale tan, usually circular. Very young autozoids at the very edge of the colony may possess a pair of delicate hollow spines; they are soon lost, but are diagnostic. A detailed description is available in D. and J. Soule (1964). So far *S. occidentale* is known only from the vicinity of Scammon's Lagoon off western Baja California, but it may also occur in the Gulf. Figure 24.56.

Schizoporella inarmata (Hincks)

Colonies are unilaminar encrustations, mostly on shells, yellowish to tan. Autozoids are rectangular, regularly arranged in a brickwork pattern ("quincunx"), about 0.45 mm long by 0.35 mm wide. The frontal wall is evenly perforated by fine pores, which become somewhat obscured in older zoids by heavy calcification. Small knobs or granulations occur between pores, often building into a prominent knob or spike proximal to the aperture. The aperture, 0.13 by 0.13 mm, is skull-shaped. No spines or avicularia are present. Ovicells are 0.3 mm wide, perforated like the frontal wall, low and inconspicuous, and often missing (even on large colonies). Beware confusing this species with *S. "unicornis"* with only a few avicularia, or with species of *Dakaria*. Common all through the Gulf. A well-known eastern Pacific species from British Columbia to Costa Rica (J. Soule, 1961). Figure 24.57.

Schizoporella trichotoma Waters

An encrusting species on shells, usually one-layered. Autozoids are about 0.5 mm long, with a typical skull-shaped schizoporellid aperture. The frontal wall is evenly perforated by star-shaped (stellate) pores. No avicularia are present. There may be about four spines around the aperture in very young zoids, but they are soon lost. Ovicells are conspicuous, perforated like frontal walls, sometimes ridged radially. Occasional in the tropical Atlantic and Pacific. Figure 24.58.

Schizoporella cornuta (Gabb and Horn)

Colonies are mostly unilaminar, encrusting (usually on shells), and pale yellow or cream-colored. Autozoids are rhomboid, about 0.5 mm long by 0.35 mm wide. The frontal is finely perforate, but the pores may be hard to see unless the specimen is treated with KOCl and dyed with ink. The aperture is skull-shaped, 0.13 mm long, and there are no spines. A pair of small avicularia, sometimes unpaired, are lateral and slightly distal or proximal to the aperture, the mandibles being hemicircular to triangular, directed distolaterally or proximolaterally. They may be borne on a large chamber. The ovicells are diagnostic: they are circular, often partly embedded by secondary calcification, imperforate, with a central area marked by radial ridges.

This species probably better belongs in the genus *Stephanosella* because of its characteristic ovicell, and may be identical to *S. biaperta* (Michelin). Topotype material of the latter species has frontal perforations

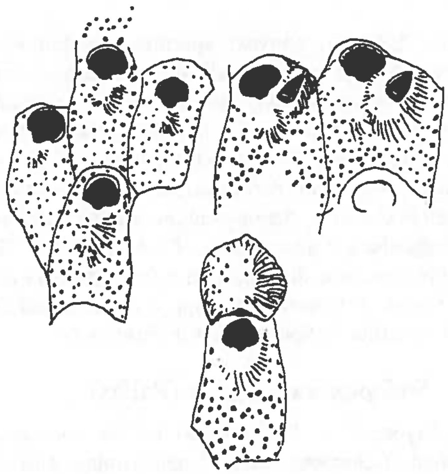


Fig. 24.55 *Schizoporella unicornis* (after Powell, 1970)

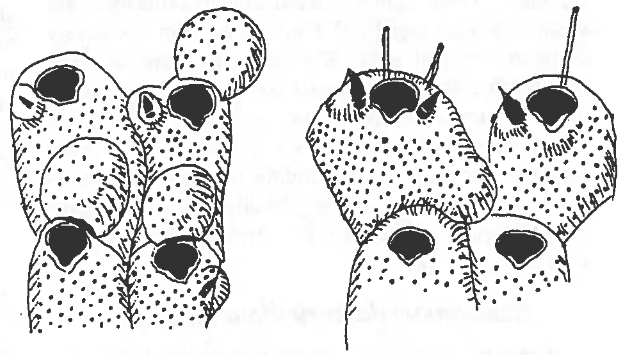


Fig. 24.56 *Schizoporella occidentalae* (after D. Soule and J. Soule, 1964)

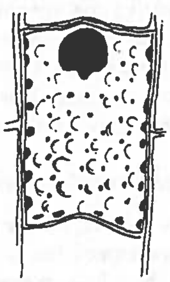


Fig. 24.57 *Schizoporella inarmata* (after Osburn, 1952)

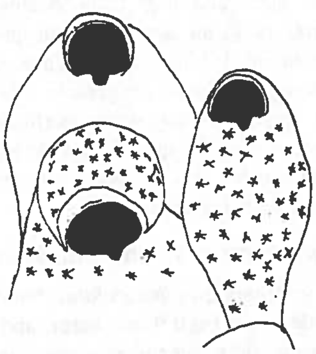


Fig. 24.58 *Schizoporella trichotoma* (after Osburn, 1952)

(Banta and Sanner, unpublished). Widely distributed in boreal to tropical waters, if all the records are to be believed. Easily confused with *S. dissimilis*. Figure 24.59.

Schizoporella dissimilis Osburn

Similar to *S. cornuta*, with these differences: colonies multilaminar; pores relatively prominent; most important, the proximal apertural notch is more U-shaped than in *S. cornuta;* ovicells become more embedded by secondary calcification. Another candidate for the genus *Stephanosella*. A tropical eastern Pacific species. Rare, but the ready confusion with *S. cornuta* makes it significant. Figure 24.60.

Dakaria sertata (Canu and Bassler)

An abundant encrusting species sometimes confused with *Schizoporella* and *Watersipora* species. It forms multilaminar pale tan encrustations on hard substrates. Autozoids are at first regularly arranged, but new zoids are budded frontally in older colonies (a common phenomenon among ascophoran cheilostomes); the younger zoids are turned every which way and are not so neat as primary layers. Autozoids are about 0.6 mm long and coarsely perforate. The frontal is roughened, sometimes forming a low knob proximal to the aperture. The aperture is nearly circular with strong hinge teeth. The aperture may be surrounded by a low calcareous rim, sometimes provided with tubercles, like a rude pearl necklace. No spines or avicularia are present. I have not seen ovicells on any Gulf of California material, but J. Soule (1961) describes them as partly embedded by secondary calcification, perforate. Warm temperate to tropical in the eastern Pacific and Atlantic. Especially abundant in the northern Gulf of California in shallow water. Figure 24.61.

Dakaria ordinata (O'Donoghue and O'Donoghue)

Encrusting or forming cylindrical unjointed branches; white, shining, multilaminar. Autozoids are about 0.6 mm long by 0.4 mm wide with a coarsely perforated frontal wall. The aperture is broader than long, with a shallow proximal notch and hinge teeth. It may be surrounded by a low calcareous rim, not so prominent as in *D. sertata*. No spines or avicularia are present. The ovicells are slightly flattened and perforated centrally, but not peripherally. Easily confused with *D. sertata*. Eastern Pacific: British Columbia to the Galápagos. Figure 24.62.

Schizomavella auriculata (Hassall)

Pale tan, one-layered encrustations on shells. Autozoids are small (about 0.45 mm long), with a finely perforate frontal wall and a nearly round aperture with a shallow proximal notch and hinge teeth. A single avicularium just proximal to the aperture in the midline is diagnostic. Its mandible is blunt; it may be mounted on a low calcareous knob. No spines are present. The ovicell is comparatively large (0.25 mm wide), perforated, and slightly flattened. A variable species, but the avicularia and aperture distinguish it at once. Widely distributed in temperate to tropical waters. Figure 24.63.

Codonellina anatina (Canu and Bassler)

Similar to *Schizomavella auriculata*, but the autozoids are a little larger (to 0.9 mm long), and a large spoon-shaped avicularium sometimes replaces the small median avicularium. *Codonellina* is generally placed in the Smittinidae (see Osburn, 1952:422); it is arranged here in the text because of its similarity to *S. auriculata*. So far known from Japan, Hawaii, and the Galápagos, but it may occur in the Gulf of California and be confused with *S. auriculata*, hence its inclusion. Figure 24.64.

Arthropoma circinata (MacGillivray)

This species forms single-layered, tan encrustations on shells. It resembles most schizoporellids, but the narrow V-shaped proximal notch in the aperture, 6 or so apertural spines, imperforate smooth ovicell, and semicircular knob proximal to the aperture distinguish it reasonably well. No avicularia are present. Warm temperate to tropical Atlantic and Pacific waters. Figure 24.65.

Escharina vulgaris (Moll)

This bryozoan forms one-layered encrustations on shells and may be distinguished by the following combination of characters: autozoids square to rectangular or ovoid, about 0.5 mm long; frontal wall evenly perforate (Osburn, 1952:335) or only marginally perforate (J. Soule, 1961:15), convex; aperture rounded with U-shaped proximal notch, small hinge teeth and three short hollow spines, quickly lost with age; two, sometimes one, small avicularia on either side of the aperture, slender, pointed mandibles directed proximally or distally; ovicell prominent, perforated, with a knob on top; the ovicell is closed by the operculum, a diagnostic feature distinguishing it from species of *Schizoporella*. The presence of avicularia distinguishes it from *Dakaria* and *Hippodiplosia*. Temperate and tropical Atlantic and the Gulf of California (J. Soule, 1961). Figure 24.66.

Stylopoma spongites (Pallas)

This bryozoan is distinguished by the following combination of characters: mostly multilaminar encrustations on shells, reddish; autozoids rectangular with finely perforated frontal; aperture with a distinct V-shaped or even slitlike proximal notch; scattered avicularia, usually around the aperture, with pointed or blunt mandibles, variable in size and shape; no spines; the ovicell is huge, usually greater in diameter than autozoids are long, obscuring the aperture of the fertile zoid; the ovicell and aperture shape are highly diagnostic. Abundant all through the Gulf of California. Widely distributed in warm waters. This species is often referred to as *S. informata* (Lonsdale). Figure 24.67.

Hippodiplosia insculpta (Hincks)

This species forms one-layered encrustations on shells and algae, or sometimes forms short 2-layered fronds. It is pale to bright yellow or orange (because of the orange embryos); color is lost in preservation. Autozoids quadrangular, 0.5 mm long; frontal wall coarsely perforate, characteristically with a knob proximal to the aperture. The knob has a crescent-shaped pore next to the aperture, but no avicularium. No spines are present. The aperture is rounded distally, straight, or rounded proximally, with strong hinge teeth. The ovicells are large (0.25 mm wide), imperforate, and radially striated, their aperture closed by the operculum of the fertile autozoid. Alaska to Costa Rica. Osburn (1952) noted that the autozoids are larger to the north (to 0.75 mm long). Common in the Gulf of California. Figure 24.68.

Hippoporella gorgonensis Hastings

Heavy one-layered to many-layered encrustations on shells. Autozoids are, at the margins, distinct, with 8–13 marginal pores, which are hard to see except in dyed KOCl-treated colonies. There are 2–4 hollow apertural spines, and a single knob or branched calcareous spike proximal to the aperture. The aperture is roughly circular, broader proximally, with an almost straight proximal edge and strong hinge teeth. The margin of the aperture is sometimes delicately serrated or beaded. Zoids are

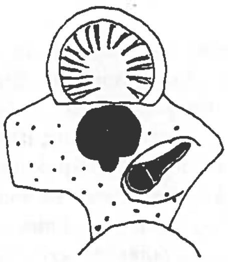


Fig. 24.59 *Schizoporella comuta* (after Osburn, 1952)

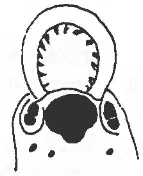


Fig. 24.60 *Schizoporella dissimilis* (after Osburn, 1952)

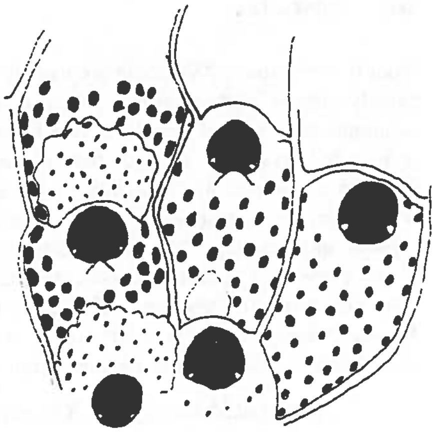


Fig. 24.61 *Dakaria sertata* (after Marcus, 1937)

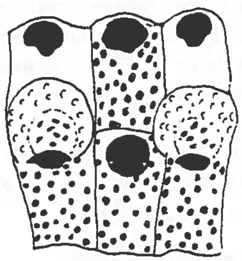


Fig. 24.62 *Dakaria ordinata* (after O'Donoghue and O'Donoghue, 1923)

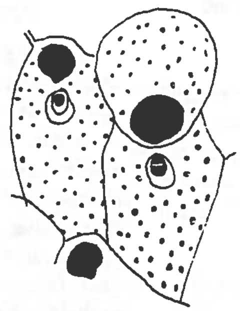


Fig. 24.63 *Schizomavella auriculata* (after Osburn, 1952)

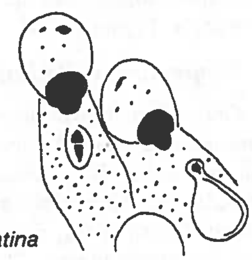


Fig. 24.64 *Codonellina anatina* (after D. Soule and J. Soule, 1973)

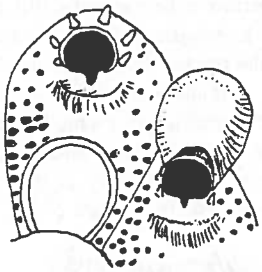
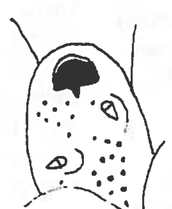
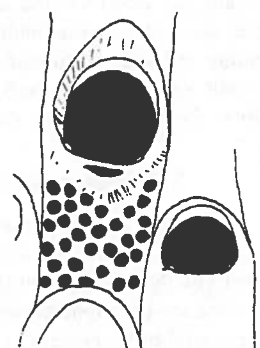


Fig. 24.65 *Arthropoma circinata* (after Osburn, 1952)





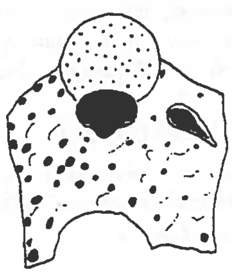


Fig. 24.66 *Escharina vulgaris* (after Osburn, 1952)

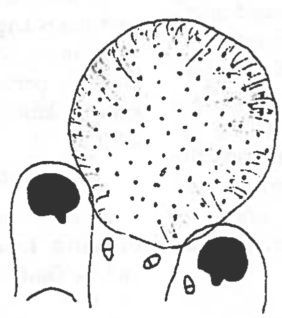


Fig. 24.67 *Stylopoma spongites* (after Osburn, 1952)

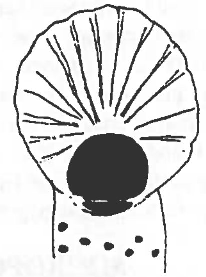


Fig. 24.68 *Hippodiplosia insculpta* (after Osburn, 1952)

about 0.3 mm long. Avicularia are usually present, extremely variable, and sometimes almost as long as a zoid (although usually much smaller). Mandibles are pointed or rounded, typically located near the aperture, but common elsewhere, and typically directed proximally. Ovicells are prominent, imperforated, sometimes with a knob or spike on top. Old zoids are heavily calcified, deeply embedded, and lack spines. An extremely variable, but common, bryozoan. Readily confused with *Aimulosia uvulifera* and sometimes species of *Rhynchozoon*. Southern California to Panama. Figure 24.69.

Aimulosia uvulifera (Osburn)

Similar to *Hippoporella gorgonensis* with these differences (see D. and J. Soule, 1964:23): autozoids 0.5 mm long; only a "few" marginal pores; 6 apertural spines on marginal zoids; avicularia usually smaller, never much longer than the aperture. Tropical Atlantic and Pacific. Figure 24.70.

Hippomonavella longirostrata (Hincks)

Gray or light brown encrustations on hard substrates. Autozoids are about 0.6 mm long, regularly arranged. The frontal wall is perforated by two or three rows of pores, leaving the central area imperforate. The aperture is straight on the sides, with a broad U-shaped proximal notch and strong hinge teeth. Young zoids bear about 6 spines, but they are quickly lost. Avicularia are pointed, typically just proximal and lateral to the aperture; mandibles are directed proximally, but they vary greatly in location and size (up to half the length of an autozoid). Ovicells are prominent, perforated, and 0.25 mm wide. British Columbia to the Gulf of California. Figure 24.71.

Stephanosella vitrea Osburn

Small one- or many-layered encrustations on hard substrates. Autozoids are small (0.4 mm long), rectangular to polygonal, calcifying heavily. The frontal wall has some small peripheral pores and a few even smaller, more central ones, evident only when cleaned and dyed. The aperture is rounded distally with a V-shaped proximal notch, about 0.1 mm long; the aperture remains easily visible even after heavy calcification of the frontal wall. No spines are present, even on young zoids. Two avicularia (or occasionally one) are lateral to the aperture, their pointed or blunt mandibles directed laterally and distally. Ovicells are 0.18 mm wide, imperforate, with radial striations in the central area, becoming deeply embedded in the frontal wall with age. Southern California to the Galápagos. Figure 24.72.

MICROPORELLIDS

Two genera are represented in the Gulf of California, *Microporella* (about 7 species) and *Fenestrulina*. They generally resemble schizoporellids, but are readily distinguished from them by the shape of the aperture (notched proximally in schizoporellids, straight in microporellids), and by the presence of an ascopore. The ascopore opens directly into the ascus; it is a small pore in the midline of the autozoid just proximal to the aperture, often associated with a calcareous knob proximal to it. The ascopore may be circular, kidney-shaped, or a plate with numerous tiny pores (*M. cribosa*). Most are subtidal, but some occur on algae or in shallow water.

Fenestrulina malusi (Audouin)

Delicate lacy encrustations on algae or shells. Autozoids are rectangular, hexagonal, or oval, very distinct and one-layered. Autozoids are thinly calcified, evenly perforate, with at least a few pores between the aperture and ascopore. A calcareous knob may occur behind the ascopore ("variety *umbonata*"). The ascopore is kidney-shaped, and no avicularia are present. Young zoids bear 4–6 hollow spines around the aperture (often lost). Ovicells are perforate or imperforate [imperforate in the Gulf of California (Soule, 1961)]. Cosmopolitan in temperate to tropical waters. Figure 24.73.

Microporella ciliata (Pallas)

Solid white to tan one-layered encrustations on shells or algae. Autozoids are 0.5 mm long, ovoid or rectangular, delicate when young and heavily calcified but distinct when older. The frontal wall is perforate, marginal pores being larger. The aperture is hemicircular (0.1 mm long), and the ascopore is kidney-shaped distal to a calcareous knob or spike on the frontal wall. There are 4–7 hollow apertural spines. Avicularia are single, rarely paired, with the long slender mandibles oriented distally and laterally. Ovicells are roughened and finely perforate, not closed by the operculum. Widely distributed; Oregon to Chile in the eastern Pacific. Figure 24.74.

Microporella californica (Busk)

Like *M. ciliata*, but the zoids are larger (0.65 mm long), the frontal wall is more coarsely perforated, the aperture is larger (0.12 mm long), and the avicularia are more often paired (two per autozoid). The ovicell is coarsely perforated and relatively smaller than in *M. ciliata*. British Columbia to the Galápagos. Figure 24.75.

Microporella cribosa Osburn

Like *M. californica*, but with a perforated calcareous cover to the ascopore. Mostly on algae. California and the Gulf of California. Figure 24.76.

Porella porifera (Hincks)

This bryozoan forms white encrustations on hard substrates. Autozoids are about 0.5 mm long, ovoid and distinct when young but polygonal and indistinct when

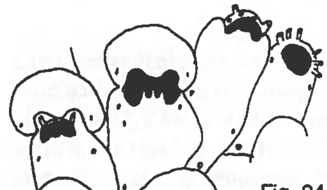


Fig. 24.70 *Aimulosia uvulifera*
(after Osburn, 1914)

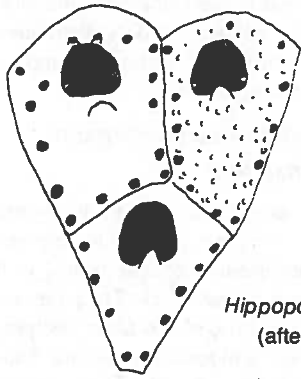
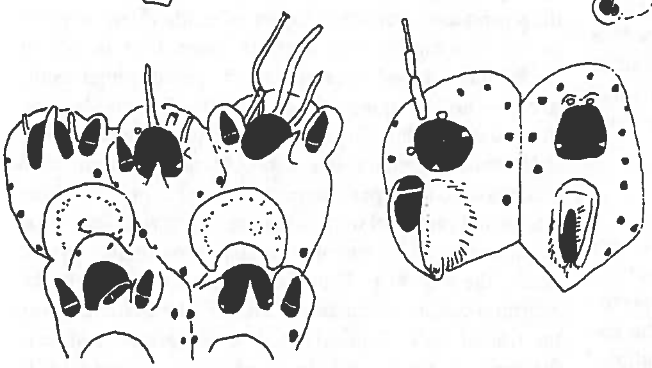


Fig. 24.69
Hippoporella gorgonensis
(after Hastings, 1930)



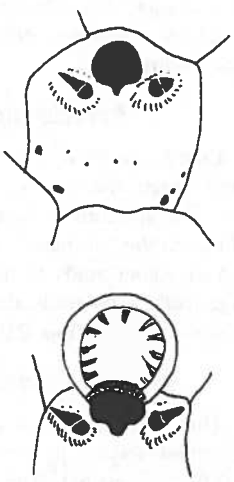


Fig. 24.72 *Stephanosella vitrea*
(after Osburn, 1952)

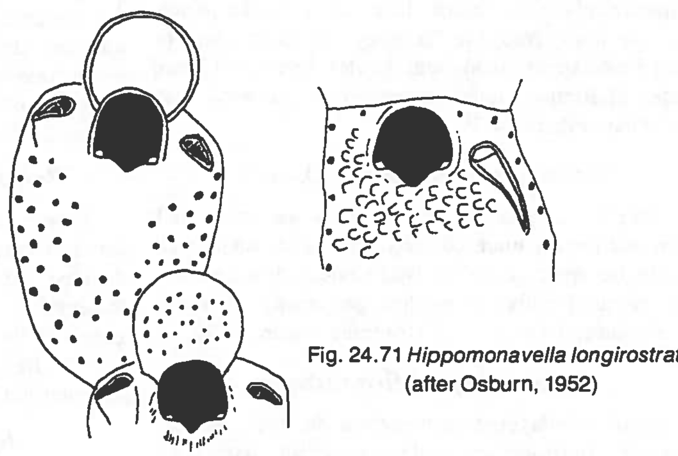


Fig. 24.71 *Hippomonavella longirostrata*
(after Osburn, 1952)

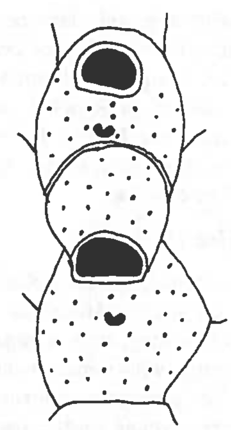


Fig. 24.73 *Fenestrulina malusi*
(after Osburn, 1952)

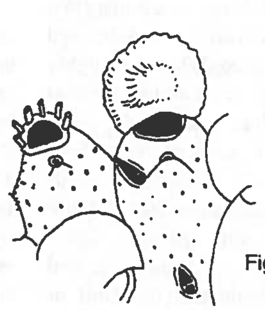


Fig. 24.74 *Microporella ciliata*
(after Osburn, 1952)

old. Autozoids bear a few tiny marginal pores and a heavy frontal wall. The aperture is almost hemicircular, surrounded by a calcareous collar, about 0.13 mm wide. A small avicularium with a round or blunt mandible is proximal to the aperture, surmounting a large chamber with several external pores. Avicularia may occur elsewhere on the frontal wall; as many as three may surround the aperture. In young zoids 1–4 hollow spines are present but are soon lost. Ovicells are conspicuous when young, imperforate, 0.17 mm wide, becoming buried by secondary calcification. Oregon to Costa Rica. Figure 24.77.

Porella rogickae Soule

Like *P. porifera*, but the marginal pores (6–8) are much larger, and the ovicells have a depressed central area. The aperture is surrounded by a high calcareous collar, but the "primary" aperture at the bottom can be seen in young zoids to have a small lyrule and small hinge teeth. Autozoids also are smaller, 0.4 mm long. Known only from Baja California. Figure 24.78.

Smittina landsborovi (Johnston)

This bryozoan forms encrustations on shells, one-layered but thickening when older. Autozoids about 0.7 by 0.6 mm, distinct. The frontal wall is evenly perforate, with a high, thin calcareous collar around the aperture, enclosing an avicularium with a blunt mandible. When avicularia are absent, the collar is circular in outline. On young zoids the "primary" aperture is seen to have a median proximal tooth (lyrule). Ovicells 0.3 mm wide, perforated, later embedded. Considered cosmopolitan. Figure 24.79.

Smittina maccullochae Osburn

Like *S. landsborovi*, but the zoids are larger (to 1 mm) and have a more coarsely perforated frontal wall and higher apertural collar. When avicularia are absent, the apertural collar is notched proximally. Southern California and the Gulf of Californnia. Figure 24.80.

Smittoidea prolifica Osburn

Small, one-layered encrustations on shells, stones, or algae. Autozoids are oval or polygonal, about 0.45 mm long. The frontal wall has a dozen or so marginal pores with ribs between them, becoming heavier and more granular with age. Young autozoids have a roughly circular aperture with distinct hinge teeth and a proximal tooth (lyrule). There are 2–4 spines distal to the aperture (soon lost). The operculum is soon obscured by a calcareous apertural collar which encloses a small avicularium proximally; the avicularium has a blunt mandible, pointing proximally and upward. There are no other avicularia. Ovicells are prominent and finely perforate. Southern California and the Gulf of California. Figure 24.81.

Smittoidea reticulata (MacGillivray)

This species is very similar to *S. prolifica*, but the avicularium is proximal to the calcareous apertural collar and its mandible is pointed. Widely distributed in cold temperate to subtropical waters. Compare *Schizomauvella auriculata*. Figure 24.82.

Parasmittina californica (Robertson) *sensu lato*

This species forms orange or buff multilayered crusts on hard substrates; common. Autozoids are about 0.5 mm long, with a translucent to opaque frontal wall that bears a row of coarse marginal pores. The pores are frequently separated by radial ridges and tubercles, producing a rough appearance in older zoids. Frontal budding produces secondary layers of zoids oriented more or less randomly. The aperture, seen best in young zoids, has a broad proximal tooth, strong hinge teeth, and 2–4 hollow spines which soon break away, leaving their bases behind. The aperture is almost circular, about 0.12 mm in diameter. It is soon obscured, in part, by a calcareous collar (peristome) formed of a pair of ridges lateral and proximal to the aperture which rises into what is almost a tube, leaving a notch proximally. In old zoids, the frontal wall thickens and nearly engulfs the apertural collar. Avicularia of all sizes are scattered over the frontal wall. Typically, one or two are present near the aperture, their mandibles ascending the apertural collar, directed distally and medially. An extremely variable and abundant species; *P. trispinosa* (Johnston) of most American authors is included here. See D. and J. Soule (1973). The species complex is cosmopolitan. Figure 24.83.

Parasmittina crosslandi (Hastings)

Like *P. californica*, but with large avicularia proximal and lateral to the aperture, their mandibles being directed proximally. Common; Gulf of California to Panama. A very similar species, *P. triangularis*, also occurs in the Gulf of California. See D. and J. Soule (1973). Beware of confusing this species with *Hippomonavella longirostrata*. Figure 24.84.

Escharella major (Hincks)

This species forms conspicuous, almost colorless single-layered encrustations on shells. Autozoids are large and distinctive, to 0.75 mm long, with a translucent frontal wall with small pores with minute tubules leading to the zoid margin. The peristome is made of 8–10 fused spines. The aperture in young zoids is nearly round, 0.1 mm long, with a straighter proximal border. There is a broad proximal tooth (lyrula). No avicularia are present. Ovicells are imperforate, smooth, soon engulfed by the frontal wall of the distal zoid. Also known as *Mucronella major*. British Columbia to the Galápagos. Figure 24.85.

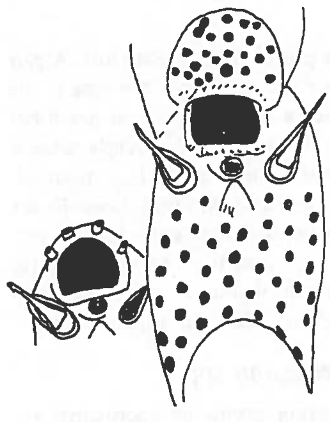


Fig. 24.75 *Microporella californica* (after Osburn, 1952)

Fig. 24.76 *Microporella cribosa* (after Osburn, 1952)

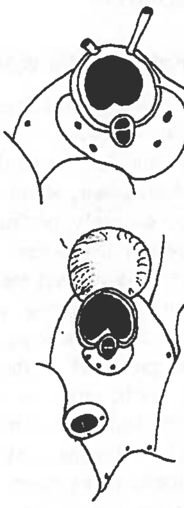


Fig. 24.77 *Porella porifera* (after Osburn, 1952)

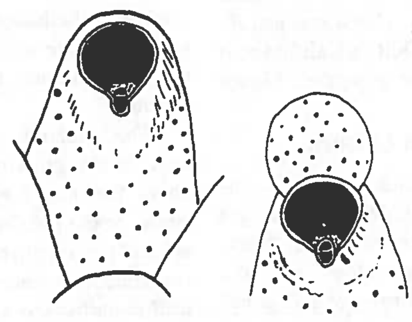


Fig. 24.79 *Smittina landsborovi* (after Osburn, 1952)

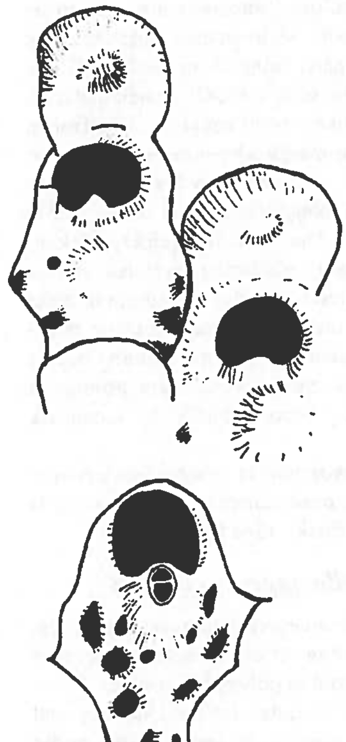


Fig. 24.78 *Porella rogickae* (after D. Soule and J. Soule, 1964; J. Soule, 1961)

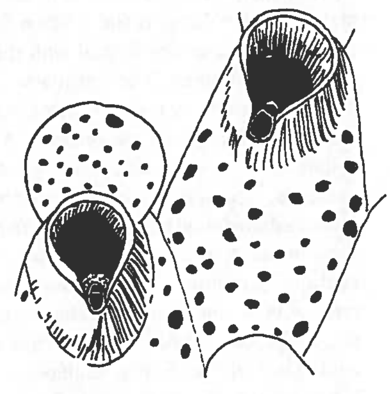


Fig. 24.80 *Smittina maccullochae* (after Osburn, 1952)

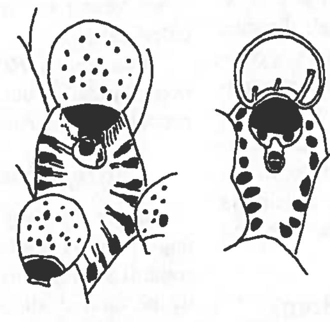


Fig. 24.81 *Smittoidea prolifica* (after Osburn, 1952)

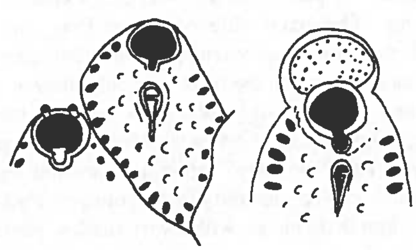


Fig. 24.82 *Smittoidea reticulata* (after Osburn, 1952)

Reptadonella violacea (Johnston)

This bryozoan is distinguished by the following set of characters: lavender to black or blue-black encrustations, often nodular, on hard substrates; single-layered; autozoids hexagonal, about 0.5 mm long; frontal wall roughened, coarsely perforate at the margins, with ridges between the pores; a central, kidney-shaped medioproximal pore represents the ascopore; aperture hemicircular, 0.1 mm long, without spines; a large avicularium with a pointed mandible, directed distally, is in the midline proximal to the aperture, supported on a calcareous knob; embryos brooded in "gonozoids," with enlarged apertures. Circumglobal in warm waters. Also known as *Adeona violacea*. A related species, *R. hymanae* Soule, is restricted to the Gulf of California; it lacks avicularia and has a circular ascopore. Figure 24.86.

Reteporellina bilabiata Osburn

A pretty, stony, branching species with little colonies that are around 25 mm in height. Branches are about 1 mm wide and look like little calcareous trees. Autozoids open to the inside of the colony only, the reverse side being formed of several rows of polygonal "kenozoids," with occasional avicularia. Autozoids are about 0.5 mm long, distinct when young, but soon becoming less so as the frontal wall thickens. There are 4 or 5 marginal pores. The "primary" aperture, seen only on young zoids, is roughly hemicircular, 0.1 mm long and wide. No spines are present. A pair of calcareous collars, one on each side, soon grow up to enclose the aperture, leaving an irregular, prominent notch. A near-median avicularium is on the frontal wall well proximal to the aperture; the mandible is pointed, directed laterally, proximally, and upward. Ovicells are imperforate, with a longitudinal median slit, occluded by cuticle, and soon embedded in the frontal wall of the distal zoid. Gulf of California, Galápagos, Columbia. A related species, *R. denticulata* (Busk), also occurs in the Gulf. In this latter species there are minute avicularia with rounded mandibles on the colony back side and between autozoids. Figure 24.87.

Phidolopora labiata (Gabb and Horn)

This attractive bryozoan forms large, orange, lacy colonies the size of a man's head. The stony, brittle fronds are perforated by oval pores about a millimeter long. The back side of the colony has polygonal "kenozoids" and avicularia with triangular mandibles. Autozoids are on the front side only; they are polygonal, about 0.5 mm long, with two or more inconspicuous marginal pores; the frontal wall thickens greatly with age. The "primary" aperture, covered by the operculum, can be seen only in the youngest zoids; it is about 0.1 mm in diameter, with a very shallow proximal notch. At first 1 or 2 spines are present but soon are lost. A pair of calcareous ridges soon grows up on either side of the aperture, obscuring it; they leave a proximal notch between them. A large avicularium is frequently present well behind the aperture. Its mandible is pointed, hooked at the end, and its tip is elevated. Ovicells are imperforate, 0.2 mm wide, and soon embedded in secondary calcification. Also known as *Phidolopora* (or *Retepora*) *pacifica*. Oregon to Peru, sometimes abundant. Subtidal in the Gulf of California. Figure 24.88.

Rhynchozoon spp.

An extremely common group of encrusting ascophoran cheilostomes. The several species present are typically white with reddish or orange embryos, producing pink colonies, typically on shells or rock. Most are subtidal.

The autozoids change rapidly with age. At the very edge of the growing colony, autozoids are seen to be about 0.6 mm long with skull-shaped apertures; the sinus, or the proximal part, being V- or U-shaped. The edge of the aperture, best seen in KOCl-treated material, is serrated, or beaded like a pearl necklace. The frontal wall is perforated at the margins by pores ("areolae"), with a few other pores scattered elsewhere. Avicularia are large, with pointed mandibles located below and to one side of the aperture. The avicularia quickly thicken, along with the frontal wall, obscuring apertures, so that the colonies must be tilted to see the operculum in older zoids. The frontal of older zoids may become decorated with knobs and tubercles. Frontal budding occurs extensively in some species. Ovicells are prominent when young but quickly become buried by secondary calcification.

The genus *Rhynchozoon* is poorly understood taxonomically, but the most common Gulf species is probably *R. rostratum* (Busk). (See fig. 24.89.)

Hippopodinella adpressa (Busk)

Single- or many-layered encrustations on shells, distinguished by the following set of characters: autozoids about 0.55 mm long, ovoid to polygonal, distinct, heavily perforated all over; apertures rounded distally and proximally with very strong hinge teeth; a little wider proximally, 0.1 mm; a low calcareous rim surrounds the aperture, sometimes higher proximally, and rarely with a tiny avicularium just proximal to the aperture; no spines; no obvious ovicells. This bryozoan resembles the larger *Cryptosula pallasiana*, a familiar inhabitant of harbors in California. Southern California to Chile. Figure 24.90.

Watersipora arcuata Banta

This is a common intertidal to shallow subtidal species. Its black color and brilliant crimson fringe make

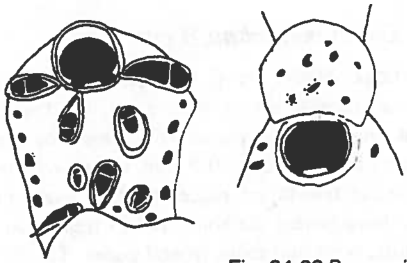


Fig. 24.83 *Parasmittina californica* (after Osburn, 1952)

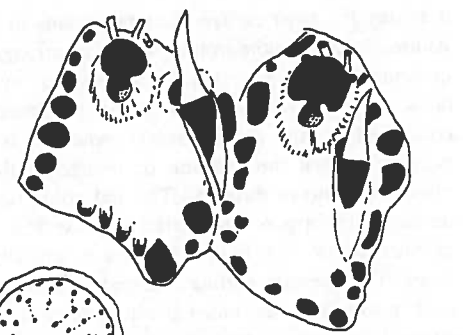
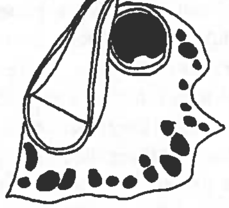
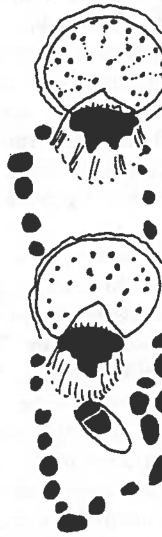


Fig. 24.84 *Parasmittina crosslandi* (after Hastings, 1930)





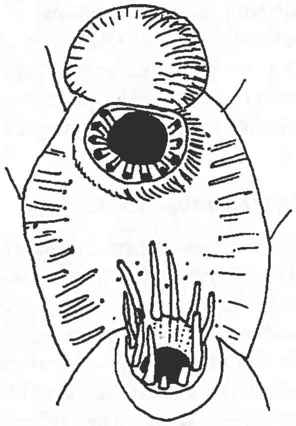


Fig. 24.85 *Escharella major* (after Osburn, 1952)

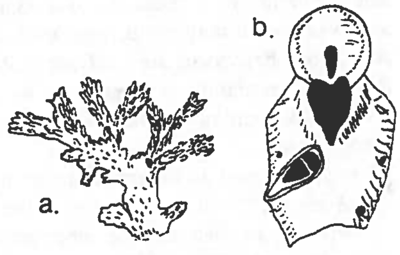


Fig. 24.87 *Reteporellina bilabiata*. (a) Colony about life size. (b) An ovicelled zoid. (After Osburn, 1952.)

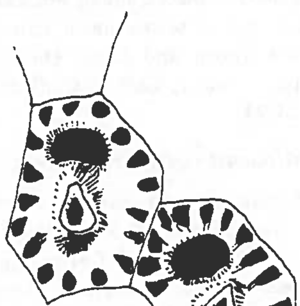


Fig. 24.86 *Reptadonella violacea* (after Banta and Carson, 1977)

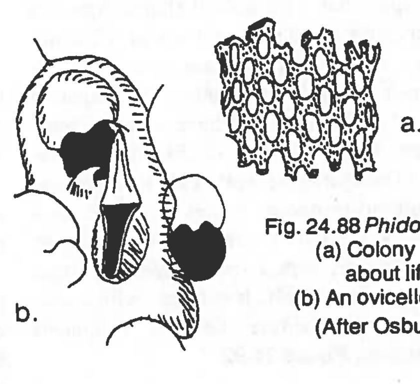


Fig. 24.88 *Phidolopora labiata*. (a) Colony fragment, about life size. (b) An ovicelled autozoid. (After Osburn, 1952.)

it among the most conspicuous bryozoans in the Gulf. Autozoids are monomorphic (all alike), arranged in neat quincunx. The white skeleton is covered by a heavy black cuticle. The cuticle is almost transparent at the colony edges (the distal border), where it is first deposited, so that the crimson or orange of the tissues themselves shows through. The red color fades to an uninteresting brown when dried or preserved. The calcareous frontal wall is pierced by a hundred or so tiny pores. The aperture outline is rounded distally but concave proximally, an unusual situation among cheilostomes. The operculum bears two little bumps (lucidae) proximolaterally; these are characteristic of watersiporids. The function is unknown. There are no spines, avicularia, ovicells, or other conspicuous polymorphs. The autozoids are very large, sometimes exceeding 1 mm in length.

Although *W. arcuata* is fairly distinctive, it can be confused with other watersiporids with dark cuticles and red fringes, and it is necessary to examine specimens microscopically to be certain of their identification. The shape of the aperture is the characteristic feature, but intermediates occur between the *arcuata*-like and *cucullata*-like apertures. Intermediates may also occur between *W. arcuata*, *Uscia*, and species of *Pachycleithonia*. It seems likely that there is a large "rassenkreiss" of closely related species involved. Careful study of variations is necessary to sort out the taxonomy, and even then it may not be possible without considerable effort. Bryozoans are evolving rapidly, and we are looking at speciation in progress as we attempt to subdivide a spectrum of differences by placing animals into specific taxa.

Watersipora is an internal brooder; the large reddish larvae are held in an evagination of the vestibule. The ancestrula is smaller than the other autozoids, but like them otherwise. *Watersipora arcuata* is readily cultivated and will release larvae almost at your will if held in the dark overnight and brought into the light the next morning. Figure 24.91.

Watersipora cucullata (Busk)

Like *W. arcuata*, but with a skull-shaped aperture (that is, a U-shaped proximal apertural notch). Colonies may be black or dark, but occasional specimens are found that have pale tan or white colonies. Occasional in the southern Gulf of California. I have one specimen from the northern Gulf, possibly of this species, resembling *Uscia*. Thought to be worldwide in warm waters, but the confused taxonomy makes this conclusion suspect. A closely related species, *Pachycleithonia nigra* Canu and Bassler, with a similar aperture shape may occur in the southern Gulf. It is black, with a low, solid collar around the aperture. See also comments under *Uscia mexicana*. Figure 24.92.

Uscia mexicana Banta

A conspicuous, black, erect, foliaceous bryozoan, probably with a crimson fringe when alive, the fringe fading to dark brown when preserved. Autozoids are extremely large (1.5 mm long, 0.5 mm wide); colony bilaminar, with the two layers placed back to back. In life a black epitheca covers the zoids; KOCl-treated autozoids are white, with numerous frontal pores. The aperture is skull-shaped, round distally, with a U-shaped proximal notch and hinge teeth. There is an imperforate area proximal to the aperture. The operculum is black, 0.4 by 0.33 mm, with characteristic paired dots ("lucidae") just proximal to the hinge teeth. About 1 percent of the zoids have enlarged apertures and a pair of calcareous spikes just distal to the aperture. No spines, ovicells, or avicularia are present. So far known only from the Gulf of California (see Banta, 1969b).

Occasional large bilaminar colonies similar to *U. mexicana* occur in the northern Gulf. They have smaller zoids and lack zoids with modified apertures. A related species with tan-colored colonies, zoids with modified apertures and perforate ovicells, occurs near San Diego, California. An important monograph on these variable and diverse watersiporids is in preparation by D. and J. Soule. Figure 24.93.

Anexochona anchorata Osburn

Flat, smooth encrustations on hard substrates, rarely algae. Occasionally colonies rise up into branching fronds, zoids placed back to back. Light yellow or brownish when preserved. Autozoids are rectangular, about 0.75 mm long, with the frontal wall coarsely perforate. The aperture is 0.18 mm long, squarish like a TV screen, with strong hinge teeth. The operculum is brown, and no spines are present. Avicularia replace autozoids in the colony and are about as long; mandibles are spiney and hooked. There are no obvious ovicells. This species is generally placed among anascans (family Arachnopusiidae), but it seems much more logically placed near *Watersipora* and *Uscia* (family Watersiporidae). Tropical waters, Gulf of California to Colombia. Figure 24.94.

Hippalosina rostigera (Smitt)

This species grows as buff colonies, encrusting on hard substrates. Autozoids are 0.5 mm long, ovoid to polygonal; frontal roughened, with fine marginal pores. No spines are present. The aperture is elongate with strong hinge teeth, giving it the shape of a rude keyhole. A pair of small avicularia are lateral to the aperture, with pointed mandibles curving slightly around the aperture, directed distally and medially. No obvious ovicells are present, although fertile zoids have broader apertures. Southern California to Colombia. A related species, *H. inarmata* Osburn, with a shorter aperture and no avicularia, may occur in the Gulf. Figure 24.95.

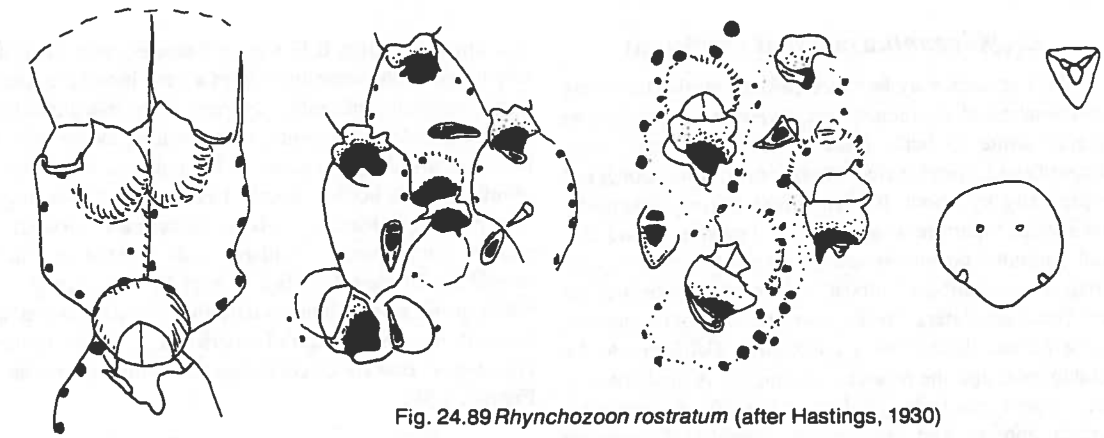


Fig. 24.89 *Rhynchozoon rostratum* (after Hastings, 1930)

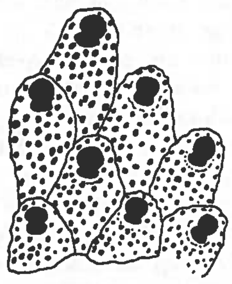


Fig. 24.90 *Hippopodinella adpressa* (after Osburn, 1952)

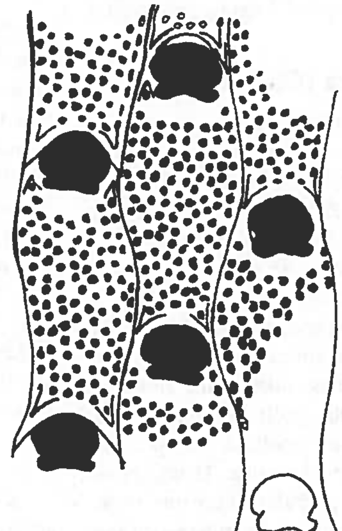


Fig. 24.91 *Watersipora arcuata* (after Banta, 1969a)

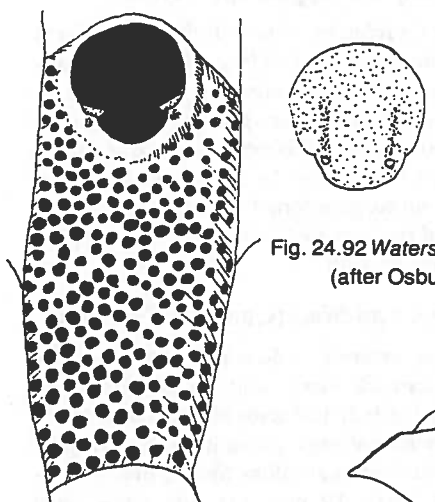
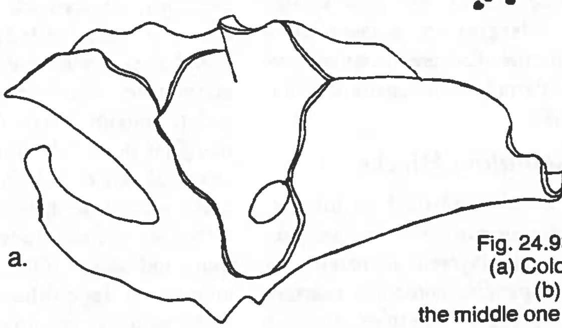
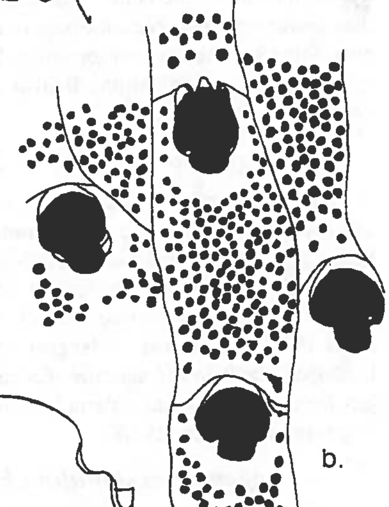


Fig. 24.92 *Watersipora cucullata* (after Osburn, 1952)



a.



b.

Fig. 24.93 *Uscia mexicana*.
(a) Colony about life size.
(b) Three zoids, the middle one with a modified aperture.
(After Banta 1969b.)

Crepidacantha poissoni (Audouin)

This species may be distinguished by the following combination of characters: one-layered encrustations on shells, white to buff; autozoids about 0.5 mm long, kite-shaped, perforated marginally, and bordered marginally by about 10 thin spines (a very diagnostic character); aperture shaped like a keyhole, round distally, pointed proximolaterally; a pair of avicularia with long thin mandibles (almost as long as the zoid) occur proximal and lateral to the aperture; ovicells spherical, imperforate, closed by the operculum. California to the Galápagos, and the tropical Atlantic. A related species, *C. setigera*, has more gently rounded proximolateral apertural borders, and avicularia are lateral to the aperture instead of proximolateral. Tropical Atlantic and Pacific. Figure 24.96.

Lagenipora punctulata (Gabb and Horn)

Colonies are erect, branching, stony, white to pale buff, occur on hard substrates or algae, and grow to several centimeters in height. Branches are circular in cross section, solid, with 4 to 12 autozoids around a stem section. Autozoids are jug-shaped. Young autozoids at the very tips of the branches have an oval aperture 0.15 mm long. There are no hinge teeth. Autozoids are 0.7–0.8 mm in length, with roughened, coarsely perforated frontal walls. The aperture is almost immediately surrounded by a circular calcareous collar, some almost as long as the zoid, ribbed longitudinally, sometimes scalloped at the end. Avicularia are small, at the tip of the collar, their mandibles directed laterally. There are no obvious spines. Ovicells are globular, 0.25 mm wide, and at the base of the collar with a crescent-shaped median perforated area. Near the base of the colony, almost everything but the aperture openings becomes engulfed by secondary calcification. British Columbia to the Galápagos. Figure 24.97.

Lagenipora mexicana Osburn

This species closely resembles *L. punctulata*, but the autozoids are smaller, 0.5 to 0.6 mm long. Limited to Baja California and the Gulf of California. *Lagenipora admiranda* Osburn, so far known only from western Baja California (Guadalupe Island), has even smaller zoids (0.4 mm or less in length) and a deep V- or U-shaped notch in the aperture. Calcareous spikes project from the base of avicularia into the aperture in this latter species. Figure 24.98.

Lagenipora spinulosa Hincks

This bryozoan may be distinguished as follows: forming roughened irregular encrustations on hard substrates or algae, usually many-layered; autozoids not neatly oriented into a lacy pattern; autozoids coarsely perforate, 0.5 mm long; "primary" aperture of young zoid almost circular, 0.13 mm in diameter, with a pair of tiny hinge teeth, sometimes with a very broad proximal notch, scarcely noticeable; aperture surrounded quickly by a long calcareous collar, often as long as the rest of the zoid; distal half or more of the collar is ridged longitudinally, its border usually has a ring of 2–6 long, thin pointed calcareous spikes, sometimes missing; a pair of conspicuous avicularia with pointed or blunt mandibles directed distally and laterally at the tip of the collar, projecting well beyond its end on stalks; ovicell at base of the collar centrally perforate. Alaska to the Galápagos. Beware of confusing this with *Celleporina*. Figure 24.99.

Lagenipora lacunosa Bassler

Colony encrusting, white or buff, on hard substrates. Autozoids are large, more than 0.7 mm long, 0.5 mm wide. Apertures of young zoids are oval, 0.6 mm long; tiny hinge teeth; no spines. The aperture soon is surrounded by a calcareous collar a little shorter than usually seen in the *Lagenipora*, and not ribbed longitudinally. The frontal wall is coarse and perforated, calcifying heavily. Avicularia are at the tip of the aperture and have pointed or blunt mandibles directed distally and laterally. They are more distal on the collar than in most *Lagenipora* species (distal to its midline). Ovicells occur at the base of the collar, with a hemicircular, finely perforated central area. California to Chile. Figure 24.100.

Lagenipora hippocrepis (Busk)

Similar to *L. spinulosa* but with these differences: autozoids a little larger, 0.6 mm long; distal end of collar not ridged (except for connecting tubules to the avicularia); without the calcareous spikes at the end of the collar. Southern California to the Galápagos. *Lagenipora marginata* Canu and Bassler also occurs in the Gulf of California, but colonies form from creeping strings of zoids instead of crusts of zoids. Gulf of California to the Galápagos. Figure 24.101.

Schismopora anatina (Canu and Bassler)

The colonies are erect, 2–5 cm tall, with cylindrical branches, on hard substrates, white or pale buff. The colony is many-layered, new zoids being budded on top of old ones (frontal budding), giving it a rough, irregular appearance. Young zoids at colony tips are oval to polygonal, smooth, about 0.7 mm long with a few small marginal pores. Apertures are oval, with a V-shaped proximal notch, 0.15 mm long. There is a calcareous collar around the aperture, but it stays low and thin. No spines are present. Avicularia are variable in size, location, and shape. One avicularium with a triangular, blunted, or spoon-shaped mandible is usually present proximal to the aperture, sometimes slightly elevated on

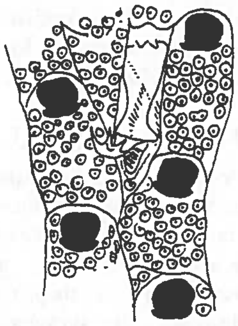


Fig. 24.94 *Anexochona anchorata* (after Osburn, 1950)

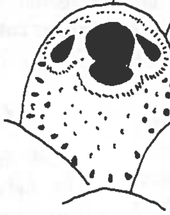


Fig. 24.95 *Hippalosina rostigera* (after Osburn, 1952)

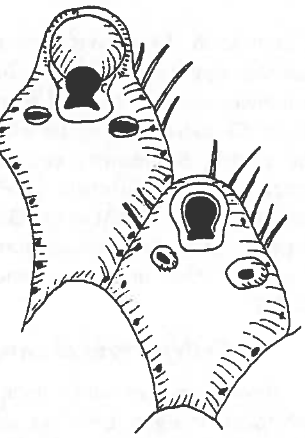


Fig. 24.96 *Crepidacantha poissoni* (after Osburn, 1952)

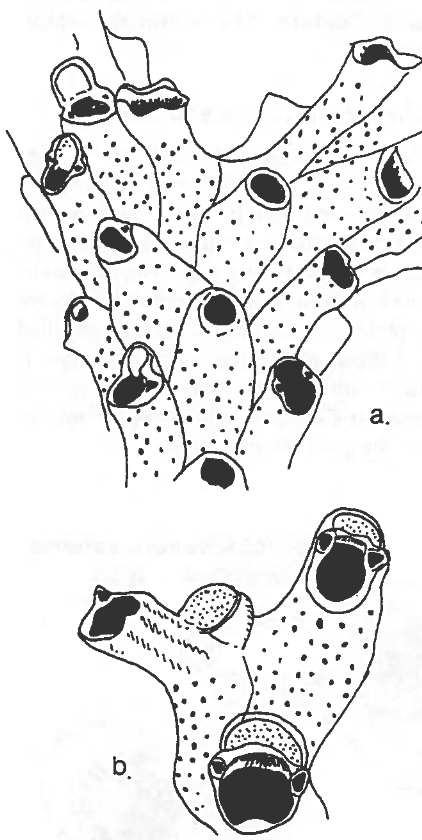


Fig. 24.97 *Lagenipora puctulata*. (a) Old zoids. (b) Young zoids. (After Osburn, 1952.)

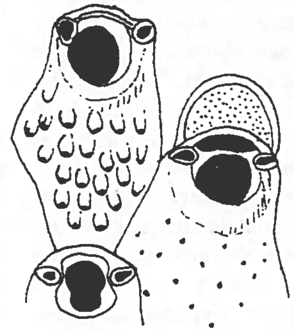


Fig. 24.98 *Lagenipora mexicana* (after Osburn, 1952)

Fig. 24.99 *Lagenipora spinulosa* (after Osburn, 1952)

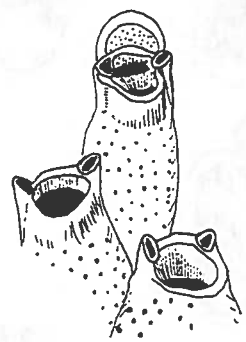


Fig. 24.100 *Lagenipora lacunosa* (after Osburn, 1952)

a short knob. Large avicularia (almost the size of autozoids) may replace frontally budded autozoids. Their mandibles are like those of apertural avicularia but are larger. Ovicells are globular with coarse perforations at the center. Sometimes confused with *Celleporina* species. Baja California to Panama. *Schismopora globosa* Soule, limited to the Gulf of California, forms little nodular or hemicircular colonies instead of branches; there are other minor differences. Figure 24.102.

Celleporaria brunnea (Hincks)

Brown, gray, or white, thick nodular crusts on hard substrates or algae. Colonies sometimes form massive branches or even spikes. Colonies are many-layered; autozoids are budded frontally as well as marginally and are not neatly arranged. Frontal walls are smooth or slightly roughened with tiny nodules, perforated marginally with 10 or so pores. The aperture is about 0.15 mm long, rounded distally, straight proximally, with a distinct but small median proximal notch. The operculum is usually thin but darkened. Two or more hollow spines with dark joints rarely occur around the aperture, and a calcareous knob or spike is usually found beside the aperture; the knob bears a small but conspicuous avicularium with a dark-colored hemicircular mandible on its distal side. The giant avicularia, up to 0.5 mm long, replace autozoids in the colony. They are oval, with blunt mandibles, usually darkened in a spade-shaped pattern. Ovicells are imperforate, globular, smooth, with a very large aperture. Very common. British Columbia to Ecuador. Also known as *Holoporella quadrispinosa* (see D. and J. Soule, 1964). A related species, *C. minuta* Soule, is similar, but has smaller autozoids and lacks giant avicularia. Its distribution is limited to the Gulf of California. Figure 24.103.

Celleporina costazi (Audouin)

Colorless to white or buff irregular encrustations on rocks. Secondary autozoids are quickly produced on top of old ones by frontal budding, the new ones oriented every which way. The aperture, seen only on young autozoids, is rounded distally, with a U-shaped proximal notch. A high, thin, calcareous collar surrounds the aperture, with a pair of avicularia with blunt mandibles projecting beyond the collar. Ovicells are prominent, with a radially perforated central area. Easily confused with species of *Lagenipora*, but the pattern of ovicell perforations and more marginal frontal wall perforations distinguish it. California and the Gulf of California; also widely distributed elsewhere. Also known as *Costazia costazi*. Figure 24.104.

Cigclisula porosa (Canu and Bassler)

Brownish one- to many-layered colonies on hard substrates. Autozoids are hexogonal, with the aperture in the middle, surrounded by a row of large pores and about 4 erect calcareous spikes. Small avicularia with blunt mandibles are on the frontal wall. The aperture is 0.2 mm long, oval, with strong hinge teeth. Ovicells are globular, finely perforate, 0.35 mm wide, soon engulfed by secondary calcification. Mexico to the Galápagos. It is readily confused with *C. hexagonalis*, known from the Galápagos Islands to California. Both species are frequently placed in the genus *Trematooecia*.

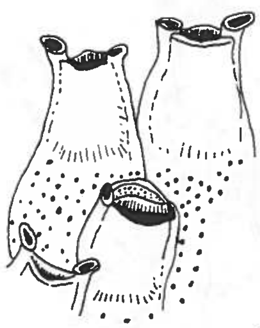


Fig. 24.101 *Lagenipora hippocrepis* (after Osburn, 1952)

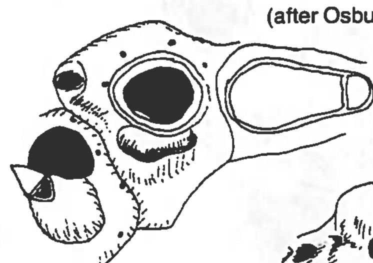


Fig. 24.102 *Schismopora anatina* (after Osburn, 1952)

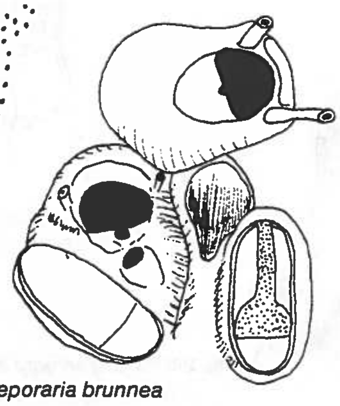


Fig. 24.103 *Celleporaria brunnea* (after Osburn, 1952)

Fig. 24.104 *Celleporina costazi* (after Osburn, 1952)

25

BRACHIOPODA (Lamp Shells)

Preservation: The brachiopods, or lamp shells, should be preserved in 70 to 90 percent alcohol. Relaxation may be accomplished with magnesium sulfate.

Taxonomy: The taxonomy of this group is based largely on valve and hinge anatomy and the anatomy of the soft parts. Most authors divide the Brachiopoda into two classes, the Inarticulata (ecardines) and the Articulata (testicardines). These bivalve creatures greatly resemble the pelecypod molluscs but differ by possessing a *lophophore*, a fleshy *peduncle*, and in having the valves fixed dorsoventrally as opposed to right and left, as in the clams.

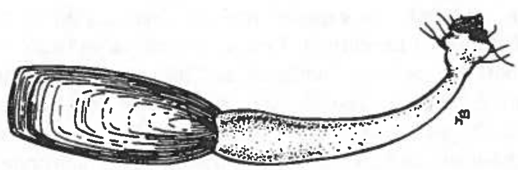


Fig. 25.1 *Glottidia* sp. (from Allen, 1976)

Brachiopods of the Gulf: There are probably at least three species of lamp shells in the Gulf: *Glottidia audebarti* (Hinds), *Glottidia palmeri* Dall, and *Terebratulina ungulcùla* Carpenter. Members of the first genus have long thin shells, while members of the latter genus have wider, more typically clam-shaped shells. *G. audebarti* is a large species, with the distal half of the valves a brilliant blue-green. It is reported from the intertidal of Topolobampo. *G. palmeri* lacks this blue-green coloring. *T. ungulcula* is reported from the Cabo San Lucas region. Jones and Barnard (1963) reported the common United States Pacific species *G. albida* (Hinds) from as far south as Mazatlán, but they stated it is replaced in the Gulf by *G. palmeri*. I have collected only *G. palmeri*, which occurs from depths of 2 to 15 meters in the region around El Golfo de Santa Clara. Figures 25.1 and 25.2.

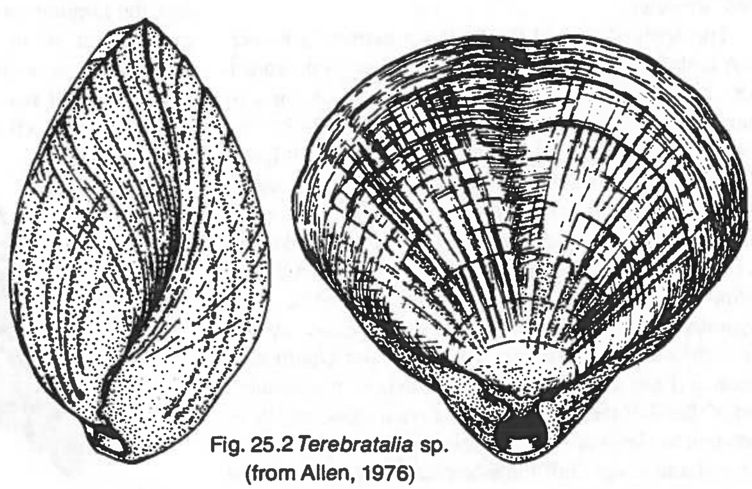


Fig. 25.2 *Terebratalia* sp. (from Allen, 1976)

26

ECHINODERMATA

Preservation: See individual class.

Taxonomy: See individual class.

Echinoderms of the Gulf: The vast majority of echinoderms of the Gulf of California are affiliated with the Panamic fauna. Fifty-two of the 58 species of echinoderms collected by the East Pacific Expedition of the New York Zoological Society were considered by Clark (1940) to be Panamic in origin, 53 of the 65 species collected by the Templeton Crocker Expedition can be considered Panamic, and Clark (1948) reported 19 of the 22 species of echinoids he treated from the Gulf as having Panamic origins. Steinbeck and Ricketts reported all the asteroids, ophiuroids, and echinoids they collected as being affiliated with the Panamic fauna, while 13 of the 20 holothurians from their expedition were considered Panamic. Deichmann (1941, 1958) stated that the holothurians of the Gulf show close affinities to both the Panamic and West Indies faunas, probably the majority having their origin in the Caribbean.

The echinoderms of the Gulf are extremely numerous, both in individuals and species. The group constitutes one of the dominant taxa of the region, and its members are conspicuous inhabitants of all intertidal environs from El Golfo de Santa Clara to Cabo San Lucas and Mazatlán. The sun star *Heliaster kubiniji* is possibly the most common echinoderm of the Gulf, as well as one of the most conspicuous animals of the intertidal zone throughout this region. The holothurian *Selenkothuria lubrica* and several of the brittle stars (*Ophioderma teres*, *Ophioderma panamense*, *Ophiothrix spiculata*, *Ophiocoma aethiops*, and *Ophiocoma alexandri*) are also extremely common. In the northern end of the Gulf the asteroid *Othilia tenuispina* may be as common as *Heliaster*, particularly in the winter, while in the mid and lower Gulf the asteroids *Pharia pyramidata* and *Phataria unifascialis* are almost as abundant as *Heliaster*. The blunt-spined sea urchin *Eucidaris thouarsii* and the sharp-spined purple urchin *Echinometra vanbrunti* are the most common and widespread intertidal echinoids of the Gulf, being found on almost all rocky shores of this region.

The sand dollars avoid heavy surf and are seldom found alive without diving or waiting for the very lowest tides of the year. The person fortunate enough to find a bed of these animals will often see hundreds or even thousands of them lying flat on the bottom, or standing slightly on edge with two-thirds or so of the disk buried in the sand, the exposed portion often angled in the direction of the current. *Encope grandis* is probably the most common sand dollar of the Gulf, but in the northern extremes its abundance is somewhat rivaled by *Mellita longifissa* and *Encope micropora*. The sand dollars and heart urchins are found only on sandy substrates. Hedgpeth (1969), Caso (1961), and Clark (1940) stated that the familiar west coast bat star *Patiria miniata* occurs around the tip of Baja California and north to La Paz, but I have not collected it in the Gulf (fig. 26.1).

Because of numerous recent name changes, partial synonomies are given for the echinoderms in the species descriptions.

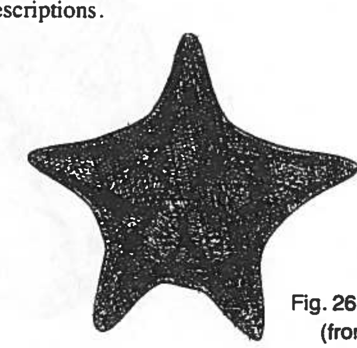


Fig. 26.1 *Patiria miniata* (from Allen, 1976)

KEY TO THE COMMON CLASSES OF INTERTIDAL ECHINODERMS

1 Animal with 4 or more radiating arms 2
-Animal without arms 3

2(1) Arms with ambulacral grooves; animal without a distinct central disk (figs. 26.1 to 26.13) .... **Asteroidea,** the sea stars
-Arms without ambulacral grooves; animal with a distinct central disk (figs. 26.14 to 26.20) .... **Ophiuroidea,** the brittle stars

3(1) Body covered with stiff, movable spines; without tentacles around the mouth; body with a rigid external skeleton (figs. 26.21 to 26.32) .... **Echinoidea,** the sand dollars and sea urchins
-Body without stiff spines; mouth surrounded by tentacles; body without rigid skeleton (figs. 26.33 to 26.36) .... **Holothurioidea,** the sea cucumbers

CLASS ASTEROIDEA

Preservation: Sea stars may be dried, or preserved in 10 percent buffered formalin or 70 percent alcohol. Formalin usually keeps the color better than alcohol, but, if its buffering quality is not retained, the calcareous plates of the sea star will begin deteriorating. Carefully covering the sea star with fine sand during preservation will usually result in the spines of the dorsal surface remaining erect.

Dr. Earl Segal has developed an excellent technique for preparing dried asteroids, ophiuroids, and echinoids with original color retention. It is as follows:

1. Place specimen in 70 percent alcohol for 1–2 hours. If pigments leach rapidly, reduce this time.
2. Rinse well in fresh water.
3. Place animal with oral side up and sprinkle entire surface with 10 percent formalin, especially in ambulacral grooves. Leave in this position for 4–6 hours.
4. Place specimen in container and cover with a 1:1:1 solution of 95 percent alcohol, glycerine, and water. Let stand for 3–4 days.
5. Rinse in fresh water and allow to air-dry.

Taxonomy: The sea stars are free-living, pentaradial echinoderms that crawl about the substrate by use of the tube feet. The central disk bears five arms, or rays, in most species. In the Gulf, *Heliaster* and *Acanthaster* are the only common multirayed starfish (with 10 to 42 arms). The central disk of asteroids is not marked off from the arms as in the ophiuroids (brittle stars), but grades into them. The taxonomy of this group is based largely on the morphology of the rays, calcareous body plates, pedicellariae, and other external features. The majority of the species are distinct and easily differentiated. The systematic scheme used in this presentation is based on H. L. Clark (1913). L. Lyman (1955), and D. Nichols (1962).

KEY TO THE COMMON INTERTIDAL ASTEROIDS

1 Starfish with more than 10 arms 2
-Starfish with 5 to 6 arms 4

2(1) 10 to 17 arms; body and arms with long, pointed spines; usually with multiple madreporites .... ***Acanthaster ellisii***
-Usually more than 18 arms; body and arms without long, pointed spines; single madreporite 3

3(2) 10 to 24 arms; diameter of central disk less than length of individual arm (fig. 26.11) .... ***Heliaster kubiniji***
-30 to 42 arms; diameter of central disk equal to or greater than length of individual arm (fig. 26.12) .... ***Heliaster microbrachius***

4(1) Spines wanting or, if present, only on marginal arm plates; aboral surface of disk and arms covered with granular plates or compacted paxillae (star-shaped pedestals) 5
-Spines present on both disk and arms (spines may be blunt or pointed) 10

5(4) Large spines present, but only on marginal arm plates 6
-Large spines absent, small spines only on ambulacra 8

6(5) Large rectangular marginal arm plates present; aboral surface sunken below level of marginal plates (fig. 26.6) .... ***Astropecten armatus***
-Small marginal arm plates present; aboral surface not sunken as above 7

7(6) Lateral margins of arms with paired black spots; several large spines on aboral margin between arm bases; body mosaic tan and black, usually with orange markings (fig. 26.5) .... ***Luidia phragma***

-Lateral margins of arms without paired black spots; without large spines on aboral margin as above; body dark gray to black (fig. 26.4) .... ***Luidia columbia***

8(5) Aboral surface of disk and arms with alternating plates, and spherical granules arranged irregularly; arms very rounded in shape, normally 6 present, but highly variable; mottled gray and red color (fig. 26.9) .... ***Linckia columbia***

-Aboral surface of disk and arms with plates and granules arranged in more definite rows; arms more flattened in shape, always 5; color variable **9**

9(8) Distinct aboral plates; lemon-colored body with white ambulacral spines; a single row of small flat spines present on each side of the ambulacral grooves (fig. 26.7) .... ***Pharia pyramidata***

-Indistinct aboral plates; grayish body, with reddish ambulacral spines; double rows of small flat spines on each side of the ambulacral grooves (fig. 26.8) .... ***Phataria unifascialis***

10(4) Spines of body minute, less than 2 mm tall; aboral surface yellow-brown to brick red, with dark spots on the tips of the arms (fig. 26.2); maximum diameter about 100 mm .... ***Othilia tenuispina***

-Spines of body larger, more than 3 mm in height; aboral surface not as above, lacking dark spots on the arm tips; maximum diameter about 110–180 mm **11**

11(10) Base of arms slightly constricted at disk (fig. 26.13); aboral spines brightly colored (violet-blue at base, red-orange at tip) .... ***Astrometis sertulifera***

-Base of arms not constricted at disk; aboral spines not colored as above **12**

12(11) Ambulacra curve up on arm tips to reach aboral surface; aboral surface pale brown to lavender but covered (to varying degrees) with a greenish hue; spines of aboral surface purple to dark brown; maximum diameter about 130 mm .... ***Nidorellia armata***

-Ambulacra do not curve up to aboral surface; aboral surface red-orange or red-brown, only occasionally with a greenish hue; spines of aboral surface red; maximum diameter 110–160 mm **13**

13(12) Body cushion-shaped and inflated (fig. 26.3); aboral spines blunt and immovable; body occasionally with a partial greenish hue .... ***Oreaster occidentalis***

-Body not cushion-shaped or inflated; aboral spines sharp and movable; body never with a greenish hue **14**

14(13) Arms webbed at base (fig. 26.10); maximum diameter about 110 mm; aboral spines very heavy; aboral surface unicolorous red-orange to red-brown .... ***Amphiaster insignis***

-Arms not webbed; maximum diameter about 160 mm; aboral spines very thin; aboral surface with large brown blotches on an orange-pink background .... ***Mithrodia bradleyi***

SUBCLASS EUASTEROIDEA

Order Spinulosa

FAMILY ACANTHASTERIDAE

Acanthaster ellisii (Gray)

A thick, soft-bodied multirayed sea star, easily recognized by its thin gray to red-brown skin, long pointed spines on the body and arms, and the numerous small spines that cover the aboral surface. This species usually has more than one madreporite and 10 to 13 arms. *Acanthaster* is largely subtidal, occasionally brought up by the shrimp trawlers, but also occurs in the low intertidal. Its depth range is shore to at least 24 meters. It ranges from the lower central Gulf of California to Peru and the Galápagos Islands. This species has been previously reported as *Echinaster ellisii*. I have recorded *A. ellisii* at Isla San José, Isla Espíritu Santo, all along the southeast Gulf coast and in the Tres Marías Islands.

A great deal has been written concerning the Indo-Pacific Crown-of-Thorns (*Acanthaster planci*), and excellent reviews of the biology and ecology of this species can be found in Yamaguchi (1973a, 1973b, 1973c, 1974a, 1974b, 1974c and 1975), Newman and Dana (1974), Sugar (1970), Chesher (1969), and others. Our eastern Pacific species, *A. ellisii*, is less well understood but is known to graze on coral in a manner similar to *A. planci* (Porter, 1972; Barham, Gowdy and Wolson, 1973; Glynn, 1974, 1977; and Dana and Wolfson, 1970). See Plate 4.

FAMILY ECHINASTERIDAE

Othilia tenuispina Verrill

A small, yellow-brown to brick-red sea star of the low intertidal rocky coasts of the upper Gulf (and infrequently in the southern Gulf). The tips of the arms tend to curl up slightly and are marked with a dark red, purple, or black spot. In large specimens the arm span reaches 100 mm. Investigations by Miller (1967) indicate that individuals of this species can move at a rate of 15 cm/min, in any direction, and can right themselves in about 4 minutes. *Othilia* is photopositive, usually being found on the tops of rocks during the day, rather than hiding beneath them as do most echinoderms. This species occurs most frequently on beds of colonial zoanthid anemones, sponges, and algae turf substrates, suggesting it may feed upon animal mucus, small molluscs, or even in a saprophagous mode. It is very common from El Golfo de Santa Clara to Bahía Kino, but occurs only sporadically south of the midriff region. I have occasionally found a variant of it in some of the isolated warm water bays on the outer coast of Baja, Bahía Magdalena in particular. The variant form is more robust, the arms having a somewhat swollen appearance. This form appears to be what some authors have referred to as *Echinaster tenuispina*, although considerable confusion exists in regards to the status of the latter name. *Othilia tenuispina* may be considered as essentially a Gulf of California endemic species. Figure 26.2.

FAMILY MITHRODIIDAE

Mithrodia bradleyi Verrill

This is a large and very long-armed sea star, with striking orange-pink body color and large brown blotches. The disk is somewhat small and constricted. Both surfaces are covered with tall blunt spines. I have encountered this species on most rocky, shallow subtidal regions from Guaymas south, including all of the southern Gulf islands. It has previously been reported from rocky shores at low tide zone to 13 fathoms in the Panamic region. Its range is listed by other authors as Panama and the Galápagos to the Gulf of California, and also in Hawaii. It has not been reported north of Guaymas in the Gulf. Large specimens reach arm spans of 160 mm.

Order Phanerozonia

FAMILY OREASTERIDAE

Oreaster occidentalis Verrill

An inflated sea star, with a red-orange to reddish-green aboral surface, attaining arm spans of 100–150 mm. The spines and marginal plates are bright red. The pedicellariae are sessile (not on movable stalks), and the tube feet are usually hidden well within the deep ambulacral grooves. The aboral surface is covered with numerous blunt, immobile spines. The commensal polychaete worm *Ophiodromus pugettensis* (Johnson) has been reported from the ambulacral grooves of this species. This is the same worm that is so common in the bat star *Patiria miniata* on the west coast of the United States and Baja California. *Oreaster occidentalis* ranges from the northern Gulf of California to Peru and the Galápagos Islands and is restricted to the lowest low tide zone and the subtidal, being most frequently encountered when one dives over rocks in 2–10 m of water. Figure 26.3.

Nidorellia armata (Gray)

A beautiful lavender to chocolate-brown or red-orange sea star with indistinct, large marginal plates, and large movable spines on the dorsal surface. The

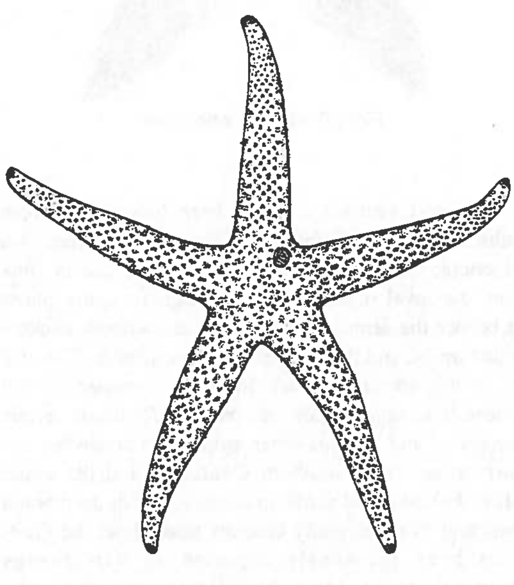


Fig. 26.2 *Othelia tenuispina*

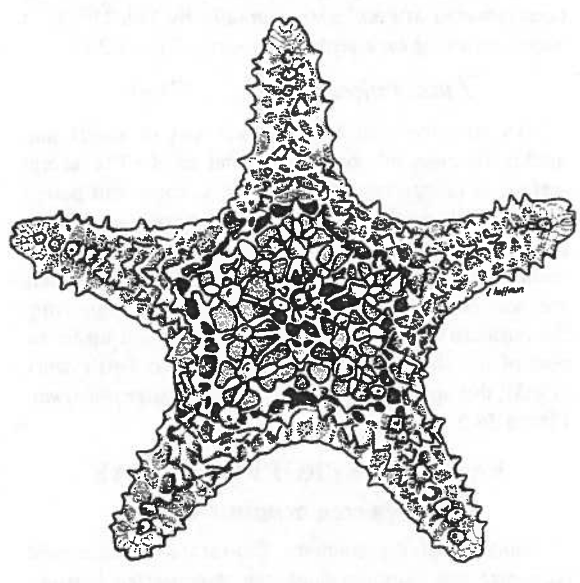


Fig. 26.3 *Oreaster occidentalis*

aboral surface is generally covered, to varying degrees, with a greenish hue. A close examination of this green area will reveal it to be coloration present in the sea stars' protruding papillae, gills, and pedicellariae. The aboral spines are usually purple with dark tips. The pedicellariae are sessile. This species occurs in the rocky low intertidal and subtidal from the upper Gulf to Peru and the Galápagos Islands, and is most often encountered when diving [Lyman (1902) reported in from southern California]. It has previously been reported as *Pentaceros armatus*. Dried specimens have deflated bodies and turn a dirty chocolate brown. One of the most characteristic features of this sea star is the tendency of the ambulacral grooves to curve up on the arm tips so as to be visible in a dorsal view. Large individuals attain arm spans of 130 mm. See Plate 7.

FAMILY LUIDIIDAE

Luidia columbia (Gray)

A dark gray to black sea star, similar to *Luidia phragma* but two or three times larger, and without the distinctive black arm blotches of the latter. The tube feet are without suckers, and the pedicellariae are sessile. It inhabits sandy and muddy bottoms of the low intertidal and subtidal, where it is often found buried under a few centimeters of the substrate. This sea star can grow to be a real giant, occasionally obtaining an arm-tip to arm-tip diameter of 500 mm, although most specimens range from 50 to 250 mm. *Luidia columbia* ranges from the Gulf of California to Peru and the Galápagos Islands. It is one of the commonest invertebrates picked up in otter trawls of shrimp boats throughout the Gulf. These trawls are usually fished at 20 to 40 fathoms. This species has been reported as *Petalaster columbia* by Fell (1963) in his recent article on asteroid phylogeny. Figure 26.4.

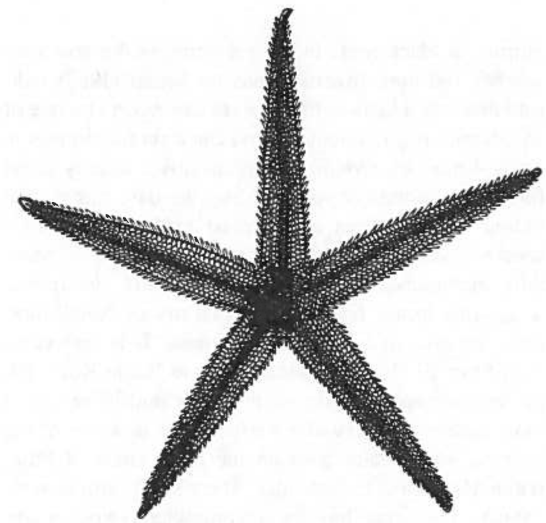


Fig. 26.4 *Luidia columbia*

Luidia phragma H. L. Clark

An attractive and common sea star of sandy and muddy bottoms of open coasts and bays. The aboral surface is orange to gray, with black spots and paired black patches on the arms. The pedicellariae are sessile, and the tube feet lack suckers. The arm span of this species reaches about 225 mm, but smaller individuals are more commonly found. *Luidia phragma* ranges from the northern Gulf to Chile. It is often picked up in the nets of the shrimp trawlers. According to Fell's work (1963), this species would now be *Alternaster phragma*. Figure 26.5.

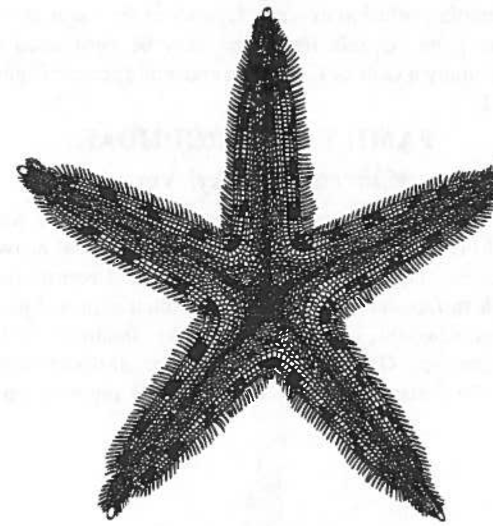


Fig. 26.5 *Luidia phragma*

FAMILY ASTROPECTINIDAE

Astropecten armatus Gray

Students of the southern California seashore will recognize this common sand star. *Astropecten* burrows just under the sand or mud-sand substrate in the low intertidal and subtidal and has been brought up from depths as great as 83 fathoms. The aboral surface is a dull orange to gray-brown or gray-violet, and is sunk below the level of the large, rectangular, spiny plates that border the arms. The tube feet are without suckers in this family, and the pedicellariae are sessile. The arm span of this species reaches 360 mm. *Astropecten* will eat dead fish, sand dollars, sea pansies *(Renilla)*, certain gastropods, and various other animals. *Astropecten armatus* ranges from southern California and the upper Gulf to Ecuador and turns up consistently in deep water trawls and subtidal sandy beaches throughout the Gulf. It has been previously reported as *Astropecten erinaceus*, *Astropecten braziliensis armatus*, and *Astropecten orstedii*. Figure 26.6.

FAMILY OPHIDIASTERIDAE

Pharia pyramidata (Gray)

This colorful starfish is found on rocks and reefs in the low intertidal throughout the Gulf. It is purplish-brown to dull green-brown and has a large, red, irregular madreporite (to 1 cm in diameter). The arms are lined with longitudinal bands of orange or yellow spots. The tube feet of members of this family have weakly developed suckers and cannot cling to rocks with the tenacity of many other sea stars. The pedicellariae are sessile. The arm span reaches 300 mm. Once the color has been bleached out of this sea star by preservatives, it may resemble preserved specimens of *Phataria unifacialis*. It may be distinguished by its wider ambulacral grooves, which tend to remain open when preserved, exposing the tube feet, whereas in *Phataria* the grooves usually close tight upon preservation, making the tube feet impossible to see. Another feature distinguishing these two stars in their preserved state is the single row of stubby, flattened spines along the outside of each ambulacral groove in *Pharia*, whereas *Phataria* has a double row of these stout, flat spines along the outside of each ambulacral groove. *Pharia* is undoubtedly one of the most beautiful sea stars of the eastern Pacific, ranging from the northern Gulf to Peru and the Galápagos Islands. I have found it in greatest abundance on the low intertidal and subtidal rocks of Bahía San Carlos and Puerto Lobos, north of Guaymas. It has previously been reported as *Ophidiaster pyramidatus*. Figure 26.7.

Phataria unifascialis (Gray)

A very common starfish of the mid and lower Gulf, only occasionally turning up north of the midriff region. It is large and narrow-rayed, with the aboral surface dull brown to orange, often with traces of ultramarine and with reddish ambulacral spines. The arms are tan and have numerous, lateral pores embedded in an orange streak. The tube feet lack suckers, and the pedicellariae are sessile. Unlike most sea stars, both *Phataria* and *Pharia* seem to be strongly herbivorous in their feeding habits, although they do consume considerable animal matter also. This species ranges from the lower Gulf to Peru, including the Galápagos Islands, inhabiting rocky shores in the low intertidal and subtidal to about 60 feet. It has been previously reported as *Linckia unifascialis*. (See *Pharia pyramidata*, above.) Figure 26.8.

Linckia columbiae Gray

This is one of the most variable starfish known, both in habitat and morphology. It resembles both *Pharia* and *Phataria* but differs in having more rounded arms and a more irregular arrangement of plates and granules on the aboral surface. It is found from the rocky intertidal, under stones and in crevices in the low intertidal, to flat

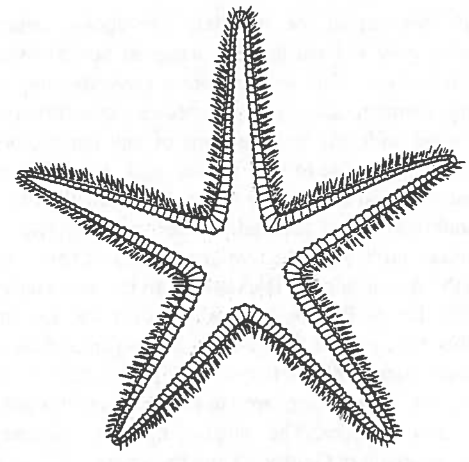


Fig. 26.6 *Astropecten armatus*

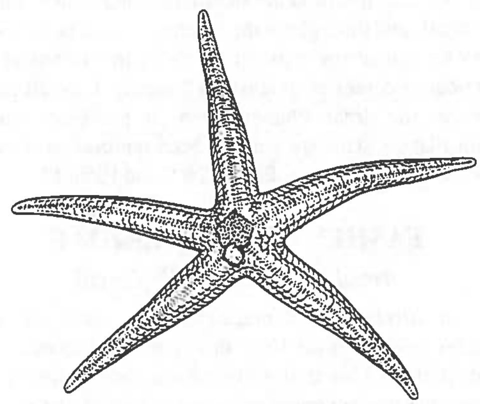


Fig. 26.7 *Pharia pyramidata*

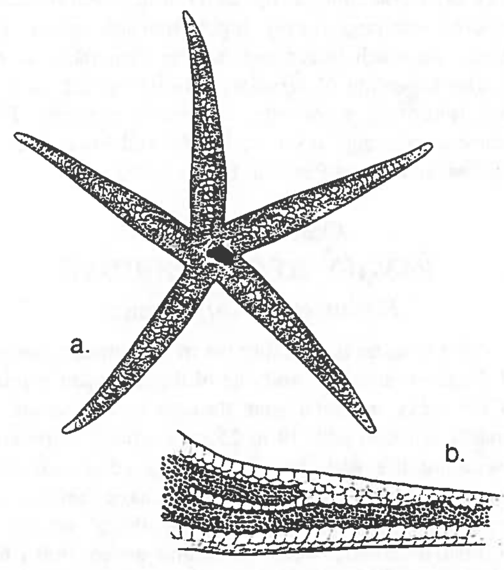


Fig. 26.8 *Phataria unifascialis*.
(a) Dorsal view. (b) Side view of arm.

sandy bottoms of the subtidal. The aboral surface is mottled gray and red and has irregular bumps over the entire surface. This species rarely possesses any symmetry, owing to autotomy and species variability. It may be found with one to nine arms of any length, one to seven mouths, one to four anuses, and one to five madreporites (usually two). The best specimens are undoubtedly found subtidally, where the majority of individuals probably have five or six arms of nearly equal length. According to Ricketts, Calvin, and Hedgpeth (1968), Dr. S. P. Monks examined over 400 specimens of this species and found only four symmetrical individuals, stating that no two were alike. Anderson (1962) stated that *Linckia* appeared to be structurally organized as a detrital feeder. The range of *Linckia columbiae* is given as southern California and the upper Gulf, to Peru and the Galápagos Islands. I have collected this species from the intertidal and the subtidal at Puertecitos, Puerto Libertad, and throughout the southeast coast of the Gulf. This sea star seems to prefer the rocky low intertidal and subtidal to depths of at least 50 fathoms. Like all members of the order Phanerozonia, it possesses sessile pedicellariae. This species has been reported previously as *Phataria columbiae*. Figure 26.9 and Plate 12.

FAMILY GONIASTERIDAE

Amphiaster insignis Verrill

An attractive and distinctive sea star, the only species so far known from this monotypic genus. The body and arms are uniformly colored red-orange to red-brown and the maximum arm span is about 110 mm. The arms are "webbed" near the disk, as in *Nidorellia armata* or *Patiria miniata* (fig. 26.1). The aboral surface is covered with large, heavy, highly movable spines. The spines are much larger and heavier than those of the similar appearing *N. armata*, and are spread more or less randomly across the sea star's surface. This echinoderm occurs from the central and lower Gulf at least as far south as Panama. Figure 26.10.

Order Forcipulata

FAMILY HELIASTERIDAE

Heliaster kubiniji Xantus

This sun star is probably the most common asteroid of the Gulf intertidal, and one of the dominant animals of the rocky intertidal zone throughout this region. It usually is found with 19 to 25 rays, young individuals beginning life with five but adding additional ones rapidly as they mature. The tube feet have suckers, and the pedicellariae are stalked. The aboral surface is pinkish-lavender, with black-and-green mottling, younger specimens being darker than the pinkish adults. *Heliaster* may be seen crawling about on and under rocks in the mid and low intertidal, younger individuals being more common in the mid and occasionally high intertidal zones. It seems to show a preference for large, smooth, basalt-type rocks. In the very low intertidal and subtidal, it is often replaced by *Othilia tenuispina* in the northern Gulf and by *Phataria unifascialis* in the southern Gulf. Its feeding habits are similar to those of the familiar west coast *Pisaster*. *Heliaster* is an indiscriminate, top level carnivore and prefers the sessile mussels (*Brachiodontes multiformis*, *Cardita affinis*, etc.) and barnacles (*Chthamalus* and *Balanus*) for food. It has also been seen feeding on a variety of snails, including *Tegula*, *Acanthina*, *Nassarius*, and *Turbo*, the chitons *Stenoplax conspicua* and *Chiton virgulatus*, small crabs, the sea cucumber *Selenkothuria lubrica*, and the colonial sea anemone *Palythoa*. In the aquarium *Heliaster* can be forced, through starvation, to feed on algae and a great variety of small invertebrates. *Heliaster* will, like most sea stars, often feed by passing a bit of food along the ventrum of the arm, by use of the tube feet, to the mouth. Tanzer (1967) reported the occurrence of a commensal ophelid polychaete in the ambulacral and oral areas of *Heliaster*. The worm was brown, small (8–30 mm long), and had 30–50 body segments. Glidden (1967) showed that these same polychaetes are apparently attracted to the sun star by a chemical transmitted through the water and that these worms may be host-specific for *Heliaster*. Glidden reported the worm as *Polyophalmus*, although Jerry Kudenov, author of the polychaete section of this handbook, informs me they are more likely members of the genus *Ophiodromus*.

The range of *Heliaster kubiniji* is given by Caso (1961) as Cape Mendocino, California, to Nicaragua, and throughout the Gulf. I have collected it in abundance throughout the northern Gulf, and in fewer numbers at Guaymas and Mazatlán; however, the occurrence of this species north of Mexico is unlikely. Caso also described a variety of this species, *H. kubiniji* var. *nigra* Caso, but did not give any details of its alleged distribution, merely stating it occurs in the Gulf of California. She stated the variety *nigra* differs from the former by having only 19 arms and a nearly black aboral surface, as opposed to what she describes as a dark red color for the typical form. *Heliaster kubiniji* is one of the first northern Gulf littoral invertebrates to begin reproducing after the cold winter draws to a close early in the year. Figure 26.11.

Heliaster microbrachius Xantus

This sun star is a close relative of *H. kubiniji*, and the two are sympatric in the regions of Guaymas, Mazatlán, and further south. *Heliaster microbrachius* is a more compact, short-rayed version of *H. kubiniji*. It has 30–40 arms (as opposed to 25 or fewer in *H. kubiniji*) and is distributed from Guaymas as far south as Chile. This is a truly tropical form that apparently cannot stand the cold winter temperatures above Isla Angel de la

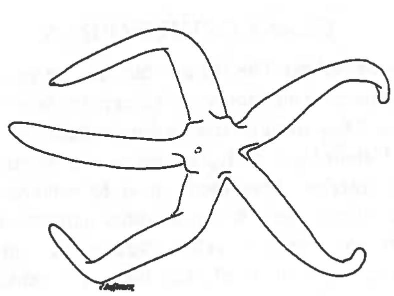


Fig. 26.9 *Linckia columbiae*

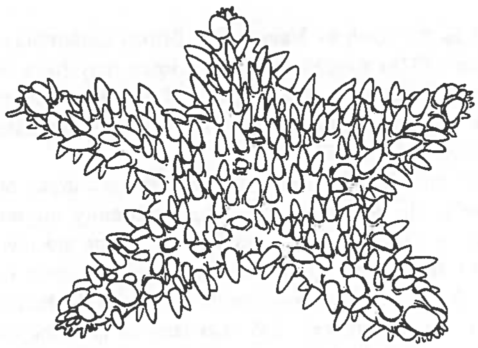


Fig. 26.10 *Amphiaster insignis*

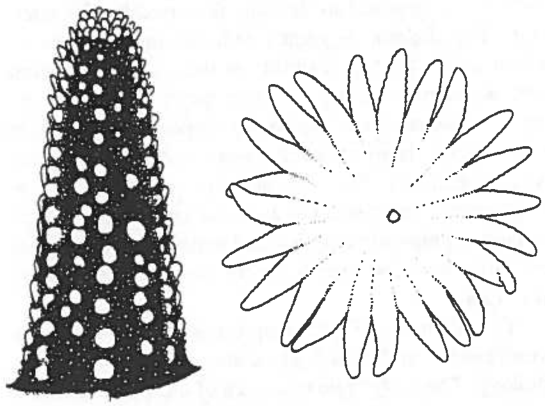


Fig. 26.11 *Heliaster kubiniji*

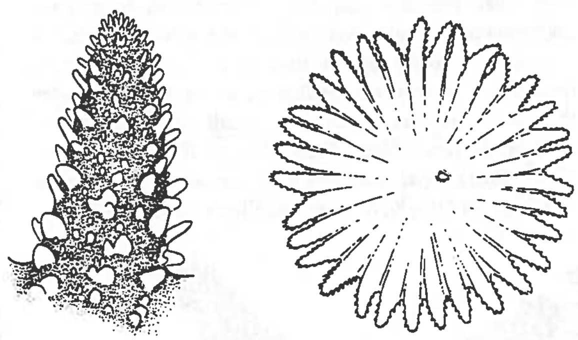


Fig. 26.12 *Heliaster microbrachius*

Guarda. Its aboral surface is darker than that of *H. kubiniji*, and the many small bumps that cover the surface of both species are much smaller and more uniform in size than in *H. kubiniji*. I have collected it in abundance at Guaymas, Cabo San Lucas, and Mazatlán. Caso (1961) described a variety of this species also, *H. microbrachius* var. *polybrachius* Caso, as differing by having the free portion of the radius 26 to 29 percent of the total radius, as opposed to 16 to 22 percent in *H. microbrachius*, and in some other minor morphological differences.

Although I have collected both *H. kubiniji* and *H. microbrachius* from the regions of Guaymas and Mazatlán, I have never found both occurring in the same place at the same time. This may be just chance and the result of random collection, or perhaps some interesting factors of population dynamics and interspecific competition are taking place. Data from a study of this genus in the Western Hemisphere could provide someone with a good Ph.D. dissertation. There is, in fact, a third and possibly a fourth species of *Heliaster* on the west coast of Mexico and Central America. Caso reports *H. heliantus* (Lamarck) distributed from Acapulco to Valparaiso, Chile, and Lyman (1902) reported *H. cumingi* (Gray) from Peru and the Galápagos islands. Figure 26.12.

FAMILY ASTERIIDAE

Astrometis sertulifera Xantus

A large, soft, highly flexible and spiny sea star of the lowest intertidal and subtidal. The slimy rays are constricted basally by several millimeters and may number five to six. The aboral surface is mottled gray-green to brown with indistinct dark bands across the arms. The spines are very distinctively marked, being blue-violet at the base and red-orange on the tips. The aboral spines are more or less random across the arms but form a fairly distinct circle around the periphery of the disk. The long tube feet are white to yellow and possess suckers. The pedicellariae are stalked. In the low intertidal, this sea star usually hides under large rocks in a sandy substrate, but subtidally it may be seen crawling about on exposed sand or rock surfaces. *Astrometis* is a voracious predator of gastropods, pelecypods, and barnacles. It is one of the few species of asteroids that easily and readily sheds its arms when handled. The arm span reaches 180 mm.

This species ranges from Oregon and Washington to the Gulf of California south at least as far as Mazatlán, reappearing on the Galápagos Islands. It is fairly common on the open coast, where it often is encountered in great numbers subtidally, although it is rarely seen above Santa Barbara on the California coast. There is a record of it as far north as Vancouver, British Columbia, but Fisher (1928) suggested this specimen may have been carried to Canada on the bottom of a lumber schooner. This sea star cannot be dried or it will disintegrate; it must be preserved in alcohol.

In the Gulf of California smaller specimens often occur in the low intertidal zone, apparently migrating offshore as they mature. Larger specimens are always found subtidally. These smaller representatives (arm span 50–70 mm) are considerably less flexible than their older, larger brothers, and also tend to lack the basal constriction of the arms seen in larger specimens. Because of these differences in habitat and morphology several authors have confused these smaller individuals with other species of sea stars. This confusion has been compounded by the existence of the name *Echinaster tenuispina* and its (apparently) senior synonym *Othilia tenuispina*. *Echinaster tenuispina* of the first edition of this handbook was, in reality, a small intertidal form of *Astrometis sertulifera*. The photo of *E. tenuispina* in Caso (1961) appears to be a badly preserved or air-dried specimen of *Othelia tenuispina*. Figure 26.13.

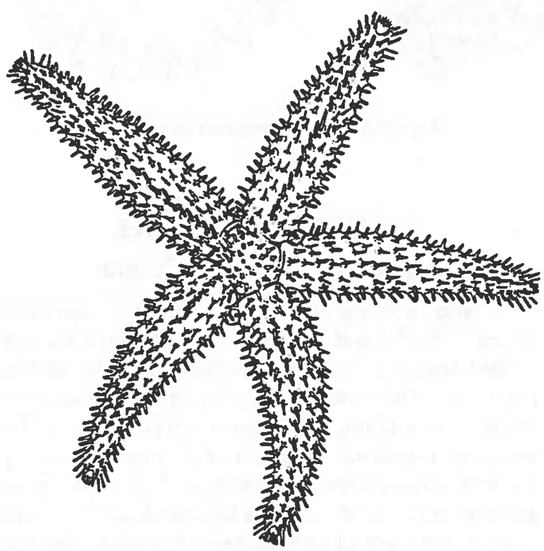


Fig. 26.13 *Astrometis sertulifera*

CLASS OPHIUROIDEA

Preservation: The brittle stars can be preserved in 50 to 60 percent alcohol or a 5 percent buffered formalin solution. They must be handled with great care, as they break off their long, delicate arms readily by autotomy if handled roughly. Specimens must be relaxed in magnesium sulfate, fresh water, or other narcotizing agents prior to preservation. After preservation the larger species can be air-dried, but they will remain quite fragile.

Taxonomy: The ophiuroids are pentaradial echinoderms with long, slender, flexible arms used for walking, as opposed to the tube feet used by the asteroids. The skeleton is greatly reduced and fragmented, which allows for the flexibility of the arms. The central disk is sharply marked off from the rays and may be round or pentagonal. The aboral surface of the disk, in most species, bears exposed, paired radial shields at the base of each arm. The arms of brittle stars, unlike those of asteroids, lack distinct ambulacral grooves on the oral surface. Ophiuroids can be found under rocks or in other protective habitats, usually where the substrate is sandy or muddy.

The taxonomy of this group is based largely on spine arrangement, and mouth parts and skeletal plate morphology. The systematic treatment of this presentation is based on Caso (1961) and agrees with Hyman (1955) and Nichols (1962).

One brittle star not treated in the keys, *Ophiolepis variegata* (Lutken), may be encountered in the northern Gulf only below 20 to 40 meters and is occasionally brought up by shrimp trawls. It is a rather stiff species, the arms displaying very little flexibility. The arm spines are short, and the arms are banded with blue and black, with a large white spot covering several plates of the disk on many specimens. A second species, too rare in the Gulf to have been included in the key, is *Ophiophragmus marginatus* (Lutken). This ophiuroid occurs buried in the lower reaches of tidal flats from the upper Gulf, possibly as far south as Peru. It has extremely long arms, attached to an unusually small disk. The tips of the arms are extended above the surface of the substrate, presumably to capture passing food items in the water column.

KEY TO THE COMMON INTERTIDAL OPHIUROIDEA

1	Arms branch (fig. 26.20)	2
	-Arms do not branch	3
2(1)	Arms banded; small, maximum expanded diameter about 40 mm	***Astrodictyum panamense***
	-Arms not banded; large, maximum expanded diameter over 150 mm (fig. 26.20)	***Astrocaneum spinosum***
3(1)	Arm spines very short, forming an acute angle with the arm axis, and lying flat against the arm, pointing toward the tip	4
	-Arm spines long, perpendicular to arm axis	6

4(3) Body and arms tan; arms with red bars .... ***Diopederma danianum***
-Body and arms slate-colored; arms without red bars 5

5(4) Arms uniformly slate-colored; aboral arm plates fragmented and broken up into subplates (fig. 26.14) .... ***Ophioderma teres***
-Arms banded or spotted with white, at least distally; aboral arm plates entire (fig. 26.15) .... ***Ophioderma panamense***

6(5) Animal with 5 rays; arm span greater than 25 mm; 6 or more oral papillae per jaw (or, no oral papillae present at all) 7
-Animal with 6 rays (occasionally 5); size minute, arm span less than 20 mm; 2 to 5 oral papillae or jaw 10

7(6) Spines of disk and arms are themselves serrated or spiculated (fig. 26.18c); oral surface of arms banded with tan and orange (fig. 26.18b); disk covered with minute spicules, appearing fuzzy or glasslike .... ***Ophiothrix spiculata***
-Spines of disk and arms not spiculated; oral surface of arms not banded as above; disk not as above 8

8(7) Arms unicolored, not banded .... ***Ophiocoma aethiops***
-Arms banded 9

9(8) Diameter of disk 18 to 24 mm; animal brown with a white blotch at the base of each arm spine; aboral surface of disk granulated (fig. 26.16) .. ***Ophiocoma alexandri***
-Diameter of disk less than 16 mm; animal without a white blotch at the base of each arm spine; surface of disk not granulated but covered with minute scales (fig. 26.17) .... ***Ophionereis annulata***

10(9) 5 to 6 spines on each side arm plate (fig. 26.19); always with 6 rays; radial shields large, joined in pairs distally; 4 to 5 oral papillae per jaw .... ***Ophiactis savignyi***
-4 spines on each side arm plate; with 5 or 6 rays; radial shields small, not joined in pairs; 2 oral papillae per jaw .... ***Ophiactis simplex***

Order Ophiurae

FAMILY OPHIODERMATIDAE

Ophioderma teres (Lyman)

This species (and the one following) has short arm spines, lying flat against the arms. The arm spines are arranged in vertical rows all along the lateral margin of the arm. Members of this genus also have 4 bursal slits per interradius, generally quite visible to the naked eye. *Ophioderma teres* is a large, solid slate-colored brittle star (resembling *O. esmarki* of the California coast), with a disk diameter of 20 to 26 mm. The upper arm plates are fragmented and broken up into numerous small subplates. Members of this genus appear to be primarily carnivorous, as opposed to members of the genera *Ophiocoma* and *Ophionereis*, which appear to spend a great deal of their energy by suspension feeding. *Ophioderma teres* ranges from the upper Gulf to Panama, reappearing again in the Galápagos Islands. It is found under large stones in the lower mid intertidal. *O. teres* has been previously reported as *Ophiura teres*. Figure 26.14.

Ophioderma panamense Lutken

A large brittle star, at first resembling *Ophioderma teres*, but with paired white spots on the arm tips and without the aboral arm plates fragmented. The color varies from pale brown to black. The arm spines are short, lying close to the arm. The disk is granulated, with a greatly thickened epidermis, and reaches 25 mm in diameter, while the arm span may occasionally exceed 200 mm. This species ranges from southern California and the upper Gulf to Peru and the Galápagos Islands, occurring in the rocky, lower midintertidal. Figure 26.15.

Diopederma danianum (Verrill)

A relatively uncommon brittle star in the Sea of Cortez, ranging from the southern Gulf at least as far south as Panama. The body and arms are tan, the arms bearing a series of reddish bars across the surface. The disk is usually 15–25 mm in width and finely granulated. The arm spines are short. I have recorded it with fair consistency from the coral reefs of Bahía Pulmo.

FAMILY OPHIOCOMIDAE

Ophiocoma aethiops Lutken

The largest and most striking brittle star of the east Pacific region, with a disk diameter to 40 mm and an arm span of 340 to 440 mm (nearly 20 inches). The arm spines are long and perpendicular to the arm axis. The aboral surface is purple-brown, unicolored, and the disk is covered with minute granules. The oral shields are much longer than wide. This species is common on rocky shores, under rocks in sand or muddy sand of the lower mid intertidal zone, from the upper Gulf to Panama and the Galápagos Islands. To the student as yet uninitiated to the Gulf fauna, this may well be the most impressive animal he encounters during his first visit to this seashore. Nowhere in western America, north of Mexico, will one encounter a robust, spiny brittle star the size of this giant. See Plate 8.

Ophiocoma alexandri Lyman

Another large brittle star, common in the rocky low mid intertidal from the upper Gulf to Panama and the Galápagos Islands and also possibly occurring in the Caribbean region. The arm spines are perpendicular to the arm axis, and the arms are banded with gray and white on the aboral surface. The disk is light brown or pale green, usually with a white blotch at the base of each arm spine, covered with minute granules. The disk reaches 30 to 35 mm in diameter, and the arm span reaches approximately 330 mm. The oral shields are about as long as wide. This species is more slender than *Ophiocoma aethiops* and much lighter in color. Figure 26.16.

FAMILY OPHIOCHITONIDAE

Ophionereis annulata (LeConte)

A small to medium-sized species of brittle star, with the arm spines perpendicular to the arm axis. This species is black and white, with a disk diameter of 10 to 17 mm, and an arm span of 50 to 100 mm. The arms are usually pale, with dark bands completely encircling them. The surface of the disk is covered with minute scales, not granulated. There are 9 to 10 oral papillae. *Ophionereis annulata* ranges from southern California and the upper Gulf to Ecuador and the Galápagos Islands. It occurs in the midtidal zone and occasionally in the low intertidal. It has been reported previously as *Ophiolepis annulata*. Ricketts *et al.* reported this species to be the southern counterpart of the similar appearing *Amphiodia occidentalis*, which ranges from Alaska to central California. Figure 26.17.

FAMILY OPHIOTRICHIDAE

Ophiothrix spiculata LeConte

This attractive little brittle star should be another "familiar face" to California students. It has the appearance of being covered with glasslike, fuzzy spines. The arm spines are perpendicular to the arm axis, and they (as well as the disk spines) bear minute spinulets or serrations. The disk is more or less pentagonal. The color of this species varies from blue or gray-green to a beautiful violet, and the arms are nearly always banded with orange, at least on the oral surface. When the individual is gravid, conspicuous egg masses bulge out between the rays. The disk lacks oral papillae and attains a diameter of 10 to 15 mm, while the arm span of a large individual often exceeds 100 mm. This brittle star is found in the mid and low intertidal, under rocks and in large sponges, or clinging to algae. It is often abundant among the roots of the red mangrove trees (*Rhizophora mangle*), especially in association with estuarine sponges. It ranges from Monterey, California, and the upper Gulf to Peru and the Galápagos Islands, and is abundant throughout its range from the mid intertidal to at least 100 fathoms. It previously has been reported as *Ophiothrix dumosa*. Figure 26.18.

FAMILY OPHIACTIDAE

Ophiactis savignyi (Muller and Troschel)

A small, six-armed brittle star (occasionally seven-armed), with arm spines perpendicular to the arm axis. The predominant color is yellow-green to pale green. It is found in the mid and low intertidal, under rocks and in mangrove swamps from southern California, and the upper Gulf to Panama. It is reported by Clark (1940) and Caso (1961) as tropicopolitan. I have collected it at Puerto Lobos, Puerto Peñasco, and Guaymas. It previously has been reported as *Ophiolepis savignyi*. Figure 26.19.

Ophiactis simplex (LeConte)

A small five- or six-armed brittle star, similar in appearance to the above species. The arms are marked with light and dark green or occasionally brown bands. It has arm spines perpendicular to the arm axis. *Ophiactis simplex* may be distinguished from *O. savignyi* by the presence of four smooth spines on each arm plate, while in the latter the spines of each arm plate are rough and number five and six. I have found this species to be common throughout the Gulf and have collected it in great abundance from the pores of large sponges (*Geodia*, *Leucosolenia*, and *Leucetta*) and living in the thick mats of algae on rocks. This species ranges from southern California and the upper Gulf to Peru. It previously has been called *O. arenosa*.

Order Euryalae

FAMILY GORGONCEPHALIDAE

Astrocaneum spinosum (Lyman)

This is the Gulf basket star. The body is a glossy tan, and the arms have a single aboral row of white spots, circled by black rings, extending down the midline. The arms branch dichotomously near the disk but alternate distally in a panicle fashion. Large individuals will have a disk diameter of 35 to 45 mm. Living baskets, when placed in the aquarium, are beautiful sights. The long, knotted arms unfold to form a giant flowerlike creature, whose tendrils wave slowly in the water. This species ranges from the upper Gulf to Panama. In the Gulf it probably is never seen in water shallower than three or four fathoms. It previously has been reported as *Astrophyton spinosum*. The best place to look for basket stars is in the catch of the shrimp trawlers, where they

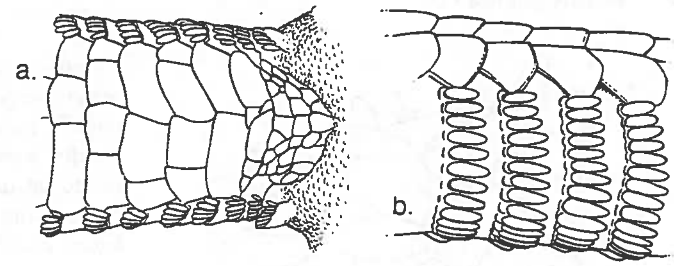
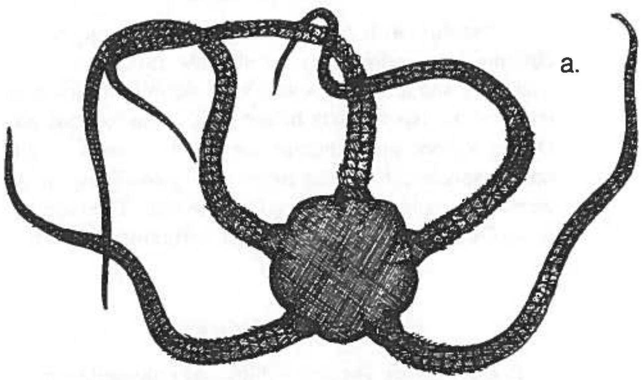


Fig. 26.14 *Ophioderma teres*.
(a) Close-up of arm showing dorsal plates.
(b) Close-up of arm showing side spines.



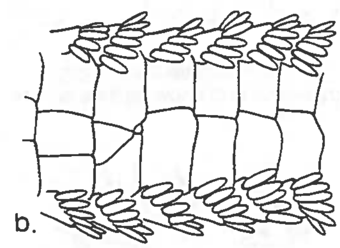


Fig. 26.15 *Ophioderma panamense*.
(a) Dorsal view.
(b) Close-up of arm showing dorsal plates.

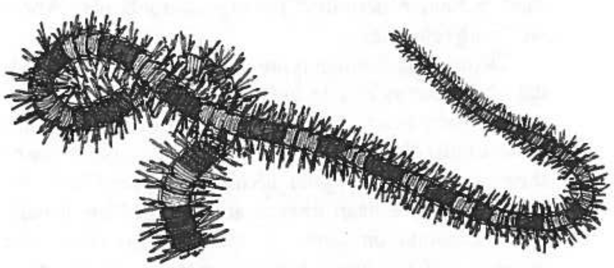


Fig. 26.16 *Ophiocoma alexandri* (arm)

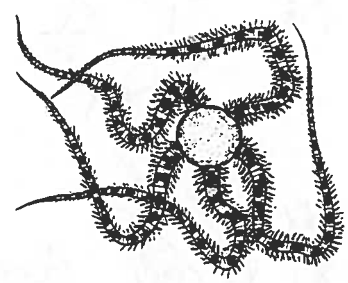
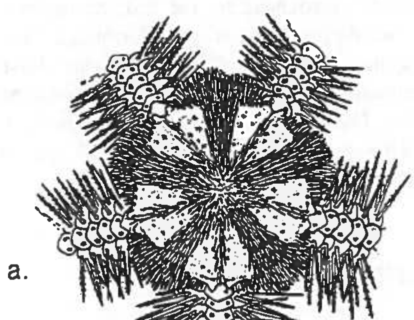
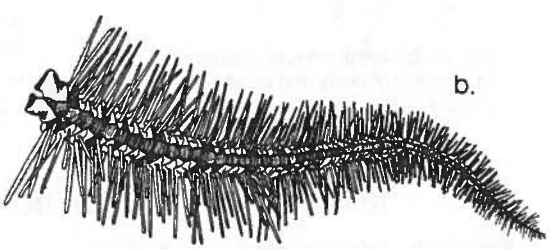


Fig. 26.17 *Ophionereis annulata*
(from Allen, 1976)





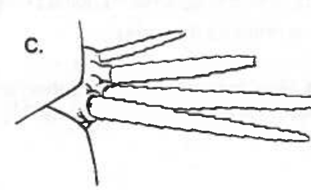


Fig. 26.18 *Ophiothrix spiculata*.
(a) Disc (from Allen, 1976).
(b) Arm.
(c) Close-up of side arm spines.

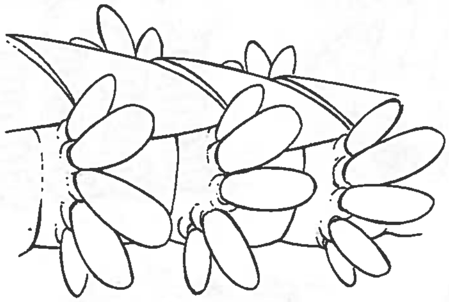


Fig. 26.19 *Ophiactis savignyi*.
Close-up of arm showing side spines.

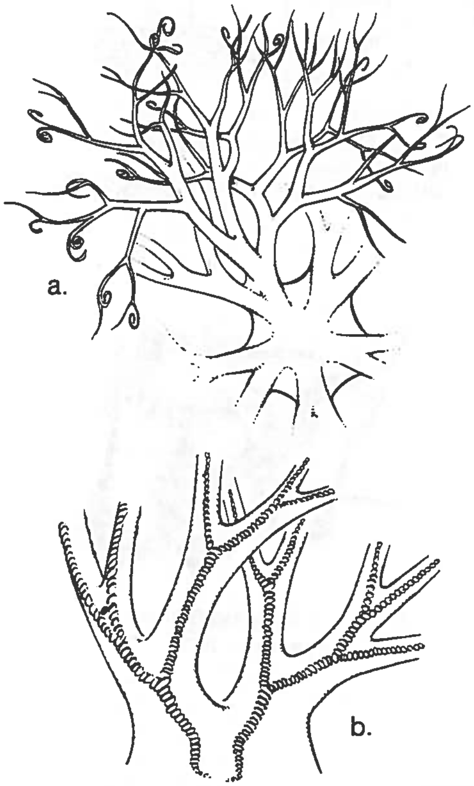


Fig. 26.20 *Astrocaneum spinosum*.
(a) Portion of body and arms.
(b) Oral view of arms.

are often brought up in small numbers, wrapped tightly around gorgonian coral (upon which many feed) or other objects, including the shrimp net itself. During the unusually warm years of 1976 and 1977 this basket star turned up on the islands off Punta Eugenio, on west Baja, living in association with *Eugorgia aurantica*. Figure 26.20.

Astrodictyum panamense (Verrill)

A beautiful little miniature basket star, usually found clinging to gorgonians in the shallow subtidal region. The body and arms are yellow to violet-red or pink and the arms are banded with brown. Many basket stars are known to feed on gorgonian corals and several of the smaller species, in the size range of *A. panamense*, may spend their entire life on a single gorgonian. The biology of the Gulf basket stars is, however, virtually unknown.

CLASS ECHINOIDEA

Preservation: The sea urchins and sand dollars may be dried, or preserved in 70 percent alcohol. The fine-sand technique described for the asteroids also works well with echinoids.

Taxonomy: Echinoids are globose, ovate, or discoidal echinoderms that include sand dollars, regular sea urchins, and heart urchins (= sea biscuits). The Gulf fauna of this class includes representatives of all three of these groups. The regular urchins are found in rocky areas, while the heart urchins and sand dollars usually may be found on sandy or muddy tidal flats. The taxonomy of this group is based primarily on the position and morphology of the spines, test plates, pedicellariae, mouth parts (Aristotle's lantern), and other external features. References in the key to the *internal lunule* of sand dollars refer to that lunule whose margins are entirely surrounded by the test, as opposed to the lunules whose distal end is open, forming a "slit" in the test margin. The systematics of this class have undergone numerous revisions by various authors over the last 60 years. The taxonomic scheme followed in this treatment is based on Clark (1912, 1914, 1917, and 1948) and Caso (1961).

KEY TO THE COMMON INTERTIDAL ECHINOIDS

1 Body ovate or globose in shape (urchins) 7
-Body discoidal, or flattened in shape (sand dollars) (figs. 26.26–26.30) 2

2(1) Test with holes, slits, or notches (lunules) 3
-Lunules absent 5

3(2) Lunules narrow and slitlike; test extremely flattened and fragile; maximum disk diameter about 75 mm (fig. 26.30) .... ***Mellita longifissa***

	-Lunules rounded, not slitlike; test thicker and more robust; maximum disk diameter about 130 mm	4
4(3)	Posterior lunule large and internal, other lunules all open at the margin (fig. 26.28)	***Encope grandis***
	-All lunules internal (fig. 26.29)	***Encope micropora***
5(2)	Test circular or oval, with interradial margins convex (fig. 26.27)	***Clypeaster rotundus***
	-Test more or less pentagonal, with interradial margins concave or straight	6
6(5)	Diameter of test may reach 200 mm; color pale pink to red	***Clypeaster europacificus***
	-Diameter of test rarely over 130 mm; color dark purple to black (fig. 26.26)	***Clypeaster testudinarus***
7(1)	Body globose (regular urchins)(figs. 26.21–26.25)	8
	-Body ovate to spherical (heart urchins)(figs. 26.31–26.32)	17
8(7)	Test armed with rows of blunt, club-shaped spines; spines usually covered with encrusting organisms (fig. 26.21)	***Eucidaris thouarsii***
	-Test armed with sharp pointed spines; spines rarely, if ever, with encrusting organisms	9
9(8)	Spines very short, shorter than height of test	10
	-Spines long, much longer than height of test	12
10(9)	Pedicellariae end in petaloid "suckers" upon which is often fixed bits of algae or other debris	***Toxopneustes roseus***
	-Pedicellariae not as above	11
11(10)	Test diameter to 50 mm; buccal membrane (peristome) provided with heavy plates; color pale straw to greenish with a faint rose overtone (fig. 26.24)	***Lytechinus pictus***
	-Test diameter to 150 mm; buccal membrane (peristome) not provided with heavy plates; ground color rose to purple, spines pale brown	***Tripneustes depressus***
12(9)	Surface with 5 spineless rows running down from aboral pole (fig. 26.23)	***Arbacia incisa***
	-Surface without 5 spineless zones	13
13(12)	Spines unicolored, not banded	14
	-Spines banded with 2 or more colors, or dark basally and lighter distally	15
14(13)	Spines with numerous barbs, projecting toward the tip of each spine; length of longest spines greater than 2 times height of test	***Diadema mexicanum***
	-Spines without barbs as above; length of longest spines less than 2 times height of test (fig. 26.25)	***Echinometra vanbrunti***
15(13)	Spines unbanded or banded near base only; spines not annulated; body of urchin lavender with 5 large, pale interradial spots	***Astropyga pulvinata***
	-Spines banded near tip, or of 2 colors (brown basally reddish distally); spines annulated; urchin body unicolored, not spotted as above	16
16(15)	Short claviform spinelets present on upper most interambulacral plates; peristomium (around mouth) bears spines as well as pedicellariae (fig. 26.22)	***Centrostephanus coronatus***
	-Without claviform spinelets on upper most interambulacral plates; peristomium (around mouth) bears pedicellariae only, without spines	***Diadema mexicanum***
17(7)	Urchin with numerous long dorsal spines (subequal to test width); color purple; body strongly ovate (fig. 26.32)	***Lovenia cordiformis***
	-Urchin with very short, close-cropped spines; color tan to dark brown; body slightly ovate to spherical	18
18(17)	Test elongate-oval (width equals 0.77 to 0.84 percent of length); aboral surface with a well-defined, 5-pointed star pattern; test and spines gray to white	***Brissus latecarinatus***
	-Test more circular (width equals 0.82 to 0.93 percent of length); aboral surface with a poorly defined 5-point star pattern; test and spines almost always uniformly dull brown	19
19(18)	Length 15 to 60 mm; test extremely rounded; occasionally with white spines (fig. 26.31)	***Agassizia scrobiculata***
	-Length 70 to 150 mm; test ovate; never with white spines	***Meoma grandis***

SUBCLASS ENDOCYCLICA or REGULARIA

(regular sea urchins)

Order Cidaroidea

FAMILY CIDARIDAE

Eucidaris thouarsii (Valenciennes)

One of the most common echinoids of the Gulf and Panamic region in general. This sea urchin has ten vertical rows of five to eight clubbed spines each. The test diameter reaches 70 mm. The primary (large) and secondary (small) spines differ in shape, the secondaries being short and flat (truncate or chisel-tipped), while the primaries are large and round, tapering gradually toward the blunt tip. The brownish-purple spines are nearly always coated with white bryozoan colonies, sponges, and calcareous algae. This species occurs on rocks and reefs in the mid and low tide zone, often exposed to violent surf. It also ranges subtidally to depths of 150 m. It also has been reported as *Cidaris thouarsii*. *Eucidaris thouarsii* is the most characteristic urchin of tropical and subtropical west America, ranging from the upper Gulf of California to Ecuador and the Galápagos Islands. Clark (1923) reported this urchin as a possible enemy of pearl shell growers, and it has been witnessed feeding on certain coral species in the Galápagos. These urchins are occasionally grazed upon by large wrasses, triggerfish, and other well-toothed fishes. Some workers give Agassiz and Desor as the authors of this species, and the correct authorship may be open to debate, as both names appeared in the same year, 1846. Fitch (1962) reported the finding of a single large individual (test diameter 72 mm) at Catalina Island, off Los Angeles, and during unusually warm years I have noted its occurrance along the western shores of Baja. Figure 26.21. and Plate 14.

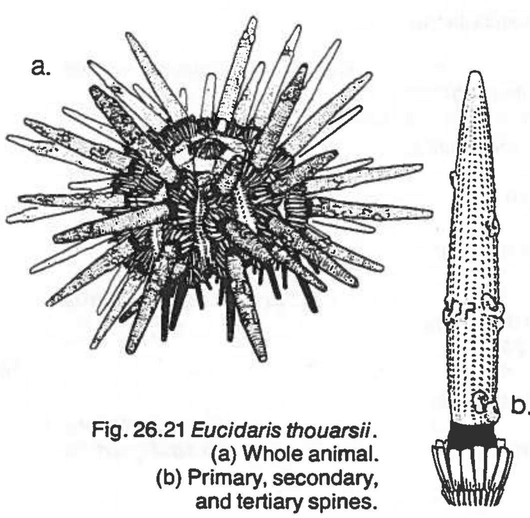


Fig. 26.21 *Eucidaris thouarsii*. (a) Whole animal. (b) Primary, secondary, and tertiary spines.

Order Aulodonta

FAMILY DIADEMATIDAE

Diadema mexicanum A. Agassiz

A large purple, black, or dark blue sea urchin with long slender spines. The spines are covered with a toxic mucoid substance that can be quite painful, although relatively harmless otherwise, and should probably be classified as an irritant rather than a true poison. The spines break off readily and are difficult to remove because they possess many rows of spinelets. Certain Caribbean and Indo-Pacific species are known to be quite poisonous, and in cases of extreme individual reaction to sea urchin spine toxins the use of vinegar and antihistamines is a standard remedy. Analgesic substances, such as Solarcaine, may also relieve the pain temporarily. Extremely large pieces of spine that cannot be easily removed should be treated by a physician. The test diameter of *Diadema mexicanum* reaches 40–80 mm, and the dorsal spines reach 50–150 mm in length. Owing to the fragility of its spines, this species can rarely be preserved with all the spines intact. Fully mature adults are uniformly black-purple, while younger specimens have banded spines, usually white and purple. This species is restricted to the rocky low intertidal and subtidal zones and occurs from the mid-Gulf of California (Bahía de los Angeles and Bahía Kino) and lower west coast of Baja to Colombia and the Galápagos Islands. It also has been reported as *Centrechinus mexicanus*. Caso (1961) reported *Diadema mexicanum* from Puget Sound, Washington, but this record is highly doubtful, since this species appears to be strictly Panamic. In the Gulf it probably occurs in greatest numbers between Loreto and Cabo San Lucas, on the Baja California peninsula. *Diadema mexicanum* may be regarded as an opportunistic scavenger (as may be *Centrostephanus coronatus*).

Astropyga pulvinata (Lamarck)

This urchin is highly variable in color (violet, red, yellow, or brown), usually brown-violet with reddish-violet markings. It is easily recognized by the five large, pale, triangular blotches present in the interradial area of the aboral surface, and the rather flattened test. The test diameter reaches 120 mm. It is largely subtidal and somewhat rare in the Gulf, ranging from the mid-Gulf to Ecuador and the Galápagos Islands. It also has been reported as *Cidarites pulvinata*, *Astropyga venusta*, and *Astropyga depressa*.

Centrostephanus coronatus (Verrill)

This species is often mistaken for *Diadema mexicanum* and avoided, but the spines of *Centrostephanus coronatus* are not toxic. The test diameter reaches 60 mm, and the length of the largest spines is

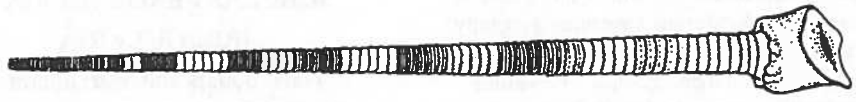


Fig. 26.22 *Centrostephanus coronatus*, single spine

approximately twice this dimension. The spines have an annulated texture and are fragile and easily broken (fig. 26.22). The peristomium bears 5 clusters of short, but obvious and diagnostic, spines. The uppermost interambulacral plates possess short, claviform spinelets, with bright red or purple tips. Young individuals have the spines banded with purplish-brown and yellow. Large adults may be without banding, although the spines are usually dark brown basally and a lighter red or purple distally. This species has previously been reported as *Echinodiadema coronata*. It occurs in the low tide zone and subtidal from the upper Gulf to the Galápagos Islands and Ecuador, and has been reported from depths of up to 125 m. It is especially common on rocky subtidal substrates: between Puerto Lobos and Guaymas; at Puerto Refugio; and along the lowest east coast of Baja California, in 3–30 meters. It also occurs subtidally on some southern California and upper Baja California islands. Kennedy and Pearse (1975) have shown the Catalina Island (California) population to have a monthly reproductive rhythm synchronized not with tidal cycles but with lunar phases, summer spawning occurring near the third lunar quarter.

Order Stirodonta

FAMILY ARBACIIDAE

Arbacia incisa (A. Agassiz)

One of the more common urchins of the Gulf, with the test diameter reaching 40 mm, although the average size is closer to 20 mm. Young individuals are red, becoming violet to black in adults. The interambulacral areas of the aboral surface are without spines and usually bear red spots on the plates. This species has short dorsal and ventral spines, but long lateral spines. *Arbacia incisa* prefers surf-protected rocky shores and is found in the mid and low intertidal from southern California and the upper Gulf of California to Peru and the Galápagos Islands. It has been reported as *Echinocidaris incisa* and *Arbacia stellata*. Figure 26.23.

Order Camarodonta

FAMILY TOXOPHEUSTIDAE

Lytechinus pictus (Verrill)

This short-spined urchin has a test diameter reaching nearly 40 mm. The spines are short, thick, and blunt. The color is a pale straw brown to gray, occasionally with a rosy hue. The basal half of the spines usually remains white, regardless of the distal coloring. Young specimens occasionally may have banded spines. In California this species is found in the mid and low intertidal, but in the Gulf it is restricted to the very lowest minus tides and the subtidal. *Lytechinus pictus* occasionally attaches bits of shell and gravel to its tube feet, as do many species of sea urchins. It is most active at night and often found partially buried in the sand during the day. Its range is from central California and the northern Gulf to Ecuador. This species is nearly identical to *Lytechinus anamesus* H. L. Clark, differing mainly in its shorter spines and larger test, the test diameter of *L. anamesus* being only 10 to 20 mm. Ricketts *et al.* (1968) reported *L. anamesus* as occuring in the Gulf, but I have seen no other reference to it from Gulf waters. Clark (1940) stated these may be ecological types of a single species. Figure 26.24.

Toxopneustes roseus (Agassiz)

A beautiful and robust sea urchin fairly common in the extreme southern Gulf, especially around Cabo San Lucas, La Paz, and the coral reefs of Bahía Pulmo. The test is strongly globoid, about twice as wide as tall. Average specimens are 50 mm in height and 100 mm in diameter. The spines are very short and grade from uniformly tan to purple in color. Between the spines lie the

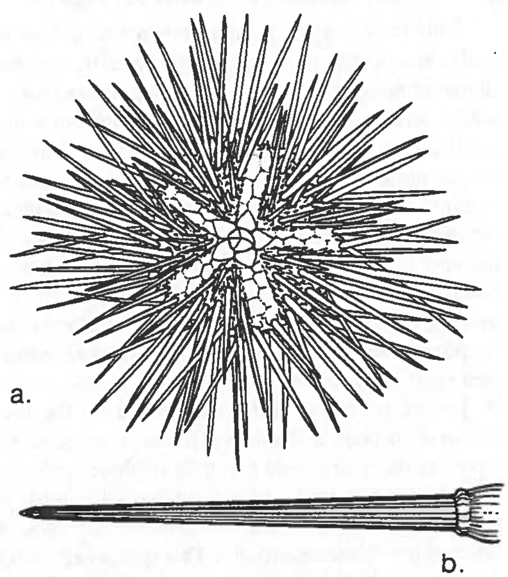


Fig. 26.23 *Arbacia incisa*.
(a) Whole animal. (b) Single spine.

many odd-shaped pedicellariae for which this genus is known. These stalked, globiferous structures generally come in two sizes. The smaller type is usually held wide open, covering the animal and producing a "flowerlike" effect. These pedicellariae appear petaloid when open, the "petal" being tan with a central dark brown spot. When they close, the three corners of the "petal" fold in to form a cone. The tube feet occur in five double rows down the test. This urchin is distributed from the southern Gulf to Ecuador, including most offshore islands in its range. See Plate 6.

Tripneustes depressus Agassiz

Another strongly globose sea urchin, resembling *Toxopneustes* but lacking the obviously petaloid pedicellariae of the latter. Ground color is dark brown to purple with pale brown spines. This urchin grows to a whopping 150 mm in test diameter. The gonads of a similar species (*T. ventricosus*) are eaten with enjoyment in the West Indies, as are other species of urchins the world over. Although there is no record of anyone having tried the gonads of *T. depressus*, they are probably large enough to form quite a satisfactory and tasty meal during the proper time of the year. The exact range of this species seems to be a mystery, although it has been reported from the lower west coast of Baja and the southern Gulf, as well as the offshore islands of Socorro, Clarión, and the Galápagos. I have recorded it from Cabo San Lucas, Isla San José, and the Pulmo reef area, in 3–30 m of water.

FAMILY ECHINOMETRIDAE

Echinometra vanbrunti A. Agassiz

This is one of the most common sea urchins of the Gulf. Young individuals are nearly circular, with the test diameter being 5 to 10 mm, while adults are more oval, with a test length reaching 70 mm. In the adult the test width equals about 90 percent of its length. This purple urchin prefers crevices and cavities in rocks and reefs, where it can avoid the full impact of the surf, although it occasionally is found on exposed rock surfaces where the surf is calm. *Echinometra vanbrunti* occurs in the lower mid intertidal zone, from the upper Gulf to Peru and the Galápagos Islands. As in the California species of purple urchins, *Strongylocentrotus purpuratus*, *E. vanbrunti* often is found singly, each urchin occupying its private pocket in soft rock, eroded by the rotating action of its body and spines. However, at Bahía Kino I have regularly observed handfuls of these urchins congregated on the sand under a single rock, and at Cabo San Lucas I've seen them so thick on the rocks as to obscure the substrate entirely. This species also has been reported as *Heliocidaris stenopora*. Figure 26.25 and Plates 3 and 8.

SUBCLASS EXOCYCLICA or IRREGULARIA

(sand dollars and heart urchins)

FAMILY CLYPEASTRIDAE

Clypeaster europacificus H. L. Clark

A large sand dollar, reaching 200 mm in length. The width usually equals 95 percent of the length, making the test nearly circular. The body margin is easily broken, which leads to large numbers of deformed adults with strange-looking tests. This species is pale red-violet when young and violet to brown when adult. *Clypeaster europacificus* is largely subtidal, as are all sand dollars,

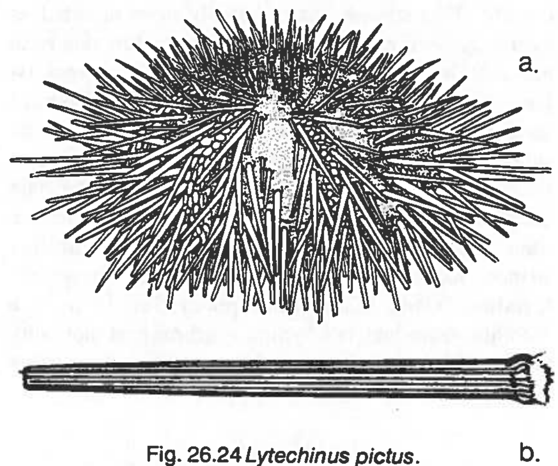


Fig. 26.24 *Lytechinus pictus*.
(a) Whole animal. (b) Single spine.

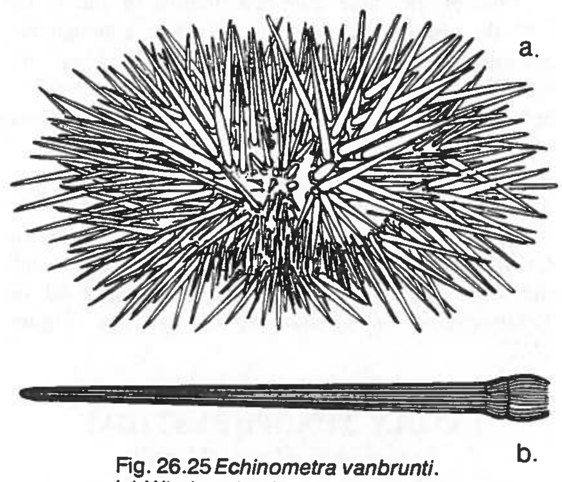


Fig. 26.25 *Echinometra vanbrunti*.
(a) Whole animal. (b) Single spine.

and it ranges from the mid Gulf to Ecuador and the Galápagos Islands. This and other species of sand dollars and heart urchins are rarely collected alive, although the naked tests are quite commonly found washed up on the expanse of a sand flat or estuary. One is most likely to encounter the living animals during the lowest of low tides, when large beds of hundreds or even thousands of them may be partially exposed in lagoons and large bays, where water circulates over a sandy bottom.

Clypeaster testudinarus Gray

This sand dollar attains a test diameter of 130 mm, with a width of 87 to 95 percent of the length. Young are lavender to brown, and the adults dark purple to black, much darker overall than the above species. It also has been reported as *Clypeaster speciosus*. I have collected it only at Guaymas and in Bahía Magdalena (on outer Baja). Records indicate it has a range similar to the above species in the Gulf, but it probably does not occur as far south as Ecuador. Figure 26.26 and Plate 14.

Clypeaster rotundus A. Agassiz

A nearly circular sand dollar, the width being 90 to 95 percent of length, which reaches 175 mm. The spines are black, dark purple, or dark brown. This species is often called a "sea biscuit," a name probably best reserved for the heart urchins. Like most sand dollars, it has a prominent star pattern on its aboral surface, formed by the wide ambulacra. It ranges from the upper Gulf to Ecuador and the Galápagos Islands. The species is nearly an identical twin to the common, but smaller, *Dendraster excentricus*, which ranges from Alaska to northern Baja California. Figure 26.27.

FAMILY SCUTELLIDAE

Encope grandis L. Agassiz

The giant keyhole sand dollar is abundant in the Gulf. It has a very coarse and heavy test, with a large, unpaired posterior lunule. The test is nearly circular, up to 120 mm in length. The unpaired lunule varies from a nearly circular hole to a long, narrow slit. This species is dull purple to black or dark brown. *Encope grandis* is probably endemic in the Gulf of California. Minute hermit crabs in tiny shells of *Cerithidea mazatlanica* are often found wedged into the lunules of individuals of this species at Puerto Peñasco. This and the following species of *Encope* are also quite often inhabited by a commensal pea crab of the genus *Dissodactylus*, which usually inhabits the posterior (anal) lunule. These commensal crustaceans apparently feed on anal wastes and food being carried to the mouth in the food grooves of the sand dollar. I have also found a small porcelain crab and a minute gastropod (*Turveria encopendema*) on *E.*

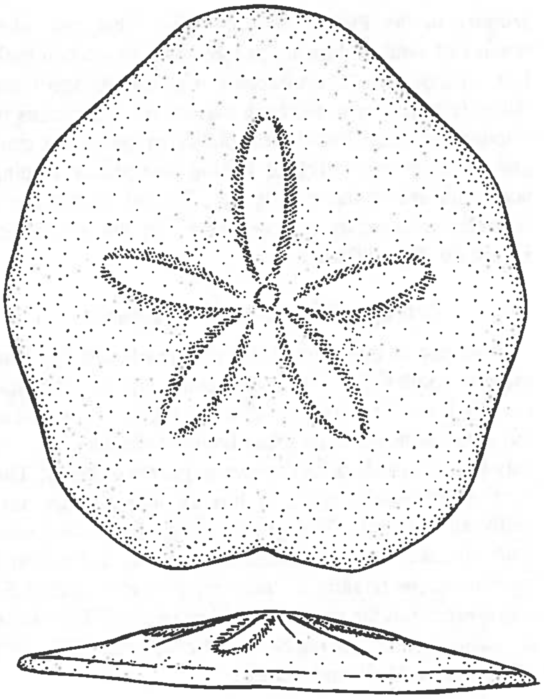


Fig. 26.26 *Clypeaster testudinarus*

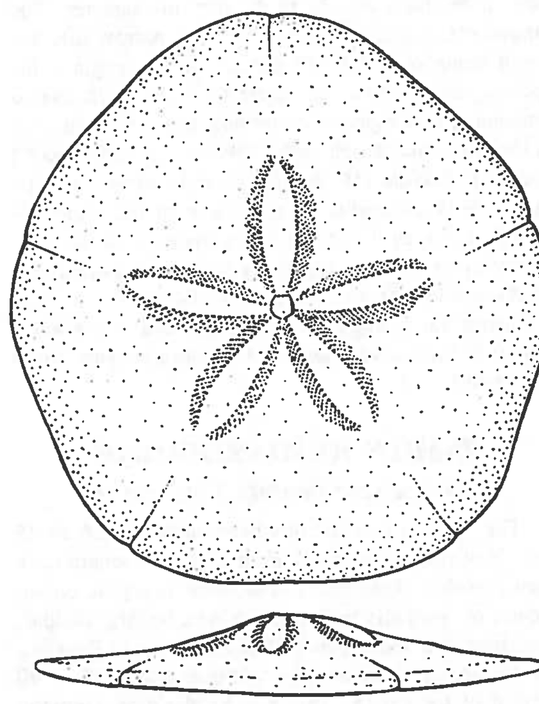


Fig. 26.27 *Clypeaster rotundus*

grandis in the Puerto Peñasco area. This and other species of sand dollars are preyed upon by certain molluscs (*Cassis* spp.), crustaceans (*Callinectes* spp.) and fishes (cartilagenous fishes in particular). Specimens of *Encope* are often found with highly irregular test margins, usually indicative of having survived a feeding bout with one of these predators. Species in this genus are often referred to as "*comalitos*" by the Mexicans. Figure 26.28 and Plate 8.

Encope micropora L. Agassiz

The test of this sand dollar may reach 130 mm, but usually smaller individuals are found with the diameter ranging from 30 to 70 mm. *Encope micropora* is circular, often with rounded lobes between the lunules, and may be various shades of brown to purple or black. The lunules are usually more or less circular and are normally all enclosed. The species ranges from the upper Gulf of California (and Bahía Magdalena) to Chile and the Galápagos Islands. *E. micropora* is often called *E. californica*, but the former name has priority. This is the *E. californica* of Steinbeck and Ricketts (pp. 186, 193, 400). Figure 26.29 and Plate 8.

Mellita longifissa Michelin

This small sand dollar is purple to gray when alive, but has a prominent green-gray pattern when preserved. It is circular, with a test diameter reaching 75 mm, but most individuals are 20 to 40 mm in diameter. The lunules are unique in that they are long, narrow slits, the width being only 5 to 10 percent of the length. This species ranges from the upper Gulf of California to Panama, and is especially common north of Bahía Kino in the Gulf. Mortensen (1948, 1949) described a second species of *Mellita* (*M. grantii*) from the upper Gulf. Its existence is somewhat of a mystery at this time, although it can, in theory, be distinguished from *M. longifissa* by its more rounded body shape, the length being nearly equal to the width. Ebert and Dexter (1975) have discussed the biology of *Encope grandis* and *Mellita grantii* in the northern Gulf of California. Figure 26.30 and Plate 8.

FAMILY HEMIASTERIDAE

Agassizia scrobiculata Valenciennes

The normal size for this heart urchin is 20 to 25 mm. However, individuals up to 55 mm in length have been reported. *Agassizia scrobiculata* is a pale brown urchin, occasionally with white spines, largely subtidal, occurring from the upper Gulf of California to Peru and the Galápagos Islands. The width is about 80 to 90 percent of the length. This may be the most common heart urchin of the northern Gulf. Figure 26.31.

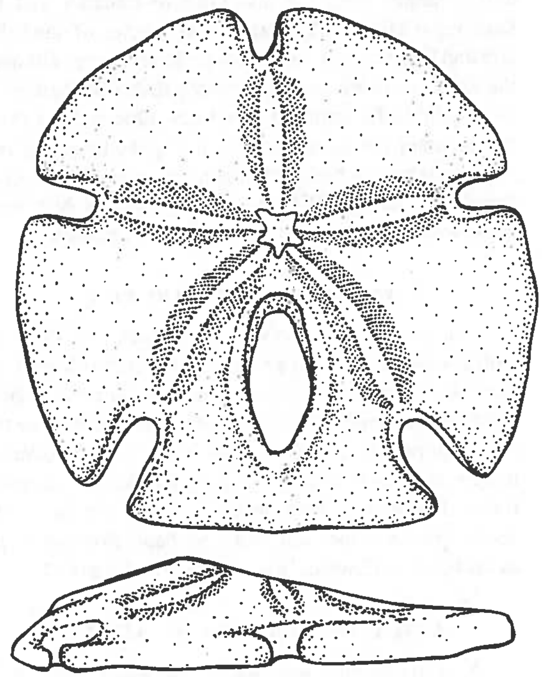


Fig. 26.28 *Encope grandis*

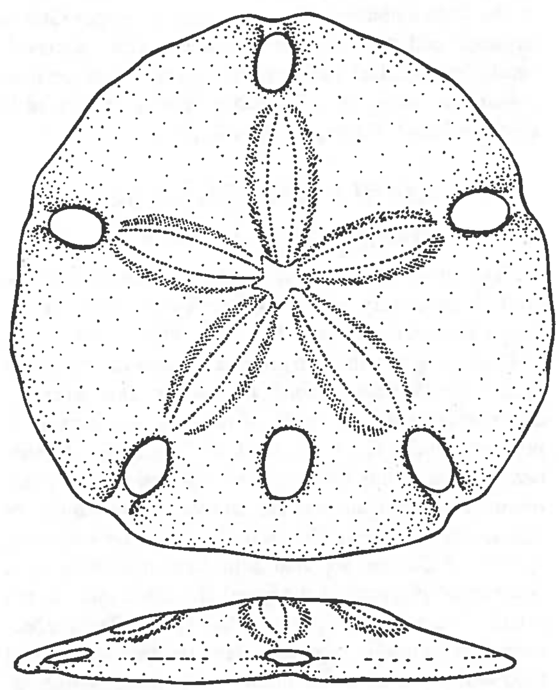


Fig. 26.29 *Encope micropora*

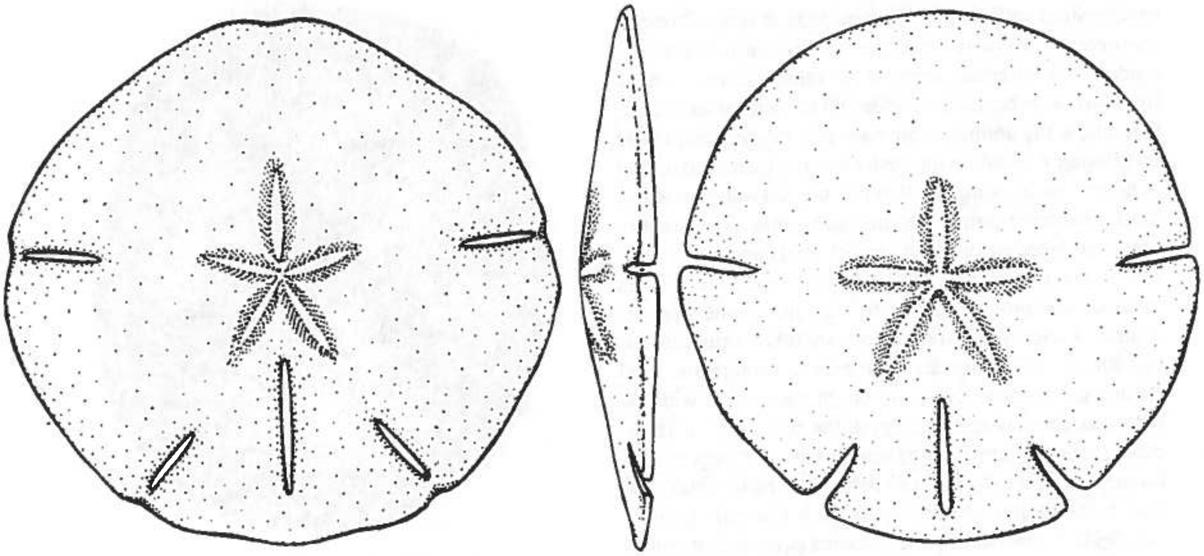


Fig. 26.30 *Mellita longifissa*

FAMILY SPATANGIDAE

Brissus latecarinatus (Leske)

This heart urchin is usually about 40 mm long and 30 mm wide; however, a giant of 166 mm has been reported. It has been listed previously as *Spatangus brissus* and *Brissus carinatus*. The width of the test equals about 77 to 85 percent of the length, and it has a normal, well-defined, star-shaped, petaloid pattern on the oral surface. *Brissus latecarinatus* ranges from the upper Gulf of California to Panama and across most of the Indo-Pacific region. Unlike the other heart urchins, it seems to prefer the intertidal habitat over the subtidal. I have recorded it from Puerto Peñasco to Puerto Libertad. In all cases it was taken in 15–30 cm of sand under large boulders.

Meoma grandis Gray

A brown to violet or nearly black heart urchin with a strong test. One of the largest heart urchins in the Gulf, with its length reaching 150 mm in large individuals and averaging 70 to 80 mm in smaller specimens. The width equals about 90 to 92 percent of the length. This giant heart urchin is found intertidally and subtidally, from the upper Gulf to Ecuador and the Galápagos Islands.

Lovenia cordiformis A. Agassiz

This unique heart urchin is the only species in the Gulf with long aboral spines and a nearly consistent, deep purple color. *Lovenia* is a large urchin, reaching 75 mm in length and 50 mm in width. The test is more oblong than the other heart urchins of the Gulf and has an odd-shaped petaloid pattern. Its color occasionally varies to a gray-brown (rarely), and the dorsal spines are often banded with a variety of colors. This species, like the majority of heart urchins, burrows in the sand or sandy mud of the lowest tide zones and subtidal. *Lovenia* is reported from southern California (and Hawaii) and the upper Gulf to the Galápagos Islands. It is commonly referred to as the "sea porcupine." The extremely long dorsal spines (up to 100 mm long) are said to contain a toxic substance. When disturbed they become erect, forming a defense mechanism to be avoided by barefoot beachcombers. I have recorded this urchin irregularly from Isla Angel de la Guarda, Bahía de los Angeles and Guaymas, south to Isla Espíritu Santo. Figure 26.32.

CLASS HOLOTHUROIDEA

Preservation: Sea cucumbers should always be preserved in alcohol, as formalin tends to erode the calcareous plates of the epidermis, upon which the systematics of this class are based and identification of its members ultimately depend. Inol or glycerine added to the alcohol will often increase its color retention ability. It is difficult to preserve holothurians without rigorous narcotizing techniques, such as relaxing with Epsom salts (magnesium sulfate) over long periods of time. Properly preserved specimens must have the buccal tentacles extended. An alternate method of relaxing, one I have found to be successful in about 80 percent of the cases, is to allow the animal to die naturally in seawater, either by diluting it slowly with freshwater over a period of 5 to 8 hours, or by simply allowing the seawater to stand until it becomes putrid and the animal dies. This usually prevents eversion of the digestive tract, and the animal dies with the buccal tentacles still extended. This method has proven successful for numerous invertebrates, including polychaete annelids, sipunculans, ophiuroids, coelenterates, octopuses, nemerteans, and flatworms. Another trick you might want to try with the sea cucumbers is simply to grab the base of their tentacles when they are fully extended with a strong pair of forceps or pliers (I use large forceps or hemostats), and then hold the animal in formalin for a few minutes until it is dead. Once dead, with tentacles extended, it can be washed and placed in 70 percent alcohol.

Taxonomy: The sea cucumbers differ from all other echinoderms one may encounter in the Gulf in that they have lost their radial symmetry and reverted to the ancestral, bilateral symmetry. They are also soft, the skeleton being reduced to many small, calcareous ossicles embedded in the body wall. The mouth is surrounded by feeding tentacles, and the body has numerous rows of tube feet, sometimes restricted to the ventral surface and sometimes scattered all over the body surface. The systematic scheme used in this handbook follows that of Nichols (1962) and Deichmann (1941, 1958). Two circumstances make the writing of a nontechnical field key to the Holothuroidea difficult. First, the taxonomy of the class is based largely on the ossicles confined to the thick, muscular body wall and other internal structures, and, second, the vast majority of species are variable in color, while greatly resembling one another in general body form. For this reason, only those species of sea cucumbers collected by the author are included in the following key. It is hoped these represent the more common species of the Gulf intertidal region.

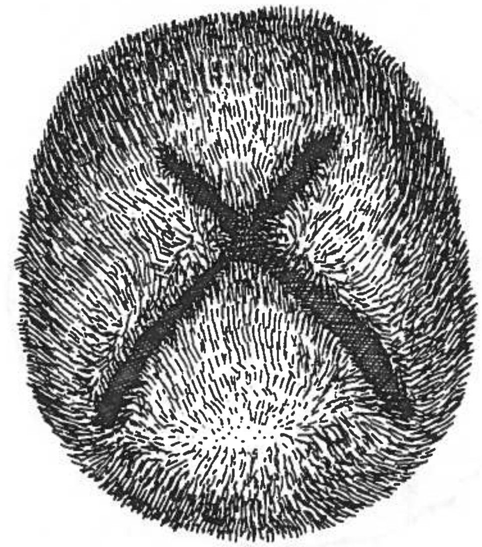


Fig. 26.31 *Agassizia scrobiculata*

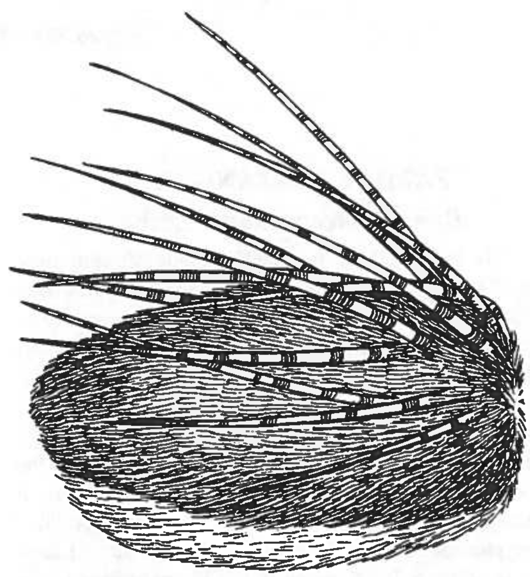


Fig. 26.32 *Lovenia cordiformis*

KEY TO THE COMMON INTERTIDAL HOLOTHURIANS

1 Body length less than 2 cm; dorsal surface covered by imbricating scales; ventral surface modified into a creeping sole .... ***Psolidium dorsipes***

-Body length greater than 3 cm; dorsal surface not covered by imbricating scales; ventral surface may or may not form a flat, creeping sole **2**

2(1) Very large, length 25–100 cm; surface covered with large densely packed papillae, resembling kernels of corn; body brown to gray with white bars; body highly contractile .... ***Euapta godeffroyi***

-Small to medium-sized cucumbers, length under 30 cm; body not as above; color variable but rarely with white bars; body considerably less contractile **3**

3(2) Tube feet absent; small vermiform animals; usually found burrowing in sand **4**

-Tube feet present; large nonvermiform animals; usually found clinging to rocks 5

4(3) 12 buccal tentacles (fig. 26.35) .... ***Chiridota aponocrita***

-10 buccal tentacles .... ***Epitomapta tobagae***

5(3) Surface covered with heavy layer of adhering sand grains; body wall very rigid; with a well-developed ventral sole; body brick red .... ***Holothuria inhabilis***

-Surface not covered with a heavy layer of adhering sand grains; body wall soft to rigid; with or without a well-developed ventral sole; body not brick red in color 6

6(5) Tube feet occur only on ventral surface; ventral surface (sole) strongly flattened; body chocolate-brown to red-orange with large orange-tipped dorsal spines .... ***Isostichopus fuscus***

-Tube feet not restricted to ventral surface; ventral surface not strongly flattened; body not colored as above 7

7(6) Buccal tentacles highly dendritic; buccal tentacles begin branching near base; 10 buccal tentacles 8

-Buccal tentacles rarely dendritic, usually peltate (leaf or shieldlike); buccal tentacles if branched, branch distally only; 15 to 30 buccal tentacles 10

8(7) Body pure white, gray or black; buccal tentacles same length as body .... ***Pseudocnus californicus***

-Body usually lavender to purple (occasionally white); buccal tentacles much shorter than body 9

9(8) Feet restricted to ambulacra (in 5 narrow bands); body reddish-lavender; usually assumes an L-shape or lies straight when clinging to rocks, etc. (fig. 26.36) .... ***Pentamera chierchia***

-Feet not restricted to ambulacra, present in interambulacral regions; body white to purple; usually assumes U-shape when clinging to rocks, etc. .... ***Neothyone gibbosa***

10(7) Dorsal surface primarily dark (black, dark gray, brown, or purple) 11

-Dorsal surface primarily light (white, pale gray, or tan) 12

11(10) Body bottle-shaped with a long "neck"; paired black blotches dorsally; body papillae large, not yellow-tipped (fig. 26.33) .... ***Brandtothuria impatiens***

-Body not bottle-shaped; without paired black, dorsal blotches; body papillae minute and yellow-tipped (fig. 26.34) .... ***Selenkothuria lubrica***

12(10) Body cylindrical, not flattened dorsoventrally; usually with paired black spots dorsally .... ***Brandtothuria arenicola***

-Body noticeably flattened dorsoventrally; usually without paired black spots dorsally .... ***Fossothuria rigida***

Order Aspidochirota

FAMILY STICHOPODIDAE

Isostichopus fuscus (Ludwig)

This is a large, robust sea cucumber, chocolate-brown to orange-brown, with large orange papillae on the dorsal surface. It attains a length of 30 cm. Its body is heavy and rigid, with the skin being smooth and tough to the touch. The ventral surface forms a strongly flattened sole, with three rows of close-set tube feet. The mouth is circular and ventrally located. *Isostichopus fuscus* is found in sheltered areas where the wave shock is not too great, in the low intertidal and subtidal, where its attractive body may be seen slowly moving across the surface of submerged rocks and sand bottoms. This species, and most other holothurians, tend to occur in their greatest numbers where abundant detritus exists, such as near the mouths of estuaries or on broad, algal covered "reefs." The local distribution of sea cucumbers is no doubt strongly affected by patterns of debris accumulation. For some reason this species does not preserve well, and pickled specimens generally do not resemble the living cucumber at all. It ranges from the upper Gulf of California to Ecuador and the Galápagos Islands. It also has been reported as *Stichopus fuscus*.

FAMILY HOLOTHURIIDAE

Brandtothuria arenicola (Semper)

A slender, spindle-shaped sea cucumber attaining a length of 20 cm, although most specimens average 10 to 15 cm in length. The tube feet bear a faint central band of pink and are arranged in five indistinct rows. The body of this cucumber tends to contract strongly when handled, becoming quite hard and stiff. The Cuvierian organs are not sticky. The dorsal surface is slightly papilliform, and the ventral surface is convex, not flattened. This species is white to gray with dark spots, usually in two dorsal rows, that tend to fuse into longitudinal lines (some individuals may be black or red, possibly from pigments in the substrate). It may be found buried under the sand or sandy mud in the rocky mid intertidal zone, from the upper Gulf of California to Ecuador and the Galápagos Islands. *Brandtothuria arenicola* is nearly circumtropical in distribution. It has been reported previously as *Holothuria arenicola* and *H. monsuni*.

Brandtothuria impatiens (Forskal)

This sea cucumber reaches 15 cm in length and is usually distinctly bottle-shaped, with a long "neck." Unlike *B. arenicola* (above), *B. impatiens* tends to become limp and flaccid with handling, and the Cuvierian organs are quite sticky. The tube feet lack the pink band seen on the feet of *B. arenicola* and are on the ends of long mammarylike papillae, randomly spaced or in indistinct rows. *B. impatiens* is mottled gray or brown (occasionally reddish), with paired black blotches posteriorly that merge together anteriorly to form black bands. The surface is rough and sandy to the touch. This cucumber ranges from the upper Gulf of California to Colombia and the Galápagos Islands and is nearly circumtropical. It is commonly found wedged between large rocks, or partly buried in the substrate where rocks are present. It also has been reported as *Fistularia impatiens* and *Holothuria impatiens*. Figure 26.33.

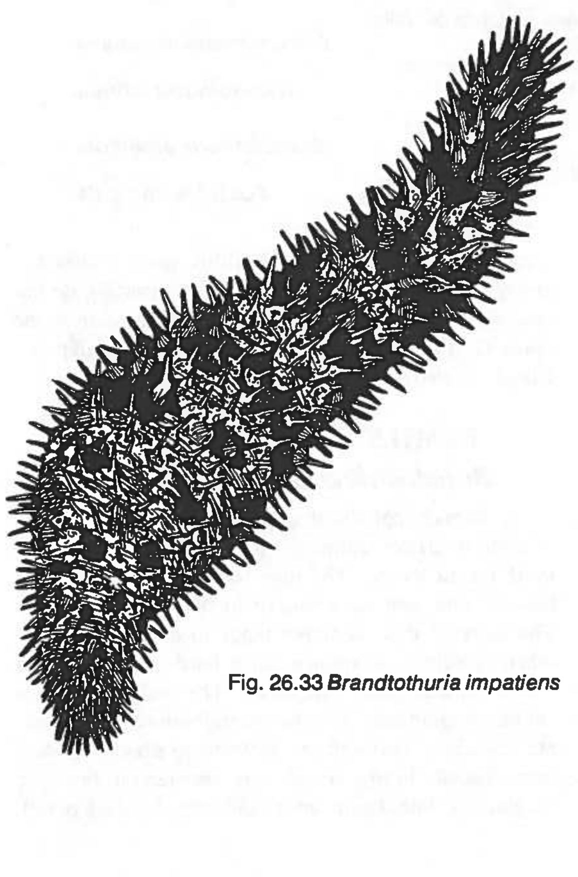


Fig. 26.33 *Brandtothuria impatiens*

Selenkothuria lubrica (Selenka)

One of the most common cucumbers of the Gulf, this species attains a maximum length of about 15 cm, although most individuals average 5 to 12 cm. It is often called the "sulfur cucumber" because the tips of the feet and body papillae are usually a sulfur-yellow color (Mexicans often refer to this, and several other species of holothurians, as "*miones*"). The ground color is slate gray to mottled gray or brown, or a dark purplish-black. The lighter specimens often have two rows of dark, dorsal blotches. The tube feet form a rather indistinct ventral sole. *Selenkothuria lubrica* is found under rocks in the lower mid intertidal zone, where large numbers of individuals are often clustered. The buccal tentacles are often seen protruding from a rock crevice and quickly retract at the least provocation. Crayton (in Hendrickson and Brusca, 1975) studied the numerous variables he thought might be affecting the vertical distribution of this animal. He concluded that its vertical range in the intertidal zone was largely controlled by substrate particle size, exposure time, moisture retention of substrate, and the positioning of the boulder/sediment interface. This very common species has, in the past, carried the names *Holothuria lubricata* and *H. kapiolaniae*. It ranges from the upper Gulf of California to Ecuador and the Galápagos Islands. Figure 26.34.

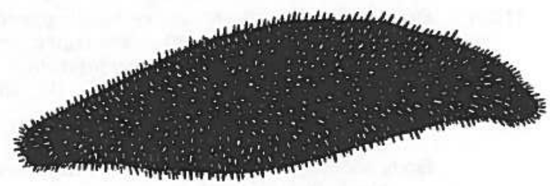


Fig. 26.34 *Selenkothuria lubrica*

Fossothuria rigida (Selenka)

A white to gray species of sea cucumber, usually with two rows of dark blotches on the dorsal surface. This species buries itself just under the surface of the sand in shallow water of the low tide zone and subtidally. The ventral surface is slightly flattened. *Fossothuria rigida* ranges from the upper Gulf of California and the west coast of Baja California to the Galápagos Islands and is also found in Africa and the Red Sea. It has been described also as *Stichopus rigidus*, *Holothuria rigida*, *Cystipus pleuripus*, *Holothuria pleuripus*, *Mulleria aegyptiana*, and *Holothuria aegyptiana*.

Holothuria inhabilis Selenka

A very large, flat, brick-red to red-brown cucumber resembling *Isostichopus fuscus* but with considerably smaller body papillae (or "warts"). The small tube feet are scattered somewhat at random across the surface. The ventral surface is flattened into a definite sole. The mouth is ventral and the anus terminal. There are about 20 buccal tentacles. The body is quite rigid and has a rather characteristic tendency to become encrusted with sand grains. Specimens kept out of water for any length of time tend to "settle," becoming flattened both dorsally and ventrally, and expanded laterally. This holothurian is known from offshore islands in the tropical east Pacific, including Hawaii, Cocos, and Clarion, from depths of 1–25 meters. I have found it with some irregularity on sand and rubble bottoms of Bahía Concepción and Puerto Libertad. The general ecology and toxic qualities of other members of the genus *Holothuria* (and other tropical genera) have been discussed by Bakus (1968, 1973).

Order Apoda
FAMILY CHIRIDOTIDAE
Chiridota aponocrita

This is a small, white to pinkish-red sea cucumber, with many minute papillae. It lacks visible tube feet and is quite vermiform in shape. *Chiridota aponocrita* is found buried in the sand, usually under rocks, in the mid and low intertidal zone. It is common in the northern Gulf, but uncommon south of Bahía Kino. I have recorded the remains of this little cucumber from gut contents of the round stingray *Urolopus halleri*. Figure 26.35.

Epitomapta tabogae Heding

Another small, pale sea cucumber. It is white, about 6 cm long, and somewhat vermiform. Tube feet are lacking, and the buccal tentacles number ten. *Epitomapta tabogae* burrows in the sand in the low intertidal zone throughout the Gulf.

Euapta godeffroyi (Semper)

This is the most unusual holothurian in the Gulf and without a doubt one of the most striking animals occurring in the east Pacific. The body is soft, flexible, and highly extensible. A 30-cm individual, when expanded, will attain lengths approaching 120 cm. These snakelike creatures are usually found undulating across the sea bed in the shallow subtidal region, although storm waves occasionally strand them on beaches where they may be seen limply draped across the rocks, being somewhat helpless out of water. Being an apodus cucumber, it lacks tube feet; however, the body is very rough and sticky to the touch, owing to the protuberant skeletal ossicles in the skin. The surface is covered with several rows of closely packed "papillae" that strongly resemble large kernels of corn. Most of these "papillae" are brown but some are white or pale, giving the appearance of white bars on the animal's surface. The tentacles are pinnate. This engaging creature contracts its body quite dramatically when disturbed, often fragmenting or rupturing the body wall to spill out the viscera. *Euapta godeffroyi* is a widespread Indo-Pacific form, known from throughout the Indian Ocean and east to Hawaii and the Panamic region. I have found it with irregularity throughout the southern Gulf. See Plate 13.

Order Dendrochirota
FAMILY PSOLIDAE
Psolidium dorsipes Ludwig

A very small sea cucumber with a flattened, creeping sole. The length of this species rarely exceeds 1 or 2 cm. The sole is set off by three crowded bands of tube feet. The dorsal surface is covered by imbricating scales, about 10 to 12 from anterior to posterior. The dorsal scales bear several papillae (feet) each. This species is mainly subtidal and ranges from the Gulf of California to Panama. It also has been reported from the Strait of Magellan.

FAMILY CUCUMARIIDAE
Pseudocnus californicus (Semper)

A small, soft, slippery sea cucumber, attaining a maximum length of only about 10 cm. It has ten soft, bushy buccal tentacles, approximately the same length as the body. The feet are large, soft, and completely retractable and are restricted to the five ambulacra. This species is red to gray or black (or occasionally white). It ranges from the upper Gulf and west coast of Baja California to Peru, occurring in the rocky mid and low intertidal. This species was formerly known as *Cucumaria californica* (see Panning, 1962).

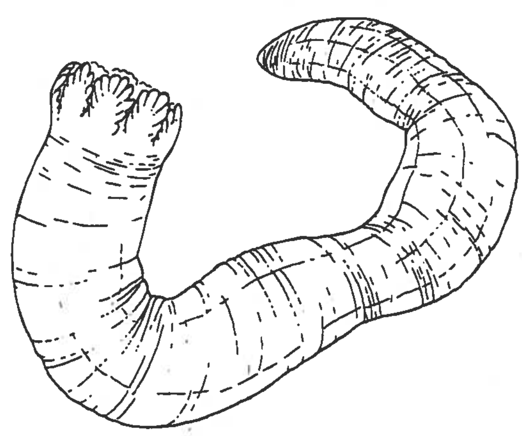


Fig. 26.35 *Chiridota aponocrita*

Pentamera chierchia (Ludwig)

A small sea cucumber, only 3 to 6 cm long. It has numerous tube feet in five narrow bands. It is black or dark brown to reddish-purple and is one of the most common cucumbers of the Panamic region. Individuals of this species often assume an L-shape when attached to the rocks of the mid intertidal zones. *Pentamera* has a tendency to evicerate the gut out the mouth region as opposed to the anus. *Pentamera chierchia* ranges from the upper Gulf of California to Ecuador and the Galápagos Islands. It also has been reported as *Cucumaria chierchia*. Figure 26.36.

Neothyone gibbosa Deichmann

A small to medium-sized cucumber, with a white to purple body. It has long tube feet and a rigid body wall. This species often assumes a U-shape when attached to the rocks of the mid intertidal zones. *Neothyone gibbosa* occurs throughout the Gulf, and also has been reported from Peru. I have found this cucumber in great numbers at Guaymas, Bahía Kino, and Bahía Pulmo.

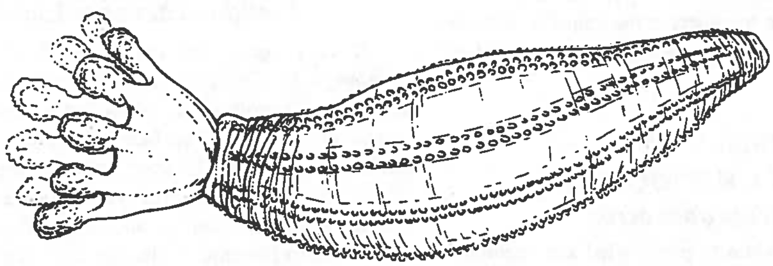


Fig. 26.36 *Pentamera chierchia* (with tentacles distended)

27

HEMICHORDATA (Acorn Worms)

CLASS ENTEROPNEUSTA
(acorn worms)

Preservation: The acorn worms should be carefully narcotized to prevent extreme contraction. Knudsen recommends allowing the worms to fully expand in fresh seawater, then adding alcohol, drop by drop, until a 10 percent solution is attained. The worms are then allowed to set for 4 to 6 hours before preservation in 5 percent formalin or 70 percent alcohol.

Taxonomy: The phylum Hemichordata is generally divided into three classes: Pterobranchiata, Graptolita, and Enteropneusta. The pterobranches are rare, benthic, deep-water marine forms; the graptolites are extinct forms, known mainly from the structure of their tubes; while the enteropneusts (acorn worms) are free-living, wormlike creatures of the marine intertidal and subtidal. The acorn worms do not differ a great deal among themselves, so have not been placed in categories higher than the family level. There are three families: Ptychoderidae, Harrimaniidae, and Spengelidae. The systematics of the enteropneusts are based largely on the internal anatomy and its corresponding external morphology. The systematics used in this handbook are from Hyman (1959).

Enteropneusts of the Gulf: There are at least three species of acorn worms occurring in the Gulf of California intertidal region. Dr. T. H. Bullock reports (personal correspondence) the following: *Ptychodera flava* Eschscholtz, of the family Ptychoderidae, collected by E. F. Ricketts at Espíritu Santo Island in 1940; *Saccoglossus "sonorensis"* Rao, Ritter and Bullock (M. S.) of the family Harrimaniidae, from Bahía Cholla; and *Balanoglossus "sonorensis"* Rao, Ritter and Bullock (M. S.), of the family Harrimaniidae, taken by Steve Glassell in 1935 at Bahía Cholla, by Ricketts in 1940 on the west side of the Gulf south of Santa Rosalía, and in Sonora (Estero de la Luna), and by Dr. Bullock in 1949 at Bahía Cholla. *Ptychodera flava* is a well-known species from the Indo-Pacific region and throughout the tropics. The species of *Saccoglossus* and *Balanoglossus* are both new and are being described at this writing by Bullock *et al.* (see reference section).

Saccoglossus (see fig. 27.1) can be differentiated from *Ptychodera* and *Balanoglossus* by the length of the proboscis, which is very long in *Saccoglossus*, more than six times longer than wide and two to three times the length of the collar, which is the ring-shaped region immediately behind the proboscis. There are, however, no obvious and reliable external characters with which to differentiate *Ptychodera* and *Balanoglossus*. Dr. Bullock has informed me that the following characteristics are *usually* reliable: *Balanoglossus* is most likely to be in mud and to show spiral castings (like those of *Saccoglossus*, only larger), while *Ptychodera* seems to prefer a coarse sand, frequently made up of fragmented coral; *Ptychodera* rarely burrows to a depth greater than 7–13 cm, whereas *Balanoglossus* is frequently found at depths of 15–25 cm (because of its habit of burrowing at these depths, *Balanoglossus* is frequently recovered only in fragments); *Ptychodera* is commonly 10 cm or less in length, whereas *Balanoglossus* is frequently several times that length.

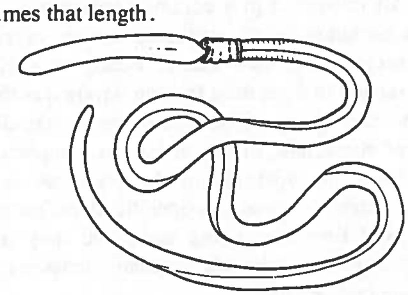


Fig. 27.1 *Saccoglossus* sp.

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CHORDATA: SUBPHYLUM UROCHORDATA
CLASS ASCIDIACEA (Ascidians)

Preservation: For general preservation, where expanded individuals are not required, 5 percent formalin or 70 percent alcohol are good preservatives. If the specimens are going to be kept for any length of time, alcohol is preferable, even though it will bleach the color from the animal. For purposes of laboratory study and specific identifications, individuals with fully expanded siphons are desirable, requiring slow relaxation prior to preservation. Relaxing can be done with magnesium sulfate or chloral hydrate. Bianco (1899) recommended adding small quantities of chromacetic fixative to the container of seawater holding the expanded specimens. This diffuses into the water, killing the animals slowly over a period of several hours.

Taxonomy: The subphylum Urochordata is divided into three classes: Larvacea, Thaliacea, and Ascidiacea. The first two classes are pelagic, free-living marine forms, while the ascidians are sedentary benthic forms. The intertidal ascidians may be loosely grouped into two categories, solitary and compound. The solitary (or simple) ascidians develop only from eggs and do not bud. Solitary ascidians are usually saclike animals, often transparent or translucent, with two large siphons. Compound (or colonial) ascidians can reproduce by budding, to form aggregations of a few to many individuals, all imbedded in a common gelatinous matrix. Colonial ascidians often appear as a mass of colored jelly with clusters of individuals, usually of a different color, arranged in a petaloid fashion throughout the matrix. The taxonomy of the ascidians is based on a number of characters, of which the most important are growth form and anatomy of the branchial sac, alimentary system, and gonads. Specific identification is a difficult and time-consuming task, and may require examination of the endostyle, branchial tentacles, folds of the branchial sac, etc.

There is some general disagreement on the taxonomic arrangement of the higher taxa of ascidians. Various schemes of classification have been suggested, based on different aspects of the animal's anatomy. Borradaile and Potts (1961) discuss three principal classifications, those of Lahille, Seeliger, and Berrill. However, the classification of this group at the generic level is claimed by Van Name (1945) to be quite stable, and he states, "More than 90 percent of the known ascidiants fit perfectly into a comparatively small number of genera ... that are selfevidently natural groups ..." This puts the tunicates in a comfortably workable category, which may be due in part to the fact that no fossil ascidians are known, thus placing the burden of natural phylogenies on the 2,000 or so extant forms.

Ascidians of the Gulf: Specific determination of ascidians requires rather exacting microscopic dissections and is rarely attempted by anyone other than a specialist. In addition, the ascidians tend to exhibit a great deal of variability in growth form and color, while different species with similar growth patterns often look very much alike. For these reasons no key has yet been attempted for this group. The species list below represents only specimens collected by the author. These certainly represent only a fraction of the total Gulf intertidal ascidian fauna but should, on the other hand, include many of the most commonly encountered forms in the Gulf. Identifications were made by Donald P. Abbott, and many of the following comments are derived from personal correspondence with him. For those students interested in the pelagic classes of Urochordata (the larvaceans and thaliaceans), as well as other "gelatinous" plankters, the publications of Hamner and of Alldredge will be of special interest (see bibliography).

CLASS ASCIDIACEA
Order Enterogona
Suborder Aplousobranchia
FAMILY POLYCLINIDAE
Aplidium Savigny

This common and widespread genus is often still referred to as *Amaroucium*, a name no longer valid. All species of *Aplidium* have the zooids divided into a thorax, abdomen, and postabdomen. The atrial aperture bears one to several small processes, or languets. The stomach has a series of longitudinal folds on the wall. There are at least three species of this genus common to the Gulf intertidal. "Species A" forms a massive, fleshy colony, with the zooids bearing 15 to 18 rows of stigmata, and the stomach wall thrown into ten weakly developed folds. This species resembles the typical "sea-pork" so often found washed ashore, or dragged up from the bottom in shrimp nets. The color is usually pale to vivid orange. "Species B" consists of a compact cluster of slender lobes, each lobe completely encrusted with sand. The lobes are joined only basally, but they arise close to one another. They are of approximately the same length, so that the whole cluster forms a very compact mass, at first resembling a zoanthid anemone colony. The zooids have 10 to 11 rows of stigmata and only 5 to 7 folds on the stomach wall. This may be *A. pellucidum* (Leidy). "Species C" is a massive, fleshy colony, resembling "sea-pork," with the zooids bearing 9 to 10 rows of stigmata, and the stomach folded into 20 to 25 regular and marked folds. See Plate 10.

Synoicum Phipps

A species of this genus found commonly on tidal flats consists of a cluster of globular lobes, 1 to 3 cm or more in diameter. The zooids have the body divided into thorax, abdomen, and postabdomen (as in *Aplidium*). The postabdomen is long and broadly attached to the posterior end of the abdomen. The stomach wall is smooth.

Polyclinum Savigny

Polyclinum laxum Van Name is a common inhabitant of the Puerto Peñasco region. It generally forms a smooth, raised colony, dark brown to black, with yellow to white individuals arranged in oval or circular groups. The colonies grow to 5–10 cm across, and are more or less hemispherical, or rounded and depressed. A slice taken across the colony will reveal the zooids are all near the outer surface, and that most of the colony is a more or less transparent, stiff, jellylike tunic. The zooids have their body divided into a thorax, abdomen, and postabdomen. The thorax is the largest of the three divisions. The postabdomen is quite short and joined to the abdomen by only a narrow neck. Steinbeck and Ricketts reported this species (as *Polyclinum* sp., page 565) from Isla Espíritu Santo and El Mogote. They described it as small, circular, brown colonies and reported a description given them by Van Name in a personal communication as, "Forms large rounded colonies of soft consistency, not raised on a pedicel."

FAMILY DIDEMNIDAE
Diplosoma MacDonald

A species of ascidian, probably in this genus, is common on the rocks of the Puerto Peñasco region. It is a solid black, encrusting form. Dr. Abbott informs us that this species is related to *Didemnum* and its allies, but lacks spicules.

FAMILY POLYCITORIDAE
Archidistoma Garstang

This genus was formerly called *Eudistoma*, but the latter genus was recently largely placed in the genus *Archidistoma*. *Archidistoma pachecae* (Van Name) is a common encrusting tunicate found throughout the Gulf. It is most easily recognized by the more or less colorless tunic that bears dark lavender, purple, or almost black zooids. The zooids are sometimes arranged geometrically, other times irregularly. Steinbeck and Ricketts described this species (as *Eudistoma* sp., page 567), as a soft, fleshy encrustation, dark brown or purplish in preservation. They collected it at Isla Espíritu Santo, Punta Marcial, Puerto Escondido, Bahía Concepción, Bahía de los Angeles, Puerto Refugio, and the south end of Isla Tiburón.

Suborder Phlebobranchia
FAMILY ASCIDIIDAE
Ascidia Linnaeus

Members of this genus are mostly solitary tunicates, found attached to the undersides of rocks. *Ascidia interrupta* Heller is a common species found throughout the Gulf. It has a transparent body with orange-tipped siphons. Dr. Abbott informs me that he has been calling this west coast form *A. interrupta*, although there are a few minor differences from the Caribbean form. He considers these differences too trivial and undependable to substantiate specific separation of the two forms at this time. I have found this species to be common in the rocky intertidal, at least as far south as Guaymas and La Paz.

FAMILY DIAZONIDAE
Rhopalaea Philippi

A lovely solitary ascidian of this genus has been found with some regularity throughout the southern Gulf, especially on the offshore islands. It is somewhat translucent, pale rose to bright purple in color and attaches to large rock surfaces in depths of 5–45 m. *Rhopalaea* sp. is about 30–70 mm in length. This is probably just one of several undescribed species, in this genus, in the tropical east Pacific.

Order Pleurogona
Suborder Stolidobranchia
Pyura Molina

The solitary ascidian *Pyura lignosa* is fairly widespread along the eastern tropical Pacific shoreline, in shallow water. I have recorded it irregularly in the central and southern Gulf, from Bahía Concepción and the Cape region, around to Bahía Magdalena and Bahía Tortola on the lower west coast of Baja. The test is usually tough, hard, leathery, and wrinkled. It reaches several centimeters in the greatest diameter and is tan to orange-brown in color. The surface usually has a tesselated or "tiled" appearance.

In addition to the above genera, Dr. P. Pickens (1970) reported the following from the Puerto Peñasco region (identified by Dr. Abbott): *Cystodytes*, *Botryllus*, *Symplegma*, and *Styela*. Steinbeck and Ricketts reported the following species: *Amaroucium californicum* Ritter and Forsyth (= *Aplidium californicum*) from Bajío Plumo, Isla Espíritu Santo, La Paz area, Bahía de los Angeles, Puerto Refugio (Isla Angel de la Guarda) and Isla Tiburón; *Didemnum carnulentum* Ritter and Forsyth, from Cabo San Lucas, La Paz, Islas Coronado, Bahía Concepción, Bahía de los Angeles, Bahía San Francisquito, and Puerto Refugio; *Trididemnum opacum* (Ritter), from Cabo San Lucas; *Cystodytes dellechiajei* (Della Valle) from Isla Espíritu Santo, Puerto Escondido, Bahía Concepción, Bahía de los Angeles, Puerto Refugio, and Isla Tiburón; *Clavelinia* sp. from La Paz; *Botrylloides diegensis* Ritter and Forsyth from La Paz, Isla Espíritu Santo and Bahía San Francisquito; and *Pyura* sp., a solitary tunicate, from Isla Espíritu Santo, Islas Coronado, and Puerto Escondido.

Supplementary Material

APPENDIXES

A. Approximate Latitudes of Selected Localities in the Gulf

Puerto Peñasco	31°19′N
San Felipe	31°02′N
Desemboque (norte)	30°33′N
Puertecitos	30°21′N
Puerto Lobos (Bahía Tepoca)	30°17′N
Puerto Libertad	29°55′N
Bahía San Luis Gonzaga	29°47′N
Isla Angel de la Guarda (Puerto Refugio)	29°34′N
Desemboque (sur)	29°30′N
Bahía de los Angeles	28°57′N
Bahía Kino	28°50′N
Isla San Lorenzo Sur	28°38′N
Guaymas	27°56′N
Santa Rosalía	27°19′N
Bahía Concepción (and Mulege)	26°54′N
Topolobampo	25°36′N
Boca del Río	25°19′N
Isla las Animas	25°04′N
La Paz	24°08′N
Mazatlán	23°14′N
Cabo San Lucas	22°49′N

B. Principal Mexican Centers of Teaching and Research in the Marine Sciences

UNIVERSITIES

1. Institute of Oceanological Investigations (IIO), School of Marine Sciences, Ensenada, Baja California Norte.
2. Center of Scientific and Technological Investigations (CICTUS), University of Sonora, Hermosillo, Sonora.
3. School of Marine Ecology, University of Guerrero, Acapulco, Guerrero.
4. School of Marine Biology, University of Sinaloa, Mazatlán, Sinaloa.
5. School of Fisheries Engineering, University of Nayarit, Tepec, Nayarit.
6. School of Biological Sciences, National Polytechnic Institute, México D.F.
7. Institute of Geophysics; Institute of Biology; Institute of Geology; and, Institute of Geography, National University of Mexico, México D.F. (UNAM)
8. Technological Institute of Higher Studies at Monterrey (ITEMS), Escuela de Ciencias Marítimas y Tecnología de Alimentos, Guaymas, Sonora.

GOVERNMENTAL AGENCIES

1. Center of Scientific Investigations and Higher Education for Baja California (CONAC y T, UABC-UNAM), National Council of Science and Technology.
2. National Institute of Fisheries, under the secretary of Industry and Commerce.
3. Directorate of Aquaculture and General Directorate of Uses of Water and Prevention of Contamination, under the Secretary of Hydraulic Resources.
4. General Directorate of Maritime Works and General Directorate of Oceanography and Maritime Aids to Navigation, under the Secretary of the Navy.

C. Wind Scales and Sea Descriptions

(An aid to students, scientists and divers working in the field, who are faced with the necessity of describing the sea state in their field notebooks or journals.)

Beaufort Scale	Seaman's Description of Wind	Wind Velocity Knots	Estimating Wind Velocities On Sea	Int'l Scale Sea Description and Wave Heights	Int'l Code for State of Sea
0	Calm	Less than 1 knot	Calm; sea like a mirror; smoke rises vertically.	Calm, Glassy 0	0
1	Light air	1 to 3 knots	Light air-ripples, no foam crests; smoke gives indication of movement.	Same	
2	Light breeze	4 to 6 knots	Light breeze; small wavelets, crests have glassy appearance and do not break; wind felt on face.	Rippled 0 to 1 foot	1
3	Gentle breeze	7 to 10 knots	Gentle breeze; large wavelets, crests begin to break; scattered whitecaps; flags extended.	Smooth 1 to 2 feet	2
4	Moderate breeze	11 to 16 knots	Moderate breeze; small waves becoming longer. Frequent whitecaps.	Slight 2 to 4 feet	3
5	Fresh breeze	17 to 21 knots	Fresh breeze; moderate waves taking a more pronounced long form; mainly whitecaps, some spray; small trees begin to sway.	Moderate 4 to 8 feet	4
6	Strong breeze	22 to 27 knots	Strong breeze; large waves begin to form extensive whitecaps everywhere, some spray; large branches in motion.	Rough 8 to 13 feet	5
7	High wind Moderate gale	28 to 33 knots	Moderate gale; sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; whole trees in motion.	Very rough 13 to 20 feet	6
8	Gale Fresh wind	34 to 40 knots	Fresh gale; moderately high waves of greater length; edges of crests break into spindrift: foam is blown in well-marked streaks in direction of wind; twigs break off trees.	Very rough 12 to 20 feet	6
9	Strong gale	41 to 47 knots	Strong gale; high waves, dense streaks of foam in direction of wind; spray may affect visibility; sea begins to roll; slight structural damage to buildings may occur.	Very rough 13 to 20 feet	6
10	Whole gale	48 to 55 knots	Whole gale; very high waves; surface of sea takes on white appearance; rolling of sea becomes heavy and shock-like; visibility affected; widespread damage to trees and buildings.	High 20 to 30 feet	7
11	Storm	56 to 63 knots	Storm; exceptionally high waves; small and medium sized ships are lost to view long periods.	Very high 30 to 45 feet	8
12	Hurricane	64 and Above	Hurricane; air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected.	Phenomenal over 45 feet	9

D. Metric Conversions

ABBREVIATIONS

centimeter(s),	cm.
fluid ounce(s),	fl. oz.
foot (feet),	ft.
gram(s),	g.
inch(es),	in.
kilogram(s),	kg.
liter(s),	l.
meter(s),	m.
milliliter(s),	ml.
millimeter(s),	mm.
ounce(s),	oz.
pound,	lb.
quart(s),	qt.

VOLUME

1 ml.	= 0.034 fl. oz.			
1 fl. oz.	= 29.6 ml.			
1 qt.	= 946.0 ml.	= 32.0 fl. oz.	= 0.946 l.	
1 l.	= 1000.0 ml.	= 33.8 fl. oz.		

WEIGHT

1 g. = 0.032 oz.
1 oz. = 31.1 g.
1 lb. = 0.454 kg. = 454 g.
1 kg. = 2.2 lb. = 1000 g. = 32.15 oz.

LENGTH

1 mm.	= 0.10 cm.	= 0.039 in.	= 0.0032 ft.
1 cm.	= 10.0 mm.	= 0.394 in.	= 0.0328 ft.
1 in.	= 25.4 mm.	= 2.54 cm.	= 0.0833 ft.
1 m.	= 1000.0 mm.	= 39.37 in.	= 3.281 ft.

E. Centigrade-Fahrenheit Conversions

$°F = 1.8(°C) + 32$

$°C = \frac{F° - 32}{1.8}$

GLOSSARY

NOTE: Definition of highly specific terms used in the keys or species descriptions, but not included in the glossary, may be found in the introductory section of their respective chapters.

—A—

Aboral. The region or end of an animal's body opposite its mouth.

Acontia. Coelenterates: internal, threadlike processes constituting a continuation of the middle lobe of a free-edged mesentery. The acontia are sites of enzyme production and intracellular digestion and absorption. They also may bear nematocysts.

Ala. A winglike projection or structure.

Allopatric. Referring to the geographical relationship of different populations of animals or plants, usually of two different species or subspecies, wherein the populations do not occur together; having different areas of distribution.

Ambulacral groove. Asteroids: a furrow along the oral surface of each ray of a sea star, sheltering the tube feet.

Ambulatory. Used for walking.

Amorphous. Shapeless, or lacking symmetry.

Anastomose. To branch and intertwine; interconnecting branches.

Andesite. A fine-grained volcanic rock composed largely of plagioclase feldspar.

Annulate. Composed of rings or ringlike structures.

Anterior. At or near the head or front of the body.

Anterolateral. The region where the front and sides join; as, on a crab, the angular or rounded meeting of the front and side of the carapace (=anterio-lateral).

Antipentultimate. The third segment (or article) from the distal end of the object in question; the segment (or article) just before (proximal to) the pentultimate segment (or article).

Article. The "joints" or "segments" of an arthropod appendage. (Note that these articles are often referred to as segments, thus confusing these exoskeletal regions of appendages with the true body segments or somites.)

Asconoid. Sponges: the simplest and probably most primitive body plan, wherein the external ostia of the sponge body open directly into the spongocoel and little or no folding of the body wall has taken place.

Asymmetrical. Having no symmetry.

Athecate. Hydrozoa: when the hydranth or gastrozooid is *not* encased in a chitinous outer covering (the perisarc); gymnoblastic hydroids are athecate.

Autotomy. The process whereby an animal can "voluntarily" break off certain appendages, or break its body apart at certain locations; self-amputation.

—B—

Basal. Located at or near the base of a structure.

Basalt. A dark, dense, igneous rock.

Berm. An accumulation of sand and other material found a little way above the high water mark on sand beaches.

Bifid. Forked; divided into two parts by a median cleft (=bifurcate).

Bilamellar. Consisting of two lamina or thin plates.

Biogeography. The science that deals with the geographical distribution of organisms.

Bioluminescence. The production of light by living organisms.

Biota. The animal and plant life of a region.

Biradial symmetry. The type of symmetry in which the body consists of radially arranged parts, half of which lie on each side of a median longitudinal plane.

Biramous. Consisting of or divided into two branches.

Biungulate. Having the unguis forked into two parts.

Blastostyle. Cnidaria: a modified zooid (gonozooid) from which the medusoids are budded; may or may not be protected by a surrounding theca.
Bouin's solution. A preservative/fixative made of 75 parts picric acid, 20 parts formalin, and five parts acetic acid.
Branchial. Of or pertaining to the gills.
Buccal. Of or pertaining to the mouth.

—C—

Calcareous. Composed of or containing large amounts of calcium carbonate ($CaCO_3$).
Calyptoblastea. Cnidaria: the suborder of thecate hydroids having each hydranth protected by a cuplike hydrotheca.
Campanulate. Bell-shaped.
Cancellate. Radiating ribs and concentric ridges intersecting at right angles.
Capitate tentacle. Cnidaria: short tentacles with a terminal knob, which is usually studded with nematocysts.
Carapace. Crustacea: the exoskeletal, dorsolateral shield covering the cephalothorax of some crustaceans.
Carina. A keellike ridge or prominence.
Carnivorous. Flesh-eating (as opposed to plant eating); preying or feeding upon animals.
Caudal. Referring to the tail or posterior region of an animal.
Caudal rami. Crustacea: projecting caudal appendages, generally of two branches (two rami), seen in some crustacean groups. The caudal rami actually represent the uropods of the terminal body somite.
Cephalic. Of or pertaining to the head or head region.
Cephalon. Head.
Cephalothorax. A body region combining the head and all or part of the thorax as one.
Cerrata. Fingerlike projections on the dorsum of sea slugs (used for respiration).
Chelae. Crustacea: in strict sense, the arrangement of certain thoracic appendages, which are modified to form a pincer; in common usage, the term has come to mean the "hand region" or terminal part of the cheliped. (Sing., chela)
Chelate. Bearing chelae.
Chelicera. The first pair of appendages of arachnids.
Cheliped. Crustacea: the entire first thoracic leg of an arthropod (especially Crustacea) that is modified to form a pincer. (Pl., chelipeds)
Chloretone. A chemical used as a relaxing agent for invertebrates (made by the Parke-Davis drug firm). Available at drug stores.
Circumtropical. Referring to a geographical distribution spread around the globe in the tropical regions.
Cirrus. A small, slender, and usually flexible appendage, generally threadlike. (Pl., cirri)
Clavate. Club-shaped, gradually thickened near one end.
Clove oil. A chemical used as a relaxing agent for invertebrates and vertebrates. Available at drug stores and supply houses.
Commensal. Members of two different species living in close association, with little or no mutual influence, or with one member significantly benefiting (but not at the expense of the other).
Convection current. A current within a fluid created by differences in temperature between various layers, causing differences in density.
Cortex. An outer layer or outer region.
Cosmopolitan. Of worldwide distribution.
Crenulate. With a wavy or regularly notched edge.

—D—

Dactyl. Terminal or distal article of a crustacean leg or maxilliped. The movable finger of a cheliped is the dactyl.
Dactylozooid. Cnidaria: the long nematocyst-bearing tentacles of some hydrozoans, such as the Portuguese Man-of-War, *Physalia* sp. The dactylozooid is a specific type of polyp used for defense and food capture. Hyman in 1940 described it as being derived from the gastrozooid (feeding zooid) by reduction or loss of mouth, tentacles, and gastric cavity. (=machozooid or protective polyp)
Demersal. Living on or very near the seafloor.
Denticulate. With teeth or small pointed projections. (dentate)
Depauperate. Impoverished; poorly developed.
Depressed. Flattened.
Diabase. A dark igneous rock occurring as intrusive formations.
Dichotomous. Dividing into two equivalent or similar branches, or progressively dividing in such a manner.
Digitiform. Shaped like a finger.
Dimorphism. The existence of two forms among individuals of a species.
Discoidal. Disklike.
Distal. Away from, especially from the place of attachment of an appendage, or an entire animal.
Diurnal. Pertaining to the day; occurring daily; active during the day.
Dorsal. Referring to the back or back side.

—E—

Ebb tide. The outgoing tidal flow; the retreating tide.
Ecdysis. The act of molting or shedding an exoskeleton. (= exuviation)
Ecomorph. An ecotype bearing recognizable morphological distinctness.
Ecotype. A subgroup within a species having a wide geographical distribution, which has developed specific and recognizable adaptations to local conditions (such as substrate, moisture, light, temperature, etc.).
Encrusting. Forming a crustlike layer on another object.
Endemic. Something that is constantly present in, and restricted to, a specific locality.

Endocoel. Cnidaria: referring to the paired septa of sea anemones and corals, the space between the members of a pair being the endocoel.
Endoecism. A symbiotic association in which one symbiont lives in the tube or burrow of the other symbiont. (*See* Inquilinism.)
Endopod. Inside lateral ramus of a biramous appendage.
Entire. A smooth region or margin, without interruption along the edge.
Epidermis. The outermost layer of cells of a plant or animal. In most invertebrates the epidermis is one cell layer thick.
Epiphyte. A symbiotic association in which one plant lives on another.
Epiphytozoon. A symbiotic association in which a plant lives on an animal.
Epizoon. A symbiotic association in which one animal lives on another.
Epizoophyte. A symbiotic association in which an animal lives on a plant.
Epsom Salts. A crude compound of magnesium sulfate. May be used for narcotizing and relaxing various invertebrates; $MgSO_4 \cdot 7H_2O$.
Euryhaline. Able to tolerate wide fluctuations in salinity, or osmotic pressures in general.
Eurythermic. Able to tolerate wide fluctuations in temperatures.
Eversible. Capable of turning inside out, or everting.
Exocoel. Cnidaria: referring to the region of paired septa of sea anemones and corals, the space between the pairs of septa being the exocoel.
Exopod. Outside lateral ramus of a biramous appendage.
Exoskeleton. Any invertebrate skeleton existing as the outermost covering of the body; principally in arthropods.
Extirpation. Eradication of a species from a given area.
Exuvia. The cast-off exoskeleton of an arthropod; cast-off material from the surface of an organism (skin, scales, hair, etc.). (Pl., exuviae)

—F—

FAA. Formal-Acetic-Alcohol; 10 parts commercial formaldehyde, 50 parts alcohol, 2 parts acetic acid, and 38 parts water.
Falcate. Curved or shaped like a sickle.
Falciform. = falcate.
Fasciate. Bound or compressed into a bundle.
Fathom. A unit of length equal to 6 feet (= 1.83 m); generally used in measuring depth of a body of water.
Fenestra. A small opening or transparent spot.
Fenestrated. Possessing fenestra.
Fibrous. Consisting principally of fibers or fibrous structures.
Filiform. Filamentous or threadlike.
Filose. Terminating in a threadlike structure.
Filum. A threadlike structure.
Fimbria. A fringe or fringelike border.
Fimbriate. Having a fimbria.
Fistular. Cylindrical; elongated and hollow.
Flabellate. Shaped like a fan; fanlike.
Flaccid. Soft; limp; flabby.
Flood tide. The incoming tidal flow; the rising tide.
Fluted. Bearing alternating ridges and grooves.
Foliose. Leafy or leafy appearing. (= foliaceous)
Formaldehyde. A colorless, water-soluble, toxic gas (HCHO) derived by the oxidation of methyl alcohol. U.S.P. formaldehyde solution is 30 to 40 percent dissolved gas in water, or 38 to 40 percent saturation.
Formalin. An aqueous solution of 38 to 40 percent formaldehyde. (= commercial formaldehyde)
Fossa. A depression, pit or concavity, especially on the surface of something.
Furcula. A forked or fork-shaped structure.
Fusiform. Spindle-shaped.

—G—

Gape. A wide opening, as that between (a) the opened jaws of a vertebrate; (b) the two valves of a clam; (c) the plates of a barnacle.
Gastrozooid. Cnidaria: a nutritive polyp. (= hydranth)
Geniculate. Bent sharply.
Globose. Spherical or globular.
Gnathopod. A prehensile maxilliped; also used for the first two prehensile pereopods of amphipods (whether chelate or subchelate).
Gonangium. Cnidaria: term applied to the reproductive polyp, consisting of the gonotheca together with its enclosed blastostyle and gonophores.
Gonopod. A name given to certain appendages in arthropods that are modified to function as copulatory structures.
Gonotheca. Cnidaria: the vaselike case of periderm that surrounds the gonophores and blastostyles, the whole reproductive polyp being termed the gonangium.
Gonozooids. Cnidaria: modified polyps that bud off medusoids or their morphological equivalents, especially on hydroid colonies.
Gravid. With eggs.
Guttate. Shaped like a drop; with droplike markings.
Gymnoblastea. Cnidaria: the suborder of athecate hydroids. The polyps lack the skeletal cups of other hydroids into which the soft parts can be withdrawn.

—H—

Halophyte. A plant which grows where salt concentration is high, as in salt marshes or on alkaline soils.
Handbook. In taxonomy, a publication designed primarily as an aid to field and laboratory identification, as opposed to the presentation of new taxonomic conclusions (Mayr, 1969, *Principles of Systematic Zoology*).
Herbivorous. Feeding entirely (or nearly so) on plants or plant material; = phytophagous.
Hexagonal. Having six angles and six sides.

Holotype. The single specimen designated or indicated as "the type" by the original author at the time of the publication of the original species description.

Horny. Composed of chitinous or corneous material.

Hyaline. Glassy; transparent or translucent.

Hydrotheca. Cnidaria: the vaselike case of periderm (perisarc) that surrounds the feeding polyp of a hydroid, the entire feeding zooid being the hydranth or gastrozooid.

—I—

Igneous rock. Rock that has crystallized from a high-temperature molten silicate (or rarely carbonate) liquid or magma.

Imbricated. Overlapping in a regular order, like shingles.

Infraspecific. Within the species; as, infraspecific variation.

Inquilinism. A symbiotic association in which one symbiont lives in close association with the other, generally in the tube or burrow or actually within a body chamber of the host.

Introvert. A closed tubular pocket capable of being unrolled and extended inside out.

—J—

Junior synonym. The later published (or otherwise invalid) of two or more available names for the same taxon.

—K—

KAAD. A fixing chemical used to rapidly penetrate soft-bodied invertebrates: 10 parts alcohol; 2 parts glacial acetic acid; 1 part kerosene; 1 part dioxan; 86 parts water.

Key. A tabulation of diagnostic characters for specific animals or animal groups (or plants) facilitating rapid identification.

Key character. In taxonomy, a character of special utility in a key or diagnosis of an animal (or plant).

Knot. A unit of speed, being one nautical mile per hour (.515 m/sec.).

—L—

Lamella. A thin, flat plate or scale. (Pl., lamellae)

Lamellar. Bearing lamellae.

Lamellate. Consisting of any number of lamellae, in any type of arrangement.

Lanceolate. Lance-shaped and usually elongate.

Lateral. Referring to the side of an animal (or plant).

Leuconoid. Sponges: the most complex and probably most advanced body plan, wherein the sponge wall, the incurrent canals, and the radial canals have all undergone folding, giving the sponge a complex, asymmetrical body. The spongocoel has been reduced in these forms to numerous small water channels, and there are usually several to many oscula.

Limestone. Any rock composed of carbonate materials, principally calcium carbonate.

Littoral zone. The region of a coastline between the highest of the high tides (HHHW) and the lowest of the low tides (LLLW). (= intertidal zone)

Local population. Individuals in a population of a given, specific locality which potentially form a single interbreeding community.

Lunule. Crescent-shaped, or approximating a crescent shape. In sand dollars, the elongate oval holes in the test or body. In clams, the heart-shaped depression anterior to the umbo.

—M—

Macula. A spot or mark. (Pl., maculae)

Madreporite. Echinoderms: The button-shaped structure on the aboral surface of certain echinoderms that serves as the external connection of the water-vascular system.

Magnesium sulfate. A chemical often used for relaxing invertebrates prior to preservation; $MgSO_4$; available in drug stores.

Mantle. A fold of the body wall (that secretes the shell) in molluscs.

Manus. Hand.

Marginal. Peripheral or along the edge or side.

Marsupium. A pouch or cavity in which young develop, as in the brood pouch of a peracarid crustacean or a sea horse.

Median. Situated in or toward the plane which divides a bilaterally symmetrical organism or organ into right and left halves; centrally located.

Medusoid. Cnidaria: referring to an animal having the medusa form, which is bell- or umbrella-shaped, like the jellyfish.

Megascleres. Sponges: the larger spicule types, comprising the major structural elements of most sponge skeletons.

Menthol. A chemical often used to relax or narcotize invertebrates; a colorless, crystalline, slightly water-soluble alcohol obtained from peppermint oil or synthesized; $CH_3C_6H_9(C_3H_7)OH$; available in drug stores.

Merus. The fourth leg article of a decapod crustacean.

Micrometer. One thousandth of a millimeter (= γ).

Microscleres. Sponges; the smaller spicules of a sponge skeleton.

Mixed tide. Any tidal cycle that is not clearly of either the diurnal or the semidiurnal type.

Monaxon spicule. Sponges: Spicules formed by growth in one or both directions along a *single* axis, which may be straight or curved; an unbranched spicule.

Monograph. In taxonomy, an exhaustive treatment of a higher taxon in terms of all available information pertinent to the group.

Mutualism. A symbiotic relationship wherein both partners receive a definite benefit.

—N—

Narcotize. To subject an animal to a narcotizing agent, which is a chemical that induces torpor or relaxation of the individual.

Neotype. A specimen selected as the type subsequent to the original description in cases where the original types are known to have been destroyed or suppressed by the International Commission on Zoological Nomenclature.

Niche. The precise group of environmental factors into which a species fits, or which is required by a species.

Nicotine. A chemical that may be used as a narcotizing agent for invertebrates; a colorless, oily, water-soluble, highly toxic liquid alkaloid, $C_{10}H_{14}N_2$.

Nomenclator. A book containing a list of scientific names assembled for nomenclatural, rather than taxonomic, purposes.

Nomenclature. A system of names.

Nomen dubium. A name for which available evidence is insufficient to permit recognition of the species to which it was applied; thus, a questionable name.

Nominate. The type subdivision of a higher category; bearing a name derived from another, higher category, and in so doing being designated as typical (the type) of that higher category.

—O—

Obovate. Inversely ovate.

Ocelli. Simple eyes. (Sing., ocellus).

Ommatidium. An individual component of a compound eye in arthropods. (Pl., ommatidia).

Omnivorous. Feeding on both animal and plant food.

Operculum. A horny or calcareous plate for closure of an aperture; as the operculum of certain bryozoans, barnacles or the Gastropoda.

Opesium. The uncalcified frontal part of some anascan bryozoans.

Oral. Of or pertaining to the mouth.

Oral disk. Cnidaria: the flat surface surrounding the mouth of anthozoans, which bears the tentacles.

Oral papillae. Echinoderms: nipple-shaped projections around the mouth of ophiuroids.

Orifice. A mouthlike opening or aperture.

Ornate. Elaborately marked or embellished with colors or structural elaborations.

Osculum. Sponges: the opening to the spongocoel where the water leaves the body of the sponge.

Ostium. Sponges: the opening through which water initially enters the body.

Ovate. Egg-shaped.

Ovigerous. With eggs.

—P—

Papilla. Small, nipplelike process or projection. (Pl., papillae).

Papillate. Bearing many papillae. (= papillose).

Parasitic. A symbiotic relationship in which one symbiont (the parasite) is living at the expense of the other (host) symbiont.

Paratype. A specimen, other than the holotype, which was before the author at the time of preparation of the original description and was so designated by the original author.

Pectinate. Comblike in appearance or structure.

Pedicellariae. Echinoderms: small, specialized jawlike appendages found on asteroids and echnoids that are used for protection and to capture small animals. Pedicellariae may be stalked or sessile. Stalked pedicellariae (as in the order Forcipulata of the asteroids) have the jawlike apparatus surmounted upon a short fleshy stalk, while the sessile pedicellariae (as in the order Phanerozonia of the asteroids) do not have the jaws mounted at the ends of flexible stalks.

Pelagic. Living in the open sea, as opposed to bottom dwelling (benthic). Pelagic animals may be free-swimming (nekton) or planktonic and may live at any depth, although deep-water forms are usually referred to as bathypelagic; some authors restrict the term "pelagic" to those animals living at or near the sea surface, for example to a depth of 100 fathoms or so.

Peltate. Shield- or leaf-shaped; having the stalk attached to the central portion of a flattened end.

Pentultimate. The next to the last; as in crustacean appendages, the next to the terminal article.

Phenotype. The complete appearance of an individual as based on the totality of its characteristics. The phenotype is the result of the interaction between the genotype (the animal's heredity) and the environment.

Photonegative. Showing a negative reaction to light. An animal that attempts to maintain a position away from the sunlight is photonegative.

Photopositive. Showing a positive reaction to light. An animal that has a preference for light and will attempt to maintain a position where he receives a certain degree of sunlight is photopositive.

Phylogeny. The study of the history of the lines of evolution in a group of organisms; the origins and evolution of taxa.

Pilose. Hairy or furry.

Pinnate. Resembling a feather; having side branches arranged on either side of a common stalk.

Plankton. Small plant and animal life floating (primarily) in the upper layer of a body of water. All large-scale movement of planktonic life is at the mercy of the water currents.

Plesiomorphic characters. Features or characters considered as primitive, or found in ancestral forms.

Pleurite. One of the 2 lateral portions of the body wall of an arthropod segment.

Podia. Echinoderms: tube feet.

Polymorphism. The simultaneous occurrence of several different phenotypes in a population.

Polyp. Cnidaria: an individual having a hollow cylindrical body, closed and attached at one end and open and free at the other, which bears the mouth. Examples of the polypoid form include sea anemones and individual members of a coral or hydroid colony.

Polyphyletic. A term applied to a composite taxon, derived from two or more ancestral groups.

Posterior. Toward the back or tail; opposite the head or anterior end.

Prehensile. Elongated and modified for curving back upon itself; as in the prehensile legs and/or dactylopods of certain crustaceans.

Priority. The principle of taxonomy wherein of the two or more competing names for a single taxon, the name given that taxon is the one with priority, which is in almost all cases the name first validly published.

Proboscis. A long, flexible, anterior snout.

Proximal. Near or toward the point of origin, especially in regard to place of attachment of an appendage or an entire animal.

—R—

Race. In taxonomy, a subspecies.

Rachis. Cnidaria: the main axis or stem of a gorgonian coral.

Radial shield. Echinoderms: a calcareous plate at the base of each arm in Ophiuroids.

Ramus. A branch of something, as a ramus or branch of a thoracic appendage. (Pl., rami)

Reef. A ridge, submerged island, or area of rocks, coral or other material that rise from the sea bed to, or very near, the surface. Reefs may be entirely exposed, entirely submerged, or their exposure may vary with the tides. Any such formation that constitutes a navigational hazard should be considered a reef.

Reniform. Kidney-shaped.

Reticulate. Radiating ribs and concentric ridges crisscrossing at right angles, giving the surface a crosshatched or netlike appearance.

Rhyolite. A fine-grained igneous rock, rich in silica; the volcanic equivalent of granite.

Robust. Strong; healthy appearing; vigorous; well-formed.

Rostrum. Any snoutlike extension of the head of an animal.

Ruff. Resembling the old-time neckpieces or collars of lace (ruffs) worn in the 16th and 17th centuries. These were gathered and drawn into regular folds, and anything consisting of a series of regular folds is said to be ruffled; the circular disk around the mouth of some sea anemones is often incised and thrown into a series of rounded rays and is called a ruff.

Rugae. Folds or wrinkles.

—S—

Scientific name. The binominal or trinominal designation of an animal; the formal (and correct) nomenclatural designation of a taxon.

Sedentary. Remaining stationary much of the time, but not necessarily permanently attached to the substrate.

Sediment. Particulate matter that has been deposited by a fluid medium.

Segment. Strictly speaking, the visible or definable region representing a metamere or embryonic body somite; casually speaking, the parts of a body or appendage marked off from one another.

Seiche. An oscillation of a body of water. Temporary seiches may be caused by rapid changes in air pressure, seismic events, winds, etc. Long duration seiches may be well established in confined bodies of water (small bays, marinas, etc.) The period of oscillation of a seiche is determined by the characteristics of the basin itself.

Senior synonym. The earliest published (or otherwise valid) of two or more available names for the same taxon.

Series. In taxonomy, the samples of animals (or plants) which a taxonomist collects in the field or has available for study.

Serrate. A margin that is notched or toothed.

Sessile. Permanently attached to the substrate.

Setaceous. Bearing setae.

Setae. Hairlike filaments.

Sibling species. Pairs or groups of closely related species which are reproductively isolated but morphologically identical or nearly so.

Siphonoglyph. Cnidaria: In polyps the oral disk often has a ciliated groove, the siphonoglyph, at one or both ends of its elongated mouth. It is by means of these structures that water currents are directed into the interior.

Somite. A body segment or metamere.

Specialization. An evolutionary improvement in efficiency for a particular mode of life.

Species. Groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups (Mayr, 1969, *Principles of Systematic Zoology)*.

Specific name. The second component of the binominal name of a species.

Speciose. Refering to a geographic region or a taxon containing a relatively large number of species.

Spongin. The flexible substance making up the skeleton of some sponges, composed of a fibrous protein related to keratin and collagen.

Steno. A prefix meaning narrow limits of tolerance or preference. Thus a stenohaline animal can withstand only a narrow fluctuation of salinities (or osmotic change) and a stenothermal animal can withstand only a narrow fluctuation in temperature.

Sternite. The sclerotized ventral portion of a segment in a crustacean (or other arthropod).

Striations. Narrow lines, grooves, or ridges.

Sub. A prefix meaning near or almost; subequal means nearly equal though not necessarily exactly equal in all dimensions.

Subchelate. A "cheliped" formed simply by hinging the terminal article of an appendage against the pentultimate article, without any gross modification of the latter; see figure 12.2 d–e.

Symbionts. The partners in a symbiotic relationship.

Symbiosis. The living together, in a constant and definite relationship, of two (different) organisms.

Sympatry. The occurrence of two or more populations in the same area.

Synconoid. Sponges: A secondary or intermediate degree of body wall folding wherein the size of the spongocoel has been decreased from that of the ascon types, and the choanocytes no longer line the spongocoel but are confined to specialized evaginations called radial canals or flagellated canals. The corresponding invaginations on the outside of the sponge are the incurrent canals. The two canal systems are connected by openings called prosopyles.

Synonym. In nomenclature, each of two or more different names for the same taxon.

Syntype. Every specimen in a type-series in which no holotype was designated.

Systematics. The science dealing with the diversity of organisms, generally involving taxonomy.

—T—

Taxocene. A group of related (by phylogeny or ecology) taxa (a fairly loosely used term); a taxonomic segment of a community.

Taxon. A taxonomic group that is sufficiently distinct to be worthy of being distinguished by name and to be ranked in a definite category (Mayr, 1969, *Principles of Systematic Zoology*). *(Pl., taxa)*

Taxonomic category. Designates rank or level in a hierarchic classification. It is a class, the members of which are all taxa assigned a given rank (Mayr).

Taxonomic character. Any attribute of a member of a taxon by which it differs or may differ from a member of a different taxon (Mayr).

Taxonomy. The theory and practice of classifying organisms.

Tentacle. Short or long, fleshy, flexible appendage on an animal, usually restricted to the anterior region.

Tergite. The dorsal surface of a body somite or segment in a crustacean (or other arthropod).

Terminal. The end or tip of a structure.

Tetraxon spicule. Sponges: Sponge spicules that have four rays, each pointed in a different direction. The rays may be equal or one may be longer than the others.

Thecate. Cnidaria: hydroids that possess a protective, cuplike hydrotheca surrounding the hydranth; the Calyptoblastea are thecate hydroids.

Thigmotropism. An innate tendency to seek enclosing contact with a solid or rigid surface, as in a burrow. (An animal that is thigmotactic is one that displays thigmotropism.)

Trade winds. The predominantly easterly winds that blow steadily over certain ocean areas, converging towards the equator.

Tropicopolitan. Referring to a widespread geographical occurrence, encompassing the tropical regions throughout the world.

Truncate. Abruptly cut off, or cut short; an abrupt, flat ending.

Tube feet. Echinoderms: hollow extensile appendages connected to the water vascular system. In starfish and sea urchins they usually end in suckers and are locomotor, while in brittle stars and crinoids suckers are absent. In holothurians the ones around the mouth are used for feeding, and in crinoids they are ciliated and form part of the food-collecting mechanism.

Tubercle. A small knobby protuberance.

Turbinate. Whorled, usually in an inverse conical shape.

Type. The zoological (or botanical) object which serves as the base for the name of a taxon; the actual animal specimen(s) on which the name is based.

Type locality. The locality at which a type is collected (whether it be the holotype, lectotype, neotype, etc.)

—U—

Ubiquitous. Widespread; occurring nearly everywhere.

Unguis. The terminal region on an article of an ambulatory appendage, such as the leg on a crustacean; often clawlike or at least pointed.

Upwelling. An ascending water current, not necessarily from the bottom, which transports deeper (and usually colder) water up into the surface layers of the sea.

—V—

Valve. One of the two halves of a clam shell; one of the 8 plates of a chiton.

Ventral. Bottom or belly surface; abdominal; opposite from dorsal.

Vermiform. Wormlike; long and slender like a worm.

Vernacular name. The colloquial designation of a taxon; the common name applied to an animal or group of animals, as opposed to its scientific name.

Verrucae. Cnidaria: protuberances along the column of some sea anemones, usually in longitudinal rows between the septal attachments. They are hollow projections of the body wall provided with a special musculature and having a concavity lined by a glandular epidermis, by which means they can attach bits of shell and sand to their bodies, presumably for some protective purpose.

—W—

Westerlies. The main winds blowing between 40° and 70° latitude.

—Z—

Zooecium. The compartment containing a zooid.

Zooid. The individual members of a colony or compound organism, having more or less an independent life of its own, i.e., the zooids of hydroid colonies, corals, bryozoans, ascidians, etc. (= zoid).

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The following bibliography will serve as an introduction to the literature on the systematics and ecology of the tropical east Pacific in general. A complete list of all published references to the Gulf of California alone, however, would fill an entire book this size. Below are listed only what the author feels are the most significant contributions dealing with this region, plus recent relevant general texts and review papers and some rather obscure publications and reports not generally recovered during conventional literature searches. Plankton references have not been included in this bibliography. The University of Arizona's Marine Science Program has, since 1964, been printing annual compilations of student reports for their course in Marine Ecology, which relies heavily on fieldwork in the northern Gulf of California. Although these reports are not printed in large quantities for general distribution, they have proven to be a valuable reference source for preliminary or qualitative data and ideas. Papers from these reports that have been deemed especially pertinent or of very high quality have been cited in the following list.

Students with a burgeoning interest in a particular taxocene are encouraged to peruse the bibliographies of the various references cited here. Additional references to these and similar taxa may be found in Hedgpeth's excellent annotated index (Ricketts, Calvin and Hedgpeth, 1968). The list of Baja "guidebooks" of various sorts has lengthened considerably in the past few years. I have included below only those I feel are especially accurate and useful for the student carrying on fieldwork in that region. Remember, references not listed in the chapter bibliographies will be found in the bibliography to Introductory Material.

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(Lamp Shells)

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(Acorn Worms)

The literature does not deal specifically with the Gulf of California enteropneust fauna. What follows is a list of some of the more significant general papers dealing with this group. Dr. T. H. Bullock was, at the time of this writing, approaching completion of the manuscript for a much anticipated monograph on the Enteropneusta (by T. H. Bullock, W. E. Ritter, and K. P. Rao).

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BRAMBELL, F. W. R., AND H. A. COLE
1939. The preoral ciliary organ of the Enteropneusta: its occurrence, structure, and possible phylogenetic significance. Proc. Zool. Soc. London, B. 109:181–193.
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1940. The functional organization of the nervous system of Enteropneusta. Biol. Bull. 79:91–113.
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1948. Stomocordes. *In* Traité de Zoologie, edited by P. Grasse. Masson, Paris. Pp. 367–532.
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KNIGHT-JONES, E. W.
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NEWELL, G. E.
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RITTER, W. E.
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1902. The movements of the Enteropneusta and the mechanism by which they are accomplished. Biol. Bull. 3:255–261.

RITTER, W. E., AND B. N. DAVIS
1904. Studies on the ecology, morphology and speciology of young of some Enteropneusta of western North America. Univ. Calif. Publ. Zool. 1:171–210.
TREWAVAS, ETHYLWYNN
1931. Enteropneusta. British Museum, Great Barrier Reef Exped. 4(2):39–67.

28. CHORDATA: Ascidiacea (Ascidians)

There are almost no good references on the ascidians of the Gulf of California. Major references for this group in western North America are as follows:

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ABBOTT, D. P., AND W. B. TRASON
1968. Two new colonial ascidians from the west coast of North America. Bull. S. Calif. Acad. Sci. 67:143–154.
ALLDREDGE, A. L.
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1898. Descriptions of some simple ascidians collected in Puget Sound, Pacific Coast. Proc. Trans. Liverpool Biol. Soc. 12:248–267.
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1939. The method of feeding in tunicates. Biol. Bull. 77:443–447.
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RITTER, W. E., AND RUTH A. FORSYTH
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1855. Descriptions of some of the new marine invertebrata from the Chinese and Japanese seas. Proc. Philadelphia Acad. Sci. 7:375–384.
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GENERAL INDEX

***In the Index to Scientific Names**

Localities are indexed when they are cited in the text as specific places where an animal has been collected. Geographic localities are not indexed when they are given in the text as part of an animal's range (e.g. Guaymas to Ecuador).

Common Intertidal Invertebrates of the Gulf of California

by
Richard C. Brusca *et al.*

Identifying and discussing more than 1,300 species of marine invertebrates, this expanded second edition of the popular *Handbook* by Brusca has more than 700 illustrations and 14 color plates! An indispensable field guide and standard reference for professional biologists, students, teachers, and eager amateurs, this edition includes:

- ☐ simplified dichotomous keys for identification
- ☐ 28 major animal groups, including insects and arachnids of the coastal fringes
- ☐ the first comprehensive scheme of intertidal zonation for the Gulf of California
- ☐ an introductory section on geological origins of the Gulf and biological origins of its fauna
- ☐ information on physical features of the region, including geology, meteorology, water circulation, temperature, and salinity
- ☐ an extensive glossary and bibliography.

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