OCS Study
MMS 96-0031

TAXONOMIC ATLAS OF THE BENTHIC FAUNA OF THE SANTA MARIA BASIN AND WESTERN SANTA BARBARA CHANNEL

FINAL REPORT
Volume 10 of 14

The Arthropoda — The Pycnogonida
The Crustacea Part 1 — The Decapoda

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

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The Arthropoda — The Pycnogonida
The Crustacea Part 1 — The Decapoda

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This report is not deemed nor intended to be a valid publication for the naming of new taxa as stipulated in the International Code of Zoological Nomenclature, Article 8b.

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BACKGROUND: The Taxonomic Atlas of the Santa Maria Basin and western Santa Barbara Channel is an extension of the benthic reconnaissance (Phase I) and monitoring programs (Phase II) that were conducted by the MMS since 1983. The organisms that were collected as part of those programs provide the material on which the Atlas is developed. In order to fully document the fauna collected by those programs, a series of 14 volumes will be prepared that provide keys, descriptions, and illustrations of the benthic fauna of the hard and soft substrate environments. A team of 40 experts on the fauna has been assembled to carry out this work and their contributions are distributed among the 14 volumes.

OBJECTIVES: The objectives of Volume 10 are to continue coverage of the Crustacea that was initiated in Volumes 11 and 12. This volume treats the pycnogonid arthropods and begins treatment of the crustaceans with the decapods.

DESCRIPTION: Volume 10 includes a treatment of the sea spiders (Pycnogonida) and the shrimps and crabs (Decapoda). The 2 chapters are organized into sections that include the morphology, taxonomic history, biology, keys of species, and descriptions of genera and species. Each species is fully illustrated with relevant characteristics labeled and identified.

SIGNIFICANT CONCLUSIONS: Volume 10 represents the first of three arthropod volumes and includes treatment of the Pycnogonida (sea spiders) and the decapod crustaceans (shrimps and crabs). The Pycnogonids include 6 families, 8 genera, and 11 species. All are previously known. A key has been prepared to these species and others that are likely to occur in the study area. The author has prepared an extensive review of pycnogonid morphology that will assist readers in using the key and interpreting the descriptions and illustrations. The chapter on the decapods includes treatment of 14 crab and 11 shrimp species distributed among 14 families and 20 genera. One species of commensal crab, Pinnixia scamit, was new to science and described in an earlier paper. A key is developed to the species occurring in the MMS collections, but is not inclusive to those other species likely to occur in the area. Each species is described and illustrated. Both chapters include an extensive review of the literature and a comprehensive bibliography.

STUDY RESULTS: The fauna of the Santa Maria Basin and Western Santa Barbara Channel is evaluated from samples that were taken from depths of about 50 to 1,000 m. Organisms were collected from soft sediments using box cores and from rocks using manipulator arms of submersibles and remotely operated vehicles. The collections are organized into sets of vouchers from Phase I and II that have been made available to the team of investigators. Additional material from the bulk collections now archived with the Los Angeles Museum of Natural History is also being examined. The total number of species treated in the entire Taxonomic Atlas (14 volumes) may exceed 1,000 species.

The pycnogonids or sea spiders, are familiar, yet enigmatic invertebrates found in epifaunal and cryptic habitats. The present study represents the first comprehensive compilation of the offshore pycnogonid fauna of the central California region. The author has compiled a key to all of the species expected to occur in the area thus ensuring that readers will be able to account for rare species. A total of 11 species were encountered in the MMS collections. All were previously known to science. Many of the common crabs and shrimps encountered in MMS studies have been well known since the monographic works of Schmidt and Rathbun. Although the 25 species encountered in the MMS studies were not a high number for the number of species expected in the region, at least one new species, *Pinnixia scamit* was encountered and described in an earlier paper by the authors of this chapter. The descriptions and illustrations provided as part of both chapters will greatly assist users in the identification of the local arthropods.

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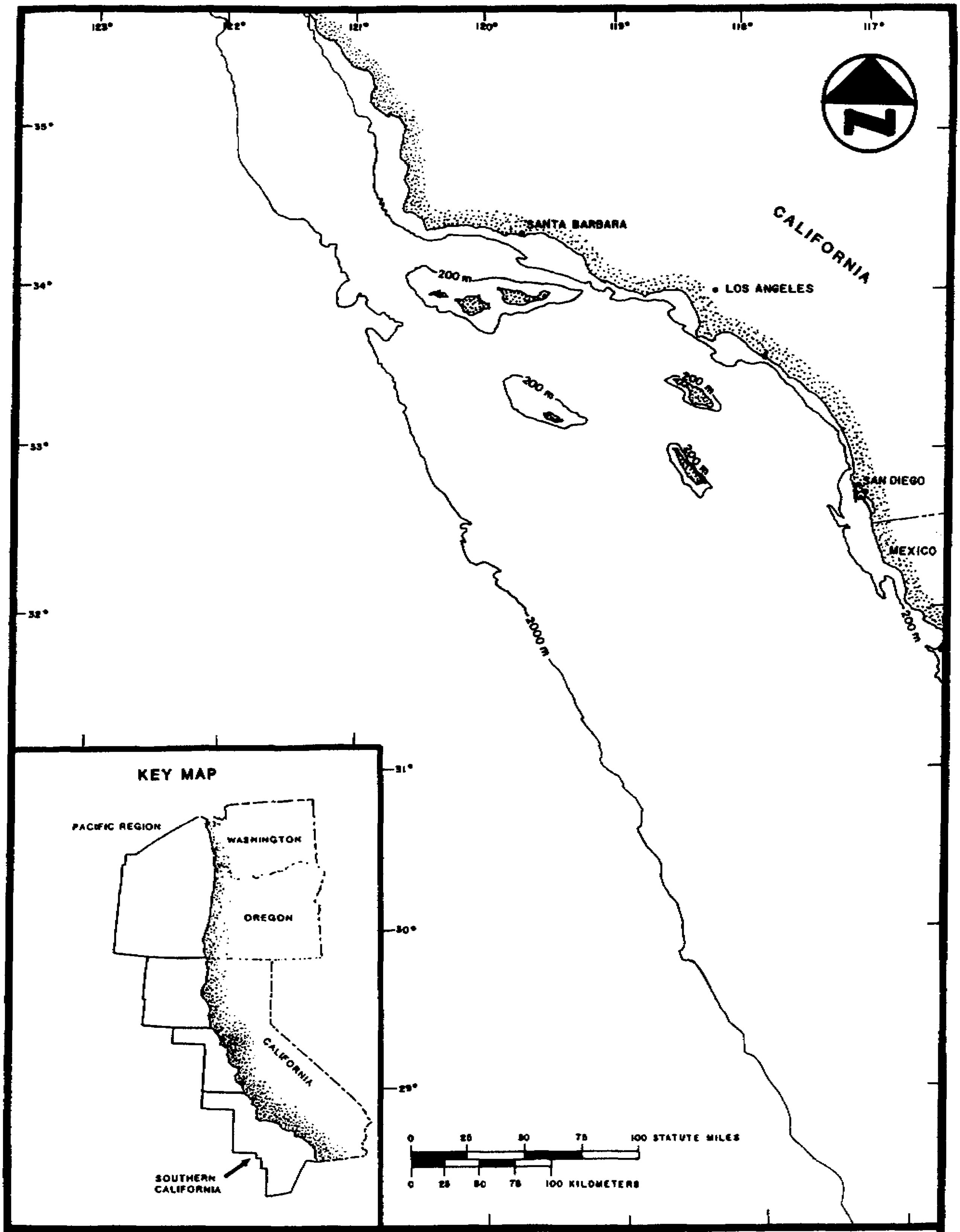

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Volume 10 represents the first of three arthropod volumes and includes treatment of the Pycnogonida (sea spiders) and the decapod crustaceans (shrimps and crabs). The Pycnogonids include 6 families, 8 genera, and 11 species. All are previously known. A key has been prepared to these species and others that are likely to occur in the study area. The author has prepared an extensive review of pycnogonid morphology that will assist readers in using the key and interpreting the descriptions and illustrations. The chapter on the decapods includes treatment of 14 crab and 11 shrimp species distributed among 14 families and 20 genera. One species of commensal crab, Pinnixia scamit, was new to science and described in an earlier paper. A key is developed to the species occurring in the MMS collections, but is not inclusive to those other species likely to occur in the area. Each species is described and illustrated. Both chapters include an extensive review of the literature and a comprehensive bibliography.

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List of Acronyms

ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania.
BLM	Bureau of Land Management.
BRA	Refers to a station designation from the MMS Phase I Reconnaissance: Benthic Rocky, transect A/B.
BRC	Refers to a station designation from the MMS Phase I Reconnaissance: Benthic Rocky, transect C/D.
CAS	California Academy of Sciences, Department of Invertebrate Zoology, San Francisco, California, USA.
LACM	Natural History Museum of Los Angeles County, Los Angeles, California, USA.
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA.
MMS	Minerals Management Service.
NHML	The Natural History Museum, London, United Kingdom.
SCAMIT	Southern California Association of Invertebrate Taxonomists.
SBMNH	Santa Barbara Museum of Natural History, Santa Barbara, California, USA.
SDNHM	San Diego Natural History Museum, San Diego, California, USA.
USNM	United States National Museum. A historical designation for the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, D.C., USA.

1. SUBPHYLUM PYCNOGONIDA

by

Donald B. Cadien[1]

Introduction

The pycnogonids (or sea-spiders) are a small group of cheliceriforms with about 1,100 species world-wide. They are exclusively marine, although some species are tolerant of reduced salinities. Pycnogonids can be found from the intertidal zone to depths of nearly 7,400m. They have a long evolutionary history, but the fragility of the pycnogonid body (or failure to recognize members of the group) has left this history poorly documented in the fossil record. They are only distantly related to the true spiders (Arachnida), having diverged from a common ancestor prior to the Carboniferous (Manton, 1978). One group of pycnogonids, the Pantopoda, is extant, and has Devonian fossil representatives similar to the living genus *Pigrogromitus* (Arnaud and Bamber, 1987). Two other groups, the Paleoisopoda and Paleopantopoda, are extinct.

Of the approximately 44 species of pycnogonids which are known to occur in or adjacent to the study area, only a few are routinely taken on soft substrata. The vast majority of pycnogonids are found on hard substrates, or on the epibiota which occupies them. At least one genus, *Rhynchothorax*, has interstitial members (Child, 1988).

Sexes are separate in pycnogonids, although hermaphroditism has been reported in one species. Sexual dimorphism is usually manifested in presence or absence of ovigers; in differences in oviger size, segmentation, or ornamentation; and in number, shape, and position of the gonopores. Gynandromorphy is also reported in the literature (Child, 1978; Child and Nakamura, 1982; Miyazaki and Makioka, 1993). Both sexual mosaics and bilateral gynandromorphs have been found.

The higher classification of animals of the arthropod grade is still unsettled. Definitive determination of the position of the Arthropoda may always remain a matter of conjecture. Although there is little controversy about the relatedness of the various taxa with jointed appendages encased in a chitinous exoskeleton (arthropods), there are two clear lines of thought as to their status. One holds that the concept of "arthropod" embraces a series of extant and extinct phyla and, if used at all, must be accorded the level of Superphylum. Willmer (1990), for instance, considers that "arthropodization" has occurred in a number of related, but independent evolutionary lines. The other maintains that, while there is considerable diversity among "arthropods", they share a common ancestor and belong within a phylum level taxon. Here I adopt the view that embryological and morphological evidence available (summarized in Schram, 1986) supports phylum status for each of the three major extant divisions within the arthropod grade. Of these the Phylum Cheliceriformes has two subphyla - the Chelicerata and the Pycnogonida. For organizational purposes within the Atlas, these animals have been included with the arthropods.

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It must be emphasized, however, that the controversy over a monophyletic or polyphyletic Arthropoda still rages. Brusca and Brusca (1990) provide cogent summary of the issue (and support monophyly), based on much the same evidence used by Schram (1986), who supports polyphyly. Even more recent phyletic reanalyses (Eernisse *et al.,* 1992; and Backeljau *et al.*, 1993) of a common character set assembled by Schram (1991), while yielding congruent consensus trees, were interpreted as evidence of arthropod polyphyly and monophyly, respectively.

Knowledge of the natural history, ecology, functional morphology, and physiology of pycnogonids is relatively recent. Until the 1960's, most reports of pycnogonids were restricted to either anatomy, taxonomy, or biogeography. Two recent comprehensive reviews of the Pycnogonida are available (King ,1973; Arnaud and Bamber, 1987) and should be consulted for additional information.

Although opinions differ, an arrangement of the pycnogonids into nine families is generally used. Fry (1978) attempted a radical reorganization of the group based on application of numerical taxonomic methods, but his system has received little acceptance. There is only one extant order, the Pantopoda, containing the families Endeidae, Pycnogonidae, Phoxichilidiidae, Colossendeidae, Nymphonidae, Callipallenidae, Ammotheidae, Austrodecidae, and Rhynchothoracidae.

Morphology

The first impression of most people upon viewing a pycnogonid is of appendages, but no body. So decentralized is the appearance of sea spiders that the Reverend T. R. R. Stebbing used the term "nobodies" as a popular name for the group (Stebbing, 1902). Ignoring appendages for the moment, the basic pycnogonid plan consists of a body divided into four sections - the proboscis, the cephalon, the thorax (or trunk), and the abdomen (Figure1.1A). The proboscis is a tube or cone-like anterior projection on the front of the animal. It is attached to the cephalon, or "head", which is the first section of the body proper. The cephalon is the attachment site of the chelifores, palpi, and ovigers, and also bears a dorsal ocular tubercle. The first pair of walking legs are attached near the posterior margin of the cephalon. The next three (or atypically four or five) body segments form the thorax or trunk. Each bears one pair of walking legs, but no other appendages. The final body segment is the abdomen, which is attached terminally on the last thoracic segment. This segment is often flexed dorsally, especially if it is elongate.

Proboscis

The proboscis is perhaps the most unique feature of the group, being present in one form or another in every pycnogonid. It is the feeding organ of sea-spiders, and its form reflects the type of prey each animal consumes. It is essentially a muscular tube projecting anteriorly or ventrally from the cephalon (Figure 1.1A). The proboscis bears no appendages, but is terminally equipped with small lappet-like lips. Proboscis shape is generally species specific (although either shape or relative size of the proboscis changes with growth in some species), and particular proboscis arrangements may be characteristic at the family level. The proboscis is attached to the underside or anterior face of the cephalon by an arthrodial membrane of varying width. This is also termed the soft collar, and its width is generally an indication of the degree of mobility of the proboscis; species with narrow soft collars having nearly immobile proboscides.

Proboscis shape can be complex. The organ is never just a simple tube, being either tapered, bent, or with some complex of bends, swellings, and tapers over it's length. Proboscis length relative to the remainder of the body also varies widely within the group, from a mere rounded button on the cephalon to a long stylus nearly the length of the body. Fry and Hedgpeth (1969) introduced a system of expressing proboscis shape which, while generally accepted, is often not included with descriptions.

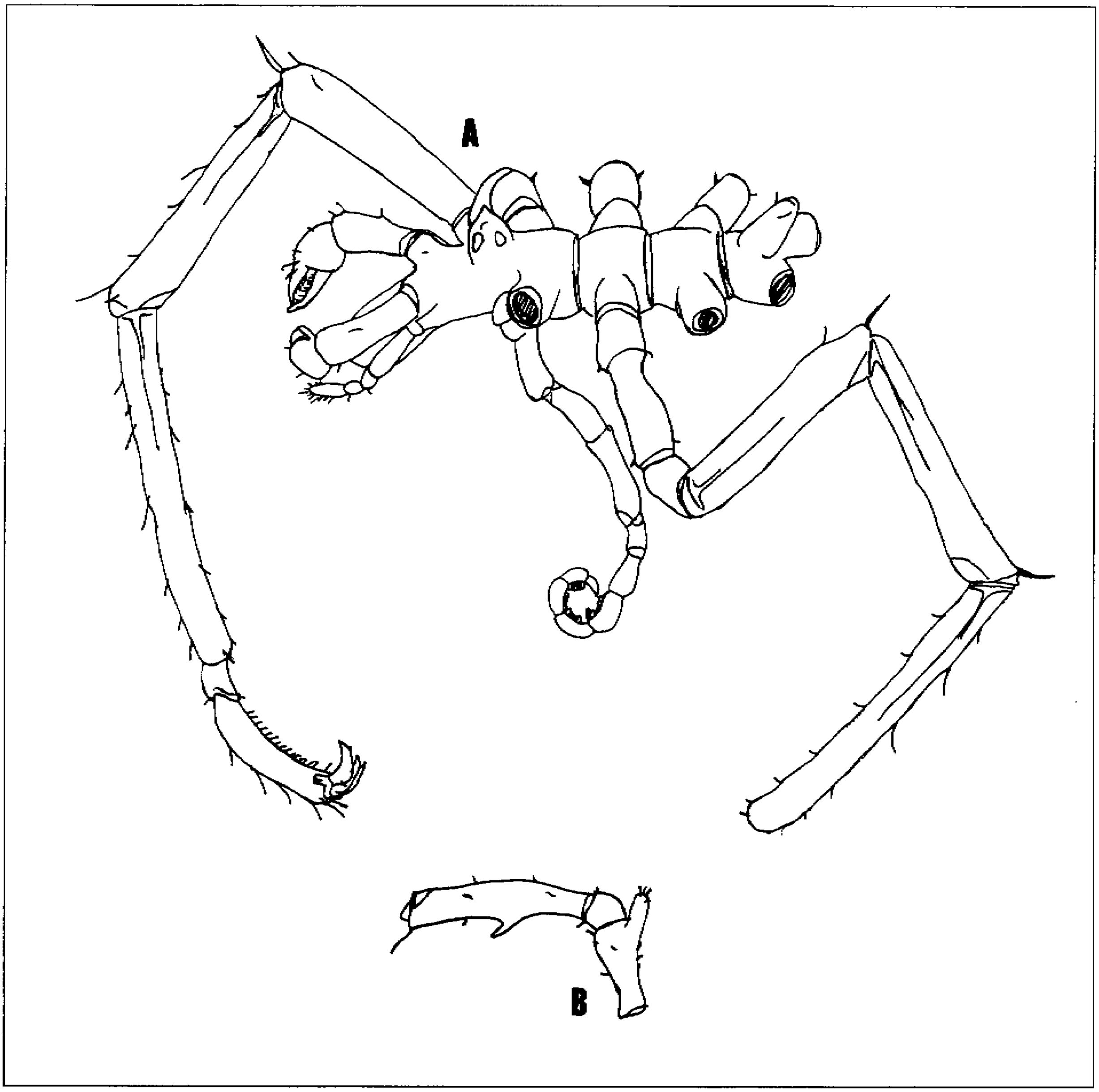

Figure 1.1. Pycnogonid external morphology; A. body, B. second and third coxae, and femur of leg (after Child, 1979).

Cephalon

The proboscis is attached to the cephalon, as are the first four sets of appendages; the chelifores, the palpi, the ovigers, and the first set of ambulatory legs. Depending on species, age, or sex of an animal, one or more pairs of appendages may be missing. These appendages are distributed around the attachment of the proboscis. The chelifores are dorsal, overhanging the proboscis (Figure 1.2A) or extending along its upper surface. The palpi originate lateral to the proboscis insertion, and extend anteriorly along its sides. Ovigers are ventrally attached to the cephalon anterior to the attachment of the legs. The legs attach laterally on the cephalon, posterior to the insertion of the proboscis. The cephalon usually bears an ocular tubercle dorsally, on which the eyes are situated. The position of this tubercle varies from the anterior margin of the cephalon to near the posterior end of the segment. It is anocular in some deep-sea and interstitial forms, but usually bears two pairs of eyes distally. These pairs are usually equal in size, but in some forms the anterior pair is enlarged. The ocular tubercle is usually of moderate size (three to six times higher than broad), but ranges from a barely perceptible bump on the cephalon to a tall turret raised high above the segment surface.

Cephalon shape varies from compact to attenuated. The insertion of the proboscis is close to that of the walking legs in the former, while in the latter the proboscis, chelae, and palpi are situated at the distal end of an extended neck. A further variation is seen in the local species *Prototrygaeus jordani*, in which the ocular lobe is extended forward and overhangs the insertions of the proboscis, palpi, and chelifores.

The chelifores are composed of a basal scape of one or two segments and a terminal chela which bears one moveable and one fixed finger (Figure 1.2B and D). Functional chelae are always longer than the proboscis, and are assumed to be involved in transferring food to the mouth. Chelifores are present in all pycnogonid larvae. In the Ammotheidae, chelae are fully developed in juveniles, but become reduced or vestigial in the adult (Figure 1.2C). In the Austrodecidae, Colossendeidae (with the exception of *Decolopoda*), Pycnogonidae, Rhynchothoracidae, and Endeidae chelifores are present in juveniles and absent in adults. Members of the Callipallenidae, Nymphonidae, and Phoxichilidiidae have well-developed chelae both as juveniles and adults.

The palpi are composed of between one (*Pallenopsis*) and twenty (*Nymphonella*) segments, although most palps have between five and ten segments (Figure 1.2E and F). Their function is assumed to be sensory, and they bear sensory hairs, especially on their terminal segments. In *Achelia echinata* they appear to assist in orientation of the proboscis to the ectoproct prey (Wyer and King, 1973). As with chelifores, palpi are not found in all families. Palpi are present in Ammotheidae, Nymphonidae, Rhynchothoracidae, and Colossendeidae; either present or absent in Callipallenidae; and absent in the remaining families. In the Ammotheidae the number of palp segments varies considerably, but is always at least four. Colossendeids have eight or nine, nymphonids five, and callipallenids four or fewer palp segments.

Ovigers (Figure 1.2G and H) are specialized cleaning appendages which have become secondarily modified in the males of some species into egg carriers. In the Pycnogonidae, Endeidae, and Phoxichilidiidae they are found only on males, while they occur on both sexes in the remaining five families. They may bear a brush-like elaboration of the last few segments termed a strigillus, which is of diagnostic value, as are both the number of oviger articles and their proportions.

Thorax

The thorax typically consists of three segments and their associated walking legs. The segments are joined along their midline and separate towards the side of the body into lateral processes. These are closely approximated in some species, forming a disc with barely perceptible gaps between adjacent processes. More often, however, they are broadly separated so that the lateral processes appear to be the bases of the legs rather than extensions of the body. In some forms the cuticle of adjacent segments is fused in the adult, obscuring their articulation.

In a number of species from Antarctic seas (and a few from the Caribbean), there are four or five thoracic segments, each bearing a pair of walking legs. When first found, such forms were considered aberrant, and some individuals with extra legs have been reported in species normally having three thoracic segments (Arita, 1936). Additional observation has shown that most specimens with extra legs are not aberrant, although the co-occurrence of very similar three segmented species nearby remains suggestive. Ten or twelve-legged species have not been reported from the northeastern Pacific.

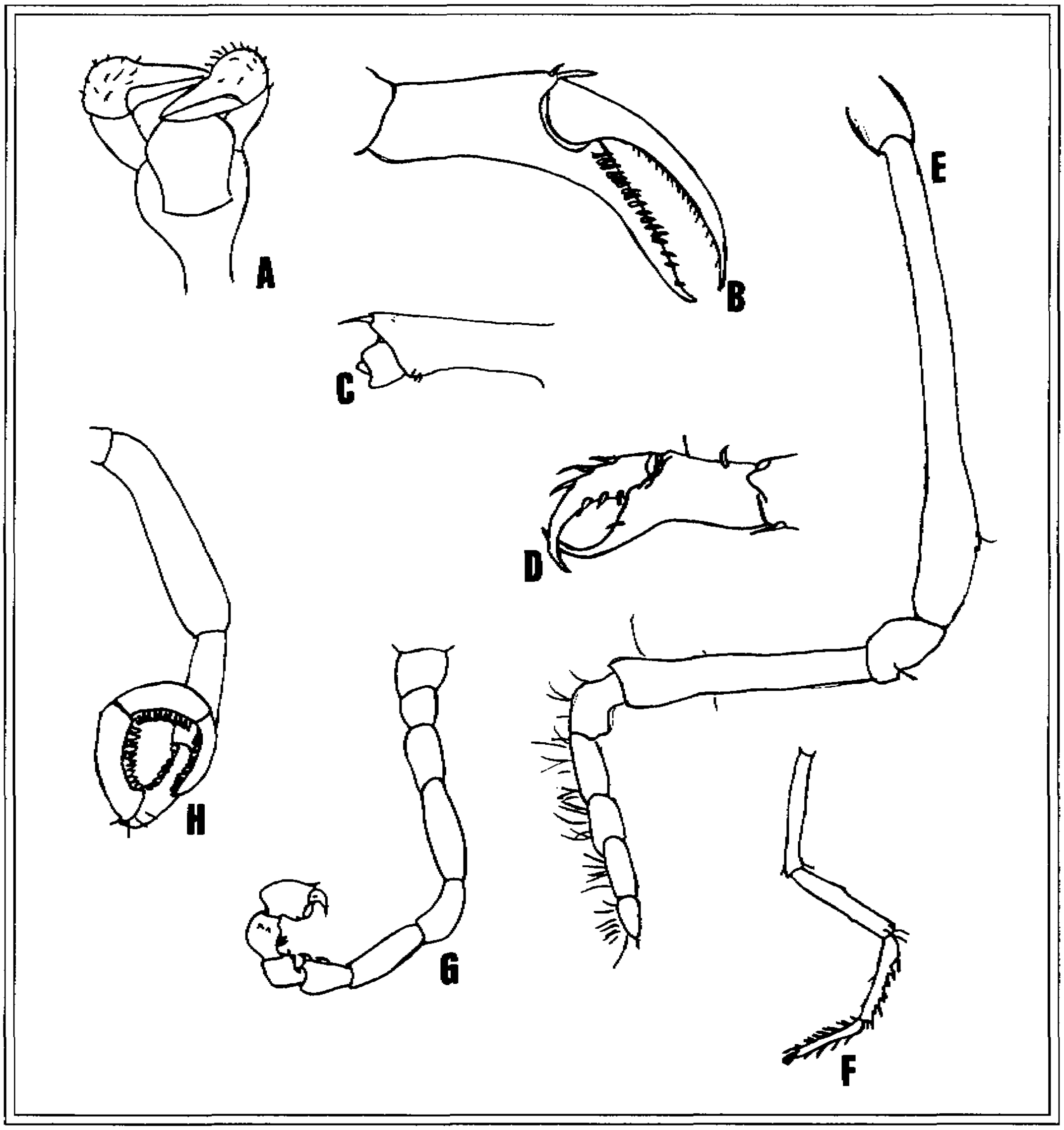

Figure 1.2. Appendages of the cephalon; A.-D. chelae, E. and F. palpi, G. and H. ovigers.

Thoracic legs are invariably nine-segmented. This is also true of the cephalic legs with the exception of the genus *Nymphonella*, where the last two leg segments of the first walking legs are themselves multisegmented (Ohshima, 1927). The segments are (sequentially from the lateral process) three coxae, a femur, two tibiae, a tarsus, a propodus, and a terminal claw (Figure 1.1A). In species with short legs (about equal to thorax width) none of these leg segments are elongate. In long-legged species, the added length results from elongation of the femur and/or tibiae, with the other segments remaining relatively short. Segment widths do not normally differ greatly in any given leg, with the widest segment typically being the femur.

Abdomen

The abdomen is terminally attached to the posterior thorax. Its articulation may be readily apparent, or obscure so that the abdomen appears fused to the last thoracic segment. The abdomen itself terminates in the anus. There are no abdominal appendages.

The Integument

The pycnogonid external surface is composed of a chitinous cuticle overlying a layer of epithelium. Unlike the exoskeleton of crustaceans, the cuticle of pycnogonids is never stiffened by calcium deposits (Arnaud and Bamber, 1987). The cuticle is perforated by pores providing exits to cutaneous glands for mucous production and excretion. It is composed of three layers: the epi-, ecto-, and endocuticles. At points of flexion, such as joint articulations, the cuticle is thinned by loss of the ectocuticular layer (King, 1973).

All organisms with exoskeletal structures must either modify or shed these in order to accommodate soft tissue growth. In pycnogonids, the cuticle is shed in sections rather than as a single piece as in crustaceans. During molting, the cuticle of each leg separates from the body and is shed as a sleeve, while that covering the body splits laterally, and is shed as dorsal and ventral halves (Lotz and Bückmann, 1968).

Sensory Organs and Nervous System

Although it may be inferred with some confidence that at least some of the hairs and setae of the palpi are related to environmental sensing, such function has only been demonstrated for the eyes. These are simple, with a cupped retina, a single lens, and a layer of photoreceptive cells. They are light sensitive, but not image-forming. There appear to be no other light sensitive areas on the body, as loss of the ocular tubercle results in unresponsiveness to light (Cole, 1901). A number of deep-water species have the eyes reduced or lacking, as do some true infaunal forms such as *Rhynchothorax philopsammum* (Krapp, 1973).

Chemoreception has been demonstrated for pycnogonids, but has not yet been associated with particular structures. Ablation of chelifores, palpi and ovigers did not remove chemosensitivity. Innervated epidermal setae were suspected of being the site of chemosensory localization (Stock, 1978). Such structures occur on both the proboscis and on walking legs. Bifid setae, hollow setae with terminal pores, and setae set into cuticular cups are seen on various pycnogonids. All are basally innervated, and all certainly serve either a mechanosensory or chemosensory purpose. Either chemoreception or thermoreception has also been suspected in specialized structures (Sokolow's organ - Hanström, 1965)) on the ocular tubercle adjacent to the eyes (Richter, 1982).

The central nervous system consists of a bilobed cephalic "brain" of paired supraesophageal ganglia, circumesophageal commissures, and subesophageal ganglia. The optic nerve arises dorsally from the supraesophageal ganglion, while the chelifore nerve arises anteriorly. The stomodeal nerve, dorsal and ventral proboscis nerves, and the palp nerve arise anteriorly on the subesophageal ganglion, while the oviger nerve arises ventrally. A ventral chain of ganglia extends from the rear of the cephalon, through the trunk, and into the abdomen. Except for the last three, all of which supply the abdomen, each ventral ganglion innervates a leg pair.

The Digestive System

The mouth, at the tip of the proboscis, forms the entry point of the digestive system. This empties into the esophagus (foregut), then into the midgut (in the posterior portion of the cephalon, and throughout the trunk), and into the hindgut in the abdomen. Each division of the alimentary canal is separated by a tripartite valve. These one-way valves are held closed by presence of food on their posterior sides. Once digestion and/or evacuation has reduced the volume of the material occupying the digestive lumen, muscular activity in the proboscis can force more food through the valve. The system terminates in a slit-like anus at the end of the abdomen. The foregut is lined with a continuation of the external cuticle, which is shed during molting. The distributed nature of the pycnogonid body precludes development of an enlarged midgut mass, and adequate digestive surface is provided by lateral midgut caecae extending into the legs. In some Nymphonidae and Phoxichilidiidae the midgut is also anteriorly elaborated into the chelifore scape .

Ingested food is macerated by muscular action within the pharynx, which extends from the mouth to the esophagus. The resulting food pulp is strained through a group of setae projecting into the proboscis lumen at the beginning of the esophagus. These form a sieve (the "oyster basket") serving to retain larger particles within the pharynx for further maceration.

Digestion is performed by epithelial cells of the midgut lining. Schlottke (1933) proposed a model of pycnogonid intracellular digestion in which these cells become dislodged during digestion and wander freely through the lumen, later becoming secondarily reattached to the gut wall. Intracellular digestion proceeds within these cells, which retain unusable digestive products within themselves. They then detach from the gut wall, and are, along with their unusable inclusions, voided through the anus. Observations on digestion in several Antarctic species (Richards and Fry, 1978) suggest that this model is misleading, and that digestion normally proceeds within attached digestive cells, followed by release of digestive byproducts into the gut lumen. Enzymes released into the lumen concurrently may also provide some extracellular digestion.

At least in the antarctic species investigated digestion was a very slow process, with two months of non-feeding to empty the guts. It is likely that higher ambient temperatures would raise the rate of digestion along with other aspects of metabolic activity. Such low rates of digestion also provided high resistance to starvation, with survival for over 18 months without apparent damage (Richards and Fry, 1978).

The Circulatory System

The pycnogonid heart is an elongate sinus extending along the underside of the dorsal body wall from the rear of the cephalon through the thorax. Its lower boundary is the horizontal septum (attached to the dorsal side of the gut), and its upper is the inside of the body wall (Tjonneland *et al.*, 1985). The horizontal septum divides the entire body into an upper and lower half and separates the haemocoel into upper efferent and lower afferent compartments. The septum does not reach the ends of the appendages, and is slit near the lateral processes, consequently separation of the two flows is only partial. It is sufficient, however, to guarantee movement of hemolymph from the heart throughout the body. It appears that the heart itself provides little propulsion to circulate the hemolymph, which is accomplished by a combination of gut peristalsis and muscular movement within the legs. Up to three pulses of hemolymph movement have been observed per second (Loman, 1907). The ventral return flow to the heart is via paired ostia opposite the bases of the second and third legs, and an unpaired opening at the base of the abdomen (Cole, 1910).

Pycnogonid respiratory pigment is apparently hemocyanin, which is present in the plasma but not localized in blood cells. This may reflect the lack of respiratory organs in pycnogonids. It is assumed, partly because of the absence of specialized gas exchange structures, and partly because of their high surface to volume ratio, that oxygen is normally obtained over the entire body surface by diffusion from the surrounding medium. Blood cells similar in appearance to those normally associated with oxygen transport are present (Dawson, 1934; Redmond and Swanson, 1968), but their function is unclear.

The Excretory System

Specialized organs for excretion are lacking in pycnogonids. Removal of metabolic byproducts is thus either across the general body surface, or into the gut for subsequent elimination through the anus.

The Reproductive System

Sexes are separate in all known pycnogonids with the exception of *Ascorhynchus corderoi*, a true hermaphrodite species from Brazil (Marcus, 1952). Fertilization is external, and fertilized eggs are usually borne on the ovigers of the male.

The ovaries of the female lay along and above the gut, with lateral diverticulae extending into the legs in most species (Figure 1.3B). The testes of the male (Figure 1.3A) are similarly situated, and usually extend into the legs. Ova are usually stored in the femurs of all legs between their production in the ovary and their fertilization and release. In some species it is the second coxae that serve as the storage area for the eggs. In either case, the segment becomes expanded to accommodate storage of the mature eggs prior to their release.

Eggs are released just prior to fertilization through a female genital pore on the second coxa of each walking leg. Typically these pores are anteroventral, but are posterodorsal in *Pycnogonum littorale*. In the genus *Rhynchothorax*, they are found ventrally on the second coxae and only on the last pair of legs. The opening of the pore is closed by a lid or operculum, but not in *Achelia echinata*, where the pore is raised on a tubercle, rather than flush with the segment surface.

Early stages in development of pycnogonids from vitellogenesis of the egg to embryology is extensively reviewed by King (1973). Postembryonic development is anamorphic, with the developing egg yielding a protonymphon larva (Figure 1.4). Subsequent growth is through addition of segments posteriorly. Very juvenile pycnogonids are two-legged (the first leg pair on the cephalon). Addition of the thoracic segments yields four, six, and finally eight legged individuals. More than one molt may be required for complete development of each leg pair, so that the last pair may consist of incomplete legs composed of just a few segments.

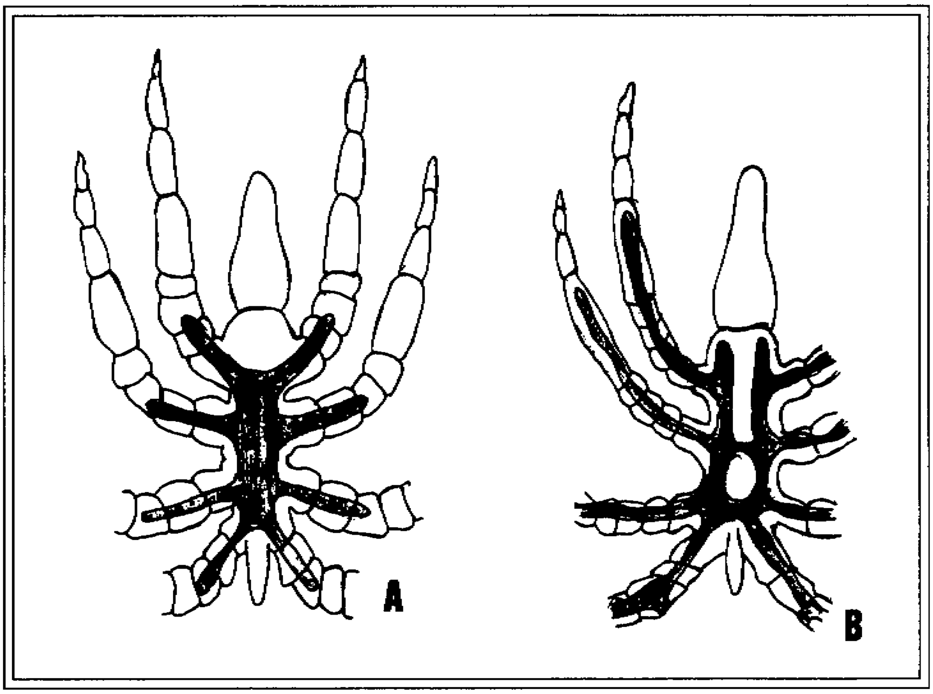

Figure 1.3. Location and extent of gonads in; A. male (after El-Hawawi and King, 1978), and B. female *Pycnogonum littorale* (after Jarvis and King, 1972).

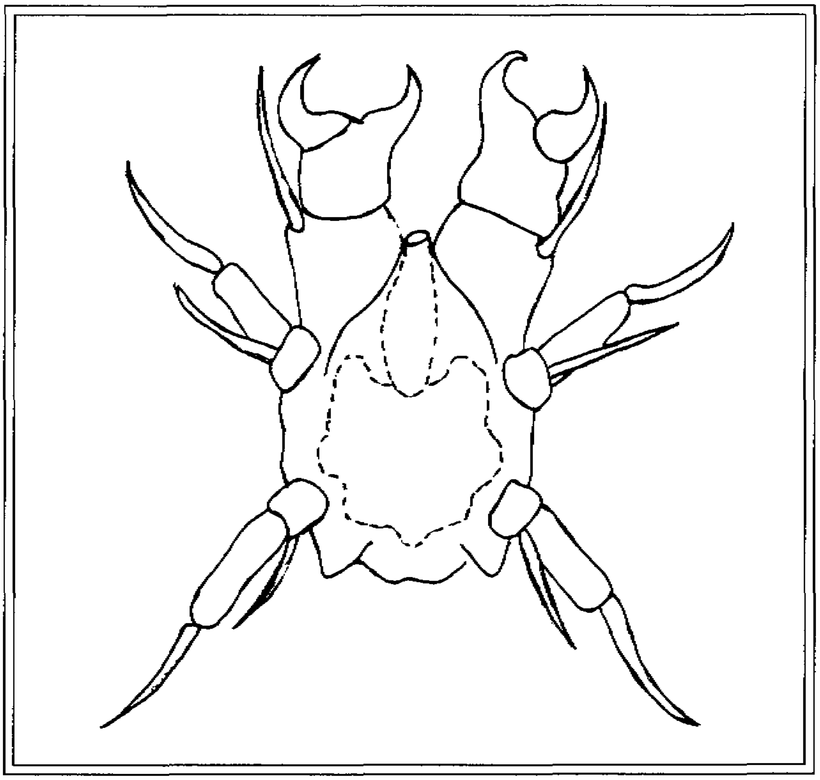

Figure 1.4. Protonymphon larva of *Achelia echinata* (after King, 1973).

Ecology and Behavior

Reproductive Behavior

The reproductive behavior of relatively few species of pycnogonids has been directly observed, and the existing observations indicate that the process is far from uniform. Some variation is dictated by the positions of the genital openings in various species. Males and females typically engage in pseudocopulation, with their gonopores opposed. In *Anoplodactylus lentus*, where both the male and female gonopores are on the ventral surfaces of the leg, pairing is ventrum to ventrum. In *Pycnogonum littorale* the male gonopores open on the ventral side of the leg, while the female gonopores are dorsal. Consequently, this species pairs ventrum to dorsum, with the gonopores appressed. As eggs are extruded by the female they are fertilized and gathered into a ball by the ovigers of the male (King and El-Hawawi, 1978). The ball is carried under the male until hatching. The form of the egg mass differs in other members of the genus, being a flattened mass held laterally by the ovigers in *P. panamum.*

Nakamura and Sekiguchi (1980) made detailed observations of *Propallene longiceps* reproductive behavior in the laboratory. They found that oviposition was stimulated by male mate holding. The egg then migrated from the ovary to the female gonopore, was extruded, and was caught by the female with her ovigers. It was then transferred to the male's ovigers where it was added to others to fashion "bracelets" of eggs which were carried around the ovigers until hatching. The pseudocopulatory position in this species was male ventrum to female dorsum, with both facing in the same direction. Pairing lasted several hours, with the male maintaining his position by grasping the base of the female's chelifores with his chelae. A similar period of pairing and the same ventrum to dorsum position was reported for *Parapallene avida* (Hooper, 1980).

The duration of pairing was much shorter (minutes) in *Anoplodactylus lentus* (Cole, 1901), and particularly extended (up to five weeks) in *Pycnogonum littorale* (Jarvis and King, 1972).

Seasonality of reproduction is characteristic of littoral species such as *Nymphon gracile* while offshore species tend to have maturing eggs throughout the year. Species with both littoral and sublittoral populations, such as *Achelia echinata*, have pulsed seasonal reproduction in the former and fairly continual reproduction in the latter (King, 1973).

Locomotion

Pycnogonids are capable both of walking and swimming. The former was discussed at length by Schram and Hedgpeth (1978), who separated walking motion into two general categories related to leg length: the crawling motion of short-legged species, and the walking of long-legged species.

Swimming is used by pycnogonids to raise themselves off the bottom both for onshore/ offshore tidal driven migration (Morgan, 1977) and current driven relocation by individuals in deeper water (Grassle *et al.*, 1975). Such activity may be relatively frequent as reports of positive phototropism and catches of pycnogonids in the plankton with night lights are numerous (see reports listed by Arnaud and Bamber, 1987).

The functional morphology of the musculature and leg articulations of pycnogonids with regard to both walking and swimming was discussed by Manton (1978).

Feeding Behavior

Most pycnogonids are carnivores feeding on sessile marine invertebrates, especially ectoprocts and cnidarians. Algae and/or detritus apparently forms the majority of the diet in other species. Some Antarctic species have been found to be necrophagous and can be attracted to baited traps (Arnaud, 1972).

Careful observation or experimentation is necessary to separate recurrent association from predator/ prey relationship. Consistent association of *Achelia longipes* with *Flustellidra hispida* suggested feeding by the pycnogonid on the ectoproct until Wyer and King (1973) observed the pycnogonid ignoring ectoproct zooids, and consuming red algal sporelings growing epiphytically on the colony. Consumption by *Achelia echinata* of both red and brown algae, but not bacteria or other epibionts on the algae, was demonstrated using radioactive tracers (Bamber and Davis, 1982). Where *Achelia echinata* was associated with *Bugula turbinata*, the food source was organic detritus accumulated near the colony base, not the ectoproct (Ryland, 1976).

In other cases, observation has demonstrated predator/prey relations in commonly associated organisms. Members of the genus *Pycnogonum* have, for instance, been shown to prey on anemones with which they are usually found (Gruet, 1972; Wyer and King, 1974). Preference experiments show *P. littorale* will also feed avidly on anemones not normally accessible to it (Bamber, 1985).

The actual attack on the prey usually involves the proboscis and some combination of the chelifores and palpi if they are present. Ectoproct feeders may range over the face of an encrusting colony, avoiding defensive avicularia and orienting themselves for a forced entry past the operculum and into the zoarial aperture, where the zooid is then consumed. The shape of the proboscis is usually modified in ectoproct feeders with distinct preferences for particular prey species. In species of *Austrodecus* with particularly attenuate flexible proboscides, the apparent prey has the zoarial aperture restricted by internal structures (Fry, 1965). Movements of the lips and pumping by the muscular pharynx are involved in ingestion of prey. Prey may be partially digested prior to ingestion by enzymes pushed forward from the midgut and released through the proboscis.

Cnidarian feeders tend to feed suctorially, but may also tear apart hydroid polyps with their chelae and then carry the fragments to the mouth. *Pycnogonum* feeds suctorially on anemones, and *Nymphon rubrum* pumps body fluids from the hydroid *Laomedea* after first tearing a hole in the hydroid with a chelifore (King, 1973). *Pigrogromitus timsanus* suctorial feeding on the anemone *Bartholomea annulata* is tolerated by the anemone if only a single pycnogonid is involved. Attack by multiple individuals, however, led to death of the anemone within one month (Mercier and Hamel, 1994)

Feeding habits of most California species can only be inferred from investigations on related species from other areas. Bain (1991), however, provides some direct observations on the feeding of *Anoplodactylus californicus* in captivity. Both living and dead animals were consumed. The soft-bodied opisthobranch gastropod *Berthella engeli* was immediately attacked when the pycnogonids were first introduced into an aquarium. First attack was with the proboscis unaided by the chelae, but chelae were seen carrying fragments of the mollusk prey the following day. Capture and consumption of brine shrimp was also observed. The chelae were used to rapidly snap swimming brine shrimp from the water and pass them to the mouth. The pycnogonids would also accept pieces of mussel flesh offered to them. Pycnogonids have been observed feeding on mussels *in situ* as well (Benson and Chivers, 1960), causing extensive damage to the clams. This was termed a parasitic infestation at the time, but can also be interpreted as predation.

At least some pycnogonids may be somewhat opportunistic, feeding on organisms not usually considered prey. Piel (1991) observed *Anoplodactylus carvalhoi* attack the aeolid nudibranch *Dondice occidentalis,* provoking it into defensive shedding of the finger-like processes (cerata) on its back. Ceratal autotomy is a defensive strategy of many aeolids, but in this case it failed. The pycnogonids harvested cerata from the mollusk, one in each chela, then proceeded to suck out the ceratal tissue with the proboscis. This same species also consumed small polychaetes taken from the same hydroid mass.

Symbioses

Both parasitic and commensal relationships between pycnogonids and other organisms have been reported. Commensal association is usually between pycnogonids and echinoderms, and have been reported for asteroids, ophiuroids, and echinoids. Stock (1981) found numerous *Pycnosomia asterophila* clinging to the oral surface of the starfish *Calliaster corynetes* in the Philippines, and *Decachela dogieli* has been found attached to the ambulacral groove of *Pteraster tesselatus* in the Santa Barbara Channel (D. B. Cadien, unpublished). In both of these cases, and in the observation of *Anoplodactylus ophiurophilus* on three ophiuroid species by Sloan (1979), the pycnogonids may have been feeding on the mucus produced by the echinoderm. Associations between pycnogonids and echinoids have been reported for *Pycnosomia strongylocentroti* by Losina-Losinsky (1933), and for *Anoplodactylus insigniformis* and *Ascorhynchus castelloides* by Stock (1975a), in all cases as ectocommensals clinging to the urchin test or spines.

Ectoparasitic relations with pycnogonids are reported for polychaetes, cnidarians, and mollusks. Both reports of ectoparasitism on polychaetes involve juvenile pycnogonids: *Hannonia* sp on *Audouinia australis* (Stock, 1959), and *Ammothella spinifera* on *Sabella melanostigma* (Salazar-Vallejo and Stock, 1987). Ectoparasitism on cnidarians also typically involves juvenile not adult pycnogonids. Russel (1990) reports juveniles of *Tanystylum duospinum* as ectoparasites of *Eucopella everta*, and *Ammothea hilgendorfi* juveniles endoparasitic in the same hydroid in the Central California intertidal.

Both adults and young of several species of *Pallenopsis* are associated with midwater pelagic cnidarians (Hedgpeth ,1962; Mauchline, 1984), and cnidarian tissues have been found in the gut of the pycnogonid by Child and Harbison (1986). In California waters *Anoropallene palpida* have been taken from the bell of a large undescribed medusa (Martin and Kuck, 1991). Since the medusae were in water so shallow they occasionally contacted the bottom, this may reflect only an accidental phoresy and not ectoparasitism.

Juvenile pycnogonids have been reported as either endo- or ectoparasites of a variety of bivalves, and both benthic and pelagic mollusks (summarized in Arnaud and Bamber, 1987). The only reports of parasitism by adults are those of Benson and Chivers (1960 - here considered predation) and that of Arnaud (1978) who found an adult female *Ascorhynchus endoparasiticus* nearly filling the mantle cavity of the shelled opisthobranch *Scaphander punctostriatus.*

Predators

Pycnogonids have been viewed as being incidentally consumed along with substrate (such as algae), or with other target invertebrates (Fry, 1980; Arnaud and Bamber, 1987). At least in one case, however, they are apparently actively sought by fish predators. Up to 30% (Zander and Heymer, 1992) and 40% (Krapp and Nieder, 1993) of examined guts of several Mediterranean blennioid fish species contained pycnogonids. Blennioid fishes have also been reported to take pycnogonids in the northeast Atlantic (Gibson, 1972), and in the Gulf of California (Kotrschal and Thomson, 1986). Further investigations may find similar patterns of predation by some groups of specialized vertebrates or invertebrates.

With their thick cuticle pycnogonids are probably not normal prey of most small invertebrates. Larger invertebrates, which are either strong enough to dismember pycnogonids or consume them whole, require protection beyond that offered by the cuticle alone. Ecdysteroids used normally in control of growth, molting, and gametogenesis by *Pycnogonum littorale* are also released as a feeding deterrent in response to molestation by potential predators (Tomaschko, 1994b). They effectively deter predation by *Carcinus maenas*, leading within seconds of release to the suspension of feeding by the crab (Tomaschko, 1994a). Chemical defenses have yet to be demonstrated for other pycnogonid species.

Collection and Preservation

Few pycnogonids are taken on soft substrates compared to the number that frequent rocks and their associated epibiota. In the deep-sea soft substrate forms are more common, as the lightweight pycnogonid body is well suited to the muds and clays of deep basins. As these forms tend towards large size, they can be individually harvested from grab samples or trawls. In shallower areas soft bottom pycnogonids are usually smaller, although some nymphonids reach relatively large sizes. Such forms are still not likely to be noted among the screenings of benthic grab samples and will probably only be found during processing of preserved samples.

Samples collected remotely from offshore rock substrates, either by directly in scrapings, or indirectly on collected rocks, are likely to yield at least some pycnogonids. Again, these cryptic organisms will probably only be detected during laboratory processing of field collections.

Although the strong thigmotaxis of pycnogonids, combined with their gangly body form, makes relaxation in isolation desirable prior to fixation, it is usually not possible . Relaxation of bulk samples with propylene phenoxytol or magnesium chloride prior to fixation may help prevent damage to pycnogonids they contain. Most arthropods have less damage and leg loss in samples where relaxing agents have been added prior to preservation. Collected pycnogonids do not require different fixation from other benthic forms; fixation in 10% buffered seawater formalin being recommended. After a 24 to72-hour fixation period, samples should be washed in freshwater until the formalin is removed, and preserved in either 70% isopropyl or ethyl alcohol.

Laboratory Methods

Particular care must be exercised in the removal of pycnogonids from debris and other organisms in bulk samples. Their eight legs are usually spread in such a way that as soon as one leg is freed from entanglement, two more become caught. Application of force to extricate tangled specimens will usually result in lost legs, or loss of terminal claws. It is beneficial to place a pycnogonid, once finally extricated from all entanglements, in a separate vial. Placing it in a vial with other arthropod specimens will only result in re-entanglement, especially if more than one pycnogonid is involved. When live, pycnogonids are strongly thigmotactic, and will gather together in a ball of embracing arms. Somehow this tendency seems to persist even in preserved specimens.

Once a single animal has been separated it should be examined with a dissecting microscope. Availability of magnifications up to 100x is generally advisable, because details of propodal spination usually require close examination. Adequate lighting is a necessity, with both fiber optic illumination, and dark field substage lighting advantageous. Where possible, the animals should be examined entire, with disarticulation of appendages undertaken only if absolutely necessary. It may be necessary to gently brush debris from the specimen with an extra fine sable or camel hair artists brush during the examination.

A few very small species, such as *Rhynchothorax philopsammum* can be usefully examined in whole mount under a compound microscope. The animal should be protected from crushing by the coverslip either by use of a depression slide, or through use of wedges (coverslip fragments, bits of clay or sand, etc.) to provide additional space between slide and coverslip. Fine detail of legs of larger species (such as femoral cement gland shape, or propodal armament) can also be examined in this manner. Specimens should be temporarily mounted in glycerol for examination, then removed and returned to preservative for maintenance. Rather than preparation of permanent slides for small specimens or body parts, these should be kept in small vials associated with the main sample. Rubber or silicone stoppered glass insect genitalia vials provide safe storage, and are recommended for retention of small disarticulated parts.

Since all characters of taxonomic importance in pycnogonids are external, clearing and staining are not necessary for species determination.

Glossary

Abdomen. Last body segment. Articulated or fused to the posterior end of the last thoracic segment. Often bent dorsally if elongate, and usually continuing any dorsal ornamentation of the thorax. Bears the anus at its terminus.

Auxiliary claw(s). Secondary claws (one or two) which may be present behind the primary claw; they may be larger, but are usually smaller than the primary claw.

Cephalic hood. An anterior prolongation of the ocular tubercle over the attachment points of the proboscis, chelae, and palpi in some species.

Chela(ae). Paired pincer-like structures flanking the proboscis and borne on a one or two-segmented scape. A chela has a fixed basal segment and a moveable terminal segment (finger). In some families they are degenerate in the adult; reduced to knobs at the end of the scape.

Chelifore(s). The first pair of cephalic appendages, which bear the chelae at their ends. Formed of a basal scape of one or two segments, and the chelae (unless lost or reduced). Attached on the dorsal side of the proboscis just behind its insertion on the cephalon.

Coxa(e). The first three segments of the walking legs (first, second, and third coxae). The first coxa is attached to the lateral process of the body, and the third is attached to the proximal end of the femur. Usually short relative to the femur and tibiae. In the female the gonopore is typically located anteroventrally on the second coxae of the walking legs.

Cruriger(s). See **Lateral processes.**

Denticulate spines. Spines which bear lateral denticles. Often located on the strigillus, or on the chelae, but occasionally on the walking legs.

Femoral cement gland(s). Glands located in the femur of the males of many species which secrete a sticky mucus used to form egg balls carried by the ovigers, or to stick eggs to other substrates. Usually a single exit pore which may be raised on a tubercle, or prolonged into a tube. In Colossendeidae usually numerous simple pores flush with the segment surface.

Femur(ae). Fourth segments of the walking legs. Attached proximally to the ends of the third coxae and distally to the first tibia. In some cases, males bear one or more cement glands in the femur. Used by females of many species for storage of eggs prior to their release and inflated as a result.

Genital pore(s) See **Gonopores.**

Gonopores. Openings of the male or female reproductive system, usually located on the second coxae of one or more pairs of legs.

Heel. Tarsus of the walking legs, often bearing large spines.

Lateral processes. Lateral extensions of the body (either cephalon or thorax) to which the first coxae of the walking legs are attached.

Ocular tubercle. Dorsal hump or tubercle on the cephalon which bears the eyes. Typically near the middle of the cephalon, exceptionally near its anterior or posterior edges. May be extremely tall to nearly absent.

Oviger(s). Third cephalic appendages (although one or both of the first pairs may be absent) which originate ventrally just in front of the first leg pair. May be used for egg carrying in male, and as grooming appendages in both sexes.

Palp(s). Second cephalic appendages (first pair may be absent) which originate lateral to the proboscis near its base.

Primary claw(s). Moveable sickle shaped structure(s) which form the last segment of the walking legs. Usually with one or two auxiliary claws near the attachment of the primary to the propodus. Exceptionally reduced or absent .

Proboscis (ides). Muscular bulbous, tubular, or cone-shaped organ bearing the mouth at its end and attached to the cephalon along the midline of the body. Usually points anteriorly, but is bent down or even under the body in some species.

Propodus. The eighth (penultimate) segment of the walking leg. Attached proximally to the tarsus, and distally to the primary claw. Usually curved and bearing spines and/or a blade of fused spines on its concave surface.

Strigillus(ae). The modified four terminal segments of the ovigers. Curved inward into a near circle, and bearing modified spines on the concave side. Used in grooming of legs.

Tarsus. The seventh segment of the walking legs. Attached proximally to the second tibia and distally to the propodus. Usually a small segment with a short anterior and long posterior margin; seldom ornamented with tubercles or spines.

Terminal claw(s). See **Primary claw(s).**

Tibia(e). The fifth (first tibia) and sixth (second tibia) segments of the walking legs. Often elongate in long-legged species, and often bearing setae, tubercles or spines. The first tibia is attached proximally to the femur, the second tibia distally to the tarsus.

Tubercle(s). a rounded to sharply pointed outgrowth of the cuticle, sometimes bearing setae or spines at its apex. Tubercles can occur on all portions of the body and walking legs, with the exception of the proboscis.

Key to the Pychnogonids of California

The present key is based on those previously presented by Child, 1979; Hedgpeth, 1941b; and Hedgpeth, 1975. Species reported or known to occur from intertidal to upper slope depths in California are included. Those marked with an asterisk (*) were not taken in the present collection, and are not described in the text. They are included to increase the utility of the key, which otherwise would include only one-quarter of the species one might encounter in California waters. Species from basin and lower slope depths are not treated here (see Child, 1994, for information on this deep-water fauna).

1A. Chelifores and palps present; ovigers in both sexes 2
1B. Chelifores and/or palps absent or greatly reduced; ovigers in both sexes or male only 4

2A. Chelifores and/or chelae vestigial in adult; palps 4 to 10-segmented - Family Ammotheidae 8
2B. Chelifores and chelae well developed in adult; palps 4 to 5-segmented - Families Nymphonidae and Callipallenidae (in part) 3

3A. Palps 5-segmented, ovigers 10-segmented - Family Nymphonidae 29
3B. Palps 4-segmented, ovigers 9-segmented .... *Anoropallene palpida**

4A. Palps present - Families Colossendeidae and Rhynchothoracidae 5
4B. Palps absent 6

5A. Proboscis longer than body, fusiform; ocular tubercle tall, eyes well developed; auxiliary claws lacking on legs .... *Hedgpethia californica** (Family Colossendeidae)
5B. Proboscis shorter than body, widest near base and tapering distally; ocular tubercle a low anoculate boss; short auxiliary claws present on legs .... *Rhynchothorax philopsammum*

6A. Chelifores absent - Family Pycnogonidae 31
6B. Chelifores present - Families Callipallenidae (in part) and Phoxichilidiidae 7

7A. Ovigers in both sexes, 10-segmented - Family Callipallenidae (in part) 32
7B. Ovigers in male only, 5 to 6-segmented - Family Phoxichilidiidae 35

8A. Body circular or discoidal, lateral processes touching or only narrowly separated distally; chelifore scape 1-segmented; palps 4 to 8-segmented 9
8B. Body more slender, lateral processes separated for at least half their length or widely separated; chelifore scape 1 or 2-segmented; palps 9 to 10-segmented 10

9A. Palps 8-segmented; chelae vestigial; proboscis pyriform; 1st and 2nd coxae with tall dorsolateral tubercles .... _Achelia_* 14

9B. Palps 4 to 7-segmented; chelae usually absent, scape reduced to short knob; proboscis a tapering cylinder or tubular; 1st coxae only with low rounded tubercles .... _Tanystylum_* 20

10A. Proboscis 2-segmented, a proximal cylinder articulated with a distal pyriform segment .... _Eurycyde spinosa_

10B. Proboscis 1-segmented, pyriform, ovoid, or cylindrical 11

11A. Palps 9 or 10-segmented; chelifores inserted at anterior margin of cephalon 12

11B. Palps 8-segmented; chelifores and palps inserted underneath anterior margin of cephalon .... _Prototrygaeus jordani_

12A. Proboscis ovoid or modified cylindrical; palps 9-segmented 13

12B. Proboscis pyriform; palps 9 or 10-segmented .... _Ammothella_* 24

13A. Proboscis ovoid; trunk with spiny median tubercles; legs with tall setose tubercles; chelifores 3-segmented; abdomen long, bent posteriorly .... _Nymphopsis spinosissima_*

13B. Proboscis cylindrical, ends constricted; lacking median tubercles; chelifores blunt, 1-segmented; abdomen short, blunt .... _Ammothea hilgendorfi_*

14A. Chelae lacking in adult 15

14B. Chelate in adult .... _Achelia chelata_*

15A. Trunk and legs conspicuously spinose, with small spinose tubercles on 1st coxae 16

15B. Trunk and legs at most slightly spinose; 1st coxae lack spinose tubercles, but may bear finger-like spurs 17

16A. Terminal segments of palps with ventral lobes .... _Achelia spinoseta_*

16B. Terminal palp segments subcylindrical, lacking ventral lobes .... _Achelia echinata_

17A. First coxae with fingerlike dorsal processes; propodus with basal spines; palps 8-segmented 18

17B. First coxae lack fingerlike processes; no large basal spines on propodus; palps 7-segmented 19

18A. Processes on 1st coxae three-quarters coxa length; proboscis narrowly elliptical .... _Achelia gracilipes_*

18B. Processes on 1st coxae less than half coxa length; proboscis broadly elliptical _Achelia alaskensis_*

19A. Chelifore with conspicuous dorsal tubercles .... _Achelia latifrons_*

19B. Chelifore smooth, without dorsal tubercles .... _Achelia simplissima_*

20A. Proboscis tapered to a point; body not particularly compact 21
20B. Proboscis rounded; body very compact .... *Tanystylum occidentalis**

21A. Without spines on body or lateral processes; proboscis bluntly pointed .... *Tanystylum nudum**
21B. Lateral processes with spines or tubercles; proboscis acutely pointed 22

22A. Fourth palp segment with medial proximal tubercle .... *Tanystylum californicum**
22B. Fourth palp segment lacking proximal tubercle 23

23A. Lateral processes bearing sharp spine-like tubercles; auxiliary claws nearly half length of primary claw .... *Tanystylum intermedium**
23B. Lateral processes without spine-like tubercles; auxiliary claws only one-fourth length of primary claw .... *Tanystylum duospinum**

24A. Legs with both primary and auxiliary claws well developed 25
24B. Primary claw absent or vestigial .... *Ammothella biunguiculata**

25A. Second segment of chelifore scape clavate 26
25B. Second segment of chelifore scape linear 28

26A. Ocular tubercule height several times diameter; lateral processes separated by one-fourth their width or more 27
26B. Ocular tubercle about as wide as tall; lateral processes touching or nearly touching .... *Ammothella tuberculata**

27A. Single tubercles mid-dorsally .... *Ammothella menziesi**
27B. Paired hollow tubes mid-dorsally .... *Ammothella spinifera**

28A. Lateral processes each with single smooth projection; abdomen lacking spines or tubercles .... *Ammothella setosa**
28B. Lateral processes each with multiple spined tubercles; abdomen with spined tubercles .... *Ammothella killix**

29A. Ocular tubercle located about midlength on cephalon, preceeding insertion of ovigers, and well before first leg pair .... *Nymphon stipulum**
29B. Ocular tubercle located above or slightly behind insertion of ovigers, and next to first leg pair . 30

30A. Tarsus slightly longer than propod; terminal oviger spine nearly equal to length of terminal segment .... *Nymphon heterodenticulatum*

30B. Tarsus more than twice propod length; terminal oviger spine half length of terminal segment or less .... *Nymphon pixellae*

31A. Body unicolor; dorsal tubercles short, about as tall as basal diameter .... *Pycnogonum stearnsi**

31B. Body reticulate; dorsal tubercles tall, height greater than basal diameter ..... *Pycnogonum rickettsi*

32A. Chelae with serrate or denticulate fingers; auxiliary claws present on legs .... *Callipallene* 33

32B. Chelae with smooth fingers; auxiliary claws lacking .... *Decachela** 34

33A. Segmentation of thorax incomplete .... *Callipallene californiensis**

33B. Segmentation of thorax complete .... *Callipallene pacifica*

34A. Thorax and legs not conspicuously spinose .... *Decachela discata**

34B. Thorax and legs heavily spinose .... *Decachela dogieli**

35A. Cephalon projecting over proboscis forming long neck (except in *A. viridintestinalis*); oviger 6-segmented, with terminal segment very small .... *Anoplodactylus* 36

35B. Cephalon not elongated anteriorly into neck; oviger 6-segmented, with terminal segment partially or completely fused to 5th segment .... *Phoxichilidium** 41

36A. Cephalon only slightly overhanging proboscis .... *Anoplodactylus viridintestinalis**

36B. Cephalon extended forward over proboscis forming long neck 37

37A. Lateral processes separated at base 38

37B. Lateral processes contiguous at base, body very compact .... *Anoplodactylus californicus**

38A. Lateral processes and first coxae each with a pair of tubercules .... *Anoplodactylus oculospinus*

38B. Lateral processes and first coxae each with one tubercle or none 39

39A. Tibiae and femur of legs with prominent nodulation .... *Anoplodactylus nodosus**

39B. Tibiae and femur of legs not conspicuously nodose 40

40A. Lateral processes with a single dorsal tubercle .... *Anoplodactylus erectus*

40B. Lateral processes lacking dorsal tubercles .... *Anoplodactylus pacificus*

41A. With small knobs (vestigial palps) just posterior to chelifores .... *Phoxichilidium parvum**

41B. Without vestigial palp knobs posterior to chelifores .... *Phoxichilidum femoratum**

Description of Species

Family Ammotheidae

Achelia echinata Hodge 1864

Figure 1.5

Achelia echinata Hodge, 1864:115; pl. XII, figs. 7-10.—Hilton, 1943a:94-95.—Utinomi, 1954:11-14, figs. 4-5;1959:201-202, fig. 1—King, 1974:28, fig. 11.—Lissner *et al.*, 1986:D-26.

Ammothea echinata Bouvier, 1923:55-57, fig. 55.

Material Examined. California, off Morro Bay, Sta. 6 (1).

Description. Thorax compact, circular; lateral processes short, subequal in length, little separated, bearing 2 dorsal tubercles near ends. Thoracic segmentation well defined to nearly absent. Abdomen about equal in length to cephalon, angled upward, slightly larger in diameter terminally.

Proboscis longer than cephalon, about equal to thorax in length; conical, widest at about two-thirds of length.

Neck nonexistent. Ocular tubercle low, height about twice basal diameter; 2 pairs of eyes borne near top. A pair of laterally directed tubercles at base of ocular tubercle, larger and more attenuate in male.

Chelate only in juvenile, although scape retained in adult with chela reduced to small terminal knob. Chelifore extending one-half to two-thirds length of proboscis. Scape bearing variable number of spines and tubercles dorsally. Palpi 8-segmented, with final 4 segments setose; segment 2 longest, segment 4 somewhat shorter, with remaining segments much shorter and subequal.

Ovigers 9-segmented in both male and female, but slightly smaller in female; both sexes with well-developed strigillus bearing digitate spines. Few setae except on strigillus. Segments 1 and 4 longest; remainder somewhat shorter and subequal.

Legs not particularly long (about 3 times width of thorax), length about 10 times diameter, spiny, spine pattern variable. Coxa 1 about 2 times length of other coxae; femur and tibia 2 subequal, about twice length of coxa 2. Tibia 1 intermediate in length between coxa and femur. Tarsus about one-fifth tibia 2 length; propod about two-thirds length. Terminal claw about one-half propod length; auxiliaries between one-half and two-thirds length of primary, longer in male.

Coxa 1 bearing pair of tubercles in male, only one in female; male genital pore situated at end of a large genital spur on second coxae of third and fourth legs. Female pore not elevated; second coxa broadened distally. Femoral cement gland of male not prominent. Tarsus armed with 3 or 4 spines ventrally. Heel of propodus weak, scarcely differentiated from rest of segment, bearing 3 to 4 large spines; about 10 sole spines; no lamina.

Biology. *Achelia echinata* is a widely distributed species associated with sponges, hydroids, ectoprocts, and algae (Peattie and Hoare 1981). The species feeds on hydroids (Wyer, 1972), ectoprocts (Wyer and King, 1973), algae (Bamber and Davis, 1985), and detritus (Ryland, 1976). The unspecialized diet and association with fouling organisms, may account for its wide distribution in the northern hemisphere.

Remarks. The examined specimen is not typical for the species. The cephalic tubercles are more slender and acute than usual, the chelifore scapes bear dorsal tubercles, and the lateral margins of the coxae are very setose. The combination of these characters is reminiscent of *Achelia salebrosa* (Losina-Losinsky, 1961). Widely-distributed species should be more polymorphic than those with narrowly constrained niches

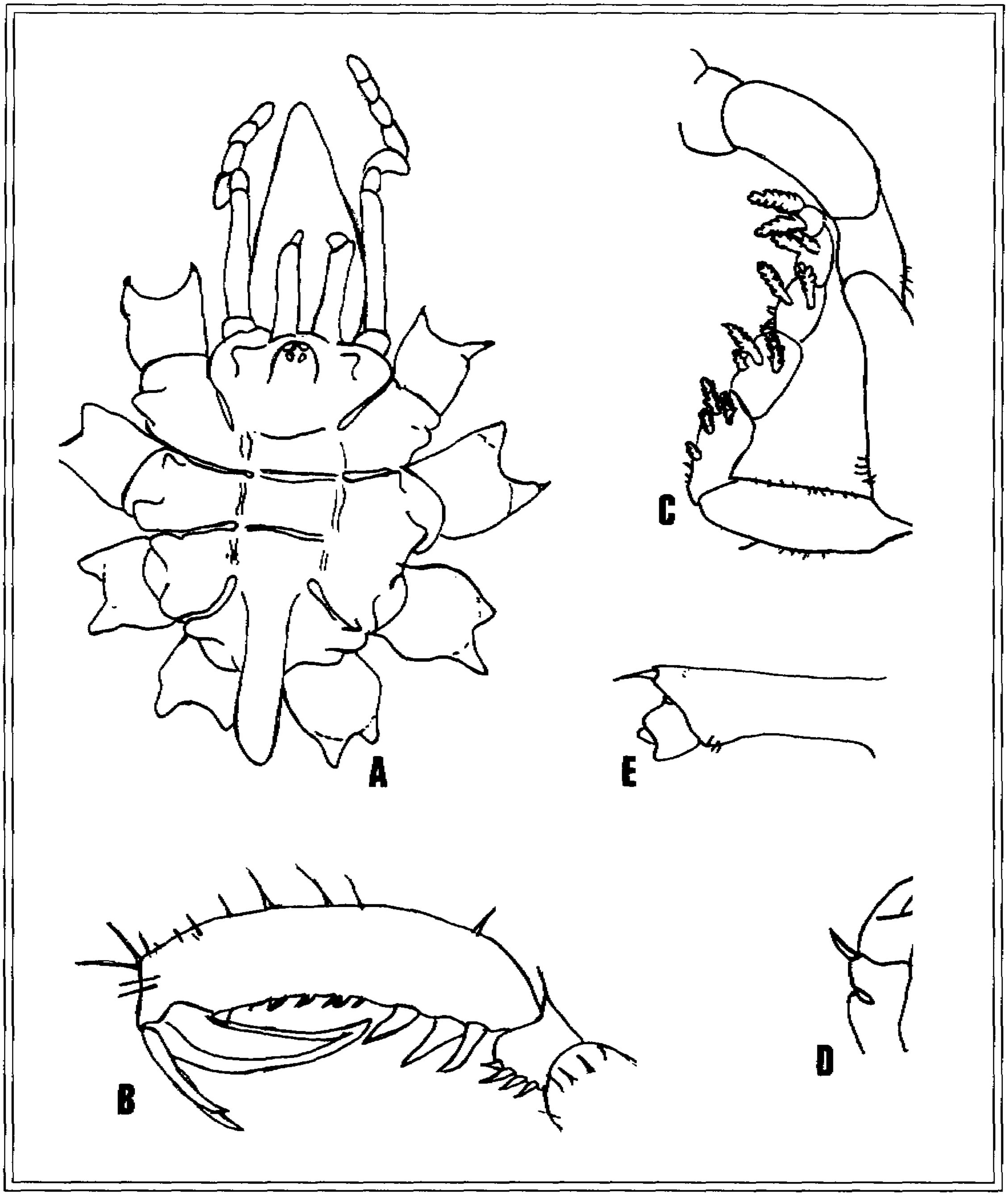

Figure 1.5. *Achelia echinata*; A. body, dorsal, B. terminal claw, C. female oviger, D. juvenile chela, and E. adult chela (all after Utinomi, 1954).

and distributions. Such variation has been documented for *A. dohrni* by Clark (1971), and the *A. echinata* illustrations of Utinomi (1954) show an animal differing in some respects (especially proboscis shape) from North Atlantic material (King, 1974). Alternatively, an unresolved species complex may exist. In England, *A. echinata* has been reliably differentiated from several similar species. North Pacific material has yet to be critically examined to determine the limits of variation in this and related species. Additional specimens from the northeast Pacific with the same or similar variations from typical *A. echinata* should prompt re-evaluation of this specimen, which may represent a new species.

Type Locality and Type Specimens. Not designated by Hodge (1864).

Distribution. North Atlantic; Mediterranean; Alaska, Hawaii; California, San Francisco to San Diego; intertidal-109m.

Eurycyde spinosa Hilton 1916a

Figure 1.6

Eurycyde spinosa Hilton, 1916:19-24, figs. 1-6;1939:72, fig. 11;1943a:98.—Hedgpeth, 1941b:254, pl. 9.—Lissner *et al.*, 1986:D-26.

Material Examined. California: off Morro Bay, Sta. 27 A/B (1); Santa Maria Basin, off Purisima Pt. Sta. 20 A/B (3).

Description. Thorax compact, nearly circular; segmentation complete, distinct; lateral processes of moderate length, separated by less than their diameter, divergent, and broadening distally. Abdomen longer than cephalon, slightly longer than lateral processes of fourth legs; borne vertically over last thoracic segment. Swollen at about 80% of length, with abdomen diameter increased by nearly half. A corona of 4 long spines (length 4 times abdomen diameter) directed anterolaterally on the swelling. Beyond abdomen tapering rapidly to rounded tip.

Proboscis with 2 joints, with bulbous terminal segment connected to narrow cylindrical pedicel, as typical of genus. Pedicel as long as cephalon; terminal proboscis segment half again as long, its greatest diameter about one-third segment length from pedicel, tapering evenly from that point to bluntly rounded tip. Second proboscis segment bent downward and to rear under body.

Neck very short and broad, half length of rest of cephalon. Ocular tubercle at base of neck, just behind insertion of palps; height two and one-half times basal diameter, with 2 equal pairs of eyes just below midpoint. Ocular tubercle topped by 3 dorsally directed spines shorter than those on abdomen.

Chelifore scape 2-segmented, with chelae nonfunctional in adult; fingers lost and palm reduced to stub bearing 2 terminal spines. Scape basal segment smooth, without tubercles or setae; segment 2 with series of sharply pointed tubercles, 3 on segment dorsal midline, 1 ventrolateral, and 1 at distal edge of segment at base of chela stub. Palp 9-segmented, slender, about double length of pedicel, but shorter than combined proboscis length. Basal segment, and segments 3, 5, 6, and 8 subequal. Segment 2 about 5 times, segment 4 three times their length. Segments 7 and 9 slightly shorter than segment 8. Last 5 segments setose dorsally.

Oviger 10-segmented, about as long as thorax. Segments 1-3 short and subequal; segments 4 and 5 subequal and equal to combined length of first 3 segments. Segments 6 through 10 successively shorter; segment 10 bearing pair of large simple spines at its end. Segments 7-10 bearing a double row of denticulate spines.

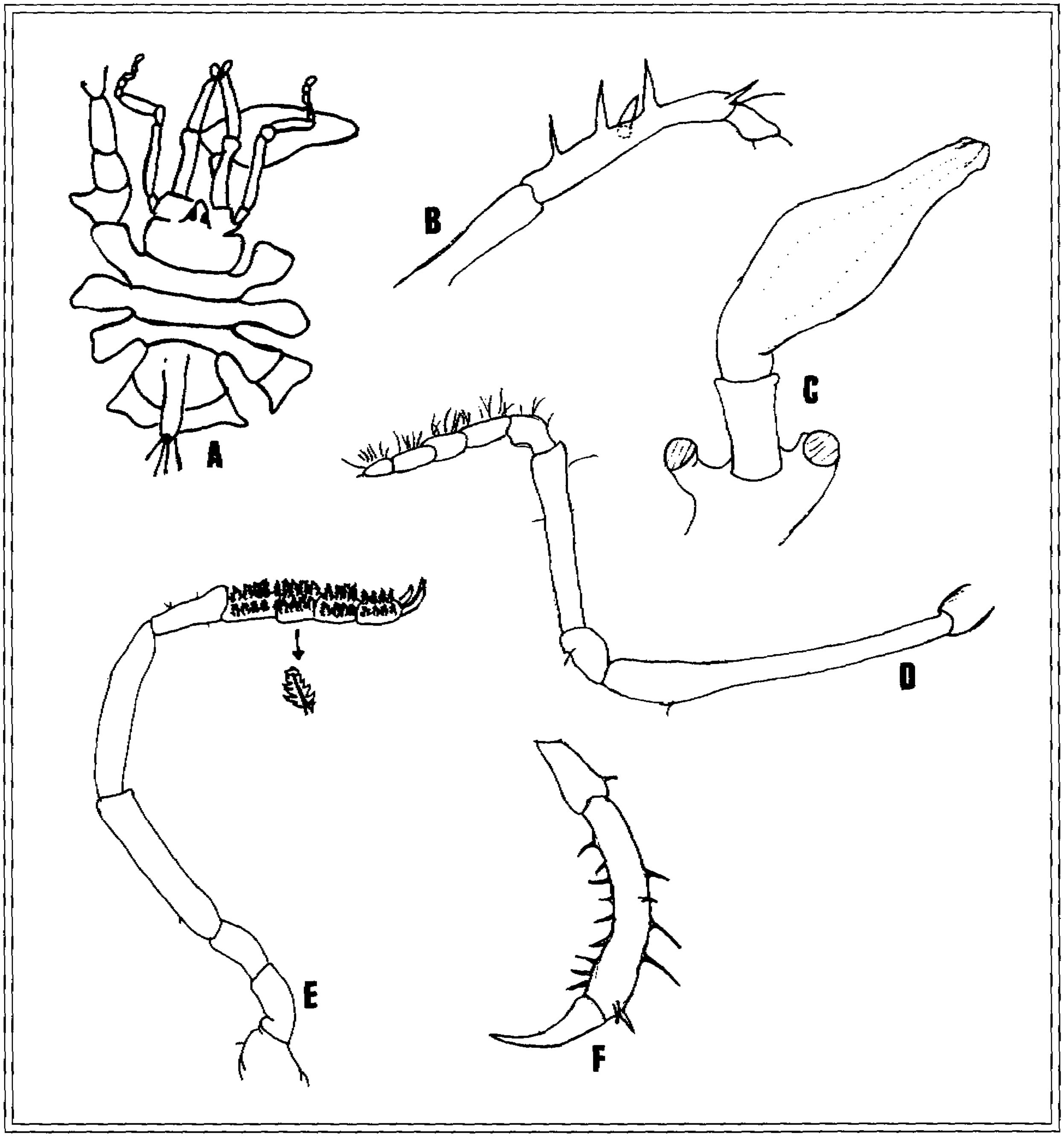

Figure 1.6. *Eurycyde spinosa*; A. body, dorsal (after Hedgpeth, 1941b), B. chelifore, C. proboscis, D. palp, E. oviger, and F. terminal claw.

Legs slender, length 25 times diameter. Coxa 2 twice length of coxae 1 and 3, and half femur length. Femur four-fifths length of tibia 1, and three-quarters length of tibia 2; tarsus equal to coxa 1 length, propod 3 times tarsus length. Propod lacking heel and lamina, with about 9 sole spines, and 3 longer dorsal spines. Terminal claw strongly tapering, about half propod length; no auxiliary claws

Biology. The broad bathymetric occurrence of this species may indicate a lack of habitat specificity. The present specimens were taken from small rocks that were retrieved with a submarine. The species has also been collected among *Zostera* roots (Hilton, 1939). No direct observations of feeding in *Eurycyde spinosa* have been reported. Absence of functional chelae in the adult, the terminally narrowed bulbous proboscis born on a basal pedicel, and the well developed palps suggest this is an ectoproct feeder. Collection among eel-grass roots suggests that detritus may also serve as a food source.

Type Locality and Type Specimens. Types were collected intertidally at Laguna Beach, California, and deposited at Pomona College, California.

Distribution. California: Morro Bay to Laguna Beach; intertidal-117m.

Prototrygaeus jordani Child 1990a

Figure 1.7

Prototrygaeus jordani Child, 1990a:157-160, fig. 1.

Ammotheidae Genus A sp. A Lissner *et al.*, 1986:D-26.

Material Examined. California: eastern Santa Barbara Channel, between Santa Cruz and Anacapa Islands, BLM Sta. 24848 (1).

Description. Thorax slender, longer than wide; lateral processes slender, each as long as thorax, approximated basally, but diverging over length, with large tapering tubercle distally; thoracic segmentation incomplete. Abdomen about as long as cephalon, held nearly vertically, slightly broadened distally, with a few distal setae.

Proboscis nearly twice length of cephalon; inserted ventrally with insertion overhung by anterior edge of cephalon; sharply angled down, cylindrical, blunt, slightly narrowed distally. Neck very short, broad, not differentiated from rest of cephalon. Ocular tubercle shorter than abdomen, about twice basal diameter in height, with 2 pairs of eyes near top, anterior pair slightly distal to posterior pair.

Scape of chelifore 2-segmented, inserted beneath overhanging front of cephalon, and extending to end of proboscis. Chela nonfunctional in adult, with fingers lost and palm reduced to nub at end of scape. Basal scape article about half length of clavate second article. Second article with 2 distal setae; chela with 1; chelifore otherwise bare of setae.

Palp with 7 articles, fourth longest, article 2 slightly shorter, and remaining 5 one-quarter the length of article 2. Only last 4 segments setose. Palps, like proboscis and chelifores, inserted underneath overhanging anterior cephalon margin.

Ovigers 10-segmented in both sexes, with that of male considerably larger. Male oviger segments 4 and 5 each shorter than segment preceding them, segments 2 and 3 subequal and longer than others. Basal segment about half length of segment 4. Segments 6-10 decreasing in length; segment 10 very short and bearing 2 curved tridentate spines, central tooth longest. Segment 9 lacks spines or setae, segments 6-8 bear setae longer than segment diameter. Female oviger with fourth and fifth segments subequal and longest, articles 1-3 subequal and shorter than 4 and 5; strigillus with few setae, articles 8 and 9 each with pair of non-digitate spines, article 10 with 1 pair.

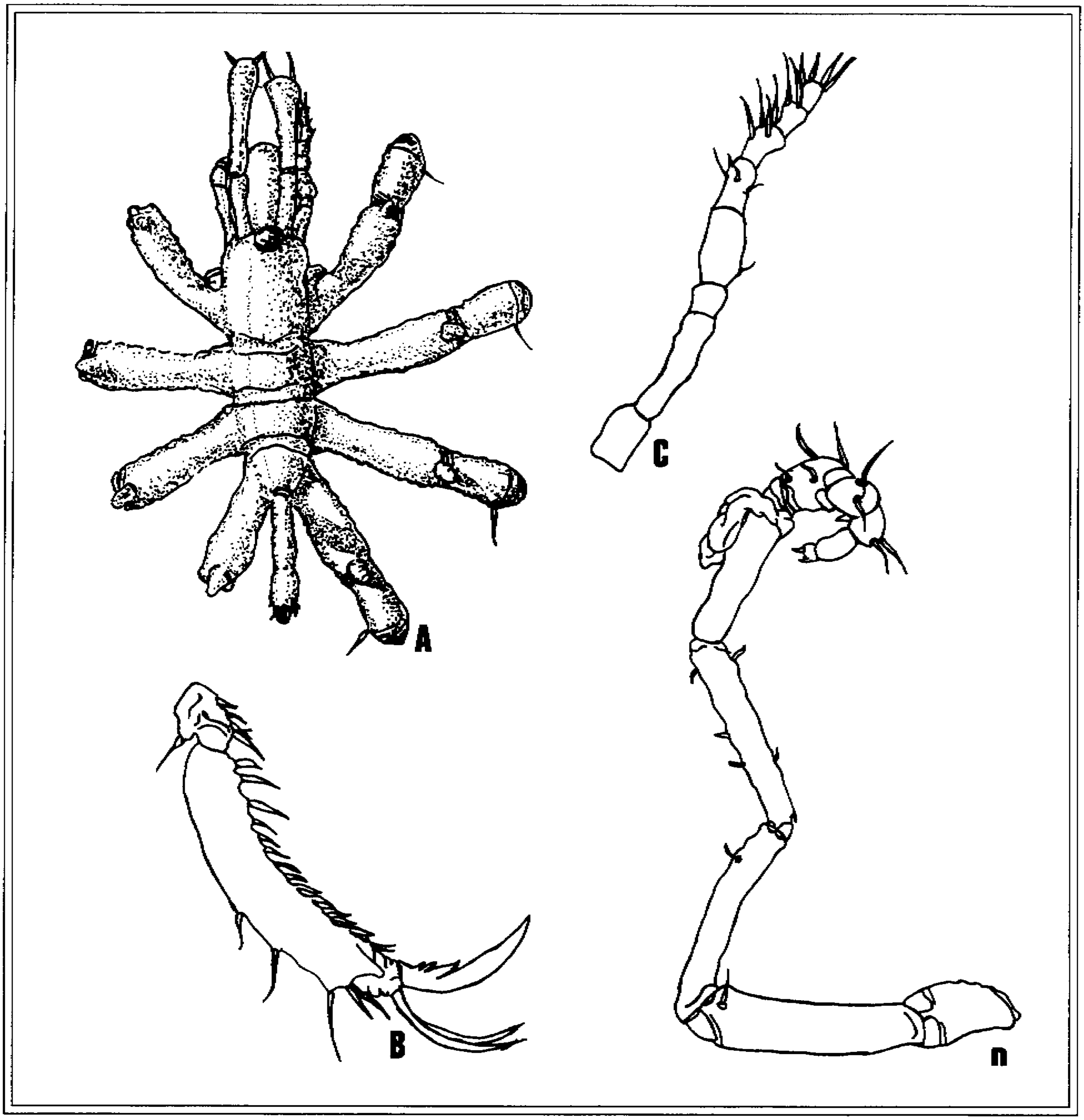

Figure 1.7. *Prototrygaeus jordani*; A. body, dorsal, B. terminal claw, C. palp, and D. oviger (after Child, 1990).

Legs of moderate length (about 3 times thorax width), appearing long because of elongate lateral processes. First coxa about two-thirds length of coxae 2 and 3. Female genital pores ventrodistal on coxa 2 of all legs. Femur and tibiae subequal, each about twice length of last 2 coxae. Tarsus short, less than one-quarter length of propodus. Terminal claw about half length of propod, which is two-thirds length of long segments. Articles increasingly setose distally; first coxa bearing only 1 long seta. Femoral cement gland distal, with short tapering duct. Terminal claw with 3 basal denticles on concave face, distally increasing in size. Auxiliary claws nearly length of primary; slender. Propod heel poorly marked, with 3 large spines; sole with 12-13 anteriorly curved spines.

Biology. The species was found to co-occur with *Anoplodactylus erectus* in Monterey Bay, and may have similar habitat requirements. The species has only been taken with remote gear (epibenthic sled, grab sampler), and has not been observed in aquaria. Hydroids are numerous on the soft bottom from which the types were collected, and may represent its food.

Remarks. The single specimen examined came from a sample collected off the north side of Anacapa Island during the BLM study of 1976-79. It was not taken either further to the west in the Santa Barbara Channel, or in the Santa Maria Basin, although many samples were collected from it's reported bathymetric range. The species has been seen further south in the Southern California Bight, but no definite southern range limit has been established. This is the second species in the genus, which was established by Stock (1975a) for the similar Caribbean *Prototrygaeus ammothelloides.*

Type Locality and Type Specimens. Holotype male (USNM 234509); paratypes 1 female, 1 juvenile (USNM 234510), on soft sediments with hydroids, mollusks, and wood debris, Monterey Bay, California.

Distribution. California: Monterey Bay to the eastern Santa Barbara Channel; 50-70m.

Family Rhynchothoracidae

Rhynchothorax philopsammum Hedgpeth 1951

Figure 1.8

Rhynchothorax philopsammum Hedgpeth, 1951:111-115, pl. 3;1975: 418; 421; 424; pl. 101, fig. 15.—Krapp, 1973:123.—Clark, 1976:295.—Child, 1979:72.—Lissner *et al.*, 1986:D-26.

Material Examined. California: Santa Maria Basin, off Purisima Pt., Sta. 16 A/B (6).

Description. Thorax compact, elongate, segmentation well defined, with short lateral processes separated by less than their diameter and diverging distally. Integument with a granular texture caused by presence of numerous tiny pearl-like rounded processes. Abdomen horizontal, bluntly tubular, short, only about half cephalon length. Cephalon and thorax subequal in length.

Proboscis about as long as cephalon, widest just above base, and tapering to broad conical tip. Neck broad, short, with pair of processes on anterior lateral corners bearing palps. Ocular tubercle and eyes absent, but in large specimens a low anoculate boss located dorsally near anterior margin of cephalon between 2 stubby anteriorly directed tubercles. Two smaller acute tubercles located behind and slightly lateral to boss.

Chelifores absent in adult, but may be present in juveniles. Palpi 4-segmented; segments 1 and 3 longest, subequal; extending to end of proboscis. Attached basally to lateral projection from cephalon with dorsal tubercle at midlength; segment 3 with setose tubercle dorsally near end. Terminal segment distally rounded, expanded dorsally, ending in setal brush.

Ovigers similar in both sexes, with 10 segments and terminal claw; lacking setae. Segments 4-6 somewhat longer than others; first six segments smooth, segments 7, 8, and 9 with 2 distally directed spines; segment 10 terminating in large claw, fitting into pocket at end of segment.

Leg length about 3 times width of thorax, with sparse short setae, and single long spine near ends of femur and tibiae. Coxae 1 and 3 subequal in length, and half as long as coxa 2. Femur and tibiae subequal and about half again as long as coxa 2. Tarsus short, about one-fifth the length of propodus or coxa 2. Propodus only slightly curved, covered with short setae, with about 7 sole spines. Heel not defined, without enlarged spines at proximal end of propod. Terminal claw robust, terminally hooked; auxiliaries about half

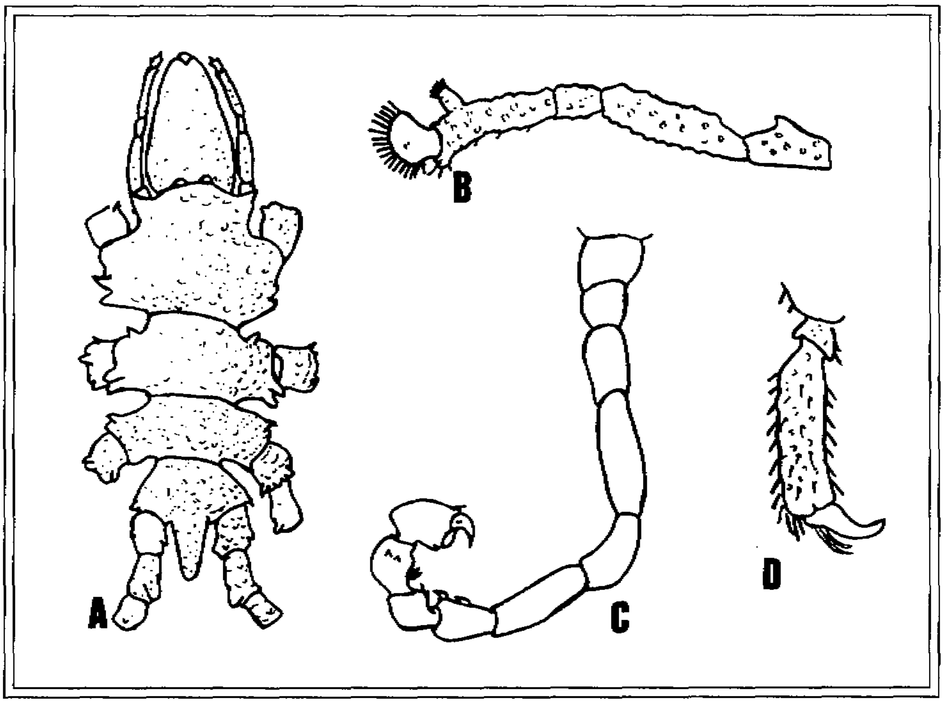

Figure 1.8. *Rhynchothorax philopsammum*; A. body, dorsal, B. palp, C. oviger, D. terminal claw (after Hedgpeth, 1951).

length of primary and less curved. Lateral process of first and second legs with pair of tubercles posterodistally; legs 3 and 4 with an anterior tubercle on lateral process; in large males a smaller posterior tubercle may also occur. Female with genital pore projecting posterodorsally as a spur on coxa 2 of fourth leg; male with corresponding spur posteriorly on coxa 2 of third leg.

Biology. This small species was originally described from under 5-6 inches of coarse intertidal sands, and is considered to be one of the three true interstitial forms in the genus (Clark, 1976). The attenuate shape, lack of eyes, and small size are all specializations for this habitat. It is assumed that the species was living in sand pockets on the rocks recovered off Purisima Pt. This is only the third time the species has been reported, and the first time it has been reported offshore. In addition to the type collection, specimens were taken in the Gulf of Tehuantepec, southern Mexico (Child, 1979). These were shore and shallow water collections from intertidal rocks and coral rubble (Fraser, 1943). Child (1979) mentioned further unaccessioned lots of this species from southern California in the collections of the National Museum of Natural History, but provided no further details.

Remarks. Several points in the original description were misleading or inaccurate. Child (1979) reexamined the type, and clarified the structure of the palp. Hedgpeth originally described it as five-segmented. Child found the basal "segment" not to be separated from the cephalon by a suture line, concluding it was actually a process to which the palp was attached. Similarly, while illustrating a 10-segmented oviger, Hedgpeth described it as 9-segmented in the accompanying text. As pointed out by Child (op. cit.), the supposed chelifores mentioned by Hedgpeth are really tubercles at the anterior rim of the cephalon. In a particularly large female from the present collections a second set of small cephalic tubercles was located. It is unlikely these were overlooked by Child, and must be assumed to be of variable occurrence, or restricted to the largest individuals.

Type Locality and Type Specimens. Holotype female (USNM 91245), 2 paratype females (USNM), 1 paratype female (Pacific Marine Station, Dillon Beach); Tomales Bluff, opposite Dillon Beach, Tomales Bay, California.

Distribution. Tomales Bay, California to Tangola Tangola Bay, Mexico; intertidal-123m.

Family Callipallenidae

Callipallene pacifica (Hedgpeth 1939)

Figure 1.9

Pallene pacifica Hedgpeth, 1939:460-461, figs. f-l.—Hilton, 1939:72, fig. 4.

Callipallene pacifica Hedgpeth, 1941b:257, pl. 11.—Hilton, 1942c:38.

Material Examined. California: Santa Maria Basin, off Purisima Pt., Sta. R5 (1).

Description. Thorax slender, elongate; segmentation complete, distinct; lateral processes of moderate length, with first and fourth pairs shorter than others; separated by about half their diameter. Abdomen erect, shorter than lateral processes of fourth leg, but equal in height to ocular tubercle; slightly bilobed posteriorly.

Proboscis short, bluntly rounded, as wide as long. Neck long, nearly 4 times length of cephalon posterior to it; narrowed at midlength then broadened distally for insertion of chelae; equal in width to lateral processes of first leg. Ocular tubercle at base of neck, just above insertion of oviger; only slightly taller than basal diameter; bearing 2 equal pairs of large eyes; bluntly pointed dorsally.

Chelifore scape 1-segmented, reaching slightly beyond end of proboscis; chelae robust, longer than scape; fingers longer than setose palm. Palpi lacking. Oviger twice thorax length, 10-segmented. Segments 1, 2 and 10 subequal; segments 3 and 4 slightly longer; segments 5, 8, and 9 half again as long as basal segment; segment 7 twice and segment 6 more than twice length of basal segment. Last 4 oviger segments armed ventrally with leaf shaped spines, forming a strigillus.

Legs slender, length 23 times diameter, with a few scattered short setae. Coxa 2 twice length of coxa 1 and 3, and half femur length. Tibia 1 slightly shorter than femur, second tibia 25% longer. Tarsus extremely short, only one-eighth length of coxa 1, propodus subequal to coxa 1 length. Propodal heel undeveloped, marked only by presence of 5 large spines; sole lacking lamina, and bearing 15-16 small spines. Terminal claw two-thirds propod length; auxiliary claws three-quarters length of primary.

Biology. The single specimen examined was taken on soft sediments. The type specimens may have come from offshore rocks. Additional specimens were reported by Hilton (1939) and Hewatt (1946), from collections in shallow water at Santa Cruz Island. The area sampled has both kelp beds and a mixed rock and soft-sediment bottom, so it is not possible to determine the exact substrate from which *Callipallene pacifica* was taken.

Remarks. The specimen taken in the Santa Maria Basin was quite near the type locality of this species, but from somewhat deeper water. The other member of *Callipallene* in California waters, *C. californiensis*, can easily be separated from *C. pacifica* by a much shorter neck, more compact thorax, and lack of complete dorsal thorax segmentation.

Type Locality and Type Specimens. Holotype female (No. 3211), paratype female (No. 3212), Stanford University Natural History Museum. Taken off Pt. San Luis, California; 112m.

Distribution. Puget Sound, Washington to Santa Cruz Island, northern Channel Islands, California; 4-154m.

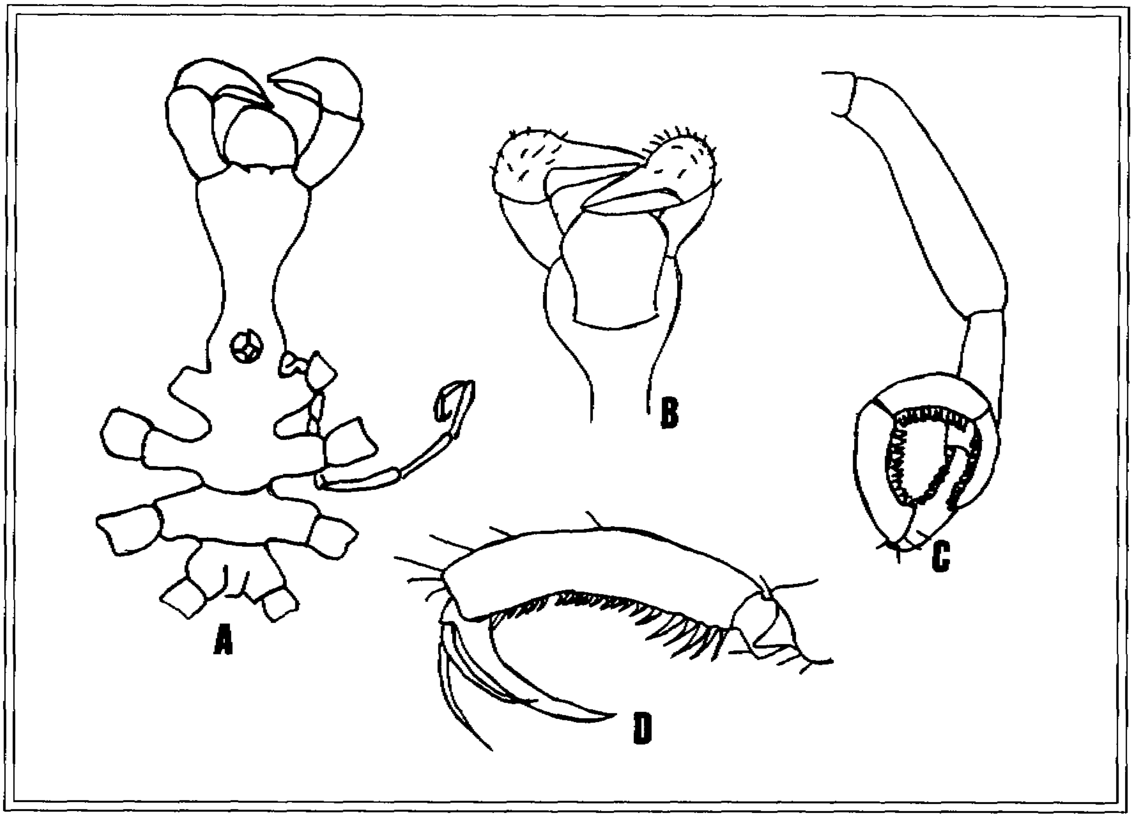

Figure 1.9. *Callipallene pacifica*; A. body, dorsal, B. chelae and proboscis, C. oviger, D. terminal claw (after Hedgpeth, 1939).

Family Nymphonidae

Nymphon pixellae **Scott 1912**

Figure 1.10

Nymphon pixellae Scott, 1912:206-209, pl. VII.—Hilton, 1942a:4; 1942b:279-280, pl. 35.—Hedgpeth, 1941b:258.—Stock, 1955:216-217, fig. 1b-d.—Child, 1979:40;1990b:42.

Nymphon solitarium Exline, 1936:414-416, fig. 33a-d.

Nymphon variatum Hilton 1942a:4.—Hedgpeth, 1949:271, fig. 34b.

Material Examined. California: Santa Maria Basin, off Pt. Sal; Sta. PJ-6 (1), Sta. PJ-10 (1).

Description. Thorax slender, elongate; segmentation complete, distinct; lateral processes moderately long, separated by about their diameter except for first and second pair, which are separated by nearly twice their diameter; all pairs subequal in length. Abdomen short, somewhat longer than last thoracic segment, but shorter than lateral processes of fourth legs; not fused to last thoracic segment, and inclined at about 30°.

Proboscis shorter than neck, about one-third combined length of cephalon and thorax; cylindrical, with slight constriction at midlength, bluntly rounded.

Neck slender and very long, 3 times length of remainder of cephalon; broadened distally accommodating insertion of chelifores and palpi. Ocular tubercle at base of neck, over and slightly behind insertion of oviger bases, immediately anterior to lateral processes of first leg pair. Ocular tubercle low, height slightly less than twice basal diameter, with 2 equal pairs of large eyes occupying central half. Above eyes, tubercle attenuates rapidly to sharp point.

Chelifore scape long, reaching end of proboscis, broadening slightly distally. Chelae about three-quarters length of scape, overhanging end of proboscis; palm and fingers subequal in length, both fingers attenuate, with acutely pointed crossing tips. Fixed finger bearing 24-30 distally pointing spines, moveable finger with 40-45 similar spines. Palpi 5-segmented, slender, about twice proboscis length. Basal segment very short; segments 2 and 3 subequal, and about one-third longer than segments 4 and 5.

Oviger 10-segmented, longer than combined length of cephalon and thorax if extended. Segments 1-3 short, together only one-third length of segment 4; segment 5 subequal to 4; segment 6 one-third length of 5. Segments 7-10 comprising a strigillus, armed ventrally with rows of denticulate spines. Spines evenly denticulate, tapered distally from origin of denticulation. Segment 10 bearing long terminal spine about half length of segment.

Legs slender, length 17 times diameter, bearing numerous short setae. Coxae together less than 10% of leg length; coxa 2 twice length of other coxae. and one-third femur length. Tibia 1 25% longer than femur; tibia 2 nearly double femur length, narrower than segments proximal to it. Tarsus one-sixth length of tibia 2, and two and one-half times propod length. Both tarsus and propod slightly narrower than tibia 2. Propod lacking heel and lamina, with short ventral setae only. Terminal claw one-third propodus length; auxiliary claws half length of primary.

Biology. This species bears sufficiently long legs that it is frequently caught in trawl nets fished over sandy mud bottoms offshore. The specimens examined were taken with a benthic grab sampler, and are small for the species. Large specimens can have a leg spread exceeding 5 cm. In southern California *Nymphon pixellae* has been taken several times in association with the sand star *Luidia foliolata.* Although these specimens were recovered from trawl catches, they were repeatedly found in the same situation, on the dorsal surface of the star, and not elsewhere in the trawl collection. It seems incredible that so delicate an organism could withstand the rigors of such handling without dislodgement, but it has happened on several occasions. The pycnogonids remain in association with the star when first placed in an aquarium, but soon disappear (R. Velarde, pers. com. 1993). When live these animals have red-banded legs.

Remarks. This is the common shallow shelf representative of the genus *Nymphon* in the northeast Pacific. Nearly the same depth range is occupied by *N. heterodenticulatum*, but it is rarely reported. The two species are similar in many respects, but differ in the number of spines on the chelae, the relative length of the tarsi and propodi, the relative length of the oviger terminal spine, and the length of the neck. The differences in shape of the oviger denticulate spines illustrated by Hilton (1942b) and by Hedgpeth (1941a) are of no diagnostic value as the illustrated range in spine morphology can be found on a single oviger. Unfortunately *N. pixellae* is a large species, and *N. heterodenticulatum* is a small delicate form, so the specter of ontogenic change cannot be easily dismissed. Until full growth series of both species can be assembled, the possibility that *N. heterodenticulatum* is a junior synonym of *N. pixellae* based on juvenile females must be considered. A third species, *Nymphon stipulum* was recently described from upper slope depths in the northern Channel Islands (Child, 1990b). This species differs from both *N. pixellae* and *N. heterodenticulatum* by the position of its ocular tubercle in advance of the oviger insertion, by proboscis shape, and by having tarsi shorter than propodi. Child (1994) added yet another species to the northeast Pacific fauna, *Nymphon aculeatum.* This deep-water species (2450-4100m) is blind, lacks an ocular tubercle, has chelae longer than the chelifore scape, and also differs in leg and oviger spination from it's shallower water congeners.

Type Locality and Type Specimens. Type in British Museum of Natural History.

Distribution. Gulf of Alaska to San Diego; 59-196m.

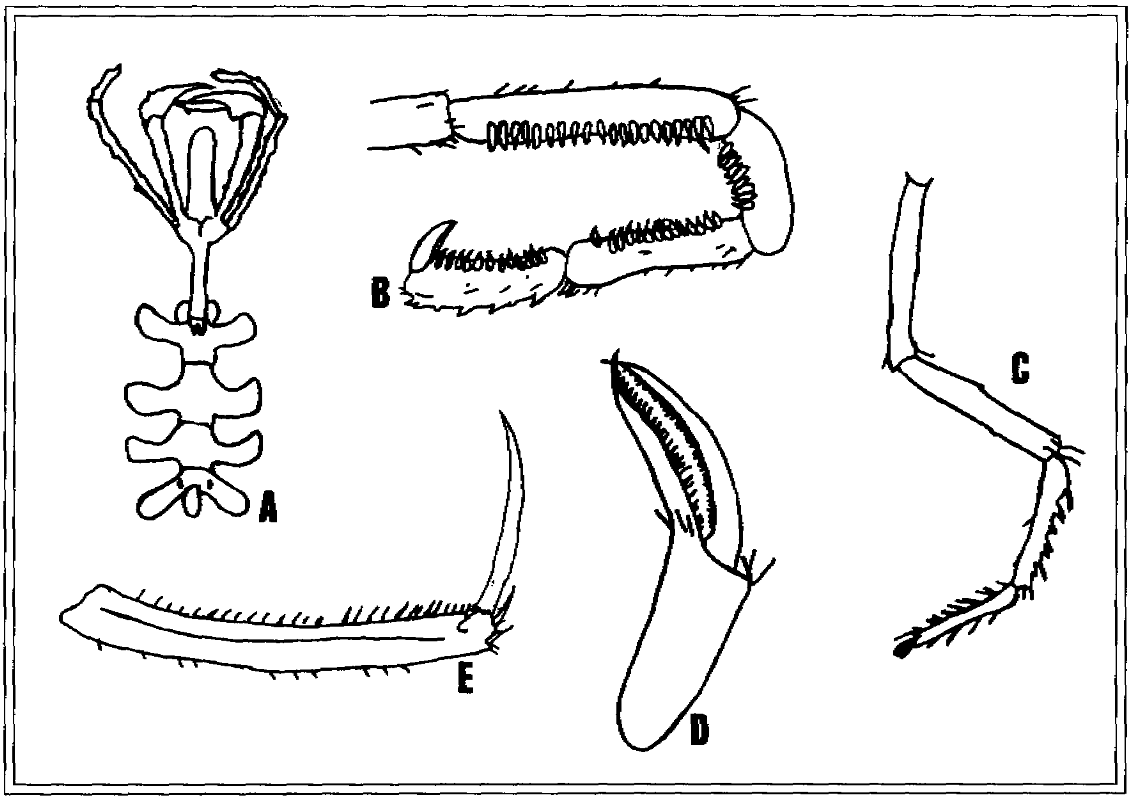

Figure 1.10. *Nymphon pixellae*; A. body, dorsal, B. oviger, C. palp, D. chela, E. terminal claw (after Hilton 1942a).

Nymphon heterodenticulatum Hedgpeth 1941a

Figure 1.11

Nymphon heterodenticulatum Hedgpeth, 1941a:447-449, pl. 1.—Child, 1990b:42.

Material Examined. California: Santa Maria Basin, off Pt. Sal; Sta. PJ-1 (2), Sta. PJ-10 (2).

Description. Thorax slender, elongate; segmentation complete, and distinct; lateral processes moderately long, separated by more than their width, slightly divergent; all pairs subequal in length. Abdomen short, equal in length to last thoracic segment; tapering slightly to bluntly rounded tip; lacking setation, and inclined upwards at about 45°.

Proboscis equal in length to neck and thorax, cylindrical, constricted slightly at two-thirds length.

Neck long, slender, broadened distally for attachment of proboscis, chelae and palpi; more than twice length of rest of cephalon, and equal to proboscis and thorax in length. Ocular tubercle at base of neck above insertion of ovigers, and just anterior to lateral processes of first legs. Two equal pairs of eyes located near base of ocular tubercle, which is twice basal diameter in height, terminating in sharp anteriorly bent point.

Chelifore scape nearly length of proboscis, which is overhung by chelae. Chelae about two-thirds scape length, slender, with finger length subequal to palm. Chelae slender, with sharply pointed tips, with 17 small spines lining fixed finger, and 19 on moveable finger. Palpi 5-segmented, slender, nearly twice length of proboscis. First segment very short, segments 2 and 3 subequal and about 50% longer than segments

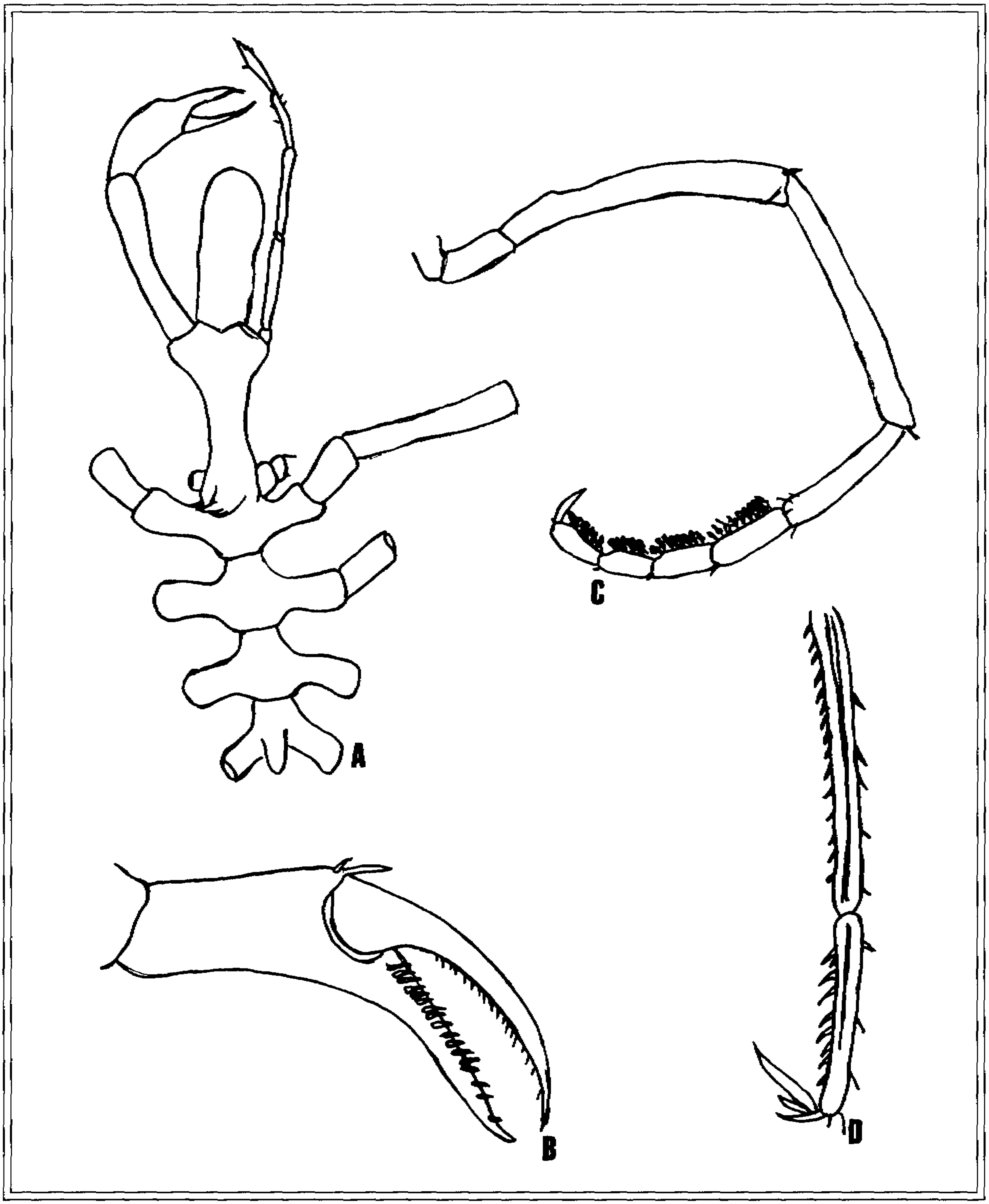

Figure 1.11. *Nymphon heterodenticulatum*; A. body, dorsal, B. chela, C. oviger, D. terminal claw (after Hedgpeth 1941a).

4 or 5. Oviger 10-segmented, male and female ovigers very similar; fourth and fifth segments longest and subequal; segments 1-3 together half length of segment 4, and subequal in length to segment 6. Strigillus segments 7-10 of decreasing length; each bearing row of denticulate spines ventrally; segment 10 bearing terminal spine nearly equal to length.

Legs long, slender; sparsely setose. Coxa 2 twice length of coxa 3, which is nearly twice length of coxa 1; femur over half length of tibia 2, and about three-quarters length of tibia 1; tarsus long, equal in length to second coxa, and about one-third longer than propodus. Tarsus and propodus armed ventrally with row of small spines, and sparsely setose dorsally. No trace of heel on propodus; lamina also absent; terminal claw slender, about half propod length; auxiliary claws slender, about half length of primary.

Biology. Nymphonids are typically found on soft bottoms rather than on hard substrates.

Remarks. The examined specimens deviate in some respects from *Nymphon heterodenticulatum* as described by Hedgpeth. The tarsus of the Santa Maria Basin specimens is subequal to the propodus length. While the proportions of the chela fingers and palm are the same in the present specimens as described for the type, the entire chela of the Santa Maria Basin specimens is less slender than described by Hedgpeth. Spination of the chela fingers also differs, with spines larger and less numerous than described by Hedgpeth. In other characters the present specimens agree with Hedgpeth's species, and they are treated here as variants.

Type Locality and Type Specimens. Holotype female (No. 3215), and paratype female (No. 3216) in Stanford University Natural History Museum; paratype female in collection of J. W. Hedgpeth.

Distribution. California: off Pt. Sal to Catalina Island; 91-160m.

Family Phoxichilidiidae

Anoplodactylus erectus Cole 1904

Figure 1.12

Anoplodactylus erectus Cole, 1904: 289-291; pl. XIV, fig. 12; pl. XXVI, figs. 1-9.—Stock, 1975b:74-76, figs. 22, 23.

Material Examined. California: Santa Maria Basin; off Pt. Sal, Sta. R8 (3); off Purisima Pt., Sta. 42 (1); off Pt. Arguello, Sta. 65 (1).

Description. Thorax slender, elongate; segmentation complete and distinct; lateral processes of moderate length, separated by about their diameter, diverging slightly; those of first legs longest, with length decreasing slightly in each remaining pair. Abdomen tapering from about midlength to blunt tip; about half cephalon length, longer than lateral processes of fourth legs; inclined upwards at nearly 60°, and bearing few very short setae.

Proboscis about twice neck length, cylindrical, blunt, increasing slightly in diameter distally; angled downward from cephalon at about 15°.

Neck as long as rest of cephalon, slender, bearing ocular tubercle dorsally at end. Ocular tubercle height about twice basal diameter; 2 pairs of eyes situated under its bluntly pointed apex; anterior pair slightly lower and larger than posterior pair.

Chelifore scape inserted at base of ocular tubercle; scape cylindrical, of 1 segment, longer than neck, but shorter than cephalon; lacking tubercles, and with few very short scattered setae. Chelae with palm rectangular, shorter than or equal to fixed finger length; fingers unequal, moveable finger longer, more strongly curved distally, and bearing a group of setae dorsally. Neither finger with spines or teeth. Chelae attached to scape at nearly right angle, projecting ventrally. Palpi lacking.

Oviger in male only; 6 segmented, slender, as long as combined cephalon and thorax. Basal segment with length and diameter subequal; segment 2 only two-thirds diameter and twice as long as segment 1. Segment 3 bent at nearly right angle to segment 2, projecting along underside of body to rear. Segments 3-6 all of smaller diameter than segments 1-2; segments 3, 5 and 6 setose; segment 4 lacking setae. Segment 3 about half oviger length. Segments 4-6 forming strigillus-like loop, with segments 5 and 6 bent back along segment 4.

Legs long, about twice combined length of cephalon and thorax; slender, length about 16 times diameter. Lateral processes with single conical tubercle distally. First and third coxae subequal; coxa 2 twice their length. Femur about 50% longer than tibia 1, 25% longer than tibia 2. and twice the length of coxa 2; tarsus short, about 10% length of tibia 2; propodus curved, about half length of femur. Terminal claw as long as sole, nearly equal to propodus length; auxiliary claws very short, about one-eighth length of primary.

Coxae lacking dorsal tubercles; male genital aperture at end of ventral genital spurs distally on second coxae; female coxa 2 swollen distally, with genital aperture flush with segment surface. Femur bearing tubercle dorsally at distal end in male, but not in female. Femoral cement gland beyond segment midpoint, aperture at end of tapering duct projecting above femur by about one-third diameter. No other tubercles. Legs sparsely scattered with short setae. Propodus with heel well defined, but short; bearing 2 spines and 3 setae. Sole bearing a lamina for distal one-third, with between 7-11 distally curved spines proximally. Propodus with row of setae dorsally.

Biology. The life history of *Anoplodactylus erectus* has been detailed by Hilton (1916), who found them associated with the hydroid *Tubularia crocea*. Larvae of *A. erectus*, once hatched from the egg mass, pierce the body wall of the hydroid and enter the digestive tract. Eventually these endoparasites eat their way out, becoming adult predators on the hydroid. The shape of the terminal segments of the oviger are held recurved into a loop, as are those of species whose spinose oviger ends form a true strigillus. Male phoxichilidiids have, however, not been observed to use the oviger in grooming, and ovigers are lacking in the female.

Remarks. This is by far the most commonly encountered of the three species of *Anoplodactylus* taken in the Santa Maria Basin samples. To some extent this is due to its occurrence in the intertidal zone, and in association with hydroids in the fouling community. It can be distinguished from the co-occurring *Anoplodactylus* species by having one tubercle on the lateral processes; *Anoplodactylus oculospinus* has two, and *A. pacificus* none. It differs from *A. nodosus*, which was not represented in these collections, in lacking the tuberculations of the tibiae which characterize that species.

Type Locality and Type Specimens. Holotype male, allotype female, (University of California No. 19,514); San Diego, California.

Distribution. British Columbia, Canada to Punta Arenas, Chile; intertidal-107m.

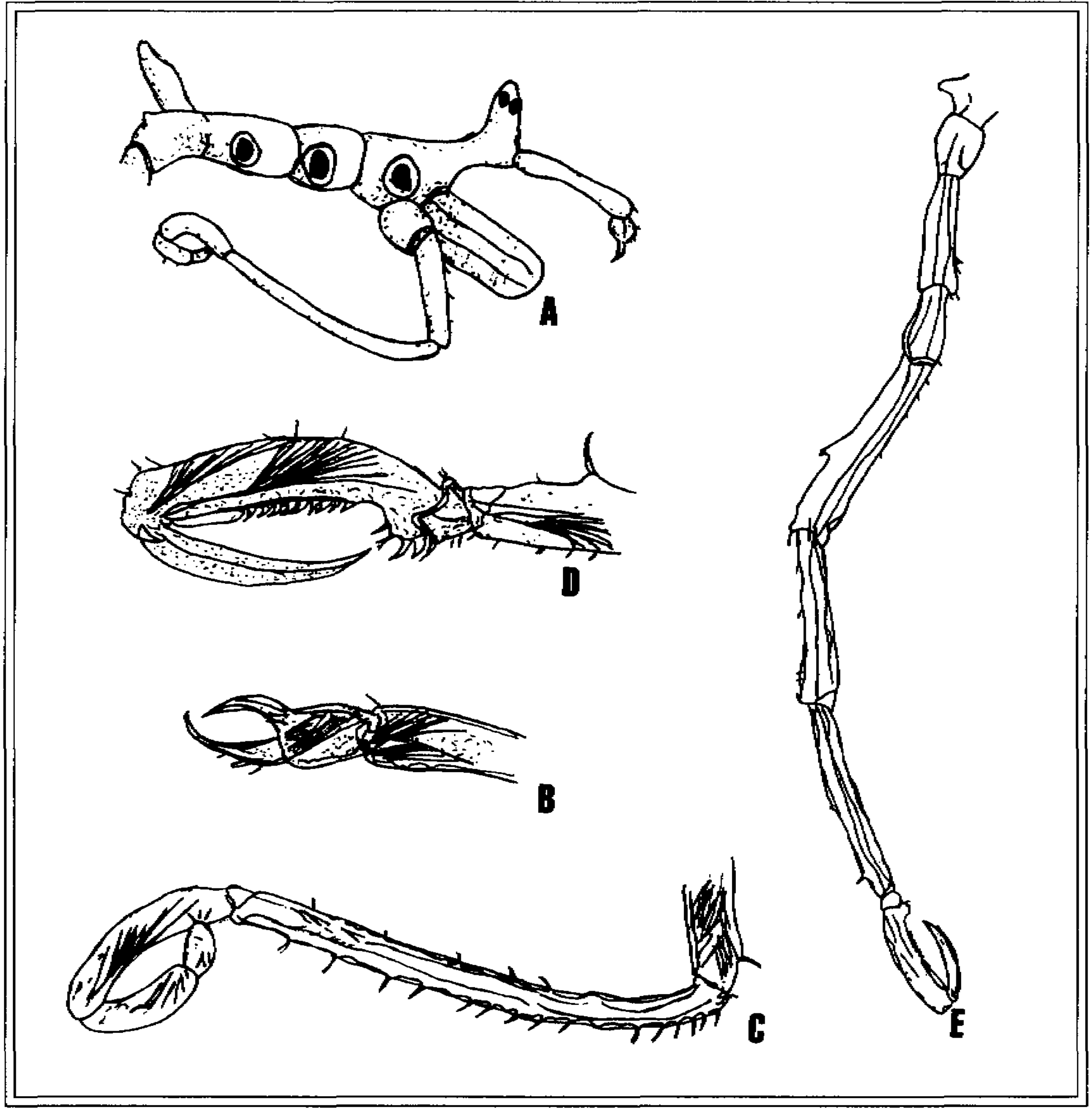

Figure 1.12. *Anoplodactylus erectus*; A. body, lateral, B. chela, C. oviger, D. terminal claw, E. leg (after Cole, 1904).

Anoplodactylus oculospinus Hilton 1942d

Figure 1.13

Anoplodactylus oculospinus Hilton 1942d:72-73.—Child, 1975:196-198, fig. 3.

Anoplodactylus nr. *pacificus* (in part) Lissner *et al.*, 1986:D-26

Material Examined: California: Santa Maria Basin, off Purisima Pt., Sta. 16 A/B (2); Sta. 20 A/B (1).

Description. Thorax slender, elongate; segmentation complete, distinct; lateral processes of moderate length, separated by about their diameter, diverging slightly; those of first leg pair slightly longer than others. Abdomen tapering slightly to blunt tip, about one-third cephalon length, equal in length to lateral processes of fourth legs, inclined upwards at about 30°, with single dorsal seta.

Proboscis about twice length of neck, cylindrical, blunt, tapering slowly from base to about three-quarters of length, then enlarging again to nearly basal diameter at tip.

Neck somewhat shorter than rest of cephalon, relatively robust, and shouldered into cephalon for nearly half of length. Ocular tubercle at anterior cephalic margin, capped by anteriorly directed spine, with 2 pairs of eyes at about midheight. Anterior pair of eyes somewhat below posterior pair, flanked by small laterally directed tubercles. Ocular tubercle short, with height and diameter about equal.

Chelifore scape of single segment, about 3 times chela length, overhanging proboscis by more than chela length; scapes approximated basally, bearing low seta-tipped tubercles both dorsally and laterally. Chelae with palm rectangular, longer than fingers, with neither dorsal or ventral setae. Both moveable and fixed fingers strongly curved, attenuate, ending in sharp crossing tips. Fixed finger with several dorsal setae, but no ventral setae; moveable finger with 2 dorsal setae, and no ventral setae. Neither finger with spines or teeth. Palpi lacking. Adult oviger unknown; juvenile male with 5-segmented oviger.

Each lateral process with 2 seta tipped tubercles, one anterodistal, and one posterodistal. Legs intermediate, neither slender or robust, length about 9 times diameter. First and third coxae subequal, second about 50% longer; femur and tibiae subequal, about 3 times length of coxa 2; tarsus very short, barely one-sixth length of propod; propodus subequal to coxa 2. Terminal claw as long as sole, fully four-fifths propodus length; auxiliary claws strong, but very short, only 10% of primary length.

First coxae with spine tipped tubercles as on lateral processes; second and third coxae without tubercles or setae; femur slightly inflated, bearing scattered short setae; both tibiae with row of short lateral setae, tibia 2 also bearing row of short setae ventrally; both with long dorsodistal seta. Propod with 4 dorsal setae, and with a distinct heel bearing 2 spines and 2 large setae; sole with 10-11 anteriorly curved spines and 7-8 setae; lamina short, about one-eighth length of propodus.

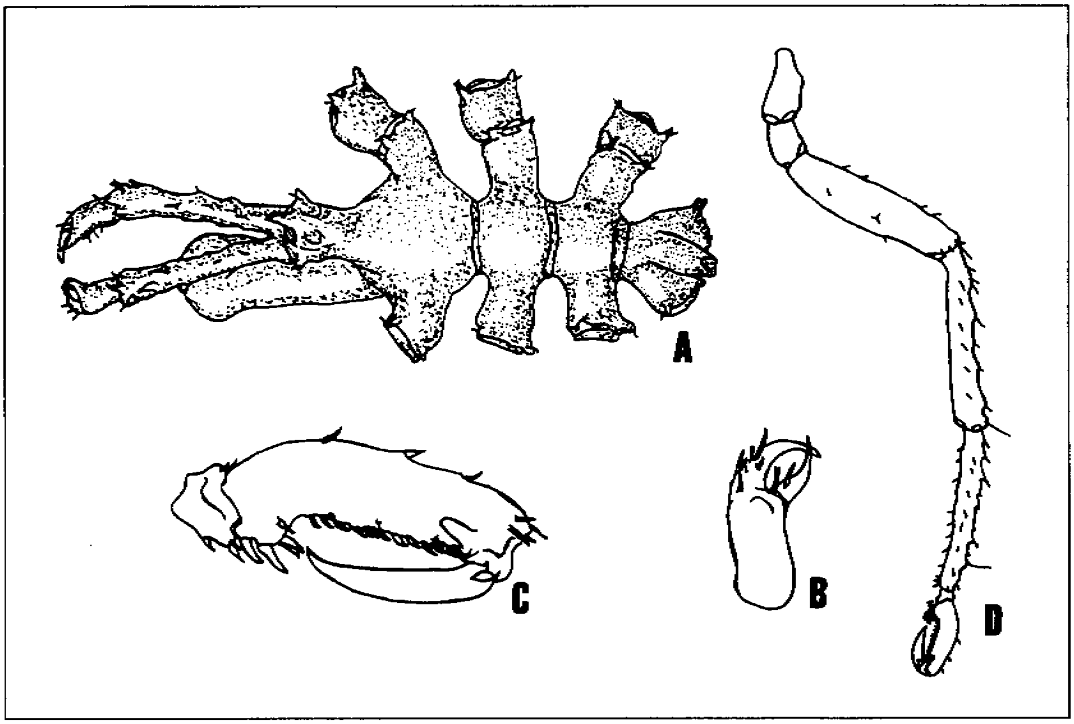

Figure 1.13. *Anoplodactylus oculospinus*; A. body, dorsal, B. chela, C. terminal claw, D. leg (after Child, 1975).

Biology. The type was taken from rock substrate by dredging; the specimens examined here were associated with medium sized rocks (over 1000 cm^2 surface area) that were collected with manipulating arms on a submarine.

Remarks. The present collection appears to include the only specimens of *Anoplodactylus oculospinus* reported since the type female was described (Hilton 1942d). As no adult male is reported here, details of the oviger, the femoral cement gland and duct, and the male genital aperture remain unknown. The juvenile male examined was not sufficiently mature sexually to predict what these secondary sexual characteristics would be like in the adult. Of the three species of *Anoplodactylus* in the present collection, *A. oculospinus* is the easiest to recognize. The combination of long chela palm, lateral cephalon tubercles, and paired tubercles on the lateral process and coxa one quickly separates it from the others. Like *A. pacificus*, more *A. oculospinus* probably await discovery in existing collections mixed with *A. erectus*.

Type Locality and Type Specimens. Holotype female; off Moss Landing, Monterey Bay, California; 91m; USNM 81494.

Distribution. Central California, from Monterey Bay to off Purisima Pt.; 91-123m.

Anoplodactylus pacificus Hilton 1942d

Figure 1.14

Anoplodactylus pacificus Hilton 1942d:73.—Stock, 1955:242-243.—Child, 1975:198-201, fig. 4.

Anoplodactylus nr. *pacificus* (in part) Lissner *et al.*, 1986:D-26.

Material Examined. California: Santa Maria Basin off Purisima Pt., Sta. 14 C/D (1). Western Santa Barbara Channel, Sta. S1 C/D (1).

Description. Thorax slender, oval; lateral processes long, separated by more than their diameter; tubercles absent, but with 2 small spines distally. Lateral processes of first leg pair longest; each successive pair a bit shorter. Abdomen slender, about half cephalon length, and longer than lateral processes of fourth legs, tapering to a relatively acute terminus bearing several distal setae, and held vertically.

Proboscis nearly twice length of neck, cylindrical, blunt, bent upwards at about one-third of length, slightly swollen at bend.

Neck equal in length to rest of cephalon, slender, with line continued anteriorly by tapering and terminally acute ocular tubercle. Two pairs of large eyes borne near base of ocular tubercle, the latter about twice basal diameter in height. Chelifore scapes touching basally, long, 1-segmented, with row of dorsal setae, and distal tubercle. Scape nearly 3 times chela length; with distal one-third overhanging proboscis.

Chelae with palm rectangular, subequal to fingers, bearing several dorsal setae. Both moveable and fixed fingers strongly curved, attenuate, ending in sharp crossing tips. Fixed finger bearing seta dorsally near base; moveable finger with 3 setae ventrally, and 4 longer setae dorsally, without either spines or teeth. Palpi lacking.

Oviger 6-segmented, thin, basal segment short, relatively wide; segment 2 with length 9 times width; segment 3 twice length of segment 2; segments 4 and 5 subequal, half length of segment 2; terminal segment a minute button, one quarter length of segment 5. Scattered setae on segments 2-4, segment 5 strongly setose on concave surface, segment 6 with 2 small setae.

Legs slender, length about 13 times diameter; coxa 1 and 3 subequal, coxa 2 2-3 times length of 1 and 3; femur, tibia 1, and tibia 2 subequal; tarsus very short, propodus about one-third length of 3 long segments; terminal claw about two-thirds propod length; auxiliary claws minute, little more than setae. Coxa 2 bearing distal tubercle and both dorsal and ventral setae. Femur and tibiae also with short setae dorsal and ventral. Femoral cement gland at about midsegment, produced into raised, slightly flared duct. Heel poorly differentiated, bearing 2 curved spines and 2 setae. Propodus with about 15 sole spines bent anteriorly at their ends; lamina less than one-third propod length.

Biology. The type was taken in a trawl, presumably over soft bottom. Both specimens examined here were associated with small rocks collected with a submarine.

Remarks. The original description was cryptic and probably prevented recognition of *Anoplodactylus pacificus* until the redescription and figuring of the type by Child (1975). Only Stock (1955) managed to identify his specimens from the original description. This off-shore species is perhaps more common than the number of specimens reported would indicate. It is found with at least two similar congeners, *A. erectus* and *A. oculospinus*, both represented in the present collections. *Anoplodactylus pacificus* can be readily distinguished from both by the absence of tubercles distally on the lateral processes.

Type Locality and Type Specimens. Holotype male; off Avalon, Santa Catalina Island, southern California; 86m; USNM 77078.

Distribution. Santa Maria Basin, central California to Southern California Bight: 74-105m.

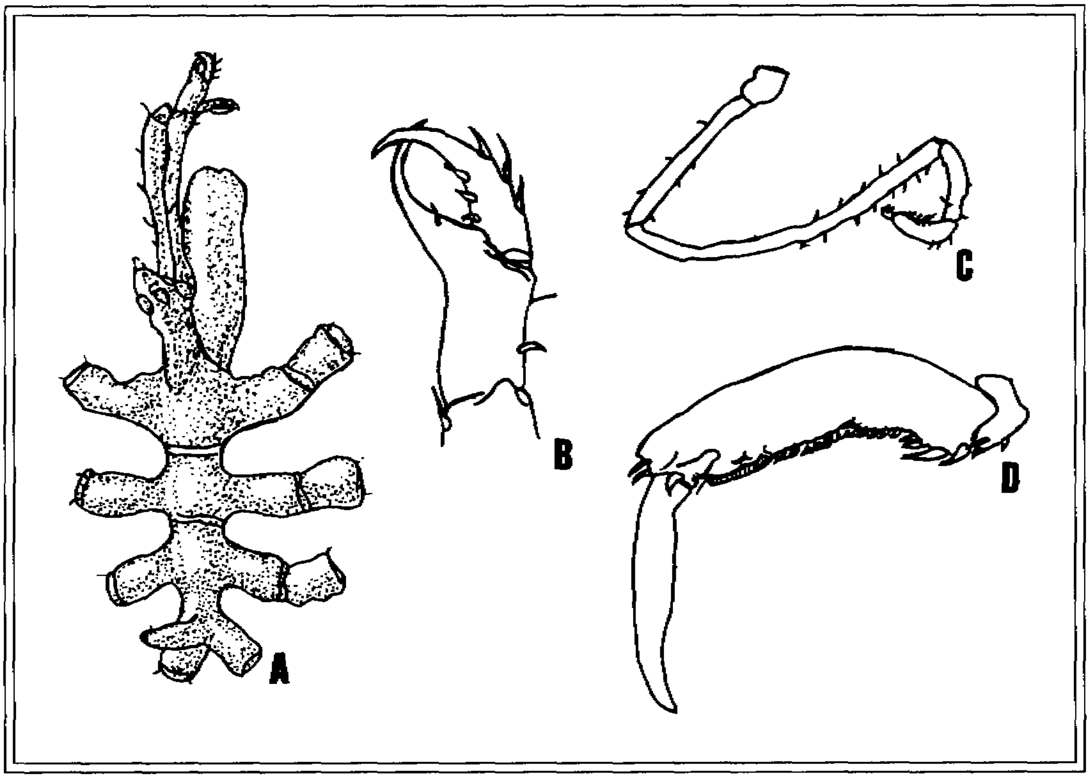

Figure 1.14. *Anoplodactylus pacificus*; A. body, dorsal, B. chela, C. oviger, D. terminal claw (after Child, 1975).

Family Pycnogonidae

Pycnogonum rickettsi Schmitt 1934

Figure 1.15

Pycnogonum rickettsi Schmitt, 1934:62-65, fig. 1.—Hilton, 1943b:19.—Hedgpeth, 1975:417, 424; pl. 99, fig. 3.—Hedgpeth and Haderlie, 1980:638, fig. 27.2.

Material Examined. Central California off Morro Bay, Sta. 27 A/B (3); off Oso Flaco, Sta. 25 A/B (1); off Pt. Arguello, Sta. 6 A/B (1). Western Santa Barbara Channel off Tajiguas, Sta. 1 C/D (3).

Description. Thorax compact, elongate; segmentation complete and well-defined. Lateral processes short, subequal, separated by less than half their diameter, diverging slightly. Integument reticulate. Cephalon and first two thoracic segments bearing tall, conical middorsal tubercles; tubercles shortest on cephalon, and increasing in height posteriorly. All 3 middorsal tubercles taller than ocular tubercle. Abdomen short, tubular, horizontal, between and not exceeding length first coxae of fourth leg.

Proboscis more than twice length of cephalon, fusiform, blunt, widest at midlength; proboscis integument reticulate.

No neck apparent; ocular tubercle near anterior cephalic margin, short, with height and basal diameter subequal, with 2 equal pairs of eyes. Chelifores absent in both adult and juvenile, present only in protonymphon larva. Palpi lacking. Ovigers only in male, 9-segmented with a terminal claw; basal 3 segments with width exceeding length; segments 4 and 5 longer, with length twice width; strigillus segments (6-9) progressively more slender. Segment 3 with 1 dorsal and 1 ventral seta, segments 5 and 6 with 1 ventral seta, segment 7 with 1 dorsal and 3 ventral setae, segments 8 and 9 with field of very short ventral setae. Segment 9 tapering to basal diameter of terminal claw.

Legs robust, length about 8 times diameter. Coxae subequal on first 3 leg pairs; coxa 1 both longer and broader than coxae 2 and 3 on fourth pair of legs. Femur and tibia 1 subequal and about twice coxa length, tibia 2 about two-thirds femur length on legs 1-3. On leg 4 femur and both tibiae subequal, about 50% longer than coxae 2 and 3. Tarsus short, one-third to one-quarter length of propodus, bearing field of short setae ventrally. Propod lacking heel and enlarged heel spines; sole with numerous very small setae, but lacking spines and lamina. Terminal claw about half propod length; auxiliary claws lacking. Lateral processes bearing low conical tubercle distally, largest on fourth legs and decreasing in size on more anterior leg pairs. Coxa 1 with distal tubercle like that of cruriger; femur and tibia 1 each bearing a pair of dorsodistal tubercles, tibia 2 unarmed.

Biology. Type specimens were taken from soft substrate offshore, in association with the large plumose anemone *Metridium*. The present specimens were taken on rocks collected by submarine. Although none of the collected rocks supported *Metridium*, or other likely anemone prey for *Pycnogonum*, anemones (primarily *Metridium*) were abundant in the sampled habitat nearby (pers. obs.). Association with *Metridium senile*, *Anthopleura xanthogrammica*, *Aglaophenia spp*, and *Clavelina huntsmani* are reported in the Pacific Northwest by Hedgpeth (1987).

Remarks. The report that *Pycnogonum rickettsi* ranges to the Galapagos Islands (Hedgpeth, 1951), seems to represent a misreading of Hilton's (1943b) statement that several specimens had been taken from Santa Cruz Island by Hewatt and Williams in 1939. This report referred to one of the southern California channel islands (Hewatt, 1946), and not to one of the Galapagos group. Child and Hedgpeth (1971), while not specifically addressing the prior record, did not mention *P. rickettsi* as a member of the Galapagos fauna in their review.

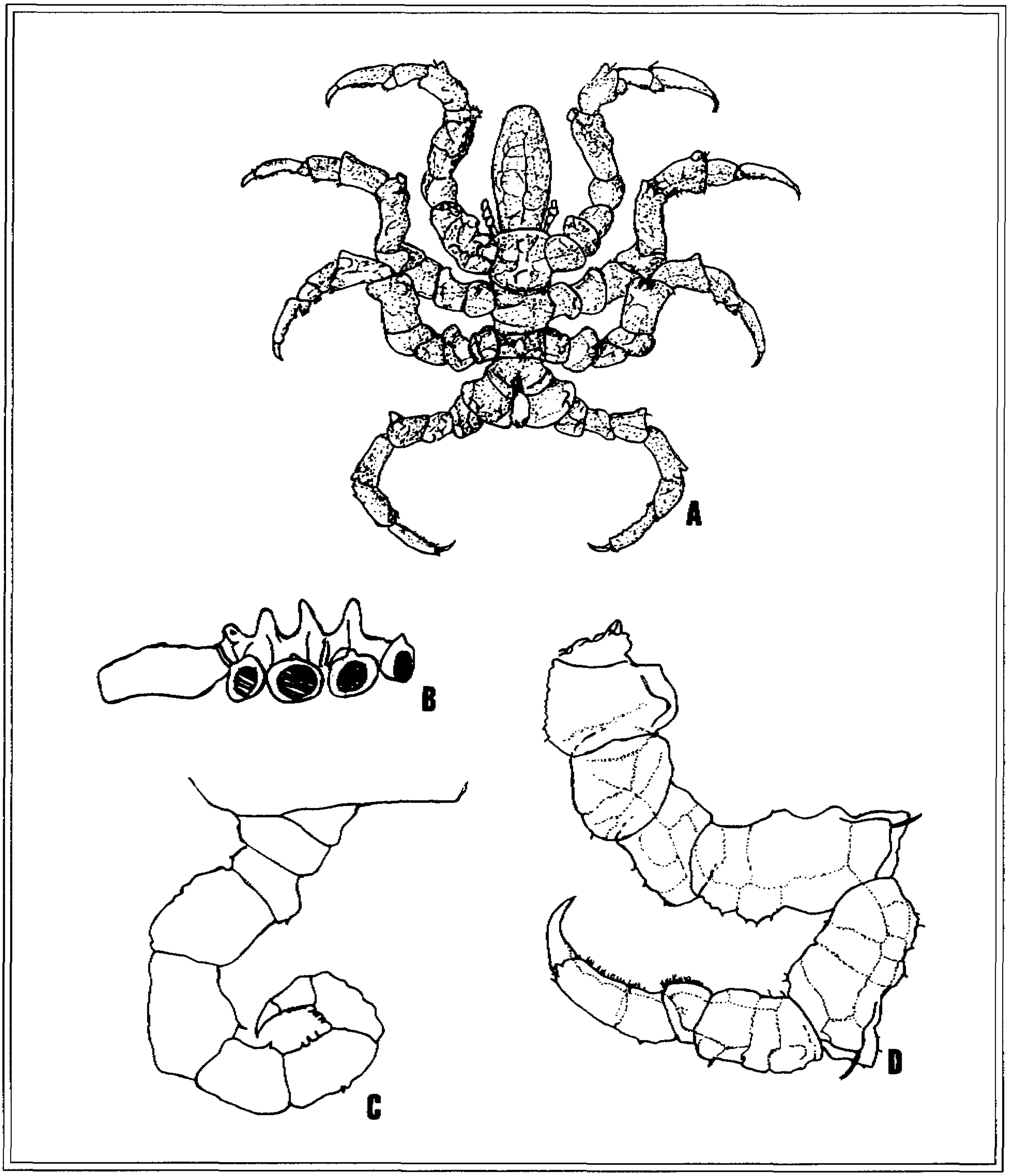

Figure 1.15. *Pycnogonum rickettsi*; A. habitus, dorsal, B. body, lateral, C. oviger, D. leg (after Schmitt, 1934).

This species is clearly distinguished from *P. stearnsi*, it's only congener in northeast Pacific temperate and boreal waters, by its much higher middorsal tubercles, and by the reticulation of the integument. The two species do co-occur, and, while reported from the same prey species, have not been reported together on any single anemone (Hedgpeth and Haderlie, 1980).

Type Locality and Type Specimens. Holotype male; off Pacific Grove, Monterey Bay, central California; 120m; USNM.

Distribution. Puget Sound to the Southern California Bight; intertidal-117m.

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SUBPHYLUM CRUSTACEA

2. THE DECAPODA

by

Joel W. Martin[1] and Todd L. Zimmerman[2]

Introduction

Decapod crustaceans are among the most common and easily recognized invertebrate groups, representing a large number of species found in many habitats. Because of their popularity, and because some groups are of considerable economic importance, there are numerous guides to the identification and natural history of decapods. However, most of these guides are restricted either to specific areas outside southern California (e.g., Austin Williams' 1984 guide to the decapods of the east coast of the United States) or, if pertaining to southern California, are restricted to one or two families or genera (e.g. Zmarzly's 1992 review of the pinnotherid crab genus *Pinnixa*). It is surprising that for the California coast, an area that has been subjected to much study, no updated and thorough treatment of the Decapoda exists subsequent to Waldo Schmitt's (1921) classic (but now outdated, and long out of print) volume *The Marine Decapod Crustacea of California*. Several guides to, or treatments of, the west coast decapods have appeared since Schmitt's publication (e.g. Kozloff, 1987; Allen, 1980; Jensen, 1995, etc.), but these tend to include only those species restricted to more shallow waters (and therefore more likely to be seen and collected by naturalists), and so they are of limited use in identification of the deeper fauna.

The most surprising result from the present study of the MMS collections is the relatively small number of species encountered, most of which are relatively well known, compared to those anticipated (for expected source pool see Wicksten, 1989). For many of the taxa encountered, the descriptions and biological information have been summarized from older literature, such as Garth's (1958) monograph on Pacific "Oxyryncha".

One of the most valuable assets in identification and taxonomy of California invertebrates are the members of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT). These biologists have been responsible for publishing numerous new records and taxonomic changes to the knowledge of southern California species. Primarily because of the active input of information from that group, the present list should not be considered a definitive checklist of the fauna of the Santa Maria Basin. Despite the size of most decapods and the interest they generate, it is clear that there still is much to learn about them, even from such populated regions as southern California.

The current report is a list of species identifications and a corresponding compilation of information that stems primarily from preexisting literature. For that reason and by way of this disclaimer, this report is not to be considered to have met the criteria for publication as outlined in Article 8 of the International Code of Zoological Nomenclature, third edition (1985).

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General Biology and Ecology

Decapods occupy such a wide range of habitats and ecological "niches" that no general statements of their biology and ecology can be made without many caveats inserted. The group includes scavengers, strict herbivores, predators (both sit-and-wait predators as well as hunters), filter feeders, symbionts, and probably any other feeding mode that could be imagined. The majority are benthic, although many species, particularly among the shrimp, are pelagic, at least during part of the life cycle; there are of course freshwater, terrestrial and semiterrestrial species as well, but these need not be mentioned for purposes of this report. Most of the species mentioned in this report are benthic, macrophagous animals, as might be guessed from where and how they were collected (see Volume 1 of this series). In general the group might best be described as opportunistic scavengers, meaning that, from what little we know, they will eat just about anything they happen upon. Some of the species in this report are almost certainly more specialized in their feeding habits than the above statement would seem to indicate. Commensal pinnotherid crabs, as one example, are often highly dependent upon their "host" as a source of nutrition, yet for some no host is known. Although many species of decapods will eat shrimp and just about any other proffered food item in captivity, it is not always appropriate to extend observations made in the laboratory to what might be happening in the field.

Terminology and Glossary

For decapod crustaceans, the glossary of Williams (1984), although written to assist in the identification of decapods from the east coast of the United States, serves equally well for identifying characters used in the taxonomy of west coast decapods. We have borrowed *verbatim* the glossary found in his introductory section (Williams, 1984: 8-17), and his schematic labeled diagrams of a shrimp and crab are reproduced here as Figures 1 and 2. We have added to Williams' glossary the relatively few terms used in this report that are not found in his glossary. In the following section, any word and its definition taken directly from Williams (1984) is followed by the notation [ABW]. Other terms and definitions have been taken from various sources, among which are McLaughlin (1980) [McL] and Moore and McCormick (1969, in Glaessner, 1969) [M&M], which are also good starting points for learning the terminology of other crustacean taxa. Some of the more descriptive terms are included here as well, and definitions for some of these have been taken from the American Heritage Dictionary of the English Language [AHD]. When no concise definition could be located, we have used our own; these are designated as [M&Z]. Figures referred to in the definitions are those of Williams (1984) and not of the current report.

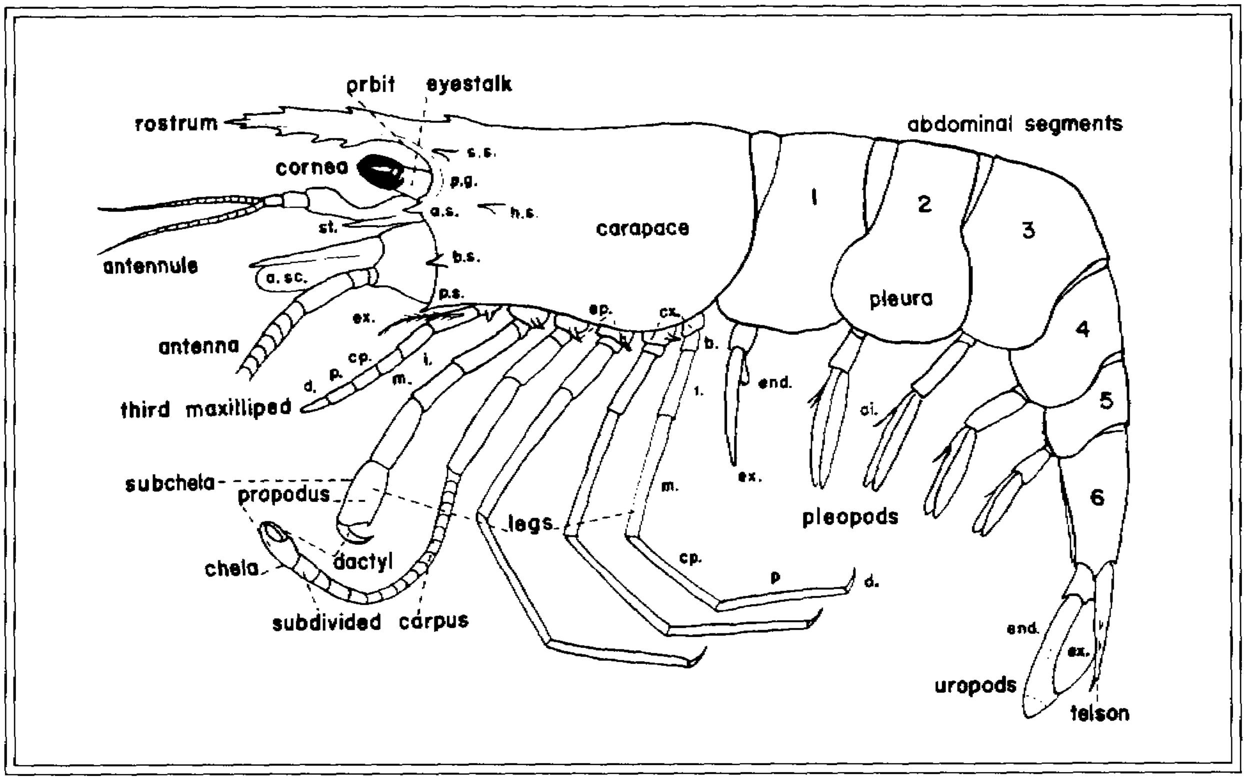
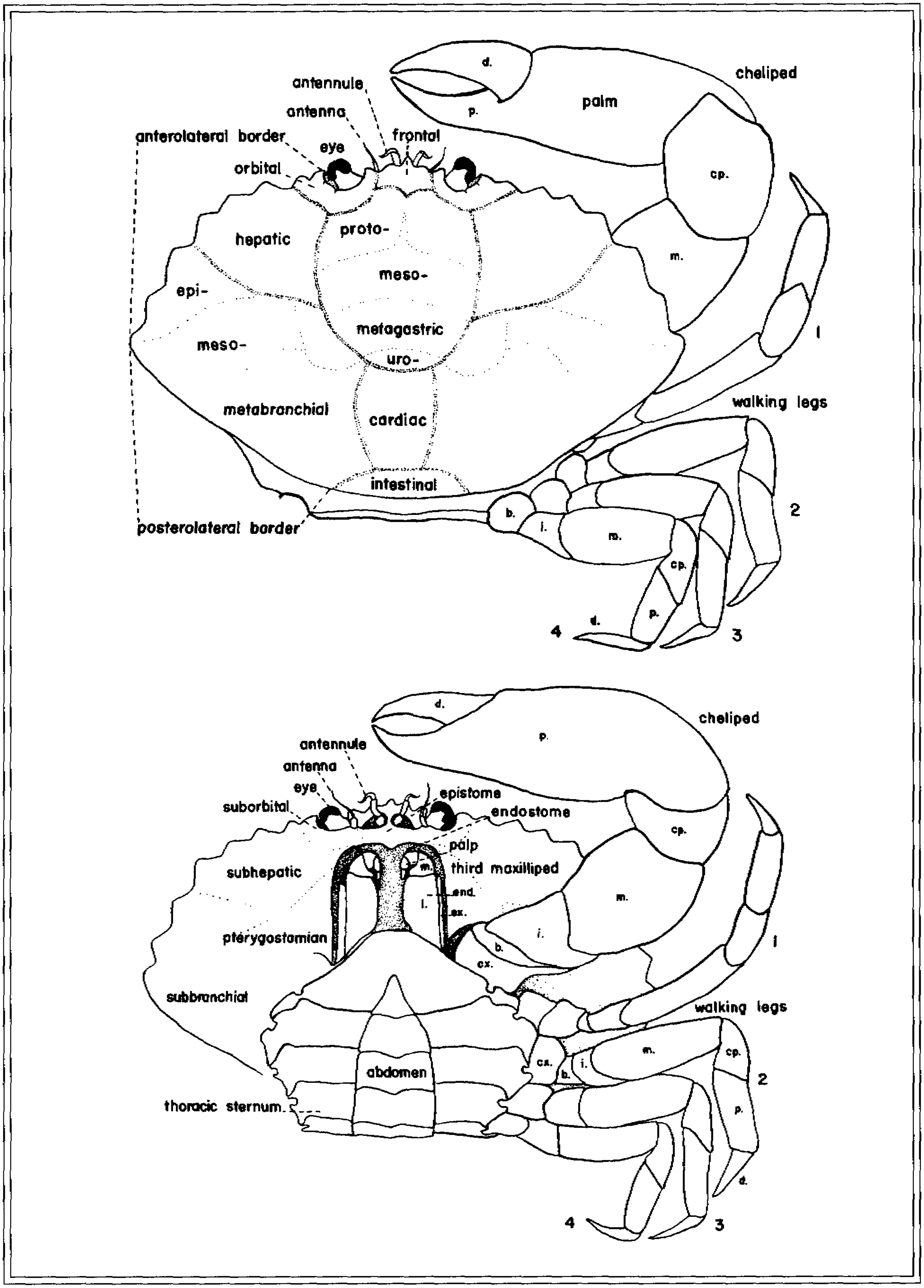


Figure 2.1. Schematic drawing of shrimp in lateral view: ai, appendix interna; as, antennal spine; asc, antennal scale; b, basis; bs branchiostegal spine; cp, carpus; cx, coxa; d, dactyl; end, endopod; ep, epipod; ex, exopod; hs, hepatic spine; i, ischium; m, merus; p, propodus; pg, postorbital groove; ps, pterygostomian spine; ss supraorbital spine; st, stylocerite (from Williams 1984, modified from Holthuis 1955; Schmitt 1921).


d.
cheliped
antennule
antenna
p.
palm
anterolateral border
eye
frontal
orbital
cp.
hepatic
proto-
m.
meso-
epi-
metagastric
I
meso-
uro-
metabranchial
cardiac
walking legs
intestinal
b.
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2
posterolateral border
m.
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antennule
antenna
eye
epistome
suborbital
endostome
cp.
palp
subhepatic
m.
third maxilliped
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pterygostomian
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subbranchial
walking legs
m.
cp.
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abdomen
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thoracic sternum
p.
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3

Glossary

Abdomen. Trunk somites (tagma) between thorax and telson; somites with or without limbs; syn., **pleon**. [McL]

Acicle. Antennal scale reduced to a spine. [ABW]

Afferent channels. Openings through which water passes to gills. In brachyuran crabs, usually opening behind pterygostomian regions and in front of chelipeds except in certain Oxystomata in which they open at anterolateral angles of palate or endostome. [ABW]

Apodeme. Any cuticular ingrowth of body wall. [ABW]

Appendix interna. Small separate branch on mesial side of pleopodal endopodite, usually tipped with hooks which interlock with opposite member in swimming. [ABW]

Appendix masculina. Accessory male organ located mesially on second pair of pleopods between endopodite and appendix interna. [ABW]

Arthrobranchiae. Gills attached to articular membrane between coxa of appendage and body wall. [ABW]

Antepenultimate. Second from the last; third from the end in a series. [AHD]

Antenna(e). One of a pair of appendages of the second cephalic somite; syn., *2nd antenna.* [McL]

Antennal scale. See stylocerite.

Antennule. One of a pair of appendages of the first cephalic somite; syn., *1st antenna.* [McL]

Areolation. Demarcated and usually elevated regions of the brachyuran carapace (see M. J. Rathbun, 1930, page 6). [M&Z]

Basis (basipodite). Second article (from body) of leg or maxilliped. Sixth segment from distal end of limb. [ABW]

Basicerite. Spine on dorsal side of basis of antenna; sometimes more lateral than dorsal. [ABW]

Branchiocardiac groove. Groove separating branchial and cardiac regions. [ABW]

Branchiostegal spine. Spine on anterior edge of carapace, or near it, immediately below branchiostegal groove (Fig. 2). [ABW]

Branchiostegite. Part of carapace not coalesced ventrally with thoracic somites, but overhanging on each side as covering for gill chamber. [ABW]

Buccal cavity. Cavity on ventral surface of body in which mouthparts are situated; bounded anteriorly by epistome, laterally by free edges of carapace. Within this "frame" lie the mouthparts, which in most Brachyura are covered by operculiform third maxillipeds. [ABW]

Capitate. Enlarged or globular at end. [AHD]

Carina. Keel-like ridge or prominence. [ABW]

Carpus (carpopodite). Third article from distal end of leg. [ABW]

Figure 2.2. Schematic drawing of brachyuran crab in: A—dorsal view; areas of carapace indicated; legs of right side only shown; b, basis; cp, carpus; d, dactylus; i, ischium; m, merus; p, propodus. B—ventral view; areas of carapace indicated; legs of left side only shown; b, basis; cp, carpus; cx, coxa; d, dactylus; end, endognath; ex, exognath; i, ischium; m, merus; p, propodus (from Williams, 1984).

Chela. Arrangement of distal 2 articles of crustacean limb in which terminal article is opposed to article preceeding it in an adaptation for grasping. In true chela, terminal 2 articles shaped as fingers, one closing against other. In subchela, terminal article (dactyl) usually closes against distal surface of penultimate article (propodus). [ABW]

Chelipeds. Pair or pairs of thoracic legs behind maxillipeds; bearing chelae, or pincer-like claws, and often stouter, sometimes much stouter, than other legs. [ABW]

Coxa (coxopodite). First or proximal article of leg or maxilliped. [ABW]

Dactyl (dactylus or dactylopodite). Terminal or distal article of leg; movable finger of cheliped. [ABW]

Efferent channels. Channels through which water passes from gills. Openings at sides of endostome, except in Section Oxystomata in which they open at middle of endostome. [ABW]

Endognath. Inner or principal branch of a maxilliped. [ABW]

Endopodite. Mesial ramus of biramous appendage. [ABW]

Endostome. Part of epistome forming palate in brachyurans and usually separated from epistome proper by transverse ridge. [ABW]

Epibranchial (epibranchial region). Part of porcellanid (crab) carapace situated behind orbit and above metabranchial region. Region situated between cervical groove and *linea anomurica.* Often a strong spine on region, referred to as epibranchial spine. [ABW]

Epigastric lobes. Anterior lobes or subregions of gastric regions. [ABW]

Epimere. Lateral part of wall of body somites situated between tergum and insertion of appendages. [ABW]

Epipodite. Outgrowth of first 7 thoracic coxae. [ABW]

Epistome. Antennal sternum mainly represented by epistome, a plate of varying shape lying betweeen labrum and bases of antennae. In shrimps, comparatively narrow and separated on each side from lateral portions of carapace by exhalant branchial channels. In Astacidea and Anomura, broad and in contact with carapace on each side; in Brachyura, becoming firmly united with carapace. The epistome forms the anterior part of the buccal frame. [ABW]

Exognath. Lateral or secondary branch of maxilliped. [ABW]

Exopod. see Exopodite.

Exopodite. Lateral ramus of biramous appendage. [ABW]

Fingers (digits). Narrow scissorlike blades of pincer end of cheliped, movable finger being dactyl, and fixed finger the terminal part of propodus. [ABW]

Flagellum. Multiarticulate distal portion of antennule, antenna, or exopod. [McL.]

Front. Frontal portion of carapace; that portion of crab carapace lying between orbits. [ABW]

Frontal teeth. True frontal teeth; those teeth originating on front but exclusive of inner orbital teeth. [ABW]

Gastric region. Large median area, in crab carapace, bounded behind by cervical suture, laterally by hepatic regions, and anteriorly by frontoorbital regions. Divisible into following subregions or lobes: epigastric, protogastric, mesogastric, metagastric, and urogastric. [ABW]

Genital region. See urogastric lobe. [ABW]

Gonopore. Outlet for genital products; syn., *sexual pore.* [McL.]

Hand (chela). Propodus and dactyl of cheliped. [ABW]

Hepatic region. Small (paired) subtriangular, anterolateral region, wedged between branchial and gastric regions, and either margin of carapace or margin of orbit in Brachyura. [ABW]

Hepatic spine. Spine on hepatic region in shrimps (Fig. 2). [ABW]

Holotype. The single specimen used as the basis of the original published description of a species and later designated as the type specimen. [AHD]

Incisor process. Biting portion of gnathal lobe of mandible; syn., *pars incisiva.* [McL.]

Ischium (ischiopodite). Fifth article from distal end of leg; usually first large article of maxilliped. [ABW]

Keel. see Carina.

Lacinia(e). Inner distal spiny lobe of second segment of maxillule. [McL.]

Linea anomurica, L. homolica, L. thalassinica. Longitudinal groove or uncalcified line on carapace which may form a hinge; such lines found in various groups, from which come the names. [ABW]

Mandible. One of the third pair of cephalic appendages, used to masticate food. [McL.]

Mandibular palp. Distal articulated part of mandible used in feeding or cleaning. [McL.]

Manus. Broad proximal part of propodal cheliped; syn., *palm.* [McL.]

Maxillipeds. Paired appendages modified for feeding on 1st, up to 3rd, thoracic somites, usually fused to cephalon. [McL.]

Maxillule. One of a pair of the 4th cephalic appendages, usually serving as a mouthpart; syn., *1st maxilla.* [McL.]

Merus (meropodite). Fourth article from distal end of leg; sometimes called arm of cheliped. [AW]

Mesogastric lobe. Median lobe or subregion of gastric region; pentagonal in form, and with long, narrow, anterior prolongation. [ABW]

Metabranchial (metabranchial region). That region of porcellanid (crab) carapace situated below *linea anomurica* and, therefore, not completely united with main part of carapace. [ABW]

Metagastric lobe. Posterolateral lobe or subregion of gastric region; often not defined. [ABW]

Molar process. Grinding portion of gnathal lobe of mandible; syn., *pars molaris.* [McL.]

Obsolescent. Vestigial. [AHD]

Ocellus. Little eye, distinct from main organ of vision. [ABW]

Ocular peduncle. Eyestalk. [ABW]

Orbit. Cavity in carapace containing eye. [ABW]

Orbital fissure. see orbital hiatus.

Orbital hiatus. Gap in orbital margin of carapace at its lower (inner) angle. [M&M]

Orbital region. Narrow space bordering upper margin of orbit; not always distinguishable. [ABW]

Palate. Roof of buccal cavity in crabs. [ABW]

Palm. Proximal part of propodus of chela. [ABW]

Palp. Usually one ramus (endopod), sometimes both, and basis, reduced distally to 1 to 3 segments, associated with mouthparts. [McL.]

Peduncle. A stalklike structure. [AHD]

Pereiopod (also spelled peraeopod or pereopod). Thoracic appendage used in locomotion; syn., ambulatory leg, walking leg. [McL.]

Petasma. Endopodite of first pleopods in male Penaeidae; a complicated membranous plate bearing coupling hooks mesially which interlock with those on member of opposite side; may terminate distally in various complex-shaped lobes. [ABW]

Phyllobranchia(e). Gill with leaflike filaments. [McL.]

Pleurobranchia(e). Gills attached to lateral wall of body dorsal to articulation of appendage. [ABW]

Pleuron. See epimere.

Podobranchiae. Gills attached to coxa of appendage. [ABW]

Postorbital groove. Groove on carapace behind orbit and more or less parallel to margin of orbit (Fig. 2). [ABW]

Propodus (propodite). Second article from distal end of leg. Propodus of cheliped consists of palm and narrower fixed finger. [ABW]

Prosartema (dorsal eye brush). Long, thin, ciliated lobe arising dorsally from proximomesial border of first antennular segment and extending anteriorly; found in Penaeidae. [ABW]

Protogastric lobe. Anterolateral lobe of subregion of gastric region. [ABW]

Protopodite. Peduncle of an appendage; in unmodified form, consisting of one coxal and one basal article. [ABW]

Pterygostomian region. Triangular space on ventral surface of carapace, on either side of buccal cavity in Brachyura. Region at anterolateral corner of carapace in shrimps. [ABW]

Pterygostomian spine. Spine at anterolateral (anteroventral) corner or border of carapace in shrimps (Fig. 2). [ABW]

Pubescence. A covering of down or short hairs. [AHD]

Rugose. Having a rough or ridged surface. [AHD]

Scaphocerite. Antennal scale (Fig. 2). [ABW]

Stylocerite. Spine or rounded lobe on lateral aspect of basal article of antennule. [ABW]

Subhepatic region. Area below hepatic region and anterolateral border of carapace. [ABW]

Suborbital spine. Spine on lower rim of orbit (Fig. 2). [ABW]

Sulcus, sulci. Groove or furrow. [McL.]

Suture. Weakly calcified areas of integument separating at ecdysis. [McL]

Supraorbital spine. Spine above and behind orbit (Fig. 2). [ABW]

Telson. Terminal somite of abdomen. [ABW]

Tergite. Dorsal plate of segment. [ABW]

Thelycum. External seminal receptacle, variously developed, lying on sternum of thorax and formed by outgrowths from last and next to last thoracic somites. [ABW]

Urogastric lobe. Posteromedian lobe or subregion of gastric region, sometimes called genital region. [ABW]

Institutional Abbreviations

AHF — former Allan Hancock Foundation Collection (now part of the Crustacea collection of the Natural History Museum of Los Angeles County).

CAS — California Academy of Sciences

CMM — Cabrillo Marine Museum, San Pedro, California

LACM — Natural History Museum of Los Angeles County

MMS — Minerals Management Service

SBMNH — Santa Barbara Museum of Natural History

SIO — Scripps Institution of Oceanography

USNM — United States National Museum of Natural History, Smithsonian Institution.

Methods of Preservation

Ideally, decapods should be initially fixed in buffered formalin. Commercially available "full strength" formalin represents a 37% solution of formaldehyde; a 1:20 mixture of this solution with water will result in a very strong fixative that is commonly referred to as "5% formaldehyde" (actually 5% formalin). Stronger solutions may be used but those exceeding 10% often result in very brittle specimens. Decapods tend to cast off appendages when subjected to severe shocks, such as immersion in formalin. This tendency often can be moderated by euthanizing them, either by using initially a slightly weaker solution (1-2%) of formalin and gradually increasing the percent of formalin to 5-10%, or by chilling them in ice water prior to fixation. The latter technique has the added advantage that color of the integument is retained. Smaller specimens (e.g. less than 100 mm carapace width for crabs and 100 mm carapace length for shrimp and lobsters) may be placed directly into the fixative solution. For larger specimens, it is best to use a syringe to inject this solution into the major body cavities, gill chambers, and even into the joints of the appendages to assure proper fixation, prior to placing the entire specimen in a 10% solution. Several workers (e.g. see Lincoln and Sheals, 1979: 63) then recommend addition of small amounts of glycerol to the fixative at this time to keep specimens from becoming too brittle. After fixation for at least 24 hours (and up to 3 or 4 days for large specimens), they should be thoroughly rinsed in fresh water and transferred to 70% ethyl-alcohol for long-term storage. Specimens with detailed collection information (including date of collection, depth, habitat, method of capture, etc.) should be deposited in a major and reputable institution that is committed to the long term care of marine invertebrates (e.g., the Natural History Museum of Los Angeles County).

List of Families, Genera, and Species in the MMS Collections

- Order Decapoda
  - Dendrobranchiata
    - Penaeidea
      - Family Sicyoniidae Ortmann, 1898
        - *Sicyonia ingentis* (Burkenroad, 1938)
  - Pleocyemata
    - Caridea
      - Family Crangonidae Haworth, 1825
        - *Neocrangon zacae* (Chace, 1937)
        - *Neocrangon resima* (Rathbun, 1902)
        - *Neocrangon communis* (Rathbun, 1899)
        - *Crangon alaskensis* Lockington, 1877
        - *Metacrangon spinosissima* (Rathbun, 1902)
      - Family Alpheidae Rafinesque, 1815
        - *Alpheus bellimanus* Lockington, 1877

Family Hippolytidae Dana, 1852

Eualus lineatus Wicksten and Butler, 1983

Spirontocaris sica Rathbun, 1902

Spirontocaris holmesi Holthuis, 1947

Family Palaemonidae Rafinesque, 1815

Pseudocoutierea elegans Holthuis, 1951

Thalassinidea

Family Axiidae Huxley, 1879

Acanthaxius spinulicaudus (Rathbun, 1902)

Calocarides quinqueseriatus (Rathbun, 1902)

Calocarides sp.

Anomura

Family Paguridae Latreille, 1803

Paguristes ulreyi Schmitt, 1921

Parapagurodes laurentae McLaughlin and Haig, 1973

Family Galatheidae Samouelle, 1819

Munida quadrispina Benedict, 1902

Pleuroncodes planipes Stimpson, 1860

Family Lithodidae Samouelle, 1819

Paralomis multispina (Benedict, 1894)

Brachyura

Family Homolidae De Haan, 1839

Paromola faxoni (Schmitt, 1921)

Family Xanthidae MacLeay, 1838

Lophopanopeus bellus diegensis (Rathbun, 1900)

Family Parthenopidae Alcock, 1895

Heterocrypta occidentalis (Dana, 1854)

Family Majidae Samouelle, 1819

Erileptus spinosus Rathbun, 1893

Family Pinnotheridae De Haan, 1833

Pinnixa occidentalis Rathbun, 1893

Pinnixa scamit Martin and Zmarzly, 1994

Key to Families and Species

Williams (1984) presented a key to the 48 families of decapods known from the east coast of the United States. While some families in that key have no west coast representatives, the west coast families are a subset of those 48. Further, the key is updated to correct family names, authors, and dates, and is thus preferable to the older key of Schmitt (1921) or the various popularized guides to west coast fauna (e.g. Kozloff, 1987; Allen, 1980; Jensen, 1995, etc.). Because that key was constructed to help in the identification of east coast species, it was never intended to be used in other geographic regions, and reliance upon it for identification of west coast species without some modification of the couplets could present problems.

The following key is a modified subset of Williams' (1984) key to families, and includes *only those families and species mentioned in this report.* This is of course very misleading, in that if a species belonging to a family or genus not among those in our report is found for the first time in this study area, it will not be possible to identify it using the following key. In fact, even species known to occur in this area will not always be identifiable using such an artificial key. For example, a worker attempting to identify commercially important penaeid shrimp or a species of the crab genus *Cancer* will have no luck. Even though penaeids and species of the family Cancridae are commonly encountered in California waters, and occur in our study area, none was found in this particular survey. The reader is referred to more specific keys to the particular families or genera in question, such as that of Zmarzly (1992) for the pinnotherid genus *Pinnixa* or that of Wicksten (1990) for the shrimp family Hippolytidae, or to more encompassing and more general guides to decapods outside this immediate study, when similar problems present themselves. Specific couplets for separating species within families are taken from earlier published sources, such as Word and Charwat (1976) and Butler (1980), or are newly created by us.

1A. General form shrimplike, usually compressed. Pleura of second abdominal segment never overlapping those of first segment. First 3 pairs of legs chelate. [Suborder Dendrobranchiata; infraorder Penaeidea] .... Family Sicyoniidae: *Sicyonia ingentis*

1B. General form shrimplike, lobsterlike, or crablike; if shrimplike then with pleura of second abdominal segment overlapping those of first segment. Of first three pairs of legs, third not chelate .... Suborder Pleocyemata 2

2A. Form shrimplike, usually with body compressed .... Infraorder Caridea 3

2B. Form lobsterlike or crablike 15

3A. First pair of legs chelate 10

3B. First pair of legs subchelate .... Family Crangonidae .. 4

4. Gastric region of carapace depressed below general level of the carapace .... *Metacrangon spinosissima*

5. Gastric region of carapace not depressed below general level of carapace 6

6A. Carapace with only one median gastric spine .... *Crangon alaskensis*

6B. Carapace with two median gastric spines 7

7A. The rostrum tilts up at an angle of 45 degrees; the tip of the rostrum has a small flag-like structure (not evident in specimens less than 20 mm TL) .... *Neocrangon resima*

7B. The rostrum may be tilted upward, but not at a 45 degree angle; flag-like structure at tip absent. 8

8. All abdominal segments except first and second carinate on dorsal surface, with two carinae separated by median sulcus on sixth abdominal segment .... *Neocrangon communis*

9. Only sixth abdominal segment carinate on dorsal surface, with two carinae separated by median sulcus .... *Neocrangon zacae*

10A. Carpus of second legs entire .... Family Palaemonidae: *Pseudocoutierea elegans*

10B. Carpus of second legs subdivided into two or more joints; first pair of legs with chelae asymmetrical . 11

11A. Chelae of first legs very large and distinct, at least on one side; eyestalks short and covered by carapace .... Family Alpheidae: *Alpheus bellimanus*

11B. Chelae of first legs not obviously large and distinct; eyestalks not covered by carapace .... Family Hippolytidae 12

12A. Carapace without supraorbital spines .... *Eualus lineatus*

12B. Carapace with two or more supraorbital spines 13

13. Carapace with three median spines, which blend together with the rostral teeth .... *Spirontocaris holmesi*

14. Carapace with two median spines, which are slightly anterior to the midline .... *Spirontocaris* sp.

15A. Either lobster-like or crab-like; abdomen extended, bent upon itself, or flexed beneath thorax; last thoracic sternite free; uropods present; carapace not fused with epistome; first, second, or first 2 pairs of legs chelate or subchelate .... Infraorders Thalassinidea and Anomura 16

15B. Crab-like, abdomen permanently flexed beneath carapace; last thoracic sternite fused with preceding; uropods rarely present, never biramous; carapace fused with epistome; first pair of legs chelate or subchelate .... Infraorder Brachyura 27

16A. Abdomen asymmetrical 17

16B. Abdomen symmetrical 21

17. Abdomen membranous and with uropods adapted for holding body in hollow objects 19

18. Abdomen asymmetrical and sclerotized, flexed under body .... Family Lithodidae: *Paralomis multispina*

19. Third maxillipeds approximated at base; antennae setose, moth-like .... Family Diogenidae: *Paguristes ulreyi*

20. Third maxillipeds widely separated at base by sternum; antennae sparsely setose .... Family Paguridae: *Parapagurodes laurentae*

21A. Body subcylindrical; first 2 pairs of legs chelate or subchelate; abdomen extended .... Infraorder Thalassinidea, Family Axiidae 22
21B. Body depressed; only first legs chelate; abdomen bent under thorax .... Family Galatheidae .. 25

22A. Eyes pigmented .... *Acanthaxius spinulicaudus*
22B. Eyes pale, without pigment 23

23. Distoventral spines present on carpus of second leg .... *Calocarides* sp.
24. Distoventral spines absent on carpus of second leg .... *Calocarides quinqueseriatus*

25. Lateroinferior edges of carapace greatly swollen so that epimeral structures, sides of carapace, are visible in dorsal view; pereiopods flattened for swimming .... *Pleuroncodes planipes*
26. Lateroinferior edges not greatly swollen; pereiopods more cylindrical for walking .... *Munida quadrispina*

27A. Linea homolica present on carapace laterally; 5th pereiopods carried dorsally or subdorsally .... Family Homolidae: *Paramola faxoni*
27B. Linea homolica absent; 5th pereiopods carried laterally, as other pereiopods 28

28A. Body conspicuously narrowed in front; rostrum distinct 29
28B. Body moderate to broad in front; rostrum absent 31

29. Chelipeds with fingers straight; hooked hairs present .... Family Majidae: *Erileptus spinosus*
30. Chelipeds with fingers deflexed; hooked hairs absent .... Family Parthenopidae: *Heterocrypta occidentalis*

31A. Carpus of third maxilliped articulating at or near anterointernal angle of merus; lateral margins of mouth frame parallel or divergent .... Family Xanthidae: *Lophopanopeus bellus diegensis*
31B. Carpus of third maxilliped not articulating at or near anterointernal angle of merus; lateral margins of mouth frame convergent, becoming ellipsoid .... Family Pinnotheridae 32

32. Propodus of pereiopod 4 nearly as broad as long .... *Pinnixa occidentalis*
33. Propodus of pereiopod 4 approximately 2.6 times longer than broad .... *Pinnixa scamit*

Descriptions of Species

Order Decapoda Latreille, 1803

Suborder Dendrobranchiata Bate, 1888

Infraorder Penaeidea de Haan, 1849

Family Sicyoniidae Ortman, 1898

Sicyonia ingentis **(Burkenroad, 1938)**

Figure 2.3

Eusicyonia ingentis Burkenroad, 1938:

Sicyonia ingentis.—Word and Charwat, 1976:19.—Perez Farfante, 1988:25, Fig. 41A-C.—Jensen, 1995:79.

Material Examined. One small (carapace length = 4.4 mm including rostrum, total length = 12.4 mm) juvenile, USNM Phase I voucher, 073-BSR, 03-TX.

Description. Postrostral carina with 1 tooth posterior to level of hepatic spine. Dorsomedial carina on first abdominal segment produced into tooth smaller or only slightly larger than posterior tooth on carapace. Petasma with distal projections of dorsolateral lobules divergent and produced in short filament. Thelycum with posterior component of median plate bearing paired short lateral bosses cut by transverse suture (adapted from Perez Farfante, 1988, key).

Color in life not reported.

Commonly referred to as the ridge backed prawn, rock shrimp, Pacific rock shrimp, camaron de piedra, and cacahuete.

Biology. Commercially harvested between Santa Barbara and Ventura, California (Frey, 1971). Attains a total length of 157 mm (males) to about 180 mm (females) (Perez Farfante, 1988).

Taxonomic Remarks. The single specimen examined was small and in poor condition, with carapace, telson, and appendages slightly damaged. Assignment to *S. ingentis* is therefore tentative, although *S. ingentis* is the only species in the genus reported from as far north as California. *Sicyonia ingentis* is one of only 4 eastern Pacific members of this genus that are of commercial importance (Perez Farfante, 1988), the other 3 being *S. brevirostris* Stimpson, 1874, *S. penicillata* Lockington, 1879, and *S. disdorsalis* (Burkenroad, 1934). However, other species in the genus, not of commercial importance, are also present (e.g., see Perez Farfante and Boothe, 1981). Spination on the dorsal keel of the carapace of our specimen agrees most closely with descriptions of *S. ingentis*, based on the key of Perez Farfante (1988).

Type Locality and Type Specimens. Station 127, Dredge 1, off east coast of Cedros Island, west coast of Baja California, in 76-120 m. Type and Cotypes, Cat. No. 361,025, Department of Tropical Research, New York Zoological Society (6 males, 4 females).

Distribution. Isla Maria Madre and throughout the Gulf of California (Perez Farfante, 1988), including Cedros Island, Baja California (Burkenroad, 1938), north to Santa Barbara, California, including Santa Catalina Island (Carlisle, 1969; Frey, 1971; Word and Charwat, 1976) and to Monterey Bay (Perez Farfante, 1988). From 5 to 183 m, occasionally to 293-307 m (Perez Farfante, 1988).

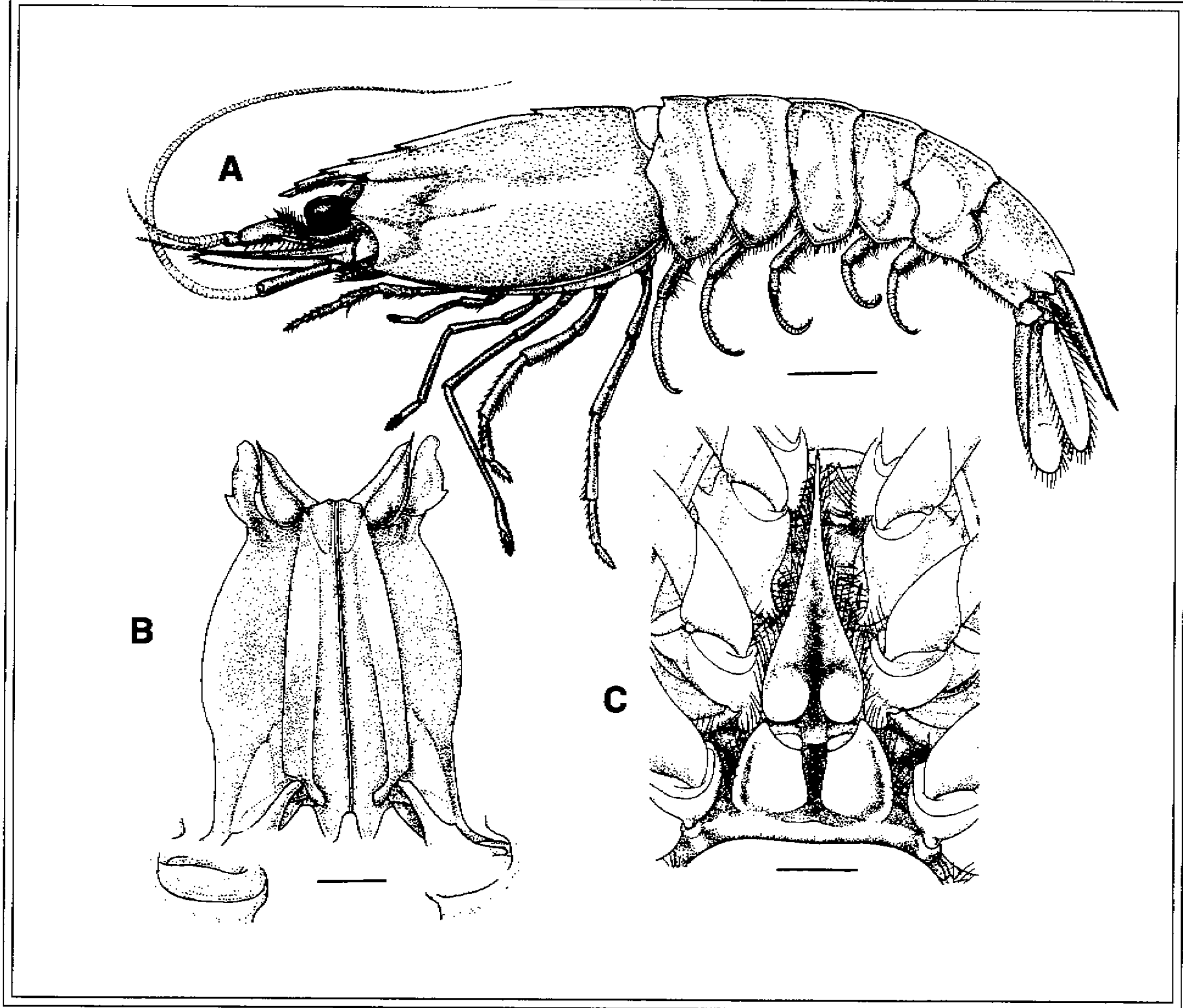

Figure 2.3. *Sicyonia ingentis* (Burkenroad, 1938): A, lateral view; B, dorsal view of petasma; C, thelycum; scale for B = 1mm, scale for C = 2mm (after Perez-Farfante, 1988).

The northern range record for this species, Monterey Bay, California, was first given by a footnote in Perez Farfante and Booth (1981:424), based on a single female archived at the California Academy of Sciences (CAS 009269). The present record is the second report of *S. ingentis* north of Pt. Conception, California, which was the northern range of the species given by Frey (1971).

Suborder Pleocyemata Burkenroad, 1963

Infraorder Caridea Dana, 1852

Family Crangonidae Haworth, 1825

Neocrangon zacae (Chace 1937)

Figure 2.4

Crago zacae Chace, 1937:136, Fig. 9.

Crangon communis.—Rathbun, 1904 in part.

Crangon zacae.—Word and Charwat, 1976:93, Fig. 5-3

Neocrangon zacae.— Kuris and Carlton, 1977:554.—Wicksten, 1980:39.—Wicksten and Hendrickx, 1992:6.

Material Examined. USNM 073-BSR-02-TX Phase I primary voucher, 1 specimen; SBMNH 058-BSS-01-TX Phase I secondary voucher, 1 specimen; MMS Phase II voucher, M/V *Aloha*, Cruise1-3, Station R-4, 91 m, 3 specimens, largest - female, carapace length 7.2 mm including rostrum; MMS Phase II voucher, M/V *Aloha*, Cruise 1-1, Station PJ-15, 155 m, 1 specimen.

Description. Gastric region not depressed below general outline of carapace. Two spines on dorsal midline of carapace, posterior one in front of midpoint of carapace. A pair of lateral spines in line with anterior dorsal spine. Rostrum moderately ascendent, narrowly rounded at tip, not reaching as far forward as eyes. Abdomen with no carina on first five somites, sixth somite with parallel carinae divided by median sulcus. Blade of antennal scale exceeded by outer spine. Chelae of first legs more than three times as long as wide.

Carapace to base of rostrum about one-fourth as long as abdomen. Gastric region not depressed below the general outline of the carapace. Two spines in dorsal midline, posterior one much longer, arising in front of middle of carapace. A strong lateral spine present in line with anterior dorsal spine. Anterior margin with two spines, one at lower orbital angle, other at antero-lateral angle of carapace.

Rostrum ascends at slight angle which varies somewhat, but never becoming as great as 45°, bearing pronounced dorsal sulcus, tapering to blunt point, never reaching as far forward as eyes.

The abdomen without carina on first five somites. Posterior portions of first two segments slightly elevated; elevations preceded by broad, shallow, transverse sulci. Sixth segment about one and two-thirds times as long as fifth, bearing pair of dorsal longitudinal carinae separated by median sulcus and bounded on outer side by shallower sulci. Telson longer than sixth somite; with two pairs of dorsolateral spinules.

The eyes large and black.

Second segment of antennular peduncle about twice as long as third. Flagella extending to ends of hairs fringing antennal scale; latter about three and one-half times as long as wide, with outer spine easily exceeding blade in length.

Third maxillipeds extending slightly beyond antennular flagella. First legs exceed antennal scale but not reaching as far as terminal fringe of the latter. A spine present at outer angle of distal end of merus. Palm almost three and one-third times as long as wide, and dactyl closes very obliquely. Second pair of legs shorter than the first. Third pair extending well beyond third maxillipeds and fourth falls just short of latter.

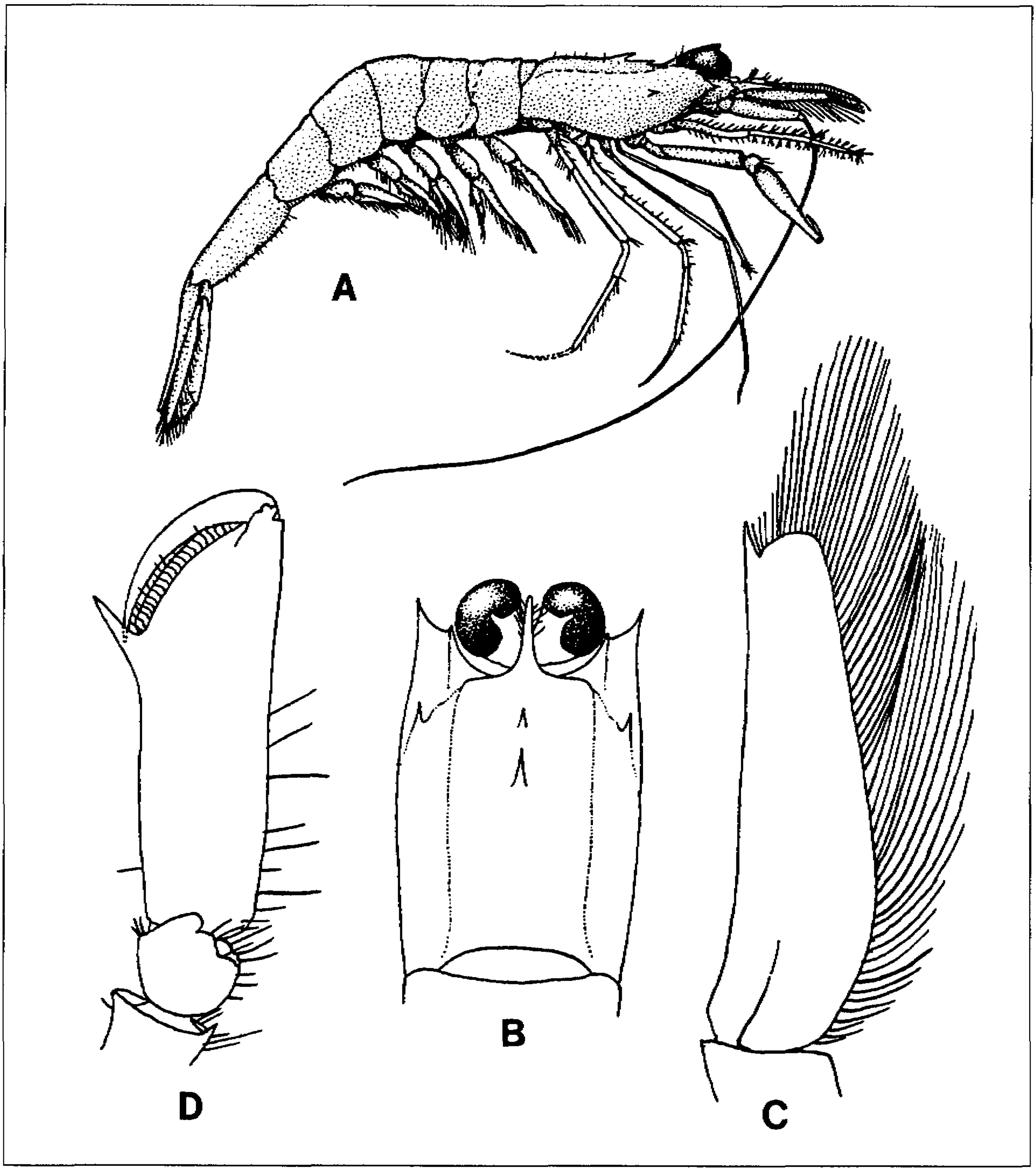

Figure 2.4. *Neocrangon zacae* (Chace, 1937): A, Female holotype, lateral view; B, female holotype, dorsal view of carapace; C, paratype, antennal scale; D, paratype, chela of first pereiopod (from Chace, 1937).

Color in life: Body semi-translucent, mottled finely with greenish-brown and scarlet on dorsal and lateral surfaces; ventral surface white. Antennae banded with scarlet and white; eye mottled greenish and black; uropods and telson same color as body; remaining appendages translucent white (after Chace, 1937).

Biology. Wicksten (1980) states that specimens from 105 stations in southern California and Baja California, Mexico in the collections of the Allan Hancock Foundation were taken at depths ranging from shore to 572 m from bottoms ranging from mud to coralline algae.

Taxonomic Remarks. Chace (1937) states that this species is closely allied to *N. communis* (Rathbun), *N. resima* (Rathbun), and *N. abyssorum* (Rathbun). It is distinguished from the latter by the smaller eyes, longer palm of the first leg and lack of a carina on the fifth abdominal somite. It differs from *N. resima* in the differently shaped and less ascendent rostrum and longer palm. *N. zacae* most closely resembles *N. communis* but differs in the total absence of a carina on any but the sixth segment of the abdomen.

Zarenkov (1965) proposed a separation of the genus *Crangon* into the subgenera *Crangon* s. s. and *Neocrangon*. Kuris and Carlton (1977) elevated *Neocrangon* to generic status and although Wicksten (1980) and Wicksten and Hendrickx (1992) refer to the above species as *Neocrangon zacae*, Butler (1980) did not feel that Zarenkov's diagnosis for *Neocrangon* was valid.

Dr. M. Wicksten, Texas A &M University, feels that this species and the following one (*N. resima*) are synonymous and has a paper submitted to that effect (pers. comm.). Without having seen that manuscript, we still feel comfortable with the recognition of the two species.

Specimens of *N. zacae* seen by us, including the material from the Santa Barbara Channel, appear to differ consistently from specimens of *N. resima* by the setation on the extremity of the rostrum, which is restricted to a distal tuft in *N. resima* but is more widely scattered along both sides of the rostrum in *N. zacae*. This distinction holds true also for local specimens (D. Cadien, pers. comm.). However, the illustration of the holotype of *N. zacae* (reproduced here as Fig. 4B) shows setae of the local "*resima*" form. Further investigation of this character might be warranted.

Type Locality and Type Specimens. Station 125, D-1, East of Cedros Island, 28°13'N., 115° 07'W., 88 m, on a muddy bottom, 27 March, 1936. Holotype female, Cat. No. 36,1096, Department of Tropical Research, New York Zoological Society.

Distribution. Monterey Bay, California, U.S.A., to Cedros Island, Baja California Norte, Mexico; off Gonzaga Bay, Gulf of California, Mexico; Clarion Island; north of Gorgona Island, Columbia (Wicksten and Hendrickx, 1992)

Neocrangon resima (Rathbun, 1902)

Figure 2.5

Crangon resima Rathbun, 1902:889; 1904:124, Fig. 65.

Crago resima.—Schmitt, 1921:96, Fig. 64.—Goodwin, 1952:171.

Crangon resima.—Butler, 1980:95.—Word and Charwat, 1976:87

Neocrangon resima.—Kuris and Carlton, 1977:554.—Jensen, 1987b:402, Fig. 19.16.

Material Examined. M/V *Aloha* Station PJ-1, May, 1987, 1 ovigerous female, carapace length 10.8 including rostrum.

Description. First five abdominal segments smooth. First and second segments with thickened band along posterior margin, in front of which a slight transverse depression. Fifth segment with an obscure median carina, with short depression on either side at anterior end. Sixth segment has two prominent carinae and corresponding median depression. Telson with a slight median sulcus. Eyes of moderate size. Second segment of antennular peduncle three times as long as third. Rostrum long, narrow, pointed, advanced beyond eyes, ascending at an angle of about 45°, slightly curved, and prolonged downward in thin, compressed plate, which appears spatulate in side view. The development of this plate is dependent on age; specimens 20 mm long show no evidence of it. Hands shorter than in *N. communis*, about three times as long as wide, anterior margin also more longitudinal than in *N. communis*. Antennal scale about four-fifths length of carapace, exclusive of rostrum; spine exceeding blade (after Schmitt, 1921).

Biology. According to Schmitt (1921) three specimens of *Neocrangon resima* were taken at D5788 in San Francisco Bay, and were associated with *Neocrangon communis*, *Crangon alaskensis*, and *Metacrangon spinosissima*.

Taxonomic Remarks. See remarks for *Neocrangon zacae*

Type Locality and Type Specimens. Off San Diego, California, 124 fathoms (227 m) *Albatross* Station 2935 (Rathbun, 1904).

Distribution. Monterey Bay, California, to San Domingo Point, Baja California, 44-266 fathoms (80 to 486 m) (Rathbun, 1904).

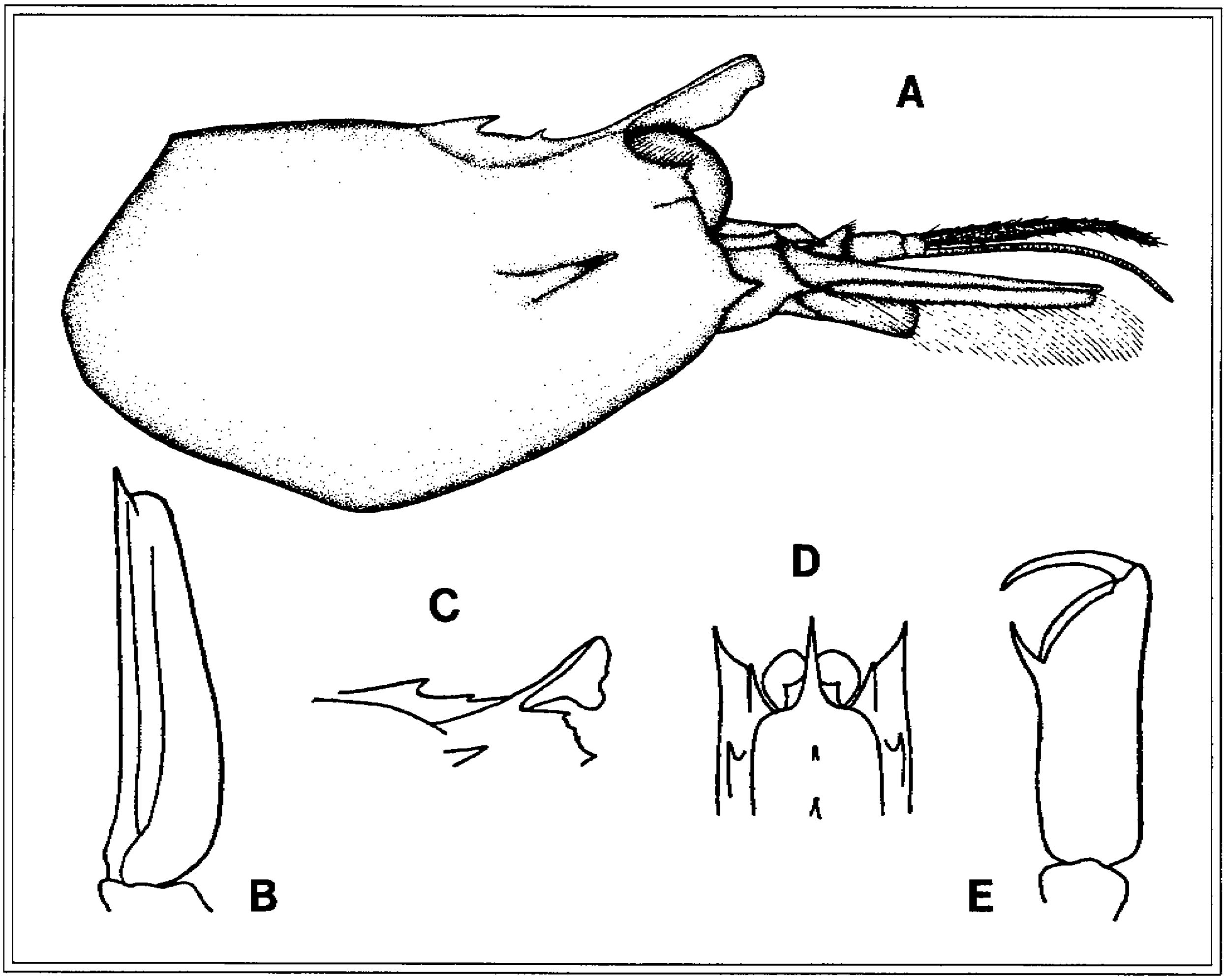

Figure 2.5. *Neocrangon resima* (Rathbun, 1902): A, lateral view of carapace; B, antennal scale; C, anterodorsal view of carapace; D, chela (A from Word and Charwat, 1976; B-D from Rathbun, 1904).

Neocrangon communis (Rathbun, 1899)

Figure 2.6

Crangon communis Rathbun, 1899:556: 1904:112 (key), 123, Fig. 64.—de Man 1920.—Word and Charwat 1976:77.—Butler 1980:110, Plate 5D.

Crago communis.—Schmitt, 1921:95, Fig. 63.—Goodwin, 1952:171.

Sclerocrangon communis.—Derjugin and Kobjakowa, 1935:84.—Vinogradov, 1950:256.

Crangon (Neocrangon) communis.—Zarenkov, 1965.

Neocrangon communis.—Kuris and Carlton, 1977:554.—Jensen, 1987b:402, Fig. 19.17.

Material Examined. USNM 018-BSS-01-TX Phase I primary voucher, 1 specimen, carapace length 18.5mm including rostrum; SBMNH 014-BSS-01-TX Phase I secondary voucher, 1 specimen.

Description. Body slender, depressed. Shell thin, pubescence on anterior part of carapace, and in abdominal sulci. Rostrum short, about 0.2 carapace length, median sulcus, ascending, tip rounded.

Carapace spines: 2 median in anterior half of carapace, anterior spine slightly smaller; median dorsal carina, ahead of anterior spine extending to posterior half of carapace; antennal moderate, with supporting carina; branchiostegal strong, with carina; pterygostomian weak; hepatic strong; lateral margin of rostrum extending posteriorly over orbital fissure as ridge above and beyond hepatic spine. Eye moderately large; cornea well developed; weak tubercle.

Antennule: peduncle short, second segment over twice length of first, latter with dorsal distal lobe; stylocerite short; inner flagellum longer than outer, and extending beyond antennal scale.

Antenna: scale shorter than telson, spine exceeding lamella; basicerite, upper lateral lobe, lower oblique spine; peduncle long; flagellum about as long as body.

Third maxilliped: long, slender; distal part of antepenultimate segment twisted; exopod long, with lash.

Pereiopod 1 as long as third maxilliped, stout except for ischium and proximal portion of merus. Merus with strong distal spine. Carpus with 2 weak distal spines. Propodus widens distally, fixed finger long and stout. Dactylus obliquely transverse when flexed. Pereiopod 2 shorter than 1, slender, chelate. Pereiopod 3 longer than 2 and as slender. Dactylus slender, about 0.5 times propodus length. Pereiopod 4 shorter than 3, stouter. Dactylus slender, about 0.65 times propodus length. Pereiopod 5 shorter than 4, slightly stouter. Dactylus slender, about 0.8 times propodus length.

Abdomen: all sulci filled with sparse short pubescence easily rubbed off. First and second somites, each with long transverse sulcus. Third to fifth somites each with wide median dorsal carina; third with an anterior transverse sulcus through carina and a wide vertical sulcus below carina. Fourth somite with 2 transverse sulci, one at each end of carina. Fifth somite with an anterior transverse sulcus through carina, and a wide sulcus or depression on each side of carina. Pleuron of fourth somite with a moderate posteroventral spine. Fifth pleuron with a moderate posterolateral spine. Sixth pleuron with 2 median dorsal carinae, a sulcus on outer side of each carina, and a weak posteroventral spine. Telson moderately wide, tapering to rounded tip. Median sulcus of telson with 2 pairs of dorsolateral spines. Inner uropod longer than outer with neither reaching end of telson.

Color in life: Medium gray background over most of body. More or less uniform brown over branchial region of carapace, overlaid with pale yellow spots, and fine brown to charcoal dots over rest of carapace. Abdomen has brown spots and blotches, light yellow spots, more intense along midlateral line of first to fourth, and sixth somites; ventral margins of all somites bordered by magenta mottling. Magenta on pleopods, and chela of pereiopod I, which also has brown spots. Other pereiopods with magenta to rust patches; latter color repeated distally on antennal flagellum. Brown spots on telson and uropods; outer margin of outer uropod magenta (from Butler, 1980)

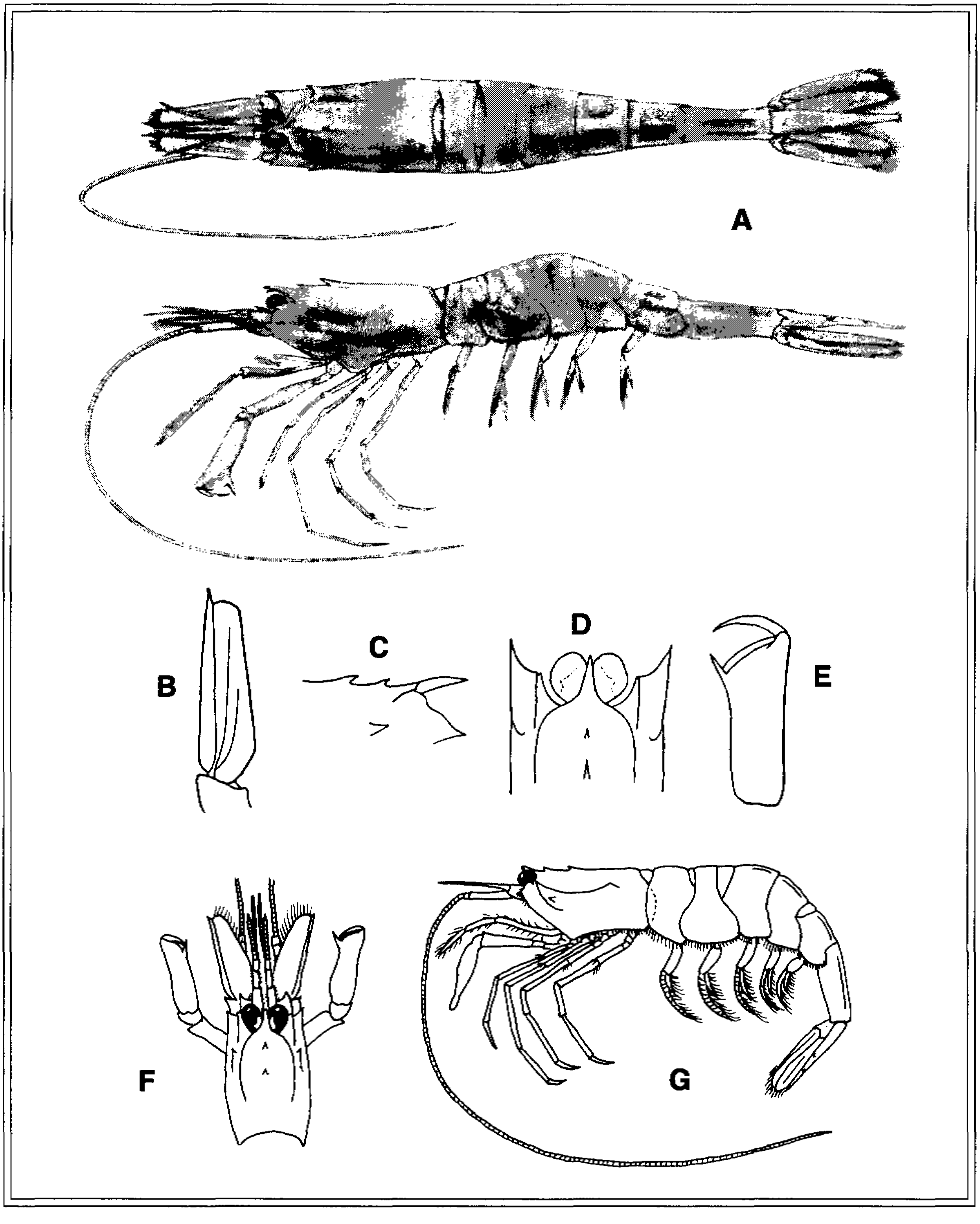

Figure 2.6. *Neocrangon communis* (Rathbun 1899): A, dorsal and lateral views (from Butler 1980); B, antennal scale; C, anterolateral view of carapace; D, anterodorsal view of carapace; E, chela (B-

Biology. Butler (1980) states that "this species may rank as the most common local shrimp [along the Pacific coast of Canada]. It occurs coastwide on mud bottoms from the shallow sublittoral to the lower continental slope. On grounds where *Pandalopsis dispar*, *Pandalus jordani*, and *P. borealis* are trawled commercially, *N. communis* is the most abundant associated shrimp species. In addition to capture by bottom trawls, it also has been collected by midwater trawls, At one locality off Active Pass at maximum depths of 128-161 m, specimens were caught at intermediate depths from 20-67 m.

Ovigerous females, 9.1-13.9 mm carapace length, occurred in January, February, May, and June to September.

Known parasites are the branchial isopod, *Argeia pugettensis* and the rhizocephalalan, *Mycetomorpha vancouverensis*."

Taxonomic Remarks. Rathbun (1904) noted some variation in rostral morphology caused by breakage and subsequent regrowth of the rostrum. See remarks for *Neocrangon zacae*.

Type Locality and Type Specimens. Off Pribilof Islands, Bearing Sea, 94 m *Albatross* Station 3441. Holotype female length 64 mm, carapace length 16 mm, antennal scale length 10.5 mm.

Distribution. Bering Sea to San Diego, California (including Puget Sound and Strait of Juan de Fuca), 20 - 309 fathoms (37 to 565 m) (Rathbun, 1904).

Crangon alaskensis Lockington, 1877

Figure 2.7

Crangon alaskensis Lockington, 1877:170 in part.—Rathbun, 1904:112 (key), 114, Figs. 52, 53.—Butler, 1980:108, Plate 3E in part.—Kuris and Carlton, 1977:553.—Jensen, 1995:40, Plate 59.

Crangon nigricauda.—Lockington, 1878:229, 465-480, in part.

Crangon crangon affinis.—Ortman, 1895:173 in part.

Crangon vulgaris.—Kingsley, 1899:709 in part.

Crangon alaskensis elongata Rathbun, 1902:888; 1904:112 (key), 115, Fig. 54.—de Man, 1920

Crago alaskensis elongata.—Schmitt, 1921:88, Fig. 58

Crago alaskensis.—Carlisle, 1969:237.

Material Examined. 1 specimen, MV *Aloha* Station R-8, Oct., 1988.

Description. Our specimen more closely resembles the "elongata" form previously treated as a subspecies by various authors. This form differs from the typical form as follows: longer and narrower rostrum; outer antennular flagellum not reaching to end of antennal scale; longer antennal scale, as long as carapace; faint dorsal median carina on fourth somite; tip of telson more acute.

Description of *C. alaskensis* typical form: Body slender, depressed. Shell thin surface smooth. Rostrum short, about 0.2 times carapace length, with median sulcus, ascending, tip rounded.

Carapace spines: 1 median in anterior third of carapace; antennal moderate; hepatic moderate, with short oblique supporting carina, anterior to median; branchiostegal strong with supporting carina, almost to end of basicerite of antenna; pterygostomian moderate; lateral margin of rostrum extending posteriorly over orbital fissure as ridge almost to center of carapace. Band around ventral margin of carapace, widening to lobe adjacent to bases of pereiopods 1 and 2.

Eye moderately large, cornea well developed, weak tubercle.

Antennule: peduncle moderately long, third segment subequal to second; stylocerite short; outer flagellum extending to about end of antennal scale, inner longer.

Antenna: scale 0.8-1.0 times carapace length, as long as or slightly shorter than telson, tip of lamella rounded, spine exceeding lamina somewhat; basicerite, 2 lateral spines; peduncle moderately long; flagellum shorter than body.

Third maxilliped: moderately long and slender, short exopod with lash.

Pereiopod 1 longer than third maxilliped, stout. Merus with inner spine in proximal half, and a strong distal spine. Propodus oblong, moderately long, 2.6-3.0 times average width, fixed finger moderate, slender. Dactylus transverse when flexed obliquely. Pereiopod 2 about as long as 1, slender and chelate. Pereiopod 3 longer than 2, slender, about 0.55 times length of propodus. Pereiopod 4 longer than 3, slightly stouter; dactylus slender, about 0.8 times propodus length.

Abdomen: ventral margins of pleura of first and second somites concave. Fifth somite with faint dorsal median carina and short transverse sulcus at anterior end. Sixth somite with faint median dorsal sulcus, moderate posteroventral spine, and ventral sulcus. Telson narrow, tapering to acute tip, dorsal distally flattened with two lateral spines evenly spaced with respect to tip of telson. Inner uropod narrower, as long as or longer than outer, former reaching tip of telson (after Butler, 1980).

Color in life: Light brownish gray background over almost entire shrimp, lighter on most appendages; closely spaced dark gray and brown spots over body, pleopods, pereiopods, and all parts of antenna. Scattered spots of pale yellow, white, and light brown on carapace and abdomen. Pale yellow spots on antennal peduncle, proximal segments of pereiopods 2, 4, and 5, basipodites of pleopods. With a dense covering of fine black dots on posterior midline of carapace, around posterior margin of sixth somite, and on telson and uropods. Tip of inner uropod orange (Butler, 1980, Plate 3E; Jensen, 1995, Plate 59).

Biology. Very common along the west coast of the United States (Rathbun, 1904:115).

Taxonomic Remarks. Butler (1980) chose not to recognize the subdivision into two subspecies first suggested by Rathbun (1902, 1904) for specimens from Canadian waters, instead attributing the slight morphological differences between those "forms" to intraspecific variability. Rathbun (1904) discussed rostral variation in the "elongata" form. The specimen illustrated here is from the Los Angeles Harbor area and adheres most closely to the "elongata" form.

Type Locality and Type Specimens. For *C. a. elongata*, off Santa Barbara, California, 29 fathoms (53 m), *Albatross* Stations 2970, 2971 (Rathbun, 1904:115).

Distribution. East part of Bering Sea and along the Aleutian Islands, south to off Wilmington, California (Rathbun, 1904, as *C. alaskensis elongata*). 3.25 to 41 fathoms (6 to 75 m) (Rathbun, 1904).

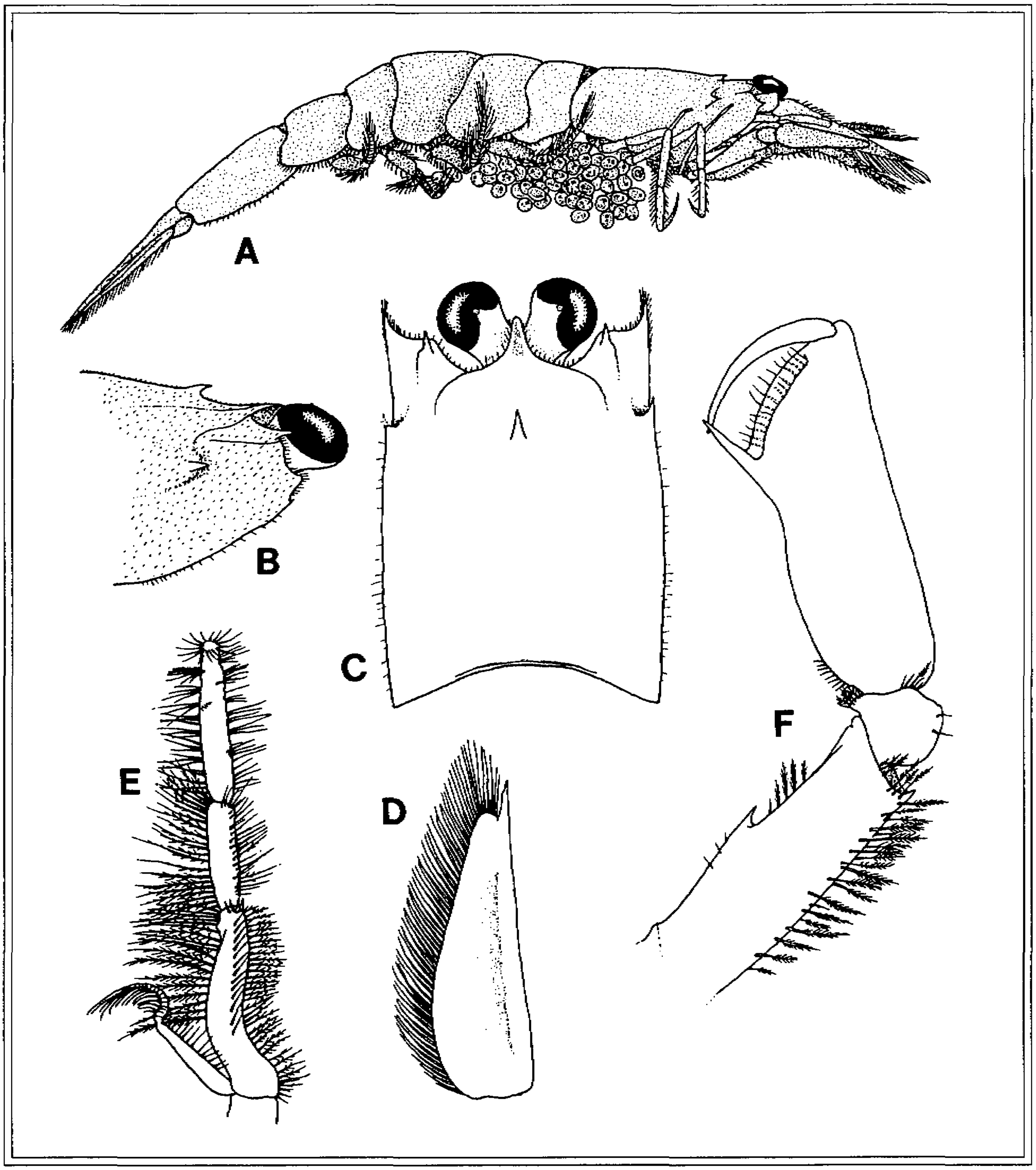

Figure 2.7. *Crangon alaskensis* Lockington, 1877: A, lateral view of ovigerous female; B, anterolateral view of carapace; C, dorsal view of carapace; D, antennal scale; E, third maxilliped; F, chela. Original illustration from specimen taken from Los Angeles Harbor.

Metacrangon spinosissima (Rathbun, 1902)

Figure 2.8

Crangon spinosissima Rathbun, 1902:891; 1904:112 (key), 130, Fig. 70.—deMan, 1920:217.—Wicksten, 1977:282.—Word and Charwat, 1976:89, Fig. 5-2.

Crago spinisissima Schmitt, 1921:100, Fig. 69.—Goodwin, 1952:171.—Butler, 1950:50.

Metacrangon spinosissima Zarenkov, 1965:298.—Jensen, 1987b:400.—Butler, 1980:115, Plate 1B.

Material Examined. USNM 038-BSS-01-TX Phase I primary voucher, 1 specimen, carapace length 6.2 mm including rostrum.

Description. Body stout, depressed. Shell thick, mainly rugose, depressed portion of carapace pubescent. Rostrum short, 0.15-0.2 carapace length, median sulcus, ascending, tip acute or rounded, Carapace spines: 2 median, anterior larger, just posterior to rostrum, posterior in posterior half of carapace, the 2 joined by a median carina; submedian, about center of carapace, with supporting carina; hepatic with supporting carina; antennal strong, ascending; postorbital moderate, confluent with antennal; weak spine below antennal; branchiostegal strong, with supporting carina; pterostomian weak; fine carina extending from slight fissure below antennal spine posteriorly across depression in carapace. Band around ventral margin of carapace, widening as pronounced lobe adjacent to base of pereiopod 2 or 3.

Eyes small, corneas well developed, stalks taper distally, deflected obliquely.

Antennule: Peduncle long, second segment longer than third, first and second each with distal lateral spine; stylocerite moderately long, broad, pointed laterally; inner flagellum longer than outer, both exceed antennal scale.

Antenna: Scale shorter than telson, lamella exceeds spine; basicerite, 2 blunt lateral spines; peduncle long; flagellum longer than body, with plumose setae.

Third maxilliped: Moderately long, slender, except antepenultimate segment, setiferous; exopod long, with lash.

Pereiopod 1 longer than third maxilliped, stout. Merus with ventral longitudinal carina. Propodus widens distally, length 3.6-4.0 times average width, fixed finger moderate. Dactylus obliquely transvers when flexed. Pereiopod 2 longer than 1, slender and chelate. Pereiopod 3 longer than 2, as slender; dactylus slender and about 0.44 times propodus length. Pereiopod 4 shorter than 3, moderately stout and setiferous. Dactylus flattened, about 0.9 times propodus length. Pereiopod 5 shorter than 4, moderately stout and setiferous; dactylus flattened, about 0.55 times propodus length.

Abdomen: Pleura of first 3 somites each with 2 ventral spines. Fourth to sixth somite each with moderate posteroventral spine. Sixth somite with strong spine at dorsoposterior margin. Depressions in pleura of first and third somites accommodate pleuron of second. First to third somites each with faint median dorsal carina. Dorsal anterior margin of first deeply concave. Second with dorsal transverse furrow, adjacent anterior margin produced, forming slight hood over furrow. Third with dorsal transverse sulcus through median carina. Dorsal median carina on posterior half of fourth, lateral carina in line with articular knobs. Fifth with transverse sulcus through anterior end of faint median dorsal carina, lateral carina extending to middle of somite from articular knob. Sixth with 2 prominent dorsal carinae, shorter than somite, lateral carina extending obliquely from articular knob toward dorsal margin. Posteroventral regions of sixth flared strongly giving a wing-like appearance in dorsal view. Telson narrow, tapering to acute tip. Median dorsal sulcus of telson with 2 pairs of widely spaced dorsolateral spines. Inner uropods longer than outer, and exceeding tip of telson.

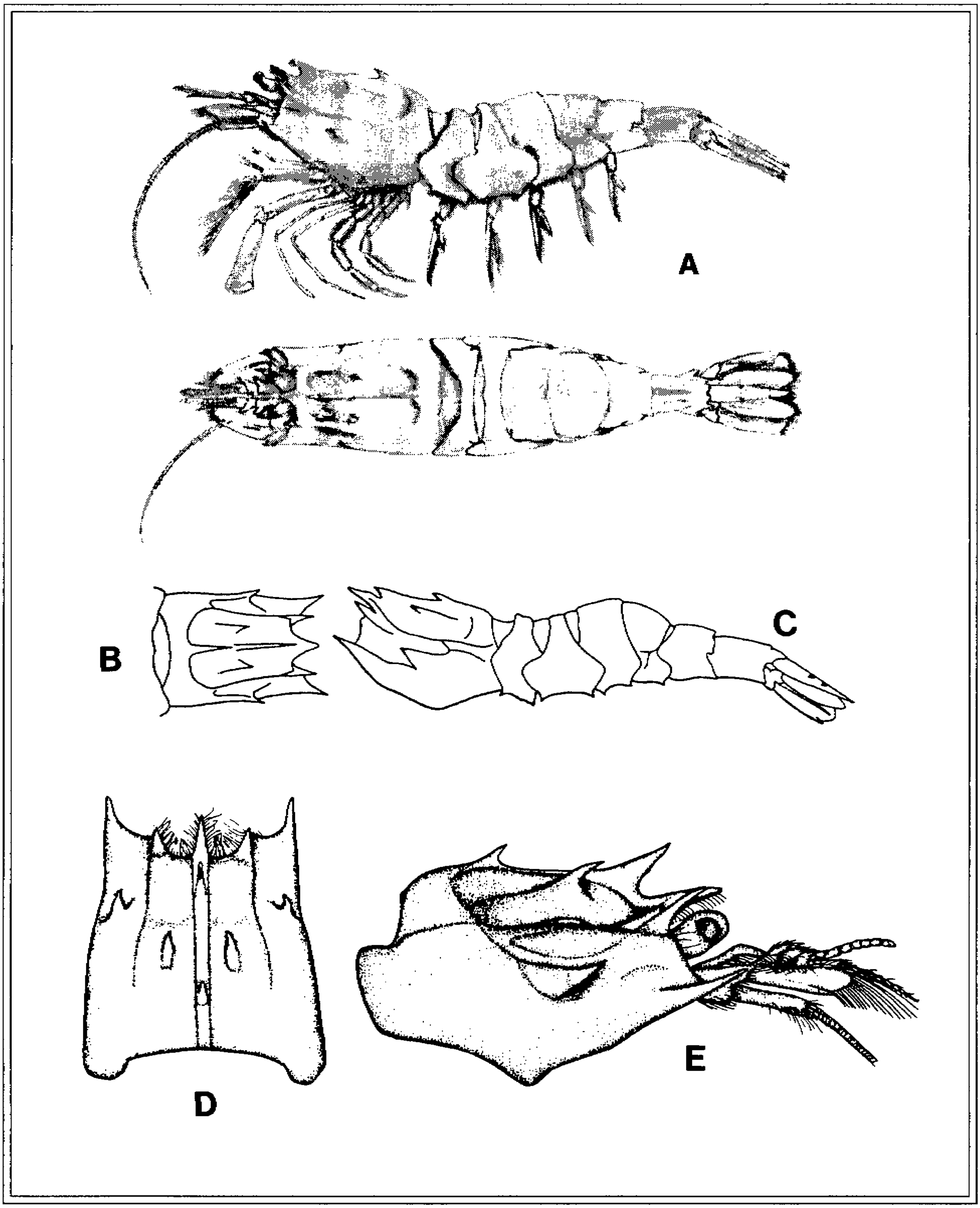

Figure 2.8. *Metacrangon spinosissima* (Rathbun, 1902): A, dorsal and lateral views (from Butler, 1980); B, dorsal view of carapace (from Rathbun 1904); C, lateral view (from Rathbun, 1904); D, dorsal view of carapace; E, anterolateral view (D and E from Word and Charwat, 1976).

Color in life: Background of body and appendages buff. Brownish mottling blending with background on posterior branchial region of carapace. Other brown patches occur at bases of median spines and bordering anterolateral margin. Light brown patches on pleura of first to third abdominal somites. Darker areas are found dorsally on first abdominal somite and lateral surfaces of fourth to sixth somites. This borders conspicuous light swath and rectangular patch near ventral margin of second pleuron. Light brown transverse bars are on telson and inner uropods. Pleopods are light red to pink. Third maxilliped and pereiopods 1, 4, and 5 are light rust. Latter appendages, anterolateral margin of carapace, and anterior appendages, with light rust setae (Butler, 1980, Plate 1B).

Biology. Butler (1980: 116) notes that the shape of first and second abdominal somite of this shrimp allows it to assume a "defensive cataleptic position as in *Argis levior* and *Lebbeus schrencki.*" He also notes that it is common off the southwest coast of Vancouver Island and in the southern Strait of Georgia, is often trawled over mud bottoms (depths of 97-157 m), and has been found ovigerous in February, March, April, and August in that region.

Taxonomic Remarks. Distinguished from other species in the genus by having 1 or 2 ventral spines on each of the first to fifth pleura and a transverse furrow on the second abdominal somite, with the adjacent margin produced as a hood over this furrow (Butler, 1980: 116).

Type Locality and Type Specimens. Off Point Arena, California, 51 fathoms (93 m) (*Albatross* Station 3351) (Rathbun, 1904).

Distribution. From Nootka Sound, Alaska (Butler, 1980), southward to Isla San Martin, Baja California (Wicksten, 1977), at a depth of 51 to 96 fathoms (93 to 176 m) (Rathbun 1904).

Family Alpheidae Rafinesque, 1815

Alpheus bellimanus Lockington, 1877

Figure 2.9

Alpheus bellimanus Lockington, 1877:34; 1878:470.—Kingsley, 1878a:199; 1878b:59; 1883:111; 1899:716.—Bate, 1888:54.—Sharp, 1893:112.—Coutiere, 1899:28.—Holmes, 1900:184, Plate 2. Fig. 41.—Rathbun, 1904:108.—Word and Charwat, 1976:42.—Luke, 1977:4.—Brusca, 1980:252.—Wicksten, 1983:41; 1984:189.—Kim and Abele, 1988:13, Fig. 5.—Jensen, 1995:44, Plate 70.

Crangon bellimanus.—Schmitt, 1921:75, Fig.51.—Chace, 1937:188.

Material Examined. USNM 006-BRS-02-TX Phase I primary voucher, 3 specimens, largest - male, carapace length 9.3 mm; SBMNH 004-BRA-04-TX Phase I secondary voucher, 2 specimens.

Description. Major chela with sinuous inferior margin (distal to inferior transverse groove) sinuous because of deep transverse groove; movable finger of major chela shallowly arched along proximal two-thirds of superior margin, and then regularly arched distally, tip stout, often bulbous; appendix masculina subequal to or slightly overreaching distal end of appendix interna. Rostrum long, far overreaching middle of visible part of first antennular segment; movable finger of minor chela laminate in male; merus of major first pereiopod bearing 6 to 10 small movable spines on inferior inner margin and a strong, acute immovable spine at the distal end, ischium likewise armed with 3 to 4 spines on inner margin. Palm of major chela with deep transverse groove on superior margin and with deep, distinct superior and inferior grooves on outer face. Stylocerite narrowing to a long sharp point, almost reaching to distal margin of first antennular segment. Basicerite with sharp lateral spine; spine broad at base. Ocular hood with sharp tooth directed slightly inward and downward (modified from key and description of Kim and Abele 1988).

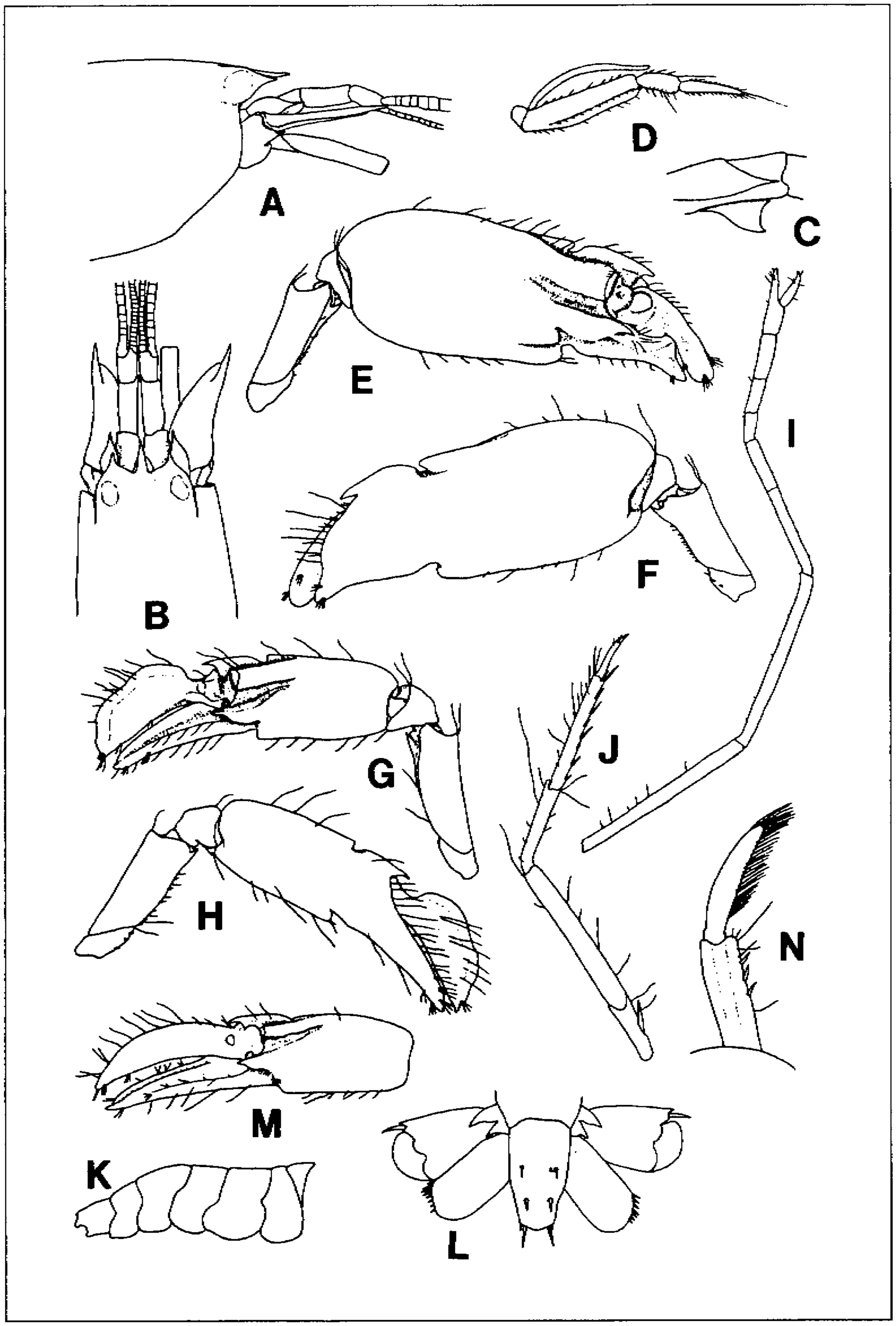

Figure 2.9. *Alpheus bellimanus* Lockington, 1877: male, carapace length 5.2 mm; A, anterolateral view; B, anterodorsal view; C, carina below first antennular segment; D, right third maxilliped; E, outer face of major first pereiopod; F, inner face of same; G, outer face of minor first pereiopod; H, inner face of same; I, left second pereiopod; J, right third pereiopod; K, abdomen; L, telson and uropods; M, outer face of minor chela from first pereiopod of ovigerous female (carapace length 6.5mm); N, right second pleopod (female, carapace length 4.6 mm)(from Kim and Abele, 1988).

Color in life: Body uniformly blood red changing to olive green after capture (Jensen, 1995:44, Plate 70), orange at tip of tail fan; tips of chelae and branchial regions orange; white mark on palm of major chela (Wicksten, 1983:42).

Biology. Found in the lowest intertidal zones to 300 m, usually dredged on sand, rocks, soft mud, fine gravel or among corallines (Kim and Abele, 1988).

Taxonomic Remarks. Belongs to the *Macrocheles* (= *Megacheles*) group of species of this very diverse genus (Kim and Abele, 1988).

Type Locality and Type Specimens. San Diego, California (Kim and Abele, 1988). Types probably lost in the San Francisco fire of 1906 (M. Wicksten, pers. comm.)

Distribution. Monterey, California, south along outer coast of Baja California, Mexico; southern Gulf of California, Islas Socorro and Clarion; western Mexico; Panama; Chile; Colombia; Galapagos Islands (Kim and Abele, 1988).

Family Hippolytidae Dana, 1852

Eualus lineatus Wicksten and Butler, 1983

Figure 2.10

Spirontocaris herdmani.—Rathbun, 1904:100 (in part).

Eualus herdmani.—Holthuis, 1947:11 in part.—Hobson and Chess, 1974:579.—Word and Charwat, 1976:103 in part.—Butler, 1980: 197-198 (in part).

Eualus lineatus Wicksten and Butler, 1983:1, Figs 1-2.—Jensen, 1987a:399; 1995:45.

Material Examined. USNM 016-BRA-01-TX Phase I primary voucher, 3 specimens; SBMNH 016-BRS-04-TX Phase I secondary voucher, 1 specimen.

Description. Rostrum short, reaching second segment of antennular peduncle, straight, with 3-6 dorsal teeth and 1-3 ventral teeth, all of dorsal margin toothed.

Carapace smooth, dorsum straight, small suborbital spine, moderate antennal spine with supporting carina, moderate pterygostomial spine.

Abdomen smooth. Pleura of segments 1-3 rounded, pleura of fourth segment with weak posterolateral spine, fifth with strong posterolateral spine. Median dorsal margin of third segment strongly produced posteriorly. Telson with 3 pairs dorsolateral spines.

Eyes moderately large, darkly pigmented.

Stylocerite reaching end of first segment of antennular peduncle. First segment with 3 moderate dorsal spines. Second segment about 0.5 times length of first, with 2 strong spines. Third segment shorter than second, with 2 spines. Inner flagellum more than 2 times length of outer.

Basis of second antenna with sharp ventral spine, large blunt upper lobe. Scaphocerite oblong, shorter than carapace, lamella slightly longer than spine. Flagellum slightly exceeding body length.

Mandible with slender incisor process, ending in small teeth. Molar process with spinules. Two-jointed palp present. First maxilla with lower endite slender, upper broad; palp faintly bilobed, Second maxilla with lower endite reduced, upper endite larger, bilobed; palp and scaphognathite well developed. First maxilliped with exopod and 2-jointed palp; epipod bilobed, caridean lobe very small; endites of coxa and basis separated by notch. Second maxilliped with exopod, podobranch, and epipod. Third maxilliped with exopod and epipod, exceeding antennular peduncle, stout and setose.

First pereiopod shorter than third maxilliped, stout, with epipod. Fingers of chela less than 0.5 times length of palm. Carpus slightly shorter than palm. Merus about 2 times length of carpus. Ischium less than 0.5 times merus. Second pereiopod chelate, longer than first pereiopod, with epipod. Fingers shorter than length of palm. Carpus with 7 segments, the third and fourth the longest. Merus about 0.6 times length of carpus, slightly longer than ischium. Third pereiopod slightly longer than second, with epipod. Dactyl stout, about 0.2 times length of propodus, with 5 spines. Propodus with 16-19 spinules in 2-3 rows. Carpus about 0.4 times length of propodus. Merus about same length as propodus, with 3 spines. Ischium less than 0.5 times length of merus. Fourth pereiopod about as long as third. Dactyl stout, similar to that of third pereiopod, Propodus with 15 spinules in single row. Merus with 2-3 spines. Fifth pereiopod as long as fourth. Dactyl about 0.2 times length of propodus, with 4-5 small spines. Propodus with 14-22 spinules in 1 or 3 rows. Merus with 0-1 spine. No epipods on pereiopods 3-5.

Second pleopod with appendix interna. Appendix masculina little more than half length of appendix interna, stout, apex truncated, with 8 long spinules. Uropods reaching end of telson, with long tooth on outer margin (from Wicksten and Butler, 1983).

Color in life: Red diagonal lines on carapace and first and second abdominal segments; red spots and blotches on third to sixth abdominal segments, telson, uropods, and protopodites of pleopods; smaller red spots on all anterior appendages, including eye stalk and pereiopods (from Wicksten and Butler, 1983; Butler, 1980; color Plate 1C, as *Eualus herdmani*).

Biology. This species has been found in rocky rubble below 18 m (Jensen, 1995). Most specimens have been taken by trawl. One specimen was collected by a SCUBA diver on the wreck of the *Olympic*, off Long Beach, California. A first stage larva of the species has been hatched in the laboratory (Butler, 1980). The species is eaten by rockfishes of the genus *Sebastes* off Santa Catalina Island, California (Hobson and Chess, 1974).

Some individuals have been found to be parasitized by *Bopyroides hippolytes* (Butler, 1980).

Taxonomic Remarks. *Eualus lineatus* is related to *E. avinus* (Rathbun), *E. pusiolus* (Kroyer), and *E. berkeleyorum* Butler in having epipods on the first 3 pereiopods. In *E avinus* the rostrum is arched over the eye, and bears 12-14 upper teeth and 1-3 ventral teeth. The dactyl of the third pereiopod is slender and simple. *Eualus pusiolus* has a straight rostrum shorter than the second segment of the antennular peduncle, with 2-5 upper teeth and at most 1 lower tooth. The dactyl of the third pereiopod is stout. *Eualus berkeleyorum* has a straight rostrum with 8-11 dorsal teeth and 2-5 ventral teeth. The dactyls of its third pereiopods are slender and simple. It does not have a ventral spine on the pleura of the fourth abdominal segment (Wicksten and Butler 1983).

Type Locality and Type Specimens. 1.5 mi. SW of Gulf Island, off Santa Cruz Island, California (33°56'00"N, 119°50'55"W), 89 m, mud and sponge bottom, 8 Nov 1941, *Velero III* Sta 1435-41. Holotype female total length 21.0mm; AHF type number 4129.

Distribution. Sitka, Alaska to Puget Sound (Butler, 1980); Santa Monica Bay, Palos Verde Peninsula, Santa Catalina Island, and Point Loma California (Word and Charwat, 1976).

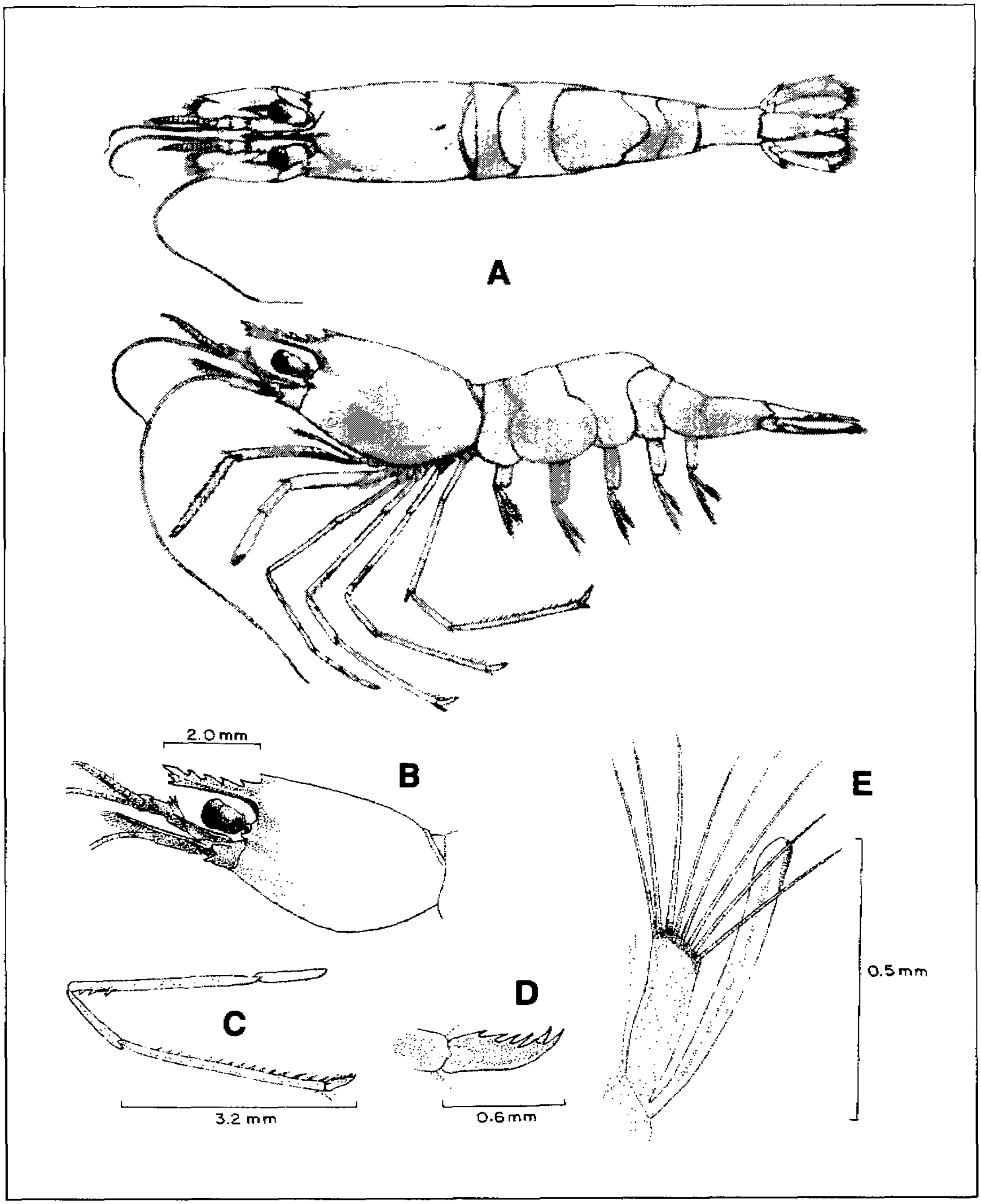

Figure 2.10. *Eualus lineatus* Wicksten and Butler, 1983: A, dorsal and lateral views; B, anterolateral view of female (carapace length 3.1 mm); C, left third pereiopod of same; D, dactyl of left third pereiopod of same; E, appendix masculina of male (carapace length 4.1 mm)(from Wicksten and Butler, 1983).

Spirontocaris sica Rathbun, 1902

Figure 2.11

Spirontocaris sica Rathbun, 1902:894.—Rathbun, 1904:69, Fig. 25.—Schmitt, 1921:55, Fig. 32.—Holthuis, 1947:37.—Word and Charwat, 1976:154.—Butler, 1980:167, Plate 7D.—Wicksten, 1990:590.

Material Examined. USNM 055-BSS-01-TX Phase I primary voucher, 1 specimen, carapace length including rostrum 10.5 mm, rostrum length 4.7 mm.

Description. Body slender and somewhat compressed. Rostrum moderately long, 0.9-1.2 times carapace length, constricted at base, median section as broad blade, lower limb broader and tapering sharply, distal portion as long ascending styliform process, tip acute.

Carapace spines: 2 supraorbitals, widely space, with upper spine stronger; suborbital strong and rounded; antennal moderate with carina; pterigostomian weak or obsolescent.

Eye: Large and cornea well developed.

Antennule: Peduncle long, third segment half length of second, dorsal distal spine present on each; stylocerite moderately long and knifelike; inner flagellum longer than rostrum, outer extending slightly beyond antennal scale.

Antenna: Scale slightly shorter than telson, lamella exceeds spine somewhat; basicerite with two lateral lobes; peduncle moderately long; flagellum longer than body.

Third Maxillaped: Moderately long, moderately stout with an epipod and an exopod.

Pereiopod 1 shorter than third maxillaped and a little stouter, chelate, epipod present.

Pereiopod 2, chelate, slender and longer than 1, carpus with 7 segments. Pereiopod 3 longer and stouter than 2, merus with 5-9 spines, propodus with 4 spinules and a distal fringe of setae, dactylus slender. Pereiopod 4 slightly longer than 3, merus with 6-8 spines, propodus with 4-7 spinules, setae as in 3. Pereiopod 5 shorter than 4, merus with 4-7 spines, propodus with 1-8 spinules, long setal band around distal end.

Abdomen: Ventral margin of pleuron of second somite broadly convex; posterodistal margins of fourth and fifth deeply recessed at articular knobs; fifth with week posterolateral spine; sixth about as long as telson, slender with moderate posteroventral spine; telson narrow, tapering to acute tip, 4 pairs of dorsolateral spines; uropods about same length as telson, extending to tip (after Butler, 1980).

Color in life: Background of body milkish white to dull yellow. Carapace with red blotches, large specimens with red band along ventral margin, large red area on branchial region. Most have a pinkish dorsal patch. Rostrum with a few red dots on the midrib. Antennule, basicerite and base of antennal scale pinkish. Lateral surface of first five abdominal somites with fine red spots. Telson and uropods pinkish. Pereiopods deep red (Butler, 1980: Plate 7D).

Biology. Butler (1980) states that in almost all cases along the western coast of Canada this species has been found in coastal inlets, and that as an adult may be pelagic rather than demersal. It is parasitized by the branchial isopod *Bopyroides hippolytes*.

Taxonomic Remarks. This specimen was sent to us with a tentative identification as *S. dalli* Rathbun, 1902, a species whose southern most range is Sitka, Alaska except for a single record from near Los Angeles (Word and Charwat 1976). We felt comfortable with this identification based upon rostral characteristics and the key of Word and Charwat (1976). However, upon review of this manuscript both D. Cadien and M. Wicksten suggested that this specimen probably is not *S. dalli*. In fact if rostral characteristics are ignored this specimen seems to be *S. sica*, Rathbun, 1902 based on the keys of Schmitt (1921), Holthuis (1947), Butler (1981), and Wicksten (1990). This specimen differs from typical specimens in that the rostrum is lacking the long ascending styliform process and instead terminates in a short triangular point. Defining characteristics

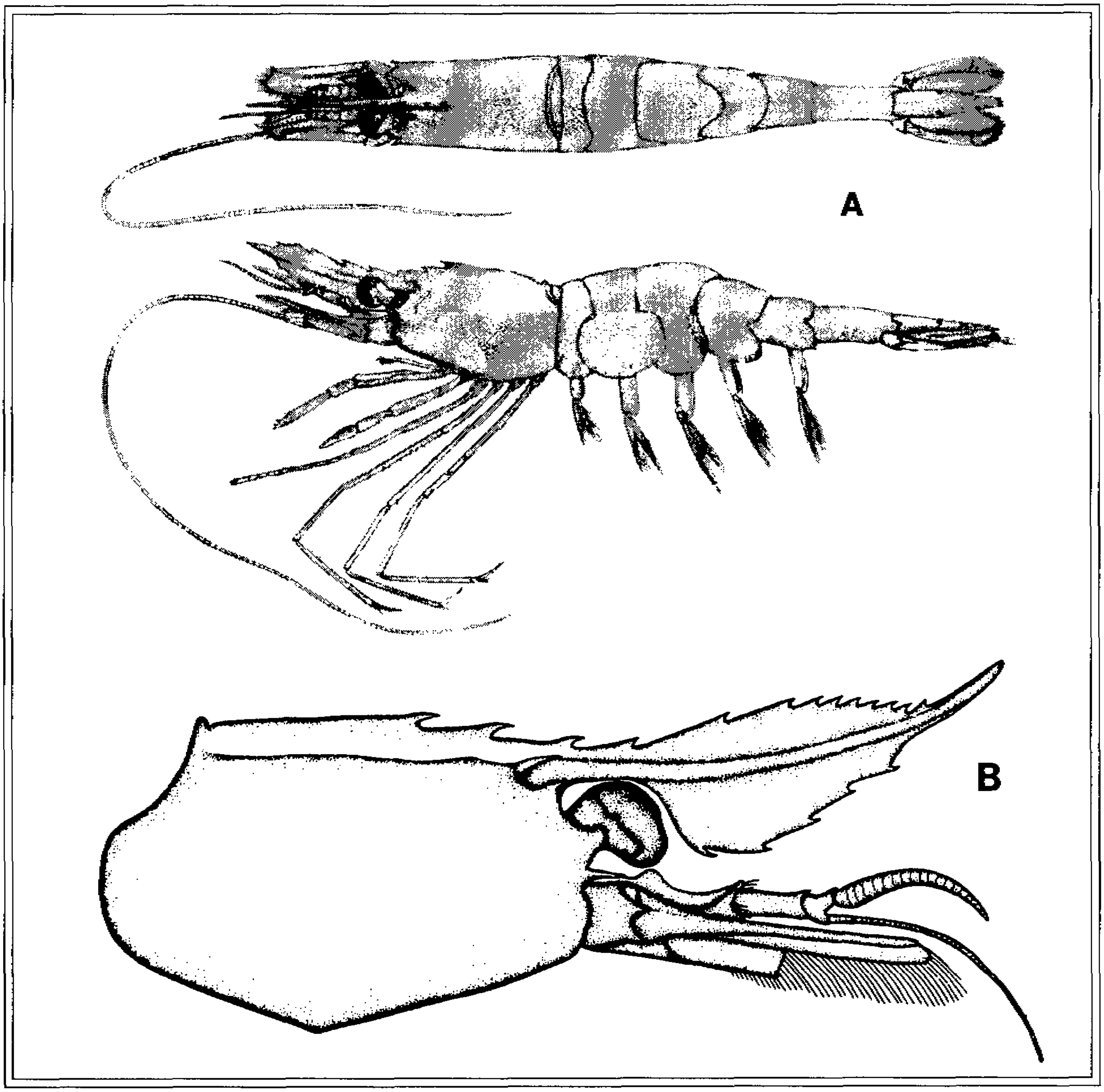

Figure 2.11. *Spirontocaris sica* Rathbun, 1902: A, dorsal and lateral views; B, anterolateral view (A, from Butler, 1980; B, from Word and Charwat, 1976).

that place our specimen with *S. sica* are as follows: Carapace with 2 supraorbital spines; pleurae of abdominal segments 1 and 2 rounded; epipod on first pereiopod only (after Holthuis, 1947). *Spirontocaris holmesi* (see below), on the other hand, has epipods on both the first and second pereiopods.

Type Locality and Type Specimen. Holotype female: total length 58 mm; carapace length 24.8 mm including rostrum; rostral length 12.8mm. Type locality: Santa Barbara Channel, 265 fms (485 m) *Albatross* station 3200.

Distribution. Restoration Bay, British Columbia to between San Benito Islands and Cedros Island, Baja California; 88-849 m (Wicksten, 1990)

Spirontocaris holmesi Holthuis, 1947

Figure 2.12

Spirontocaris bispinosa Holmes, 1900:128.—Rathbun 1904:219, Fig. 23.—Schmitt, 1921:54, Fig. 30.—Goodwin, 1952:170.

Hippolyte bispinosus.—Williamson 1915.

Spirontocaris holmesi Holthuis, 1947:129.—Word and Charwat, 1976:149.—Butler, 1980:159 (key), 165, Plate 6E.—Jensen, 1987a:399.—Wicksten, 1990:590.

Material Examined. USNM 007-BSS-01-TX Phase I primary voucher, 1 specimen, carapace length including rostrum 12.4 mm, rostrum length 6.0 mm; SBMNH 103-BSS-01-TX Phase I secondary voucher, 1 specimen.

Description. Body slender and compressed. Shell thin and smooth. Rostrum moderately long, 1.0-1.5 times carapace length, constricted at base. Median section of rostrum broad blade with lower limb broader and rounded. Distal portion slender, ascending, styliform process with a solitary distal ventral spine.

Carapace spines: 2 supraorbitals widely separated, upper spine stronger; suborbital moderate, pointed; antennal moderate; pterygostomian weak or obsolescent.

Eyes large, corneas well developed.

Antennule: peduncle moderately long, third segment shorter than second, each with dorsal distal spine; stylocerite moderately long, inner flagellum shorter than rostrum, outer extending beyond antennal scale slightly.

Antenna: scale shorter than telson, lamella exceeds spine somewhat; basicerite with 2 weak lateral spines; peduncle long; flagellum longer than body.

Third maxilliped: moderately long, stout, with an exopod and an epipod.

Pereiopod 1 shorter than third maxilliped, a little stouter, chelate, with epipod. Pereiopod 2 longer than 1, slender and chelate, carpus with 7 segments, epipod present. Pereiopod 3 longer than 2 and a little stouter, merus with 6 or 7 spines, propodus with 4-8 spinules, distal fringe of setae present. Dactylus slender, about 0.6 times propodus length, tip acute. Pereiopod 4 about as long as 3 and as slender, merus with 5-8 spines, propodus with about 4 spinules, distal fringe of setae present. Dactylus slender, about 0.6 times propodus length, tip acute. Pereiopod 5 shorter than 4 and as slender. Merus with 4 or 5 spines, propodus with 3-6 spinules, distal fringe of setae present. Dactylus slender, about 0.55 times propodus length, tip acute.

Abdomen: ventral margin of pleuron of second somite mainly straight or slightly concave. Fifth somite posterolateral margin widely recessed at articular knob, and with moderate spine. Sixth somite with moderate posteroventral spine, and small lobe above it. Telson narrow, tapering to rounded tip, with 3 or 4 pairs of dorsolateral spines. Uropods about same length, reaching to tip of telson.

Color in life: Background of body yellowish wash; carapace, 2 oblique red lines starting in branchial region, meeting wide red bar along ventral margin adjacent to third maxilliped and pereiopods 1 and 2; patches of red posterior to antennal spine; large patch of red dots in gastric and cardiac regions; rostrum mainly transparent with fine red dots on lower limb; antenna, basicerite, and scale with red patches; peduncle and flagellum pinkish; third maxilliped and pereiopods, red spots on milkish base; red blotches on abdomen, mainly on lateral surfaces; faint, fine red speckling on telson and uropods; pleopods with distinctive red lines on basiopodites. (from Butler, 1980: Plate 6E)

Biology. According to Butler (1980), this specis "almost invariably forms part of the catches of dredge or shrimp trawl hauls made at 70 m and deeper" in coastal areas of southwestern Canada. See Butler (1980) for data on density, ovigery, and parasitic isopods infesting this species in that region.

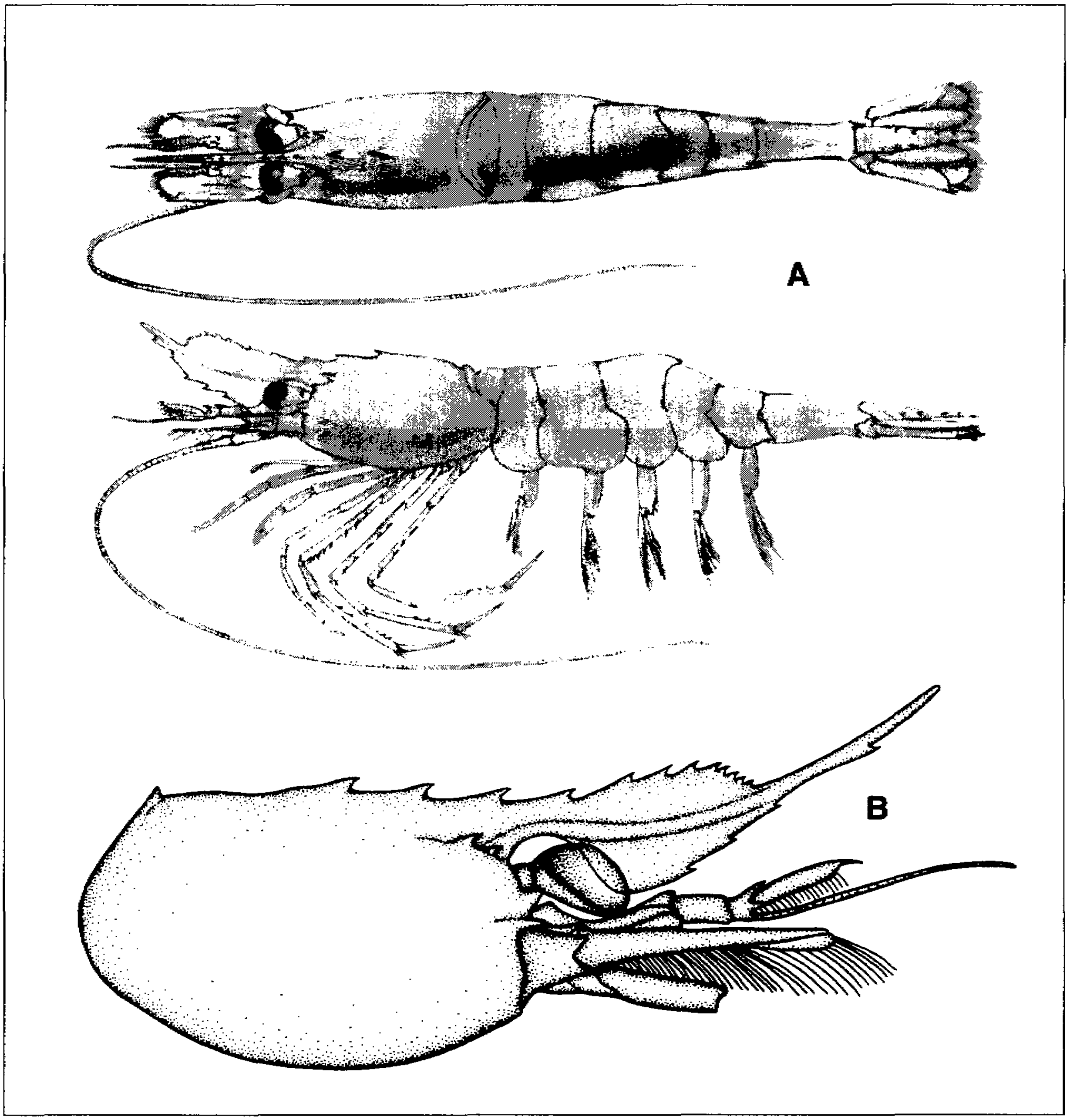

Figure 2.12. *Spirontocaris holmesi* Holthuis, 1947: A, dorsal and lateral views; B, anterolateral view (A, from Butler, 1980; B, from Word and Charwat, 1976).

Taxonomic Remarks. Characterized by having a very slender body, bladelike rostrum with styliform projection armed with solitary ventral spine, 2 widely spaced suborbital spines, and epipods on pereiopods 1 and 2 (Butler, 1980).

Type Locality and Type Specimens. Puget Sound.

Distribution. Yes Bay, Alaska, to San Diego, California (Schmitt, 1921; Butler, 1980).

Family Palaemonidae Rafinesque, 1815

Pseudocoutierea elegans Holthuis, 1951

Figure 2.13

Pseudocoutierea elegans Holthuis, 1951:182, Plate 57.—Holthuis, 1955:75, Fig. 46d.—Word and Charwat, 1976; 171.—Wicksten, 1983a:19; 1992:8.—Abele, 1976:71.

Material Examined. USNM 001-BRA-02-TX Phase I primary voucher, 3 specimens, largest - carapace length including rostrum 5.2 mm, rostrum length 2.9 mm.

Description. Genus description: Body more or less compressed. Distal part of rostrum cylindrical and unarmed. Basal part wing-like expanded and partly covers eyestalks. These wing-like expansions end anteriorly in sharp supraocular tooth. Carapace smooth. Antennal spines present, but postorbital and pterygostomial spines lacking. Branchiostegal groove runs over length of lateral part of carapace.

Abdomen with pleurae of third to fifth segments ending in sharp tooth. Posterior margin of telson bears three pairs of spines.

Scaphocerite is well developed.

Mandible without palp, incisor process well developed. Laciniae of maxillula rather broad. No exopods present on second and third maxillipeds. Only caridean lobe present on first maxilliped, but no flagellum is visible.

The carpus of first pereiopod not segmented. Second legs very unequal in size, but about equal in shape. Last three legs rather slender. Dactylus is simple, without basal protuberance.

Second to fifth pleopods with appendix interna. An appendix masculina present on endopod of second pleopod of male.

The uropodal exopod has the outer margin ending in tooth, which at inner side bears movable spine (after Holthuis, 1951:182).

Color in life: Not recorded (but see below).

Biology. Associated with and colored to match the red gorgonian *Muricia californica* where it co-occurs with *Heptacarpus kincaidi* (pers. comm., D. Montagne via D. Cadien). Ovigerous females among the 8 specimens examined by Holthuis ranged from 9 to 16 mm total length (Holthuis, 1951).

Taxonomic Remarks. This species is the sole member of the genus *Pseudocoutierea* Holthuis. Subsequent to the original description (Holthuis, 1951), wherein 8 specimens were listed from Allan Hancock Expeditions in 1934, 1935, 1937, and 1941, there have been no reports of this species in the literature.

An unfortunate error exists in the original description (Holthuis, 1951), where the illustrations of this species (Plate 55) were switched with those of *Anchistioides antiguensis* (Plate 57).

Type Locality and Type Specimens. Holotype is an ovigerous female, 16 mm long, from off Santa Catalina Island, California (*Blake* Station 1405-41) (AHF, now part of LACM collection) (Holthuis, 1951). Additional paratypes exist in the LACM collections and at the USNM (AHF No. 411, according to Holthuis, 1951:185).

Distribution. Santa Catalina Island, California, south along the west coast of Baja, California, to the Galapagos Islands, from 20 to 50 fathoms (37 to 91 m) (Holthuis, 1951:185). This report extends the range northward to the Santa Barbara Channel.

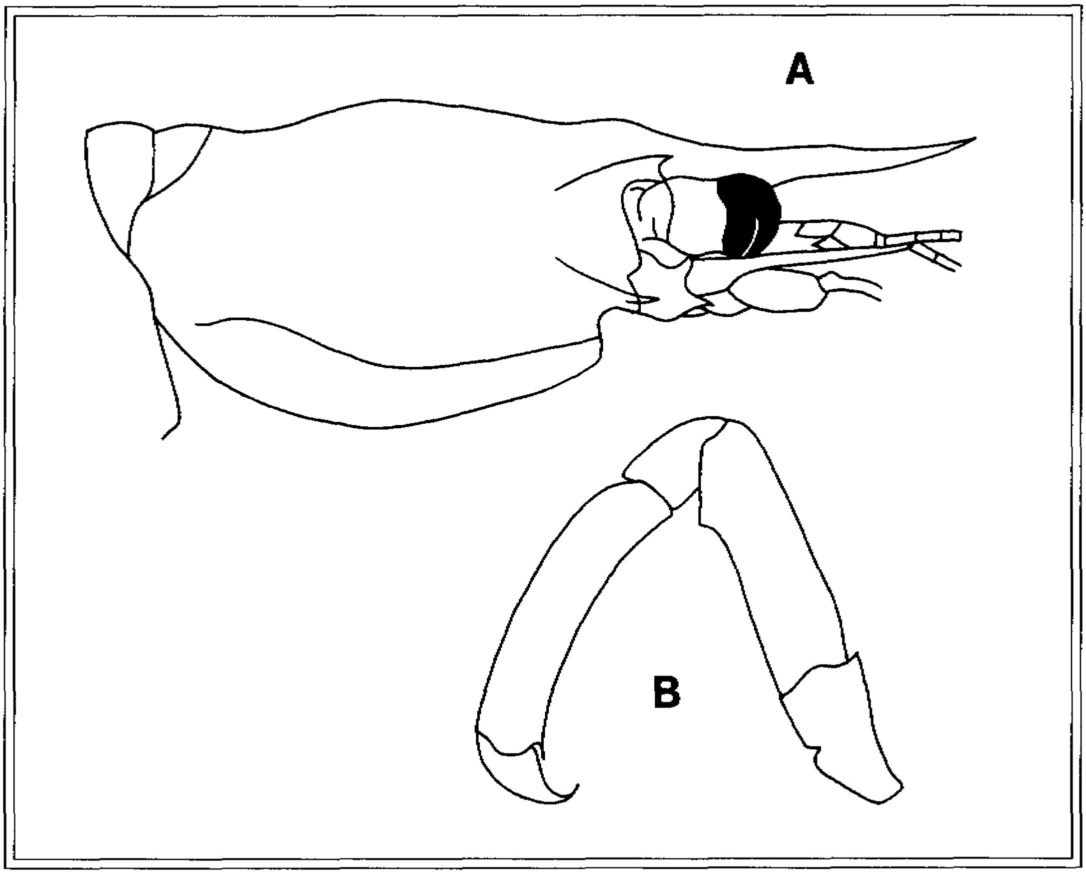

Figure 2.13. *Pseudocoutierea elegans* Holthuis, 1951: A, anterolateral view; B, third pereiopod (both from Holthuis, 1951).

Infraorder Thalassinidea Latreille, 1831

Family Axiidae Huxley, 1879

***Acanthaxius spinulicaudus* (Rathbun, 1902)**

Figure 2.14

Axius spinulicauda Rathbun, 1902:886; 1904:149, Fig. 90

Axius (Paraxius) spinulicauda.—Borradaile, 1903:538.

Axiopsis spinulicauda.—Schmitt, 1921:111, Fig. 74.—Hart, 1982:44, Fig. 8.—Kozloff, 1987:404.

Axiopsis (Axiopsis) spinulicauda.—de Man, 1925:69.

Acanthaxius spinulicaudus.—Sakai and St. Laurent, 1989:66.

Material Examined. USNM073-BSR-03-TX Phase I primary voucher, 1 specimen; MMS California OCS Phase II, voucher lot, Cruise 3-1, station R-1, Rep:3, 35°05.8'N, 120°49.2'W, 91 m, one female, carapace length = 17.8 mm, including 3.5 mm rostrum.

Description. Rostrum reaching middle of second joint of antennular peduncle, slightly deflexed, longitudinally channeled; armed on either side with five to six teeth. Gastric region of carapace traversed by five carinae, all of which fade out before reaching cervical groove; median one extending along basal third of rostrum, and armed with four spines just behind line of the orbits; outer carinae a continuation of side margins of the rostrum; outer and intermediate carinae unarmed; in front of the narrow median posterior lobe of the carapace, the surface is compressed or pinched to form a short smooth ridge. Eyes black, of same diameter as stalk, not reaching middle of basal antennular segment. Outer maxillipeds reaching end of antennal peduncle. Abdomen smooth above; pleura sculptured and pubescent (Schmitt, 1921).

Color in life: Carapace translucent pink with coral rostrum and ridges with greenish tinge laterally. Antennules and antennae pale pink and white with yellowish flagella. Eyestalks translucent, corneas black. Chelipeds with shell-pink and white ischium and merus, coral red carpus and hand, and orange teeth. Walking legs pink, coral and white. Abdomen with pleopods and tail fan orange with patches of pale orange or pink (Hart, 1982).

Biology. According to Hart (1982), in British Columbia this species burrows in subtidal mud substrate especially in fjords. Very little concerning the natural history of this species has been published.

Taxonomic Remarks. The illustrations of male and female major chela by Hart (1982, Fig. 8 c and d) are mislabeled in that they are reversed from her description. We have taken this into account and corrected the labeling in Fig. 12.1.

Type Locality and Type Specimens. Off Bodega Head, California, 62 fathoms (113 m), *Albatross* Station 3172. Holotype female, carapace length (including rostrum) = 19.6 mm, rostrum length = 3.5 mm, abdomen = 31.5 mm.

Distribution. Schmitt (1921) and Sakai and de Saint Laurent (1989) mention only the type locality (off Bodega Head, California); there are additional unpublished records from other southern California localities.

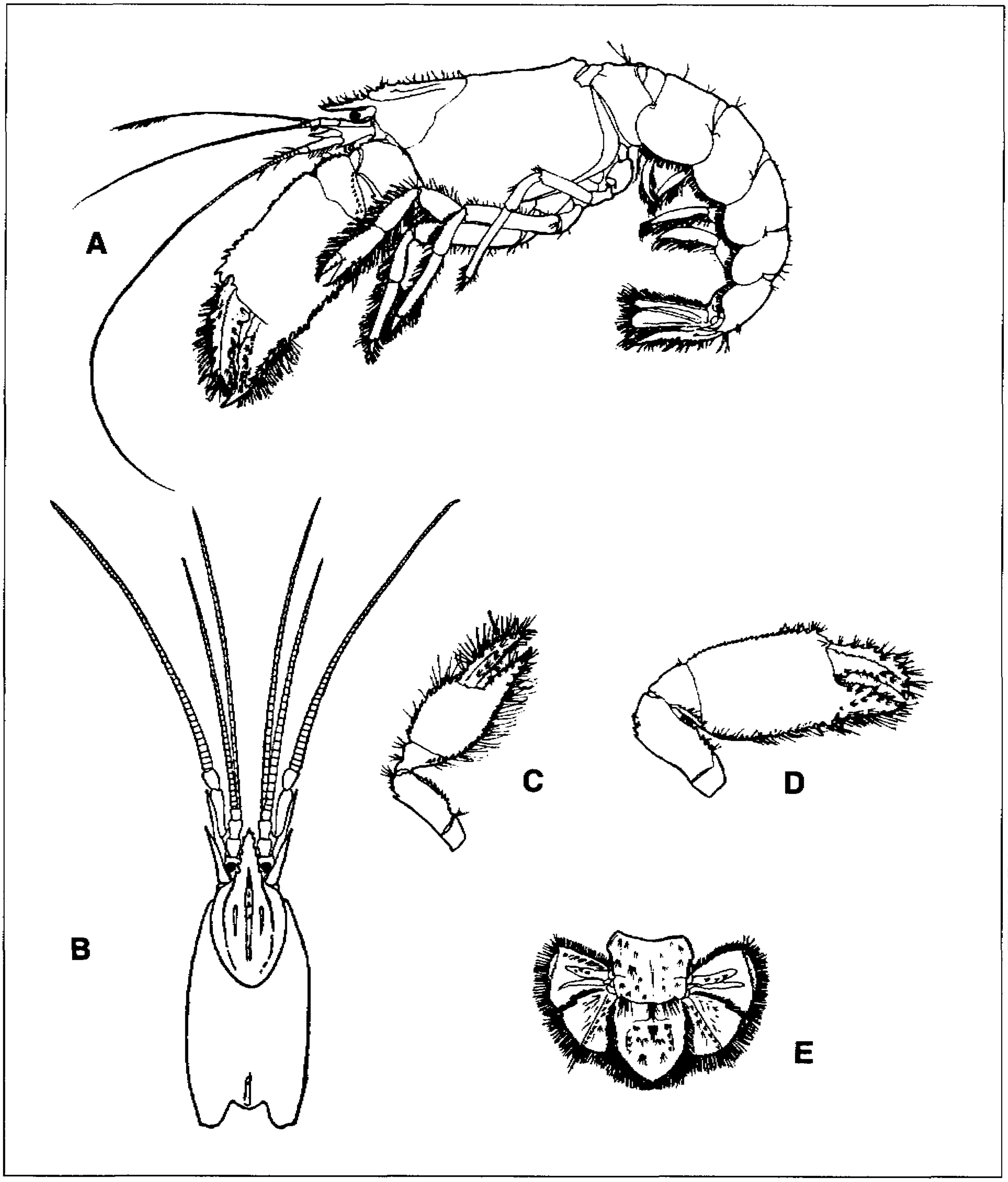

Figure 2.14. *Acanthaxius spinulicauda* (Rathbun, 1902): A, male, lateral view; B, carapace dorsal view; C, female, right cheliped; D, male, right cheliped; E, tail fan. (A,C,D modified from Hart, 1982, see text; B,E from Rathbun, 1904).

Calocarides quinqueseriatus (Rathbun, 1902)

Figure 2.15

Calastacus quinqueseriatus Rathbun, 1902:887; 1904:151, Fig. 91.—Schmitt, 1921:113, Fig. 76.—Balss, 1925:209.—Goodwin, 1952:175.

Calocaris (Calastacus) quinqueseriatus.—Borradaile, 1903:539.—de Man, 1925:118.—Hart, 1982: 50, Fig. 11.—Kozloff, 1987:404.

Calastacus rostriserratus Andrade and Baez, 1977:65, text-Fig. 1.

Calocarides quinqueseriatus.—Sakai and St. Laurent, 1989:79.

Material Examined. Male, SBMNH Phase I secondary voucher collection, 005-BSS-01-TX, carapace length (including rostrum) = 23.7 mm, abdomen length = 37.8 mm.

Juvenile, MMS California OCS Phase II voucher lot, Cruise 2-4, Station R-6, Rep. 2, 34°41.4'N, 120°57.9'W, 410 m, carapace length = 7.2 mm, abdomen length undetermined (damaged specimen).

Juvenile, MMS California OCS Phase II voucher lot, Cruise 1-2, Station R-6, Rep. 1, 34°41.4'N, 120°57.9'W, 410 m, carapace length = 5.9 mm, abdomen length = 9.3 mm.

Description. Carapace surface smooth, cervical groove deep. Rostrum flattened, with toothed margins continuing as ridges on gastric area. Median ridge spined from mid-rostrum to gastric area. These ridges are separated by 2 more short, spined ridges, making 5 in all. Eyestalk short and cornea without dark pigment. Antenna with relatively short projections or "thorns" on 2nd and 3rd segment of peduncle. Unequal, elongated chelipeds with toothed margins and surface of hands covered with numerous small sharp granules. A slight gape proximally between fingers of large cheliped but none on smaller. 1st walking leg short and chelate, with spines on posterior margin of merus and ischium. Others long and slender with setae terminally. Abdomen stout, pleura broad and lateral margins rounded. Tail fan with telson only slightly longer than 6th abdominal segment: Lateral margins parallel and toothed, distal margin curved and with a median tooth. Two spined ridges on telson and 1 on endopod of uropod. No pleopod on 1st abdominal segment. Slender biramous pleopods on 2nd to 5th segments with appendix interna. In male 2nd pleopod has an appendix masculina as well (Hart, 1982).

Biology. According to Schmitt's (1921) key, known only from depths of 200 fathoms (366 m) or greater, although in his list of distributions he included a depth of only 160 fathoms off San Simeon Bay. Hart (1982) lists the habitat type as abyssal mud, 288-2200 m.

Taxonomic Remarks. Differs from *C. investigatoris* (now known as *Lophaxius rathbunae* Kensley, 1989, family Calocarididae), which is known from Alaska to San Diego (Schmitt, 1921:113), in having a carapace that is not granulate and in having 5 rows of spines posterior to the rostrum (Schmitt, 1921).

Type Locality and Type Specimens. Off San Luis Obispo Bay, 200 fathoms (370 m), *Albatross* Station 3196 (Schmitt, 1921). Type is a male, length of carapace and rostrum 28 mm, length of abdomen 41 mm (Schmitt, 1921).

Distribution. Point Sur, California, south to the Santa Barbara Channel, including Anacapa Island and San Nicolas Island, at depths greater than 160 fathoms (293 m) (Schmitt, 1921).

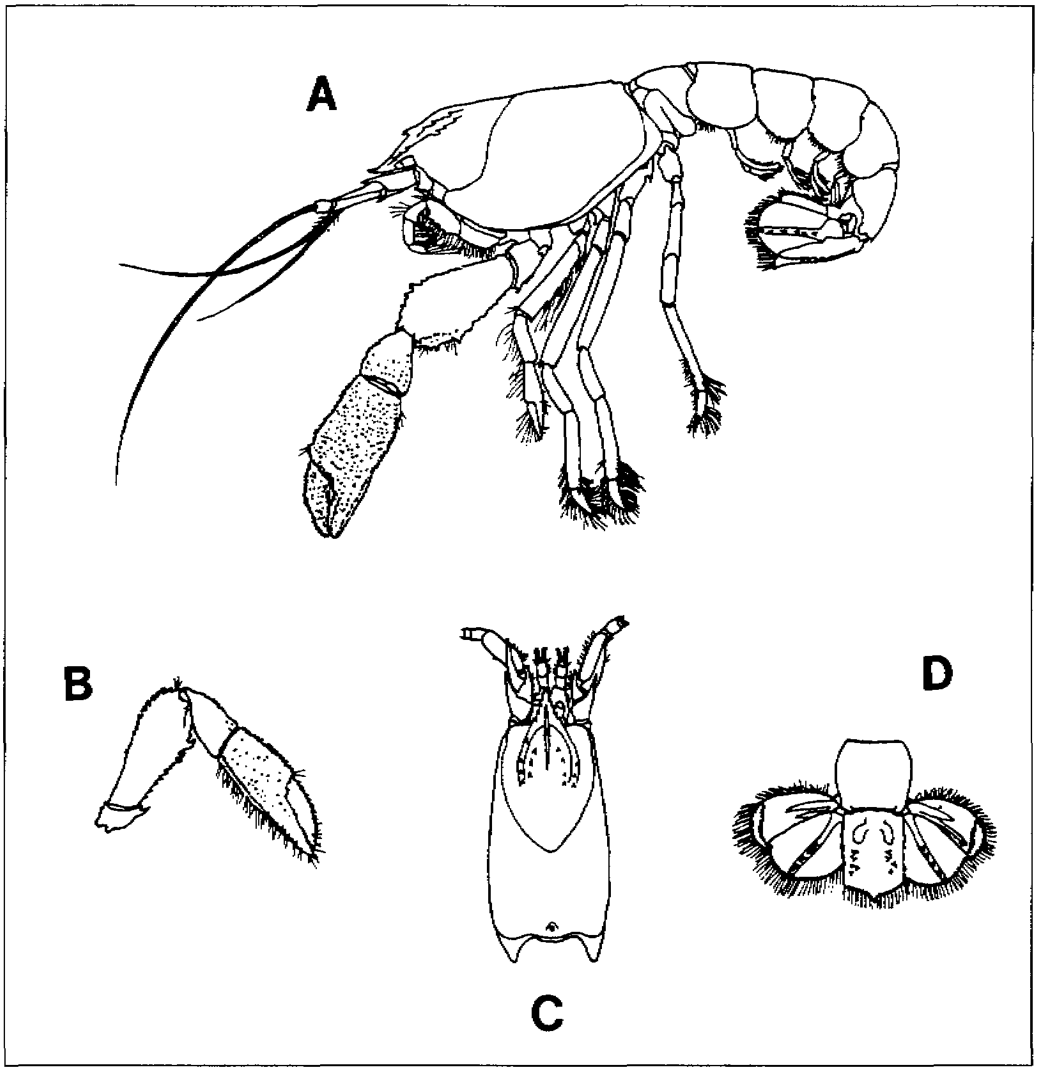

Figure 2.15. *Calocarides quinqueseriatus* (Rathbun, 1902): A, male, lateral view; B, male, right cheliped; C, male, carapace, dorsal view; D, tailfan (from Hart, 1982).

Calocarides sp.

Figure 2.16

Material Examined. Male, USNM Phase I primary voucher collection, 082-BSR-02-TX, carapace length (including rostrum) = 22.3 mm, abdomen length = 30.5 mm.

Remarks. Among the specimens sent to us as *Calocarides quinqueserriatus* was one specimen (illustrated) that differed significantly from that species in several morphological characters, most notably the shape of the first and second pereiopods and relative length of the carapace and abdomen. Consultation with Brian Kensley, Smithsonian Institution, confirms that this is most likely an undescribed species of *Calocarides*. The species complex along the west coast of the United States is currently undergoing investigation by J. Martin and D. Cadien. Pending the results of their findings, which have indicated thus far that either additional west coast species remain undescribed or that the species displays considerable morphological plasticity, this specimen is referred to here as *Calocarides* sp..

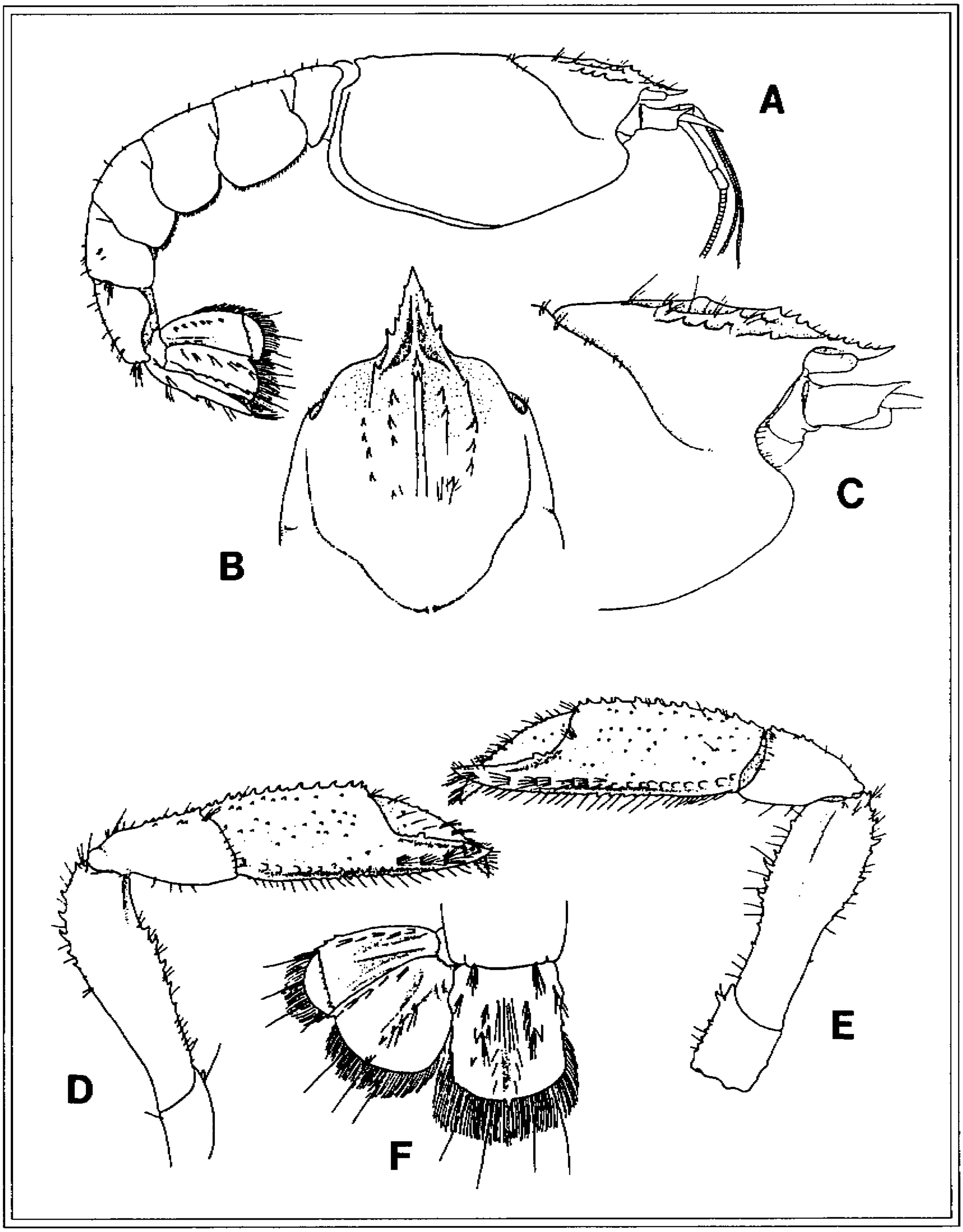

Figure 2.16. *Calocarides sp. A.*: A, lateral view; B, dorsal view of rostrum and anterior carapace; C, lateral view of rostrum and anterior carapace; D, right cheliped; E, left cheliped; F, telson and left uropod.

Infraorder Anomura Milne Edwards, 1832

Family Diogenidae Ortmann, 1892

Paguristes ulreyi **Schmitt, 1921**

Figure 2.17

Paguristes ulreyi Schmitt, 1921:125, Plate 18, Figs. 3-5, 7.—Hart, 1982:106, Fig. 37.—Gotshall, 1994:62, Plate 145.—Jensen, 1995:67, Plate 128.

Paguristes occator Listed as a synonym by Hart (1982) but not cited.

Material Examined. USNM 013-BRC-02-TX Phase I primary voucher, 1 specimen; SBMNH 095-BSS-01-TX Phase I secondary voucher, 2 specimens, largest - shield length 12.1 mm.

Description. Anterior portion of carapace longer than wide; front tridentate, rostriform tooth triangular, acute, extending forward at least to base of the eye scales, exceeding lateral teeth by one-half their length; lateral teeth blunt and somewhat tuberculiform. Eye-stalks comparatively very long and slender, length measured from orbital margin about as long as greatest width of anterior portion of carapace, or slightly longer; eye scales each with four to five spiniform teeth at tip; third segment of antennular peduncle exceeds cornea by one-fourth its length. Antennae thickly long-haired beneath, few short hairs above.

Chelipeds equal, hairy; merus spined on upper or anterior edge and on inner border of lower face, outer border of lower face of merus in occasional specimens slightly rugose, and in one specimen from Monterey somewhat spinulose; carpus with five stout spines on upper inner edge; upper surface of hand well spined dark tipped spines, which are larger on the outer anterior edge of the immovable finger; inner edge of palm behind the dactyl armed with three prominent spines, with two much smaller ones below on inner face, and intermediate between them. Hands somewhat like those of *P. turgidus*, one-third to sometimes nearly one-half longer than wide, but with fingers less acuminate.

Ambulatory legs very hairy on inner or anterior face of dactylus and propodus, anterior pair more so than in any of the species listed in Schmitt, (1921); armature of anterior pair much as in *P. bakeri* (from Schmitt, 1921:125).

Color in life: Carapace red-brown with 3 irregular lighter stripes on shield and 1 on each branchial area. Chelipeds white with orange, light and dark red bands; fingers pink and white with black tips. Walking legs rust and white, with black claws. Abdomen mottled red and white. Antennule white with dark red streaks and flagellum red ventrally. Antenna pink and red base; flagellum dark red with light areas at joints and setae light colored. Eyestalk white with dark red, almost black stripes dorsolaterally and ventrally; cornea black (after Hart, 1982; Jensen, 1995:67, Plate 128).

Biology. This species is often found intertidally in rock crevices on exposed shores and subtidally in rocky and graveled areas (Hart, 1982).

Taxonomic Remarks. *Paguristes ulreyi* differs from *P. perrieri* in having the eye scales toothed or incised and not entire, longer antennular peduncles, which exceed the eye-stalks instead of being considerably shorter, and in having the antennal flagella well haired beneath instead of sparsely so (Schmitt, 1921).

Paguristes ulreyi differs from *P. turgidus* by the antennal flagellum being densely setose ventrally and sparsely dorsally, eyestalks proportionately long and more slender, nearly as long as shield and hand with dark corneous teeth only at tips of fingers. Brood pouch of female subrectangular (Hart, 1982).

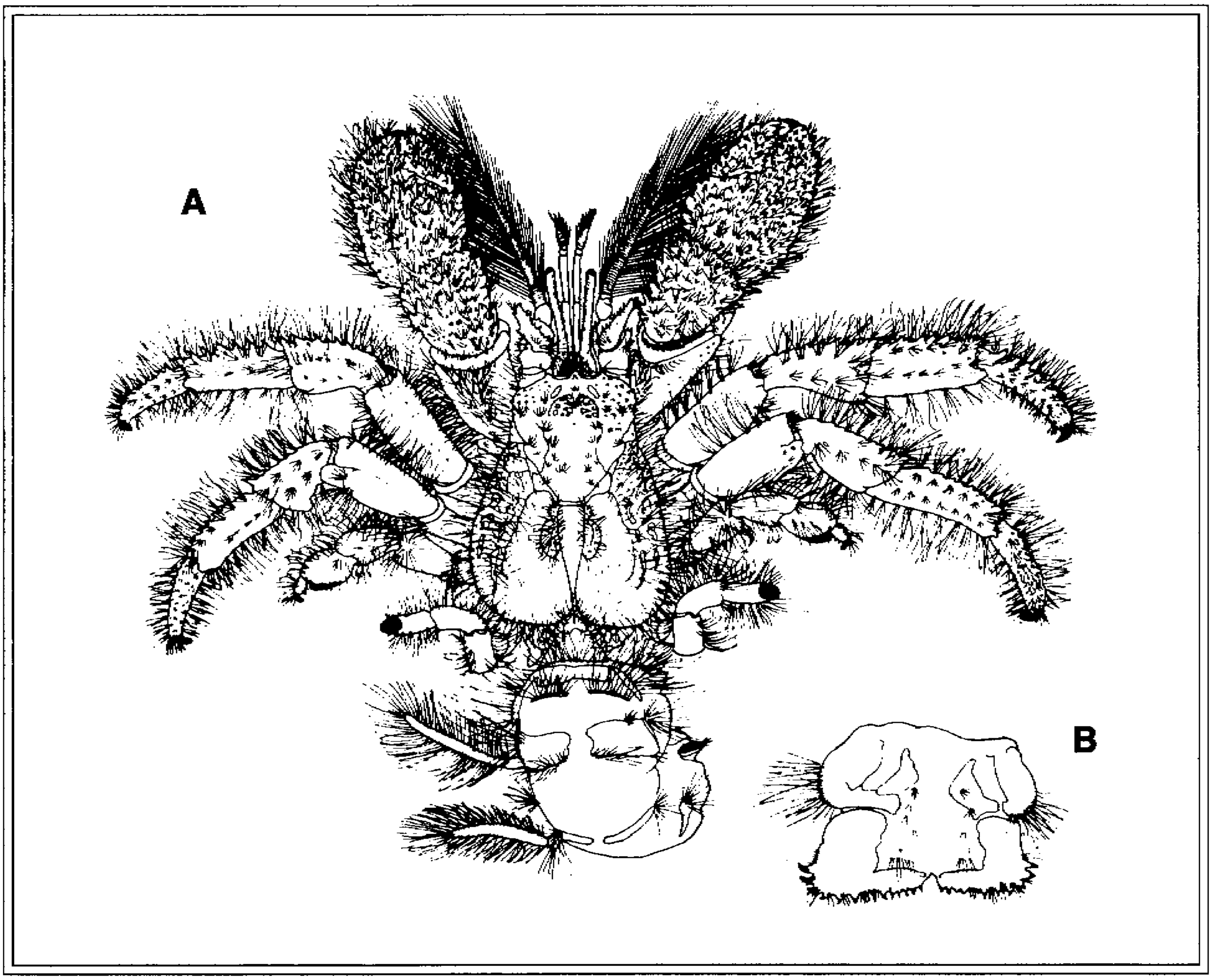

Figure 2.17. *Paguristes ulreyi* Schmitt, 1921: A, male, dorsal view; B, telson (from Hart, 1982).

Type Locality and Type Specimens. Holotype (USNM 50427) is a 59 mm male (carapace length 22 mm), from off Point Loma, California, *Albatross* Station 4304, 25 fathoms (46 m) (Schmitt, 1921). Schmitt gives additional measurements and mentions paratypes, which we assume are also housed at the USNM.

Distribution. Monterey to off San Diego, California, and San Geronimo Island, Baja California, to a depth of 59 m (Schmitt, 1921).

Family Paguridae Latreille, 1803

Parapagurodes laurentae McLaughlin and Haig, 1973

Figure 2.18

?Pagurus [sp]: —Menzies and Miller, 1954:153.

Parapagurodes laurentae —McLaughlin and Haig, 1973:129, Figs. 4b, 9-11.

Material Examined. USNM 006-BSS-01-TX Phase I primary voucher, 1 ovigerous female, shield length 1.3 mm, 11eggs (near hatching), diameter about 0.45 mm each.

Description. Palm of right cheliped with dorsal surface armed proximally with four or five irregular rows of widely spaced, strong, tubular spines, not extending onto fixed finger. Palm of left cheliped with dorsal surface havng single or double row of strong, tubular spines, not extending onto fixed finger. Palm of left cheliped with dorsal surface having single or double row of strong tubular spines.

Eleven pairs of phyllobranchiate gills. Third maxilliped with basis-ischium fusion incomplete; ischium with crista dentata well developed, one accessory tooth; merus and carpus each with spine at dorsodistal margin. Maxillule with proximal endite tapered; endopodite with external lobe moderately well-developed, not recurved. Ocular peduncles short or moderately short, stout, with corneae dilated. Ocular acicles slender to moderately broad, triangular or subtriangular, terminal spine submarginal. Antennal peduncles with one or two short setae on dorsodistal surface of ultimate segment. Chelipeds unequal, right larger than left. Second and third pereiopods with dactyl moderately elongate, slender, not strongly twisted. Fourth pereiopods subchelate or not subchelate; dactyls usually with preungual process (cf. de Saint Laurent, 1970) on lateral face; propodal rasp weakly or moderately well-developed. Males with coxae of fifth pereiopods symmetrical, right with short sexual tube; no paired pleopods, pleopods 3 through 5 biramous with rami weakly developed, or absent. Females with paired gonopores; no paired pleopods, biramous pleopods, pleopods 2 through 4 weakly or moderately well-developed, pleopod 5 weakly developed or absent. Uropods asymmetrical. Telson with terminal margins generally straight, slightly concave, or slightly oblique, with a row of small spines or spinules. Sternite of third pereiopods with anterior margin unarmed (from McLaughlin and Haig, 1973).

Color in life: Carapace translucent gray. Pereiopods with two broad bands at mid propodus (D. Cadien, pers. comm.).

Biology. Often found infested with a bopyrid isopod of the genus *Stegophryxus*.

Taxonomic Remarks. According to Mclaughlin and Haig (1973), although *Parapagurodes laurentae* is most closely related to *P. makarovi*, its superficial resemblance to an undescribed species of *Pagurus* may cause mistakes in identification. To avoid such mistakes, distinguishing characters of *P. laurentae* include the presence of sexual tubes in the males, the lack of spines on the distal portions of the dorsal surfaces of the dactyls of the chelipeds, the moderately long and relatively slender dactyls of the second and third pereiopods, and the lack of regular setation on the articles of the antennal flagella (after McLaughlin and Haig, 1973). In freshly preserved or living material, *P. laurentae* and *P. makarovi* are easily separated by color pattern. In *P. laurentae* red bands circle the propodus of the pereiopods, whereas in *P. makarovi* red stripes extend the length of both the carpus and propodus (D. Cadien, pers. comm.).

Type Locality and Type Specimens. 2.5 mi SE of Seal Rocks, Santa Catalina I., California, 33° 16' 20" N, 118° 15' 20"W, *Velero III* Station 1429-41, 159-174 m. Holotype: Male (sheild length = 3.5 mm), AHF 4127. Paratypes listed in McLaughlin and Haig, 1973: Table 3.

Distribution. Southern California, Channel Islands to west coast of Baja California, Mexico; Gulf of California; 16 to 475 m (McLaughlin and Haig, 1973).

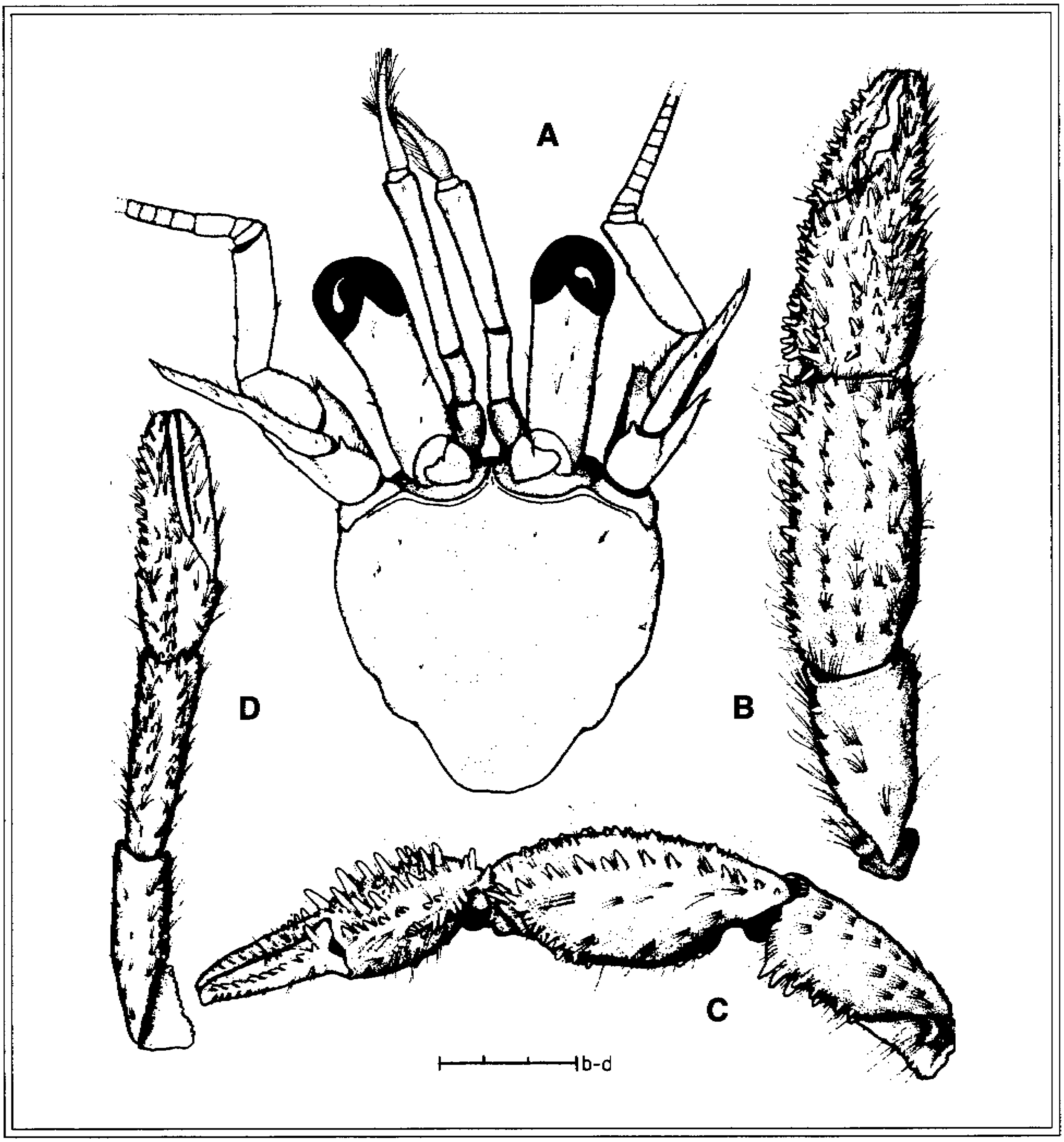

Figure 2.18. *Parapagurodes laurentae* McLaughlin and Haig, 1973: male paratype - A, shield; B, mesial view of right cheliped: C, dorsal view of right cheliped: D, mesial view of left cheliped (modified from McLaughlin and Haig, 1973).

Family Galatheidae Samouelle, 1819

Munida quadrispina Benedict, 1902

Figure 2.19

Munida quadrispina Benedict, 1902:269, Fig. 17.—Rathbun, 1904:166.—Schmitt, 1921:165, Fig. 105 (after Benedict).—Hart, 1982:168, Fig. 66.—Kozloff, 1987:411, Fig. 19.20.—Gotshall, 1994:65, Plate 154.—Jensen, 1995:73, Plate 145.

Material Examined. USNM 004-BRA-04-TX Phase I primary voucher, 4 specimens, largest - carapace length including rostrum 10.2 mm, rostrum length 3.2 mm.

Description. Abdomen unarmed. Rostrum long, slender, spine-like, laterally compressed, unarmed, moderately serrate above and slightly so below. The straight, slender supraocular spines do not reach quite to the ends of the eyes and are united to the rostrum for nearly one-half their length. The marginal spines of the carapace vary from eight to ten on a side; there are six spines on the gastric area, four in a line behind the supraocular spines, and one on each side near the hepatic region; the terminal spines of the line are very weak and small, but one spine occupies the anterior branchial region; posterior margin unarmed. Chelipeds well set with spines and spinules, not hairy (after Schmitt, 1921).

Carapace longer than wide. 6 spines on gastric area; 4 in one line, and 1 on each side of the ridge near the hepatic region. 8 to 10 marginal spines. Rostrum long and compressed and minutely spined. Chelipeds with numerous spines and narrow fingers. Walking legs compressed and armed with short spines. Abdomen ridged but not spined except for minute spines on tail fan. Males with paired uniramous gonopods on 1st and 2nd abdominal segments. Female with small paired pleopods on segments 2 to 5.

Color in life: Carapace and abdomen red-brown overall, ventrally lighter or white; ridges red with grooves white, and blue spots in cervical groove. Chelipeds with red spines; fingers red with distinct white tips. Walking legs with irregular light bands. Tail fan light colored (after Hart, 1982; Jensen, 1995:73, Plate 145).

Biology. These animals inhabit rocky areas, gravel, mud, and sponge beds. They are predators on other Crustacea and can do considerable damage in shrimp traps (Hart, 1982).

Taxonomic Remarks. Commonly referred to as a squat lobster. Rathbun (1904:166) remarked that this is "probably the species designated by Owen (1839?) as *M. gregaria.*"

Type Locality and Type Specimens. Holotype is a 35 mm long individual from off Cape Beale, Vancouver Island, British Columbia, 66 fathoms (121 m), *Albatross* Station 2878 (Schmitt, 1921).

Distribution. Sitka, Alaska, to San Diego, California, 50 to 559 fathoms (91 to 1,022 m) (Rathbun, 1904; Schmitt, 1921).

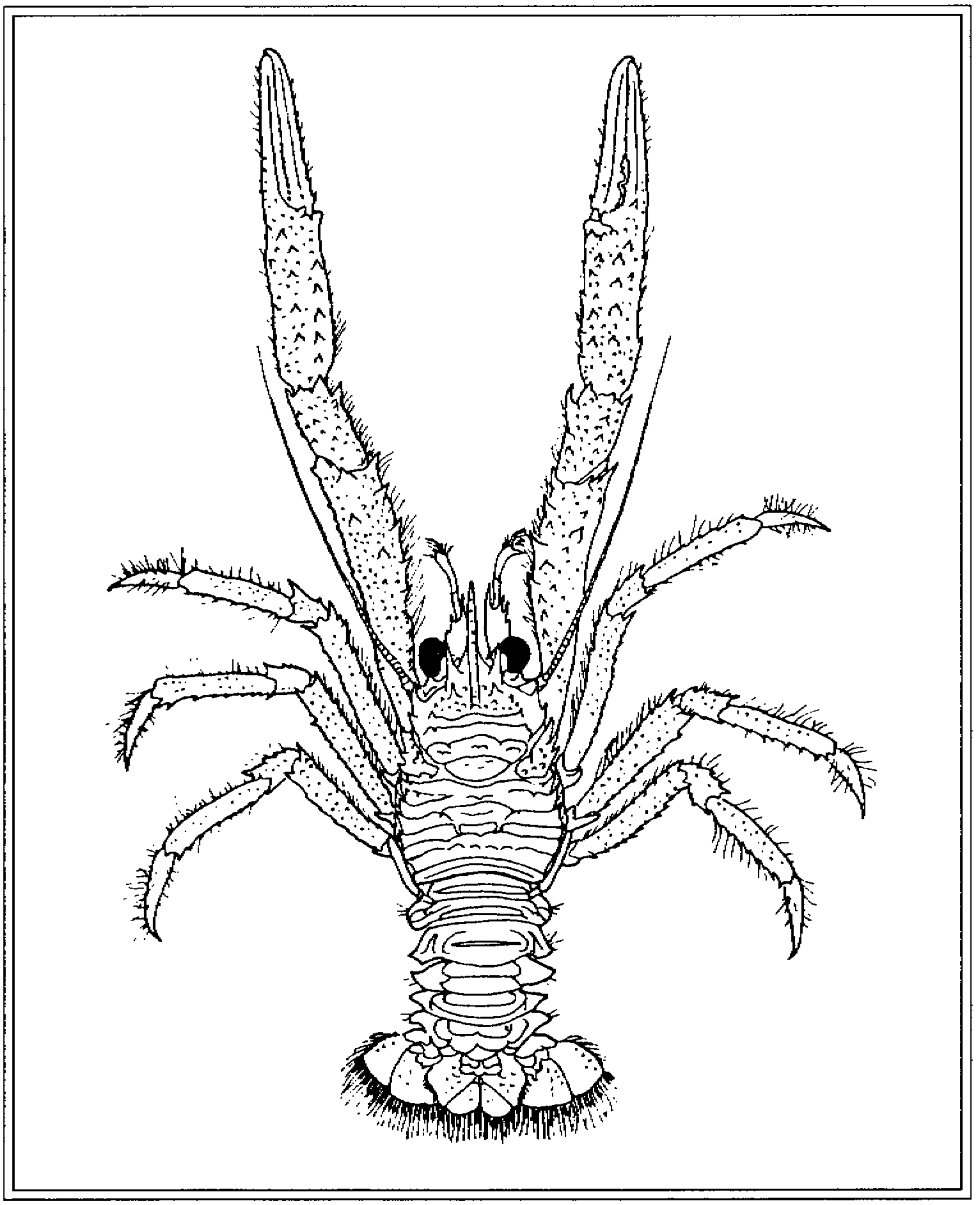

Figure 2.19. *Munida quadrispina* Benedict, 1902: male, dorsal view (from Hart, 1982).

Pleuroncodes planipes Stimpson, 1860

Figure 2.20

Pleuroncodes planipes Stimpson, 1860:245.—Holmes, 1900:112.—Rathbun, 1904:166.—Schmitt, 1921:163, Plate 31, Fig. 2.—Boyd, 1967:394, Figs. 1-4.—Gotshall, 1994:64, Plate 153.—Jensen, 1995:74, Plate 146.

Material Examined. USNM 102-BSS-01-TX Phase I primary voucher lot; SBMNH 023-BSR-02-TX Phase I secondary voucher lot.

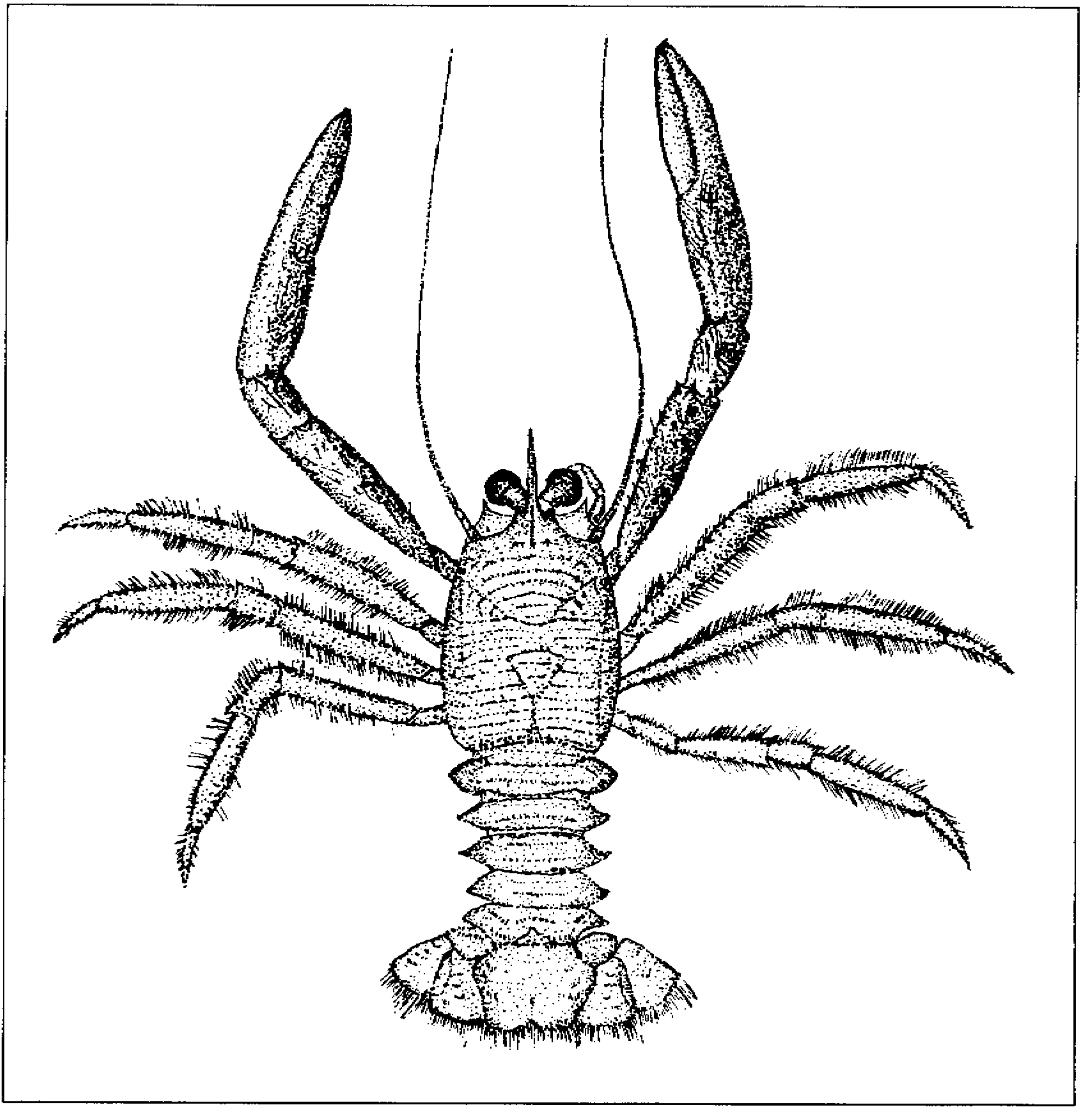

Figure 2.20. *Pleuroncodes planipes* Stimpson, 1860: male, dorsal view (from Boyd, 1967).

Description. Carapace more or less convex, tapering anteriorly, transversely rugose, anterior edges of rugae fringed with closely set short hairs; with the exception of a few spinules behind the supraorbital teeth, carapace is devoid of spines above; there is a spine at the rounded anterolateral angle, behind which there are a few spines on the lateral margin. Rostrum long and slender, scabrous above, and continued on the carapace as a carina; supraorbital teeth spine-like, confluent at base with rostrum. Chelipeds slightly hairy; ambulatory legs scabrous, with penultimate joints distinctly flattened and ciliated (Schmitt, 1921).

Color in life: Red (Jensen, 1995:74, Plate 146)

Biology. One of the most common species in southern California, *P. planipes* is usually encountered as a pelagic species in huge schools which occasionally wash ashore in vast numbers. Boyd (1967) however, found that this species is partially benthic during its first two years and wholly benthic after this time with densities measuring as high as 9 to 11 individuals per m^2. Animals were dredged and trawled at depths ranging from 70 to 900 m on gray muddy sand and gray mud along the western coast of Baja California, Mexico. Boyd (1967) states that this species is a voracious omnivore that is in turn fed upon by large oceanic game fishes such as albacore, yellowfin tuna, and skipjack tuna, and is also fed upon by kelp-bed fishes. During its pelagic phase, *P. planipes* is a filter feeder near the surface. It spreads its setae-fringed legs to form a filter basket and slowly sinks through the water column collecting particulates, small zooplankters, and perhaps larger phytoplankton. these are ingested as the legs are groomed, and the animal swims back to the surface to repeat its slow feeding descent (D. Cadien, pers. comm., based on his observations from the Texas A&M University submarine *Diaphus*, in the Santa Maria Basin). Schmitt (1921) reports that a mass stranding which occured in 1859 was the source of specimens for the species description by Stimpson in 1860; subsequent reports of this phenomenon are numerous.

Taxonomic Remarks. This species is often referred to as the tuna crab or red crab. It is also included with those species known as squat lobsters.

Type Locality and Type Specimens. Schmitt (1921) gives two type localities: Monterey, California, and a latitude and longitude of 24°N 130°W, Pacific Ocean (Schmitt, 1921:163).

Distribution. From 90 miles southwest of San Francisco, California, to 150 miles southwest of Cape St. Lucas, Lower (Baja) California (Rathbun, 1904; Schmitt, 1921).

Family Lithodidae Samouelle, 1819

Paralomis multispina (Benedict, 1894)

Figure 2.21

Leptolithodes multispinus Benedict, 1894:484.—Rathbun, 1904:165.

Paralomis multispina.—Bouvier, 1896:25.—Schmitt, 1921:159, Plate 23, 30, Figs. 7-8.—Goodwin, 1952:176, Fig. 8.—Hart, 1982:88, Fig. 28.—Kozloff, 1987:408.—MacPherson, 1988:76.

Material Examined. USNM 013-BRA-04-TX Phase I primary voucher, 1 specimen, carapace length including anterior and posterior spines 3.02 mm, without spines 2.57 mm, carapace width with spines 2.57 mm, without spines 2.13 mm; SBMNH 016-BRA-01-TX Phase I secondary voucher, 1 specimen.

Description. Carapace about as broad as long; areolations well defined. Median line at summit of gastric region has a sharp spine about 4 mm in length. The lateral margins are armed with from twelve to sixteen spines about 3 mm in length. In young and in some adults there are small spines on the branchial region. A semicircular line of six or seven spines marks the limits of the branchial and intestinal regions. Carapace thickly studded with blunt spines, each terminating in a flattened face or surface cut obliquely to the surface of the carapace; this face is encircled by a fringe of short, stiff bristles. Rostrum consists of simple median spine with two basal spines. Under the rostrum proper there is a very short, conical spine homologous with the subrostral spine of *Lithodes*; behind the spine are one or more spinules. Abdomen in male composed, after the second segment, of several rows of leathery plates; second segment better calcified and harder. Abdomen of female twisted to the right as in *Lithodes*.

Chelipeds moderately slender, extending almost to distal end of carpal joints. Spines on inner margin of carpal segments the most prominent. Ambulatory legs long and slender, thickly set with spines. Spines of merus not so distinctly arranged in rows as on carpal and propodal segments; there is, however, a distinct row on the upper margin. Spines of carpus arranged in eight more or less distinct rows; on the propodal segment the spines are arranged in six full rows and two half rows. There are four short rows of spines on the proximal end of the dactylus. Dactyli compressed, slightly bent, a little twisted (Schmitt, 1921:159, after Benedict).

Color in life: Carapace scarlet with spines dark and nodules light. Chelipeds and walking legs scarlet with lighter colored spines and tips of fingers. Eyestalks scarlet; corneas black. Antennal flagellum scarlet (Hart, 1982).

Biology. Hart (1982) reports habitat as deep sea mud.

Taxonomic Remarks. According to MacPherson (1988:76), there are 24 species of this genus in the Pacific (including Antarctic waters). Off California only two species occur, *P. multispina* and *P. verrilli* (Benedict, 1894). The species are easily separated by the more spiny carapace and legs of *P. multispina* (compare Plates 23 and 24 of Schmitt, 1921). The correct date of Benedict's description is apparently 1895, although the date appearing on the frontispiece of that volume is 1894 (Dawson, 1989).

Type Locality and Type Specimens. Off Queen Charlotte Islands, British Columbia, 876 fathoms (1,602 m), *Albatross* Station 2860.

Distribution. From off Shumagin Bank, Alaska, to off San Diego, California, 625 to 876 fathoms (1,143 to 1,602 m) (Schmitt, 1921, after Rathbun, 1904); Japan to Gulf of California, deep water (Dawson, 1989).

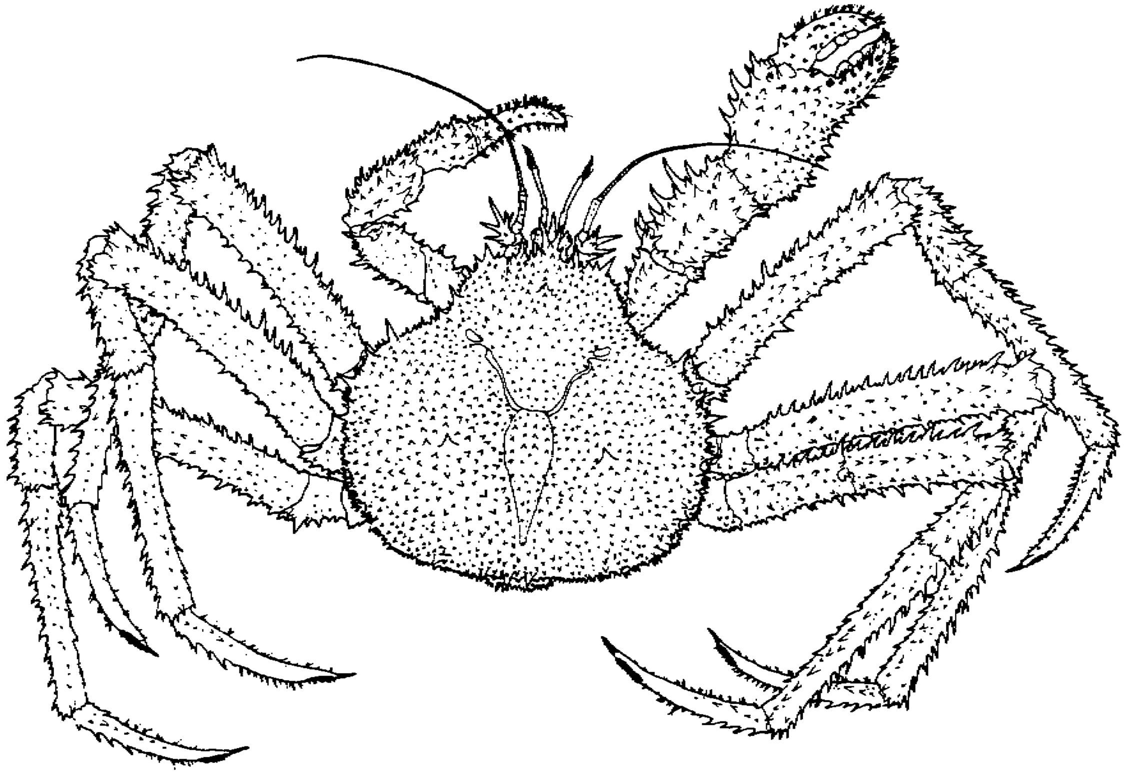

Figure 2.21. *Paralomis multispina* (Benedict, 1894): male, dorsal view (from Hart, 1982).

Infraorder Brachyura Latreille, 1803

Family Homolidae De Haan, 1839

Paromola faxoni Schmitt, 1921

Figure 2.22

Paromola faxoni Schmitt, 1921, Plate 31, Fig. 7.—Rathbun, 1937: 68-69, Plate 18; Plate 19, Fig. 1; Table 19.— Crane, 1937: 107.— Church, 1971: 113 (color photograph, presumably this species).— Luke, 1977: 32.— Wicksten, 1983b: 185, Fig. 1b (drawing based on Church's (1971) photograph). Kuck and Martin, 1994: 178, Figs. 1-4.

Material Examined. California: Santa Maria Basin, 250 m, MMS BioSurvey Station 1 C/D. One male, carapace length (including 4.9 mm rostrum) 35.8 mm; carapace width = 31.2 mm (USNM 001-BRC-02-TX).

Type Locality and Type Specimens. Off Point Loma, California, 67 to 73 fathoms (123 to 134 meters), *Albatross* Station 4309, 03 March 1904. Type specimen USNM 53331, female.

Description. Carapace: Very short covering of setae over entire carapace, but not obscuring surface (i.e., not with "entire surface more or less obscured by a rather thick, short pubescence" [Schmitt, 1921]). Supraorbital spines directed outward, with two (sometimes one; e.g., MMS 1 C/D) small, hooked spines. Branchial and hepatic regions distinctly inflated; body subrectangular in cross section, becoming more inflated with increased size of crab. Lateral margins with row of 4-6 spines. Linea homolica visible along dorsolateral margins (see Martin and Abele [1986: 587; 1988: 32] for discussion of lineae of decapods; see McLaughlin [1980: 167] for definitions of types of lineae found in decapods). Small tubercles of varying number and size covering carapace both dorsally and laterally, largest concentration on dorsal branchial region (Kuck and Martin, 1994).

Chelipeds: Long, slender, equal in length; covered with dense, short setation; merus with row of 5-8 spines dorsally in females. Six specimens with variously sized, darkly pigmented, subcircular spot distally on both sides of propodus (LACM 62-204.1 has spots only on inner side of propodus; CMM 86.26.001 has spot on inner side of right propodus only.) Nature of this spot, and why it appears in only some specimens of both sexes, is unknown. Fingers with non-serrate, acute inner margins; dactyl crossing propodus inwardly at tip (except one chela of specimen from MMS 1 C/D); with patches of long, thick setae in most specimens; finger pigmentation (preservation in 70% ethanol) ranging from white to brown to black .

Pereiopods: Pereiopods 2-4 with row of 15-22 corneous spines on inner (ventral) margin of dactyl; merus with 6-9 dorsal and 3-12 ventral spines along margins; Pereiopod 5 dactyl with 5-8, and propodus with 7-10 (proximal 5-6 in circular pattern) corneous spines on inner margin. Dorsal and lateral surfaces of propodus densely covered with short setae; ventral surfaces of dactyl and propodus mostly devoid of setae.

Abdomen: Seven-segmented; large tubercle at posterior margin of first, and in center of second, segments; occasionally, small tubercle at anterior margin of first, large or small tubercle in center of third, and small tubercle on anterior margin of fourth, segments.

Male: Chelipeds more robust; larger specimens with propodus and carpus covered with prominent tubercles, fewer and sometimes absent in smaller males and in females. Merus with 9 to 19 dorsal spines; occasionally, additional parallel row of up to 11 spines in larger specimens. Abdomen with tubercle along horizontally raised posterior border of sixth segment (also found in small female from LACM 41-33.9); anterior half to two-thirds of seventh segment generally narrower at base than in females. Pleopod 1 large, robust, minutely crenulate at distolateral tip; overlapping ventral folds with long setae covering posterior opening. Pleopod 2 as in Fig. 3c. Pleopods 1 and 2 becoming more robust and better defined with increased size of specimen.

Small individuals (e.g., LACM 41-33.9): Carapace with spines longer and sharper than in adults; virtually no setae dorsally, except at tips of largest lateral, gastric, and hepatic spines; short hooked setae along some margins; rostrum, supraocular spines, pereiopods, antennae, and eyestalks with long, slender, irregularly spaced setae; very few well-spaced setae covering chelipeds. Supraocular spines directed forward with small, hooked dorsal spines sometimes lacking (e.g., LACM 40-148.1). Chelipeds with 5 dorsal spines on merus; fingers without pigmentation. Pereiopods 2-4 proportionately longer and more slender, and with fewer and less prominent spines along dorsal and ventral margins of merus, than in adults. Pereiopod 5 dactyl with 6 and propodus with 8 spines.

Color: All specimens examined by Kuck and Martin (1991) appeared uniformly light to dark cream (preservation in 70% ethanol) except for LACM 66-371.1, which had a whitish carapace. See "chelipeds" above for description of cheliped spots and finger pigmentation. Crane (1937) describes "color in life" as "entirely buff, except anterior part of carapace which is suffused with scarlet"(Kuck and Martin, 1991).

Biology. Very little is known about the basic biology of *P. faxoni*, as is the case for many deep-sea brachyurans. They have been recovered from vase-shaped hexactinellid sponges off Point Loma, California, and were loath to leave the sponges' protective cover once collected (pers. comm., R. Velarde, via D. Cadien). The reduced and subchelate fifth pereiopods suggest a carrying behavior, as has been seen in other members of the genus (e.g., Wicksten, 1985, for *P. japonica*), with these legs holding some object(s) over the back of the carapace for protection or camouflage. Wicksten (1983b: fig. 1b) shows what is probably a *P. faxoni* "from southern California" carrying a sponge; her drawing was based on a color photograph in Church (1971) of a "10-inch-long [specimen] at a depth of 1,200 feet [366 m] off San Diego." Based on pereiopod morphology, Guinot and Richer de Forges (1981) and Wicksten (1985, 1986) inferred carrying behavior in all species of the family Homolidae. Similar behavior has been documented or inferred for other crabs with chelate or subchelate posterior pereiopods (e.g., Dromiidae, Latreillidae, and Dorippidae).

Only one ovigerous female exists in examined collections (LACM 62-205.1). A second was collected off San Diego, California, on 28 January 1992 by the Pt. Loma Biology Laboratory (OMP), but was discarded. We know of only four *P. faxoni* that have been held successfully in aquaria (three females at the Cabrillo Marine Museum, and one male at the Scripps Institution of Oceanography). The only behavioral notes available are from observations by S. Vogel (CMM; pers. comm.) of crabs in aquaria carrying gorgonians with the fifth pereiopods, and by R. McConnaughey (SIO; pers. comm.) of a crab that lived in an aquarium (5-10° C) from 05 May to October 1992. McConnaughey noted that the crab maintained the fifth pereiopods in an elevated position, but no obvious carrying behavior was observed (although shells and other items were introduced). The species has also been found when trawled to still carry a gorgonian colony not otherwise represented in the trawl (and thus not likely to have been picked up after capture) (pers. comm., R. Velarde via D. Cadien).

Taxonomic Remarks. Although the holotype (USNM 53331) is a female, and is the only specimen mentioned by Schmitt (1921), his figure (Plate 31, Fig. 7) was erroneously referred to as a male in the accompanying figure legend. Rathbun (1937) used the same photograph, but correctly referred to it as a female (holotype), and also included a photograph of the holotype in ventral view (clearly showing it to be female). Rathbun (1937: 72, Table 18) listed the five previously known specimens, all of which were collected by the *Albatross* in 1904 and are housed at the USNM (R.B. Manning, pers. comm.).

The male first and second pleopods have been illustrated for relatively few species of *Paramola*. Griffin (1965: Figs. 1-4) provided figures for *P. spinimana*, as did Serene and Lohavanijaya (1973: figs. 36-37) for *P. alcocki faughni*, and Guinot and Richer de Forges (1981: Figs. 5A, A1 and 5C, C1) for *P. profundorum* and ?*P. japonica* Parisi, 1915. The general shapes of the pleopods of these species and those of *P. faxoni* are quite similar, including the distinctive overlapping ventral folds of the first pleopod (Fig. 3a; ventral view not shown in Serene and Lohavanijaya, 1973). The apex of the first pleopod is distinctive in these species, as in many brachyurans, and most likely provides a good distinguishing characteristic among males of *Paromola* species.

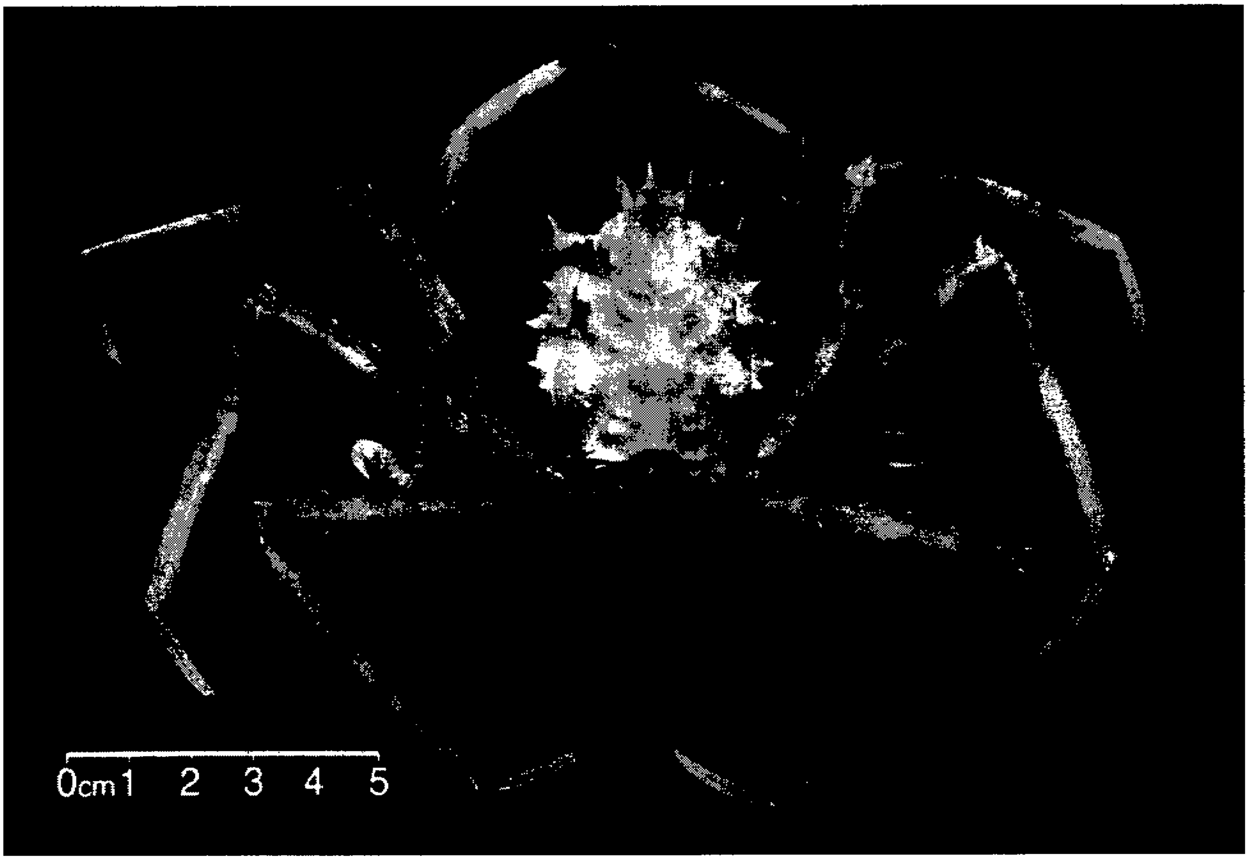

Figure 2.22. *Paramola faxoni* (Schmitt, 1921): Holotype female (carapace width 39.60 mm) USNM 53331, dorsal view (from Kuck and Martin, 1994).

Distribution. All five specimens of *P. faxoni* listed by Schmitt (1921) and again by Rathbun (1937) were taken off Point Loma, California, in depths from 123 to 247 m. Wicksten (1985) examined another specimen housed at the Allan Hancock Foundation (AHF), Los Angeles, California, where we found nine additional unreported specimens (Tables 1 and 2) distributed from Tajiguas, California (approximately 27 miles east of Point Conception, Santa Barbara County, CA), to Isla Cedros, Baja California, Mexico. The only other published record for this species is a collection catalog by Luke (1977) documenting ten specimens (six males, three females, and one juvenile) housed at the Scripps Institution of Oceanography and distributed from La Jolla, California, to Cabo Colonet, Baja California, Mexico. According to staff of the Monterey Bay Aquarium Research Institute (MBARI), Monterey, California, there have been no sightings of *P. faxoni* in the area during the past four years either by personnel or in extensive video footage (J. Berry, J. Connor, L. Lewis, pers. comm.). Queries to the California Academy of Sciences (CAS; R. Van Syoc, pers. comm.), San Francisco, California, and to the Universidad Nacional Autonoma de Mexico (UNAM; M. Hendrickx, pers. comm.), Mazatlan, Mexico, did not result in any additional specimens. Additionally, Hendrickx (1992) did not list *P. faxoni* as occurring in the Gulf of California, Mexico. Therefore, it is likely that the geographic distribution of *P. faxoni* does not greatly exceed the boundaries defined by present specimen collections, although distribution of the species west to Point Conception, CA (northernmost border of the California Province; e.g., Brusca and Wallerstein, 1979:73), is highly probable.

The report of Kuck and Martin (1991) extended the range of *P. faxoni* northward to Tajiguas, California, and southward to Isla Cedros, Baja California, Mexico, and extends the depth range to 18-460 m.

Family Xanthidae MacLeay, 1838

Lophopanopeus bellus diegensis (Rathbun, 1900)

Figure 2.23

Lophopanopeus diegensis Rathbun, 1900:37; 1904:184, Plate 9, Fig. 3; 1930:327, Plate 153, Figs. 6-7, 10, text-Fig. 49.—Weymouth, 1910:52, Plate 12, Fig. 39.—Schmitt, 1921:245, text-Fig. 146, Plate 37, Fig. 5.—Johnson and Snook, 1935:387.

Lophopanopeus bellus diegensis.—Menzies, 1948:7, Figs. 6-8, (male hypotype, AHF Station 1407-40).—Allen, 1980:238, Plate 35, Figs. 402, 405.—Hart, 1982:200, Fig.81.—Jensen, 1995:19, Plate 7.

Lophopanopeus bellus.—Charwat, 1977:71.

Material Examined. USNM 013-BRA, 04-TX Phase I primary voucher, 1 immature female; carapace length = 3.3 mm, carapace width = 4.2 mm. SBMNH 001-BRC, 02-TX Phase 1 primary voucher, one immature male, carapace length = 2.8 mm, carapace width = 3.9 mm.

Description. Ambulatory legs with dorsal and lateral surfaces, except on the lobations, covered with a pubescence; carpus markedly bilobed. Carpus of cheliped covered with irregular generally isolated elevated bumps; carpal number for bumps 4-6; a deep sulcus is located on dorsal surface of carpus near its anterolateral margin. Lobe at proximomedial part of dorsal surface of manus small. An enlarged tooth is present at the proximal end of cutting edge of dactylus of major cheliped. Dorsal surface of carapace pubescent as in *L. b. bellus*. Morphology of tip of flagellum of male identical with that of *L. b. bellus* (after Menzies, 1948:7).

Original description: Upper margin of meral joints of ambulatory legs not spinulous. Hands with one or more lobes or teeth on upper margin. Carpus of cheliped very rough. Carpal joints of ambulatory legs strongly bilobed. Carpus of chelipeds covered with tubercles (Rathbun 1900:137).

Discussion of constant features: Only two characters, (1) the presence of irregular, elevated, isolated bumps on the dorsal surface of the carpus of the cheliped and (2) the presence of markedly bilobed carpal segments of the ambulatory legs, serve to distinguish this species from *L. bellus bellus* (Menzies, 1948).

Color in life: Color and pattern variable ranging from purple and orange to brown, white, or mottled (Jensen, 1995:19, Plate 7).

Biology. This species has been collected from various habitats ranging from unprotected rocky shores to protected bays at depths ranging from intertidal to 100 fathoms (185 m), on bottoms ranging from mud to course sand to rock. Below 20 fathoms (37 m) *L. bellus diegenensis* is frequently taken with *L. leucomanus leucomanus*. Intertidal specimens are in general much larger than those found below 10 fathoms (Menzies, 1948).

Ovigerous females have been found from February to July and also in September.

Taxonomic Remarks. This subspecies of *Lophopanopeus bellus* was initially described by Rathbun (1900) as a distinct species, *L. diegensis*. Menzies (1948) considered it a subspecies of *L. bellus* and described the differences between this and the other, more northern, subspecies, *L. bellus bellus*. However, Menzies noted several problems, including areas of geographic and morphological overlap (see Menzies, 1948).

In the two juveniles in these collections, the pubescence of the pereiopods and carapace that Menzies (1948) employed in his key is not readily evident. However, the distinctive nature of the bilobed crest on the carpus of the walking legs, and the irregular raised bumps of the cheliped carpus, are evident even at these early developmental stages.

Adult specimens of *L. bellus diegenensis* average approximately one half the size in carapace width of adults of *L. bellus bellus*.

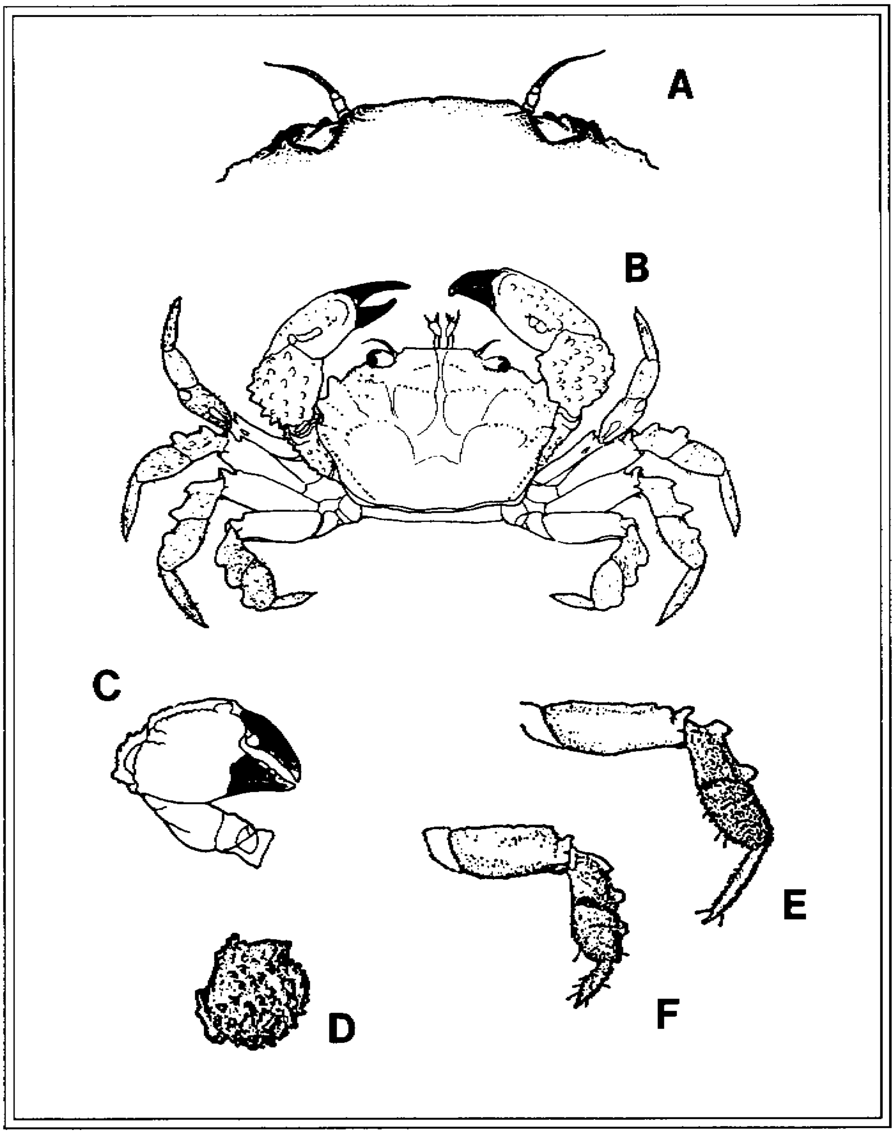

Figure 2.23. *Lophopanopeus bellus diegensis* Rathbun, 1900: A, anterodorsal margin of carapace; B, male, dorsal view; C, male, lateral view of right cheliped; D, male holotype, dorsal view of right carpus; E, male holotype, lateral view of second ambulatory leg; F, male holotype, lateral view of fourth ambulatory leg (A, from Allen, 1980; B,C, from Hart, 1982; D-F, from Menzies, 1948).

Type Locality and Type Specimens. San Diego, 10 fathoms (18.3 m), holotype male (Rathbun's (1900) *L. diegensis*), USNM 4281. Hypotype, AHF Station 1407-40.

Distribution. *Lophopanopeus bellus diegenensis* is the southern form of the species and ranges from Mission Bay to Monterey Bay, California. A sharp intergradation zone between *L. b. diegenensis* and *L. b. bellus* is found between Point Conception and Point Sur, California, but specimens of *L. b. diegenensis* have been identified from as far north as Washington and Alaska (Menzies, 1948). In some areas near Tacoma, Washington, in Puget Sound, *L. b. diegensis* far outnumber *L. b. bellus*, with both forms occurring in a single sample (D. Cadien, pers. comm.). This suggests to us that specific rather than subspecific status may be warranted.

Family Parthenopidae Alcock, 1895

Heterocrypta occidentalis (Dana, 1854)

Figure 2.24

Cryptopodia occidentalis Dana, 1854:430.—Stimpson, 1857:458.—Lockington, 1877b:78.—A. Milne Edwards, 1878:169.

Lambrus frons-acutis Lockington, 1877a:31. Type locality, Santa Catalina Island, California; type not extant (destroyed in San Francisco fire).

Heterocrypta occidentalis.—Holmes, 1900:44.—Rathbun, 1904:170; 1925:559, Plates 204, 205; 1926:28.—Weymouth, 1910:21, Plate 2, Figs 4, 5.—Hilton, 1916:71, Fig. 7.—Nininger, 1918:36, Fig. 1.—Schmitt, 1921:192, Fig. 119. Johnson and Snook, 1927:363, Fig. 316.—Ricketts and Calvin, 1939:182, Plate 35.—Garth, 1958:476, Plate Z_4, Figs. 14 and 14a, Plate 55, Fig. 2.—Allen, 1980:236, Plate 32, Fig. 379.—Gotshall, 1994:69, Plate 165.—Jensen, 1995:34, Plate 53.

Material Examined. One juvenile, damaged, possessing only left pereiopod 1 (cheliped) and right pereiopod 5, carapace length = 2.9 mm, carapace width = 2.8 mm, USNM 021-BSR, 02-TX Phase I primary voucher.

Description. Size to 21.0 mm carapace length, 34.0 mm carapace width. Branchial ridges sinuous, terminating at lateral angle, and not continuing on gastric region, marked by two ridges coming to a point posteriorly. Fingers short, making a distinct angle, though less than a right angle, with palm. Male first pleopod thick, capitate, contorted, tapering to "neck" then flaring; longer setae on lip of groove, in two rows in concavity of terminal portion, and marginally. Male second pleopod little more than half the length of first, reflexed, corneous tip marginally denticulate; a subterminal cluster of denticles.

Carapace broadly triangular; median region narrow, the flattened upper surface bounded by two granulated ridges, converging to a point behind. Cardiac region furnished with a three-sided, pyramidal elevation, the edges usually granulated. Posterolateral regions large, and furnished with an S-shaped, granulated crest, extending from near the posterior end of the median region to the acute lateral angles on the carapace; in front of the anterior bend of this crest a pair of minute tubercles. Rostrum triangular, subacute, not depressed. Anterolateral margins straight or slightly concave in front, convex near the middle, the posterior portion passing outwards and backwards, arching over the legs; the teeth on the anterior part small and irregular, but becoming larger posteriorly, there furnished with secondary denticles. Posterolateral margins transverse; posterior margin not produced over the abdominal segments. Ischium of the maxillipeds smooth, the anterointernal angle produced; merus small, the surface concave and bearing a prominent tooth near the middle.

Chelipeds long, trigonal; the sides of the merus convex, the edge sharply granulate to dentate; carpus with three of four granulate lines; hand about as long as the merus. The angles prominent and dentate and the sides concave; pollex short, deflexed; dactyl short, but longer than long axis of the hand. Ambulatory legs compressed, strongly carinated above; dactyls narrow, strongly sulcate, and corneous-tipped (Garth, 1958:476, modified from Holmes, 1900:44).

A long triangular concave area extends from the subhepatic region back to the afferent branchial openings. It includes the exognath and is surrounded by a fringe of hair; outside this area, and above the ischium of the cheliped, a raised, level, oval area against which the inner surface of the manus contacts when the cheliped is flexed (modified from Rathbun, 1925:559).

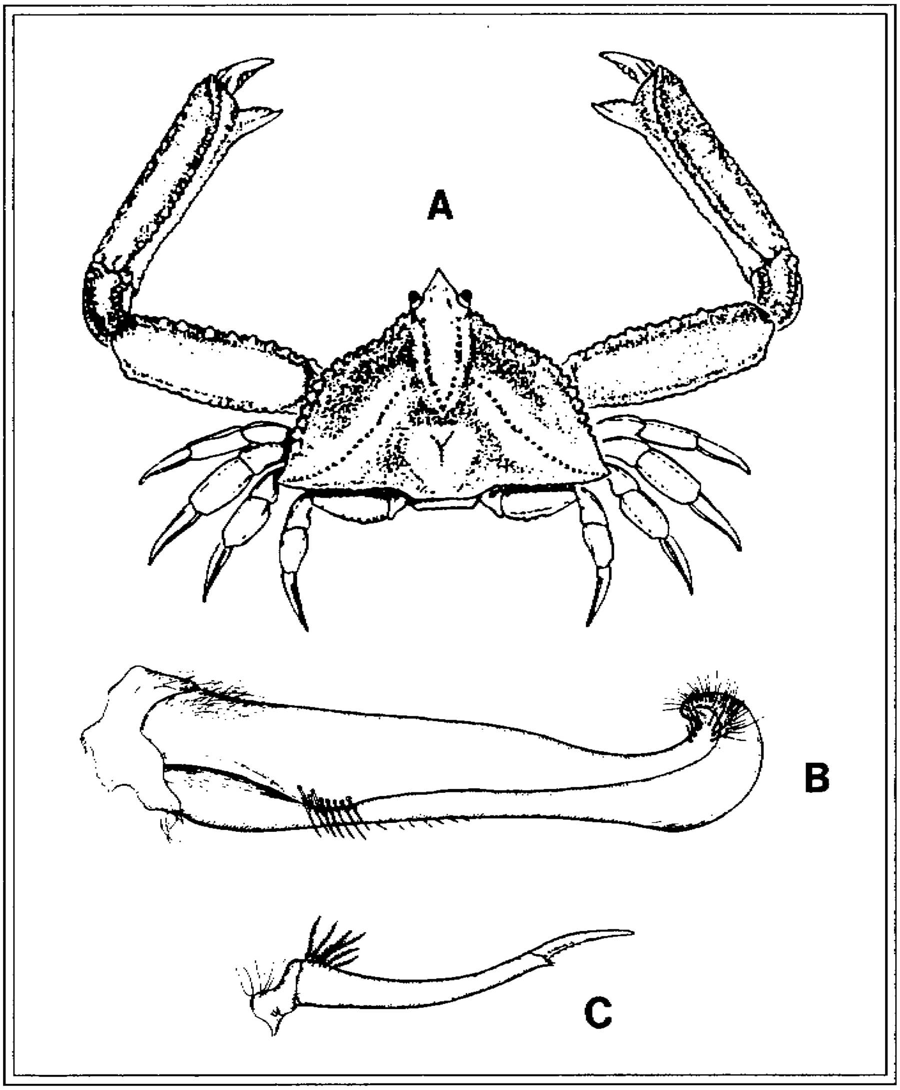

Figure 2.24. *Heterocrypta occidentalis* (Dana, 1854): A, dorsal view; B, male, first pleopod; C, male, second pleopod (A, from Allen, 1980; B-C, from Garth, 1958).

Color in life: Tips of tubercles white, with ridges bearing tubercles light purpleish, and remainder of carapace mottled with numerous minute spots of white and purplish, giving a pink effect which often closely approaches white. Ambulatory legs usually a light yellow (Weymouth, 1910:21) (see Gotshall 1994, Plate 165; Jensen, 1995:34, Plate 53). A specimen collected on SCUBA off of Malibu by one of us (TLZ) had the following coloration; carapace white, raised regions gray with purple ridges.

Biology. This species has been found on sand, sand and shell, algae, gravel, mud, rock with kelp, algae, and coralline substrates. Often associated with sponges, worm tubes, and/or urchins.

Collected from depths normally ranging from 4-57 fathoms (7-105 m) with extreme records being intertidal and 95 fathoms (175 m).

Ovigerous females have been taken from February through May, and July through September. In February at San Diego, 38 of 44 females were with ova, and in April off Newport Beach, 51 of 51 females were in this condition (Garth, 1958:476).

Taxonomic Remarks. Garth (1958) states that this species is most abundant off Huntington Beach and in Newport Harbor. Many large males were found in the 20 mm range, but none were found over 21 mm. Young under 10 mm are considered to be immature, but individuals can be sexed at 5 mm. Often a sharp rostrum is present and encrustations of barnacles occur on carapaces and chelipeds of older specimens.

Type Locality and Type Specimens. Monterey, California, carapace width = 31.7 mm, sex not stated, "probably in Yale Museum" (Garth, 1958, after Rathbun, 1925).

Distribution. Gulf of Farallones to San Diego, California, and Los Coronados Islands, 13 to 36 fathoms (24 to 66 m) (Rathbun, 1904) (see Garth, 1958, for additional records).

Family Majidae Samouelle, 1819

Erileptus spinosus Rathbun, 1893

Figure 2.25

Anasimus rostratus Rathbun, 1893:227; 1904:171, Plate 10, Fig. 4.—Weymouth, 1910:27.

Anasimus spinosus.—Schmitt, 1921:196, Fig. 121.

Erileptus spinosus Rathbun, 1893:227; 1904:171, Plate 10, Fig. 1; 1925:68, Plates 212, 213, Fig. 18.—Holmes, 1900:21.—Weymouth, 1910:27, Plate 3, Fig. 7.—Crane, 1937:54.—Garth, 1958:91, Plate E, Fig. 8; Plate 5, Fig. 2.—Jensen, 1995:27, Plate 28, Fig. 6.

Material Examined. One ovigerous female, carapace length (including 1.4 mm rostrum) 7.1 mm, carapace width = 4.7 mm. Specimen number 027-BRA, 02-TX, Phase I Voucher specimen, USNM. One ovigerous female, carapace length = 4.9 mm (including rostrum, broken at tip), SBMNH Phase I secondary voucher collection, 006-BRA, 02-TX. One juvenile male, carapace length = 4.2 mm (including rostrum, which is broken at tip) in vial with two other, smaller (unidentified), majids, labeled "Majid sp. 1," MMS California OCS Phase II, voucher lot, Cruise 3-4, Station R-4, rep. 3, 34°43.0'N, 120°47.4'W, 91 m.

Description. Size to 11.5 mm (Rathbun, 1925). Carapace pyriform, convex, regions well defined; rostrum simple, slender; postorbital and supraorbital spines present. Basal article of antennae long and narrow, with spine at distal end. Anterointernal lobe of ischium of outer maxilliped large and strongly advanced; merus subtriangular, the anterior margin the longest; outer, or principal, margin of next article nearly as long as outer margin of merus and almost straight until near distal end where it forms an elbow; terminal article unusually long.

Sexes markedly dissimilar. Rostrum a slender spine half as long as postrostral portion of carapace in male, shorter in female. Two median spines, one gastric, one cardiac; one long branchial spine. Postorbital spine small. Chelipeds very long, from three to four times length of carapace in male, only one and a half times carapace length in female. A spine on first abdominal somite.

Male: Carapace spinous; two spines on the median line, one on posterior part of the gastric region and the other on the cardiac region; one long spine on the branchial region, with a small one in front of it and two on the margin; a spine on the margin of the hepatic region and two very small ones arranged transversely on the gastric region; a slender spine on the orbital arch. Rostrum slender, spinulous on the margins, about one-half the length of the postfrontal portion of the carapace. Postorbital spine small, at some distance behind eye. Abdomen bearing a spine on the first segment. Chelipeds nearly three times as long as carapace, granulate; merus one-spined above at the anterior margin; hand slender, slightly flattened vertically, increasing in width toward the distal end; dactyl and pollex arched, gaping for one-half length. Ambulatory legs decreasing regularly in length from the first to the fourth; fourth pair a little more than one-half the length of the first (Rathbun 1893).

Female: Carapace with two median spines, one on the posterior part of the gastric region and one on the cardiac region. Two spines on each branchial region and, almost in line with these, one on each protogastric lobe, Lateral margins spinulous. Surface pubescent. rostrum slender, spinulous on the margins, curving upwards for its distal half. A prominent supraorbital spine. The first article of the abdomen carrying a spine; a slender spine above near the carpus; hand granulous; fingers nearly as long as palm, in contact. Ambulatory legs slender, pubescent, decreasing slightly in length from the first to the fourth pair; dactyls spinulous below (modified from Rathbun, 1893 [of *Anasimus rostratus*]).

The length of the rostrum is subject to considerable variation. The females of the species, with their shorter legs, are difficult to tell from *Inachoides laevis*, but the ranges of these species only overlap in the Gulf of California (Garth, 1958:91).

Color in life: Cryptic, nondiscript tan carapace (Jensen, 1995:26, Plate 28). In alcohol, chelipeds and legs conspicuously banded and marbled (Crane, 1937).

Biology. This species has been recorded from sand, mud, rock, coral, and "coralline" [algae], with the majority of recordings (fully one third of the cases reviewed by Garth, 1958) coming from shell [debris] associated with sand. *Velero III* specimens came from depths ranging from 2 to 300 fathoms (4-554 m). Ovigerous females have been recorded in every month of the year along the coasts of southern California and northern Baja California, although there is a seasonal trend with lows in the frequency curve in January, a rise in April, and highs in August and September (Garth, 1958).

Taxonomic Remarks. The rostrum for small females has never been drawn adequately; existing figures do not depict adequate spination. Marked sexual dimorphism and variation within a given sex has lead to taxonomic confusion such that the different sexes were originally assigned to seperate genera. Specimens are often covered with debris and attached material.

Three MMS voucher lots bore the label "Majid sp. 1" and were not identified further. Collection data is the same for all vials, differing only in the "Rep:" field on the label. Of these, the lot mentioned above (Rep: 3) contained three individuals, the largest of which is a small male *E. spinosus*. The other two specimens in that lot are too undeveloped to allow confident identification. This is also the case with the other two lots (identical collection data as above, except that one vial is Rep: 1, the other Rep: 2), although the sole juvenile in the lot marked Rep: 2 (CL= 3.4 mm including strongly bifurcate rostrum), while clearly a majid, definitely is not a young *E. spinosus*.

Type Locality and Type Specimens. Marked sexual dimorphism led to the sexes being treated by Rathbun (1893b) as separate species, the male assigned to *Erileptus spinosus*, the female to *Anasimus rostratus*, each with a designated holotype (see Garth, 1958).

Type material: Holotype USNM 17341, male, carapace length = 10 mm, carapace width = 6 mm, off San Diego, California, 36 fathoms (66 m), *Albatross* Station 2934. Female holotype (of *Anasimus rostratus*) USNM 17340, northwest of Cedros Island, off Baja California, 58 fathoms (106 m).

Distribution. Broadly distributed off southern California, from San Miguel Island and Point Santa Barbara in the northern part of its range to Entrada Point, Magdalena Bay, Baja California, Mexico, and in the Gulf of California from Rocky Point, Sonora, to Gorda Banks (Garth, 1958). A single specimen from south of the Ladrones Islands, Panama, was reported by Garth (1958). The present report extends the range northward into the Santa Maria Basin.

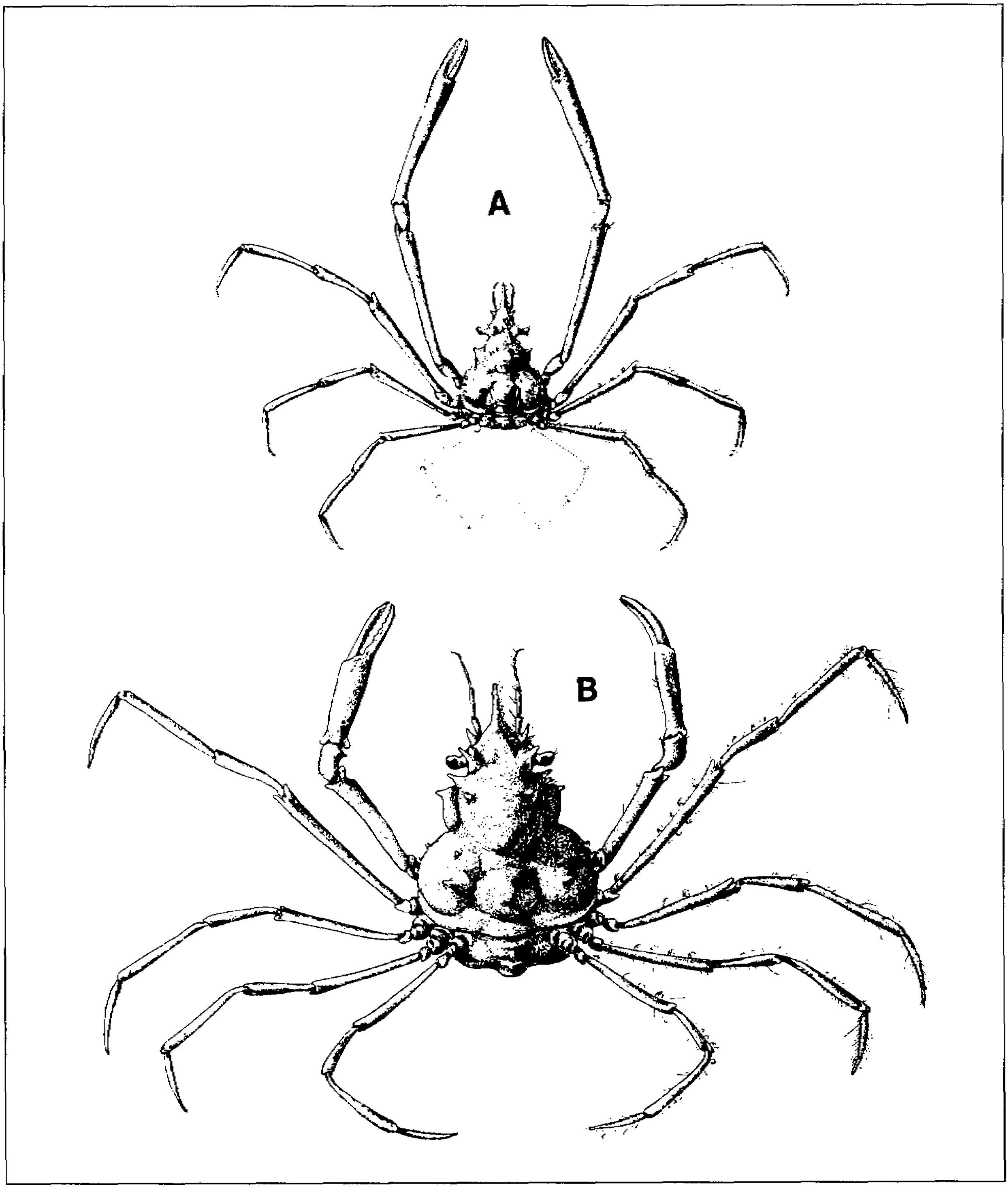

Figure 2.25. *Erileptus spinosus* Rathbun, 1893: A, male; B, female (A and B after Rathbun, 1904, as *Erileptus spinosus* and *Anasimus rostratus* respectively).

Family Pinnotheridae De Haan, 1833

Pinnixa occidentalis Rathbun, 1893

Figure 2.26

Pinnixa occidentalis Rathbun, 1893:248, Fig. 12 (in part; not the specimen from San Diego); 1904:187, Plate 7, Fig. 4; Plate 9, Figs. 6, 6a (in part; not specimens from Cape Fox); 1918:155, text Fig. 96, Plate 34, Fig. 1.—Holmes, 1900:89.—Weymouth, 1910: 56 text Fig. 3.—Schmitt, 1921:262, Fig. 156.—Roesijadi, 1978:259 (larval physiology).—Hart, 1982:242, Fig. 101 (ecology).—Kozloff, 1987:417. —Zmarzly, 1992:677, Fig. 1 (map), Fig. 12.

Pinnixa californiensis Rathbun, 1893:249.—Holmes, 1900:90.—Rathbun, 1904:187, Plate 7, Fig. 3.—Weymouth, 1910:56 (in part; not young female from Pacific Grove).

Material Examined. Two males, (USNM 071-BSS-01-TX, and SBMNH 018-BSS-01-TX) (one from 91 m, no depth info on other specimen) [identification confirmed by D. Zmarzly]; USNM Phase I primary voucher collection, 071-BSS-01-TX, 29 November 1983, one mature female, carapace length = 3.8 mm, carapace width = 7.7 mm; one juvenile, carapace length = 1.9 mm, carapace width = 3.4; SBMNH Phase I secondary voucher collection, 018-BSS-01-TX, one male, (carapace length = 2.7 mm, carapace width = 5.2 mm), two females, three juveniles.

Description. Large species to 19.5 mm carapace width, males, 20.5 mm carapace width, females (Rathbun 1918). Carapace 2.0-2.2 times wider than long in adults, 1.6-1.9 times wider in juveniles. Dorsal surface pitted and highly irregular. Longitudinal median groove extending from frontal margin to mesogastric region. Hepatic region delineated by grooves; cervical groove well developed, connection with deep gastric depression. Sharp transverse ridge in cardiac region; cardiac ridge formed of two crescent-shaped ridges, appearing bilobed in male, not as acute or as bilobed in female. Anterolateral margin with granulate ridge. Granules sometimes also present dorsolaterally on carapace, behind ridge. Ventral margin of anterolateral region granulate, with long plumose setae.

Chelae robust, sexually dimorphic, distinctive among California species due to deflection and form of fixed finger. In males, fixed finger short, about one-quarter length of palm, stout, and strongly deflexed; inner margin with large flat tooth proximally and small triangular tooth, occasionally worn flat, distally. Dactylus becoming increasingly curved with age, strongly hooked in mature males; fingers gaping when closed. Dorsal margin of dactylus smooth, sparsely setose; inner margin of dactylus typically toothless; some specimens with small triangular tooth at midpoint. Dactylar tooth usually present in small males and those regenerating chelae; persisting in some mature males. Presence of dactylar tooth in mature males apparently unrelated to size of animal or geographic occurrence. Dorsal margin of palm granulate; line of granules above ventral margin of palm on anterior face.

Female chela more slender than that of male. Fixed finger longer, about 0.4 length of palm; obviously deflexed, but less so than in male; inner margin paralleling ventral margin proximally; small triangular tooth at midpoint, followed by row of sharp transparent teeth that precede the upwardly curving distal tip. Dactylus of female not as strongly curved as in male; dorsal margin granulate, setose; inner margin with large triangular tooth, occasionally worn flat, at midpoint, row of small transparent teeth between triangular tooth and distal tip, meeting row of similar teeth on opposing margin of fixed finger when fingers closed. Anterior face of propodus with several rows of granules running entire length just above ventral margin.

In adults, ambulatory legs fringed with plumose setae. Pereiopod 2 with ventral margin of merus granulate to tuberculate; distal half of ventral margin of propodus with sharp spines; dactylus as long as propodus, with longitudinal row of 4 or 5 spines. In ventral view, ischium with single tubercle on posterior margin. On pereiopod 3, posteroventral margin of ischium with several small tubercles; dorsal and ventral

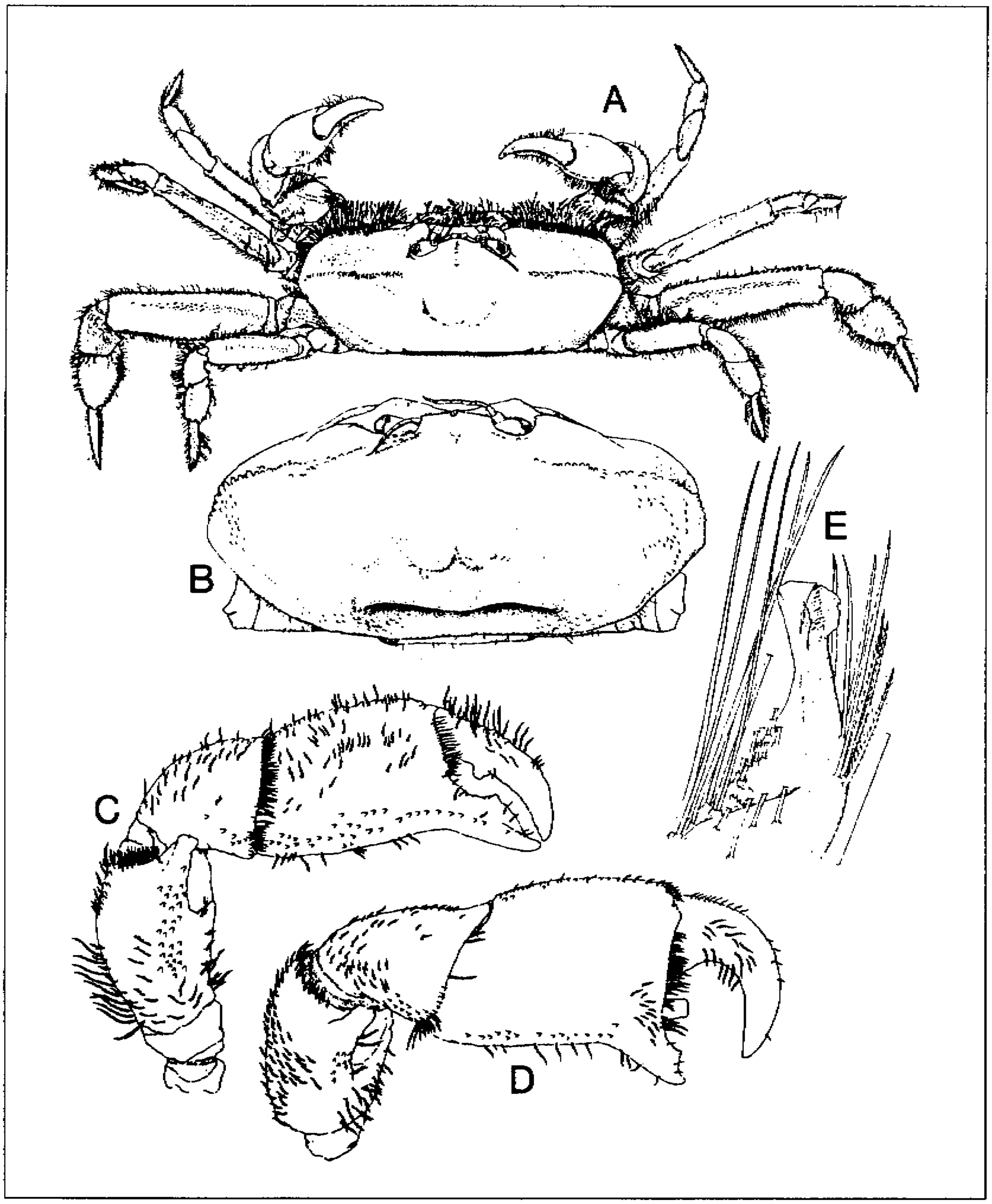

Figure 2.26. *Pinnixa occidentalis* Rathbun, 1893: A, anterodorsal view of male; B, anterodorsal view of carapace (juvenile male); C, anterior face of female cheliped; D, anterior face of male cheliped; E, abdominal face of right gonopod (A-E from Zmarzly, 1992).

margins of merus and dorsal margins of carpus and propodus granulate to tuberculate; ventral margin of propodus with sharp spines on distal half. Dactylus as long as propodus, with longitudinal carina on each side and 2 longitudinal rows of sharp spines on ventral margin. On pereiopod 4, dorsal and ventral margins of merus heavily granulate to tuberculate; ventral margin of propodus bicarinate, carina serrate. Dactylus about as long as propodus, with 2 longitudinal carinae laterally and 5 longitudinal rows of spines: 1 on dorsal margin, 2 on ventral margin, and 2 laterally. On pereiopod 5, ischium and merus with granulate margins; dactylus as long as propodus. Dorsal and ventral margins of dactylus with rows of spines; setose. Distal tip of dactylus of pereiopod 5 reaching will beyond distal edge of merus of pereiopod 4 when both legs extended.

In specimens (greater than or equal to) 8 mm carapace width, ambulatory legs very slender; dactyls also slender, cylindrical, nearly straight, as long as or longer than propodus on each leg. With maturity, density of granules on all legs increasing; size relationships of ambulatory legs changing dramatically; robustness of pereiopod 4 increasing allometrically

Male and female abdomen consisting of 7 free somites (after Zmarzly, 1992).

Biology. Found subtidally in burrows of the echiurid worm *Echiurus echiurus alaskanus* at northern extreme of *P. occidentalis* range, also found free living (Hart, 1982; Zmarzly, 1992). On soft mud substrates in Puget Sound (Lie, 1968).

Taxonomic Remarks. Although southern California specimens tend to be slightly smaller than Alaska specimens (D. Zmarzly, pers. comm.), there appears to be little morphological difference between specimens from these two areas. Hart (1982) cautioned that this may be a species complex in light of its wide geographic and bathymetric range. This was reitterated by Martin and Zmarzly (1994) when they recognized a new species in this complex (see below, *P. scamit*).

Type Locality and Type Specimens. South of Unimak Island, Alaska, 61 fathoms (112 m). Holotype male, USNM 17474, carapace length = 9.5 mm; carapace width = 19.5 mm.

Distribution. Alaska to Bahia Magdalena, west coast of Baja California, Mexico; intertidal to 238 fathoms (435 m) (Schmitt, 1921; Hart, 1982; Zmarzly, 1992).

Pinnixa scamit Martin and Zmarzly, 1994

Figure 2.27

Material Examined. USNM 267500, and USNM 267501, see holotype and paratype below.

Description. Carapace highly sculptured, with anterolateral ridge bearing pronounced and slightly anteriorly-curved teeth; frontal margin with deep median cleft; cardiac ridge present, granular, not sharp. Fixed finger on major cheliped slightly deflexed; both fingers of major cheliped with single stout tooth located almost at midlength on inner margin. All ambulatory pereiopods with markedly serrate and setose dorsal and especially ventral margins. Propodus of pereiopod 4 at least 2.5 times longer than wide (Martin and Zmarzly, 1994).

Biology. Nothing is known.

Taxonomic Remarks. Most California species of *Pinnixa* White, 1846, have a ridge. which may be granular to tuberculate, along the anterolateral margin of the carapace. Exceptions include *P. faba* (Dana 1851), *P. longipes* (Lockington 1876), *P. tubicola* Holmes, 1894, and *P. weymouthi* Rathbun, 1918, where an anterolateral ridge is either absent or at best very weakly developed. Other exceptions are *P. forficulimanus* Zmarzly, 1992, *P. minuscula* Zmarzly, 1992, and *P. littoralis* Holmes, 1894, where the ridge is absent (Zmarzly 1992). In the remaining California species of *Pinnixa*, this ridge is obvious in dorsal view, and sometimes is as pronounced as in *P. scamit*. Juvenile stages of two species, *P. occidentalis* Rathbun, 1893, and *P. franciscana* Rathbun, 1918, sometimes exhibit acute teeth on the anterolateral ridge; however, this feature changes dramatically between the juvenile and adult stages. In addition, *P. scamit* has relatively slender legs with acute marginal serrations as an adult, which is also characteristic only of juvenile stages in *P. occidentalis* and *P. franciscana* Thus *P. scamit* appears to have retained several "juvenile" characters in the adult stage (from Martin and Zmarzly, 1994).

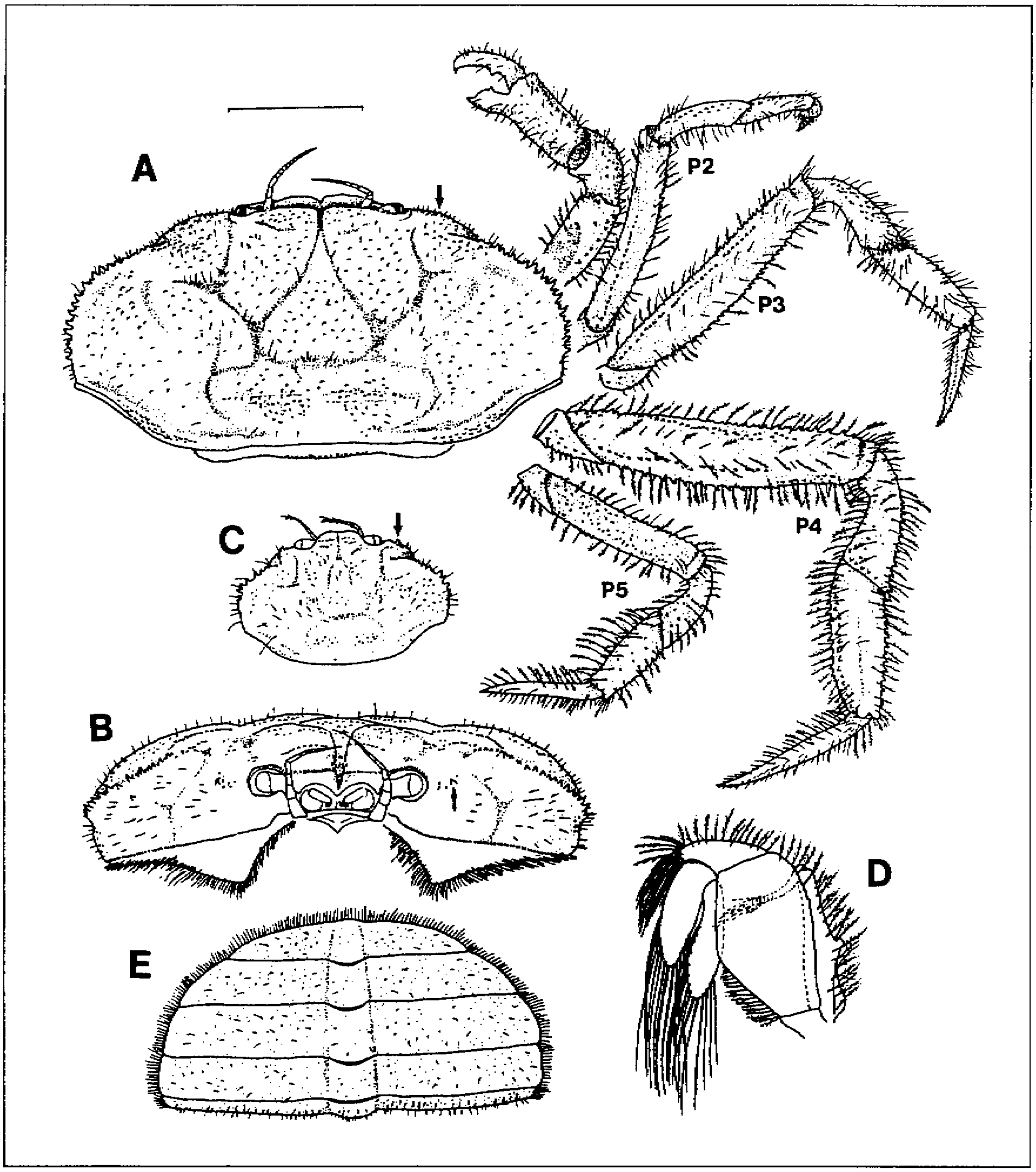

Figure 2.27. *Pinnixa scamit* Martin and Zmarzly, 1994: USNM 267500, and USNM 267501 (C only), western Santa Barbara Channel, California. A, female holotype, dorsal view of carapace and right side appendages, pereiopods 1-3 drawn in situ, pereiopods 4 and 5 removed and figured separately (to ensure correct proportions): B, same specimen, frontal view showing sculpturing of carapace and subhepatic tooth (arrow): C, dorsal view of immature paratype; note that subhepatic tooth (arrow) and acute serrations along anterolateral margin are already present at this size: D, third maxilliped of holotype, left side, outer view; E, abdomen of holotype, ventral view illustrated in situ (first two segments not visible, and segments not visible, and segment 3 shortened due to curvature of abdomen). Scale bar = 2.0 mm for A-C, E; 1.0 mm for D (from Martin and Zmarzly, 1994).

All other California species are easily distinguished from *P. scamit* by the length:width ratio of the propodus of pereiopod 4. In true *P. occidentalis* Rathbun, the species to which *P. scamit* appears to be most closely allied, the propodus of P4 is distinctly broader, nearly as broad as long. In contrast, in *P. scamit* the propodus of pereiopod 4 is approximately 2.6 times longer than wide.

Type Locality and Type Specimens. MMS station data 071-BSS-01-TX, 34°29.040'N, 120°44.013'W, western Santa Barbara Channel, just seaward of, and SSW of, Pt. Arguello, California; 311 m. Holotype female USNM 267500, carapace width 7.4 mm, carapace length 3.7 mm 29 Nov 1983. Paratype juvenile, USNM 267501 (sex indeterminate), carapace width 3.4 mm, carapace length 2.1 mm, same collecting data as holotype (Martin and Zmarzly, 1994).

Distribution. Presently known only from the type locality.

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Appendix

Lists and Maps of Stations

Table A.1. Position of soft-substrate stations taken during the Phase I Reconnaissance.

Station	Latitude	Longitude	Depth (m)
1	35°27.86′N	121°05.33′W	98
2	35°27.70′N	121°06.52′W	200
3	35°27.07′N	121°10.20′W	291
4	35°26.56′N	121°14.93′W	393
5	35°25.77′N	121°21.69′W	585
6	35°20.88′N	120°59.62′W	109
7	35°20.65′N	121°02.57′W	197
8	35°20.00′N	121°06.58′W	308
9	35°19.48′N	121°10.06′W	398
10	35°18.28′N	121°18.65′W	591
11	35°17.80′N	121°22.13′W	690
12	35°15.03′N	120°57.31′W	98
13	35°14.54′N	120°59.77′W	197
14	35°14.15′N	121°02.04′W	299
15	35°13.98′N	121°04.54′W	393
16	35°12.23′N	121°16.29′W	591
17	35°11.61′N	121°22.55′W	654
18	35°09.08′N	120°56.55′W	197
19	35°08.93′N	120°59.66′W	296
20	35°15.72′N	121°04.68′W	396
21	35°06.11′N	120°44.82′W	49
22	35°05.85′N	120°50.23′W	99
23	35°05.60′N	120°55.18′W	195
25	35°05.07′N	121°00.75′W	390
26	35°04.38′N	121°15.99′W	590
27	35°04.30′N	121°19.27′W	611
28	35°04.22′N	121°19.65′W	603
30	34°54.19′N	120°47.07′W	98
31	34°53.76′N	120°52.96′W	200
32	34°53.56′N	120°56.81′W	297
33	34°53.43′N	120°59.66′W	396
34	34°53.15′N	121°04.40′W	492
35	34°52.96′N	121°10.30′W	548
36	34°52.77′N	121°15.37′W	492
38	34°49.81′N	120°52.66′W	197
39	34°49.53′N	120°56.85′W	294
40	34°49.24′N	121°00.81′W	392
41	34°48.35′N	121°19.14′W	495
42	34°48.04′N	120°47.50′W	100
43	34°46.59′N	120°52.92′W	197
45	34°44.91′N	120°59.59′W	395
46	34°41.22′N	121°13.56′W	597
47	34°41.99′N	121°10.81′W	378
48	34°45.11′N	120°52.85′W	196
49	34°45.03′N	120°56.31′W	290
50	34°37.80′N	121°01.66′W	591
52	34°39.56′N	120°47.64′W	98
53	34°37.69′N	120°50.38′W	196
54	34°36.57′N	120°52.02′W	396
55	34°33.66′N	120°56.31′W	590
56	34°30.32′N	121°01.02′W	900

Table A.1 (Continued)

Station	Latitude	Longitude	Depth (m)
58	34°34.35'N	120°45.18'W	99
59	34°33.65'N	120°47.18'W	216
60	34°33.25'N	120°48.34'W	275
61	34°33.01'N	120°48.89'W	345
62	34°30.46'N	120°52.13'W	582
63	34°26.29'N	120°58.08'W	930
64	34°33.15'N	120°40.90'W	59
65	34°31.27'N	120°43.27'W	107
66	34°30.46'N	120°44.55'W	201
67	34°30.29'N	120°45.50'W	282
68	34°29.24'N	120°45.99'W	390
69	34°22.88'N	120°54.20'W	927
70	34°29.67'N	120°43.70'W	200
71	34°29.04'N	120°44.01'W	306
72	34°28.41'N	120°44.76'W	401
73	34°28.21'N	120°36.80'W	98
74	34°26.84'N	120°38.61'W	201
75	34°26.08'N	120°39.65'W	293
76	34°25.59'N	120°40.98'W	387
77	34°22.62'N	120°44.02'W	578
78	34°18.78'N	120°49.30'W	762
79	34°24.12'N	120°28.32'W	98
80	34°22.86'N	120°28.34'W	196
81	34°21.26'N	120°28.83'W	294
82	34°18.71'N	120°29.55'W	394
83	34°17.20'N	120°30.20'W	444
84	34°13.54'N	120°31.19'W	394
85	34°25.88'N	120°16.31'W	113
86	34°24.45'N	120°17.02'W	197
87	34°21.60'N	120°17.11'W	299
88	34°17.89'N	120°16.86'W	393
89	34°13.79'N	120°16.56'W	471
90	34°09.44'N	120°16.30'W	375
91	34°11.73'N	120°07.43'W	540
92	34°08.70'N	120°07.50'W	444
93	34°07.63'N	120°07.51'W	357
96	34°22.91'N	120°05.42'W	296
94	34°24.54'N	120°05.47'W	96
95	34°23.70'N	120°05.47'W	198
97	34°22.28'N	120°05.49'W	393
98	34°12.87'N	120°05.59'W	561
99	34°11.22'N	120°05.86'W	540
100	34°08.67'N	120°05.50'W	443
101	34°07.51'N	120°05.65'W	357
102	34°59.71'N	120°48.22'W	99
103	34°59.63'N	120°53.56'W	197
104	34°59.45'N	120°56.49'W	294
105	34°59.23'N	120°59.60'W	392
106	34°58.95'N	121°04.42'W	492
107	34°58.65'N	121°15.08'W	573
108	34°58.21'N	121°17.88'W	492

Note: Sample labels from the Soft-substrate stations have several identification codes which include a station number, sample type, replicate number, and analysis type. These are as follows: 001 to 200 = the range of station numbers; BSS = Benthic Sediment Single (i.e., a non-replicated station); BSR = Benthic Sediment Replicate (three replicates taken at this station); BSV = Benthic Sediment Variance (subsamples); 01-09 = replicate numbers; TX = a taxonomy sample. Sample labels having the designation BRA, represents a sample from rocks taken as part of the hard bottom survey.

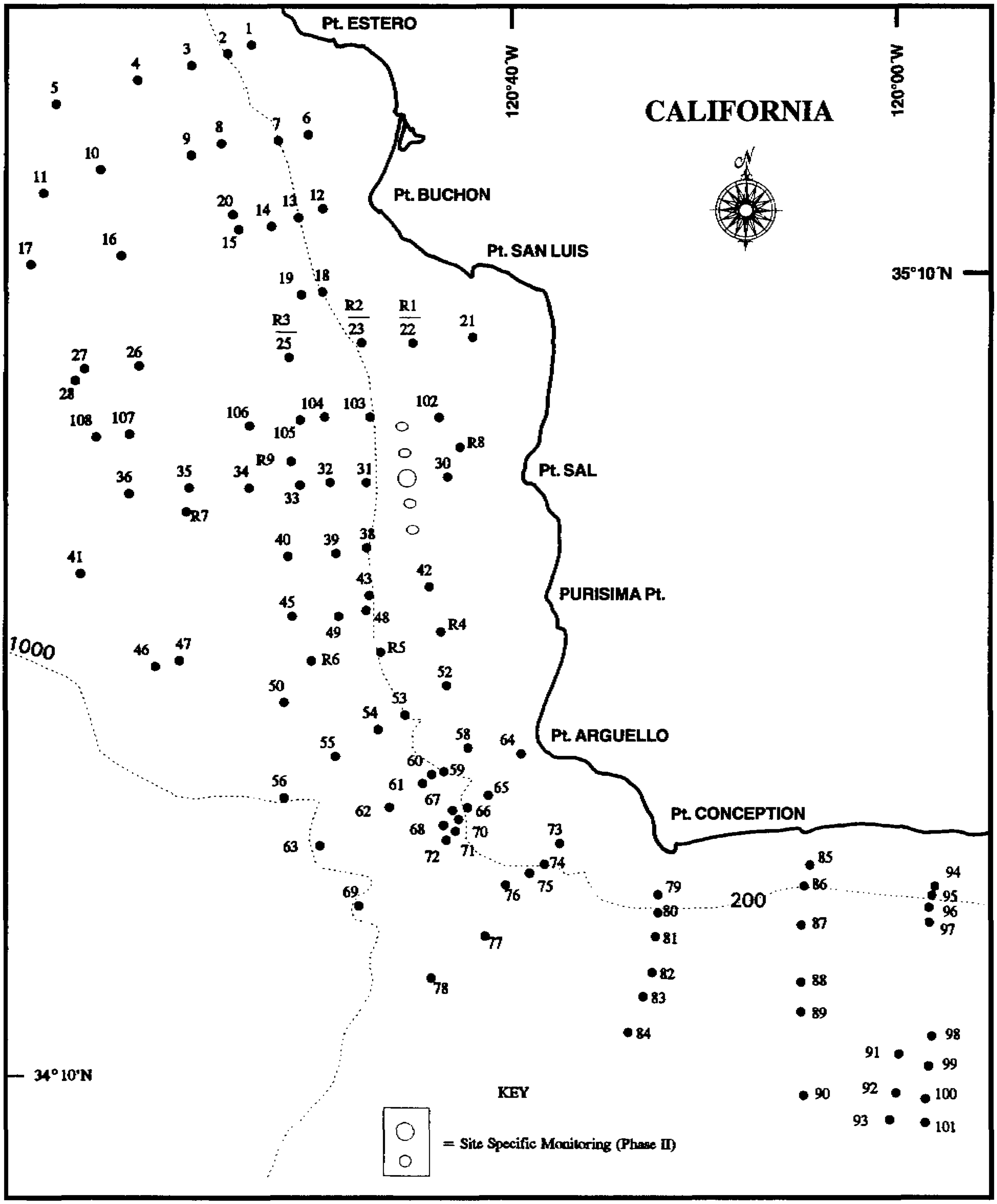

Figure A.1. Map showing location of soft-substrate stations from the Phase I Reconnaissance and Phase II Monitoring Programs.

Table A.2. Location of soft-substrate stations taken during the Phase II Monitoring Program.

Station	Latitude	Longitude	Depth (m)
R-1	35°05.83'N	120°49.16'W	91
R-2	35°05.50'N	120°53.40'W	161
R-3	35°05.30'N	121°00.90'W	409
R-4	34°43.01'N	120°47.39'W	92
R-5	34°42.69'N	120°50.83'W	154
R-6	34°41.40'N	120°57.90'W	410
R-7	34°52.90'N	121°10.30'W	565
R-8	34°55.30'N	120°45.87'W	90
R-9	34°53.68'N	120°59.12'W	410
PJ-1	34°55.79'N	120°49.91'W	145
PJ-2	34°55.32'N	120°49.59'W	142
PJ-3	34°56.26'N	120°49.58'W	138
PJ-4	34°56.26'N	120°50.24'W	150
PJ-5	34°55.32'N	120°50.24'W	152
PJ-6	34°54.71'N	120°49.91'W	148
PJ-7	34°55.79'N	120°48.60'W	123
PJ-8	34°56.87'N	120°49.91'W	142
PJ-9	34°55.79'N	120°51.23'W	169
PJ-10	34°53.63'N	120°49.91'W	147
PJ-11	34°57.95'N	120°49.91'W	136
PJ-12	34°55.58'N	120°49.91'W	145
PJ-13	34°56.01'N	120°49.91'W	144
PJ-14	34°55.79'N	120°49.26'W	134
PJ-15	34°55.79'N	120°50.57'W	155
PJ-16	34°55.03'N	120°48.99'W	130
PJ-17	34°56.56'N	120°48.98'W	126
PJ-18	34°56.56'N	120°50.84'W	158
PJ-19	34°55.03'N	120°50.84'W	167
PJ-20	34°50.38'N	120°49.91'W	148
PJ-21	35°01.23'N	120°51.15'W	143
PJ-22	34°55.25'N	120°49.93'W	143
PJ-23	34°56.33'N	120°49.90'W	143

Table A.3. Sampling dates of MMS Phase II Monitoring Program.

Cruise	Date
1-1	October 1986
1-2	January 1987
1-3	May 1987
2-1	July 1987
2-3	October 1987
2-4	January 1988
2-5	May 1988
3-1	October 1988
3-4	May 1989

Table A.4. MMS Phase I - Locations of hard-substrate transects.

Station	Beginning Latitude	Longitude	End Latitude	Longitude	Depth (m)
1 A/B	34°24.454′N	120°01.876′W	34°24.464′N	120°00.878′W	69-73.5
1 C/D	34°24.076′N	120°00.443′W	34°24.184′N	120°01.480′W	73.5-78
2 A/B	34°11.377′N	120°29.318′W	34°11.289′N	120°28.774′W	110-126
2 C/D	34°10.984′N	120°28.094′W	34°10.780′N	120°27.554′W	120-123
4 A/B	34°27.539′N	120°40.364′W	34°28.162′N	120°40.189′W	168-237
6 A/B	34°30.246′N	120°35.555′W	— —.—	— —.—	54-63
6 C/D	— —.—	— —.—	34°30.421′N	120°34.315′W	54-63
13 A/B	34°42.570′N	120°47.899′W	34°42.107′N	120°48.253′W	92-100
13 C/D	34°42.556′N	120°48.147′W	34°42.974′N	120°47.424′W	88.5-100.5
14 A/B	34°43.589′N	120°49.093′W	34°42.826′N	120°48.370′W	96-105
14 C/D	34°43.244′N	120°49.406′W	34°42.893′N	120°48.822′W	105-117
16 A/B	34°46.544′N	120°50.197′W	34°45.912′N	120°49.726′W	91.5-123
17 A/B	34°49.382′N	120°50.768′W	34°49.600′N	120°50.688′W	160.5-168
19 A/B	34°47.833′N	120°51.425′W	34°47.097′N	120°50.793′W	148.5-177
20 A/B	34°46.470′N	120°50.289′W	34°46.140′N	120°49.885′W	90-130.5
21 A/B	34°47.335′N	120°45.903′W	34°47.548′N	120°46.123′W	75-90
22 A/B	34°50.365′N	120°48.221′W	34°50.990′N	120°48.365′W	114-115.5
23 A/B	34°49.868′N	120°47.393′W	34°50.003′N	120°47.480′W	93-102
25 A/B	35°05.662′N	120°47.562′W	35°06.036′N	120°47.652′W	64.5-72
26 C/D	35°11.586′N	120°55.556′W	35°11.555′N	120°55.233′W	108-111
27 A/B	35°20.906′N	120°59.657′W	35°21.035′N	120°59.603′W	96-126
28 A/B	35°21.539′N	120°59.641′W	35°21.867′N	120°59.299′W	96-105
29 A/B	35°27.864′N	121°05.331′W	35°27.805′N	121°05.277′W	102-106.5

Table A.5. MMS Phase II - Locations of hard-substrate photosurvey stations.

Station	Latitude	Longitude	Depth (m)
PH-E	34°30.26′N	120°42.76′W	119
PH-F	34°30.81′N	120°42.36′W	105
PH-I	34°29.96′N	120°41.68′W	107
PH-J	34°29.82′N	120°41.82′W	117
PH-K	34°29.37′N	120°42.26′W	160
PH-N	34°29.21′N	120°42.05′W	166
PH-R	34°29.11′N	120°42.67′W	213
PH-U	34°31.48′N	120°43.51′W	113
PH-W	34°31.52′N	120°45.86′W	195

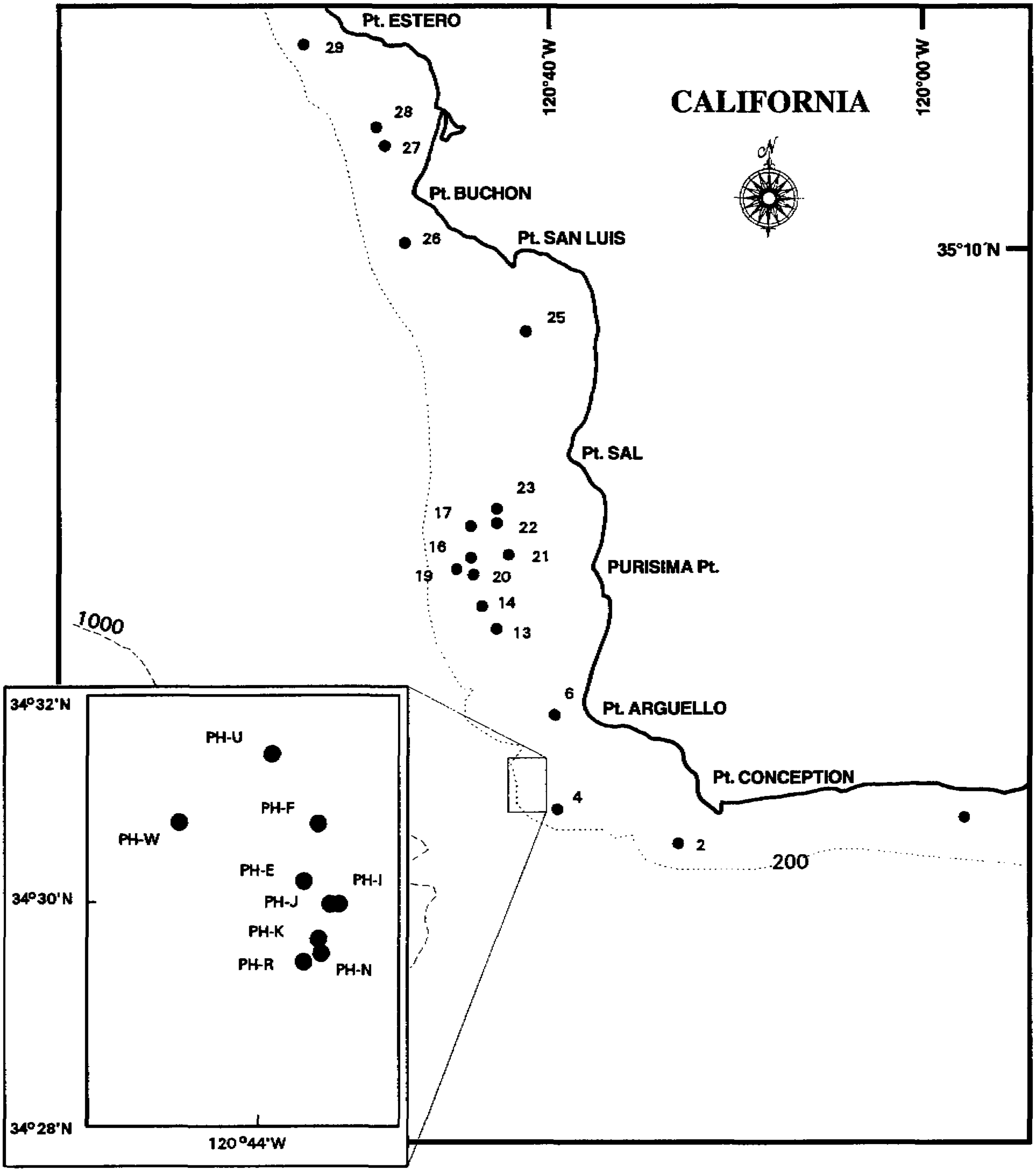

Figure A.2. Map showing location of hard-substrate stations from the Phase I Reconnaissance and Phase II Monitoring Programs. Phase II stations are indicated in the inset.

MARCH 3, 1849

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

OCS Study
MMS 96-0031

TAXONOMIC ATLAS OF THE BENTHIC FAUNA OF THE SANTA MARIA BASIN AND WESTERN SANTA BARBARA CHANNEL

FINAL REPORT
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The Arthropoda — The Pycnogonida
The Crustacea Part 1 — The Decapoda

U.S. Department of the Interior
MMS Minerals Management Service
Pacific OCS Region