

MAUREEN E. DOWNEY

*Starfishes  
from the Caribbean  
and the Gulf of  
Mexico*

## SERIAL PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

The emphasis upon publications as a means of diffusing knowledge was expressed by the first Secretary of the Smithsonian Institution. In his formal plan for the Institution, Joseph Henry articulated a program that included the following statement: "It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge." This keynote of basic research has been adhered to over the years in the issuance of thousands of titles in serial publications under the Smithsonian imprint, commencing with *Smithsonian Contributions to Knowledge* in 1848 and continuing with the following active series:

*Smithsonian Annals of Flight*  
*Smithsonian Contributions to Anthropology*  
*Smithsonian Contributions to Astrophysics*  
*Smithsonian Contributions to Botany*  
*Smithsonian Contributions to the Earth Sciences*  
*Smithsonian Contributions to Paleobiology*  
*Smithsonian Contributions to Zoology*  
*Smithsonian Studies in History and Technology*

In these series, the Institution publishes original articles and monographs dealing with the research and collections of its several museums and offices and of professional colleagues at other institutions of learning. These papers report newly acquired facts, synoptic interpretations of data, or original theory in specialized fields. These publications are distributed by mailing lists to libraries, laboratories, and other interested institutions and specialists throughout the world. Individual copies may be obtained from the Smithsonian Institution Press as long as stocks are available.

S. DILLON RIPLEY  
*Secretary*  
Smithsonian Institution

SMITHSONIAN CONTRIBUTIONS TO  
ZOOLOGY

NUMBER 126

*Maureen E. Downey* Starfishes  
from the Caribbean  
and the Gulf of  
Mexico

SMITHSONIAN INSTITUTION PRESS  
CITY OF WASHINGTON  
1973

## ABSTRACT

Downey, Maureen E. Starfishes from the Caribbean and the Gulf of Mexico. *Smithsonian Contribution to Zoology*, number 126, 158 pages, 2 figures, 48 plates, 1973.—Asteroidea collected in the Gulf of Mexico and around the Caribbean by vessels of the Bureau of Commercial Fisheries at Pascagoula, Mississippi, and the Texas A&M University research vessel *Alaminos* numbered 95 species, 8 of which, described elsewhere, were new. Fifty-six genera, of which three were new, are represented in the collections. Keys to the orders, families, genera, and species are provided. A brief historical resume and a general discussion of zoogeography are included, as well as short descriptions of each genus and species.

---

*Official publication date is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, Smithsonian Year.*

---

### Library of Congress Cataloging in Publication Data

Downey, Maureen E.

Starfishes from the Caribbean and the Gulf of Mexico.

(Smithsonian contributions to zoology, no. 126)

Bibliography: p.

1. Starfishes—Caribbean Sea. 2. Starfishes—Mexico, Gulf of. I. Title. II. Series: Smithsonian Institution. Smithsonian contributions to zoology, no. 126.

QL1.S54 no. 126 [QL384.A8] 591'.08s [593'.93'0916364] 72-10019

---

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402  
Price \$2.85 domestic postpaid, or \$2.50 GPO Bookstore

## Contents

	<i>Page</i>
Introduction .....	1
Acknowledgments .....	2
Historical Review .....	2
Zoogeography .....	5
Station Data .....	9
Glossary .....	17
Key to the Orders of Asteroidea .....	21
Order Platyasterida .....	21
Family Luidiidae .....	21
Genus <i>Luidia</i> .....	21
Key to the Species of <i>Luidia</i> .....	22
<i>L. senegalensis</i> .....	22
<i>L. clathrata</i> .....	22
<i>L. alternata</i> .....	23
<i>L. sagamina</i> .....	24
<i>L. barbadensis</i> .....	24
<i>L. elegans</i> .....	25
Other Tropical-Subtropical Species of <i>Luidia</i> Not Represented in This Collection .....	25
Order Paxillosida .....	25
Key to the Families of Paxillosida .....	26
Family Astropectinidae .....	26
Key to the Genera of Astropectinidae .....	26
Genus <i>Astropecten</i> .....	26
Key to the Species of <i>Astropecten</i> .....	27
<i>A. americanus</i> .....	27
<i>A. articulatus</i> .....	28
<i>A. cingulatus</i> .....	28
<i>A. comptus</i> .....	29
<i>A. duplicatus</i> .....	29
<i>A. marginatus</i> .....	29
<i>A. nitidus</i> .....	30
Other Species of <i>Astropecten</i> Not Taken in These Collections .....	31
Genus <i>Psilaster</i> .....	31
Key to the Species of <i>Psilaster</i> .....	31
<i>P. cassiope</i> .....	31
<i>P. patagiatus</i> .....	32
Other Atlantic Species of <i>Psilaster</i> .....	32
Genus <i>Persephonaster</i> .....	32
<i>P. echinulatus</i> .....	33
Other Atlantic Species of <i>Persephonaster</i> .....	33
Genus <i>Plutonaster</i> .....	34
<i>P. intermedius</i> .....	34
Genus <i>Dytaster</i> .....	35
<i>D. insignis</i> .....	35
Genus <i>Blakiaster</i> .....	36
<i>B. conicus</i> .....	36
Genus <i>Tethyaster</i> .....	36
<i>T. grandis</i> .....	37
Other Species of <i>Tethyaster</i> .....	37

	<i>Page</i>
Genus <i>Dipsacaster</i> .....	37
<i>D. antillensis</i> .....	38
Family Gonioplectinidae .....	38
Key to the Genera of Gonioplectinidae .....	38
Genus <i>Goniopecten</i> .....	38
<i>G. demonstrans</i> .....	38
Genus <i>Prionaster</i> .....	39
<i>P. elegans</i> .....	39
Family Benthoplectinidae .....	39
Key to the Genera of Benthoplectinidae .....	40
Genus <i>Benthopecten</i> .....	40
<i>B. simplex</i> .....	40
Genus <i>Cheiraster</i> .....	41
Key to the Species of <i>Cheiraster</i> .....	41
<i>C. mirabilis</i> .....	41
<i>C. echinulatus</i> .....	42
<i>C. enoplus</i> .....	42
Genus <i>Pectinaster</i> .....	43
Key to the Species of <i>Pectinaster</i> .....	43
<i>P. mixtus</i> .....	43
<i>P. gracilis</i> .....	44
Order Valvatida .....	44
Key to the Families of Valvatida .....	44
Family Odontasteridae .....	44
Genus <i>Odontaster</i> .....	45
Key to the Species of <i>Odontaster</i> .....	45
<i>O. hispidus</i> .....	45
<i>O. setosus</i> .....	45
Family Goniasteridae .....	46
Key to the Genera of Goniasteridae .....	47
Genus <i>Goniaster</i> .....	46
<i>G. tessellatus</i> .....	46
Genus <i>Anthenoides</i> .....	48
Key to the Species of <i>Anthenoides</i> .....	48
<i>A. piercei</i> .....	48
Genus <i>Ceramaster</i> .....	49
<i>C. grenadensis</i> .....	49
Genus <i>Peltaster</i> .....	50
Key to the Species of <i>Peltaster</i> .....	50
<i>P. nidarosiensis</i> .....	50
<i>P. placenta</i> .....	51
Genus <i>Plinthaster</i> .....	52
<i>P. dentatus</i> .....	52
Genus <i>Tessellaster</i> .....	53
<i>T. notabilis</i> .....	53
Genus <i>Tosia</i> .....	53
<i>T. parva</i> .....	54
Genus <i>Rosaster</i> .....	54
<i>R. alexandri</i> .....	54
Genus <i>Circeaster</i> .....	55
<i>C. americanus</i> .....	55
Genus <i>Litonotaster</i> .....	55
Key to the Species of <i>Litonotaster</i> .....	56
<i>L. intermedius</i> .....	56
Genus <i>Paragonaster</i> .....	56
Key to the Species of <i>Paragonaster</i> .....	56
<i>P. subtilis</i> .....	57
Genus <i>Nymphaster</i> .....	57

	<b>Page</b>
Key to the Species of <i>Nymphaster</i> .....	57
<i>N. arenatus</i> .....	58
<i>N. subspinosus</i> .....	59
Genus <i>Pseudarchaster</i> .....	59
Key to the Species of <i>Pseudarchaster</i> .....	59
<i>P. gracilis</i> .....	59
Family Oreasteridae .....	60
Genus <i>Oreaster</i> .....	60
<i>O. reticulatus</i> .....	60
Family Ophidiasteridae .....	61
Key to the Genera of Ophidiasteridae .....	62
Genus <i>Chaetaster</i> .....	62
<i>C. nodosus</i> .....	63
Genus <i>Drachmaster</i> .....	63
<i>D. bullisi</i> .....	63
Genus <i>Tamaria</i> .....	64
Key to the Species of <i>Tamaria</i> .....	64
<i>T. floridae</i> .....	64
<i>T. halperni</i> .....	65
<i>T. passiflora</i> .....	65
Genus <i>Linckia</i> .....	66
Key to the Species of <i>Linckia</i> .....	66
<i>L. guildingii</i> .....	66
<i>L. nodosa</i> .....	67
<i>L. bowieri</i> .....	67
Genus <i>Ophidiaster</i> .....	68
Key to the Species of <i>Ophidiaster</i> .....	68
<i>O. guildingii</i> .....	68
Genus <i>Narcissia</i> .....	69
<i>N. trigonaria</i> .....	69
Order Spinulosida .....	70
Key to the Families of Spinulosida .....	70
Family Solasteridae .....	70
Key to the Genera of Solasteridae .....	70
Genus <i>Solaster</i> .....	70
Key to the Species of <i>Solaster</i> .....	70
<i>S. notophrynus</i> .....	71
<i>S. caribbaeus</i> .....	71
Genus <i>Lophaster</i> .....	71
<i>L. verrilli</i> .....	72
Family Pterasteridae .....	72
Key to the Genera of Pterasteridae .....	72
Genus <i>Hymenaster</i> .....	72
Key to the Species of <i>Hymenaster</i> .....	73
<i>H. rex</i> .....	73
<i>H. modestus</i> .....	74
<i>H. anomalus</i> .....	75
Genus <i>Pteraster</i> .....	75
Key to the Species of <i>Pteraster</i> .....	76
<i>P. personatus</i> .....	76
<i>P. caribbaeus</i> .....	77
<i>P. rugosus</i> .....	77
<i>P. militaroides</i> .....	78
<i>P. acicula</i> .....	79
<i>P. species</i> .....	79
Genus <i>Calyptraster</i> .....	79
<i>C. personatus</i> .....	80
Family Ganeriidae .....	80
Genus <i>Leilaster</i> .....	80
<i>L. radians</i> .....	80

	<i>Page</i>
Family Poraniidae .....	81
Genus <i>Poraniella</i> .....	81
<i>P. regularis</i> .....	81
Genus <i>Marginaster</i> .....	82
<i>M. pectinatus</i> .....	82
Family Echinasteridae .....	82
Key to the Genera of Echinasteridae .....	83
Genus <i>Henricia</i> .....	83
Key to the Species of <i>Henricia</i> .....	83
<i>H. sexradiata</i> .....	83
<i>H. antillarum</i> .....	84
<i>H. species</i> .....	85
Genus <i>Echinaster</i> .....	85
Key to the Species of <i>Echinaster</i> .....	86
<i>E. serpentarius</i> .....	86
<i>E. echinophorus</i> .....	86
<i>E. sentus</i> .....	87
<i>E. modestus</i> .....	87
<i>E. species A</i> .....	88
<i>E. brasiliensis</i> .....	88
<i>E. species C</i> .....	89
<i>E. species B</i> .....	89
Genus <i>Verrillaster</i> .....	89
<i>V. spinulosus</i> .....	89
Order Forcipulatida .....	90
Family Asteriidae .....	90
Key to the Genera of Asteriidae .....	91
Genus <i>Ampheraster</i> .....	90
<i>A. alaminos</i> .....	91
Genus <i>Sclerasterias</i> .....	91
<i>S. contorta</i> .....	92
Genus <i>Asterias</i> .....	92
<i>A. forbesi</i> .....	93
Genus <i>Coscinasterias</i> .....	93
<i>C. tenuispina</i> .....	93
Genus <i>Coronaster</i> .....	94
<i>C. briareus</i> .....	94
Order Zorocallida .....	95
Family Zoroasteridae .....	95
Key to the Genera of Zoroasteridae .....	95
Genus <i>Doraster</i> .....	95
<i>D. constellatus</i> .....	95
Genus <i>Mammaster</i> .....	97
<i>M. sigsbeeii</i> .....	97
Genus <i>Zoroaster</i> .....	97
<i>Z. fulgens</i> .....	97
Order Euclasterida .....	98
Family Brisingidae .....	98
Key to the Genera of Brisingidae .....	98
Genus <i>Odinia</i> .....	99
<i>O. antillensis</i> .....	99
Genus <i>Midgardia</i> .....	99
<i>M. xandaros</i> .....	99
Literature Cited .....	100
Plates .....	111



Maureen E. Downey

# Starfishes from the Caribbean and the Gulf of Mexico

## Introduction

Two collections of Asteroidea, probably the most comprehensive ever made in the Caribbean and the Gulf of Mexico, have yielded 95 species, of 56 genera. Eight new species and three new genera have been described from these collections. On the basis of these collections, which cover a wider area, greater depth range, and longer collecting period than any previous starfish collections from this region, certain revisions in the classification and corrections to the taxonomy have been made possible. Keys to the taxa are given and brief descriptions of each species, as well as indications of the distribution, both vertical and horizontal. Keys are to be construed as applying only to the starfishes of this area. Despite the scope of these collections, about fifty nominal species previously reported in the literature from the area were not included in the present collections.

The source of the collections was the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) at Pascagoula, Mississippi, where a survey of the fauna of the Gulf and Caribbean has been underway for about 20 years, first under the direction of Dr. Stewart Springer, and later under the direction of Harvey R. Bullis. The Department of Oceanography of Texas A&M University has, for the past six years, been surveying the deepwater fauna of the Gulf of Mexico, under the direction of Dr. Willis Pequegnat. Over a thousand specimens of Asteroidea collected by these two

operations have been examined, as well as comparative material in the National Museum of Natural History, the Museum of Comparative Zoology at Harvard, and material borrowed from other institutions and individuals.

The classification used is essentially that of Spencer and Wright (1966), with certain modifications. The abundant material available has allowed the solution of several taxonomic problems, the most important being the separation of the family Zoroasteridae from the order Forcipulatida and the establishment of a new order, Zorocallida (Downey, 1970), to contain it, and the abolition of the family Chaetasteridae (only one genus)—the genus *Chaetaster* has been returned to the family Ophidiasteridae. Of the three new genera discovered in these collections, *Verrillaster* (in the Echinasteridae) accommodates *Echinaster spinulosus* Verrill; the remaining species of the genus *Echinaster* form a coherent group, from which *spinulosus* differs generically. *Drachmaster* (in the Ophidiasteridae) has been added (Downey, 1970) for a new species which clarified the systematic position of the genus *Chaetaster*; and *Midgardia* (in the Brisingidae) to contain a new species which could not be included in any of the existing genera. The figures in parentheses in the list that follows represent the total number of genera in the family (before the diagonal) and the number of genera in each family represented in these collections (after the diagonal):

Class Asteroidea (288/56)  
Order Platyasterida (2/1)  
Platasteriidae (1/0)  
Luidiidae (1/1)

Maureen E. Downey, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

- Order Paxillosida (41/14)
  - Astropectinidae (20/8)
  - Goniopectinidae (4/2)
  - Porcellanasteridae (9/0)
  - Benthopectinidae (8/4)
- Order Valvatida (93/23)
  - Sphaerasteridae (1/0)
  - Odontasteridae (5/1)
  - Archasteridae (1/0)
  - Goniasteridae (44/13)
  - Oreasteridae (20/1)
  - Ophidiasteridae (21/8)
  - Radiasteridae (2/0)
- Order Spinulosida (72/11)
  - Helianthasteridae (3/0)
  - Solasteridae (7/2)
  - Korethrasteridae (4/0)
  - Pythonasteridae (3/0)
  - Pterasteridae (9/3)
  - Asterinidae (17/0)
  - Ganeriidae (8/1)
  - Poraniidae (13/2)
  - Echinasteridae (8/3)
  - Valvasteridae (1/0)
  - Acanthasteridae (1/0)
  - Mithrodiidae (1/0)
  - Metrodiridae (1/0)
- Order Forcipulatida (82/5)
  - Heliasteridae (1/0)
  - Asteriidae (57/5)
- Order Zorocallidae (7/3)
  - Zoroasteridae (7/3)
- Order Euclasterida (17/2)
  - Brisingidae (17/2)

Nearly 20 percent of the known genera of starfishes are represented in the restricted area covered by this report. All of the orders are present, as are all but two of the larger families.

ACKNOWLEDGMENTS.—It would be impossible to adequately express my gratitude to all of the people who have given me so much help and encouragement during the course of this study. First, I would like to thank Mr. Harvey R. Bullis and Dr. Willis Pequegnat for supplying the material for this study; Dr. Pequegnat and Dr. Thomas Bright, of Texas A&M University, and Dr. Ivan Goodbody, of the University of the West Indies, for allowing me to participate in collecting trips in the Gulf of Mexico, the Yucatan Peninsula, and Jamaica; Dr. Jerald A. Halpern, of Hobart and William Smith College, for the use of his unpublished PhD thesis and for his invaluable help and advice on certain taxonomic problems; and last, but far from least, Dr. Raymond B. Manning, Chairman of the Depart-

ment of Invertebrate Zoology of the National Museum of Natural History, for permission to pursue this study; Dr. David L. Pawson, Curator, Division of Echinoderms, without whose sympathetic ear and sound advice none of this could have been done; and Dr. Daniel Cohen, of the NMFS Systematics Laboratory, who kindly read the manuscript and offered valuable suggestions. I am deeply grateful to those individuals and institutions who loaned me specimens for comparison.

HISTORICAL REVIEW.—The first major report on the Asteroidea of the Caribbean and Gulf of Mexico was published by Edmond Perrier, in 1884, on the starfishes collected by the *Blake* between 1877 and 1879. Collections were made from Key West to Havana, along the north coast of Cuba, Tortugas to Yucatan Bank at Cape Catoche and Cape San Antonio, and off the mouth of the Mississippi River during the first expedition (1877–1878). During the second expedition (1878–1879), the *Blake* collected from Key West to Havana, Jamaica, the Bahama Straits, the Windward Passage, St. Thomas, Haiti, Puerto Rico, St. Croix, Saba Bank, Montserrat, St. Kitts, Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, the Grenadines, and Barbados. In all, 289 dredge hauls were made, in depths varying from 14 to 2,412 fathoms. From these collections, Perrier described 54 species, 46 of them new.

W. Percy Sladen (1889), reporting on the Asteroidea collected by the *Challenger* expedition, included in his report 94 tropical-subtropical western Atlantic species and extended the range of many others.

The University of Iowa's Bahamas expedition of 1893 resulted in a report by A. E. Verrill (1915) on the starfishes of the West Indies, Florida, and Brazil. This comprehensive study covered mainly the shallow-water Asteroidea (87 nominal species and subspecies) and also listed 44 deepwater species. Although it continues to be a useful work for the area, it is somewhat outdated by nomenclatural changes, the discovery of new forms, and the limited region covered.

In his *Handbook of the Littoral Echinoderms of Puerto Rico*, H. L. Clark (1933) lists 17 nominal species of Asteroidea from the West Indies, mostly from shallow water. In 1941, he published a report on the echinoderms of the West Indies collected by

the Havana-Harvard *Atlantis* expeditions which included 16 new species. Clark pointed out that 21 of the species were represented in the collections by a single specimen.

Other reports on Caribbean and Gulf of Mexico starfishes exist, of course, but they are generally limited in area, or include species from a much wider area, or are concerned only with certain families. Reference to these reports will be found in the literature cited.

Following is a list of the species in this and the five above-mentioned collections (1, this report; 2, Perrier, 1884; 3, Sladen, 1889; 4, Verrill, 1915; 5, Clark, 1933; 6, Clark, 1941; italicized names are junior synonyms, indented under valid name):

Species	1	2	3	4	5	6	Page
<i>Luidia alternata</i> .....	x	x	x	x	x		23
<i>L. alternata bicolor</i> .....					x		
<i>L. variegata</i> .....				x			
<i>Luidia barbadensis</i> .....	x	x	x	x		x	24
<i>L. convexiuscula</i> .....			x	x			
<i>Luidia clathrata</i> .....	x	x	x	x	x		22
<i>Luidia elegans</i> .....		x	x	x			25
<i>Luidia sagamina</i> .....	x						24
<i>Luidia senegalensis</i> .....	x		x		x		22
<i>L. maregravii</i> .....					x		
<i>Astropecten alligator</i> .....		x	x	x			
<i>Astropecten americanus</i> .....	x			x			27
<i>Archaster americanus</i> .....			x				
<i>Astropecten antillensis</i> .....			x	x	x		
<i>Astropecten articulatus</i> .....	x	x	x	x	x	x	28
<i>A. articulatus dubius</i> .....					x		
<i>Astropecten brasiliensis</i> .....			x	x			
<i>Astropecten ciliatus</i> .....				x			
<i>Astropecten cingulatus</i> .....	x			x			28
<i>Astropecten comptus</i> .....		x		x			29
<i>Astropecten duplicatus</i> .....	x		x	x	x		29
<i>Astropecten marginatus</i> .....	x						29
<i>Astropecten nitidus</i> .....	x			x			30
<i>A. nitidus forcipatus</i> .....				x			
<i>Astropecten nuttingi</i> .....				x			
<i>Astropecten richardi</i> .....				x			
<i>Psilaster cassiope</i> .....	x						31
<i>P. squameus</i> .....						x	
<i>Psilaster florae</i> .....							
<i>Archaster florae</i> .....			x				
<i>Psilaster</i> sp., cf <i>florae</i> .....				x			
<i>Psilaster patagiatus</i> .....	x						32
<i>Persephonaster spinulosus</i> .....					x		
<i>Persephonaster echinulatus</i> .....	x				x		33
<i>Persephonaster leptactis</i> .....					x		
<i>Persephonaster pulcher</i> .....					x		
<i>Archaster pulcher</i> .....		x					
<i>Plutonaster pulcher</i> .....				x			
<i>Pontaster pulcher</i> .....			x				

Species	1	2	3	4	5	6	Page
<i>Plutonaster bifrons</i> .....						x	
<i>Plutonaster efflorescens</i> .....						x	
<i>Archaster efflorescens</i> .....		x	x				
<i>Plutonaster intermedius</i> .....	x			x		x	34
<i>Goniopecten intermedius</i> .....		x					
<i>Dytaster insignis</i> .....	x			x			35
<i>Archaster insignis</i> .....		x	x				
<i>Dytaster exilis carinatus</i> .....				x			
<i>D. grandis</i> .....				x			
<i>D. madreporifer</i> .....				x			
<i>Dytaster</i> sp., cf <i>robustus</i> .....					x		
<i>Blakiaaster conicus</i> .....	x	x	x	x			36
<i>Tethyaster grandis</i> .....	x						37
<i>Sideriaster grandis</i> .....				x			
<i>Tethyaster vestitus</i> .....							
<i>Astropecten vestitus</i> .....				x			
<i>Sideriaster vestitus</i> .....				x			
<i>Dipsacaster antillensis</i> .....	x						38
<i>Leptychaster</i> sp. ....					x		
<i>Goniopecten demonstrans</i> .....	x	x	x	x		x	38
<i>Prionaster elegans</i> .....	x			x		x	39
<i>Ctenodiscus crispatus</i> .....					x		
<i>Benthopecten simplex</i> .....	x		x				40
<i>Archaster simplex</i> .....			x				
<i>Pararchaster simplex</i> .....				x			
<i>Benthopecten spinosus</i> .....				x		x	
<i>Cheiraster echinulatus</i> .....	x			x			42
<i>Archaster echinulatus</i> .....		x					
<i>Pontaster echinulatus</i> .....				x			
<i>Cheiraster enoplus</i> .....	x			x			42
<i>Luidiaster enoplus</i> .....						x	
<i>Cheiraster mirabilis</i> .....	x			x		x	41
<i>Archaster coronatus</i> .....		x					
<i>Archaster mirabilis</i> .....		x					
<i>Cheiraster coronatus</i> .....						x	
<i>Pontaster coronatus</i> .....				x			
<i>Cheiraster mirabilis coronatus</i> .....					x		
<i>Pontaster mirabilis</i> .....				x			
<i>Cheiraster planus</i> .....					x		
<i>Pectinaster forcipatus</i> .....							
<i>Pontaster forcipatus</i> .....				x			
<i>Pectinaster dispar</i> .....					x		
<i>Pectinaster gracilis</i> .....	x			x			44
<i>Pectinaster mixtus</i> .....	x			x			43
<i>Luidiaster mixtus</i> .....						x	
<i>Pectinaster oligoporus</i> .....					x		
<i>Pectinaster vincenti</i> .....					x		
<i>Luidiaster dubius</i> .....						x	
<i>Odontaster hispidus</i> .....	x		x	x			45
<i>Odontaster setosus</i> .....	x						45
<i>Odontaster</i> sp., cf <i>setosus</i> .....					x		
<i>Odontaster</i> sp. (compact species) .....					x		
<i>Goniaster tessellatus</i> .....	x						47
<i>G. americanus</i> .....					x		
<i>Pentagonaster semilunatus</i> .....				x			
<i>Ceramaster grenadensis</i> .....	x			x		x	49
<i>Pentagonaster affinis</i> .....		x	x	x			
<i>Pentagonaster grenadensis</i> .....		x	x				

Species	1	2	3	4	5	6	Page
<i>Sphaerodiscus bourgeti</i> .....							
<i>Astrogonium bourgeti</i> .....			x				
<i>Cladaster rudis</i> .....				x			
<i>Plinthaster dentatus</i> .....	x			x		x	52
<i>P. comptus</i> .....				x			
<i>P. nitidus</i> .....				x			
<i>Pentagonaster dentatus</i> .....		x	x				
<i>Pyrenaster dentatus</i> .....				x			
<i>Tessellaster notabilis</i> .....	x					x	53
<i>Tosia parva</i> .....	x						54
<i>Pentagonaster parvus</i> .....		x	x				
<i>Anthenoides piercei</i> .....	x	x	x	x		x	48
<i>Hippasteria caribbaeus</i> .....				x			
<i>Pseudarchaster gracilis</i> .....	x						59
<i>P. concinnus</i> .....						x	
<i>Pseudarchaster granuliferus</i> .....				x			
<i>Pseudarchaster hispidus</i> .....				x			
<i>Pseudarchaster ordinatus</i> .....				x			
<i>Pseudarchaster parelii</i> .....						x	
<i>Paragonaster formosus</i> .....							
<i>Archaster formosus</i> .....			x				
<i>Paragonaster grandis</i> .....						x	
<i>Paragonaster subtilis</i> .....	x			x			57
<i>Goniopecten subtilis</i> .....		x					
<i>Mediaster agassizi</i> .....				x			
<i>Mediaster bairdii</i> .....							
<i>Archaster bairdii</i> .....			x				
<i>Mediaster pedicellaris</i> .....				x		x	
<i>Goniodiscus pedicellaris</i> .....		x	x				
<i>Nymphaster arenatus</i> .....	x		x	x		x	58
<i>N. basilicus</i> .....				x			
<i>N. ternalis</i> .....			x	x			
<i>Pentagonaster arenatus</i> .....		x					
<i>Pentagonaster ternalis</i> .....		x					
<i>Nymphaster subspinosus</i> .....	x		x	x		x	59
<i>Pentagonaster subspinosus</i> .....		x					
<i>Asteroceramus brachyactis</i> .....						x	
<i>Circeaster americanus</i> .....	x						55
<i>C. occidentalis</i> .....						x	
<i>Litonotaster intermedius</i> .....	x					x	56
<i>Pentagonaster intermedius</i> .....		x	x	x			
<i>Peltaster nidarosiensis</i> .....	x			x			50
<i>P. hebes</i> .....						x	
<i>Peltaster placenta</i> .....	x						51
<i>Peltaster planus</i> .....						x	
<i>Rosaster alexandri</i> .....	x			x		x	54
<i>Pentagonaster alexandri</i> .....		x	x				
<i>Oreaster reticulatus</i> .....	x			x	x	x	60
<i>Pentaceros reticulatus</i> .....			x				
<i>Ophidiaster alexandri</i> .....				x		x	
<i>Ophidiaster guildingii</i> .....	x		x	x	x		68
<i>Ophidiaster pinguis</i> .....						x	
<i>Fromia</i> sp. ....						x	
<i>Linckia bouvieri</i> .....	x				x	x	67
<i>Linckia guildingii</i> .....	x		x	x	x		66
<i>Linckia nodosa</i> .....	x				x	x	67
<i>Narcissia trigonaria</i> .....	x		x	x			69
<i>Drachmaster bullisi</i> .....	x						63

Species	1	2	3	4	5	6	Page
<i>Tamaria floridae</i> .....	x						64
<i>Ophidiaster floridae</i> .....		x	x	x			
<i>Tamaria halperni</i> .....	x						65
<i>Tamaria passiflora</i> .....	x						65
<i>Chaetaster longipes</i> .....			x	x			
<i>Chaetaster nodosus</i> .....	x		x	x			63
<i>Tremaster laevis</i> .....						x	
<i>Radiaster elegans</i> .....		x	x	x			
<i>Solaster abyssicola</i> .....				x			
<i>Solaster caribbaeus</i> .....	x			x		x	71
<i>Solaster notophrynus</i> .....	x						71
<i>Laetmaster spectabilis</i> .....							
<i>Ctenaster spectabilis</i> .....		x	x	x			
<i>Lophaster furcifer</i> .....						x	
<i>Lophaster verrilli</i> .....	x						72
<i>Lophaster radians</i> .....				x			
<i>Korethraster radians</i> .....				x			
<i>Korethraster hispidus</i> .....							
<i>Remaster palmatus</i> .....					x	x	
<i>Korethraster palmatus</i> .....		x	x				
<i>Pteraster acicula</i> .....	x						79
<i>Pteraster caribbaeus</i> .....	x	x	x	x		x	77
<i>Pteraster militaroides</i> .....	x					x	78
<i>Pteraster personatus</i> .....	x						76
<i>Pteraster rugosus</i> .....	x					x	77
<i>Pteraster stoibe</i> .....						x	
<i>Pteraster</i> sp. ....	x						79
<i>Calyptaster coa</i> .....			x	x			
<i>Calyptaster personatus</i> .....	x						80
<i>Hymenaster anomalus</i> .....	x						75
<i>Hymenaster modestus</i> .....	x		x				74
<i>Hymenaster pellucidus</i> .....						x	
<i>Hymenaster regalis</i> .....						x	
<i>Hymenaster rex</i> .....	x						73
<i>Hymenaster</i> sp. 1 .....					x		
<i>Hymenaster</i> sp. 2 .....					x		
<i>Asterina folium</i> .....				x		x	
<i>Asterinides folium</i> .....					x		
<i>Asterina hartmeyeri</i> .....						x	
<i>Asterina lymani</i> .....		x	x				
<i>Asterinopsis lymani</i> .....					x		
<i>Asterina minuta</i> .....				x			
<i>Asterina pilosa</i> .....			x	x			
<i>Asterinopsis pilosa</i> .....					x		
<i>Stegnaster wesseli</i> .....				x	x	x	
<i>Asterina wesseli</i> .....		x					
<i>Asterinides modesta</i> .....						x	
<i>Enoplopatiria marginata</i> .....						x	
<i>Enoplopatiria siderea</i> .....						x	
<i>Leilaster radians</i> .....	x						80
<i>Marginaster pectinatus</i> .....	x	x	x	x		x	82
<i>Poraniella echinulatus</i> .....						x	
<i>Marginaster echinulatus</i> .....		x	x				
<i>Poraniella regularis</i> .....	x				x		81
<i>Porania austera</i> .....					x		
<i>Porania grandis</i> .....				x			
<i>Henricia antillarum</i> .....	x			x		x	84
<i>Cribrella antillarum</i> .....		x	x				

Species	1	2	3	4	5	6	Page
<i>Henricia microspina</i> .....				x		x	
<i>Henricia sexradiata</i> .....	x			x		x	83
<i>Cribrella sexradiata</i> .....		x	x				
<i>Henricia</i> sp. ....	x						85
<i>Echinaster brasiliensis</i> .....	x		x	x			88
<i>Echinaster echinophorus</i> .....	x			x	x		86
<i>Echinaster modestus</i> .....	x	x	x	x		x	87
<i>Echinaster sentus</i> .....	x		x	x	x	x	87
<i>Echinaster spinosus</i> .....				x			
<i>Echinaster serpentarius</i> .....	x		x				86
<i>Thyraster serpentarius</i> .....				x			
<i>Echinaster</i> sps. A, B, C .....	x						88-89
<i>Verrillaster spinulosus</i> .....	x						89
<i>Echinaster spinulosus</i> .....			x	x	x		
<i>Zoroaster fulgens</i> .....	x		x	x			97
<i>Zoroaster ackleyi</i> .....		x	x	x		x	
<i>Zoroaster diomedea</i> .....				x			
<i>Mammaster sigsbeei</i> .....	x			x		x	97
<i>Zoroaster sigsbeei</i> .....		x	x				
<i>Doraster constellatus</i> .....	x						95
<i>Asterias crassisпина</i> .....						x	
<i>Asterias forbesii</i> .....	x		x				93
<i>Asterias tanneri</i> .....			x				
<i>Coscinasterias tenuispina</i> .....	x			x			93
<i>C. tenuispina atlantica</i> .....				x			
<i>Asterias (S.) tenuispina</i> .....				x			
<i>Stolasterias tenuispina</i> .....						x	
<i>Leptasterias hartii</i> .....				x			
<i>Leptasterias mexicana</i> .....				x			
<i>Sclerasterias contorta</i> .....	x						92
<i>Asterias angulosa</i> .....		x	x				
<i>Asterias contorta</i> .....		x	x				
<i>Asterias linearis</i> .....		x	x				
<i>Orthasterias contorta</i> .....					x		
<i>Coscinasterias linearis</i> .....					x		
<i>Orthasterias subangulosa</i> .....					x		
<i>Stephanasterias gracilis</i> .....					x		
<i>Asterias gracilis</i> .....		x	x				
<i>Stephenasterias hebes</i> .....					x		
<i>Pedicellaster pourtalesi</i> .....		x	x	x		x	
<i>Ampheraster alaminos</i> .....	x						91
<i>Tarsaster fascicularis</i> .....							
<i>Asterias fascicularis</i> .....		x	x				
<i>Leptasterias fascicularis</i> .....					x		
<i>Coronaster briareus</i> .....	x			x		x	94
<i>Asterias briareus</i> .....				x			
<i>Brisinga</i> sp., cf <i>costata</i> .....					x		
<i>Brisinga</i> sp., cf <i>elegans</i> .....					x		
<i>Craterobrisinga cricophora</i> .....							
<i>Brisinga cricophora</i> .....			x	x			
<i>Odinia antillensis</i> .....	x						99
<i>Odinia pandina</i> .....						x	
<i>Freyella elegans</i> .....						x	
<i>Freyella trispinosa</i> .....						x	
<i>Freyella</i> sp., cf <i>sexradiata</i> .....					x		
<i>Midgardia xandaros</i> .....	x						99
<i>Hymenodiscus agassizi</i> .....		x	x	x			
<i>Porcellanaster caeruleus</i> .....						x	

ZOOGEOGRAPHY.—Although at first glance it would appear that over half of the species reported from the Caribbean and the Gulf of Mexico are restricted to the area, such a conclusion would be hasty on the basis of our present knowledge of the Asteroidea and their distribution. Many of the so-called endemic Gulf and Caribbean species are known from few specimens, or even single specimens. The starfish fauna of Cuba comprises more than sixty species and includes at least five valid endemic species. Jamaica, on the other hand, separated from Cuba by the Cayman Trench, has a very depauperate asteroid fauna, with less than a dozen species, all common and widespread in the tropical western Atlantic. The eastern extension of the Cayman Trench separates Cuba and Haiti-Dominican Republic (the Island of Hispaniola), but so little collecting has been done, at least in recent years, around Hispaniola that its asteroid fauna is practically unknown. Other major unexplored (or little-known faunistically) areas in the region are the three basins of the Caribbean: the Yucatan Basin, the eastern Colombian Basin, and the Venezuelan Basin.

The order Platyasterida, with one family and one genus, is well represented in the Gulf and Caribbean, as would be expected from this circumtropical shallow-water order, by nine species.

The order Paxillosida is also well represented; three of the four families occur in the area. By far the largest number of paxillosid species are moderate to deepwater forms. Two families, the Porcellanasteridae and the Benthoplectinidae, are found only in deep water, the Benthoplectinidae below 100 fathoms and the Porcellanasteridae below 500 fathoms. Benthoplectinids, represented by six species, of three genera, are abundant in the deep waters of the Gulf and Caribbean, but no specimens of porcellanasterids have been reported. Madsen (1961) stated that, even when ripe, the gonads of the Porcellanasteridae are quite small and the eggs few. This would indicate either direct development or a demersal larval stage (see also Pearse, 1969), which would certainly limit distribution; it is possible that the porcellanasterids have been unable to cross the shallow rim of the Gulf. This would not limit the Benthoplectinidae if, as has been suggested (Spencer and Wright, 1966, and others), the dorsal muscle bands on the

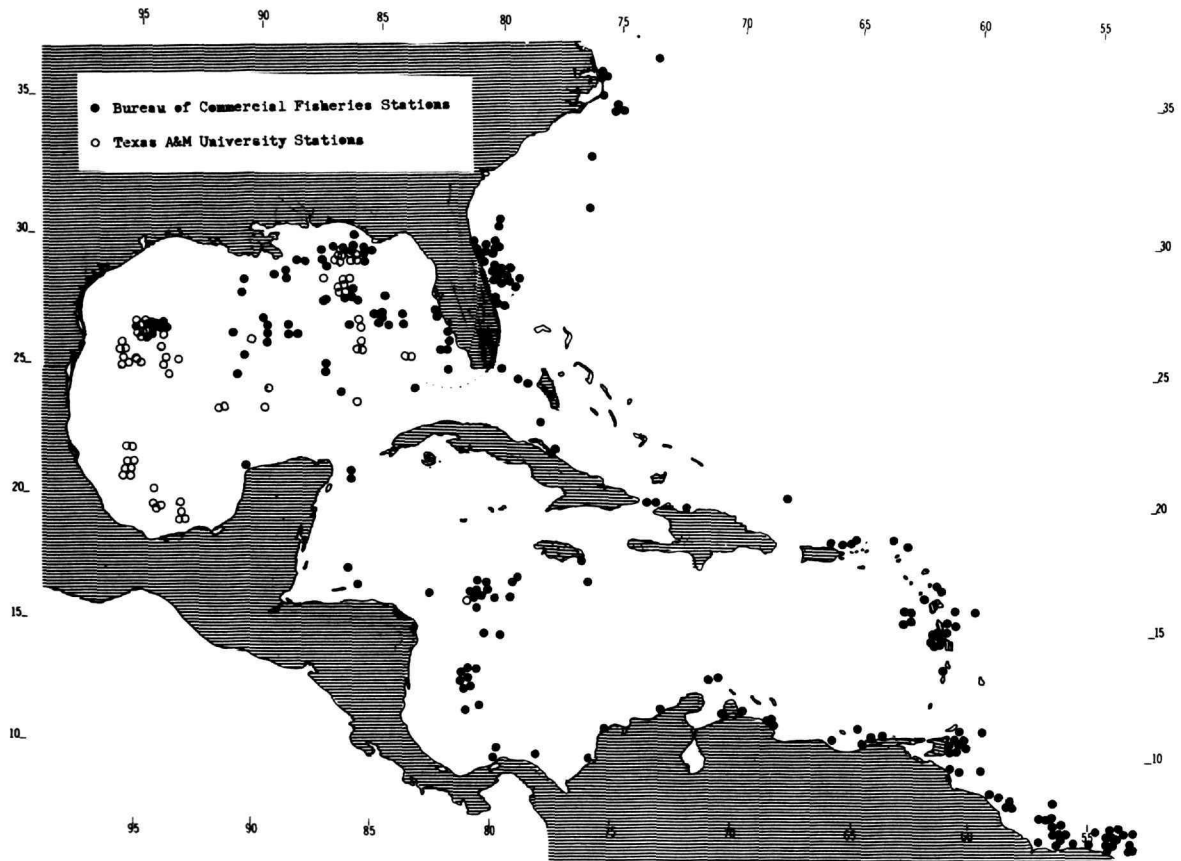


FIGURE 1.—Map showing stations at which Asteroidea were collected.

arms (present only in this family) enable them to swim.

The other two paxilloid families, *Astropectinidae* (eight genera, fifteen species) and *Goniopectinidae* (two genera, two species), are mainly from moderately deep waters, with the exception of the abundant genus *Astropecten*, with seven species in the area, which has much the same distribution as the *Luidiidae*.

Of the seven families of the order *Valvatida*, five are represented in the Gulf and Caribbean. However, by far the greatest number of species belong to two families, *Goniasteridae* (15) and *Ophiasteridae* (10). The goniasterids are widespread in moderately deep waters all over the world, with the exception of the polar and subpolar regions. *Ophiasterids* are mainly tropical-subtropical shallow-water starfish, well represented in both the

Caribbean and the Indo-Pacific. Four of the other five valvatid families are small, with a fairly limited distribution; the remaining family, *Oreasteridae*, is principally Indo-Pacific in distribution, and is represented in the western Atlantic by only one species, *Oreaster reticulatus*. Possibly this species is either a Tethyan relict or a recent arrival in the Caribbean; it does not appear to enter the Gulf of Mexico.

Only six of the thirteen families in the order *Spinulosida* occur in the Gulf and Caribbean. The *Solasteridae*, mostly a boreal family, are represented by two or three genera of rare occurrence. The deepwater *Pterasteridae*, with nine species, are the best represented spinulosid family; nearly half of the known genera occur in the western Atlantic. The *Ganeriidae* occur mostly in the Southern Hemisphere, with only one (doubtful) representative in

the tropical western Atlantic. The Poraniidae, a mainly boreal, deepwater family, are represented by two genera in the Gulf and Caribbean; both include the smallest starfishes known, although their more northern relatives reach a considerable size. The family Echinasteridae is again mostly boreal, in moderate depths, but the genus *Echinaster* is abundantly represented in the Gulf and Caribbean in shallow water by eight species; most of the known species of this genus occur here. The cosmopolitan family Asterinidae is abundantly represented in tropical and subtropical shallow waters, but surprisingly absent from the present collections; however, at least five species have been reported from the Gulf and Caribbean in the past, two of them apparently endemic to Cuba.

The deepwater order Zorocallida (one family) is well represented in the western Atlantic, nearly half (3) of the known genera occurring here; the rest are from the North Pacific and the Indian Ocean. Two of the three species in these collections are apparently confined to the Gulf of Mexico.

The order Forcipulatida is poorly represented in the Gulf and Caribbean. The small family Heliasteridae does not occur here. The very large family Asteroiidae, with nearly sixty known genera, is represented in the area by only six or seven genera; most of the species in these genera have ranges extending to either the northern Atlantic or the eastern Atlantic.

The order Euclasterida, of very wide distribution in deep waters of the world, is well represented in the Gulf and Caribbean by five of the sixteen or seventeen known genera.

At least a dozen of the 95 species in these collections have never been taken in the Gulf of Mexico, while about seven species have been reported only from the Gulf. It would be premature to draw any conclusions about the existence of a Gulf fauna, or a Caribbean fauna, on the basis of our present knowledge of asteroid distribution.

The greatest number of species (62) occurs at depths of 50 to 200 fathoms. However, larger populations of fewer species probably occur in waters below 1,000 fathoms, as this depth yields the greatest number of specimens per dredge haul.

In the present collections, all of the stations below 500 fathoms were occupied in the Gulf of Mexico; the following deepwater species have been collected in the Gulf, and undoubtedly occur also in the deep basins of the Caribbean, which are as yet largely unexplored.

- Plutonaster intermedius* (200–1000 fms)
- Dytaster insignis* (200–2000+ fms)
- Dipsacaster antillensis* (1000–2000+ fms)
- Benthopecten simplex* (1000–2000 fms)
- Litonotaster intermedius* (1000–2000 fms)
- Paragonaster subtilis* (1000–2000 fms)
- Hymenaster rex* (1000–2000 fms)
- Hymenaster modestus* (500–2000 fms)
- Hymenaster anomalus* (1000–2000 fms)
- Pteraster personatus* (500–1000 fms)
- Zoroaster fulgens* (200–2000+ fms)

TABLE 1.—Depth ranges of Gulf and Caribbean Asteroidea (the number of stations at which each species was taken is given, with number of specimens in parentheses)

Species	Depth ranges in fathoms (total number of stations in parentheses)							
	0–25 (41)	25–50 (43)	50–100 (22)	100–200 (37)	200–500 (85)	500–1000 (16)	1000–2000 (17)	2000+ (3)
<i>Luidia senegalensis</i> .....	2 (5)							
<i>Luidia clathrata</i> .....	6 (10)	3 (3)						
<i>Luidia alternata</i> .....	4 (4)							
<i>Luidia sagamina</i> .....		1 (1)						
<i>Luidia barbadensis</i> .....			1 (1)		1 (1)			
<i>Luidia elegans</i> .....				3 (5)				
<i>Astropecten americanus</i> .....			1 (1)	5 (18)	1 (3)			
<i>Astropecten articulatus</i> .....	3 (4)							
<i>Astropecten cingulatus</i> .....		5 (10)						
<i>Astropecten comptus</i> .....	2 (10)	1 (1)						
<i>Astropecten duplicatus</i> .....	6 (35)	1 (12)			1 (2)			
<i>Astropecten marginatus</i> .....	3 (4)	1 (1)						
<i>Astropecten nitidus</i> .....			3 (7)	6 (18)				

TABLE 1.—Continued

Species	Depth ranges in fathoms (total number of stations in parentheses)							
	0-25 (41)	25-50 (43)	50-100 (22)	100-200 (37)	200-500 (85)	500-1000 (16)	1000-2000 (17)	2000+ (3)
<i>Psilaster cassiope</i> .....					5 (7)			
<i>Psilaster patagiatus</i> .....					2 (5)			
<i>Persephonaster echinulatus</i> .....				1 (1)	13 (30)			
<i>Plutonaster intermedius</i> .....					5 (23)	4 (26)		
<i>Dytaster insignis</i> .....					2 (7)	2 (3)	7 (18)	2 (3)
<i>Blakiastrer conicus</i> .....				1 (1)				
<i>Tethyaster grandis</i> .....		2 (4)	1 (1)	3 (6)				
<i>Dipsacaster antillensis</i> .....							1 (1)	1 (1)
<i>Goniopecten demonstrans</i> .....					12 (27)			
<i>Prionaster elegans</i> .....				1 (1)				
<i>Benthopecten simplex</i> .....							4 (15)	
<i>Cheiraster mirabilis</i> .....					7 (11)			
<i>Cheiraster echinulatus</i> .....			1 (9)	1 (1)	2 (2)			
<i>Cheiraster enoplus</i> .....					1 (1)			
<i>Pectinaster mixtus</i> .....			1 (2)	2 (7)				
<i>Pectinaster gracilis</i> .....				1 (2)				
<i>Odontaster hispidus</i> .....			3 (5)					
<i>Odontaster setosus</i> .....				1 (1)	1 (1)			
<i>Goniaster tessellatus</i> .....	5 (10)	10 (72)						
<i>Anthenoides piercei</i> .....		2 (3)	1 (1)	6 (7)	1 (1)			
<i>Ceramaster grenadensis</i> .....						4 (9)		
<i>Peltaster nidarosiensis</i> .....					1 (1)			
<i>Peltaster placenta</i> .....	1 (2)			1 (1)	1 (1)			
<i>Plinthaster dentatus</i> .....				2 (7)	23 (36)	1 (1)	1 (1)	
<i>Tessellaster nobilis</i> .....				1 (1)				
<i>Tosia parva</i> .....		1 (1)				1 (1)		
<i>Rosaster alexandri</i> .....			1 (1)	1 (1)				
<i>Circeaster americanus</i> .....					7 (11)			
<i>Litonotaster intermedius</i> .....							4 (11)	
<i>Paragonaster subtilis</i> .....							2 (6)	
<i>Nymphaster arenatus</i> .....				3 (3)	30 (80)	8 (26)	1 (1)	
<i>Nymphaster subspinosus</i> .....				1 (1)	1 (1)			
<i>Pseudarchaster gracilis</i> .....				1 (1)	11 (23)			
<i>Oreaster reticulatus</i> .....	6 (7)							
<i>Chaetaster nodosus</i> .....		1 (1)	1 (2)					
<i>Drachmaster bullisi</i> .....		2 (2)						
<i>Tamaria floridae</i> .....				1 (1)	1 (3)			
<i>Tamaria halperni</i> .....			2 (2)	5 (8)				
<i>Tamaria passiflora</i> .....				1 (1)				
<i>Linckia guildingi</i> .....		1 (4)						
<i>Linckia nodosa</i> .....		1 (2)						
<i>Linckia bouvieri</i> .....				2 (2)				
<i>Ophidiaster guildingii</i> .....	1 (1)							
<i>Narcissia trigonaria</i> .....		6 (13)	1 (1)					
<i>Solaster notophrynus</i> .....					1 (1)			
<i>Solaster caribbaeus</i> .....		1 (1)						
<i>Lophaster verrilli</i> .....				2 (2)	1 (1)			
<i>Hymenaster rex</i> .....							1 (1)	
<i>Hymenaster modestus</i> .....						1 (3)	1 (2)	
<i>Hymenaster anomalus</i> .....							1 (1)	
<i>Pteraster personatus</i> .....						1 (1)		
<i>Pteraster caribbaeus</i> .....					1 (1)			
<i>Pteraster rugosus</i> .....		1 (1)			1 (1)			
<i>Pteraster militaroides</i> .....					3 (3)			



TABLE 1.—Continued

Species	Depth ranges in fathoms (total number of stations in parentheses)							
	0-25 (41)	25-50 (43)	50-100 (22)	100-200 (37)	200-500 (85)	500-1000 (16)	1000-2000 (17)	2000+ (3)
<i>Pteraster acicula</i> .....						1 (1)		
<i>Pteraster</i> species .....					1 (1)			
<i>Calyptaster personatus</i> .....							1 (1)	
<i>Leilaster radians</i> .....				1 (6)				
<i>Poraniella regularis</i> .....		1 (1)						
<i>Marginaster pectinatus</i> .....				1 (5)				
<i>Henricia sexradiata</i> .....			1 (1)	1 (1)				
<i>Henricia antillarum</i> .....				1 (1)	2 (2)			
<i>Henricia</i> species .....			1 (1)		1 (1)			
<i>Echinaster serpentarius</i> .....	4 (8)	1 (1)						
<i>Echinaster echinophorus</i> .....	1 (1)							
<i>Echinaster sentus</i> .....	4 (13)							
<i>Echinaster modestus</i> .....	2 (2)		1 (1)					
<i>Echinaster</i> species A.....		1 (8)						
<i>Echinaster brasiliensis</i> .....	4 (6)	7 (8)	2 (3)					
<i>Echinaster</i> species C.....		1 (1)						
<i>Echinaster</i> species B.....	1 (1)							
<i>Verrillaster spinulosus</i> .....		1 (2)	1 (1)	1 (2)				
<i>Ampheraster alaminos</i> .....							4 (12)	
<i>Sclerasterias contorta</i> .....					1 (1)			
<i>Asterias forbesi</i> .....	6 (20)							
<i>Coscinasterias tenuispina</i> .....		1 (1)						
<i>Coronaster briareus</i> .....			1 (1)					
<i>Doraster constellatus</i> .....				1 (6)	4 (5)			
<i>Mammaster sigsbeeii</i> .....				1 (5)	2 (11)			
<i>Zoroaster fulgens</i> .....				2 (12)	12 (40)	2 (4)	3 (6)	
<i>Odinia antillensis</i> .....				1 (1)	2 (3)			
<i>Midgardia xandaros</i> .....					1 (1)			

## Station Data

## Oregon Stations

2. 28°00' N, 94°49' W. 50-52 fms. May 1950.  
Bottom temperature: 69.2. Pacific otter trawl.  
*Astropecten cingulatus*
33. 25°55' N, 83°55' W. 62 fms. June 1950.  
Bottom temperature: 61.5. 55' shrimp trawl.  
*Pectinaster mixtus*
35. 25°35' N, 83°42' W. 60 fms. June 1950.  
Bottom temperature: 62.6. 55' shrimp trawl.  
*Henricia* species
36. 28°30' N, 85°36' W. 120 fms. June 1950.  
Bottom temperature: 64.3. 55' shrimp trawl.  
*Henricia sexradiata*
102. 29°07.5' N, 88°50.5' W. 45 fms. October 1950.  
Bottom temperature: 64.4. 100' Texas trawl.  
*Astropecten cingulatus*
123. 28°46.5' N, 89°45' W. 40 fms. September 1950.  
Bottom temperature: 66.2. 100' Texas trawl.  
*Astropecten cingulatus*
150. 27°43' N, 96°51' W. 15 fms. November 1950.

- Bottom temperature: 66.8. 40' flat trawl.  
*Astropecten duplicatus*
272. 29°16' N, 86°39' W. 216 fms. February 1951.  
Bottom temperature: 50. 40' flat trawl.  
*Odontaster setosus*
382. 29°11.5' N, 88°07.5' W. 190-210 fms. June 1951.  
Bottom temperature: 83.5. 100' flat trawl.  
*Astropecten americanus*  
*Doraster constellatus*  
*Zoroaster fulgens*
489. 27°44' N, 85°09' W. 254 fms. September 1951.  
Bottom temperature: 82.5.  
*Plinthaster dentatus*  
*Nymphaster arenatus*  
*Henricia antillarum*
491. 27°49' N, 84°59' W. 200 fms. September 1951.  
Bottom temperature: 52.2. 40' flat trawl.  
*Henricia antillarum*
1408. 28°02' N, 90°15' W. 200 fms. October 1955.  
Bottom temperature: 48.9. 40' flat trawl.  
*Odinia antillensis*
1416. 28°06' N, 91°02' W. 29 fms. October 1955.  
Bottom temperature: 71.6. 4' shell dredge.

1495. *Chaetaster nodosus*  
28°48' N, 89°26' W. 45 fms. May 1956.  
Bottom temperature: 65.3. 40' flat trawl.
1505. *Astropecten cingulatus*  
27°48' N, 94°55' W. 250 fms. May 1956.  
Bottom temperature: 53.1. 40' flat trawl.
1507. *Nymphaster arenatus*  
27°43' N, 95°05' W. 300 fms. May 1956.  
40' flat trawl.
- Persephonaster echinulatus*  
*Cheiraster mirabilis*  
*Plinthaster dentatus*
1508. 27°40' N, 95°35' W. 200 fms. May 1956.  
Bottom temperature: 53.1. 40' flat trawl.
1509. *Plinthaster dentatus*  
27°38' N, 95°35' W. 225 fms. May 1956.  
Bottom temperature: 49.8. 80' balloon trawl.
1510. *Astropecten americanus*  
27°40' N, 95°45' W. 100 fms. May 1956.  
Bottom temperature: 61.2. 40' flat trawl.
1513. *Luidia elegans*  
27°51' N, 94°53' W. 100 fms. May 1956.  
Bottom temperature: 61.2. 40' flat trawl.
1514. *Luidia elegans*  
27°50' N, 94°45' W. 130 fms. May 1956.  
Bottom temperature: 59. 40' flat trawl.
1537. *Luidia elegans*  
*Astropecten nitidus*  
24°29' N, 83°27' W. 212 fms. June 1956.  
Bottom temperature: 50.4. 72' balloon trawl.
1538. *Zoroaster fulgens*  
24°29' N, 83°32' W. 200 fms. June 1956.  
Bottom temperature. 48.7. 72' balloon trawl.
1648. *Zoroaster fulgens*  
30°11' N, 86°55' W. 17 fms. January 1957.  
52-70 eastern trawl.
1672. *Astropecten comptus*  
29°41' N, 85°34' W. 135 fms. February 1957.  
8' scallop dredge.
1865. *Echinaster serpentarius*  
16°20' N, 83°20' W. 42 fms. August 1957.  
40' flat trawl.
1885. *Luidia clathrata*  
*Echinaster brasiliensis*  
16°54' N, 81°18' W. 250 fms. August 1957.  
40' flat trawl.
1890. *Nymphaster arenatus*  
*Pteraster militaroides*  
16°35' N, 80°55' W. 100 fms. August 1957.  
40' flat trawl.
1906. *Astropecten nitidus*  
12°19' N, 82°27' W. 325 fms. August 1957.  
40' trawl.
1909. *Cheiraster mirabilis*  
12°35' N, 82°19' W. 350 fms. September 1957.  
40' trawl.
1917. *Persephonaster echinulatus*  
*Cheiraster mirabilis*  
13°20' N, 82°02' W. 325 fms. September 1957.  
40' shrimp trawl.
- Persephonaster echinulatus*  
*Cheiraster mirabilis*  
*Pteraster militaroides*
1920. 13°31' N, 81°54' W. 300 fms. September 1957.  
40' shrimp trawl.
- Persephonaster echinulatus*  
*Nymphaster arenatus*
1929. 13°22' N, 82°04' W. 300 fms. September 1957.  
40' shrimp trawl.
- Pteraster militaroides*
1934. 16°00' N, 82°05' W. 21 fms. September 1957.  
40' shrimp trawl.
- Oreaster reticulatus*  
*Echinaster sentus*
1936. 15°54' N, 82°06' W. 21 fms. September 1957.  
40' shrimp trawl.
1937. *Echinaster sentus*  
16°02' N, 82°07' W. 21 fms. September 1957.  
40' shrimp trawl.
- Luidia alternata*  
*Oreaster reticulatus*  
*Echinaster sentus*
1938. 16°05' N, 82°05' W. 24 fms. September 1957.  
40' shrimp trawl.
- Oreaster reticulatus*  
*Echinaster sentus*
1946. 16°42' N, 82°36' W. 300 fms. September 1957.  
40' trawl.
- Nymphaster arenatus*
2000. 07°34' N, 54°50' W. 45 fms. November 1957.  
45' Ballerina.
- Echinaster brasiliensis*
2005. 07°34' N, 54°50' W. 200 fms. November 1957.  
40' flat trawl.
- Nymphaster arenatus*
2027. 07°12' N, 53°02' W. 225 fms. November 1957.  
40' flat trawl.
- Anthenoides piercei*
2164. 26°37.5' N, 82°53.5' W. 18-19 fms. April 1958.  
41' midwater trawl.
- Astropecten articulatus*
2199. 24°42' N, 92°18' W. 2000 fms. June 1958.  
40' flat trawl.
- Dytaster insignis*
2202. 28°52' N, 88°11' W. 625 fms. June 1958.  
40' flat trawl.
- Zoroaster fulgens*
2205. 27°40' N, 82°50' W. 5-6 fms. July 1958.  
40' midwater trawl.
- Echinaster serpentarius*
2207. 09°58' N, 61°11' W. 20-22 fms. August 1958.  
40' flat trawl.
- Luidia clathrata*
2209. 09°48' N, 60°47' W. 20-22 fms. August 1958.  
40' flat trawl.
- Astropecten marginatus*
2226. 08°32' N, 59°05' W. 23-33 fms. August 1958.  
40' flat trawl.
- Astropecten marginatus*
2240. 07°56' N, 58°20' W. 11 fms. August 1958.

- 40' flat trawl.  
*Echinaster brasiliensis*
2243. 08°03' N, 58°24' W. 23–25 fms. August 1958.  
40' flat trawl.
- Astropecten duplicatus*
2245. 08°15' N, 58°17' W. 39–50 fms. August 1958.  
40' flat trawl.  
*Goniaster tessellatus*
- Echinaster brasiliensis*
2248. 07°45' N, 57°34' W. 30–35 fms. August 1958.  
40' flat trawl.
- Narcissia trigonaria*
2249. 07°40' N, 57°34' W. 27–30 fms. August 1958.  
40' flat trawl.
- Echinaster brasiliensis*
2250. 07°38' N, 57°34' W. 26–27 fms. August 1958.  
40' flat trawl.
- Narcissia trigonaria*
2267. 06°58' N, 56°02' W. 25 fms. September 1958.  
40' flat trawl.
- Echinaster brasiliensis*
2272. 06°30' N, 55°52' W. 17 fms. September 1958.  
40' flat trawl.
- Luidia senegalensis*  
*Luidia clathrata*
2289. 07°25' N, 54°35' W. 75–80 fms. September 1958.  
40' flat trawl.
- Henricia sexradiata*
2329. 06°40' N, 54°25' W. 25–27 fms. September 1958.  
40' flat trawl.
- Echinaster brasiliensis*
2343. 07°34' N, 57°45' W. 19–20 fms. September 1958.  
40' flat trawl.
- Echinaster brasiliensis*
2345. 08°12' N, 58°25' W. 34–35 fms. September 1958.  
40' flat trawl.
- Echinaster brasiliensis*
2353. 11°35' N, 62°41' W. 212–250 fms. September 1958.  
40' flat trawl.
- Nymphaster arenatus*
2547. 29°15' N, 88°05' W. 100 fms. May 1959.  
40' midwater trawl.
- Ampheraster alaminos*
2566. 26°24' N, 90°45' W. 1450–1500 fms. July 1959.  
40' flat trawl.
- Postlarval astropectenid
2567. 25°21' N, 91°02' W. 1725–1750 fms. July 1959.  
30' balloon.
- Calyptaster personatus*
2571. 26°20' N, 90°31' W. 1300 fms. July 1959.  
40' flat trawl.
- Benthopecten simplex*  
*Zoroaster fulgens*
2572. 26°53' N, 89°56' W. 1325 fms. July 1959.  
40' flat trawl.
- Dytaster insignis*  
*Benthopecten simplex*
2574. 26°34' N, 89°53' W. 1450 fms. July 1959.  
40' flat trawl.  
*Benthopecten simplex*
- Ampheraster alaminos*  
*Zoroaster fulgens*
2575. 27°06' N, 89°13' W. 1100–1200 fms. July 1959.  
40' flat trawl.
- Brisingid discs, unidentified*
2643. 18°03' N, 64°27' W. 150–180 fms. October 1959.  
40' semiballoon trawl.
- Tamaria halperni*
2644. 18°12' N, 67°42' W. 260 fms. October 1959.  
40' semiballoon trawl.
- Henricia species*
2650. 18°16' N, 67°17' W. 250 fms. October 1959.  
40' semiballoon trawl.
- Zoroaster fulgens*
2652. 18°18' N, 67°18.5' W. 300 fms. October 1959.  
40' semiballoon trawl.
- Zoroaster fulgens*
2771. 11°40' N, 62°27' W. 220 fms. April 1960.  
40' trawl.
- Plinthaster dentatus*  
*Pseudarchaster gracilis*
2774. 11°32' N, 62°40' W. 195–212 fms. April 1960.  
40' trawl.
- Persephonaster echinulatus*  
*Nymphaster arenatus*
2775. 11°35' N, 62°37' W. 220–230 fms. April 1960.  
40' trawl.
- Plinthaster dentatus*  
*Mammaster sigsbeeii*
2776. 11°36' N, 62°42' W. 235 fms. April 1960.  
40' trawl.
- Plinthaster dentatus*
2779. 11°35' N, 62°59' W. 240–260 fms. April 1960.  
40' trawl.
- Zoroaster fulgens*
2780. 11°36' N, 62°52' W. 215–230 fms. April 1960.  
40' trawl.
- Doraster constellatus*
2813. 28°48' N, 87°57' W. 1000 fms. July 1960.  
Trawl.
- Dytaster insignis*
2814. 28°53' N, 87°47' W. 950–1050 fms. July 1960.  
Trawl.
- Nymphaster arenatus*
2820. 28°23' N, 88°21.5' W. 1000 fms. July 1960.  
Trawl.
- Plutonaster intermedius*  
*Nymphaster arenatus*  
*Hymenaster modestus*
2821. 28°47.5' N, 87°57' W. 1000–1100 fms. July 1960.  
Trawl.
- Dytaster insignis*  
*Hymenaster modestus*
2824. 29°07.5' N, 88°04' W. 365–395 fms. July 1960.  
Trawl.
- Plinthaster dentatus*  
*Zoroaster fulgens*
3210. 29°50' N, 87°08' W. 66 fms. February 1961.  
5' scallop dredge.  
*Verrillaster spinulosus*

3555. 17°17' N, 78°23' W. 15 fms. May 1962.  
5' dredge.  
*Luidia clathrata*  
*Luidia alternata*  
*Astropecten duplicatus*
3560. 16°35' N, 80°10' W. 315 fms. May 1962.  
Bottom temperature: 45. 40' shrimp trawl.  
*Nymphaster arenatus*  
*Zoroaster fulgens*
3561. 16°35' N, 80°04' W. 400 fms. May 1962.  
Bottom temperature: 46. 40' shrimp trawl.  
*Plinthaster dentatus*  
*Zoroaster fulgens*
3573. 14°18' N, 81°44' W. 410-420 fms. May 1962.  
Bottom temperature: 41. 40' shrimp trawl.  
*Plinthaster dentatus*
3574. 12°31' N, 82°21' W. 200 fms. May 1962.  
40' shrimp trawl.  
*Nymphaster arenatus*
3583. 09°16' N, 81°37' W. 280 fms. May 1962.  
40' shrimp trawl.  
*Persephonaster echinulatus*  
*Doraster constellatus*
3601. 09°07' N, 81°10' W. 400 fms. May 1962.  
Bottom temperature: 43. 40' shrimp trawl.  
*Plinthaster dentatus*
3603. 12°16' N, 82°54' W. 15-20 fms. June 1962.  
5' dredge.  
*Astropecten duplicatus*  
*Oreaster reticulatus*
3608. 12°28' N, 82°28' W. 110 fms. June 1962.  
40' shrimp trawl.  
*Anthenoides piercei*
3621. 16°00' N, 81°09' W. 120-130 fms. June 1962.  
5' dredge.  
*Tethyaster grandis*
3637. 17°13' N, 87°55' W. 120-170 fms. June 1962.  
Bottom temperature: 51. 40' shrimp trawl.  
*Pectinaster mixtus*
3654. 29°08.5' N, 88°00.5' W. 400-401 fms. July 1962.  
Bottom temperature: 46.4. 40' flat trawl.  
*Psilaster cassiope*  
*Plinthaster dentatus*  
*Nymphaster arenatus*  
*Zoroaster fulgens*
4086. 27°46' N, 84°06' W. 31 fms. December 1962.  
6' tumbler dredge.  
*Astropecten comptus*  
*Goniaster tessellatus*  
*Narcissia trigonaria*  
*Echinaster species "B"*
4089. 27°43' N, 83°34' W. 22 fms. December 1962.  
6' tumbler dredge.  
*Astropecten duplicatus*
4226. 00°18' N, 44°17' W. 150 fms. March 1963.  
Bottom temperature: 47. 6' tumbler dredge.  
*Leilaster radians*  
*Marginaster pectinatus*
4300. 07°44' N, 54°19' W. 300 fms. March 1963.  
65' shrimp trawl.  
*Pseudarchaster gracilis*
4302. 07°35' N, 54°25' W. 150 fms. March 1963.  
6' tumbler dredge.  
*Astropecten americanus*
4392. 12°32' N, 71°05' W. 40 fms. September 1963.  
Bottom temperature: 81. 40' flat trawl.  
*Goniaster tessellatus*
4398. 12°46' N, 70°41' W. 110 fms. September 1963.  
Bottom temperature: 62. 6' tumbler dredge.  
*Astropecten nitidus*  
*Pectinaster mixtus*  
*Rosaster alexandri*
4413. 11°53' N, 69°25' W. 350 fms. October 1963.  
Bottom temperature: 46. 40' flat trawl.  
*Nymphaster arenatus*  
*Zoroaster fulgens*
4416. 11°54' N, 69°18' W. 500 fms. October 1963.  
Bottom temperature: 44. 40' flat trawl.  
*Psilaster patagiatus*  
*Plinthaster dentatus*  
*Circeaster americanus*  
*Nymphaster arenatus*  
*Pseudarchaster gracilis*
4421. 11°49' N, 69°24' W. 200 fms. October 1963.  
40' flat trawl.  
*Anthenoides piercei*  
*Pseudarchaster gracilis*
4459. 10°50' N, 66°58' W. 53 fms. October 1963.  
Bottom temperature: 73. 6' tumbler dredge.  
*Chaetaster nodosus*
4472. 10°13' N, 65°23' W. 18 fms. October 1963.  
40' flat trawl.  
*Luidia senegalensis*
4474. 10°43' N, 64°29' W. 300 fms. October 1963.  
Bottom temperature: 63. 40' flat trawl.  
*Astropecten duplicatus*
4480. 11°10' N, 65°07' W. 220 fms. October 1963.  
40' flat trawl.  
*Persephonaster echinulatus*  
*Odinia antillensis*
4574. 23°13' N, 87°50' W. 210 fms. December 1963.  
Bottom temperature: 50.2. 40' shrimp trawl.  
*Odinia antillensis*
4702. 27°50' N, 90°33' W. 400 fms. February 1964.  
Bottom temperature: 45. 40' shrimp trawl.  
*Goniopecten demonstrans*  
*Cheiraster mirabilis*
4703. 27°55' N, 90°28' W. 300 fms. February 1964.  
Bottom temperature: 50. 40' shrimp trawl.  
*Persephonaster echinulatus*
4731. 27°35' N, 92°32' W. 250-300 fms. February 1964.  
40' flat shrimp trawl.  
*Sclerasterias contorta*
4855. 11°16.5' N, 74°21.5' W. 400 fms. May 1964.  
40' flat shrimp trawl.  
*Psilaster cassiope*  
*Goniopecten demonstrans*  
*Plinthaster dentatus*  
*Nymphaster arenatus*
4902. 09°02.4' N, 76°31' W. 400 fms. May 1964.

4928. *Goniopecten demonstrans*  
14°05' N, 81°21' W. 100 fms. June 1964.  
6' tumbler dredge.  
*Astropecten nitidus*  
*Tamaria halperni*
4938. 20°31' N, 86°12' W. 150–164 fms. June 1964.  
40' flat trawl.  
*Linckia bouvieri*
4939. 20°25' N, 86°13' W. 150 fms. June 1964.  
6' tumbler dredge.  
*Linckia bouvieri*
4994. 15°30' N, 63°38' W. 200–205 fms. September 1964.  
40' shrimp trawl.  
*Pteraster rugosus*
5023. 11°14' N, 60°51' W. 38 fms. September 1964.  
6' tumbler dredge.  
*Narcissia trigonaria*  
*Verrillaster spinulosus*
5390. 17°45' N, 77°21' W. 8–9 fms. May 1965.  
40' shrimp trawl.  
*Oreaster reticulatus*
5438. 20°20' N, 69°59' W. 6–11 fms. May 1965.  
6' tumbler dredge.  
*Ophidiaster guildingii*
5456. 18°03' N, 67°18' W. 12–14 fms. June 1965.  
Bottom temperature: 82. 40' shrimp trawl.  
*Luidia alternata*  
*Oreaster reticulatus*  
*Echinaster echinophorus*
5700. 12°12' N, 72°26' W. 38 fms. October 1965.  
40' shrimp trawl.  
*Narcissia trigonaria*
5723. 09°12' N, 76°20' W. 24 fms. October 1965.  
65' shrimp trawl.  
*Echinaster brasiliensis*
5739. 09°43' N, 79°20' W. 52 fms. October 1965.  
Bottom temperature: 79. 40' shrimp trawl.  
*Narcissia trigonaria*  
*Echinaster brasiliensis*
5784. 24°28' N, 83°39' W. 310 fms. November 1965.  
Bottom temperature: 48. 40' flat trawl.  
*Plinthaster dentatus*  
*Nymphaster arenatus*
5882. 28°59' N, 80°48' W. 10.5–11.5 fms. January 1966.  
Bottom temperature: 60. 65' flat net.  
*Asterias forbesii*
5894. 29°08.5' N, 80°38' W. 13–14 fms. January 1966.  
Bottom temperature: 61. 6' tumbler dredge.  
*Luidia clathrata*  
*Luidia alternata*  
*Astropecten articulatus*  
*Asterias forbesii*
5913. 18°11' N, 63°15' W. 162 fms. February 1966.  
Tumbler dredge.  
*Astropecten nitidus*  
*Tethyaster grandis*  
*Cheiraster echinulatus*
5915. 14°10' N, 61°05' W. 900 fms. March 1966.  
Tumbler dredge.  
*Tosia parva*
5920. 15°37' N, 61°22' W. 34 fms. March 1966.  
Tumbler dredge.  
*Astropecten duplicatus*
5923. 15°36' N, 61°15' W. 40 fms. March 1966.  
Bottom temperature: 78. Tumbler dredge.  
*Drachmaster bullisi*
5929. 15°39' N, 61°10' W. 355 fms. March 1966.  
Shrimp trawl.  
*Goniopecten demonstrans*  
*Plinthaster dentatus*  
*Pseudarchaster gracilis*  
*Solaster notophrynus*  
*Pteraster militarioides*  
*Zoroaster fulgens*
5930. 15°38' N, 61°07' W. 442 fms. March 1966.  
Shrimp trawl.  
*Circeaster americanus*
5934. 15°31' N, 61°12' W. 195 fms. March 1966.  
Tumbler dredge.  
*Verrillaster spinulosus*
5937. 15°34' N, 61°29' W. 50 fms. March 1966.  
Tumbler dredge.  
*Pteraster rugosus*
5970. 11°13' N, 60°52' W. 34 fms. March 1966.  
Shrimp trawl.  
*Drachmaster bullisi*
6300. 29°17' N, 81°00' W. 9 fms. November 1966.  
Bottom temperature: 74. 60' Shrimp trawl.  
*Luidia clathrata*  
*Asterias forbesii*
6403. 17°24' N, 87°56.5' W. 143 fms. January 1967.  
Bottom temperature: 59. 40' 4-seam shrimp trawl.  
*Anthenoides piercei*
6696. 17°46' N, 62°59' W. 355–365 fms. May 1967.  
Bottom temperature: 49. 40' flat net.  
*Persephonaster echinulatus*  
*Goniopecten demonstrans*  
*Cheiraster mirabilis*  
*Ceramaster grenadensis*  
*Peltaster placenta*  
*Circeaster americanus*  
*Nymphaster arenatus*  
*Pseudarchaster gracilis*  
*Pteraster caribbaeus*
6697. 17°47' N, 63°09' W. 440–460 fms. May 1967.  
40' flat net.  
*Goniopecten demonstrans*  
*Circeaster americanus*
6699. 17°38.5' N, 62°16' W. 180–185 fms. May 1967.  
Bottom temperature: 60. 40' flat net.  
*Astropecten nitidus*  
*Anthenoides piercei*  
*Peltaster placenta*  
*Tessellaster notabilis*
6703. 16°53' N, 61°53' W. 410–460 fms. May 1967.  
65' flat net.  
*Persephonaster echinulatus*  
*Goniopecten demonstrans*  
*Cheiraster enoplus*  
*Circeaster americanus*

- Nymphaster arenatus*  
*Pseudarchaster gracilis*  
 6715. 18°36' N, 63°27' W. 110–130 fms. May 1967.  
 Bottom temperature: 61. 6' tumbler dredge.  
*Blakiaster conicus*  
*Tamaria halperni*
- Oregon II Stations**
10184. 17°08' N, 80°28' W. 106 fms. November 1968.  
 100' flat trawl.  
*Anthenoides piercei*  
 10206. 12°44' N, 82°16' W. 270 fms. November 1968.  
 71' shrimp trawl.  
*Nymphaster arenatus*  
 10212. 09°55' N, 76°03' W. 70 fms. November 1968.  
 150' flat trawl.  
*Echinaster brasiliensis*  
 10353. 28°10' N, 92°11' W. 40 fms. January 1969.  
 71' shrimp trawl.  
*Anthenoides piercei*  
 10491. 10°28' N, 60°04' W. 355 fms. April 1969.  
 40' shrimp trawl.  
*Plinthaster dentatus*  
*Nymphaster arenatus*  
 10499. 08°43' N, 59°10' W. 40 fms. April 1969.  
 Bottom temperature: 79. 40' shrimp trawl.  
*Astropecten duplicatus*  
 10505. 08°13' N, 58°40' W. 20 fms. April 1969.  
 40' shrimp trawl.  
*Astropecten marginatus*  
 10507. 08°10' N, 58°36' W. 20 fms. April 1969.  
 40' shrimp trawl.  
*Astropecten marginatus*  
 10513. 08°26' N, 58°11' W. 100 fms. April 1969.  
 52' flat trawl.  
*Rosaster alexandri*  
*Tamaria halperni*  
 10514. 08°06' N, 57°41' W. 202 fms. April 1969.  
 52' flat trawl.  
*Nymphaster arenatus*  
 10517. 07°23' N, 57°04' W. 32 fms. April 1969.  
 40' shrimp trawl.  
*Narcissia trigonaria*  
 10518. 07°03' N, 57°03' W. 20 fms. April 1969.  
 Bottom temperature: 81. 40' shrimp trawl.  
*Goniaster tessellatus*  
 10533. 06°51' N, 55°47' W. 26 fms. April 1969.  
 40' shrimp trawl.  
*Goniaster tessellatus*  
 10559. 06°54' N, 53°50' W. 36 fms. May 1969.  
 40' shrimp trawl.  
*Tethyaster grandis*  
 10561. 06°52' N, 53°46' W. 35 fms. May 1969.  
 40' shrimp trawl.  
*Echinaster brasiliensis*  
 10602. 07°46' N, 54°35' W. 299 fms. May 1969.  
*Goniopecten demonstrans*  
*Nymphaster arenatus*
- Pseudarchaster gracilis*  
*Doraster constellatus*  
 10619. 07°51' N, 54°23' W. 425 fms. May 1969.  
 100' shrimp trawl.  
*Zoroaster fulgens*  
 10624. 07°30' N, 55°29' W. 440 fms. May 1969.  
 100' shrimp trawl.  
*Nymphaster arenatus*  
*Pseudarchaster gracilis*  
 10628. 27°10' N, 85°02' W. 1 fm. June 1969.  
*Peltaster placenta*  
 10633. 27°53' N, 85°13' W. 265 fms. June 1969.  
 204' shrimp trawl.  
*Plinthaster dentatus*  
*Circeaster americanus*  
 10636. 28°17' N, 86°21' W. 367 fms. June 1969.  
 204' shrimp trawl.  
*Plinthaster dentatus*  
*Circeaster americanus*  
 10667. 36°17' N, 74°49' W. 99 fms. July 1969.  
 40' shrimp trawl.  
*Odontaster hispidus*  
 10715. 36°48' N, 74°40' W. 75 fms. July 1969.  
 Bottom temperature: 52. 8' tumbler dredge.  
*Odontaster hispidus*  
 10728. 36°11' N, 74°49' W. 75 fms. July 1969.  
 Bottom temperature: 56. 8' tumbler dredge.  
*Odontaster hispidus*  
 10794. 07°50' N, 54°15' W. 405 fms. November 1969.  
 191' shrimp trawl.  
*Nymphaster arenatus*  
 10795. 07°48' N, 54°01' W. 392 fms. November 1969.  
 191' shrimp trawl.  
*Pseudarchaster gracilis*  
 10802. 07°26' N, 53°16' W. 330–345 fms. November 1969.  
 191' shrimp trawl.  
*Plinthaster dentatus*  
 10825. 15°42' N, 61°08' W. 35 fms. December 1969.  
 71' shrimp trawl.  
*Solaster caribbaeus*  
 10827. 15°40' N, 61°09' W. 355 fms. December 1969.  
 71' shrimp trawl.  
*Peltaster nidarosiensis*  
*Plinthaster dentatus*  
*Pteraster species*  
 10841. 71°24' N, 62°33' W. 352 fms. December 1969.  
 70' shrimp trawl.  
*Ceramaster grenadensis*  
 10842. 17°15' N, 62°22' W. 317 fms. December 1969.  
 40' shrimp trawl.  
*Ceramaster grenadensis*  
 10843. 17°06' N, 62°17' W. 322 fms. December 1969.  
 40' shrimp trawl.  
*Nymphaster arenatus*  
 10844. 17°06' N, 62°28' W. 344 fms. December 1969.  
 40' shrimp trawl.  
*Ceramaster grenadensis*  
*Nymphaster arenatus*  
 10849. 20°50' N, 73°23' W. 170 fms. December 1969.  
 Bottom temperature: 64. 40' shrimp trawl.

10850. *Tamaria halperni*  
20°49' N, 73°26' W. 170 fms. December 1969.  
Bottom temperature: 64. 40' shrimp trawl.
10858. *Tamaria halperni*  
22°59' N, 78°43' W. 152 fms. December 1969.  
40' shrimp trawl.
10895. *Tamaria passiflora*  
23°04' N, 78°46' W. 198 fms. December 1969.  
40' shrimp trawl.
10872. *Prionaster elegans*  
28°59' N, 87°09' W. 500 fms. January 1970.  
150' TT.
10876. *Nymphaster arenatus*  
28°55.2' N, 87°23' W. 800 fms. January 1970.  
70' shrimp trawl.
10877. *Plinthaster dentatus*  
*Nymphaster arenatus*  
28°34' N, 87°26' W. 900 fms. January 1970.  
70' shrimp trawl.
10900. *Nymphaster arenatus*  
28°50' N, 86°59' W. 400 fms. February 1970.  
70' shrimp trawl.  
*Nymphaster arenatus*

#### Silver Bay Stations

35. 29°20' N, 85°31' W. 25-30 fms. July 1967.  
8' scallop dredge.  
*Luidia clathrata*
41. *Astropecten articulatus*  
29°19' N, 85°09' W. 13 fms. July 1957.  
8' scallop dredge.
48. *Goniaster tessellatus*  
29°00' N, 85°15' W. 23-30 fms. July 1957.  
8' scallop dredge.
281. *Echinaster species "B"*  
27°45' N, 95°46' W. 40 fms. February 1958.  
52'4.5" nylon roller net w/8' brkt. doors.
961. *Anthenoides piercei*  
20°02' N, 91°53' W. 26 fms. January 1959.  
54' fish trawl.
1515. *Poraniella regularis*  
33°37' N, 76°49'3" W. 48-55 fms. December 1959.  
8' scallop dredge.
1564. *Luidia clathrata*  
*Luidia sagramina*  
29°04' N, 80°45' W. 8-9 fms. January 1960.  
8' scallop dredge.
1710. *Asterias forbesii*  
34°36' N, 75°35' W. 7.5-7 fms. March 1960.  
Clam dredge.
1909. *Gonister tessellatus*  
*Echinaster serpentarius*  
*Asterias forbesii*  
29°06' N, 80°31' W. 13 fms. April 1960.  
8' scallop dredge.
1952. *Echinaster modestus*  
28°05' N, 80°11' W. 16-16.5 fms. April 1960.  
10' scallop dredge.

1963. *Luidia clathrata*  
*Asterias forbesii*  
27°28' N, 80°08' W. 10-11 fms. July 1960.  
8' scallop dredge.
1970. *Astropecten duplicatus*  
28°25' N, 80°01' W. 50 fms. April 1960.  
8' scallop dredge.
1972. *Echinaster serpentarius*  
28°42' N, 80°08' W. 30-31 fms. April 1960.  
8' scallop dredge.
2009. *Linckia guildingii*  
28°15' N, 80°02' W. 40-41 fms. April 1960.  
10' scallop dredge.
2010. *Goniaster tessellatus*  
28°17' N, 80°01' W. 34-41 fms. April 1960.  
10' scallop dredge.
2020. *Goniaster tessellatus*  
*Linckia nodosa*  
*Coscinasterias tenuispina*  
28°22' N, 80°02' W. 41-45 fms. April 1960.  
10' scallop dredge.
2390. *Tosia parva*  
24°42' N, 80°44' W. 50 fms. October 1960.  
40' balloon trawl.
2432. *Goniaster tessellatus*  
24°29' N, 83°13' W. 33-35 fms. October 1960.  
8' scallop dredge.
2453. *Astropecten cingulatus*  
23°47' N, 80°02' W. 160-180 fms. November 1960.  
6' tumbler dredge.
2775. *Astropecten nitidus*  
*Anthenoides piercei*  
29°10' N, 80°18' W. 20 fms. February 1961.  
8' scallop dredge.
2863. *Astropecten comptus*  
*Echinaster serpentarius*  
36°04' N, 74°49' W. 60 fms. March 1961.  
40' balloon trawl.
2926. *Astropecten americanus*  
34°54' N, 75°32' W. 28 fms. March 1961.  
6' tumbler dredge.
3284. *Goniaster tessellatus*  
27°55' N, 80°03' W. 30 fms. July 1961.  
Bottom temperature: 57. 8' tumbler dredge.
5106. *Goniaster tessellatus*  
27°59' N, 80°02' W. 35 fms. October 1963.  
6' tumbler dredge.  
*Tethyaster grandis*

#### Combat Stations

90. 28°52' N, 80°05' W. 65 fms. September 1956.  
10' beam trawl.
98. *Echinaster modestus*  
29°40' N, 80°17' W. 40 fms. September 1956.  
40' flat trawl.
180. *Goniaster tessellatus*  
30°39' N, 78°39' W. 125 fms. November 1956.  
40' balloon trawl.

- Astropecten nitidus*  
185. 29°55' N, 80°10' W. 185 fms. November 1956.  
40' flat trawl.  
*Odontaster setosus*  
*Lophaster verrilli*  
339. 29°19' N, 80°18' W. 25 fms. June 1957.  
10' beam trawl.  
*Goniaster tessellatus*  
*Echinaster modestus*  
364. 34°10' N, 75°59' W. 210 fms. June 1957.  
Bottom temperature: 52.9. 40' flat trawl.  
*Plinthaster dentatus*  
450. 23°59' N, 79°43' W. 350 fms. July 1957.  
10' beam trawl.  
*Plinthaster dentatus*  
*Nymphaster arenatus*  
*Nymphaster subspinosus*  
*Mammaster sigsbeeii*

#### George M. Bowers Stations

43. 31°26' N, 80°05' W. 24 fms. March 1956.  
Bottom temperature: 67. 40' flat trawl.  
*Goniaster tessellatus*  
85. Eleuthra, Bahamas (no data).  
*Echinaster* species "C"

#### Alaminos Stations

- Cruise 64-A-10  
13. 27°52' N, 94°56' W. 62-96 fms. August 1964.  
*Tethyaster grandis*  
Cruise 65-A-9  
15. 23°00' N, 86°48' W. 320 fms. July 1965.  
*Cheiraster echinulatus*  
*Nymphaster arenatus*  
20. 25°00' N, 84°00' W. 67 fms. July 1965.  
*Luidia barbadensis*  
*Astropecten nitidus*  
*Cheiraster echinulatus*  
*Anthenoides piercei*  
*Coronaster briareus*  
21. 25°00' N, 84°00' W. 70 fms. July 1965.  
*Luidia barbadensis*  
Cruise 67-A-5  
2H. 28°20' N, 88°22' W. 980 fms. July 1967.  
*Nymphaster arenatus*  
Cruise 68-A-3  
3B. 25°09' N, 94°11' W. 2000 fms. March 1968.  
Skimmer.  
*Dytaster insignis*  
5B. 23°44' N, 95°36' W. 2100 fms. March 1968.  
*Dytaster insignis*  
7D. 23°50' N, 90°55' W. 2030 fms. March 1968.  
*Dytaster insignis*  
10B. 25°09' N, 96°16' W. 530-550 fms. March 1968.  
*Zoroaster fulgens*  
Cruise 68-A-7

- 3C. 27°36' N, 87°41.5' W. 1500 fms. July 1968  
*Dytaster insignis*  
*Plinthaster dentatus*  
*Litonotaster intermedius*  
*Ampheraster alaminos*  
*Zoroaster fulgens*  
4A. 25°26.6' N, 86°06' W. 1750 fms. July 1968.  
*Dytaster insignis*  
*Litonotaster intermedius*  
*Paragonaster subtilis*  
*Ampheraster alaminos*  
4E. 25°23.8' N, 86°06.7' W. 1750 fms. July 1968.  
*Dytaster insignis*  
*Nymphaster arenatus*  
*Ampheraster alaminos*  
9A. 29°25.5' N, 86°44' W. 200 fms. August 1968.  
*Astropecten americanus*  
10A. 29°15.5' N, 86°55' W. 300 fms. August 1968.  
*Persephonaster echinulatus*  
*Pseudarchaster gracilis*  
11A. 29°14' N, 87°00' W. 400 fms. August 1968.  
*Psilaster patagiatus*  
*Goniopecten demonstrans*  
*Cheiraster echinulatus*  
12B. 29°21.5' N, 86°59.5' W. 500 fms. August 1968.  
*Dytaster insignis*  
*Plinthaster dentatus*  
13A. 29°03' N, 87°15' W. 600 fms. August 1968.  
*Plutonaster intermedius*  
*Nymphaster arenatus*  
13D. 28°59' N, 87°23.3' W. 800 fms. August 1968.  
*Plutonaster intermedius*  
14C. 28°51' N, 87°36' W. 1150 fms. August 1968.  
*Hymenaster rex*  
15D. 29°10.3' N, 87°31.5' W. 600 fms. August 1968.  
*Plutonaster intermedius*  
15H. 29°10.5' N, 87°16' W. 500 fms. August 1968  
*Plutonaster intermedius*  
*Plinthaster dentatus*  
*Nymphaster arenatus*  
17B. 29°09.5' N, 87°02' W. 500 fms. August 1968.  
*Plutonaster intermedius*  
Cruise 68-A-13  
1. 25°42' N, 96°04' W. 480 fms. November 1968.  
Skimmer.  
*Psilaster cassiope*  
*Nymphaster arenatus*  
*Zoroaster fulgens*  
4. 25°38.4' N, 96°15.3' W. 280 fms. November 1968.  
Skimmer.  
*Persephonaster echinulatus*  
5. 26°12.5' N, 96°19.8' W. 150 fms. November 1968.  
Skimmer.  
*Tethyaster grandis*  
7. 26°17' N, 96°18' W. 150 fms. November 1968.  
Skimmer.  
*Astropecten americanus*  
8. 26°15' N, 96°09' W. 400 fms. November 1968.  
Skimmer.  
*Persephonaster echinulatus*



- Goniopecten demonstrans*  
*Cheiraster mirabilis*
9. 25°14' N, 95°12' W. 1840 fms. November 1968.  
Skimmer.
- Dytaster insignis*  
*Litonotaster intermedius*
10. 25°16' N, 95°09' W. 1850-1910 fms. November 1968.  
2-meter dredge.  
*Litonotaster intermedius*
11. 25°17' N, 95°57' W. 720-750 fms. November 1968.  
Skimmer.  
*Nymphaster arenatus*
- 12A. 25°31' N, 95°51' W. 580-720 fms. November 1968.  
Skimmer.  
*Pteraster acicula*
15. 27°85' N, 95°10' W. 360-470 fms. November 1968.  
Skimmer.  
*Goniopecten demonstrans*  
*Pseudarchaster gracilis*
19. 27°44' N, 95°16' W. 200 fms. November 1968.  
Skimmer.  
*Astropecten americanus*
21. 27°37.5' N, 95°20' W. 350 fms. November 1968.  
Skimmer.  
*Persephonaster echinulatus*  
*Doraster constellatus*
23. 27°36' N, 95°20' W. 400 fms. November 1968.  
Skimmer.  
*Plutonaster intermedius*
24. 28°29' N, 95°22' W. 480 fms. November 1968  
Skimmer.  
*Psilaster cassiope*  
*Plutonaster intermedius*  
*Nymphaster arenatus*
27. 27°15' N, 95°06' W. 600-650 fms. November 1928.  
Skimmer.  
*Plutonaster intermedius*
- Cruise 69-A-11
27. 18°54' N, 94°53.8' W. 425-450 fms. August 1969  
Skimmer.  
*Psilaster cassiope*  
*Dytaster insignis*  
*Goniopecten demonstrans*
58. 19°02.6' N, 95°27.5' W. 260 fms. August 1969.  
Large skimmer.  
*Midgardia xandaros*
78. 21°30' N, 96°55' W. 370-400 fms. August 1969.  
Skimmer.  
*Nymphaster arenatus*
87. 21°44' N, 96°46' W. 970 fms. August 1969.  
Large skimmer.  
*Nymphaster arenatus*  
*Pteraster personatus*
- Cruise 69-A-13
4. 26°25' N, 91°55' W. 1085 fms. October 1969.  
Skimmer.  
*Benthopecten simplex*  
*Hymenaster anomalus*
9. 24°40' N, 90°39' W. 2015 fms. October 1969.  
Skimmer.

*Dipsacaster antillensis*

29. 25°30' N, 86°09' W. 1765 fms. October 1969.  
Skimmer.

*Dipsacaster antillensis**Paragonaster subtilis*

## Cruise 70-A-10

25. 16°43' N, 82°38' W. 235-335 fms. July 1970.  
57' trawl.  
*Henricia antillarum*

**Glossary**

Abactinal, dorsal, aboral= surface opposite mouth.

Aboral= see abactinal.

Aciculate spine= slender, pointed spine.

Actinal, ventral, oral= surface containing mouth.

Actinal face (of adambulacral plate)= external surface of adambulacral plate exclusive of furrow margin.

Actinal intermediate area, oral intermediate area= interradial area of actinal surface.

Actinolateral plates= plates between the adambulacra and the inferomarginals.

Actinolateral spines= see lateral spines.

Actinostome= see mouth.

Adradial, dorsolateral= the row or rows of plates between the carina and the superomarginals.

Adambulacra, adambulacral= plate immediately below the ambulacral plate, forming the border of the furrow.

Alveolar pedicellaria= see sugar-tongs pedicellaria.

Alveolus= an elongate pit in a plate containing a sugar-tongs pedicellaria.

Ambitus= the periphery of a starfish.

Ambulacra, ambulacral, ambulacral groove, furrow= channel on actinal surface containing the tube feet; the paired series of plates lining said channel.

Ambulacral channel= see ambulacra.

Ambulacral groove= see ambulacra.

Ampulla= the bulblike portion of the tube foot, internal to the ambulacral plate; it may be single or double.

Anus, anal pore= small opening in center of disc dorsum, not present in all starfishes.

Aperture papilla= small flattened and expanded spine or flap of tissue covering a tiny aperture (segmental pore) of unknown function between the adambulacra in Pterasteridae.

Apical spines= see preoral spines.

Arm, ray=radial portion of starfish exclusive of disc.

Bipinnaria=planktonic larval stage in the development of a starfish.

Bivalved pedicellaria, valvate pedicellaria=pedicellaria with two low, broad valves lying in a depression in a plate and somewhat resembling a clamshell.

Carina, carinal ridge=median ridge or row of plates on dorsal arm.

Carinal ridge—see carina.

Carinate adambulacral=adambulacral plate with a shoulder or ridge projecting into the furrow.

Costae, skeletal arches=rows of plates forming arches across the arm. Found only in the *Brisingiidae*.

Costal plates=plates of the costae.

Cribiform organs=specialized channels between adjacent marginal plates, of unknown function.

Cruciform plates=plates with 3–5 flattened, expanded basal lobes, found usually in the *Pterasteridae*.

Diplacanthid=with two spines.

Disc=central portion (body) exclusive of arms.

Distal=away from the disc center.

Dorsal—see abactinal.

Dorsolateral—see adradial.

Dorsum=abactinal disc surface exclusive of marginals.

Duck-billed pedicellaria=pedicellaria with two valves expanded at base and tip, but with slender shank; one valve usually larger than the other. Found only in the *Zoroasteridae*.

Epioral spines, suboral spines=spines on actinal surface of mouth plates exclusive of margin.

Epiproctal cone=a small blind tube projecting from the center of the dorsum in some starfish.

Excavate pedicellaria—see sugar-tongs pedicellaria.

Fasciculate pedicellaria, spiniform pedicellaria=simple pedicellaria formed by 2–5 straight or slightly curved upright movable spines.

Fascioles=channels between series or rows of plates, frequently lined with spinules.

Feliped pedicellaria=pedicellaria formed of a basal piece and two valves, toothed on the margin, resembling small clasped hands or paws.

Fissiparous=reproducing by fission.

Furrow—see ambulacrum.

Furrow spines, groove spines=spines on the fur-

FIGURE 2.—A, Major divisions, directions, and measurements of a starfish (schematic) [Ar=arm, D=disc, d=distal, Ir=inter-radial, p=proximal, R=major radius, r=minor radius]. B, Abactinal surface (schematic) [a=anus, m=madreporite, o=ocular plate, Sm=superomarginal plates]. C, Actinal surface (schematic) [amb=ambulacra, Im=inferomarginal plates, mp=mouth plates]. D, Cross section through a starfish arm (schematic) [ad=adambulacral plates, al=actinolateral plates, am=ambulacral plates, c=carinal plate, dl=dorsolateral (or adradial) plates, Im=inferomarginal plates, sa=superambulacral plates, Sm=superomarginal plates, l=pointed tube feet with simple ampulla, 2=suckered tube feet with double ampulla. Typical starfish pedicellariae: E, crossed pedicellaria of the type found mainly in the *Brisingiidae*; F, sugar-tongs pedicellaria (in alveolus) typical principally of the *Ophidiasteridae* [a=erect, b=open and lying flat within the alveolus]; G, straight pedicellaria of the type found in the *Luidiidae* and *Astropectinidae*; H, pectinate pedicellaria found only in the *Benthopectinidae*; I, feliped pedicellaria found in the order *Forcipulatida* [a=frontal view, b=side view]; J, valvate pedicellaria found only in starfishes of the order *Valvatida*; K, straight pedicellaria consisting of a basal piece and two valves found in the orders *Forcipulatida* and *Zorocallida*; L, duck-billed pedicellaria found only in the *Zoroasteridae*.

row margin of the adambulacrals, or within the furrow.

Glassy tubercles=small, low, transparent, pebbly projections on some plates of certain starfish.

Granule=a small, deciduous, spherical or hemispherical external ornamentation.

Groove—see ambulacrum.

Groove spine—see furrow spine.

Gyri=irregular channels on the surface of the madreporite.

Inferomarginal plates, inferomarginals=marginals pertaining to the actinal surface.

Interbrachial—see interrachial.

Interbrachial septum, interrachial strut=an internal interrachial strut of muscle tissue or of fused plates between the mouth and the interrachial margin.

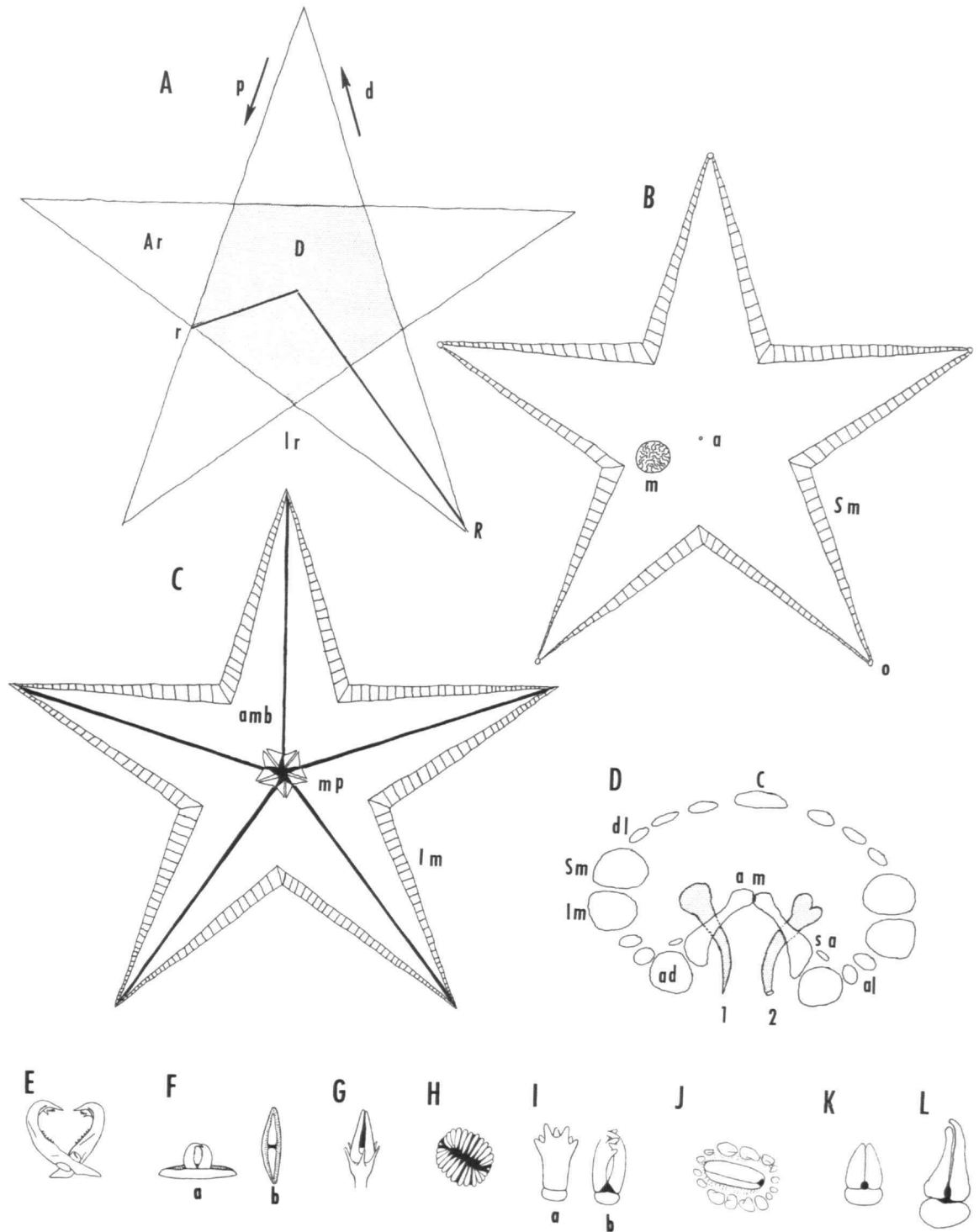
Intermarginal=between the two series of marginals.

Interrachial, interbrachial=the area of the disc between the arms.

Interrachial strut—see interbrachial septum.

Jaw plate—see mouth plate.

Lateral fringe=a fringe of tissue, usually not supported by spines, around the ambitus of certain *Pterasteridae*.



- Lateral spines (as in Pterasteridae)=long spines projecting from the adambulacrals and supporting the actinal surface in Pterasteridae.
- Madreporite=a specialized plate on the abactinal surface, forming a sievelike opening for the water vascular system.
- Major radius—see R.
- Marginal mouth spines=spines on the margin of mouth plates exclusive of preoral spines.
- Marginal plates, marginals=one or two rows of plates generally defining the ambitus and usually larger and more regular than the other plates.
- Marginal spines=spines ornamenting the marginals.
- Median furrow=suture between the paired mouth plates.
- Minor radius—see r.
- Monacanthid=with one spine.
- Mouth, peristome, actinostome=opening to digestive system, in center of actinal surface.
- Mouth plate, jaw plate=paired plates at apex of actinal interradial area, around the mouth.
- Ocular plates, oculars=the terminal plate on the abactinal surface of the arms.
- Oscular valves=valves surrounding osculum.
- Osculum=central opening in the supradorsal membrane, found in Pterasteridae.
- Oral—see actinal.
- Oral intermediate—see actinal intermediate.
- Oral spines=spines on the mouth plates.
- Ossicle—see plate.
- Papulae=respiratory organs, fingerlike or glovelike projections of soft tissue issuing from pores between plates, and usually confined to abactinal surface.
- Papular area=area containing papulae.
- Papular pores=pores through which papulae project.
- Papularia=small specialized areas on abactinal surface containing papulae; usually found in Benthoptectinidae.
- Paxilla, paxillate, paxilliform=a more or less columnar plate with, usually, an expanded base and bearing spines or granules on the top.
- Paxillar column—see pedicel.
- Pectinate pedicellaria=pedicellaria usually lying between two plates and formed by two opposing rows of short, curved spines, like the teeth of a rake. Found only in the Benthoptectinidae.
- Pedicel, paxillar column=the column, or shank, of a paxilla.
- Pedicellaria=small pincerlike organ on body surface, used to catch and hold particulate matter.
- Peristome—see mouth.
- Plate, ossicle=any single skeletal element except the spines and pedicellariae.
- Podia—see tube feet.
- Preoral spine, apical spine=spine or spines at apex of mouth plate.
- Primary plates=the first-formed, usually large, plates of the disc, generally obscured or lost in development, but still plainly distinguishable in certain starfish, such as the Zoroasteridae.
- Proximal=toward the disc center.
- R, major radius=the distance from the center of the disc to the tip of an arm.
- r, minor radius=distance from center of disc to interradial margin.
- Ray—see arm.
- Recurved hyaline epioral spine=large, heavy, semi-transparent spine on the surface of the mouth plate, directed away from the mouth. Found in Odontasteridae.
- Reticulate=skeleton of plates arranged in a loose network surrounding irregular plateless spaces.
- Sacculate=enveloped in tissue, as sacculate spines.
- Secondary plates=smaller plates between the primary or larger plates.
- Segmental pore=a tiny aperture between the adambulacrals in Pterasteridae.
- Skeletal arches—see costae.
- Skeleton=the hard, calcite elements of the starfish body.
- Spine=a spikelike, thornlike, or peglike external ornamentation.
- Spinelet, spinule=a small spine.
- Spiniform pedicellaria—see fasciculate pedicellaria.
- Spiraculæ=small round or irregular holes in the supradorsal membrane.
- Subambulacral=plate next to adambulacral on actinal surface.
- Suboral spine—see epioral spine.
- Sugar-tongs pedicellaria, excavate pedicellaria, alveolar pedicellaria=small pedicellaria with two slender, toothed valves, usually lying in an alveolus. Found mostly in the Ophidiasteridae.
- Superambulacral plate=an internal plate above the juncture of the ambulacral and adambulacral.

Superomarginal plates, superomarginals=marginal pertaining to the abactinal surface.

Supradorsal membrane=the external dorsal surface above the true abactinal surface. Found only in the Pterasteridae.

Tessellate=skeleton of flat plates fitting closely together, like a mosaic.

Tube feet, podia=soft locomotor organs, in two or four rows, within the ambulacral groove.

Tubercle=a large conical or low, rounded projection on a plate, not deciduous.

Valvate pedicellaria=see bivalved pedicellaria.

Ventral=see actinal.

### Key to the Orders of Asteroidea

1. Marginal plates usually large, conspicuous, defining ambitus; pedicellariae spiniform, pectinate, valvate, or excavate, never of basal piece and two valves; papulae restricted to abactinal surface (except in some Ophidiasteridae); abactinal surface paxillate, tessellate, or imbricate, never reticulate or absent .....2  
Marginal plates usually small, inconspicuous, not defining ambitus; pedicellariae straight and/or crossed, or absent; papulae frequently on all surfaces; abactinal surface reticulate, imbricate, or absent, never tessellate or truly paxillate.....4
2. Only one series of marginal plates; actinal plates in single transverse series, separated by continuous spinous fascioles from furrow to margin; arms five to many, flat, straplike; abactinal surface always paxillate ..... **Platyasterida**  
Two series of marginal plates; actinal plates not in single transverse series; arms always five; abactinal surface usually tessellate or imbricate (rarely paxillate) .....3
3. Mouth plates keeled, prominent, with median furrow; marginals either alternate or with intermarginal channels; pedicellariae usually spiniform or pectinate; abactinal surface usually paxillate ..... **Paxillosida**  
Mouth plates inconspicuous; marginals corresponding and without intermarginal channels; pedicellariae valvate, sunken in ossicles; abactinal surface usually tessellate or imbricate ....  
..... **Valvatida**
4. Mouth plates prominent, broad, unkeeled; no pedicellariae ..... **Spinulosida**  
Mouth plates not particularly broad; straight and/or crossed pedicellariae present and usually abundant .....5
5. Dorsal skeleton reticulate, plates not in regular series; ambulacral and adambulacral plates crowded and compressed; papulae on all surfaces ..... **Forcipulatida**  
Dorsal skeleton imbricate or in costae, never reticulate; papulae absent or confined to dorsal surface .....6
6. Disc domed, with definite arrangement of enlarged primary plates; arm plates in compact and imbricating longitudinal and transverse series; adambulacral plates alternating carinate and noncarinate; arms always five, not sharply distinct from disc ..... **Zorocallida**  
Disc plane, no enlarged primary plates; arm plates, not extending beyond proximal third of arm, usually in costae; adambulacral plates not carinate; arms always more than five, sharply distinct from disc ..... **Euclasterida**

#### Order PLATYASTERIDA Spencer, 1951

Plates in transverse series, at least on actinal surface; fascioles continuous from furrow to margin; only one series of marginals (none in certain fossils). Luidiidae is only living family.

#### Family LUIDIIDAE Verrill, 1899

Arms five to many, flat, strap shaped. Superambulacral plates present. Abactinal surface paxillate.

#### Genus *Luidia* Forbes

*Luidia* Forbes, 1839:123. [Type, by original designation, *L. fragilissima* Forbes=*L. ciliaris* (Philippi).]

*Hemicnemis* Muller and Troschel, 1840:105. [Type, by original designation, *L. ciliaris* (Philippi).]

*Petalaster* Gray, 1840:183 [Type, by original designation, *P. hardwickii* Gray.]

The genus *Luidia* is distinguished by its long, flat, straplike arms, small disc, absence of superomarginal plates, paxillar abactinal surface, and elongate inferomarginal plates extending from the ambitus

to the adambulacral plates. Inferomarginals, with a conspicuous fringe of inferomarginal spines, are present. This is mainly a shallow-water genus, species in this collection ranging from shore to 130

fathoms. All of the species are sand or sand/mud dwellers. They are generally more active and agile than other starfishes, and they feed principally on small molluscs and on other echinoderms.

### Key to the Species of *Luidia*

1. Arms nine ..... *L. senegalensis*  
Arms five or six ..... 2
2. Paxillae square or rectangular; skeleton compact and sturdy ..... *L. clathrata*  
Paxillae rounded; skeleton loose or fragile ..... 3
3. Arms banded or blotched with black ..... *L. alternata*  
Arms not banded or blotched with black ..... 4
4. Abactinal surface mostly black; marginal spines large, erect; pedicellariae numerous .....  
..... *L. sagamina*  
Abactinal surface gray or brown; marginal spines fine, not usually erect; pedicellariae few  
or none ..... 5
5. Inferomarginal plates with single long marginal spine and numerous small spines .....  
..... *L. barbadensis*  
Inferomarginal plates with three long tapering spines ..... *L. elegans*

#### *Luidia senegalensis* (Lamarck)

PLATE 1: FIGURES A, B

*Asterias senegalensis* Lamarck, 1816:255.

*Luidia senegalensis*.—Muller and Troschel, 1842:78, pl. 5: fig. 4.—Perrier, 1876a:262; 1878:34, 66–67, 91, 96–97.—Rathbun, 1879:149.—Sladen, 1889:246, 742.—H. L. Clark, 1898a:5; 1919:54, 71; 1933:20.—Doderlein and Hartmeyer, 1910:151.—Doderlein, 1920:238, 249–250, figs. 9, 20.—A. H. Clark, 1939:442.—Engel, 1939:3, 7.—Bernasconi, 1943:5–6.—Tommasi, 1958:9–11, pl. 2: fig. 2; 1970:8, fig. 21.—Cherbonnier, 1959:170.—Durand, 1959:21–22, fig. 2.—Engel and Schroevers, 1960:5.—Ummels, 1963:94–95, pls. 10, 11.

*Luidia marcgravi* Lutken, 1859:43–46.—Verrill, 1867:343; 1915:208–209.—Boone, 1933:76–77, pls. 33–36.

There are nine arms, and the abactinal surface is compact. The paxillae are square, in regular longitudinal and transverse rows, except in the mid-region of the arms and disc, where they are small and irregular. The center of the paxilla is compactly covered with small granules, and the periphery bears numerous fine spinules. The inferomarginal plates bear one or two (two in larger specimens) rather short, acute marginal spines, thickened near the base, sometimes curved, not at all flattened, usually more or less appressed to the arm. Below, the inferomarginals are covered with short flattened spines and spinules. The adambulacral plates bear two flattened, curved furrow spines, one above the other, the inner furrow spine

more slender than the outer one, and behind them are two stout spines, side by side. There are no actinal interradial plates, the very elongate inferomarginals in this region extending to the mouth. The jaws are narrow, projecting across the peristome, and armed with a tuft of stout spines. No pedicellariae were noted. The madreporite is concealed by paxillae.

Specimens in this collection are from 10–20 fathoms, from the northeast coast of South America. The species is known from Florida, the Antilles, and Senegal.

MATERIAL EXAMINED.—Oregon Stations: 2272 (4) [R=50 mm, r=9 mm; Rr=1.5]; 4472 (1) [R=? (all arms broken), r=20 mm; this specimen ingested a large *Cardium*, which caused the disc to appear much inflated].

#### *Luidia clathrata* (Say)

PLATE 1: FIGURES C, D

*Asterias clathrata* Say, 1825:142.

*Luidia clathrata*.—Lutken, 1859:37–39.—Gray, 1866:4.—Verrill, 1867:343; 1895:134; 1901:36; 1914:7, 31, pl. 103; 1915:200, pl. 24: fig. 2.—A. Agassiz, 1877:116, 117–119, pl. 20.—Perrier, 1878:34, 91, 95, 96.—Sladen, 1889:253, 742.—H. L. Clark, 1898a:5; 1901, p. 339, 343; 1919:54, 55, 71; 1933:19–20.—Doderlein and Hartmeyer, 1910:150–151.—Doderlein, 1920:238, 239, 251–252, figs. 1, 21.—A. H. Clark, 1939:442.—Caso,

1943:46-50, pl. 12: figs. 1-2, pl. 13: figs. 1-2; 1961:39-41.—Bernasconi, 1943:6-7, pl. 2: fig. 1.—Tommasi, 1958:9, pl. 2: fig. 1; 1970:8, fig. 22.—Cherbonnier, 1959:170.—Durand, 1959:21-23, pl. 3.—Engel and Schroevers, 1960:5.—Ummels, 1963:95-97, pls. 10-11.—Gray, Downey, and Cerame-Vivas, 1968:139, fig. 8.

There are five arms, and the skeleton is compact. The paxillae are square, in regular longitudinal and transverse rows except on the midregion of the arms and disc. The center of the paxillae is covered with granules, the periphery with fine spinules. The broad midregions of the arms and disc have small irregularly shaped and arranged paxillae. The inferomarginal plates bear one moderately long, curved, flattened marginal spine and one or two small spines above it, not appressed to the arm. Below, there is a covering of very short spines and spinules. The adambulacral plates have two furrow spines, one behind the other, laterally flattened and somewhat curved, the inner spine more slender than the outer one. Behind these are two spines, side by side, flattened in the plane of the furrow. A few actinal interradiial plates are present, one series extending a short distance on the arm. The oral spines form a thick cluster, and the jaws are covered with fine spinules. No pedicellariae were noted. The madreporite is concealed by paxillae.

Specimens in this collection are from 0-45 fathoms, from Cape Hatteras to northeastern South America and from the Gulf of Mexico. The known range is from New Jersey to Brazil. The color is usually light gray, with a darker gray stripe down the middle of the arm; however, specimens from the southern part of the range may be pastel. Also, the arms have a broader base; there are usually two or even three marginal spines, and an extra pair of side-by-side adambulacral spines may occur, especially proximally. These are not specific differences but geographic variations, of less than subspecific importance.

**MATERIAL EXAMINED.**—Oregon Stations: 1865 (1) [R=100 mm, r=12 mm, Rr=1:10]; 6300 (5) [R=77 mm, r=12.5 mm, Rr=1:7]; 3555 (1) [R=20 mm, r=6 mm, Rr=1:4]; 2272 (1) [R=54 mm, r=9 mm, Rr=1:5]; 2207 (1) [R=42 mm, r=9 mm, Rr=1:4]; 5894 (1) [R=67 mm, r=9 mm,

Rr=1:6]; Silver Bay Stations: 1515 (1) [R=24 mm, r=6 mm, Rr=1:4]; 35 (1) [R=90 mm, r=11 mm, Rr=1:9]; 1952 (1) [R=120 mm, r=6 mm, Rr=1:20].

### *Luidia alternata* (Say)

#### PLATE 2: FIGURES A, B

*Asterias alternata* Say, 1825:144-145.

*Luidia alternata*.—Lutken, 1859:42-43; 1871:301.—Verrill, 1867:343.—Perrier, 1876a:254; 1878:34, 91, 96.—Sladen, 1889:250-251, 740.—Ives, 1890:326.—H. L. Clark, 1898a:5; 1919:54, 55, 71; 1933:20, pl. 1.—Doderlein and Hartmeyer, 1910:151.—Doderlein, 1920:241, 267-268, figs. 7, 11.—Caso, 1943:56-57, pl. 16: figs. 1-2, pl. 17: figs. 1-2; 1961:44-47, figs. 11-12.—Engel and Schroevers, 1960.—Ummels, 1963:97-98, pls. 8, 10.—Gray, Downey and Cerame-Vivas, 1968: fig. 6.—Tommasi 1970: pl. 8: fig. 24.

*Luidia granulosa* Perrier, 1869:109.

*Luidia variegata* Perrier, 1876b:257.

This species has five arms, and the skeleton is not compact. The paxillae are small, high, and well separated, in regular rows along the side of the arm, irregular and compact in the middle of the arm and disc. The sides of the arms appear higher in this species because the paxillae of the second, third, or fourth row above the inferomarginals bear a stout acute spine. Similar spines may appear on a few other paxillae as well. Paxillae without a central spine have 1-8 central clavate spinules, and all paxillae have numerous subclavate peripheral spinules. The inferomarginal plates bear 2 or 3 long, acute, erect marginal spines, not at all flattened, and below, 2-5 moderately long, somewhat flattened spines; the channels between the inferomarginals are deep and bordered on each side by numerous fine spinules. The adambulacral plates bear a long, fine, curved, laterally flattened furrow spine and 2 or 3 other spines, long, acute, and not flattened. There may be small supplementary spines as well. The very few actinal interradiial plates usually bear pedicellariae. The mouth plates are prominent, each plate bearing a double row of short, stout, acute spines. Actinal pedicellariae, stout and three- or four-valved, are usually present. The madreporite is hemispherical, with fine shallow channels.

This is the only nonbrooding starfish showing what I believe to be sexual dimorphism. The female (the specimen from Oregon Station 5894) is

much larger, looser of skeleton, and bears many more pedicellariae.

The color in life is distinctive: blotched or banded in creamy white and black or brown. Specimens in this collection came from 0–20 fathoms, from Florida and the Caribbean. The range of the species is from Cape Hatteras to northern South America; it is not known from the western Gulf of Mexico.

**MATERIAL EXAMINED.**—Oregon Stations: 5894 (1) [R=115 mm, r=7 mm, Rr=1:17]; 1937 (1) [R=44 mm, r=6 mm, Rr=1:6]; 5456 (1) [R=56 mm, r=10 mm, Rr=1:5.6]; 3555 (1) [R=7 mm, r=3 mm, Rr=1:3].

### *Luidia sagamina* Doderlein

PLATE 2: FIGURES C, D

*Luidia sagamina* Doderlein, 1920:290, fig. 37.

*Luidia aciculata* Mortensen, 1933a:425, fig. 7, pl. 20; figs. 7–12.

*Luidia sagamina aciculata*.—Madsen, 1950:199, figs. 6–7.

There are five long arms, and the skeleton is moderately compact, the body flat. The paxillae are in irregular longitudinal and transverse rows, with a short, stout central spinule and 6 or 7 glassy, very thorny peripheral spinules. The inferomarginal plates have 2 or 3 long, rough-textured marginal spines, usually alternating 2–3–2–3. The upper spine is longest and is usually black at the base; paxillae also are mostly black. The channels between the inferomarginals are wide, bordered by long, fine spinules. The adambulacral plates have one slender, curved furrow spine, not flattened, and one other very much larger, long, acute, evenly tapered spine. There is only one actinal interradial plate, which bears a large three-valved pedicellaria; the valves of the pedicellariae are somewhat flattened at the tip. The jaws are armed with 4–6 long, rough spines and within the peristome on each side are two small, subequal blunt spines arising from a common furcate base. The madreporite is concealed by paxillae.

The distribution of this species is of considerable interest. Previously, it was known only from Sagami Bay, Japan (the type locality); Durban, South Africa; St. Helena; from Gaboon to Senegal in tropical West Africa; and the Cape Verde Islands. Madsen (1950) states that he could find no difference between the Japanese *L. sagamina* and

Mortensen's (1933) *L. aciculata* from St. Helena, but kept them separate for geographical reasons only. With this further extension of range, I do not believe such separation is justifiable. Although not common, *L. sagamina* may have a nearly worldwide distribution. A possible clue as to how this species became so widely distributed may be found in a report by Tokioka (1942) of a gigantic *Luidia* bipinnaria (12 mm) taken in the plankton near Seto, Japan. Mortensen (1939) stated that luidiids of the *ciliaris* group (to which *L. sagamina* belongs), with very large bipinnariae, have a free-swimming larval planktonic life of some months. These bipinnariae are, moreover, active swimmers, and it is possible that under particularly favorable conditions of currents, wind, etc., large actively swimming larvae could become very widely distributed, even though the adults are rather rare. Another specimen, examined after the above description was written, has been collected by the Duke University R/V *Eastward* off North Carolina.

**MATERIAL EXAMINED.**—Silver Bay Station 1515 (1) [R=8 mm, r=3 mm, Rr=1:2.5].

### *Luidia barbadensis* Perrier

PLATE 3: FIGURES A, B

*Luidia barbadensis* Perrier, 1876a:29; 1884:267, pl. 10: figs. 7, 8.—Verrill, 1915:205, pl. 24: fig. 1.—John and Clark, 1954:145.

*Luidia convexiuscula* Perrier, 1881a:30; 1884:268, pl. 10: fig. 6.—Verrill, 1915:207.—John and Clark, 1954:145.

This species has six long, slender arms. The skeleton is fragile. Paxillae are in regular longitudinal and transverse rows except in the midregion of the arms and disc; they have a uniform covering and peripheral border of 20–30 short, thorny, subclavate spinules. The inferomarginal plates have two long, tapering, acute spines, the upper one smaller than the lower, both somewhat curved. Below are 3–6 small spines; the channels between the inferomarginals are wide and shallow, with the bordering spinules long and few. The adambulacral plates bear a very long, slender furrow spine, behind which is a row of three obliquely placed unequal spines, and behind them another row of two spines, frequently replaced by a large three-valved pedicellaria. The actinal interradial area has 3–6 large, stout three- or four-valved pedicel-



lariae, around the bases of which are fringes of spinules. The jaws are concealed by a bundle of numerous long stout spines. The madreporite, barely visible beneath the paxillae, is flat and covered with deep gyri.

Specimens in this collection were collected in 65–80 fathoms, in the Gulf of Mexico west of the Florida Keys. The known range is from Florida to Venezuela.

MATERIAL EXAMINED.—*Alaminos* Stations: 20/65–A–9 (1) [R=75 mm, r=5 mm, Rr=1:15]; 21/65–A–9, arm fragments.

### *Luidia elegans* Perrier

PLATE 3: FIGURES C, D

*Luidia elegans* Perrier, 1876a:256; 1884:269.—Verrill, 1880:403; 1895:134; 1915:203, pl. 16: figs. 4, 4a, pl. 29: fig. 1.—Gray, Downey, and Cerame-Vivas, 1968:140, fig. 9.

This species has five arms, and the skeleton is loose and fragile. The paxillae are small, high, in vaguely transverse rows on a narrow portion of each side of the arms, but otherwise quite irregularly distributed. They have one central and 7–15 peripheral slender spinules of moderate length, not acute; the central spinule on certain disc paxillae is sometimes replaced by a small, blunt, two-valved pedicellaria. The inferomarginal plates have two or three (alternating 2–3–2–3) long, stout, straight, evenly tapered, acute marginal spines, and below a few tiny spinules and sometimes one or two small spines. The adambulacral plates have a stout, curved furrow spine, and behind it two long, stout, tapering spines, one above the other. Between the adambulacral and inferomarginal plates there is usually a stout, blunt-tipped, two- or three-valved pedicellaria. The actinal interradial area bears a number of these short, blunt, two-valved pedicellariae. The jaws have two very large, stout, oral spines, behind which are two rows of 3–7 spines diminishing in size distally, the outer row much smaller than the inner one. Within the peristome, each mouth plate bears a large pedicellaria. The madreporite is hemispherical, covered with bumps rather than gyri.

This species was taken in 100–130 fathoms, in the western Gulf of Mexico, a westward extension of the range. It does not occur in very shallow

water. The previously known range was from Martha's Vineyard to the eastern Gulf of Mexico and the West Indies.

MATERIAL EXAMINED.—*Oregon* Stations: 1514 (2) [R=77 mm, r=10 mm, Rr=1:7]; 1519 (2) [R=83 mm, Rr=1:10]; 1513, arm fragments.

### Other Tropical-Subtropical Species of *Luidia* Not Represented in This Collection

Only three other *Luidias*, not taken in these collections, are reported from the area here included. *L. bernasconiae* A. H. Clark (1945) is a perfectly valid species, despite A. M. Clark's placing it in the synonymy of *L. alternata* in her otherwise excellent paper (1951a). It differs from *L. alternata* in having 5–10 clavate peripheral spinules on the paxillae vs 10–16 slender, acute ones on *L. alternata*, and there are two adambulacral spines in *L. bernasconiae*, vs 3–4 in *L. alternata*. Pedicellariae are abundant on *L. bernasconiae*, and are shorter and broader than in *L. alternata*.

The other two species, interestingly enough, were collected in the same dredge-haul by the *Rosaura* expedition. *L. rosaurae* John and Clark (1954) is closely allied to *L. barbadensis*, but where *L. barbadensis* has six arms, *L. rosaurae* has only five. *L. rosaurae* has both dorsal and ventral pedicellariae, but *L. barbadensis* has only ventral ones. *L. barbadensis* has two marginal spines, *L. rosaurae* only one. The third species, *L. barimae* John and Clark (1954), is ten-rayed; the skeleton is loose and fragile, and none of the paxillae are arranged in regular rows.

A fourth species, *L. atlantidae* Madsen (1950), from western and northwestern Africa, has not been reported in the literature from the western Atlantic, but I have seen specimens collected off the coast of North Carolina south of Cape Fear, and specimens have also been taken in the Florida area (Halpern, personal communication).

### Order PAXILLOSIDA Perrier, 1884

Mouth plates prominent, with keel and median furrow. Actinal interradial area with small ossicles. Plates not in transverse series. Ambulacral areas not compressed. Tube feet in two rows.

### Key to the Families of Paxillosida

1. Aboral surface paxillate; oral interradial area with flat ossicles extending onto arms; cribriform organs or specialized marginal fascioles present; papulae scattered over most of abactinal surface; no dorsal muscle bands on arms; tube feet in two rows, pointed.....2  
 Abactinal surface with simple flattened plates carrying few spinelets; oral interradial plates not extending onto arms; marginals alternate, without fascioles or cribriform organs; papulae confined to base of arms and disc, frequently in localized papularia; pair of dorsal muscle bands on arms; tube feet in two rows, suckered.....**Benthopectinidae**
2. Cribriform organs present, continuous with actinal channels bordered by webbed spinelets; spinelets of abactinal paxillae webbed; marginals covered with smooth membrane; disc broad .....**Goniopectinidae**  
 Marginal fascioles present; paxillar spinelets not webbed; marginals not covered with smooth membrane; disc small .....**Astropectinidae**

#### Family ASTROPECTINIDAE Gray, 1840

Disc small; arm long, pointed, straight-sided (rarely petaloid). Marginal fascioles present. Aboral sur-

face paxillate. Oral interradial areas with flat ossicles extending onto arms. Superambulacral plates present. Tube feet pointed, ampullae double.

### Key to the Genera of Astropectinidae

1. Madreporite large, and superomarginals confined to aboral surface, with inferomarginals defining the ambitus .....**Dipsacaster**  
 Either one of above conditions, but not both .....2
2. Inferomarginals not separated from adambulacral plates by actinal intermediate plates.....**Astropecten**  
 Inferomarginals separated from adambulacrals for part or whole of ray by actinal intermediate plates .....3
3. Superomarginals thin and confined to side of ray.....**Dytaster**  
 Superomarginals not thin and confined to side of ray .....4
4. Actinal interradial areas small .....6  
 Actinal interradial areas large .....5
5. Madreporite concealed by paxillae .....**Plutonaster**  
 Madreporite naked and large .....**Tethyaster**
6. Actinal spinelets sacculate .....**Psilaster**  
 Actinal spinelets not sacculate .....7
7. Odd interradial actinal intermediate plates present .....**Blakiaaster**  
 No odd interradial actinal intermediate plates .....**Persephonaster**

#### *Astropecten* Gray

*Astropecten* Gray [from Linck, 1733], 1840:180. [Type, by subsequent designation, *Asterias aranciatus* Linnaeus=*A. aurantiacus* Tiedemann (Fisher, 1908:93).]

*Stellaria* Nardo, 1834:716. [Type, by monotypy, *S. aurantiaca*. Invalidated by *Stellaria* Møller.]

*Asterias* L. Agassiz [non Linnaeus], 1835b:168. [Type, by original designation, *A. aurantiaca* Linnaeus.]

*Astropectinides* Verrill, 1914:321. [Type, by original designation, *A. mesacutus* (Sladen).]

Conspicuous marginal plates, ambital fringe of spines, paxillate dorsal surface, few or no actinal interradial plates; inferomarginal spines born on

horseshoe-shaped tubercles; inferomarginal and superomarginal plates opposite, usually massive, never overlapping; superomarginals encroach more or less upon aboral surface, inferomarginals frequently project beyond them; arms normally five, body flat; distinct fascioles between marginal plates; equal number of adambulacral, inferomarginal, and superomarginal plates; adambulacral plates bear 3 or 4 furrow spines in a longitudinal row, additional spines on actinal face of plate; pedicellariae rare.

There are over 150 known species of *Astropecten*, mostly from tropical and subtropical waters. They occur in shallow to moderate depths, princi-

pally on sandy or shelly bottoms. Their food consists mainly of small molluscs. Doderlein monographed the genus in 1917, but unfortunately, this

paper is now somewhat out of date. The genus has an extensive fossil record, reaching back possibly to the Upper Cretaceous.

### Key to the Species of *Astropecten*

1. Marginals spinous, superomarginals concave..... *A. americanus*  
Marginals granulose, superomarginals convex ..... 2
2. Two basal superomarginals (and frequently other proximal superomarginals) with single large stout spine ..... *A. duplicatus*  
No spine or tubercle on proximal superomarginals ..... 3
3. Single spine on distal superomarginals..... *A. articulatus*  
No spines or tubercles on any superomarginals..... 4
4. Body extremely flat, arms broad-based, inferomarginals projecting far beyond superomarginals ..... *A. marginatus*  
Body not particularly flat, arms not broad-based, inferomarginals scarcely or not at all projecting beyond superomarginals ..... 5
5. Superomarginals very numerous (over 40)..... *A. comptus*  
Superomarginals few (25 or less) ..... 6
6. Adambulacral spines small ..... *A. cingulatus*  
Adambulacral spines long, slender..... *A. nitidus*

### *Astropecten americanus* (Verrill)

PLATE 4: FIGURES A, B

*Archaster americanus* Verrill, 1880:402; 1885:542.

*Astropecten americanus*.—Verrill, 1894:255; 1895:133; 1915:184, pl. 16; figs. 1, 1a.—Doderlein, 1917:106, pl. 2; fig. 11, pl. 9; figs. 9, 9a, 9b.—Gray, Downey, and Cerame-Vivas, 1968:143, figs. 13, 14.

The five arms are long, narrow, and taper evenly to an acute terminus. Paxillar areas on the arms are very narrow, less than the width of the supermarginals. Paxillae are small, high, set in the dorsal membrane, and not usually in contact with one another. The 6–10 moderately long peripheral spinules of the paxillae are not acute; in preserved specimens they are usually erect, and paxilla and spinules together look like a paint brush. The papular pores between the paxillae are moderately large. At the side of the arms, the paxillae are in transverse rows, and they diminish in size from the disc to the end of the arm. The superomarginal plates are tumid and wedge shaped in the interradius, but on the arms they are square and flat or slightly concave. They have a sparse covering of tiny spinules. The inferomarginals project strongly beyond the superomarginals; they bear two long, slender, acute marginal spines, somewhat curved and usually appressed to the arm and directed outward and upward. The lower spine is

generally smaller than the upper one. In the interradial area, these spines are flattened and blade-like. Below, the inferomarginals are covered with tiny acute spines and spinules. The three adambulacral furrow spines are flattened laterally, the central one is the largest, and behind them is a small group of spines, sometimes replaced by a large three-valved pedicellaria, especially proximally. The mouth plates are long, narrow, and prominent; each bears a row of small spinules, and on either side of the jaw are two rows of moderately long fine spinules.

In life, this species is a lively reddish brown. It is perhaps the most abundant western Atlantic species; in places, it literally paves the ocean floor. Specimens in this collection came from 150–230 fathoms. This species does not occur in shallow water; it was taken in the Gulf of Mexico, off Cape Hatteras, and off Guyana.

MATERIAL EXAMINED.—*Alaminos* Stations: 10/68–A–13 (1) [R=72 mm, r=9 mm, Rr=1:7]; 9A/68–A–7 (1) [R=56 mm, r=9 mm, Rr=1:5]; 7/68–A–13 (2). *Oregon* Stations: 382 (1) [R=82 mm, r=12 mm, Rr=1:8]; station unknown (1) [R=81 mm, r=9 mm, Rr=1:8]; 4302 (13) [R=20 mm, r=4 mm, Rr=1:5]; 1509 (3). *Silver Bay* Station 2863 (1) [R=24 mm, r=5 mm, Rr=1:5].

*Astropecten articulatus* (Say)

PLATE 4: FIGURE C, D

*Asterias articulatus* Say, 1825:141.

*Astropecten articulatus*.—Muller and Troschel, 1842:72.—Lutken, 1864:128, 129.—Verrill, 1868:343; 1885:40, 77; 1895:133; 1915:159.—Perrier, 1876b:290.—A. Agassiz, 1877:114, pl. 19: figs. 1–8.—Ives, 1891:337, pl. 16: figs. 4–8.—H. L. Clark, 1898a:4.—Fontaine, 1953:181, fig.—Cherbonnier, 1959:320–322, pl. 7.—Engel and Schroevers, 1960:2.—Hulings and Hemlay, 1963:354–359.—Dragovich and Kelly, 1964:91.—Gray, Downey and Cerame-Vivas, 1968:143, fig. 15.—Tommasi, 1970:6, fig. 17.

*Astropecten dubius* Gray, 1840:182; 1866:4.*Astropecten articulatus duplicatus*.—Roa, 1967:277, fig. 6.

The five arms of this species are moderately long, high on the side, and not at all acute. The paxillar areas on the arms are about twice the width of the marginals and very compact. The paxillae are in regular transverse rows except in the midregion of the arm and on the disc; they have a uniform covering of granuliform spinules and are very close together, giving an even granulate appearance to the entire dorsum. Supermarginals are higher than wide, with a uniform covering of granules. The interradial supermarginals never bear spines, but some on the arms may bear a small tuberculate spine. The inferomarginal plates do not project beyond the supermarginals. They bear a pair of flattened spines, side by side, and there is frequently a third tiny spine proximal to them. Below, they are covered with small spines and spinules. There are a few tiny actinal interradial plates (never more than six), bearing a small, central spine and surrounded by tiny fine spinules. The adambulacral plates have 3 or 4 slender furrow spines, side by side; behind them are two larger, flattened, truncate spines, also side by side, and behind them are three smaller similar spines. The mouth plates are prominent, elongate, and covered with small short spines. On either side there is a double row of spinules, and at the apex a cluster of short, thick, blunt spines. The madreporite is conspicuous, round, flush with the dorsal surface, and covered with fine gyri.

The known range of this species is from Chesapeake Bay to Colombia, including the Gulf of Mexico. Specimens in this collection came from 0–100 fathoms, mostly from around Florida. In life, this species is usually bright blue or purple, with conspicuous yellow or orange marginals.

MATERIALS EXAMINED.—Oregon Stations: 5894 (1) [R=84 mm, r=14 mm, Rr=1:8]; 2164 (2) [R=70 mm, r=14 mm, Rr=1:6]. *Silver Bay* Station 35 (1) [R=73 mm, r=14 mm, Rr=1:7].

*Astropecten cingulatus* Sladen

PLATE 5: FIGURES A, B

*Astropecten cingulatus* Sladen, 1889:218, pl. 35: figs. 5, 6, pl. 39: figs. 1–3.—Verrill, 1915:178.—Bernasconi, 1941:42, pl. 7: figs. 1–2; 1958a:130–131, pl. 3: figs. 1–2; 1961:22, pl. 1: fig. 2; 1966:161–162.—Engel and Schoevers, 1960:3.—Tommasi, 1970:5, fig. 16.

This compact five-armed species has a relatively small paxillar area. The paxillar area on the arms is less than half the width of the massive supermarginals, and somewhat sunken below them. The paxillae are high and, on the arms, flattened longitudinally. They are compact on the disc, less so on the arms. They have 1–3 central granules and 7–11 peripheral clavate spinules. The supermarginals are massive and tumid and encroach quite far on the dorsal surface; they are covered with granules, those on the outer half of the plate usually larger than those on the inner half (but sometimes the other way around). The channels between the plates are bordered with many fine setiform spinules. The inferomarginals project very slightly beyond the supermarginals and bear three flattened marginal spines of moderate length. Below, the plates are bare, save for a few acute spinules. The adambulacral plates bear 3 or 4 furrow spines parallel to the furrow, the central one large, sturdy, and curving slightly inward toward the furrow.

The actinal face of the plate bears one long acute tapering spine, and, usually, 1–3 tiny spinelets. The mouth plates are small and narrow, covered with spinules, and with a cluster of small, blunt oral spines. The madreporite is very small, round, covered with deep gyri, and almost touching the interradial marginals.

The depth range of this species in this collection is 30–50 fathoms, and all are from the Gulf of Mexico. The range is Cape Hatteras to Brazil.

MATERIAL EXAMINED.—Oregon Stations: 1495, (2) [R=31 mm, r=10 mm, Rr=1:3]; 2, (1) [R=8 mm, r=5 mm, Rr=1:1.5]; 102 (3) [R=55 mm, r=10 mm, Rr=1:5]; 123 (3) [R=50 mm, r=10 mm, Rr=1.5]. *Silver Bay* Station 2432, (1) [R=23 mm, r=8 mm, Rr=1:3].

*Astropecten comptus* Verrill

PLATE 5: FIGURES C, D

*Astropecten comptus* Verrill, 1915:176, pl. 12: figs. 3–3c, pl. 22: fig. 1.

The five arms in this species are moderately long and slightly constricted at the base. The very even granular appearance of the dorsum and superomarginal plates is strongly reminiscent of *A. articulatus*, but the arms are longer and narrower and taper to a more acute point. The paxillae have 4–10 central granules and 9–15 peripheral clavate spinules. The first three or four series of paxillae on the arms are in regular transverse rows. The superomarginal plates, evenly covered with granules, are higher than wide, particularly in the interradius, forming a high side to the arms. The inferomarginal plates project slightly beyond the superomarginals and bear two flattened curved spines, side by side. Below, they bear numerous small spines and spinules. The adambulacral plates bear three long slender furrow spines, flattened in the plane of the groove, and behind them are two shorter but broader truncate spines, side by side; behind these are about three small spines. The mouth plates are short and narrow, covered with moderately long spines and with a cluster of short, flat oral spines at the apex. The madreporite is small, round, and covered with coarse gyri.

Specimens in this collection are from 10–30 fathoms, from around Florida. The known range is Cape Hatteras to Cuba, and the Gulf of Mexico.

**MATERIAL EXAMINED.**—*Oregon* Stations: 1648 (1) [R=61 mm, r=12 mm, Rr=1:6; 4806 (1) [R=53 mm, r=8 mm, Rr=1:7. *Silver Bay* Station 2775 (4) [R=16 mm, r=5 mm, Rr=1:3].

*Astropecten duplicatus* Gray

PLATE 6: FIGURES A, B

*Astropecten duplicatus* Gray, 1840:185; 1866:3.—Perrier, 1876b:271.—Verrill, 1915:165, pl. 22: fig. 2, pl. 23: figs. 1, 2.—H. L. Clark, 1898a:5.—Gruvel, 1909:1018.—Boone, 1928: 5.—Fontaine, 1953: pl. 181; fig.—Cherbonnier, 1956:322–323; 1959:108–109, fig. 1.—Caso, 1961:27–29, fig. 4.—Gray, Downey and Cerame-Vivas, 1968:144, fig. 16.

*Astropecten valenciennii* Muller and Troschel, 1842:68.

*Astropecten variabilis* Lutken, 1859:51.—Verrill, 1867:343.—

A. Agassiz, 1869.—Field, 1893:82.—Loriol, 1899:16, pl. 2.

*Astropecten articulatus duplicatus*.—Roa, 1967:277, fig. 6.

The five arms of this species are of moderate length and taper to a rather acute point. The paxillar area on the arms is about twice the width of the superomarginal plates. Paxillae are in regular transverse rows on the arms, and bear 15–25 capitate spinules. The superomarginal plates are higher than wide, extending above the paxillar surface, and the midportion of each plate is covered with spherical granules, while the sides bear numerous uniform fine blunt spinules. In the interradius, the first pair of superomarginals (and usually a few on each side of them) bear a stout tuberculate spine on the inner edge of the upper surface; superomarginals on the arms may bear a similar smaller spine on the outer edge of the upper surface. The inferomarginal plates extend beyond the superomarginals; each bears a single large, flattened spine and beside it a much smaller spine. Below, the inferomarginal plates bear a dense covering of flattened spines and spinules. The central furrow spine of the adambulacral plates is laterally flattened, with a rounded tip, and flanked by two shorter truncate spines. Behind the furrow spines are two truncate spines, the distal one large and flattened in the plane of the groove. Behind these are 2 or 3 small spines. The mouth plates are thickly covered with small blunt spines. The madreporite is small, round, evenly covered with deep gyri.

This spinous *Astropecten* ranges from shallow water to over 300 fathoms; it occurs all over the Gulf of Mexico and the Caribbean, and north to Cape Hatteras.

**MATERIAL EXAMINED.**—*Oregon* Stations: 3602 (1) [R=19 mm, r=7 mm, Rr=1:3]; 4089 (2) [R=15 mm, r=4 mm, Rr=1:4]; 2243 (1) [R=20 mm, r=5 mm, Rr=1:4]; 3555 (2) [R=29 mm, r=7 mm, Rr=1:4]; 5920 (12) [R=34 mm, r=9 mm, Rr=1:4]; 4472 (2) [R=33 mm, r=6 mm, Rr=1:5]; 150 (27) [R=15 mm, r=5 mm, Rr=1:3]. *Oregon II* Station 10499 (3) [R=2 mm, r=5 mm, Rr=1:4]. *Silver Bay* Station 1953 (2) [R=45 mm, r=11 mm, Rr=1:4].

*Astropecten marginatus* Gray

PLATE 6: FIGURES C, D

*Astropecten marginatus* Gray, 1840.—Kenk, 1944:185, figs. 2, 5.—Cherbonnier, 1956:320.—Bernasconi, 1957:67–68, pl. 2: figs. 3, 4.—Tommasi, 1959:14, pl. 2: fig. 5; 1970:5, fig. 15.—

Brito, 1960:8, pl. 2: fig. 1.—A. M. Clark, 1962; fig. 30a.—Roa, 1967:267.

An extremely flat and thin-bodied species, this five-armed starfish has a larger disc area than most astropectinids. The short arms taper rapidly to an acute point. The small paxillae are in regular transverse rows except for a narrow section on the midarm and disc. The paxillae have 3–6 central granules and 8–16 peripheral subclavate spinules. The superomarginal plates are higher than wide and confined to the dorsal surface; they are covered with an even coating of small spaced granules, and the channels between are bordered by fine uniform spinules. The inferomarginals project strongly beyond the superomarginals and the upper edge of the plate thus exposed is covered with granules continuous with those of the superomarginals. The inferomarginal plates bear two subequal, slightly curved marginal spines, not flattened, and proximally, one tiny blunt spine. Below, the long narrow inferomarginals bear a row of 4 or 5 moderate long acute spines on their outer edge (under the marginal spines) and a few scattered acute spines elsewhere. A single row of small spinules borders the channels between the inferomarginals. The adambulacral plates bear three blunt slender furrow spines, the middle one slightly longer, and one acute spine of about the same length on the actinal face. On either side of the plate is a row of small spinules continuous with and similar to those bordering the channels between the inferomarginals.

The narrow mouth plates are covered with short stout spines and there are two rows of longer truncate oral spines. The madreporite is moderately large, flat, round, and covered with radiating gyri.

All these specimens occurring in this collection, from 20–30 fathoms, are from northeastern South America; the normal range also includes Puerto Rico, so presumably the species will be found also in the Lesser Antilles.

MATERIAL EXAMINED.—*Oregon* Stations: 2209 (1) [R=55 mm, r=15 mm, Rr=1:5]; 2226 (1). *Oregon II* Stations: 10502 (2) [R=45 mm, r=12 mm, Rr=1:4]; 10507 (1) [R=41 mm, r=10 mm, Rr=1:4].

### *Astropecten nitidus* Verrill

PLATE 7: FIGURES A, B

*Astropecten nitidus* Verrill, 1915:179, pl. 10: fig. 2.—Gray, Downey, and Cerame-Vivas, 1968:145, fig. 17.

*Astropecten nitidus forcipatus* Verrill, 1915:180, pl. 16: fig. 3, pl. 20: fig. 1.

The five arms of this species are long, narrow, and tapered very little. The paxillar areas are narrow, about the width of the superomarginals, and the paxillae are in regular transverse rows on the arms. The paxillae have 1–9 blunt central spinules, and 6–15 peripheral ones, also blunt. The superomarginal plates are higher than broad, not forming high sides to the arms but encroaching quite far on the dorsal surface. They are covered with numerous, small, flattened granules and, around the edge, with many fine spinules. The inferomarginal plates extend beyond the superomarginals and each bears two long, acute, slightly curved marginal spines, appressed to the arm and directed upward and distad. Below, they bear a few long, slender, acute spines and some fine tiny spinules. The adambulacral plates have three subequal, flattened furrow spines and behind them are two groups of smaller spines or one group of spines and a large conical pedicellaria. There is a single row of actinal interradial plates, not extending beyond the first inferomarginals, which are usually armed with either a large conical pedicellaria or a group of small spines. The short narrow jaws are covered with small spines and spinules and bear at their apex a pair of flattened oral spines, with a group of shorter flattened spines behind them. The madreporite, located very near the border, is tiny and concealed by paxillae.

Verrill (1915) distinguished a variety which he called *Astropecten nitidus forcipatus*; it is by no means a subspecies, as it varies from the species only in number of pedicellariae (a very unstable character in astropectinids) and its vertical and horizontal ranges fall well within the limits for the species. The range of this species is from Cape Hatteras to the Gulf of Mexico, in 20–200 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 1514 (1) [R=15 mm, r=4 mm, Rr=1:4]. 5913 (2); 4928 (1); 6699 (1) [R=38 mm, r=7 mm, Rr=1:5]; 4398 (12); 1890 (1) [R=27 mm, r=6 mm, Rr=1:4]. *Alaminos* Station 20/65-A-9 (5) [R=40 mm, r=9

mm, Rr=1:4]. *Silver Bay Station 2453* (1) [R=33 mm, r=7 mm, Rr=1:5]. *Combat Station 180* (1).

#### Other Species of *Astropecten* Not Taken in These Collections

Of the four other *Astropectens* reported from the area included in this report, the most puzzling "absentee" from this collection is *A. nuttingi* Verrill, 1915. This common species ranges from North Carolina to Florida, in depths of 90–225 fathoms. It somewhat resembles *A. americanus*, but the shape is more regularly stellate, with broader arms and a wide paxillar area. The superomarginals bear 1 or 2 small spines on the upper side, and the paxillae are stellate.

*A. alligator* Perrier, 1881a, may be the same species, but Perrier's description is not clear, and I have not had an opportunity to examine the type. The same is true of *A. richardi* Perrier, 1876b, which may possibly be a synonym of *A. articulatus*, and *A. antillensis* Lutken, 1859, which Verrill believed to be a local variety of *A. duplicatus* and

H. L. Clark considered a synonym of *A. marginatus*. Also, *A. ciliatus* Grube, 1857, is probably a junior synonym of *A. marginatus*; it has been reported from Puerto Rico, which is in the known range of *A. marginatus*.

#### *Psilaster* Sladen

*Psilaster* Sladen, 1885:611. [Type, by original designation, *Astropecten andromeda* Muller and Troschel.]

*Phidiaster* Koehler, 1909a:28. [Type, by monotypy, *P. agassizi* Koehler.]

Superomarginals massive, unarmed, encroaching far onto dorsal surface, covered with granules or scales; two series of spines or spinules behind furrow series on adambulacral plates; paxillae rather crowded, at least on disc; inferomarginal spines usually appressed to arm; actinal interradial area of moderate size, its plates covered with spinules; fascioles quite shallow; madreporite small.

The genus is distributed worldwide, in moderately deep waters. These starfishes, like most astropectinids, feed mainly on small molluscs.

#### Key to the Species of *Psilaster*

- Actinolaterals extending far out on arm ..... *P. cassiope*  
Actinolaterals not extending beyond the 5th or 6th inferomarginal ..... *P. patagiatus*

#### *Psilaster cassiope* Sladen

PLATE 7: FIGURES C, D

*Psilaster cassiope* Sladen, 1889:228, pl. 41: figs. 1, 2, pl. 7: figs. 9, 10.—Madsen, 1950:187.

*Psilaster andromeda* var. *cassiope*. Grieg, 1907b:13.

*Psilaster squameus* H. L. Clark, 1941:17–18, pl. 2: fig. 1.

This robust species has five arms that taper smoothly to an acute point. The disc is broad, and the paxillar area on the arms, relatively broad at the base, becomes extremely narrow by the end of the arm. The oval paxillae are in regular transverse rows across the arm, not compact, and small. They are short and bear a flat even covering of 15–25 granules. The massive superomarginal plates are about twice as high as broad and encroach quite far on the dorsal surface. They are covered with spaced squamiform granules, and the shallow channels between the plates are filled with fine spinules. The inferomarginal plates, with similar

but fewer granules, bear, near their edge, an oblique row of 2 or 3 small, acute, flattened spines, appressed to the arm and directed upward. The interradial actinal areas, of moderate size, are covered with flattened, squamiform spinules. A single row of actinolateral plates extends more than two-thirds the length of the arm. The furrow margin of the adambulacral plates bears a chevron of 7 or 8 flattened spines, and behind them, on the actinal face, are a few more flattened, much shorter spines. The mouth plates bear, in the center, a few granuliform spinules and, on either side, two uniform rows of small, short, contiguous spines. There are two short, flattened, oral spines. The madreporite is small, round, and covered with deep gyri.

Occurring at about 400–500 fathoms, one specimen off the Mississippi Delta, one off Venezuela, and several in the western Gulf, this species was previously reported from Cuba by H. L. Clark, as *P. squameus*. The differences between his speci-

mens and Sladen's are too minor to constitute specific characters; Clark also seems to have misinterpreted Sladen's figures of *P. cassiope*. However, Clark did concede that his specimens were possibly *P. cassiope*, which, of course, they are. Although Grieg (1907b) regarded *P. cassiope* as a variety of *P. andromeda*, the two species are clearly different, on the basis of granulation of the marginals, armature of the adambulacrals, and general facies.

The specimen from off Colombia (*Oregon* Station 4855) has unusually broad superomarginal plates, encroaching much further onto the abactinal surface than they do in the specimens from the Gulf of Mexico. It is an altogether more robust-looking starfish, and the arms, although broken, obviously did not taper as sharply to an acute point as in the Gulf specimens. Despite the difference in general appearance, however, there are no specific differences.

**MATERIAL EXAMINED.**—*Oregon* Stations: 3654 (1) [R=22 mm, r=7 mm, Rr=1:3]; 4855 (1) [R=82 mm, r=19 mm, Rr=1:4]. *Alaminos* Stations: 24/68-A-13 (1) [R=22 mm, r=6 mm, Rr=1:3]; 1/68-A-13 (3) [R=82 mm, r=17 mm, Rr=1:7]; 27/69-A-11 (1) [R=47 mm, r=11 mm, Rr=1:4].

### *Psilaster patagiatus* Sladen

PLATE 8: FIGURES A, B

*Psilaster patagiatus* Sladen, 1889:232, pl. 41: figs. 3, 4, pl. 7: figs. 11, 12.

*Psilasteropsis patagiatus*. Koehler, 1907:29.—Farran, 1913:7.—Grieg, 1932:19.

This robust species has five arms of moderate length, tapering smoothly to an acute point. The paxillar area on the medium-sized disc is somewhat reduced by the intrusion of the massive superomarginal plates, and still further reduced on the arms. The small paxillae are in regular transverse rows on the arms; they have 1–6 central and 12–18 peripheral spinules, small, acute, and frequently all erect and in contact, like a wet paintbrush. The superomarginal plates are large and encroach far onto the dorsal surface. They are higher than wide and are covered sparsely with small round granules, mostly concentrated in the center of the plate. The fascioles between the plates are shallow, and, on the arms, the plates fit so closely that there are no fascioles. The inferomarginal plates have granules

similar to those of the superomarginals and, in addition, bear 2 or 3 small, flattened, acute spines, appressed to the arm and directed upward. The adambulacrals plates, nearly square on their actinal face, bear a furrow series of 7 or 8 slender contiguous spines and behind them a few small spinelets. The actinal interradial areas have about six chevrons of polygonal plates, none extending beyond the fifth or sixth inferomarginal. They are covered with small spinules. The jaws are prominent, with regular series of small, blunt spines and, at their apex, two larger, heavy, blunt, oral spines.

Inside the mouth, on the abactinal surface of the jaw plates above the oral spines, is a row of spines similar to the furrow spines of the adambulacrals. These in no way resemble the small group of supraoral spines in *Persephonaster* except in position. The madreporite is small and surrounded by a series of slightly enlarged paxillae.

The two lots in this collection are from off Louisiana and off Venezuela, in 400–500 fathoms. It seems odd that both this species and the previous one should be recorded by Sladen from the Cape Verde Islands; I would suspect some error in labeling.

**MATERIAL EXAMINED.**—*Oregon* Station 4416 (2) [R=64 mm, r=18 mm, Rr=1:5]. *Alaminos* Station 11A/68-A-7 (3) [R=24 mm, r=9 mm, Rr=1:3].

### Other Atlantic Species of *Psilaster*

Other species of *Psilaster* reported from the North Atlantic include *P. andromeda* (Muller and Troschel) and *P. floriae* (Verrill), from the east and west North Atlantic respectively, north of 35°, and thus outside the range covered by this report; they are probably one and the same species. They differ from *P. cassiope* and *P. patagiatus* mainly in having the marginals vertical, almost entirely confined to the sides of the arms.

### *Persephonaster* Wood-Mason and Alcock

*Persephonaster* Wood-Mason and Alcock, 1891:430. [Type, by original designation, *P. croceus*.]

*Psilasteropsis* Fisher, 1906:1023. [Type, by original designation, *P. cingulatus* Fisher.]

For the present, it was thought best to leave this genus and the two species in the previous genus



(*Psilaster*) in the genera assigned by the original authors; however, considerable confusion exists as to what really constitutes *Persephonaster* or *Psilaster*. *Psilaster* is probably a perfectly good genus, and most of the species in it are probably correctly assigned, but *Persephonaster*, ill-defined to begin with, has had assigned to it by various authors some species which rightly belong to *Psilaster*, some which may be correctly assigned, and a few which probably constitute a third genus. The problem is insoluble without examination of the types of the species in these two genera; unfortunately, type specimens of many of the species, including the three species originally assigned to *Persephonaster* by Alcock, are in the Indian Museum and therefore unavailable to anyone outside India. Alcock (1893a) restricted the definition of the genus without solving these problems.

### *Persephonaster echinulatus* Clark

PLATE 8: FIGURES C, D

*Persephonaster echinulatus* H. L. Clark, 1941:20, pl. 3: fig. 2.

The five slender arms taper evenly to an acute point. The abactinal surface is plane, and the paxillae are not crowded; on the arms, there are frequently large bare spaces between them. The small paxillae bear 4–8 long slender spinules; occasionally, especially on the proximal parts of the arms, a paxilla may be replaced by a two-, three-, or four-valved simple pedicellaria of stout bent spines. The superomarginal plates are, at least in the interradiar area, confined almost wholly to the sides of the disc, and the inner margin bears a stout erect spine or group of coalesced spinules (on the arms, the position of the superomarginals depends on the stretching or contraction of the abactinal membrane). The rest of the plate is covered with a fine furlike covering of slender spinules, especially fine, numerous, and long in the wide sulci between the plates. The inferomarginals, with a similar but sparser covering of fine spinules, have their distal edge slightly overlapping the plate ahead, and a ridge down the center of the plate bears 2–4 long slender spines appressed to the arm and directed forward, overlapping the plate ahead.

The actinal interradiar area has four rows of elongate imbricate plates; beyond them are several rows of two or three rounded plates, and a single

row of actinolateral plates continues almost to the end of the arm; all these plates are clothed in long fine spinules and one or more stout pedicellariae are usually present. The adambulacral plates bear a curved fan of about five long, slender furrow spines; behind them are spinules similar to those on the actinolateral plates. The prominent, narrow mouth plates bear two rows of spinules, one row on each edge, and there are two large, flattened oral spines, one on each jaw half. Inside the mouth, above the oral spines, is a group of 5 or 6 short spinules. The small hemispherical madreporite is covered with deep gyri. In the abactinal center of the disc, an epiproctal cone is usually conspicuous in preserved specimens.

Ranging in depth from about 200 fathoms to about 450 fathoms, this species has a much wider distribution in the Gulf of Mexico, the Caribbean, and the Lesser Antilles than Clark indicated.

MATERIAL EXAMINED.—Oregon Stations: 2771 (1) [R=7 mm, r=3 mm, Rr=1:3]; 6696 (4) [R=20 mm, r=5 mm, Rr=1:4]; 1917 (2) [R=29 mm, r=7 mm, Rr=1:4]; 4480 (1) [R=55 mm, r=7 mm, Rr=1:6 (specimen differs from others examined in having one very long inferomarginal spine, a large spine on the superomarginal, and flattened, leaflike oral spines)]; 4703 (2) [R=34 mm, r=8 mm, Rr=1:4]; 1507 (2) [R=29 mm, r=7 mm, Rr=1:4]; 3583 (1) [R=45 mm, r=8 mm, Rr=1:5]; 1920 (3) [R=22 mm, r=5 mm, Rr=1:5]; 1909 (1) [R=28 mm, r=7 mm, Rr=1:4]. Alaminos Stations: 21/68-A-13 (5) [R=30 mm, r=5 mm, Rr=1:6]; 8/68-A-13 (1); 4/68-A-13 (1) [R=43 mm, r=6 mm, Rr=1:8]; 10A/68-A-7 (5) [R=50 mm, r=11 mm, Rr=1:5].

### Other Atlantic Species of *Persephonaster*

The other two western Atlantic species of *Persephonaster*, *P. leptactis* and *P. spinulosus*, were described by H. L. Clark (1941) from Cuba; the first is known only from one specimen, and the second is probably *Psilaster patagiatus*. *P. leptactis* differs from *P. echinulatus* principally in having very narrow paxillar areas on the arms, granulous rather than spinous marginals, and 6–8 furrow spines on the adambulacral plates; it lacks pedicellariae.

***Plutonaster* Sladen**

*Plutonaster* Sladen, 1885:610; 1889:81. [Type-species, by original designation, *Archaster bifrons* Wyville Thomson.]

Although at least seven species of *Plutonaster* have been described from the Atlantic (two from the east coast of North America, two from the Azores, and one from the South Atlantic near Ascension Island), examination of over a thousand specimens in the National Museum of Natural History, mostly labelled *P. agassizi*, led me to conclude that there are probably no more than two or three species. The four small specimens of *P. notatus* (Sladen, 1889) in the National Museum of Natural History, from the mid-Atlantic ridge south of the Azores, represent a clear-cut species, evidently with a very restricted distribution. On the basis of comparisons between the National Museum of Natural History *Plutonaster* material and descriptions and/or specimens of the other Atlantic *Plutonasters*, I suspect that they constitute one quite variable species. The spinulation of the marginals is certainly variable, even in specimens from the same or adjacent stations. This is true also for length and width of arms, width of paxillar area on arms, size of marginals, and armature on actinal face of the adambulacrals, as well as granulation (or spinulation) of the interradial actinal plates.

It is interesting to note that frequently specimens from one station will have short, broad arms with massive marginals and little or no spinulation on the superomarginals, granulose abactinal interradial plates, and a large prominent spine on the actinal face of all the adambulacrals, while those from an adjacent station a few miles away and at comparable depths have long, narrow arms, with smaller marginals, one or more stout spines on both series or marginals, a slender peglike spine on many of the actinal interradial plates, and a single large spine on the actinal face of only a few distal adambulacrals. However, no correlation could be discovered with range, depth, bottom type, or other known factors, and other specimens from the same general area show all variations between these two extremes. An examination of the types of the described species and of collections of *Plutonaster* in other museums would probably resolve these into one abundant, variable, ampho-Atlantic species. Until this question is resolved, the name *P. intermedius*, to which the western Atlantic

*Plutonasters* from 0° to 30° N have usually been referred, will be used for the purposes of this report.

***Plutonaster intermedius* (Perrier)**

PLATE 9: FIGURES A, B

*Goniopecten intermedius* Perrier, 1884:251, pl. 7: figs. 1, 2, pl. 4: fig. 4.

*Plutonaster intermedius*.—Perrier, 1894:316.

This rather large five-armed species has a much-flattened body form, with a large disc and moderate to long arms. The paxillar area is broad on the disc and narrow on the arms, with the only regularity in arrangement of paxillae occurring around the interradial arcs. The polygonal paxillae are compact and much smaller in the center of the disc than elsewhere. They are flat-topped and covered with small granules which become spiniform around the periphery of the paxillae. The superomarginals are broad and covered with a uniform coating of small granules which become slightly spiniform at the narrow, deep fascioles. Frequently, each superomarginal, at least proximally, bears a stout erect spine, bulbous at the base, on the outer edge. These spines may occur all the way out to the tip of the arm, or may be confined to the superomarginals of the interbrachial arc. In small specimens, they are often lacking altogether. The inferomarginal plates, directly opposite the superomarginals and of about the same size, are similarly clothed with granules, and most of them bear one or two stout erect spines on the outer edge.

The actinal interradial area is large and reaches to about the sixth or seventh inferomarginal. The distinct oval plates are in regular rows and are covered with granules; a few may bear a slender peglike spine in the center. The adambulacrals bear 7–10 nearly equal, long furrow spines in straight longi-series, only slightly curved. Behind them, on the actinal surface of the plate, is a loose assemblage of much shorter spinelets or granules, some of which may be grouped to form a crude sort of pedicellaria (as are some of the spinelets or granules on the actinal interradial plates). Frequently there is a large spine in the center of the actinal face of the adambulacrals; some specimens lack these altogether, some have one on every adambulacrals plate, and some have them only on the distal adambulacrals. The mouth plates are

large, tumid, and covered with short spines; at the oral edge is a cluster of longer spines. The madreporite is large and covered, or partly covered, with paxillae larger than those on the rest of the dorsum.

The species seems to be restricted in these collections to the northern Gulf of Mexico, in 350–1,000 fms.

MATERIAL EXAMINED.—Oregon Station 2820 (1) [R=21 mm, r=8 mm, Rr=1:3]. Alaminos Stations: 13A/68-A-7 (16) [R=26 mm, r=8 mm, Rr=1:3]; 15D/68-A-7 (5) [R=28 mm, r=9 mm, Rr=1:3]; 13D/68-A-7 (5) [R=20 mm, r=7 mm, Rr=1:3]; 17B/68-A-7 (3) [R=11 mm, r=4 mm, Rr=1:3]; 15H/68-A-7 (15) [R=23 mm, r=9 mm, Rr=1.2:5]; 24/68-A-13 (2) [R=111 mm, r=28 mm, Rr=1:4]; 27/68-A-13 (1) [R=80 mm, r=25 mm, Rr=1:3]; 23/68-A-13 (2) [R=111 mm, r=29 mm, Rr=1:4].

### *Dytaster* Sladen

*Dytaster* Sladen, 1885:608; 1889:60. [Type, by original designation, *D. nobilis* Sladen.]

*Crenaster* Perrier [non d'Orbigny], 1885:71; 1894:306. [Type by original designation, *C. mollis* Perrier.]

Disc rather small, five arms long, thin; ambulacral plates large, high; dorsal tegument thin, flexible (as if it were several sizes too large for the starfish); rays usually quite carinate; marginals rectangular, opposite, straight-edged, usually bearing one prominent acute spine; superomarginal plates thin, confined to side of arm; dorsal paxillae tiny; actinal interradial areas of moderate size; mouth plates very prominent; adambulacral furrow spines in straight, subequal series; madreporite large, covered with paxillae.

*Dytaster* is a deepwater genus, specimens in this collection reaching a greater depth than any other seastars in the area. They are also, apparently, the most abundant of the starfishes in depths below 500 fathoms (to 2,200 fathoms) in the Gulf of Mexico. They are detritus feeders: bits of algae, many forams, and worm tubes and small molluscs have been found in the stomach.

With additional material now available, it is easy to see that the five species described from the North Atlantic really constitute only one variable species, for which the name *D. insignis* has priority. Sladen's *Dytaster nobilis*, from off Buenos Aires, may be simply another variation of the same species, but as I have not had an opportunity to

examine specimens, it should be maintained as a separate species for the time being, on the basis of Sladen's description of shorter, broader arms, larger disc, and larger paxillae sheathed in membrane, as well as differences in adambulacral armature.

### *Dytaster insignis* (Perrier)

PLATE 9: FIGURES C, D

*Archaster insignis* Perrier, 1884:253, pl. 9: fig. 5.

*Archaster grandis* Verrill, 1884: 218.

*Dytaster exilis* Sladen, 1889:65, pl. 2: figs. 3, 4, pl. 4: figs. 9, 10.

*Dytaster exilis gracilis* Sladen, 1889:68, pl. 2: figs. 3, 4, pl. 4: figs. 9, 10.

*Dytaster exilis carinata* Sladen, 1889:69.

*Dytaster madreporifer* Sladen, 1889:70, pl. 3: figs. 3, 4, pl. 32: figs. 5, 6.

*Dytaster biserialis* Sladen, 1889:77, pl. 10: figs. 3, 4, pl. 13: figs. 3, 4.

The five narrow, elongate arms, and small- to moderate-sized disc of this species are distinctive. The dorsum, covered with small "fuzzy" paxillae, is usually somewhat wrinkled and velvety looking. The crowded, low paxillae are crowned with 5–10 long, slender, thorny spinules; on the midline of the arms, they are fewer and may be reduced to a few spinules without paxillar column. Occasionally a specimen may have a few two-, three-, or four-valved pedicellariae on the dorsal surface near the base of the arms. The superomarginal plates are prominent, mostly confined to the sides of the arms, and each bears a single, large, erect spine near the upper edge. The rest of the plate is covered with fine spinules.

The inferomarginal plates are similar, except that they may bear, in the interradius, more than one spine. The small oval or polygonal plates of the actinal interradial area are imbricate and covered with small spinules; there may be up to a dozen large two-, three-, or four-valved pedicellariae in each interradial area (but in some specimens these may be altogether lacking). Actinal interradial plates extend to about the fifth inferomarginal. The adambulacral plates, rectangular and well separated from one another, bear 8–12 slender, subequal furrow spines in close longitudinal series. The actinal face of the plate bears a random group of small spinelets. Distally there may be a single large spine in the center of the

plate. The mouth plates are large, prominent, and distinctive; they resemble somewhat the eletra of a beetle and are covered with small spinelets. Their armature is similar to that of the adambulacral plates, with a cluster of heavier spines at the apex. The madreporite is very large, near the margin, and covered with paxillae which are larger than the rest of the dorsal paxillae.

MATERIAL EXAMINED.—*Oregon* Stations: 2199 (3) [R=54 mm, r=8 mm, Rr=1:5]; 2572 (1) [R=80 mm, r=9 mm, Rr=1:8]; 2821 (2) [R=57 mm, r=10 mm, Rr=1:6]; 2813 (1) [R=20 mm, r=8 mm, Rr=1:3]. *Alaminos* Stations: 5B/68-A-3 (1) [R=54 mm, r=9 mm, Rr=1:5]; 7D/68-A-3 (2) [R=50 mm, r=12 mm, Rr=1:5]; 3B/68-A-3 (1) [R=40 mm, r=10 mm, Rr=1:5]; 3B/68-A-7 (1) [R=72 mm, r=13 mm, Rr=1:7]; 4A/68-A-7 (3) [R=8 mm, r=4 mm, Rr=1.2 (juveniles)]; 4E/68-A-7 (8) [R=86 mm, r=12 mm, Rr=1:8]; 12B/68-A-7 (5) [R=8 mm, r=5 mm, Rr=1:2 (juveniles)]; 9/68-A-13 (1) [R=39 mm, r=9 mm, Rr=1:4]; 27/69-A-11 (2).

### ***Blakiaster* Perrier**

*Blakiaster* Perrier, 1881a:28; 1885:265. [Type, by monotypy, *B. conicus* Perrier.]

### ***Blakiaster conicus* Perrier**

PLATE 10: FIGURES A, B

This small species has a moderately broad disc; the five arms are broader than high and taper evenly to a subacute end. The disc dorsum is slightly larger than the space confined by the marginals, so that dorsal covering seems "too large," and the marginals are not visible from above, except on the arms. The dorsal paxillae are large, low, and rounded, with about 25 thorny, subclavate spinules, thick and almost granuliform in the center of the central paxillae, but fine and long around the periphery and on the outer paxillae. The superomarginal plates are ovate, slightly tumid, and have a uniform covering of fine, thorny spinules, thicker and clavate in the center of the plate and longer and more acute around the edges. The inferomarginal plates are subprismatic, due to the presence of a central vertical ridge of spine-bearing tubercles near the upper edge of the plate, which carry three

strong, distally directed spines of moderate length. The rest of the plate is covered with spinules similar to those of the superomarginals. In the inter-radii, the superomarginals extend considerably beyond the inferomarginals. Actinal interradial plates are rounded or subpolygonal and bear divergent spinules; there are a few unpaired median plates, and a single row extends almost to the middle of the arm. The adambulacral plates bear a furrow series of 4 or 5 long, slender spines, a second row of four slightly shorter spines, and about two more irregular rows of much shorter spines. The mouth plates are oval, convex, and covered with small spinules distally, clavate spines proximally, and terminate in a cluster of heavy subprismatic apical spines. The madreporite is of moderate size, covered with coarse gyri, and located a little more than halfway between the center of the disc and the margin. No pedicellariae were noted.

This species is apparently restricted to the Antilles, in 92–200 fathoms.

MATERIAL EXAMINED.—*Oregon* Station 6715 (1) [R=26.5 mm, r=10 mm, Rr=1:2.5].

### ***Tethyaster* Sladen**

*Plutonaster* (subgenus *Tethyaster*) Sladen, 1889:101. [Type, by original designation, *Asterias subinermis* Philippi.]  
*Sideriaster* Verrill, 1899:210. [Type, by original designation, *S. grandis* Verrill.]  
*Moiraster* Sladen, 1889:192. [Type, by monotypy, *Archaster magnificus* Bell.]  
*Anthosticte* Fisher, 1911:417. [Type, by monotypy, *A. aulophora* Fisher.]

The genus *Tethyaster* has been very thoroughly reviewed and revised by Clark and Clark (1954) and is now so well defined as to need no further discussion. The only reservation I personally have about their work as regards the Atlantic *Tethyasters* concerns the separation of *T. vestitus* and *T. magnificus*, the former occurring from New Jersey to the Orinoco River and the latter from St. Helena and Ascension Islands. In view of the Caribbean flavor of the St. Helena echinoderm fauna (see Mortensen, 1933a; Madsen, 1950; and Downey, 1968), and the fact that specimens keying out to *T. magnificus* have been taken in the Caribbean (Leviton, personal communication), the single character used by Clark and Clark, that is, when during growth of the starfish the enlarged and flat-

tened spines of the actinal plates develop, seems to me a matter of individual variation, not worthy of even subspecific separation. This character is further invalidated by the fact that a small *T. magnificus* and a large *T. vestitus* may be armed exactly the same. Of the five species of *Tethyaster* from the Atlantic, *subinermis* is confined to the eastern Atlantic and Mediterranean, and *T. pacei* is known only from South Africa. Only *T. grandis* and *T. vestitus* come within the scope of this report.

### *Tethyaster grandis* (Verrill)

PLATE 10: FIGURES C, D

*Sideriaster grandis* Verrill, 1899:220, pl. 30: figs. 8-8b; 1914: 21; 1915:192, pl. 12: figs. 5, 5b.  
*Tethyaster grandis*.—Clark and Clark, 1954:17, fig. 1b, pls. 11, 12.

This stellate species has a large disc and five broadly based arms which taper evenly to a moderately acute point. Both actinal and abactinal surfaces are extremely plane and even, the only height being defined by the marginals. The dorsal paxillae are less than twice as high as wide and arise from a lobed base to a rounded top which bears 3-8 granuliform central spinules and about a dozen longer peripheral spinules. The high, narrow superomarginals, confined mostly to the sides of the rays, are densely covered with granules which become small and spiniform at the deep interplate fascioles. The inferomarginals, of similar size and shape, bear three or more large, flattened lanceolate spines and many small flattened spinules. The actinal interradial areas are large, with large subpaxilliform plates in regular rows (there are frequently a few odd interradial actinals just below the jaw). They are covered with large granules and small peripheral spinules, and a single row extends nearly to the end of the arm. The adambulacral plates project slightly into the furrow and bear three flattened furrow spines, the central one at right angles to the groove and the other two nearly parallel to it. Behind, on the actinal face of the plate, are 3 or 4 stouter truncate spines, and behind them are a few much smaller spines and frequently 1 or 2 stout, short, three-valved pedicellariae. The mouth plates are slightly raised above the actinal surface and bear many stout granuliform spinules, with a cluster of stout trun-

cate spines at the apex. In many specimens, three- or four-valved pedicellariae are scattered all over the actinal surface. The tube feet are small and pointed. The madreporite is large and flat, with shallow radiating gyri.

**JUVENILES.**—Young specimens of *Tethyaster* differ from the adults in that the marginals extend more onto the dorsal surface, the spines are not developed on the inferomarginals, the madreporite is small and nearly concealed by paxillae, and the adambulacral furrow spines are not flattened and are more palmate.

Known previously only from the Gulf of Mexico, this species has a depth range of 35-162 fathoms.

**MATERIAL EXAMINED.**—*Silver Bay* Station 5106 (3) [R=16 mm, r=7 mm, Rr=1:2]. *Oregon* Stations: 5913 (3) [R=18 mm, r=6 mm, Rr=1:3]; 3621, 1. *Oregon II* Station 10559 (1) [R=82 mm, r=21 mm, Rr=1:4]. *Alaminos* Stations: 13/64-A-10 (1) [R=105 mm, r=31 mm, Rr=1:3]; 5/68-A-13, 2.

### Other Species of *Tethyaster*

*Tethyaster vestitus*, the other species falling within the scope of this report, bears a large flat spine on the actinal plates, and the inferomarginal spines are broadly truncate, rather than sharp pointed. It ranges from 08° to 40° north, and apparently does not occur east of 75° west. Its depth range is 44-146 fathoms.

### *Dipsacaster* Alcock

*Dipsacaster* Alcock, 1893a:87; 1893b:172. [Type, by original designation, *D. sladeni* Alcock.]

Rays five; form depressed, disc broad, with well-developed actinal interradial areas; marginal plates large; inferomarginals broader than superomarginals with tuft of spines at outer edge; superomarginals sometimes with 1-3 small tubercles; paxillae with round or stellate base, tall pedicel crowned with tuft of many small, crowded, erect spinelets; papulae all over abactinal surface, 5 or 6 around each plate; actinal intermediates bearing paxilliform group of spinules; fasciolar channels from inferomarginals to adambulacral; adambulacral with palmate or pectinate cylindrical or compressed furrow spines, smaller spinelets on actinal face; mouth plates prominent, broad, with numerous

spinules; madreporite large, hidden by paxillae; tube feet pointed.

### *Dipsacaster antillensis* Halpern

PLATE 11: FIGURES A, B

*Dipsacaster antillensis* Halpern, 1968:231-240.

Among the seastars collected by the *Alaminos* in the middle of the Gulf of Mexico were two small specimens of *Dipsacaster antillensis*, described from the western Atlantic by Halpern (1968), from Little Bahama Bank, in less than 900 meters. These two small specimens are from the middle of the Gulf of Mexico, in depth greater than 3,200 meters. They are evidently juveniles of *D. antillensis*, and quite apart from size (much smaller than Halpern's specimens), have quite small dorsal paxillae, not at all compact at least on the arms; the paxillar spinules are longer, finer, and very thorny; the inferomarginals are armed with a central, rather than distomarginal, group of spines, at least one of which is quite thick and thorny; massive pedicellariae are present on some of the inferomarginals, the actinal interradials, and many of the adambulacral plates; the adambulacral furrow spines are fewer in number and distinctly pal-

mate; the madreporite is, as yet, rather small and concealed by enlarged paxillae.

The disc is large, but the arms are moderately long, narrow, and tapered, rather than being broad and subpetaloid as in most *Dipsacasters*; in this and in the armature of the inferomarginals, they resemble *D. nesiotetes* Fisher (1910b), but the dorsal paxillae are decidedly different from those of Fisher's Hawaiian species. These specimens are quite obviously juvenile, but Dr. Halpern has examined these and other specimens and determined that they are indeed young *D. antillensis*.

MATERIAL EXAMINED.—*Alaminos* Stations: 9/69-A-13 (1) [R=12 mm, r=4 mm, Rr=1:3]; 29/69-A 13 (1) [R=12 mm, r=3.5 mm, Rr=1:4].

### Family GONIOPECTINIDAE Verrill, 1899

This family is mainly distinguished by having cribriform organs between all the marginals; they are continuous with channels on the oral surface covered with webbed spinelets, between transverse rows of plates. The marginals are thin, high, and lamelliform, smooth and covered with membrane. The two rows of tube feet are pointed and the ampullae are single. Superambulacral ossicles are present. The abactinal surface is paxillose.

### Key to the Genera of Gonioplectinidae

- With odd interradial marginals and corresponding unpaired series of actinal interradial plates . . . . . *Prionaster*  
 Without odd interradial marginal and actinal plates . . . . . *Goniopecten*

### *Goniopecten* Perrier

*Goniopecten* Perrier, 1881a:24. [Type, by original designation, *G. demonstrans* Perrier.]

There is only one Atlantic species.

### *Goniopecten demonstrans* Perrier

PLATE 11: FIGURES C, D

*Goniopecten demonstrans* Perrier, 1881a:24 [without description]; 1894:295 [described]; Verrill, 1899:213, pl. 27.

This large five-armed species has a small disc, and the moderately narrow arms taper to an acute point. The paxillar area, broad on the disc, is quite

narrow on the arms. The paxillae are polygonal (many rectangular), very crowded, with short paxillar columns, and crowned with an even coating of small granules; they become progressively smaller on the arms. The large superomarginals are confined entirely to the dorsal surface (in the adult); there may be a small sharp spine on the distal edge of some of the superomarginals, but in most specimens they are smooth and without ornamentation. The long, broad inferomarginal plates form both the sides of the arms and the ventral border; they are similar to the superomarginals. Both series of marginals are bordered by a row of small webbed spinules, between which are deep fascioles that extend across the actinal surface to the mouth plates.

There are no odd interradial marginals. The actinal interradial plates, plane, polygonal, and slightly imbricate, are in double rows between the fascioles and extend only to the fifth or sixth inferomarginal; they may bear a few small prickly-like spinules. There is no odd interradial series. The adambulacral plates are nearly square, slightly concave on their actinal face, and the proximal inner corner projects slightly into the groove. They bear a furrow series of about nine short, subequal spines. The actinal face of the plate is bare, save for a row of small spinules on the actinal edge. The mouth plates are raised and prominent; they stand nearly at right angles to the actinal surface. They are covered with tiny prickles and bear, at the apex, a cluster of short, stout, sharp spines. The madreporite is very large, flat, and bare, and covered with fine radiating gyri. All plates except those of the paxillar area are covered with a smooth, slippery skin.

This species occurs in the Gulf and Caribbean, in 299–470 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 6696 (6) [R=104 mm, r=21 mm, Rr=1:5]; 6703 (10) [R=114 mm, r=16 mm, Rr=1:7]; 5929 (1) [R=138 mm, r=28 mm, Rr=1:5]; 4702 (1) [R=125 mm, r=25 mm, Rr=1:6]; 6697 (2) [R=108 mm, r=23 mm, Rr=1:5]; 4855 (1) [R=109 mm, r=21 mm, Rr=1:5]; 4902 (1) [R=21 mm, r=6 mm, Rr=1:4; juvenile, with superomarginal spines, small madreporite, large epiproctal cone, marginals more vertical than in adult]. *Oregon II* Station 10602 (1) [R=109 mm, r=22 mm, Rr=1:6]. *Alaminos* Stations: 8/68-A-13 (1) [R=137 mm, r=22 mm, Rr=1:5]; 27/69-A-11 (1) [R=133 mm, r=25 mm, Rr=1:6]; 15/68-A-13 (1) [R=28 mm, r=9 mm, Rr=1:3]; 11A/68-A-7 (1) [R=8 mm, r=3 mm, Rr=1:2.5].

### *Prionaster* Verrill

*Prionaster* Verrill, 1899:205. [Type, by original designation. *P. elegans* Verrill.]

There is only one species, *Prionaster elegans* Verrill, known from the Atlantic.

### *Prionaster elegans* Verrill

PLATE 12: FIGURES A, B

*Prionaster elegans* Verrill, 1899:216, pl., figs. 4, 4a-c; 1915:197, pl. 12: figs. 4-4c.—Fisher, 1919:50.

The five arms of the species are narrow and taper gradually to an acute point; they are slightly constricted near the base. The disc is of moderate size, and the paxillar area on the arms is narrow. The paxillae are in regular transverse rows on the arms. They are small, rounded, moderately high, not crowded, and crowned with 8–12 short subclavate spinules. The superomarginals are confined to the sides of the rays, making the sides nearly vertical. They are smooth in the interradial arc but ornamented with small, irregular, glassy low-relief tubercles on their upper surface on the arms. Most bear a short, stout spine with a sharp hyaline tip. The inferomarginals are bare on their lateral surface; a few may bear a small spine near the distal edge. The broad, deep fascioles between the marginals extend to the mouth and are bordered with short, webbed spinules. There is an odd interradial marginal, and two rows of actinal plates extend from this to the base of the mouth plates. Two rows of plates extend from the two marginals on either side, but there are no actinal interradial plates beyond the third marginal. The adambulacral plates are semicircular and project slightly into the furrow; they bear about 10–14 spines around the free edge, of which approximately eight belong to the furrow series. The actinal face of the adambulacral plate is bare. The mouth plates are oval, slightly tumid, and bear scattered small spinules; at the apex are two strong, stout spines; on either side, within the mouth, is a row of spines like those of the adambulacrals. The madreporite is small and covered with small spinules rather than gyri.

This species is known only from the Gulf of Mexico, in 150–200 fathoms.

MATERIAL EXAMINED.—*Oregon II* Station 10858 (1) [R=37 mm, r=7 mm, Rr=1:5].

### Family BENTHOPECTINIDAE Verrill, 1894

This family is characterized by a unique pair of dorsal muscle bands on the flexible arms; it is thought they may be used for swimming. The marginals are alternate and imbricate and bear long spines. Pedicellariae are pectinate. The tube feet, in two rows, are suckered and the ampullae are

double. There are no superambulacral ossicles. It is possible that some members of this family are

luminescent, but reports to this effect are unconfirmed.

### Key to the Genera of Benthopectinidae

- |   |                                |
|---|--------------------------------|
| 1. Papular pores confined to specialized areas on the disc (papularia)..... | 2                              |
| Papular pores not confined to papularia.....                                | 3                              |
| 2. Papulae in U- or V-shaped papularia, not swollen.....                    | <i>Cheiraster</i>              |
| Papularia not U- or V-shaped, more or less swollen.....                     | <i>Pectinaster</i>             |
| 3. Odd interradial marginals present.....                                   | <i>Benthopecten</i>            |
| No odd interradial marginals.....   | <i>Luidiaster</i> <sup>1</sup> |

<sup>1</sup> Although no species referable to *Luidiaster* have been taken in these collections, the genus is included in this key because some of the species here included have been referred to it from time to time in the past.

### *Benthopecten* Verrill

*Benthopecten* Verrill, 1884:218. [Type, by original designation, *B. spinosus* Verrill.]

*Pararchaster* Sladen, 1885:610. [Type, by original designation, *P. pedicifer* Sladen.]

There is only one species of *Benthopecten* known from the area covered by this report.

### *Benthopecten simplex* (Perrier)

PLATE 12: FIGURES C, D

*Archaster simplex* Perrier, 1884:264, pl. 1: fig. 8.

*Pararchaster simplex*.—Perrier, 1894:254.

*Benthopecten simplex*.—Fisher, 1911:143.

This fragile seastar has five long, slender arms and a small disc. The thin dorsal membrane is set with small, rounded plates bearing 1–3 tiny thorny spinules. These plates are crowded on the disc, some even fused together, but are widely scattered on the arms. There are 1–10 large spines in the center of the disc. The anus is large and surrounded by a cluster of small spinules. The long, oval superomarginal plates, confined mostly to the side of the arms, have a central mammelon bearing a long, stout, thorny spine; 1 or 2 small spinules may occur near the base of this spine. The distal edge of the plate overlaps the proximal edge of the plate ahead. There is a larger odd interradial marginal, rather triangular in shape, confined wholly to the dorsal surface and bearing a single very large, acute spine. The smaller inferomarginal plates are similar to the superomarginals and alternate with them. There is almost always a large pectinate pedicellaria between all the inferomarginals. In

the actinal interradial area, there is a single row of 2–6 small, rounded plates, each bearing a small acute spinule; some or all of these plates may be replaced by 1 or 2 large pectinate pedicellariae. The adambulacral plates bear six long, somewhat flattened, and blunt spines, parallel to the groove and fused at the base; on the actinal face is a single large spine and 1 or 2 small, slender spines. The mouth plates are rounded and tumid; there are a pair of stout spines at the apex, one to each jaw half, and three smaller spines on each side. There are 2–4 smaller spines on the actinal face of each jaw half. The madreporite is raised, irregular, and deeply channeled; it forms part of the base of one of the odd interradial superomarginals.

This is a deepwater species, occurring from 1,100–1,500 fathoms from Nova Scotia to the central Gulf of Mexico.

MATERIAL EXAMINED.—*Alaminos* Station 4/69–A–13 (7) [R=48 mm, r=6 mm, Rr=1:8]. *Oregon* Stations: 2572 (1) [r=9 mm (all arms broken)]; 2574 (6) [r=9 mm (all arms broken)]; 2571 (1) [R=48 mm, r=6 mm, Rr=1:8].

### *Cheiraster* Studer

*Cheiraster* Studer, 1884:129. [Type, by original designation, *C. gazellae* Studer.]

No odd interradial marginal plate; papulae form bilobed U- or V-shaped group on disc dorsum near base of rays; dorsal plates paxillate; marginals covered with small spinules or granules; furrow spines continuous with a series of smaller spines around outer edge of adambulacral plate.

Five species of *Cheiraster* have been reported



from the West Indies: *C. mirabilis* (Perrier), *C. coronatus* (Perrier), *C. echinulatus* Perrier, *C. planus* Verrill, and *C. enoplus* Verrill. Perrier (1894), Ludwig (1910), and Verrill (1915) all considered *C. coronatus* no more than a subspecies of *C. mirabilis* at most, and I am inclined to view it as well within the range of variation of *C. mirabilis*; the name *coronatus* should be considered a junior synonym of *mirabilis*. Based on Verrill's (1915) descriptions, I am also inclined to believe that his *C. planus* is simply a large *mirabilis*. None of the differences he notes between the two species seem to be anything more than normal growth factors,

or characters well within the range of variation. *Cheiraster enoplus* is readily distinguished from the other species by its numerous papular pores in paired, elongate, leg-of-mutton-shaped papularia, and by its truncate, grooved-tipped preoral spines. It usually has a dense cluster of fairly long, acute spines in the center of the disc (these may also be present in *C. mirabilis*). *C. echinulatus* seems a perfectly good and distinct species; it is quite small, with a more broadly stellate shape than the other species ( $Rr=1:4$ ). It has fewer marginal plates (less than 20, as opposed to 35–60 in other species). The dorsal plates are also more distinctly paxillate.

### Key to the Species of *Cheiraster*

1. About 200 papular pores per papularium; preoral spines truncate.....*C. enoplus*  
Less than 50 pores per papularium; preoral spines not truncate .....2
2.  $Rr=1:4$  (approximately) .....*C. echinulatus*  
 $Rr=1:8$  (approximately) .....*C. mirabilis*

### *Cheiraster mirabilis* (Perrier)

#### PLATE 13: FIGURES A, B

*Archaster mirabilis* Perrier, 1881a:27.—Perrier, 1884 (part); 256, pl. 8: figs. 7, 8, pl. 9: fig. 4, pl. 10: fig. 3.  
*Cheiraster coronatus* Perrier, 1894:271.—Ludwig, 1910:455.  
*Archaster coronatus*.—Perrier, 1884:262; 1894:271.  
*Cheiraster mirabilis*.—Verrill, 1915:124, pl. 14: figs. 5, 5a.  
*Cheiraster mirabilis coronatus*.—Verrill, 1915:127.  
*Cheiraster planus* Verrill, 1915:133, pl. 18: fig. 2.

The moderate-sized disc and five long, flexible arms of this species are flat and plane. The dorsal plates are small, hemispherical, and crowded and bear, on their upper surface, a ring of up to a dozen small thorny clavate spinules around the base of a large, central, acute spine. The papular pores are in two U-shaped rows of approximately 7 or 8 each, in papularia between the bases of the arms and the center of the disc. The superomarginals are oval, set diagonally on the arms, and confined to the sides of the arms, encroaching very little on the dorsum. They bear a single large, acute spine on a tubercle in the center of the plate, and the rest of the plate is covered with fine spinules carried on glassy bosses. They number about 40–50 on adult specimens. The inferomarginal plates are similar and alternate with the superomarginals. Their central spine is slightly smaller, and they may bear 1–5 supplementary smaller spines, espe-

cially proximally. They are almost wholly confined to the ventral surface. The actinal interradiar areas have 1–3 rows of flat, rounded plates, none extending beyond the third marginal. They usually bear a central spine and a number of small, blunt spinules. A pectinate pedicellaria may occur between two adjacent plates. Pectinate pedicellariae may also occur between adambulacral and inferomarginal plates.

The adambulacral plates project into the furrow and bear a furrow series of about ten slightly divergent, flattened spines. Other smaller spinelets continue around the side margins of the plate, and the actinal face bears a single large spine. The mouth plates are broad, and each half bears two large acute preoral spines and 7–9 lateral spines, as well as numerous small epioral spinules. The madreporite is irregular in shape, may be small or large, and is deeply channeled with coarse gyri.

This species occurs from George's Bank to the West Indies to the western Gulf of Mexico, in 200–800 fathoms.

MATERIAL EXAMINED.—Oregon Stations: 1909 (1) [ $R=120$  mm,  $r=15$  mm,  $Rr=1:8$ ]; 1906 (4) [ $R=128$  mm,  $r=13$  mm,  $Rr=1:9$ ]; 1507 (2) [ $R=60$  mm,  $r=10$  mm,  $Rr=1:6$ ]; 1917 (1); 4702 (1) [ $R=50$  mm,  $r=8$  mm,  $Rr=1:6$  (specimen abnormal in having very narrow arms and scattered papulae on disc

and arms outside the papularia)]; 6696 (1) [R=82 mm, r=11 mm, Rr=1:7.5]. *Alaminos* Station 8/68-A-13 (1) [R=11 mm, r=4 mm, Rr=1.3].

### *Cheiraster echinulatus* (Perrier)

PLATE 13: FIGURES C, D

*Archaster echinulatus* Perrier, 1876a:268; 1884:263, pl. 10: fig. 4.

*Cheiraster echinulatus*.—Perrier, 1894:278.—Verrill, 1915:129, pl. 14: figs. 2, 3, pl. 19: fig. 2, pl. 25: fig. 1.

*Pectinaster echinulatus*.—Ludwig, 1910:449.

This is the smallest of the Atlantic *Cheirasters*. Its form is more stellate, and the arms more rigid. The dorsal plates are distinctly paxillate, and each bears 8–25 small spinous peripheral granules and a small acute central spine. Each papular area has 3–8 pores at the base of the arms, often not in any particular arrangement, but sometimes, especially in larger specimens, distinctly bilobed. The superomarginal plates (15–26) are large, rectangular, and encroach considerably on the disc, so that the paxillar areas on the arms are quite narrow. Except for the first two interradial plates, they bear a single erect, acute spine, and there may be other small spines around it, especially on the proximal superomarginals. The rest of the plate is clothed in small spinous granules. The inferomarginal plates bear one large spine and up to eight smaller spines on the upper (or lateral) half of the plate, and the lower (or ventral) half is covered with small spinules.

The marginals may be opposite or alternate. The interradial actinal areas have a single row of 6 or 7 round plates, not extending beyond the second inferomarginal. They are covered with small acute spines. The adambulacral plates project strongly into the furrow and bear a palmate series of about ten long furrow spines. On the actinal face of the plate there are usually two large subequal spines and a few small spinules. On each half of the broadly rounded mouth plate are two stout preoral spines and about eight small lateral spines; the actinal face bears one or two large epioral spines and a row of 2–5 smaller spines. The madreporite is of modest size, and deeply grooved with coarse gyri.

This species occurs principally in the Gulf of Mexico, although the *Albatross* took it also in the

West Indies, according to Verrill. Its depth range is from 65–400 fathoms. I do not believe this species gets much over 35 mm (R), and specimens of less than half this size are fully mature.

MATERIAL EXAMINED.—*Oregon* Station 5913 (1) [R=35 mm, r=8 mm, Rr=1:4]. *Alaminos* Stations: 11A/68-A-7 (1) [R=10 mm, r=3 mm, Rr=1:3]; 20/65-A-9 (9) [R=16 mm, r=3 mm, Rr=1:4]; 15/65-A-9 (1) [R=25 mm, r=6 mm, Rr=1:4].

### *Cheiraster enoplus* Verrill

PLATE 14: FIGURES A, B

*Cheiraster enoplus* Verrill, 1915:135, pl. 18: fig. 1.

This is a more massive-appearing species than the previous two, with long narrow arms and a rather small disc. The dorsal plates are small, crowded, slightly rounded, and not at all paxillate. They bear 6–8 tiny spinules on top, and a few of the central disc plates are enlarged and bear, on a mammelon, a large central spine. The papularia are distinctive: they are shaped like a pair of rabbit ears and extend from near the disc center to beyond the fourth superomarginal plate on the arms. Each contains about 200 papular pores. The superomarginals are nearly square, set obliquely on the arms, and do not encroach on the dorsal surface. They bear a large, stout, erect spine in the center of the plate and are sparsely clothed with fine spinules. The inferomarginal plates are larger, rectangular, and bear 3 or 4 large spines, several smaller spines, and a number of spinules. Many also bear a pectinate pedicellaria near the actinal margin of the plate. The actinal interradial area has 2–4 rows of rounded plates, none of which extend beyond the third inferomarginal. Each plate bears one large slender spine and several spinules, and between many adjacent plates is a pectinate pedicellaria. The adambulacral plates project into the furrow, and there are 6 or 7 long, slender, subequal furrow spines, not acute.

A large stout spine and a few spinules are on the actinal face. The mouth plates are not very large, are broadly rounded on the oral margin, and bear one or two large, truncate preoral spines with tips grooved or bifurcate, and 6 or 7 smaller, slender lateral spines. There is a single pair of epioral spines and a row of small spines on either side of

the suture between the mouth plates. The raised madreporite is of moderate size and covered with coarse gyri.

This species has been recorded only from east of Cuba, in 400 fathoms, and this record, from off Guadeloupe, in 410–460 fathoms.

MATERIAL EXAMINED.—Oregon Station 6703 (1) [R=104 mm, r=14 mm, Rr=1:8].

### *Pectinaster* Perrier

*Pectinaster* Perrier, 1885b:70. [Type, by original designation, *P. filholi* Perrier.]

Papularia of enlarged dorsal plates raised above dorsal surface, papular pores not in bilobed arrangement; triangular adambulacral plates projecting so strongly across furrow as to meet, or nearly

meet, in middle of groove.

Fisher (1911) considered the mode of attachment of dorsal muscle bands in the arms at the proximal terminus a useful and important character for separating these genera, but such an internal character cannot be examined in unique specimens, dry specimens, or very small specimens, and as *Pectinaster* and *Cheiraster* present a clear and distinct external character in the nature of the papularia, dissection is unnecessary anyway.

Verrill (1915) described three new species of *Pectinaster* from the West Indies: *P. mixtus*, *P. gracilis*, and *P. dispar*. He also reported on two previously known species, *P. vincenti* and *P. oligoporus*. All of these seem to be perfectly good species, but only two, *P. mixtus* and *P. gracilis*, were taken in these collections.

### Key to the Species of *Pectinaster*

Dorsal plates tessellate, crowded, many enlarged.....	<i>P. mixtus</i>
Dorsal plates rounded, subpaxillate, not crowded.....	<i>P. gracilis</i>

### *Pectinaster mixtus* Verrill

PLATE 14: FIGURES C, D

*Pectinaster mixtus* Verrill, 1915:140, pl. 5: fig. 2, pl. 15: fig. 2, pl. 17: fig. 1.

The disc is small and the five arms slender and moderately long. The dorsal plates are subtessellate and bear very small thorny peripheral spinules which might almost be called granules. A larger erect spinule or small spine occurs in the center of most plates, some of which are enlarged. The 3–7 papular pores in a median cluster between the base of each arm and the center of the disc are associated with several enlarged plates (surrounding a central papular pore), but not necessarily four, as Verrill states. Verrill's type of this species has four enlarged plates in two of the papularia, 5–7 in two others, and eleven in the fifth. The superomarginal plates are large and encroach quite far onto the dorsal surface; they are set obliquely on the arms, giving the starfish the appearance of having its ambitus defined by braid trim. Each plate bears an erect acute spine near the outer margin, whose length is less than the width of the plate. The two interradial superomarginals

usually lack a spine. The superomarginals are densely covered with minute granule-like spinules. The inferomarginals alternate with the superomarginals and bear one large and 2–7 smaller spines; the rest of the plate is covered with spinules larger than those of the superomarginals.

The actinal interradial areas bear one or two series of rounded spinule-covered plates, none extending beyond the second inferomarginal. A large pectinate pedicellaria usually occurs between each two. The adambulacral plates project strongly across the furrow and bear a marginal series of 7–9 long, slender furrow spines and two large, subequal, acute, sometimes slightly curved spines on the actinal face. Each mouth plate bears four very large, stout preoral spines and about nine small lateral spines on each side. The actinal surface bears several pairs of smaller spines. The madreporite is small, irregular, and covered with coarse gyri; it almost or quite touches the superomarginals.

This species has a wide distribution in the West Indies and the eastern Gulf of Mexico, although it apparently does not get into the western Gulf. It has a considerable depth range, from about 70 fathoms to about 1,000 fathoms.

**MATERIAL EXAMINED.**—*Oregon* Stations: 3637 (1) [R=41 mm, r=8 mm, Rr=1:5]; 4398 (6) [R=29 mm, r=5 mm, Rr=1:6]; 33 (2) [R=18 mm, r=4 mm, Rr=1:4.5.]

***Pectinaster gracilis* Verrill**

PLATE 15: FIGURES A, B

*Pectinaster gracilis* Verrill, 1915:145, pl. 6: fig. 1, pl. 14: fig. 4, pl. 15: figs. 1-1b.

This small species has slender, evenly tapered arms, and the regularly stellate form is depressed. The dorsal plates are hemispherical, not at all crowded or tessellate, and bear a tuft of small spinules. The plates are of all sizes, and some of the larger ones bear a small central spine. A few thickened and enlarged plates, raised slightly above the general disc surface, surround the 3-7 papular pores in each papularium. The superomarginals encroach less on the dorsal surface than in *P. mixtus*, and they are set at a less oblique angle on the arms. They are covered with small, rough spinules and each bears a central erect spine a little longer than the width of the plate. The inferomarginal plates are nearly square, alternate with the superomarginals, and bear one (interradially sometimes two) spine like that of the superomarginals. They are sparsely covered with small, rough spinules. The single series of rounded actinal interradial plates does not

extend beyond the first pair of inferomarginals; they bear a few short spinules, not sharp. No pedicellariae were observed.

The projecting adambulacral plates bear a circlet of spines and spinules, a few small spinules on the actinal edge and 7 or 8 slender spines on the furrow edge. There is one (rarely two) large spine on the actinal face. The mouth plates are wide, short, and rounded. Each jaw half bears one large preoral spine and 6 or 7 long, slender, divergent lateral spines. The actinal surface bears several pairs of short, acute spines. The small, slightly sunken madreporite is very deeply channeled and touches or nearly touches the adjacent superomarginals.

Verrill reports this species as very common in the West Indies, in 70-300 fathoms.

**MATERIAL EXAMINED.**—*Oregon* station unknown (6) off the Florida Keys, 200 fathoms [R=13 mm, r=3 mm, Rr=1:4].

**Order VALVATIDA Perrier, 1884**

The mouth plates in this order are inconspicuous. The inferomarginal and superomarginal plates correspond with one another, and are without intermarginal channels. The tube feet are in two rows. Pedicellariae, when present, are valvate and sunken into the ossicles.

**Key to the Families of Valvatida**

1. Disc broad, arms not cylindrical; actinal interradial area generally large; marginals large and conspicuous ..... 2  
    Disc small, arms usually long and cylindrical; marginals small, inconspicuous..... **Ophidiasteridae**
2. Mouth plates with one or two conspicuous recurved hyaline spines..... **Odontasteridae**  
    No recurved spines on mouth plates..... 3
3. Body thick, cushion-like; interbranchial septa calcareous..... **Oreasteridae**  
    Body not thick and cushion-like; interbranchial septa membranous..... **Goniasteridae**

**Family ODONTASTERIDAE Verrill, 1899**

In this family, the form is pentagonal or broadly stellate; the abactinal surface is more or less paxillate. The tube feet are suckered, in two rows. The marginal plates correspond and are not conspicuously spiny; there is an odd interradial marginal in both series. The mouth plates bear one or two conspicuous recurved hyaline spines per plate.

There are no superambulacral ossicles.

Only one genus in this family is represented in western North Atlantic.

***Odontaster* Verrill**

*Odontaster* Verrill, 1880:402. [Type, by original designation, *O. hispidus* Verrill.]

*Gnathaster* Sladen, 1889:285. [Type, by subsequent designa-

tion, *Astrogonium meridionale* Smith (Verrill, 1899; 204.) [*Gnathodon* Verrill, 1899;204. [Erroneous spelling of *Gnathaster* Sladen.]

*Peridotaster* Koehler, 1920:190. [Type, by original designation, *Calliderma grayi* Bell.]

*Epidontaster* Koehler, 1921b:190–195. [Type, by original designation, *E. pentagonalis* Koehler.]

*Gymnognathaster* Doderlein, 1927:297. [Type, by original designation, *G. gaussae* Doderlein.]

Disc broad, arms short; form generally stellate; a single heavy recurved spine with hyaline tip at apex of mouth plates; entire body densely covered

with short spines; surface, particularly on ventral side, looks furry.

Verrill has described three species of *Odontaster* from the western North Atlantic. One, *O. robustus*, is limited to the vicinity of Martha's Vineyard, and is anyway easily distinguished by its broad heavy marginals and by having the odd interradial marginals of both series triangular and exsert (not touching the intermarginal suture). It otherwise resembles *O. setosus*. *O. setosus* and *O. hispidus* are limited to the northern part of the range covered by this report, in 40–400 fathoms.

### Key to the Species of *Odontaster*

- Papular pores over entire dorsum except for narrow interradial area on disc; spines of ventral plates heavy, peglike ..... *O. hispidus*  
 Papular pores in definite papularia; ventral spines fine, setose..... *O. setosus*

#### *Odontaster hispidus* Verrill

PLATE 15: FIGURES C, D

*Odontaster hispidus* Verrill, 1880:402; 1894:263; 1895:136; 1899:205, pl. 29: fig. 8, 8a; 1915:119, pl. 13: fig. 6.—Fisher, 1928a:489.—Gray, Downey, and Cerame-Vivas, 1968:148, fig. 22.

The disc is broad and the five (not uncommonly four or six) arms are short. The form is generally stellate, but may vary from nearly pentagonal to stellate with relatively long arms. The dorsal plates have stellate, imbricating bases and a rounded, elevated, subpaxillate top bearing a bundle of 6–25 spinules. Papular pores occur singly between the plates except in a narrow interradial area and near the extreme tip of the arm. The superomarginal plates are nearly square, confined to the dorsal surface, and covered with dense spinules. The sides of the plates are broadly bevelled and the sutures between the plates are wide, deep, and bare. The odd interradial superomarginal is wedge shaped. The inferomarginal plates extend beyond the superomarginals, defining the ambitus. They are more rectangular than the superomarginals and bear a dense coat of thicker, heavier spines.

The actinal interradial plates are round, compact, and in regular rows parallel to the groove; one series extends nearly to the tip of the arm. These plates each bear several heavy spines, larger than those of the inferomarginals. The adambulacral plates are small, short, and crowded. They

bear 2 or 3 stout, heavy furrow spines; the actinal face bears 2 or 3 rows of one or two similar spines. All the adambulacral spines are subequal and thicker than those of the actinal interradial plates. Contrary to Verrill's description, the mouth plates are small, being no larger than the next adjoining adambulacral plates (Verrill was probably misled by the very dense spination). The two halves are joined by a membranous suture and each bears 5 or 6 heavy spines like those of the adambulacrals. There is an odd, central, recurved spine at the apex. It is not much longer than the other spines, but is very much heavier, and the tip is hyaline. The madreporite, halfway between the disc center and the margin, is of moderate size, hemispherical, and covered with fine, deep gyri.

This species ranges from New England to Florida, in 40–400 fathoms.

MATERIAL EXAMINED.—*Oregon II* Stations: 10728 (2) [R=35 mm, r=14 mm, Rr=1:2.5]; 10667 (1) [R=37 mm, r=16 mm, Rr=1:2.5]; 10715 (1) [R=32 mm, r=15 mm, Rr=1:2].

#### *Odontaster setosus* Verrill

PLATE 16: FIGURES A, B

*Odontaster setosus* Verrill, 1899:207, pl. 29: figs. 1–1c, 2; 1915: 120.

This five-armed stellate or pentagono-stellate species is generally smaller than *O. hispidus*. The round-

topped dorsal plates bear 10–25 long, fine spinules. The papular pores are in six well-defined areas, a small circular area in the center of the disc, and five large papularia extending from near the central area to the base of the arms. The dorsal plates in these areas are larger and higher than the other dorsal plates. The superomarginal plates encroach quite far onto the dorsal surface but are not confined to it. They are rectangular, broader than long, and the odd interradial marginal is not differentiated from the others. The edges of the plates are not beveled and the sutures between them are shallow. Several pairs of superomarginals near the tip of the arm may be in contact dorsally. The inferomarginal plates are similar and both series are clothed densely with fine spinules. The large actinal interradial areas are filled with rounded plates in regular rows, at least one of which extends more than two thirds the length of the arm. They are clothed with moderately long setose spinules.

The adambulacral plates are square and bear a furrow series of 5 or 4 stout, blunt, divergent spines; the actinal edge of the plate bears 5 or 6 long, acute spines, and between the two series are 3–5 spines similar to those of the furrow series. The small mouth plates bear a cluster of small preoral spines, about five larger lateral spines, two pairs of stout epioral spines, and a very large, heavy, hyaline-tipped, unpaired, recurved spine. The madreporite is small, round, channeled, closer to the center of the disc than the margin, and surrounded by a few enlarged dorsal plates.

Verrill states that this species is often taken with *O. hispidus*. I am inclined to the view that, although their ranges overlap, essentially *O. hispidus* is a northern species, while *O. setosus* is more southern.

**MATERIAL EXAMINED.**—Oregon Station 272 (1) [R=28 mm, r=12 mm, Rr=1:2.3]. *Combat Station* 185 (1) [R=23 mm, r=14 mm, Rr=1:1.9].

#### Family GONIASTERIDAE Forbes, 1841

The Goniasteridae have a large disc and large marginals. The actinal and abactinal plates are usually tessellate. Papulae are confined to the dorsal surface, usually single, and in a circumscribed area. The tube feet, in two rows, have large suckers. There is no large recurved spine on the mouth

plates. The actinal interradial areas are extensive. The interbrachial septa are membranous.

The Goniasteridae of the North Atlantic have undergone a recent extensive revision by Dr. Jerald A. Halpern<sup>1</sup>. The section here on this family is mainly a paraphrase of parts of this very excellent monograph, done with the kind permission and assistance of Dr. Halpern.

#### *Goniaster* Agassiz

*Goniaster* L. Agassiz, 1835b:441. [Type, by original designation, *Asterias tessellatus* Lamarck.]

*Phaneraster* Perrier, 1894:388. [Type, by original designation, *Pentagonaster semilunatus* Linck.]

Only one species, *Goniaster tessellatus* (Lamarck), is known from the western Atlantic.

#### *Goniaster tessellatus* (Lamarck)

PLATE 16: FIGURES C, D

*Pentagonaster semilunatus* Linck, 1733:21, pl. 23: no. 37, pl. 24: no. 39, pl. 27: no. 45.—Perrier, 1876a:24–28; 1876:64, 67.—Rathbun, 1879:148–149.—Sladen, 1889:265, 266, 267–268, 655, 694, 748–749.—Ludwig, 1899:539.

*Artocreatis tertia* species Seba, 1761:11, pl. 6: figs. 9, 10.

*Asterias granularis* [part] Gmelin, 1791:3164.

*Asterias tessellata* [var. C and D] Lamarck, 1816:552.—de Blainville, 1834; pl. 23: fig. 4.

*Goniaster tessellatus*.—L. Agassiz, 1835a:143; 1835b:191.—H. L. Clark, 1909:110; 1946:81.—Fisher, 1910a:172; 1911a:167–168.—Verrill, 1914:286.—Halpern, 1970a:256–265, figs. 23–25.

*Goniaster cuspidatus* Gray, 1840:280; 1866:10.—Tortonese, 1937:31–34, pl. 2: fig. 6, pl. 6: figs. 25–31.—Madsen, 1950: 209–211.—John and Clark, 1954:139.—A. H. Clark, 1954: 375.—A. M. Clark, 1955:18, 22.—Engel et al., 1960: p. 12.

*Astrogonium cuspidatum*.—Muller and Troschel, 1842:56.—Dujardin and Hupe, 1862:394.—Perrier, 1869:85, 1876b: p. 67.

*Goniaster semilunatus*.—von Martens, 1866:86.—Koehler, 1909b: 87, pl. 5: fig. 5.

*Astrogonium dubium* Perrier, 1869:85.

*Goniaster americanus* Verrill, 1871:130–131; 1899:151–156, pl. 24a: figs. 1–2, pl. 26: figs. 1–6; 1915:104–107, pl. 13:5, 5a.—Perrier, 1875a:1273; 1876a:261; 1876b:67. — Bernasconi, 1958a:13–15, pl. 1: figs. 1, 2.—Cherbonnier, 1959:107–108.—Gray, Downey, and Cerame-Vivas, 1968:148–150, fig. 23.

*Goniaster africanus* Verrill, 1871:131–132; 1899: 156–157, pl. 25: figs. 1–2.—Perrier, 1875a:1273; 1876a:261; 1876b:67.

*Astrogonium semilunatum*.—Perrier, 1885:37.

*Phaneraster semilunatus*.—Perrier, 1894:388–390.

<sup>1</sup> PhD dissertation, 1970, University of Miami, published in part.

**Key to the Genera of Goniasteridae \***

- 1. Large prominent spines on abactinal surface ..... *Goniaster*
- No spines on abactinal surface ..... 2
- 2. Entire body covered by skin obscuring plates ..... *Anthenooides*
- Body not covered by skin ..... 3
- 3. Superomarginal plates in contact medially throughout length of arm; form never pentagonal ..... 4
- Superomarginals in contact medially for less than half the length of arm; form pentagonal or not ..... 5
- 4. Furrow margins not strongly angular; internal radiating connecting ossicles present.....
- ..... *Rosaster*
- Furrow margins strongly angular; no internal connecting ossicles ..... *Nymphaster*
- 5. Abactinal plates of arms larger than those of disc..... *Circeaster*
- Abactinal plates of arms not larger than those of disc..... 6
- 6. Unpaired median spine common to each pair of mouth plates..... 7
- Two median spines to each pair of mouth plates..... 8
- 7. Single row of plates separating superomarginals along arm..... *Paragonaster*
- Several rows of plates separating superomarginals..... *Pseudarchaster*
- 8. Abactinal plates not completely covered by granules..... 9
- Abactinal plates completely covered by granules..... 11
- 9. Central naked area on some actinal plates..... *Tosia*
- Actinal plates completely covered by granules..... 10
- 10. Abactinals surrounded by single row of granules..... *Plinthaster*
- Abactinals with more than single row of granules..... *Litonotaster*
- 11. Adambulacral granulation very crowded..... *Peltaster*
- Adambulacral granules spaced ..... 12
- 12. Rr about 4; adambulacral furrow margin strongly angular..... *Tessellaster*
- Rr less than 2; adambulacral furrow margin not strongly angular..... *Ceramaster*

\* Key adapted from Halpern to accommodate only those genera included in these collections.

This species has a broad, convex disc and five short, broad arms. The abactinal surface is covered with large conical spines on the primary plates. Secondary plates are present only in the papular areas, which form broad bands from the center of the disc down each arm. There are six papular pores around each primary plate. Abactinal plates are covered with flat granules and each has a border of larger flattened granules. The marginals are massive and bare, each bordered by a single row of flattened granules. The superomarginals are larger than the inferomarginals, and the center of the plate is drawn up to form a large, blunt, conical spine. The last two pairs of superomarginals are contiguous medially. The inferomarginals are tumid, smaller, and more numerous than the superomarginals. A few granule-covered triangular plates occur intermarginally. The actinal inter-radial areas are large; the actinal plates are large, flat, and polygonal, covered with coarse, rounded granules; a few plates near the mouth may also bear a large conical spine. The straight margin of

the adambulacral plates bears a furrow series of 4-6 long, flattened, truncate, subequal spines. There are three rows of subambulacral spines, of 2-4 large, blunt spines, those of the second row thicker and heavier than those of the first and third rows. The mouth plates are small, narrow, and armed like the adambulacral plates. The madreporite, nearer the center of the disc than the margin, is moderate to large in size, flat, roundly triangular, and covered with fine gyri.

Small sugar-tongs pedicellariae are numerous on both surfaces, with broad-lipped alveoli and long spoon-shaped valves. The oculars are small and truncate-conical. This is quite a variable species in size and distribution of spines, but surprisingly uniform in shape. Small specimens have a plane, rather than inflated, abactinal surface, and the superomarginals are less tubercle-like. They may also lack the spines on the abactinal primary plates.

The distribution in the western Atlantic is from Cape Hatteras to Brazil; elsewhere, it is known from

the tropical eastern Atlantic and the Indo-West Pacific. The depth range is 22–430 meters.

MATERIAL EXAMINED.—*Oregon* Stations: 4392 (1) [R=79 mm, r=43 mm, Rr=1:1.85]; 4086 (6) [R=71 mm, r=41 mm, Rr=1:1.8]; 2245 (2) [R=27 mm, r=15 mm, Rr=1:1.9]. *Oregon II* Stations: 10518 (1) [R=59 mm, r=31 mm, Rr=1:1.9]; 10533 (1) [R=65 mm, r=29 mm, Rr=1:1.8]. *Bowers* Station 43 (5) [R=45 mm, r=25 mm, Rr=1:1.9]. *Silver Bay* Stations: 41/43 (1) [R=52 mm, r=27 mm, Rr=1:1.9]; 1710 (2) [R=45 mm, r=25 mm, Rr=1:1.8]; 2926 (1) [R=21 mm, r=14 mm, Rr=1:1.6]; 2009 (1) [R=16 mm, r=9 mm, Rr=1:1.8]; 3284 (1) [R=9 mm, r=6 mm, Rr=1:1.5]; 2390 (2) [R=33 mm, r=20 mm, Rr=1:1.6]; 2010 (1) [R=5 mm, r=3 mm, Rr=1:1.7]. *Combat* Stations: 339/340 (1) [R=25 mm, r=14 mm, Rr=1:1.8]; 98 (1) [R=10 mm, r=6 mm, Rr=1:1.7].

#### *Anthenoides* Perrier

*Anthenoides* Perrier, 1881a:23. [Type, by original designation, *A. piercei* Perrier.]

*Leptogonaster* Sladen, 1889:326. [Type, by original designation, *L. cristatus* Sladen.]

*Antheniaster* Verrill, 1899:173. [Type, by original designation, *Anthenoides sarissa* Alcock.]

Entire body covered by skin of moderate thickness which obscures plates below it; granules, when present, beneath skin; numerous secondary abactinal plates, extending along arms; secondary plates increasing in number with age.

Of the two species occurring within the area covered by this report, only *A. piercei* is represented in the present collection. *A. brasiliensis*, described by Bernasconi (1956), is known only from a few specimens from south of 07°N; Halpern (1970, unpublished) points out that it may be an infraspecific geographic variety of *A. piercei*, from which it differs principally in lacking secondary abactinal plates, large central granules and bivalved pedicellariae on most actinal plates, and well-developed inferomarginal spinules.

#### Key to the Species of *Anthenoides*

- Two rows of secondary abactinal plates along each arm..... *A. piercei*  
 No secondary abactinal plates ..... *A. brasiliensis*

#### *Anthenoides piercei* Perrier

PLATE 17: FIGURES A, B

*Anthenoides piercei* Perrier, 1881a:23; 1884:168, 170, 184, 247–248, pl. 8: fig. 1; 1894:38.—A. Agassiz, 1888; fig. 379.—Sladen, 1889:326, pl. 756.—Verrill, 1915:113, pl. 3: fig. 2, pl. 10: figs. 1–1b, 2–2f.—Fisher, 1919:328, 331, 332.—H. L. Clark, 1941:49.—John and Clark, 1954:139.—A. H. Clark, 1954:375.

The general form is stellate, with a large disc and five short, narrow arms. The entire animal is covered by a thick membrane, full of small scattered granules, which obscures the plates. The plates are in regular rows, and small secondary plates separate the carinal and adradial rows on the disc and for a short distance out on the arm. The large single papular pores extend in regular rows from the disc center to two-thirds the length of the arm. A broad, triangular interrational area on the disc is without papulae; the plates in this area

are conspicuously larger than other abactinal plates near the center of the disc. The disc dorsum is decidedly inflated.

The superomarginal plates are of moderate size, conspicuous, and square to wider than long, and unarmed. The two series of marginals correspond, more or less, and form together a vertical ambitus. Eight to ten pairs of distal superomarginals are medially contiguous. The lateral and actinal faces of the inferomarginals form an abrupt angle, the actinal face being quite plane and flat. They are covered with granules and bear, on the angled edge, one to several short flattened truncate spines or a group of enlarged granules. The actinal intermediate areas are large. Actinal plates are large, polygonal, and tumid; they are covered with rounded granules, those in the center of some plates being quite coarse. The adambulacral plates bear a furrow series of 6–8 long, slender spines; there is a naked area between these and the subambulacral



series, which consists of two large and one or two small, thick, rather conical or truncate spines. The mouth plates are of moderate size and are swollen; the two halves are well separated. Each half bears a large apical spine and 8–10 marginal spines similar to those of the furrow series. Spines on the actinal face are similar to the subambulacral. The madreporite is large, plane, and nearer the center than the margin; it is covered with coarse radiating gyri. Large bivalved pedicellariae occur on many of the actinal plates, and also frequently on some inferomarginals; smaller ones may occur on the abactinal surface. The oculars are small and inconspicuous. The color in life is orange to deep red abactinally, cream white actinally.

This species is known from Florida to Guyana, in 20–844 fathoms.

**MATERIAL EXAMINED.**—*Oregon II* Stations: 10353 (2) [R=82 mm, r=33 mm, Rr=1:2.5]; 10184 (2) [R=58 mm, r=24 mm, Rr=1:2.5]. *Oregon* Stations: 3608 (1) [R=82 mm, r=32 mm, Rr=1:2.5]; 4421 (1) [R=51 mm, r=22 mm, Rr=1:2.5]; station unknown (3) [R=83 mm, r=30 mm, Rr=1:2.5]; 6699 (1) [R=49 mm, r=16 mm, Rr=1:3 (aberrant specimen with unusually long arms and very few secondary abactinal plate)]; station unknown (1) [R=23 mm, r=10 mm, Rr=1:2.3]. 2027 (1) [R=27 mm, r=11 mm, Rr=1:2.5]; 6403 (1) [R=21 mm, r=8 mm, Rr=1:2.4]. *Alaminos* Station 20/65-A-9 (1) [R=57 mm, r=27 mm, Rr=1:2]. *Silver Bay* Stations: 281 (1) [R=51 mm, r=18 mm, Rr=1:3 (like the specimen from *Oregon* Station 6699)]; 2453 (1) [R=22 mm, r=9 mm, Rr=1:2.5].

### *Ceramaster* Verrill

*Ceramaster* Verrill [Section C of *Tosia*], 1899:161. [Type, by subsequent designation, *Asterias granularis* Retzius (Fisher, 1906:1054).]

*Philonaster* Koehler [subgenus], 1909b:74. [Type, by monotypy, *Pentagonaster (Philonaster) mortenseni* Koehler.]

Abactinal plates completely covered by granules; radial abactinal plates tabulate; peripheral granules distinct from central; usually no secondary abactinal plates (when present, confined to disc); no superambulacral ossicles; no internal radiating ossicles.

Only one species is known from the tropical and subtropical western Atlantic.

### *Ceramaster grenadensis* (Perrier)

PLATE 17: FIGURES C, D

*Pentagonaster grenadensis* Perrier, 1881a:19–20; 1884:168, 181, 186, 232–233, pl. 8: fig. 2; 1894:39, 390.—Sladen, 1889:265, 266, 744.

*Pentagonaster affinis* Perrier, 1884:168, 183, 186, 243, pl. 8: fig. 4; 1894:40, 390.—Sladen, 1889:265, 267, 744.

*Tosia affinis*.—Perrier, 1884:183.

*Pentagonaster gosselini* Perrier, 1884:35; 1885b:886; 1891a:1226; 1894:399–401, pl. 26: fig. 4; 1896:45.—Koehler, 1909b:84, pl. 1: fig. 9.

*Pentagonaster haesitans* Perrier, 1885a:36; 1894:397–399, pl. 23: fig. 7, pl. 25: fig. 2.

*Pentagonaster deplasi* Perrier, 1885a:34; 1885b:886.

*Pentagonaster crassus* Perrier, 1885a:34; 1885b:886; 1891a:1226; 1896: p. 45.

*Astrogonium greeni* Bell, 1889:433–434, pl. 19: fig. 4.

*Pentagonaster balteatus* Sladen, 1891:688–690, pl. 25.—Farran, 1913:9–10.

*Pentagonaster hystericis* Marenzeller, 1891:439, 442, 445; 1893:4–5, pl. 1: figs. 2–2a, pl. 2: figs. 2b–2c.

*Pentagonaster greeni*.—Bell, 1892:74–75, text-fig.—Nichols, 1903:249.

*Pentagonaster granularis* var. *deplasi*.—Perrier, 1894:401–402, pl. 26: fig. 3.

*Pentagonaster kergroheni* Koehler, 1895:453–454, fig. 2.

*Tosia grenadensis*.—Verrill, 1899:162.

*Pyrenaster affinis*.—Verrill, 1899:168; 1915:222.

*Ceramaster affinis*.—Fisher, 1911:165.

*Ceramaster grenadensis*.—Verrill, 1915:222.—H. L. Clark, 1941:38–39.—A. H. Clark, 1954:375.—Halpern, 1970a:213–218, figs. 8–9.

*Ceramaster hystericis*.—Koehler, 1924:176–178. — Tortonese, 1938:272.—Cherbonnier, 1956:4.—Dieuzeide, 1960: pp. 69–71, fig. 5.

*Ceramaster balteatus*.—Mortensen, 1927:82–83, fig. 45.—Tortonese, 1965:156.

The form is stellate to pentagonal, with five short arms. The abactinal plates are low-tabulate, and secondary plates, if present, are restricted to the center of the disc. The plates of the conspicuous radial areas are slightly enlarged and are in 3–5 regular rows from near the disc center to the marginals. The papulae are single, between the plates of the radial areas. All plates are covered with rounded granules; the peripheral series on each plate is flattened and rectangular. The superomarginal plates are rectangular, about twice as wide as long, and 10–17 in number (usually 12). They may be completely covered with granules, but usually there is a more or less extensive naked area. The inferomarginal plates correspond to the superomarginals and are covered with granules. The interradial actinal area is large and the flat,

polygonal, actinal plates are in regular rows and covered with granules coarser than those of the abactinal surface. The adambulacral plates bear 5 or 6 subequal compressed furrow spines with rounded tips. The armature is in 3 or 4 irregular rows of large rounded granules. Each mouth plate half bears a large median spine and about eight spines like the adambulacral furrow spines; the face of the half-plate bears three large, compressed spines along the suture, and the rest of the plate is covered by a few granules. The madreporite is small and rhombic. The oculars are small, bare, and cordiform.

Small excavate sugar-tongs pedicellariae are usually present both actinally and abactinally.

According to Halpern (1970, unpublished), this species is known in the western Atlantic from Florida to Brazil, in 200 to 2,500 meters. It also occurs in the eastern Atlantic from Ireland to the

Equator, in the Mediterranean, and in the Azores.

MATERIAL EXAMINED.—*Oregon* Station 6696 (5) [R=21 mm, r=13 mm, Rr=1:1.8]. *Oregon II* Stations: 10841 (1) [R=22 mm, r=14 mm, Rr=1:1.7]; 10842 (1) [R=27 mm, r=16 mm, Rr=1:1.7]; 10844 (2) [R=33 mm, r=18 mm, Rr=1:1.8].

### *Peltaster* Verrill

*Peltaster* Verrill, 1899:168-169. [Type, by original designation, *P. hebes* Verrill (= *Goniaster nidarosiensis* Storm).]

Form pentagonal to arcuate pentagonal; abactinal plates flat, covered by granules; secondary plates present throughout radial areas; adambulacral furrow spines stout, moderately short; subambulacral series graduated in size, grading from furrow spines to granules of actinal intermediate plates; adambulacral granulation crowded.

### Key to the Species of *Peltaster*

- Many actinal plates adjacent to adambulacrals bearing short bivalved pedicellariae..... *P. nidarosiensis*  
 Pedicellariae, when present, only of small excavate sugar-tongs type ..... *P. placenta*

### *Peltaster nidarosiensis* (Storm)

#### PLATE 18: FIGURES A, B

*Goniaster nidarosiensis* Storm, 1881:90-91.

*Pentagonaster vincenti* Perrier, 1885c:34-35; 1885a:886; 1894:396-397, pl. 26: figs. 2a-2b.

*Pentagonaster nidarosiensis*.—Storm, 1888:61, 1901:12.

*Goniaster acutus* Lutken, 1890:359.

Non *Goniaster acutus*.—Heller, 1863:419, pl. 1: figs. 1-4.

*Pentagonaster placenta* [part] Ludwig, 1897:157.

*Peltaster hebes* Verrill, 1899:169-170, pl. 28: fig. 4.—Fisher, 1911a:162.—H. L. Clark, 1941:41-42.—A. H. Clark, 1954:375.

*Hippasteria phrygiana* [part] Ludwig, 1900:457-458.

*Peltaster nidarosiensis*.—Grieg, 1905:3-13, figs. 1-2, 4-5; 1927:131.—Fisher, 1911a:162.—Verrill, 1915:28, figs. 4, 4a.—Mortensen, 1924:20.—Tortonese and Clark, 1956:348, 350, 351, figs. 1A, 2A.—Halpern, 1970a:235-238, fig. 14.

The form of this species is pentagonal and the disc is very large and flat. Both primary and secondary abactinal plates are flat, irregularly round, and covered with moderately large, rounded or slightly angular, crowded granules. The arrangement of the primary plates is regular, except in the center of the disc. There are six papular pores around each primary plate over a large area of the disc; only

small triangular interradial areas lack pores. The 18-20 massive superomarginal plates are about twice as wide as long. They are covered with granules similar to those of the abactinal plates. The inferomarginal plates correspond to the superomarginals except distally, where they become smaller and more numerous; they bear granules like those of the superomarginals. The large, rhombic, regularly arranged plates of the broad actinal intermediate areas are closely covered with granules larger than those of the marginals. Most of the actinal plates in the row adjoining the adambulacral plates bear a small bivalved pedicellaria; similar pedicellariae occur on some of the other actinals. The adambulacral plates bear, on a slightly curved furrow margin, 4-6 short, thick, compressed furrow spines with blunt tips; a first subambulacral row of three shorter, thicker, prismatic spines, and about three irregular rows of 3 or 4 smaller spines, becoming reduced to granules, occupy the actinal face of the adambulacral plates.

The moderate-sized mouth plates bear, on each half, 7-10 strongly compressed marginal spines

similar to the adambulacral furrow spines, and five shorter, thicker spines behind them. The madreporite is moderate to large, flat, covered with deep gyri, and surrounded by a row of slightly enlarged granules. The oculars are small, triangular, and bare. Tiny excavate sugar-tongs pedicellariae occur on many of the abactinal plates, and small bivalved pedicellariae on the actinal surface as noted. The anus is surrounded by five large, triangular or teardrop-shaped plates and a group of enlarged flattened granules.

In the western Atlantic, this species occurs from Georgia to Cuba, and in the eastern Atlantic from Norway to the Bay of Biscay and the Canary Islands; the depth range is 95–1,107 meters. This specimen represents a range extension for the species, to Martinique Passage.

MATERIAL EXAMINED.—*Oregon II* Station 10827 (1) [R=75 mm, r=54 mm, Rr=1:1.2].

### *Peltaster placenta* (Muller and Troschel)

PLATE 18: FIGURES C, D

*Goniodiscus placenta* Muller and Troschel, 1842:59.—Dujardin and Hupe, 1862:402.

*Goniodiscus placentaeformis* Heller, 1863:419–420, pl. 1: figs. 1–2; 1868:54.—Gasco, 1876:40–41, fig. 11.

*Goniodiscus acutus* Heller, 1863:420–421, pl. 1: figs. 3–4; 1868:54.

*Goniaster placenta*.—von Marenzeller, 1875:361.—Stossich, 1883:189.

*Goniaster acutus*.—von Marenzeller, 1875:362.—Stossich, 1883:189.

*Pentagonaster mirabilis* Perrier, 1876a:40–41; 1878:21, 84; 1894:390.—Ludwig, 1879:540.—Carus, 1885:88.—Sladen, 1889:265, 746.

*Pentagonaster placenta*.—Perrier, 1878:21, 84; 1894:390.—Ludwig, 1879:540; 1897:157–179, pl. 5: figs. 1, 2, 10, pl. 7: figs. 24–42.—Carus, 1885:87.—Colombo, 1888:68.—Sladen, 1889:265, 266, 748.—von Marenzeller, 1895:11, 23.—Koehler, 1895:454–455.—Griegel, 1905:4.—Mangold, 1909:134.—Lo Bianco, 1909:561.

*Pentagonaster acutus*.—Perrier, 1878:21, 84.—Carus, 1885:87.

*Pentagonaster minor* Koehler, 1895:451–453, fig. 1; 1896: pp. 61–62, pl. 2: figs. 5–7.

*Pentagonaster planus* Verrill, 1895:135–136.

*Tosia placenta*.—Verrill, 1899:161.

*Peltaster planus*.—Verrill, 1899:170–171, pl. 28: figs. 3, 3a.—H. L. Clark, 1941:42.—Gray, Downey, and Cerame-Vivas, 1968:151–152, [not fig. 26].

*Ceramaster placenta*.—Koehler, 1921a:42, fig. 31; 1924:174; 1929: 2 [unnumbered], 1 pl.—Mortensen, 1927:80, 81.—Tortonese, 1937:60; 1952:187, fig. 3.—Kolosvary, 1937:447, pl. 32: fig. 19.—Cuenot, 1948:238.—Wilson, 1955; fig. 3.—For-

est, 1955: pl. 40.—Cherbonnier, 1956:10; 1958:15.—Vevers, 1956:485.—Buchsbaum and Milne, 1960; pl. 130.—Strenger, 1963:446, pl. 164.

*Peltaster placenta*.—John and Clark, 1954:149. — Halpern, 1970a:238–244, figs. 15–16.

*Sphaerodiscus placenta*.—Tortonese and Clark, 1956:347–352, figs. 1b, 2b.—Madsen, 1958:90–94, fig. 2.—Tortonese, 1965: 157–159, figs. 72–74.

In this species, the form is pentagonal and flat. The disc is large. The abactinal plates are arranged in regular rows from center to margin, and secondary plates are limited to the center of the disc and the papular areas. The abactinal plates are flat, irregularly polygonal, and covered with crowded, rounded granules; the peripheral granules are flattened, movable, and slightly larger than the other granules. Six papular pores surround each primary plate except in a narrow interradial area. The large square superomarginals, 12–20 in number, may be completely covered with coarse, crowded, hemispherical granules or may have a more or less extensive naked area in the center, bearing a few scattered granules. The inferomarginal plates correspond generally to the superomarginals and are similarly granulated; there are usually a few more of them.

The actinal intermediate areas are very large, covered with small, flat, polygonal plates in regular rows, which in turn are covered with closely crowded granules larger than those of the abactinal plates. The adambulacral plates bear a furrow series of 4–6 thick, compressed, blunt-tipped, subequal spines. The three prismatic spines of the first subambulacral row are thicker and shorter than the furrow spines, and there are three additional irregular rows of 3 or 4 progressively smaller granuliform spines. The mouth plates are of moderate size and bear two parallel rows of large, compressed, thick spines, 7–9 on the margin and five on the actinal face; the rest of the mouth plate is covered with granules. The madreporite is large, round, and not surrounded by specialized granules. The oculars are small, cordiform, and naked. Small excavate sugar-tongs pedicellariae, with rounded, spoon-shaped valves, are generally abundant on both surfaces; those on the actinal surface are larger than those on the abactinal surface.

In the western Atlantic, this species occurs from Martha's Vineyard to Key West and throughout the Caribbean. It ranges from the Bay of Biscay

and the Mediterranean to the Equator in the eastern Atlantic. Its depth range is from 10 to 695 meters.

MATERIAL EXAMINED.—*Oregon II* Station 10628 (2) [R=81 mm, r=59 mm, Rr=1:1.5]. *Oregon* Stations: 6699 (1) [R=75 mm, r=50 mm, Rr=1:1.5]; 6696 (1) [R=75 mm, r=50 mm, Rr=1:1.5]. This slightly aberrant specimen has been the source of confusion; placed variously at one time or another in four different genera in the Goniasteridae, it was only by a careful feature by feature (almost plate by plate) study that its true position was recognized. The arms are longer and more produced than is normal for a *Peltaster*. The flat tessellate abactinal plates are irregularly arranged, and secondary plates in the radial areas are numerous. The superomarginal plates are smaller than is usual in *P. placenta*, and they are slightly concave. They are also more numerous, and the inferomarginals correspond interbrachially, but are almost two to one on the arms. Pedicellariae are very abundant on abactinal, marginal, and actinal plates, and a few occurring on the adambulacrals near the mouth are very large. Many of the adambulacrals spines, particularly those near the mouth, are very thick and their tips are grooved and pitted. Every actinal plate in the row adjacent to the adambulacrals bears a pedicellaria.

### *Plinthaster* Verrill

*Plinthaster* Verrill [Section B of *Tosia*], 1899:161. [Type, by original designation, *Pentagonaster perrieri* Sladen.]  
*Pyrenaster* Verrill, 1899:166. [Type, by original designation, *Pentagonaster dentatus* Perrier.]

Only one species, *Plinthaster dentatus* (Perrier), is known from the Atlantic.

### *Plinthaster dentatus* (Perrier)

PLATE 19: FIGURES A, B

*Pentagonaster dentatus* Perrier, 1884:168, 170, 179, 180, 185, 242–243, pl. 3: fig. 8; 1894:36, 39, 40.—Sladen, 1889: 265, 267, 744.—Farran, 1913:10–11.—Grieg, 1921:21–23.  
*Pentagonaster grandis* Perrier, 1885c:35; 1885a:886; 1894:32.  
*Pentagonaster perrieri* Sladen, 1889:265, 267, 746.—Perrier, 1894:31, 34, 391, pl. 25: figs. 1a, 1b.—Koehler, 1895:15; 1896:60–61, 124–125; 1909b:85–86, pl. 2: fig. 7; 1924:182.  
*Pentagonaster concinnus* Sladen, 1891:690, pl. 26: figs. 1–5.  
*Tosia* (*Plinthaster*) *perrieri*.—Verrill, 1899:161.—Fisher, 1906: 1054.

*Tosia* (*Plinthaster*) *compta* Verrill, 1899:161, 163–165, pl. 27: fig. 2.—Fisher, 1906:1054.

*Tosia* (*Plinthaster*) *nitida* Verrill, 1899:151, 163–165, pl. 27: figs. 1, 1a, 1b.—Fisher, 1906:1054.

*Pyrenaster dentatus*.—Verrill, 1899:167, pl. 27: figs. 3–3b.

*Plinthaster dentatus*.—Fisher, 1910a:172; 1911a:165.—Verrill, 1915:107.—H. L. Clark, 1941:42–43.—A. H. Clark, 1954:375.—Gray, Downey, and Cerame-Vivas, 1968:151.—Halpern, 1970a:244–252, figs. 17–19.

*Plinthaster perrieri*.—Fisher, 1910a:172; 1911a:165.—Koehler, 1921a:2.—Mortensen, 1927:83–84, figs. 46, 47.

*Goniaster africanus* Koehler, 1914:169–170, pl. 7: figs. 1–4.

This extremely variable species varies in shape from stellate to arcuate-pentagonal, to simple pentagonal, to pentagonal with very short arms produced at the angles of the pentagon. The disc is large and flat. The abactinal plates are thin, flat, polygonal, and naked save for a single row of small granules around each plate, which vary in number. Secondary plates are few and confined to the disc center and proximal radial areas. Papular pores are large; six surround each plate over the entire dorsum except in a narrow triangular interradiar area.

The superomarginal plates vary in shape, size, and number; the number, from 10–22; the shape, from longer than wide to square, to wider than long; and the size, from forming a flat, narrow border around the ambitus to forming a thick, raised border of tumid plates. Frequently the distal pair of marginals is enlarged, being twice as long as the next adjacent pair; 1–4 distal pairs are in contact medially. Superomarginal plates may be completely covered with spaced granules, but usually there is a bare area along each side and across the abactinal edge. Inferomarginal plates correspond to superomarginals except distally, where they are smaller and more numerous; they are covered with spaced granules. The actinal plates are large, flat, and rhombic; they are covered with coarse, evenly spaced granules larger than those of the marginals. The adambulacrals plates bear a furrow series of 5–8 close, slightly compressed, blunt spines, and the actinal face of the plate is covered with spaced granules larger than those of the adjoining plates. The mouth plates are large, long, and triangular; they are conspicuously outlined with angular enlarged granules; the spines of the furrow margin are like the adambulacrals furrow spines, but thicker and subprismatic. The median spines are large and triangular in cross section.

The madreporite is of moderate size, slightly tumid, and irregularly square. The oculars are small, cordiform, and naked. Small excavate sugartongs pedicellariae may occur on either surface, or both, or neither; they are usually not abundant, or, if so, are confined to the abactinal surface.

In the western Atlantic, this species is abundantly distributed from North Carolina to Brazil and in the Gulf of Mexico. In the eastern Atlantic, it is known from Ireland to Liberia and the Canary, Cape Verde, and Azores Islands. The depth range is 229–2,117 meters.

**MATERIAL EXAMINED.**—*Oregon* Stations: 3654 (1) [R=51 mm, r=30 mm, Rr=1:1.7]; 2775 (1) [R=51 mm, r=37.5 mm, Rr=1:1.4]; 2824 (1) [R=44 mm, r=31 mm, Rr=1:1.4]; 5784 (1) [R=36 mm, r=25 mm, Rr=1:1.4]; 3601, (1) [R=40 mm, r=25 mm, Rr=1:1.6]; 2776 (2) [R=46 mm, r=30 mm, Rr=1:1.5]; 3561 (1) [R=58 mm, r=36 mm, Rr=1:1.5]; 1508 (1) [R=40 mm, r=20 mm, Rr=1:2]; 3573 (1) [R=43 mm, r=25 mm, Rr=1:1.7]; 5929 (2) [R=47 mm, r=30 mm, Rr=1:1.5]; 2771 (2) [R=57.5 mm, r=35 mm, Rr=1:1.4]; 4855 (2) [R=37 mm, r=25 mm, Rr=1:1.5]; 4416 (4) [R=25 mm, r=16 mm, Rr=1:1.9]; 1507 (2) [R=40 mm, r=21 mm, Rr=1:1.9]; 489 (4) [R=31 mm, r=25 mm, Rr=1:1.2]. *Oregon II* Stations: 10491 (1) [R=43 mm, r=30 mm, Rr=1:1.4]; 10636 (1) [R=27 mm, r=20 mm, Rr=1:1.3]; 10802 (1) [R=67 mm, r=43 mm, Rr=1:1.5]; 10876 (1) [R=48 mm, r=30 mm, Rr=1:1.5]; 10633 (1) [R=32 mm, r=25 mm, Rr=1:1.2]; 10827 (1) [R=37 mm, r=24 mm, Rr=1:1.5]. *Alaminos* Stations: 3C/68-A-7 (1) [R=32 mm, r=18 mm, Rr=1:1.9]; 12B/68-A-7 (1) [R=32.5 mm, r=20 mm, Rr=1:1.6]; 15H/68-A-7 (2) [R=42 mm, r=30 mm, Rr=1:1.4]. *Combat* Stations: 364 (2) [R=26 mm, r=20 mm, Rr=1:1.4]; 450 (1) [R=30 mm, r=20 mm, Rr=1:1.5]. *Combat* station unknown (1) east of St. Augustine [R=53.5 mm, r=40 mm, Rr=1:1.3].

### ***Tessellaster* Clark**

*Tessellaster* H. L. Clark, 1941:36. [Type, by monotypy, *T. notabilis* Clark.]

### ***Tessellaster notabilis* H. L. Clark**

PLATE 19: FIGURES C, D

*Tessellaster notabilis* H. L. Clark, 1941:36, pl. 5: fig. 1.—

A. H. Clark, 1954:375.—Halpern, 1970a:218, figs. 10–11.

This stellate species has a large disc and five long, narrow arms. The low-tabulate, mostly hexagonal abactinal plates are in regular series parallel to the carinals and are covered with rounded granules; the peripheral granules on each plate are slightly flattened and rectangular. The papular pores are restricted to moderately small, oval, radial areas. Six pores surround each plate. The marginals correspond except on the distal half of the arms, where they alternate. The superomarginal plates are approximately square, and 15–17 distal pairs are in contact medially. A single row of small, rounded granules surrounds each plate except the distal ones. Many of the mostly naked superomarginals have a central, irregularly shaped indentation filled with granules. The inferomarginal plates are similar, except that the granule-filled indentations are larger and more numerous. The large, flat, rhombic actinal plates are closely covered with granules slightly larger than those of the marginals.

The furrow margin of the adambulacral plates is strongly angular and bears 7 or 8 short, stout, compressed but slightly divergent spines with rounded tips. There is a wide, bare area between the furrow spines and the subambulacral spines, which are in 2 or 3 irregular rows of 4–6 large, coarse granules. The mouth plates bear a marginal series of 8 or 9 stout, compressed spines and a larger, rounded, compressed median spine; the actinal face of the plate bears three regular rows of granules similar to the subambulacral spines of the adambulacral plates. The madreporite is of moderate size, irregular shape, and deeply honeycombed. The oculars are small, oval, and bare. There are no pedicellariae.

This species is known only from Florida to Cuba, in 329–575 meters.

**MATERIAL EXAMINED.**—*Oregon* Station 6699 (1) [R=76 mm, r=21 mm, Rr=1:3.5].

### ***Tosia* Gray**

*Tosia* Gray, 1840:11. [Type, by original designation, *T. australis* Gray.]

In this genus only one species, *Tosia parva*, occurs in the Caribbean and Gulf of Mexico.

***Tosia parva* (Perrier)**

PLATE 20: FIGURES A, B

*Pentagonaster parvus* Perrier, 1881a:19; 1884:36, 37, 231, pl. 7: figs. 7–8.—Sladen:265, 267, 746–747.*Goniaster americanus* (part) Verrill, 1899:154–156, pl. 26: fig. 6.*Plinthaster dentatus* (part).—Gray, Downey, and Cerame-Vivas, 1968: fig. 25.*Tosia parva*.—Halpern, 1969b:503–506, fig. 1.

The form is pentagonal. The abactinal plates are polygonal to round, slightly convex, and surrounded by a single row of large, flat, square granules which, in the radial areas, are frequently fused to form a continuous ring around the plate. Five or more of the abactinal primary plates are larger than the rest of the abactinal plates. The center of each abactinal plate bears 0–6 round granules embedded in deep pits. Papulae are confined to an oval radial area. There are 6–8 massive, tumid superomarginal plates, each surrounded by a single row of small, rounded granules. Single, small, round granules or clusters of up to twelve granules are scattered over the surface of the plates.

There are 8–10 inferomarginal plates corresponding to the superomarginals and similar to them, but usually bearing more than one row of peripheral granules. Between the two series of marginals are several rows of enlarged granules, those at the inferomarginal angles being particularly large. The large, flat, rhombic actinal plates are arranged in five chevrons and are surrounded by two or three rows of coarse, round granules; many of the plates have a more or less extensive central naked area. The adambulacral plates have a straight furrow margin bearing five subequal, compressed, blunt-tipped spines. The subambulacral spines are in 3 or 4 irregular rows of 3–5 short, granuliform spinules. The mouth plate margin bears spines similar to the adambulacral furrow spines but more compressed; the median spine is not conspicuously enlarged. The rest of the mouth plate bears a few angular granules. The madreporite is of moderate size and roundly triangular. The oculars are small and naked. Pedicellariae are rare; when present, they are small, with two slender valves embedded in deep pits, and confined to the actinal surface.

This species ranges from North Carolina to Trinidad, in 30–597 meters.

MATERIAL EXAMINED.—*Silver Bay* Station 2020

(1) [R=18 mm, r=12 mm, Rr=1:1.5]. *Oregon* Stations: 5915 (1) [R=12 mm, r=8 mm, Rr=1:1.5]; station unknown (6) [R=22 mm, r=15 mm, Rr=1:1.5].

***Rosaster* Perrier***Rosaster* Perrier, 1894:36. [Type, by monotypy, *Pentagonaster alexandri* Perrier.]***Rosaster alexandri* (Perrier)**

PLATE 20: FIGURES C, D

*Pentagonaster alexandri* Perrier, 1881a:22–23; 1884:168–172, 177–178, 183, 238–242, pl. 6: figs. 3–8; 1894: pp. 37, 335.—Sladen, 1889:256, 267, 296, 748.*Rosaster alexandri*.—Perrier, 1894:36, 38–40, 387.—Verrill, 1899:197; 1915:111–113, pl. 11: figs. 3–3b, pl. 7: fig. 2.—Fisher, 1919:240–243, 247, 255.—H. L. Clark, 1941:41.—Madsen, 1951:89.—A. H. Clark, 1954:375.—Halpern, 1970a:208–212, figs. 6–7.

The five arms of this stellate species are short, narrow, and strongly tapered. The abactinal surface is flat and the plates tabulate and irregularly round. The bases of the plates are lobed and connected by internal radiating ossicles. Each plate bears a central group of two or three short, clavate spinules and 12–20 divergent, peripheral spinules more pointed and quite thorny. The radial papular areas are oval and conspicuous; there are six large pores around each plate.

The 18–20 inferomarginal and superomarginal plates correspond except on the distal half of the arm, where they may alternate. The superomarginals are wider than long and contiguous throughout the length of the arm, about seven pairs in contact medially. They are covered with spinules like those of the abactinal plates, and the spinules along the edges of the superomarginals are like the peripheral spinules of the abactinals. The inferomarginals are like the superomarginals. The actinal intermediate area is of moderate size, and the plates are large and convex. They are covered with regularly spaced conical spinules. The rectangular adambulacral plates bear 4 or 5 long, thin, blunt furrow spines. The two or three divergent spines of the first subambulacral row are longer and stouter than the furrow spines, and behind them are one or two irregular rows of conical spinules. The mouth plates bear about six

marginal spines similar to the adambulacral furrow spines, with the median spine large, compressed, and rounded at the tip. There are about four pairs of long, stout, moderately acute spines on the actinal face. The madreporite is small and irregularly square. The oculars are moderately small, cordiform, and naked. Small excavate sugar-tongs pedicellariae may occur on actinal, abactinal, and/or marginal plates, or may be entirely absent.

This species is distributed from the Straits of Florida and the Gulf of Mexico throughout the West Indies to Brazil. The known depth range is 60–443 meters.

**MATERIAL EXAMINED.**—*Oregon II* Station 10513 (1) [R=24 mm, r=12 mm, Rr=1:2]. *Oregon* Stations: 4398 (1) [R=15 mm, r=6 mm, Rr=1:2.5]; station unknown (4) [R=27 mm, r=11.5 mm, Rr=1:2.3].

### *Circeaster* Koehler

*Circeaster* Koehler, 1909a:83. [Type, by subsequent designation, *C. marcelli* Koehler (Spencer and Wright, 1966).]

In this genus only one species, *Circeaster americanus* (A. H. Clark), occurs in the area covered by this report.

### *Circeaster americanus* (A. H. Clark)

PLATE 21: FIGURES A, B

*Lydiaster americanus* A. H. Clark, 1916:141–144; 1954: 367.  
*Circeaster occidentalis* H. L. Clark, 1941:46–49, pl. 4: fig. 2.—  
A. H. Clark, 1954:376.  
*Circeaster americanus*.—Halpern, 1970a:265–270, figs. 26–28.

The form is stellate, with a large inflated disc and five broad, tapering arms. The abactinal plates are round or irregularly polygonal and surrounded by a single row of flat, square granules. The centers of the plates are mostly naked, but some, especially near the center of the disc, may bear up to ten round granules in deep pits. The abactinal plates of the arms are conspicuously larger than those of the disc. Secondary abactinals are present only in the papular areas, which are extensive, papulae being absent only from a narrow interradial area. The papular pores are single, and six surround each primary plate. The superomarginal plates, about forty-four in number, are square interradially, and

twice as wide as long distally. They are surrounded by a single row of granules and bear 15–25 scattered granules on the surface. Three to fourteen superomarginals are in contact medially.

The inferomarginal plates correspond to and resemble the superomarginals except that the surface granules are more numerous (40–50). The large actinal intermediate areas extend about half-way down the arm. The plates are surrounded by large prismatic granules, and the center of each plate is occupied by a large bivalved or spatulate pedicellaria. The furrow margin of the adambulacral plates is slightly angular and bears 4–6 short, stout, prismatic, truncate spines, somewhat compressed; behind is a row of 3 or 4 smaller, similar spines and behind them a large, bivalved pedicellaria; the rest of the plate is surrounded by granules similar to those of the actinals. The mouth plates are long, narrow, and bear a furrow series of six spines, longer and stouter than the adambulacral furrow spines. The median spine is longest, and very compressed. A row of stout prismatic granules occurs on either side of the wide median suture. The madreporite is irregularly round to somewhat stellate, about three times the size of the adjacent abactinals. The oculars are large, oval, and may bear a few truncate tubercles. Small bivalved or spatulate pedicellariae occur on many of the abactinals and a few of the marginals; similar but larger pedicellariae are abundant actinally.

This species is known from the Gulf of Mexico, the Straits of Florida, Cuba, Colombia, Trinidad, and Guyana, in 503–1,446 meters.

**MATERIAL EXAMINED.**—*Oregon* Stations: 6702 (3) [R=76 mm, r=33 mm, Rr=1:2.3]; 6696 (1) [R=77 mm, r=28 mm, Rr=1:2.9]; 6697 (2) [R=62 mm, r=26 mm, Rr=1:2.9]; 4416 (1) [R=62 mm, r=25 mm, Rr=1:2.4]; 5930 (1) [R=53 mm, r=21 mm, Rr=1:2]. *Oregon II* Stations: 10636 (2) [R=98 mm, r=34 mm, Rr=1:2.9]; 10633 (1) [R=90 mm, r=39 mm, Rr=1:2.3].

### *Litonotaster* Verrill

*Litonotaster* Verrill, 1899:171–172. [Type, by original designation, *Pentagonaster intermedius* Perrier.]

Abactinal plates flat, thin; not completely covered by granules, but bearing more than single marginal

row; no secondary abactinal plates; papular areas narrow; no superambulacral ossicles; no internal radiating ossicles.

There are two species in this genus which occur in the area covered by this report, but only one, *L. intermedius*, has been taken in these collections.

### Key to the Species of *Litonotaster*

Actinal plates covered by conical spines .....	<i>L. intermedius</i>
Actinal plates covered by hemispherical granules .....	<i>L. rotundigranulum</i>

### *Litonotaster intermedius* (Perrier)

PLATE 21: FIGURES C, D

*Pentagonaster intermedius* Perrier, 1884:243, pl. 5: figs. 5–6.  
Non *Pentagonaster intermedius*.—Alcock, 1893a:90.

*Litonotaster intermedius*.—Verrill, 1899:172, pl. 28: figs. 5–5b,  
—H. L. Clark, 1920:85; 1941:43.—Madsen, 1951:88.—A. H. Clark, 1954:375.—Halpern, 1969a:130, figs. 1b, 2, 3.

The form of this species is stellate and the disc is large, with a thin, flexible, inflated dorsal tegument. The five arms taper smoothly from the rounded interbrachial arcs to narrow blunt tips. The abactinal plates are small, flat, and irregularly round; they are covered with small, closely crowded granules, save for a bare space in the center of some of the plates. The small papular areas are restricted to a narrow band from the base of the arms to the center of the disc. The superomarginal plates, about twenty in number, are square to slightly longer than wide, and one or two pairs may be in contact medially. They are surrounded by a row of granules similar to those of the abactinal plates, and in the interbrachial arc they are flattened in the vertical plane and the lower two-thirds of the plate is covered with coarse granules. Distally, the plates become more angular and the surface granulation is reduced or absent.

The inferomarginal plates correspond to the superomarginals and are covered with short conical spinules. The actinal intermediate area is large, and the flat polygonal plates do not extend down the arms. They are covered with short conical granules. The large rectangular adambulacral plates have a straight furrow margin bearing 6–8 short, blunt, compressed spines; the rest of the plate bears small

conical spinules similar to those of the actinals. The large mouth plates bear 12 or 13 furrow spines similar to those of the adambulacrals, and the median spine is longer and strongly compressed. The rest of the plate is covered by conical spinules parallel to the suture, which is broad and prominent. The madreporite is irregularly round and slightly tumid. The oculars are small, cordiform, and frequently bear a few truncate tubercles. Two- or three-valved short excavate pedicellariae occur on some inferomarginals and actinals and on most of the adambulacral plates.

This species is known from the Gulf of Mexico, the Windward Passage between Cuba and Hispaniola, and from Guyana, in 1,958–3,294 meters.

MATERIAL EXAMINED.—*Alaminos* Stations: 10/68-A-13 (1) [R=16 mm, r=7 mm, Rr=1:2]; 9/68-A-13 (4) [R=17 mm, r=7 mm, Rr=1:2.4]; 4A/68-A-7 (5) [R=25 mm, r=11.5 mm, Rr=1:2]; 3C/68-A-7 (1) [R=18 mm, r=9 mm, Rr=1:2].

### *Paragonaster* Sladen

*Paragonaster*, Sladen, 1889:617. [Type, by subsequent designation, *P. ctenipes* Sladen (Fisher, 1919:228).]

Single row of large, flat (not paxilliform) abactinal plates along most of arm; always reaching terminal plate. Unpaired (but not recurved) median spine at apex of each mouth plate pair.

Of the two species found in western Atlantic tropical and subtropical waters, only *P. subtilis* was taken in these collections. *P. grandis*, from northern Cuba and Brazil (275–540 meters), is mainly distinguished by having much shorter arms and large, crowded spines on the actinal plates.

### Key to the Species of *Paragonaster*

Rr greater than 4; small spaced spines on actinals .....	<i>P. subtilis</i>
Rr less than 3; large crowded spines on actinals .....	<i>P. grandis</i>



***Paragonaster subtilis* (Perrier)**

PLATE 22: FIGURES A, B

*Goniopecten subtilis* Perrier, 1881a:26; 1884:168, 183, 187, 253–254, pl. 5: figs. 3–4; 1885c:41; 1885a:884.—Sladen, 1889:726.

*Archaster formosus* Verrill, 1884:383–384; 1885:519, 543.

*Pentagonaster elongatus* Perrier, 1885c:38.

*Paragonaster cylindricus* Sladen, 1889:311, 314–318, 655, 693, 713, 752, pl. 51: figs. 3, 4, pl. 53: figs. 3, 4.—Perrier, 1894:357.—Verrill, 1894:257; 1899:196.

*Paragonaster formosus*.—Verrill, 1894:257; 1895:137; 1899:196.

*Paragonaster elongatus*.—Perrier, 1894:35, 357, 362–363, pl. 21: fig. 3, pl. 24: fig. 4.—Verrill, 1899:196.

*Paragonaster strictus* Perrier, 1894:35, 357, 363–365, pl. 25: fig. 5.—Verrill, 1899:196.

*Paragonaster subtilis*.—Perrier, 1894:31, 35, 40, 357, 358–362, pl. 23: fig. 5, pl. 24: fig. 3.—Verrill, 1899: p. 196.—Kochler, 1909b:86–87, pl. 4: fig. 2.—Grieg, 1921:20–21.—Mortensen, 1927:79.—Macan, 1938:361.—Madsen, 1951: p. 89.

This stellate species has a relatively small disc and five long, narrow arms. The abactinal plates are paxillate, with a short, stout pedicel and a rounded top bearing large, round, flattened granules centrally and a single row of slender spinelets peripherally. A single row of large, flat, rectangular plates, similarly ornamented, extends out the arms. Papular areas are large, covering most of the disc except a small central and interradial area. There are about eighty-four nearly square superomarginal plates that are mainly in the horizontal plane. They are covered by large, round, flattened granules and are separated medially on the arms by a single row of plates. The inferomarginal plates correspond to the superomarginals and are covered with short, spaced spinules and 6–10 longer lanceolate spines. The actinal areas are small, not extending beyond the third marginal. The plates are covered with short, spaced spinules and some also bear one or two longer lanceolate spines. The pectinate adambulacral plates bear a curved furrow series of 5–8 blunt, cylindrical spines, 1–3 lanceolate spines on the face of the plate, and subambulacral spinules

like those of the actinal plates.

The mouth plates are convex and prominent; they are covered with long lanceolate spines, thickly clustered at the apex of the plate and more widely spaced on the actinal face of the plate; the spines at the apex are quite thorny. The suture between the plates is narrow. The madreporite is small, irregular in shape, and mostly or entirely hidden by the adjoining abactinal plates. It is covered with very coarse deep gyri. The oculars are large, long, oval, and covered with spaced, round granules. There are no pedicellariae. In all of the specimens I have seen, the first pair of tube feet is greatly enlarged and extended toward the mouth. The significance of this feature escapes me.

In the western Atlantic, this species occurs in the Gulf of Mexico and from about 37° to 41° N; it is also known from the Azores, the Cape Verde Islands, and the Bay of Biscay. Its bathymetric range is 2,455–4,375 meters.

MATERIAL EXAMINED.—*Alaminos* Stations: 29/69-A-13 (5) [R=56 mm, r=12 mm, Rr=1:4.9]; 4A/68-A-7 (1) [R=65 mm, r=13 mm, Rr=1:5].

***Nymphaster* Sladen**

*Nymphaster* Sladen, 1885:612. [Nomen nudum.]

*Nymphaster* Sladen, 1889:294–295. [Type, by subsequent designation, *Nymphaster protentus* Sladen, 1889 (= *Pentagonaster arenatus* Perrier, 1881a.—objective synonym). (Fisher, 1917:90).]

Arms long; R/r greater than three; superomarginals contiguous medially throughout length of arm; abactinal plates low-tabulate; adambulacral plates with strongly angular furrow margins, becoming apophyses distally; gonads in single tuft; no internal radiating ossicles.

Two species in this genus occur in the tropical western Atlantic; a third, *N. ternalis* (Perrier), has been placed in the synonymy of *N. arenatus* by Halpern (1970a).

**Key to the Species of *Nymphaster***

- Actinal plates covered by rounded granules; no spines on inferomarginal plates..... *N. arenatus*  
 Actinal plates covered by short conical spinules; prominent spines on some inferomarginals.....  
 ..... *N. subspinosus*

*Nymphaster arenatus* (Perrier)

PLATE 22: FIGURES C, D

- Pentagonaster arenatus* Perrier, 1881a:21; 1884:168, 176, 178, 179, 181, 182, 186, 236-238, pl. 7: figs. 3, 4; 1894:39.  
*Pentagonaster ternalis* Perrier, 1881a:20; 1884:168, 180, 181, 186, 233-234, pl. 1: fig. 1.—A. Agassiz, 1888: fig. 377.  
*Dorigona arenata*.—Perrier, 1885c:39, 40; 1885a:884; 1894:31, 32, 33, 34, 38, 39, 40, 379-382, pl. 21: fig. 5, pl. 22: fig. 6, pl. 24: figs. 5, 6.—Koehler, 1895:15; 1896:57-58, 124-125; 1909b:83, pl. 3: fig. 7.—Grieg, 1921:19-20, pl. 4: figs. 5-8.  
*Dorigona ternalis*.—Perrier, 1885c:39, 40; 1894:39, 371-375.  
 Non *Dorigona ternalis*.—Koehler, 1909a: 54-58, pl. 8: figs. 5, 6.  
*Nymphaster basilicus* Sladen, 1889:295, 296, 306, 308-310, 655, 693, 709, 752, pl. 57: figs. 8, 9.—Verrill, 1899:186.  
*Nymphaster arenatus*.—Sladen, 1889:752.—Verrill, 1899:186.—Farran, 1913:11-12.—Fisher, 1919:277.—Koehler, 1924:182.—Mortensen, 1927:84-85, fig. 48.—H. L. Clark, 1941:39-40.—A. H. Clark, 1954:375.—John and Clark, 1954:139.—Halpern, 1970a:223-228, fig. 28a.  
*Nymphaster ternalis*.—Sladen, 1889:752.—Verrill, 1899:185, pl. 26: fig. 7.—Fisher, 1919:264, 266, 268, 276, 278, 282.—A. H. Clark, 1954:375.

The general form is stellate, with a broad disc and five long, sharply tapered arms. The abactinal surface is pentagonal, and the plates are low-tabulate and irregularly round. They are covered by regularly spaced, rounded granules. The bases of the radial plates are prominently lobed. Single papular pores cover most of the abactinal surface except for a small, triangular, interradial area. The superomarginal plates, in contact medially throughout the length of the arm, number 24-64, depending on size. They are two and one-half times as wide as long interbranchially, and approximately square distally. The abactinal and lateral surfaces are at right angles to each other. They are covered by rounded, regularly spaced granules. The inferomarginal plates correspond to the superomarginals and are similarly granulated.

The large rhombic actinal plates, which do not extend beyond the third or fourth marginal, are covered with coarse, rounded, regularly spaced granules. The adambulacral plates are strongly angular (becoming apophyses beyond the actinal areas) and bear a furrow series of 6-11 moderately long, compressed spines with blunt tips. The subambulacral spines are in three or four irregular rows of 4 or 5 large granules. The mouth plates are long, narrow, and triangular; they bear 10 or 11 furrow spines slightly longer than the adambulacral furrow spines. The median spine is longest and

most compressed. A row of tall, rounded spines lines the median suture; the rest of the plate is covered with scattered granules. The madreporite is tumid and covered with coarse, radiating gyri. The ocular plates are small, oval, and covered with granules. Small excavate pedicellariae, when present, occur on some of the abactinal, inferomarginal, and/or actinal plates, and two-three- or four-valved spatulate pedicellariae occur on some adambulacral plates.

This species is abundant from the northern Gulf of Mexico to Brazil, in 275-3,000 meters. In the eastern Atlantic, it occurs from Ireland to Morocco and the Canary Islands.

MATERIAL EXAMINED.—*Oregon II* Stations: 10206 (11) [R=60 mm, r=20 mm, Rr=1:3]; 10624 (2) [R=84 mm, r=22 mm, Rr=1:4]; 10514 (1) [R=84 mm, r=22 mm, Rr=1:4]; 10844 (1) [R=75 mm, r=19 mm, Rr=1:4]; 10876 (1) [R=? (all arms broken), r=20 mm,]; 10877 (5) [R=62 mm, r=16 mm, Rr=1:4]; 10872 (1) [R=70 mm, r=15 mm, Rr=1:4.7]; 10900 (2) [R=74 mm, r=20 mm, Rr=1:3.8]; 10491 (2) [R=18 mm, r=5 mm, Rr=1:3.5]; 10602 (2); 10794 (3); 10843 (1) [R=43 mm, r=12.5 mm, Rr=1:4]. *Oregon* Stations: 2820 (10) [R=75 mm, r=17 mm, Rr=1:4.5]; 4855 (3) [R=57 mm, r=14 mm, Rr=1:4]; 4413 (2); 1946 (1); 1885 (1); 2774 (1); 1920 (2); 6703 (3) [R=53 mm, r=13 mm, Rr=1:4]; 2005 (1) [R=74 mm, r=21 mm, Rr=1:3.6 (specimen has cluster of enlarged granules on most interbranchial marginals)]; 4416 (9) [R=35 mm, r=12.5 mm, Rr=1:2.5]; 3654 (2) [R=66 mm, r=17 mm, Rr=1:4]; 2353 (7) [R=86 mm, r=21 mm, Rr=1:4 (largest specimen and few others have small spinules on some marginals)]; 3560 (3) [R=47 mm, r=13 mm, Rr=1:3]; 1505 (4) [R=69 mm, r=18 mm, Rr=1:4]; station unknown (2); 6696 (4) [R=41 mm, r=11 mm, Rr=1:4]; 2814 (5) [R=63 mm, r=16 mm, Rr=1:4]; 3574 (1) [R=90 mm, r=21 mm, Rr=1:4.5]; 489 (1) [R=19 mm, r=6 mm, Rr=1:3]; 5784 (1). *Alaminos* Stations: 87/69-A-11 (2) [R=67 mm, r=12 mm, Rr=1:5]; 78/69-A-11 (2) [R=70 mm, r=15 mm, Rr=1:4.5]; 11/68-A-13 (1) [R=59 mm, r=14 mm, Rr=1:4]; 2H/67-A-5 (1) [R=80 mm, r=15 mm, Rr=1:5]; 1/68-A-13 (1) [R=61 mm, r=13 mm, Rr=1:4.5]; 15H/68-A-7 (1) [R=70 mm, r=20 mm, Rr=1:3.5]; 13A/68-A-7 (1); 4E/68-A-7 (1); 15/65-A-9 (3) [R=20 mm, r=6

mm, Rr=1:3]; 24/68-A-13 (1) [R=19 mm, r=4 mm, Rr=1:5]. *Combat* Station: 450 (3) (small spinules on a few of the superomarginals).

### *Nymphaster subspinosus* (Perrier)

PLATE 23: FIGURES A, B

*Pentagonaster subspinosus* Perrier, 1881a:21; 1884:168, 176-178, 185, 234-236, pl. 6: fig. 1.

*Dorigona subspinosus*.—Perrier, 1885c:39, 40; 1894:38, 39, 375-379.

*Nymphaster subspinosus*.—Sladen, 1889:752.—Verrill, 1899:185.—H. L. Clark, 1941:40.—A. H. Clark, 1954:375.—Halpern, 1970a:228-232, figs. 12-13.

This species is very similar to *N. arenatus*, except that most of the inferomarginal plates bear 1-3 short, conical spines, some of the superomarginal plates may bear a similar spine, and one or two small conical spines may occur on some of the actinal plates. I do not consider these differences as being of a specific nature, especially as many specimens of *N. arenatus* bear more or less conical granules on the actinal plates, and enlarged granules or incipient spines on the marginals. Two

specimens collected by the *Oregon* off the Florida Keys in 200 fathoms could easily be assigned, one to *N. arenatus* and one to *N. subspinosus*—in fact, there is no other way one could interpret these specimens if both species are to be maintained.

MATERIAL EXAMINED.—*Combat* Station 450 (1) [1 (with 1 specimen of *N. arenatus*)]. *Oregon*, no station, off Florida Keys, 200 fms. [R=70 mm, r=22 mm, Rr=1:3].

### *Pseudarchaster* Sladen

*Pseudarchaster* Sladen, 1885:617. [Nomen nudum.]

*Pseudarchaster* Sladen, 1889:109. [Type, by subsequent designation, *Pseudarchaster discus* Sladen (Verrill, 1899:191).]

*Aphroditaster* Sladen, 1889:116. [Type, by original designation, *A. gracilis* Sladen.]

Several rows of abactinal plates extending far along arm; usually more than one row reaching terminal plate. Unpaired (but not recurved) median spine at apex of each mouth plate pair.

Of the two species in this genus known from the western North Atlantic, only *P. gracilis* was taken in these collections.

### Key to the Species of *Pseudarchaster*

- Actinal plates bear conical spines 3-5 times longer than wide ..... *P. gracilis*  
 Actinal plates usually bear lanceolate spines ..... *P. parelli*

### *Pseudarchaster gracilis* (Sladen)

PLATE 23: FIGURES C, D

*Aphroditaster gracilis* Sladen, 1889:117-120, pl. 17: figs. 1-2, pl. 18: figs. 7-8.—Verrill, 1899:195.—Fisher, 1919:227-228.

*Pseudarchaster concinnus* Verrill, 1894:250-255; 1895:132; 1899:193, pl. 30: figs. 3-3b.—H. L. Clark, 1941:31-32.—Madson, 1951:89.—A. H. Clark, 1954:375.

*Astrogonium gracile*.—Perrier, 1894:342, 354.

*Astrogonium aphrodite* Perrier, 1894:342, 354, pl. 21: fig. 2, pl. 23: fig. 2.

*Astrogonium necator* Perrier, 1894:350-352, pl. 23: fig. 1.—Koehler, 1909b:74-75.

*Pseudarchaster aphrodite*.—Verrill, 1899:195.

*Pseudarchaster necator*.—Verrill, 1899:195.

*Pseudarchaster ordinatus* Verrill, 1899:194-195, pl. 30: figs. 4-4b.—A. H. Clark, 1954:375.

*Astrogonium eminens* Koehler, 1907:34-37; 1909b:68-71, pl. 16: figs. 3-6.

*Astrogonium aequabile* Koehler, 1907:37-40; 1909b:66-68, pl. 11: figs. 1-4.

*Astrogonium marginatus* Koehler, 1909b:71-73, pl. 14: figs. 1-4.

*Pseudarchaster gracilis*.—Mortensen, 1927:86.—Macan, 1938:p. 355.

The general form of this species is stellate and plane, with a broad disc and five arms of moderate length which taper to an acute point. The abactinal plates are paxillose, and more than one row extends nearly or quite to the terminal plate. The paxillae are short, with rounded tops covered with large, round, flattened granules and a peripheral row of short spinules. Papulae occur singly between plates over most of the disc, except for a narrow, triangular, interrational area. The superomarginal plates are two to four times as wide as long, and mainly in the vertical plane, forming a broad border to the abactinal surface. They are densely covered with large, round, flattened granules. The inferomarginal plates correspond to the superomarginals and are covered with short, sharp

spinules and longer conical spines. The actinal interradial areas are covered with irregularly shaped plates in regular rows from adambulacral to marginals; the plates are covered with short, terete spinules and a few longer lanceolate spines. The plates of the row next to the adambulacral plates are larger and more regular than the others, and between many of them a pectinate pedicellaria occurs.

The adambulacral plates are strongly angular and bear a furrow series of 6–9 cylindrical spines. The subambulacral spines are similar but more widely spaced, and there are 1–3 longer conical spines in the center of each plate. The mouth plates are prominent and tumid, with a wide suture between the halves. They bear a furrow series of eleven spines, and an unpaired, large, thick, median spine occurs at the apex of each jaw. The rest of the plate is covered with spaced spinules. The madreporite is small, rhombic, and covered with coarse gyri. The ocular plates are small, more or less oval, and usually naked. Pedicellariae are as noted above.

In the western Atlantic, this species is distributed from Cape Cod to Surinam, and in the eastern Atlantic it is known from the Azores and the West Coast of Africa to the Equator. Its depth range is 1,090–2,174 meters.

**MATERIAL EXAMINED.**—*Oregon II* Stations: 10795 (1) [R=190 mm, r=38 mm, Rr=1:5—by far the largest specimen of *Pseudarchaster* I have seen, being nearly four times the size of an average adult specimen]; 10624 (3) [R=85 mm, r=25 mm, Rr=1:3]; 10602 (1) [R=33 mm, r=13 mm, Rr=1:3]. *Oregon* Stations: 5929 (1) [R=58 mm, r=17 mm, R=1:4]. 6696 (2) [R=51 mm, r=15 mm, Rr=1:3 (abactinal gonopores, two to each interradial area of disc near margin, plainly visible in these specimens)]; 4421 (1) [R=30 mm, r=11 mm, Rr=1:3]; 2771 (3) [R=51 mm, r=17 mm, Rr=1:3]; 4300 (6) [R=46 mm, r=18 mm, Rr=1:3 (gonopores on these specimens plainly visible)]; 4416 (1); 6703 (3) [R=50 mm, r=14 mm, Rr=1:4]. *Alaminos* Stations: 15/68–A–13 (1) [R=63 mm, r=20 mm, Rr=1:3]; 10A/68–A–7 (1) [R=43 mm, r=13 mm, Rr=1:3.8 (four-armed specimen)].

#### Family OREASTERIDAE Fisher, 1911a

The body is thick, cushion-like, and covered with

granulose skin. The papulae are numerous and in definite areas. The abactinal plates are stellate-reticulate, granulose, and usually bear large, conical spines or tubercles. The interbranchial septa are calcareous. The tube feet are in two rows, with large suckered discs.

Only one genus and species in this family is known from the Caribbean and Gulf of Mexico.

#### *Oreaster* Muller and Troschel

*Oreaster* Muller and Troschel, 1842. [Type, by original designation, *Asterias reticulatus* Linnaeus, 1758.]

*Pentaceros* Schultze, 1760 [non binom.].

*Pentaceros* Gray [non Cuvier and Valenciennes], 1840:276. [Type, by original designation, *Asterias reticulatus* Linnaeus, 1758.]

#### *Oreaster reticulatus* (Linnaeus)

PLATE 24: FIGURES A, B

*Asterias gigas* Linnaeus, 1753:114, pl. 9: fig. 1.

*Asterias reticulata* Linnaeus, 1758:661.—Retzius, 1783; 1805; pl. 14.—Lamarck, 1816:556.

*Pentaceros reticulatus*.—Gray, 1840:276; 1866:6.—A. Agassiz, 1877:108–112, pl. 16: figs. 6–11.—Perrier, 1878:21, 52, 83.—Viguier, 1879:193, pl. 11: figs. 4–6, pl. 12: figs. 3, 4.—Sladen, 1889:344, 762.—Ives, 1891:339.—Nutting, 1895:52, 187, 202, 212.—Leipoldt, 1895:634.—(incl. *P. lapidarius* Grube).—Sluiter, 1895:56.—H. L. Clark, 1898a:5, 6; 1901:237.—Ihering, 1898:155.—Conant, 1900.—Duerden, 1900:613, 620.—Tennent and Keiller, 1914.

*Oreaster gigas*.—Verrill, 1867:278–279; 1868:367.—Lutken, 1859:64–75.—Rathbun, 1879:149.

*Oreaster reticulatus*.—Muller and Troschel, 1842:45, pl. 3: fig. 2.—Field, 1893:84.—Doderlein and Hartmeyer, 1910:151–152.—H. L. Clark, 1919:53–55, 71; 1933:22–23.—Boone, 1933:80–82, pls. 41–42.—Doderlein, 1936:319–320, pl. 31: figs. 3–3a.—Engel, 1939:3, 7.—A. H. Clark, 1939:442.—Caso, 1944:248–253, 2 figs.; 1961:59–62, figs. 20–21.—Fontaine, 1953:182, fig.—Breder, 1955: pl. 1: fig. 4.—Bernasconi, 1958b:135–136, pl. 4: figs. 1–2; 1960:25.—Tommasi, 1958:16–17, 32–33, pl. 3: fig. 2.—Madsen, 1959:163, fig. 1.—Brito, 1960:5–6, pl. 1: fig. 3.—Stanek, 1960:49, figs.—Thomas, 1960:167–168.—A. M. Clark, 1962: pl. 2: figs. a–d.—Ummels, 1963:73–81, pls. 3–6.—Gray, Downey, and Cerame-Vivas, 1968:146, figs. 19a–b.

*Oreaster lepidosus* Grube, 1857.

*Asterias sebae* Blainville, 1834:240.

*Oreaster aculeatus* Gray, 1866.

*Oreaster reticulata*.—Duerden, 1896:285.

*Oreaster reticulatus* var. *bermudensis* H. L. Clark, 1944:372–374, figs. 1–2.

This very massive starfish normally has five arms, but may have from four to seven. Linck's *De Stellis*

*Marinis* (1733) has a woodcut of Linck in his laboratory examining a four-armed specimen; as he based most of his classification on the number of arms, he described this specimen as belonging to a separate group. The disc is broad and high. The arms are short to moderately long, becoming proportionately shorter with increased size. The primary dorsal plates are thick and irregularly shaped; there is a conspicuous circle of plates in the center of the disc and three irregular rows of plates on each arm. The numerous other primary plates are not in any particular pattern. All the primary plates are connected in a reticulate pattern by small, irregular, or rod-shaped secondary plates. Most primaries bear a large, heavy tubercle or stout spine. Spaces between the reticulations are papular areas, with numerous tiny papular pores. The entire surface, dorsal and ventral, with the exception of the spines themselves, is covered with a moderately thick membrane closely set with small granules. The large tumid superomarginal plates define the ambitus and each bears a very stout, blunt spine. The inferomarginal plates are confined to the ventral surface; they are large and rounded and sometimes bear a short, stout, central spine, but usually the center of the plate bears instead a few enlarged granules. The actinal interradial areas are large, the plates (concealed by granules somewhat larger than those of the dorsum) are tessellate, and many of the proximal ones bear one or more short, stout, central tubercles or spines. One series of actinolaterals continues nearly to the end of the arm. Valvate pedicellariae, set into small cup-shaped plates or granules, are numerous, especially proximally, and small pedicellariae also occur on the dorsal surface. The small, square adambulacral plates bear a furrow series of about five short, flat, subequal spines and the actinal face of the plate bears a large, flat lanceolate spine with, usually, a small spine beside it. The mouth plates are small and armed with heavy blunt spines. The madreporite is of moderate size, flat, smooth, plane, and covered with fine shallow gyri. The young *Oreaster reticulatus* is not inflated, and the marginals are relatively larger and more conspicuous than in the adult. The variation in shape, from pentagonal to stellate, the differing degrees of inflation of the disc, and the variety of colors, from dark green, brown, dark red, orange and red, and

yellow to light tan, make this an extremely variable species.

The species is common in shallow-water grass-and-sand flats from Florida to Brazil; it has also been taken in the Cape Verde Islands, Bermuda, and occasionally occurs as far north as Cape Hatteras.

MATERIAL EXAMINED.—*Oregon* Stations: 5390 (2) [R=91 mm, r=40 mm, Rr=1:2.3 (height of disc = 34 mm)]; 1937 (1) [R=71 mm, r=34 mm, Rr=1:2.2 (height of disc=34 mm)]; 1934 (1) [R=47 mm, r=22 mm, Rr=1:2 (height of disc=22 mm)]; 1938 (1) [R=69 mm, r=30 mm, Rr=1:2.3 (height of disc=29 mm)]; 3603 (1) [R=15 mm, r=7 mm, Rr=1:2 (height of disc=5 mm)]; 5456 (1) [R=15 mm, r=8 mm, Rr=1:2 (height of disc=5 mm)]. Note that all of the above specimens are rather small; this species commonly reaches a size of R=200 mm, r=100 mm, and height of disc=80 mm.

#### Family OPHIDIASTERIDAE Verrill, 1867

In this family, the disc is small and the arms are usually long and cylindrical. The actinal interradial areas are generally small, as are the marginal plates. The skeleton is tessellate and covered with a granular skin (smooth in *Leiaster*). The tube feet are in two rows, with well-developed suckers. The ambulacral furrow is narrow.

Among the best understood, taxonomically, of the families of starfishes are the Ophidiasteridae. The genera are clearly defined, and the characteristics used to separate species within the genera are stable and valid. The present comfortable status of this family is due largely to H. L. Clark (1921), whose careful analysis of the group was done with such simple clarity as to make his keys intelligible and useful to all.

It is, therefore, surprising to find A. H. Clark in 1954 confusing *Tamaria floridae* (he called it *Ophidiaster floridae*), *Ophidiaster alexandri*, *Ophidiaster pinguis*, and *Hacelia superba*, which he apparently thought all one species, and synonymized under the name *Hacelia floridae*! I have examined the types of all of these species, and there is no doubt in my mind that they are all valid and distinct.

H. L. Clark himself did not, apparently, examine in any comparative way *Linckia bouvieri* and *Linckia nodosa*; he considered *L. nodosa* a junior

## Key to the Genera of Ophidiasteridae

1. With internal connecting plates .....	2
Without internal connecting plates .....	3
2. Covered with glassy spinules .....	<i>Chaetaster</i>
Without glassy spinules .....	<i>Drachmaster</i>
3. Abactinal plates in regular longi-series .....	4
Abactinal plates not in regular longi-series .....	7
4. Papular areas occurring below inferomarginals .....	5
No papular areas below inferomarginals .....	<i>Tamaria</i>
5. Eight series of papular areas .....	6
Ten series of papular areas .....	<i>Hacelia</i>
6. Alternating large and small adambulacrals .....	<i>Leiaster</i>
Adambulacrals plates all alike .....	<i>Ophidiaster</i>
7. Adambulacrals armature spiniform .....	<i>Narcissia</i>
Adambulacrals armature granuliform .....	<i>Linchia</i>

synonym of *L. bouvieri*. The two species are, of course, quite distinct, as I pointed out in 1968.

Four new genera, *Neoferdina* Livingston (1931), *Celerina* A. M. Clark (1967), *Drachmaster* Downey (1970), and *Copidaster* A. H. Clark (1948), have been added to the family since Clark's revision, and the genus *Chaetaster*, long considered the type of a monogeneric family, is here restored to the Ophidiasteridae (see discussion under that genus).

Although *Leiaster* has a smooth, thin tegument completely lacking in granules or scales and *Copidaster* has a granulose or scaly covering, the affinities between these genera are unmistakable. In addition to having the same number of rows of plates, arranged exactly the same and of a similar shape, both of these genera have a subambulacrals spine, not on every adambulacrals plate, but on alternate plates. The adambulacrals plates themselves are alternately broad and narrow. *Copidaster* and *Leiaster* also share the same peculiar pedicellariae (few in *Leiaster*, abundant in *Copidaster*) with very long, thin, straight valves in deep alveoli. I do not believe *Copidaster lymani* can be maintained in a separate genus; it rightly belongs in the genus *Leiaster*.

The character of alternating large and small adambulacrals plates in the genus *Leiaster* is, of course, suggestive of the Zoroasteridae, as is the shape and arrangement of the dorsal plates. These characters hardly seem likely ones for parallel evolution as an adaptation to the environment, especially as the Ophidiasteridae are mainly restricted to shallow water and the Zoroasteridae to deep water.

Ocular plates, seldom mentioned in asteroid taxonomic literature, and of little importance in most families, seem to be quite a reliable specific character in the Ophidiasteridae. Even with growth changes, the basic shape, ornamentation, and relative size of the oculars is usually consistent.

*Chaetaster* Muller and Troschel

*Chaetaster* Muller and Troschel, 1840:321. [Type, by original designation, *Asterias subulata* Lamarck, 1816 (= *Asterias longipes* Retzius, 1805).]

Disc small, arms five, long, rounded; all plates above adambulacrals similar, in definite rows, marginals difficult to distinguish; paxilliform plates raised in center, with expanded base connected to adjoining plates by small internal radiating ossicles; plates bear numerous very sharp, slender, glassy spinules; single rather large papular pores confined to dorsal surface (none below marginals); adambulacrals plates bear furrow series of straight, subequal spines parallel to groove; on actinal face, a dense bundle of spines longer and larger than those of adjoining plates; odd interradial marginal plate frequently present; ampullae single; interradial septa calcified; pedicellariae unknown.

This is apparently a tropical-subtropical genus, with a depth range of 30–1,000 fathoms.

This is undoubtedly one of the most puzzling of the starfish genera; it has features suggesting at least five other widely separated genera. The presence of internal connecting plates in a recently described ophidiasterid (*Drachmaster bullisi* Dow-

ney, 1970) would seem to justify the restoration of *Chaetaster* to the family Ophidiasteridae, from which it was removed on the basis of this single character by Sladen in 1889 and Ludwig in 1897. The lack of a thick smooth or granulose tegument and the presence of bundles of glassy spinules are thus the only important features left separating *Chaetaster* from the other Ophidiasteridae. I do not believe these characters to be of familial significance. At the time I published my description of *Drachmaster bullisi*, I failed to notice that the internal connecting plates of this species invalidated the separation of the family Chaetasteridae from the Ophidiasteridae.

Certain features of this genus also seem to point to the Asterinidae. Although the Asterinidae commonly have a larger actinal interradiial area, the elliptical plates, their arrangement and ornamentation, the type of adambulacral armature, and the small marginals seem to draw the Ophidiasteridae and the Asterinidae closer together; certainly I do not believe they can possibly belong in separate orders, as they are now classified.

### *Chaetaster nodosus* Perrier

PLATE 24: FIGURES C, D

*Chaetaster nodosus* Perrier, 1876b:250.—Sladen, 1889:398, 399, 778.—Verrill, 1915:116, pl. 8: figs. 1, 2, pl. 13: figs. 4, 4a.—A. M. Clark, 1951b:1260.

*Chaetaster longipes* Sladen [part], 1889:399.—Verrill [part], 1915:117.

This stellate species has a small disc and five long, well-rounded arms. The well-spaced plates are in regular rows; carinal, 4 or 5 adradials, superomarginal and inferomarginal. They are all similar (elliptical, center raised and flat-topped, base slightly expanded, top covered with numerous small, sharp glassy spinules) save for a few scattered plates here and there on the arms which are larger, raised above the general surface, and distinctly nodose. The plates above the superomarginals are connected to one another by small internal plates and large papular pores occur singly between each plate. No pores occur below the superomarginals, and superomarginal and inferomarginal plates are alike and indistinguishable from the dorsal plates. A single row of similar interradiial actinal plates does not extend much beyond the disc. The small adam-

bulacral plates are nearly square and bear a furrow series of six spines, the proximal one small and the other five subequal and in a straight row parallel to the groove; unlike all the other spines, the furrow series of spines are not hyaline. The actinal face of the adambulacral plate bears a dense bundle of larger, stouter spines. The two halves of the mouth plate are long, narrow, and well separated. They are densely covered with long fine spines, those at the proximal end longest and extending across the mouth. The madreporite is small, flat, and deeply channeled.

This species is found in 30–200 fathoms, in the West Indies and the Gulf of Mexico; it is not common. A specimen was recently collected off Cape Hatteras.

MATERIAL EXAMINED.—Oregon Stations: 4459 (2) [R=60 mm, r=8 mm, Rr=1:7]; 1416 (1) [R=55 mm, r=7 mm, Rr=1:8]; station unknown (1) [R=53 mm, r=6 mm, Rr=1:9].

### *Drachmaster Downey*

*Drachmaster Downey*, 1970a:77. [Type, by monotypy, *D. bullisi* Downey.]

### *Drachmaster bullisi* Downey

PLATE 25: FIGURES A, B

*Drachmaster bullisi* Downey, 1970a:77, figs. 1–6.

The disc is small and rather flat, with a central anal pore surrounded by a number of enlarged spiniform granules. The madreporite is irregularly triangular or elliptical, sunken below the general disc surface, and covered with deep gyri. The arms are long, cylindrical, not much tapered, and terminate bluntly. All plates are covered with moderately thick skin, closely beset with small squamiform or minutely spinous granules of uniform size. There are eleven very regular longitudinal rows of smooth, slightly tumid plates on the arms, connected internally in transverse series by small tumid plates. There are eight longitudinal rows of conspicuous papular areas, with from one to three pores per area. There are two rows of actinolateral plates, the row next to the adambulacrals containing twice the number of plates as the row above. The adambulacral armature consists of two short,

blunt, somewhat flattened furrow spines, connected near their bases by skin, and a much longer, flat, acute subambulacral spine. The spines of the margin of the mouth plates are similar to and continuous with the furrow spines; on the actinal face of the mouth plates are two pairs of large spines, each spine of the distalmost pair accompanied by a small spinelet.

Small, typically ophidiasterid pedicellariae occur either on each superomarginal or between the adambulacrals and the inferomarginals; they also occur on the abactinal surface. The oculars are large and tumid, and the terminal portion bears large, low, rounded tubercles.

MATERIAL EXAMINED.—Oregon Stations: 5970 (1 holotype) [R=33 mm, r=4.5 mm, Rr=1:6]; 5923 (1 paratype) [R=14 mm, r=4.5 mm, Rr=1:4].

### *Tamaria* Gray

*Tamaria* Gray, 1840:283. [Type, by original designation, *T. fusca* Gray.]

Body wall rigid; abactinal plates well developed; in regular longitudinal series; test granulose; no spines on abactinal surface of arms; madreporite small, simple; papular areas in 4–6 series, none below inferomarginals.

### Key to the Species of *Tamaria*

1. Four series of papular areas; arms short, subpetaloid ..... *T. passiflora*  
Six series of papular areas; arms moderately long, tapering..... 2
2. Oculars small, concealed by granules; average 3 or 4 pores per papular area..... *T. floridae*  
Oculars large, bare; average 7 or 8 pores per papular area ..... *T. halperni*

### *Tamaria floridae* (Perrier)

PLATE 25; FIGURES C, D

*Ophidiaster floridae* Perrier, 1881a:9; 1884:221, pl. 4: fig. 1.—Verrill, 1915:90.

*Tamaria floridae*.—H. L. Clark, 1921:91.—Downey, 1971b:44.

*Hacelia floridae* [part].—A. H. Clark, 1954:376.

Although no specimens of this species were taken in the present collections, a brief description of the holotype is included here.

There are six longi-series of papular areas, 1–7 pores per area. There are two equal adambulacral furrow spines, and a single, nearly round, very flat and appressed subambulacral spine, with a small spinelet or granule on each side of the base. Spines similar to the subambulacral spines occur on many proximal interradial actinal plates. There seem to be about three regular rows of actinal interradials. The few pedicellariae, similar to those of *T. passiflora*, are confined to the actinal surface. The oculars are small and concealed by granules. The madreporite is small to moderate in size, triangular, flat, and inconspicuous. The carinal, adradial, superomarginal, and inferomarginal plates are equal and similar; there are no supplementary plates. The anus is inconspicuous, not much larger than a papular pore, but with about three enlarged granules surrounding it.

This small species has caused considerable confusion. Perrier gave the locality for the type as “. . . ramene par la drague de 123 pieds de profondeur dans le detroit de Floride Communique par M. Alex. Agassiz avant les dragues du Blake.” Verrill (1915) suggested that Perrier meant 123 fathoms, not 123 feet. H. L. Clark (1921) assumed that 123 fathoms was meant, and from this deduced that the locality given was wrong, as none of the Blake stations listed by Agassiz were at 123 fathoms. He concluded that one of two Bibb stations off Florida was meant. The label accompanying the holotype gives no data but “Blake coll.” Dr. William N. Eschmeyer (1965) corrected station data errors for the fishes collected by the *Blake*, but was then of the opinion that no errors had been made in data for the invertebrates. Perrier did give some depths in feet and some in fathoms, and I can see no reason for the assumptions made by Verrill and Clark. Similar confusion exists about the dimensions of the holotype; here Perrier did make a mistake, but Verrill and Clark did not improve matters. I carefully measured the holotype, and the correct dimensions are given below.

Finally, A. H. Clark (1954) apparently did not examine the type at all—he called it *Hacelia flo-*



*ridae*, and included in its synonymy three other quite distinct species.

MATERIAL EXAMINED.—Holotype (MCZ No. 757), Blake, Straits of Florida, 123 ft [R=31 mm, r=7.5 mm, Rr=1:4 (arm base=9 mm, midarm=7.5 mm, arm tip=3 mm)]. Albatross Station 2672, 31°31'N, 79°05'W, 227 fms, May 1886 (1) [R=25 mm, r=5.7 mm, Rr=1:4 (arm base=7 mm, midarm=4.9 mm, arm tip=2.1 mm)].

### *Tamaria halperni* Downey

PLATE 26: FIGURES A, B

*Tamaria halperni* Downey, 1971b, p. 46, fig. 1.

The disc of this species is of moderate size, and the five arms taper evenly to rounded points. There is a conspicuous central anus surrounded by enlarged granules. The carinal, adradial, superomarginal and inferomarginal plates are slightly tumid, equal, and similar; there are no secondary plates. There are six series of papular areas, with 7–10 pores per area (fewer on small specimens). In most specimens, a few of the distal marginals, which are slightly enlarged, have a central naked area devoid of granules; otherwise, all plates bear an even coating of small granules. There are 4 or 5 rows of actinolateral plates, one row extending two-thirds the length of the arm. The two thin, flat furrow spines of the adambulacral plates are nearly square, even, regular, and equal. The subambulacral spine is oval, longer than broad, flat, and appressed. Small specimens frequently have a small spinule or enlarged granule between the subambulacral spines. There are two subambulacral spines on the first adambulacral plate. There is a pair of similar spines on the actinal face of the mouth plates, while the spines of the mouth margin are like the furrow spines. The pedicellariae are numerous, one on each adambulacral plate and others scattered on all surfaces; their valves are short and triangular, in deep, well-defined alveoli.

The madreporite is of moderate size, plane, with radiating gyri. The oculars are large, smooth, oval, and raised above the general surface.

This species is apparently widespread in the Caribbean and would undoubtedly have been reported on before had it not been confused with *T. floridae*. Unfortunately, when this species was described, I failed to give the derivation of the

specific name; it is named for Dr. Jerald A. Halpern, to whom I am very grateful for his many helpful comments during the preparation of this study.

MATERIAL EXAMINED.—Oregon Stations: 4928 (1) [R=22 mm, r=5 mm, Rr=1:4.5]; 2643 (1) [R=26 mm, r=7 mm, Rr=1:4]; station unknown (1) [R=20 mm, r=6 mm, Rr=1:3.5]; 6715 (3) [R=28 mm, r=6 mm, Rr=1:4.5]. Oregon II Stations: 10513 (1) [R=36 mm, r=10 mm, Rr=1:3.5]; 10849 (1 holotype) [R=53 mm, r=12 mm, Rr=1:4]; 10850 (1) [R=50 mm, r=11 mm, Rr=1:4.5]. Also, 1 (MCZ No. 3999, as *Ophidiaster alexandri*), Atlantis Station 3480, Cuba, off Bahia de Matanzas, 200 fms [R=52 mm, r=12 mm, Rr=1:4.5].

### *Tamaria passiflora*<sup>1</sup> Downey

PLATE 26: FIGURES C, D

*Tamaria passiflora* Downey, 1971b:49, fig. 3.

This heavy, solid species has a small disc and five short, stubby, massive arms, slightly constricted at the base, high on the sides, and plane on the actinal surface. The central anus is tiny, inconspicuous, and not marked by specialized granules. The carinal, superomarginal, and inferomarginal plates are large and separated by two series of papular areas (none below the inferomarginals). There are 3–15 pores per papular area. Between the carinals and the superomarginals, and between the proximal marginals, a few small irregular secondary plates occur. The granules covering the surface of the starfish are squamiform and larger than those of *T. floridae*. The actinal surface is plane, with numerous small irregular plates, not in regular rows except for the slightly larger series next to the adambulacral plates, which, although irregular in size and shape, are more or less in series; they continue to the end of the arm and most bear a pedicellaria. The two short, broad adambulacral furrow spines are thick, flattened, and granuliform; there is a shorter, smaller spine behind them. The subambulacral spine is large, flat, leafshaped, and appressed; a similar spine occurs on a few of the actinal interradial plates.

<sup>1</sup> Etymology (not given in original description): *L. passiflora*, passionflower, for the five rather petaloid arms.

The jaws are concealed by large, flattened granules and leaflike spines; they are bordered by spines similar to those of the adambulacral furrow series. The sugar-tongs pedicellariae are confined to the actinal surface; the valves are short and sunken in deep alveoli with high, raised, thickened lips. The madreporite is small, flat, and deeply channeled. The oculars are minute.

MATERIALS EXAMINED.—*Oregon II* Station 10858 (1 holotype) [R=24 mm, r=8.5 mm, Rr=1:2.8].

### *Linckia* Nardo

*Linckia* Nardo, 1834:717. [Type, by original designation, *L. typus* (= *Asterias laevigatus* Linnaeus, 1758).]

### Key to the Species of *Linckia*

1. Large tumid plates occurring randomly on disc and arms.....2  
No large tumid plates ..... *L. guildingii*
2. Minute spines on some lateral plates; ocular without granules..... *L. nodosa*  
No spines on lateral plates; oculars covered with granules..... *L. bowieri*

### *Linckia guildingii* Gray

PLATE 27: FIGURES A, B

*Linckia guildingii* Gray, 1840:285; 1866:14.—Perrier, 1875b:408.—A. Agassiz, 1877:105, pl. 14: figs. 1-6.—Rathbun, 1879:148.—Sladen, 1889:410.—Ives, 1891:339.—Russo, 1894:163.—Leipoldt, 1895:634.—H. L. Clark, 1898b:412; 1898a:6; 1899:130; 1901:340; 1921:67.—Verrill, 1901:36; 1907:281, pl. 34: fig. c; 1915:96, pl. 28: fig. 3; 1902:36.—Richters, 1912:121, figs. 1-42.—Livingstone, 1932:254.—Boone, 1936:241.—Tortonese, 1937:395, pl. 7: fig. 77; 1937a:75, pl. 4: figs. 10-11.—Domantay and Roxas, 1938:222, pl. 14: figs. 80-81.—H. L. Clark, 1938:133; 1944:374.—Hayashi, 1939:284, fig. 4, pl. 5: figs. 8-10, pl. 6: fig. 2.—Caso, 1941:155, figs. 1-5.—Ely, 1945:18, pl. 1.—Habe, 1952:80.—Anon., 1953:188, figs. 1-5.—Fontaine, 1953:183, fig.—Tommasi, 1959:17, pl. 3: fig. 3.—Utinomi, 1959:108, pl. 54: fig. 6.—Brito, 1960:5, pl. 1: fig. 2.—Caso, 1962:70.—Ummels, 1963:81, pl. 7.—Clark in Clark and Davies, 1966:608, pl. 18.—Pope, 1967:311, 314, fig.—Roa, 1967:279.—Downey, 1968:41; 1970a:81.

*Ophidiaster ornithopus* Muller and Troschel, 1842:31.—Lutken, 1859:80.—Dudjardin and Hupe, 1862:361.

*Linckia ornithopus*.—Verrill, 1867:344; 1868:367.—Lutken, 1859:80; 1871:266.

*Scytaster stella* Duchassaing, 1850:4.

*Linckia pacifica* Gray, 1840:285.—Studer, 1884:24.—Sladen, 1885:36.—Russo, 1894:162.—Sluiter, 1895:60.—Whitelegge, 1897:157.—Kellogg, 1904:354.—Ludwig, 1905:158.

*Ophidiaster ehrenbergi* Muller and Troschel, 1842:31.

*Linckia nicobarica* Lutken, 1871:265.

*Linckia ehrenbergi*.—de Loriol, 1885:31, pl. 10: figs. 1-7a.—Sladen, 1885:31.—Leipoldt, 1895:649.—Sluiter, 1895:60.—Lud-

*Acalia* Gray, 1840:285. [Type, by original designation, *Linckia pulchella* Gray.]

Disc small, arms long, cylindrical; papulae in irregularly disposed papular areas, confined to abactinal surface; abactinal plates not in regular longi-series; no pedicellariae; granuliform adambulacral armature in two series.

There are three species known from the Atlantic, one of which (*L. guildingii*) is circumtropical, except for the eastern Pacific.

wig, 1899:542.—Bell, 1903:245.—Tortonese, 1937:74, pl. 9: fig. 58.

This versatile starfish has a small disc and, normally, five long, cylindrical, blunt-tipped arms. The arms readily autotomize, and 2-7 arms are not uncommon; a specimen in the National Museum of Natural History has only one arm, with no trace of a disc or regenerating arms at all. The arms may also vary in length on a single specimen, due to regeneration after injury or spontaneous autotomy. The plates of the dorsum are not arranged in regular rows. The papular areas between the plates increase in size and in number of pores per area with growth; small specimens have small papular areas, with 1-5 pores per area, while in large specimens, the areas are as large as the plates, with up to forty pores per area. Superomarginal and inferomarginal plates are of a uniform size, and separated by a series of papular areas. Two regular rows of actinal plates extend nearly to the end of the arm; there are about twice as many actinal plates per row as there are inferomarginals. The entire surface is covered with a dense coating of small, flat-topped granules. There are two adambulacral furrow spines, side by side, the proximal one longer and broader than the distal one; behind and between them, the single subambulacral spine

is heavier. These adambulacral spines are so close, and so crowded by adjacent granules, that they are difficult to distinguish. The mouth plates are similarly armed.

The madreporites are of moderate size, flat, and covered with deep gyri; they may be multiple, but I have seen specimens with none. Two is the usual number for normal, five-armed adults. They are usually interradiar, as in other starfishes, but one specimen in this collection has, in addition to the normal interradiar madreporite, another one half-way out on an arm. The oculars are usually large and covered with granules; they may be compound (made up of two or three plates).

This species is distributed throughout the tropical waters of the world, except for the eastern Pacific. It is a shallow-water starfish, mostly reef-dwelling.

**MATERIAL EXAMINED.**—*Silver Bay* Station 1972 (4) [R=38 mm, r=5 mm, Rr=1:7.5].

### *Linckia nodosa* Perrier

PLATE 27; FIGURES C, D

*Linckia nodosa* Perrier, 1875c:417; 1884:226.—Sladen, 1889:409, 786.—Fisher, 1906:1088.—Bell, 1884:509.—Caso, 1962:72, fig. 26.—Downey, 1968:42.

*Linckia formosa* Mortensen, 1933a:430, fig. 10b, pl. 22: figs 2-4.

*Linckia bullisi* Moore, 1960:414, fig. 1.

Non *Linckia nodosa*.—Verrill, 1915:93 [see *L. bouvieri*].

This is a much less variable species than *L. guildingii*; I have never seen specimens with other than five arms, of approximately equal length. The disc is small and the arms moderately long, slender, cylindrical, tapering, and blunt tipped. The dorsal plates are irregularly arranged, and many are enlarged and tumid. The papular areas are inconspicuous, none like the inferomarginals, a series between the inferomarginals and the superomarginals, and about four irregular series on the abactinal surface. There are 2-8 pores per area. The superomarginal and inferomarginal plates are in regular, nearly equal rows, with, occasionally, a few of the superomarginals enlarged and tumid. The marginals may or may not bear a central small tubercle or enlarged granule. The actinal surface is plane, with 2 or 3 rows of regular, rectangular actinal plates, only one row extending to the end of the arm.

All plates are covered with a fine, dense coat of small granules, those of the actinal surface slightly larger than those of the abactinal surface. The adambulacral furrow spines are two, one broad, blunt, and flat, and the other slender and less blunt; behind is a single thick, heavy, granule-like subambulacral spine. The mouth plates are armed with two slender and two broad, square-tipped, flattened spines at the apex, and behind them are two broader, square, flat spines. The madreporite (when present) is flat and inconspicuous, with gyri few and deep. The oculars are prominent, raised, rounded, and bare. There are no pedicellariae.

This species has undergone all kinds of taxonomic vicissitudes; Verrill (1915) confused it with *L. bouvieri*, H. L. Clark (1921) synonymized it with *L. bouvieri*, and Mortensen (1933a) and Moore (1960) overlooked it entirely. Perrier (1875c) based his description of this species on "Deux individus de la collection Michelin. Localite inconnu." The Michelin collection was a wide-ranging one, and contained many specimens from the western Atlantic, as well as from other parts of the world. It was acquired by the Paris Museum in 1868. Perrier indicates that quite a few specimens were without locality labels. Fortunately, specimens identified as *L. nodosa* by Perrier himself are in the collection of the Museum of Comparative Zoology at Harvard.

This species ranges, apparently, from Florida to Brazil and St. Helena, in 62-475 fathoms.

**MATERIAL EXAMINED.**—No data, probably collected by the *Oregon* (1) [R=36 mm, r=7 mm, Rr=1:5]. *Silver Bay* Station 2010 (2) [R=27 mm, r=5 mm, Rr=1:5].

### *Linckia bouvieri* Perrier

PLATE 28; FIGURES A, B

*Linckia bouvieri* Perrier, 1875c:414.—Studer, 1884:24; Koehler, 1909b:632.—Madsen, 1951:214, pl. 15: fig. 2.—Downey, 1968:42.—Gray, Downey, and Cerame-Vivas, 1968:148, fig. 21.

*Linckia nodosa*.—Verrill, 1915:93, pl. 13: figs. 2-2a, pl. 29: figs. 1a, 1b.

This species has a small disc and five long, thick, and flabby cylindrical arms, slightly constricted at the base and tapering to an acute terminus. Owing to the size of the papular areas, the skeleton is looser than in the two previous species, and the

animal has a flaccid appearance. It is the largest of the western Atlantic *Ophidiasteridae*. The disc dorsum has a large, tumid, hemispherical central plate, with a ring of 5–7 similar plates around it; these primary plates are separated by small tumid and nontumid plates. The inconspicuous anus is at the base of the centrodorsal plate, surrounded by slightly enlarged granules. The abactinal surface of the arms bears about five irregular rows of plates (some enlarged like the primary plates of the disc) connected by small, narrow ossicles.

The large papular areas between the marginals and on the abactinal surface are separated by small, narrow, elongate ossicles; there are 10–40 pores per papular area. The superomarginal plates are similar to the inferomarginals—subtriangular, somewhat imbricate, and connected to them by narrow slender ossicles. There are 3–5 rows of crowded actinolateral plates, irregular except for the row next to the adambulacral. The actinal plates overlap from inferomarginals to adambulacral. The plates of the row overlapping the adambulacral plates are larger and regular. The entire surface is densely covered with small granules; those on the marginals and major actinal plates are noticeably larger. The adambulacral furrow spines consist of one broad, flat spine and one small, slender spine per plate, with a broad, flat, circular subambulacral spine on the actinal face. The mouth spines are similar. The madreporite is large, raised, and covered with very fine gyri. The oculars are of moderate size, raised, and usually covered with granules (the gran-

ules may be worn off in large specimens). There are no pedicellariae.

The known distribution of this species is North Carolina to Florida, Yucatan, and the Cape Verde Islands, in 35–300 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 4938 (1) [R=134 mm, r=14 mm, Rr=1:9]; 4939 (1) [R=144 mm, r=16 mm, Rr=1:9].

### *Ophidiaster* L. Agassiz

*Ophidiaster* L. Agassiz, 1835b:191. [Type, by original designation, *Asterias ophidiana* Lamarck, 1816.]

Body wall rigid, abactinal plates well developed, in regular longitudinal series; no spines on abactinals; skin uniformly granulose; papular areas in eight series, only one below inferomarginals in each side; rays cylindrical; madreporite small, simple.

Of the known species of *Ophidiaster* reported from the area covered here, only *O. guildingii* is represented in this collection. *O. alexandri* is known only from a few specimens, and its distribution is limited to the northernmost part of the area under study (Florida and Georgia), in 200–276 fathoms. *O. pinguis* is known only from the type, which was from off southwest Cuba, in 320 fathoms. It is superficially very like *Hacelia superba*. A fourth species, *O. bayeri*, from Florida, was described by A. H. Clark (1948) from a single immature specimen in very poor condition. I have been unable to distinguish any characters on which this species might have been based.

### Key to the Species of *Ophidiaster*

1. No pedicellariae; no supplementary subambulacral spinelet ..... *O. guildingii*  
Pedicellariae present; small supplementary spinelet at base of at least some  
subambulacral spines ..... 2
2. Base of arms distinctly swollen; five rows of actinal intermediate plates ..... *O. pinguis*  
Base of arms not swollen; three rows of actinal intermediate plates ..... *O. alexandri*

### *Ophidiaster guildingii* Gray

PLATE 28: FIGURES C, D

*Ophidiaster guildingii* Gray, 1840:284; 1866:13.—Lutken, 1871:230.—Perrier, 1875c:387; 1878:16, 47, 80, 96.—Sladen, 1889:402, 782.—Doderlein and Hartmeyer, 1910:152.—Verrill, 1915:90.—H. L. Clark, 1921:79; 1901:237; 1933:23, pl. 2; 1898a:6.—Fisher, 1928:490.—Tortonese, 1937:79, pl. 8: fig. 48.—Fontaine, 1953:182.—Ummels, 1963:86, pl. 8.

*Scytaster mulleri* Duchassaing, 1850 [not seen].

*Ophidiaster flaccidus* Lutken, 1859:86.—Verrill, 1867:344.

This five-armed species, usually of small to moderate size, has a small disc and long, cylindrical arms, slightly constricted at the base. The plates are in regular rows—carinal, one adradial, superomarginal, inferomarginal, and one actinolateral, all reaching the end of the arm. The papular areas

occur between each row; they are large and contain 5–12 pores each.

The plates are roughly triangular and imbricate. The entire surface is covered with fine, even granulation. The adambulacral plates each bear one large and one small, granuliform, flattened, furrow spine and a larger flat, blunt, appressed, subambulacral spine, separated from the furrow series by an area of granules. The mouth plates are armed like the adambulacrals. The madreporite is small, plane, and slightly sunken. The oculars are large, rounded, raised, and bear a number of small tubercles. There are no pedicellariae.

This species is distributed throughout the West Indies, in shallow water.

**MATERIAL EXAMINED.**—Oregon Station 5438 (1) [R=33 mm, r=4 mm, Rr=1:8].

### *Narcissia* Gray

*Narcissia* Gray, 1840:287. [Type, by original designation, *N. teneriffae* Gray (= *Asterias canariensis* d'Orbigny, 1839).]

Only one species in this genus occurs in the western Atlantic.

### *Narcissia trigonaria* Sladen

*Narcissia trigonaria* Sladen, 1889:414, pl. 65: figs. 5–8.—Verrill, 1915:97.—H. L. Clark, 1921:58.—Brito, 1962:3, pl. 1: fig. 9.—Tommasi, 1966:244.—Gray, Downey, and Cerame-Vivas, 1968:147, fig. 20.

*Narcissia trigonaria* var. *helenae* Mortensen, 1933a:429, fig. 10a, pl. 20: figs. 4–6.

This distinctive species is well represented in the collection by a good growth series showing the progressive reduction in relative size of the disc, and the development of the arms from flat and plane in small specimens to high and triangular in cross section, with a marked carinal ridge, in adult specimens. In small specimens, the carinal plates are large and in a regular row; they are irregular and obscure in larger specimens. Papular pores occur singly, none below the inferomarginals, and none in a narrow interradial band on the disc. Both marginal series are regular, even, and large, and are mostly confined to the lateral arm surface.

A single regular row of actinal intermediate plates extends to the end of the arm; in most specimens, each bears one or two small sugar-tongs ped-

icellariae between flat-sided granules. Similar pedicellariae occur also on many of the marginal plates and on most of the larger abactinal plates as well. The two valves of the pedicellariae are long, delicate, and slender, with 2 or 3 small terminal teeth. All plates are covered with flattened polygonal granules, those of the actinal surface coarser than those of the abactinal surface. The adambulacral plates bear a furrow series of 4 or 5 thick, blunt, somewhat flattened spines; the five subambulacral spines are thicker and broader, subprismatic, but shorter than the furrow spines; behind them is a row of 3–5 prismatic spinules or enlarged granules. These three rows of spines are on distinct “terraces” of the adambulacral plates. The mouth plates bear a crowded marginal row of huge, blunt, triangular spines, constricted at the base; behind them is a similar shorter row of spines, and behind them are three short, prismatic spines on each jaw half. The madreporite is small and inconspicuous, near the apex of one interradius. The oculars are nearly round, rather large, and bare (save for a few terminal tubercles) in the adult, but covered with fine granules in small specimens.

This species is distributed from North Carolina to Brazil, in 20–50 fathoms. Although most of the specimens in this collection are small, the species reaches a size of more than 200 mm (R).

**MATERIAL EXAMINED.**—Oregon II Station 10517 (4) [R=70 mm, r=8 mm, Rr=1:9 (height of disc=16.5 mm)]. Oregon Stations: 5739 (1 juvenile) [R=24 mm, r=6 mm, Rr=1:4 (height of disc=4 mm)]; 2086 (1) [R=69 mm, r=11 mm, Rr=1:6.5 (height of disc=14 mm)]; 2250 (4) [R=74 mm, r=9 mm, Rr=1:8 (height of disc=16 mm)]; 5023 (2 juvenile) [R=20 mm, r=6 mm, Rr=1:3 (height of disc=4 mm)]; 2248 (1) [R=51 mm, r=9 mm, Rr=1:6 (height of disc=12 mm)]; 5700 (1) [R=88 mm, r=21 mm, Rr=1:4 (height of disc=25 mm)].

Two other Ophidiasteridae, *Leiaster lymani* (A. H. Clark, 1948) and *Hacelia superba* H. L. Clark (1921), have been described from the area covered by this report (Key Largo, Florida, and Barbados, respectively), but were not taken in these collections.

**Order SPINULOSIDA Perrier, 1884**

This order is characterized by having prominent, unkeeled mouth plates; there is no definite and distinct marginal frame; pedicellariae are usually absent, but if present, they consist merely of grouped spines. The aboral skeleton may be reticulate, imbricate, or absent, and in many forms the

plates are pseudopaxillate; the principal plates are often cruciform. Ambulacral plates are not crowded. The tube feet, generally in two rows, have well-developed sucking discs.

The undefinable family Poraniidae, represented in this collection by the genera *Poraniella* and *Marginaster*, is not included in the key that follows.

**Key to the Families of Spinulosida**

1. Dorsal membrane above abactinal surface; no marginal or actinal plates; mouth plates broad, plowshare shaped ..... **Pterasteridae**  
No supradorsal membrane; marginal and, usually, actinal plates present; mouth plates not broad and plowshare shaped ..... **2**
2. Mouth plates prominent, unkeeled; marginal plates paxillate ..... **Solasteridae**  
Mouth plates small; marginal plates not paxillate ..... **3**
3. Marginal plates large, blocklike; actinal plates in regular transverse rows ..... **Ganeriidae**  
Marginal plates inconspicuous; actinal plates absent, or, if present, not in regular transverse rows ..... **Echinasteridae**

**Family SOLASTERIDAE Perrier, 1884**

The family Solasteridae is characterized by having a large disc and five to many long arms; the aboral skeleton is open and irregularly reticulate. Marginal paxillae and oral intermediate plates are present. There are no conspicuous marginal plates,

and the mouth plates are prominent and unkeeled. There are no pedicellariae, and the suckered tube feet are in two rows. Bundles of spinelets usually ornament the plates.

Two genera in this family have been reported from the tropical-subtropical western Atlantic.

**Key to the Genera of Solasteridae**

- Superomarginal plates as large as inferomarginals ..... **Lophaster**  
Superomarginal plates much smaller than inferomarginals ..... **Solaster**

***Solaster* Forbes**

*Solaster* Forbes, 1839:129. [Type, by original designation, *Asterias endeca* Linnaeus, 1771.]

*Endeca* Gray, 1840:183. [Type, by original designation, *Solaster endeca* Forbes (= *Asterias endeca* Linnaeus; *Asterias aspera* Muller).]

*Polyaster* Gray, 1840:183. [Type, by original designation, *Solaster papposus* Forbes (= *Asterias papposus* Linnaeus; *Asterias stellata* Retzius).]

One series of marginals well developed, superomarginals always smaller than inferomarginals; abactinal pseudopaxillae with stellate or cruciform base; actinal intermediate plates extending more or less along arm.

Two species of *Solaster* are represented in this collection.

**Key to the Species of *Solaster***

- Rr 2 or 3; dorsum very inflated; pseudopaxillae low, minute; subambulacral spines 6-8 ..... ***S. notophrymus***  
Rr 4; dorsum not much inflated; pseudopaxillae high, small; subambulacral spines 3 or 4 ..... ***S. caribbaeus***

*Solaster notophrynus* Downey

PLATE 29: FIGURES C, D

*Solaster notophrynus* Downey, 1971a:39, fig. 1.

This large, handsome species has a broad disc and seven short, broadly based arms tapering to a small point. The dorsum is inflated and moderately thin. The papular pores are single and numerous, and the papulae are unusually large. The abactinal plates are Y-shaped or cruciform, with long imbricating lobes, irregular on the central disc and midarms, but in regular, oblique-transverse rows elsewhere. Small, low, well-spaced pseudopaxillae bear 10–40 minute thorny spinules. Narrow interradial bands of fused plates have few or no papulae. The superomarginal plates are indistinguishable from the adjacent abactinal plates. The high-crescentic inferomarginal plates are confined to the actinal surface; they are about three times as wide as long, and bear numerous small spinules on the crest. Bare spaces between the inferomarginals are about twice the length of the plate. The well-spaced actinal plates are in irregular chevrons, one row extending nearly three-quarters the length of the arm. They may be small and round, or larger and elongate, and bear 4–14 small spinules. The curved adambulacral furrow margin bears 4 or 5 setose spines, and a transverse ridge on the actinal face of the plate bears 6–8 longer, stouter, acute spines.

The mouth plates are wide and prominent, with 8–10 long, tapering, webbed oral spines, the central pair longest, and a pair of fans of 4 or 5 smaller setose spines, one above the other, at the sides; the face of the plate is covered with small setose spinules, and the suture is wide and bare. The madreporite is small and nearly hidden by enlarged pseudopaxillae; it is located nearer the margin than the center, at the top of a patch of fused interradial abactinal plates. Internally, an interradial strut between the mouth and the body wall is a single column of plates embedded in a strand of tissue supporting the abactinal roof.

**MATERIAL EXAMINED.**—*Oregon* Station 5929 (1 holotype) [R=114 mm, r=49 mm, Rr=1:2.3].

*Solaster caribbaeus* Verrill

PLATE 30: FIGURES A, B

*Solaster caribbaeus* Verrill, 1915:54, pl. 28: figs. 1–1a.—Gray, Downey, and Cerame-Vivas, 1968:152, fig. 27.

The disc is moderately broad, and the eight arms are short, rounded, and tapering. The dorsum is slightly inflated, and the cruciform dorsal plates form a close reticulum. The pseudopaxillae are about as high as the width of a plate and bear 6–10 upright spinules about as long as the pedicel. Solid areas of fused plates, mostly without paxillae, occur in the interradii. Papular pores are single and occur over the entire surface. The superomarginal plates are indistinguishable from the adjacent abactinal plates. The inferomarginal plates are raised, broader than long, and bear 10–15 spinules. They define the actinal ambitus. The actinal interradial areas are narrow and the plates extend far out on the arm. They are spaced, not much raised from the surface, and bear 1–6 short, sharp, stout spines larger than the spinules of the abactinal surface. The adambulacral plates bear, on a curved furrow margin, four moderately long, subequal spines, and on the actinal face of the plate, a transverse series of 3 or 4 longer, stouter, acute spines. The large mouth plates have a rounded apical margin bearing 6–8 long, stout spines, evenly graded from two large apical spines to small spinules at the side.

Behind these, on the side of the plate, is a fan of three small appressed spines. There are two stout suboral spines. The rest of the plate is bare or has a few small setose spinules. The madreporite is small, round, raised, and surrounded by enlarged paxillae. Internally, the interradial strut of the supporting plates from mouth to body wall is a solid triangular composite of plates hanging like an apron nearly to the actinal floor.

This species is known from North Carolina to the West Indies in about 35–355 fathoms.

**MATERIAL EXAMINED.**—*Oregon II* Station 10825 (1) [R=58 mm, r=15 mm, Rr=1:4].

*Lophaster* Verrill

*Lophaster* Verrill, 1878:214. [Type, by original designation, *Solaster furcifer* Duben and Koren.]  
*Sarkaster* Ludwig, 1905:185. [Type, by original designation, *S. validus* Ludwig.]

Only one species is known from the tropical western Atlantic.

***Lophaster verrilli* A. H. Clark**

PLATE 30: FIGURES C, D

*Lophaster verrilli* A. H. Clark, 1938:6.*Lophaster radians*.—Verrill, 1915:51, pl. 5: fig. 2, pl. 7: fig. 3, pl. 11: figs. 1–1c [non *Lophaster radians* Perrier, 1884].

This species is stellate, and the disc is moderately broad. The five arms are of moderate length and subacute. The abactinal surface is convex, regularly and openly reticulate. The dorsal plates are cruciform or stellate, with large, high, flat-topped pseudopaxillae bearing numerous setose spinules. Large papulae occur singly or in small groups over the entire abactinal surface. The marginals are equal and opposite or alternate, similar to but much larger than the abactinal plates. The small actinal intermediate areas have few plates, one row extending nearly to the end of the arm. The actinal plates are small, round, and bear a central group of small spinules. The adambulacral plates are wider than long and spaces between them are twice the width of the plate. They bear a webbed furrow series of 4–7 long, slender, subequal spines parallel to the groove and, on the actinal face, an oblique series of 2–5 shorter, stouter spines.

There is a bare space between the two series of spines, and behind the oblique subambulacral series nearly half the plate is bare. The mouth plates are broad, roundly triangular, and prominent. A raised ridge borders the broad suture on

each side. There are 20–22 webbed spines around the margin of each pair of mouth plates, the two apical pairs being longer and stouter than the others. A few small spinules occur on the rest of the plate, mainly along the ridges. The small madreporite is round and raised.

This species is known from Florida and the West Indies, in 56–200 fathoms.

MATERIAL EXAMINED.—Oregon Station 4912 (1) [R=38 mm, r=13 mm, Rr=1:3]. *Combat* Stations: 171 (1) [R=15 mm, r=6 mm, Rr=1:3]; 185 (1) [R=20 mm, r=6 mm, Rr=1:3.5].

**Family PTERASTERIDAE Perrier, 1875c**

The family Pterasteridae is characterized by having a dorsal membrane distinct from the abactinal surface and supported above it by bundles of spines arising from the cruciform abactinal plates. A central osculum in this membrane opens into the so-called nidamental chamber, the space between the abactinal surface proper and the upper dorsal membrane. Elongate lateral spines on the adambulacral plates serve the same function as that of the actinal plates in other asteroid families. The mouth plates are broad and plowshare shaped. Calcareous parts in these starfishes are reduced and usually fragile. The tissue is frequently flabby or gelatinous. This is principally a deepwater family, and its distribution is worldwide.

**Key to the Genera of Pterasteridae**

1. Adambulacral spines not webbed, not in transverse series ..... *Hymenaster*  
Adambulacral spines partially or completely webbed, in transverse or oblique series ..... 2
2. Adambulacral furrow spines webbed to actinolateral spines; paxillar spines long, setose .....  
..... *Pteraster*  
Adambulacral furrow spines only partially webbed, not webbed to actinolateral spine;  
paxillar spines short, robust ..... *Calyptaster*

***Hymenaster* Thomson**

*Hymenaster* Thomson, 1873:120. [Type, by original designation, *H. pellucidus* Thomson.]

Armature of adambulacral plates not in transverse webbed combs; spinelets of paxillae not protruding through membrane; membrane contains many muscle fibers and few to many spiraculæ.

At the time Sladen published his report on the *Challenger* asteroids, 24 species of *Hymenaster* had

already been described, a remarkable advance in the knowledge of a genus which was first described from a single specimen discovered by Wyville Thomson a mere 25 years before, especially for a group confined (with the exception of a single species) to the abyssal depths. Seven of these species had been described from the Atlantic, and Verrill subsequently added another species from off the east coast of the United States. As H. L. Clark



(1920) pointed out, the species of *Hymenaster* are difficult to determine; a deep-sea group, they usually arrive at the surface in a damaged condition, further complicated by the fact that they are soft bodied and gelatinous, with hard parts few and delicate. Clark quite rightly based the classification of *Hymenaster* on hard-part morphology, as, indeed, is the case for all asteroids. However, hard parts in *Hymenaster* are usually deeply embedded in thick flesh, and nearly impossible to examine critically without drying the specimen. Clark considered the oral and suboral spines and the adambulacral spines as the most important and dependable features for separating species within the genus; unfortunately, these spines are loosely attached and

frequently lost in collecting and preservation. Even the surfaces to which they attach are often badly abraded, due to the generally soft and delicate calcite of all hard structures within the group. Another factor hampering the determination of species is the rarity of specimens; most of the 49 species presently included in the genus are based on single specimens. Because of the difficulty of preserving these animals, many of the types have been lost, and the genus is in dire need of a thorough revision on a worldwide basis.

Because of the paucity of material and the poor state of preservation, the identifications of species of *Hymenaster* herein should probably be considered as only tentative.

#### Key to the Species of *Hymenaster*

1. One suboral spine on each jaw plate ..... *H. modestus*  
More than one suboral spine ..... 2
2. Two suboral spines on each jaw plate; disc round to pentagonal ..... *H. rex*  
Three suboral spines on each jaw plate; disc substellate ..... *H. anomalus*

#### *Hymenaster rex* Perrier

PLATE 31; FIGURES A, B

*Hymenaster rex* Perrier, 1894:186, pl. 13: fig. 2.

The form of this species is more round than pentagonal, and inflated in life. It is of the consistency of a dense jellyfish; the hard parts are few and delicate. The five radial areas are well defined, and the broad interradial areas are without plates, spines, or calcareous deposits. Over the ambulacral areas, there are about 5-7 rows of delicate cruciform plates with long, thin, flattened lobes and a moderately high columnar pedicel. On top of the pedicel are 3 or 4 long, fine hyaline spines with expanded bases. On the carinals, these spines are about twice the length of the short pedicel, but both pedicel and spines increase in length from carinal to outer row. The lobes are in contact or slightly overlap those of the adjacent plates, and all abactinal plates are also in contact with the ambulacral and/or adambulacral plates. The spines support the dorsal membrane but do not protrude through it. I could find no spiraculae. The central osculum is large, and the webbed valves of 12-18 long, delicate glassy spines, as long as the longest abactinal paxillar spines, have an expanded base,

each mounted on a small, triangular, flattened plate which in turn is borne on the upper ridge of the large, heavy, crescentic, oscular plate.

There are five of these plates forming a ring in the center of the abactinal surface proper, inside the nidamental chamber. The interradial madreporite, just outside this ring, is hemispherical and covered with deep gyri. The central stomach contains a few large, round, flat, delicate sieve plates. The gonads lie in clusters on either side of the ambulacrals, separated by a membranous interbranchial septum containing a few large, flattened, elongate or cruciform plates. The upper part of the ambulacral plates is about three times as long as wide and quite thin; they overlap. Below this broad, winglike flange, the plate narrows to a strut, connecting it with the flared outer or lower part of the plate that rests on the inner adambulacral plate. There are two sets of plates in the adambulacral position; the inner plate is by far the largest, cruciform to nearly square, with the lobes quite short except for the outer lobe (away from the groove) on a few of the proximal plates, which may be long, broad, and strong. The outer adambulacral plate rests on the actinal face of the inner adambulacral and bears three short, acute, conical

spines on the furrow margin, and a small leaflike opercular plate on the actinal margin covering the small segmental pore. The inner adambulacral plate bears a single, long, slender, lateral spine which supports the actinal interbranchial membrane.

This spine has an expanded base and the tip is thicker than the midsection of the spine. There are 28–30 of these spines, the first 5 and the last 6 or 7 comparatively short; the rest are subequal. The broad mouth plates are nearly straight along the front, or apical, margin; each pair bears a stout pair of apical spines and a similar pair of epioral spines; they are thick, slightly flattened, and may be bifurcate at the tip. The margin also bears, to the side, 3 or 4 smaller acute spines. Interradially, between the mouth plates and resting on them, is a large round plate (odontophore) with an upward-extending flange. The ambulacral grooves are wide and there are two rows of large tube feet. The peristomial membrane is broad.

This specimen was badly damaged and poorly preserved; it was necessary to dry it to prevent further deterioration and to examine plates. During drying, large fatty globules were observed over the entire surface of the specimen.

While this specimen closely resembles others in the genus *Hymenaster*, it differs from the description of that genus in several important respects; there are no muscle fiber bands, no spiraculae, and the two series of adambulacral plates have not, to my knowledge, been observed in any other asteroid. I suspect that this may be the same species as that described by Perrier as *Hymenaster rex*; it would be impossible for him to have seen the double row of adambulacral plates without drying the specimen. The muscle fiber bands he describes may have been merely stretched strands of tissue. Although no spiraculae are present on the specimen before me, the very poor state of preservation may account for this; the dorsal membrane at the center of the disc had entirely disintegrated by the time the specimen was received.

This species has previously been reported only from the eastern Atlantic, in 400–800 fathoms.

MATERIAL EXAMINED.—*Alaminos* Station 14C/68-A-7 [R=81 mm, r=73 mm, Rr=1:1.1].

### *Hymenaster modestus* Verrill

PLATE 31: FIGURES C, D

*Hymenaster modestus* Verrill, 1885:151; 1894:277; 1895:203.

This substellate form has a broad disc and five short, broad, petaloid arms. The dorsal membrane is thin and fragile and contains a few minute granular deposits. The paxillar abactinal plates are cruciform, with a moderately high pedicel that bears 3 or 4 long, slender spines, about twice the length of the pedicel. There are roughly five rows of plates on each arm. The spiraculae are numerous and small; larger holes in the membrane, which might be mistaken for large spiraculae, are tears in the dorsal membrane. These are present in every specimen I have seen, including the type. The osculum is large and has five valves of 6–14 long spines, evenly graded from the longest in the center of the valve to the shortest at the ends. These are webbed together throughout their length, and the valve is longer than the diameter of the osculum, so there is considerable overlap when the osculum is closed. The five ossicles supporting the valves are the most massive ossicles present, crescentic, with a short, sturdy pedicel broadly expanded at the top into a tumid, crescentic knob. The actinal surface is without deposits of any kind; the actinal tissue is supported by actinolateral spines of moderate length, and there is a naked interradian area.

The lateral fringe is wide and unsupported; in contracted specimens, however, the actinolateral spines may extend beyond the fringe. The ambulacral grooves are wide, with two rows of massive tube feet. The adambulacral plates bear three slender, subequal furrow spines. There are 15–25 actinolateral spines, of which the fifth to the seventh are the longest. The mouth plates are longer than wide, and each half bears a long, stout preoral spine, a similar suboral spine, and 3 or 4 smaller, more acute marginal spines, the outermost one of which might be considered a second suboral, as it sits slightly behind the line of the other 2 or 3 marginal spines. The aperture papillae are broad, flat, leaf shaped, and bear longitudinal ridges. They are borne on the adambulacral plates between the furrow spines and the actinolateral spine.

I have examined the type specimen of this species, and it is a juvenile, as indicated by the small size and the presence of several long spines at the terminus of the arms, in the position of the oculars, a juvenile character in most asteroids. Nevertheless, I have no hesitation in assigning the larger speci-

mens below to the species *H. modestus*, thus extending the range of this species, previously reported as occurring from Nantucket to Cape Hatteras, in 1,098–1,451 fathoms.

MATERIAL EXAMINED.—Oregon Stations: 2821 (2) [R=30 mm, r=19 mm, Rr=1:1.1]; 2820 (3) [R=38 mm, r=23 mm, Rr=1:1.3].

### *Hymenaster anomalus* Sladen

PLATE 32: FIGURES A, B

*Hymenaster anomalus* Sladen, 1882:228; 1889:512, pl. 89: figs 3, 4, pl. 91: figs. 4–6.

This substellate species has a broad plane disc and five broad-based arms tapering to an acute point. The dorsal membrane consists of a dense network of thick fibrous muscle bands, forming a firmer dorsum than is usual in *Hymenaster*. The membrane is supported in regular rounded elevations over the whole abactinal surface; these elevations are produced by the paxillar spines, of which there are three on a short pedicel to each H-shaped dorsal plate; the three spines are not divergent, but are carried erect as a single unit. The osculum is enclosed by a ring or coronet of low papillose elevations, within which the reticulate muscle bands continue partway up the five triangular valves. The valves consist of about 5 or 6 moderately long spines; because of the fleshy covering over the spines, the exact number is difficult to determine. The spiraculae are minute and occur in the meshes of the reticulum. The actinal surface is covered with fine muscle fibers. The ambulacral grooves are wide and lanceolate, with two rows of stout, straight, untapered tube feet. The adambulacral plates bear 3 or 4 glassy furrow spines, usually webbed, either all together or in 2–2 or 2–3 groupings, and not in transverse series.

The aperture papillae are large, flat, and nearly circular; Sladen described them as small and elongate-oval, but I believe this may be variable. The actinolateral spines number about 13–17, with the sixth the longest; there is a narrow interradiar area unsupported by spines, but the sixth spine on each side touches the sixth spine of the adjacent arm at the ambitus. The narrow, lateral fringe is scalloped between the actinolateral spines which protrude slightly through it. The mouth plates are small, and each bears three large, stout suboral spines.

Because of the position in which this specimen is preserved, it is impossible to see the marginal edge without destroying the specimen; Sladen says this species has two small marginal spines on the oral edge of each plate.

With its relatively sturdy dorsal membrane and its partially webbed adambulacral spines, this species is almost as close to *Pteraster* as to *Hymenaster*; a new genus should probably be erected for it when additional material becomes available. For the time being, it is best left in the genus *Hymenaster*.

This species was known previously only from Tristan da Cunha, in 1,425 fathoms.

MATERIAL EXAMINED.—Alaminos Station 4/69-A-13. (1) [R=14 mm, r=8 mm, Rr=1:1.7].

### *Pteraster* Muller and Troschel

*Pteraster* Muller and Troschel, 1842:128. [Type, by original designation, *Asterias militaris* O. F. Muller.]

*Pterasterides* Verrill, 1909:547. [Type, by original designation, *Pteraster aporus* Ludwig.]

*Lophopteraster* Verrill, 1895:203. [Type, by original designation, *L. abyssorum* Verrill.]

*Hexaster* Perrier, 1891b:1227. [Type, by original designation, *H. obscurus* Perrier.]

*Temnaster* Verrill, 1894 (as subgenus):275; 1905 (as genus): 202. [Type, by original designation, *Pteraster (Temnaster) hexactis* Verrill (= *Hexaster obscurus* Perrier).]

Muscle bands present in supradorsal membrane, but not usually reticulate; adambulacral armature in transverse webbed combs; actinolateral spines forming free, independent lateral fringe, not merged in actinal floor; small spiraculae sometimes present.

Some confusion exists about the western Atlantic tropical and subtropical species of *Pteraster*. Perrier's original description of *P. caribbaeus* (1881b) is vague, and it is impossible to determine on which specimen he based his description. In a later (1884), more complete description, one of the two specimens from Nevis (*Blake* Station 151) evidently formed the basis for the description. Perrier here stated that one of the specimens was in bad shape, and at least his measurements of major and minor radii are based on the best of the two specimens. He also had three smaller specimens, badly deteriorated, from two other stations, and a sixth specimen, from Sand Key, Florida (*Blake* collection), which differed in important respects from the good specimen from Nevis. Obviously, this latter specimen

must be considered the type of *P. caribbaeus*; Perrier did not designate a holotype, so the specimen now in the collection of the Museum of Comparative Zoology at Harvard bearing catalog number 957 (the "good" specimen from Nevis) is hereby designated the lectotype of *Pteraster caribbaeus* Perrier. The two small specimens marked paratypes of *P. caribbaeus* in the Museum of Comparative Zoology (MCZ 958) from Frederikstadt (Blake Station 130), along with the above-mentioned specimen from Sand Key, correspond more nearly to the type of *P. militaroides* H. L. Clark; it is unfortunate that Clark (1941) mentions, as the distinctive feature of *P. caribbaeus*, the heavy, white epioral spines. He apparently examined the Sand Key specimen, rather than the Nevis specimen. This makes all the more peculiar the fact that he described a new species in the same paper, *P. militaroides*, which is in fact identical with Perrier's Sand Key specimen of "*P. caribbaeus*." His speci-

men of *P. caribbaeus*, from Station 2978C, is the same species as his specimens from Cuba which he called *P. militaroides*. To compound the confusion, Verrill (1915) redescribed *P. caribbaeus* on the basis of a specimen from Albatross Station 2667, which is in fact the species later described by Clark as *P. militaroides*. Clark's description of this species is wholly inadequate, and it is only by comparison of type material that the two species can be distinguished. And contrary to Clark's statement, there is a much greater contrast between *P. militaris* and *P. militaroides* than between *P. militaris* and *P. caribbaeus*. Heavy white or hyaline suboral spines of very dense, solid calcite are not present on the lectotype of *P. caribbaeus* (which has large, rather blunt, and sometimes slightly curved suborals of a echinoid-like lattice-structured calcite), but are present on the holotype of *P. militaroides*. Other differences are discussed in the descriptions of the two species.

#### Key to the Species of *Pteraster*

- |  |                          |
|--|--------------------------|
| 1. Suboral spines present .....                                  | 2                        |
| Suboral spines absent .....                                      | <i>P. personatus</i>     |
| 2. Suboral spines hyaline .....                                  | 3                        |
| Suboral spines not hyaline .....                                 | <i>P. caribbaeus</i>     |
| 3. Broad lateral fringe present .....                            | <i>P. rugosus</i>        |
| Lateral fringe narrow or absent .....                            | 4                        |
| 4. Supradorsal membrane with numerous calcareous deposits .....  | 5                        |
| Supradorsal membrane without deposits, spongy, transparent ..... | <i>P. acicula</i>        |
| 5. Spiraculae small, numerous .....                              | <i>P. militaroides</i>   |
| Spiraculae large, not numerous .....                             | <i>Pteraster</i> species |

#### *Pteraster personatus* Sladen

PLATE 32: FIGURES C, D

*Pteraster personatus* Sladen, 1891:694, pl. 27: figs. 1-5.—Bell, 1893:94.—Koehler, 1896a:447; 1896b:49; 1907:24.—Nichols, 1903:251.—H. L. Clark, 1908:285 [in key].—Fisher, 1911a:369 [in key].—Farran, 1913:23.

*Pteraster reductus* Koehler, 1907:25; 1909b:96, pl. 3: figs. 8, 9, pl. 20: fig. 10.—Grieg, 1932:28, pl. 5: figs. 6, 7.

This substellate species has a broad disc and five broad-based arms which taper to an acute point. The dorsal membrane is fine and lacy, with many small spiraculae. The abactinal plates are cruciform, with the lateral extensions flattened and broadly truncate; they are not as long as the tall pedicel, which is expanded at the top, like a tall, attenuate, inverted cone. The pedicels bear 10-25

fine, hairlike, glassy spines which are not quite as long as the pedicel. These spines cross over and mingle with the spines of adjacent plates, so the whole abactinal surface appears to be covered with dense, matted fur.

The valves of the moderate-sized osculum are supported on five large fan-shaped pedicels and consist of a great number of fine long spines. There is a narrow but distinct lateral fringe visible from the abactinal side. The actinal membrane is supported by 18-25 long actinolateral spines which meet in midinterradius. There is frequently a smaller, finer supplementary spine embedded in the membrane beside the actinolateral spine. The adambulacral furrow spines are 3-7 (usually five), webbed together in a curved series; these spines are

long, acute, and subequal. The high, plowshare-shaped mouth plates bear a marginal series of 5 or 6 long webbed spines similar to but longer than the adambulacral furrow spines; there are no suboral spines, the face of the mouth plate being quite bare.

Sladen and others have reported this species off the coast of Ireland; I am convinced, although I have not examined his types, that Koehler's *Pteraster reductus*, from the Azores, is a juvenile of this species; he based his species on the smaller size and longer spines (correlative characters in asteroids), and on the presence of six, instead of five, adambulacral spines. As noted above, the number of adambulacral spines is variable.

MATERIAL EXAMINED.—*Alaminos* Station 87/69-A-11 (1) [R=70 mm, r=28 mm, Rr=1:2.5].

### *Pteraster caribbaeus* Perrier

PLATE 33: FIGURES A, B

*Pteraster militaris* A. Agassiz [non Muller], 1877.

*Pteraster caribbaeus* Perrier, 1881a:13; 1884 [part]:216.

Non *Pteraster caribbaeus*.—Verrill, 1915:82, pl. 7: fig. 4.—H. L. Clark, 1941:60.

This form is broadly stellate, with a broad disc and five acutely pointed arms. The dorsal surface is moderately inflated. The dorsal membrane is crisscrossed with tough transparent irregular muscle bands which connect the underlying paxillar spines. There are a few calcareous deposits in the membrane, and spiraculae are small to moderate in size, and numerous. The tall slender pedicels of the abactinal plates arise from flattened, broadly lobed bases and support up to a dozen long, fine, glassy spines which protrude a short distance through the membrane. The central osculum is surrounded by five ill-defined valves of 10–15 long, subequal, blunt spines, all webbed together and forming a continuous ring of closely set spines. The actinal surface is relatively small; the membrane is without deposits and is supported by 12–16 long, sturdy, ridged actinolateral spines, the sixth or seventh being the longest and meeting at the ambitus. Occasionally, there are two spines, side by side. The tips of the spines support a broad lateral fringe. There are 5 or 6 long slender adambulacral furrow spines, webbed together in a curved series, and grading from shortest inner spine to longest

outer spine. The mouth plates bear, on the side, five small, equal spines, and apically, two longer, stouter spines. There may be up to three long, sturdy, nonhyaline suboral spines, or there may be none. None of the mouth spines are webbed.

This species seems to be confined to the Leeward Islands, in 350–360 fathoms.

MATERIAL EXAMINED.—*Oregon* Station 6696 (1) [R=36 mm, r=16 mm, Rr=1:2].

### *Pteraster rugosus* Clark

PLATE 33: FIGURES C, D

*Pteraster rugosus* H. L. Clark, 1941:61, pl. 6: fig. 1.

This nearly pentagonal species has a highly inflated disc and five short, broad arms which curve upward at the tip, so the end of the ambulacral groove is actually on the abactinal surface; the interradial arcs are wide and shallow. The dorsal membrane is thin, with numerous small spiraculae, and contains many small calcareous deposits. It is produced in a regular pattern of peaks by the underlying spines. The cruciform abactinal plates have long, flat lobes and a tall pedicel, narrow at the base but expanded to a stout, ridged or grooved top which bears 5–8 spines, about as long as the pedicel and not particularly slender or acute. The central osculum is small and surrounded by a series of continuous spines about the same length as the paxillar spines. The actinal surface is plane and distinctive by reason of its 20–30 flat, closely set actinolateral spines whose square tips support a broad lateral fringe. The adambulacral furrow spines are erect and webbed, in a curved series; there are 4–6 spines (Clark says 5 or 6) and the inner one or two are small, but the others are long and not particularly slender or acute.

The mouth plates bear seven marginal spines, webbed together, on each half; the two at the apex of the plate are long and slender, and the others decrease gradually in length to a small spine at the outer edge of the margin. On the actinal face of the mouth plate is a single large, stout suboral spine, white at the base but hyaline at the tip. The tube feet are notably smaller and more delicate than those of most species of *Pteraster*. This species is distinctive because of its generally neat and regular appearance compared to other *Pterasteridae*. The largest specimen in the collection has an

average of four adambulacral furrow spines, as compared to the 5 or 6 noted by Clark, but it is larger than Clark's largest specimen, and is undoubtedly the same species; this may be a function of growth. The white color noted by Clark in live material is retained in preserved specimens.

The distribution presently known is from northern Cuba to the Leeward Islands, in 50–255 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 4994 (1) [R=24 mm, r=17 mm, Rr=1:1.5]; 5937 (1) [R=12 mm, r=7 mm, Rr=1:1.8].

### *Pteraster militaroides* Clark

PLATE 34: FIGURES A, B

*Pteraster caribbaeus* [part] Perrier, 1884:216.—Verrill, 1915: 82, pl. 7: fig. 4.—H. L. Clark, 1941:60.

Non *Pteraster caribbaeus*.—Perrier, 1881a.

*Pteraster militaroides* H. L. Clark, 1941:61.

The form of this species is plump and stellato-pentagonal, with the interradial slightly indented. The five arms are recurved at the tip, so the end of the ambulacral groove is on the abactinal surface. The supradorsal membrane is heavily encrusted with numerous small calcareous deposits, and has a lacy appearance due to the many small spiraculae. The membrane rests loosely on the underlying paxillar spines, so the dorsal surface is rugose, but the spines do not protrude through the membrane nor lift it in tent-like peaks above the general surface. The lobes of the abactinal plates are short, broad, and flat, and the pedicel is thick, columnar, and short; it bears 6–12 long, slender, glassy spines, not acute. Usually, there is one central spine and about nine peripheral spines, all about of equal length. The central osculum is of moderate size and surrounded by a continuous ring of numerous, close-set spines about the same length as the paxillar spines.

The actinal membrane is mostly without deposits; it is supported by 20–25 short, ridged, blunt-tipped actinolateral spines which neither reach the ambitus nor support a marginal fringe; the supradorsal membrane extends well onto the actinal surface interradially. There are a few small, supplementary actinolateral spines, either near the base of the large actinolaterals or between a pair

of them. There are seven adambulacral furrow spines (six distally; on the smallest specimens, there are 6 or 5 spines) webbed together in a curved series and graded from shortest at the inner (or groove) end of the series to longest at the outer end. The mouth plates have a prominent central ridge along the suture. Each plate bears a long, stout, hyaline suboral spine and a marginal series of about eight spines (6–10), four at the side of the plate and, at right angles to these, four along the front margin. The four spines on the side are short and subequal; the four on the front margin are longer and grade upward to longest at the apex. All are slender and blunt tipped, and none are nearly as long as the suborals.

Clark reported this species as occurring only in northwestern Cuba; this collection contains specimens from off the Leeward Islands and from the western Caribbean, between the Caymen Islands and Panama. The depth range is 250–355 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 1917 (2) [R=23 mm, r=11 mm, Rr=1:2]; 1885 (1) [R=17 mm, r=9 mm, Rr=1:9]; 1929 (1) [R=22 mm, r=13 mm, Rr=1:1.8]; 5929 (1) [R=19 mm, r=11 mm, Rr=1:1.7].

Since the publication of my brief paper on *Marsipaster acicula* Downey, 1970c, I have had the opportunity to examine many more specimens of Pterasteridae and have concluded that *Marsipaster* Sladen (1882) is not a good genus; it is practically indistinguishable from *Pteraster*. The characters on which Sladen based *Marsipaster* are minor and subject to variation even within a species. The nature of the supradorsal membrane in *Marsipaster* is certainly distinctive, but scarcely of generic significance when one considers how this feature may vary between species of *Pteraster*. The web connecting the suboral spine to the other mouth plate spines is certainly not of sufficient importance to be a generic character, while the placement of the adambulacral spines (Sladen says high in the furrow and horizontal in position) does not hold true for both of the species described by Sladen in his paper (true for *M. spinissimus*, not true for *M. hirsutus*). In light of these conclusions, it is thought appropriate to include here a more thorough description of the species I described as *Marsipaster acicula*.

*Pteraster acicula* (Downey)

PLATE 34: FIGURES C, D

*Marsipaster acicula* Downey, 1970c:309, fig. 1.

This small, plump form is pentagonal, with an inflated disc and five short arms, hardly produced beyond the disc. The supradorsal membrane is thin, fragile, and transparent, and strongly reminiscent of spongin. Spiraculæ are small and numerous. The pedicels of the abactinal plates are of moderate length, sturdy and columnar. They bear a crown of 8–25 long, fine, glassy, acute spines which are webbed together at their bases, below the supradorsal membrane, like an inverted umbrella. These spines protrude through the supradorsal membrane for as much as half their length. The central osculum is inconspicuous and is surrounded by numerous fine spines, exactly like the paxillar spines, webbed together in a continuous ring around the osculum. The actinal interradial area is small, the supradorsal membrane continuing onto the actinal surface in this region. The actinolateral spines are large, but not much longer than the longest adambulacral spine. A few spines extend beyond the actinal membrane and may be webbed together, but there is no continuous lateral fringe. The six erect adambulacral furrow spines are webbed together for their entire length; the inner two are small and parallel to the groove, while the outer ones are longer and set at right angles to the groove.

The first adambulacrals are webbed continuously across the base of the mouth plates. The mouth plates are broad and bear five free marginal spines and one suboral spine, the suboral and apical marginal spines subequal, long, stout, acute, and glassy-tipped.

This species seems to be confined to the northern Gulf of Mexico, in 142–720 fathoms.

**MATERIAL EXAMINED.**—*Alaminos* Station 12A/68–A–13 (1). Specimen too damaged for meaningful measurements, but the species is very small (holotype: R=8 mm).

*Pteraster* species

PLATE 35: FIGURES A, B

The form of this specimen is distinctly stellate, with a moderately broad disc and five long attenuate arms. The dorsal membrane is thin. Spiraculæ are

moderately large and few. Large rounded granules of calcite are present in the membrane. The pedicels of the cruciform abactinal plates are columnar, stout, and about as long as the lobes of the plate; they bear 6–15 longer, clear spines, ridged and lattice structured like the spines of many echinoids. The five plates surrounding the osculum have a thick pedicel, only slightly expanded at the top and bearing about twenty long, slender, webbed spines. On the actinal surface, 25–30 long, sturdy, blunt-tipped spines, of the same lattice structure as the dorsal spines, support a narrow marginal fringe. These spines meet at the interradius. The adambulacral plates bear a curved series of six webbed, subequal spines, fine and acute. The broad mouth plates bear a single long, blunt suboral spine, slightly curved; the rest of the mouth-plate armature is, unfortunately, badly damaged. It seems to consist of a thick preoral spine, webbed to an adjacent, slightly smaller spine, and, at the side of the plate, three small unwebbed spines. The oral armature and the structure of the spines in general, as well as the height and thickness of the pedicels and the presence of round granular deposits in the supradorsal membrane and the attenuate arms, serve to distinguish this specimen from *Pteraster caribbaeus*, which appears to be its nearest relative. Although I believe this to be a hitherto undescribed species, formal description will have to await more and better-preserved material.

**MATERIAL EXAMINED.**—*Oregon II* Station 10827 (1) [R=26 mm, r=10 mm, Rr=1:2.5].

*Calyptraster* Sladen

*Calyptraster* Sladen, 1882:207. [Type, by original designation, *C. coa* Sladen.]

This genus, because of the partly webbed furrow spines, not webbed to the actinolateral, and oblique, rather than transverse, in position, seems to fall exactly between *Pteraster* and *Hymenaster*. The fact that one species, *C. coa*, has a delicate lacy supradorsal membrane like many *Pterasters*, and the other, *C. personatus*, a thick, robust, somewhat gelatinous membrane, like most *Hymenasters*, further supports this view, which Sladen pointed out in his original diagnosis of the genus.

Only two species of this genus are known; *Calyptraster coa* Sladen is known only from off Brazil.

***Calyptaster personatus* (Perrier)**

PLATE 35: FIGURES C, D

*Cryptaster personatus* Perrier, 1894:191, pl. 14: fig. 3.*Calyptaster personatus*.—Madsen, 1947:3, figs. 1–2.

The depressed form of this species is broadly stellate and the abactinal surface is plane. There is a sharp ambital demarcation between the actinal and abactinal surfaces. The supradorsal membrane is strong, muscular, and gelatinous, and spiraculae are of moderate size and numerous. The dorsal paxillar columns are short and robust and bear a crown of 4–6 short, blunt, divergent spines which support the membrane but neither protrude through it nor raise it in peaks. The central osculum is surrounded by a ring of short spines, and the five large triangular valves consist each of 11 or 12 spines webbed together, the shortest at either end and the longest in the middle. The actinal membrane is supported by eighteen or more sturdy, slightly flattened actinolateral spines with blunt (or even expanded) tips, the sixth or seventh being the longest. The actinolateral spines do not meet in the interradius. There are four short, slender, acute adambulacral furrow spines in oblique series, partially webbed by a delicate membrane; the webbing does not extend to the actinolateral spine, and there is a distinct hiatus between the furrow spines and the actinolateral spine.

The mouth plates are small and nearly concealed by 3 or 4 pairs of huge, clavate, thorny-tipped suboral spines (Sladen and Madsen were inclined to consider the anterior pair as epioral, but I believe that, because their character and position are the same as the two or three pairs behind them, they must be considered suborals). Well within the mouth and on the side margin of each mouth plate is a single small acute spine (sometimes two).

This specimen establishes beyond a doubt that, despite Madsen's speculations, *C. personatus* and *C. coa* are separate and distinct species. Madsen calls *C. coa* the "western Atlantic species" and *C. personatus* the "eastern Atlantic species"; this species has hitherto been reported only from the Azores and the Madeira Islands, from 2,150–2,995 meters.

MATERIAL EXAMINED.—Oregon Station 2567 (1) [R=20 mm, r=10 mm, Rr=1:2].

**Family GANERIIDAE Sladen, 1889**

This family is characterized as having small mouth plates, not spade shaped or plowshare shaped. The ambulacral grooves are narrow, and the marginal plates are large and blocklike. The abactinal skeleton is reticulate or imbricate, and the actinal plates are in regular transverse rows, with one or two large spines or a group of small spinelets.

Only one species, of the monotypic genus *Leilaster*, is represented in the Caribbean; all other members of the family are confined to the polar regions.

***Leilaster* A. H. Clark**

*Leilaster* A. H. Clark, 1938:1–7. [Type, by original designation, *Korethraster radians* Perrier.]

***Leilaster radians* (Perrier)**

PLATE 36: FIGURES A, B

*Korethraster radians* Perrier, 1881a:12.*Korethraster hispidus* Perrier [non Wyville Thomson], 1884: 212, pl. 6: figs. 9–11.*Solaster radians*.—Perrier, 1884:275 [in explanation of plates], pl. 6: figs. 9–11.*Lophaster radians*.—Perrier, 1884:167–170 [in list of species].*Korethraster ? radians*.—Sladen, 1889:459, 463.*Leilaster radians*.—A. H. Clark, 1938:1–7, pl. 1.

This small form has a broad disc and five moderately long, broad arms. The disc is strongly arched upward and the downward-directed arms, high in the midregion, slope off steeply at the sides. The tumid dorsal plates are oblong except at the disc center, where the primary plates are round. Papulae are single and confined to the radial areas. The plates on the arms are in regular longitudinal rows, a carinal and two adradials extending the full length of the arm; between the second adradial row and the superomarginals are one or two additional rows which do not reach the end of the arm. The second adradials are larger than the carinals and the first adradials. The plates imbricate upon one another in the direction of the disc. The large blocklike superomarginals are rectangular and vertical. The inferomarginal plates are paxilliform, with the plate produced in a stout column extending downward. All abactinal plates bear short clavate spinules with thick, rounded, thorny heads, so the general appearance of the dorsum is openly



granular. The spinules of the dorsum are so spaced that conspicuous channels occur between the plates, and a broad sulcus is present in the interradius. The inferomarginals bear, on the outer edge, spinules of quite a different character: large, stout, and conical.

There is a single row of small actinal plates between the inferomarginals and the adambulacral plates, unornamented or bearing one or two small spinules. The adambulacral plates bear a furrow series of three long acute spines, webbed together and nearly parallel to the groove, the proximal spine shorter than the other two. On the actinal face of the plate is a comb of three longer spines in transverse series, incompletely webbed. The mouth plates are long and broad, and bear six long, subacute, divergent spines on the margin. In the specimens on hand, the actinal face of the mouth plate is bare. The madreporite is small, inconspicuous, and slightly sunken between two of the primary dorsal plates. The oculars are large and cordiform.

This odd little species is a classificatory puzzle; Clark placed it in the Ganeriidae, and Fisher (1911a) does not disagree, although he points out its affinities with the genera *Mirastrella* and *Kampylaster*, of the family Asterinidae. The character of the inferomarginal plates is quite like the genus *Lophaster*, of the family Solasteridae. The ill-defined Ganeriidae are a rather unsatisfactory family whose systematic position is open to question.

This species has previously been reported from Cuba, Barbados, and Puerto Rico, in 56–140 fathoms.

MATERIAL EXAMINED.—Oregon Station 4226 (6) [R=8 mm, r=4 mm, Rr=1:2].

#### Family PORANIIDAE Perrier, 1894

It is interesting that this family, commonly represented in colder waters by medium to large species, should apparently be limited in the Caribbean and Gulf of Mexico to very small, immature-looking species. Verrill (1915) reported *Poraniella regularis* (R=12 mm), *Poraniella echinulata* (R=5 mm), *Marginaster pectinatus* (R=5 mm), and *Porania ? austera* (R=17 mm), and speculates that they may be juveniles of some species of *Porania*. I find this hard to believe, as at least some of the

specimens were sexually mature, and no larger Poraniidae have been taken in this area. All of the above species were taken in 23–163 fathoms.

Systematically, this whole family is in need of revision, consisting as it does of very diverse forms, related variously to the Asterinidae, the Echinasteridae, the Ganeriidae, and the Oreasteridae, far removed in the currently accepted classification. *Poraniella*, as Verrill pointed out, is very close to *Asterina*, in the family Asterinidae; *Spoladaster*, according to Fisher, is close to *Perknaster*, in the family Ganeriidae; and *Pseudoporania* and *Sphaeraster* seem close to some of the Oreasteridae (notably *Culcita*). *Chondraster* and *Tylaster* may lack any skeleton except for certain radial elements, and it is hard to see why they should be placed in this family rather than practically any other. As presently constituted, the family Poraniidae defies reasonable definition.

#### *Poraniella* Verrill

*Poraniella* Verrill, 1914:19. [Type, by original designation, *P. regularis* Verrill.]

#### *Poraniella regularis* Verrill

PLATE 36: FIGURES C, D

*Poraniella regularis* Verrill, 1914:19; 1915:70, pl. 7: figs. 1–1a, pl. 15: figs. 5–5b.

This small stellate starfish has a broad disc and five short, broad-based, tapering arms. It is depressed, and the dorsum is sunken interradially, throwing the radial areas into prominence. The large abactinal plates are in regular longitudinal rows. The primary radials are large and roughly rectangular; their distal ends are overlapped, as are the rest of the carinals, by the pentagonal or stellate first adradials. All abactinal plates are slightly tipped up at the proximal end, and a large papular pore appears under the proximal edge of each radial plate; there are no interradiial papular pores. The upraised edge of the plate also bears 1–4 small acute spinules. The superomarginal plates are large, oval, and (unlike Verrill's type specimen) broader than long; they bear a few small acute spinules near the outer edge. The inferomarginal plates project beyond the superomarginals, but do not lie side by side with them as they do in the

type, where the two series of marginals form a double border around the abactinal surface. The inferomarginals bear, on their outer edge, a row of about half a dozen small acute spines and above them 1–3 smaller spines. The actinal interradials are large, roundish, slightly tumid, in regular chevrons with an unpaired interradial in all but the first row.

They usually bear a small acute spinule near the distal edge. The adambulacral plates bear, on the furrow margin, three (four proximally, two distally) short, blunt, palmate spines and on the actinal face of the plate two longer, erect, thorny spines. The mouth plates bear two large, blunt, slightly flattened apical spines, the first larger than the second, and on the side margin, three small spines similar to the adambulacral furrow spines. There is a single large suboral spine on each mouth plate. The madreporite is small, round, and deeply channeled; the oculars are oval; and there are no pedicellariae. Actinal, abactinal, and marginal plates are covered with minute glassy tubercles.

This species has been found off west Florida, the Bahamas, and Cuba, in 36–169 fathoms.

MATERIAL EXAMINED.—*Silver Bay* Station 961 (1) [R=17 mm, r=10 mm, Rr=1:1.7].

### *Marginaster Perrier*

*Marginaster Perrier*, 1881a:16. [Type, by subsequent designation, *M. pectinatus* Perrier (Sladen, 1889:364).]

*Cheilaster* Bell, 1892:81. [Type, by original designation, *Marginaster fimbriatus* Sladen.]

### *Marginaster pectinatus Perrier*

PLATE 37: FIGURES A, B

*Marginaster pectinatus* Perrier, 1881a:16; 1884, p. 229, pl. 1: figs. 4, 5; 1894, p. 167.—Sladen, 1889, p. 366.—Verrill, 1914, p. 18; 1915, p. 76.

This small subpentagonal form has an arched dorsum and the actinal surface is plane. There is a ridge down each midarm, and the abactinal interradial areas are sunken. The carinal plates are large and the primary interradials enormous, but other dorsal plates are generally small and irregular. Most plates bear 1–8 small, stumpy, thorny spinules at the periphery of the plate. Papular pores occur in the area between midarm and mid-interradius. The superomarginal plates increase in

size from interradius to the end of the arm, becoming broader than long, and the last three or four plates are separated on the midarm only by a single carinal plate. In the interradial area, they bear spinules similar to those of the dorsal plates (they are scarcely distinguishable from the dorsals), but distally the superomarginals are bare. They are broader and imbricating near the top, but narrower and separated by a papular pore at the bottom, between the superomarginals and the inferomarginals.

The inferomarginal plates project beyond the superomarginals. They are about twice as broad as long and bear on the outer edge 4 or 5 moderately long, stout, ridged, and rather thorny subhyaline spines, slightly flattened dorsoventrally. Above these is a row of 3 or 4 much shorter similar spines. The actinal face of the inferomarginals is plane and bare. The actinal interradial plates are in 3 or 4 rows parallel to and alternating with the inferomarginals; the central plate in each row is larger than the others. The plates are irregularly discoid and bare. The adambulacral plates bear three moderately long, sturdy, blunt spines in transverse series, the inner furrow spine smallest. The mouth plates, longer than broad, bear a stout, blunt, flattened preoral spine at the apex, a similar but smaller spine beside it, and two small spines at the side; there are 2 or 3 larger suboral spines. The madreporite is small, flat, round, and deeply channeled. The oculars are square, with a rounded distal edge which tilts up slightly.

This uncommon species occurs in the West Indies, in about 100 fathoms.

MATERIAL EXAMINED.—*Oregon* Station 4226 (5) [R=11 mm, r=6.5 mm, Rr=1:1.8].

### Family ECHINASTERIDAE Verrill, 1867

The family Echinasteridae is characterized by having a well-developed abactinal skeleton, with plates in more or less irregular longitudinal and transverse series forming an open meshwork, the plates bearing isolated spines or groups of spinules. The marginals are inconspicuous; the ambulacral grooves are narrow; and the suckered tube feet are in two rows. The mouth plates are small, and there are no pedicellariae.

In the Gulf of Mexico and the Caribbean Echinasteridae, there is some confusion not only about the species, but also the genera. Of the eight genera in the family, only *Henricia*, *Echinaster*, and *Thyraster* have been reported from this area. *Henricia* is distinguished from the other two (so-called) genera in having groups or bundles of spinules on the plates, rather than isolated spines or spinelets. *Thyraster* (type species by monotypy—*T. serpentarius*) is supposedly distinguished from *Echinaster* by having rectangular plates which imbricate at the corners; however, the plates of specimens in this collection range from rectangular to triangular, to polygonal to round, and other characters of this monotypic genus are specific characters, not generic

ones. I believe that the genus *Thyraster* should be dropped and *T. serpentarius* returned to its original position in the genus *Echinaster*, where it was first described by Muller and Troschel.

The western Atlantic species of *Echinaster* could then be readily distinguished from other genera in the family by the presence of a patch of glassy tubercles on the plates. This would necessitate the removal of *Echinaster spinulosus*, which lacks these patches of glassy tubercles, from the genus, and a new genus is here erected for this common Gulf and Caribbean echinasterid, which I propose to call *Verrillaster*, for A. E. Verrill, whose report on the starfishes of Florida, the West Indies, and Brazil has been an invaluable aid in this present study.

**Key to the Genera of Echinasteridae**

- 1. With a patch of glass tubercles, concealed by skin, on most principal plates ..... *Echinaster*  
Without glassy tubercles on plates ..... 2
- 2. With a bundle or group of spinules on principal plates ..... *Henricia*  
With isolated spines or spinelets ..... *Verrillaster*, new genus

***Henricia* Gray**

*Henricia* Gray, 1840:184. [Type, by original designation, *H. oculata* Gray (= *Asterias sanguinolenta* O. F. Muller).]  
*Linckia* Forbes [non Nardo], 1839:120. [Type, by original designation, *Asterias oculata* Pennant.]  
*Cribrella* Forbes [non *Cribrella* L. Agassiz, 1835b], 1841:100.—*Lapsus calami*.  
*Cribrella* Lutken [non L. Agassiz, 1835b], 1859:93. [Type, by original designation, *C. sanguinolenta* (= *Asterias sanguinolenta* O. F. Muller).]  
*Madgalenaster* Koehler, 1907:19. [Type, by original designation, *M. arcticus* Koehler.]

*Cyllaster* A. H. Clark, 1916:61. [Type, by original designation, *C. seminuda* Clark.]  
*Spinohenricia* [subgenus] Heding, 1936:8. [Type, by original designation, *Henricia* (*Spinohenricia*) *scabrior* (= *Cribrella sanguinolenta* forma *scabrior* Michailovski, 1903).]

Closely meshed skeleton bearing numerous spinelets in groups or scattered along ridges of skeleton; marginal plates more or less distinguishable; adambulacral plates with one or more spinelets deep within furrow.

**Key to the Species of *Henricia***

- 1. With five arms ..... 2  
With six arms, or more ..... *H. sexradiata*
- 2. Two to five inner furrow spines, one above the other in single series ..... *H. antillarum*  
Six inner furrow spines, not one above the other in single series (may be roughly in two series of three each) ..... *Henricia* species

***Henricia sexradiata* (Perrier)**

PLATE 37: FIGURES C, D

*Cribrella sexradiata* Perrier, 1881a:8; 1884:209, pl. 4: fig. 6.  
*Henricia sexradiata*.—Verrill, 1914:371; 1915:47, pl. 11: fig. 7.  
 H. L. Clark, 1941:58.

This small species is the most distinctive *Henricia* of the Caribbean and Gulf of Mexico, quite apart from its six or more arms. The disc is small and the arms long, rounded, evenly tapering to a subacute point. The irregularly shaped abactinal

plates—elongate, lobed, or rounded—imbricate upon one another to form a close reticulum. The papulae are small, and usually there are several to each pore area. The abactinal plates are covered with a dozen or more small, erect, thorny spinules. Both series of marginals are large, distinct, equal, and imbricate; they bear spinules similar to those of the abactinals and are separated from the adambulacral plates by a single row of actinals extending less than one third the length of the arm. Papular pores occur between the marginals and between the inferomarginals and the adambulacral plates. Actinal plates are few and rounded, with papular pores extending to the mouth plates; they bear spinules similar to those of the marginals and abactinals.

The adambulacral plates are broader than long, rectangular, and bear, on the strongly carinate furrow face, three short appressed furrow spines, one above the other, deep within the narrow ambulacral groove. On the outer furrow margin are three stout, thorny, subclavate spines, about twice the length of the actinal spinules, and behind them is a second series of 2 or 3 similar, slightly shorter spines. The actinal face of the plate is covered with spinules similar to those of the marginals. The mouth plates are narrow and triangular, with one or two stout, blunt, flattened preoral spines; the rest of the spination is like that of the adambulacral plates. There is usually more than one madreporite, raised, flattened, and bearing numerous spinules. The oculars are small, round, and covered with small thorny spinules. This is a fis-siparous species.

This species ranges from the northern Gulf of Mexico to Surinam, in 75–190 fathoms.

MATERIAL EXAMINED.—Oregon Stations: 2289 (1) [R=46 mm, r=6 mm, Rr=1:8 (three long arms, four short arms)]; 36 (1) [R=49 mm, r=10 mm, Rr=1:5 (six equal arms)].

### *Henricia antillarum* (Perrier)

PLATE 38: FIGURES A, B

*Cribrella antillarum* Perrier, 1881a:8; 1884:207, pl. 3: fig. 3.  
*Henricia antillarum*.—Verrill, 1914:210; 1915:46.—H. L. Clark, 1941:56.

*Henricia microspina* Verrill, 1915:48.—H. L. Clark, 1941:57.

This species has a small disc and five long, slender,

emaciated-looking arms. The arms are broad at the base, but beyond the basal one fourth or one fifth portion they are extremely attenuate. The abactinal plates are mostly C-, Y-, or X-shaped, with many small round plates scattered among them. They are covered with minute, glassy-tipped spinules, mostly in irregular rows on the plates. The papular pores are large and the papulae are single. Superomarginal plates are smaller than the nearly square inferomarginals, but distally the two series tend to become more equal. They bear spinules like those of the abactinal plates. A single row of actinals may extend a short distance beyond the disc; the interradial actinals are few, crowded, and small. Papular pores occur to the adambulacral plates. Actinal spinules are smaller than those of the abactinal surface.

The adambulacral plates have a sharply carinate furrow face bearing 2–5 small furrow spines, one above the other. On the furrow margin are 4–6 long, stout, blunt spines, and the actinal face of the plate bears up to twenty short, stout, acuminate spinules, becoming increasingly similar to those of the inferomarginals. The long narrow mouth plates bear one or two stout, blunt preoral spines at the apex and 2 or 3 minute spines on the side margin, well within the mouth. Behind the preoral spines are 2–5 similar spines, not quite so stout. The rest of the plate is covered with short, stout, acuminate spinules. The single madreporite is rounded, raised, and covered with spinules.

I believe Verrill's *Henricia microspina* is the same as *H. antillarum*, despite H. L. Clark's assertion that the two species were distinguishable on the basis of length of spinules and size of skeletal meshes. I have examined the types of both species and can find no specific differences. Allowing for the difference in size of the two specimens (*H. antillarum*, R=54 mm, vs *H. microspina*, R=20 mm), there is no essential difference in the length of spinules or size of mesh of the skeleton. The number, size, type, and arrangement of the adambulacral spines, and the general form of the starfish seem to be more reliable characters for distinguishing the species of *Henricia*.

However, there is a third species of *Henricia* in the Caribbean. Because the types of so many species are not available, or are in very poor condition as regards essential features, it is probably not de-

sirable to add still another name to this already overcrowded genus without more material.

*Henricia antillarum* probably does not occur south of about 15° N. Its depth range is 175–390 fathoms.

MATERIAL EXAMINED.—*Alaminos* Station 25/70–A–10 (1) [R=55 mm, r=10 mm, Rr=1:5.5]. *Oregon* Stations: 489 (1) [R=26 mm, r=4 mm, Rr=1:6]; 491 (1) [R=28 mm, r=5 mm, Rr=1:5.5].

### *Henricia* species

#### PLATE 38. FIGURES C, D

This species has a small disc and five long, tapering, cylindrical arms, thick at the base, and slightly constricted. The abactinal plates are thick, elongate, and imbricate. There are also some small irregularly rounded plates. All bear numerous small, divergent, thorny-headed spinules. The meshes of the skeleton are large, as are the papulae, and the papulae are usually single, but there may be up to four per mesh. The superomarginal plates are small and triangular, and proximally they may be separated from the inferomarginals by a few small rounded plates. The inferomarginals are broader than long, and about twice the size of the superomarginals. The spinulation is like that of the abactinals. The adambulacral plates are about twice as broad as long. On the broadly carinate furrow surface, they bear, deep within the furrow, about six short, stumpy spines, roughly in two vertical rows of three each. Above them, on the outer furrow margin of the adambulacrals, are about 6–10 long, thick, blunt spines; owing to the sloping face of the furrow margin, they do not reach much beyond the height of the short, thick, thorny spinules on the actinal face of the plate, which are numerous but spaced. The spines on the apical margin of the mouth plates are thick, blunt, and crowded.

The plates themselves are long, narrow, and triangular, and the actinal face is evenly covered with short, thick, thorny, spaced spinules. The madreporite is small, round, raised, and covered with radiating gyri; the smaller of the two specimens below had three madreporites.

MATERIAL EXAMINED.—*Oregon* Stations: 35 (1) [R=30 mm, r=6 mm, Rr=1:5]; 2644 (1) [R=62 mm, r=12 mm, Rr=1:5].

### *Echinaster* Muller and Troschel

*Echinaster* Muller and Troschel, 1840:102. [Type, by subsequent designation, *Asterias seposita* Lamarck (non Retzius) (= *Asterias sagera* Retzius, 1805) (Fisher, 1913:195).]

*Othilia* Gray, 1840:281. [Type, by original designation, *Asterias spinosa* Retzius (= *Pentadactylosaster spinosus* Linck).]

*Rhopia* Gray, 1840:282. [Type, by original designation, *Asterias seposita* Retzius (= *Pentadactylosaster reticulatus* Linck).]

*Henricides* Verrill, 1914:210. [Type, by original designation, *Henricia heteractis* H. L. Clark, 1909.]

*Thyraster* Ives, 1890:329. [Type, by original designation, *Echinaster serpentarius* Muller and Troschel.]

Disc small, five arms long, more or less cylindrical; spines on plates isolated, never in groups or bundles; patch of glassy tubercles on most principal plates; skeleton an open meshwork of plates connected by secondary plates.

This genus is perhaps the most confusing one occurring in the tropical and subtropical Atlantic. Not only are the species ill-defined, but the genus itself has undergone various taxonomic changes. Fisher (1919), in attempting to define the status of the genus, compounded the confusion by making several unwarranted assumptions and overlooking important references. His arguments for separating the American species from the European ones and placing them in another genus, *Othilia*, are so involved and seem to me so feeble that it would be preferable to retain *Echinaster* for these very common Gulf and Caribbean species, a name well known and firmly established in the literature.

In examining the *Echinasters* in this collection, I found it relatively easy to distinguish what seem to be eight species. *Echinaster braziliensis*, *E. senatus*, *E. echinophorus*, *E. modestus*, and *E. serpentarius* could be identified definitely. Rather than add what are probably quite unnecessary names to the genus, the other three species I have distinguished have here been given letters in the hope that this will simplify matters for some future reviser. Of the three species I have been unable to identify, none seem to fit Tommasi's (1970) new species, *E. densispinus* or *E. nudus*.

Key to the Species of *Echinaster*

- |  |                              |
|--|------------------------------|
| 1. Five rows of primary plates .....   | 2                            |
| More than five rows of primary plates .....  | 6                            |
| 2. Arms tapering .....   | 3                            |
| Arms thick and blunt .....   | 5                            |
| 3. Numerous small calcareous deposits under skin .....                             | <i>Echinaster</i> species A  |
| No calcareous deposits under skin .....  | 4                            |
| 4. Glassy tubercles few, sunken in pits in plates .....                            | <i>Echinaster</i> species B  |
| Glassy tubercles not sunken in pits .....  | <i>E. modestus</i>           |
| 5. Adambulacral plates with one spine within furrow and one on margin.....         | <i>E. echinophorus</i>       |
| Adambulacral plates with 3 or 4 spines, 1 or 2 in furrow and 1 or 2 on margin..... | <i>E. sentus</i>             |
| 6. Two to five spines on each primary plate .....                                  | <i>E. serpentarius</i>       |
| One spine on each primary plate .....  | 7                            |
| 7. Arms thick and blunt .....  | <i>Echinaster</i> species C. |
| Arms tapering .....  | <i>E. brasiliensis</i>       |

*Echinaster serpentarius* Muller and Troschel

PLATE 39: FIGURES A, B

*Echinaster serpentarius* Muller and Troschel, 1842:24.—Perrier, 1875c:370.—Lutken, 1871:285.*Thyraster serpentarius*.—Ives, 1890:329, pl. 8: figs. 19–21.—Verrill, 1915:44.—Tommasi, 1970:15, fig. 40.

This stellate species has a small disc and five moderately long, smoothly tapering arms. The regular longitudinal rows of plates distinguish it from other Echinasteridae. The plates are rectangular to round, and imbricate. A carinal row of plates alternates left and right of the median dorsal line on the arm; the adradial rows on either side of the carinals (usually only one on each side, but in the largest specimen there are two) appear to cross each other at the base of the arm and continue down the opposite side of the adjacent arm. The superomarginal plates define the ambitus, and the inferomarginals, larger than the other plates, adjoin the adambulacral plates. Frequently, there is an incomplete row of plates between the adradials and the superomarginals and between the superomarginals and the inferomarginals. All plates except the adambulacrals have a large irregularly rounded patch of glassy tubercles on the surface and bear, near the distal edge, 2–5 short, thick, stubby spinules.

The papular areas between the plates may bear up to ten large papulae, or more on the largest specimens. The adambulacral plates bear, within the furrow, a single slender spine, and two thicker, obliquely situated spines on the furrow margin. On the actinal face, they usually bear one or two short spinules. The adambulacral plates are

broader than long, and spaces between them are about the same length as the plate. The mouth plates are small and narrow and bear one or two large, stout subclavate preoral spines, one or two similar large marginal spines, and usually a small acute suboral spinule. The round, slightly raised madreporite is covered with radiating gyri with small spinules. The small oculars are round or oval. The tegument is fairly thick.

This species has hitherto been considered a strictly Mexican species, distributed from Vera Cruz around the Yucatan Peninsula; the specimens below are all from northern Florida north. It is a shallow-water species, not found in depths much below about 50 fathoms.

MATERIAL EXAMINED.—Oregon Stations: 2205 (1) [R=29 mm, r=5 mm, Rr=1:6]; 1672 (1) [R=43 mm, r=9 mm, Rr=1:5]. Silver Bay Stations: 1970 (1) [R=20 mm, r=5 mm, Rr=1:4]; 2775 (4) [R=40 mm, r=9 mm, Rr=1.4]; 1710 (2) [R=92 mm, r=20 mm, Rr=1:4.5].

*Echinaster echinophorus* (Lamarck)

PLATE 39: FIGURES C, D

*Asterias spinosa* [part ?] Retzius, 1805:18 [non *Asterias spinosa* Pennant, 1777].*Asterias echinophora* Lamarck, 1816:560.*Othilia spinosa*.—Gray, 1840:281; 1866:12.*Echinaster spinus* Muller and Troschel [part], 1842:22.—Lutken, 1859:90.—Perrier, 1869:57.*Echinaster (Othilia) crassispinus* Verrill, 1868:368, pl. 4: fig. 7.*Echinaster crassispinus*.—Lutken, 1871:283 [61].—Ives, 1890:326.*Echinaster echinophorus*.—Perrier, 1875c:364.—Rathbun, 1879:147.—Ives, 1889:171.—Verrill, 1915:42.—Tommasi, 1970:16, figs. 41–43.

This species has a small disc and five short straight arms, terminating abruptly. The rows of plates are carinal, adradial, superomarginal, inferomarginal, and adambulacral, with no intermediate plates except a few small actinal interradial plates on the ventral surface of the disc. Only a few plates bear spines, but those which do are tumid, almost mammiform, and the spines are huge, movable, and acute. Usually, the carinal and superomarginal plates lack spines.

All plates without spines bear a large round patch of coarse glassy tubercles. Papular areas between the plates are large and papulae numerous. A large tissue-covered area at the center of the disc dorsum contains one or two small "floating" plates and a small, off-center anus raised in a minute epi-proctal cone. The small madreporite is raised, round, and the gyri are concealed by small spinules. The ventral surface of the disc is without spines, and the papulae on the ventral surface are small, single, and scattered. The adambulacral plates bear a single small acute spine within the furrow and a single larger subacute spine on the margin. The small mouth plates bear a single epioral spine common to each pair, and on the margin of each plate are two similar, widely separated spines; these spines are small and blunt.

This is mainly a Brazilian species, and has not previously been reported north of Yucatan. It is confined to shallow water.

MATERIAL EXAMINED.—*Oregon* Station 5456 (1) [R=37 mm, r=9 mm, Rr=1:4].

### *Echinaster sentus* (Say)

PLATE 40: FIGURES A, B

*Asterias sentus* Say, 1825:143.

*Othilia aculeata* Gray, 1840:281; 1866:12.

*Echinaster spinosus* [part] Muller and Troschel, 1842:22.—Verrill, 1867:343.—Ives, 1890:325.—H. L. Clark, 1898a:6.

*Othilia spinosa*.—A. Agassiz, 1869:308.

*Echinaster sentus*.—Lutken, 1871:60 [284].—Perrier, 1875a:366.—A. Agassiz, 1877:97, pl. 10: figs. 1–6.—Rathbun, 1879:147.—Verrill, 1915:36, pl. 29: fig. 2.—Tommasi, 1970:17, figs. 46–48.

The small disc and five thick, stumpy arms of this species are distinctive. The rows of plates are: carinal, adradial, superomarginal, inferomarginal, and adambulacral. Each plate bears a large conical acute spine, and many plates, particularly the sec-

ondaries (which lack a spine), bear a small round flat patch of glassy tubercles. The papular areas are large and the papulae numerous, less numerous on the actinal surface. The adambulacral plates bear one or two slender spines within the furrow, and one or two heavier, subacute spines, one behind the other, on the marginal and actinal surfaces.

The mouth plate bears a heavy, blunt apical spine, 2 or 3 smaller marginal spines, and a small acute suboral spine. The adambulacral marginal spines are webbed together longitudinally. The madreporite is small, round, with radiating gyri, and small spinules. Scattered over the entire dorsal surface, not confined to the papular areas, are large discrete globules of a dark reddish brown, of unknown nature and function (photoreceptive pigment spots?).

This species is widely distributed from North Carolina to Brazil, in shallow water.

MATERIAL EXAMINED.—*Oregon* Stations: 1936 (2) [R=62 mm, r=15 mm, Rr=1:4]; 1937 (3) [R=70 mm, r=20 mm, Rr=1:3.5]; 1938 (3) [R=67 mm, r=16 mm, Rr=1:4]; 1934 (5) [R=75 mm, r=18 mm, Rr=1:4].

### *Echinaster modestus* Perrier

PLATE 40: FIGURES C, D

*Echinaster modestus* Perrier, 1881a:7; 1884:206, pl. 3: fig. 7.—Verrill, 1915:43.

The disc of this species is small, and the five arms are slender, moderately long, and cylindrical, tapering to a subacute terminus. The longitudinal rows of plates are: carinal, adradial, superomarginal, inferomarginal, and adambulacral. There are few actinal interradial plates between the superomarginals and the inferomarginals. Each plate bears, on the distal edge, one or two small, stout, blunt spines (regularly two on the inferomarginals, usually two on the superomarginals). The plates are irregularly round and imbricate on the distal edge, while the proximal surface of the plates bears a round patch of glassy tubercles. The plates become small, crowded, and decidedly imbricate at the end of the arm. The adambulacral plates bear a small slender spine deep within the furrow, and two subequal blunt, thick spines set obliquely on the furrow margin; on the actinal face, well separated

from the furrow margin spines, is a single short, blunt spine. The papulae are large, 6–8 per papular area. The mouth plates are small and narrow, with one median and two marginal spines on each plate; the spines are round, thick, and clavate. The madreporite is small, round, raised, and covered with small blunt spinules.

The oculars are small, rounded, and raised. The covering tegument is quite thick.

The species distribution is from Florida to the Lesser Antilles, in 13–123 fathoms.

MATERIAL EXAMINED.—*Silver Bay* Station 1909 (1) [R=49 mm, r=11 mm, Rr=1:4.5]. *Combat* Stations: 90 (1) [R=52 mm, r=11 mm, Rr=1:5]; 339–340 (1) [R=48 mm, r=11 mm, Rr=1:4.5].

### *Echinaster* species A

PLATE 41: FIGURES A, B

The small disc and five moderately long, smoothly tapering cylindrical arms which terminate in an acute point are covered with a smooth, thick dermis. The most conspicuous feature of this species is the numerous small, irregular calcareous deposits under the skin. The plates are in regular longitudinal rows; carinal, adradial (connected by small secondary ossicles), superomarginals (connected to the adradials by small elongate secondary ossicles), inferomarginals (close to, and corresponding with, superomarginals), and adambulacrals. Actinal interradial plates are few or none. The round patch of glassy tubercles on each plate (except the secondaries) is particularly well developed. A single, small, somewhat spatulate spine occurs on the distal edge of many, but not all, plates. The adambulacrals bear 1–3 small slender spines deep within the furrow, and 2 or 3 stouter blunt spines, more or less at right angles to the furrow, on the furrow margin. The papular areas are large and distinct, and the large papulae 6–20 per area dorsally, but fewer ventrally. The small, raised, flat madreporite bears coarse radiating gyri without spinules. The oculars are broader than long and covered with glassy tubercles.

MATERIAL EXAMINED.—*Oregon* Station 4086 (8) [R=84 mm, r=15 mm, Rr=1:5.5].

### *Echinaster brasiliensis* Muller and Troschel

PLATE 42: FIGURES C, D

*Echinaster brasiliensis* Muller and Troschel [part], 1842: 22. —Lutken, 1859:9 [67].—Verrill, 1868:343, 368; 1915:41, pl. 26:1. —Perrier, 1875c:367. —Rathbun, 1879:148. —Ludwig, 1882:7. —Ives, 1890:324, 326, pl. 8: figs. 16–18. —Tommasi, 1970:17, figs. 44–45.

*Othilia brasiliensis*.—A. Agassiz, 1869:308.

The disc of this species is small, and the five arms are stout, cylindrical, and taper to a subacute tip. The regular rows of roughly triangular plates are connected by oval or rectangular secondary plates and bear a flat, triangular patch of glassy tubercles and a single small, conical, blunt, erect spine on the distal edge of the plate. The spines of the marginals are larger and more thornlike than those of the other plates. The rows are: carinal, adradial, dorsolateral (with a spine, but without a patch of glassy tubercles), superomarginal, intermarginal (short, not extending much beyond the disc, without spines or glassy tubercles), inferomarginal, and adambulacrals.

Large papulae cover the entire surface except where interrupted by plates. There are 1–3 slender, blunt adambulacrals spines deep within the furrow, and two larger, stouter spines, one behind the other, at the furrow margin (1–3, usually two). The one closest to the groove is the largest. The mouth plates are small, with a short, stubby epioral spine at the apex of each, two similar, slightly longer spines on the side margin, and, frequently, a suboral spine. The madreporite is small, oval, raised, covered with radiating gyri, and without spinules or with a few small ones. The tips of the arms turn up, and the oculars are small and broader than long.

This species is supposedly distributed from Florida to Brazil; the Florida record is doubtful. Its depth range is 11–57 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 5739 (2) [R=41 mm, r=10 mm, Rr=1.4]; 5723 (1 with four arms) [R=57 mm, r=10 mm, Rr=1:5.7]; 2267 (1) [R=48 mm, r=10 mm, Rr=1:4.8]; 2000 (1) [R=27 mm, r=4 mm, Rr=1:7]; 2245 (1) [R=25 mm, r=5 mm, Rr=1:5]; 2249 (1) [R=40 mm, r=6 mm, Rr=1:7]; 2329 (2) [R=49 mm, r=10 mm, Rr=1:4.9]; 2240 (2) [R=62 mm, r=12 mm, Rr=1:6]; 2345 (1) [R=42 mm, r=10 mm, Rr=1:4.2]; 2343 (2) [R=38 mm, r=9 mm, Rr=1:4]; 1865 (1) [R=60 mm, r=11 mm, Rr=1:6]. *Oregon II* Stations: 10212 (1) [R=65 mm, r=14 mm, Rr=1:4.5]; 10561 (1) [R=45 mm, r=6 mm, Rr=1:7].



***Echinaster* species C**

PLATE 42: FIGURES A, B

This robust species has a small disc and five thick, bluntly terminated arms. The rows of plates are: carinal, two adradials, superomarginals, inferomarginals, and adambulacrals. Each plate bears a single large, robust, acute, movable spine mounted on a mammiform plate which is connected to the adjoining plates by small secondary plates bearing a small round patch of glassy tubercles. The large papular areas bear numerous papulae, usually more than twenty per area. All plates are covered with a thick, heavily pigmented tegument. The adambulacrals bear two slender spines within the furrow, the innermost one the smallest, and a larger, more robust, subacute spine on the furrow margin. The mouth plates bear a preoral spine and 3 or 4 larger marginal spines that are webbed together at the base. The madreporite is small, round, raised, and bears a double corona of small spinules.

This may possibly be an aberrant *E. brasiliensis*, from which it differs mainly in the number of adambulacrals furrow margin spines (two vs one), and in the size of the abactinal spines, which are very large and thornlike, in contrast to the small conical spines of *E. brasiliensis*.

MATERIAL EXAMINED.—*George M. Bowers* Station 85 (1) [R=72 mm, r=15 mm, Rr=1:5].

***Echinaster* species B**

PLATE 41: FIGURES C, D

This robust species has a moderate disc and five stout, tapering arms. The plates are in regular longitudinal rows: carinals (regularly alternating left and right of the midline), adradials, superomarginals, inferomarginals, and adambulacrals. Between the adradials and the superomarginals, and between the superomarginals and the inferomarginals are one or two incomplete rows of secondary plates. All plates are small and connected to one another by small secondary plates. The primary plates bear a single small, straight, blunt spine distally, and proximally there is a minute patch of a few glassy tubercles sunken in a small pit in the plate. There are no spines on the actinal surface of the disc. There are two small slender spines on

the adambulacrals plates, deep within the furrow, and on the furrow margin are two stout, blunt spines of moderate length, slightly curved and webbed together. There are three short, stout, blunt spines of moderate length, slightly curved and webbed together. There are three short, stout, blunt spines on each narrow mouth plate, and also a small suboral spinelet. The madreporite is round and plane, with radiating gyri which probably bore small spinules; however, the surface of the madreporite in this specimen is much eroded. The upturned oculars are small and broadly oval. The covering tegument is thick.

In the regular arrangement of plates, this species resembles *E. serpentarius*, but the shape of the specimen is quite different, with a much larger disc and thicker arm. Also, the size and ornamentation of the plates differs, as well as the spinulation of the adambulacrals plates.

MATERIAL EXAMINED.—*Silver Bay* Station 48 (1) [R=65 mm, r=23 mm, Rr=1:3].

***Verrillaster*, new genus**

TYPE-SPECIES.—*Echinaster spinulosus* Verrill, 1869.

DIAGNOSIS.—Single isolated spine on each abactinal plate; no patch of glassy tubercles; tegument relatively thin, lifted in tentlike peaks by spines.

***Verrillaster spinulosus* (Verrill)**

PLATE 43: FIGURES A, B

*Echinaster spinulosus* Verrill, 1869:386; 1915:40, pl. 4: figs. 1, 2.—Lutken, 1871:285 [61].—Ives, 1890:326.

This species has a moderate-sized disc and five broadly based arms tapering to an acute tip. There are more than six rows of plates between the carinal series and the adambulacrals at the base of the arm. The rows of plates are: an irregular row of carinals, an adradial, one or two dorsolaterals, superomarginals, and short intermarginal, inferomarginal, 1–3 actinolaterals, and adambulacrals. The plates are small, lobate, imbricate, and without glassy tubercles. Each carries a small, erect, acute or blunt spine. The papular areas are numerous and contain 1–6 papulae; they are scarce or lacking below the inferomarginals. The thin tegument is lifted in tentlike peaks by the spines.

The central anus, although small, is conspicuous and surrounded by numerous small spinules. The small, raised, round madreporite is covered with coarse radiating gyri and surrounded by a corona of small spinules. The very small oculars are upturned and more or less rounded. The spines of the actinal surface are smaller and fewer than those of the abactinal surface, many plates being entirely without spines. The small adambulacral plates bear one or two long, slender spines deep within the furrow, and two larger, stouter, subacute spines at the margin; on the actinal face are one or two smaller spines. The small, narrow mouth plates bear a stout preoral spine at the apex, 2-4 similar but smaller spines on the side margin, and one or two short suboral spines.

This is a description of one specimen from *Oregon* Station 5023. A second specimen from the same station differs in having more numerous papulae in the papular areas, oculars completely obscured by spines, three rows of dorsolaterals, two rows of intermarginals, and adambulacral marginal spines with a broad, flattened tip. A specimen from *Oregon* Station 3210-3216 has narrow arms, not broad-based; very small spines, usually 3 or 4 per plate; intermarginal plates confined to the disc; and the actinal spines are a little larger than those of the abactinal surface. Another specimen, from *Oregon* Station 5934, would almost justify erecting a separate subspecies, having roughly two carinal rows of plates; the spines, particularly those of the marginals, are much larger than those of the previous specimens, and the papulae per area are more numerous. The spines of the ventral surface are particularly long, numerous, and acute, and there are no suboral spines on the mouth plates. A second, smaller specimen from the same station agrees in every particular. A specimen without data is similar to the second specimen from *Oregon* Station 5023.

Verrill gives the range of this species as west coast of Florida and the northern Gulf of Mexico, in 23-32 fathoms. The specimens here from the Lesser Antilles thus represent a range extension, both vertical and horizontal.

**MATERIAL EXAMINED.**—*Oregon* Stations: 5023 (2) [R=65 mm, r=15 mm, Rr=1:4]; no station (1) [R=60 mm, r=14 mm, Rr=1:4]; 3210-3216 (1)

[R=46 mm, r=9 mm, Rr=1:5]; 5934 (2) [R=47 mm, r=12 mm, Rr=1:4].

#### Order FORCIPULATIDA Perrier, 1884

In this order, pedicellariae, straight and/or crossed, are almost always present. The dorsal skeleton is reticulate, forming a more or less open meshwork. The tube feet are suckered, and the ampullae single. Papulae occur on all surfaces. The plates are never paxillate, and the spines occur singly, never in groups or bundles. The marginals are inconspicuous and mostly irregular. The ambulacral and adambulacral plates are crowded and compressed. Only one family is represented here.

#### Family ASTERIIDAE Gray, 1840

This family is poorly represented in the Caribbean and the Gulf of Mexico. This collection contains only four genera and five species, all confined to the northern Gulf of Mexico. Asteriids are characterized by having a more or less swollen body (i.e., neither actinal nor abactinal surface plane); five or more arms; an open reticulate skeleton; numerous crowded and compressed ambulacral and adambulacral plates; two or four rows of tube feet; and, usually, numerous crossed and/or straight pedicellariae. The plates bear spines or spinules and are never paxilliform.

#### *Ampheraster* Fisher

*Ampheraster* Fisher, 1923:253. [Type, by original designation, *Sporasterias mariana* Ludwig, 1905.]

Pedicellariae unguiculate; no accessory inferomarginal spinelet; adambulacral spines predominantly monacanthid; two enlarged interbranchial superomarginal plates overlapping two corresponding inferomarginal plates; superomarginals three- or four-lobed; prominent inferomarginal spines, conspicuously larger than superomarginal spines; first pair of postoral adambulacral plates narrowly separated or touch only at their adoral corners; rays five or six; species not fissiparous.

The five species previously assigned to this genus by Fisher (1928b) are all from the eastern Pacific; this is the first species in the genus reported from the Atlantic. It seems to be most closely related to *A. hyperoncus* (Clark), from Lower California,

## Key to the Genera of Asteroiidae

- |  |                       |
|--|-----------------------|
| 1. Adambulacral plates diplocanthid throughout, or alternately diplocanthid and monacanthid .....      | 2                     |
| Adambulacral plates monacanthid throughout .....   | 4                     |
| 2. Arms usually five .....   | 3                     |
| Arms 9-11 .....  | <i>Coronaster</i>     |
| 3. Disc small; arms long, narrow, angular .....  | <i>Sclerasterias</i>  |
| Disc moderately large; arms stout, inflated .....  | <i>Asterias</i>       |
| 4. Inferomarginal plates with one spine, conspicuously larger than that of the superomarginals .....   | <i>Ampheraster</i>    |
| Inferomarginal plates with two spines, not conspicuously larger than that of the superomarginals ..... | <i>Coscinasterias</i> |

but differs strikingly from this and other species in the genus in several important respects.

*Ampheraster alaminos* Downey

PLATE 43: FIGURES C, D

*Ampheraster alaminos* Downey, 1971c:51-54.

This species has six arms, whereas other species in the genus are regularly five armed. The skeleton is weaker and more irregular than that of *A. hyperoncus*, and the arms are weakly attached to the disc. On the dorsal surface, there is a large clear patch of thin, uncalcified tissue between the base of the arms and the disc, with, at most, one or two small carinal plates between the arm and the disc. In contrast, the enlarged interbrachial superomarginals, warped and bent and rather thin, form, together with the heavy calcareous interbrachial septa, six strong and rigid areas around the periphery of the disc. The superomarginal plates are generally four lobed, and imbricate in straight (not zigzag) series. The upper lobe is usually reduced, while the lower lobe is greatly elongated, overlapping the corresponding inferomarginal plate. The small disc has a dorsum of thin tissue and a circlet of elongate primary plates, with a few unattached elongate plates in the center. Each plate bears a few short, thorny, aciculate spines, and the madreporite, borne on one of the interradial primaries, is of moderate size, covered with deep coarse gyri, and bearing around its periphery a circlet of spines.

Elsewhere the disc is covered with large straight unguiculate pedicellariae. The surface of the arms

is completely covered with small crossed pedicellariae. The small carinal plates are more or less irregular, and there are two series of meshes on either side of the carinal row. The adambulacral plates bear a single (occasionally two) long ridged, aciculate spine, and the inferomarginal plates bear a similar, somewhat shorter spine; above the inferomarginals, the superomarginals, dorsolaterals, and carinals may bear a single, short spine, or no spine. Straight unguiculate pedicellariae are abundant on the actinal disc interradial, and also occur between the proximal adambulacral plates and the inferomarginals. A few smaller pedicellariae of this type occur within the groove. The long, narrow mouth plates bear two long, slender, divergent spines on the side of the straight bare apex, and 2 or 3 similar suboral spines, one behind the other. The mouth plates also bear a number of small unguiculate pedicellariae.

All of the specimens of this species are from depths of 1,450 to 1,750 fathoms, in the north central Gulf of Mexico, where the bottom is mainly foraminiferal.

MATERIAL EXAMINED.—*Alaminos* Stations: 3C/68-A-7 (1 holotype) [R=62 mm, r=8 mm, Rr=1:7]; 4E/68-A-7 (1, plus 44 arms, 1 disc) [R=47 mm, r=4 mm, Rr=1:11]; 4A/68-A-7 (9) [R=42 mm, r=4 mm, Rr=1:10]. Oregon Station 2547 (1) [R=50 mm, r=5 mm, Rr=1:10].

*Sclerasterias* Perrier

*Sclerasterias* Perrier, 1891b:1227. [Type, by original designation, *S. guernei* Perrier.]

*Eustolasterias* Fisher, 1923:255. [Type, by original designation, *Coscinasterias (Distolasterias) euplecta* Fisher.]

Dorsal skeleton regular, with two series of skeletal meshes on either side of prominent carinal ridge; inferomarginal plates with two spines, only outer one carrying cluster of crossed pedicellariae; adambulacral plates diplacanthid throughout; straight pedicellariae lanceolate; outer inferomarginal spines webbed together at base; alternate superomarginals usually spineless; carinal, marginal, and actinal plates in regular longitudinal series; small obtuse spines above inferomarginals wreathed by collar of small crossed pedicellariae; adults regularly five-armed, but young may be six-armed and fissiparous.

Only one species occurs in the area covered by this report. *S. tanneri* (Verrill), a more northern species, is generally much smaller and bears a spine on every carinal plate, rather than every other one. *S. subangulosa* (Verrill) (= *Orthasterias* (*Stylasterias*) *subangulosa* Verrill = *Asterias angulosa* Perrier) was rightly considered the young of *S. contorta* by Fisher (1928a).

#### *Sclerasterias contorta* (Perrier)

PLATE 44: FIGURES A, B

*Asterias contorta* Perrier, 1881a:1.

*Asterias angulosa* Perrier [non Muller], 1881a:3; 1884:202.

*Orthasterias contorta*.—Verrill, 1914:48; 1915:18.

*Orthasterias* (*Stylasterias*) *subangulosa* Verrill, 1914:168, 370.

*Orthasterias subangulosa*.—Verrill, 1915:16, pl. 2: figs. 1, 2, pl. 9: figs. 1, 1a.

*Eustolasterias subangulosa*.—Fisher, 1923:255.

*Eustolasterias contorta*.—Fisher, 1923:255.

*Sclerasterias subangulosa*.—Fisher, 1928a:107, 108.

*Sclerasterias contorta*.—Fisher, 1928a:107, 108.

This species has a small disc and five long, narrow arms, angular and straight sided, tapering to an acute point. The disc dorsum has an irregular pentagon of plates, each bearing one or two spines. The carinal plates on the arm form a prominent ridge; they are lobed and bear a single, large, acuminate spine surrounded by a dense wreath of small, blunt, crossed pedicellariae. They connect by a series of elongate ossicles to the prominent superomarginal plates. There is an incomplete series of dorsolaterals, many without spines. Every other superomarginal bears a spine similar to those of the carinals on the abactinal portion of the plate, and each plate may bear, on the abactinal portion, a large round patch of low glassy tubercles. These

usually tend to become fewer and smaller with growth. A long lobe on the superomarginal connects it to the corresponding inferomarginal, leaving a wide, bare space, devoid of spines or other ornamentation, between the two series of plates.

The inferomarginal plates bear two spines; those of the outer (or abactinal) series are webbed together and bear, on the abactinal side, a dense patch of pedicellariae similar to those wreathing the upper spines. The inner (or actinal) series of inferomarginal spines are free and without pedicellariae. There is a single row of broad, low actinal plates between the inferomarginals and the adambulacral plates. Between the actinals is a single papula; elsewhere, above the inferomarginals, the papulae occur usually in pairs between the plates, but there may be as many as 5 or 6 in each area. The adambulacral plates bear two long, slender, divergent spines which form a double row down each side of the ambulacral groove. The groove is wide, and the tube feet are in four rows. The small, narrow mouth plates project into the peristome and bear an apical, forward-directed spine and a smaller oblique marginal spine on each half; there are two sets of suboral spines, the first of one spine and the next of two. Large, isolated, lanceolate pedicellariae occur here and there on both surfaces, mostly on or near the disc. The madreporite is of moderate size, irregularly round, and plane to concave.

This species differs from *S. tanneri*, which occurs from Cape Hatteras north, in having a more prominent carinal ridge, an incomplete row of dorsolaterals, fewer large lanceolate pedicellariae, and one or two spines on the dorsal disc plates, instead of a number of small spines, as well as in having angular, straight-sided arms, pentagonal in cross section (the arms of *S. tanneri* are almost round in cross section).

This species has previously been recorded from Florida to Barbados in 11–188 fathoms.

MATERIAL EXAMINED.—Oregon Station 4731 (1) [R=90 mm, r=9 mm, Rr=1:10].

#### *Asterias* Linnaeus

*Asterias* Linnaeus, 1758:661. [Type, by subsequent designation, *A. rubens* Linnaeus (Norman, 1865:126).]

*Stellonia* Nardo, 1834:716. [Type, by subsequent designation, *Asterias rubens* Linnaeus (Fisher, 1913:639).]

*Uraster* L. Agassiz, 1835a:191. [Nomen nov. for *Stellonia* Nardo.]

*Asteracanthion* Muller and Troschel, 1840:102. [Type, by original designation, *Asterias rubens* Linnaeus.]

*Allasterias* Verrill, 1909:65. [Type, by original designation, *A. rathbuni* Verrill.]

*Parasterias* Verrill, 1914:53. [Type, by original designation, *P. albertensis* Verrill.]

Large disc; five or six broad, rather short arms; aboral skeleton forms an open network, with spines in nearly regular series on carinal and marginal plates, but irregular elsewhere.

Only one species is known from the Gulf and Caribbean.

### *Asterias forbesi* (Desor)

PLATE 44: FIGURES C, D

*Asteracanthion forbesi* Desor, 1848:67.

*Asterias arenicola* Stimpson, 1851:268.

*Asteracanthion beryllinus* A. Agassiz, 1863:3; 1877:94, pl. 9.

*Asterias forbesi*.—Verrill, 1866:345.—H. L. Clark, 1902:552, pl.

1: figs. 1, 2, pl. 4: figs. 14, 15.—Fisher, 1930:205.—Gray, Downey, and Cerame-Vivas, 1968:156, fig. 34.

*Asteracanthion novae boracensis* Perrier, 1869:41, pl. 1: fig. 9a.

This is probably the commonest shallow-water species on the east coast of North America; certainly, it is the best known, for it is the one commonly used in biology classes. The disc is small, and the five arms are moderately long, thick, and constricted at the base. There is an irregular carinal row of plates down the middle of each arm. The superomarginal plates define the ambitus and are connected to the inferomarginals by an elongate ossicle; the inferomarginal plates are connected to 3 or 4 adambulacral plates by a triangular, unarmed ossicle. All plates from the carinals to the inferomarginals are connected by small, elongate secondary ossicles, forming an open meshwork, and bear a single, thick, upright, thorny-tipped spine, the spines of the superomarginals being slightly larger than those of the other plates. The spines are all surrounded, about halfway up, by a wreath of small, crossed pedicellariae. The inferomarginals bear two thicker, blunter spines. The small, crowded adambulacral plates bear either one or two spines, alternately; they are usually chisel shaped and often grooved. Between the spines, over the entire surface, and on many of the adambulacral spines are straight, flat, oval or cordiform pedicellariae, larger than the crossed pedicellariae which

wreath the spines. The papulae between the plates are small and numerous.

The long, narrow mouth plates consist of 3–7 adambulacral plates which meet across the inter-radius; each bears a long, straight, slender, somewhat flattened spine. The madreporite is large, irregularly round, raised, and wartlike, covered with many fine gyri.

This species ranges from Maine to the Gulf of Mexico, in shallow water. It is the southern form of *Asterias vulgaris*, which ranges from Labrador to the Carolinas (and, rarely, to Florida). It is sometimes difficult for even a specialist to distinguish these two species, and hybridization is not uncommon, particularly in the Cape Cod area. This is one of the many cases among marine invertebrates which compels us to realize how very unsatisfactory are any of the proposed definitions of "species."

MATERIAL EXAMINED.—Oregon Stations: 5894 (1) [R=83 mm, r=21 mm, Rr=1:4]; 6300 (12) [R=45 mm, r=11 mm, Rr=1:4]; 5882 (1) [R=22 mm, r=6 mm, Rr=1:4]. Silver Bay Stations: 1564 (1) [R=20 mm, r=5 mm, Rr=1:4]; 1710 (1, with four arms) [R=42 mm, r=10 mm, Rr=1:4]; 1952 (4, two with four arms) [R=80 mm, r=18, Rr=1:4].

### *Coscinasterias* Verrill

*Cosinasterias* Verrill, 1867:248. [Type, by original designation, *C. muricata* Verrill.]

*Stolasterias* (subgenus) Sladen, 1889:583. [Type, by subsequent designation, *Asterias tenuispina* Lamarck, 1816 (Fisher, 1923:128).]

*Lytaster* Perrier, 1894:09. [Type, by original designation, *L. inaequalis* Perrier (= *Asterias tenuispina* Lamarck, 1816).]

*Polyasterias* Perrier, 1894:108. [Type, by original designation, *Asterias tenuispina* Lamarck, 1816.]

Disc small; variable number (5–12) of moderately long, angular rays; single series of spiniferous actinal plates; adambulacral plates monacanthid throughout; only outer of two inferomarginal spines carries cluster of crossed pedicellariae; fissiparous.

Only one species is known from the western Atlantic.

### *Coscinasterias tenuispina* (Lamarck)

PLATE 45: FIGURES A, B

*Asterias tenuispina* Lamarck, 1816:561.—Perrier, 1875c:306.

*Asteracanthion tenuispinus*.—Muller and Troschel, 1842:16, pl. 1: fig. 1.—Perrier, 1869:32, pl. 1: figs. 3–3c.—Lutken, 1859:95.

*Asterias (Stolasterias) tenuispina*.—Sladen, 1889:565, 583.—Verrill, 1907:324 [280], pl. 34: fig. 2.

*Coscinasterias tenuispina*.—Verrill, 1914:45; 1915:19, pl. 26: fig. 2, pl. 27: fig. 4.—Gray, Downey, and Cerame-Vivas, 1968:159, fig. 38.

*Asterias atlantica* [part] Verrill, 1868:368.—Rathbun, 1879:144.

This species has a small disc and a variable number (5–10, usually seven) of long, angular arms of unequal length. It is fissiparous. The dorsal plates are thick and large and generally four lobed, forming an open meshwork. The carinal row is well marked, and most of the carinal plates bear a long, strong, movable, aciculate spine. The specimen before me is a juvenile, and has only a few dorsolateral plates, but larger specimens usually have one or two regular rows of dorsolaterals, armed like the carinal plates. The superomarginal plates bear an irregular patch of fine glassy tubercles, and alternate plates bear a sturdy aciculate spine, longer than that of the dorsal plates. The inferomarginals are trilobate and bear two oblique spines similar to those of the superomarginals. This juvenile specimen has no interactinal plates, but larger specimens usually have a single row of unarmed interactinals. The small, crowded adambulacral plates bear a single, long, slender spine. All spines above the inferomarginals bear a dense wreath of small, crossed pedicellariae; this juvenile specimen has only a few small, straight pedicellariae within the groove, but in larger specimens these are frequently large and abundant on all surfaces. The adambulacral spines and the inner, or actinal, inferomarginal spines are without pedicellariae. The disc dorsum is plated with large, heavy, irregularly shaped plates, most bearing a single large spine.

On the specimen before me, there are six round, raised madreporites, covered with coarse gyri.

This tropical-subtropical amphi-Atlantic species is common in the Mediterranean, and has been found at most of the islands in the Atlantic from Bermuda to St. Helena. Its depth range is unknown, but is quite possibly very great.

MATERIAL EXAMINED.—*Silver Bay* Station 2010 (1) [R=30 mm, r=4 mm, Rr=1:7.5].

### *Coronaster Perrier*

*Coronaster* Perrier, 1885c:13. [Type, by original designation, *C. parfaii* Perrier.]

*Heterasterias* Verrill, 1914:46. [Type, by original designation, *Asterias (Stolasterias) volsellata* Sladen.]

Rays 9–11; prominent, well-spaced acicular abactinal and marginal spines; large, straight, spatulate, unguiculate pedicellariae; abactinal skeleton with large square meshes; conspicuous wreath of small, crossed pedicellariae around spines; abactinal skeleton much reduced.

Only one species is known from the western Atlantic.

### *Coronaster briareus* (Verrill)

PLATE 45: FIGURES C, D

*Asterias briareus* Verrill, 1882:220; 1884:659; 1895:209.

cf. "*Asterias volsellata*".—Nutting, 1895:168, fig. 3.

*Coronaster briareus* Verrill, 1915:31, pl. 1: figs. 1, 2, pl. 9: figs. 4–4c.—Gray, Downey, and Cerame-Vivas, 1968:158, fig. 37.

This species has a small disc and eleven (9–12) long, slender arms. The disc is well covered with large, irregularly shaped and arranged plates, most of them bearing one or two long aciculate spines encircled by a dense wreath of small, crossed pedicellariae.

Elsewhere on the disc are large, isolated, straight, spatulate unguiculate pedicellariae. The madreporite is small, round, smoothly convex, and covered with deep gyri. The arms are high and inflated near the base, and the skeleton is reduced to a carinal row of lobate plates connected by long, slender, transverse ossicles to similar superomarginals, which in turn are connected by elongate lobes to trilobate inferomarginals. The inferomarginal plates are connected to one another by imbricate secondary plates. Most of the carinals, superomarginals, and inferomarginals, and a few of the secondary connective plates bear a long, slender, aciculate spine with a dense wreath of small, crossed pedicellariae encircling it. Between the narrow plates, the meshes are large, square, and contain a few papulae. The adambulacral plates bear two long, slender, divergent spines without pedicellariae. Within the groove, and also elsewhere on the surface, are large, solitary, straight unguiculate pedicellariae, expanded and spatulate near the tip, like little clasped hands. Smaller straight pedicellariae are also present. The large tube feet are

in two rows. The mouth plates bear a large acicular oral spine and a smaller marginal spine, as well as a number of small, straight pedicellariae. Behind the mouth plates, two or three adambulacral plates are united across the interradius.

The peristome is wide open, and there is a rather broad peristomial membrane. Within the peristome of the specimen before me were two tiny crabs of the family *Calapidae*.

The known distribution of this species is from New Jersey to the Florida Keys, in 31–373 fathoms.

MATERIAL EXAMINED.—*Alaminos* Station 20/65-A-9 (1) [R=125 mm, r=7 mm, Rr=1:1.3].

**Order ZOROCALLIDA Downey, 1970b**

In this order, the disc is more or less domed, with a regular arrangement of enlarged primary plates. There is a prominent median carina on the arms, and all arm plates are in compact and imbricating longitudinal and transverse series. The mouth frame is deeply sunken in the actinostome. The adambulacral plates are alternating carinate and noncarinate, and at least some of the tube feet are large and conical, with a tiny suckered disc. There

is but one living family in the order.

**Family ZOROASTERIDAE Sladen, 1889**

The disc is small, and the five arms are long, slender, and tapering. The dorsal disc plates are enlarged, in a regular arrangement of primary radials, interradians, centrodorsal, and sometimes additional plates. There is a prominent row of carinal plates along the midarm, and the other arm plates are in regular longitudinal and transverse series; in most specimens, the number of rows decreases from base to arm tip. The adambulacral plates are alternately carinate and noncarinate. Superambulacral plates are present in all zoroasterids, although they may be present only proximally in most genera, and in *Zoroaster* they are greatly reduced. Large, duck-billed pedicellariae are present in most genera, but may be absent in *Mammaster*. Small, straight pedicellariae are numerous.

The tube feet are in four rows proximally, two distally; within the peristomial cavity, they are straight, with a large suckered disc, but on the arms they become stout and conical, with a very small suckered disc.

**Key to the Genera of Zoroasteridae**

- 1. Disc plates conspicuously enlarged, more or less convex, bare, or at least not covered with spinules; disc and upper part of arms skin-covered .....2
- Disc plates plane or, if convex, closely covered with spinules; no skin-covering on dorsal surface ..... *Zoroaster*
- 2. Disc plates distinctly stellate, not much swollen..... *Doraster*
- Disc plates decidedly swollen, more round than stellate..... *Mammaster*

***Doraster* Downey**

*Doraster* Downey, 1970b:5. [Type, by monotypy, *D. constellatus* Downey.]

***Doraster constellatus* Downey**

PLATE 46: FIGURES A, B

*Doraster constellatus* Downey, 1970b:5–12, figs. 2c, 3–11.

The plates of the disc dorsum are large, flat, stellate, smooth, and skin covered. The central plate usually bears a stubby tubercle and a similar tubercle sometimes occurs on other primary disc plates. The anus, surrounded by small spinelets, is located in

one of the angles of the central plate. Surrounding the centrodorsum are five primary interradian plates, and between and underneath them are five radial plates on which the five pointed lobes of the centrodorsum rest; just outside and partly covering the primary interradians are five large primary radials; a pair of interradian plates, entirely concealed by skin and the overlapping primary radials, lie between and beneath the primary radials and four enlarged imbricating (in large specimens, fused) adradials that occupy the interradian angle. Small pedicellariae and tiny granuliform platelets occur between the plates of the disc. The madreporite is slightly smaller than the disc plates,

raised, covered with irregular channels, and located between a primary interradial and the enlarged interradial adradials; it actually rests on a pair of concealed interradials.

The first carinal is enlarged, about the same size as the interradial adradials. The jaw is one solid piece (made up of two pairs of adambulacral plates), projecting into the peristome. Behind it are four pairs of adambulacrals joined across the interradius by a tooth-and-socket arrangement reminiscent of the way the ambulacral plates are joined at the top of the ambulacral groove. Internally, the front of the jaw is flaired like the carinate adambulacral plates and bears, on each side, three subequal spines completely covered with tiny, straight pedicellariae, which thus form a wreath around the peristome. External to these three pairs of oral spines is a single pair of long, sharp spines. The next two pairs of adambulacral plates behind the jaw each bear a single pair of long sharp spines, and the two pairs behind them bear 4–6 similar spines. The seventh and eighth pairs of interradial adambulacrals are separated by a large duck-billed pedicellaria. The first two pairs of ambulacral plates are also strongly fused and greatly swollen. The ambulacrals curve sharply upward under the disc and thus support the disc in a domed position. The two fused pairs are buttressed against the body wall by a solid ridge formed of the first two (enlarged) superambulacral plates. Superambulacral plates of two kinds occur, alternately, but do not continue to end of the arm; rather, they diminish in size and eventually disappear. A straight, triangular superambulacral plate alternates with a thin, flaired superambulacral, which terminates in a broad, flat disc resting on the ambulacral plates.

They gradually become similar, small, and granuliform, and do not continue much beyond the middle of the arm. The tube feet are in four rows proximally, two distally. Around the mouth, they are straight and conspicuously annulated and terminate in a large suckered disc, but beyond the confines of the disc, they are stout and conical and taper to a tiny disc. On the arms, the carinal plates and two rows of plates on either side (adradials and superomarginals) are covered with skin, devoid of spines or spinules, but may have small pedicellariae, especially proximally. The carinals may have

a central, nonspine-bearing tubercle. Adradial plates overlap carinals and superomarginals. The carinals and adradials are about equal in size, somewhat cruciform, wider than long; the superomarginals are slightly smaller, lobed, or, in large specimens, somewhat triangular, tapering toward the actinal surface. On large specimens, an irregular row of tiny granuliform platelets occurs between the carinals and the adradials; a few also occur sporadically on the disc. Proximally, there are five rows of plates between the superomarginals and the adambulacrals, covered with small sacculate spinules; the row adjoining the superomarginals is the inferomarginal row. About halfway out on the arm, one row of plates drops out, then farther out another, until at the end of the arm only the carinals, very small adradials, superomarginals, and inferomarginals remain.

The row of plates adjoining the adambulacrals is very narrow, longer than broad, and only the edge of the plate may be visible. Most of the actinolaterals carry a long, flattened, appressed spine, directed upward and attached to a prominent tubercle. All of these arm plates are in regular longitudinal and transverse rows; however, the latter do not correspond to the adambulacrals. Papulae occur singly or in groups of up to five between the plates; none occur below the inferomarginals. The terminal ocular plates are cordiform, covering the arm tip, with three or more coarse terminal spines. Adambulacral plates are of two alternating sorts, carinate and noncarinate; the carinate adambulacrals project strongly into the ambulacral groove and bear four movable spines on a transverse row of tubercles. The spines are stout and rounded at the point of attachment, tapering rapidly to a point; they may be curved. The first or second spine usually bears a large duck-billed pedicellaria, and there are numerous small, straight pedicellariae. The noncarinate adambulacrals bear 3–5 small spinelets on their outer surface and do not project into the furrow; they may also bear small, straight pedicellariae.

This species seems to be limited to the northern Gulf of Mexico, in 190–350 fathoms.

MATERIAL EXAMINED.—*Oregon* Stations: 3583 (1) [R=80 mm, r=12 mm, Rr=1:6.6]; 382 (6) [R=122 mm, r=12 mm, Rr=1:10]; 2780 (2) [R=239 mm, r=38 mm, Rr=1:7]. *Alaminos* Station 21/68-



A-13 (1) [R=121 mm, r=15mm, Rr=1:9]. *Oregon II* Station 10602 (1) [R=183 mm, r=23 mm, Rr=1:9].

### ***Mammaster* Perrier**

*Mammaster* Perrier, 1894:125. [Type, by monotypy, *Zoroaster sigsbeeii* Perrier.]

### ***Mammaster sigsbeeii* (Perrier)**

PLATE 46: FIGURES C, D

*Zoroaster sigsbeeii* Perrier, 1881a:5.—Sladen, 1889:417, 418, 423, 790.

*Mammaster sigsbeeii*.—Perrier, 1894:125. H. L. Clark, 1941:67.—Downey, 1970b:12.

The arrangement of plates on the disc is definite and unmistakable: a centrodorsal plate, five interradial plates, then five larger radial plates. In each interradial arc are two large somewhat crowded-looking plates, and over the base of each arm are three large, tumid plates. All these plates are raised, tumid, round, and somewhat bare (although they may have small spinelets around the edge). The madreporite is small and inserted between the two interradial arc plates and the interradial primary plates. The jaws bear three transverse rows of 2, 2, and 3 or 4 long, acute spines, and inside the mouth, not visible without dissection, are two more pairs, the central pair short and blunt, and the outer pair curved away from the jaws like cow's horns, both pairs covered with small pedicellariae. Both small and large straight pedicellariae are present in the ambulacral groove and on the dorsal surface, especially on the disc.

The number of rows of tube feet diminishes from four to two about half to three quarters of the way down the arm. Only the carinal plates and one row of plates on each side extend all the way to the end of the arm. The terminal plate is as broad as long, with an indentation on the proximal side. The carinals are overlapped on each side by the plates of the next adjoining row. These three rows of plates are comparatively bare, with only a few spinules on the distal edges of the plates, and are probably covered by a thin skin. The next row of plates is covered with tiny spinules, is overlapped by the adradials, and in turn overlaps the similar row of plates below it. Both of these rows diminish and disappear before reaching the

end of the arm, the lower row first, then the upper. Next come two rows of narrow elongate plates which disappear distally before the rows above. Each of the plates in these four spinose rows bears one larger spine on a tubercle. The adambulacral plates are alternately carinate and noncarinate, with every other one projecting strongly into the furrow and bearing four stout, movable spines in a transverse row. These spines are frequently curved and the first or second often bears one or two large pedicellariae. The adambulacral plates between do not project into the furrow and have no furrow spines, but bear two to four somewhat flattened spines distally, side by side in pairs. The difference between the alternating adambulacrals becomes less distinct distally.

**JUVENILE.**—A specimen from *Combat* Station 450 has a major radius of 9 mm. The centrodorsal plate is by far the largest plate and bears a blunt tubercle. There are only two rows of plates on the arms beyond the carinals proximally, and only one row distally. There is no appreciable alternation of the adambulacral plates. There are only two rows of tube feet the whole length of the arm. The primary plates of the disc, except for the centrodorsal plate, are not appreciably raised and tumid. There are no pedicellariae.

This species apparently occurs throughout the West Indies, from Key West to Trinidad, in 195–350 fathoms.

**MATERIAL EXAMINED.**—*Combat* Station 450 (10) [R=47 mm, r=8 mm, Rr=1:6]; juvenile, [R=9 mm, r=2 mm, Rr=1:4.5]. *Oregon* Stations: 2775 (1) [R=29 mm, r=5 mm, Rr=1:6]; station unknown, Florida Keys, 200 fms (5) [R=60 mm, r=9 mm, Rr=1:6].

### ***Zoroaster* Thomson**

*Zoroaster* Thomson, 1873: 154. [Type, by original designation, *Z. fulgens* Thomson.]

All of the *Zoroasters* in the western Atlantic appear to belong to one species (see Downey, 1970b).

### ***Zoroaster fulgens* Thomson**

PLATE 47: FIGURES A, B

*Zoroaster fulgens* Thomson, 1873:154.—Studer, 1884:23 den, 1889:694.—Bell, 1893:88.—Perrier, 1894:116.—Verrill,

1895:205.—Koehler, 1895:442; 1896:42.—Chun, 1900:489, fig.—H. L. Clark, 1901:237.—Nichols, 1903:251.—Schmidt, 1905:22.—Grieg, 1907a:46; 1932:24.—Downey, 1970b:15.  
*Zoroaster ackleyi* Perrier, 1880:436; 1881b:59; 1881a:272; 1881b:1; 1894:117.—Verrill, 1895:205.—H. L. Clark, 1901:237.—Fisher, 1928a:491.  
 Non *Zoroaster ackleyi*.—Wood-Mason and Alcock, 1891:14.  
*Zoroaster trispinosus* Koehler, 1895:442; 1896:42, figs. 14, 15.  
*Zoroaster bispinosus* Koehler, 1909b:136.

A five-lobed centrodorsum, eight primary radials (in overlapping pairs), and five large interradians, plus five large first carinals, make up the disc dorsum. The anus is between the centrodorsum and two primary radials, which are single rather than being paired like the other six. The anal pore is surrounded by small, flattened spines. Small pedicellariae may be scattered over the disc. The madreporite is small, flat, channeled, and located just distal to a primary interradian. Each carinal plate on the arms has two lobes on each side and overlaps the carinal plate proximal to it. Transversely, the carinals overlap the adradials, and the superomarginals overlap both the adradials and the inferomarginals. Below the inferomarginals are 6–2 rows of actinolateral plates (six near the disc, becoming two by the end of the arm). Each actinolateral plate bears a long, slender, appressed spine, directed upward, and mounted on a horse-shoe-shaped tubercle, plus numerous small sacculate spinelets. The inferomarginals are similarly armed. The superomarginals and carinals frequently (but not always) bear a stout, erect central spine or tubercle, and these plates, as well as the adradials, are covered with small spinelets. The carinals are broader than long proximally and longer than broad distally.

The superambulacral plates are very small and do not extend beyond about the middle of the arm. The tube feet are in four rows proximally, becoming two rows less than halfway out on the arm. They are stout, conical, terminating in a small suckered disc (except for those actually within the peristomial cavity, which have large suckered discs), and the ampulae are double. The adambulacral plates are alternately carinate and noncarinate; the carinate adambulacrals bear five spines, two long, slender furrow spines with many small,

straight pedicellariae (a large duck-billed pedicellaria may replace the many small ones) and three outer spines which are similar to the three spines of the noncarinate adambulacrals; these small spines do not bear pedicellariae. The jaw of four fused adambulacral plates bears two short, stout oral spines on each side, in a row along the oral edge of the jaw, covered with small, straight pedicellariae, and behind them are two pairs of long, acute spines.

This species seems to occur all over the North Atlantic, in 200–2,000 fathoms.

MATERIAL EXAMINED.—*Alaminos* Stations: 3C/68-A-7 (1) [R=54 mm, r=7 mm, Rr=1.8]; 1/68-A-13 (2) [R=86 mm, r=8 mm, Rr=1.11]; 10B/68-A-3 (2) [R=85 mm, r=6 mm, Rr=1.14]. *Oregon* Stations: 1537 (2) [R=75 mm, r=9 mm, Rr=1.8]; 2574 (4) [R=85 mm, r=7 mm, Rr=1.12]; 3561 (1) [R=200 mm (est.), r=21 mm, Rr=1.10]; 3560 (2) [R=210 mm, r=18 mm, Rr=1.11]; 5929 (5) [R=149 mm, r=14 mm, Rr=1.10]; 4413 (3) [R=177 mm, r=22 mm, Rr=1.8]; 2571 (1); 2202 (2); 2779 (1); 2824 (2); 2652 (10); 1538 (6); 382 (6); 2650 (5); 3654 (6) [R=71 mm, r=7 mm, Rr=1.10]. *Oregon II* Station 10619 (1) [R=75 mm, r=7 mm, Rr=1.10].

#### Order EUCLASTERIDA Tortonese, 1958

With the characters of the family Brisingidae; the only family in the order is Brisingidae Sars, 1875.

#### Family BRISINGIDAE Sars, 1875

The Brisingidae have many deciduous arms, sharply distinct from the small circular disc. The vertebra-like ambulacral and adambulacral plates are not compressed, and the tube feet are biserial. The dorsal skeleton, confined to the proximal third of the arm, is weak and never reticulate. The abundant pedicellariae are crossed, never straight. The mouth plates are expanded, and the actinostome is large, with a broad peristomial membrane. Papulae are lacking or confined to the disc and/or genital region of the arms. The marginal and adambulacral spines are long, delicate, acicular, and ensacculate.

#### Key to the Genera of Brisingidae

- Papulae numerous on disc and genital region of arms ..... *Odinia*  
 Papulae limited to one pair on each radial area of disc, near disc margin ..... *Midgardia*

***Odinia* Perrier**

*Odinia* Perrier, 1885c:9. [Type, by original designation, *O. semicoronata* Perrier.]

Numerous papulae on disc and genital region of arms; mouth plates broad and fan shaped toward actinostome, nearly closing entrance to ambulacral furrow; genital region of arms with transverse skeletal arches; tegument between costae contains numerous immersed plates and papular pores; arms with regularly spaced transverse combs of slender lateral spines; adambulacral plates, higher than long, bear single prominent, frequently truncate, subambulacral spine; first 3–5 adambulacral plates united interradially, as are marginals above them.

Only one species has been reported from the Caribbean and Gulf of Mexico.

***Odinia antillensis* Clark**

PLATE 47: FIGURES C, D

*Odinia antillensis* A. H. Clark, 1934:1, pl. 1.

This species has a small disc with a plane, abactinal surface and high, abrupt sides sloping sharply to the base of 15–17 long, thin arms. The surface of the disc is covered with small polygonal plates bearing 2–16 short spinelets. In the interradiial areas of the disc, the plates form a solid bare channel which extends outward between the fused bases of the arms for a short distance. The arms are constricted at the base, and about the first 5–10 adambulacral and marginal plates are closely joined to those of the adjoining arms to form the bare channels mentioned above. Just beyond the constricted and partly fused basal area, the arms swell abruptly in the high and inflated genital area. This area, which tapers gradually distally, is about a quarter of the arm length or less. The genital region is plated with small polygonal plates, most bearing one or two small spinelets. The costae on the proximal half of the genital region are irregular and scarcely distinguishable from the general plating; they correspond to every third adambulacral plate and are mainly distinguishable by the band of large plates bearing single large spines across the arm.

On the distal half of the genital region, the costae are distinct and form conspicuous bands or ridges across the arm. Beyond the genital region,

the costae are reduced to 3 or 4 plates just above every fourth adambulacral plate, each bearing a single long spine, and the dorsal portion of the arm is covered by a thin plateless tegument through which the ambulacral plates are clearly visible. Papulae are numerous between the plates of the disc and the genital region of the arms. The adambulacral plates are cylindrical and each bears a prominent furrow spine; proximally, these are very long and heavy, and the tip is expanded and may be forked or chisel shaped. Beyond the genital region, the adambulacral spines are long and acicular. The mouth plates are large and closely connected both radially and interradially, forming a nearly closed ring around the broad peristome. They bear about five very short spines. Small, crossed pedicellariae are abundant on all surfaces and cover the spines. The small, round madreporite is on the sloping side of the disc at the edge of the abactinal surface.

This species was previously known only from off Puerto Rico.

MATERIAL EXAMINED.—Oregon Stations: 4480 (1) 1408 (1) [R=304 mm (est.), r=10 mm, Rr=1:30]; 4574 (2) [R=100 mm, r=5 mm, Rr=1:20].

***Midgardia* Downey**

*Midgardia* Downey, 1971d:421–426. [Type, by monotypy, *M. xandaros* Downey.]

***Midgardia xandaros* Downey**

PLATE 48: FIGURES A, B, C

*Midgardia xandaros* Downey, 1971d:

This species has a small, circular, plane disc and twelve very long, attenuate arms. The disc dorsum is covered with a thin membrane in which are immersed many small, irregular plates bearing one or two tiny spinules. In each radial area, near the edge of the disc dorsum, is a pair of small papulae; there are no other papulae. The madreporite is large, situated on the edge of the disc, forming a stout, heavily calcified cone with few gyri in a pit on top. At the periphery of the disc, the first pair of ambulacral plates are united by a syzygy, and the oval interbranchial adambulacral plates between are separated by the intrusion from above of a pair of partially fused marginals. On the

ventral surface, the actinostome is wide (1 cm radius), and the expanded mouth plates form a complete wall around the inside of the peristome; each mouth plate bears 2 or 3 small, fine, acicular spines on the apical margin. The peristomial membrane is rather small and fragile. No pedicellariae were noted on the disc. The arms, constricted at the base, swell rapidly in the genital region, which constitutes less than one fifth of the total arm length. The largest diameter of the arm, about 1 cm, is in this area.

The costae of the slightly inflated genital region are more or less irregular and crowded near the base of the arm, becoming less crowded and more distinct distally. They are made up of elongate overlapping plates, most of which bear a tiny aciculate spine with an expanded bulbous base. The costal plates become smaller and fewer beyond the middle of the genital region, and beyond this region are represented only by bands of pedicellariae; even these disappear at about midarm, and the distal half of the arm is covered only by a thin tegument. The tegument between the costae is filled with immersed platelets, thin, spineless, fenestrated, and somewhat imbricate. The arms become extremely attenuate at the tip, terminating in a small, broader than long, down-curved plate (less than 0.4 mm wide), well-armed on the actinal edge with small spines, so that it looks like a tiny cat's paw with claws extended. Laterally, on the arm, the first few marginals are fused together to form a smooth channel between the bases of the arms. Beyond the arm base, the small inferomarginal plates are irregularly spaced, averaging one about every third or fourth adambulacral plate. In the genital region, the costae arise from these inferomarginals. Each inferomarginal plate bears a single very long, slender, acicular spine with a flap of tissue at the tip. Beyond the genital region these spines increase in length, becoming as long as 2.5 cm beyond the middle of the arm.

On the actinal side of the arms, the somewhat cylindrical adambulacral plates bear a single long, slender spine on the actinal face, slightly shorter than the inferomarginal spine, and within the furrow they bear two pairs of tiny, fine spines that project toward the middle of the furrow. The very long suckered tube feet are biserial and stiffened at the base by a calcareous collar; they rest in large

basins between the adambulacral plates. In dorsal aspect, the ambulacral pores are covered with a thin membrane which appears to be only slightly expandable; indeed, it can hardly be called an ampulla. The tube feet were very long and agile in the live specimen and therefore probably had limited ability to contract. Sars (1875), in his study of the structure of the related genus *Brisinga*, noted that the tube feet were not so highly contractile as in other (families of) starfishes. The gonads appear to be united in a single strand on each side of the arm, but it was not possible to determine whether the gonoducts were single or double. Tiny hyaline pedicellariae cover the costae and clothe the spines of the arms to their tips.

MATERIAL EXAMINED.—*Alaminos* Station 58/69-A-11 (1) [R=680 mm, r=13 mm, Rr=1:60].

#### Literature Cited

- Agassiz, A.  
 1863. On the Embryology of *Asteracanthion berylinus* Ag. and a Species Allied to *A. rubens* M. T. *Asteracanthion pallidus* Ag. *Proceedings of the American Academy of Arts and Sciences*, 8 pages, 18 figures.  
 1869. Preliminary Report on the Echini and Starfishes Dredged in Deep Water Between Florida and Cuba Reefs, by L. H. de Pourtales. *Bulletin of the Museum of Comparative Zoology at Harvard*, 1 (9): 253-308.  
 1877. North American Starfishes. *Memoirs of the Museum of Comparative Zoology at Harvard*, 5 (1): 1-136, 20 plates.  
 1888. Three Cruises of the U. S. Coast and Geodetic Survey Steamer *Blake* in the Gulf of Mexico, in the Caribbean Sea, and along the Atlantic Coast of the United States from 1877 to 1880. *Bulletin of the Museum of Comparative Zoology at Harvard*, 15 (2): 220 pages, 545 figures.
- Agassiz, L.  
 1835a. Notice sur les fossiles du terrain cretace du Jura Neuchatelois. *Memoires de la Société des Sciences Naturelles de Neuchatel*, 1:126-145, plate 14.  
 1835b. Prodrôme d'une monographie des radières ou Echinodermes. *Memoires de la Société des Sciences Naturelles de Neuchatel*, 1:168-199.
- Alcock, A.  
 1893a. Natural History Notes from H. M. Indian Marine Survey Steamer *Investigator*, Commander C. F. Oldham, R. N., Commanding, Series 2, No. 7. An Account of the Collection of Deep-Sea Asteroidea. *Annals and Magazine of Natural History*, 11 (6): 73-121, plates 4-6.  
 1893b. Natural History Notes from H. M. Indian Marine Survey Steamer *Investigator* . . . Series 2, No. 9. An Account of the Deep-Sea Collection Made

- During the Season of 1892-1893. *Journal of the Asiatic Society of Bengal*, 62:169-184, plates 8, 9.
- Anonymous**  
1953. Regeneration of a Starfish. *Natural History Notes, Natural History Society of Jamaica*, 59:188, 5 figures.
- Bell, F. J.**  
1884. *Echinodermata*. In Report on the Zoological Collections Made in the Indo-Pacific Ocean During the Voyage of H.M.S. *Alert*, 1881-1882. Pages 117-177 and 509-512, plates 8-17, 45.  
1889. Report of a Deep-Sea Trawling Cruise off the S.W. Coast of Ireland, under the Direction of Rev. W. Spotswood Green. *Echinodermata. Annals and Magazine of Natural History*, 4 (6):432-445, plates 18, 19.  
1892. *Catalogue of the British Echinoderms in the British Museum (Natural History)*. 202 pages, 16 plates. London: Trustees of the British Museum.  
1893. On *Odontaster* and the Allied or Synonymous Genera of Asteroid Echinoderms. *Proceedings of the Zoological Society of London*, pages 259-262.  
1903. Report on a Collection of Echinoderms from the Neighborhood of Zanzibar. Part 1. *Annals and Magazine of Natural History*, (7) 12:244-248.
- Bernasconi, I.**  
1941. Los Equinodermos de la expedición del buque oceanográfico *Comodoro Rivadavia* A.R.A. *Physis* (Buenos Aires), 19:37-49, plates 1-8.  
1943. Los asteroideos sudamericanos de la familia Luidiidae. *Anales del Museo nacional de Buenos Aires*, 41:20 pages, 5 plates.  
1956. Dos nuevos equinodermos de la costa del Brasil. *Neotropica*, 2:33-36, 2 figures.  
1957. Equinoideos y asteroideos de la colección del Instituto Oceanográfico de la Universidad de San Pablo. *Boletim del Instituto Oceanográfico, Sao Paulo*, 7:119-148, 4 plates.  
1958a. Asteroideos de la colección del Instituto Oceanográfico de la Universidad de San Pablo. *Boletim del Instituto Oceanográfico, São Paulo*, 9:13-21, 2 plates.  
1958b. Equinoideos y asteroideos de la colección del Instituto Oceanográfico de la Universidad de San Pablo. Segunda contribución. *Boletim del Instituto Oceanográfico, São Paulo*, 7:119-149, 4 plates.  
1960. Los equinodermos de la campana 1958 del buque oceanográfico *Capitan Canepa* A.R.A. *Actas Trab. I Congreso sudamericanos Zoologica*, 1959, 2 (3): 21-32, 3 plates.  
1962. Asteroideos argentinos. III. Familia *Odontasteridae*. *Revista del Museo argentinos Instituto nacional Ciencias natural (Zoologica)*, 8:27-51.  
1964. Asteroideos argentinos claves para los ordenes, familias, subfamilias y generos. *Physis*, Buenos Aires, 24 (68):241-277.  
1966. Los equinoideos y asteroideos colectados por el buque oceanográfico R/V *Vema* frente a las costas Argentinas, Uruguayas y sur de Chile. *Revista Museo argentinos Ciencias nacional Bernardino Rivadavia Instituto nacional Investigacion Ciencias natural*, 9 (7):147-175, 2 plates.
- Blainville, E. de**  
1834. *Manuel d'Actinologie ou de Zoophytologie*. 694 pages, 99 plates. Paris: F. G. Levrault.
- Boone, L.**  
1928. Scientific Results of the First Oceanographic Expedition of the *Pawnee* 1925. Echinodermata from Tropical East American Seas. *Bulletin of the Bingham Oceanographic Collection*, New York, 1 (4): 22 pages, 8 plates.  
1933. Scientific Results of Cruises of the Yachts *Eagle* and *Ara* . . . Coelenterata, Echinodermata, and Mollusca. *Bulletin of the Vanderbilt Oceanographic (Marine) Museum*, 4: 217 pages, 133 plates.  
1936. Scientific Results of the World Cruise of the Yacht *Alva*, 1931, Wm. K. Vanderbilt Commanding. Part II. Echinodermata. *Bulletin of the Vanderbilt Marine Museum*, Huntington, 6 (1935):235-260, plates 69-96.
- Breder, C. M.**  
1955. Observations on the Occurrence and Attributes of Pentagonal Symmetry. *Bulletin of the American Museum of Natural History*, 106, 3 (1955):173-220, 2 plates, 33 figures.
- Brito, I. M.**  
1960. Asteroideos dos estados de Rio de Janeiro e de Sao Paulo. *Avulso Centrale Estados Zoologia Universidad do Brasil*, 5:1-13, 3 plates.  
1962. Ensaio de catalogo dos equinodermas do Brasil. *Avulso Centrale Estudos zoologica do Universidad do Brasil*, number 13: 11 pages, 3 plates.
- Buchsbaum, R., and L. J. Milne**  
1960. The Lower Animals. In *Living Invertebrates of the World*. 303 pages, 144 plates. New York: Doubleday and Company.
- Carus, J. V.**  
1885. *Prodromus faunae mediterraneae*. Vol. 1, 524 pages (echinoderms on pages 85-111).
- Caso, M. E.**  
1941. Contribucion al conocimiento de los asteridos de Mexico. I. La existencia de *Linckia guildingii* Gray en la costa Pacifica. *Anales del Instituto Biologica de Mexico*, 12:155-169, 5 figures.  
1943. Contribucion al conocimiento de los asteridos de Mexico. *Tesis. Universidad Nacional de Mexico, Faculte de Ciencias*, 136 pages.  
1944. Estudios sobre asteridos de Mexico. Algunas especies interesantes de asteridos litorales. *Anales del Instituto de Biologia*, 15 (1):236-259.  
1961. Los equinodermos de Mexico. *Universidad Nacional de Mexico, Faculte de Ciencias*, 388 pages.  
1962. Estado actual de los conocimiento acerca de los equinodermos de Mexico. *Universidad Nacional de Mexico, Faculte de Ciencias*, 1961: 388 pages, 20 plates, 124 figures.
- Cherbonnier, G.**  
1956. Les echinodermes de Tunisie. *Bulletin de Statione Oceanographie de Salammbou*, 53:1-23, figure 1.  
1958. *Faune Marine des Pyrenees-Orientales*. 2. Echinodermes. 67 pages, 8 figures. Paris: Hermann.

1959. Echinodermes de la guyane francaise (crinoides, asteroides, ophiurides, echinides, holothurides). *Bulletin du Museum d'histoire naturelle*, 31 (1): 105-111, 2 figures.
- Chun, C.  
1900. Aus den Tiefen des Weltmeeres. *Schilderungen von der deutschen Tiefsee-Expedition*. viii + 550 pages, 46 plates, 2 maps, 390 figures. Jena.
- Clark, A. H.  
1916. A New Starfish (*Lydiaster americanus*) from the Gulf of Mexico. *Journal of the Washington Academy of Science*, 6 (6):141-144.  
1934. A New Starfish from Puerto Rico. *Smithsonian Miscellaneous Collections*, 91 (14): 3 pages, 1 plate.  
1938. A New Genus of Starfishes from Puerto Rico. *Smithsonian Miscellaneous Collections*, 91 (29): 7 pages, 1 plate.  
1939. Echinoderms of the Smithsonian-Hartford Expedition, 1937, with Other West Indian Records. *Proceedings of the United States National Museum*, 86:441-456, plates 53, 54.  
1945. A New Starfish of the Genus *Luidia* from the Coast of Georgia. *Journal of the Washington Academy of Science*, 35:19-21.  
1948. Two New Starfishes and a New Brittle-Star from Florida and Alabama. *Proceedings of the Biological Society of Washington*, 61:55-66, 1 plate.  
1954. Echinoderms (Other than Holothurians) of the Gulf of Mexico. *Bulletin of the United States Fish Commission*, 55:373-379.
- Clark, A. M.  
1951a. Notes on Asteroidea in the British Museum (Natural History). III. *Luidia*. *Bulletin of the British Museum (Natural History)*. Zoology. I. 12:379-396.  
1951b. On Some Echinoderms in the British Museum (Natural History). *Annals and Magazine of Natural History*, series 12, 4:1256-1268, 4 figures, plate 22.  
1955. Echinodermata of the Gold Coast. *Journal of the West African Scientific Association*, 1 (2):16-56.  
1962. *Starfishes and Their Relations*. 119 pages, 30 figures, 14 plates. London: British Museum (Natural History).  
1966. In Clark and Davis, Echinoderms of the Maldivian Islands. *Annals and Magazine of Natural History* series 13, 8, 1965 [1966]:597-612, 1 plate.  
1967. Notes on Asteroidea in the British Museum (Natural History). V. *Nardoa* and Some Other Ophiasteroids. *Bulletin of the British Museum (Natural History)*, Zoology, 15:167-198, 6 plates.
- Clark, A. M., and A. H. Clark  
1954. A Revision of the Sea-Stars of the Genus *Tethyaster*. *Smithsonian Miscellaneous Collections*, 122 (11): 27 pages, 12 plates.
- Clark, H. E. S.  
1963. The Fauna of the Ross Sea. Part 3. Asteroidea. *Bulletin of the New Zealand Department of Scientific and Industrial Research* 151 (*Memoirs of the New Zealand Oceanographic Institute*, number 21): 84 pages, 20 figures, 15 plates.
- Clark, H. L.  
1898a. The Echinoids and Asteroids of Jamaica. *Johns Hopkins University Circular* 18 (137):4-6.  
1898b. Notes on the Echinoderms of Bermuda. *Annals of the New York Academy of Science* 11 (19):407-413.  
1899. Further Notes on the Echinoderms of Bermuda. *Annals of the New York Academy of Science* 12: 117-138, plate 4.  
1901. Bermudian Echinoderms. *Proceedings of the Boston Society of Natural History*, 29:339-444.  
1902. The Echinoderms of the Woods Hole Region. *Bulletin of the United States Fish Commission*, pages 545-576, 14 plates.  
1908. Some Japanese and East Indian Echinoderms. *Bulletin of the Museum of Comparative Zoology at Harvard*, 51:277-311.  
1909. Notes on Some Australian and Indo-Pacific Echinoderms. *Bulletin of the Museum of Comparative Zoology at Harvard* 52 (7):109-135, 1 plate.  
1919. The Distribution of the Littoral Echinoderms of the West Indies. *Carnegie Institute Publication* 281: 49-74, 3 plates.  
1920. Report on an Exploration off the West Coast of Mexico, Central, and South America, and off the Galapagos Islands by the United States Steamer *Albatross* during 1891. Part 32. Asteroidea. *Memoirs of the Museum of Comparative Zoology at Harvard*, 39 (3):75-113, 6 plates.  
1921. The Echinoderm Fauna of Torres Strait: Its Composition and Its Origin. *Department of Marine Biology, Carnegie Institute, Washington*, 10: 224 pages, 38 plates.  
1933. *Scientific Survey of Porto Rico and the Virgin Islands*, Volume 16, Part I. A Handbook of the Littoral Echinoderms of Porto Rico and the Other West Indian Islands. 147 pages, 7 plates. New York Academy of Sciences.  
1938. Echinoderms from Australia. An Account of Collections Made in 1929 and 1932. *Memoirs of the Museum of Comparative Zoology at Harvard*, 55: 596 pages, 64 figures, 28 plates.  
1941. Reports on the Scientific Results of the *Atlantis* Expeditions to the West Indies, under the Joint Auspices of the University of Havana and Harvard University. The Echinoderms (Other than Holothurians). *Memoirs de la Sociedad Cubana de Historia Natural Felipe Poey*, 15 (1): 154 pages, 10 plates.  
1944. The Echinoderm Fauna of Bermuda. *Bulletin of the Museum of Comparative Zoology at Harvard*, 89 (1942):367-391, plate.  
1946. The Echinoderm Fauna of Australia: Its Composition and Its Origin. *Publications of the Carnegie Institute*, 566: 567 pages.
- Colombo, A.  
1888. La fauna sottomarina del Golfo di Napoli. *Rivista Marittima*, 1887, 4:5-32, 195-239, 413-441.
- Conant, F. S.  
1900. Notes on Zoological Collecting in Jamaica, West

- Indies. Edited by E. A. Andrews. *Johns Hopkins University Circulars*, 19:23-25.
- Cuenot, L.  
1927. Contributions a la fauna de Bassin d'Arcachon. IX. Revue generale de la fauna et bibliographie. *Societe Scientifique d'Arcachon, Station Biologique de Bordeaux*, 24 (2):229-305.
1948. Anatomie, ethologie et systematique des echinoderms. In Grasse, P. (editor), *Traite de Zoologie*. Pages 3-363, 399 figures. Paris: Masson et Cie.
- Delage, Y., and E. Herouard  
1904. *Traite de zoologie concrete*. Tome III. Les Echinodermes. 495 pages, 53 plates. Paris.
- Desor, E.  
1848. Zoological Investigations among the Shoals of Nantucket. *Proceedings of the Boston Society of Natural History*, 3 (1848-51):11, 17, 65-68.
- Dieuzeide, R.  
1960. Le fond Chalutable a 600 metres par le travers de Castiglione. Le facies a *Isadella elongata* Esper. *Bulletin de la Station Agriculture et Peche de Castiglione*, 10:63-105.
- Doderlein, L.  
1917. Die Asteriden der Siboga-Expedition. I. Die Gattung *Astropecten* und ihre Stammesgeschichte. 81. In *Siboga-Expedition*, 46a: 191 pages, 17 plates.
1920. Die Asteriden der Siboga-Expedition. II. Die Gattung *Luidia* und ihre Stammesgeschichte. In *Siboga-Expedition* 46b:193-293, 5 figures, plates 18-20.
1927. Die Seesterne der Deutschen Sudpolar-Expedition 1901-1903. In *Deutschen Sudpolar-Expedition 1901-03*, Berlin, *Zoologische* 19 (11):289-301, plates 11-14.
1936. Die Asteriden der Siboga-Expedition. III. Die Unterfamilie Oreasterinae. In *Siboga-Expedition* 46c: 295-369, plates 21-32.
- Doderlein, L., and R. Hartmeyer  
1910. Westindische Seeigel und Seesterne. *Zoologische Jahrbucher*, supplement 11 (2):145-156.
- Domantay, J. S., and H. A. Roxas  
1938. The Littoral Asteroidea of Port Galera Bay and Adjacent Waters. *Philippine Journal of Science*, 65: 203-237, 17 plates.
- Downey, M. E.  
1968. A Note on the Atlantic Species of the Starfish Genus *Linckia*. *Proceedings of the Biological Society of Washington*, 81:41-44.
- 1970a. *Drachmaster bullisi*, New Genus and Species of Ophiasteridae (Echinodermata: Asteroidea), with a Key to the Caribbean Species of the Family. *Proceedings of the Biological Society of Washington*, 83:77-82, 6 figures.
- 1970b. *Zorocallida*, New Order, and *Doraster constellatus*, New Genus and Species, with Notes on the Zoroasteridae. (Echinodermata: Asteroidea). *Smithsonian Contributions to Zoology*, 64: 18 pages, 11 figures.
- 1970c. *Marsipaster acicula*, New Species (Asteroidea: Echinodermata) from the Caribbean and Gulf of Mexico. *Proceedings of the Biological Society of Washington*, 83 (28):309-312, 1 figure.
- 1971a. A New Species of the Genus *Solaster* (Echinodermata: Asteroidea) from Martinique. *Proceedings of the Biological Society of Washington*, 84:39-42.
- 1971b. Two New Species of the Genus *Tamaria* (Echinodermata: Asteroidea) from the Tropical Western Atlantic. *Proceedings of the Biological Society of Washington*, 84:43-50.
- 1971c. *Ampheraster alaminos*, a New Species of the Family Asteriidae (Echinodermata: Asteroidea) from the Gulf of Mexico. *Proceedings of the Biological Society of Washington*, 84:51-54.
- 1971d. *Midgardia xandaros*, New Genus, New Species, a Large Brisingid Starfish from the Gulf of Mexico. *Proceedings of the Biological Society of Washington*, 84:421-426.
- Dragovich, A. V., and J. A. Kelly  
1954. Ecological Observations of Macro-Invertebrates in Tampa Bay, Florida, 1961-62. *Bulletin of Marine Sciences of the Gulf and Caribbean*, 14:74-102, 1 figure.
- Duchassaing de Fontbressin, P.  
1850. *Animales radiales des Antilles*. Paris.
- Duerden, J. E.  
1896. Notes on the Marine Zoology of Kingston Harbour. *Journal of the Jamaica Institute*, 2:282-285.
1900. Zoophyte Collecting in Bluefields Bay. *Journal of the Jamaica Institute*, 2:619-624.
- Dujardin, M. F., and M. H. Hupe  
1862. *Histoire naturelle des zoophytes. Echinoderms*. 627 pages, 10 plates. Paris: Libraire Encyclopedique de Roret.
- Durand, J.  
1959. Les Elements principaux de la faune et leurs relations avec le fond. Notes sur le Plateau Continental Guyanais. *Cahiers de l'O.R.S.T.O.M.*, number 3, 93 pages, illustrations.
- Ely, C. A.  
1945. Shallow Water Asteroidea and Ophiuroidea of Hawaii. *Bulletin of the Bernice P. Bishop Museum*, 176 (1942): 63 pages, 8 figures, 13 plates.
- Engel, H.  
1939. Echinoderms from Aruba, Curacao, Bonaire, and Northern Venezuela. *Capita Zoologica* ('sGravenhage), series 8, 4 (4): 12 pages.
- Engel, H., A. F. Croes, and G. F. Schroovers  
1960. Les Asterides Recoltes par l'Expedition du Navire-Ecole Belge *Mercator* 1935-1936. *Bulletin de l'Institut des Sciences Naturelle de Belge*, 36 (54): 15 pages, 6 plates.
- Eschmeyer, W. N.  
1965. Station Data Errors for Fishes Collected by the Steamer *Blake*. *Copeia*, number 2, pages 236-238.
- Farran, G. P.  
1913. The Deep-Water Asteroidea, Ophiuroidea and Echinoidea of the West Coast of Ireland. *Fisheries, Ireland, Scientific Investigations*, 1912, 6: 66 pages, 2 plates.
- Field, G. W.  
1893. Echinoderms of Kingston Harbor (Jamaica). *Johns*

- Hopkins University Circular, April 1892.
- Fisher, W. K.  
 1906. The Starfishes of the Hawaiian Islands. *Bulletin of the United States Fish Commission*, 1903, 23 (3):987-1130, plates 1-49.  
 1908. Necessary Changes in the Nomenclature of Starfishes. *Smithsonian Miscellaneous Collections*, 52: 87-93.  
 1910a. New Genera of Starfishes. *Annals and Magazine of Natural History*, series 8:171-173.  
 1910b. New Starfishes from the North Pacific. I. Phanerozonia. *Zoologischer Anzeiger*, 35:546-553.  
 1911a. Asteroidea of the North Pacific and Adjacent Waters. Part I. Phanerozonia and Spinulosa. *Bulletin of the United States Museum*, 76 (1): 420 pages, 122 plates.  
 1911b. The Genus Blakiastrer. *Bulletin of the Museum of Comparative Zoology at Harvard*, 54 (4):161-165, plates 1, 2.  
 1913. Four New Genera and Fifty-eight New Species of Starfishes from the Philippine Islands, Celebes, and the Moluccas. *Proceedings of the United States National Museum*, 43:599-648.  
 1917. Notes on Asteroidea. *Annals and Magazine of Natural History*, series 8, 20:166-172.  
 1919. Starfishes of the Philippine Seas and Adjacent Waters. *United States National Museum Bulletin* 100, 3: xi + 712 pages, 156 plates.  
 1923. A Preliminary Synopsis of the Asteriidae, a Family of Sea-Stars. *Annals and Magazine of Natural History*, series 9, 12:247-258, 595-607.  
 1928a. Asteroidea of the North Pacific and Adjacent Waters. Part 2. Forcipulata (part). *United States National Museum Bulletin* 76: 245 pages, 81 plates.  
 1928b. Sea Stars from the Arcturus Oceanographic Expedition. *Zoologica*, 8:487-493.  
 1930. Asteroidea of the North Pacific and Adjacent Waters. Part 3. Forcipulata (concluding). *United States National Museum Bulletin* 76: 356 pages, 93 plates.  
 1940. Asteroidea. In *Discovery Reports*, 20:69-306, plates.
- Fontaine, A.  
 1953. The Shallow-Water Echinoderms of Jamaica. Part I. The Starfishes (Class Asteroidea). *Natural History Notes of the Natural History Society of Jamaica*, 56:179-184, 8 figures.
- Forbes, E.  
 1839. On the Asteriadae of the Irish Sea. *Memoirs of the Wernerian Society of Edinburgh*, 8:114-129.  
 1841. *A History of British Starfish and Other Animals of the Class Echinodermata*. 267 pages, figures. London: John Van Voorst.
- Forest, E.  
 1955. *Beautes de fond des mers*. 100 pages, 101 plates. Paris: Larousse.
- Gasco, F.  
 1876. Descrizione di alcuni echinodermi nuovi o per la prima volta trovati nel Mediterraneo. *Rendiconto dell' Accademia delle Scienze fisiche e matematiche*, Napoli, 15 (2) :32-41, 1 plate.
- Gmelin, J. F.  
 1791. *Caroli a Linne—Systema Naturae per Regna tria Naturae*. 13th edition, volume 1, part 6 [echinoderms on pages 3160-3201].
- Goto, S.  
 1914. Monograph of Japanese Asteroidea. *Journal of the College of Sciences, Imperial University, Tokyo*, 29: 808 pages, 29 plates.
- Gray, I. E., M. E. Downey, and M. J. Cerase-Vivas  
 1968. Sea-Stars of North Carolina. *Fisheries Bulletin*, 67 (1) :127-163, 40 figures.
- Gray, J. E.  
 1840. A Synopsis of the Genera and Species of the Class Hypostomata (Asterias, Linnaeus). *Annals and Magazine of Natural History*, series 1, 6:175-184, 275-290.  
 1866. *Synopsis of the Species of Starfish in the British Museum*. 17 pages, 16 plates. London: John Van Voorst.
- Gregory, J. W.  
 1900. The Echinodermata. In F. A. Bather, *A Treatise on Zoology*, edited by E. Ray Lankester. 3:viii+344 pages, 309 figures. London.
- Grieg, J. A.  
 1905. *Goniaster nidarosiensis*, storm og dens synonymer. *Afhandlinger og Aarsberetning udgivne af Bergens Museum*, 1905 (3), 14 pages, 5 figures.  
 1907a. Echinodermen von dem Norwegischen fischereidampfer *Michael Sars* in den jaharen 1900-1903 gesammelt. 3. Asteroidea. *Afhandlinger og Aarsberetning udgivne af Bergens Museum*, 1906, (13), 87 pages, 2 plates.  
 1907b. Echinodermata. In *Report of the Second Norwegian Arctic Expedition in the Fram, 1898-1902*. November 13, 26 pages, 3 plates.  
 1921. Echinodermata. In *Report of the Sars North Atlantic Deep Sea Expedition*, 3 (2) : 47 pages, 3 plates.  
 1927. Echinoderms from the West Coast of Norway. *Nyt Magazin for Naturvidenskaberne*, 65:127-136.  
 1932. Echinodermata. In *Report of the Scientific Research of the Michael Sars North Atlantic Expedition*, 1910, 3 (2) : 47 pages, 5 plates.
- Grube, A. E.  
 1857. Diagnosen einiger neuen Echinodermen. *Wiegmann Archiv*, 23:340-344.
- Gruvel, A.  
 1909. Dispersion de quelques especes appartenant a la fauna marine des cotes de Mauretaine. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 149:1017-1019.
- Habe, T.  
 1952. Parasitic Gastropods Found in Echinoderms from Japan. *Publications of the Seto Marine Biological Laboratory*, 2: 73-85, 6 plates.
- Halpern, J. A.  
 1968. Biological Investigations of the Deep Sea. 38. A New Western Atlantic *Dipsacaster* (Echinodermata, Asteroidea) with the Distribution of Known Species. *Proceedings of the Biological Society of Washington*,



- 81, (27):231-240.
- 1969a. Biological Investigations of the Deep Sea. 46. The Genus *Litonotaster* (Echinodermata, Asteroidea). *Proceedings of the Biological Society of Washington*, 82:129-142, 8 figures.
- 1969b. Biological Investigations of the Deep Sea. 50. The Validity and Generic Position of *Pentagonaster parvus* Perrier (Echinodermata, Asteroidea). *Proceedings of the Biological Society of Washington*, 82:503-506, figure 1.
- 1970a. Biological Investigations of the Deep Sea. 51. Goniasteridae (Echinodermata: Asteroidea) of the Straits of Florida. *Bulletin of Marine Sciences*, 20 (1):193-286.
- 1970b. *A Monographic Revision of the Goniasterid Sea Stars of the North Atlantic*. 253 pages, 8 figures. Ph.D. Dissertation, University of Miami [published in part].
- 1970c. Biological Investigations of the Deep Sea. 53. New Species and Genera of Goniasterid Sea Stars. *Proceedings of the Biological Society of Washington*, 83: 12 pages, 5 figures.
- Hayashi, R.  
1939. Sea-stars in the Vicinity of the Seto Marine Biological Laboratory. *Bulletin of the Biogeographic Society of Tokyo*, 8:271-292, 4 figures, plates 5-7.
- Heding, S. C.  
1936. Thule Expedition til Sydøstgrønland 1931-1933. 6. og 7. Echinoderms. *Meddelar Grønland* 108, 1: 34 pages, 6 figures.
- Heller, C.  
1863. Untersuchungen Über die Litoral-Fauna des Adriatischen Meeres. *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaaiserlichen Akademie der Wissenschaften*, 46 (1):415-448.  
1868. Die Zoophyten und Echinodermaten des Adriatischen Meeres. *Verhandlungen der K.-K. Zoologisch-Botanischen Gesellschaft in Wien*, 28: 88 pages, plate 3.
- Huling, N. C., and D. W. Hemlay  
1963. An Investigation of the Feeding Habits of Two Species of Sea Stars. *Bulletin of Marine Science of the Gulf and Caribbean*, 13:354-359.
- Ihering, H. V.  
1898. A Ilha de Sao Sabastiao. *Revista do Musia Paulista Publicada por H. von Ihering*, 2:129-170, plate 2.
- Ives, J. E.  
1889. *Catalogue of the Asteroidea and Ophiuroidea in the Collection of the Academy of Natural Science of Philadelphia*. Pages 169-179.  
1890. Echinoderms from the Northern Coast of Yucatan and the Harbor of Vera Cruz. *Proceedings of the Academy of Natural Sciences, Philadelphia*, series 3, 42:317-340.  
1891. Echinoderms from the Bahama Islands. *Proceedings of the Academy of Natural Sciences of Philadelphia* for 1891:337-341, plate 16.
- John, D. D., and A. M. Clark  
1954. The *Rosaura* Expedition. 3. Echinodermata. *Bulletin of the British Museum (Natural History), Zoology*, 2:139-162, 12 figures, plate 6.
- Kellog, W. L.  
1904. Restorative Regeneration in Nature of the Starfish *Linckia diplax* (Muller and Troschel). *Journal of Experimental Zoology*, 1:353-356, 6 figures.
- Kenk, R.  
1944. Ecological Observations on Two Puerto Rican Echinoderms, *Mellita lata* and *Astropecten marginatus*. *Biological Bulletin*, 87:177-187, 5 figures.
- Koehler, R.  
1895. Rapport preliminaire sur les echinodermes. Dragages profonds executes a bord du *Caudan* dans le Golfe de Gascogne. *Revue Biologique du Nord de la France*, 7 (12):439-496, 16 figures.  
1896a. Resultats scientifiques de la campagne du *Caudan* dans le Golfe de Gascogne, Aout-Septembre 1895. Fasc. 1. Echinoderms. *Annales de l'Universite de Lyon*, 26:33-127, 4 plates.  
1896b. Dragages profonds executes a bord du *Caudan* dans le Gascogne. Rapport preliminaire sur les echinodermes. *Revue biologique de Norde de la France*, 7:439-496.  
1907. Note preliminaire sur quelques asteries et ophiures provenant des campagnes de la *Princesse-Alice*. *Bulletin de l'Institute Oceanographique de Monaco*, 99: 47 pages.  
1909a. An Account of the Deep-Sea Asteroidea Collected by the Royal Indian Marine Survey Ship *Investigator*. 143 pages, 13 plates. Calcutta: Indian Museum.  
1909b. Echinodermes provenant des campagnes du yacht *Princesse Alice* (asteries, ophiures, echinides, et crinoides). *Resultat de la Campagne Scientifique du Prince de Monaco*, 34: 136 pages, 23 plates.  
1914. Echinoderma I: Asteroidea, ophiuroidea et echinoidea. *Beitrage zur Meeresfauna Westafrika*, (2): 129-303, plates 4-15.  
1920. Echinodermata Asteroidea. In *Australian Antarctic Expedition 1911-1914. Scientific Reports*. Series C. *Zoology and Botany*, 8 (1): 308 pages, 75 plates.  
1921a. Echinodermes. *Faune de France*, 13: 210 pages, 153 figures.  
1921b. Echinodermes (Asteries, Ophiures, Echinides et Crinoides) des Dernieres Campagnes de la *Princesse-Alice* et de l'*Hirondelle II*. *Bulletin de l'Institute Oceanographique de Monaco*, 396: 8 pages.  
1924. *Les Echinodermes des mers d'Europe*, Tome Premier. 362 pages, 9 plates. Paris: Gaston Doin and Co.  
1929. *Cermaster placenta* (Muller and Troschel). *Faune et Flore de la Mediterranee*, 4 plates.
- Kolosvary, G.  
1937. Echinodermen des Adriatischen Meeres. Eine Aufarbeitung der Echinoderm Sammlung der Ungarischen *Najade*-Expedition in Jahre 1913-14. *Festschrift Embrik Strand*, 2:433-473, plates 24-37
- Lamarck, J. B.  
1816. *Histoire naturelle des animaux sans vertebres*. Edition 1, volume 2, 568 pages. Paris.

- Leipoldt, F.  
1895. Asteroidea der *Vettor-Pisani* Expedition (1882–1885). Mit Anhang: Die von F. Orsini im Rothen Meere Gesammelten Asteroideen. *Aeitschrift fur Wissenschaftliche Zooloie*, 59:545–654, plates 31, 32.
- Linck, J. H.  
1733. *De stellis marinis*. Folio, 107 pages, 42 plates. Lipsiae.
- Linnaeus, C.  
1753. *Museum tessinianum*. 123 pages, 12 plates. Holmiae.  
1758. *Systema naturae*, ed. X. Holmiae 8.
- Livingstone, A. A.  
1931. On the Restriction of the Genus *Ferdina* Gray (Asteroidea). *Australian Zoology*, Sydney, 6:305–309, plates 21–24.  
1932. The Australian Species of *Tosia* (Asteroidea). *Records of the Australian Museum*, 18:373–382, 43–44.
- Lo Bianco, S.  
1909. Notizie biologische riguardanti specialmente il periodo di maturita sessuale degli animali del Golfo di Napoli. *Mittheilungen aus der Zoologischen Station zu Neapel*, 19 (4):513–763 [echinoderms on pages 556–566].
- Loriol, P. de  
1885. Catalogue raisonné des échinodermes recueillies par M. V. de Robillard a l'Îlle Maurice. II. Stellerides. *Memoires de la Societe de Physique et d'Histoire Naturelle de Geneve*, 29 (4):84 pages, plates 7–22.  
1899. Notes pour servir a l'etude des échinodermes VII. *Memoires de la Societe de Physique et d'Histoire Naturelle de Geneve*, 33 (2) (1):12–29, plates 2, 3.
- Ludwig, H.  
1879. Die Echinodermen des Mittelmeeres; Prodrum einer Monographischen Bearbeitung Dieselben. *Mittheilungen aus der Zoologischen Station zu Neapel*, 1:523–580.  
1882. Verzeichniss der von Prof. E. van Beneden an der Kuste von Brasilien Gasammelten Echinodermen. *Memoires Couronnes et Memoires des Savants Etrangers Publies par l'Academie Royale des Sciences des Lettres et des Beaux-Arts de Belgique*, 44: 26 pages.  
1897. Die Seesterne des Mittelmeeres. *Fauna und Flora des Golfes von Neapel*, Monograph 24, x+491 pages, 12 plates.  
1899. Echinodermen des Sansibargebietes. In Voeltzkow, *Wissenschaftliche Ergebnisse der Reisen in Madagaskar und Ostafrika in den Jahren 1889–1895. Abhandlungen Herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft*, 21:537–563.  
1900. Arktische seesterne. *Fauna Arctica*, 1 (3):447–502.  
1903. Seesterne. Resultats du voyage du S. Y. *Belgica*. *Zoologie. Commission de la Belgica, Anvers*, 72 pages, 7 plates.  
1905. Asteroidea. Number 35 of Reports on an Exploration of the Eastern Tropical Pacific by the United States Steamer *Albatross*, During 1891, and Number 7 of Reports on Scientific Results of the Expedition to the Tropical Pacific by the United States Steam-  
er *Albatross* During 1899–1900. *Memoirs of the Museum of Comparative Zoology at Harvard*, 32: xii +292 pages, 35 plates.
1910. Notomyota, eine neue Ordnung der Seesterne. *Sitzungsberichte der Koniglich-Preussischen Akademie der Wissenschaften zu Berlin*, 23:435–466.
- Lutken, C. F.  
1859. Bidrag til kundskab om de ved kysterne af Mellen- og Syd-Amerika levende arten af sostjerner. I. *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 1859:25–97.  
1864. Kritiske bemaerkninger om forskjellige sostjerner (Asteriden), med beskrivelse af nogle nye arter. *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 8–12a: 135.  
1871. Forsatte kritiske og beskrivende bidrag til kundskab om sostjernerne (Asteriderne). *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 15–19:227–305, plates 4,5.  
1890. Nogle temmelig unventede foregelser af den Norske havfauna. *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 1899:358–362.
- Macan, T. T.  
1938. Asteroidea. In *Scientific Reports of the John Murray Expedition*, 4:323–435.
- Madsen, F. J.  
1947. The Echinoderms Collected by the *Skagerak* Expedition in the Eastern Atlantic, 1946. I. Asteroidea, Ophiuroidea, Echinoidea, and Holothuroidea. *Goteborgs Koniglichen Vetenskap och Vitterhets samlalles Handlingar*, series 6, 5B (7), 1947:61 pages, 4 figures.  
1950. The Echinoderms Collected by the *Atlantide* Expedition 1945–46. I. Asteroidea. With Remarks on Other Sea-Stars from Tropical and Northern West Africa. *Atlantide Reports*, 1:167–222, II figures, plates 14–16.  
1951. Asteroidea. In *Report of the Swedish Deep-Sea Expedition*, 2 (6):73–92, figures 1, 2.  
1958. On *Sphaeriodiscus placenta* and a Few Other Sea-Stars from West Africa. *Bulletin de l'Institut Francaise de Afrique Noire*, 20A:90–94, 4 figures.  
1959. On Some Linnean and Mullerian Types of Echinoderms in the Zoological Museum of Copenhagen. *Videnskabelige Meddelelser fra den Naturhistorisk Forening i Kjobenhavn*, 121:161–170, 6 figures.  
1961. The Porcellanasteridae: A Monographic Revision of an Abyssal Group of Sea-Stars. In *Galathea Report*, 4:33–174, 13 plates.
- Mangold, E.  
1909. Sinnesphysiologische Studien an Echinodermen. Ihre Reaktion auf Licht und Schatten und die Negative Geotaxis bei *Asterina*. *Zeitschrift fur Allgemeine Physiologie*, 9:112–146.
- Marenzeller, E. von  
1875. Revision der Adriatischer Seesterne. *Verhandlungen der Kaiserlich-Koniglichen Zoologisch-Botanischen Gesellschaft in Wien*, 25: 14 pages.  
1891. Echinoderma. In F. Steindachner, *Veroffentliche der Commission fur Erforschung des Ostlichen Mittel-*

- meeres. Vorläufiger Bericht über die Zoologischen Arbeiten in Sommer 1891. *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften*, 100:435-447.
1893. Zoologische Ergebnisse. I. Echinodermen Gessammelt 1890, 1891, und 1892. *Denkschriften der Kaiserlichen Akademie der Wissenschaften zu Wien*, 60: 24 pages, 4 plates.
1895. Berichte der Commission für Erforschung des Ostlichen Mittelmeeres; Zoologische Ergebnisse. 5. Echinodermen Gessammelt 1893, 1894. *Denkschriften der Kaiserlichen Akademie der Wissenschaften zu Wien*, 62: 25 pages, 1 plate.
- Martens, E. von  
1866. Über Ostasiatische Echinodermen. 3. Seesterne des Indischen Archipels. *Archiv für Naturgeschichte*, 31 (1):57-88.
- Meissner, M.  
1904. Asteroideen. *Ergebnisse der Hamburger Magalhaensische Sammebreise*, 7 (1): 28 pages, 1 plate.
- Michailovskij, M.  
1903. *Zoologische Ergebnisse der Russischen Expeditionen nach Spitzbergen. Echinoderm*. vii+460-546 pages. St. Petersburg: Annuaire Museum.
- Moore, D. R.  
1960. *Linckia bullisi*, a New Asteroid from the Northeast Coast of South America. *Bulletin of Marine Science of the Gulf and Caribbean*, 10:414-416, 1 figure.
- Mortensen, Th.  
1924. Observations on Some Echinoderms from the Trondhjem Fjord. *Det Kongelige Norske Videnskabers Selskabs Skrifter*, 1923 (3), 22 pages.  
1927. *Echinoderms of the British Isles*. 471 pages, 269 figures. Oxford University Press.  
1933a. Papers from Dr. Th. Mortensen's Pacific Expedition 1914-16. 66. The Echinoderms of St. Helena (other than Crinoids). *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 93:401-472, 29 figures, plates 20-22.  
1933b. Papers from Dr. Th. Mortensen's Pacific Expedition 1914-16. Echinoderms of South Africa (Asteroidea and Ophiuroidea). *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjobenhavn*, 93:215-400, 91 figures, plates viii-xix.  
1938. Contributions to the Study of the Development and Larval Forms of Echinoderms. IV. *Det Kongelige Danske Videnskabernes Selskabs Skrifter*, series 9, 7 (3): 59 pages, 30 figures, 12 plates.  
1939. Report on the Echinoidea of the Murray Expedition. Part I. *Scientific Report John Murray Expedition, London*, 6 (1939): 28 pages, 10 figures, 6 plates.  
1944. Echinoderms from the Iranian Gulf. Asteroidea, Ophiuroidea, and Echinoidea. *Danish Scientific Investigations in Iran*, 2 (1940):55-110, 24 figures, 2 plates.
- Muller, J., and F. H. Troschel  
1840. [Not seen, title unknown] *Monatsberichte der Koniglichen Preuss. Akademie Wissenschaften*, p. 102.
1842. *System der Asteriden*. 134 pages, 12 plates. Braunschweig: Friedrich Vieweg und Sohn.
- Nardo, J. D.  
1834. De Asteriis. *Oken's Isis*, heft iii: 716,717.
- Nichols, A. R.  
1903. A List of Irish Echinoderms. *Proceedings of the Royal Irish Academy*, 24 (B):231-267.
- Nobre, A.  
1931. *Echinoderms de Portugal*. 176 pages, 14 plates, figures. Universidad do Porto: Instituto Zoologico.
- Norman, A. M.  
1865. On the Genera and Species of British Echinodermata. Part I. Crinoidea-Ophiuroidea-Asteroidea. *Annals and Magazine of Natural History*, (3) 15: 98-129.
- Nutting, C. C.  
1895. Narrative and Preliminary Report of Bahama Expedition. In *Bulletin of the Laboratories of Natural History, State University of Iowa*, 3 (1,2): 251 pages.
- d'Orbigny, A. D.  
1850. *Prodrome de palaeontology stratigraphique universelle des animaux mollusques et rayonnees, faisant seinte au cours elementaire de paleontologie*, volume 1.
- Pearse, J. S.  
1969. Slow Developing Demersal Embryos and Larvae of the Antarctic Sea Star *Odontaster validus*. *International Journal on Life in Oceans and Coastal Waters*, 3, (2):110-116.
- Pennant, T.  
1777. *British Zoology*. Volume iv, illustrated. Warrington and London.
- Perrier, E.  
1869. *Recherches sur les pedicellaires et les ambulacres des asteries et des oursins*. 188 pages, 7 plates. Paris: Victor Masson et Fils.  
1875a. Sur la Classification et la synonymie des stellerides. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 81:1271-1273.  
1875b. Revision de la collection de stellerides du Museum d'Histoire Naturelle de Paris (Asteroidea, Echinasteridae, Ophiasteridae). *Archives de Zoologie Experimentale*, 4, 5: 384 pages.  
1875c. Revision de la collection de stellerides du Museum d'Histoire Naturelle de Paris. *Archives de Zoologie Experimentale et Generale*, 4:265-450.  
1876a. Revision de la collection de stellerides du Museum d'Histoire Naturelle de Paris. *Archives de Zoologie Experimentale et Generale*, 5:304 pages.  
1876b. On the Classification and Synonymy of the Stellerida. *Annals and Magazine of Natural History*, series 4, 17:259-261.  
1876c. Les Stellerides des Iles du Cap-Vert. *Bulletin de la Societe Zoologique de France*, 1:63-71.  
1878. Etude sur la repartition geographique des Asterides. *Nouvelles Archives du Museum d'Histoire Naturelle*, series 2, 1: 108 pages.  
1880. Les Etoiles de mer des region profondes du Golfe du Mexique. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 91:436-439.

- 1881a. Report on the Results of Dredging in the Gulf of Mexico, and in the Caribbean Sea, 1877-79, by the United States Coastal Survey Steamer *Blake*. 14. Description Sommaire des Especies Nouvelles d'Asteries. *Bulletin of the Museum of Comparative Zoology at Harvard*, 9 (1): 31 pages.
- 1881b. Sur les Etoiles de mer, dragues dans les regions profondes du Golfe du Mexique, et al Mer des Antilles par le navire *The Blake*. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 92:59-61.
1884. Memoire sur les étoiles de mer recueillis dans la Mer des Antilles et la Golfe du Mexique durant les expeditions de dragage faites sous la direction de M. Alexandre Agassiz. *Nouvelles Archives du Museum d'Histoire Naturelle*, series 2, 6:127-276, 9 plates.
- 1885a. Sur les stellerides recueillis durant la mission du *Talisman*. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 101:884-887.
- 1885b. Note preliminaire sur les echinodermes, recueilles par *Travailleur* et la *Talisman*. *Nouvelles Archives du Museum d'Histoire Naturelle*, series 2, 6:154.
- 1885c. Premiere note preliminaire sur les echinodermes recueilles durant les campagnes de dragages sous-marins du *Travailleur* et du *Talisman*. *Annales des Sciences Naturelles*, series 6, 19 (8): 72 pages.
- 1891a. Stellerides nouveaux provenant des campagnes du yacht *l'Hirondelle*. *Memoires de la Societe Zoologique de France*, 4:258-271.
- 1891b. Sur les stellerides recueilles dans le Golfe de Gascogne, aux Acores et a Terre-Neuve Pendant les campagnes scientifiques du Yacht *l'Hirondelle*. *Comptes-Rendus Hebdomadaires des Seances de l'Academie des Sciences*, 112 (21):1225-1228.
- 1891c. Echinodermes de la mission scientifique du Cape Horn: I. Stellerides. In *Mission Scientifique du Cape Horn*, Zoologie, 4: 198 pages, 13 plates.
1894. Echinodermes. I. Stellerides. In *Expeditions Scientifique de Travailleur et du Talisman*, 3: 432 pages, 26 plates.
1896. Contribution a l'etude des stellerides de l'Atlantique Nord (Golfe de Gascogne, Acores, Terre-Neuve). *Resultats des Campagnes Scientifiques du Prince de Monaco*, fasc. II, viii + 73 pages, plates 1, 1c.
- Philippi, A.  
1837. Ueber die mit *Asterias auranciaca* Verwandten und Verwechselten Asterien der Sicilianschen Kuste. *Archiv fur Naturoeschichte*, 3:193,194.
- Pope, E.  
1967. Lesser Known Echinoderms of the Great Barrier Reef. *Australian Natural History*, 15:310-314, 8 figures.
- Rathbun, R.  
1879. A List of the Brazilian Echinoderms, with Notes on Their Distribution. *Transactions of the Connecticut Academy of Arts and Sciences*, 5 (3):139-158.
- Retzius, A. J.  
1783. Anmärkningur vid Asteriae Genus. *Goteborgs Konglige Vetenskaps och Vitterhets samhalles Handlingar*, 4:234-244.
1805. *Dissertatio Sistens, Species Cognitas Asteriarum*. 37 pages. Lundae.
- Richters, C.  
1912. Kenntnis der Regenerationsvorgange bei *Linckia*. *Zeitschrift fur Wissenschaftliche Zoologie (Leipzig)*, 100:116-175, 42 figures.
- Roa, E. Z. de  
1967. Contribucion al estudio de los equinodermos de Venezuela. *Acta Biologica Venezuelica*, 5:267-333, 29 figures.
- Rivera, V.  
1930. Algunos asteridos de Espana. *Boletin de la Sociedad Espanolade Historia Natural (Madrid)*, 30:101-112.
- Russo, A.  
1894. Echinodermi raccolti nel Mar Rosso degli ufficiali della R. Marine Italiana. *Bollettino della Societa di Naturalisti in Napoli*, 7:159-168.
- Sars, G. O.  
1875. On Some Remarkable Forms of Animal Life from the Great Deeps off the Norwegian Coast. II. Researches on the Structure and Affinities of the Genus *Brisinga*, Based on the Study of a New Species, *B. coronata*. *Christiania [University thesis]*, 111 pages, 7 plates.
- Say, T.  
1825. On the Species of the Linnaean Genus *Asterias* Inhabiting the Coast of the United States. *Journal of the Academy of Natural Sciences, Philadelphia*, series 1, 5:151-154.
- Schmidt, J.  
1904. Fiskeriundersogelser ved island og Faeroerne i sommeren 1903. *Skrifter udgivet af Kommissionen Havundersogelser, Kobenhavn*, 1: 148 pages, 21 figures.
- Schulze, C. F.  
1760. *Betrachtung der Versteinerten Seesterne und ihre Theile*. vi + 58 pages, 2 plates.
- Seba, A.  
1761. *Locupletissimi rerum naturalium thesauri accurata descriptio. . . historium*. Volume 3, 212 pages, 116 plates.
- Sladen, W. P.  
1882. Asteroidea Dredged During the Cruise of the *Knight Errant* in July and August, 1880. *Proceedings of the Royal Society of Edinburgh*, 1881-1882: 698-707.
1884. The Asteroidea. In T. Tizard, et al., Narrative of the Cruise of H.M.S. *Challenger* with a General Account of the Scientific Results of the Expedition. In *Report . . . Challenger Narrative*, 1 (2):607-617.
1889. Report on the Asteroidea. No. 30 in Zoology in *Report on the Scientific Results of the Voyage of H.M.S. Challenger During the Years 1873-76*. xlii + 893 pages, 117 plates.
1891. Report on a Collection of Echinodermata from the Southwest Coast of Ireland. *Proceedings of the Royal Irish Academy*, series 3, 1:687-704, plates 25-29.
- Sluiter, C. P.  
1895. Die Asteriden Sammlung des Museums zu Amster-

- dam. *Bijdragen tot de Dierkunde uitgeven door het Genootschap Nature Artis Magistra*, 17:51-64.
- Spencer, W. K.  
1951. Early Palaeozoic Starfish. *Philosophical Transactions of the Royal Society of London*, series B, 235 (623):87-129, plates 2-8.
- Spencer, W. K., and C. W. Wright  
1966. Asterozoans. Part U, *Echinodermata*, in R. C. Moore, editor, *Treatise on Invertebrate Paleontology*, 3 (1):4-107, 89 figures.
- Stanek, V. J.  
1960. *La Beauté de la nature*. 373 pages, illustrated. Prague: Artia.
- Stimpson, W.  
1851. On the Marine Fauna of the Bay of Fundy. *Proceedings of the Boston Society of Natural History*, 4:95-100.
- Storm, V.  
1881. Bidrag til kundskab om Thronhjemsfjordens fauna. 3. *Det Kongelige Norske Videnskabers Selskabs Skrifter*, 1879:73-96.  
1888. *Solaster echinatus*, n. sp. illigemed oversigt over dei Thronhjemsfjorden fundne Asteroidea. *Det Kongelige Norske Videnskabers Selskabs Skrifter*, 1886-1887: 58-64.  
1901. Oversigt over Thronhjems-fjordens fauna. Trondhjems Biologiske Station. *Medd. Stationsanlaeggets arbejdskomite 1901*, 20 pages [printed for private circulation].
- Stossich, M.  
1883. Prospetto delle fauna del Mare Adriatico, Part 5. *Boletino della Societa Adriatica di Scienze Naturali in Trieste*, 8:171-192.
- Strenger, A.  
1963. Echinodermata. In R. Reidl, editor, *Fauna und Flora der Adriatica*. Pages 446-472, plates 159-165, color plate 7. Hamburg: Verlag Paul Parey.
- Studer, T.  
1884. Verzeichniss der Warkund der Reise SMS *Gazelle* um die Erde 1874-76, Gesammelten Asteriden und Euryaliden. *Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin*, 1884, 64 pages, 5 plates.  
1885. Die Seesterne Sud-Georgiens nach der Ausbeute der Deutschen Polarstation in 1882 and 1883. *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten*, 2:143-166, plates 1, 2.
- Tennant, D. H., and V. H. Keiller.  
1914. The Anatomy of *Pentaceros reticulatus*. *Carnegie Institution of Washington, Publication 132* [Papers of the Tortugas Laboratory, number 3] 1911:111-116, plates 1-3.
- Thomas, L. P.  
1960. A Note on the Feeding Habits of the West Indian Sea Star *Oreaster reticulatus* (L.). *Quarterly Journal of the Florida Academy of Science*, 23:167,168.
- Thomson, C. W.  
1873. *The Depths of the Sea*. xx + 527 pages, 83 plates, 8 maps. London: MacMillan and Co.
- Tokioka, T.  
1942. A Gigantic Bipinnaria (*Bipinnaria setoensis*, n. sp.) from Seto. *Annotationes Zoologicae Japonenses*, 21 (3):152-154, 8 figures.
- Tommasi, L. R.  
1958. Os equinodermos do litoral de São Paulo. II. Diademataidae, Schizasteridae, Brissidae, Cidaroida (Echinoidea) e Asteroidea do Bentos Costeiro. *Contribucoes avulsas do Instituto Oceanografico*, São Paulo, 2: 27 pages, 6 plates.  
1959. Equinodermos de estado do Rio de Janeiro. I. Crinoidea, Asteroidea, Echinoidea e Holothuroidea de Regiao Compreendida Entra Cabo dos Buzios e Cabo Frio. *Anais Academia Brasileira Ciencias*, 31: 601-604.  
1966. Distribucao geografica de alguns equinodermos do Brasil. *Revista Brasileira Biologia*, 26:239-246.  
1970. Lista dos asteroides recentes do Brasil. *Contribucoes Avulsas do Instituto Oceanografico, Universidade de Sao Paulo*, 18: 61 pages, 38 plates.
- Tortonese, E.  
1935. Gli echinodermi dei Mari Italiani. *Atti Societa Italia Milano*, 75:277-294.  
1937. Gli echinodermi del Museo di Torino. Part 3. Asteroidi. *Bolletino dei Musei di Zoologia ed Anatomia Comparata della R. Universita di Torino*, 45:27-132, 11 plates.  
1938. Echinodermi raccolti presso le costa della Libia. *Bolletino dei Musei di Zoologia ed Anatomia Comparata della R. Universita dei Torino*, 9:265-277.  
1952. Gli echinodermi del Mar Ligure e della Zone Vicine. *Atti dell' Accademia dei Ligure*, 8:163-242, 10 figures, 1 plate.  
1958. Euclasteroidea: Nuovo ordine di asteroidi (echinodermi). *Doriana*, 2 (88): 3 pages.  
1965. Echinodermata. In *Fauna d'Italia*. Edizioni Calderini, Volume VI, 419 pages, 186 figures. Bologna.
- Tortonese, E., and A. M. Clark  
1956. On the Generic Position of the Asteroid *Goniodiscus placenta* Muller and Troschel. *Annals and Magazine of Natural History*, series 12, 9:347-352, 2 figures, 1 plate.
- Ulrey, A. B.  
1918. The Starfishes of Southern California. *Bulletin of the Southern California Academy of Science*, Los Angeles, 17:39-51, 13 plates.
- Ummels, F.  
1963. Asteroids from the Netherlands Antilles and Other Caribbean Localities (Oreasteridae, Ophidiasteridae, Asterinidae, Luidiidae). *Studies on the Fauna of Curacao*, 15:72-101, 3 figures, plates 3-11.
- Utinomi, H.  
1959. *Coloured Illustrations of Seashore Animals of Japan*. xvii + 227 pages, volume 167, 64 colored plates, figures. Osaka: Hoikushi. [Fauna and Flora of Japan, Number 8. In Japanese. Echinodermata on pages 105-122, placts 53-61.]
- Verrill, A. E.  
1866. On the Polyps and Echinoderms of New England,

- with Descriptions of New Species. *Proceedings of the Boston Society of Natural History*, 10:333-375.
1867. Notes on Radiata. *Transactions of the Connecticut Academy of Arts and Sciences*, 1 (2):247-613, plates 4-10.
1868. Notice of the Corals and Echinoderms Collected by Prof. C. F. Hartt, at the Abrolhos Reef, Province of Bahia, Brazil, in 1867, No. 4. *Transactions of the Connecticut Academy of Arts and Sciences*, 1:351-371, plate 4.
1869. On New and Imperfectly Known Echinoderms and Corals. *Proceedings of the Boston Society of Natural History*, xii:381-396.
1871. Brief Contributions to Zoology from the Museum of Yale College, No. 15: Descriptions of Starfishes and Ophiurans from the Atlantic Coasts of America and Africa. *American Journal of Science*, 2:130-133.
1878. Notice of Recent Additions to the Marine Fauna of the Eastern Coast of North America, nos. 1 and 2. *American Journal of Science and Arts* (3), 16: 207-215, 371-378.
1880. Notice of Recent Additions to the Marine Invertebrata of the Northeastern Coast of America, with Description of New Genera and Species and Critical Remarks on Others. *Proceedings of the United States National Museum*, 2:165-205.
1882. Brief Contributions to Zoology from the Museum of Yale College, No. 49: Notice on the Remarkable Marine Fauna Occupying the Outer Banks off the Southern Coast of New England, No. 3. *American Journal of Science*, 23:135-142.
1884. Notice of the Remarkable Marine Fauna Occupying the Outer Banks off the Southern Coast of New England, and of Some Additions to the Fauna of Vineyard Sound. *Annual Report of the United States Commissioner of Fish and Fisheries for 1882*, 26 pages.
1885. Results of the Explorations Made by the Steamer *Albatross* off the Northern Coast of the United States in 1883. *Annual Report of the Commissioner for Fish and Fisheries for 1883*: 107 pages, (503-699), 44 plates.
1894. Descriptions of New Species of Starfishes and Ophiurans, with a Revision of Certain Species Formerly Described. *Proceedings of the United States National Museum*, 17:243-297.
1895. Distribution of the Echinoderms of Northeastern America. *American Journal of Science*, 49:127-141, 199-212.
1899. Revision of Certain Genera and Species of Starfishes. *Transactions of the Connecticut Academy of Arts and Sciences*, 10:145-234, plates 24-30.
1901. Additions to the Fauna of the Bermudas from the Yale Expedition of 1901. *Transactions of the Connecticut Academy of Arts and Science*, 11:15-62.
1902. Additions to the Fauna of the Bermudas from the Yale Expedition of 1901, with Notes on other Species. *Transactions of the Connecticut Academy of Arts and Sciences*, 11:15-62, 9 plates, 6 figures.
1907. The Bermuda Islands. Part 4, Geology and Paleontology; Part 5, An Account of the Coral Reefs. *Transactions of the Connecticut Academy of Arts and Sciences*, 12:45-348, plates 16-40.
1909. Remarkable Development of Starfishes on the Northwest American Coast; Hybridism; Multiplicity of Rays; Teratology; Problems in Evolution; Geographical Distribution. *American Naturalist*, 43: 542-555.
1914. Monograph of the Shallow-Water Starfishes of the North Pacific Coast, from the Arctic Ocean to California, with Revisions of Various Extra-Limital Genera and Species. *Harriman Alaska Series*, 14: 420 pages, 110 plates.
1915. Report on the Starfishes of the West Indies, Florida, and Brazil, Including Those Obtained by the Bahama Expedition from the University of Iowa in 1893. *Bulletin of the State of University of Iowa*, 7: 232 pages, 29 plates.
- Vevers, H. G.  
1956. Observations on Feeding Mechanisms in Some Echinoderms. *Proceedings of the Zoological Society of London*, 126:484-485.
- Viguier, C.  
1879. Anatomie Comparee du Squelette des Stellerides. *Archives de Zoologie Experimentale et Generale*, 7: 33-250, plates 5-16.
- Whitelegge, T.  
1897. The Echinodermata of Funafuti. (In The Atoll of Funafuti . . . Based on Collections Made by Mr. Charles Hedley, etc. Part 2). *Memoirs of the Australian Museum*, 3:155-162.
- Wilson, D. P.  
1955. In *Illustrated London News*, 227:2-4.
- Wood-Mason, J., and A. Alcock.  
1891. Natural History Notes from H. M. Marine Survey Steamer *Investigator*. *Annals and Magazine of Natural History*, series 6, 7:12-15, 427-433.

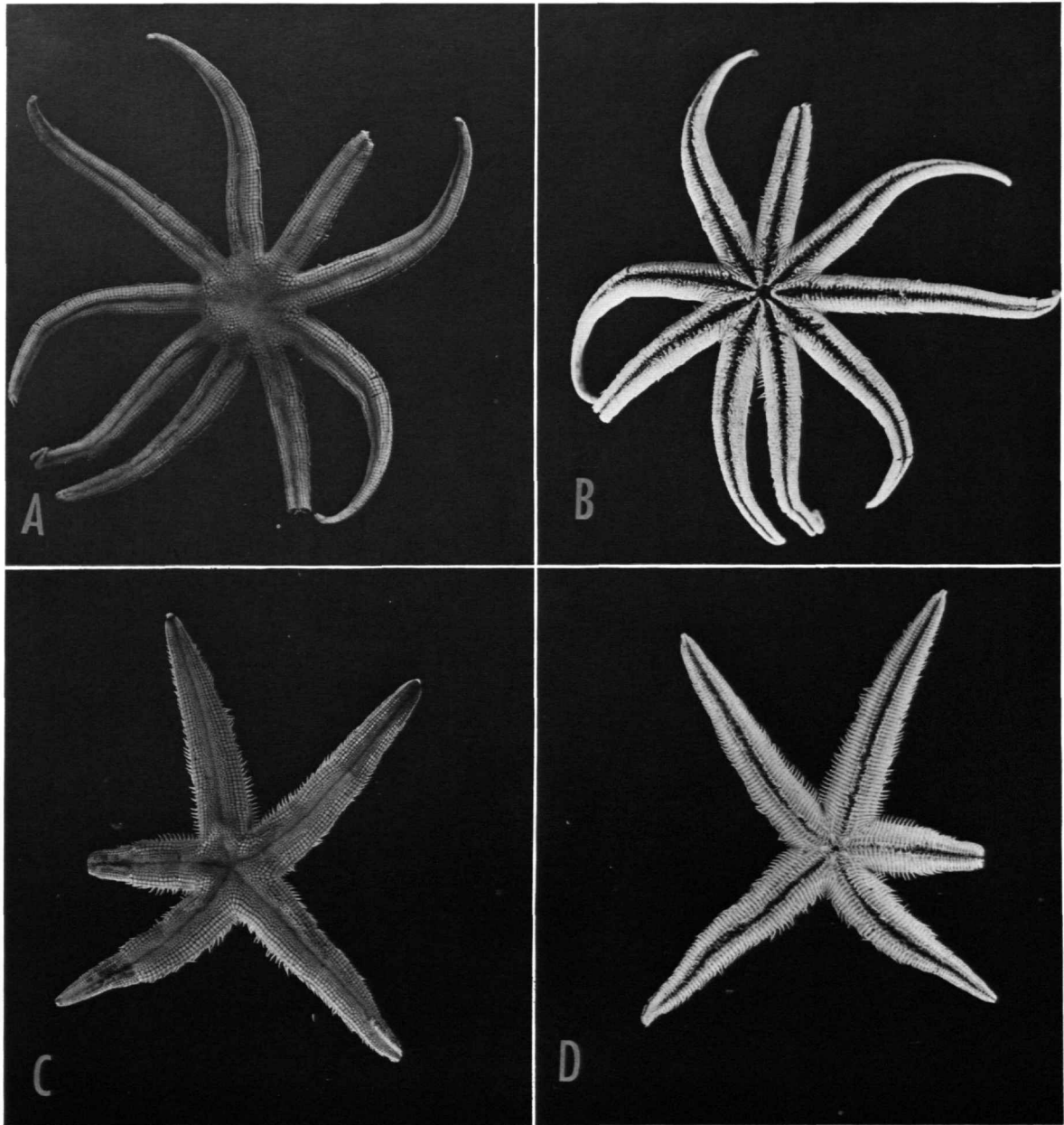


PLATE 1.—A, *Luidia senegalensis*, abactinal; B, same, actinal (actual size=50 mm R); C, *Luidia clathrata*, abactinal; D, same, actinal (actual size= 77 mm R).

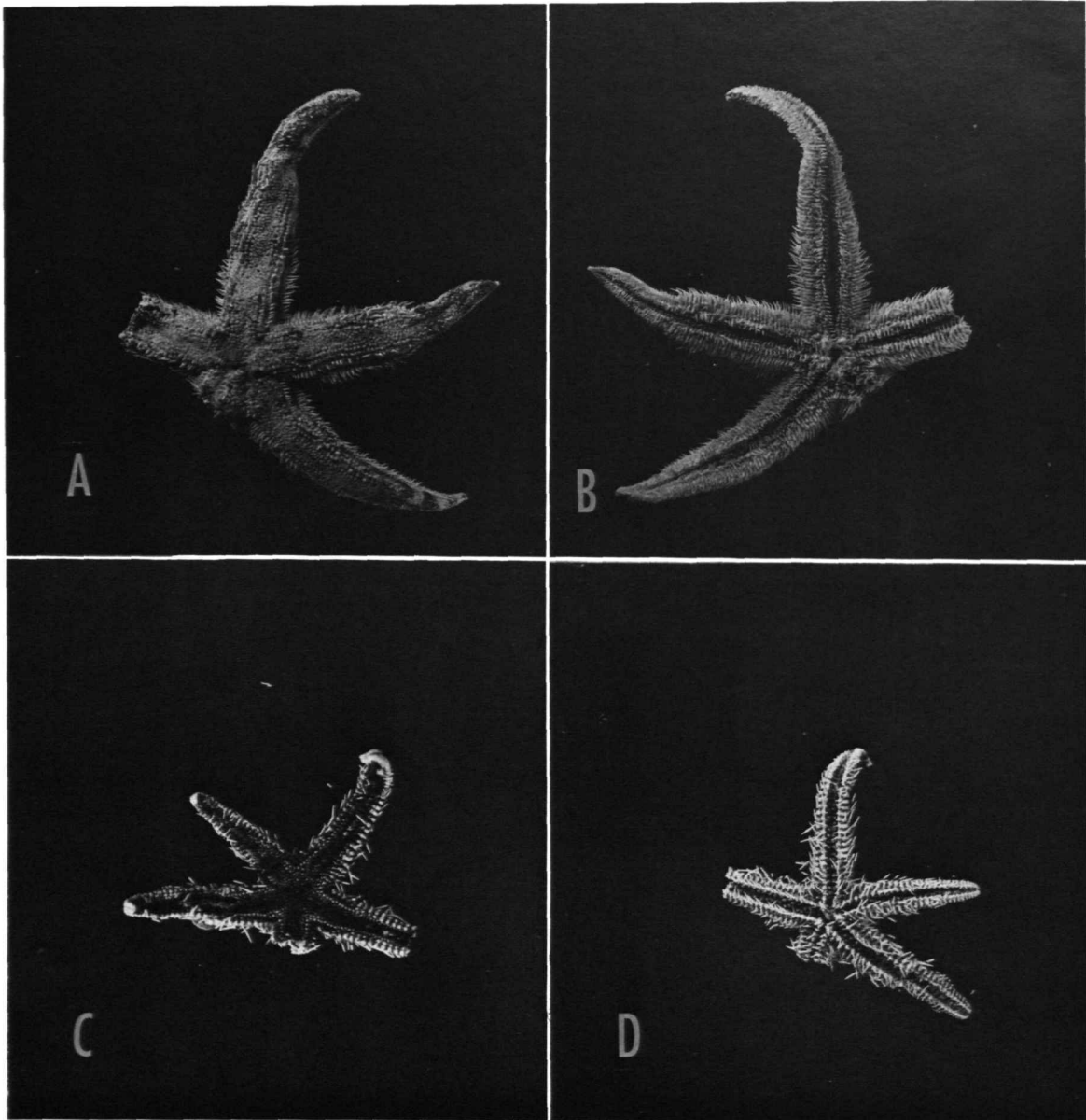


PLATE 2.—A, *Luidia alternata*, abactinal; B, same, actinal (actual size=115 mm R); C, *Luidia sagamina*, abactinal; D, same, actinal (actual size=8 mm R).



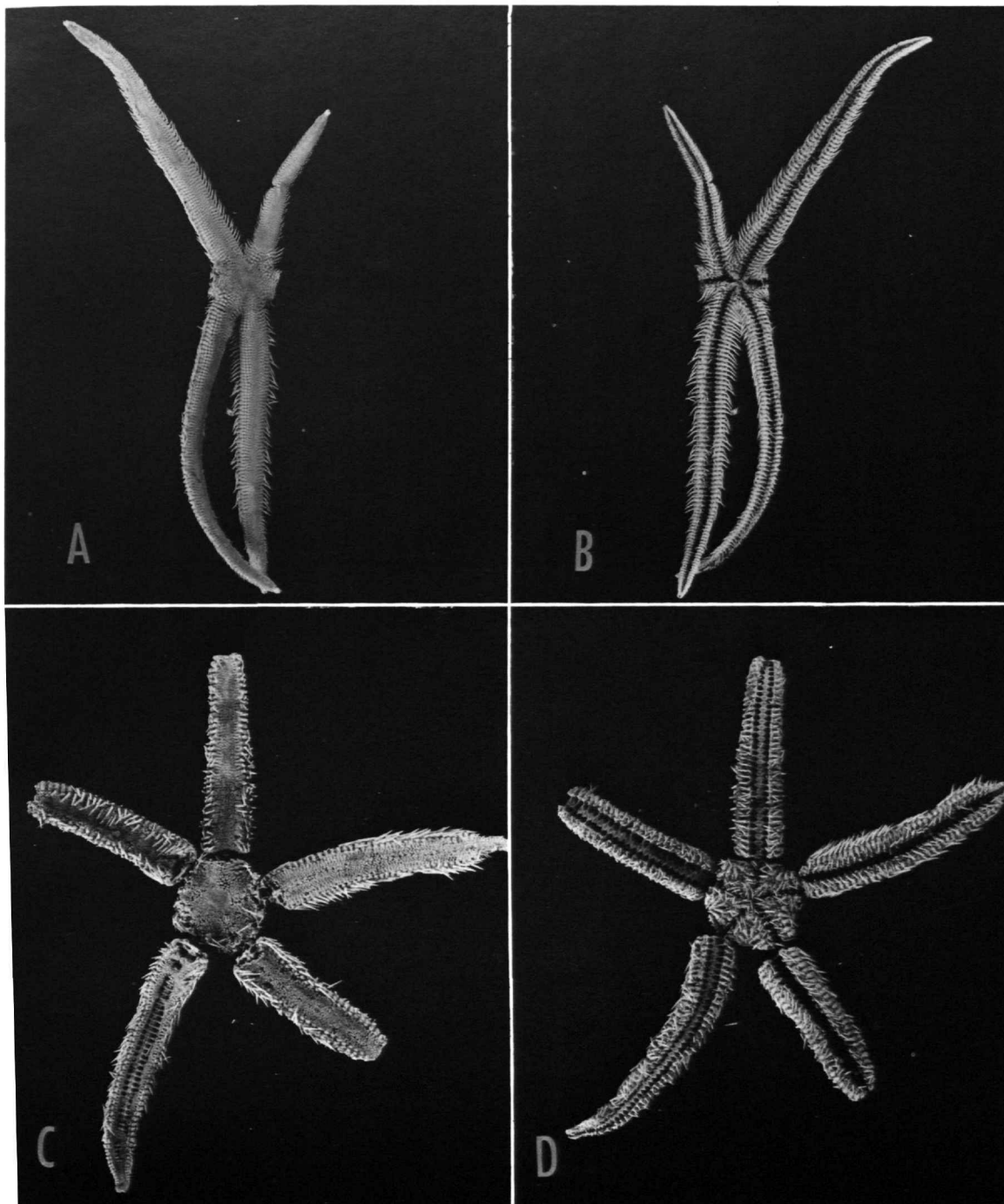


PLATE 3.—A, *Luida barbadensis*, abactinal; B, same, actinal (actual size = 75 mm R); C, *Luidia elegans*, abactinal; D, same, actinal (actual size = 77 mm R).

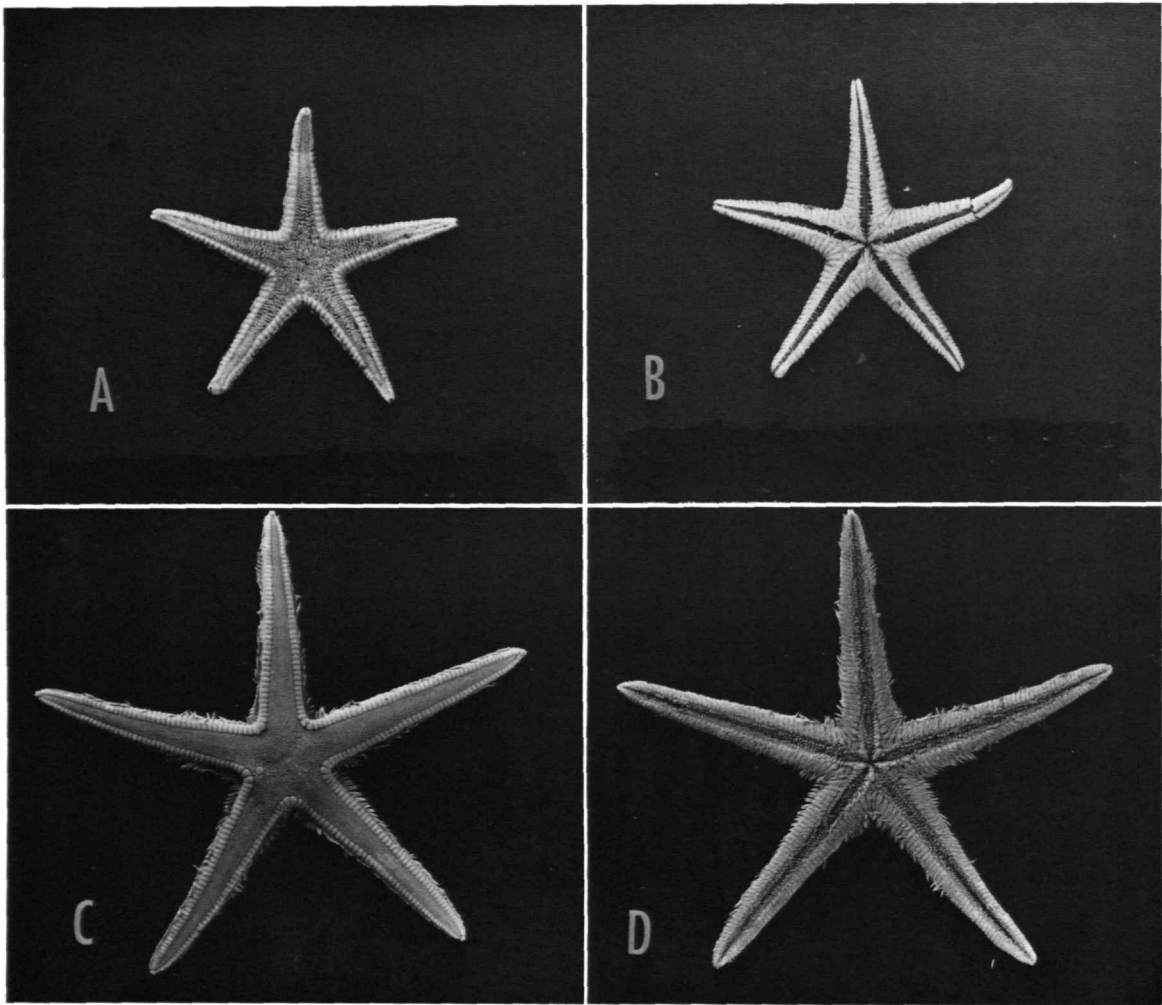


PLATE 4.—A, *Astropecten americanus*, abactinal; B, same, actinal (actual size=72 mm R); C, *Astropecten articulatus*, abactinal; D, same, actinal (actual size=84 mm R).

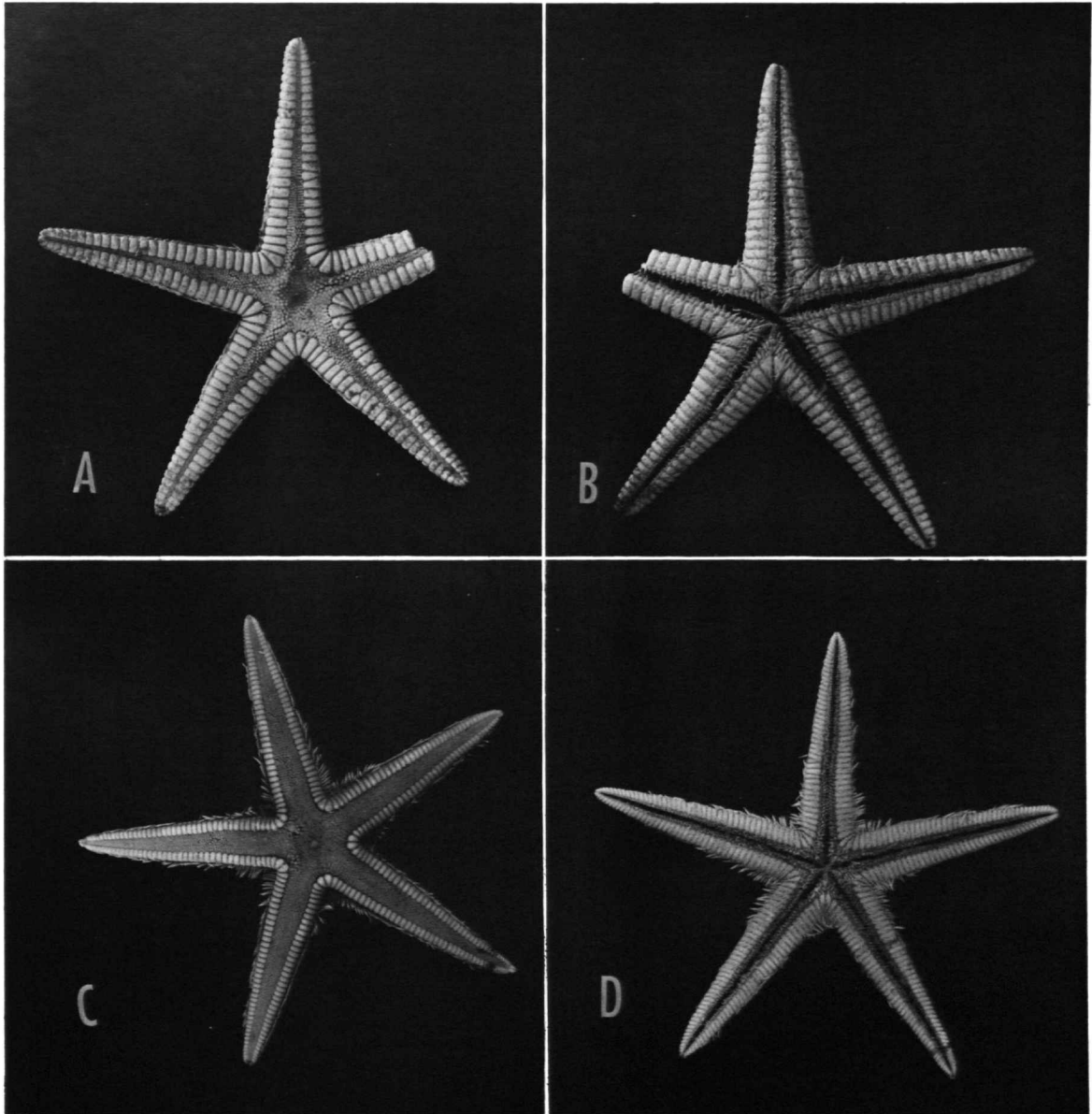


PLATE 5.—A, *Astropecten cingulatus*, abactinal; B, same, actinal (actual size=31 mm R); C, *Astropecten comptus*, abactinal; D, same, actinal (actual size=61 mm R).

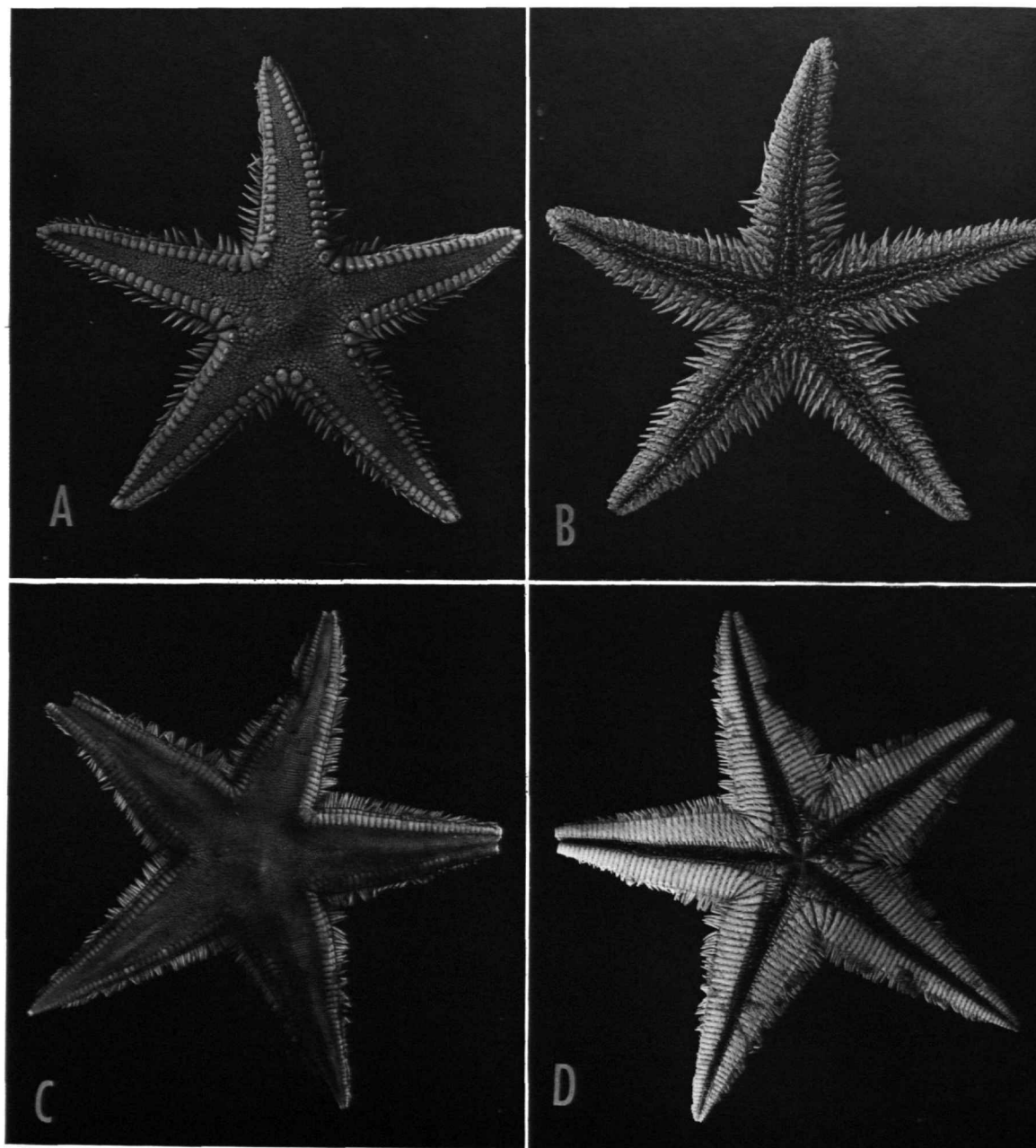


PLATE 6.—A, *Astropecten duplicatus*, abactinal; B, same, actinal (actual size=45 mm R); C, *Astropecten marginatus*, abactinal; D, same, actinal (actual size=55 mm R).

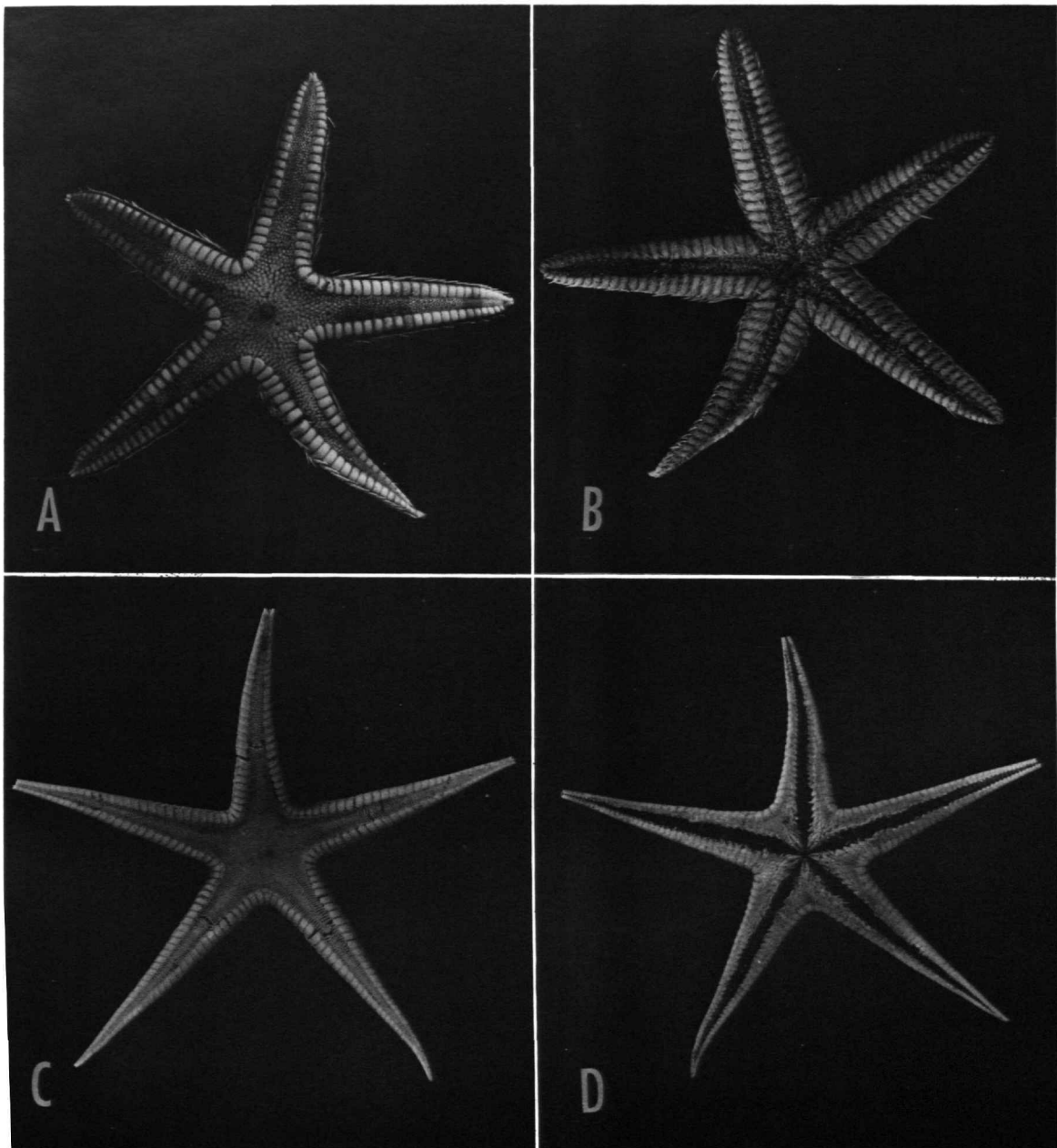


PLATE 7.—A, *Astropecten nitidus*, abactinal; B, same, actinal (actual size=40 mm R); C, *Psilaster cassiope*, abactinal; D, same, actinal (actual size=82 mm R).

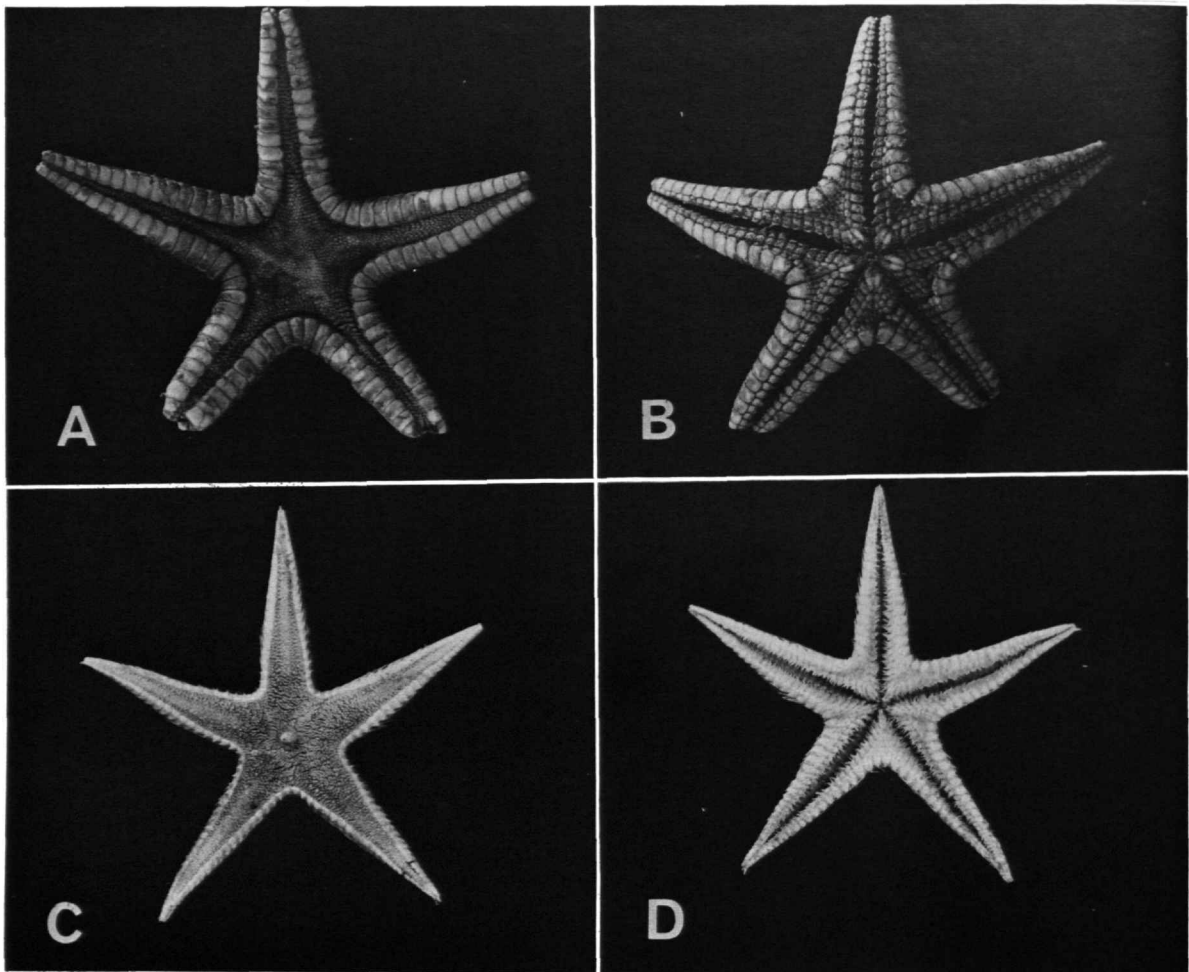


PLATE 8.—A, *Psilaster patagiatus*, abactinal; B, same, actinal (actual size=64 mm R); C, *Persephonaster echinulatus*, abactinal; D, same, actinal (actual size=45 mm R).

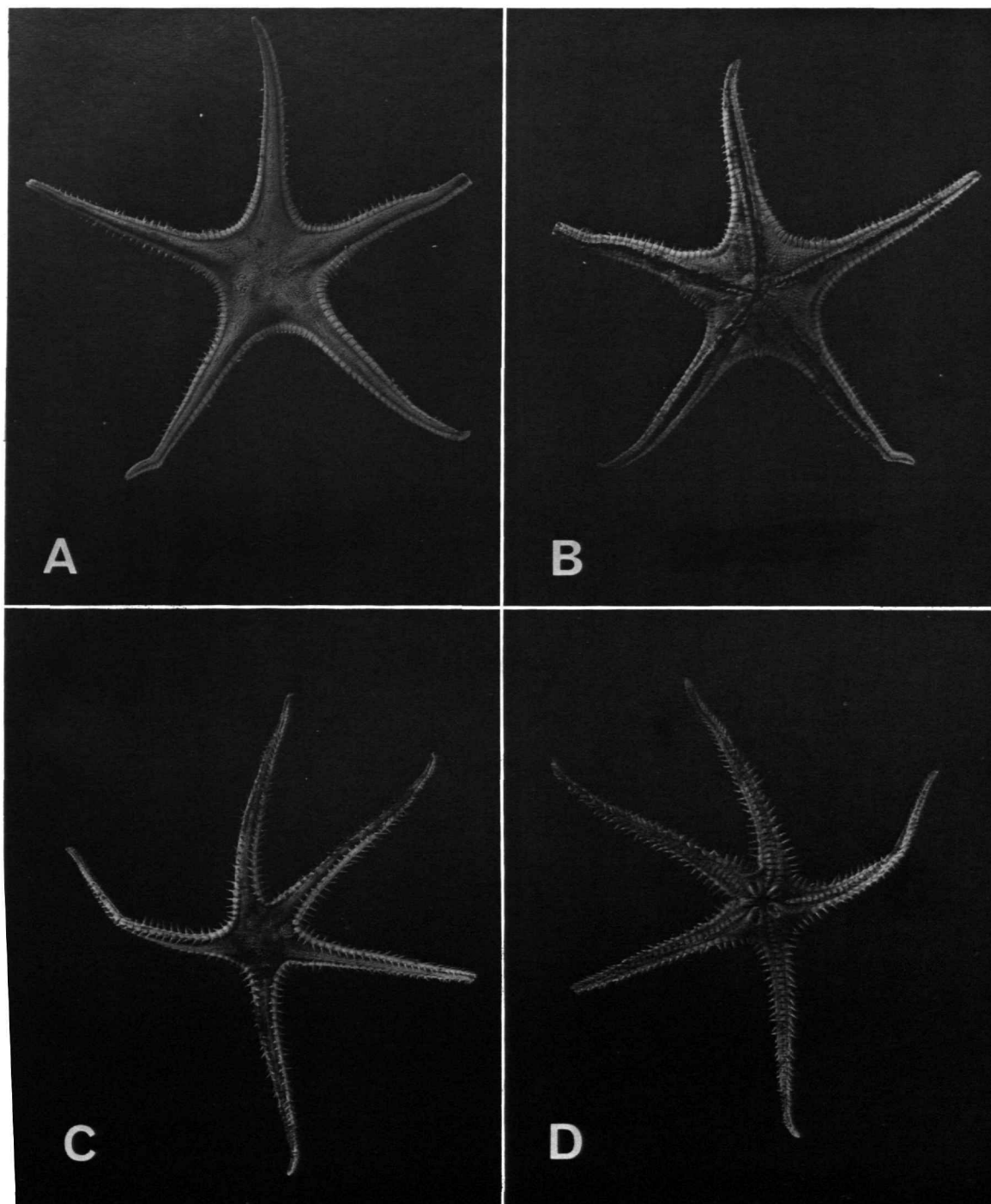


PLATE 9.—A, *Plutonaster intermedius*, abactinal; B, same, actinal (actual size=111 mm R);  
C, *Dytaster insignis*, abactinal; D, same, actinal (actual size=86 mm R).

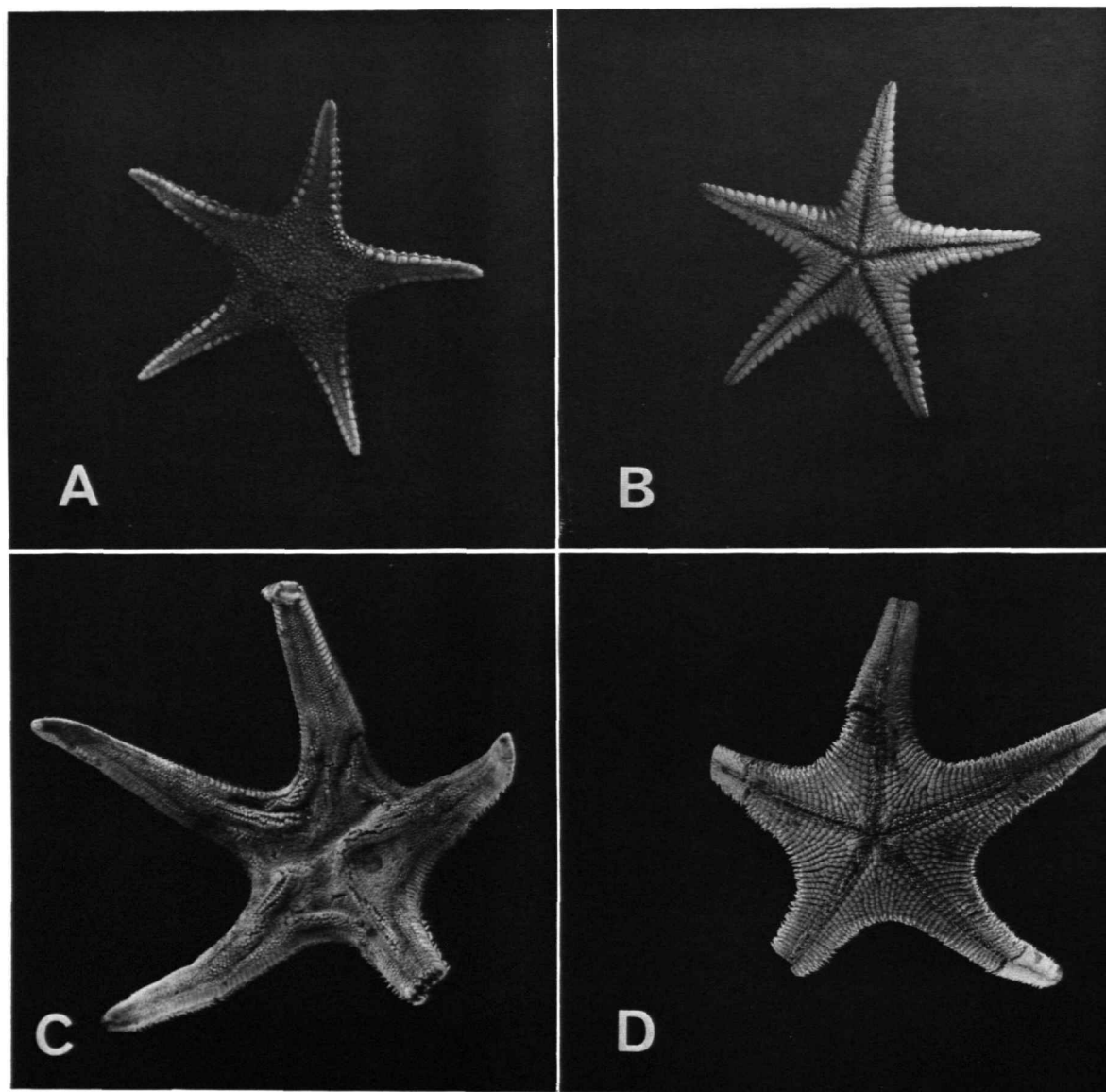


PLATE 10.—A, *Blakiaster conicus*, abactinal; B, same, actinal (actual size=26.5 mm R); C, *Tethyaster grandis*, abactinal; D, same, actinal (actual size=105 mm R).



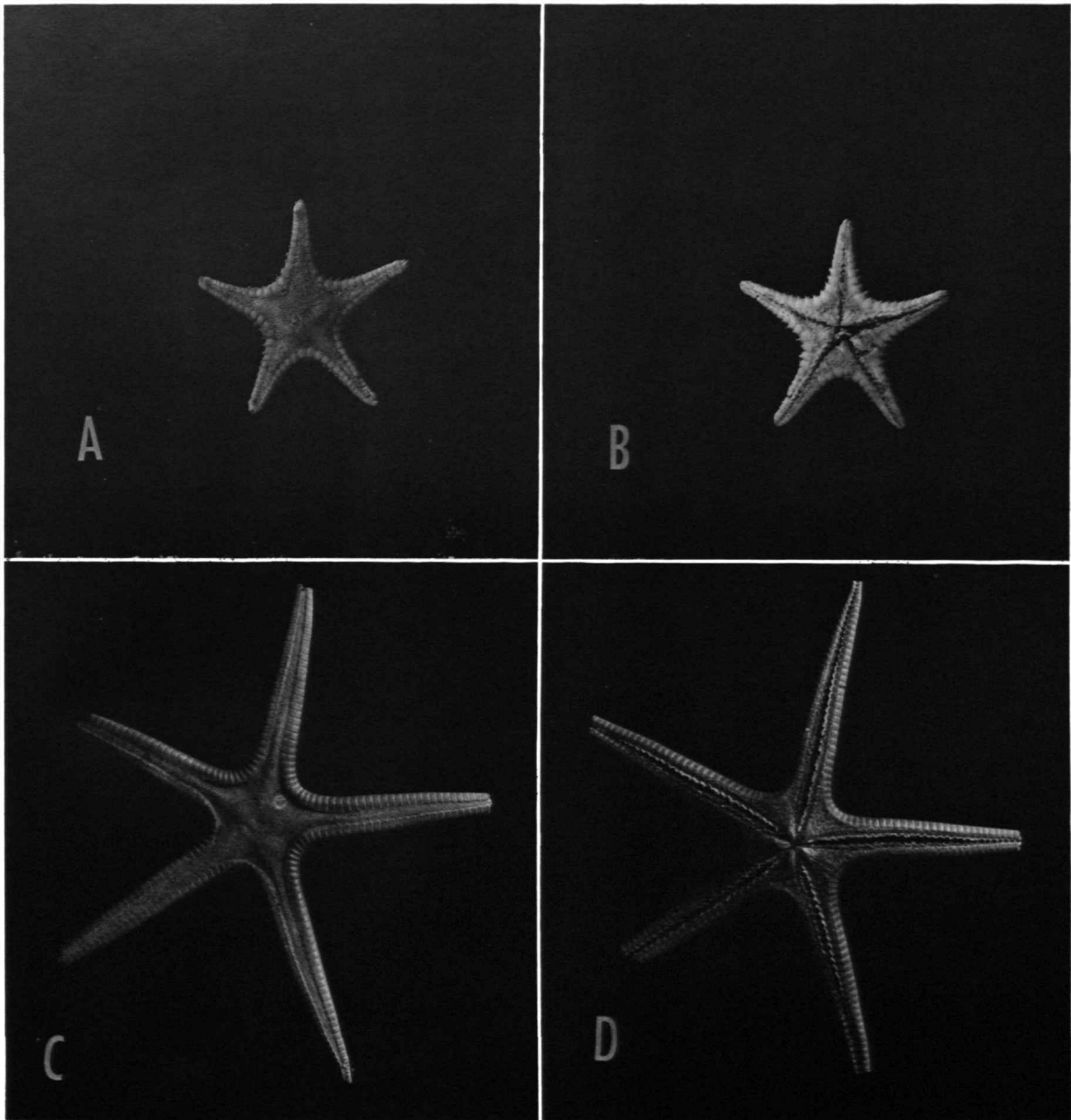


PLATE 11.—A, *Dipsacaster antillensis*, abactinal; B, same, actinal (actual size=12 mm R); C, *Goniopecten demonstrans*, abactinal; D, same, actinal (actual size=138 mm R).

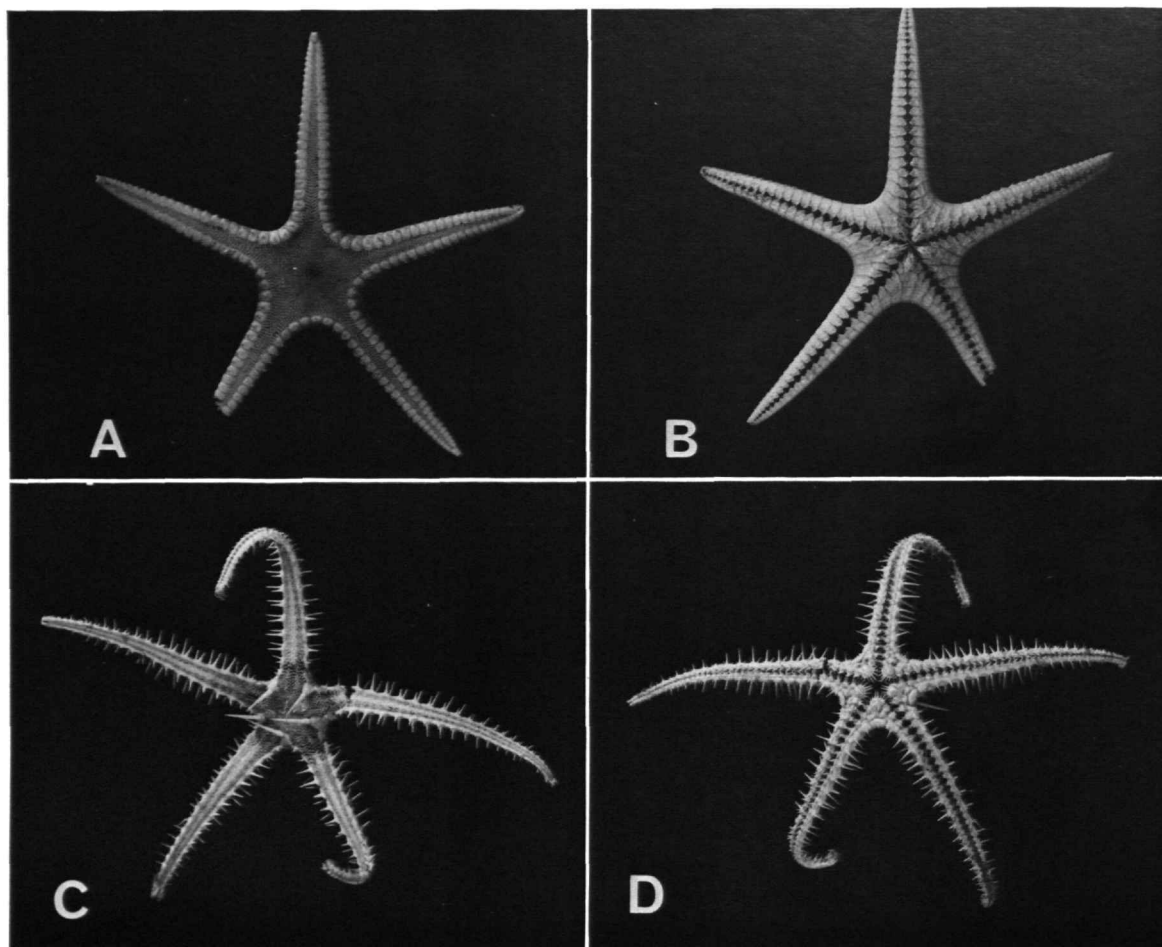


PLATE 12.—A, *Prionaster elegans*, abactinal; B, same, actinal (actual size=37 mm R); C, *Benthopecten simplex*, abactinal; D, same, actinal (actual size=48 mm R).

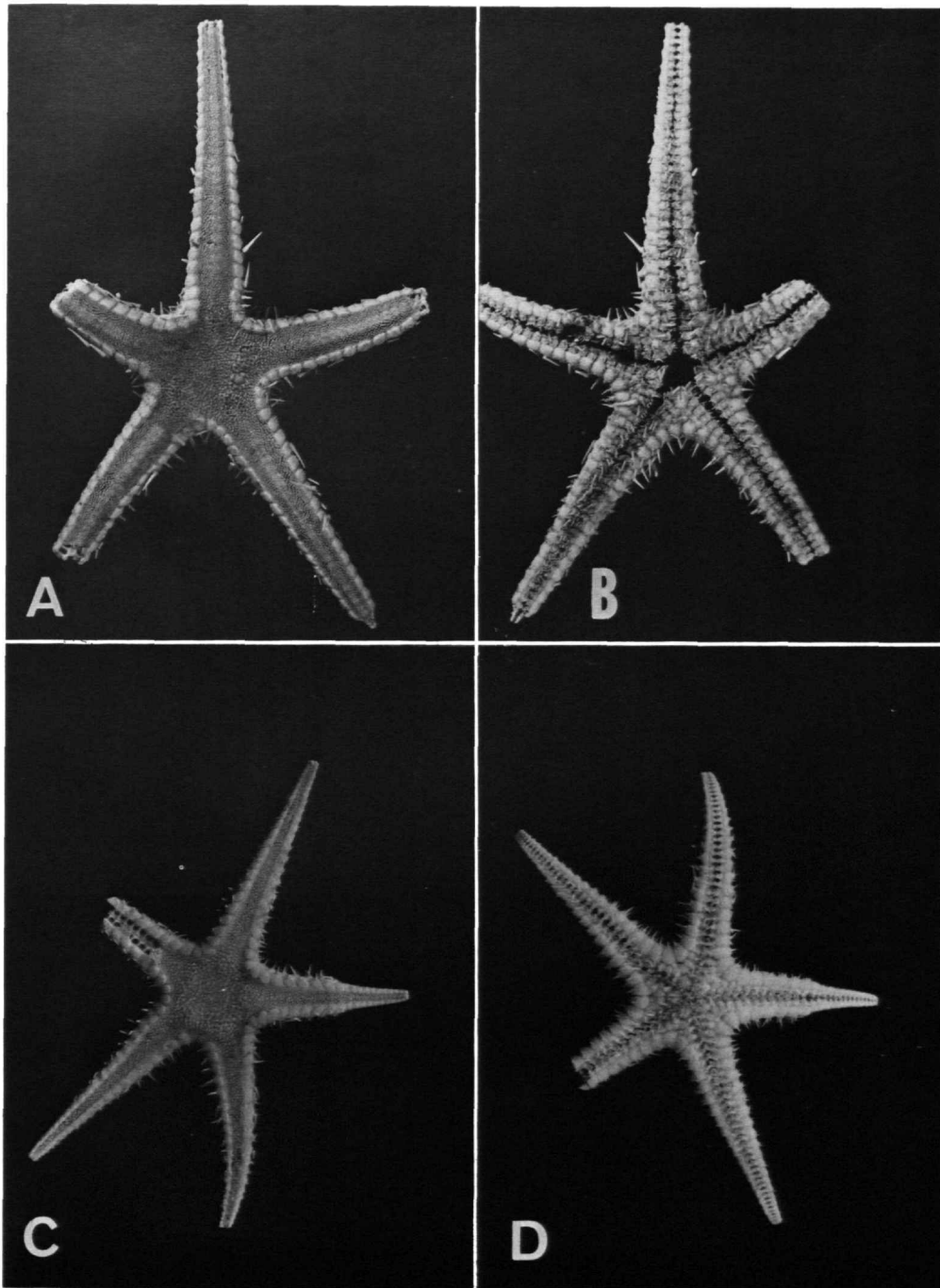


PLATE 13.—A, *Cheiraster mirabilis*, abactinal; B, same, actinal (actual size=120 mm R); C, *Cheiraster echinulatus*, abactinal; D, same, actinal (actual size=35 mm R).

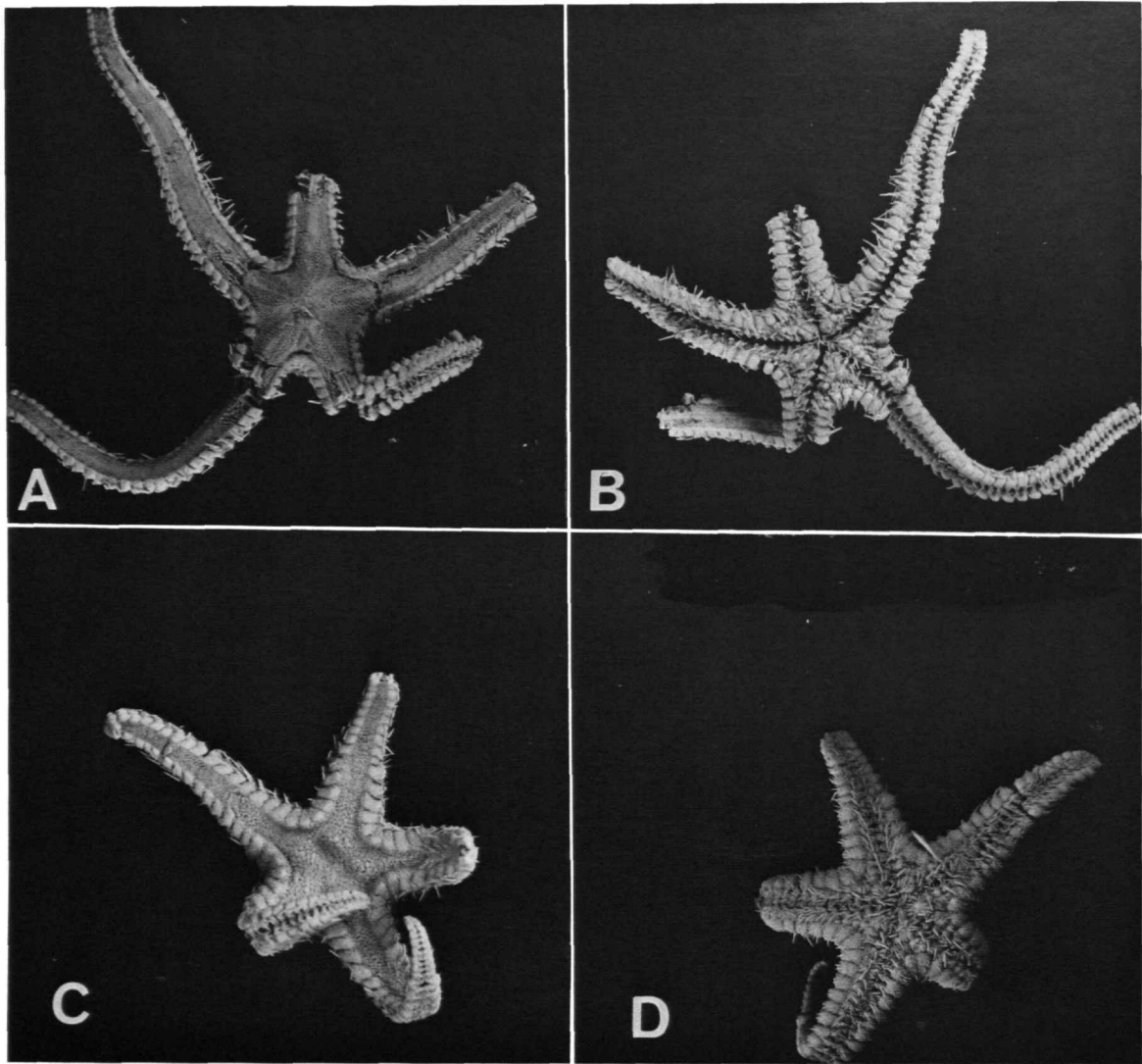


PLATE 14.—A, *Cheiraster enoplus*, abactinal; B, same, actinal (actual size=104 mm R); C, *Pectinaster mixtus*, abactinal; D, same, actinal (actual size=41 mm R).

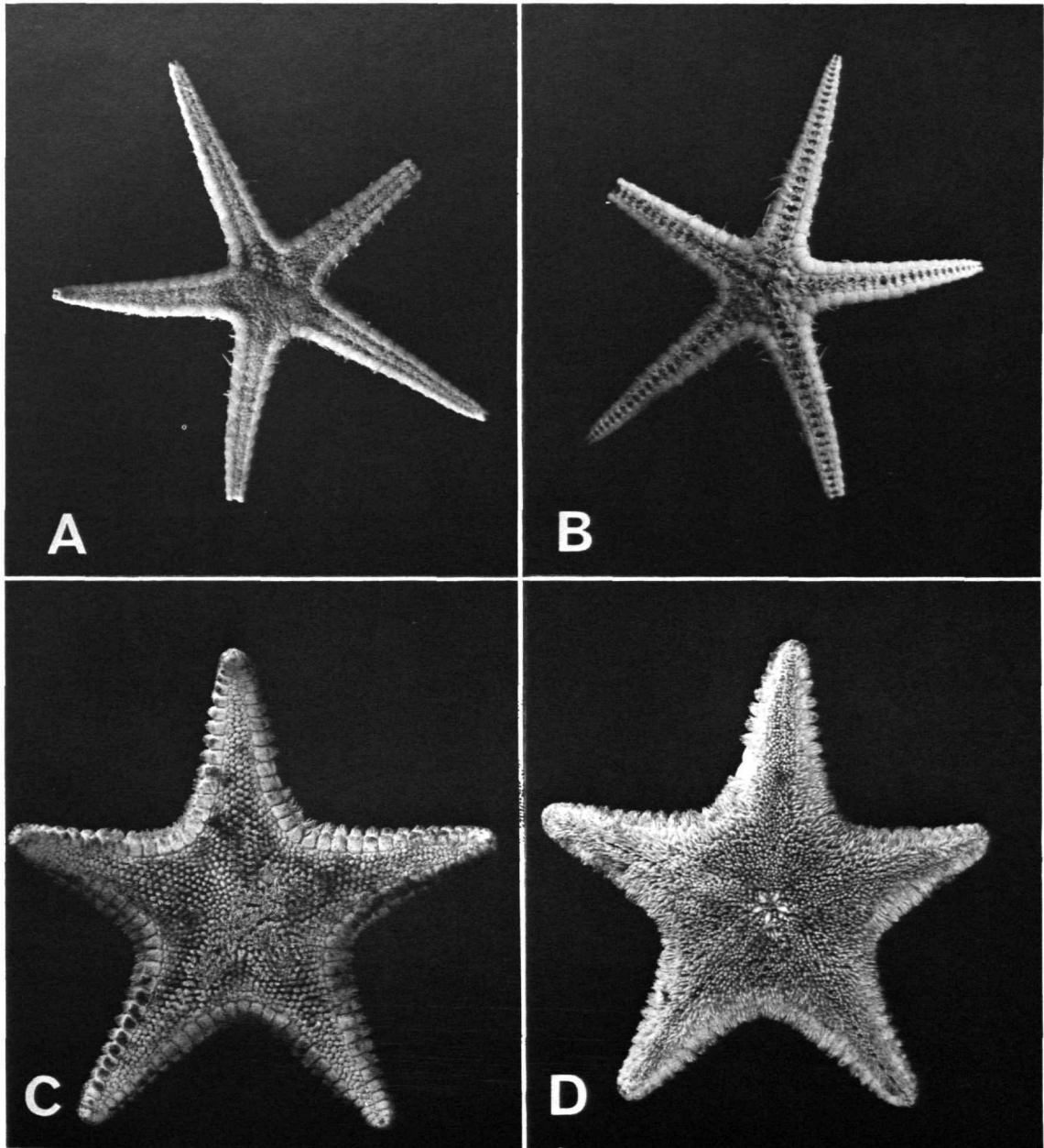


PLATE 15.—A, *Pectinaster gracilis*, abactinal; B, same, actinal (actual size=13 mm R); C, *Odontaster hispidus*, abactinal; D, same, actinal (actual size=37 mm R).

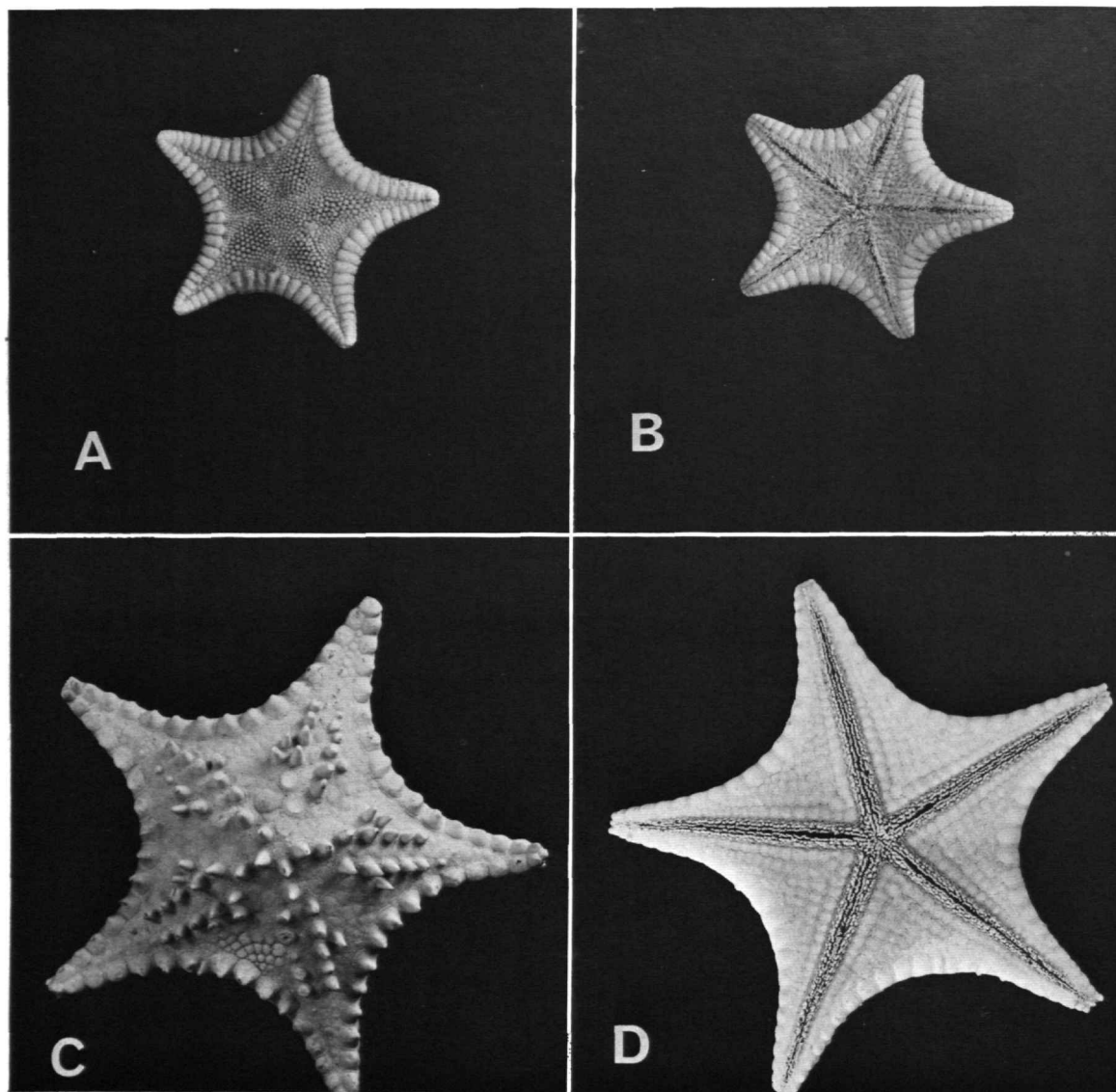


PLATE 16.—A, *Odontaster setosus*, abactinal; B, same, actinal (actual size=28 mm R); C, *Goniaster tessellatus*, abactinal; D, same, actinal (actual size=71 mm R).

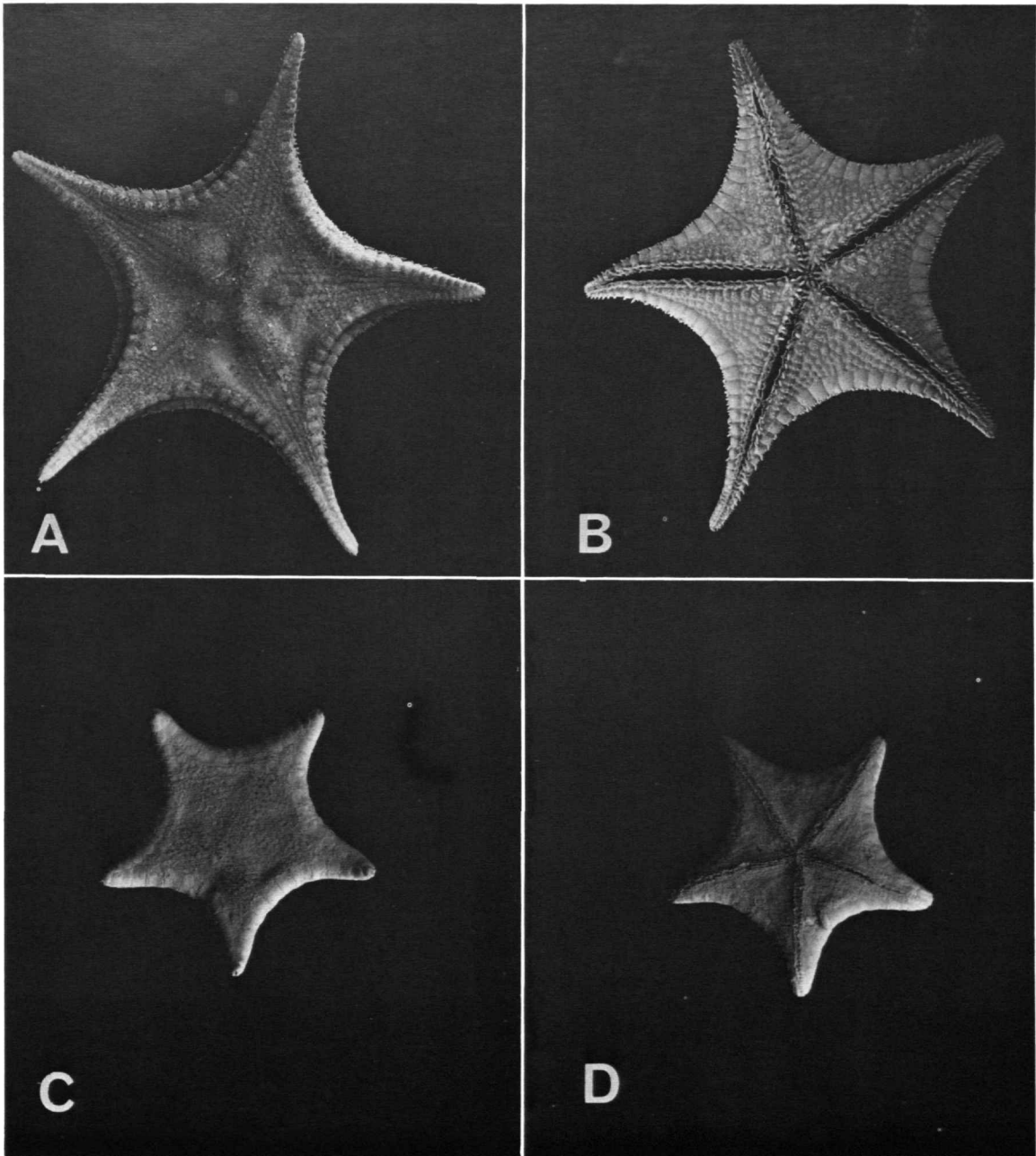


PLATE 17.—A, *Athenoides piercei*, abactinal; B, same, actinal (actual size=82 mm R); C, *Ceramaster grenadensis*, abactinal; D, same, actinal (actual size=21 mm R).

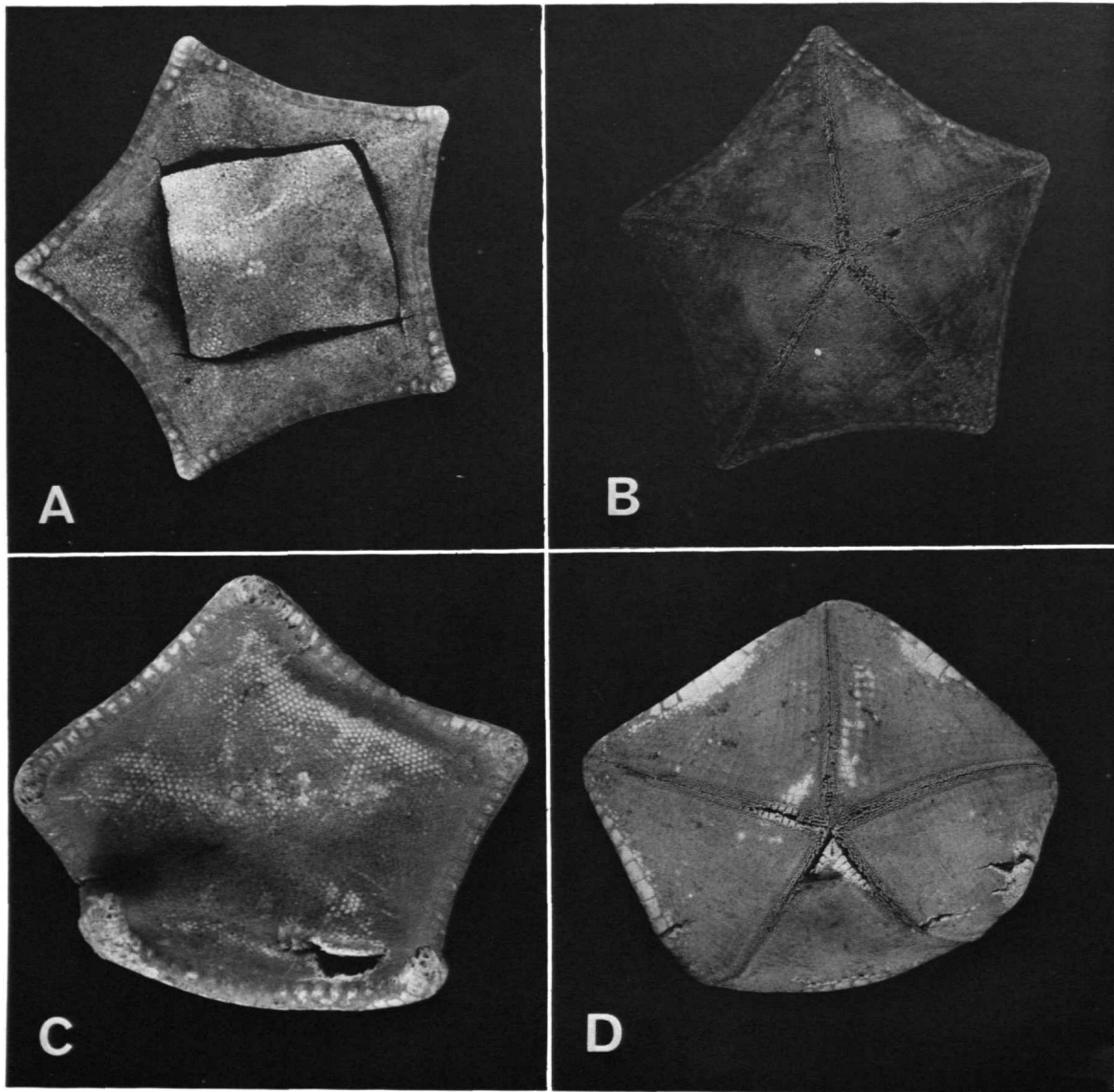


PLATE 18.—A, *Peltaster nidarosiensis*, abactinal; B, same, actinal (actual size=75 mm R); C, *Peltaster placenta*, abactinal; D, same, actinal (actual size=75 mm R).



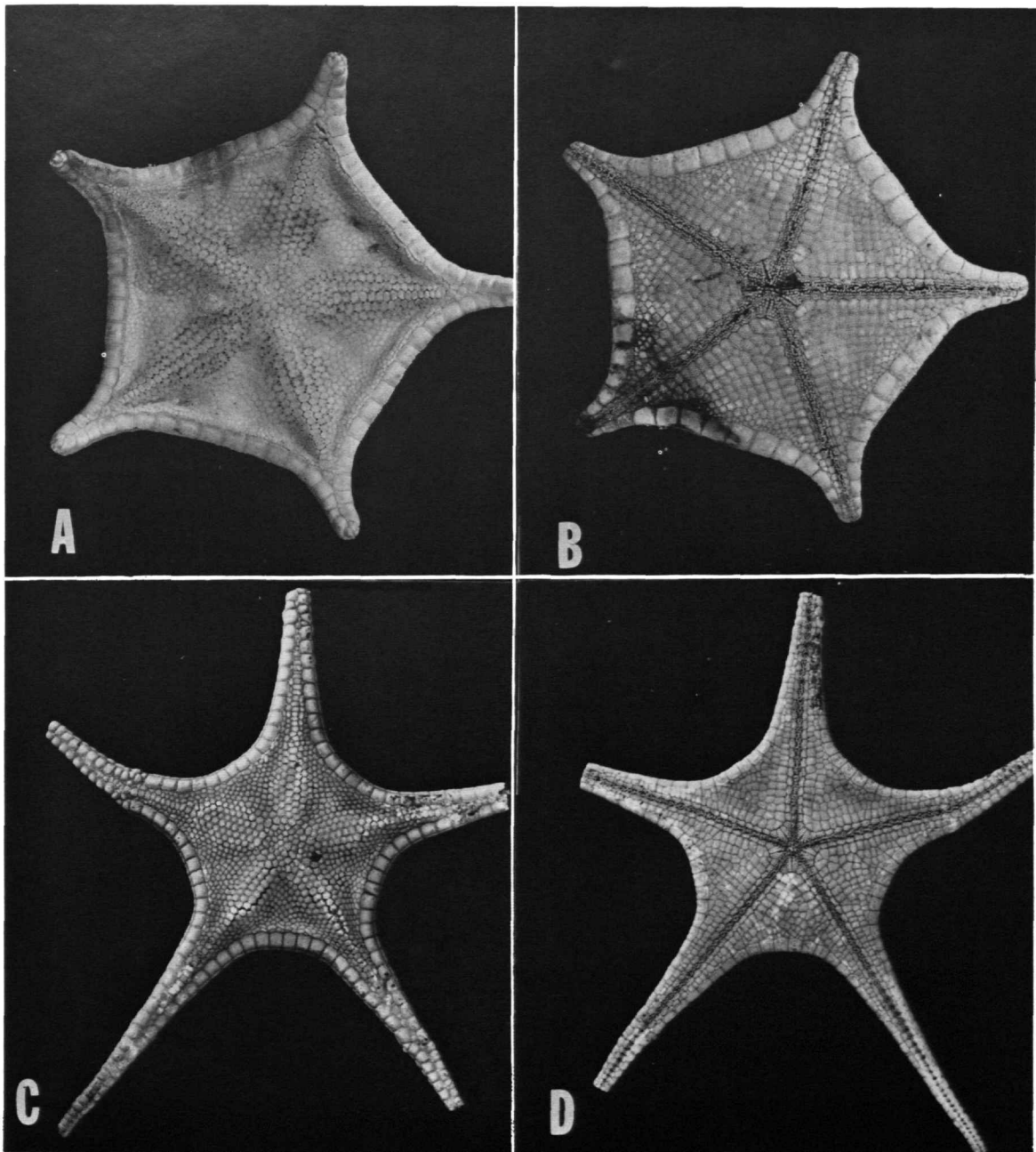


PLATE 19.—A, *Plinthaster dentatus*, abactinal; B, same, actinal (actual size=51 mm R); C, *Tessellaster notabilis*, abactinal; D, same, actinal (actual size=76 mm R).

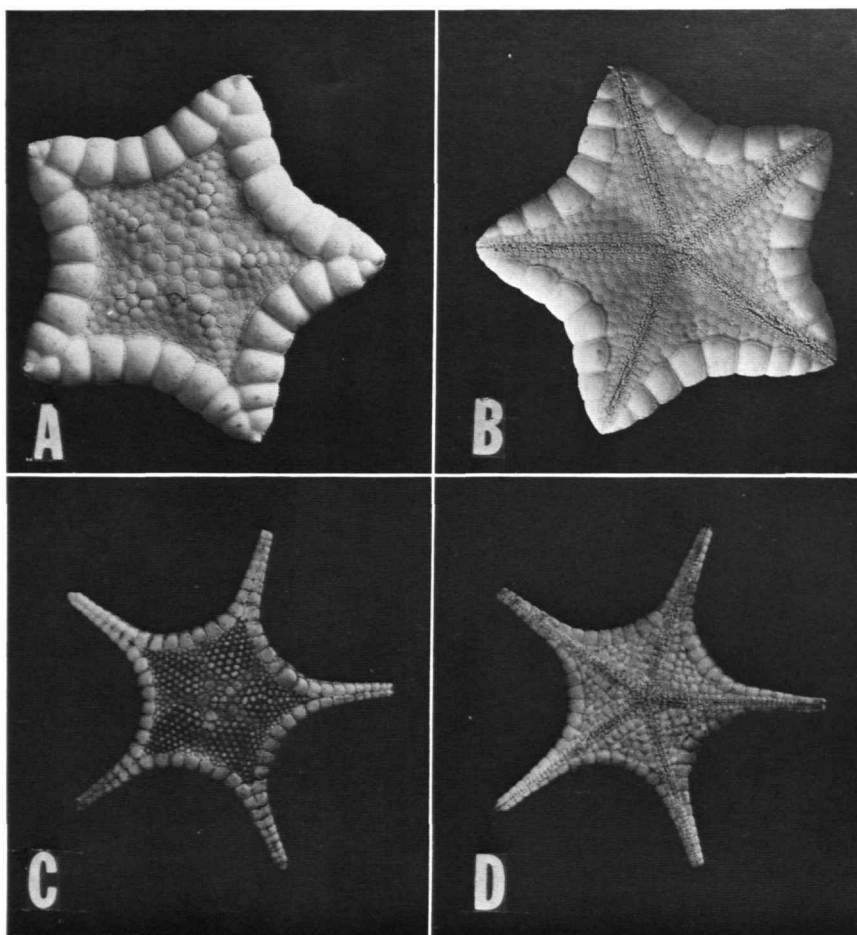


PLATE 20.—A, *Tosia parva*, abactinal; B, same, actinal (actual size=18 mm R); C, *Rosaster alexandri*, abactinal; D, same, actinal (actual size=24 mm R).

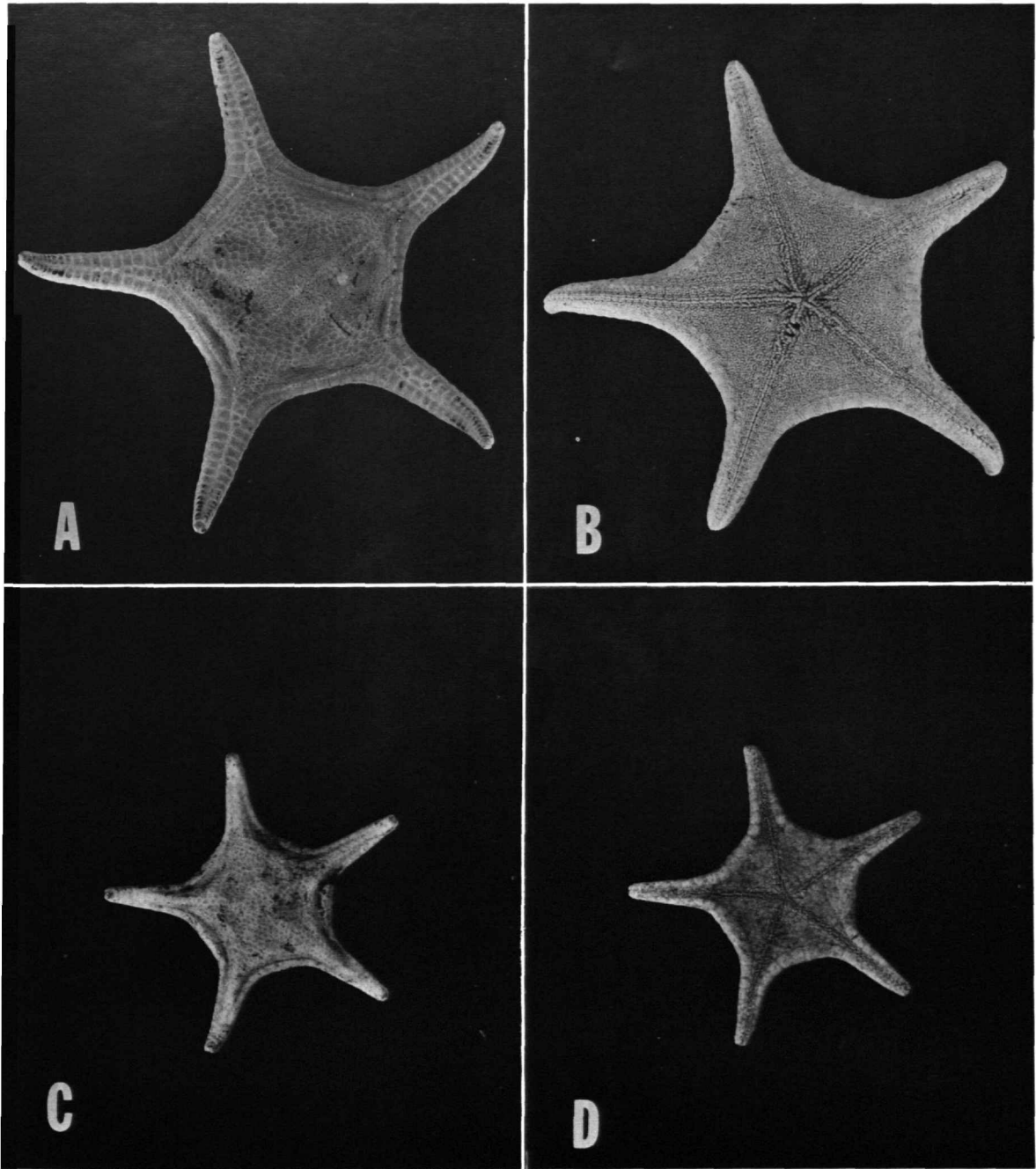


PLATE 21.—A, *Circeaster americanus*, abactinal; B, same, actinal (actual size=76 mm R); C, *Litonotaster intermedius*, abactinal; D, same, actinal (actual size=17 mm R).

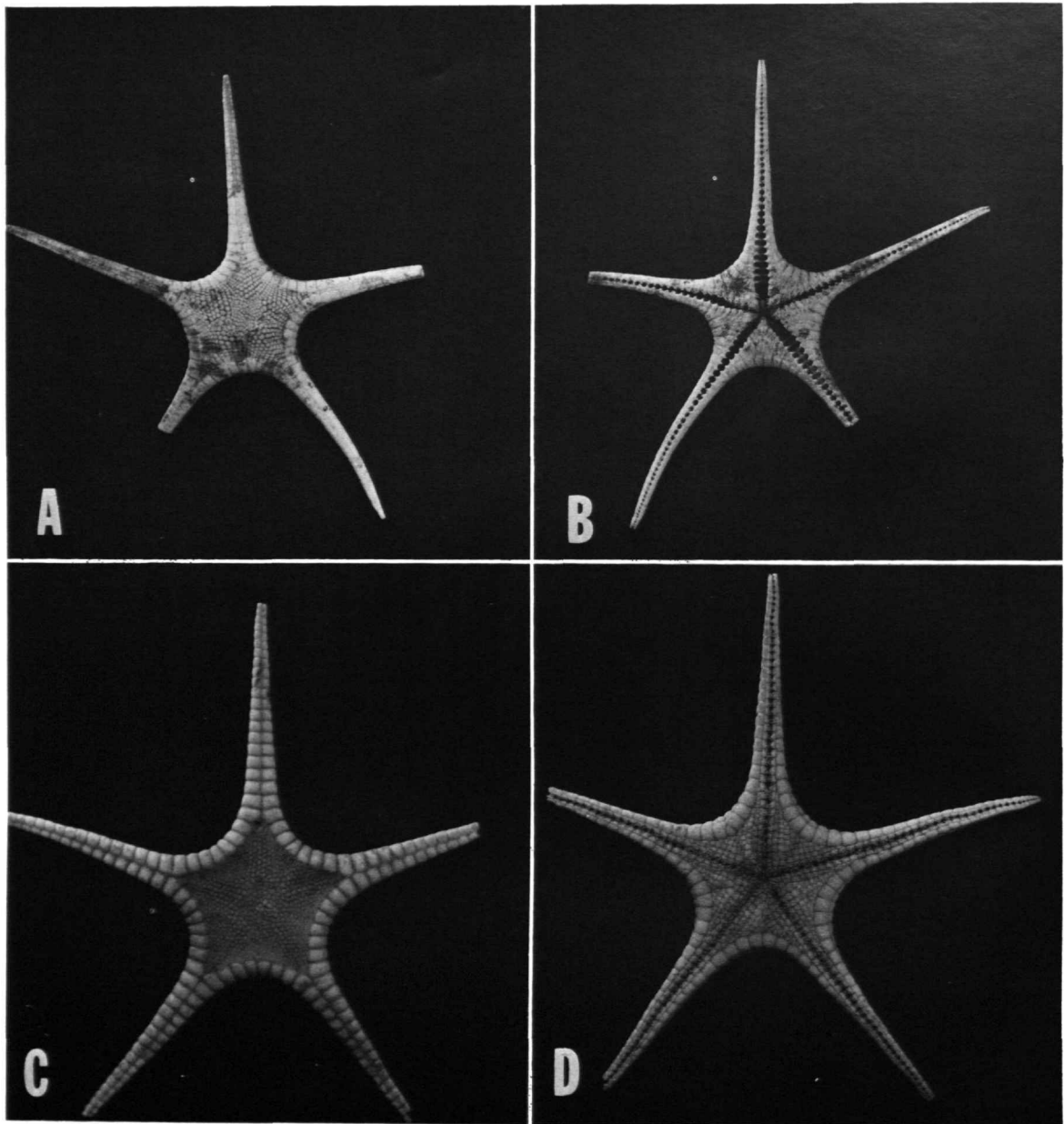


PLATE 22.—A, *Paragonaster subtilis*, abactinal; B, same, actinal (actual size=65 mm R); C, *Nymphaster arenatus*, abactinal; D, same, actinal (actual size= 84 mm R).

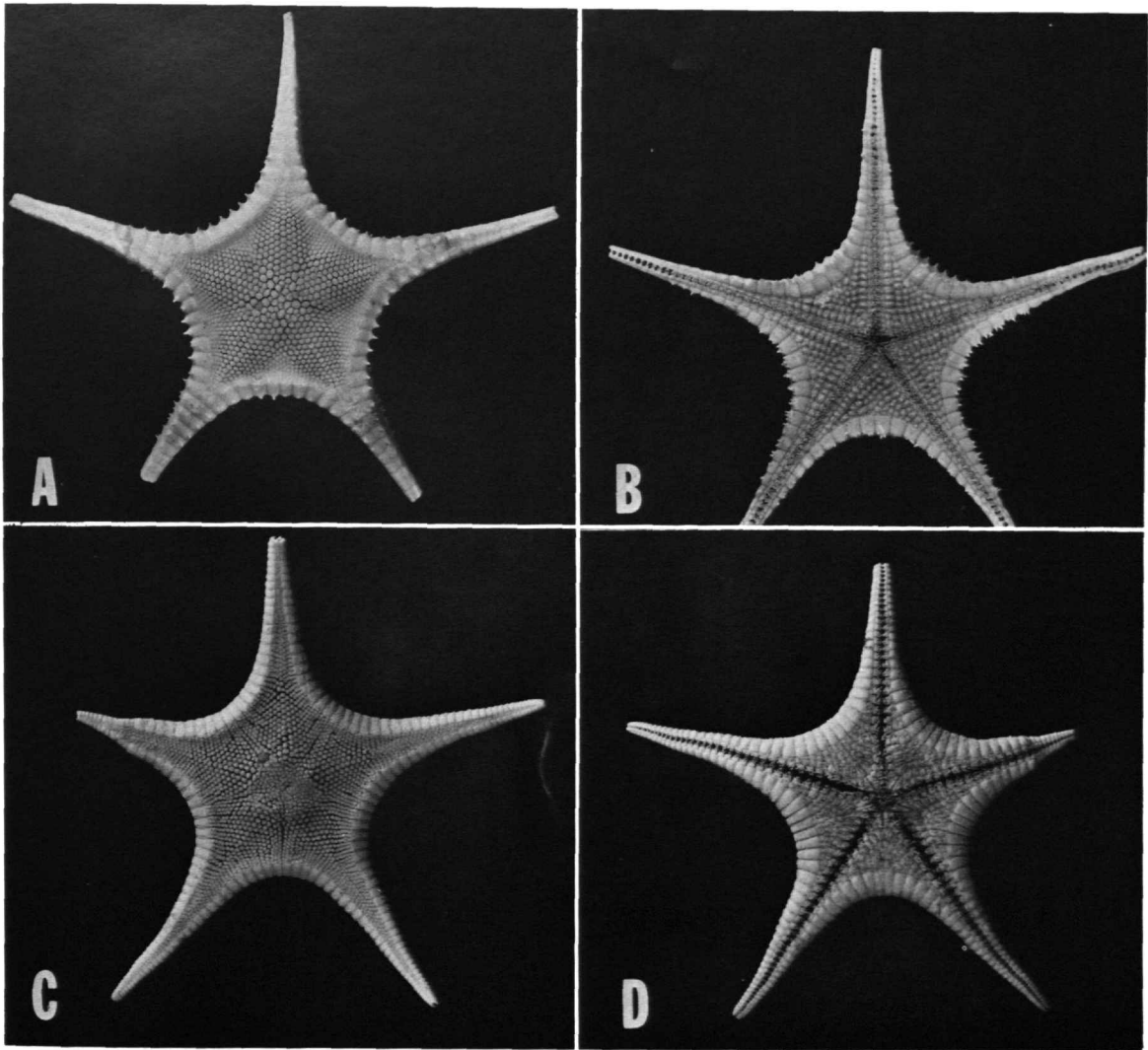


PLATE 23.—A, *Nymphaster subspinosus*, abactinal; B, same, actinal (actual size=70 mm R);  
C, *Pseudarchaster gracilis*, abactinal; D, same, actinal (actual size=190 mm R).

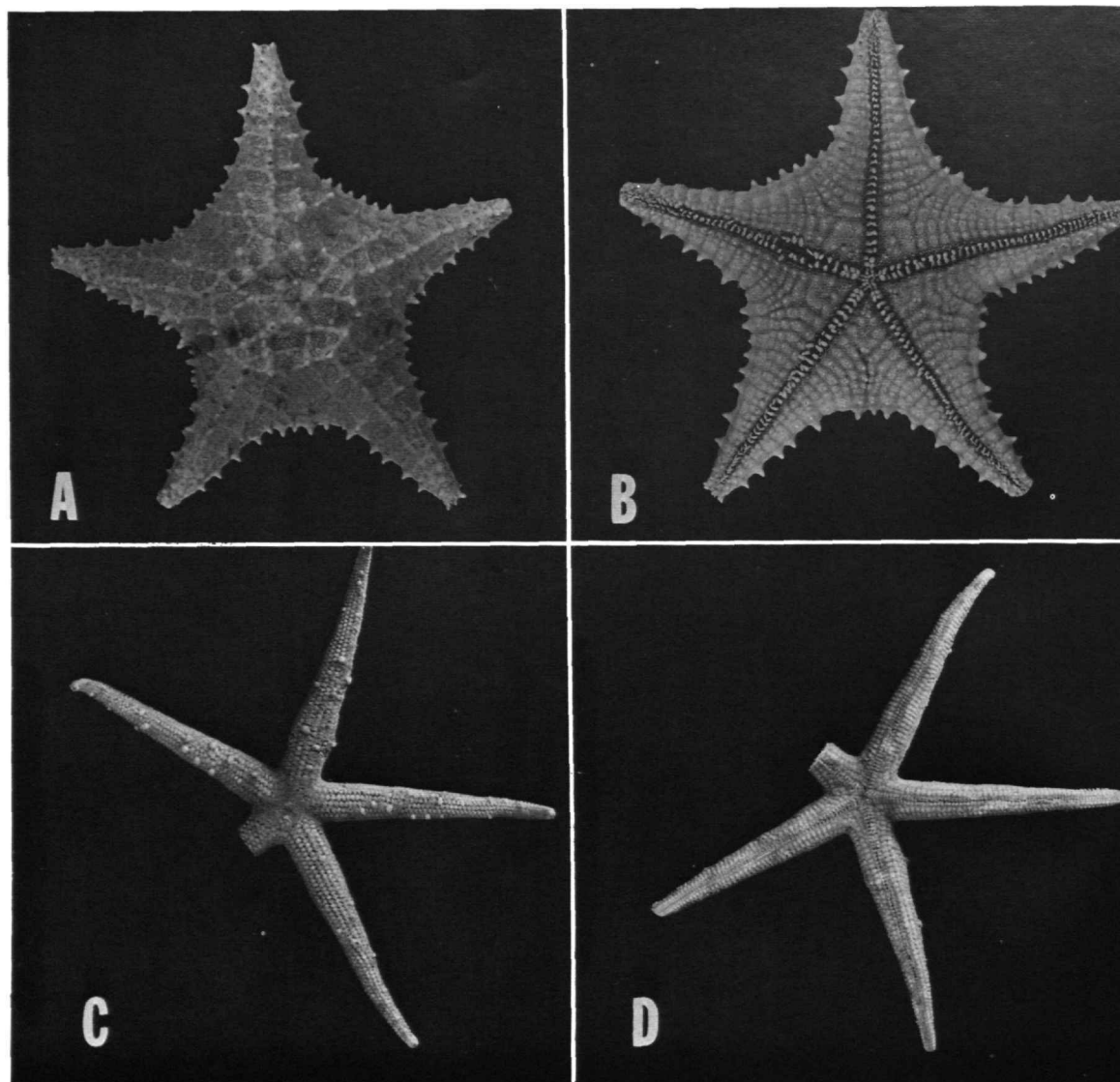


PLATE 24.—A, *Oreaster reticulatus*, abactinal; B, same, actinal (actual size=91 mm R); C, *Chaetaster nodosus*, abactinal; D, same, actinal (actual size=60 mm R).

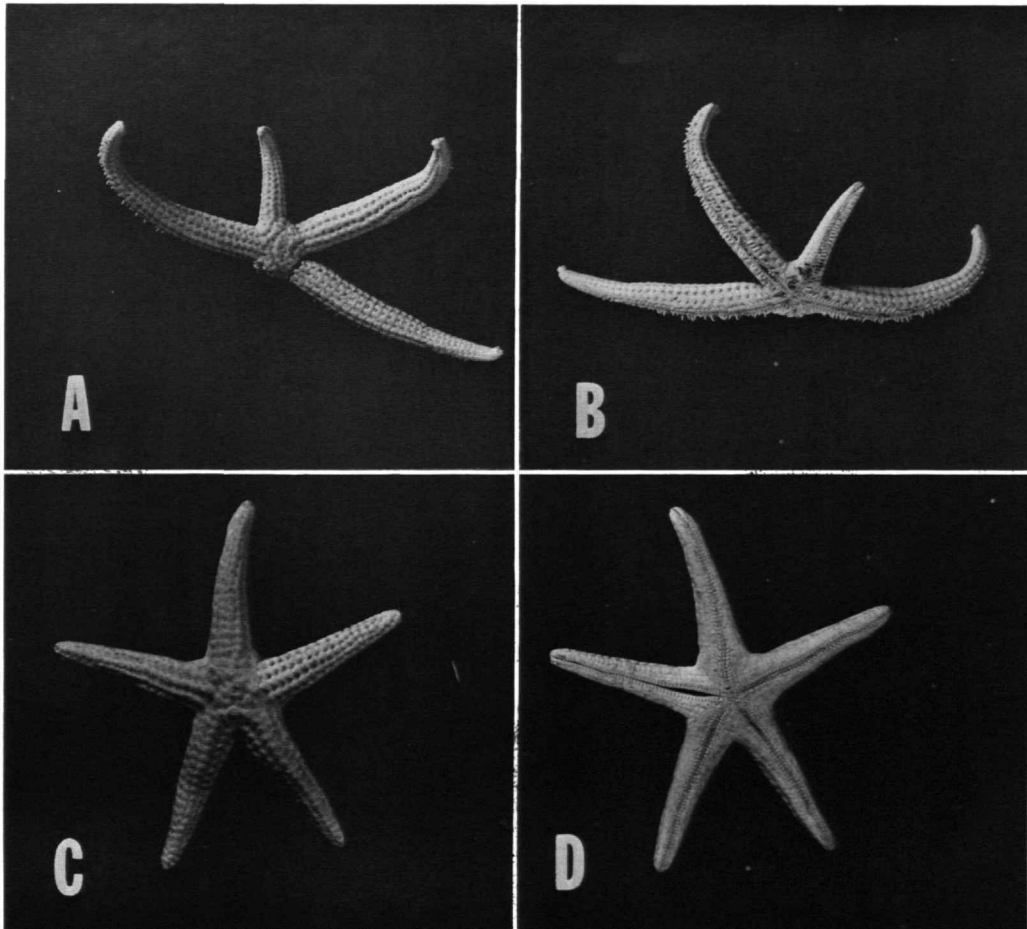


PLATE 25.—A, *Drachmaster bullisi*, abactinal; B, same, actinal (actual size=33 mm R); C, *Tamaria floridae*, abactinal; D, same, actinal (actual size=25 mm R).

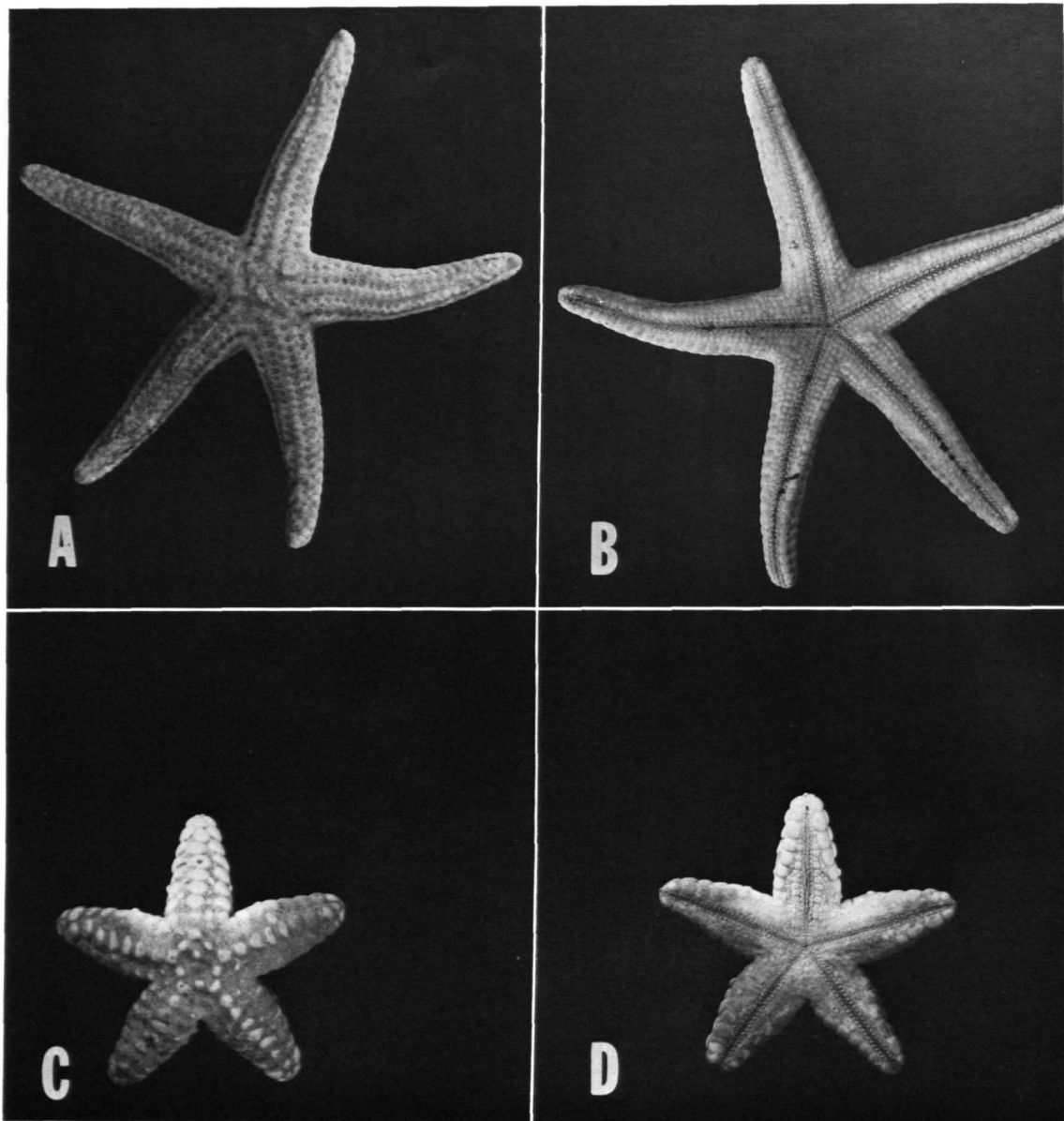


PLATE 26.—A, *Tamaria halperni*, abactinal; B, same, actinal (actual size=53 mm R); C, *Tamaria passiflora*, abactinal; D, same, actinal (actual size=24 mm R).



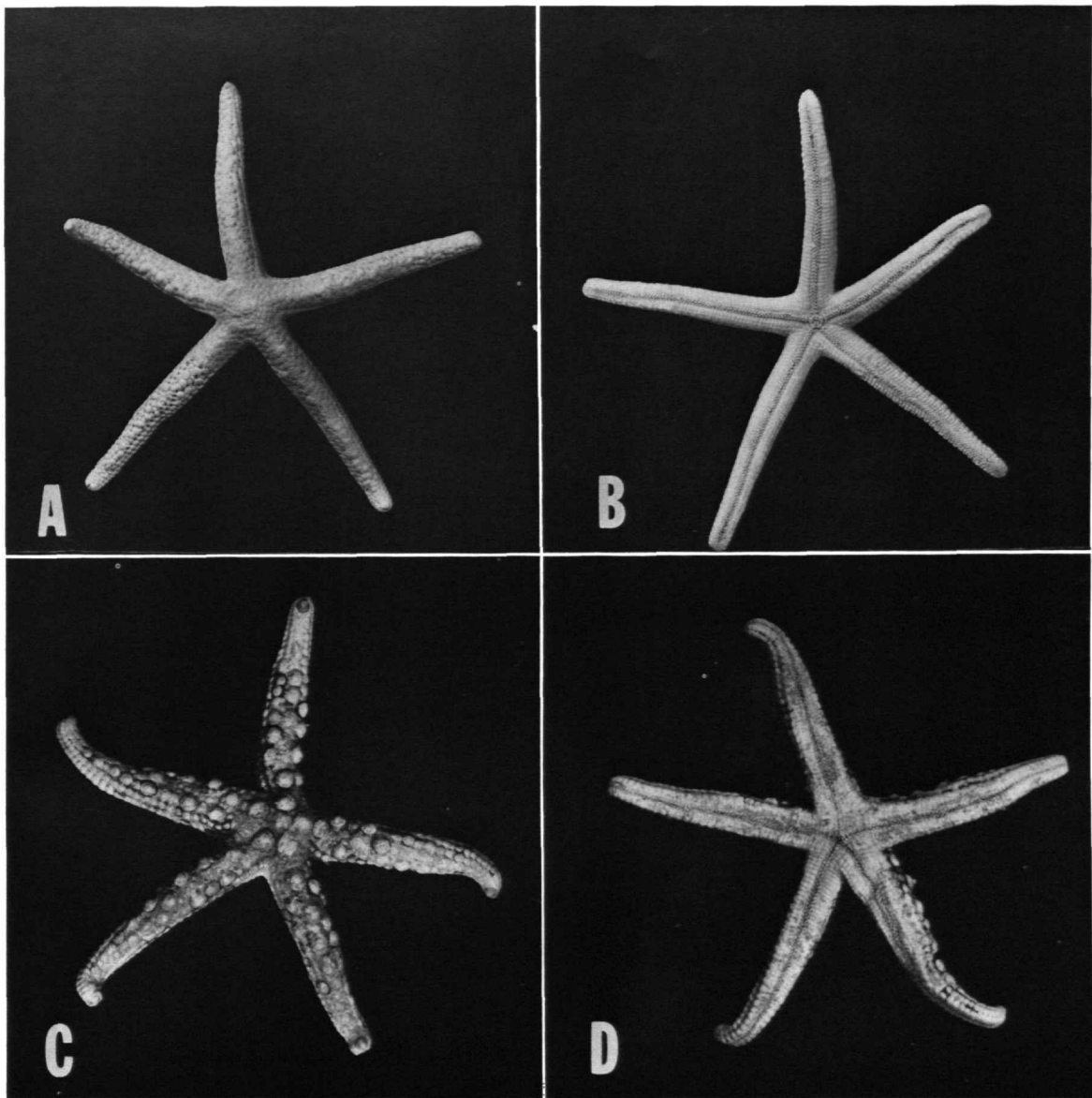


PLATE 27.—A, *Linckia guildingii*, abactinal; B, same, actinal (actual size=38 mm R); C, *Linckia nodosa*, abactinal; D, same, actinal (actual size=36 mm R).

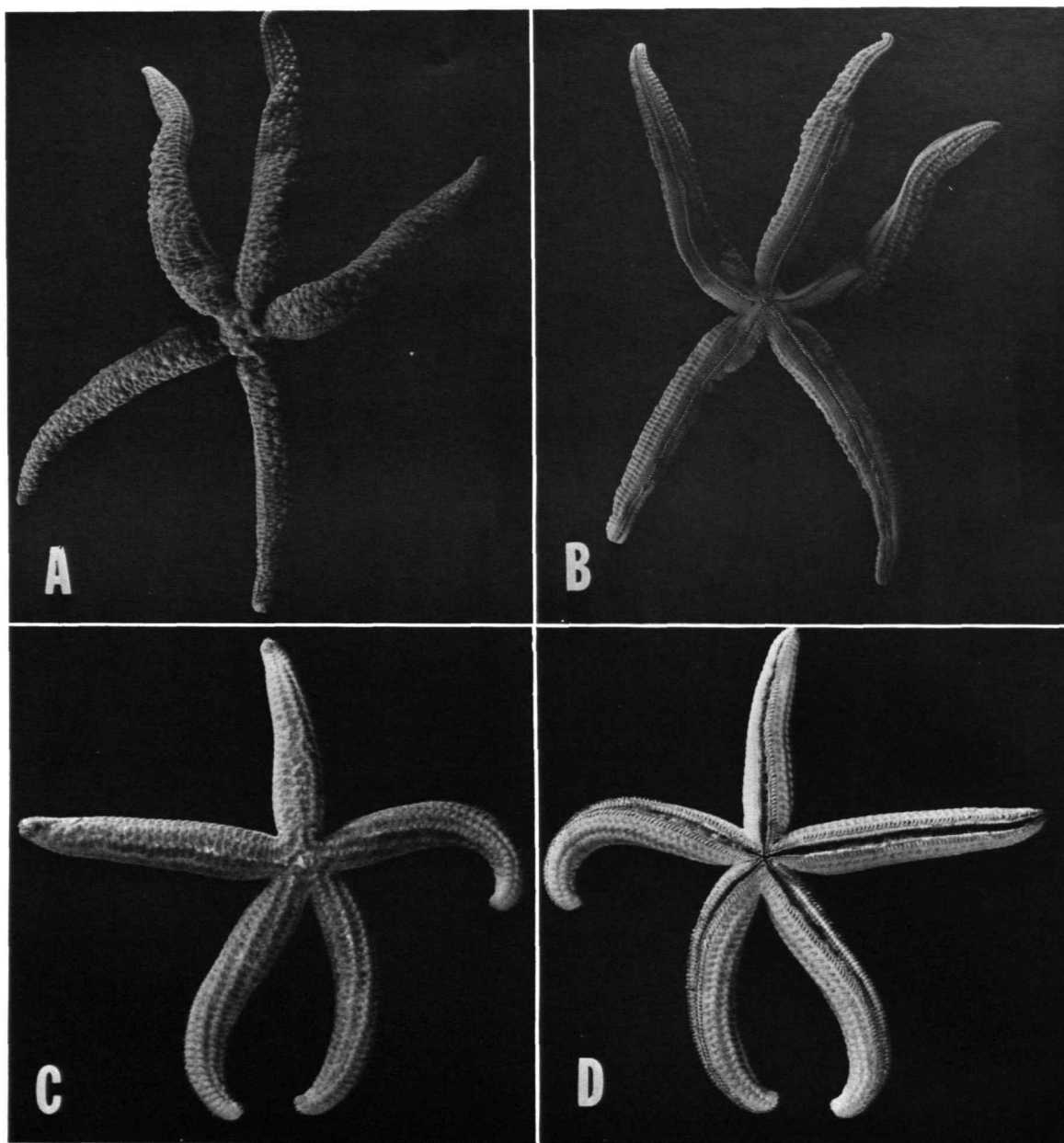


PLATE 28.—A, *Linckia bowieri*, abactinal; B, same, actinal (actual size=194 mm R); C, *Ophidiaster guildingii*, abactinal; D, same, actinal (actual size=33 mm R).

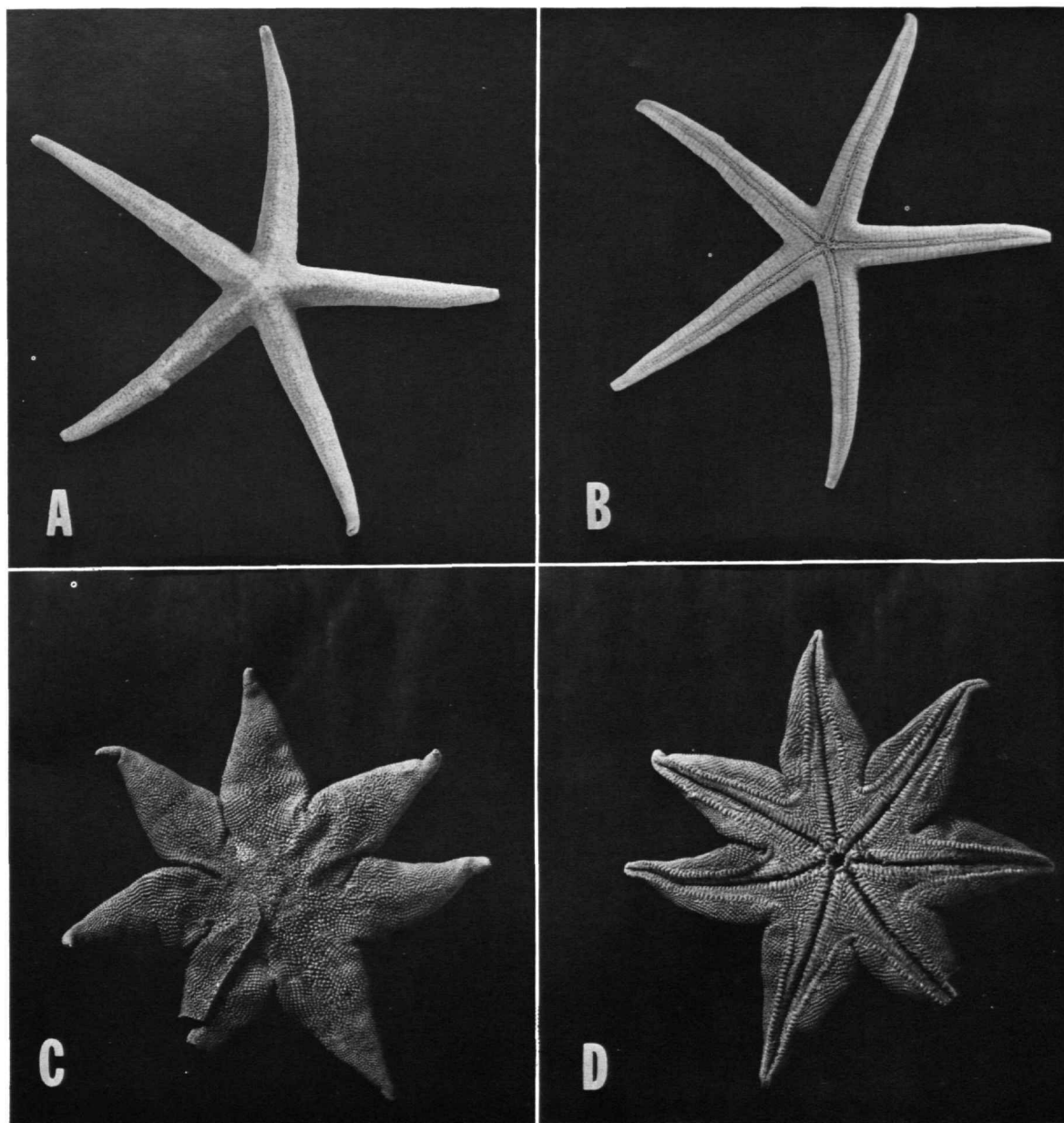


PLATE 29.—A, *Narcissia trigonaria*, abactinal; B, same, actual (actual size=74 mm R); C, *Solaster notophrynus*, abactinal; D, same, actual (actual size=114 mm R).

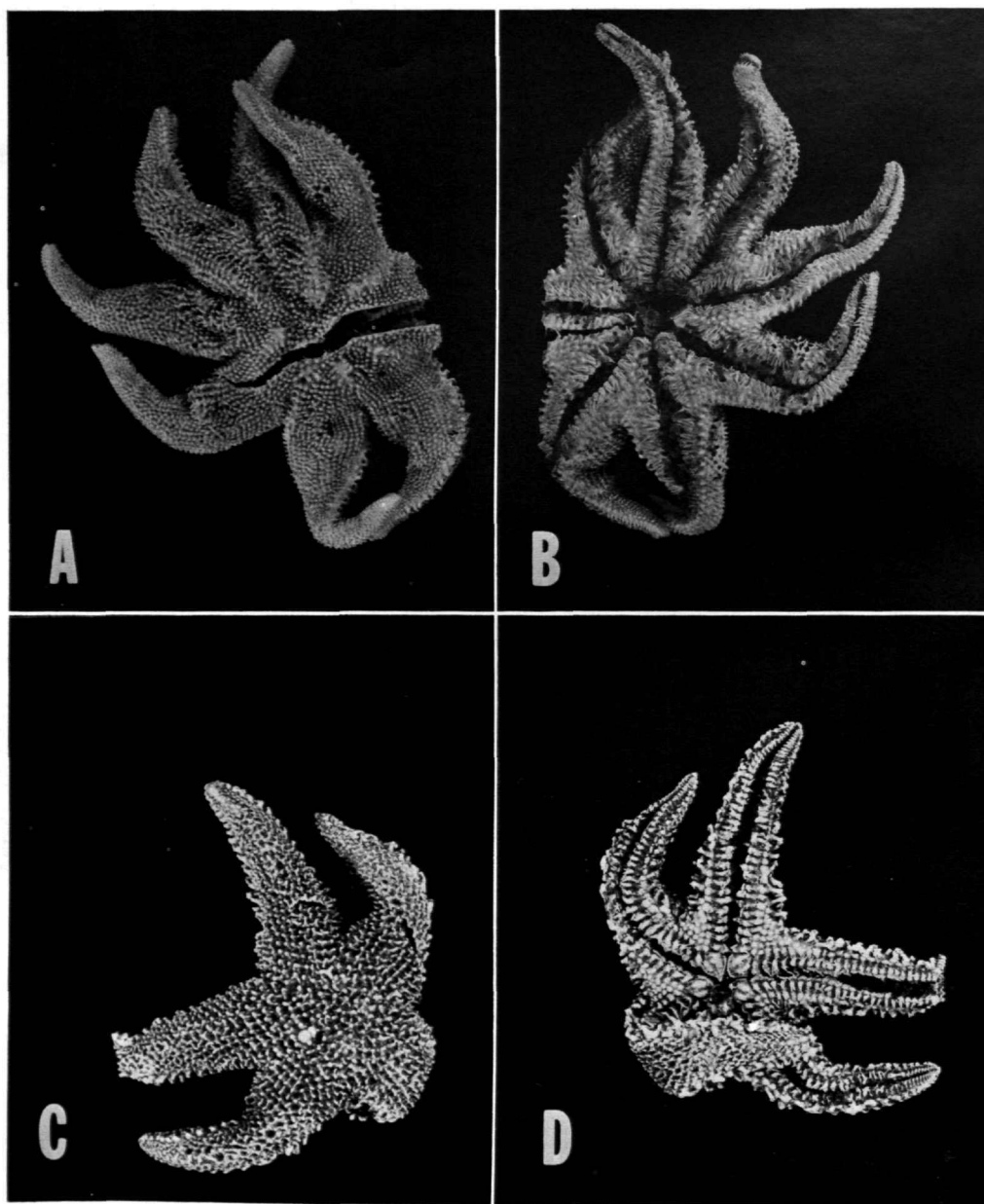


PLATE 30.—A, *Solaster caribbaeus*, abactinal; B, same, actinal (actual size=58 mm R); C, *Lophaster verrilli*, abactinal; D, same, actinal (actual size=38 mm R).

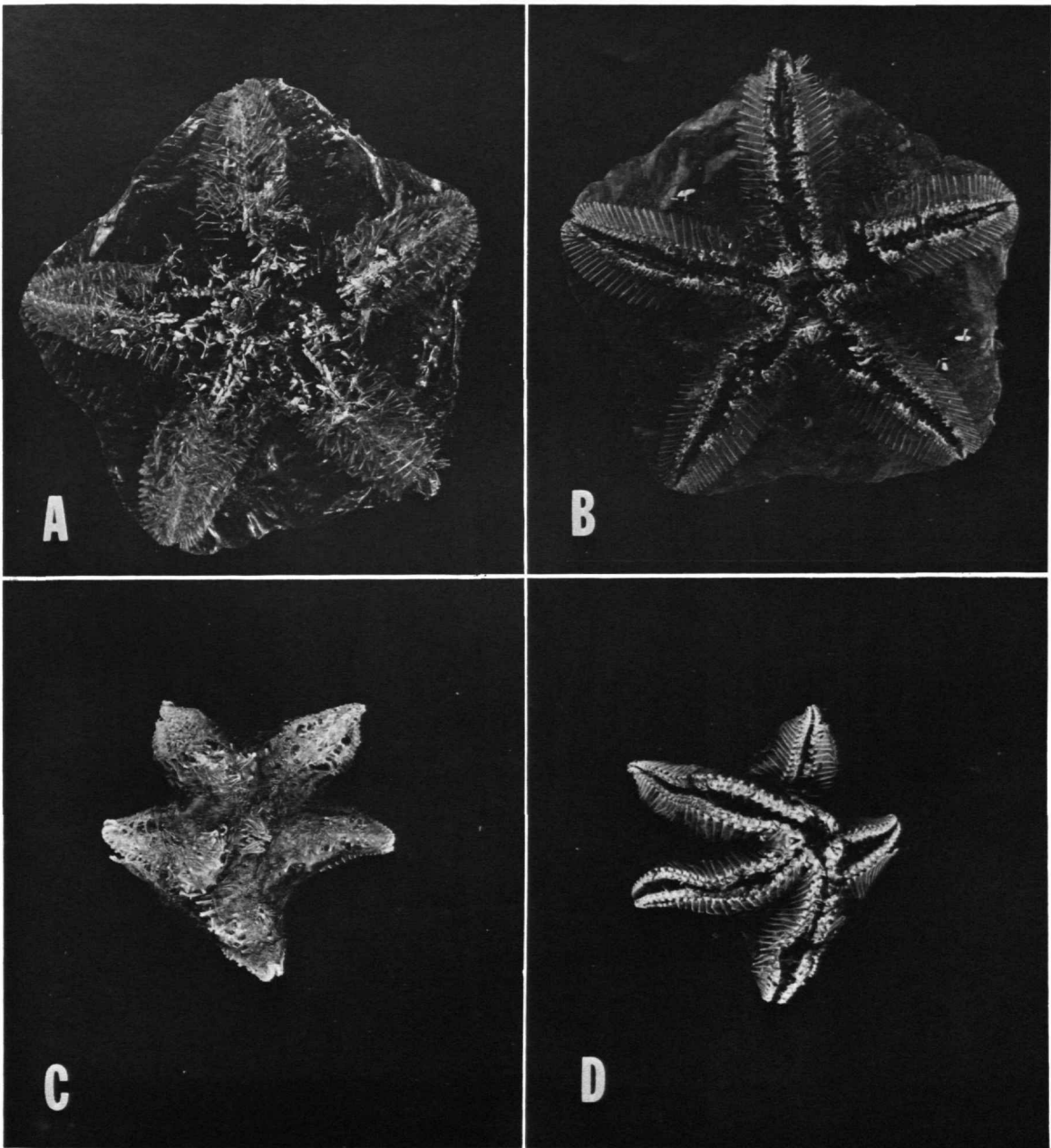


PLATE 31.—A, *Hymenaster rex*, abactinal; B, same, actinal (actual size=81 mm R); C, *Hymenaster modestus*, abactinal; D, same, actinal (actual size=30 mm R).

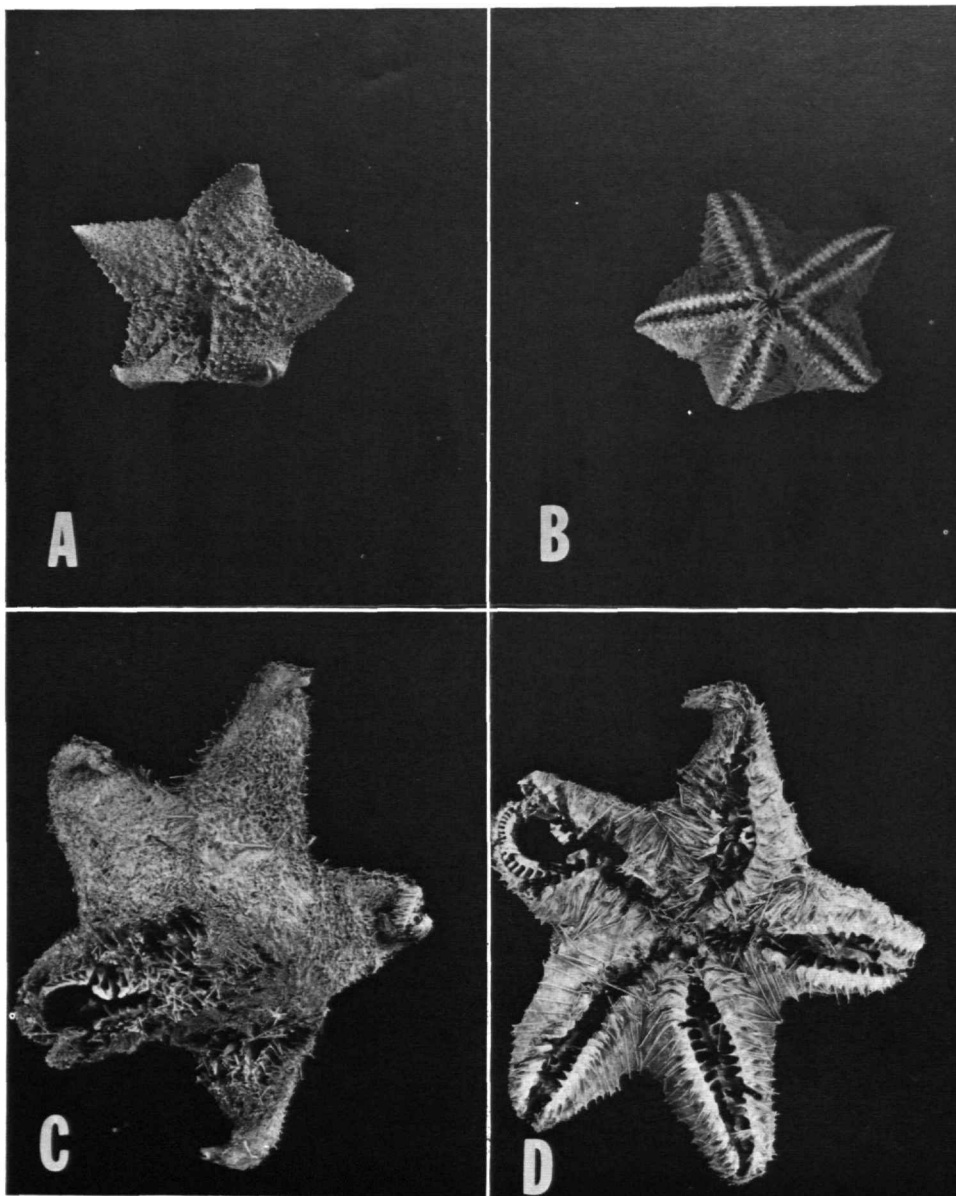


PLATE 32.—A, *Hymenaster anomalus*, abactinal; B, same, actinal (actual size=14 mm R); C, *Pteraster personatus*, abactinal; D, same, actinal (actual size=70 mm R).

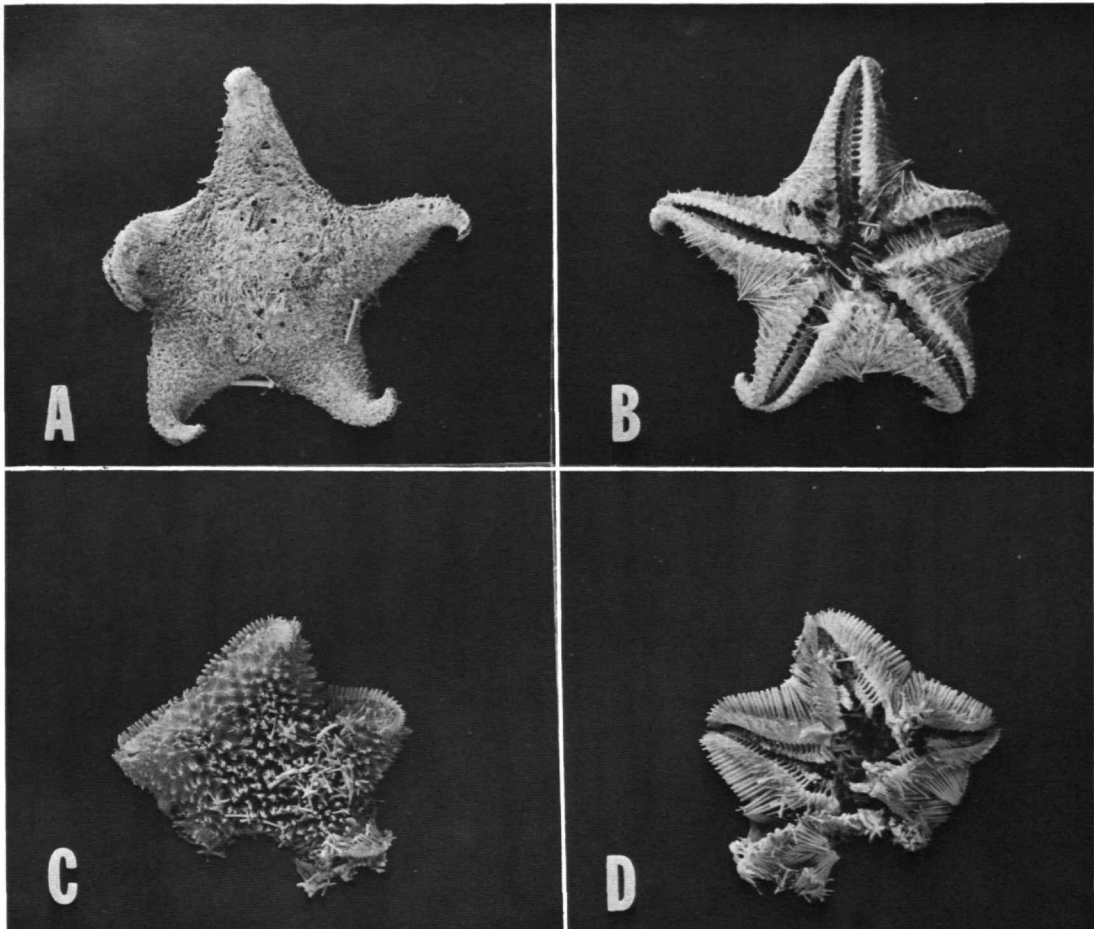


PLATE 33.—A, *Pteraster caribbaeus*, abactinal; B, same, actinal (actual size=36 mm R); C, *Pteraster rugosus*, abactinal; D, same, actinal (actual size=24 mm R).

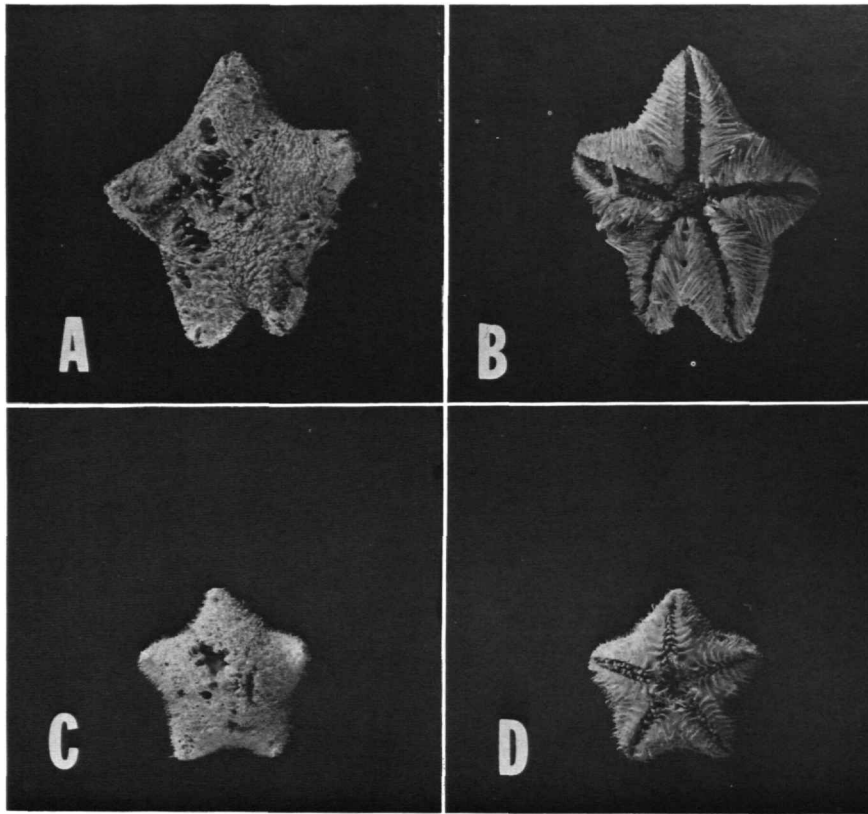


PLATE 34.—A, *Pteraster militaroides*, abactinal; B, same, actinal (actual size=22 mm R); C, *Pteraster acicula*, abactinal; D, same, actinal (actual size=10 mm R).



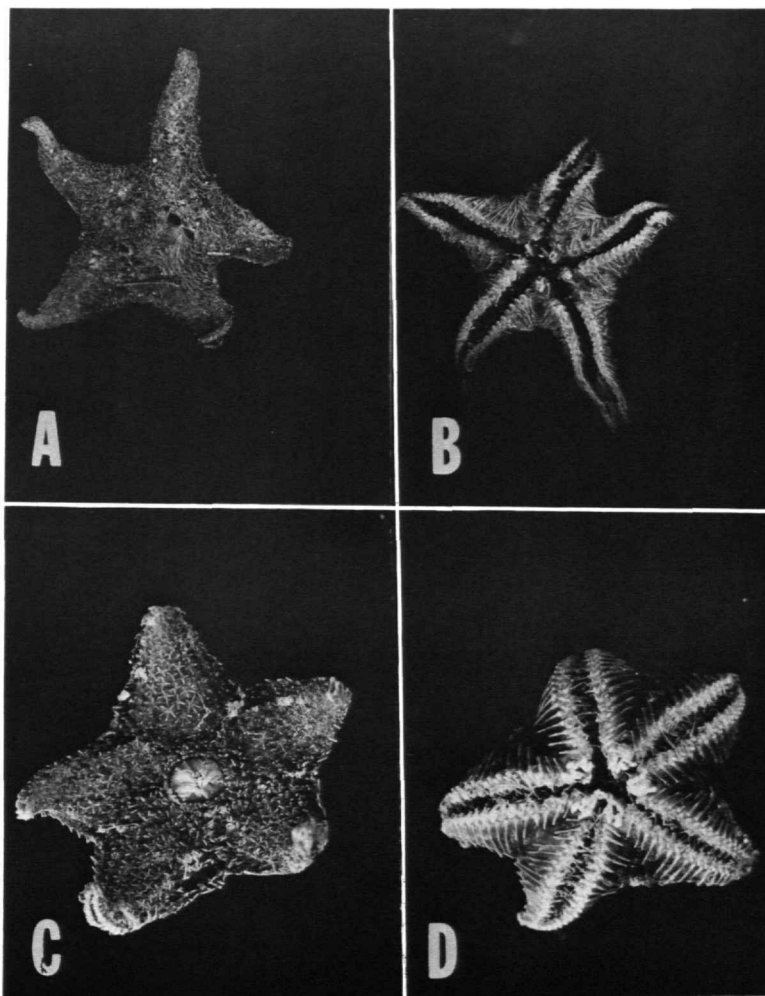


PLATE 35.—A, *Pteraster* species, abactinal; B, same, actinal (actual size=26 mm R); C, *Calytraster personatus*, abactinal; D, same, actinal (actual size=20 mm R).

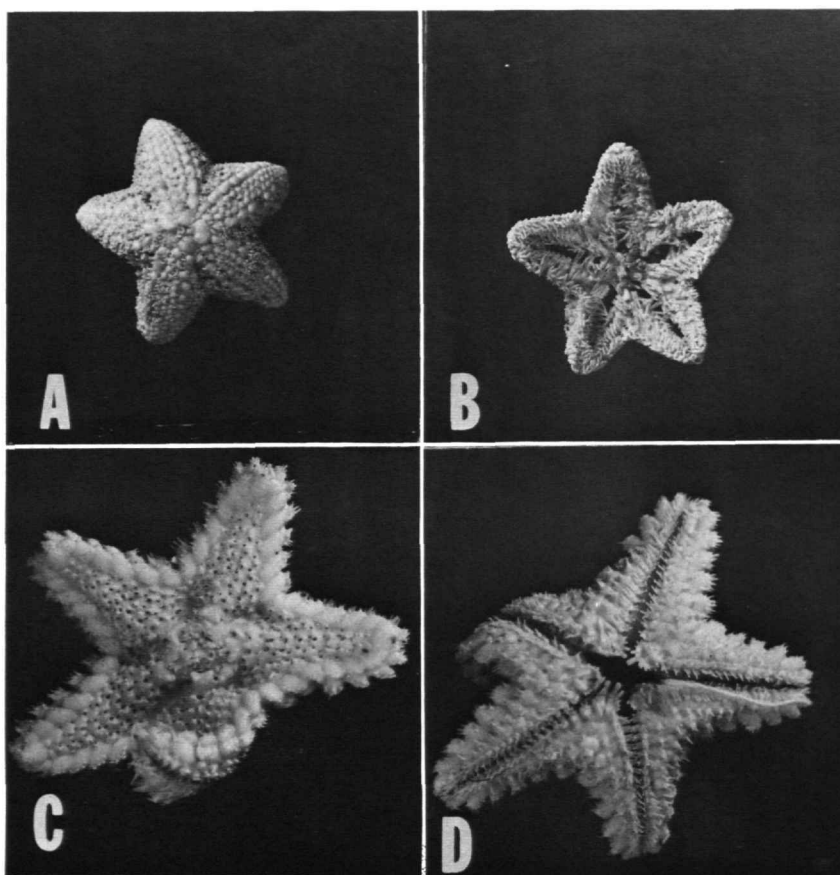


PLATE 36.—A, *Leilaster radians*, abactinal; B, same, actinal (actual size=8 mm R).  
C, *Poraniella regularis*, abactinal; D, same, actinal (actual size=17 mm R).

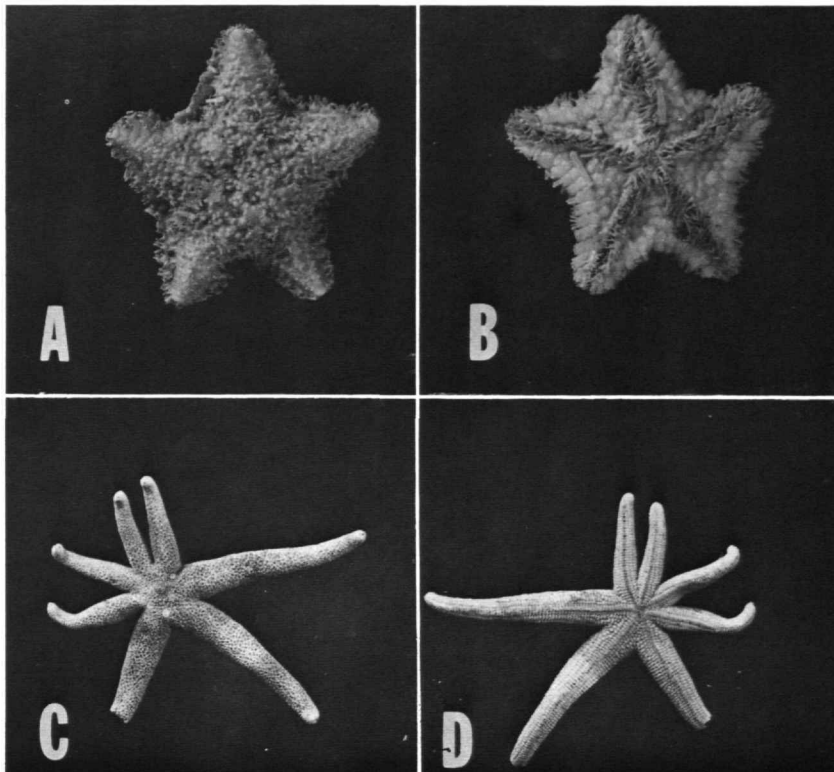


PLATE 37.—A, *Marginaster pectinatus*, abactinal; B, same, actinal (actual size=11 mm R); C, *Henricia sexradiata*, abactinal; D, same, actinal (actual size=46 mm R).

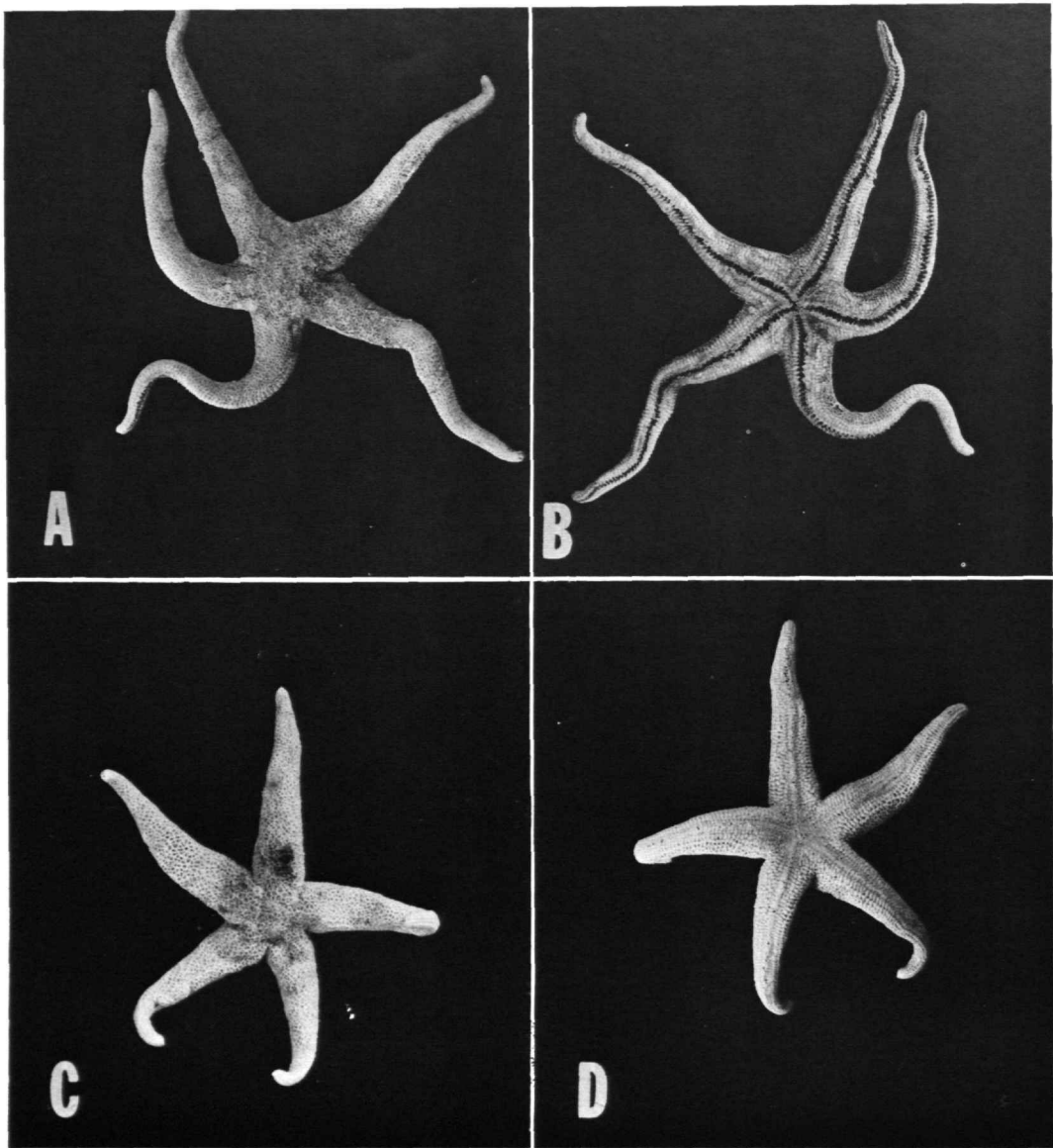


PLATE 38.—A, *Henricia antillarum*, abactinal; B, same, actinal (actual size=55 mm R); C, *Henricia* species, abactinal; D, same, actinal (actual size=62 mm R).

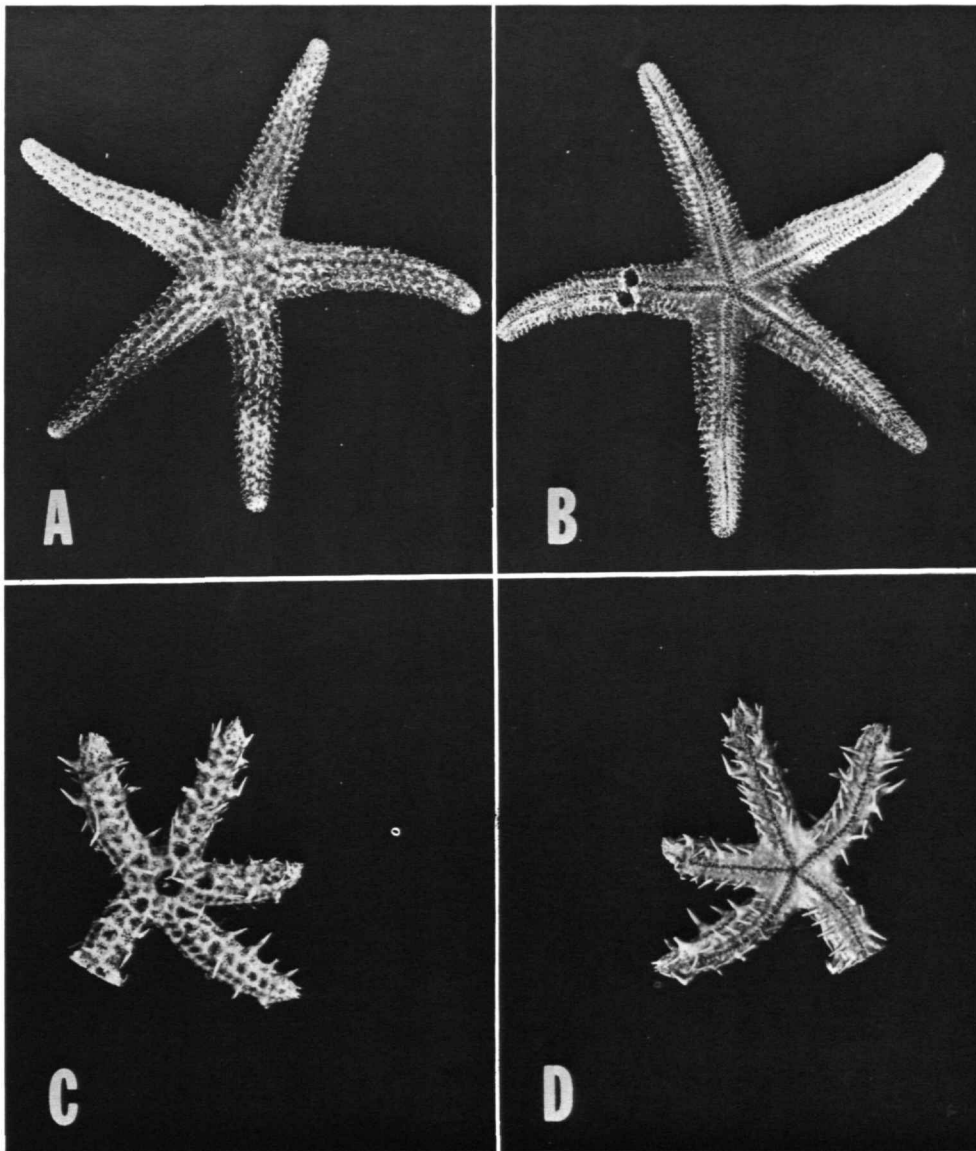


PLATE 39.—A, *Echinaster serpentarius*, abactinal; B, same, actinal (actual size=43 mm R); C, *Echinaster echinophorus*, abactinal; D, same, actinal (actual size=37 mm R).

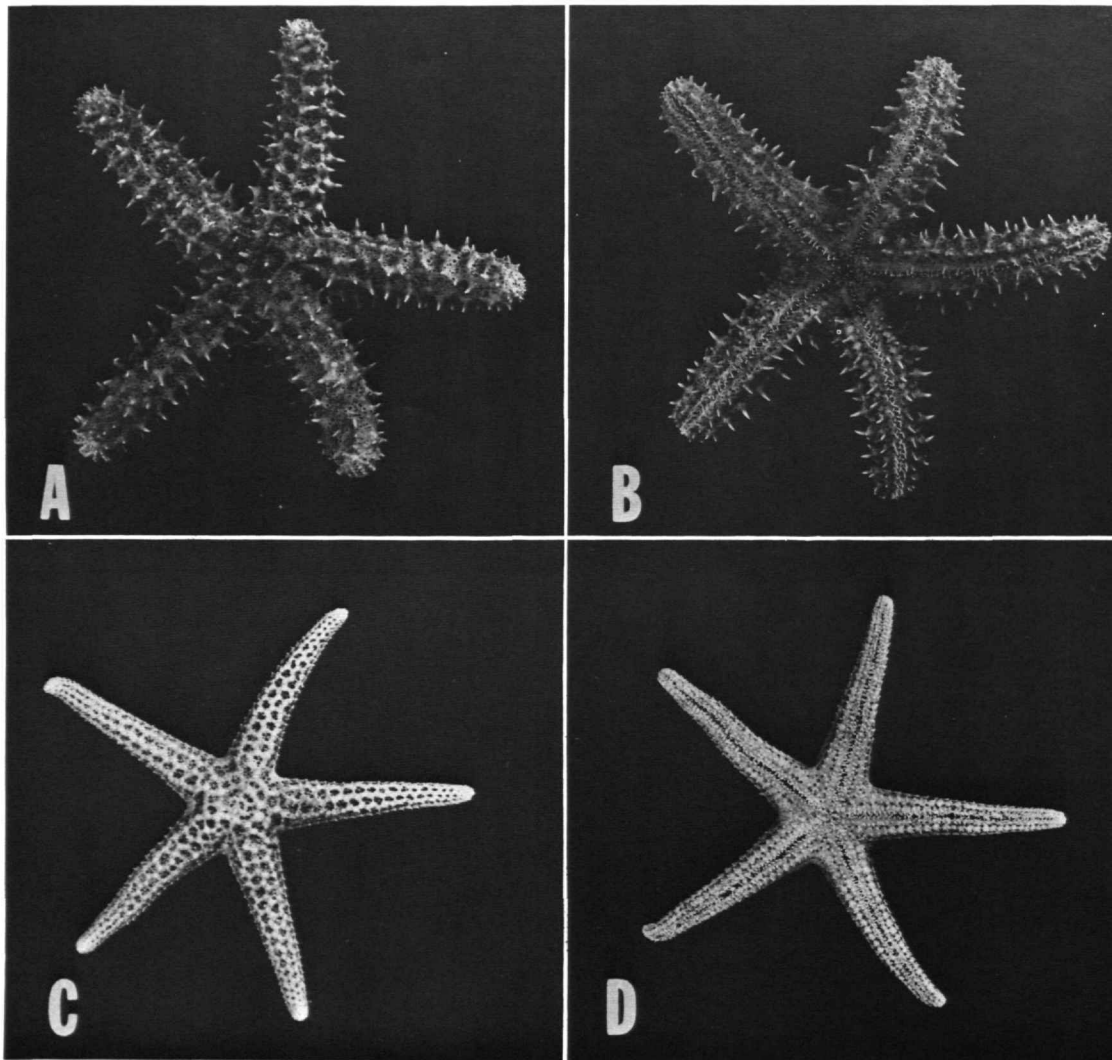


PLATE 40.—A, *Echinaster sentus*, abactinal; B, same, actinal (actual size=70 mm R); C, *Echinaster modestus*, abactinal; D, same, actinal (actual size=49 mm R).

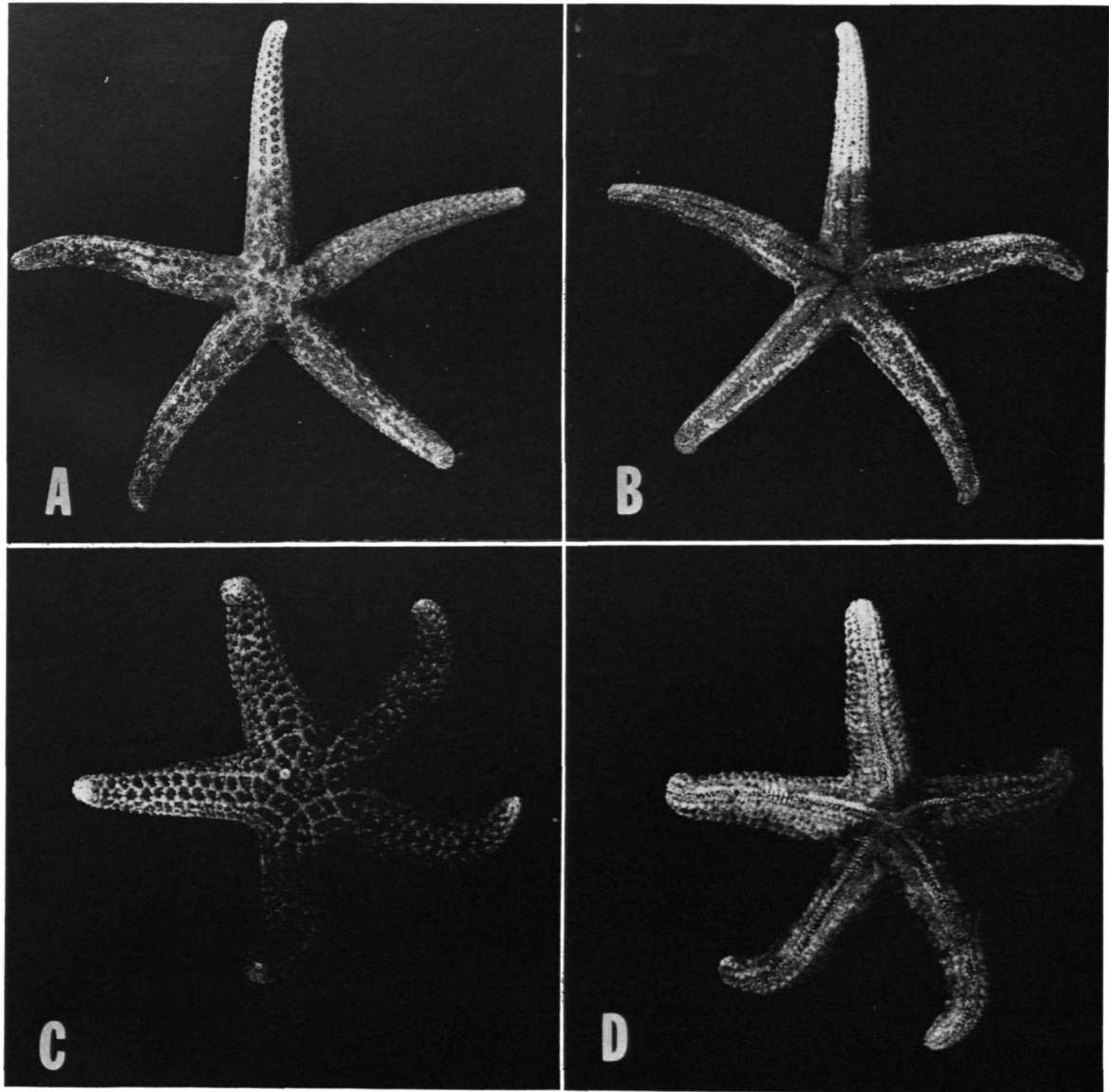


PLATE 41.—A, *Echinaster* species A, abactinal; B, same, actinal (actual size=84 mm R); C, *Echinaster* species B, abactinal; D, same, actinal (actual size=65 mm R).

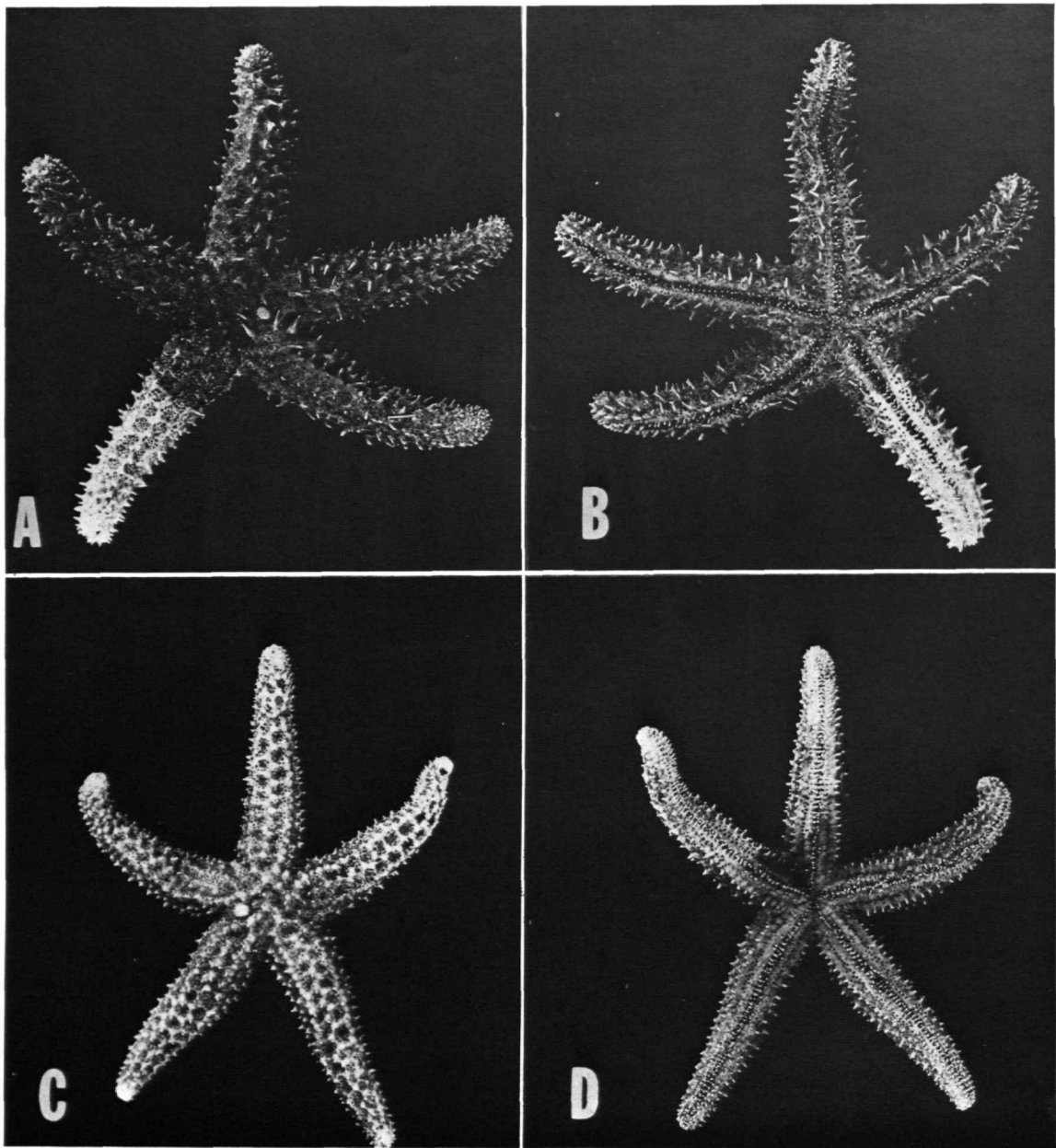


PLATE 42.—A, *Echinaster* species c, abactinal; B, same, actinal (actual size=72 mm R); C, *Echinaster brasiliensis*, abactinal; D, same, actinal (actual size=65 mm R).



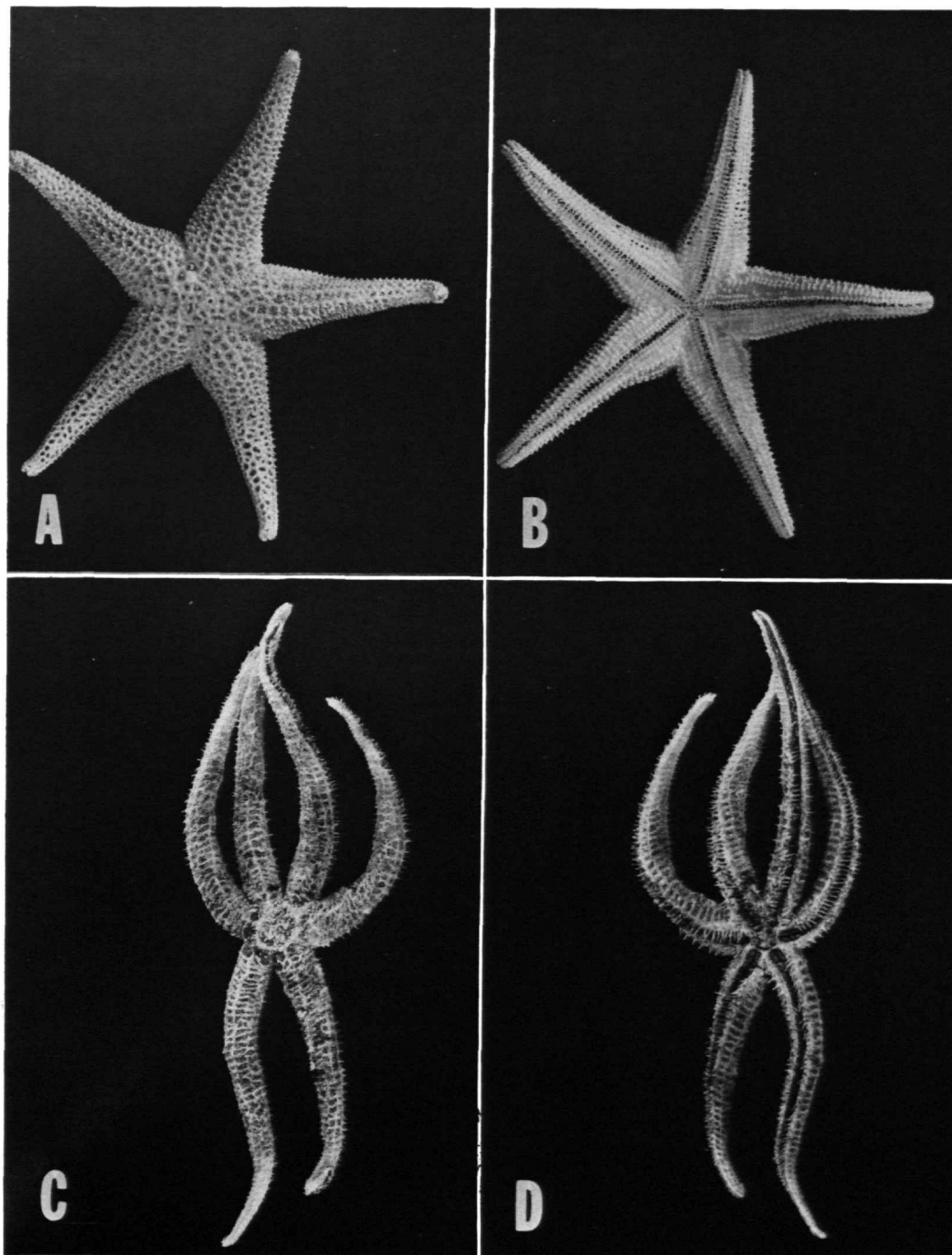


PLATE 43.—A, *Verrillaster spinulosus*, abactinal; B, same, actinal (actual size=65 mm R); C, *Ampheraster alaminos*, abactinal; D, same, actinal (actual size=62 mm R).

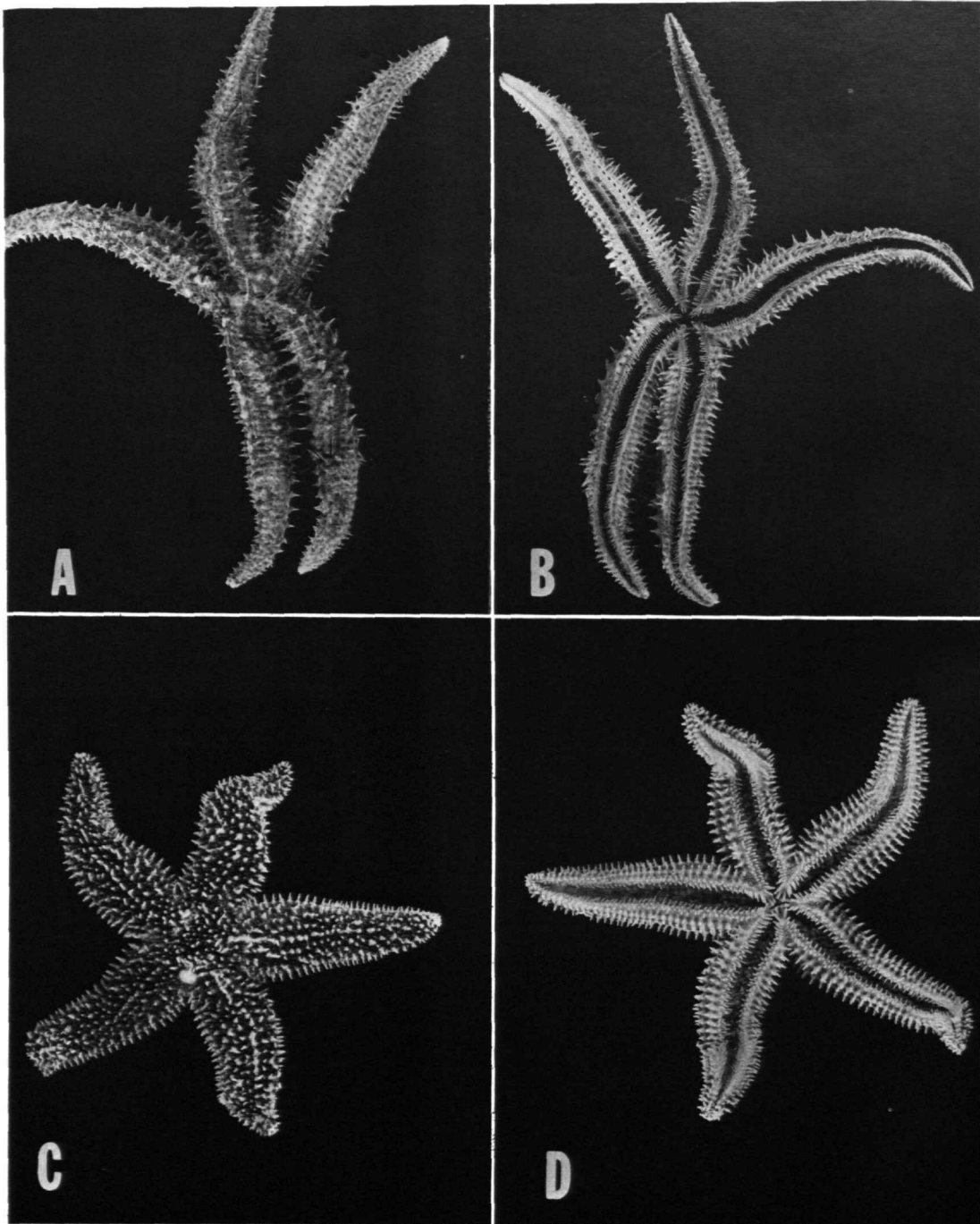


PLATE 44.—A, *Sclerasterias contorta*, abactinal; B, same, actinal (actual size=90 mm R); C, *Asterias forbesi*, abactinal; D, same, actinal (actual size=45 mm R).

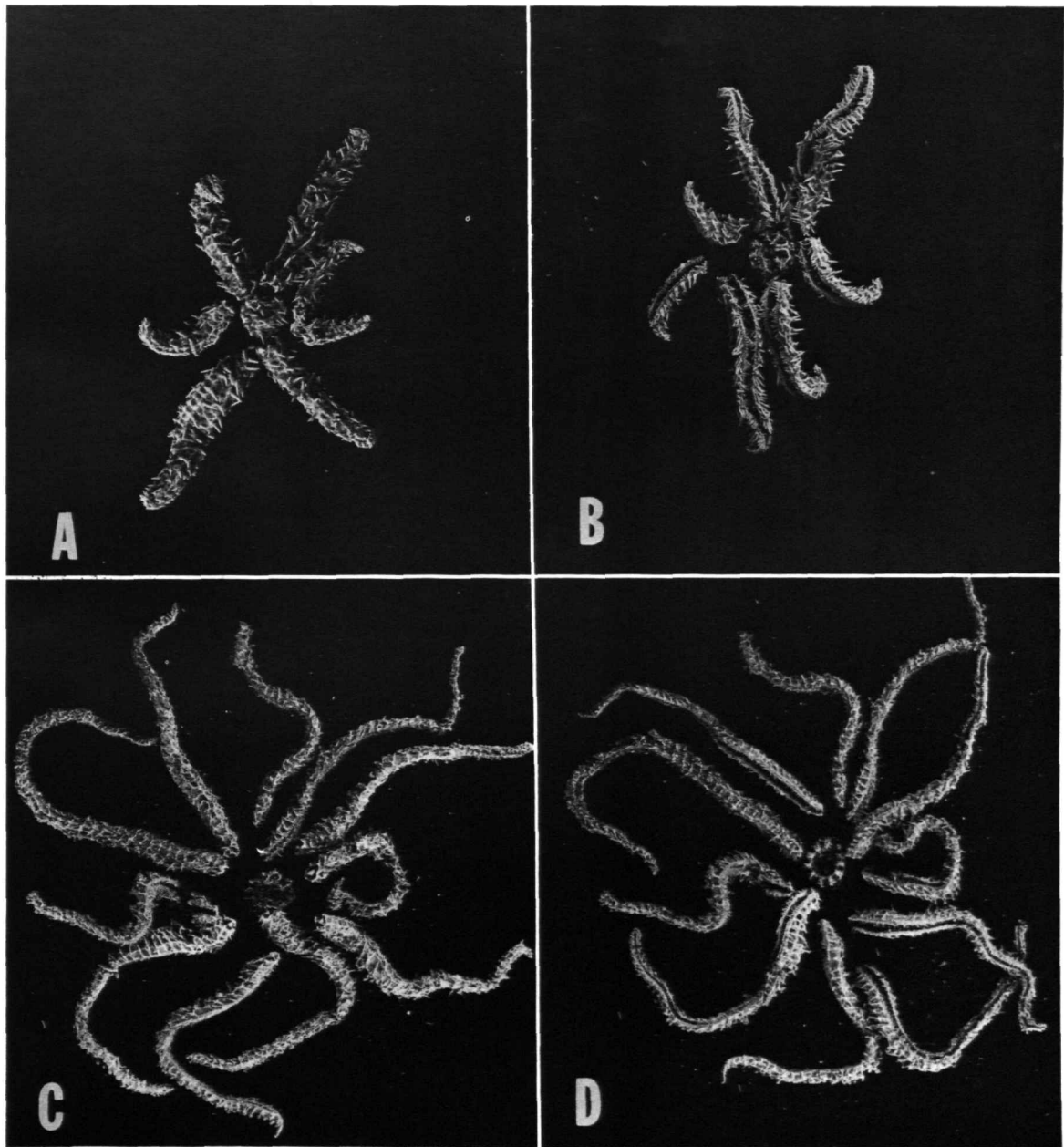


PLATE 45.—A, *Coscinasterias tenuispina*, abactinal; B, same, actinal (actual size=30 mm R); C, *Coronaster briareus*, abactinal; D, same, actinal (actual size=125 mm R).

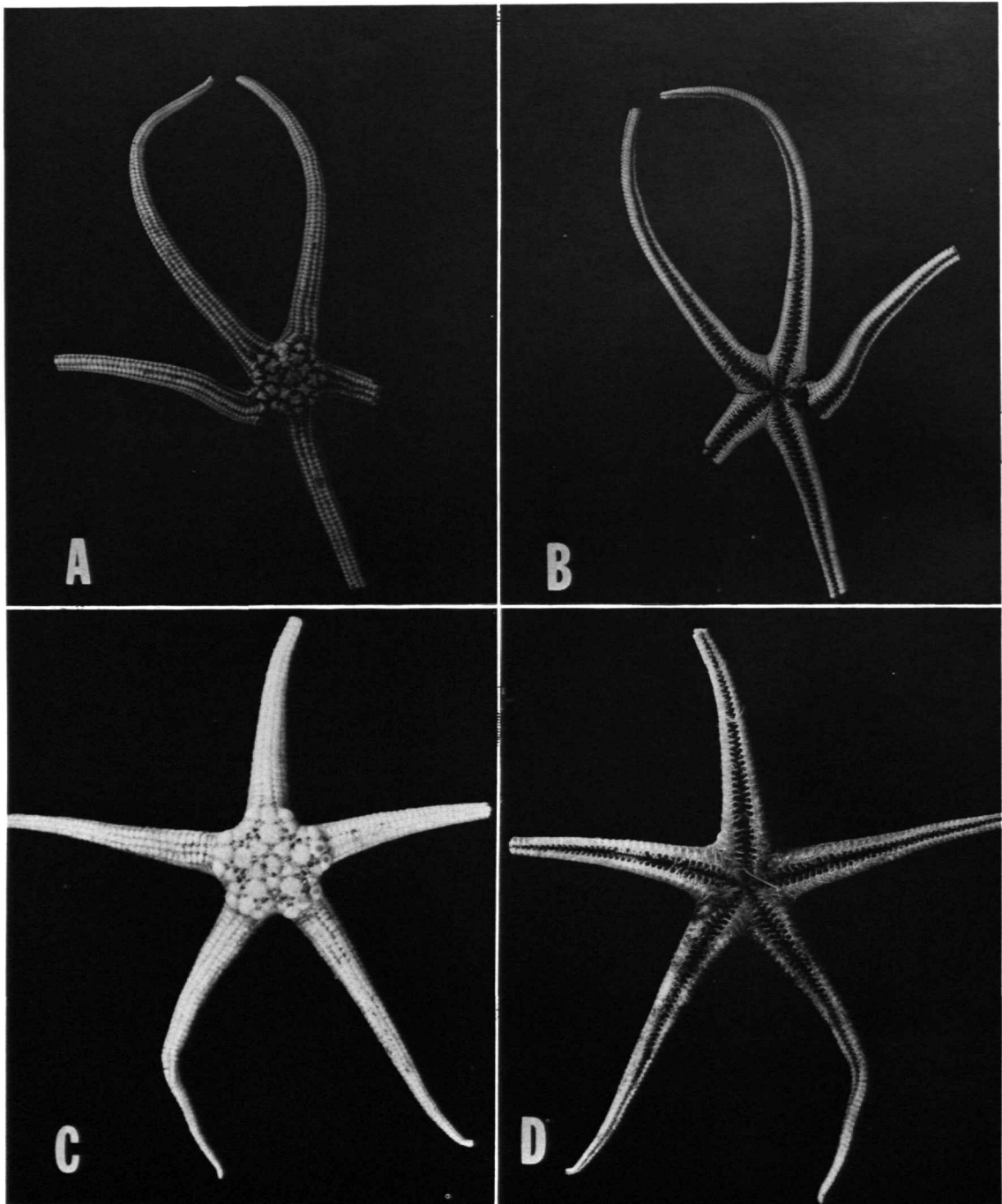


PLATE 46.—A, *Doraster constellatus*, abactinal; B, same, actinal (actual size=80 mm R); C, *Mammaster sigsbeeii*, abactinal; D, same actinal (actual size=47 mm R).

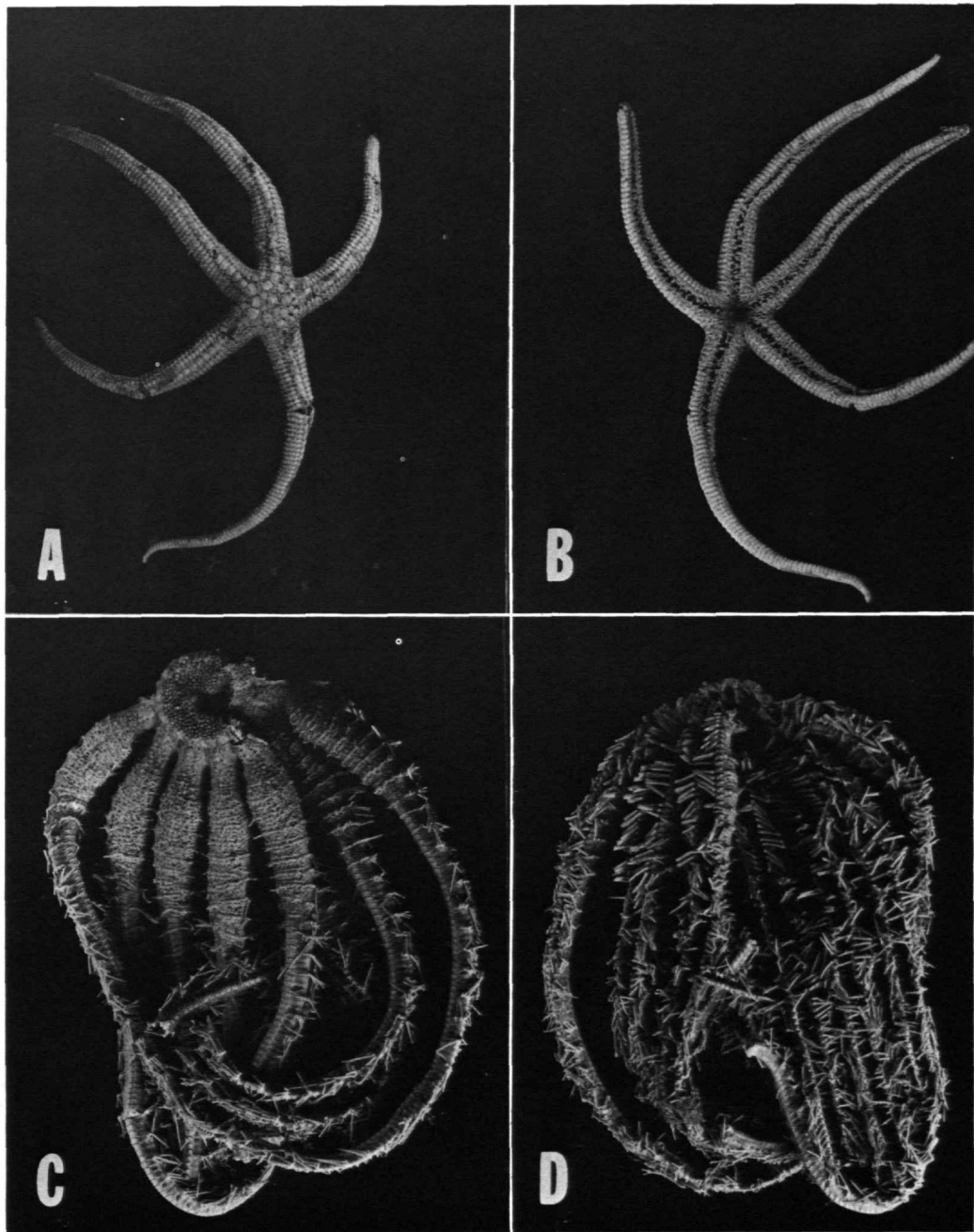


PLATE 47.—A, *Zoroaster fulgens*, abactinal; B, same, actinal (actual size=85 mm R); C, *Odinia antillensis*, abactinal; D, same, actinal (actual size=47 mm R).

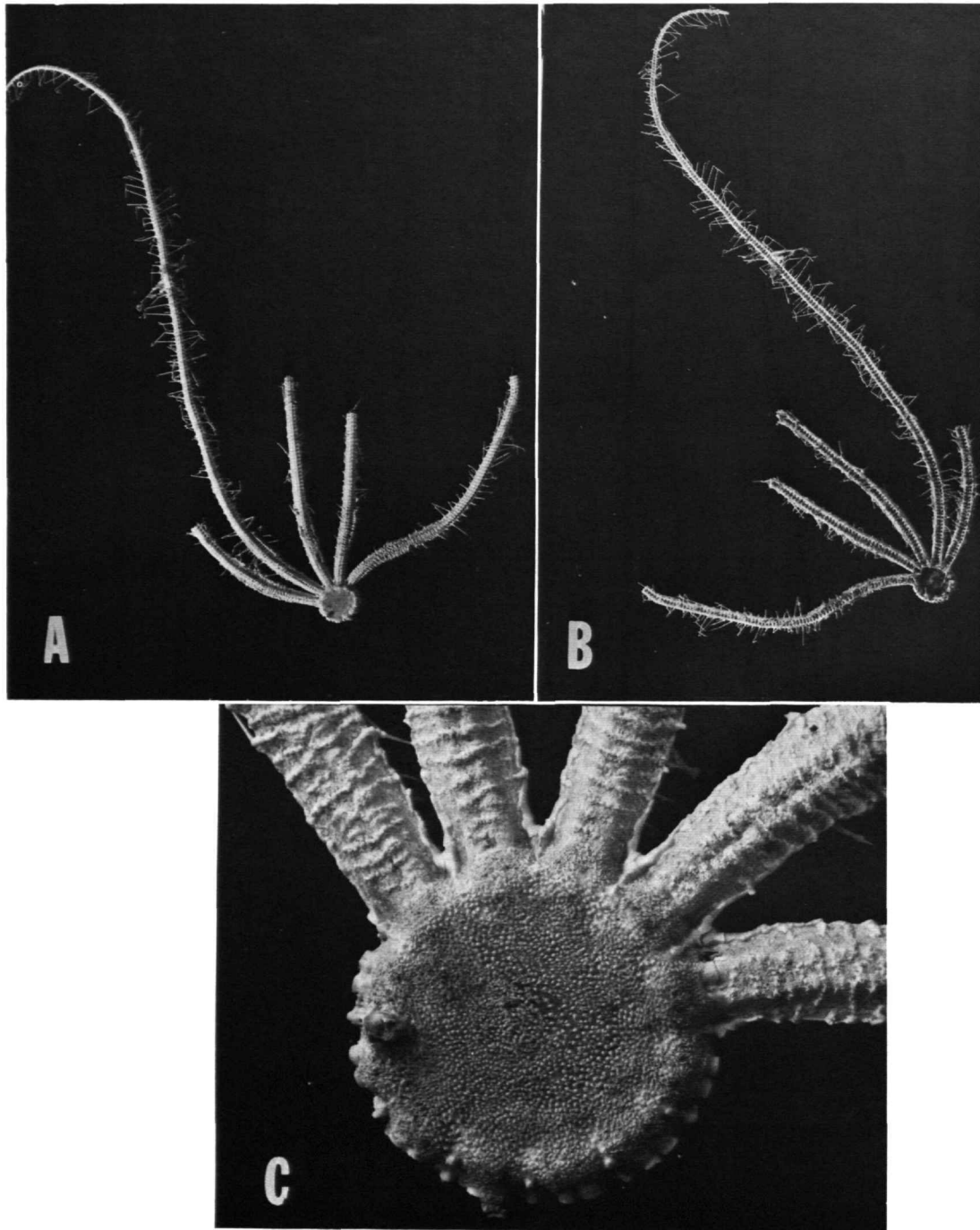


PLATE 48.—A, *Midgardia xandaros*, abactinal; B, same, actinal; C, abactinal view of disc (actual size=680 mm R).

## Publication in Smithsonian Contributions to Zoology

*Manuscripts* for serial publications are accepted by the Smithsonian Institution Press, subject to substantive review, only through departments of the various Smithsonian museums. Non-Smithsonian authors should address inquiries to the appropriate department. If submission is invited, the following format requirements of the Press will govern the preparation of copy.

*Copy* must be typewritten, double-spaced, on one side of standard white bond paper, with 1½" top and left margins, submitted in ribbon copy with a carbon or duplicate, and accompanied by the original artwork. Duplicate copies of all material, including illustrations, should be retained by the author. There may be several paragraphs to a page, but each page should begin with a new paragraph. Number consecutively all pages, including title page, abstract, text, literature cited, legends, and tables. The minimum length is 30 pages, including typescript and illustrations.

The *title* should be complete and clear for easy indexing by abstracting services. Taxonomic titles will carry a final line indicating the higher categories to which the taxon is referable: "(Hymenoptera: Sphecidae)." Include an *abstract* as an introductory part of the text. Identify the *author* on the first page of text with an unnumbered footnote that includes his professional mailing address. A *table of contents* is optional. An *index*, if required, may be supplied by the author when he returns page proof.

Two *headings* are used: (1) text heads (boldface in print) for major sections and chapters and (2) paragraph sideheads (caps and small caps in print) for subdivisions. Further headings may be worked out with the editor.

In *taxonomic keys*, number only the first item of each couplet; if there is only one couplet, omit the number. For easy reference, number also the taxa and their corresponding headings throughout the text; do not incorporate page references in the key.

In *synonymy*, use the short form (taxon, author, date:page) with a full reference at the end of the paper under "Literature Cited." Begin each taxon at the left margin with subsequent lines indented about three spaces. Within an entry, use a period-dash (.—) to separate each reference. Enclose with square brackets any annotation in, or at the end of, the entry. For *references within the text*, use the author-date system: "(Jones 1910)" and "Jones (1910)." If the reference is expanded, abbreviate the data: "Jones (1910:122, pl. 20: fig. 1)."

Simple *tabulations* in the text (e.g., columns of data) may carry headings or not, but they should not contain rules. Formal *tables* must be submitted as pages separate from the text, and each table, no matter how large, should be pasted up as a single sheet of copy.

Use the *metric system* instead of, or in addition to, the English system.

*Illustrations* (line drawings, maps, photographs, shaded drawings) can be intermixed throughout the printed text. They will be termed *Figures* and should be numbered consecutively; however, if a group of figures is treated as a single figure, the components should be indicated by lowercase italic letters on the illustration, in the legend, and in text references: "Figure 9*b*." If illustrations (usually tone photographs) are printed separately from the text as full pages on a different stock of paper, they will be termed *Plates*, and individual components should be lettered (Plate 9*b*) but may be numbered (Plate 9: figure 2). Never combine the numbering system of text illustrations with that of plate illustrations. Submit all legends on pages separate from the text and not attached to the artwork. An instruction booklet for the preparation of illustrations is available from the Press on request.

In the *bibliography* (usually called "Literature Cited"), spell out book, journal, and article titles, using initial caps with all words except minor terms such as "and, of, the." For capitalization of titles in foreign languages, follow the national practice of each language. Underscore (for italics) book and journal titles. Use the colon-parentheses system for volume, number, and page citations: "10(2):5-9." Spell out such words as "figures," "plates," "pages."

For *free copies* of his own paper, a Smithsonian author should indicate his requirements on "Form 36" (submitted to the Press with the manuscript). A non-Smithsonian author will receive 50 free copies; order forms for quantities above this amount with instructions for payment will be supplied when page proof is forwarded.

