SHALLOW-WATER ASTEROIDEA AND OPHIUROIDEA OF HAWAII

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INTRODUCTION

Our previous knowledge of the Hawaiian shallow-water Asteroidea and Ophiuroidea has been derived from brief and widely scattered references and from the reports of the several zoological expeditions which have touched the islands. Among the reports, those of the Challenger, Albatross, and Tanager expeditions should be mentioned as the most valuable. In addition, various individuals at different times have collected about the islands and added further information. Among these were C. H. Edmondson who summarized the results of his extensive collecting in "Reef and Shore Fauna of Hawaii" (14)[2], H. W. Henshaw, A. Garrett, A. E. Verrill, V. Pietschmann, and H. L. Clark.

Since literature referring to Hawaiian echinoderms is not easily available, diagnoses, keys and descriptions of all species have been included. For use by the general student, the taxonomically important skeletal structures of a representative asteroid and ophiuroid have been described in separate sections.

The arrangement and characterization of orders, families and genera of starfishes described here is taken from W. K. Fisher's extensive monographs on the Asteroidea of the North Pacific, with a few minor changes to which reference is made in the text. His descriptions of species in "The Starfishes of the Hawaiian Islands" (16) have been found so complete that little can be added, hence this work is drawn from freely. With regard to higher categories of brittle stars, Matsumoto's monograph on Japanese Ophiuroidea (36) is the source of diagnoses. Most of the descriptions of species of brittle stars are mine.

Of the 40 species considered here, 25 are starfishes and 15 are brittle stars. Among the brittle stars, three species are new to science and one of these is the type of a new genus. Two species have not previously been known from Hawaii, *Ophiactis modesta* Brock, a brittle star, and *Asterina anomala*, a starfish. Another brittle star, *Ophiocoma parva* Clark, is recorded for the first time from Oahu.

Twelve of the 40 species are endemic. Of these, six have their closest relative in the Indo-Pacific region, two in the Australian, one in the Philippine, one in the Japanese, and one in the American west coast region. The twelfth, the type species of the new genus, has as its closest relative the intertropic

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[2] Numbers in parentheses refer to the Bibliography, p. 61.

genus *Ophioconis*. Of the 28 non-endemic species, 13 are from Indo-Pacific areas and six are from the South Seas. Of three recorded from Central America, only the record of *Mithrodia bradleyi* Verrill has been adequately verified. Of the two Australian species, *Asterina anomala* Clark has been comparatively recently described so that its occurrence other than in Hawaii and Australia may not have come to light. *Coscinasterias acutispina* Stimpson has been found only in Japan and Hawaii, a fact which Fisher believes indicates a Japanese element in the Hawaiian fauna. Two of the remaining three species are tropicopolitan, and one is cosmopolitan. These observations lend further support to the view that the marine fauna of Hawaii in general shows a close affinity for that of the Indo-Pacific region.

The text figures are camera lucida drawings, and all measurements are approximate.

I am indebted to Dr. C. H. Edmondson for the use of his collection and photographs, to Bernice P. Bishop Museum for the use of its collection and facilities, and to the members of the Zoology Department of the University of Hawaii for many helpful suggestions. During the preparation of this paper I was greatly aided by Dr. Hubert Lyman Clark of the Museum of Comparative Zoology of Harvard University. I take this opportunity to express my thanks to him, and one of the new species described here has been named in his honor. All types are in the collection of Bishop Museum.

SYNOPSIS OF THE HAWAIIAN SHALLOW-WATER ASTEROIDEA

- Order Phanerozonia
  - Family Astropectinidae
    - Genus Astropecten
      - A. polyacanthus
      - A. triseriatus myobrachius
  - Family Luidiidae
    - Genus Luidia
      - L. hystrix
      - L. brevispina
  - Family Archasteridae
    - Genus Archaster
      - A. typicus
  - Family Oreasteridae
    - Genus Nidorellia
      - N. armata
    - Genus Culcita
      - C. novaeguineae forma arenosa
      - C. novaeguineae forma nesiotis
  - Family Ophidiasteridae
    - Genus Fromia
      - F. pacifica
    - Genus Gomophia
      - G. egyptiaca
    - Genus Linckia
      - L. guildingii
      - L. multifora
      - L. laevigata
    - Genus Leiaster
      - L. leachii hawaiiensis
      - L. brevispinus
    - Genus Ophidiaster
      - O. lorioli
      - O. squameus
    - Genus Dactylosaster
      - D. cylindricus pacificus
  - Family Asteropidae
    - Genus Asterope
      - A. carinifera
- Order Spinulosa
  - Family Asterinidae
    - Genus Asterina
      - A. anomala
      - A. granulosa
  - Family Mithrodiidae
    - Genus Mithrodia
      - M. bradleyi
      - M. fisheri
  - Family Acanthasteridae
    - Genus Acanthaster
      - A. planci

Order Forcipulata
  Family Asteriidae
    Genus Coscinasterias
      C. acutispina
Order Gnathophiurida
  Family Amphiuridae
    Genus Amphiura
      A. immira, new species
    Genus Amphipholis
      A. squamata
    Genus Amphioplus
      A. caelatus, new species
    Genus Ophiactis
      O. modesta
      O. savignyi
  Family Ophiotrichidae
    Genus Ophiothrix
      O. demessa

Order Chilophiurida
  Family Ophiodermatidae
    Genus Distichophis, new genus
      D. clarki, new species
  Family Ophiochitonidae
    Genus Ophionereis
      O. porrecta
  Family Ophiocomidae
    Genus Ophiocoma
      O. scolopendrina
      O. erinaceus
      O. pica
      O. brevipes
      O. insularia
      O. insularia var. variegata
      O. parva

A REPRESENTATIVE ASTEROID

The classification of echinoderms is based largely on the form and arrangement of the various calcareous ossicles which make up the skeletal framework. These have been described and given names which are applied in taxonomic studies of the echinoderms. Using *Coscinasterias acutispina* as a representative of the Asteroidea, these plates are considered below.

An understanding of the generalized echinoderm skeleton will help to clarify much of the following discussion. Certain plates which are homologous throughout the phylum are well exemplified by the larval crinoid, *Antedon*. In this form there are two principal groups or systems of plates, the oral and apical.

The oral system consists of five plates interradially placed around the mouth opening. These are called odontophores in the Asteroidea. The apical system of *Antedon* is composed of a central plate encircled by three concentric series of five plates each. The ossicles of the series nearest the center, the infrabasals, are radially placed; those of the next series, the basals, are interradially placed and those of the outermost series, the radials, are radially placed. This simple arrangement represents the starting point, but extensive modifications have occurred through the loss of old parts and the acquisition of newer and more varied ones in other forms. (See figure 1.)

The Oral System

The plates of the oral system in the Asteroidea are called odontophores and are pushed below the surface. They are five in number, interradially placed, and in *Coscinasterias acutispina* are small, rather fan-shaped ossicles (fig. 2, *a*). In order to see these plates, the roof of the disk must be removed and the tissue dissected away from the interbrachial areas.

The Apical System

The different types of plates of the apical system as seen in *Antedon* cannot be made out in *C. acutispina* nor, in fact, in most adult starfishes, with the exception of a few genera; but they can be well demonstrated ontogenetically. In the adult *C. acutispina,* they are represented by closely reticulated and irregularly arranged four-lobed plates which cover the aboral surface of the disk.

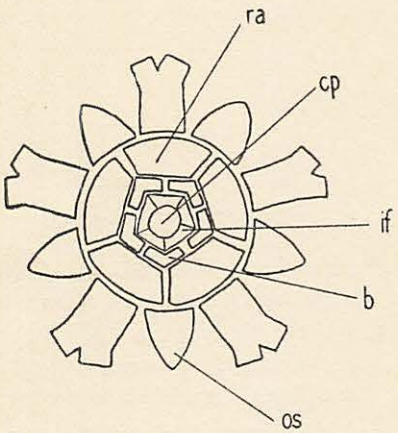

Figure 1.—Diagram of the plates of the larval *Antedon* (after Lang, Text-Book of Comparative Anatomy, p. 318) : aboral view (*ra,* radials; *cp,* central plate; *if,* infrabasals; *b,* basals; *os,* oral shield).

The Perisomatic System

A third major portion is added to the adult echinoderm skeleton. It is called the perisomatic skeleton and includes those parts which protect the body between the apical and oral systems. The homologies of this portion of the skeleton are not so evident as those of the apical and oral systems, the primitive condition of which is typified by *Antedon.* It may be subdivided into two principal parts, the ambulacral and the interambulacral.

The ambulacral portion of the perisomatic skeleton consists of those plates which form the roof and sides of the ambulacral furrow. This latter is a deep groove into which project the tube feet. The V-shaped roof of the groove is formed by a regular succession of plates which meet like rafters in pairs at the apex. These are the ambulacral plates (fig. 2, *b*). In *C. acutispina,* they are compressed, elongate, and irregularly hour-glass shaped. The compressed surfaces lie parallel to each other and are contiguous at the ends but with adequate space between each pair for the passage of the tube feet. The sides of the groove are formed by flat, semicircular ossicles which articulate above with the ambulacral plates. These are the adambulacral plates (fig. 2, *b*).

The oral aperture into which the furrows of all rays converge lies at the center of the disk and is surrounded by a circle of ten firmly united calcareous ossicles, the oral plates (fig. 2, *a*), which underpin the odontophores. These plates in *C. acutispina* are quite large, thick and square and their distal surfaces articulate with the adambulacral and ambulacral plates. It has been suggested that they may consist of the first ambulacrals and adambulacrals fused and modified.

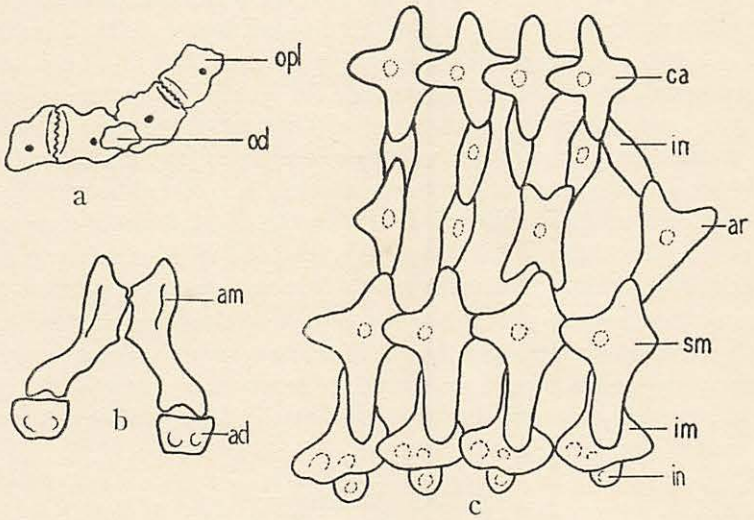

FIGURE 2.—*Coscinasterias acutispina:* **a,** portion of oral ring, aboral view (*opl,* oral plates; *od,* odontophores) × 4; **b,** ambulacral and adambulacral plates (*am,* ambulacral plate; *ad,* adambulacral plate) × 4; **c,** aboral skeleton between the first series of intermediate plates and the carinal plates inclusive (*ca,* carinal plates; *in,* intermediate plates; *ar,* adradial plates; *sm,* superomarginal plates; *im,* inferomarginal plates) × 4.

The interambulacral part of the perisomatic skeleton forms the lateral sides of the arms. The pieces composing it are called the marginal plates and are arranged on each side in two rows, one aboral to the other.

The inferomarginal plates (fig. 2, *c*), those of the lower series, are perpendicular to the adambulacral plates of the ambulacral furrow with which they are in contact. In the form under consideration the inferomarginal plates are close together. Each has four unequal lobes and bears articulating prominences for three oral lateral spines.

The superomarginal plates (fig. 2, *c*), those of the upper series, are larger than the inferomarginal plates and each has four lobes. The proximal lateral lobe of each plate overlies the distal lobe of its neighbor in the series. Approximately every other one of the superomarginal plates bears an articulating process for a spine.

Occurrence of only two primary rows of marginal plates is found in the

more primitive groups. In higher forms, such as *C. acutispina,* there are additional rows so that the entire surface of the ray is armed.

In *C. acutispina,* these plates are arranged in several successive rows extending the length of the arms. The mid-dorsal series is known as the carinal row (fig. 2, *c*). The carinal plates of *C. acutispina* have four equal lobes with the two lateral lobes overlying plates on either side and the proximal lobe of one plate of the series overlying the distal lobe of the neighboring plate in the series. Midway between the carinal row and the superomarginal row may be seen another series of three- and four-lobed plates, known as the adradial row (fig. 2, *c*). Between any of these four major series of plates (carinal, adradial, superomarginal, and inferomarginal) may be inserted one or more series of plates which are generally smaller and of different shape than those of the major series. These are known as intermediate plates (fig. 2, *c*). In *C. acutispina,* there are two series of intermediate plates, one placed between the carinals and the adradials and the other between the adradial and the superomarginal plates. The intermediate series is composed of bi-rayed, transversely elongated plates bridging the space between the major rows of plates.

The arrangement of plates over the surface of the arms produces a loose network or reticulum. Between the plates are large unprotected areas in which are located the saclike dermal branchiae, the respiratory organs of the Asteroidea. The number of dermal branchiae per space and the number of rows are of taxonomic significance.

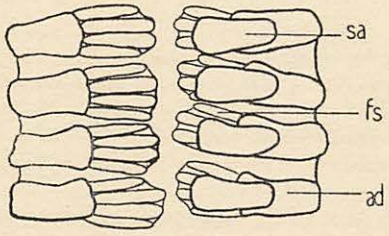

FIGURE 3.—Adambulacral armature of *Asterope carinifera,* oral view (*sa,* adambulacral spine; *fs,* furrow spine; *ad,* adambulacral plate) × 3.

At the free end of the arm in all asteroids is a single terminal plate called the ocular plate (pl. 5, *B*), which is obscured in *C. acutispina* but prominent in the Ophidiasteridae.

In some starfishes, each ambulacral ossicle is connected by a skeletal plate with a marginal plate of the same side. The superambulacral plates, as they are called, are not present in *C. acutispina.*

Spines or granules and pedicellariae usually cover the asteroid body, but they are so variable in form and arrangement that reference should be made to the descriptions of the individual species in which they occur. Of particular importance are the spines which border the furrow. These are generally

attached to the adambulacral plates; the spines on the outer margin are referred to as the adambulacral spines, and those on the inner or furrow margin of the plates are known as the furrow spines. (See fig. 3.)

Descriptions and Keys

Class ASTEROIDEA Burmeister

Free echinoderms with star-shaped bodies in which a central disk and usually five arms are more or less readily distinguishable; the arms hollow, each containing a prolongation of the coelom and its contained organs. Oral and aboral surfaces distinct; oral surface bearing mouth and ambulacral grooves; the aboral surface bearing anus and madreporite.

Key to the Orders of Asteroidea

A. Marginal plates usually large and conspicuous, defining contour of the body; aboral skeleton in the form of paxilliform plates, or flat, tesselate plates which are smooth or armed with granules or spines, and either naked or covered with a thin or thick membrane. Pedicellariae never pedunculate forcipiform, but spiniform, pectinate, valvate, or excavate. Papulae restricted to the aboral surface (except in some Ophidiasteridae and Asteropidae) circumscribed by the marginal plates. Mouth plates prominent; ambulacral plates well spaced; tube feet in two series; rays normally 5 (except in some *Luidia*).....**Phanerozonia.**

AA. Marginal plates usually not conspicuously large; aboral skeleton not composed of true paxilliform plates, nor in the form of tesselated pavement, but usually more or less reticulate or imbricated. Papulae frequently but not invariably intramarginal and oral. Some form of aboral spinulation always present; tube feet with well-developed sucking disks.

B. Actinostomial ring with adambulacral plates prominent; pedicellariae very rare, never pedunculate forcipiform nor excavate; ambulacral ossicles not crowded; aboral skeleton composed of thin, close-set overlapping plates, or forming a more or less open reticulate network, either regular or irregular; plates often cruciform with or without connecting independent ossicles.....**Spinulosa.**

BB. Pedicellariae pedunculate, either forcipiform or forficiform (crossed or straight); actinostome with ambulacral plates prominent. Skeletal plates bearing spines, often long and isolated, on or about which are usually grouped the pedicellariae, or the pedicellariae may be isolated; marginal plates inconspicuous or aborted; ambulacral plates often very crowded with tube feet in four series. Aboral skeleton formed of skeletal arches (transverse on rays) independent or bound together by intermediate plates, forming a network with rectangular or very irregular meshes. These skeletal arches correspond to every other or to every third adambulacral, and are composed of pieces corresponding in the ventral, lateral, and dorsal regions of the body. Mouth plates usually inconspicuous.....**Forcipulata.**

Order PHANEROZONIA Sladen

Key to Hawaiian Families of Shallow-water Phanerozonia (adapted from Fisher, 17)

A. Tube feet pointed without a definite flat sucking disk, but sometimes with a small pointed knob at tip.

B. Ampullae double; simple cribriform organs, or more or less specialized marginal fascioles usually present; aboral plates always paxilliform; superambulacral plates always present.

C. Superomarginal plates replaced by paxillae; broad inferomarginals; no anus, no intestinal coecum, no intestine; compound papulae ..... **Luidiidae.**

CC. Superomarginals never aborted, though sometimes small; not replaced by paxillae similar to those on dorsum; intestine present; coecum generally present; anal pore usually present, frequently minute, sometimes absent; papulae simple ..... **Astropectinidae.**

AA. Tube feet with well-developed sucking disks.

B. Aboral plates tabulate with groups of coordinated granules or spinelets; arranged in oblique transverse rows on either side of a conspicuous medioradial series and with special internal imbricating ridges. Marginal plates opposite (at least at base of ray) and not conspicuously spiny; no dorsal muscle bands; papulae not confined to base of ray and adjacent portion of disk and never localized in a special papular organ. Spinelets not slender and glassy; no odd interradial marginal; ampullae double. Oral intermediate plates aborted or very few; interbrachial septa calcareous; gonads extending along the rays ..... **Archasteridae.**

BB. Aboral plates neither tabulate nor paxilliform but flat, convex, spinous, tubercular, granulous or smooth; sometimes overlaid by a thin or thick, smooth or granulous, skin; marginal plates with or without robust spines or tubercles.

C. Disk large; oral interradial areas extensive, but no papulae on oral surface.

D. Marginal plates large, but as a rule inconspicuous, being more or less hidden by granulous skin or encroachments of papular areas; aboral skeleton stellato-reticulate; plates always granulous; papulae numerous, and in definite areas; aboral plates usually with large conical tubercles or spines. Disk usually high, or body thick and cushionlike; interbrachial septa usually calcareous ..... **Oreasteridae.**

DD. Marginal plates small, more or less imbricated and whole body covered by a thick, smooth, tough skin; aboral skeleton tesselate or reticulate, the plates loosely imbricated; prominent spines exceptional, small spines present in some genera ..... **Asteropidae.**

CC. Disk small with very small oral interradial areas as a rule (if at all well developed, then papulae on oral surface); marginals small; skeleton tesselate; tegumentary developments granulate (skeleton overlaid by a smooth skin, without prominent spines in *Leiaster*) ..... **Ophidiasteridae.**

Family ASTROPECTINIDAE Gray

Phanerozonia with large marginal plates, true paxillae, and parapaxillae; with pointed tube feet (a flat or true sucking disk being always absent); with

double ampullae; no cribriform organs, but frequently well-developed marginal fascioles which are never webbed; with an intestine and usually an intestinal coecum; anus absent, small or well developed; superambulacral plates always present.

Genus **ASTROPECTEN** Gray

Rays normally five; aboral surface flat, not arched; oral surface slightly beveled on sides; disk variable in size, usually medium to small; rays usually long and tapered; marginal plates large, the inferomarginals always broader than superomarginals and sometimes extending laterally beyond them; inferomarginals armed with spinelets and a variable number of spines which increase in size toward the edge of the ray; superomarginals, in addition to small granules or spinelets, may also bear tubercles or enlarged spines extending in one or two complete or interrupted rows along ray; or enlarged spines may be entirely absent; exposed surface of consecutive marginal plates separated by deep fasciolar grooves lined by minute capillary spinelets, these grooves acting as percolators or filters; aboral area covered with true paxillae; papulae single, usually absent from a narrow or wider midradial line, and from the center of disk; usually six about each paxilla; oral interradial areas typically very small, with few paxilliform intermediate plates which do not extend far along the ray, the inferomarginals and adambulacrals being in contact on the ray proper; intermediate plates never extend beyond middle of ray and rarely beyond proximal fourth; adambulacral plates with an angular furrow margin, bearing typically three spines, of which the middle is slightly the longest; two or three rows of spines on oral surface of plates; first adambulacral plate compressed, much wider than the rest; mouth plates narrow, with inner spines enlarged; tube feet conical, without a true sucking disk; no true pedicellariae; anus typically absent; gonads interradial, not extending along ray; superambulacral plates well developed.

Key to the Hawaiian Species of Astropecten

A. Uppermost row of lateral arm spines consisting of a single spine to each of the plates which make up the distinct margin.....**A. polyacanthus.**

AA. Uppermost row of lateral arm spines consisting of two to three spines to each of the plates which make up the distinct margin.....**A. triseriatus myobrachius.**

Astropecten polyacanthus Müller and Troschel, Syst. Ast., 69, 1842.

Rays five. Arms rigid, very gently tapering to a bluntly pointed extremity. Sides of arms rather high, perpendicular. Disk of medium size. Interbrachial arcs acute but rounded. In life the distal oral arm surface is vinaceous cinnamon; remainder of arms and disk fawn color. Dorsal integument bright vermilion. Entire oral surface light buff pink. Australian specimens are deep purple on the paxillar areas of the dorsal surface, while the oral surface is more or less red orange, with margins pale yellow.

Aboral surface covered by compact paxillae; paxillae large and arranged in definite rows. Each paxilla consists of one or two central papilliform granules, surrounded by a radiating series of from five to eight slightly longer ones, the whole crowning a rather long pedicel. On the disk the largest paxillae have upward to five central granules of unequal size, surrounded by 10 to 12 longer marginal ones, and occasionally one of the central granules is enlarged into a cylindrical pointed spinule.

Superomarginal plates are much higher than broad and do not encroach conspicuously upon paxillar area. Except the second or third plate, each bears a perpendicular, stout, pointed, and conical spine situated on the aboral face, slightly nearer the aboral than adoral margin. This series decreases in length toward the tip of the ray. The second superomarginal plate, which does not bear a spine, is smaller than

either the first or third. Plates are covered with small cylindrical papilliform spinelets, which become stouter and squamiform toward the base of the spines.

The inferomarginals which are broader than high, correspond to superomarginals. Each plate bears a transverse series of three stout and relatively long, tapering, slightly flattened, sharp-pointed spines, the upper longest; to which is added a fourth spinule at inner end of series on third to seventh plates. Plates are covered with slender papilliform spinelets in the fasciolar grooves and at upper end, these becoming longer, strongly flattened, and bluntly rounded or chisel-shaped at tip, in the vicinity of spines, and on oral surface generally.

Adambulacral armature in three series. The furrow series consists of three long, stout spinelets, the median longest, blunt, somewhat triangular. Second series consists of two stouter, much flattened, truncate spinelets. The third series consists of three blunt, flattened spinelets somewhat smaller than the furrow series. There is an odd spine situated behind the third series. Tube feet large, with an incipient conical sucker at end, easily distinguishable from the rest of the foot. (Modified from Fisher, 16.)

Widely distributed, from the Red Sea to Zanzibar, Ceylon, Hongkong, the coasts of China and Japan, New Holland, Admiralty Islands, Fiji Islands, and Port Jackson, Australia.

This is one of the smaller starfishes, having R = 47 mm.[3] One specimen of this species was taken by the *Albatross* in 1902 in the vicinity of Nihoa, and another by the *Tanager* in 1923-24 at French Frigate Shoal; both apparently were dredged at some depth, but Fisher (18) reports several specimens as having been collected along the shore of some of the Philippine Islands. Hence, it may occasionally be found in shallow water about the Hawaiian islands. One specimen in the collection of Bishop Museum was examined in this study. *Astropecten polyacanthus* is notably variable, and Fisher points out that undoubtedly when a sufficient number of specimens from different localities are examined by one person the species will be split up. A photograph is given by Fisher (16).

Astropecten triseriatus myobrachius Fisher, B. P. Bishop Mus. Bull. 27: 69, 1925.

In general form, like *A. polyacanthus*. Across base of ray 14 paxillae having 10 to 12 cylindrical round-tipped spinelets, of which one or two occupy the center. On a few paxillae a central spinelet is greatly enlarged. First and second or first and fourth superomarginal plate with one spine; then follow three to seven plates with two spines, the remainder with three in an oblique transverse series along the crest of the strongly convex plates, which are not closely covered with flattened spinelets. These are slender on the margin of the plates, gradually changing to larger, blunt, lanceolate-ovate scales at the base of the spines. Terminal plate conspicuous, bearing a long series of three or four short conical spines.

Inferomarginal spines in transverse comb of four on the first four or five plates; then three or four on a few plates; then three. The spinelets are elongate, spatulate, rounded or subtruncate and are largest around the base of the spines.

Furrow spines three, rather long; then two, rather slender, flat, round-tipped suborals; then two (or one) similar but smaller spines. (Modified from Fisher, 20.)

The individual described by Fisher measures R = 41 mm.

Pearl and Hermes Reef.

[3] "R" refers to distance from center of disk to tip of ray.

This subspecies was collected at Pearl and Hermes Reef by the Tanager Expedition and was described as a new subspecies by Fisher in 1925. It is particularly significant, since it is indicative of the relationship between the Australian and Hawaiian faunas, its closest relative being *Astropecten triseriatus* which is found exclusively in Australia. One specimen of this species in Bishop Museum was examined. A photograph is given by Fisher (20).

Family LUIDIIDAE Verrill

Phanerozonia near the Astropectinidae, but without anus, intestine or intestinal coeca; superomarginals aborted, represented by paxillae; inferomarginals, adambulacrals, and oral intermediate plates forming regular transverse series, the first two being correspondent in number; papulae compound, the extremity forming a tuft of papillae.

Genus **LUIDIA** Forbes

Rays five or more, long, usually narrow, and depressed; disk small; aboral surface covered with true paxillae, frequently in regular longitudinal rows at sides; superomarginal plates paxilliform, similar to adjacent paxillae but frequently larger; inferomarginals with a transverse series of spines or spinelets; fasciolar channels deep and wide; oral interradial area very small; oral intermediate plates extending nearly to tip of ray in a single series (exceptionally two or three series are present, and plates rarely absent), the inferomarginals, intermediate plates and adambulacrals corresponding in a transverse series. Papulae compound, with distal portion subdivided into numerous papillae. Pedicellariae frequently present, sessile, two or three jawed as a rule, either conical, tong-shaped or low bivalved. Tube feet in two rows, without true sucking disks. Superambulacral plates present, well developed. Anus and intestinal coecum absent. Gonad in numerous tufts forming a linear series all along either side of aboral integument.

Key to the Hawaiian Species of Luidia

A. Rays more than five, mottled with brown. Pedicellariae few; aboral paxillae rounded, with one or two prominent spinules.....**L. hystrix.**

AA. Rays constantly five. No prominent spines on ray.....**L. brevispina.**

Luidia hystrix Fisher, U. S. Fish Comm. Bull. (3) : 1036, 1906.

Rays eight; elongate, slightly swollen above the base, and thence gradually tapering to the bluntly pointed extremity; aboral surface more or less flattened on disk. In life, cream-colored, mottled with burnt sienna and chocolate; below, white with white spines.

Paxillae of aboral area large, crowded on disk, and there without definite arrangement. They are arranged in definite, spaced, longitudinal rows along the rays, except in a narrow median radial area where they are more crowded and not so regular. Nearly all paxillae of rays bear a robust, upright, tapering, sharp thorn or spinule. This spinule surrounded by five to eight or 10 robust, cylindrical or clavate, obtusely tipped, papilliform spinelets, placed also on the tabulum. External to these on the periphery of the tabulum are 15 to 25 slender papilliform spinelets, usually somewhat irregular in thickness.

Inferomarginals numerous, short, and wide, each with a special raised ridge between which are deep fasciolar grooves. Plates bear, along the median line, a transverse series of four or five long, slightly curved, very sharp rather delicate spines. These increase in size toward outer edge of plate, the inner two being usually much smaller than the outer three, the median spine of which is longest. The elevation or keel of the plate, upon which the spines are borne, is bordered by long, slender spinelets, a few standing on the exposed surface, between the spines. Sides of the fasciolar grooves are covered with capillary spinelets.

Adambulacral armature consists of four spines, of which three form a regular transverse row, the median being the longest and the furrow spine shortest. The fourth spine is situated between the outer two, but adorally and out of line with the series. Furrow spine is slightly curved, compressed and saberlike. External to the outermost spine, about midway between it and the innermost inferomarginal spine, is a radiating group of 8 or 9 ciliary spinelets of different sizes. In the midst of these there is sometimes a three-jawed pedicellaria. (Modified from Fisher, 16.)

Hawaiian islands.

Specimens of this form were taken at numerous points about the islands by the *Albatross*. It is apparently quite common in deeper water and undoubtedly individuals wander onto the reef at times. Its closest relative is *L. asper,* which has been taken about the Philippine group and Admiralty Island. A photograph and figures are given by Fisher (16).

Large individuals measure R = 195 mm. The specimen in Dr. Edmondson's collection measured R = 90 mm.

Luidia brevispina Lütken, Vid. Med., 288, 1871.

This species is reported by Perrier from the "Sandwich Islands", where nine specimens were collected, presumably in shallow water (from Fisher, 16).

Family ARCHASTERIDAE Viguier

Phanerozonia with tube feet having well-developed suckers. Aboral plates tabulate with groups of coordinated granules or spinelets. Marginal plates opposite (at least at the base of ray) and not conspicuously spiny; no dorsal muscle bands; papulae not confined to base of ray and adjacent portion of disk and never localized in a special papular organ. No conspicuous recurved hyaline teeth. Spinelets not slender and glassy; no odd interradial marginal; ampullae double. Aboral plates tabulate, paxilliform; arranged in oblique transverse rows on either side of a conspicuous medioradial series and with special internal imbricating ridges; oral intermediate plates aborted or very few; interbrachial septa calcareous; gonads extending far along rays; general facies astropectinoid.

This family consists of a single genus *Archaster* Müller and Troschel.

Genus **ARCHASTER** Müller and Troschel

With heavily calcified interbrachial septa, no superambulacral ossicles, tabulate aboral plates, those of the regular oblique transverse series imbricating by curious internal keels, produced toward the midradial line. The ampullae are strongly double and the tube feet have heavy sucking disks.

Archaster typicus Müller and Troschel, Monatsb. Preuss. Akad. Wiss., 104, 1840.

A specimen is recorded by J. E. Ives from the "Sandwich Islands." Others have been taken at many points along shore by the *Albatross* in the Philippine group, and it is also reported from Samoa, the Caroline Islands, and Australia.

Family OREASTERIDAE Fisher

This new family was created by Fisher (19) from the older and more inclusive Pentacerotidae. No characters beyond those in the key are given.

Key to the Hawaiian Genera of Oreasteridae

A. Marginal plates fairly distinct, defining the contour of body.....**Nidorellia.**
AA. Marginal plates hidden or inconspicuous; not visibly defining the contour of body. The aboral plates are not superficially distinguishable in the adult. Form thick.....**Culcita.**

Genus **NIDORELLIA** Gray

Oreasteridae with marginal plates fairly distinct, defining the contour of the body. Disk not so high; form nearly pentagonal. Erect conical tubercles on both surfaces.

Nidorellia armata (Gray).

Pentaceros (*Nidorellia*) *armatus* Gray, Ann. Mag. Nat. Hist. 6: 271, 1840.

Nidorellia armata Verrill, Conn. Acad., Trans. 1(2): 251, 1867.

Jeffrey Bell in his paper "The Species of Oreaster" records *Nidorellia* from the "Sandwich Islands" (from Fisher, 16).

Genus **CULCITA** Agassiz

Oreasteridae with marginal plates hidden or inconspicuous; not visibly defining the contour of the body. The aboral plates are not superficially distinguishable in the adult. Form thick, pentagonal rounded; no large plates at end of ray. Papulae distributed in large definite areas.

Key to the Hawaiian Species of Culcita

A. Many small tapering, sharp spinelets forming a close granulation over the disk.....**C. novaeguineae** forma **arenosa.**
AA. Entire surface beset with well spaced unequal tubercles.....**C. novaeguineae** forma **nesiotis.**

Culcita novaeguineae forma **arenosa** Perrier.

Culcita arenosa Perrier, Recherches sur les Pedicellaires, 66, 1869.

Culcita novaeguineae var. *arenosa* Döderlein, Zool. Fors. Malay Archip., 5: 315, 1896.

Form arcuately pentagonal. Papular areas freely confluent over the aboral surface and well down on the sides of the body. This extensive sieve area covered with rather uniform, very small, tapering, pointed, well-spaced spinelets. The skin is covered by a close granulation of very fine, tapering, sharp spinelets. There are numerous two-jawed, slender pedicellariae longer than the spinelets, and one third or one half the length of major spinelets. R = 106 mm. (From Fisher, 20.)

Hawaiian islands.

This species has been collected at Pearl Harbor and at Hilo, apparently in shallow water. There is some doubt as to its proper status. Clark (8) has indicated that it is not the same as forms found in Australia and is probably a true species. Fisher has recorded it temporarily as a "forma" until characters by which intermediates may be allocated have been pointed out. The group as a whole is regarded by Fisher as being in a state of flux, possibly due to the effects of hybridization of species formerly separated. Because of this complication and obvious uncertainty it has been considered best to keep Fisher's arrangement. A photograph is given by Fisher (20).

Culcita novaeguineae forma **nesiotis** Fisher, B. P. Bishop Mus., Bull. 27 : 72, 1925.

Form pentagonal somewhat produced at the corners. Whole aboral surface as far as upper margin of superomarginal plates, closely covered with pores, except for two small islands, in each interradius, along the interradial line. Surface beset with well-spaced, unequal tubercles, the larger 1 to 1.5 mm. in diameter, low acorn-shaped, or convex, and sometimes arranged in triangles. Much smaller, subglobular, hemispherical or acorn-shaped tubercles are scattered far apart between the larger. There are few pedicellariae resembling a granule split lengthwise.

Oral surface covered with a coarse, flat, irregular polygonal, tesselated granulation, the largest granules being toward the center of the convexities and the margin of the disk. The marginal plates are free of spines and papulae, but are covered by convex granules which increase in size as the oral surface is approached.

Furrow spines usually five, sometimes four or six; they have three or four sides at variable angles. Back of these are two or three low, unequal subtruncate tubercles, broader than high, irregular as if by mutual contact; external to these are one or two other small tubercles. R = 80 mm. (From Fisher, 20.)

The type of this species, which is in Bishop Museum, was collected at Pearl Harbor. Here is another form of this perplexing group whose relationship is at present obscure. A photograph is given by Fisher (20).

Family OPHIDIASTERIDAE Verrill

Phanerozonia with usually small marginal plates, slender, fingerlike rays and small disk; skeleton tesselate; tegumentary developments granulate; superambulacral plates usually present but small; pedicellariae, when present, foraminate or excavate; papulae sometimes occurring on oral surface. For this family the name Linckiidae Perrier has been most commonly used, but Verrill's name has several years priority.

Key to the Hawaiian Genera of Ophidiasteridae (adapted from Clark, 8)

A. Aboral plates of ray not in regular longitudinal series.
  B. Adambulacral armature spiniform, often subprismatic, in one to three series, often quite goniasteroid. (In some genera the distinction between spiniform and granuliform armature becomes very obscure.)
    C. Papulae on oral surface as well as on aboral and isolated.....**Fromia.**
    CC. No papulae on oral surface. (Very rarely isolated papulae occur just between lower corners of inferomarginals.).....**Gomophia.**

BB. Adambulacral armature granuliform, in two or three series; disk small; rays not flattened.....**Linckia.**

AA. Aboral plates in regular longitudinal series. (Not clearly shown in Ophidiasters.)

B. Whole test covered with a thick, smooth, membranous skin.....**Leiaster.**

BB. Whole test granulose; that is underlying a membrane more or less covered with granules or little tubercles.

C. Skin uniformly granulose, though granules are commonly largest on convexities of skeleton.....**Ophidiaster.**

CC. Skin naked and thin except on convexities of skeleton, each of which carries a cluster of unequal, coarse, squamiform or spinuliform grains or tubercles.....**Dactylosaster.**

Genus **FROMIA** Gray

Aboral plates of ray not in regular longitudinal series. Adambulacral armature spiniform, often in one to three series, often quite goniasteroid, no conspicuous spines on aboral plates or on small oral intermediate areas. Papulae on oral surface as well as aboral surface. Papulae isolated. Size moderate or small, usually much less than 100 mm. across alternate rays; seldom two series of oral papulae.

Fromia pacifica Clark, Dept. of Marine Biol. Carnegie Inst. **10**: 42, 1921.

This species was collected by A. Garrett in 1857-59 in the "Sandwich Islands," apparently in shallow water. It was also taken by him in the Gilbert Islands. A photograph is given by Clark (8).

Genus **GOMOPHIA** Gray

Aboral plates of ray not in regular longitudinal series. Adambulacral armature spiniform, often subprismatic, in one or three series, often quite goniasteroid. No conspicuous spines on aboral surface or on small intermediate areas. No papulae on oral surface. Rarely, single isolated papulae occur just between lower corners of inferomarginals.

Gomophia egyptiaca Gray, Ann. Mag. Nat. Hist. **6**: 286, 1840.

This species is recorded from the Hawaiian islands by Sladen (39). Clark considers that this record is probably a mistake, but thinks its occurrence here would not be at all surprising. It ranges from Mauritius to Samoa and the Philippine Islands.

Genus **LINCKIA** Nardo

Ophidiasteridae with small disk and long cylindrical arms; aboral plates irregularly disposed, not in regular longitudinal series; papulae in areas, irregularly scattered, except between the marginal plates; no oral papulae; no pedicellariae; adambulacral armature granuliform in two series.

Key to Hawaiian Species of Linckia (adapted from Clark, 8)

A. Granulation of oral surface extending upon sides of ambulacral grooves so that furrow spines are separated from each other by vertical series of minute granules.

B. Rays relatively short and stout; 1 madreporite; color of adult in life brilliant deep blue.....**L. laevigata.**
BB. Rays longer and more slender; 2 madreporites; no blue coloration.....**L. multifora.**
AA. Granulation of oral surface not extending up into ambulacral grooves; furrow spines not separated by granules.
B. No aboral plates conspicuously enlarged and swollen; intermarginal poriferous areas not in a continuous series.....**L. guildingii.**

Linckia guildingii Gray, Ann. Mag. Nat. Hist. 6: 285, 1840 (pl. 1).

Arms four to six. Diameter of disk about one sixth the length of the arms. Arms cylindrical, widest and flattened some distance from the base and gradually tapering to a blunt extremity which is slightly upturned. Rays about 12 times as long as breadth at base. Color in life chocolate-brown.

Entire surface covered by minute rounded granules enlarged and elongated over the convexity of the body plate. Smaller, shorter granules are found in the papular areas. This arrangement of granules tends to give a roughened appearance to the body surface. The elevations of the aboral area are without definite arrangement, while the lateral and oral areas appear in more or less regular rows along the arms. On the ventral surface the granules are much longer, polygonal and increase in size toward the furrow. The spines of the adambulacral plates are in two regular contiguous series. The furrow series is composed of two types of spines which may alternate. Some are flat, broad, and spatulate with heavy rounded tips, whereas the others are much narrower and about two thirds the length of the larger. A third type of small, almost scale-like spine may be present in this row, one at the base of the larger spines. The spinelets of the external series are contiguous with those of the inner row and are less numerous, there being one to about every two of the furrow spinelets. They are slightly longer, are not greatly flattened, and their tips are thick and rounded. A third row, consisting of 10 to 12 somewhat larger granules of variable shape, is distinguished from the surrounding granules by rising slightly above the general surface. (See plate 1, *B, C.*)

About five furrow spines continue around the mouth plates from the inner row of furrow spines where they are narrower and less spatulate; these maintain their vertical position and do not point horizontally into the mouth cavity.

Papular areas numerous. Pores 15 to 28 and arranged rather uniformly in a circle. Generally two madreporites, although there may be more or less.

Bordering the adambulacral plates is a row of contiguous, rectangular plates, the inferomarginals. Aboral to this row is a second series of similar though shorter rectangular plates which are bordered aborally by a row of small intermediate plates of irregular shape. The third row of plates becomes rhomboidal and appears to overlie a second series of longer intermediate plates. There follows another row of rather irregularly rhomboidal plates and a series of intermediate plates. The remaining plates of the entire aboral surface are irregular in shape and distribution. All plates bear small eruptions.

Widely distributed; found in waters southeast of the United States about Florida and from the West Indies to Brazil, and in the Indo-Pacific region at Zanzibar, Queensland, Society Islands, Samoa, and Tonga. It is common in Kaneohe Bay, Oahu, and is recorded from Laysan Island.

Small individuals of this species are said by Clark to live a concealed life on the reefs and are consequently rarely encountered. One individual collected at Kaneohe Bay measured R = 140 mm.; it was found with its arms twined about the columns of a large coral head. Another specimen taken at Kaneohe and loaned to me by Miss Evelyne Johnson of Roosevelt High School, Hono-

lulu, measured R = 270 mm., breadth of ray at base 20 mm., and diameter of disk, 30 mm. Except for a greater number of papular pores per space, the specimen showed no great difference from the smaller ones.

There is considerable doubt about the distinctness of this species from *L. diplax, L. pacifica,* and *L. columbiae.* In 1925 Fisher placed *L. diplax* in synonomy with *L. guildingii,* but Clark considers the two forms distinct. His distinction is based largely on a description by Simpson and Brown (40) of a form from Portuguese East Africa. In view of the extremely wide distribution of *L. guildingii* particularly in regions having many other animal forms in common with Hawaii, it has been considered probable that the Hawaiian form belongs to this species. In addition, the colors of the specimens collected by the author are more similar to those given by Clark (8) for *L. guildingii* than to those given for *L. diplax* by Simpson and Brown (40).

Linckia multifora (Lamarck) (pls. 2, 3).

Linckia multifora Lütken, Vid. Med., 267, 1871.

Asterias multifora Lamarck, Anim. s. Vert. 3 : 254, 1816.

Resembling *L. guildingii* in form and general appearance. Arms not flattened or widened some distance from the base, but gradually tapering. Rays about nine times as long as wide. Color in life reddish brown with maroon patches toward end of rays; under surface lighter with a few brown spots. In formalin uniformly brownish or pale orange.

Granules arranged similarly to those of *L. guildingii* but more or less polygonal, and showing little difference in size toward the furrow.

The adambulacral armature consists of two major rows. The furrow row is made up of two types of spines alternating irregularly with each other. The first is rounded and slightly broader at its free end, being rather spiniform. The two major types of spines in this row are separated from each other by a vertical row of granules, the number of which is variable. (See plate 2, *B, C.*)

The second row of spines is separated from the first by two to five granules and from each other by approximately the same number. They resemble the first type of furrow spine described, being shorter and more globular (pl. 2, *B*).

Papular areas less numerous than in *L. guildingii* with from 10 to 18 pores in each area. Two to three madreporites.

Adambulacral plates bordered by a row of incisor-shaped plates which in well-cleaned specimens appear to have an attached base and a free blunt rectangular end. The next row is squarish and somewhat smaller. The third row is even smaller with circular or oval plates. Between this row and the next are a series of tiny beadlike ossicles which disappear distally, succeeded by the third row of plates which become smaller. The plates of the fourth row are the largest of the lateral series, and are elongate, elliptical and stout. These plates are joined by intermediate plates to the next aboral row of body plates which are large and indistinctly rhomboidal. As with *L. guildingii,* the remaining plates of the aboral surface are irregular in shape and arrangement (pl. 3, *A*).

Near the disk the first three rows of plates are arranged oppositely, but farther along they may be irregular.

L. multifora has a wide distribution ranging from the Red Sea through Fiji, Samoa, Wake and Palmyra Islands. It is abundant in Kaneohe Bay which seems to be the only place where it is found about the island of Oahu.

The largest specimen taken during this work measured R = 110 mm.

An interesting and fairly constant variation of this species was encountered. It differs chiefly in color: instead of being reddish brown and maroon, it is dull grayish with faint red appearing in the papular areas and a few brown spots on the oral surface of the arms. The arrangement of the adambulacral armature also differs in regularity, one large granule of the outer row being directly opposite each large spine of the furrow series. The granules of the outer row are all of equal distance from the large spines so that a straight regular row is formed. It was concluded, however, that these differences were probably due to age and were not of sufficient value to warrant establishment of a variety. Also, *Linckia* is known for its variability in color and granulation. (See plate 3, *B*.)

Linckia laevigata (Linnaeus).

Asterias laevigata Linnaeus, Syst. Nat. Ed. **10**: 662, 1758.

Linckia laevigata Nardo, Oken's Isis, 717, 1834.

Several specimens from Hawaii are in the Museum of Comparative Zoology, but Clark believes that the labeling is probably erroneous. A photograph is given by Clark (8).

Genus **LEIASTER** Peters

Ophidiasteridae with papulae on oral surface; whole test with a smooth, thick membranous investment. Aboral plates in regular longitudinal series; adambulacral armature in two, rarely three, unequal series, the outermost largest.

Key to the Hawaiian Species of Leiaster (adapted from Fisher, 20)

A. Furrow spines three to a plate (occasionally two); the base line of the comb of three shorter than length of spines; a few pedicellariae present ..... **L. leachii hawaiiensis.**

AA. Furrow spines two to a plate, rarely three on individual plates. Furrow spines short and wide, the length about equal to width of a pair, or a little more; color (dry) dull purplish gray (probably purple in life); no pedicellariae ..... **L. brevispinus.**

Leiaster leachii hawaiiensis Fisher, B. P. Bishop Mus., Bull. **27**: 77, 1925.

General shape like that of *Linckia*. Plates having a subcircular central area surrounded by a narrow, smooth border which is covered by small subhyaline bosses. Papular areas separated and distinct; largest areas with 10 to 15 pores. A few small, entrenched aboral pedicellariae.

Furrow spinelets in crowded combs of three, or occasionally two, their tips forming a bluntly serrate border to the continuous membrane which unites them from the angle to tip of ray. The spinelets are subequal, flatfaced, and scarcely tapered. The first 10 to 20 plates each have a subcylindrical, slightly flattened, round-tipped or subtruncate subambulacral spine. This series is united with that of the adjacent ray by a continuous web across the mouth angle. Suboral spines not enlarged. Distally beyond these, usually only alternate plates carry a spine which is much heavier. It becomes wider, more flattened, and sometimes shallowly gouge-shaped. (Modified from Fisher, 20.)

The type specimen in Bishop Museum measures R = 108 mm.

Hawaiian islands.

A single specimen of this species was collected at Koloa, Kauai in 1900. Its close relative *L. leachii,* from the western part of the Indian Ocean, differs in the number and shape of the spines. A photograph is given by Fisher (20).

Leiaster brevispinus Clark, Dept. of Marine Biol. Carnegie Inst. **10**: 74, 1921.

This is another form collected by A. Garrett in 1857-59. It differs from *L. leachii* in form, color, and in the possession of short, wide furrow spines. Clark believes it reasonably certain that this form was collected in shallow water. A photograph is given by Clark (8).

Genus **OPHIDIASTER** Agassiz

Ophidiasteridae with plates in regular longitudinal series, between which are regular series of papular areas. Adambulacral armature in two (rarely three) unequal series, the outer heavier than the inner and more distinctly spaced. All plates granular.

Key to the Hawaiian Species of Ophidiaster (adapted from Clark, 8)

A. Madreporite single. Papular pores few, three to eight in each area; few or no pedicellariae; poriferous areas not conspicuous.....**O. squameus.**

AA. Madreporites two. Pedicellariae present; granules at center of aboral plates much enlarged, several times as large as adjoining papular pores.....**O. lorioli.**

Ophidiaster lorioli Fisher, U. S. Fish Comm. Bull. (3): 1077, 1906.

Four specimens of this species were taken by the *Albatross* along the south shore of Molokai in shallow water. This species can be differentiated from the other member of this genus reported here by the possession of pedicellariae, two madreporites, and much enlarged granules at the center of the aboral plates. It is also known from Samoa. A photograph is given by Fisher (16).

Ophidiaster squameus Fisher, U. S. Fish Comm. Bull. (3): 1079, 1906 (pl. 4).

Rays unequal, cylindrical, scarcely tapering at all until the outer third is reached, and then only slightly. Tip blunt; terminal plate large, conspicuous, smooth. No pedicellariae whatever. Papular pores in eight longitudinal rows, two or three conspicuous pores to each area, but only one at the tip of ray and on disk. The plates are markedly convex, and the longitudinal series are regular and separated by evident papular furrows which extend the length of the ray. In a transverse direction the plates are marked off by slightly shallower furrows, at the bottom of each of which is a narrow groove bordered by fairly regular globular granules. The plates are cordate and arranged in a radial series on either side of which is an adradial, supero- and inferomarginal, and an oral intermediate series bordering the adambulacrals, making nine series of plates from side to side. There are roughly two oral intermediate plates to each inferomarginal. The plates are covered with relatively coarse granules for the genus, and these are subcircular to oval, convex, and much larger in the convex central portion of the plate than at its edges. Along the aboral and adoral edges they frequently form a border to a narrow groove as already indicated. From two to six or seven granules in the center, especially on the marginal plates, are conspicuously larger than

the others and imbricate slightly, but slight spaces are frequently seen where the circular granules touch and do not overlap. On the interomarginal plates, one to two of the granules, especially on the outer part of the ray, are subtubercular.

Furrow spinelets are not so large, two to the plate, round-tipped and flattened. Spaced from the furrow series, on the oral surface, is a longitudinal row of much stouter, broadly ovoid or subconical granules or tubercles, two of which correspond to three furrow spinelets. The space between the two series is filled with small, compressed subsquamiform granules, about one series of which passes between the oral spinelets. (See plate 4, *B*.)

Madreporic body fairly large, regularly circular, situated about midway between the center and edge. On the adcentral border are five or six granules larger than the others, slightly modified (from Fisher, 16).

Ophidiaster squameus has been recorded from the Tuamotus, Mer Island, and Pearl and Hermes Reef in the Hawaiian islands.

The individual of this species taken by me at Black Point, Oahu, in shallow water shows some variation from the specimens described by Fisher, and measures R = 40 mm. In life, the color more nearly approached that of the closely related *O. pustulatus*. The aboral arm surface was dark brown, mottled white and yellow, with areas of old rose encroaching from the oral side of the arm. Oral surface mottled with light pink, dark red, and white. The effect produced on both surfaces was of a very fine spotting. In addition to the single oral intermediate row of plates, 7 or 8 small plates are wedged in between this row and the inferomarginal row above. These extra plates are found only near the disk. The furrow spines are not equal, as Fisher states for his specimens, but the adoral one is about half as narrow again as its mate. Each spinelet has one or occasionally two small flat elongate granules lying over the crack between adjacent spines. All are nearly four times as long as broad except the most distal ones which are, as Fisher gives, twice as long as wide. The anus, instead of having 4 triangular granules over the opening, bears about 12 squamiform granules, 4 of which are larger than the others. This character is, however, subjected to variation, as in individuals of *Dactylosaster cylindricus*.

The two specimens from which the original description was made were taken in deep water, but Clark's specimens were apparently taken in shallow water.

Genus **DACTYLOSASTER** Gray

Ophidiasteridae with a smooth, somewhat shiny skin, with granules only at the approximate center of each skeletal plate. There are but two species in this genus, *D. gracilis* having granules spiniform instead of squamiform as in *D. cylindricus*.

Dactylosaster cylindricus pacificus Fisher, B. P. Bishop Mus., Bull. 27 : 75, 1925 (pls. 5, 6).

Arms narrower at the base, perfectly rounded, and ending bluntly after tapering slightly. Aboral surface blotched with wine red and very light violet. Tips of granules white or gray. Oral surface old rose. Some furrow spines all white; others tipped with white. Dermal branchiae orange brown giving aboral arm surface appearance of

being banded with brown. One small specimen with deep orange-brown spots and light gray areas instead of the violet and red areas on larger specimens.

Surface covered by a shiny epidermis; roughened by clusters of granules arranged in nine regular series along the arms (pl. 6, *B*). About 20 median radial clusters which bear from 9 to 25 granules. In each cluster many small to large scale-like or operculiform granules are arranged in a semicircle. Between these rows of clustered granules are the papular areas forming eight regular rows down the arms. Groups on either side of the mid-dorsal plates have from six to 12 pores, the superomarginal most consistently eight but ranging from six to 10; the last row with from two to eight pores. Anus surrounded by six sharp triangular spines pointing toward the center of the aperture. The remaining papular rows similar except the two most oral rows which have clusters composed of but one or two large granules.

The adambulacral row of spines are aborally grooved, blunt, conical and scoop-shaped, the first 10 or 12 being flush with the surface, whereas those distally are erect. Between individuals of this row and between this and the next row are a few small sparsely scattered granules. The furrow series of two types of spines, one of which is large rectangular with a well-rounded tip. The smaller spines, each of which is contiguous with one of the larger, are slender and spiniform. On either side of each of the lesser spines is a small leaflike granule. Around the mouth angles the small spine drops out leaving the granules and the largest spines. The terminal plate (pl. 5, *B*) is conspicuous and bears several globular granules.

Bordering the adambulacral plates is a row of small intermediate plates, the free ends of which are broadly rounded and thick. These, and all body plates, overlap proximally. Between this row and the next near the disk may be four or five small plates, but they disappear distally and the first two rows become contiguous. At the extreme distal end there is a row of 10 or 12 globular plates between the adambulacrals and the oral intermediate series of plates. The inferomarginal plates are twice as wide as those of the oral intermediate series, roughly triangular with broadly rounded angles. The inferomarginals are separated from the superomarginals by a series of small intermediate plates which join the angles of the two series. In a similar manner the adradial series of plates is separated from the superomarginal series below and the carinal above. The plates of the disk are less regular in shape, but the network formed by the conjoining intermediate plates is evident.

Hawaiian islands.

This species is found under rocks and is fairly common at Black Point. It has also been taken at Ocean Island. It differs from *D. cylindricus* of the Indian Ocean in lacking pedicellariae.

The type specimen in Bishop Museum measures R = 66 mm.

Family ASTEROPIDAE Fisher

Phanerozonia with test covered by a skin or membrane, either smooth, granulose, or beset with spinelets; marginal plates prominent, more or less overlapping, smooth or with a single spine or several marginal spinelets; aboral skeleton loosely tesselate or reticulate; oral plates large, in chevrons or in isolated serial arrangement; papulae usually in areas never oral but sometimes intermarginal; pedicellariae when present bivalved or pincer-shaped.

Genus **ASTEROPE** Müller and Troschel

Aboral plates rounded, forming fairly regular longitudinal series; numerous oral intermediate plates; all plates covered and mostly obscured by thick skin; a medioradial and superomarginal series of spines; superomarginal plates forming the margin and

bearing large isolated spines; aboral plates in a definite medioradial and parallel series; aboral plates forming also regular transverse series, the medioradial elongated longitudinally, the dorsolaterals elongated transversely.

Asterope carinifera (Lamarck) (pl. 7, *A;* fig. 3).

Asterias carinifera Lamarck, Anim. s. Vert. 2: 556, 1816.

Asterope carinifera Müller and Troschel, Monatsb. Akad. Wiss. Berlin, 104, 1840.

Form pentagonal with rather broad, tapering, somewhat depressed, triangular rays. Clark gives the color as being variegated shades of drab olive and green predominating, but brown, white, black, bluish, yellowish, and reddish are evident. Specimens taken by me were a rich deep brown with small white areas between the papular areas joined by fine lines which form a loose network over the entire aboral surface.

Down the center of each arm is a row of six to eight blunt spines of rectangular outline which are completely encased in epidermis. At the center of the disk is a single spine of similar nature to one side of which the prominent anus is located. It is surrounded by 25 or 30 granules.

Between the body ossicles, the epidermis of the aboral surface is thrown into elevations which bear the papular pores. Some papular spaces are circular, some rectangular and many without definite shape. They may contain 20 or more openings.

The outline of the body is made serrate by blunt spines which are covered with epidermis except at the tip.

The furrow spines are in two series. The outer series consists of stout, almost spatulate spines which project horizontally over the furrow. The furrow series consists of groups of four or five palmately arranged spines for each adambulacral plate. The second most proximal spine of one of these groups is the largest. All spines are held together by a web of epidermis. Distally on the ray, the number of spines for each web drops to three. (See figure 3, p. 8.)

The mouth plates bear seven or eight spines on each side, the first five of which are small, short, and blunt; whereas the last three are almost clavate and interlock or alternate with similar spines of the opposite side. On the oral face of each mouth plate may be one or two thick, short spines.

A small specimen differs from most of the larger individuals in the greater number of adoral central arm spines (10 to 15) which may be in clusters of two or three, in the papular pores being fewer and in more precisely defined groups, and in having but one type of spine attached to the mouth plate.

The arrangement of the plates about the anus is more or less irregular. A region about the anus is enclosed by nine plates and the madreporite. Those in the interradial area are frondlike, having a base or handle and a fanshaped central portion. Between these plates and in the radial region there are three-rayed ossicles. The two longest rays join the neighboring plate of the circle with the short ray pointing from the center. Inside this circle are five other three-rayed plates the longest rays of which meet and the shortest rays of which point centrally. Besides these, there is a single stout oval plate directly in the center, and to one side of the anus.

Radiating from this central array of plates down the center of each arm are the rhomboidal carinal plates which bear the spines described above. The last few carinal plates may become circular in shape. Contiguous with the lateral angle of each carinal plate is a somewhat longer but rhomboidal plate. Below this is a third row of broader rhomboidal plates followed by a row of alternately rounded and rectangular plates which does not extend to the end of the ray.

The superomarginal plates occupy the very margin of the body. They are stout and rhomboidal with a lateral process for the attachment of a spine. The inferomarginals make up the next row and are large and irregular in shape, and in the interradial region are separated from the superomarginals by a row of rather oval plates and a few irregularly placed plates.

Of this species Clark says, "This is one of the commonest and perhaps the most widely distributed of Indo-Pacific sea-stars." It has been recorded from Mozambique, Zanzibar, the Red Sea, Society Islands, Queensland, New Caledonia, Ryukyu Islands, Galapagos, Panama, and Lower California.

Concerning the pedicellariae, Goto says, "Previous descriptions lead one to believe that there must be considerable variation in the number and position of the pedicellariae." I found no pedicellariae on the specimens I examined.

Order SPINULOSA Perrier[4]

Key to the Shallow-water Families of Hawaiian Spinulosa (adapted from Fisher, 17)

Mouth plates rather small, not spade shaped or ploughshare shaped; ambulacral furrows narrow.

A. Aboral skeleton formed of closely imbricating plates bearing small spines; oral skeleton formed of imbricating plates bearing a tuft or fan of spinelets ..... **Asterinidae.**

AA. Aboral skeleton formed of plates disposed in longitudinal and transverse series forming an irregular or regular meshwork, more or less open, the plates bearing isolated spines or groups of spinelets, but never fans of spinelets.

B. No pedicellariae; disk very small; no interbrachial septa; skeletal reticulations roughly in the form of triangles grouped in hexagons; skin, and the large obtuse spines beset with rough scales or spinelets ..... **Mithrodiidae.**

BB. Small two-jawed upright, or large low bivalved pedicellariae; disk large, interbrachial partitions well developed, with plates; no superficial covering of scales or spinelets over the skin and spines ..... **Acanthasteridae.**

Family ASTERINIDAE Gray

Spinulosa with dorsal skeleton formed of imbricating plates bearing small spinelets or granules singly or in groups or tufts; with regular imbricated oral intermediate plates bearing a few spinelets or granules, sometimes in combs; marginals minute, usually defining ambitus.

Genus **ASTERINA** Nardo

General form broadly stellate to pentagonal with large, more or less elevated disk, and sharp angular margins defined by minute regular marginal plates; aboral plates externally crescentiform, interspersed with granuliform secondary plates, and bearing granules or short spinelets; internally three or four lobed and imbricating; papulae in areas or single, widely distributed; oral and adambulacral plates with combs of spinelets sometimes united by a web.

Asterina anomala Clark, Dept. of Marine Biol. Carnegie Inst. 10: 95, 1921 (pl. 7, *B*).

[4] See key, p. 9, for diagnosis.

General shape pentagonal with slightly elevated disk. Arms quite short, notched and upturned at the ends. Many forms have a very irregular body form due to fissiparous reproduction. Many specimens with four large rays and evidence of three or four new ones developing; mostly perfect with six nearly equal rays. (Clark, 10, gives seven rays as being the average number in the 369 specimens of his collection.)

Color in life somewhat variable. One large nearly perfect specimen with a deep rich greenish-brown and light green disk and proximal oral arm region; the distal aboral arm regions pale lavender; the outer aboral fringe spotted with yellow and reddish brown, with the bright red eye spot being visible in the upturned tip of the arm. The aboral surface is entirely pale yellow or white. A second large specimen had a much paler yellow-green central aboral area with a brilliant scarlet blotch in the center of the disk, and the lavender areas likewise much paler.

The entire aboral surface is covered by short, flask-shaped, thorny spines. Fringe of disk scalloped; each scallop bearing eight or 10 long laterally projecting hyaline spines with a many-pointed tip.

Plates of oral surface visible externally, bearing a cluster of three or four thorny flask-shaped spines. Furrow spines in groups of four or five, blunt, cylindrical. The oral plates bear two pairs of spines on the oral surface. Those nearest the mouth largest, similar to the other oral spines in shape, with 10 or 12 oral spines which increase in length and width proximally, the innermost ones being flattened and broadened and quite long.

The dermal branchiae are relatively large and are placed singly at frequent intervals over the aboral surface of the disk and in four irregular series along the arms. In three nearly perfect specimens there are three madreporites which are closely infringed upon by three or four clusters of spines.

Body covered by four-lobed imbricating plates, those toward the lateral margins having the more oral angle much drawn out. However, the plates are extremely irregular, a few being triangular, star shaped, or rectangular. Three series of round plates bearing three to five spines between adambulacral plates and the superomarginals. Superomarginal plates incisor-shaped, the blunt end pointing outward, becoming distinctly flared proximally. Terminal plates as large as largest body plate, saddle shaped, covered by many very short small spines with a border of the large typical fringing spines.

Hawaiian islands; also recorded from Mer Island, Murray Island, and Torres Strait.

This species is common at certain points along Waikiki where it may be found underneath stones close to shore. Because of its small size and secretive habits, it is easily overlooked. It has also been taken at Hilo and Black Point.

The largest specimen collected measured R = 8 mm.

Asterina granulosa Perrier, Rev. Stell., Arch. Zool. Exp., 169, 1875.

The specimens upon which this species is based were collected by M. Ballieu in the "Sandwich Islands" in 1874. Ives records one specimen from Oahu. (From Fisher, 16.)

Family MITHRODIIDAE Perrier

Spinulosa with mouth plates rather small, not spade shaped; ambulacral furrows narrow. Marginal plates inconspicuous. Aboral skeleton well developed, not wholly aborted, formed of plates disposed in longitudinal and transverse series forming an irregular or regular meshwork, more or less open,

the plates bearing isolated spines or groups of spinelets, but never fans of spinelets. Ampullae double. No pedicellariae; disk very small; no interbrachial septa; skeletal reticulations roughly in the form of triangles grouped in hexagons; skin, and the large obtuse spines beset with rough scales or spinelets.

This family was created by Fisher (17) to accommodate the unique genus *Mithrodia.*

Genus **MITHRODIA** Gray

This family has but one genus.

Key to the Hawaiian Species of Mithrodia

A. Five rows of spines; the first of small palmately arranged naked spines immediately bordering the furrow; the second of equal, closely spaced spines longer and larger than the first row over which they lie, naked on the inner surface, but with a coating of granules on the outer side. Next three rows of longer well-spaced spines completely invested with a coat of granules; the first two rows being oral and the last row of which the spines are longest, on the lateral face of the ray.....**M. bradleyi.**

AA. Four rows of spines; the first of small, palmately arranged, naked spines immediately bordering the furrow; the second of equal closely spaced spines longer and larger than the first row over which they lie, completely invested with granules. Next two rows of larger well-spaced spines which are completely invested with granules.....**M. fisheri.**

Mithrodia bradleyi Verrill, Conn. Acad., Trans. 1 : 288, 1869 (pl. 8).

Rays subcylindrical, broader than high, distinctly narrowed at base and constricted next to the very small disk. Whole surface covered with a tough integument beset with sharp granules. Color variable; uniform vermilion except ambulacral furrow, which is yellow ocher or varied brown, dark brown and vermilion.

Surface of body marked off by a coarse network which isolates roundish, or irregular areas containing the papulae and covered with tiny scattered granules. The ridges are thrown into little knobs or prominences which vary considerably in number and proportions. Three longitudinal rows of cylindrical rigid spines covered with sharp, scale-like granules. The granules on summits of the lower knoblike eminences, as well as those of the spine-tips, are larger and sharper.

Each adambulacral plate bears a prominent cylindrical, blunt, upright spine on the oral surface which is free of the scale-like covering of granules. These form a regular close series at border of furrow, and are more slender, slightly shorter and much more numerous than the adjacent spines of the inner oral series. Furrow series is placed directly at the base of the large, more oral series of spines, and consists of six to nine or 10 slender spinules, united for their whole length by a fairly tough membrane forming thus a fan with a very convex margin. The three or four central spinules are much the longest, the outermost of each series being very short, especially when there are eight to 10 spinelets to each fan. (Modified from Fisher, 16.) (See plate 8, *B.*)

This species was taken at numerous localities about the islands by the Tanager Expedition, but it is not a common shore form. One dried specimen in the collection of Dr. Edmondson was examined by me. Except in Hawaii this form is common in shallow water. Other localities are Lower California, Mauritius, and Fiji islands.

Mithrodia fisheri Holly, B. P. Bishop Mus., Occ. Papers 10(1) : 6, 1932.

Attention was first called to this species when Fisher, in the U. S. Fish Commission Bulletin for 1906, made some notes on a "peculiar specimen" of *Mithrodia*. Holly, after collecting a specimen at Pearl and Hermes Reef, concluded that there was justification for describing a new species.

M. fisheri differs from its close relative *M. bradleyi* in having a relatively larger disk with rays not constricted at the base. The surface of the body is much less distinctly ridged and is entirely covered with scattered, low, thimble-shaped tubercles. The lateral row of spines is wanting, there being only two oral rows of enlarged prominent spines. The inner face of the oral adambulacral spines is covered by granules. There is a marked difference in color, *M. fisheri* being dull cinnamon with pink and maroon at the ends of the arms. A photograph is given by Holly (22).

Family ACANTHASTERIDAE Sladen

Spinulosa with mouth plates rather small, not spade shaped; ambulacral furrows narrow. Marginal plates inconspicuous. Aboral skeleton well developed, not wholly aborted, formed of plates in longitudinal series forming an irregular meshwork, more or less open, the plates bearing isolated spines or groups of spinelets, but never fans of spinelets. Ampullae double. Small two-jawed upright pedicellariae; disk large, interbrachial partitions well developed, with plates; no superficial covering of scales or spinelets over the skin and spines. Rays numerous; numerous madreporic bodies; no calcareous rosette in suckers of tube feet; skeleton open reticulate, armed with large isolated spines covered with a membrane beset with calcareous granules.

This family is equivalent to the Acanthasterinae Sladen which is so completely isolated that Fisher (17) considers it worthy of family rank. His characterization is given in a key to the families of Spinulosa.

Genus **ACANTHASTER** Gervais

This family has but one genus.

Acanthaster planci (Linnaeus) (pl. 9, *A*).

Asterias planci Linnaeus, Syst. Nat. ed. 10, 823, 1758.

Acanthaster planci Verrill, Smithsonian Inst., Harriman Ser. 14: 364, 1914.

Disk relatively enormous, flat, from which radiate many rays (16 in two specimens examined). Rays short, about one half width of disk, tapering only slightly to a blunt end. Clark (8) gives the color in life as bluish gray with spines reddish at the tip. The disk and sides and upper surface of arms basally are covered by dull reddish purple or brown papulae. Entire aboral surface covered by long (about 10 mm.) thorny spines which have prominent pedicels or columns to which they articulate. Aboral pedicellariae long and slender. Meager interradial spaces bearing flat, heavy spatulate spines which become long, slender and thornlike near the mouth. Furrow spines in groups of three, the inner one being shorter and the middle one longest. Just outside of each group may be found a very short, stubby spinelet at either or both ends.

This species ranges from Zanzibar and the Arabian Gulf to the Society Islands and is found in the Torres Strait region.

Adult specimens of this species apparently average about R = 150 mm., although the dried specimens in the collection of Dr. Edmondson are smaller. Six madreporites are evident in the small dried specimen examined by me. Two specimens from Johnston Island and one from Pearl and Hermes Reef were taken by the Tanager Expedition. This species is so unlike any of its apparent relatives that it is regarded by authorities as a holdover from a very ancient fauna.

Order FORCIPULATA Perrier[5]

Family ASTERIIDAE Gray

No discobrachial septum separating disk and ray coelom; rays five to 45, but usually five to six; skeleton of rays, aside from ambulacral and adambulacral plates, consists of five primary longiseries of ossicles—one carinal, two superomarginal, two inferomarginal, to which is generally added two dorsolateral, two oral, and rarely two intermarginal; dorsal skeleton generally elaborated into reticulate structure with or without secondary intermediate ossicles; ambulacral ossicles usually crowded; tube feet in two or four (occasionally more) longiseries.

Genus **COSCINASTERIAS** Verrill

Fissiparous Forcipulata, with seven to 12 rays, having monacanthid adambulacral plates, pedicellariae on only the outer inferomarginal spine, one series of spiniferous oral plates (sometimes abortive). Skin covering skeleton not extraordinarily thick; crossed pedicellariae with an enlarged tooth on outer side of terminal lip; large straight pedicellariae with denticulate jaws usually present.

Coscinasterias acutispina Stimpson, Boston Soc. Nat. Hist., Proc. 8: 261, 1862 (pl. 9, *B*; fig. 2).

Disk distinct, elevated, but relatively small. Arms narrowest at base enlarging abruptly, tapering to an acute tip, broader than deep, somewhat triangular in appearance. Color in life straw yellow with chocolate brown patches on arms and disk, changing to yellow brown in formalin. Many specimens collected show fissiparity, there being often four normal arms with four very small ones growing from the disk; in such specimens there may be as many as four madreporites.

The aboral and lateral surfaces bear more or less regularly arranged bluish spines. These spines spring from the sparsely scattered body plates. The spines of the carinal series are acute, subconical and slender with wreaths of crossed pedicellariae near their bases and occur on all plates of the carinal series. On either side of the carinal series are three rows of spines. The spines of the row immediately adjacent to the carinal series bear spines on every other plate while those of the row above and below are found on all plates. In young specimens this arrangement may be quite obscure, there being fewer rows of spines and fewer spines per row.

The inferomarginal spines are arranged in transverse series of three spines to each plate. They are rather stout, somewhat compressed, tapering, but scarcely acute.

[5] See key, p. 9, for diagnosis.

The outer spine of the series is longest with but a half-circle of crossed pedicellariae about the base. Furrow spines long, slender flattened and of equal length, becoming spiniform toward the mouth and at the end of the ray.

Dermal branchiae in irregular clusters over the entire oral and aboral surface in groups of three or four or singly.

Pedicellariae of two types. First type spatulate, dentate, straight with a basal ossicle; scattered sparsely over the aboral surface, but rather more abundant among the furrow spines; about 8 mm. in length. Second type crossed, having a large tooth on the outside of the terminal lip of each jaw, but not on the inside; about 0.27 mm. long. These latter pedicellariae are arranged in clusters about the base of all the spines except the inner inferomarginal spines. In life they may be elevated to the tip of the spine forming a rosette or florescence.

Hawaiian islands and Japan.

C. acutispina has been reported elsewhere only from Japanese waters, which Fisher (20) thinks is good evidence of a Japanese element in the Hawaiian fauna.

Large specimens measure about R = 100 mm.

A REPRESENTATIVE OPHIUROID

As a representative ophiuroid, *Ophiocoma erinaceus* has been chosen. It is widespread throughout the Indo-Pacific region and is common in shallow water on the leeward side of Oahu. Its characters are such that it may be used as a basis for the description of other species.

It was shown in the discussion of a representative asteroid that the larval *Antedon* exemplifies the primitive condition of the echinoderm skeleton (fig 1).

The apical system as described for *Antedon* is seldom recognizable in its entirety in the present day ophiuroids. In *Ophiocoma erinaceus,* the apical system has departed widely from the primitive arrangement. The calcareous plates of the disk have become so numerous that it is impossible to recognize primitive apical plates as such. Instead, the disk is armored with identical, overlapping, oval calcareous ossicles which are perforate and flaky. Each ossicle bears a globular spiny granule, the granules being well spaced and sufficiently long to give the disk a rough appearance (fig. 4, *c*).

The oral system is retained in its entirety, consisting of one circle of five plates arranged interradially about the mouth. They are called oral or buccal shields (fig. 4, *g*). The buccal shields of *Ophiocoma erinaceus* are quite variable in shape, ranging from oval to rectangular. They are relatively large and differ from the homologous plates in the Asteroidea in that they are easily visible externally from the oral side. The outer edge of the plate may bear a fringe of stubby granules.

The perisomatic skeleton has been divided into a brachial or appendicular and an oral portion with accessories. The appendicular portion of the perisomatic skeleton consists of those plates which are found in each segment of the arm. Each segment is made up of (1) a flat triangular dorsal arm plate with a convex base and a blunt apex, (2) two crescentic lateral arm plates which

bear elevations for articulation with the erect laterally projecting spines of the arm and (3) a pentagonal ventral arm plate. On each side of the ventral arm plate are two small oval leaflike ossicles, the tentacle scales which border the opening for the tentacle. (See fig. 4, *b.*) Together, these plates form a segmented tube within which are located the vertebral ossicles (figs. 4, *b;* 5). These ossicles are similar to a vertebra and function much the same in giving the arms a certain amount of flexibility.

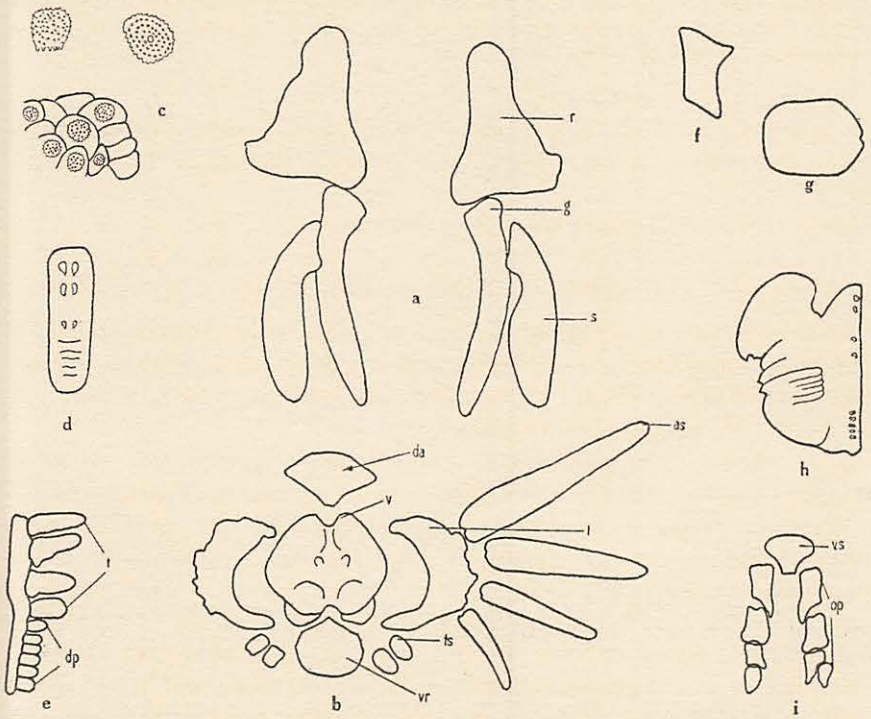

FIGURE 4.—*Ophiocoma erinaceus:* **a,** paired radial shields and attached genital scale and genital plate (*r,* radial shield; *g,* genital plate; *s,* genital scale) × 2.5; **b,** ossicles making up one segment of the arm (*da,* dorsal arm plate; *as,* arm spine; *l,* lateral arm plate; *ts,* tentacle scale; *vr,* ventral arm plate; *v,* vertebra) × 2.5; **c,** disk ossicles and granules, much enlarged; **d,** torus angularis, × 2.5; **e,** torus angularis, teeth and dental papillae, lateral view (*t,* teeth; *dp,* dental papillae) × 2.5; **f,** adoral shield, × 2.5; **g,** buccal shield, × 2.5; **h,** oral-angle plate, × 2.5; **i,** oral papillae and ventral shield (*vs,* ventral shield; *op,* oral papillae) × 2.5.

The oral portion of the perisomatic skeleton is made up of the oral-angle plates, adoral plates or lateral buccal shields, peristomial plates, and the ventral shields.

The oral-angle plates (figs. 4, *h;* 5) are large and wing shaped, extending dorso-ventrally. Distally the aboral portion becomes thin and broadened, and the oral distal portion is markedly serrate. Each plate articulates radially with

its mate by a series of interlocking elevations and depressions, and neighboring pairs articulate interradially, thus forming a ring around the mouth. Resting on pairs of oral-angle plates aborally are the tiny, triangular, paired peristomial plates (fig. 5).

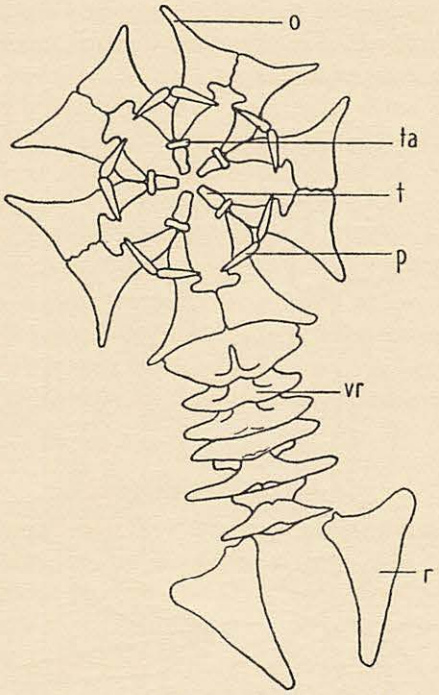

FIGURE 5.—*Ophicoma erinaceus,* disk skeleton, aboral view (*o,* oral-angle plate; *ta,* torus angularis; *t,* tooth; *p,* peristomial plate; *vr,* vertebra; *r,* radial shield) × 1.5.

Also considered with this portion of the skeleton is the ventral shield. Each is located at the distal end of the oral slits radially and is considered a slightly modified ventral arm plate (fig. 4, *i*).

Although closely associated with the buccal shields of the primitive oral system described above, the adoral shields are considered as part of the perisomatic system. They may be found just underneath, one protruding from each side of the buccal shield. They are roughly rhomboidal in shape and slightly bowed (fig. 4, *f*).

Accessory to the perisomatic skeleton are the tori angulares, five thin rectangular perforate plates, which are attached to the oral-angle plates internally where neighboring pairs articulate and which extend dorso-ventrally along their articulating surfaces (figs. 4, *d*; 5). Aborally, each torus angularis bears a vertical row of broad, blunt teeth (figs. 4, *e;* 5) and orally, a cluster of about 15 small blunt granules called dental papillae (fig. 4, *e*). Associated with these

papillae are several ossicles called the oral papillae, which project into the buccal fissure (fig. 4, *i*). They are usually attached to the oral-angle plates, but when attached to the tori angulares are described as being infradental.

Accessory plates of the disk support the genital apertures which are narrow slits in the ventral interradial portion of the disk. The adradial edge of the genital aperture is supported by the genital plate, an elongated, rib-shaped ossicle with ridges and an expanded proximal portion extending to the level of the second vertebral ossicle (fig. 4, *a*). The interradial lip of the genital opening is formed by a very similar, elongate, but more fragile plate known as the genital scale (fig. 4, *a*) which articulates with the genital plate behind the enlarged head.

The genital plate articulates by an enlarged head with a boot-shaped, flat ossicle, the radial shield (figs. 4, *a*; 5), located aborally on the disk, one on either side of each arm. In *Ophiocoma erinaceus,* they are invisible externally but much in evidence in other species. Aborally radial shields end in a gradually diminishing series of concentrically placed plates, while orally they articulate with the genital plates by two pits and two condyles.

Descriptions and Keys

Class OPHIUROIDEA

Echinoderms with the following characters: star-shaped; free; arms sharply marked off from the disk; with madreporite on oral side; ambulacral groove covered except in the fossil order; tube feet without suckers; no pedicellariae; anus absent.

Key to the Hawaiian Orders of Shallow-water Ophiuroidea

Dorsal, lateral and ventral arm plates all well developed.

A. Radial shields having a conspicuous articular pit near the outer end for the reception of a large, ball-like articular condyle of the genital plate. Arms horizontally flexible, or sometimes more or less coiled vertically ..... **Gnathophiurida.**

AA. Radial shield and genital plate on the same side of a radius articulating with each other by means of two condyles and one pit on both of the plates. Arms horizontally flexible ..... **Chilophiurida.**

Order GNATHOPHIURIDA Matsumoto

Ophiurans in which the disk is covered with fine, imbricating scales which are regular in size and arrangement. Radial shields well developed, each having a conspicuous articular pit near the anterior end for the reception of a large ball-like articular condyle of the genital plate. Genital plates usually fixed to the basal vertebrae. Genital scales short, wide, flat, leaflike, articulating with the genital plates near the outer end of the latter. An additional scale is present on the abradial border of the innermost part of each genital slit, being also short, wide, flat, leaflike and firmly fixed to the oral shield. Peristomial plates entire, or rarely double, usually very small. Oral frames stout, usually with

strongly developed lateral wings, for the attachment of voluminous masticatory muscles. Oral papillae few, often entirely absent. Dental papillae well developed only in forms without oral papillae. Teeth stout, usually quadrangular, with widened, straight or wavy apical edge. Arms slender inserted ventrally to the disk, horizontally flexible, or sometimes more or less coiled vertically. Dorsal, lateral and ventral arm plates all well developed.

Key to the Hawaiian Families of Shallow-water Gnathophiurida
(adapted from Matsumoto, 36)

Teeth quadrangular, very stout; peristomial plates small; oral frames with well developed lateral wings; genital plates firmly fixed to the basal vertebrae.
A. Oral papillae present; no vertical clump of dental papillae.....**Amphiuridae.**
AA. Oral papillae absent; dental papillae well developed, forming a vertical clump at the apex of each jaw.....**Ophiotrichidae.**

Family AMPHIURIDAE (Ljungman)

Disk covered with fine, imbricating scales, or rarely by a naked skin, sometimes beset with minute spines. Peristomial plates very small, usually entire. One to six oral papillae on either side. Vertebrae entire, not strongly notched inward. Arm spines moderately long, conical, stout and opaque. Usually one or two leaflike tentacle scales, sometimes none.

Key to the Hawaiian Genera of Amphiuridae
(adapted from Matsumoto, 36)

A. Paired infradental papillae present.
B. Not more than three oral papillae on either side of oral slit.
C. Oral papillae two or three on a side, discontinuous, the infradental and distal ones being separated from each other by a wide interval; oral slits gaping.....**Amphiura.**
CC. Oral papillae three on a side, continuous, the outermost being very large and operculiform; oral slits perfectly closed.....**Amphipholis.**
BB. More than three oral papillae on either side of oral slit. Oral papillae four or five on either side, forming a continuous row, so that the oral slits are more or less perfectly closed. Outermost oral papilla small and not operculiform .....**Amphioplus.**
AA. No paired infradental papillae. One or two flat scale-like oral papillae....**Ophiactis.**

Genus **AMPHIURA** Forbes

Disk small and delicate, covered with naked, overlapping scales, and furnished with uncovered radial shields. Teeth present; no tooth papillae. Mouth angles small and narrow, and bearing a few (usually three, rarely more) small mouth papillae. Arms long, slender, even and more or less flattened. Arm spines short and regular. Two genital openings to each interbrachial space.

Genital plates long, slender, flattened and club shaped; to each is attached a long, slender, bladelike scale. A short small jaw supports the intimately connected jaw plates and the large, flat, oblong teeth. As a rule the peristomial plate is wanting, or feebly developed.

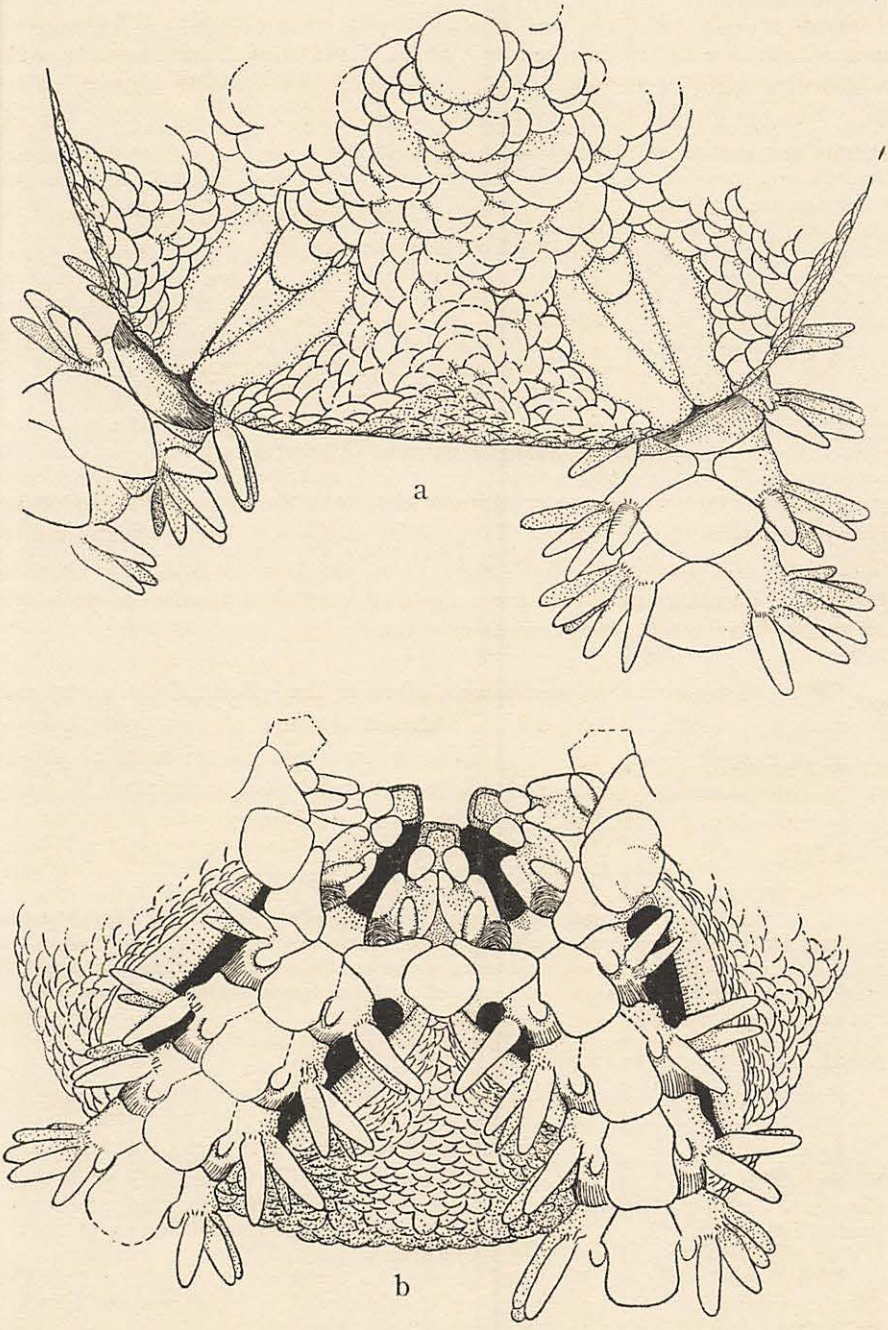

FIGURE 6.—*Amphiura immira:* a, aboral view, × 45; b, oral view, × 45.

Amphiura immira, new species (fig. 6).

Disk 2.5 mm. in diameter, flattened and circular. Arms five, about 9 mm. long; 0.5 mm. wide at base and tapering to a pointed tip. Color white. Disk covered by fairly coarse, flat, overlapping scales, among which may be distinguished six of the large primary plates, a round central plate and five infrabasals. Radial shields about four times as long as broad, encroached upon at the sides by overlapping disk scales; in contact at the distal tip, but separated proximally by a series of two or three plates, the outermost one long narrow and pointed, sometimes divided longitudinally into two, the inner one semicircular and slightly longer than broad. Upper arm plates broader than long, extending well down on the sides of the arm.

First ventral arm plate hexagonal, slightly smaller than the following plates; remaining under arm plates longer than broad, hexagonal with two distal sides concave and base convex. Lateral arm plates much reduced, not meeting above or below, leaving wide gaps between successive segments laterally; each with five or six rough spines on the basal segments which taper only slightly beyond the base. Normally these spines are probably erect, but in my dried specimen they lie against the arms. One small, flat tentacle-scale.

Oral shields wider than long, nearly oval but with a suggestion of a triangular shape. The madreporite is very much larger and heavier than the other oral shields and as a result is quite conspicuous. Adoral shields separated by the first ventral arm plate, not meeting within; the inner edge extending from the margin of the first ventral arm plate to the tip of the oral shield is nearly straight or slightly concave. Oral papillae two to a side; the outermost deep within the oral angle, elongate with a rounded end; the last pair located at the tip of the jaw on either side of and below the first tooth; stout, globular. The first tentacle scale which is attached to the adoral plates resembles the first oral papilla in shape and may be confused with the oral papillae. Oral angle deeply depressed at middle.

Eight specimens of this species were taken at Black Point, Oahu along with specimens of *Distichophis clarki.* Its closest relative, *A. constricta* Lyman, taken at Port Jackson, Australia, differs in having a minute rounded papilla at the base of the jaw, wider oral shields, the radial shields separated by many irregular scales of several sizes, and larger tentacle scales.

Genus **AMPHIPHOLIS** Ljungman

Paired infradental papillae. Three oral papillae on either side, of which the last two are attached to the oral-angle plate, the outermost one being very large and operculiform; no additional papillae just outside and above the infradental one, which, therefore, is the highest in position, oral slits closed by oral papillae. Disk entirely free of spines.

Amphipholis squamata (Delle Chiaje) (fig. 7).

Asterias squamata Delle Chiaje, Anim. s. Vert. Napoli, Mem. 3 : 74, 1828.

Amphipholis squamata Verrill, Conn. Acad., Trans. 10 : 312, 1899.

Disk 2.5 mm. in diameter, pentagonal or circular depending upon the manner of killing. Arms five, 8.5 mm. in length. Color light tan mottled with tan on disk and aboral surface; dorsal surface of lateral arm plates marked with transverse bars of tan; radial shields with a white spot at the periphery. The transverse bars of tan are said by H. L. Clark (personal letter) to be a peculiarity of Hawaiian specimens.

Disk covered with fine, thin, imbricating scales, which are again covered by a thin skin, bearing neither spines nor granules; margin of disk rather sharply defined by a line where edges of scales on the interbrachial spaces meet the scales of the disk. Radial shields about 2 to 2.5 times as long as broad; visible externally; pairs contiguous

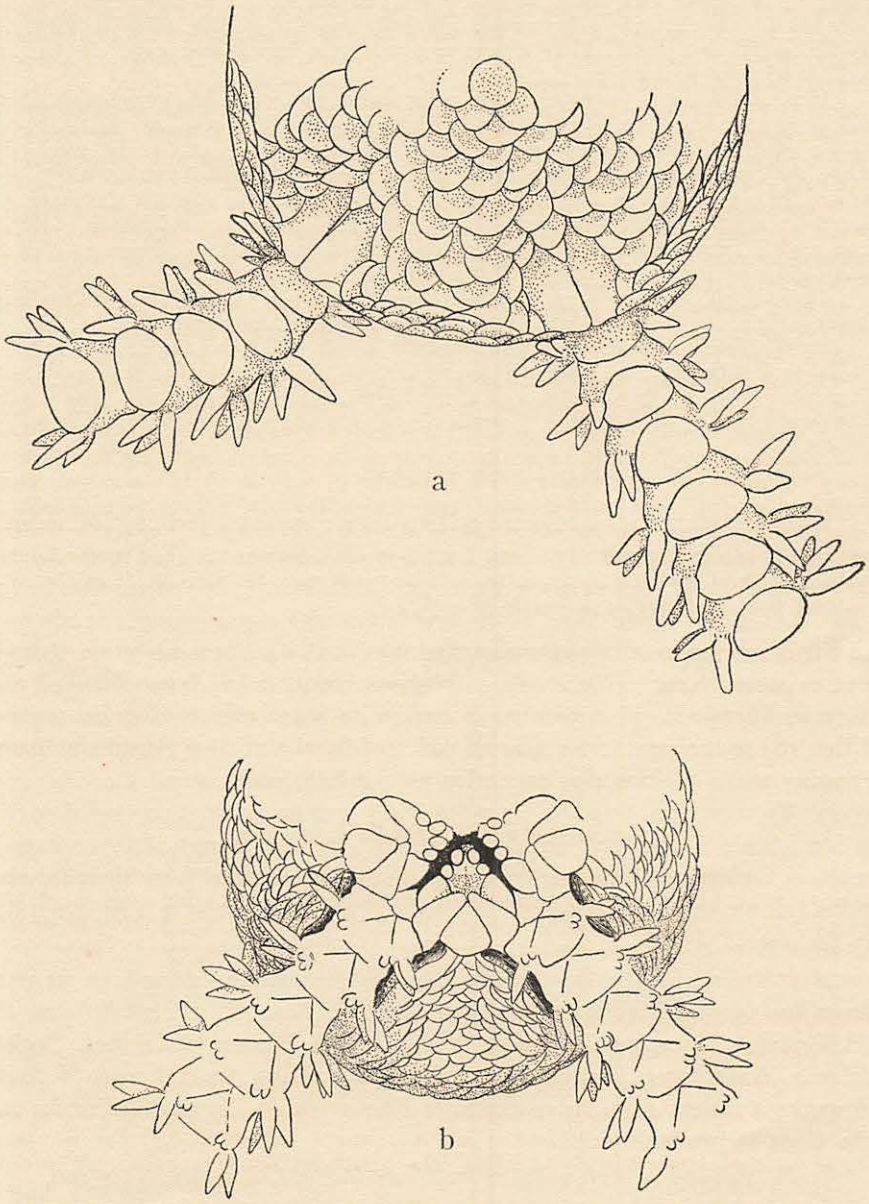

FIGURE 7.—*Amphipholis squamata:* **a,** aboral view, × 30; **b,** oral view, × 30.

except centrally where they are separated by a small wedge-shaped scale. Dorsal arm plates triangular with gently curving angles and a convex base, broader than long, changing to longer than broad down the arm; somewhat bowed so that they extend over the sides of the arms a short way; successive ones not meeting, all being separated by the lateral arm plates. They appear to overlap the lateral arm plates distally and to be overlapped proximally.

Ventral arm plates pentagonal with outer border straight or slightly curved, lateral sides concave; first few plates as long as broad, smaller than dorsal arm plates, bowed only slightly; distal plates becoming definitely longer than broad and the outer edge more noticeably curved. Lateral arm plates meeting dorsally and ventrally thus separating all plates. Arm spines three in number, generally four on the third and fourth segments; middle spine flask-shaped, the shortest, compressed laterally; dorsal and ventral spines more slender and straight, the dorsal being the longest. All bear small sharp projections. Two small flat tentacle scales.

Oral shields rhomboidal varying from longer than wide to slightly wider than long; inner angle acute, outer and lateral rounded; inner sides longer than the outer. Adoral shields triangular with long, narrow, straight sides. When the ossicle is isolated, a radial projection of the base may be observed. Oral papillae typical of the genus; three in number; the first large, wide and operculiform, next pair round and granule-like, last pair infradental being larger than the second pair and granuliform. Dental papillae absent.

Peristomial plates entire, relatively enormous.

All of the numerous specimens collected were apparently young individuals, as the adult size is generally about 5 mm. in disk diameter. This species seems to frequent sandy regions along the coast. Matsumoto (36) states that he has observed definite fluctuations of the population with changes in the consistency of the sand, the species preferring fine sand and disappearing when changes due to storm occur. While collecting these forms, it has been observed that they are always found in patches of sand, with little relation to its coarseness. Clark (8), noticing that a specimen collected by him at Mer Island was found clinging to an *Ophiocoma,* concluded that it had been carried there by currents. However, as this has been observed frequently, it is my opinion that it is a feature in the behavior of this species. In fact, on each of several specimens of *Ophiocoma* found under stones, there were several *Amphipholis squamata.* However, they did not hesitate to leave the host if it were held suspended in the water.

Amphipholis squamata is truly a cosmopolitan species. It has been reported from the North, Mediterranean, and Adriatic Seas; in the west from the Philippines, Torres Strait region, New Zealand, Kermadec Islands, Society Islands, Wake Island, and the Hawaiian islands; along the east coast of North America it ranges from Nova Scotia to Rhode Island, Bermuda, Florida, and the West Indies to Brazil.

In Hawaii it has been collected at Black Point, Oahu and at Laysan.

It seems obvious from the literature that several species have been described which will doubtless in time be abolished and placed with this *A. squamata.* These are *A. japonica* Matsumoto and *A. sobrina* Matsumoto. Clark (10) has already abandoned his *A. australiensis.*

Genus **AMPHIOPLUS** Verrill

Four or five small mouth papillae, none operculiform, arranged in a continuous series of which the outermost, at least, arises from the adoral shield and is really an oral tentacle scale. Arm spines three (rarely four). Radial shields generally quite separated. Disk scales naked.

Amphioplus caelatus, new species (fig. 8).

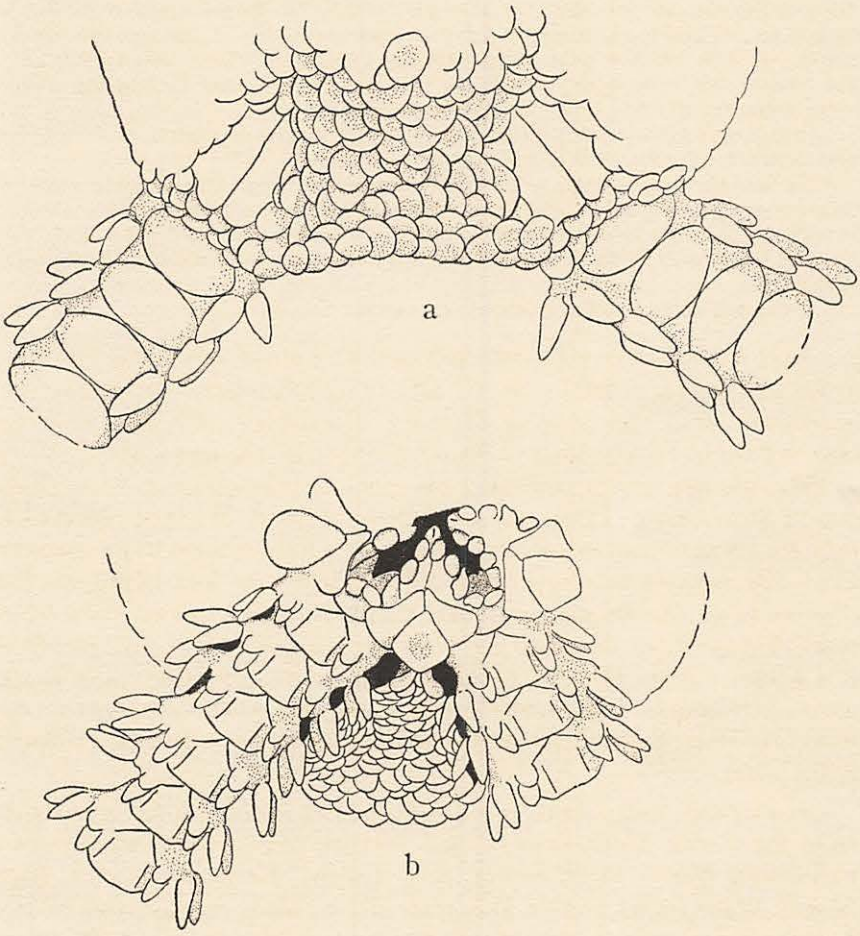

FIGURE 8.—*Amphioplus caelatus:* **a,** aboral view, × 40; **b,** oral view, × 40.

Disk 2 mm. in diameter, nearly circular. Arms five, about 10 mm. long, a trifle broadest at some distance from the base, tapering regularly to the tip. Color white except for light tan stains on the upper arm spines and on the proximal ventral arm plates.

Disk covered by relatively coarse imbricating scales of which the largest are in the center, but without definite arrangement; a few small round scales extend laterally

on the sides of the arms as far as the third segment. Radial shields four times as long as broad in contact along entire length, greatly encroached upon by disk scales. Upper arm plates broadly elliptical covering most of the aboral arm surface; all plates in contact at the point of greatest convexity.

First under arm plate very small, triangular, but separating the adoral shields; succeeding plates so thick as to appear elevated above the general arm surface or embossed; the superficial outline is pentagonal with straight sides and a notched or nearly straight base, but extending laterally from the sides a deeply situated flange projects so that the plates are actually much less perfectly pentagonal than appears. Side arm plates more in evidence orally than aborally, barely separating the distal arm plates below. Each bears three spines, the uppermost spine of the first two or three segments is quite broad, thin and flat, tapering to an acute tip; a few farther on are saber shaped; the remainder appear quite typical, being a little less than a segment in length, broad at the base and tapering rather abruptly to a blunt tip. Two tentacle scales; the first short, rounded and scale-like; the second one spatulate, projecting from beneath the first for about twice its length.

Oral shields diamond shaped, longer than wide, the proximal angle acute, the other rounded; each shield with the exception of the madreporite with a central depression; madreporite large, ovate with all angles rounded. Adoral shields thick, pairs meeting broadly within where they are quite narrow and pointed. Oral papillae four to a side; the outer flat, square, placed beside the corresponding one of the opposite side at the end of the oral angle; the next within thin, broad, but proximally drawn out into a short protrusion; the next two toward the center rather heavy globular granules.

Only a single specimen of this species has been collected, in a coral head at Black Point, Oahu with *Distichophis clarki* and *Amphiura immira*. Its closest relative is *Amphioplus relictus* Koehler from which it differs in having longer radial shields, the innermost oral papilla thick and globular rather than elongate, narrower under arm plates which are embossed and arm spines of variable shape rather than cylindrical.

Genus **OPHIACTIS** Verrill

Disk circular, robust, closely covered with radial shields and overlapping scales, the latter bearing usually a greater or less number of small spines. Teeth present; no tooth papillae. Mouth angles small and narrow, and bearing a few, usually two to four, small mouth papillae. Arms stout, somewhat flattened, of moderate length (four to seven times diameter of disk). Arm spines stout, serrate and solid. Two genital openings.

Key to the Hawaiian Species of Ophiactis (adapted from Matsumoto, 38)

A. Five arm spines in free basal joints; dorsal arm plates exceedingly wide, thrice as wide as long; single oral papilla on either side.....**O. modesta.**

AA. Six arm spines in free basal joints; dorsal arm plates less than, or nearly twice as wide as long; two or three oral papillae on either side.....**O. savignyi.**

Ophiactis modesta Brock, Zeitschr. f. wiss. Zool. 47: 482, 1888 (pl. 10, *A;* fig. 9).

Disk of most specimens collected by me measured about 2.5 mm. across, but a few were nearly 4 mm. in diameter. Arms five or six. Color resembling *Ophiactis savignyi*, but bluish green with cream instead of grass green and gray.

Disk covered with relatively larger irregular rounded ossicles bearing no spines aborally, but possessing two or three coarse spines in each oral interradius. Radial

shields quite short, concealed centrally by overlapping ossicles, and separated widely by a circular thin ossicle centrally and two long slender ones proximally. Dorsal arm plates almost three times as broad as long, rectangular with rounded angles, becoming spherical farther out on the arm, broadly in contact.

Ventral arm plates slightly broader than long, smaller than dorsal arm plates, pentagonal in outline with sides straight or slightly convex, and a concave or notched distal end; each plate has an hour-glass shaped depression in the center. Lateral arm plates quite small, barely visible on the aboral surface of the arms. Arm spines in

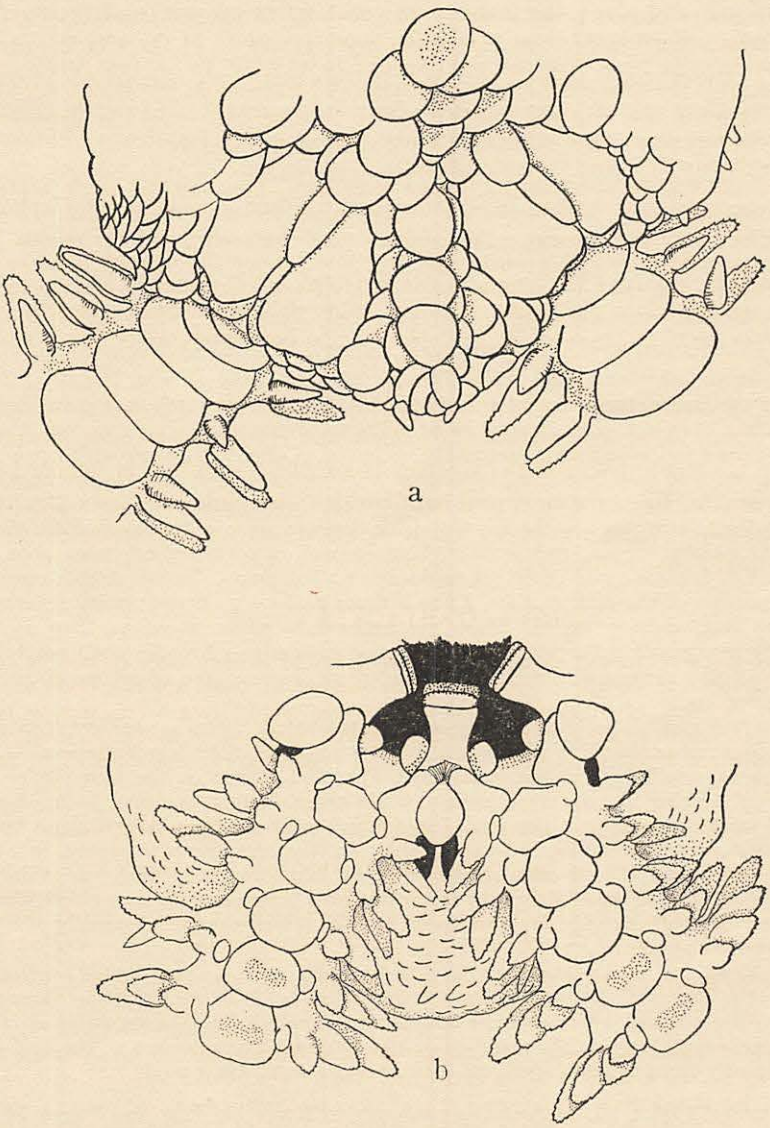

FIGURE 9.—*Ophiactis modesta:* **a,** aboral view, × 30; **b,** oral view, × 30.

some individuals number four on the first two segments, then five for about eight segments, dropping to four on the remainder of the ray, but all possible variations to this arrangement are found; all are stout, serrate and compressed, those in the middle being the longest. One tentacle scale.

Oral shields very variable in shape, generally rhomboidal with rounded angles, but in some specimens almost oval; adoral shields not meeting within. One large scale-like oral papilla.

O. modesta has previously been taken at Misaki, Japan, Amboina, Thursday Island, and along the Australian coast from Darwin to Lagrange Bay. It is now recorded for the first time from Hawaii. H. L. Clark (personal letter) believes that, as both members of this genus are carried about on boat bottoms, their arrival here may have been fairly recent. It is quite difficult to say how recently this species may have arrived in Hawaii.

The habits of this species are apparently similar to those of *O. savignyi*, since the two are collected in almost identical situations at Pearl Harbor and Kaneohe Bay. In a group, a large percentage show signs of fissiparity.

Ophiactis savignyi (Müller and Troschel) (pl. 10, *B;* fig. 10).

Ophiolepis savignyi Müller and Troschel, Syst. Ast., 95, 1842.

Ophiactis savignyi Ljungman, Ofv. Kongl. Vet.-Akad. Forh. 23 : 323, 1867.

Average specimens have disk diameter of 4 mm. and an arm length of 23 mm. Larger specimens, however, show considerably different proportions, measuring 8 mm. across the disk and only 20 mm. in arm length. Arms six in number, but five- and seven-armed individuals are frequently collected. Color variegated with grass green, light green, and gray in typical specimens, varying to all gray in rare specimens.

Aboral surface of disk covered with small, rough, round scales which become enlarged and elongated in the narrow space between pairs of radial shields; those on the oral surface fine and imbricating. There are a few scattered spines on aboral surface which become more abundant in the interradial areas. Radial shields covering a large portion of the disk surface, 2.5 to 3 times as long as broad; pairs separated by several long, slender scales. First few upper arm plates about as long as broad, roughly hexagonal; following plates becoming successively broader until nearly thrice as broad and rectangular with well-rounded angles; surface of all roughened with tiny round knobs.

Ventral arm plates only slightly longer than broad, when in position appearing to have eight rather short indistinct sides, but when isolated definitely heptagonal. Lateral arm plates small, just visible orally and aborally. Those of the first six or seven segments bearing six or seven spines, while those farther out may have only five; dorsal-most spine of first segments longest and most slender; second spine broadest and flask-shaped; remainder blunt, broad, slightly compressed, covered with small sharp projections, dorsal ones greater in length than ventral. Much variation in the number and comparative shapes of the spines on the arms of the same individual and between different individuals. One large leaflike tentacle scale, frequently two at the first tentacle pore.

Oral shields longer than broad, gourd-shaped, with a short distal projection to which the accessory genital scales attach. Adoral shields ploughshare shaped with three distinct wings, pairs meeting within and members of adjacent pairs meeting in the interradius. Two small, round scale-like oral papillae attached to the oral plates, occasionally three in some segments. Six or seven broad blunt teeth.

Around Oahu, *O. savignyi* is common in Kaneohe Bay and Pearl Harbor, habitually concealed in the canals of sponges, or even in tangled masses of sea

weed or crevices in dead coral blocks. It is a gregarious species, and many individuals may be found within a piece of sponge the size of a man's hand.

The species is widely distributed, ranging throughout the Indo-Pacific region from Zanzibar to Singapore, the Philippines and the Torres Strait region. Along the Asiatic coast it is found in Japanese and Korean waters.

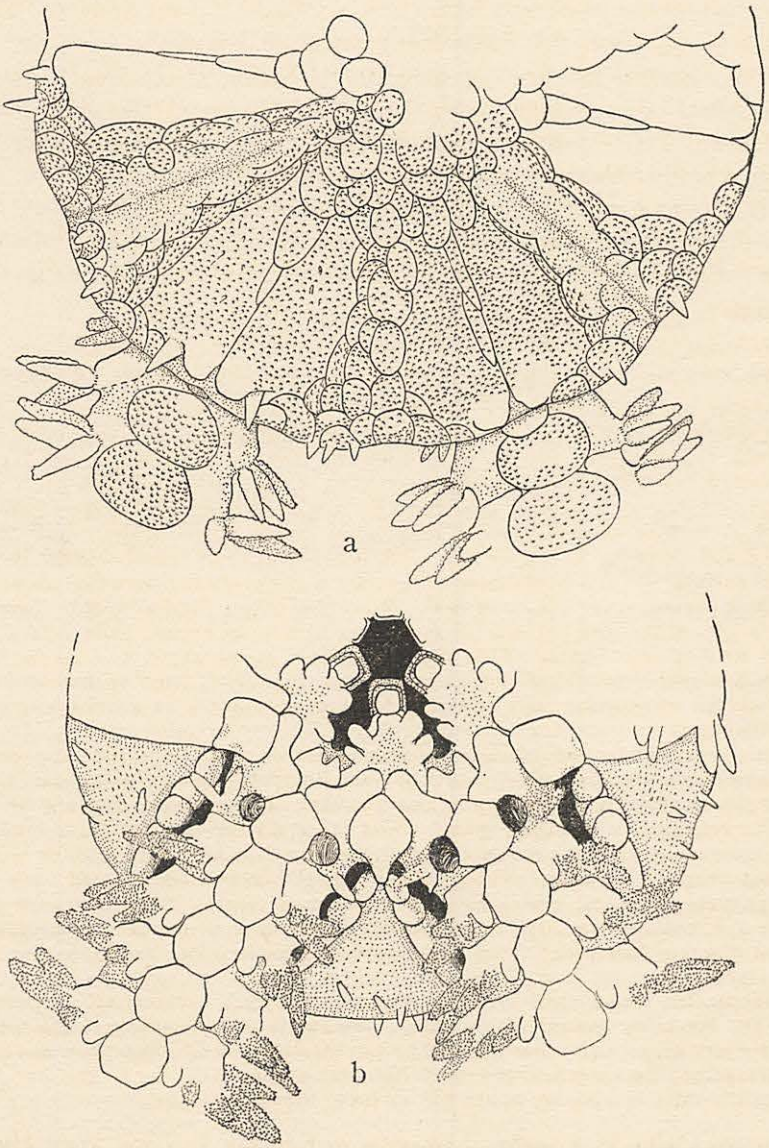

FIGURE 10.—*Ophiactis savignyi:* **a**, aboral view, × 35; **b**, oral view, × 30.

It has been reported from Fiji, Society Islands, Wake Island, and the Hawaiian islands in the Pacific Ocean. On the west coast of North America it ranges from San Diego to Panama; and on the east coast from Florida and the West Indies to Pernambuco in Brazil. The species is tropicopolitan, being confined to a fairly limited belt about the equator from about 35 degrees north to 20 degrees south.

Family OPHIOTRICHIDAE Ljungman

Disk covered with plates or scales, or by naked skin, often beset with minute spines or stumpy tubercles. Radial shields large. Peristomial plates small, entire. Teeth stout, widened, squarish. Dental papillae well developed, forming a vertical cluster at the apex of each jaw. Oral papillae absent. Dorsal side of vertebrae Y-shaped, being conspicuously notched inward. Arm spines either moderately long, conical and opaque, or very long, flattened, serrate and hyaline. Tentacle pores large, with one or two scales or none.

Genus **OPHIOTHRIX** Müller and Troschel

Disk beset with thorny grains, short spines crowned with thorns, or spines with thorns at sides and top. Radial shields like large triangular swellings, each banded on its inner sides by ridges in the skin of the back. Numerous crowded tooth papillae forming a vertical oval cluster. Teeth present; no mouth papillae. Spines numerous (five to 10) often three times as long as joints, flattened, more or less glossy, thorny, having a central shaft with slender side spurs. A small spinelike tentacle scale. The base of the jaw pierced with a hole due to lack of perfect union between the two pieces of mouth frames. Interbrachial spaces swelled out like lobes. Two genital openings begin outside the mouth shields.

Ophiothrix demessa Lyman, Boston Soc. Nat. Hist., Proc. 8: 82, 1861 (pl. 11, *A;* fig. 11).

Average specimen with disk 10 mm. in diameter. Arms five; 40 mm. in length. There are two color forms of this species. Some specimens have a uniformly brown disk with the arms spotted and barred with reddish brown; others have a blue-gray disk with the arms blue and white.

Aboral surface of disk and dorsal arm plates covered by sparsely scattered crown-shaped granules which bear numerous sharp spikes. Radial shields large, triangular, partially concealed by overlying granules. Dorsal arm plates trapezoidal, lateral sides slightly concave, outer border widest, slightly broader than long.

First ventral arm plate large and evident, with curved outer border and inner portion much elongated, projecting aborally into the oral angle; following plates hexagonal in outline, lateral sides concave, distal angles well rounded; first few plates markedly longer than wide; those farther out on the arms barely longer than wide. Lateral arm plates small, not encroaching either dorsally or ventrally. Arm spines 12 to 15, the longest being about three segments in length and centrally located, the lowest one becoming hooked with several sharp points on its concave side and at the apex; all serrate, opaque. One tentacle scale with flat scale-like base, drawn out into a sharp conical point or sometimes two or three equal points.

Oral shields rhomboidal, broader than long. Adoral shields ploughshare-shaped, the outside angle being acute and drawn out to meet the first ventral arm plate; pairs not meeting within. Oral papillae absent. Dental papillae numerous (10 to 15) and well developed.

This species is occasionally taken from within coral heads at Black Point and Waikiki, but it is not common. It has been reported from most of the larger Hawaiian islands, Gilbert Islands, Society Islands, the Torres Strait region, East Indies, and the Red Sea.

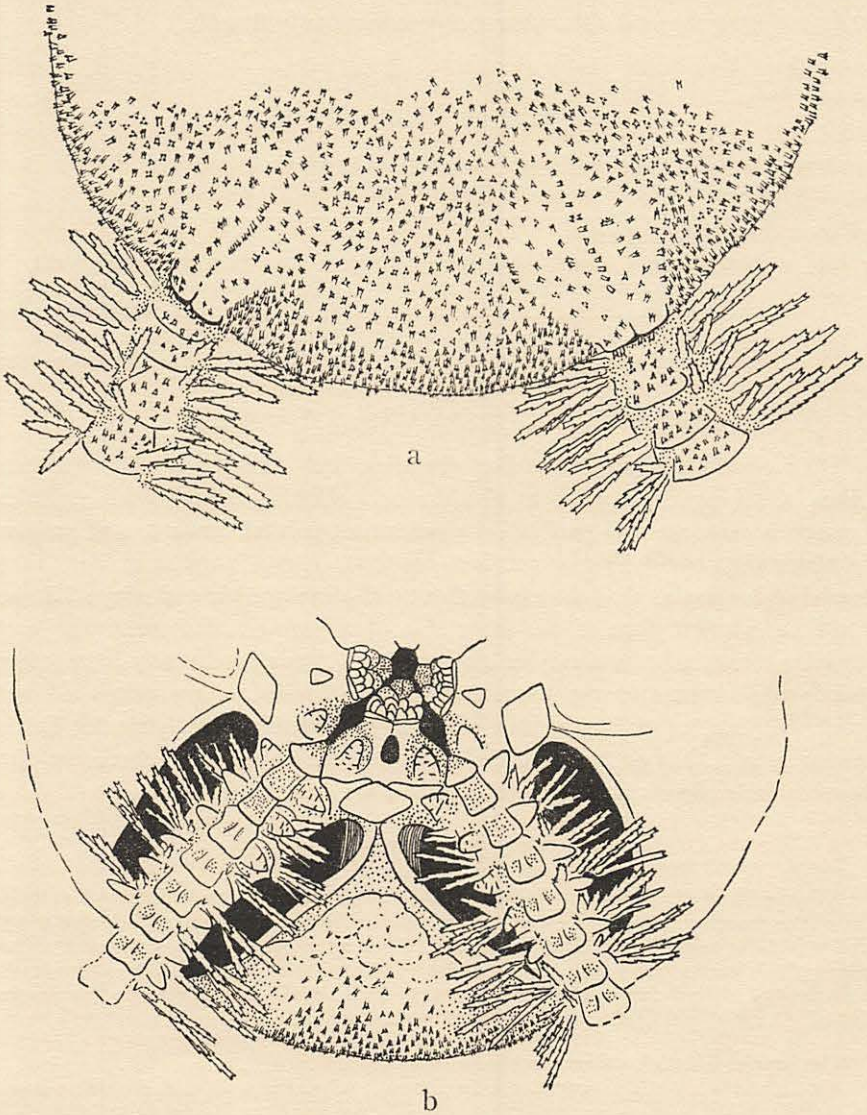

FIGURE 11.—*Ophiothrix demessa:* **a**, aboral view, × 8; **b**, oral view, × 8.

Order CHILOPHIURIDA Matsumoto

Disk covered with scales or plates, often with superficial granulations. The radial shield and genital plate on the same side of a radius articulate with each other by means of two articular condyles and one pit on each plate. Peristomial plates double or triple, not very large. Oral frames with or without well-developed lateral wings. Oral papillae well developed, close set, often entirely closing the oral slits. Arms only horizontally flexible.

Key to the Hawaiian Families of Shallow-water Chilophiurida (adapted from Matsumoto, 36)

A. Arm spines short and numerous; disk and oral angles covered with granules; second oral tentacle pores opening always within the oral slits; arms moderately or very long.....**Ophiodermatidae.**

AA. Arm spines long and erect.

B. Dental papillae absent; disk usually free of granules; oral angles not granulated; arms slender, stoutest at a distance from the base; arm spines few.....**Ophiochitonidae.**

BB. Dental papillae well developed, forming a vertical clump at the apex of each jaw; arms stout, stoutest at a distance from the base....**Ophiocomidae.**

Family OPHIODERMATIDAE Ljungman

Disk closely covered with fine granules, and sometimes with scattered spines. Oral angles, sometimes also the oral shields, covered with granules. Numerous close-set oral papillae, the outermost pointed inward, and projecting above the next papilla, which is the largest. Dental papillae absent. Peristomial plates triple. Oral frames without well-developed lateral wings. Radial shield and genital plate of the same side of a radius articulating with each other by means of two condyles and one pit. Arms moderately long, stout, cylindrical; stoutest at the base, horizontally flexible. Arm plates all well developed. Numerous arm spines, short or moderately long, lying flat on the arm or erect. One or two tentacle scales to each pore; when there are two, the abradial scale overlaps the base of the lowest arm spine.

Genus **DISTICHOPHIS,** new genus

With evident similarity to the genus *Ophioconis,* having entire disk and more or less of the mouth angles covered with granules; numerous arm spines, 7-9, and mouth papillae, 10-14; teeth, but no tooth papillae. Differing in the possession of more sturdy spines which are in two rows one immediately behind the other on each segment, the outer row of typical spines, the inner of very small needle-like spines; in the possession of strongly developed disk scales and genital plates.

Genotype, *Distichophis clarki.*

There has been some difference of opinion in the past concerning the proper position of the genus *Ophioconis,* to which the new genus *Distichophis* seems closest. Matsumoto (36) placed it in the order Chilophiurida in the family

Ophiodermatidae, but H. L. Clark (10, 11) places it in the order Laemophiurida in the family Ophiacanthidae.

The genotype has many characteristics of the Ophiodermatidae. The radial shield and genital plate articulate by means of two condyles and one pit. The condyles are especially well developed on the genital plate, whereas in the Ophiacanthidae the articulation is by means of a transverse ridge. But the arm spines are short in *Distichophis;* in the Ophiacanthidae they are characteristically long and flagellate. And lastly, all of the arm plates are well developed, unlike those in the family Ophiacanthidae. The peristomial plates, however, are not typical of the family Ophiodermatidae. Matsumoto (36) states that the family Ophiodermatidae is very uniform in its structure and that the peristomial plates are always triple. Those of *Distichophis clarki* were observed to be double and quite large. However, consideration of all available facts has led me to place the genus *Distichophis* in the family Ophiodermatidae.

Distichophis clarki, new species (fig. 12).

Disk 4 mm. in diameter, pentagonal, elevated and rounded, but with a central depressed area in dried specimens. Arms five, 11 mm. in length; about 0.5 mm. wide at base, and tapering only slightly to a blunt tip. Color uniformly dull gray or white.

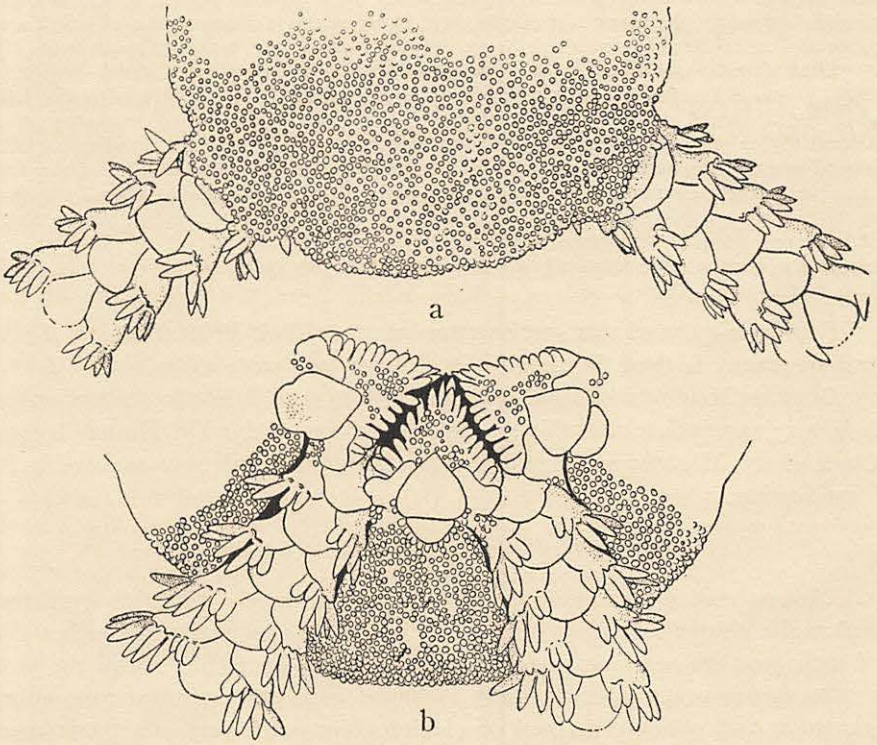

FIGURE 12.—*Distichophis clarkii:* a, aboral view, × 20; b, oral view, × 25.

Disk covered by a coat of polygonal truncate granules which appear pock marked, and separated from each other by about the width of a granule. The granulation extends over the first arm segment aborally and over the entire interbrachial area orally where as many as 50 rather sparsely scattered, somewhat longer granules may be found in the angle between the inner tip of the oral shield and the innermost tooth papillae. Radial shields concealed by granulation, but when isolated, suggestive of a spread wing in outline; with articulatory prominences not pronounced. Dorsal arm plates triangular, nearly as long as wide, with straight sides and a convex distal base; neighboring plates in contact only at the very tip of the acute angle, the lateral arm plates encroaching considerably on the dorsal surface and, distally on the arm, completely separating the dorsal arm plates.

First ventral arm plate large, arrowhead-shaped, slightly broader than long; succeeding plates longer than broad, pentagonal with concave sides and a broadened convex base; first few plates in contact at the acute proximal tip, but becoming separated by the lateral arm plates farther down the arm where the plates may become as broad as long and the sides almost straight. Lateral arm plates large, occupying a considerable portion of the oral and aboral surfaces of the arms and in contact above and below; each bears a series of 7 or 8 spines which may be flat against the arm or extending laterally depending upon the manner of killing. All are of nearly equal length except the dorsal-most spine which is the shortest and stoutest. They extend distally less than half of the length of the lateral arm plates, being broad at the base and narrowing abruptly to a moderately acute tip. Just inside of this series of spines in good specimens an additional series of six or seven tiny fragile needle-like spines may be seen. This extra row of spines is easily overlooked in poor specimens and may require high magnification to be observed. Two tentacle scales on the first six to eight segments, the innermost one longest, being nearly as long as the adjacent arm spine and spatulate; the outer one being broader at the base, tapering to an acute tip.

Oral shields wider than long, triangular with well-rounded lateral angles, a slightly concave base and irregular convex sides. Broadly in contact with the base of each oral shield, excepting the madreporite, is a semicircular naked accessory plate. Adoral plates in contact with the first ventral arm plate by a thick, somewhat rounded lateral wing; pairs not meeting within. Oral papillae nine or 10 on a side; the first one operculiform extending from the lateral wing of the adoral shields aborally underneath the next two papillae; the following six or seven very regular, short, stout, club-shaped, somewhat flattened; the remaining two or three larger at the base and tapering abruptly to an acute tip which projects into the mouth. Three or four spiniform teeth.

Four specimens of this species were taken at Black Point, Oahu, and several specimens in the collection of Dr. Edmondson were examined.

Distichophis clarki is found concealed within coral heads in shallow water. It is very appropriate that this new species be named for Dr. Hubert Lyman Clark of the Museum of Comparative Zoology, Harvard, who assisted in its identification.

Family OPHIOCHITONIDAE Matsumoto

Disk covered with fine, imbricating scales, or rarely with fine granules; oral angles always free from granules. Five or six oral papillae on either side of each jaw; the outermost one is pointed inward, projecting above the next papilla, which is the largest. Teeth arranged in a single vertical row, either triangular and obtusely pointed or quadrangular, with very stout, truncated end. Dental papillae absent. Peristomial plates double or triple. Arms long

and slender, widest at some distance from the base, horizontally flexible. Two to four, usually three, arm spines, moderately long, erect. One or two large, leaflike tentacle scales on the abradial border of each pore; sometimes one to three very small accessory ones may occur on the adradial border.

Genus **OPHIONEREIS** Lütken

Disk covered with fine overlapping scales, usually uniform, except those along margin, which are somewhat larger. Radial shields nearly hidden by the scales. Large oblong teeth. Mouth angle small and short, and bearing nine or 10 close set little papillae. A few (three to five) short, smooth arm spines. One large tentacle scale. Each upper arm plate has a supplementary piece on either side. Two genital openings beginning outside the mouth shields in each interbrachial space.

When isolated, the radial shields are found to be long and narrow with an enlarged outer end or to be wide and widely three sided, but in either case they are widely separated. The genital plates are long, club-headed and moderately stout, and have attached, just at the inner part of the head, a thin genital scale, which extends quite to the mouth shields. The mouth frames are rather simple and not large and they support very small jaws bearing a distinct jaw plate. There is nothing but an irregular lime crust to represent the peristomial plates.

Ophionereis porrecta Lyman, Boston Soc. Nat. Hist., Proc. 7: 260, 1860 (pl. 11, *B;* fig. 13).

Diameter of disk 15 mm., arms five, 100 mm. in length. Color of disk complexly variegated with gray, tan and dark brown; gray predominating while the dark brown and tan form fine lines and spots. Two specimens collected show only faint variegation, being almost uniform buff. Dorsal arm surface gray and dark brown, the dark brown coloring in spots and complex patterns arranged down the center of the dorsal arm plates and at intervals so as to give the arms a distinct banded appearance with a central longitudinal stripe. In some specimens the banding is less distinct than in others.

Disk covered by very smooth, fine scales of equal size centrally, but becoming much larger at the fringe near and between the radial shields; orally, scales are again fine where they bear sparsely scattered granules in the proximal interradius and a very regular row of stout granules along the genital slit. Radial shields long oval in shape partially concealed by disk scales, widely separated; when isolated, a narrow inner portion with a widened basal portion may be seen; articular condyles prominent. Dorsal arm plates twice as broad as long, the difference becoming greater as the arm widens; trapezoidal; inner side longest; lateral sides gently curved; outer border straight or slightly concave, overlapping the next plate slightly; two accessory plates attached to the side of each dorsal arm plate.

Ventral arm plates as broad as long, pentagonal as seen when isolated; when in place, the apex of the pentagon is concealed under the next ventral arm plate; four sides markedly concave and the base slightly convex; proximal angle blunt and depressed; the two remaining proximal angles acute, while the distal two are well rounded. Lateral arm plates invisible aborally, but in evidence to some extent orally. Arm spines three in number; the uppermost shortest and almost prismatic in shape; middle spine longest, conical and round; all smooth. One large oval heavy tentacle scale with a shallow trough-like cavity on the inside.

Oral shields slightly longer than broad, pear-shaped. Adoral shields triangular with the largest angle visible externally and the two acute ones pointing proximally and distally. Five oral papillae to a side, the last one infradental, and the second pair the largest. Dental papillae absent.

This species shows a marked preference for hiding places near shore, particularly where there are rocks and sand. It is known from the Torres Strait region, Japan, East African coast, the Philippine Islands, and many of the islands of the south Pacific.

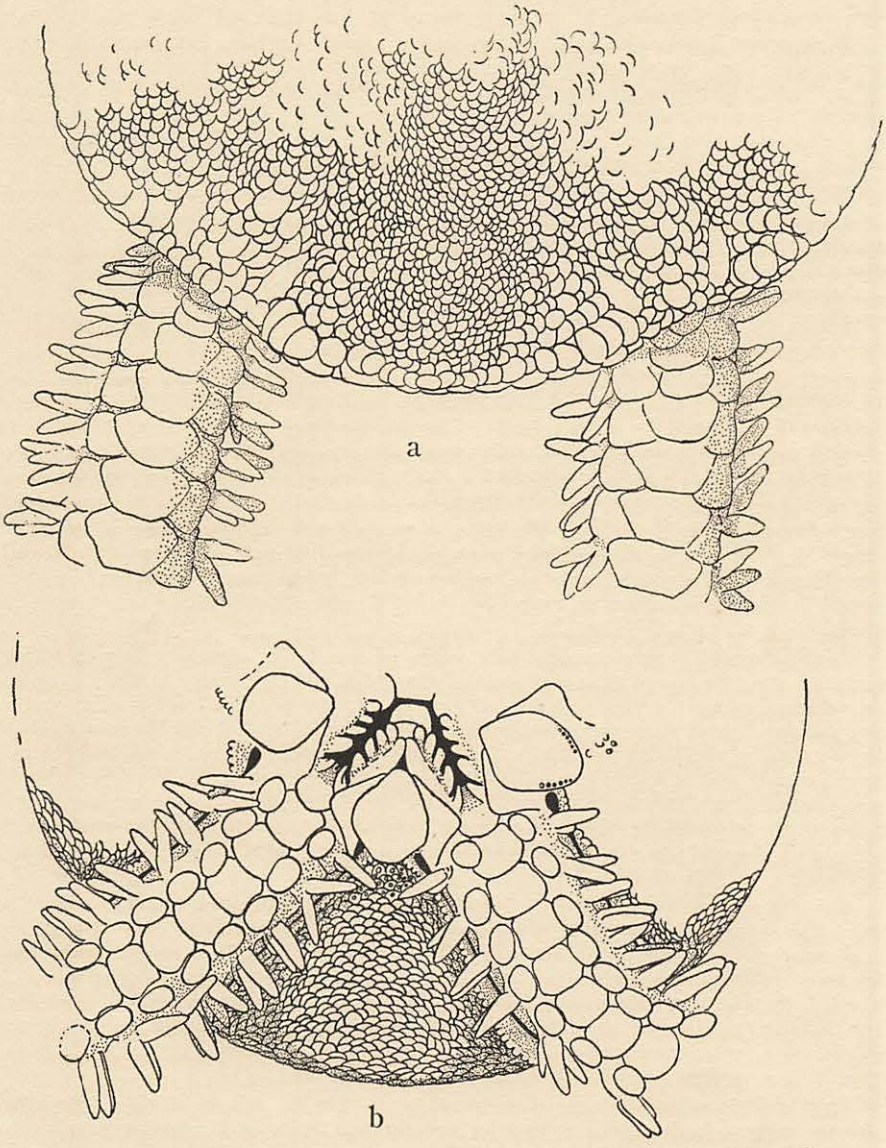

FIGURE 13.—*Ophionereis porrecta:* **a**, aboral view, × 9; **b**, oral view, × 9.

Family OPHIOCOMIDAE Ljungman

Disk covered with fine granules or by a naked skin, sometimes bearing scattered spines. Radial shields very stout, but externally invisible, those of a pair widely separated from each other. Four to six oral papillae on either side, the outermost one being pointed inward above the next one. Dental papillae well developed, forming a vertical clump at the apex of each jaw. Teeth quadrangular and very stout. Peristomial plates double. Oral frames very stout with extremely well-developed lateral wings. Arms moderately long.

Genus **OPHIOCOMA** Agassiz

Disk granulated. Radial shields covered. Teeth and mouth papillae, and very numerous close-set tooth papillae, arranged in a vertical clump. Spines, usually from four to six, smooth, solid. One or two tentacle scales. Two genital openings beginning outside the mouth shields.

Under the disk granulation is a smooth scale coat, very fine toward the center; coarse toward the border where runs a marginal belt of much larger scales connecting the outer ends of the radial shields which are oblong, with protruding corners. They are continued inward by a broad strip of large, strongly overlapping scales, a feature nowhere so developed as in this genus. The genital plate is like a thick blade with rounded edges and a slightly clubbed head for articulating with the radial shield. To the side of the genital plate is attached a short, thin bladelike genital scale. As seen from above, the vertebrae are simple structures, being short, with thin, flat, plain-edged wings, and destitute of any forward projections from the upper surface. Their outer and inner faces are of a high type, having the articulating peg and other details well marked.

Key to the Hawaiian Species of Ophiocoma (adapted from Clark, 8)

A. Five arms. Disk granules nearly or quite spherical and of more or less uniform size.

B. Disk granulation coarse, 9 to 64 granules per millimeter, covering only part and often a very small part, of oral interbrachial surface; arm spines longer dorsally than ventrally.

C. Granulation coarse, 9 to 36 per square millimeter; arm spines four or five; coloration black or blackish, or some combination of blackish and whitish.

D. Coloration varied, but often very dark orally; under arm plates, at least proximally, with more or less whitish; arms long, 4.5 to 7.5 times disk diameter ..... **O. scolopendrina.**

DD. Coloration nearly or quite uniformly black; arms four to five times disk diameter ..... **O. erinaceus.**

CC. Granulation finer, 49 to 69 granules per square millimeter; arm spines five or six; coloration very fine, variegated brown and yellow; proximal arm spines rather heavy and blunt; distal spines needle-like ..... **O. pica.**

BB. Disk granulation very fine, 64 to 100 granules per square millimeter, covering oral interbrachial areas; arm spines shorter dorsally than ventrally.

C. Coloration variegated.
D. Prevailing colors gray and brown; mature specimens measuring about 15 mm. across the disk with arm length of 40 mm. ..... **O. brevipes.**
DD. Prevailing colors blackish or brownish and whitish or pale brown; mature specimens measuring about 20 mm. across the disk, with arm length of approximately 100 mm. ..... **O. insularia** var. **variegata.**
CC. Coloration uniformly deep brownish black ..... **O. insularia.**
AA. Six arms; disk granules higher than thick, becoming more or less markedly spiniform. Size small, about 5 mm. in diameter ..... **O. parva.**

Ophiocoma scolopendrina Lamarck, Anim. s. Vert. 2 : 544, 1816.

Resembling *O. erinaceus* except in the following details. Coloration is ordinarily variegated with dark and light shades; the colors are rarely clear enough to be called black and white, but are commonly dark gray or brown and dirty whitish, dull yellow or pale brown. Large specimens may have uniformly dark disks with arms sometimes correspondingly dark, but in all such specimens the oral shields and the underarm plates, at least the basal ones, are light, with or without darker markings. Arms long, 4.5 to 7.5 times disk diameter. Disk covered with granules which extend to the oral interradial areas where they gradually disappear. Under arm plates with distal borders notched, spines frequently ringed.

Clark (8) gives an interesting account of the habits of *O. scolopendrina* at Mer Island. He points out that it occupies a restricted and peculiar habitat near the high water mark. During low tide the animal remains concealed, but as the tide comes in, three of the arms protrude from crevices in which the animal lodges, while the other two act as anchors. Numerous *Ophiocoma* were collected on the reef at Black Point where conditions are quite similar to the habitat described by Clark, but it was impossible to group them into *O. erinaceus* or *O. scolopendrina.* (See *Ophiocoma erinaceus* for discussion.) The illustration given by Clark (10), distinctly showing the variegated coloration, convinces me that this species is rare about Oahu.

O. scolopendrina ranges from the east coast of Africa east to the Torres Strait region, along the Asiatic coast from the Philippines to Japan and has been taken at many of the south Pacific islands including Fiji, the Gilbert Islands and the Society Islands. H. L. Clark (personal letter) reports that there are several specimens in the Museum of Comparative Zoology from Palmyra and Lahaina, Maui.

Ophiocoma erinaceus Müller and Troschel, Syst. Ast., 98, 1842 (pl. 12, *A;* figs. 4; 5; 14).

Disk 25 mm. in diameter in average specimens, circular, elevated. Arms five, 100 mm. in length. Color uniformly dark black. Disk covered by coarse rough granules which extend into the oral interbrachial areas to a greater or less degree. Dorsal arm plates broader than long, triangular with blunt apex and strongly concave sides; successive plates overlapping distally. Lateral arm plates of medium size visible orally and aborally where they seem to underpin the dorsal arm plates and raise them above the general surface along their distal borders. Arm spines five near the disk dropping to four, then three farther out on the arms; uppermost spine largest and longest. Some

specimens may have spines alternating from three to four along the entire length of the arm. Two equal rather heavy tentacle scales. Ventral arm plates almost as long as broad, pentagonal with short slightly concave sides and broad deeply convex base.

Oral shields varying from circular to rectangular, and from longer than broad to broader than long. Adoral shields rhomboidal when isolated, when in place, one angle visible externally which is drawn out and pointed. Four oral papillae, the second broad and operculiform. Four stout teeth; numerous dental papillae more or less regularly arranged in three rows on the torus angularis.

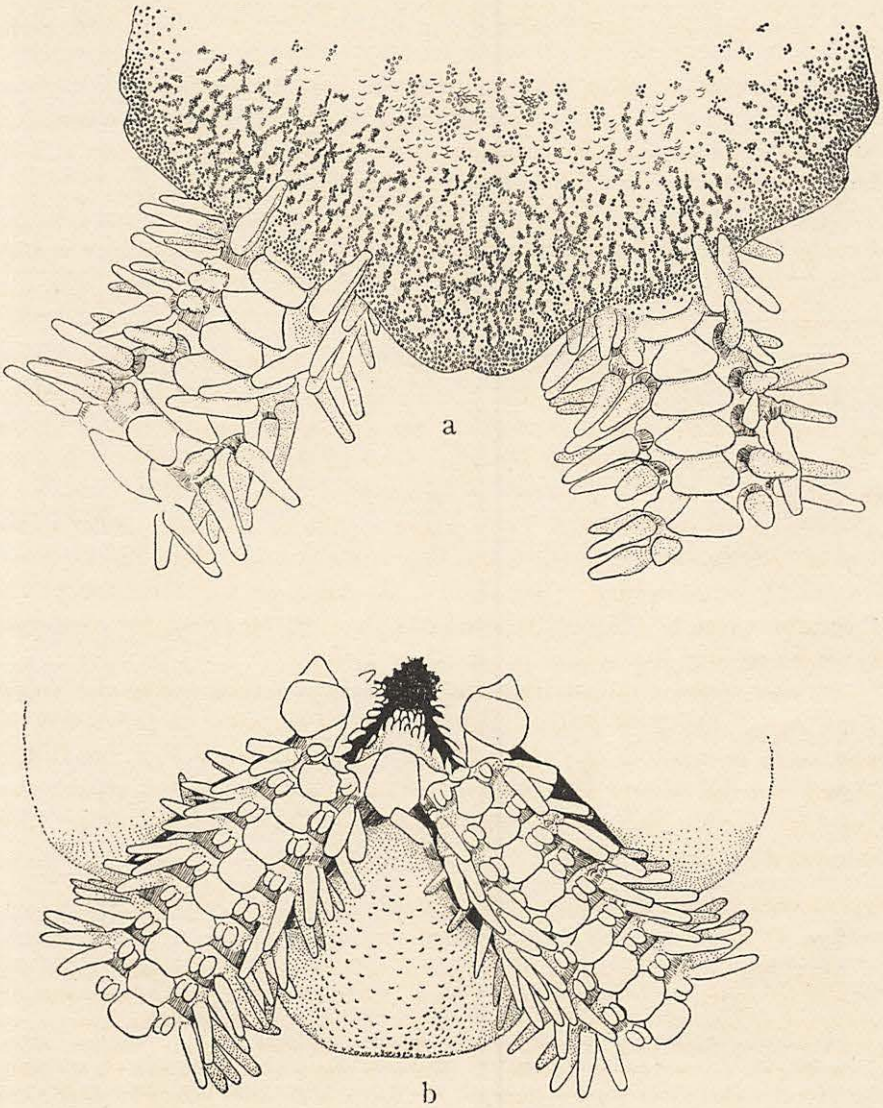

FIGURE 14.—*Ophiocoma erinaceus:* **a**, aboral view, × 3; **b**, oral view, × 3.

This species is found in great abundance along the leeward side of Oahu from shore to the edge of the reef; in sandy areas, it is less common than *O. insularia,* with which it is frequently associated. The range of *O. erinaceus* is similar to that of *O. scolopendrina,* but if they are distinct species they may have often been confused in the literature.

The problem of the relationship of this species to *O. scolopendrina* is perplexing. Matsumoto says, "There is no doubt that *O. scolopendrina, O. erinaceus,* and *O. shoenleinii* are conspecific. I have closely examined many intermediate specimens and am fully convinced that there is no line of demarcation." Koehler concludes, "After studying numerous specimens of *O. scolopendrina,* I finally arrived at the conclusion that in spite of the rather extensive variations of *O. scolopendrina, O. erinaceus* may always be distinguished from it." He bases his distinction on the following: granulation of the disk which stops abruptly at the periphery without passing over the ventral surface, notching of the distal border of the ventral plates, robustness of the dorsal spines, and the coloration of *O. erinaceus.* Clark (8) comes to the same conclusion. He bases his distinction on the uniformly black color of *O. erinaceus,* the relationship of arm length to disk diameter (arms four to five times disk diameter in *O. erinaceus;* 4.5 to 7.5 times in *O. scolopendrina*) and the habits of *O. scolopendrina.* I have found that groups may be separated when one particular character is kept in mind, but one specimen seldom possess two or three of the above specification. However, time has not permitted as extensive a study as would be necessary for the satisfactory solution of this problem. When groups from different regions are brought together, they may prove to be varieties of one species.

Ophiocoma pica Müller and Troschel, Sys. Ast., 101, 1842 (pl. 12, *B;* fig. 15).

Disk about 18 mm. in average specimens, pentagonal, cushionlike with perpendicular sides. Arms five, 35 mm. in length. Largest specimen collected by me measured 25 mm. across the disk with arms 60 mm. long. Aboral surface of disk variegated with fine, golden-yellow lines running from the periphery to the center from which they may continue to the opposite side or loop about and return to the same side; background black. About the fringe of the disk are yellowish spots, two on either side of each arm base and one or more in the center of each interradial area. Lateral angles of about every other dorsal arm plate and the lateral arm plates are yellow. Outer sides of the buccal shields and interradial portions of the adoral shields yellow. Ventral arm plates near disk yellow along peripheral borders.

Disk covered by fine close-set granules not extending far into the interbrachial regions. Granules finer than in *O. erinaceus,* but coarser than in *O. brevipes.* Dorsal arm plates only slightly broader than long, smaller than the ventral arm plates; triangular, with a blunt apex, convex sides and concave base. Those plates located distally on the arms broader than long with less deeply concave sides.

Ventral arm plates near disk broader than long, pentagonal with deeply concave sides producing hooklike lateral angles; base concave. Lateral arm plates encroaching considerably on the dorsal arm surface, less markedly so ventrally. Arm spines near disk six in number; distally five; then four. Dorsal proximal spines longest and stoutest; distally all become needle-like. Two heavy tentacle scales.

Oral shields twice as long as broad, ovate. Adoral shields triangular, the broadest angle being visible externally. Four or five oral papillae, the first two of which may be slightly broader than the others; 25 to 30 large tooth papillae.

O. pica is distributed from the Red Sea through the Torres Strait region to the Philippine Islands and in the mid-Pacific areas at Pearl and Hermes Reef, Laysan, Ocean, Wake and Johnston Islands.

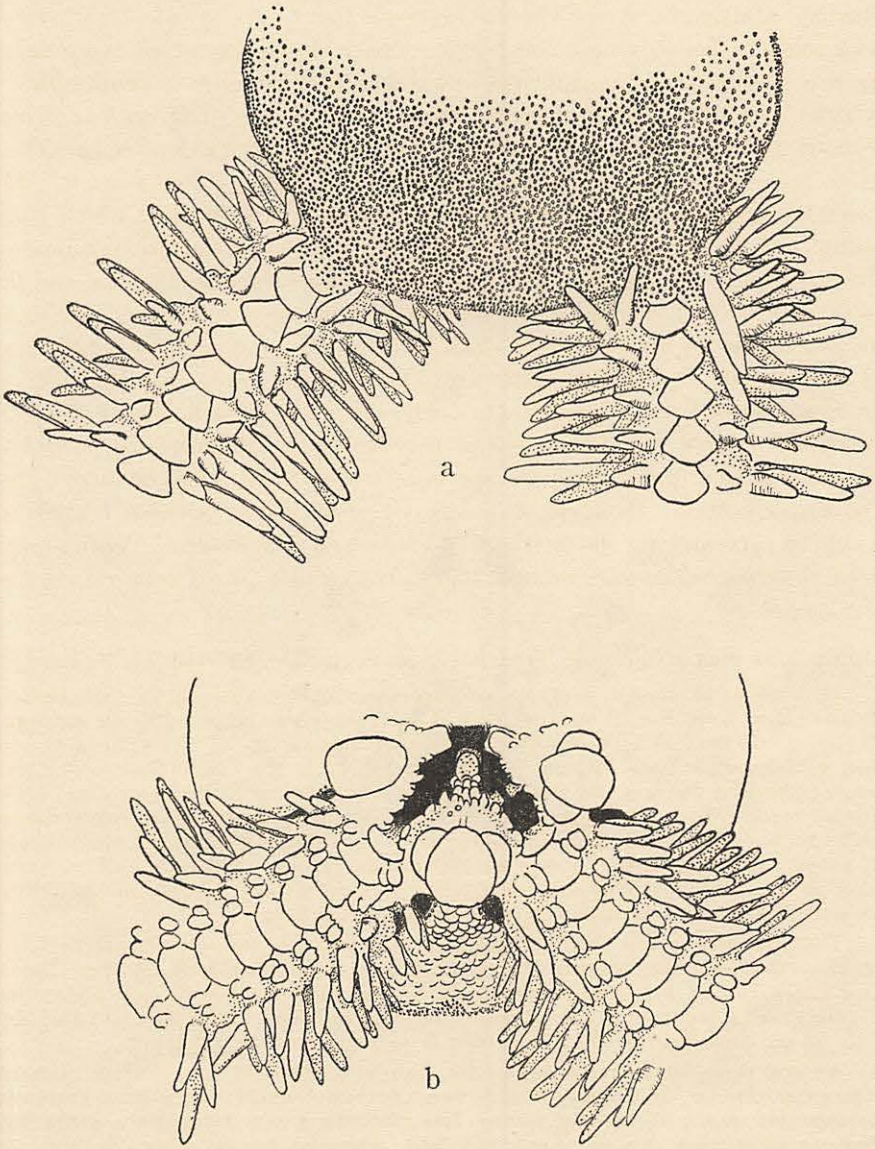

FIGURE 15.—*Ophiocoma pica:* a, aboral view, × 6; b, oral view, × 6.

This species is found on the reefs, closely associated with *O. erinaceus,* but is much less common. Koehler (26) presents photographs which show that the arm spines of *O. pica* vary considerably in shape and length.

Ophiocoma brevipes Peters, Monatsb. K. Preus. Akad. Wiss. Berlin, 465, 1851 (pl. 13, *C;* fig. 16).

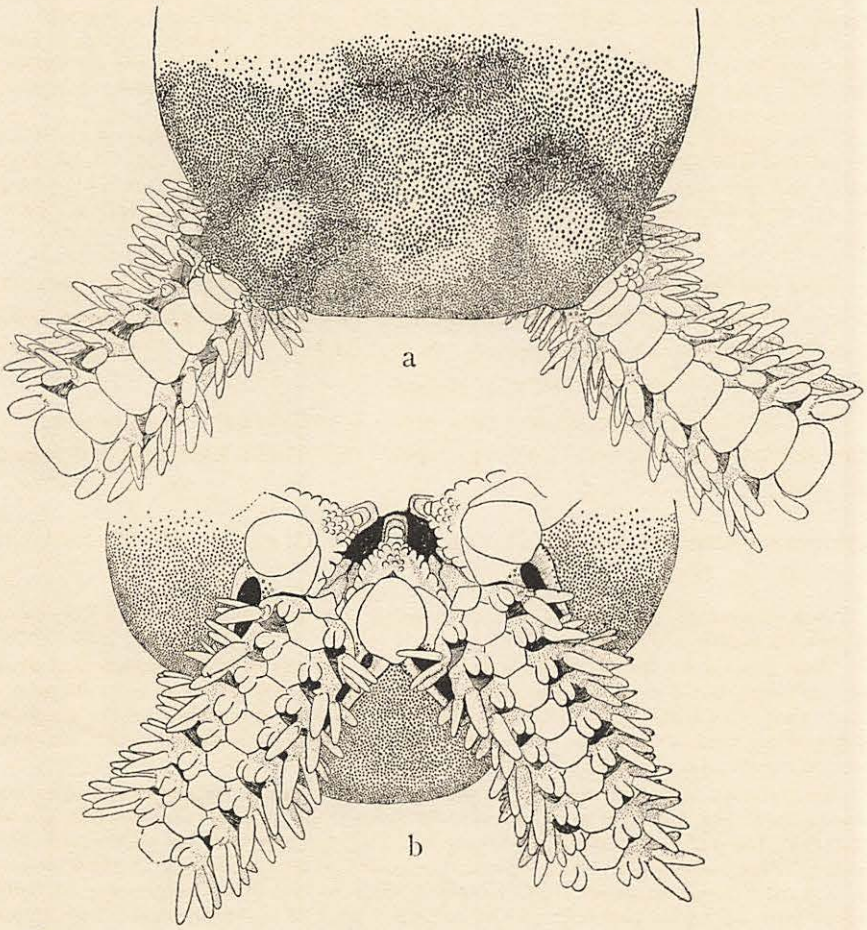

FIGURE 16.—*Ophiocoma brevipes:* a, aboral view, × 7; b, oral view, × 7.

Disk 15 mm. in diameter, rounded and rather flat. It is noteworthy that Koehler records his specimens as measuring 26 and 27 mm. while those of Hawaii collected by me and those in the collection of Dr. Edmondson are 15 mm. in disk diameter. Arms five, 50 mm. in length. Disk pattern extremely variable. In most specimens background gray, with very light brown lines forming a network over the entire disk. Superimposed upon this pattern are definite gray and brown areas due either to increased extent and depth of color of the brown network or to its complete absence.

The disk may show a central gray area with radiations into the interradial regions, or light patches only at the interradial borders of the disk. Usually, two gray spots on either side of the arms where they meet the disk aborally. Dorsal arm surface maculated with light and dark regions. Generally two or three adjacent dorsal arm plates are brown with several succeeding grayish ones. The dorsal arm plates themselves may be solidly colored or they may show variable patterns. Ventral surface uniformly gray.

Disk entirely covered by fine closely set granules extending over the oral interbrachial areas. Dorsal arm plates broader than long, triangular, with blunt apex and broadly rounded angles; proximal angle concealed beneath neighboring plate.

Ventral arm plates longer than broad, pentagonal with markedly concave sides and a convex base. Lateral arm plates scarcely visible dorsally, but quite in evidence ventrally. Five or six smooth arm spines, the dorsal spines being shorter and more compressed than the ventral ones. Two thin, ovate tentacle scales.

Oral shields oval, nearly as broad as long, but varying to longer than broad. Adoral shields rhomboidal, three of the angles being visible externally; distal angle with 5 to 7 granules. Five oral papillae, the outermost the smallest, next within largest, the remainder of equal size and columnar. Twelve to 15 tooth papillae. Torus angularis twice as broad as long, bearing four teeth.

This species is of typical Indo-Pacific distribution, ranging from Zanzibar to New Guinea and the Torres Strait region, northward along the Asiatic coast past the Philippines to Japanese waters and around most of the mid-Pacific islands as far north as the Hawaiian islands.

This species is found underneath stones which conceal large numbers of other ophiocomas. Curiously, only one or two individuals are found underneath one stone.

Ophiocoma insularia Lyman, Boston Soc. Nat. Hist., Proc. 8: 80, 1861 (pl. 13, *A;* fig. 17).

Disk of average specimen 27 mm. in diameter, circular and flat. Arms five, about 100 mm. in length. Color uniformly black.

Disk covered by fine granules extending over the entire oral interbrachial area, but becoming sparse near the oral shields; a few quite large globular ones forming a fringe about the distal border of the oral shields. Dorsal arm plates nearly 2.5 times as broad as long; triangular, with the proximal apex concealed beneath the next proximal plate; lateral angles broadly rounded.

Ventral arm plates slightly longer than broad, pentagonal with concave sides and convex base; the first few are depressed in the middle so that they become almost scooplike. Lateral arm plates in evidence dorsally, but encroaching even more completely on the ventral side. Arm spines four near the disk, dropping to three out on the arm; the dorsal spines shortest. A few of the proximal dorsal spines may be bottle shaped with a long slender neck and an enlarged head. Two broad, equal, leaf-shaped tentacle scales.

Oral shields oval, varying from longer than broad to broader than long. Adoral shields semicircular with no visible external angles; neither meeting within nor in contact with the first ventral arm plates without. Five oral papillae; the outermost largest and squamiform, pointing aborally into the mouth slit, the others nearly equal, cuboidal. Numerous tooth papillae, some attached to the oral-angle plates.

This species has been taken in many of the islands of the Pacific, and is also known from the Indian Ocean and Japanese waters.

There has been considerable doubt about the relationship of this species to *O. brevipes* on the one hand and to *O. insularia* var. *variegata* on the other. *O. insularia* was first set aside as a distinct species by Lyman in 1861, but it was later united by him with *O. brevipes*. Koehler (26) lists *O. insularia* from Hawaii. H. L. Clark (6) in 1915 considered it a distinct species, but in his work of 1921 (8) and 1925 (9) it is listed as *O. brevipes* var. *insularia* and the other member of this group as *O. brevipes* var. *variegata*. At this time he expressed some doubt as to the desirability of this arrangement. Finally in 1938 Clark (10) established the classification which is used in this work.

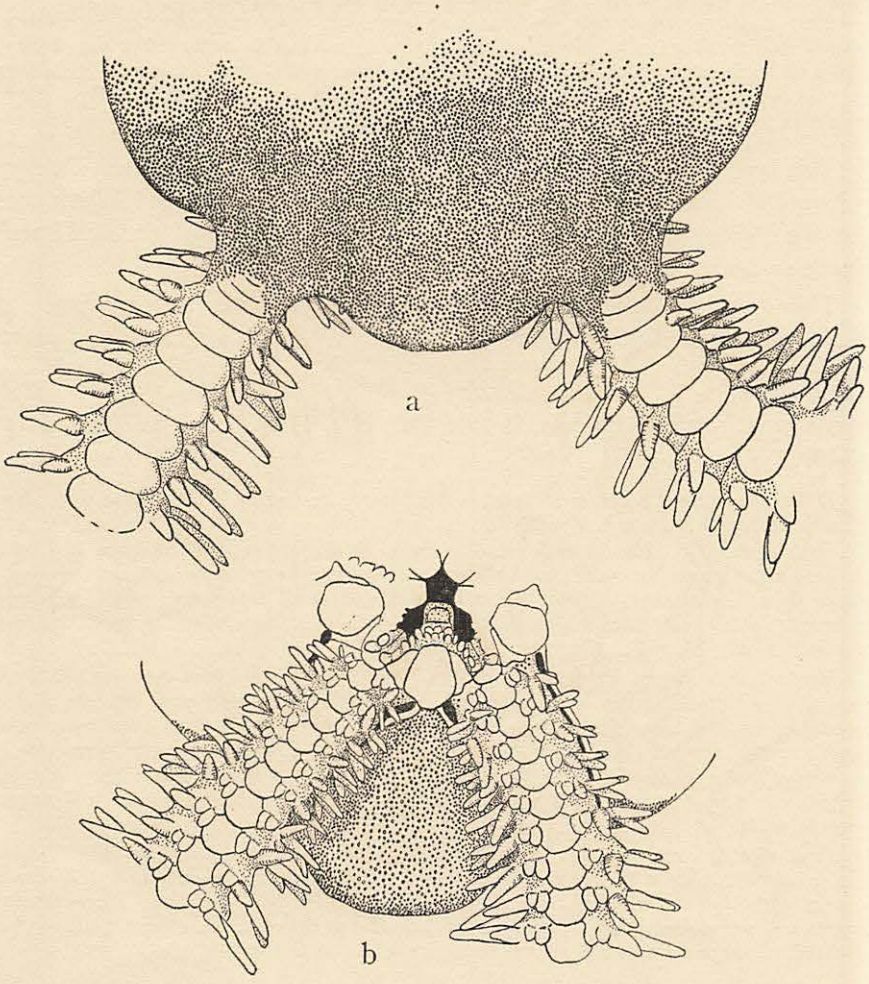

FIGURE 17.—*Ophiocoma insularia:* **a**, aboral view, × 4; **b**, oral view, × 4.

As regards the relationship of *O. insularia* to *O. insularia* var. *variegata*, (Clark 8)—in a key of the genus *Ophiocoma*—lists both as varieties of *brevipes*. *O. insularia* is distinguished as being uniformly blackish, with jaws very short; oral plates greatly reduced; arm spines three to five, often six, moderately long. Farther on in the text he says, "The uniformly blackish color and the presence of three rather long slender arm spines beyond the basal joints makes the recognition of *insularia* easy." No difficulty was found in differentiating between the two on the basis of the disk coloration, but the number and arrangement of the arm spines of both is often identical. In each, the first few segments have three spines; the next four segments four or five, with four present until the 11th or 12th segment when the number drops to three.

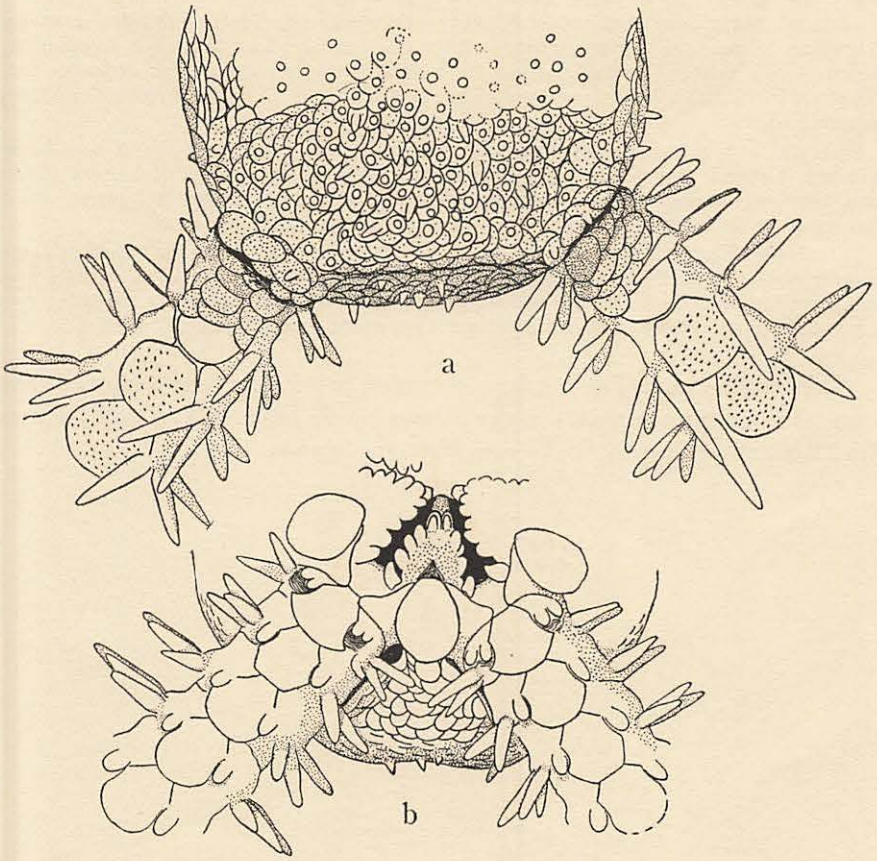

FIGURE 18.—*Ophiocoma parva:* **a**, aboral view, × 30; **b**, oral view, × 30.

Ophiocoma insularia var. **variegata** (E. A. Smith) (pl. 13, *B*).

Ophiocoma variegata E. A. Smith, Ann. Mag. Nat. Hist. IV, **19**: 39, 1876.

Ophiocoma insularia var. *variegata* H. L. Clark, Dept. Marine Biol. Carnegie Inst. **10**: 95, 1921.

Disk variegated with dark and light brown, sometimes spotted. Dorsal arm surface faintly banded with brown and dark gray or whitish. Otherwise similar to *O. insularia*.

This form is essentially Indo-Pacific in its distribution, ranging from Zanzibar to the Pelew [Palau] Islands and Hawaii.

Ophiocoma parva Clark, Mus. Comp. Zool., Mem. **25**: 292, 1915 (fig. 18).

Disk 5 mm. in diameter, circular, flattened. Arms six, 15 mm. in length. Color brown, pale gray, and whitish.

Aboral surface of disk with sparsely scattered, spiniform granules; granules extending to the oral surface where only a few may be found in each interradius. Radial shields relatively small for an *Ophiocoma;* invisible externally; articular condyles not particularly well developed. Dorsal arm plates slightly broader than long, pear shaped.

Ventral arm plates pentagonal, with three obvious angles, the distal two being rounded. Lateral arm plates quite prominent both orally and aborally. Arm spines four, relatively large for the size of the rest of the body; uppermost longest, about two segments in length; all tapering evenly to a fairly acute tip.

Oral shields oval, longer than broad. Adoral shields triangular, the broadest angle being visible externally, not meeting within. Four scale-like oral papillae; the first one being longer than high; the second larger and oval, the remaining two long and slender. Five or six large dental papillae. One ovate tentacle scale.

This small species has not been recorded previously from Oahu. It has been taken at various points in the Torres Strait region, Pearl and Hermes Reef, Lisiansky, Laysan, Wake, and Palmyra Islands.

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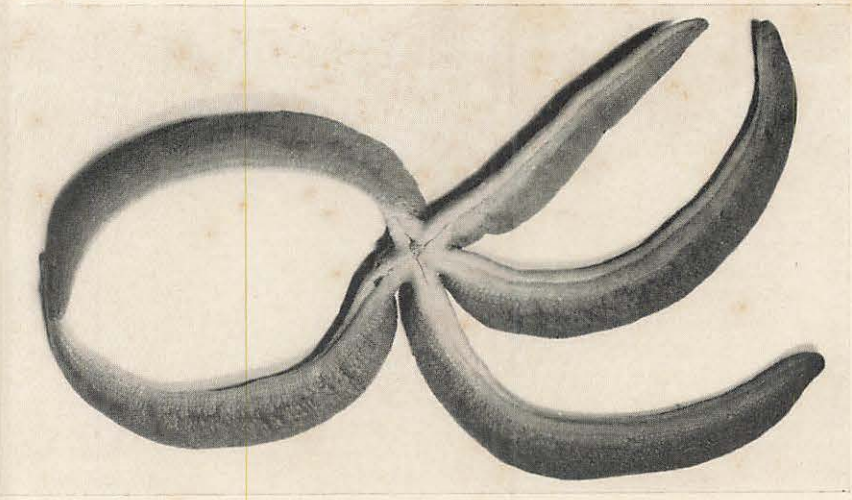
(Synonyms are in italic, new genera and species in boldface.)



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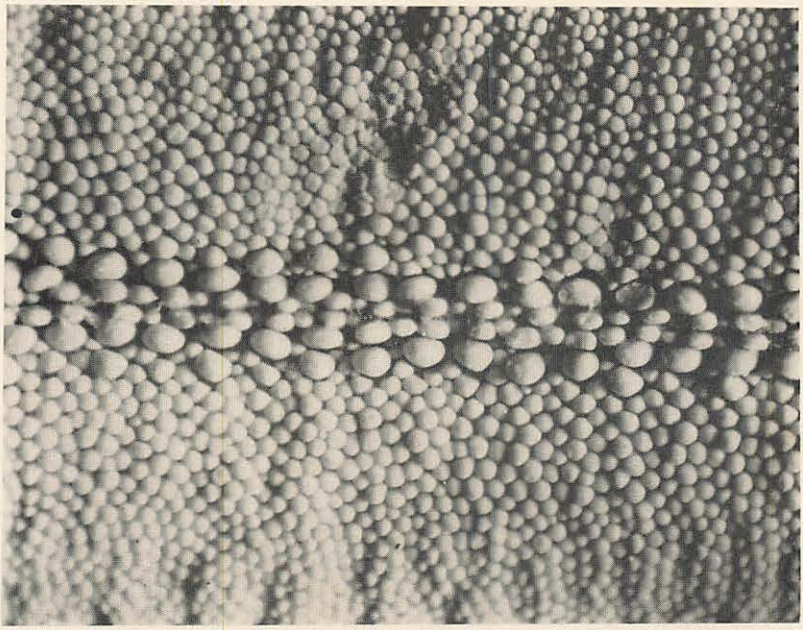

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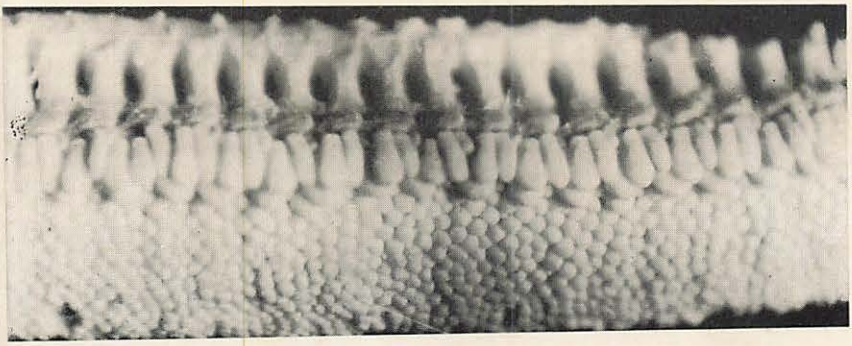

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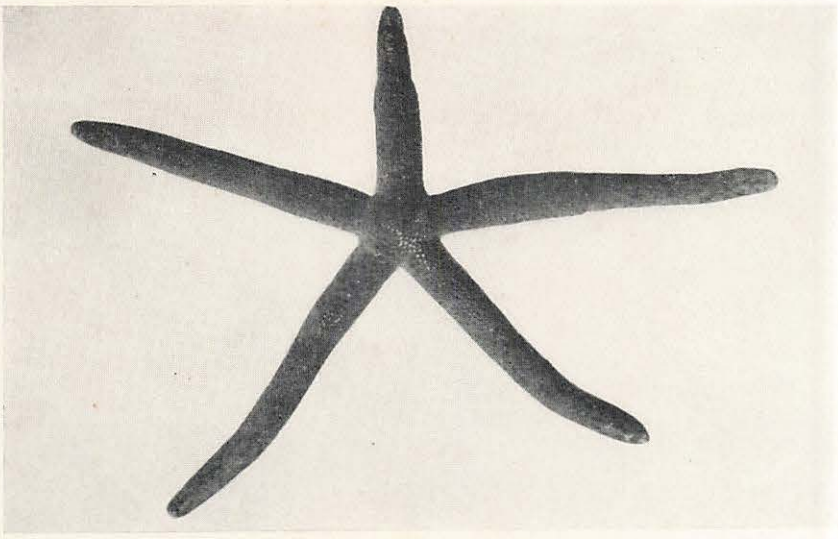
LINCKIA GUILDINGII: A, ORAL VIEW, × 0.25; B, PORTION OF A RAY, ORAL VIEW × 7; C, PORTION OF A RAY DISSECTED TO SHOW FURROW SPINES, LATERAL VIEW, × 7.



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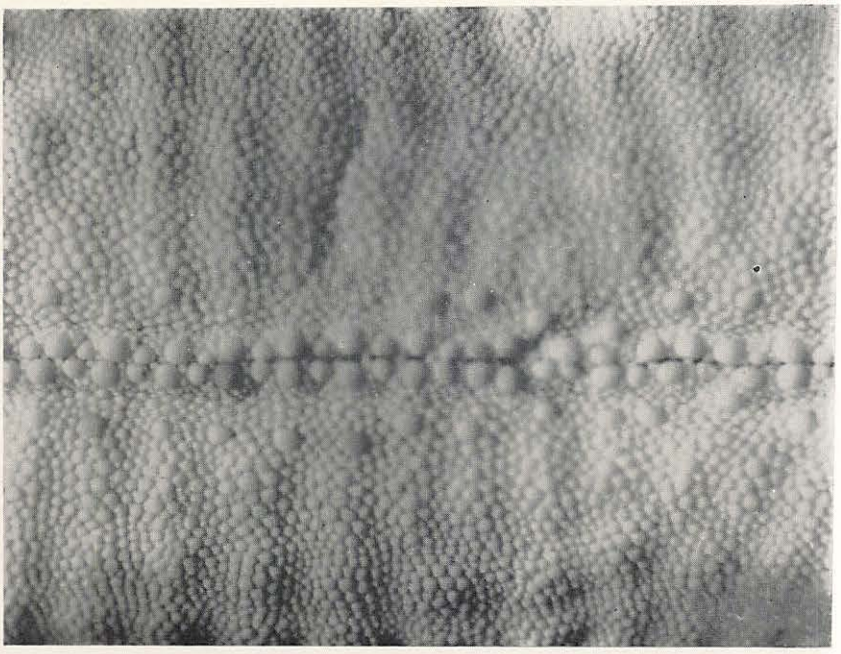

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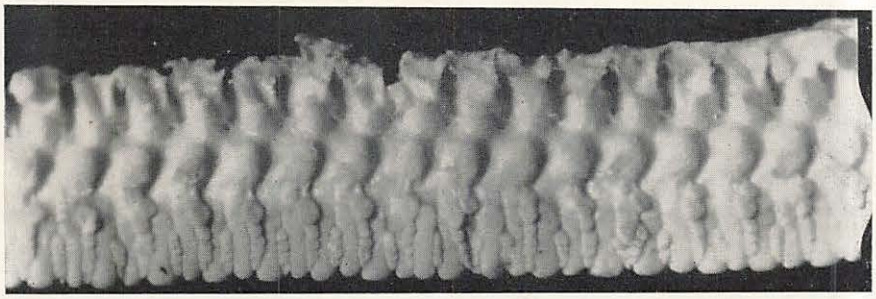
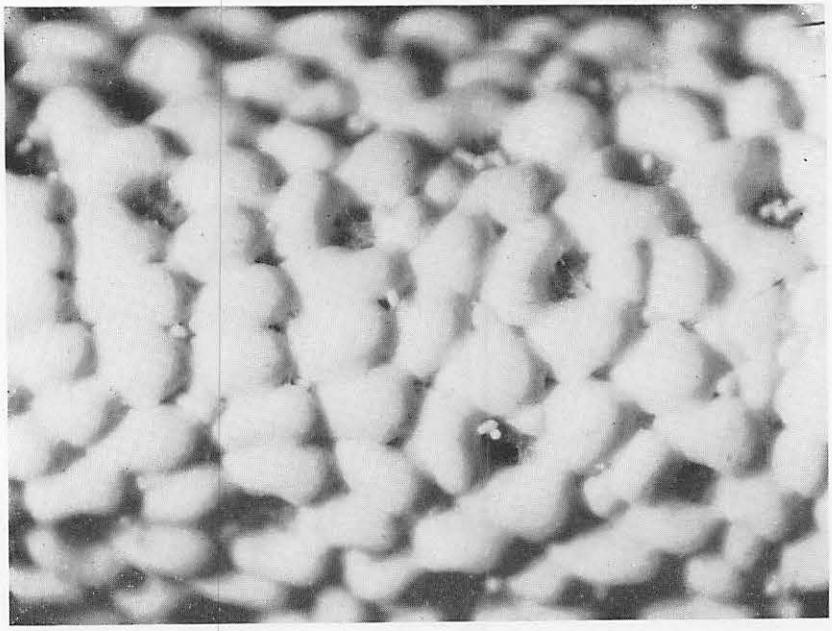
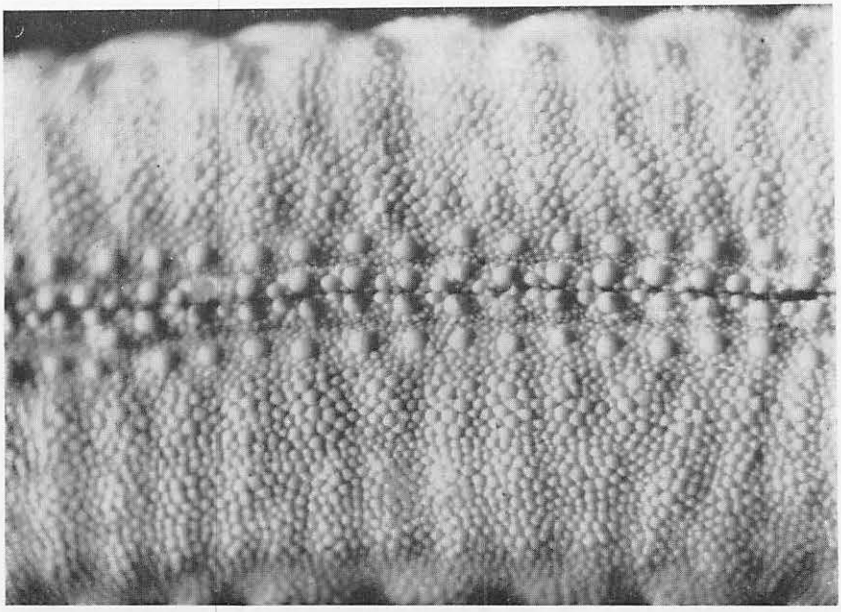


C

LINCKIA MULTIFORA: A, ABORAL VIEW, × 0.5 (PHOTOGRAPH BY C. H. EDMONDSON); B, PORTION OF A RAY, ORAL VIEW, × 7; C, PORTION OF A RAY DISSECTED TO SHOW FURROW SPINES, LATERAL VIEW, × 7.

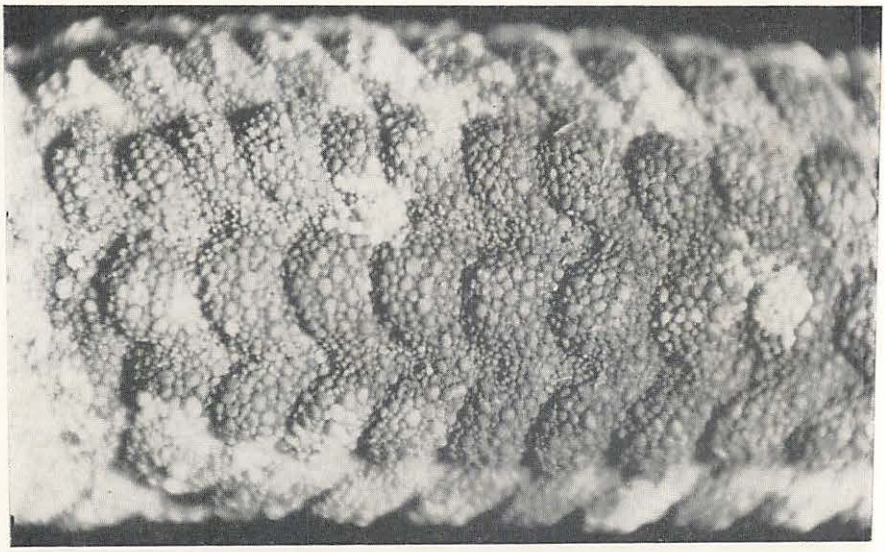


A

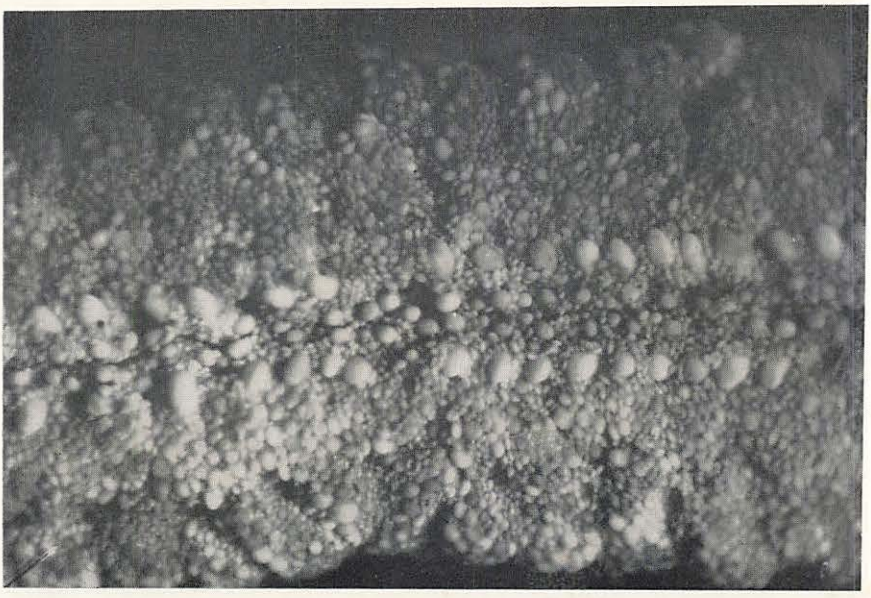


B

LINCKIA MULTIFORA: A, PORTION OF A RAY WITH INVESTING GRANULES REMOVED TO SHOW BODY PLATES, ABORAL VIEW, × 7; B, PORTION OF A RAY OF AN UNUSUAL SPECIMEN TO SHOW THE REGULAR ARRANGEMENT OF THE ADAMBULACRAL ARMATURE, ORAL VIEW, × 7.

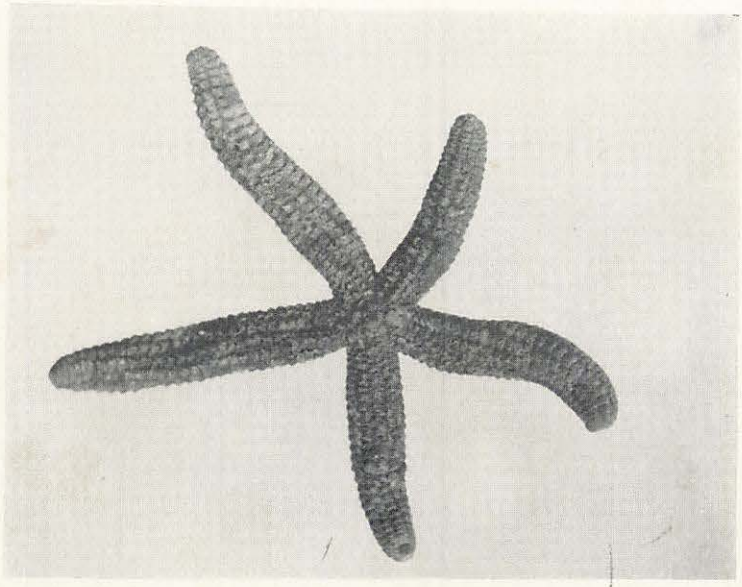


A

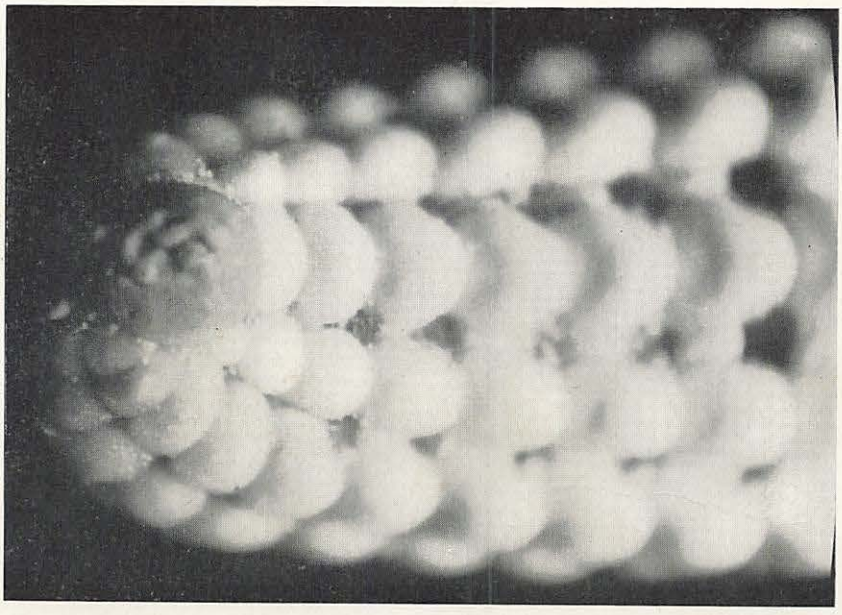


B

OPHIDIASTER SQUAMEUS: A, PORTION OF A RAY, ABORAL VIEW, × 7; B, PORTION OF A RAY, ORAL VIEW, × 7.

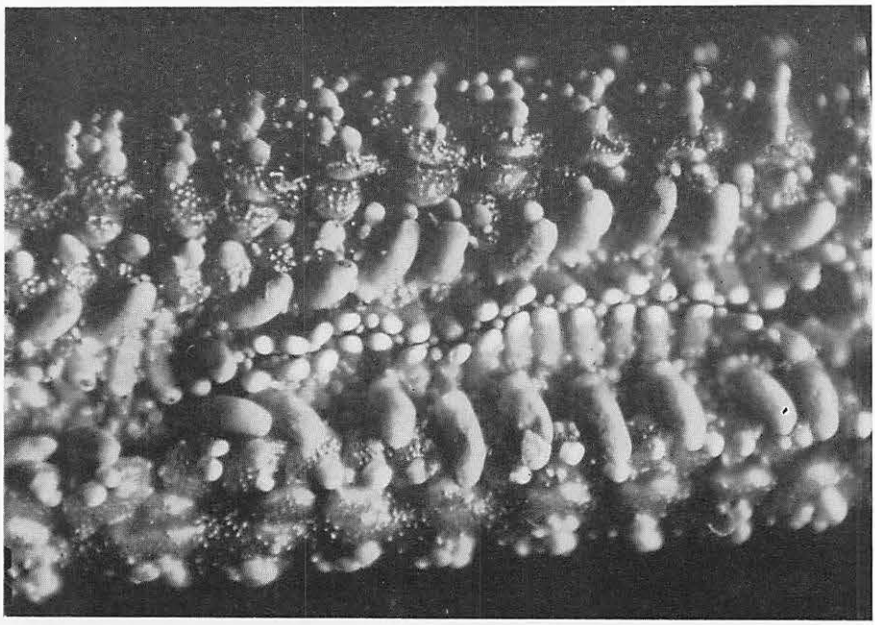


A

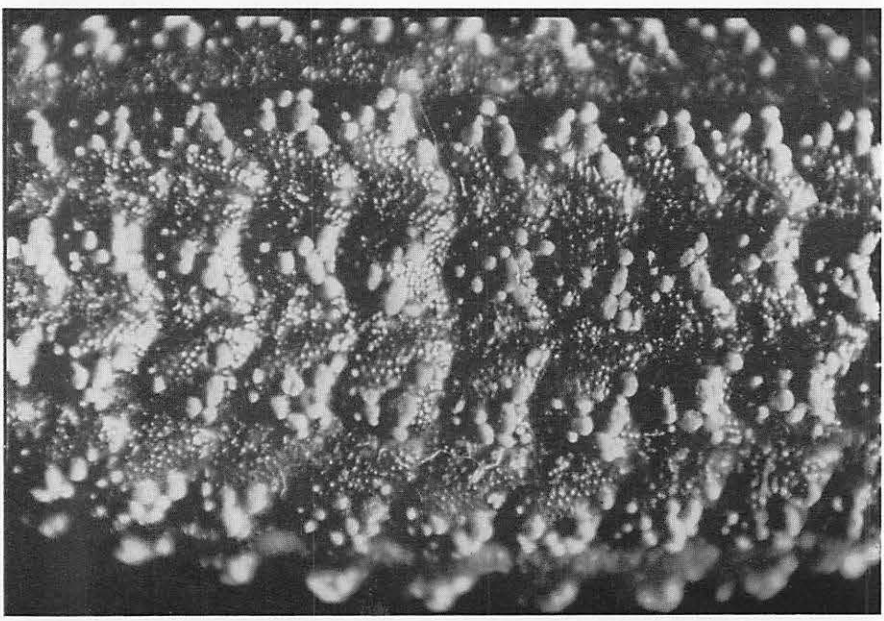


B

DACTYLOSASTER CYLINDRICUS PACIFICUS: A, ABORAL VIEW, × 1; B, PORTION OF A RAY WITH INVESTING GRANULES AND EPIDERMIS REMOVED TO SHOW BODY PLATES AND THE OCULAR PLATE, ABORAL VIEW, × 7.

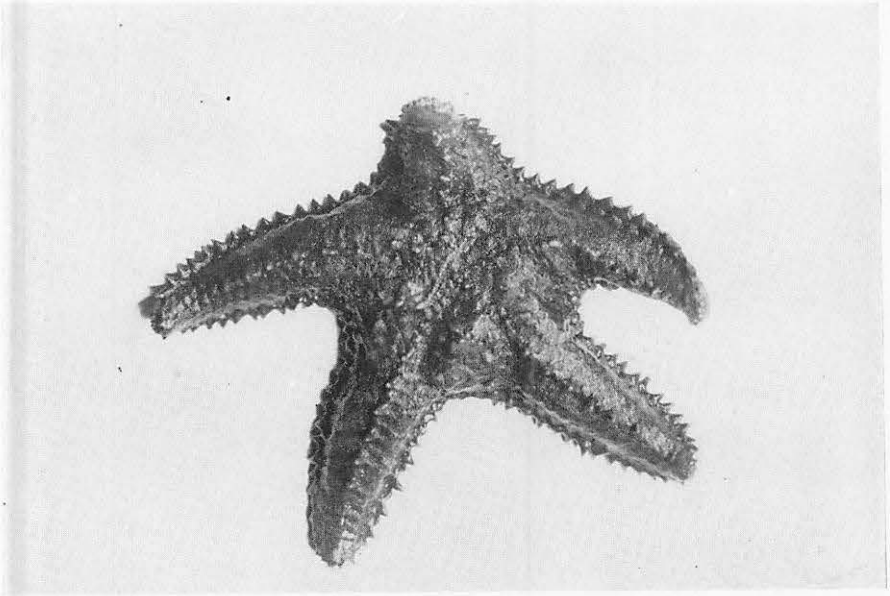


A

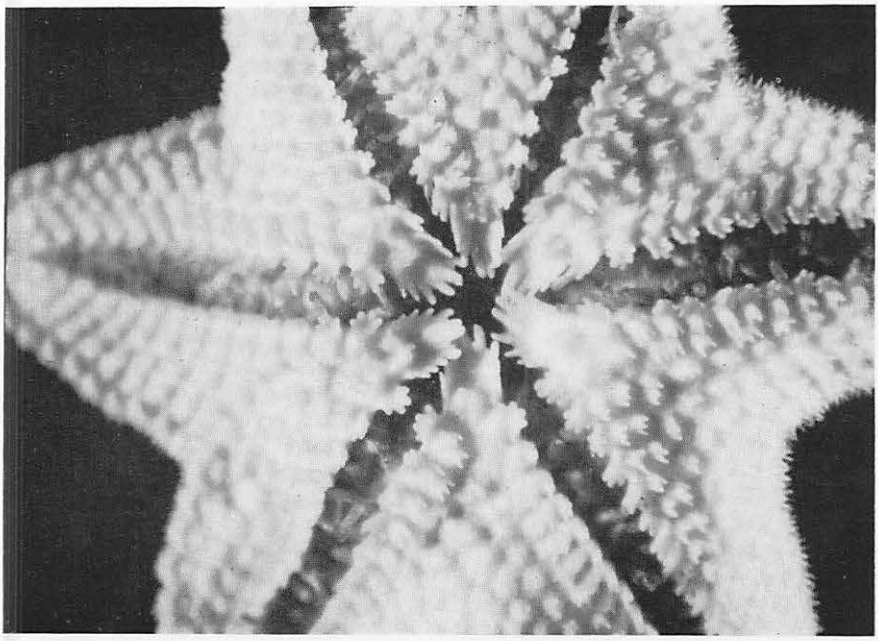


B

DACTYLOSASTER CYLINDRICUS PACIFICUS: A, PORTION OF A RAY, ORAL VIEW, × 7; B, PORTION OF A RAY, ABORAL VIEW, × 7.

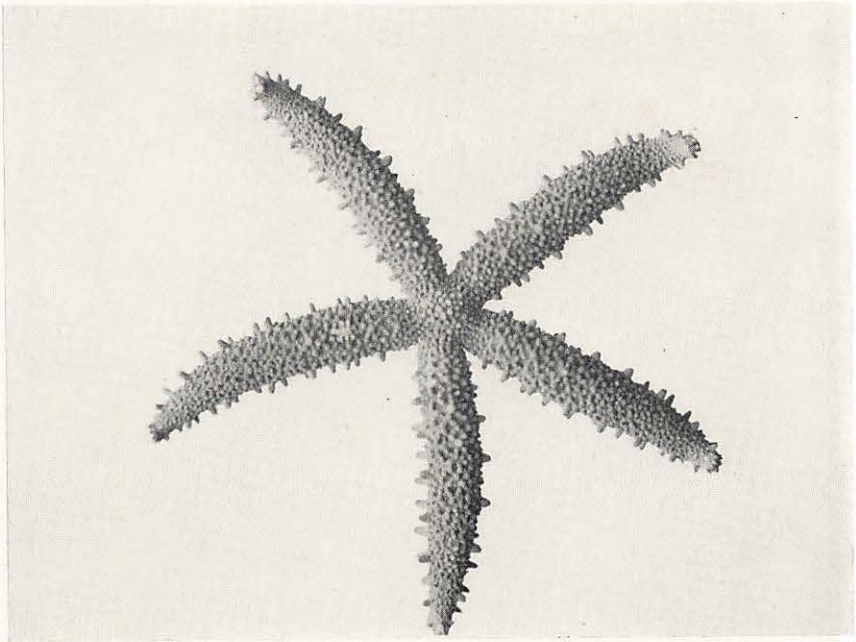


A

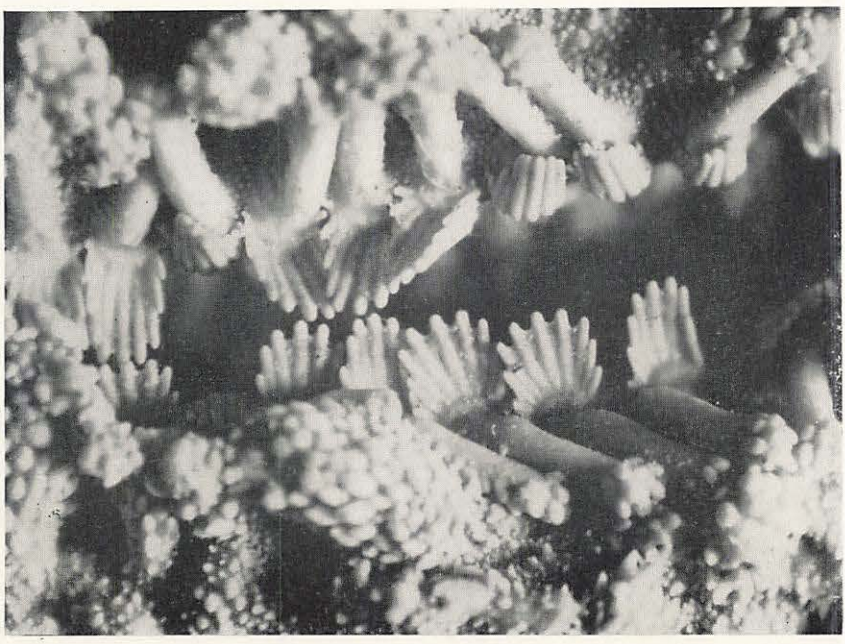


B

A, *ASTEROPE CARINIFERA*, ABORAL VIEW, × 0.5; B, *ASTERINA ANOMALA*, ORAL VIEW × 7.

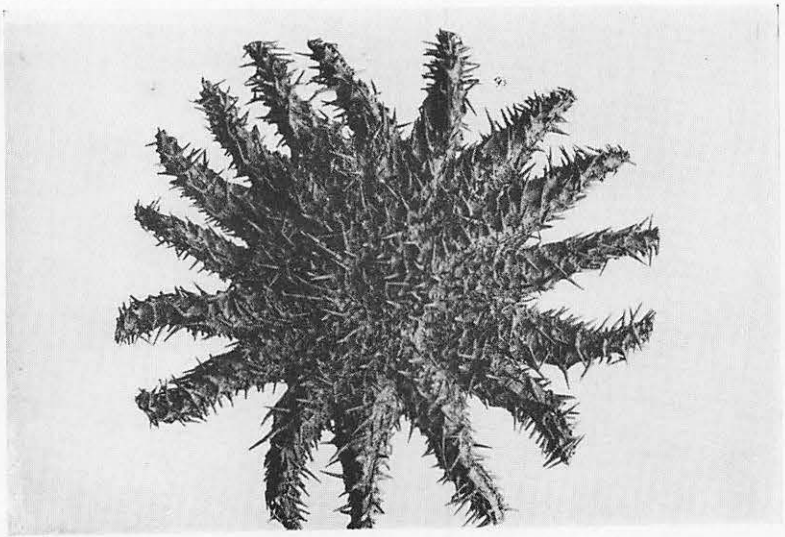


A

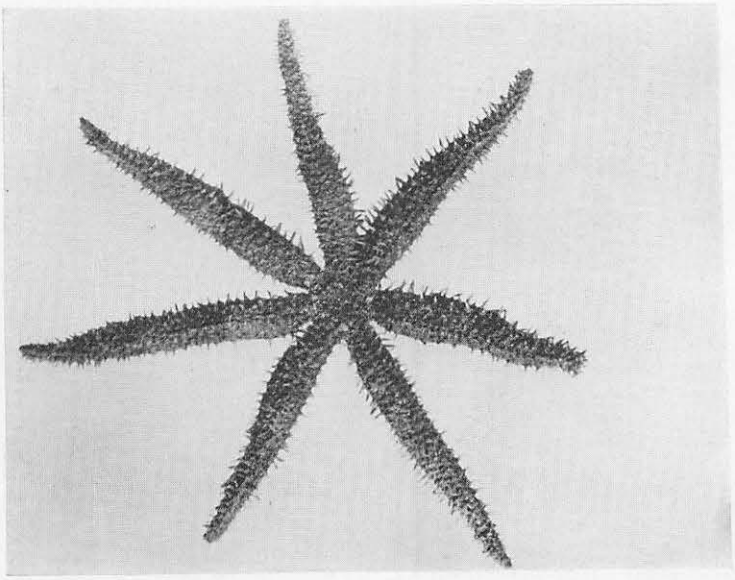


B

MITHRODIA BRADLEYI: A, ABORAL VIEW, ×0.3; (PHOTOGRAPH BY C. H. EDMONDSON); B, PORTION OF A RAY, ORAL VIEW, × 7.

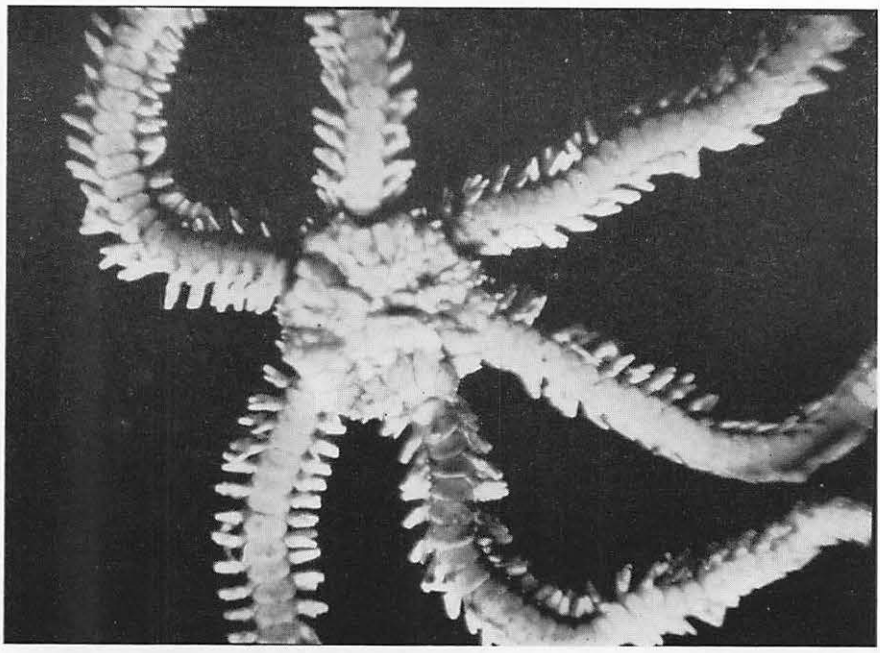


A

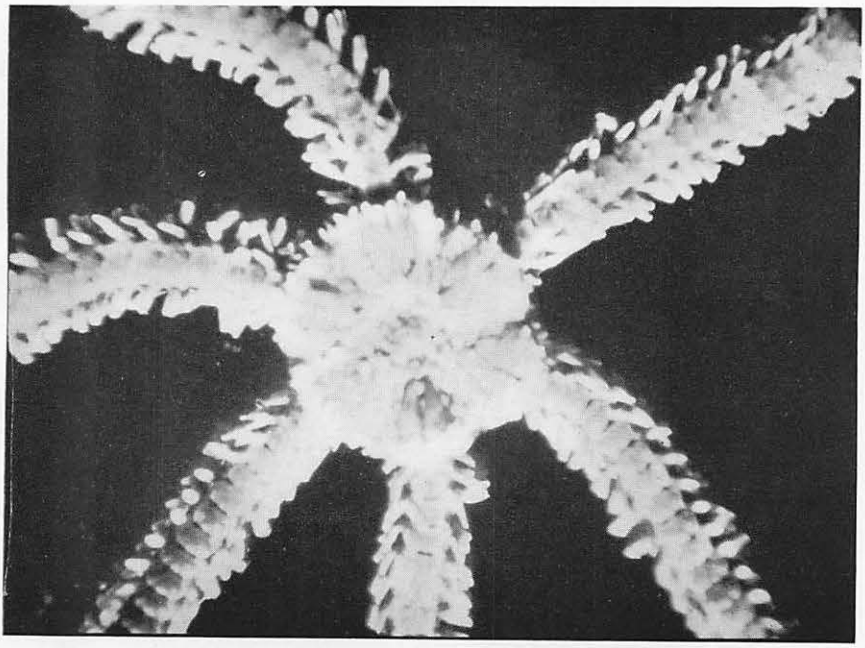


B

A, *ACANTHASTER PLANCI*, ABORAL VIEW, × 0.25; B, *COSCINASTERIAS ACUTISPINA*, ABORAL VIEW, × 0.5 (PHOTOGRAPHS BY C. H. EDMONDSON).

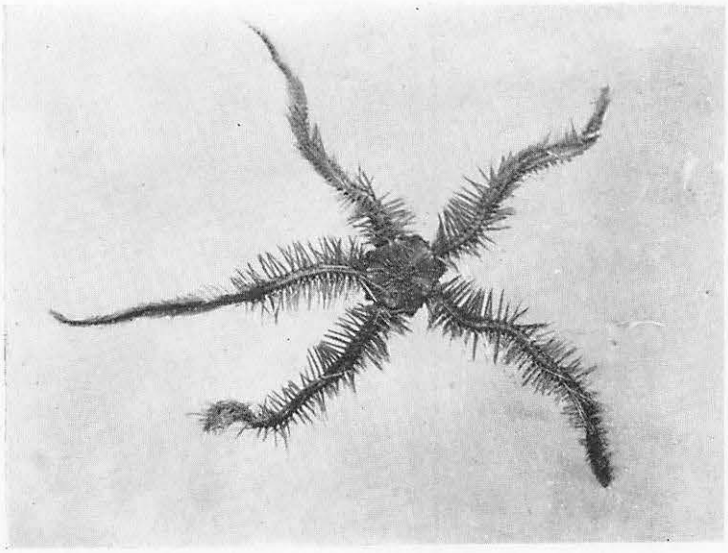


A

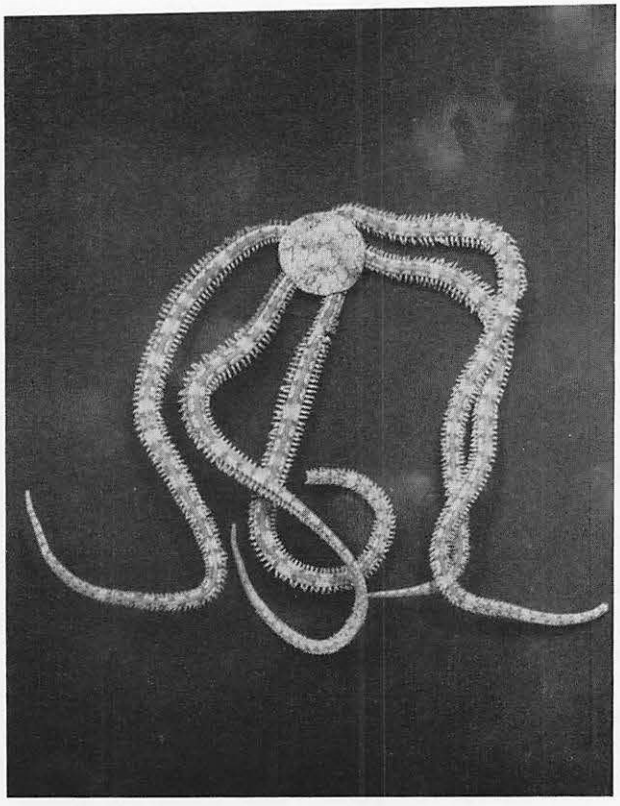


B

A, *OPHIACTIS MODESTA*, ABORAL VIEW, × 7; B, *O. SAVIGNYI*, ABORAL VIEW, × 7.

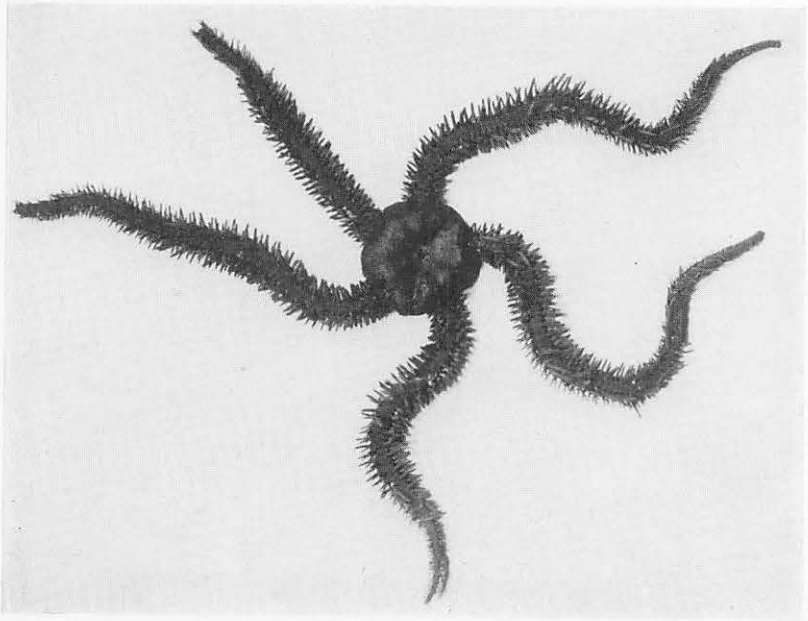


A

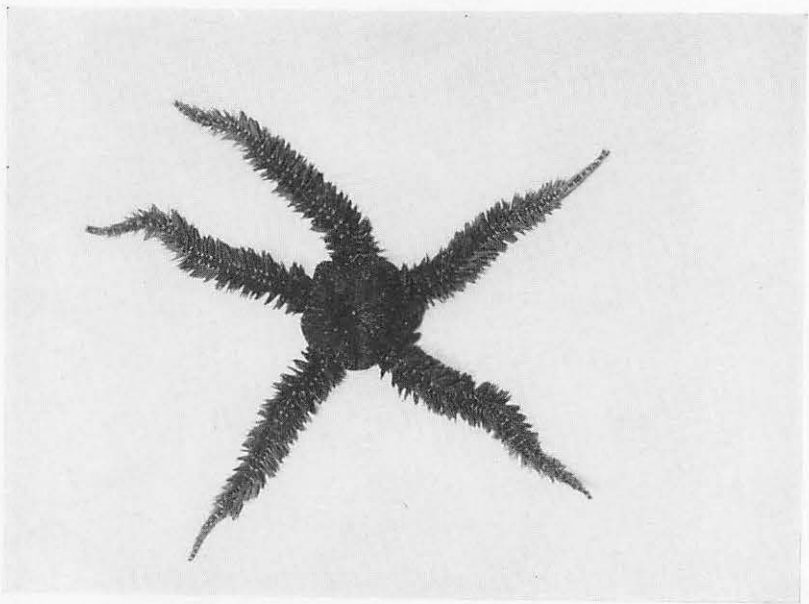


B

A, *OPHIOTHRIX DEMESSA*, ABORAL VIEW, × 1 (PHOTOGRAPH BY C. H. EDMONDSON); B, *OPHIONEREIS PORRECTA*, ABORAL VIEW, × 1.

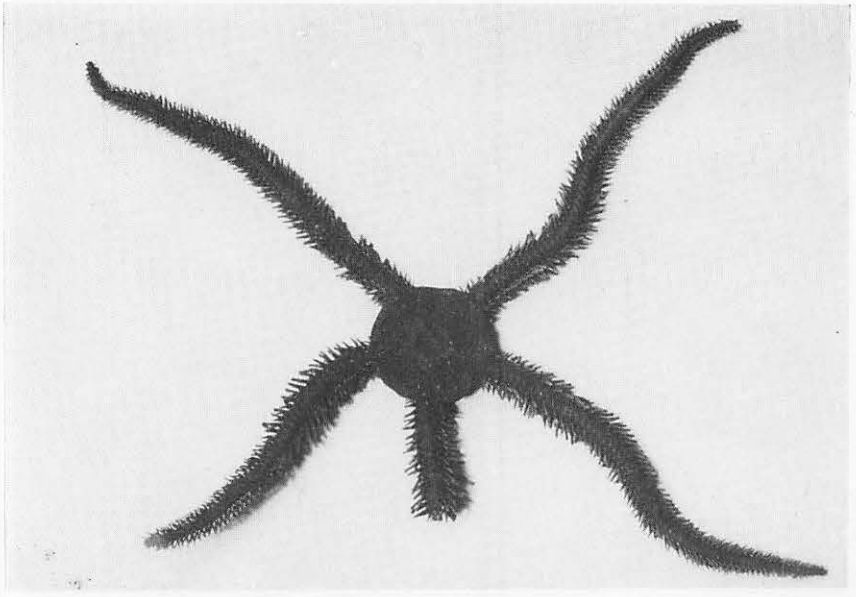


A

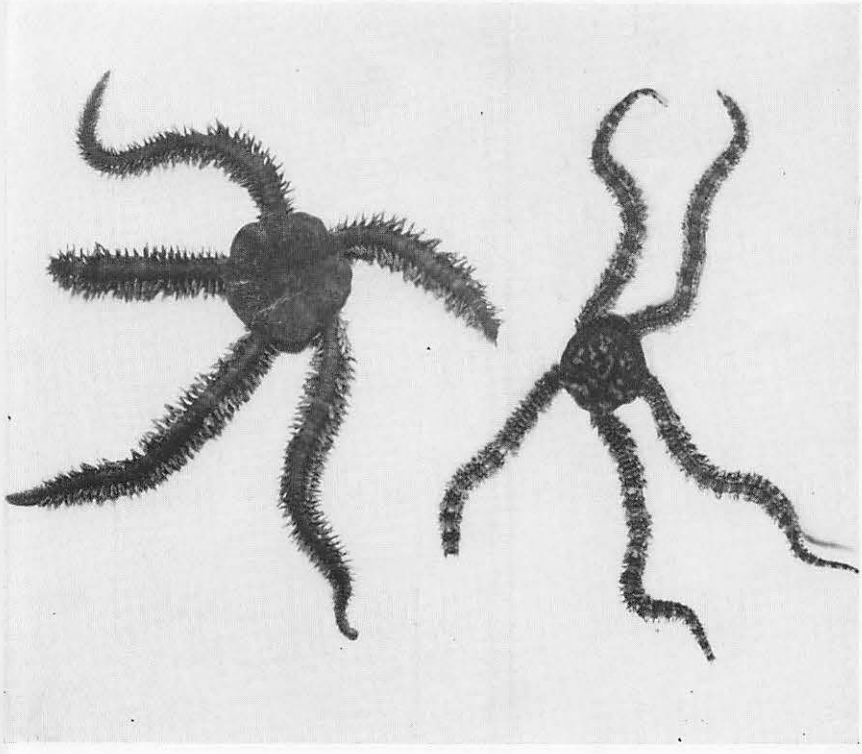


B

A, *OPHIOCOMA ERINACEUS*, ABORAL VIEW, × 0.5; B, *O. PICA*, ABORAL VIEW, × 0.5.



A



B C

A, *OPHIOCOMA INSULARIA*, ABORAL VIEW, × 0.5; B, *O. INSULARIA* VAR. *VARIEGATA*, ABORAL VIEW, × 0.5; C, *O. BREVIPES*, ABORAL VIEW, × 1.