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THE ECHINODERMS OF PERU.

BY HUBERT LYMAN CLARK.

WITH FOURTEEN PLATES.

CAMBRIDGE, MASS., U. S. A.:
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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, TO MARCH, 1905, LIEUTENANT COMMANDER L. M. GARRETT, U. S. N., COMMANDING, PUBLISHED OR IN PREPARATION:—

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[1] Bull. M. C. Z., Vol. XLVI., No. 4, April, 1905, 22 pp.
[2] Bull. M. C. Z., Vol. XLVI., No. 6, July, 1905, 4 pp., 1 pl.
[3] Bull. M. C. Z., Vol. XLVI., No. 9, September, 1905, 5 pp., 1 pl.
[4] Bull. M. C. Z., Vol. XLVI., No. 13, January, 1906, 22 pp., 3 pls.
[5] Mem. M. C. Z., Vol. XXXIII., January, 1906, 90 pp., 96 pls.
[6] Bull. M. C. Z., Vol. L., No. 3, August, 1906, 14 pp., 10 pls.
[7] Bull. M. C. Z., Vol. L., No. 4, November, 1906, 26 pp., 4 pls.
[8] Mem. M. C. Z., Vol. XXXV., No. 1, February, 1907, 20 pp., 15 pls.
[9] Bull. M. C. Z., Vol. L., No. 6, February, 1907, 48 pp., 18 pls.
[10] Mem. M. C. Z., Vol. XXXV., No. 2, August, 1907, 56 pp., 9 pls.
[11] Bull. M. C. Z., Vol. LI., No. 6, November, 1907, 22 pp., 1 pl.
[12] Bull. M. C. Z., Vol. LII., No. 1, June, 1908, 14 pp., 1 pl.
[13] Bull. M. C. Z., Vol. LII., No. 2, July, 1908, 8 pp., 5 pls.
[14] Bull. M. C. Z., Vol. XLIII., No. 6, October, 1908, 285 pp., 22 pls.
[15] Bull. M. C. Z., Vol. LII., No. 5, October, 1908, 11 pp., 2 pls.
[16] Mem. M. C. Z., Vol. XXXVII., February, 1909, 243 pp., 48 pls.
[17] Mem. M. C. Z., Vol. XXXVIII., No. 1, June, 1909, 172 pp., 5 pls., 3 maps.
[18] Mem. M. C. Z., Vol. LII., No. 9, June, 1909, 26 pp., 8 pls.
[19] Bull. M. C. Z., Vol. LII., No. 11, August, 1909, 10 pp., 3 pls.
[20] Bull. M. C. Z., Vol. LII., No. 13, September, 1909, 48 pp., 4 pls.
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Change to Matthew Lilw

No. 17. *The Echinoderms of Peru.* By HUBERT LYMAN CLARK.

The following report, prepared at the request of the Ministerio de Fomento, of the Peruvian Government, as a contribution to the knowledge of the aquatic resources of Peru, is for use in connection with marine investigations in that country, though the needs of the general zoölogist and particularly of those chiefly interested in the fishes and fisheries of Peru, have been kept in mind. The keys are therefore as simple as possible and are based, so far as practicable, on obvious external characters; they are consequently very artificial. The report is based primarily on the collection of echinoderms made by Dr. Robert E. Coker in 1907–08, and I am glad to express my thanks to him for the opportunity to study the collection, and for the use of his field notes and other data. In addition to the species found in this collection I have included all the echinoderms actually known to occur south of the equator and north of 40° S. latitude, and which may therefore be reasonably expected to occur on the coasts of Peru. I have not included any species described from such indefinite localities as "west coast of South America," "Chile," "Ecuador," or "west coast of Colombia," unless they have since been recorded from the given coastal area, excepting such rare cases as *Holothuria chilensis*, where the genus is a tropical (or subtropical) one and the species is described as from Chile. The collection in the Museum of Comparative Zoölogy, which contains many South American species, a large number of which were brought home by the "Hassler" expedition, has been of great assistance. In it were found two new starfishes.

The Peruvian echinoderm fauna is not a rich one. There are no crinoids known from the region, and only seven holothurians and ten ophiurans. The echini are represented by a dozen species, and the starfishes by twice that number. Clearly the starfishes are the predominating feature, and this would be even more striking if the numerous species described from Ecuador and Colombia, some of which may ultimately be found on the northern coast of Peru, were included. It is interesting to note that the Peruvian marine fauna is made up of two quite different elements, that from the Panamic region and that from the Chilean. The latter furnishes all of the echinoderms found south of Aguja Point,

6° S. lat., while the Panamic fauna is practically confined to the shores north of that point. In spite of its low latitude the coast of Peru south of Aguja Point is far from tropical, and the marine life is distinctly that of temperate seas, owing to the great Humboldt or Peruvian current, which brings the cold waters of the antarctic region down nearly to the equator.[1]

Of the fifty-four echinoderms included in this report, twenty-one are found only on the less than two hundred miles of coast north of Aguja Point, while of the remaining thirty-three species only about a dozen really characterize the succeeding shore line of over twelve hundred miles. Some fifteen species occur both north and south of Aguja Point, while the range of at least half a dozen species is practically unknown. A more detailed analysis of the fauna brings out some of its most interesting features and reveals the striking contrast between its two components. North of Aguja Point the following twenty-two species have been taken, none of which has yet been recorded from far south of there. Those marked * are in the Coker collection.

*Astropecten erinaceus
fragilis
* peruvianus
*Luidia columbia
Nidorellia armata
Oreaster occidentalis
Paulia horrida
Phataria unifascialis
Ophioderma panamensis
Amphiodia grisea
Hemipholis gracilis
*Ophiothrix magnifica
* spiculata
Gorgonocephalus panamensis
Arbacia stellata
Echinometra van brunti
*Encope micropora
Mellita pacifica
* stokesii
Lovenia cordiformis
*Agassizia scrobiculata
*Thyone gibber

Three of these species (*Astropecten peruvianus*, *Amphiodia grisea*, *Ophiothrix magnifica*) seem to have a very restricted range, as they are not known from north of the equator, but the remaining nineteen species are distinctly Panamic. To these nineteen should be added *Pharia pyramidata*, the occurrence of which south of Aguja Point is open to very serious question, and the single specimen of *Mithrodia bradleyi*, labeled "Arica," is not sufficient proof of its occurrence south of the Panamic region. The new *Luidia phragma* probably belongs in this

[1] For an account of the characteristics of the Peruvian coast see Coker, Bull. Bureau of Fisheries, 1910, 28, pp. 335–340.

group also, but the exact point on the South American coast where it was taken is not known. The Panamic element in the Peruvian fauna, therefore, contains twenty-five species, but many of these must be of irregular or rare occurrence, since only nine are in the Coker collection.

South of Aguja Point twenty-six species have been taken.[1] Of these, two (*Luidia bellonae* and *Stichopus fuscus*) have a remarkable range, extending from the Gulf of California to Chile and (in the case of Stichopus) even to Patagonia. Another (*Heliaster polybrachius*) is known only from the Peruvian coast in the vicinity of Aguja Point (say 3° 30′ – 7° 30′ S. lat.) and certainly cannot be classed with the Chilean fauna. The little ophiuran taken by Coker near San Lorenzo Island, off Callao, is apparently *Amphipholis pugetana*, a North American species; it is certainly not *A. laevidisca*, known from Chile; the genus is cosmopolitan, and some excellent authorities consider that *A. squamata* is equally wide-ranging, and they would doubtless refer these Peruvian specimens to it. Deducting these four species, there are twenty-two which may fairly be referred to the Chilean fauna. Of these, the following eight have been reported from north of Aguja Point:

Asterina chilensis	Tetrapygus niger
Stichaster aurantiacus	Arbacia spatuligera
Heliaster helianthus	Strongylocentrotus gibbosus
Ophiactis kröyeri	Phyllophorus peruvianus

These species are all in the Coker collection, but the specimens of Phyllophorus were not taken north of 9° S. lat. Of the remaining fourteen species supposed to occur along the southern shores of Peru, only *Strongylocentrotus albus* was taken by Dr. Coker:

Tosia verrucosa	Asterias gelatinosa
Odontaster singularis	Amphipholis laevidiscus
Asterina calcarata	Amphiodia chilensis
Parasterina obesa	Podophora pedifera
Echinaster cribella	Strongylocentrotus albus
cylindricus	Cucumaria leonina
Henricia hyadesi	godeffroyi

[1] The exact localities where *Ophidiaster ludwigi*, recorded from "Perou," *Holothuria chilensis* from "Chile," and *Colochirus peruanus* from "Peru," were taken are unknown, and they are omitted from this discussion.

The Tosia, Asterina, Parasterina, both species of Echinaster, and the Amphipholis are known only from the original specimens (all but one of which were from Chile) and have not been met with by other collectors. The Odontaster and Henricia are species of the far south and are included in this list only because each has been reported once from northern Chile, near Iquique; their occurrence on the Peruvian coast is quite unlikely. The Asterias and Amphiodia and both Cucumarias are Chilean species, which very probably occur, at least occasionally, in Peruvian waters. Although there are specimens of Podophora in the M. C. Z. collection labeled as from "Valparaiso" and "Callao," it seems extremely improbable that these specimens were actually collected in South America, for the genus is a highly specialized one, characteristic of the Indo-Pacific region, and it could hardly have escaped the notice of such collectors as Plate and Coker, if it occurred on the coasts of either Chile or Peru at the present day. It is clear, then, that the known Chilean element in the Peruvian fauna is very small, and all of the species which undoubtedly occur were taken by Dr. Coker, except an Echinaster and a Cucumaria. South of Aguja Point, then, one may expect to find, in suitable places, four species of starfish (*Luidia bellonae*, *Asterina chilensis*, *Stichaster aurantiacus*, *Heliaster helianthus*), one ophiuran (*Ophiactis kröyeri*), four sea-urchins (*Tetrapygus niger*, *Arbacia spatuligera*, *Strongylocentrotus albus*, *S. gibbosus*), and one holothurian (*Phyllophorus peruvianus*). North of Aguja Point, however, one finds a much more varied fauna and may reasonably expect ten or more species of starfishes, (three species of Astropecten, two or three of Luidia, Nidorellia, Oreaster, Paulia, Phataria, Pharia, Asterina, at least one Heliaster, and, possibly, Stichaster), several ophiurans (Ophioderma, Ophiactis, Amphipholis or Amphiodia, possibly Hemipholis, and two forms of Ophiothrix), eight or ten sea-urchins (Tetrapygus, one or two species of Arbacia, Echinometra, *Strongylocentrotus gibbosus*, Encope, one or two Mellitas, Agassizia, and perhaps Lovenia), and one or more holothurians (Thyone, Phyllophorus, or Stichopus).

Starfishes. Asteroidea.

The starfishes comprise not only almost one half of all the echinoderms known from the Peruvian region, but also the great majority of the conspicuous or structurally interesting forms. More than half are large species, reaching a diameter of over five inches, and several rank among the largest known starfishes. The twenty-five species represent

eighteen genera, of which five are known only from the west coast of Central and South America. Ten of the species are not known outside of the region included in this report, while eleven others are well-known Panamic species. There can be little question that most of the starfishes came to the Peruvian coast from the north. We know too little about *Tosia verrucosa* and *Parasterina obesa* to be positive as to their origin, but they probably came from the south. The two species of Asterina may have come from the south, but it is quite as possible that they are of northern stock. Odontaster is unquestionably a southern genus and *Henricia hyadesi* certainly came up from the south. The south also may be considered the home of *Asterias gelatinosa*, which has hardly reached the Peruvian coast yet, and while there is lack of definite evidence bearing on the point, *Stichaster aurantiacus* may be considered as an immigrant from the south. But with these exceptions the starfishes of the Peruvian coast are undoubtedly of northern (Panamic) origin.

In discussing the characteristic features of starfishes, a few terms require a word of explanation. In many species the dorsal skeletal plates develop vertical, table-like outgrowths, called *paxillae;* the tops (*tabulae*) of these paxillae are square, oblong, polygonal or more or less circular, and are usually so crowded as to form a second covering to the dorsal surface of the animal, between which and the true surface there is a more or less considerable space, traversed vertically by the columns or stalks of the paxillae; the *tabulae* bear spinelets or granules along their margins and on the free upper surface, and sometimes the central spinelet may develop into a conspicuous spine. The sides of the rays in many starfishes are defined by an upper and lower series of plates, the *supero-* and *infero-marginals;* in some starfishes the marginal plates are very large and conspicuous even in the *interbrachial areas* (*i. e.*, the space on the body between the bases of adjoining rays), while in others they are small and inconspicuous, and in the most highly specialized forms they are completely hidden and indistinguishable; in Luidia the superomarginals appear to be wanting, but the inferomarginals are fairly conspicuous. In most starfishes which lack paxillae, minute, finger-like papillae project between the plates of the dorsal skeleton; these are probably respiratory organs and are known as *papulae;* the papulae are often single, but are usually grouped in the areas between the skeletal plates, and these are then referred to as *papular areas.* The *madreporic plate* is usually conspicuous on the dorsal side in an interbrachial area, but in species having paxillae it is often hard to find. The sides of the furrow, on the under side of each ray, in which the tube-feet are located, are guarded by a series of plates, each of which carries a row or group of spines; the plates are called the adambulacral plates and the spines make up the *adambulacral armature.* In describing starfishes, it is customary, for brevity's sake, to let R stand for the major radius, *i. e.*, from the center of the mouth to the tip of a ray,

and r stand for the minor radius, *i. e.* from the center of the mouth to the middle of an interbrachial margin; in a perfectly circular starfish, we would say, R = r; in an ordinary pentagonal starfish R = r +, while in a starfish with long rays R = 6r, more or less.

Key to the Starfishes of the Peruvian Coast.

Upper surface covered with paxillae; general form decidedly flattened; inferomarginal plates with long spines forming a conspicuous lateral fringe along the ray.
Superomarginal plates conspicuous in contrast to paxillae (*Astropecten*).
Superomarginal plates, each with one or two prominent vertical spinelets.
Superomarginal plates at base of ray (but not in interbrachial area) with two spinelets each, one on inner edge and one near outer margin . . . . . *A. erinaceus*
Superomarginal plates with only a single spinelet each, except that a few near tip of ray may carry a second small one . . *A. peruvianus*
Superomarginal plates without spinelets; some of those near base of ray may carry, each, a small rounded tubercle . . . . . *A. fragilis*
Superomarginal plates reduced and not readily distinguishable beneath paxillae (*Luidia*).
Each paxilla in third longitudinal series at side of ray carries, except near tip of ray, a long slender spine . . . . . *L. phragma*
None of the paxillae carry long and slender spines.
Inferomarginal plates, each with a longitudinal (transverse to long axis of ray) series of 4–6 flattened, usually blunt or truncate spines; many paxillae have central spinelet enlarged into a blunt elevated tubercle or sharp, stout spine . . . . . *L. bellonae*
Inferomarginal plates, each with 2 or 3 long, sharp spines; no paxillae (except occasionally some along sides of ray) with large central tubercle or spinelet . . . . . *L. columbia*
Upper surface without paxillae; sides of ray without lateral fringe of slender inferomarginal spines.
Tube-feet in two series in each ambulacrum; rays normally five.
Disc large and rays short; form often pentagonal; R never more than 2.5r.
Marginal plates conspicuous, forming a definite boundary to the more or less pentagonal body.
Marginal plates and disc free from large spines.
Superomarginal plates 19–20 on each side of each ray (in specimen 75 mm. across), covered by a close pavement of crowded granules . . . . . *Tosia verrucosa*
Superomarginal plates 15–16 on side of ray (in specimen 75 mm. across), covered by a coat of distinct granules coarser than those of disc . . . . . *Odontaster singularis*
Some marginal or disc plates or both, carry large spines *Nidorellia armata*

Marginal plates more or less concealed not forming a definite boundary to a pentagonal body.
Large species (R up to 150 mm.) with dorsal surface carrying numerous big sharp tubercles or spines or both.
Dorsal surface elevated, with coarse tubercles, granulated at base . . . . . *Oreaster occidentalis*
Dorsal surface flat, with numerous, erect, smooth, very stout spines . . . . . *Paulia horrida*
Small species (R seldom exceeds 25 mm.) with dorsal surface, entirely free from conspicuous spines or tubercles (*Asterina*).
Plates of ventral interbrachial areas with only 1 spine each . . . . . *A. calcarata*
Plates of ventral interbrachial areas with 2–6 spines each . . . . . *A. chilensis*
Disc small or moderate, R more than 3r and usually more than 4r.
Rays short and thick, about equal to 3r covered, as is the disc by groups of crowded blunt spinelets, simulating low paxillae. *Parasterina obesa*
Rays longer, 4–10r.
Disc and rays closely covered with a nearly smooth, granulated coat, without projecting spines, except beside ambulacral furrows.
Papular areas arranged in a single (rarely double) broad series along each side of ray . . . . . *Phataria unifascialis*
Papular areas arranged in eight series on each ray.
Madreporic plate very large, its diameter .25 or more of disc diameter; rays somewhat trigonal; inner series of adambulacral armature made up of approximately equal and similar spines . . . . . *Pharia pyramidata*
Madreporic plate much smaller; rays more or less cylindrical; inner series of adambulacral armature made up of alternating large and small spines . . . . . *Ophidiaster ludwigi*
Disc and rays bearing spines or spinelets, sometimes minute and crowded.
Spines and spinelets large, unequal and irregularly scattered, blunt, covered to tip with scale-like granules . . *Mithrodia bradleyi*
Spines and spinelets bare, often small or even minute.
Spinelets very minute, in more or less crowded groups on dorsal plates . . . . . *Henricia hyadesi*
Spines well developed, arranged singly on dorsal plates (*Echinaster*).
Dorsal spines rather crowded, in irregular rows . . . *E. cribella*
Dorsal spines irregularly scattered . . . . . *E. cylindricus*
Tube-feet in four, more or less distinct series in each ambulacrum.
Rays few, never more than eight.
Rays 5, with about 11 longitudinal, abactinal series of groups of closely crowded granule-like spinelets . . . . . *Stichaster aurantiacus*
Rays normally 6, rarely 5 or 7, with 5 longitudinal series of large, widely separated, abactinal spines . . . . . *Asterias gelatinosa*

Rays numerous, up to forty-three (*Heliaster*).
Rays very short, free from each other for only .15–.20 of length *H. polybrachius*
Rays longer, free from each other .30–.40 of length . . . . *H. helianthus*

Astropecten erinaceus.

J. E. Gray, 1840. Ann. Mag. Nat. Hist., 6, p. 182.

Plate 1, figure 1.

Nothing is said by Gray as to either the size or color of this species. The largest specimens I have seen have the rays about 85 mm. long, but those taken by Coker do not exceed R = 75 mm. Most dry specimens are dull yellowish, more or less dusky above, while the best preserved specimens in the Coker collection are uniformly deep reddish fawn color. But in life the coloration must be much handsomer, for Coker's field notes show that the specimens taken at the mouth of the river Tumbes were "dorsally blue, except that the spines which margin the lower angles of arms are orange color in their dorsal aspect," while of the specimens taken at Capon it is said: "Under side white in small specimens, tinted orange in larger ones; bluish at tips of arms; above deep blue; the spines orange, those margining the arms are bright orange, while the dorsal spines are of a duller shade." The change from this bright coloration to the uniform reddish fawn color of the preserved specimens is very remarkable, but is of course due to the preserving fluids. These specimens were "first preserved in native spirits and subsequently transferred to formalin solution" (3–5% solution in sea-water). Such a marked change of color shows how little dependence can be placed on the color of preserved specimens not accompanied by field notes.

This is a Panamic species, ranging from about 25° N. to 3° 30′ S. lat. It was first collected by Cuming at St. Elena on the coast of Ecuador, about 2° S. lat., on a bottom of sandy mud in six fathoms of water. There are specimens in the M. C. Z. collection from Lower California and the Gulf of California. Coker took three specimens at the mouth of the river Tumbes and found the species abundant at Capon. Regarding its occurrence at Capon he says: "The water here is very quiet, and as the tide recedes most of these starfishes . . . slip away in the water, leaving, however, a very distinct impression of the form in the mud; so that when the mud-flat is exposed one may see in abundance the impressions of these starfishes, but without either the animals or any mark of their departure." It is probable that Dr. Coker is mistaken in supposing the starfishes to have slipped away in the water. Verrill (1901, p. 36) speaks of similar impressions made by Luidia, and he is satisfied, as he has himself told me, that the impression of the starfish in the sand is made *over* (not under) the starfish, and is caused by ciliary currents of water among the paxillae and marginal plates of the dorsal surface. If undisturbed, the starfish may by a sudden quick movement be captured *in situ*, but if disturbed by the approach of the collector, the animal moves away rapidly beneath the surface of the sand, leaving the impression in the

sand undisturbed, Such habits indicate unusual activity for an echinoderm and deserve detailed and very careful observation and study.

Astropecten peruvianus.

A. E. Verrill, 1867. Trans. Conn. Acad., 1, p. 275.

This species is very similar to *erinaceus* in size and general appearance. Verrill does not refer to the color and, unfortunately, neither do Coker's field notes. The dry specimens are dull yellow above and nearly white beneath, with the madreporic plate orange. Verrill's specimens and Coker's also are from Payta, so there is no clue as to the range of the species. Coker took a dozen specimens "with boat-beam trawl, southeast of Caleta, Colon, Bay of Payta, 7–8 fms., soft mud, April 13," 1907. Though occurring in so much deeper water than *erinaceus*, there is no reason for expecting any difference in the habits of these species. I fully agree with Verrill that it is impossible to determine whether Gray's *stellatus* is this species or not.

Astropecten fragilis.

A. E. Verrill, 1867. Trans. Conn. Acad., 1, p. 272.

So far as I can learn this species has not been recorded since the original description was published. Verrill says nothing of the coloration, but gives the following measurements: R = 58 mm., r = 12.5 mm.; breadth of ray at base, 15 mm. (the measurements are given by Verrill in inches and tenths). The only known specimens are from Panama and Zorritos, Peru.

Luidia phragma, sp. nov.[1]

Plate 2, figure 1.

Rays 5. R = 73 mm., r = 12 mm., R = 6r. Interbrachial arcs acute. Rays very flat, tapering gradually to a point. Breadth at base, 14 mm. Disc moderate, flat; vertical diameter only about 7 mm. Paxillae of disc and median portion of rays small (.5–1 mm. in diameter of tabulae), irregularly circular, becoming squarish at sides of rays. Each paxilla has a dozen or more very slender, marginal spines, above which are half a dozen or more stouter ones, while the center of the tabula is occupied by 1–4 short, thick, blunt spinelets. Along each side of the ray are three longitudinal series of larger paxillae (1–1.25 mm. across), similar to the others, but more nearly rectangular. Innermost of these three rows, very conspicuous, each paxilla carrying, at center of tabula, a single, slender, sharp spine, 2–3 mm. long. These conspicuous spines form a fence or "palisade" along each side of ray about three millimeters from inferomarginal edge. Inferomarginal plates, with similar, though slightly larger spines; there are two to each plate, one above the other; the marginal fringe is thus very conspicuous. Seen

[1] φράγμα, a palisade, in reference to the palisade-like series of spines along the sides of the rays.

from below the inferomarginal plates are well separated from each other; they have a marginal fringe of slender spinelets like those of the paxillae; the surface of the plate carries half a dozen flat, pointed spines, 1–2 mm. long, with a number of other smaller ones. Adambulacral armature of 3–4 spines in a single series, at right angles to furrow; innermost, smallest, sharp and slightly curved; the next is largest, 3 mm. long, straight (or nearly so) and blunt. Oral plates each with 4–6 spines, clustered at tip, and a similar number of variable size scattered on surface. Madreporic plate small, lying between the two terminal paxillae of the "palisade" series of two adjoining rays. Color (dry): disc and median area of rays pale gray with a yellowish tinge; paxillae outside of "palisade" series, all spines and entire lower surface more or less nearly white; there are several indistinct blotches of a darker gray on upper surface of rays.

The specimen described above and two others are in the M. C. Z. collection, labeled "Chile or Sandwich Islands." As they were presented by Dr. W. H. Jones, U. S. N., in April, 1874, and as most of the specimens received from him at that time were from Chile and Peru, these Luidias are doubtless from the same locality. This probability is rendered almost a certainty by the fact that the M. C. Z. collection contains 14 specimens of what appears to be the same species, from the Gulf of California, collected by W. J. Fisher. They are dry and in mediocre or poor condition, and range in size from R = 32 to R = 108 mm. In color they are all dirty yellowish, blotched above with blackish. Few of them have the "palisades" as perfectly developed as in the type, but it is evident in every specimen, even the smallest. It would seem, then, that *phragma* is a Panamic species, and it is most likely that Dr. Jones's specimens were collected at Payta, Peru. No species nearly allied is known from the Hawaiian Islands.

Luidia bellonae.

C. F. Lütken, 1865. Vid. Med. f. 1864, p. 133.

This species reaches, under favorable conditions, a much larger size than has been recorded. Lütken's types were 8 and 12 inches in diameter respectively, which would indicate R = 110–160 mm. Meissner (1896) has recorded specimens from R = 23.5 to R = 232 mm., the last being the largest specimen known hitherto. But in the M. C. Z. collection there is a specimen from Talcahuano, Chile, in which R = 250 mm. and the rays are 45 mm. wide at base. Clearly, then, *bellonae* is one of the largest starfishes known on the west coast of tropical America. The color of dry specimens is like that of many Luidias, gray above, deepest along the middle of each ray, and with more or less of a bluish cast, and white or cream color beneath. Dr. Coker's notes refer to the color of the living animal as simply "gray." This species has a wide distribution, for while Lütken's types (one of them, at least) were from Guayaquil, Verrill (1867) has recorded the species from Callao; de Loriol (1891) from Mazatlan, Mexico; Meissner (1892) from Callao, and (1896) from Iquique and Talcahuano; and Clark (1902) from Albemarle Island, Galapagos. Meissner (1896) expresses the opin-

ion that de Loriol's specimens from Mazatlan were not the true *bellonae*, and he therefore names them *lorioli*. I am not able to agree with this view, for it seems that the characters by which he attempts to separate the two forms are unreliable, and de Loriol's description and figures appear to agree very well with Peruvian specimens.

Dr. Coker took small specimens (R = 100 mm. ±) of this species "off northeast side of San Lorenzo Island" (which is off Callao) in "about 2½ fathoms," on February 5, 1907; and also "with dredge and trawl, Bay of Sechura, west of Matacaballa; about 5 fathoms in depth, April 8," 1907. The Bay of Seehura is just north of Aguja Point. Nothing is recorded of the habits of *bellonae*.

Luidia columbia.

Petalaster columbia J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 183.
Luida tessellata C. F. Lütken, 1859. Vid. Med. f. 1859, p. 40.
Petalster columbiae A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 272.
Luidia colombiae E. Perrier, 1876. Arch. Zool. Exp., **5**, p. 253.
Luidia columbiae W. P. Sladen, 1889. Rept. voy. "Challenger," **30**, p. 247.[1]

Plate 1, figure 2.

This is also a very large starfish, for while most of the known specimens have R = 100–200 mm., there are much larger specimens in the M. C. Z. collection from Magdalena Bay, Lower California. The largest of these has R = 275 mm., and the breadth of the arms at base is 38 mm. The color of preserved specimens is yellowish green, brownish green, or dull greenish gray above, and yellowish beneath. Dr. Coker's field notes show that in life the animal is "dorsally of a mouse color with many dark specks. Below yellowish white." This seems to be one of the most common starfishes of the Panamic region, and one that is widely distributed. It ranges from Magdalena Bay, Lower California, and the Gulf of California to northern Peru, and has also been reported from the Galapagos Islands. Specimens in the Coker collection were taken with *L. bellonae* in the Bay of Sechura, on April 8, 1907, and with *Astropecten erinaceus* at Capon, January 29, 1908. The habits are reported by Coker to be like those of the Astropecten (*q. v.*) with which it is found.

Tosia verrucosa.

Goniodiscus verrucosus R. A. Philippi, 1857. Arch. f. Naturg., **36**, Bd. 1, p. 132.
Pentagonaster (*Astrogonium*) *verrucosus* E. Perrier, 1878. Nouv. Arch. Mus. Hist. Nat., (2) **1**, p. 84.
Gnathaster (?) *verrucosus* W. P. Sladen, 1889. Rept. voy. "Challenger," **30**, p. 750.

To judge from Philippi's account, this starfish would appear to occur not rarely on the coast between Valparaiso and the Rio Maipu, yet strangely enough it does

[1] This is the way the name has been written for many years, but there is no reason why Gray's original spelling should not be retained.

not seem to have been met with by any other observers. Consequently its real relationships are still very doubtful. Philippi gives the diameter as three inches and the color red. It is not impossible that the species is based upon specimens of the following species, *Odontaster singularis*, but I have never seen individuals of Odontaster answering to Philippi's description.

Odontaster singularis.

Goniodiscus singularis J. Müller and F. Troschel, 1843. Arch. f. Naturg., **9**, Bd. 1, p. 116.
Pentagonaster singularis E. Perrier, 1876. Arch. Zool. Exp., **5**, p. 38.
Gnathaster singularis W. P. Sladen, 1889. Rept. voy. "Challenger," **30**, p. 286.
Asterodon singularis E. Perrier, 1891. Miss. Sci. Cap Horn. Zoöl., **3**, p. K 134.
Odontaster singularis F. J. Bell, 1893. Proc. Zool. Soc. London, p. 262.

Plate 2, figure 4.

The original specimens of this interesting starfish were from Chile, but later investigations have shown that it is a southern species most common on the south and west coasts of Patagonia. It reaches a diameter of 75–80 mm. and in life is red; preserved specimens are dull yellowish or brownish. The only claim which this species has to a place in the Peruvian fauna is based on Leipoldt's (1895) report of a small specimen (less than 30 mm. in diameter) which was taken between Iquique and Pisagua, about 20° S. lat. It is hardly likely that the northern range of Odontaster extends much above the twentieth parallel, so that its occurrence in Peruvian waters is improbable.

Nidorellia armata.

Pentaceros (*Nidorellia*) *armatus* J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 277.
Nidorellia armata A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 280.

Plate 4, figure 2.

This is a common and well-known member of the Panamic fauna, ranging from Guaymas, Mexico, to Zorritos, Peru, and also to the Galapagos Islands. The largest specimen seen has R = 88 mm. The proportion R : r is quite variable, ranging from 1.45 : 1 to 1.75 : 1. The number and arrangement of the abactinal spines is exceedingly variable. The color in life is given by Verrill as bright scarlet. Preserved specimens are more or less yellowish or brownish, seldom showing any trace of red. Although this species has been taken as far south as Zorritos, it is not represented in the Coker collection. A specimen in the M. C. Z. collection is remarkable for appearing to have *seven* rays, when seen from above; but when the oral side is examined, it is found that only *five* ambulacral furrows run out from the actinostome; of these, however, two bifurcate, one near the mouth and the other near the distal end, and thus arises the appearance of seven rays.

Oreaster occidentalis.

A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 278.

Plate 4, figure 1.

This species is, like the preceding, a common Panamic form, ranging from the Gulf of California southward. The diameter of a large specimen is about 300 mm. Preserved specimens are yellowish or brownish, but in life the dorsal plates are said to be bright crimson, the spaces between greenish brown. Dr. Coker did not meet with this species, nor has it yet been recorded from Peru, but Cuming collected a young Oreaster at Punta Santa Elena, Ecuador, along with Nidorellia, and as it seems almost certain that Oreasters will be found on the northern shores of Peru, I have included the Panamic species in this list. Verrill (1867) has given reasons why Gray's *Pentaceros cumingii*, based on the specimen taken by Cuming at St. Elena, cannot be identical with *Oreaster occidentalis*, but it seems very probable that when our knowledge of the Ecuadorian Oreasters is complete *cumingii* will prove to be the young of *occidentalis*.

Paulia horrida.

J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 278.

Plate 3, figure 3.

The original specimens of this remarkable starfish were taken by Cuming at Punta Santa Elena, Ecuador, in 12–18 fathoms, in company with Nidorellia and Oreaster. Unlike these latter, however, it has seldom been met with since and seems to be rather rare, the only specimens recorded since Cuming's day being taken at the Galapagos Islands. Gray's type was about 150 mm. in diameter, but the specimens from the Galapagos were smaller. The color of dried specimens is yellowish brown, but in life it is probable the general coloration is red or reddish as in Oreaster and Nidorellia.

Asterina calcarata.

Asteriscus calcaratus E. Perrier, 1869. Ann. Sci. Nat., (5) **12**, p. 292.
Asterina calcarata E. Perrier, 1876. Arch. Zool. Exp., **5**, p. 222.

This species is very little known, the original one (30 mm. in diameter) from Valparaiso remaining unique, so far, at least, as South American specimens are concerned. Under the name *calcaratus* Valenciennes placed a number of Asterinas from Chile, and Gay, in his account (1854) of the echinoderms of that country, made no effort to differentiate them. Perrier, however, restricted the name to this particular form, supposed to be from Valparaiso. Were it not that a variety (*selkirki* Meissner, 1896) is common at Juan Fernandez, one might be doubtful whether Perrier's specimen really came from Chile, especially as de Rochebrune (1881) records *calcarata* from the Cape Verde Islands. For the

present, however, we may retain the species in the Chilean fauna, with the hope that further collecting on the South American coast may settle the doubt concerning it.

Asterina chilensis.

Asteriscus chilensis C. F. Lütken, 1859. Vid. Med. f. 1859, p. 61.
Asterina chilensis C. F. Lütken, 1871. Vid. Med. f. 1871, p. 302.

Plate 2, figures 2 and 3.

This pretty starfish, which may be as much as 50 mm. in diameter, is one of the characteristic species of the Chilean fauna, and has been recorded from many places along the coast between Payta, Peru, and Talcahuano, Chile. In the Coker collection there are specimens from La Punta (at Callao), Lobos de Afuera Islands (southwest of Aguja Point) and Bay of Sechura (just north of Aguja Point), but unfortunately there are no notes on coloration or habits. The specimens vary greatly in form, from R = 1.5r to R = 2r and in the spinulation of both the upper and lower surfaces; in some specimens the spinules on the upper side seem rather long, while in others they are more like granules; the plates of the actinal side carry in some cases only 2 or 3 spines, in others 4–6. There is also a striking difference in the color; one group of specimens are uniformly dull yellowish or pale brown, while another shows very bright colors, mingled blue and red. The latter are from the Bay of Sechura and were at first supposed to represent a different species, but unfortunately for that view they do not agree with each other in proportions and spinulation, nor differ consistently in any character but color from the individuals taken south of Aguja Point. It seems therefore that *chilensis* is a variable species, the limits of whose variation have still to be determined.

Parasterina obesa, sp. nov.[1]

Plate 3, figures 1 and 2.

Rays 5. R = 42 mm., r = 14 mm., R = 3r. Interbrachial arcs rounded. Rays very stout, tapering slightly to a blunt point; breadth at base, 13 mm., vertical thickness 10 mm. Disc large and flat, its vertical diameter the same as that of the rays. Whole surface of disc, interbrachial spaces and rays, above and below to the adambulacral series, covered by paxilliform plates very much like those in *Odontaster singularis*, which carry crowded groups of 10–50 blunt, granule-like spinelets. Along sides of rays, and especially on under surface and in interbrachial areas these plates are in regular longitudinal and diagonal series, but dorsally no such regular arrangement is to be seen. Plates in oral interbrachial areas, largest and most widely spaced from each other, with 6–12 spinelets each. Papulae occur singly or in groups of 2–4, between dorsal plates and along sides of rays but not on lower surface. Neither supero- nor inferomarginal plates can

[1] *obesus*, fat, in allusion to the very plump rays.

be distinguished. Adambulacral armature consists of a marginal series of 3 (rarely 4) stout, blunt spines (about 1 mm. long) of which adoral is usually smallest and aboral largest; surface of plate with half a dozen (4–7) somewhat similar but slightly smaller spines, arranged in pairs or trios. Oral plates small, each with a marginal series of four spines, more or less expanded at tip and a single blunt spine on surface of plate. Madreporic plate very inconspicuous, less than 2 mm. across and only 4–5 mm. from center of disc. Color (dry) uniform, light yellowish brown.

There are two specimens of this well-characterized species in the M. C. Z. collection, which were taken at Talcahuano, Chile, by the "Hassler" expedition. I have been in doubt as to their real relationship, but as they are more nearly allied to Sladen's *Patiria bellula* than to any other starfish with which I have compared them, I consider them congeneric with that species. Fisher (1908) has shown that Patiria is untenable and has proposed Parasterina as a substitute.

Phataria unifascialis.

Linckia (*Phataria*) *unifascialis* J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 285.
Phataria unifascialis W. P. Sladen, 1889. Rept. voy. "Challenger," **30**, p. 786.

Plate 5, figure 1.

This common and well-known Panamic species, which ranges as far north as the Gulf of California, has been recorded by Verrill (1867) from Zorritos, Peru, and doubtless occurs on the northern coasts of that country although not met with by Coker. But the record from Timor (v. Martens, 1866, p. 85) is probably based on an erroneous identification, while de Loriol's (1900) specimen from Celebes can scarcely have been collected originally in the East Indies, though it may have been taken to Europe from there. Museum specimens of this species are usually yellowish or grayish in color, but we have no information as to color in life. From the appearance of the best dry specimens, the living animal was probably red of some shade. The largest specimens have R = 125 mm. and also = 9r.

Pharia pyramidata.

Ophidiaster (*Pharia*) *pyramidatus* J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 284.
Pharia pyramidata W. P. Sladen, 1889. Rept. voy. "Challenger," **30**, p. 784.

Plate 5, figure 2.

Like the preceding, this is a common Panamic species, known to range from the Gulf of California to Zorritos, Peru, but not met with by Coker. Leipoldt (1895) records two specimens from Valparaiso, but there is little reason to doubt that, if the specimens are correctly labeled, they were brought to that city from the north. Large specimens of Pharia have R = 150–160 mm. and also = 5.3–7.5r. The color of preserved specimens is dull purplish or reddish brown, often more or less yellowish along the ambulacral furrows. Verrill (1867 p. 288)

says that the color is "in life, variegated above with purple and brown," but elsewhere (1871, p. 577) he says, "the dry specimens in best condition are light straw color beneath; the poriferous zones are bright orange; the rows of large plates on the back and sides olive-green; madreporic plate, large, dark olive-green."

Ophidiaster ludwigi.

P. de Loriol, 1900. Revue Suisse Zool., **8**, p. 78.

This species is based upon a single specimen in de Loriol's collection, labeled simply "Perou." R = 40 mm., r = 9 mm. Rays, 11 mm. broad and 8 mm. high at base. Color brownish violet; papular areas lighter; ventral side, pale yellowish. While at least one species of Ophidiaster may occur in the warmer coastal waters of Peru, it should be remembered that many animals, described in Europe as from Peru, were really from the island of Peru in the Gilbert group, and it is quite possible therefore that de Loriol's Ophidiaster is not from South America.

Mithrodia bradleyi.

A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 288.

Plate 6, figure 1.

Although this species was not met with by Dr. Coker and has never been recorded from South America, I include it for two reasons, neither of which alone would warrant such a course. In the first place, it is a Panamic species with the same general distribution as Pharia, Phataria, and others, and therefore will probably be found near Zorritos. In the second place, there is a single dry specimen in the M. C. Z. collection, received in 1862 from the Academy of Natural Sciences of Philadelphia, labeled simply "Arica, Peru." This specimen is of interest because, while it is quite unlike specimens of *bradleyi* from the Gulf of California, it resembles very closely in its general appearance, though not in proportions, the "peculiar specimen" from the Hawaiian Islands, described and figured by Fisher (1906, p. 1096, pl. 37, figs. 2–3). In the Peruvian specimen, R = 135 mm., r = 15 mm., R = 9r and the color is light brown; other dry specimens are nearly black. Fisher (1906) says the rays are usually unequal, and in his largest Hawaiian specimen, R varied from 198 to 230 mm. In life, the color is more or less vermilion red, light or dark or both.

Henricia hyadesi.

Cribrella hyadesi E. Perrier, 1891. Miss. Sci. Cap Horn: Zoöl. **3**, p. K100.

Plate 2, figure 5.

This is a species of the far south, which is admitted here on the strength of Meissner's (1896) identification of a number of specimens from Iquique, which is very near the Chile-Peruvian line. It is a small species; in the largest known speci-

mens, R = 41 mm. The color in life is recorded as "ziegelroth oder gelbroth." There is no longer any justification for the use of the name Cribrella, but the name *hyadesi* does not seem to have been used hitherto in combination with the proper generic name, Henricia.

Echinaster cribella.

C. F. Lütken, 1871. Vid. Med. f. 1871, p. 288.

This is another of those unsatisfactory species which has not been met with since it was described. The type was not quite 74 mm. in diameter; nothing is said as to its color. It was supposed to have come from Valparaiso. As Echinaster is a genus characteristic of warm seas, it is quite probable that it occurs on the northern coasts of Peru, but it is hardly to be expected as far south as Valparaiso; yet its distribution may be similar to that of *Asterina chilensis*.

Echinaster cylindricus.

M. Meissner, 1892. Arch. f. Naturg., **58**, bd. 1, p. 184.

This species is based on a single specimen, said to have been taken at Callao, Peru. In this specimen R = 80–90 mm. and also = $7\frac{1}{2}$r. The color is recorded as "dark blackish brown."

Stichaster aurantiacus.

Asterias aurantiacus F. J. F. Meyen, 1834. Reise um die Erde, **1**, p. 222.
Stichaster aurantiacus A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 293.

Plate 8, figure 1.

This is one of the characteristic starfishes of the Chilean region. It reaches a large size for a Stichaster, full-grown specimens having R = 120 mm. The color in life is orange or red, but preserved specimens are dull yellowish or pale brown. Specimens have been taken as far north as Callao and as far south as Talcahuano. Dr. Coker met with this species on the rocky shores of the Pescadores Islands and at North Chinca Island. Of the former his notes say, "Abundant; red; brittle," and of the latter, "On rocky shores; color red; easily broken; abundant."

Asterias gelatinosa.

F. J. F. Meyen, 1834. Reise um die Erde, **1**, p. 222.

Plate 6, figure 2.

Although this species has not yet been recorded from north of Iquique, there is good reason to believe it will be found in suitable localities along the southern coast of Peru. It grows to a large size, full-grown specimens having R = 250 mm. and breadth of ray = 50 mm. According to Meyen's original description, the upper surface is milky white, with the spines and tubercles bright orange. Preserved specimens give no hint of such coloration, as they are dull brown of various shades.

Heliaster polybrachius.

H. L. Clark, 1907. Bull. M. C. Z., **51**, p. 54.

Plate 7, figure 1.

This interesting starfish is remarkable for its very limited range, as it is known only from Zorritos, Payta, and the Lobos de Afuera Islands. The number of rays ranges from 31 to 43 and averages rather more than 37. The largest specimen seen is about 180 mm. across. Nothing is recorded of the color in life, but preserved specimens are dull greenish or blackish above, often marked with yellowish blotches; rarely the yellowish predominates; spines and actinal surface yellowish. Two specimens in the Coker collection were taken on the shore rocks of Lobos de Afuera, March 27, 1907.

Heliaster helianthus.

Asterias helianthus J. B. P. Lamarck, 1816. Anim. s. Vert., **2**, p. 558.
Asterias (*Heliaster*) *helianthus* J. E. Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 179.
Heliaster helianthus F. Dujardin et Hupé, 1862. Hist. Nat. Zooph. Ech., p. 344.

Plate 7, figure 2.

Meyen (1834) speaks of this as the "ausgezeichnetesten" species of starfish and it certainly must always rank as one of the most notable species, because of its large size (300 mm. in diameter) and numerous rays (30–40). It ranges from northern Ecuador (about 2° N. lat.) to Valparaiso, and seems to be very common, as it has been recorded by all collectors on that coast. Dr. Coker took specimens at the Lobos de Afuera Islands, on the northeast side of San Lorenzo Island, at the Pescadores Islands, and at Independencia Bay, south of Pisco. Of the last, he says in his field notes, "white below; above black with spines red." So far as I can discover this is the only observation on the color of a living Heliaster which has ever been recorded, and it shows that the dull shades (blackish and yellowish) of preserved specimens give no clue to the fine coloration of the living starfish.

Brittle-Stars. Ophiuroidea.

The brittle-stars comprise an astonishingly small part of the Peruvian fauna, especially when it is remembered that not less than thirty species occur at Panama, most of which might reasonably be expected to occur as far south as Payta. While lack of attractive reefs and bottoms may account for the absence of some species, it is probable that more intensive collecting will increase the number considerably. The ten species herein recorded represent seven genera, none of which is characteristic of the region; all but one or two are cosmopolitan. Yet, strangely enough, five of the species are not known outside of the Chile-Peruvian region,

while four of the remaining five are Panamic. The origin of the ophiuran fauna is unquestionably Panamic; indeed, there is not a single species which seems to have come into the Peruvian fauna from the south, unless *Amphiodia chilensis* is a possible exception.

In referring to the external features of a brittle-star it is customary to speak of the body as the *disc*, and the rays as *arms*. On the sides of the arms, in parallel vertical series, are borne the more or less conspicuous *arm-spines*. On the upper surface of the disc lie the *radial shields*, a pair of plates at the base of each arm; they are sometimes covered by granules or small scales and so appear to be wanting. At the center of the lower surface of the disc is the *mouth*, made up of five radial slits meeting at a common center; between each pair of slits is a triangular or wedge-shaped interradial *jaw*, along the margins of which are the *mouth-papillae;* these papillae show great diversity in size, form, and position, and are of particular importance in classification; in Ophiothrix and some other genera they are quite wanting.

Key to the Brittle-Stars of the Peruvian Coast.

Arms simple and unbranched.
- Disc closely covered with a fine granulation; arm-spines short and appressed . . . . . *Ophioderma panamense*
- Disc not granulated but covered with more or less distinct scales; arm-spines not appressed.
  - Disc-scales smooth and free from spines and spinelets.
    - Lower surface of disc (between arms) covered with scales; 3 mouth-papillae on each side of jaw.
      - Outermost mouth-papilla very wide, equalling or exceeding the two inner ones taken together; size small, disc 2–3 mm. in diameter; arm-spines more or less pointed.
        - Disc-scales indistinct even when dry, appearing as though covered by a thin skin; arm-spines wide and very flat; no white spot at outer end of radial shield . . *Amphipholis laevidisca*
        - Disc-scales very distinct; arm-spines slender and sharp; radial shields more or less white at outer end . . . *Amphipholis pugetana*
      - Outermost mouth-papilla not conspicuously wider than the others; size large, disc 5-12 mm. in diameter; arm-spines stout and very blunt.
        - Radial shields large, their length more than one-third radius of disc; disc-scales coarse, fewer than 10 radial series in each interradial area above and only 100-200 scales in each interbrachial space below . . . . . *Amphiodia grisea*
        - Radial shields small, their length about one-fourth of radius of disc; disc-scales small, about 15 radial series in each interradial area and 500–1000 scales in each interbrachial space below . . . . . *Amphiodia chilensis*

Lower surface of disc naked; jaws narrow with only two papillae on each side, a squarish one at apex and a small one at outer corner; 3 slender, sharp arm-spines . . . . . *Hemipholis gracilis*

Disc-scales with more or fewer spines or spinelets, at least near margin.

Disc with only a few spinelets, and these short, smooth, and chiefly near margin of disc; radial shields small . . . . . *Ophiactis kröyeri*

Disc covered with thorny spines or stumps or both; radial shields very large.

Disc with long slender spines and few or no thorny stumps *Ophiothrix magnifica*

Disc with numerous thorny stumps, often with spines also *Ophiothrix spiculata*

Arms dichotomously branched . . . . . *Gorgonocephalus panamensis*

Ophioderma panamense.

C. F. Lütken, 1859. Add. ad. Hist. Oph., pt. 2, p. 91.

Plate 8, figure 2.

Although this species has not been recorded from Peru, it is a common Panamic species, and it is not strange therefore that the "Hassler" expedition should have found it at Payta. There is a single specimen from that locality in the M. C. Z. collection. Adult specimens are as much as 25 mm. across the disc, with arms 110–115 mm. long. The color is "greenish gray or brownish, sometimes with a central light spot; arms similar in color, banded with lighter and darker. Lower surface grayish or greenish white" (Verrill).

Amphipholis laevidisca.

H. L. Clark, 1909. Mem. Aust. Mus., **4**, p. 541.

This species was taken by the "Hassler" at Talcahuano and has not been met with since. It closely resembles *A. squamata* and was originally recorded as that species, but seems to be quite distinct. The small size and plain colors render these little brittle-stars so inconspicuous they are ordinarily overlooked. The type is about three millimeters across the disc and has lost whatever color markings it may have had; there is no indication that the outer ends of the radial shields were ever lighter colored than the disc itself.

Amphipholis pugetana.

Amphiura Pugetana T. Lyman, 1868. Proc. Boston Soc. Nat. Hist., **7**, p. 193.
Amphipholis pugetana A. E. Verrill, 1899. Trans. Conn. Acad., **10**, p. 312.

Plate 9, figure 2.

It is only after much hesitation that I have referred to this species, five small specimens, dredged by Dr. Coker in 2½ fathoms off the northeast side of San Lorenzo Island, near Callao, on February 5, 1907. They are certainly Amphipholis,

and they are not *A. laevidisca*, but they are not well enough preserved to make it clear whether they are *squamata* or *pugetana*. It seems better, for the present, to consider them the latter.

Amphiodia grisea.

Amphipholis grisea A. Ljungman, 1867. Öfv. Kongl. Vet.-Akad. Förh., **23**, p. 313.
Amphiodia grisea A. E. Verrill, 1899. Trans. Conn. Acad., **10**, p. 313.

No one has met with this species since its original description, which was based on a specimen from Guayaquil, Ecuador. It will probably be found on the northern coast of Peru. The type has the disc 7.3 mm. across and arms 35 mm. long.

Amphiodia chilensis.

Ophiolepis chilensis J. Müller and F. Troschel, 1843. Arch. f. Naturg., **9**, bd. **1**, p. 120.
Amphiodia chilensis A. E. Verrill, 1899. Trans. Conn. Acad., **10**, p. 313.

Plate 9, figure 1.

Originally described as from "Chili," this species has since been taken at Talcahuano by the "Hassler" expedition and at Calbuco by Plate. It is probably a southern species and its occurrence on the coast of Peru is doubtful. The adult has the disc 10–12 mm. across, and arms 70–100 mm. long.

Hemipholis gracilis.

A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 262.

This is a Panamic species, of which Ljungman had a specimen from Guayaquil; otherwise it is not known from south of Panama. Ljungman (1867) described his specimen as *Hemipholis affinis*, but Verrill's name has about two months' priority and has been generally accepted. In adult specimens the disc is 5–6 mm. across, and the arms 40–50 mm. long. The color is given by Verrill as light greenish gray (in alcohol), the arms banded with whitish; radial shields green; beneath white.

Ophiactis kröyeri.

C. F. Lütken, 1856. Vid. Med. f. 1856, p. 24.

Plate 9, figure 3.

This is the one well-defined, characteristic brittle-star of the Chile-Peruvian region. It has, however, been recorded from the Hawaiian Islands, and if its occurrence there is confirmed, its distribution is very remarkable, for unlike the starfish, *Mithrodia bradleyi*, which also occurs in the Hawaiian group, this Ophiactis is not otherwise known from north of the equator. On the South American coast between Payta, Peru, and Talcahuano, Chile, *kröyeri* appears to be very common. It is a small species, adults being about 6 mm. across the disc, with arms 18–20 mm. long, and the color is inconspicuous, reddish or purplish brown. Dr. Coker

found this species off the northeast side of San Lorenzo Island, near Callao; in Ancon Bay, on a muddy bottom, 9 fathoms, and also among shells and sea-weed; and in the Bay of Sechura in 5 fathoms. There are no notes in regard to appearance or habits.

Ophiothrix magnifica.

T. Lyman, 1868. Proc. Boston Soc. Nat. Hist., **7**, p. 254.

Plate 9, figure 4.

This handsome brittle-star is known only from the coast of Peru, between Payta and Callao, and from the Galapagos Islands. It grows to a fairly large size, the disc 10–15 mm. in diameter, the arms 50–75 mm. long. Like most species of the genus the color is more or less variable; in preserved specimens it varies from light gray to dark blue; the radial shields may be mottled with very dark and very light shades, almost black and white, or the inner half of the shield may be dark and the outer half white; in some specimens a longitudinal white stripe on the upper surface of the arm is faintly indicated. Dr. Coker met with this species only in the Bay of Sechura. From a comparison of many specimens of *magnifica* collected at Payta, with a still larger series of the following species (*spiculata*) from a number of localities, I have reached the conclusion that the two forms intergrade so completely that they are probably identical. As such a question can much better be decided from fresh or living material, it has seemed best to keep the two forms separate.

Ophiothrix spiculata.

J. Le Conte, 1851. Proc. Philadelphia Acad. Nat. Sci., **5**, p. 318.

This is a common and wide-spread Panamic species, somewhat smaller than the preceding and more variable in color. Dr. Coker took it in the Bay of Sechura and near Capon, and it has also been taken at Payta and Zorritos. The specimens in the Coker collection from Capon were found living in a sponge, but nothing else is noted as to habits.

Gorgonocephalus panamensis.

Astrophyton panamense A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 251.
Gorgonocephalus panamensis T. Lyman, 1882. Rept. voy. "Challenger," **5**, p. 264.

According to Verrill (l. c.), this species ranges from La Paz, Mexico, to Zorritos, Peru, but it was not met with by Dr. Coker. The size of an adult is, disc 35 mm. in diameter, arms 140–150 mm. long. The color of dried specimens is yellowish brown.

Sea-Urchins. Echinoidea.

The sea-urchins rank next to the star-fishes both in number of species found on the Peruvian coast and in number of species characteristic of

the region. Several species reach a large size, and at least one (*Strongylocentrotus albus*) is of considerable importance as an article of food. Of the twelve species, five are characteristic of the region, though one of these has been taken at the Galapagos Islands. Six of the remaining species are Panamic forms, while the seventh is characteristic of the southeastern Pacific Islands and its occurrence on the American coast is exceedingly doubtful. The twelve species represent nine genera, six of which occur in the West Indian region, two are characteristically Pacific, and one (*Tetrapygus*) is peculiar to the Peruvian region. With the exception of *Strongylocentrotus albus*, which probably has come up the coast from the south, all of the species have doubtless come from the north, and it is interesting that no fewer than four of them have differentiated into well-characterized forms.

The shell, or more properly *test*, of a sea-urchin to be well examined should be dry, and partly or wholly cleaned from the spines which cover it. It is made up of vertical columns of plates; in all living species there are twenty of these columns, and in most sea-urchins the plates are so firmly united with each other that the test is hard and unyielding. At the upper end of each pair of columns there is a single plate, and these ten plates form in the "regular echini" a ring around the *periproct*, the field in which lies the anus, while in "irregular echini" they form a solid group, the periproct lying outside of them, usually on the lower surface of the test. When the periproct lies outside of them, they form the *abactinal system*, but when the periproct is within, it is also included in the term "abactinal system." Examination of the columns of plates which make up the test will show that these columns are not only arranged in ten pairs, but that the plates of alternate pairs are perforated for the passage of tube-feet; there are thus five double columns of perforated plates (*i. e.* with tube-feet) called the *ambulacra*, and alternating with them five double columns of unperforated plates, the *interambulacra*. The perforations in the ambulacral plates are in pairs and these *pore-pairs* may be arranged in a vertical series on each side of an ambulacrum. Often however they are arranged in oblique arcs of three or more in each plate. In the abactinal system the five plates at the upper ends of the ambulacra are called *oculars* and the five at the ends of the interambulacra, *genitals*. Usually the genitals being larger than the oculars are readily distinguishable by their size, and in the great majority of sea-urchins three or more oculars lie outside the genitals (*i. e.* away from the anus). But the exact arrangement of the plates of the abactinal system shows great diversity in different families and genera. One of the genitals, usually easily distinguished by its larger size, is perforated with numerous small pores. This genital is known as the *madreporic plate*. The ambulacrum at the left side of the madreporic plate is considered *anterior*, *i. e.* it marks the anterior end of the animal. The test itself is more or less fully covered with

spines, which are often borne on the abactinal system too; when the spines are large and conspicuous, they are called *primaries;* smaller ones are called *secondaries;* the smallest are *miliaries.* In some flattened Echini the ambulacra on the upper surface are laterally expanded in a conspicuous manner, and from their fancied resemblance to a flower, each is called a *petal.* On the flat, lower surface of some species the ambulacra are indicated by furrows radiating from the mouth, but the pores are exceedingly small and difficult to see. The furrows divide on leaving the mouth and diverge steadily until near the margin of the test, when they abruptly converge and disappear without meeting. These *ambulacral furrows* are concealed by the spines and in most specimens can only be followed on the bare test.

Key to the Sea-Urchins of the Peruvian Coast.

Anus vertically opposite mouth, which is at center of lower surface and provided with jaws and teeth.

Periproct covered by 4 (rarely 5 or even more) approximately equal plates.

Color black or deep purple; numerous secondary spines present *Tetrapygus niger*

General coloration reddish brown; no secondary spines.

Plates of abactinal system and adjoining bare interambulacral areas, so finely granular as to have an almost velvety appearance, prettily marked with deep red in contrast to gray or whitish ground color; usually no ocular plate (sometimes one) reaches periproct . . . . . *Arbacia stellata*

Plates of abactinal system and adjoining bare interambulacral areas, coarsely granular, not marked with deep red; one, two, or three ocular plates reach the periproct . . . . . *Arbacia spatuligera*

Periproct covered by many small unequal plates.

Test (except the flattened lower side) covered by short, very stout, truncate spines, forming a close, smooth pavement over the whole . . . . . *Podophora pedifera*

Test almost completely covered by unequal, more or less elongated and pointed spines.

Test longer than wide, though often only slightly so; color, dark purplish or deep reddish brown . . . . . *Echinometra van brunti*

Test with circular outline; color, more or less greenish.

Ambulacra with 4 (rarely 5 or 6) pairs of pores in each arc . . . . . *Strongylocentrotus gibbosus*

Ambulacra with 8–10 pairs of pores in each arc *Strongylocentrotus albus*

Anus not vertically opposite mouth, the line connecting them being approximately horizontal.

Test very flat with a deep notch in the margin of each ambulacrum, or a broad slit (*lunule*) formed by the closing of this notch at

its outer end; a lunule also in posterior interambulacrum; mouth with jaws and teeth.

Size large, 100 mm. and upwards in length; brown or gray with a purplish tinge; width of area enclosed between two branches of an ambulacral furrow on lower surface, where widest, .40 or more of its length . . . . . *Encope micropora*

Size small, rarely exceeding 60 mm. in length.

Anus only 5–6 mm. back of mouth; color deep green *Mellita pacifica*

Anus 9–10 mm. back of mouth; color not green . . *Mellita stokesii*

Test not flat, without lunules or notches; no jaws or teeth.

Size large, up to 70 mm.; test somewhat flattened; some conspicuous primary spines (or tubercles) on upper surface; anterior petals hardly as long as posterior, each containing a somewhat triangular area . . . . . *Lovenia cordiformis*

Size small, rarely exceeding 25 mm. in length; test about as high as wide; no conspicuous primaries; anterior petals narrow, more than twice as long as posterior pair. . . . *Agassizia scrobiculata*

Tetrapygus niger.

Echinus niger G. I. Molina, 1782. Saggio St. Nat. Chili, p. 175.

Echinocidaris (*Tetrapygus*) *nigra* L. Agassiz et E. Desor, 1846. Ann. Sci. Nat., **6**. p. 354.

Arbacia nigra A. Agassiz, 1863. Bull. M. C. Z., **1**, p. 20.

Tetrapygus niger A. Agassiz and H. L. Clark, 1908. Mem. M. C. Z., **34**, p. 73.

Plate 10, figure 1.

This is one of the characteristic sea-urchins of the west coast of South America, and may be easily recognized by the very dark color and nearly hemispherical test. It reaches a large size, full-grown specimens being 75 mm. or even more in diameter. It ranges from Payta, Peru, to southern Chile. Dr. Coker met with this species at La Punta, near Callao; on rocks between tide-lines, Feriol Bay near Chimbote; on the rocky shores of the Pescadores Islands, where it was abundant; and at Independencia Bay, south of Pisco, on the rocky shores of Isla Vieja. Of the last, Dr. Coker's notes say: "Black, sometimes with a tinge of violet. Local name 'Gallinazos' or 'Erizos Gallinazos.' 'Gallinazo' is the turkey-buzzard, but the name is also generally applied to the black sea-urchin."

Arbacia stellata.

Echinus stellatus H. D. de Blainville, 1825. Dict. Sci. Nat., **37**, p. 76.

Arbacia stellata J. E. Gray, 1835. Proc. Zool. Soc. London, p. 38.

According to Verrill (1867), this common Panamic species occurs at Payta and Zorritos, Peru, but it was not met with by Dr. Coker. Large specimens may be 60 mm. in diameter, but most individuals are considerably smaller.

Arbacia spatuligera.

Echinus (*Agarites*) *spatuliger* A. Valenciennes, 1846. Voy. Venus Zoophytes, pl. 5, fig. 2.

Arbacia spatuligera A. Agassiz, 1872. Rev. Ech., pt. 1, p. 93.

Plate 10, figure 2.

This characteristic species ranges from Guayaquil to southern Chile. Although not so large as *Tetrapygus niger*, its spines are so much longer (40–45 mm.) that adults (65–70 mm. in diameter) cover a greater area and look fully as large. Dr. Coker met with *spatuligera* at San Lorenzo Island near Callao, and in the Bay of Sechura, about half way between Bayovar and Matacabella, in 5–6 fathoms. There are no notes to show the character of the bottom or the appearance or habits of the living animal.

Podophora pedifera.

Echinus pedifer H. D. de Blainville, 1825. Dict. Sci. Nat., **37**, p. 97.

Podophora pedifera L. Agassiz et E. Desor, 1846. Ann. Sci. Nat., **6**, p. 374.

Plate 11, figure 2.

This remarkable sea-urchin has long been known from the southern Pacific islands and was found common in the Paumotus by the "Albatross" in 1899–1900, "on the seaface of the reef, exposed to the full force of the surf" (A. Agassiz, 1908). Although there are specimens in the M. C. Z. collection labeled "Peru," "Chile," "Callao," and "Valparaiso," no recent collectors have met with Podophora on the American coast and it is highly improbable that it occurs there. Yet it has seemed well to include and figure it, in the hope that some Peruvian or Chilean collector may verify its occurrence or prove its absence.

Echinometra van brunti.

A. Agassiz, 1863. Bull. M. C. Z., **1**, p. 21.

Plate 11, figure 1.

This well-known Panamic species has been reported from Zorritos, Peru, by Verrill (1867), but it was not met with by Dr. Coker. Large specimens may be 75–80 mm. long, with the breadth rather more than nine-tenths as much.

Strongylocentrotus gibbosus.

Echinus (*Toxopneustes*) *gibbosus* L. Agassiz et E. Desor, 1846. Ann. Sci. Nat., **6**, p. 367.

Strongylocentrotus gibbosus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 164.

Plate 12, figure 2.

Among the sea-urchins of South America this species offers the most interesting subjects for investigation owing to the fact that in the very great majority of specimens (in museums at least) the test, and especially the abactinal system, is

more or less distorted by the presence of a parasitic crab (*Fabia chilensis* Dana). In specimens of *gibbosus*, less than ten millimeters in diameter, there is no evidence of the presence of the crab; the test is symmetrical and all of the ocular plates are excluded (by the large genitals) from the periproct. In larger specimens, however, the abactinal system shows the effect of the parasite, and in adults the whole periproct and the ring of genital and ocular plates are more or less profoundly modified. The number of ocular plates in contact with the periproct ranges, in adults, from one to five, but as a rule the anterior ocular and the two of the left side are in contact, while the two on the right side are exsert. Very rarely one sees an adult *gibbosus* which appears to be free from the parasite, but even in such specimens it is the left side which has the insert oculars. Among the many questions which arise in connection with this interesting case of symbiosis, are these: Is this symbiosis, with some mutual advantage, or is it pure parasitism? Is it only the urchins in shallow water, near shore, or also individuals in deep water, which are attacked by the crab? At what stage of its own development does the crab enter the urchin? How does it enter and how does it avoid being cast off? Does the presence of the crab cause the ultimate death of its host? Does the crab leave a dead host or does it die too? How does the crab distinguish *gibbosus* from *S. albus* and other Echini?

The adult *gibbosus* may be 60 mm. in diameter, but the great majority of specimens seen are under 50. The green coloration is often modified by red (or reddish brown) tips on the spines. This species seems to be most common in the region between Payta and Callao, but there is a small specimen in the M. C. Z. collection labeled "Valparaiso," and it is probable that the range extends from the Gulf of Guayaquil southwards at least along the shores of northern Chile. Dr. Coker took specimens "with short spines of olive-green color, off northeast side of San Lorenzo Island, in about 2½ fathoms"; others "from the rocks between tide-lines, northeast end of Ferrol Bay, Chimbote, March 1," 1907, where they were "abundant" and had the "spines olive-green, reddish at tips"; others, "olive-green," were "collected from the rocks in two feet of water (at half tide), at Lobos de Afuera, . . . on the bay called 'Independencia.'"

Meissner (1896) makes the rather surprising error of recording this species from Iquique as *Strongylocentrotus albus;* he says all the specimens were more or less deformed by the presence of the crab; the field note quoted calls them "rother seeigel." If it were not for the very full synonymy given, one might regard the error as a slip of the pen; as it is, it is difficult to explain.

Strongylocentrotus albus.

Echinus albus G. I. Molina, 1782. Saggio St. Nat. Chili, p. 175.
Strongylocentrotus albus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 162.

Plate 12, figure 1.

This is the largest of the sea-urchins of the west coast of South America, and of special interest because it is the only echinoderm of that region which serves

as food for man. Large specimens may be as much as 120 mm. in diameter. The color is more or less uniformly green, though the tips of the spines may be reddish, or, in young specimens, quite red. The range of *albus* is from Callao to the southern part of Chile. Dr. Coker met with this species at Mollendo, where he says it is "valued as food," and on the rocky shores of Isla Vieja, Independencia Bay, south of Pisco; of these latter he says: "The spines are green; those on the lower part of the sides are reddish; the corona appearing between the spines, deep red or reddish chestnut. These are the edible 'erizos' which are so highly esteemed. This form does not seem to be common north of Independencia. (The forms common at Callao are rarely eaten.)"

Encope micropora.

L. Agassiz, 1841. Mon. Scut., p. 50.

Plate 13, figure 1.

This is a Panamic species ranging from the Gulf of California (Guaymas) to the Galapagos Islands and Peru. It reaches a large size, individuals occasionally exceeding 150 mm. in length. The color is variable, ranging from brown to gray. Dr. Coker took a number of specimens of this Encope "with dredge and trawl — Bay of Sechura — west of Matacaballa; about 5 fathoms in depth. April 8," 1907. These specimens are all more or less rubbed, and are of a light purplish gray color.

Mellita pacifica.

A. E. Verrill, 1867. Trans. Conn. Acad., **1**, p. 313.

The type specimen of this interesting form was from Zorritos, Peru, and the species has not been taken elsewhere. The type measured about 55 mm. in length and was a trifle broader. The color of the dried specimen was deep green, but it is quite possible that in life it was red-brown, for the red-brown shades of clypeastroids have the remarkable property of becoming green, especially after death.

Mellita stokesii.

Encope stokesii L. Agassiz, 1841. Mon. Scut., p. 59.
Mellita stokesii A. Agassiz, 1872. Rev. Ech., pt 1, p. 141.

Plate 13, figure 2.

Were it not for the differences shown by the internal structure of the test, I should have no doubt that this is simply the young of *Encope micropora*, but those differences are so striking it is hard to believe they are due to age only. The smallest Encope before me is so much larger than the largest *stokesii* that a fair comparison is not possible and the true relationship of the two forms must remain undetermined. The distribution of *stokesii* is not merely throughout the

Panamic region but extends to the Galapagos Islands. Dr. Coker met with it only in a tide pond at La Boca Grande, Tumbes. These specimens are gray, with an evident purple tinge, and show no trace of the "greenish brown" or "olive" color, to which Verrill (1867) and A. Agassiz (1873) refer. The largest specimen is 63 mm. across, the width slightly exceeding the length.

Lovenia cordiformis.

A. Agassiz, 1872. Bull. M. C. Z., 3, p. 57.

Plate 13, figure 3.

This is a Panamic species recorded from Guayaquil by Lütken, and although not met with by Dr. Coker it probably occurs on the northern coast of Peru. It is light brown in color, judging from dry specimens, with a decidedly rosy tinge above, especially on the long spines, and yellowish underneath. The test is markedly longer than wide and wider than high; about 50 × 36 × 21 mm. in a fully grown individual.

Agassizia scrobiculata.

A. Valenciennes, 1846. Voy. Venus Zoophytes, pl. 1, fig. 2.

Plate 13, figure 4.

Originally described from Peru, this curious little sea-urchin has since been found throughout the Panamic region. Verrill (1871) gives the measurements of a large specimen as follows: length, 43 mm.; width, 40 mm.; height, 31 mm. The color of preserved specimens is light brown or yellowish gray. Dr. Coker met with this species at Capon, and states that it is common on the mud-flats, where it is known by the local name "Chimpanzas."

Sea-Cucumbers. Holothurioidea.

The holothurians are the least known, and appear to be the least common, of the classes of echinoderms on the Peruvian coast. Although seven species are given in the following list, one is known only from the original description of a specimen labeled "Peru," a second is very unsatisfactorily known from a specimen labeled "Chile" but belonging to a warm-water genus, a third is known from Mexico and from Patagonia and hence is assumed to occur in Peruvian waters, and a fourth is a Panamic species, hitherto very little known. Of the remaining three, two are southern species, which only reach the lower coast of Peru. Consequently there remains only a single common and well-distributed holothurian on the Peruvian coast. In view of these facts it is futile to discuss the origin of the holothurian fauna. It is only necessary to add that the nearest relative of the common Phyllophorus of Peru is apparently some one of the Australasian species.

The more or less elongate body of a holothurian terminates anteriorly in a circle of tentacles surrounding the mouth, but these are very sensitive and highly contractile organs and when the animal is alarmed or irritated, they are withdrawn (or folded) into the anterior end of the body-cavity and the body appears to terminate in a blunt point. Preserved holothurians are usually in this condition unless some artificial means are used to prevent the contraction. The tentacles differ in form in different groups, but among Peruvian holothurians they are either *arborescent, i. e.* irregularly branched from near the base, or *peltate, i. e.* the branches are confined to the tip, where they form a more or less flat and circular disk. The body of a holothurian is more or less soft and smooth, but carries, either scattered all over the surface, or confined to five longitudinal areas (the *ambulacra*), little outgrowths or projections which like the tentacles are highly contractile. When these end in a flat sucking disc, they are called *pedicels* or tube-feet, but when more or less pointed, they are *papillae*. Papillae are often borne on large conical elevations called *warts*. The positive identification of holothurians is only possible when the internal anatomy and the calcareous particles in the skin (usually microscopic) are carefully examined.

Key to the Sea-Cucumbers of the Peruvian Coast.

Tentacles peltate.
  Body with large warts and conical papillae on the back and sides . . . . . *Stichopus fuscus*
  Body without warts but covered by numerous pedicels . . *Holothuria chilensis*
Tentacles arborescent.
  Tentacles 20, or sometimes fewer, either equal or more or less unequal in size . . . . . *Phyllophorus peruvianus*
  Tentacles 10.
    Pedicels arranged in more or less distinct series confined to the ambulacra, at least on the ventral surface.
      Pedicels in distinct series along the dorsal ambulacra; body elongated as usual in holothurians.
        Pedicels relatively few in two series along each ambulacrum. . . . . *Cucumaria leonina*
        Pedicels more numerous, in three or four series along each ambulacrum . . . . . *Cucumaria godeffroyi*
      Pedicels wanting on back, but papillae present; body with ends upturned and thus ascidian-shaped . . . . . *Colochirus peruanus*
    Pedicels numerous, irregularly scattered all over body . . . . *Thyone gibber*

Stichopus fuscus.

H. Ludwig, 1874. Arb. Zool.-Zoot. Inst. Würzburg, **2**, p. 21.

This species has been recorded from San Diego, California; Mazatlan, Mexico; Machalilla, Ecuador, and the west coast of Patagonia (see Ludwig, 1898a) and therefore doubtless occurs in the Chile-Peruvian region. It reaches a length of

several hundred millimeters and the wart-like papillae of the back may be 5 mm. in diameter at base and 3–4 mm. high. The color in life, of the Ecuadorian specimen, was red.

Holothuria chilensis.

C. Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 5 heft, p. 249.

Nothing is known of this species beyond what is given in the original description, which was based on a specimen in the Hamburg Museum, labeled "Chile," and even the type specimen is no longer extant. As the genus is characteristic of the tropics and is well represented in the Panamic region, it probably occurs on the coast of Peru, and if the type of *chilensis* really came from Chile, that species is the one we should naturally expect to find. The specimen of *H. vagabunda* in the Stockholm Museum, labeled "Peru" (see Théel, 1886), is doubtless from "Peru" in the Gilbert Islands and not from South America.

Phyllophorus peruvianus.

Holothuria (*Mulleria*, Flemm.) *peruviana* R. P. Lesson, 1830. Cen. Zoöl., p. 124.
Anaperus peruanus F. Troschel, 1846. Arch. f. Naturg., **12**, Bd. 1, p. 61.
Pattalus mollis Selenka, 1868. Zeit. f. w. Zool., **18**, p. 113.
Thyonidium peruanum Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 2 heft, p. 67
Thyonidium molle Semper, 1868. *Op. cit.*, 5 heft, p. 243.
Thyone (*Stolus*) *chilensis* Semper, 1868. *Op. cit.*, 5 heft, p. 241.
Pattalus peruvianus Verrill, 1868. Trans. Conn. Acad., **1**, p. 376.
Eucyclus duplicatus Lampert, 1885. Die seewalzen, p. 290.
Phyllophorus chilensis Ludwig, 1887. SB. Akad. Berlin, No. 54, p. 24.
Phyllophorus mollis Ludwig, 1892. Die seewalzen, p. 347.

Plate 14, figure 1.

The above list of synonyms is by no means complete, but is sufficient to show how frequently this holothurian has served as the basis for a new name. This is due, not to any unusual variability, but to the unequal development of its numerous tentacles and to the very great (and usually unequal) contraction they undergo in death. Very few preserved specimens show twenty equally large and symmetrically arranged tentacles; typically ten tentacles are large and ten small, and commonly in such specimens the small tentacles are arranged in five pairs alternating more or less perfectly with the five pairs of large ones; in some specimens the tentacles appear to form two concentric circles. There can be very little doubt that the names given above all refer to the same animal. One of the specimens before me is almost exactly like Lesson's type in that it seems to have but eight tentacles and these are large and about equal; dissection shows, however, the remaining tentacles of very unequal size, strongly contracted and withdrawn into the body. Ludwig (1898 b), while inclined to the view that Lesson's species is identical with Selenka's, thinks Troschel's species and Semper's *Thyone chilensis* are different. He bases his opinion concerning the former on Troschel's statement

that anal teeth or at least calcareous anal papillae are present, whereas in *P. peruvianus* there is no trace of them. In view of the individual diversity shown by holothurians in the amount of calcification of the papillae near the anus, I do not think this objection outweighs Troschel's own opinion that his species was identical with Lesson's, and the fact that his having many specimens indicates that the species was the common holothurian of Peru. As regards *chilensis*, Ludwig maintains the separation of Semper's species from Selenka's on the strength of differences in color, calcareous ring, stone-canals and polian vessels. The examination of the specimens in the Coker collection has satisfied me that these differences are not specific, red individuals showing the characters (in their internal anatomy) which ought to go with green color and *vice versa*. Ludwig states that Plate regarded these supposed species as varieties which he designated as "die rothe" and "die grüne"; he found both forms under rocks at Iquique and Cavancha near Iquique. The largest specimen was 200 mm. long, 60 mm. thick. Coker found this species at La Punta, Callao, and north of there at the Pescadores Islands, Ancon, and in the Bay of Ferrol, near Chimbote. The known range is from Payta, Peru, to Talcahuano, Chile. Of the specimens in the Coker collection, those from La Punta are olive-green, those from Pescadores Island reddish purple, one from Bay of Ferrol bright purplish red, and those from "beach drift" at Ancon dull black. They show equal diversity in the structure of the calcareous ring, but the differences do not correlate with either color or locality. It seems to me, therefore, that we have in *Phyllophorus peruvianus* a well-characterized but somewhat variable species, the diverse forms and peculiarities of which offer a most interesting field of investigation to any one so situated that fresh material, especially of growth stages, is available.

Cucumaria leonina.

C. Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 2 heft, p. 53.

Ludwig (1898 a) has given a full synonymy and an interesting account of this species. Although Semper's type was supposed to come from Singapore, Ludwig thinks the locality was probably wrongly noted, as the species has not been found in the East Indian region since. On the contrary, it is a common species around the southern end of South America, extending eastward to the Falkland Islands and northward on the western coast of the continent to the southern part of Peru. It is usually 30–40 mm. long, but is known to reach a length of 70 mm. The color in life is usually rosy red or clear lake, but may be white tinged with red, and some of those taken by Plate at Calbuco, Chile, are recorded as "im Leben hell gelb."

Cucumaria godeffroyi.

C. Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 2 heft, p. 53.

This species, originally discovered at Iquique, is now known to range southward, at least as far as Calbuco, and will probably be found on the southern

coasts of Peru. It reaches a length of 55 mm., and in life is sulphur-yellow in color. It lives among mussel-shells (Mytilus) and stones in shallow water along shore.

Colochirus peruanus.

C. Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 5 heft, p. 239.

As this species has not been met with since it was described by Semper, there is nothing further to be recorded of it, save that the specimens he had were "yellowish," 15–18 mm. long and 6–7 mm. in diameter. They were recorded as from Peru, but whether it was Peru, South America, or Peru, Gilbert Islands, remains to be shown.

Thyone gibber.

Stolus gibber E. Selenka, 1867. Zeit. f. w. Zool., **17**, p. 356.
Thyone gibber C. Semper, 1868. Reisen im Arch. d. Phil., 2 Th., **1**, 2 heft, p. 66.

Plate 14, figures 2–6.

Selenka's description is very brief and he gives no figures, so that a detailed description and a few figures are desirable, especially as the species does not seem to have been met with since it was described; it is entirely overlooked by Lampert (1885) and omitted from his monograph. The following are the chief characters: —

Tentacles 10, of which the two ventral are very small. Pedicels very numerous, covering all parts of the body. Body wall firm and leathery. Calcareous ring well developed (fig. 2); radial pieces much larger than interradial and with conspicuous posterior prolongations. Polian vessels 3, of which one is very small. Stone-canal single, in the dorsal mesentery; madreporic body elongate, cylindrical, truncate at end and somewhat convolute or spirally wound. Reproductive organs situated *posterior* to the middle of the body, consisting of a tuft of yellowish, unbranched tubules on each side of the mesentery. Alimentary canal and respiratory-trees apparently not peculiar. Anus without calcareous teeth. Calcareous deposits in body wall abundant, in the form of knobbed, perforated buttons (figs. 3, 4) about .09 mm. long; while there is more or less diversity in details and some are not perfectly formed, most of the buttons have 4 large perforations, 10 knobs on the margin (on each surface) and 2 conspicuous, elevated knobs, connected by a thick ridge, in the middle of each surface. There seem to be no other deposits in the body wall. In the pedicels, besides terminal discs, we find that the buttons become elongated into curved supporting rods (figs. 5, 6), without knobs on the margin but flattened and perforated at the ends; the knobs at the middle of the plate disappear on the concave surface, but remain as more or less conspicuous elevations on the convex side. The tentacles are literally packed full of perforated supporting plates and rods; in the tips of the branches these are small and comparable with those in the pedicels, but in the main trunk and its branches they are much larger and are more like elongated

perforated plates; while most of them are flat, many are curved and the resemblance to those in the pedicels is occasionally marked. The calcareous particles impart a very considerable rigidity to both body wall and tentacles. The largest specimen before me is 60 mm. long and 20 mm. in diameter, the smallest is only about one-fifth as long. All the specimens agree in color, though the depth of the shades shows considerable diversity. The darkest specimens are nearly or quite black, except for the ventral surface which is more or less whitish, sometimes in very marked contrast. In lighter specimens the dark shade is brown or gray and the ventral surface is yellowish or grayish. In only a few specimens is there a lack of sharp contrast between the upper and under surfaces. As a rule, the anterior part of the lower surface is colored like the back and the tentacles are always very dark.

It is a matter of some interest that Dr. Coker should have met with this Panamic species in Peruvian waters; there seems to be no good reason for doubting that his specimens are identical with Selenka's species. He took two specimens in the Bay of Sechura, in five fathoms, but at the Lobos de Afuera Islands he found this Thyone "very abundant." They were "collected from rocks in two feet of water (at half tide), near 'muello' of Grace & Co., on the bay called 'Independencia' (this little bay to be distinguished from the great bay of 'Independencia' on the coast, south of Pisco)." The color of these specimens in life is noted as "black." It may be added that the nearest relative of this species appears to be *Thyone buccalis* Stimpson of Australia.

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EXPLANATION OF PLATES.

PLATE 1.

Fig. 1. Astropecten erinaceus. Capon, Peru. Upper surface. $\times \frac{2}{3}$.
Fig. 2. Luidia columbia. Capon, Peru. Upper surface. $\times \frac{2}{3}$.

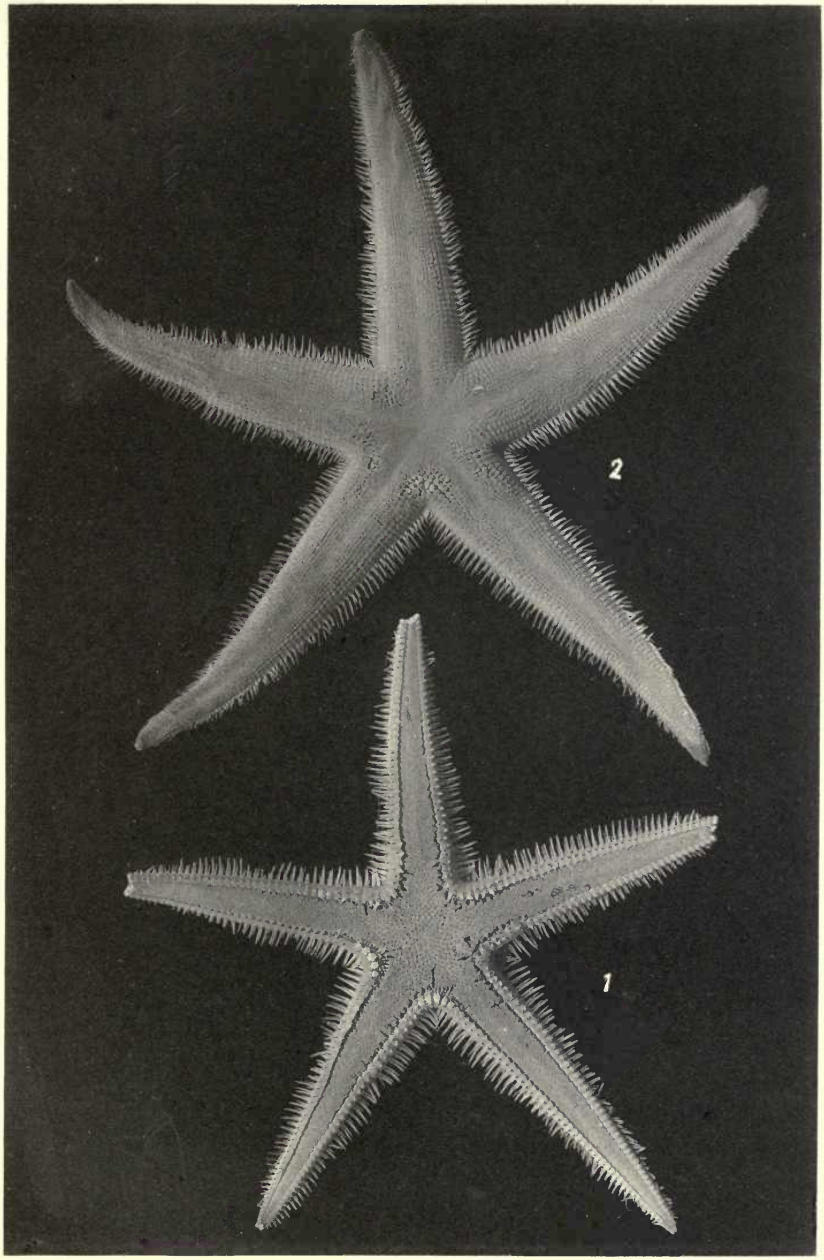
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PLATE 2.

Fig. 1. Luidia phragma. Talcahuano, Chile. Upper surface. $\times \frac{4}{5}$.
Fig. 2. Asterina chilensis. Bay of Sechura, Peru. Upper surface. $\times \frac{4}{5}$
Fig. 3. Asterina chilensis. Lobos de Afuera Islands, Peru. Upper surface. $\times \frac{4}{5}$.
Fig. 4. Odontaster singularis. Shoal Bay, Patagonia. Upper surface. $\times \frac{4}{5}$.
Fig. 5. Henricia hyadesi. Eastern Patagonia. Upper surface. $\times \frac{4}{5}$.

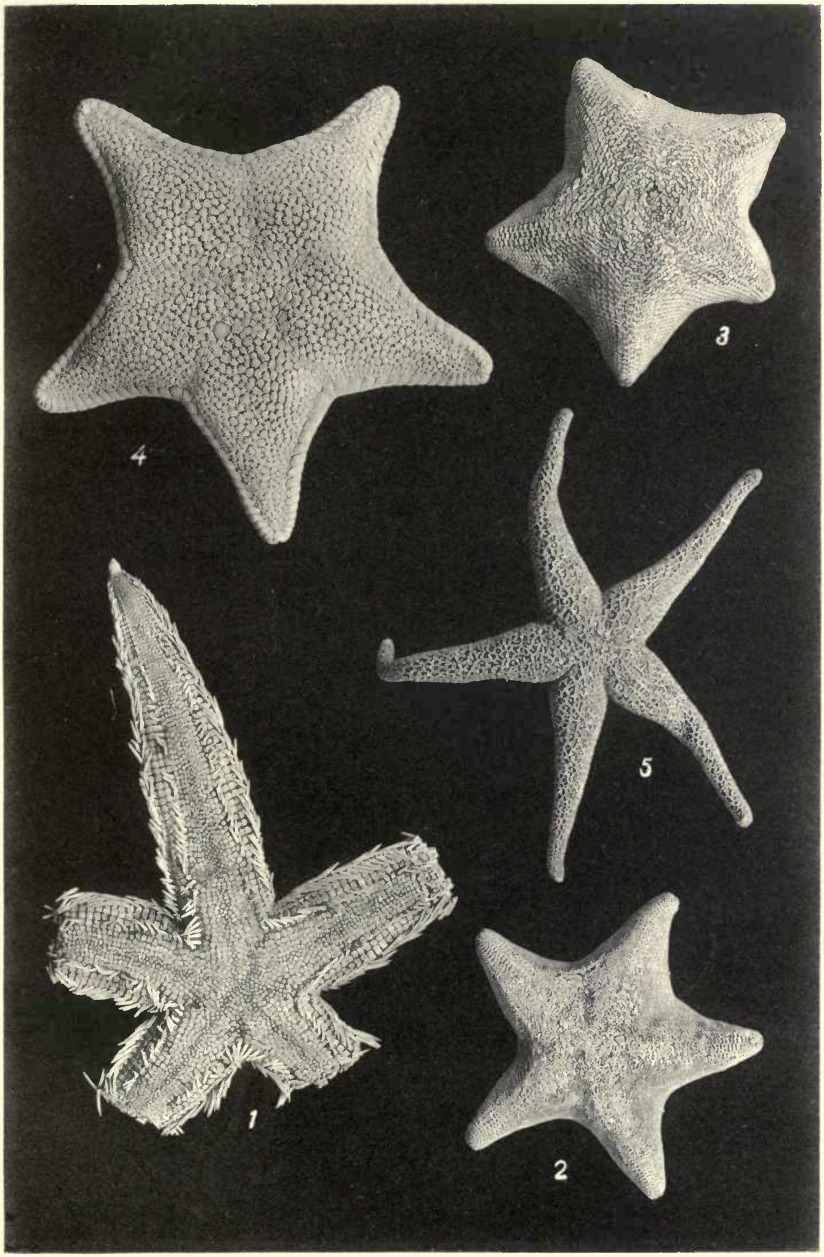
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PLATE 3.

Fig. 1. Parasterina obesa. Talcahuano, Chile. Upper surface. × ⅔.
Fig. 2. Parasterina obesa. Talcahuano, Chile. Lower surface. × ⅔.
Fig. 3. Paulia horrida. Galapagos Islands. Upper surface. × ⅔.

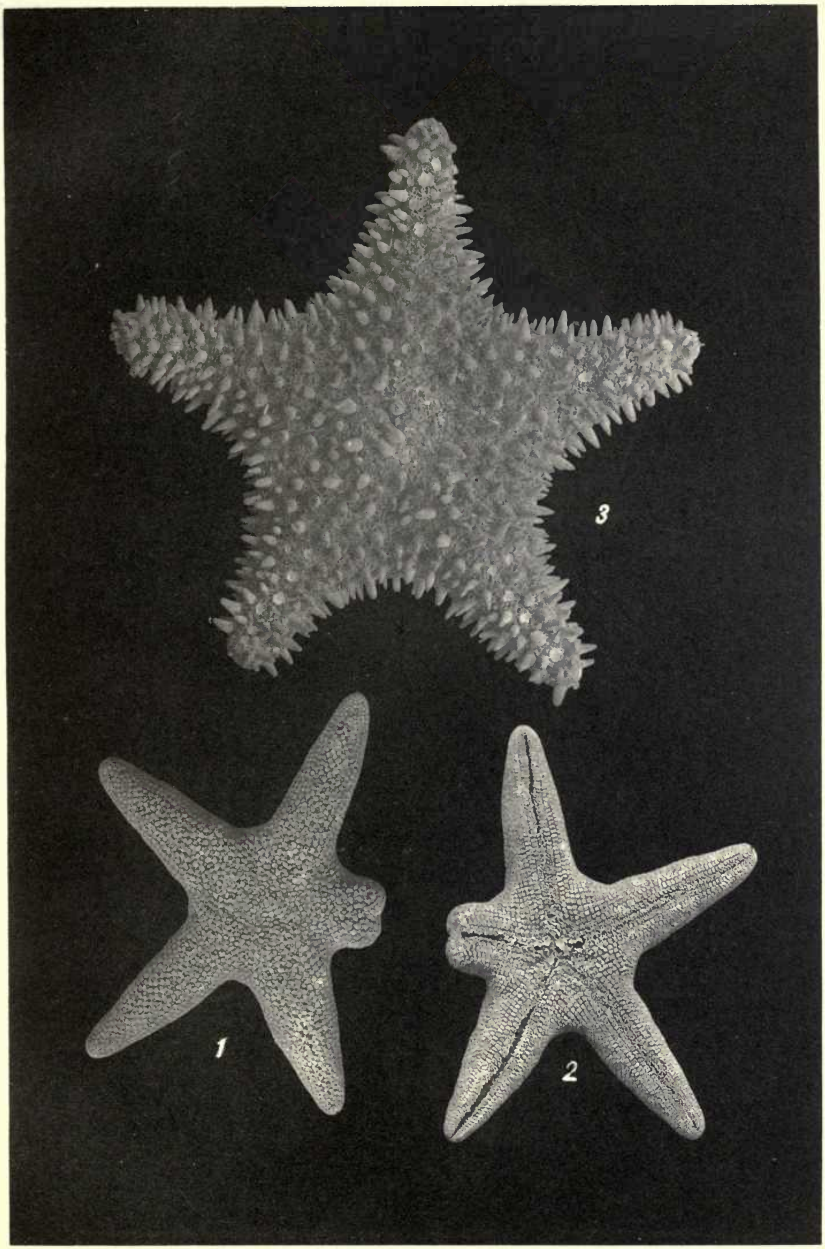
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PLATE 4.

Fig. 1. Oreaster occidentalis. Lower California. Upper surface. $\times \frac{1}{2}$.
Fig. 2. Nidorellia armata. La Paz, Mexico. Upper surface. $\times \frac{1}{2}$.

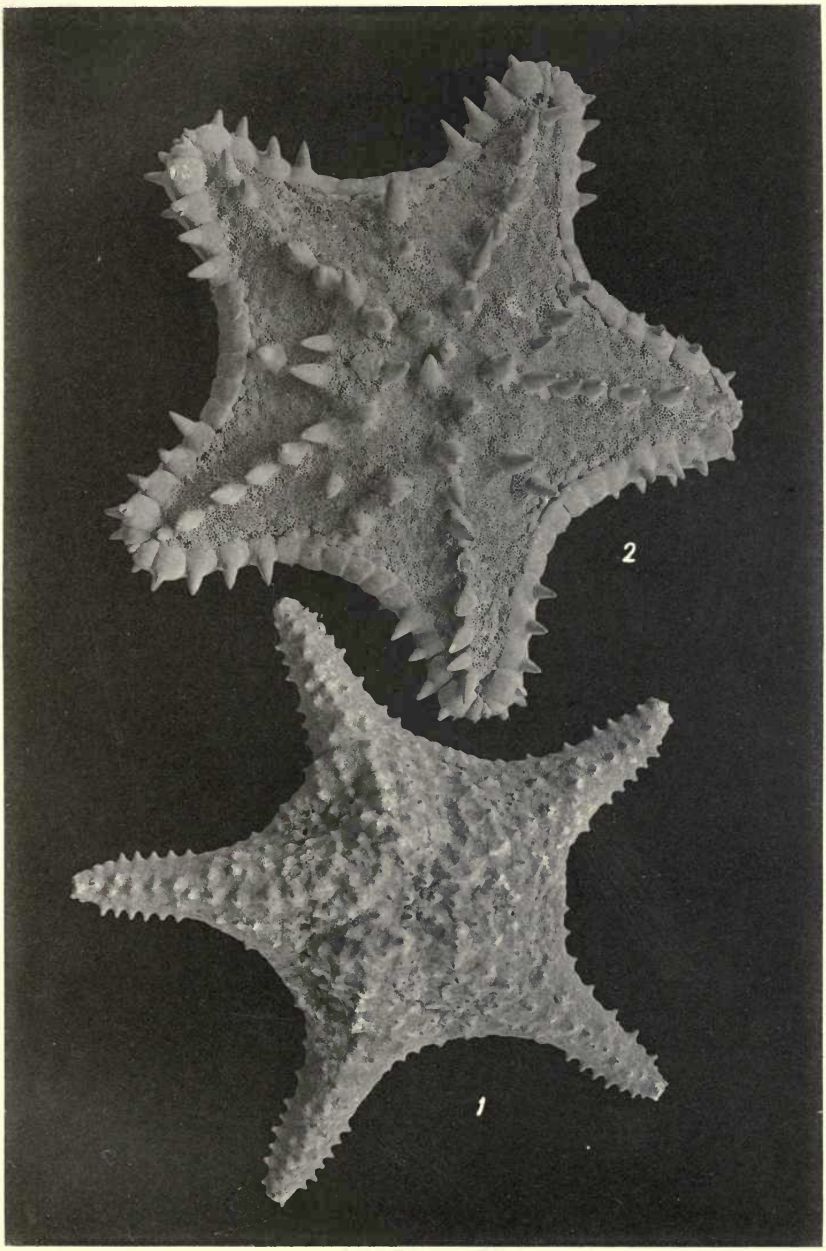
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PLATE 5.

Fig. 1. Phataria unifascialis. Acapulco, Mexico? Lower surface. × ½.
Fig. 2. Pharia pyramidata. Acapulco, Mexico? Lower surface. × ½.

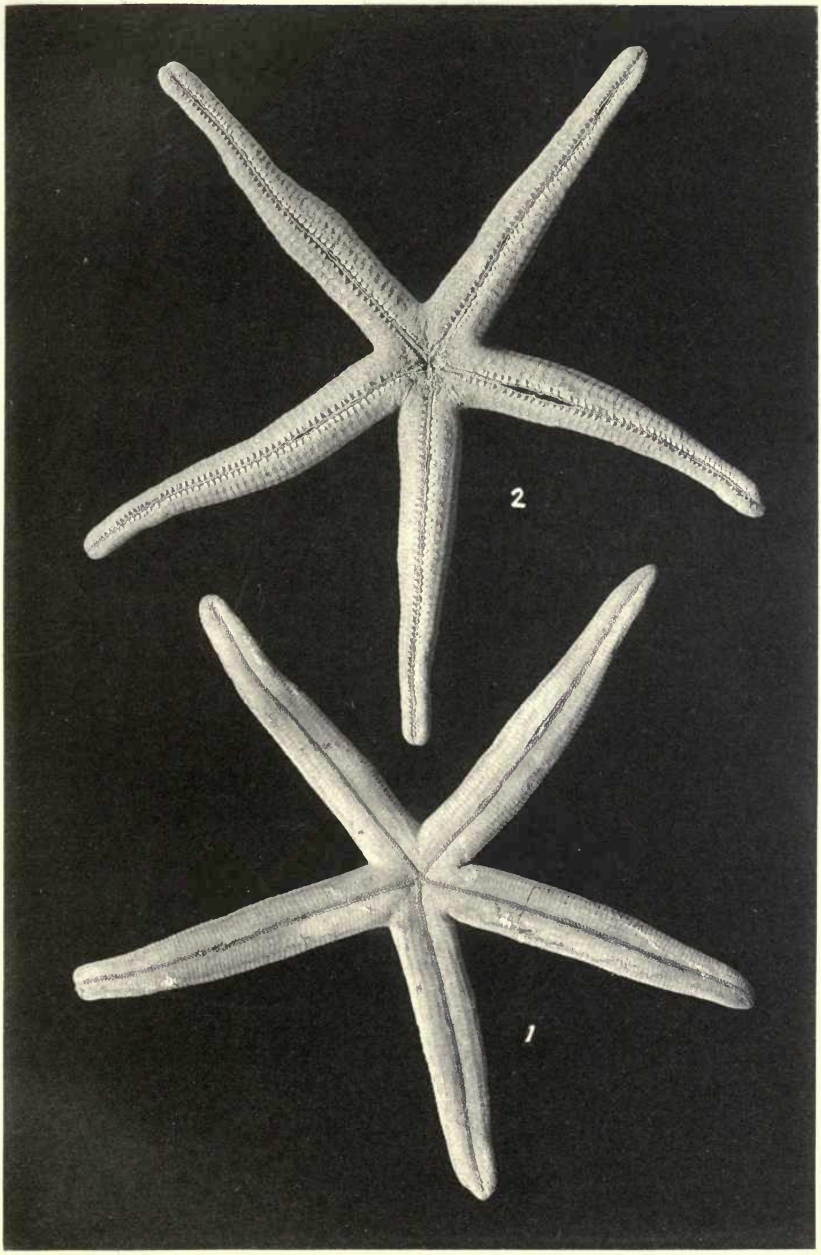
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PLATE 6.

Fig. 1. Mithrodia bradleyi. Arica, Peru ? Upper surface. $\times \frac{1}{2}$.
Fig. 2. Asterias gelatinosa. Talcahuano, Chile. Upper surface. $\times \frac{1}{2}$.

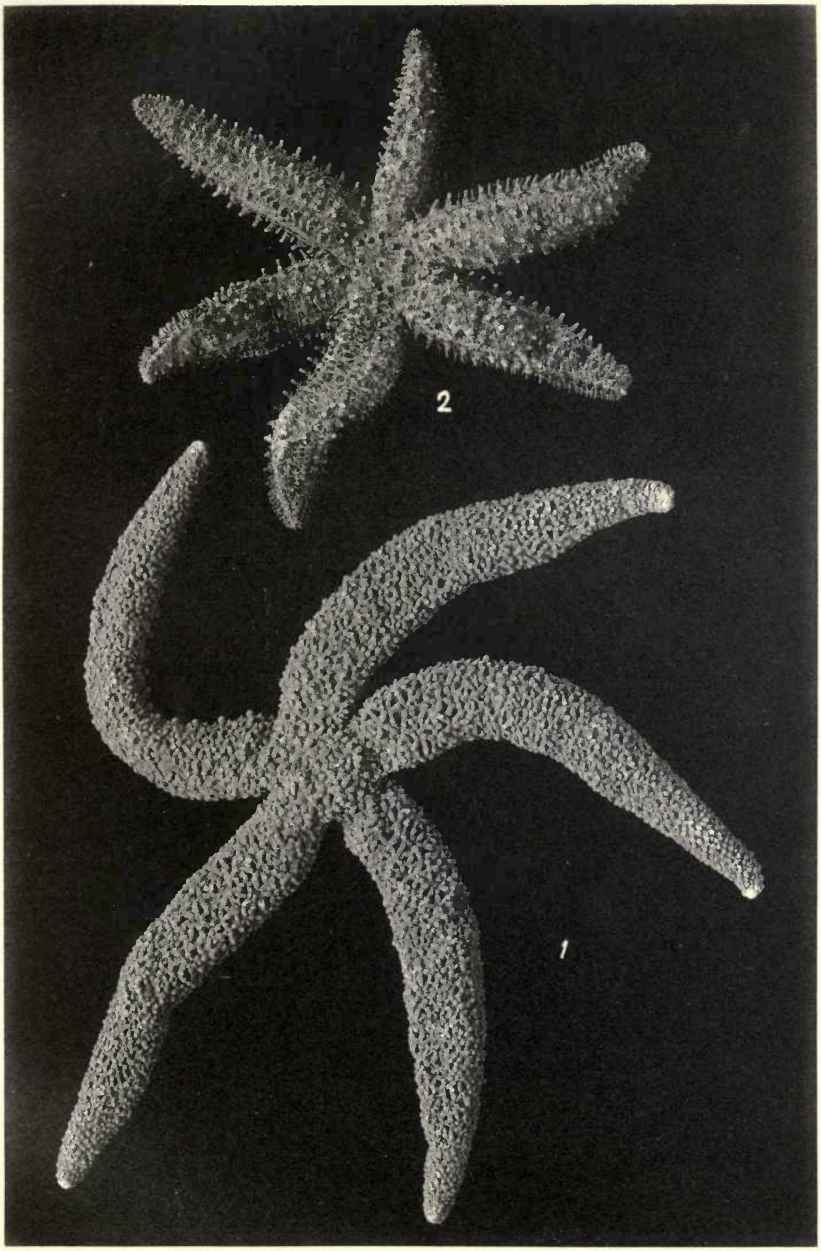
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PLATE 7.

Fig. 1. Heliaster polybrachius. Payta, Peru. Upper surface. $\times \frac{1}{2}$.
Fig. 2. Heliaster helianthus. Pescadores Islands, Peru. Upper surface. $\times \frac{1}{2}$.

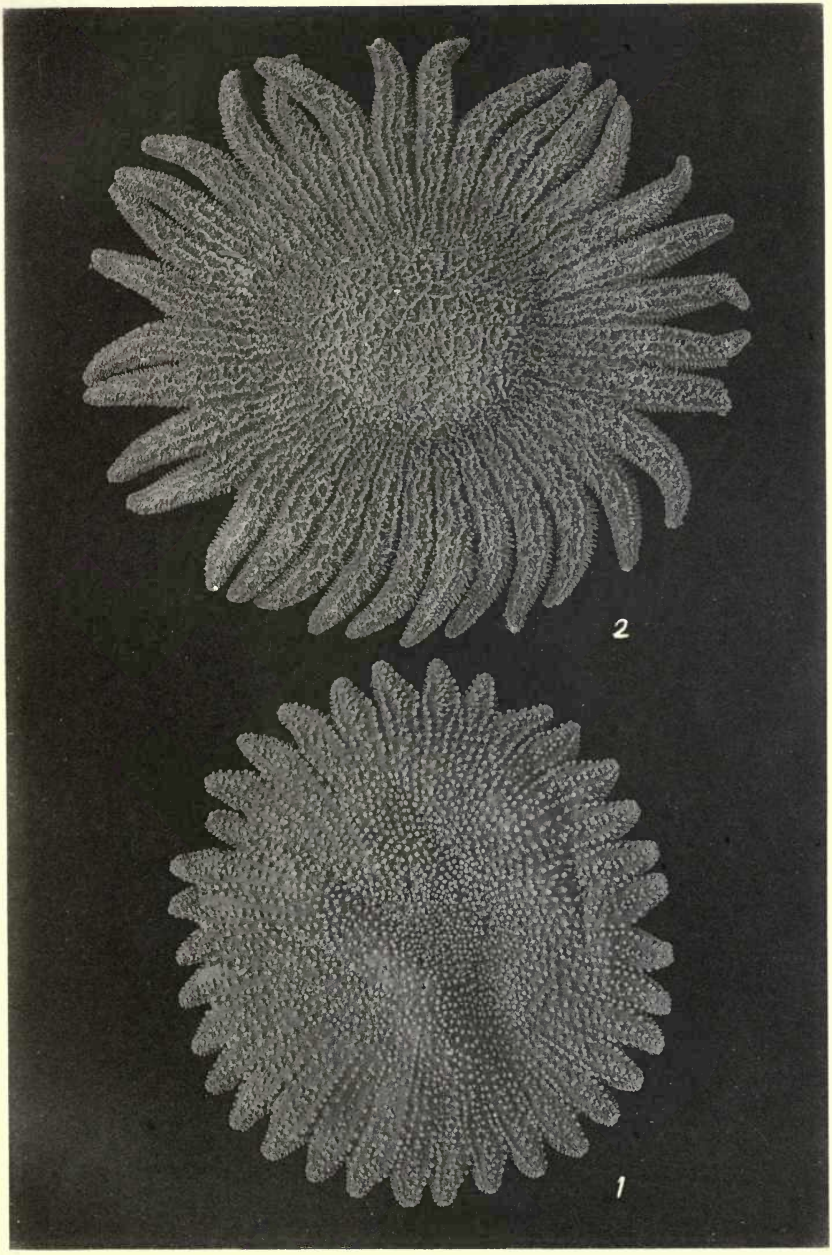
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PLATE 8.

Fig. 1. Stichaster aurantiacus. Caldera, Chile. Upper surface. × ½.
Fig. 2. Ophioderma panamense. Lower California. Upper surface. × ½.

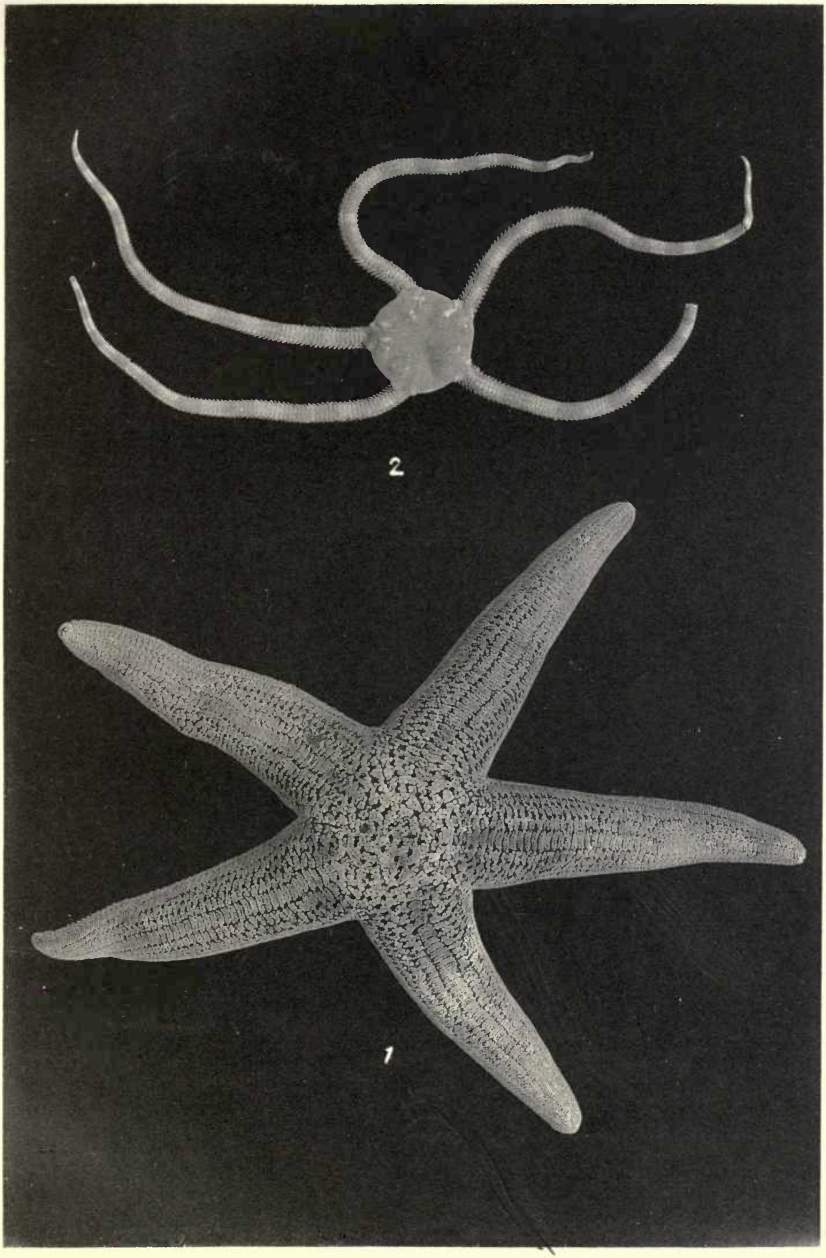
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PLATE 9.

Fig. 1. Amphiodia chilensis. Calbuco, Chile. Lower surface. × 1.3.
Fig. 2. Amphipholis pugetana. San Lorenzo Island, Peru. Upper surface. × 2.5.
Fig. 3. Ophiactis kröyeri. Talcahuano, Chile. Upper surface. × 1.3.
Fig. 4. Ophiothrix magnifica. Payta, Peru. Upper surface. × 1.3.

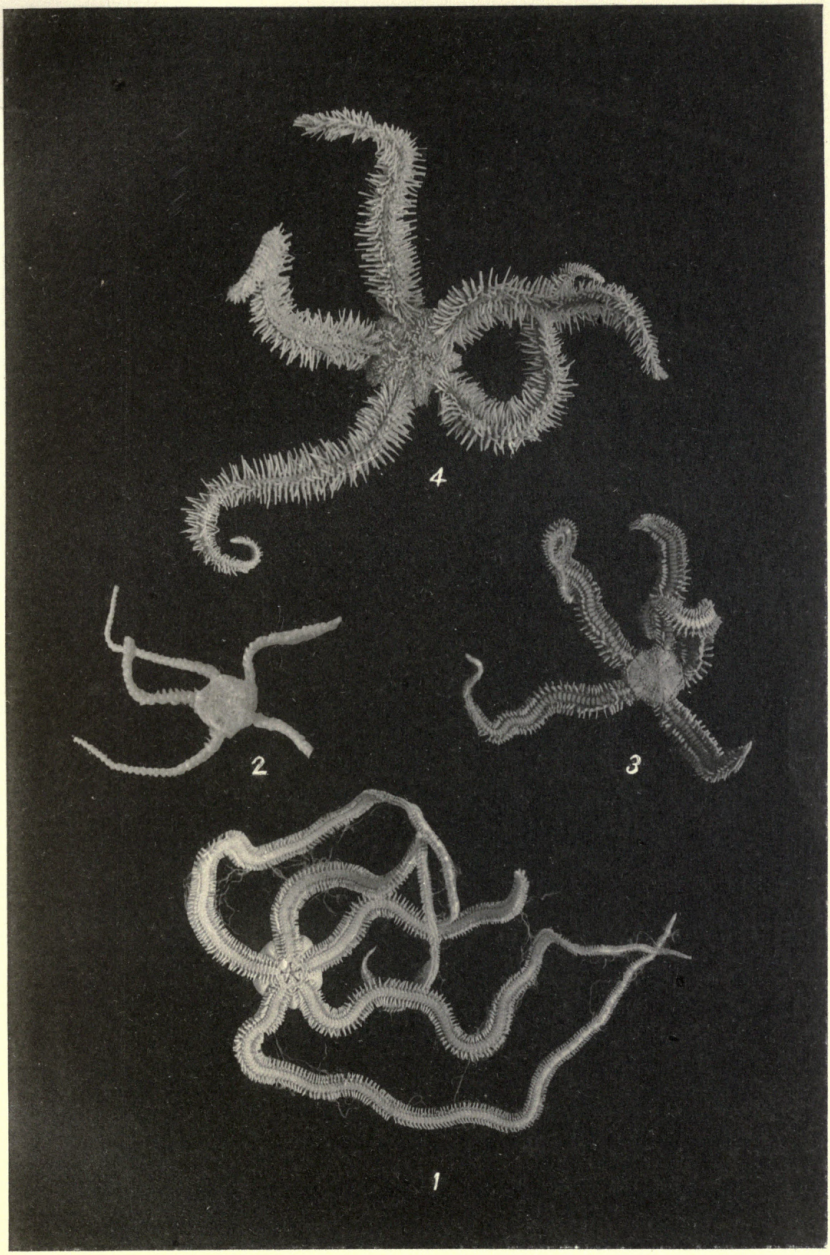
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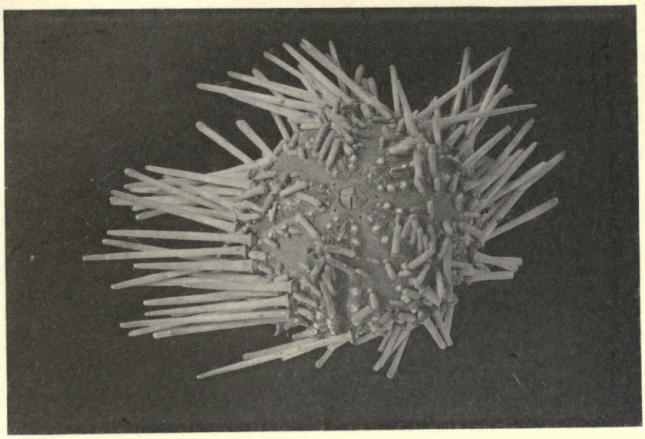
PLATE 10.

Fig. 1. Tetrapygus niger. Talcahuano, Chile. Upper surface. $\times \frac{4}{5}$.
Fig. 2. Arbacia spatuligera. San Lorenzo Island, Peru. Upper surface. $\times \frac{4}{5}$.



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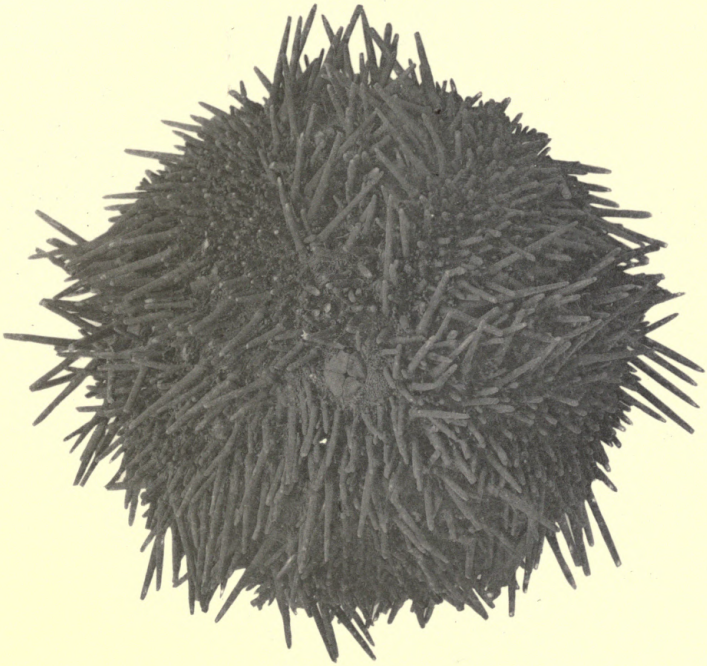

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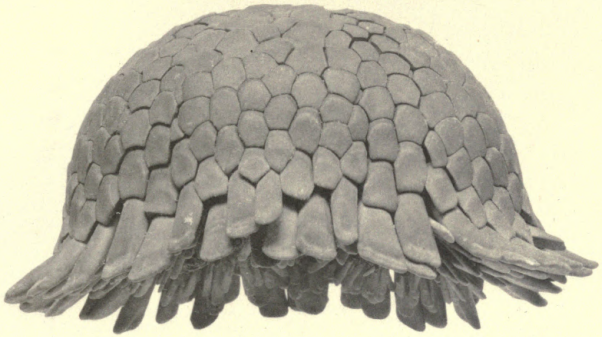
PLATE 11.

Fig. 1. Echinometra van brunti. Mazatlan, Mexico. Upper surface. Nat. size.
Fig. 2. Podophora pedifera. Fakarava, Paumotus. Side view. Nat. size.



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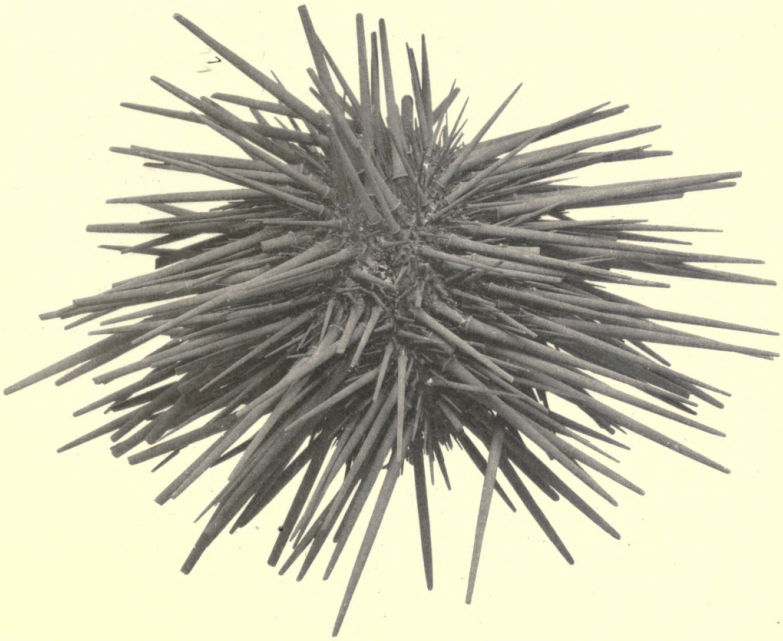

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PLATE 12.

Fig. 1. Strongylocentrotus albus. Talcahuano, Chile. Upper surface. Nat. size.
Fig. 2. Strongylocentrotus gibbosus. Payta, Peru. Upper surface. Nat. size.

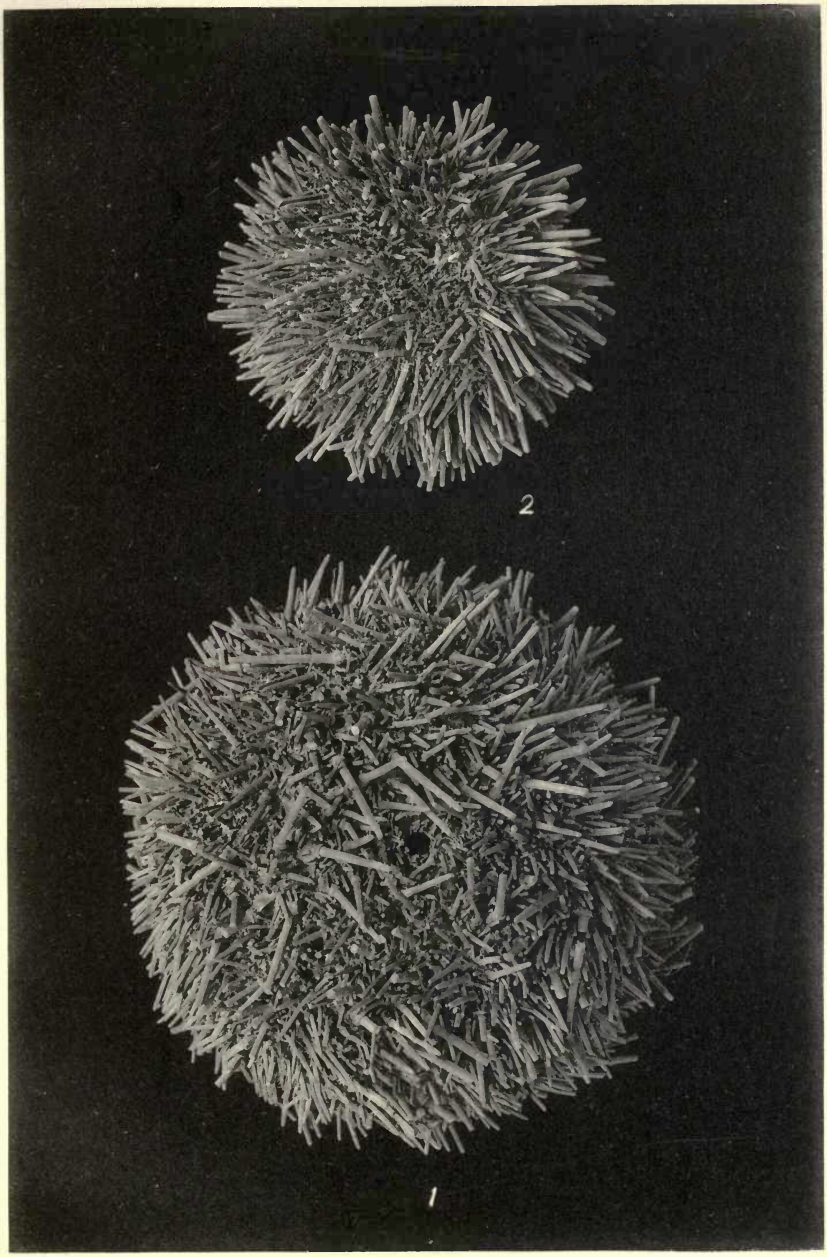
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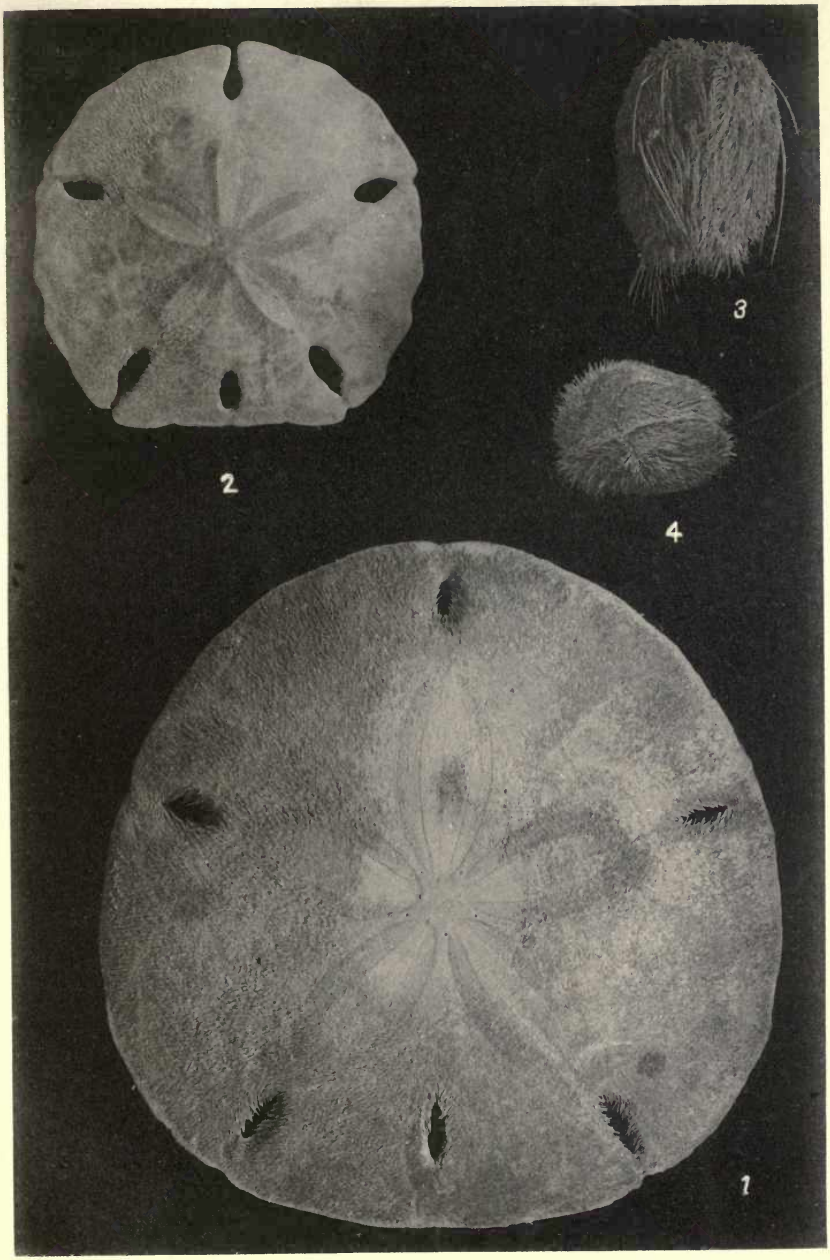
PLATE 13.

Fig. 1 Encope micropora. Bay of Sechura, Peru. Upper surface. $\times \frac{4}{5}$.
Fig. 2 Mellita stokesii. Tumbes, Peru. Upper surface. $\times \frac{4}{5}$.
Fig. 3 Lovenia cordiformis. San Diego, Cal. Upper surface. $\times \frac{4}{5}$.
Fig. 4 Agassizia scrobiculata. Capon, Peru. Side view. $\times \frac{4}{5}$.


2
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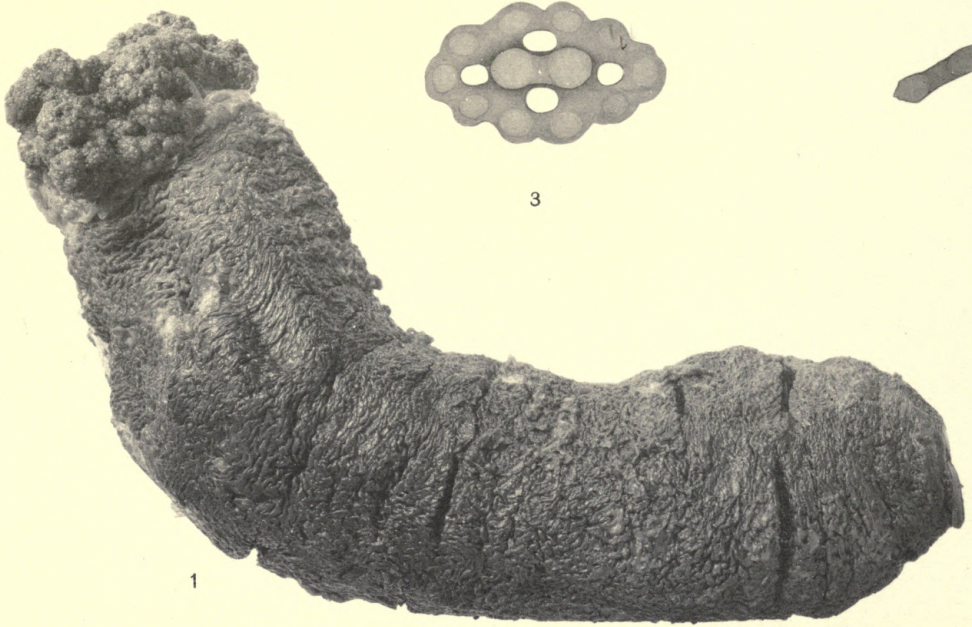
4
1

PLATE 14.

Fig. 1. Phyllophorus peruvianus. La Punta, Callao, Peru. Side view. Nat. size.
Fig. 2. Part of calcareous ring of Thyone gibber. Lobos de Afuera Islands, Peru. × 5.
Fig. 3. Calcareous "button" from body wall of Thyone gibber. Lobos de Afuera Islands, Peru. × 450.
Fig. 4. The same as 3, but seen from the side. × 450.
Fig. 5. Calcareous supporting rod of pedicel of same Thyone. × 450.
Fig 6. The same as 5, but seen from the side. × 450.



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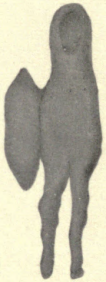

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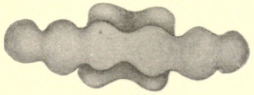

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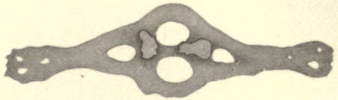

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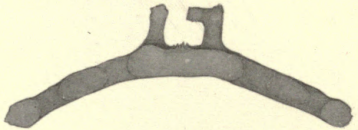

6

The following Publications of the Museum of Comparative Zoölogy are in preparation: —

LOUIS CABOT. Immature State of the Odonata, Part IV.
E. L. MARK. Studies on Lepidosteus, continued.
" On Arachnactis.
A. AGASSIZ and C. O. WHITMAN. Pelagic Fishes. Part II., with 14 Plates.
A. AGASSIZ and H. L. CLARK. The "Albatross" Hawaiian Echini.
S. GARMAN. The Plagiostomes.

Reports on the Results of Dredging Operations in 1877, 1878, 1879, and 1880, in charge of ALEXANDER AGASSIZ, by the U. S. Coast Survey Steamer "Blake," as follows: —

C. HARTLAUB. The Comatulae of the "Blake," with 15 Plates.
H. LUDWIG. The Genus Pentacrinus.
A. MILNE EDWARDS and E. L. BOUVIER. The Crustacea of the "Blake."
A. E. VERRILL. The Alcyonaria of the "Blake."

Reports on the Results of the Expedition of 1891 of the U. S. Fish Commission Steamer "Albatross," Lieutenant Commander Z. L. TANNER, U. S. N., Commanding, in charge of ALEXANDER AGASSIZ, as follows: —

H. B. BIGELOW. The Siphonophores.
K. BRANDT. The Sagittae.
" The Thalassicolae.
O. CARLGREN. The Actinarians.
W. R. COE. The Nemerteans.
REINHARD DOHRN. The Eyes of Deep-Sea Crustacea.
H. J. HANSEN. The Cirripeds.
" The Schizopods.
HAROLD HEATH. Solenogaster.
W. A. HERDMAN. The Ascidians.
S. J. HICKSON. The Antipathids.
E. L. MARK. Branchiocerianthus.
JOHN MURRAY. The Bottom Specimens.
P. SCHIEMENZ. The Pteropods and Heteropods.
THEO. STUDER. The Alcyonarians.
—— The Salpidae and Doliolidae.
H. B. WARD. The Sipunculids.
W. McM. WOODWORTH. The Annelids.

Reports on the Scientific Results of the Expedition to the Tropical Pacific, in charge of ALEXANDER AGASSIZ, on the U. S. Fish Commission Steamer "Albatross," from August, 1899, to March, 1900, Commander Jefferson F. Moser, U. S. N., Commanding, as follows: —

A. AGASSIZ. The Echini.
H. L. CLARK. The Holothurians.
—— The Volcanic Rocks.
—— The Coralliferous Limestones.
J. M. FLINT. The Foraminifera and Radiolaria.
S. HENSHAW. The Insects.
W. C. KENDALL and E. L. GOLDSBOROUGH. The Fishes.
R. LENDENFELD. The Siliceous Sponges.
H. LUDWIG. The Starfishes and Ophiurans.
G. W. MÜLLER. The Ostracods.
MARY J. RATHBUN. The Crustacea Decapoda.
RICHARD RATHBUN. The Hydrocoralidae.
G. O. SARS. The Copepods.
L. STEJNEGER. The Reptiles.
C. H. TOWNSEND. The Mammals, Birds, and Fishes.
T. W. VAUGHAN. The Corals, Recent and Fossil.
W. McM. WOODWORTH. The Annelids.

Contributions from the Zoological Laboratory, Professor E. L. Mark, Director.
Contributions from the Geological Laboratory.

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