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NEW STARFISHES FROM THE PACIFIC COAST OF
NORTH AMERICA.

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THE United States National Museum recently sent the writer most of the starfishes in its collections from the west coast of North America. These collections comprise material dredged by the Fisheries Steamer *Albatross*, as well as specimens from other sources. As it will be some time before the final report can be completed and published, the following species are described in advance:

Leptychaster pacificus.

Leptychaster anomalus.

Astropecten ornatissimus.

Luidia ludwigi.

Luidia asthenosoma.

Henricia aspera.

Henricia polyacantha.

Crossaster alternatus.

Crossaster borealis.

Rathbunaster californicus, new genus and species.

In the Bulletin of the Bureau of Fisheries for 1904, Vol. XXIV, June 10, 1905, pp. 291 to 320, the writer published 1 new genus, 2 new subgenera, and 24 new species, based on material collected by the *Albatross* in Alaska in 1903, and off

California in 1904. Most of these forms are found also in the National Museum material, collected at an earlier date.

The new forms described below will be figured in the final report.

Family **ASTROPECTINIDÆ** Gray.

Genus **Leptychaster**¹ Smith.

Leptychaster Smith, Ann. and Mag. Nat. Hist., Ser. 4, xvii, 1876, 110.

Leptoptychaster Smith, Philos. Trans., Zool. Kerguelen Island, CLXVIII, 1879, 278.

LEPTYCHASTER PACIFICUS Fisher, new species.

Rays 5. $R = 43$ mm.; $r = 14$ mm.; $R = 3r$. Breadth of ray at base 16 mm.

General form similar to that of *L. arcticus* (Sars) but disk rather broader. General form flattened; rays evenly tapered, bluntly pointed; interbrachial angle slightly rounded, but abrupt; abactinal surface subplane; margin of rays defined by inferomarginal plates, rounded; superomarginal plates well-developed, relatively larger than in *L. arcticus*, forming a fairly conspicuous margin to abactinal paxillar area; actinal surface slightly convex; actinal interradiial areas slightly smaller, and intermediate plates fewer than in *L. arcticus*. Tube-feet pointed, the proximal with a rudimentary subconical disk; superambulacral plates small.

Abactinal paxillar area fairly compact, the paxillæ decreasing in size toward center of disk, midradial line, and end of ray; smallest paxillæ in center of disk, the largest on margin of area at base of ray. Paxillæ similar in character to those of *L. arcticus*, but slightly larger, and spinelets a trifle longer. Base of pedicel flaring into a roundish plate with 4 or 5 short rather irregular lobes by which the plates touch or imbricate slightly, and between which the papulæ emerge. Larger paxillæ with about 25 peripheral and 30 central slender delicate

¹This is the original spelling, and, as it is very evident that there is no typographical error, this name should be employed instead of *Leptoptychaster*.

terete blunt spinelets; spinelets occupying center of tabulum form a coördinate flat-topped group, usually stand upright and are crowded; peripheral spinelets usually radiate and are not equal in length.

Marginal plates short, band-like, but both series more conspicuous than in *L. arcticus*; superomarginal plates, 30 in number from interradiial line to extremity of ray much wider than long on proximal half of ray, the width rapidly decreasing on outer portion until plates are nearly quadrate. Plates form an arched bevel to margin of abactinal area, are separated by deep fasciolar grooves, and are covered with short delicate terete spinelets which form a close nap all over exposed surface.

Inferomarginals corresponding to superomarginals, beyond which they extend laterally forming margin of ray; separated from superomarginals by rather wide groove; short, band-like, separated by fasciolar furrows, forming well-arched bevel to actinal surface; first plate about twice as wide as corresponding superomarginal; all densely covered with small spinelets similar to those of superomarginals, but a trifle larger, those of transverse median region slightly squamiform and directed outward.

Actinal intermediate areas rather smaller than in *L. arcticus*; one series of intermediate plates extending about three-fourths length of ray or to eighteenth inferomarginal; a second series extending to seventh or eighth plate, and a third series confined to angle bounded by adjacent first 2 plates. Intermediate plates with a low tabulum crowned by a coördinate group of 15 or 20 papilliform spinelets, those in center being slightly thicker and more clavate than the peripheral ones.

Adambulacral plates about as wide as long with a rounded furrow margin, but first 2 or 3 plates wider than long and with more angular margin. Armature consists of (1) a furrow series of 4 (more rarely 5) slender, rather long, blunt cylindrical spinules, the two central being slightly the longest or the 4 subequal; (2) on actinal surface are 2 or 3 longitudinal series of about 4 similar spinules which decrease in size toward outer edge of plate; third series when present more irregular, its spinelets distinctly tapered, slenderer, shorter and sharper. Furrow spinelets usually bent back from furrow, and armature has a decidedly crowded appearance.

Mouth-plates narrow, the free margin of each being longer than that adjacent to first adambulacral, and the combined plates forming a salient angle into actinostome. Margin of plate with a series of about 15 slender tapering spinules, decreasing in length from inner to outer end of plate. About 8 to 10 of these are more regular and occupy the free actinostomial margin, the rest being adjacent to first adambulacral plate, between which and the mouth-plate there is a fairly wide suture. A series of numerous similar spinules stands on edge of suture furrow, and sometimes an incomplete, irregular, intermediate series is present.

Madreporic body situated about its own diameter from inner edge of superomarginal plates, fairly large, surrounded and partially obscured by large paxillæ; striations deep, coarse, irregular, centrifugal.

Type, No. 21925, U. S. Nat. Mus. Type locality, Albatross Station 2862, near north end of Vancouver Island (inside) in 238 fathoms, on gray sand and pebbles.

This well-marked form has larger superomarginals than any previously described species. I have compared the type with a specimen of *L. arcticus* (No. 17992, U. S. Nat. Mus., "Sta. 21, Cashes Ledge") having a major radius of 35 mm. In *L. arcticus* the proximal superomarginal plates are not conspicuously larger than those of outer third of ray. They are roundish and resemble large paxillæ, but in *L. pacificus* the proximal plates are much wider than those of distal half of ray, and the plates decrease regularly in width all along ray. The marginal plates of *L. arcticus* are shorter, hence more band-like, than in *L. pacificus*, there being 36 plates to $R=35$ mm., while in *L. pacificus*, with R 43 mm., there are but 28 to 30 plates. On account of the difference in size of the superomarginals in the 2 species, the abactinal paxillar area is narrower in *L. pacificus*. The actinal interradiar areas of *L. arcticus* are slightly larger than in *L. pacificus* and the paxillæ are more crowded. The present species seems to bring *Leptychaster* nearer to both *Bathybiaster* and *Psilaster*, on account of the larger superomarginal plates. There are, of course, no special spines on the marginal plates of any *Leptychaster*.

LEPTYCHASTER ANOMALUS Fisher, new species.

Rays 5. $R = 27$ mm.; $r = 17$ mm.; $R = 1.6r$. Breadth of ray at base, 19 mm.

In general form and ornamentation greatly resembling *Parastropecten incermis* Ludwig. Disk broad, rays short, broad and blunt; interbranchial arcs shallow and wide; abactinal surface subplane, capable of slight inflation; marginal plates conspicuous, devoid of enlarged spines or spinelets, but covered with granules and granuliform spinelets; actinal intermediate areas broad; adambulacral plates with 3 or 4 furrow spines; small superambulacral plates present; a very tiny anal pore present.

Abactinal paxillar area compact; paxillæ arranged in not very regular oblique transverse rows at sides of ray; without order in median radial area and center of disk. Paxillæ largest at base of ray and in interradial areas decreasing conspicuously in size toward center of disk and tip of ray; larger at sides of paxillar area than in mid-radial region. Paxillæ with subcircular bases having 5 or 6 very short irregular lobes, by which neighboring plates touch, or even imbricate in center of disk and mid-radial area. Papulæ in 5's and 6's (except in center of disk and along mid-radial lines where they are absent). Column of paxilla about as high as breadth of base, flaring at summit, the largest crowned with a coördinate floriform group of about 40 or 45 short, terete, often clavate, round-tipped spinelets; of these about one-half form a peripheral series and are a trifle slenderer and longer. On the smaller paxillæ the spinelets decrease markedly in size, but only slightly in number.

Superomarginal plates, 15 in number from median interradial line to extremity of ray form an arched bevel to border of abactinal surface; plates shorter than wide, but increase in length on outer half of ray. Plates of both series separated by transverse narrow deep fasciolar grooves and a narrow deep groove (not so deep as transverse grooves) separates superomarginal from inferomarginal series. Superomarginal plates covered with short, terete, blunt granuliform spinelets, similar to but larger than paxillar spinelets, becoming well-defined slender

spinelets in fasciolar grooves. Superomarginal covering is to be considered as a spinelet rather than granules.

Inferomarginal plates much wider than long, encroaching more onto actinal area than do superomarginals onto abactinal, and corresponding in position to superomarginals. Spinelets, densely covering surface of plates, larger than those of superomarginals, and increasing in size toward outer end of plate which projects slightly beyond adjacent end of superomarginal, thus defining the ambitus. Inferomarginal spinelets granuliform in middle of plate, often attaining a squamiform appearance at outer end; spinelets in fasciolar furrows, slender. No enlarged spines of any sort on either marginal series. Terminal plate small, granulose, deeply notched below.

Actinal interradiar areas large; intermediate plates low-paxilliform, arranged in chevrons, the series adjacent to adambulacrals extending about three-fourths length of ray or to eighth inferomarginal. Plates decrease in size toward margin, are strongly imbricated internally, and the paxillar crowns which are composed of about 25 to 30 clavate obtuse, not very crowded, spinelets (slender when dry) surmount a low convex elevation or tabulum. Well-defined fasciolar channels separate these tabula.

Adambulacral plates about as wide as long, with a slightly rounded, angular furrow margin, the angularity being more pronounced in vicinity of mouth plates. Armature consists of (1) a furrow series of 4 (sometimes 3) terete or slightly flattened bluntly pointed tapering spinules about as long as plate and graduated in length orad, the longest spine being on aboral end of plate; or the spinules may be disposed like rays of fan and graduated in length toward either end of series. (2) On actinal surface are about 3 longitudinal series of smaller spinelets, decreasing in length toward outer edge of plate where the spinelets are like those of actinal intermediate plates. Four spinelets commonly occur in the inner actinal series and about 3-5 in each of the outer; or the 2 latter series may be wanting, the spinelets, instead, forming an irregular group, especially on outer part of ray where there are frequently upwards to 16 or 20 actinal spinelets.

Mouth plates narrow, rather prominent actinally, the free margins of the combined plates forming a salient angle into actinostome; free margin of each plate slightly angular near inner end and longer than the margin adjacent to first adambulacral. Armature consists of a furrow series of about 6 or 7 tapering spinules decreasing in length from the inner enlarged tooth, outward, and thence continued along margin adjacent to first adambulacral in about 9 much smaller spinelets similar to those of actinal intermediate plates. A superficial series of similar spinelets follows margin of median suture, increasing in size toward inner angle of plate, and an incomplete more or less irregular series often, but not always, occurs between marginal and superficial series. There is more or less variation in the details of dental armature.

Madreporic body rather large, about midway between center and extreme edge of disk. Striations coarse, centrifugal, very irregular; madreporic body sometimes nearly hidden by 5 or 6 large paxillæ.

Type, No. 21926, U. S. Nat. Mus. Type locality, Albattross Station 3310, Bering Sea, in 58 fathoms, on dark sand and mud.

Remarks.—This species bears a close resemblance to *Parastropecten inermis* Ludwig,¹ and is probably congeneric with that form, although *anomalus* has a minute anal pore. The presence of an anal pore is, I believe, a character of scarcely more than specific importance. For instance one species of *Astropecten* has been shown by Verrill to possess a minute anus. Although I have not yet had an opportunity to make serial sections of the anal region of *anomalus*, I have been able to make out a tiny pore in 2 specimens, and the intestine leading to the pore is well developed. It may perhaps seem heretical to classify the present species with *Leptychaster*, but *anomalus* differs chiefly from *L. pacificus* in having a larger disk, shorter rays, broader actinal interradial areas, and a slightly different ornamentation on paxillæ and marginal plates.

¹ Mem. Mus. Comp. Zool., XXXII, July, 1905, 76, pl. iv, fig. 21, 22; pl. xxi, fig. 117; pl. xxii, fig. 126. (Gulf of Panama and Cocos Id., 1,271 and 1,408 meters.)

The superomarginals are only a trifle, if any, larger in *anomalus* although the inferomarginals are a little longer and not quite so broad. The chief differences are therefore in proportion. But *pacificus* is an undoubted *Leptychaster*, an evident offshoot of *arcticus*, of the circumpolar fauna. It therefore follows in due course that *anomalus* is a *Leptychaster*, although superficially different enough from *keerguelenensis*, perhaps, to warrant another generic designation if we did not have the intermediate steps.

Without having examined specimens of *Parastropecten inermis* I hesitate to further question the validity of the genus, although frankly I find no generic characters other than the size of the superomarginals that can separate the form from *Leptychaster*. At any rate, *L. anomalus* differs from *P. inermis* in having fewer furrow spines, more paxillæ spinelets, 5 and 6 papulæ about the very short-lobed roundish plates (instead of 4), and finally in possessing a minute anal pore. The general facies of the 2 forms is strikingly alike.

Genus *Astropecten* Schulze.

Astropecten Schulze, Betrachtung der versteinerte Seesterne u. ihre Theile, 1760.

There appear to be 3 species of *Astropecten* off the California coast. One, which I have provisionally identified as *A. erinaceus* Gray, does not range much north of San Diego, and seems to be a shore form. I have been unable to identify the other two species with any previously described form. I have recently described one of these as *Astropecten californicus*¹ and the other is diagnosed below. In order to contrast the principal characters a synopsis of the 3 forms is added.

- a. A series of spines along upper edge of superomarginals, and usually, also, a second, parallel longitudinal series, spaced from the above; size large; littoral.....*erinaceus*.
- aa. Superomarginals entirely devoid of enlarged tubercles or spines.
 - b. Paxillæ larger, about 3 transverse series opposite 2 superomarginals at base of ray; paxillæ not irregular and more crowded along radial lines; the enlarged spine of actinal surface of adambulacral plates, slender, tapering and bluntly pointed.

ornatissimus.

¹ Zool. Anzeiger, Bd. XXX, Nr. 10, June 19, 1906, 299.

bb. Paxillæ smaller, about 4 or 5 transverse series opposite 2 superomarginals at base of ray, crowded and more or less irregular along radial lines; enlarged adambulacral spine with rounded or truncate tip, and not conspicuously tapered...*californicus*.

ASTROPECTEN ORNATISSIMUS Fisher, new species.

This species differs from its nearest relative, *A. californicus*, in having shorter rays, larger paxillæ with longer spinelets, longer and slenderer adambulacral spines, and longer marginal spines.

$R = 56$ mm.; $r = 14$ mm.; $R = 4r$. Breadth of ray at base, 16.5 mm.

The paxillæ afford the most evident difference between *ornatissimus* and *californicus*. In *californicus* there is a considerable area around center of disk in which the paxillæ are smaller and more crowded than on remainder of disk and on rays, and paxillæ of midradial regions are more irregular, at least in arrangement, than along margins of ray. In the present form the large paxillæ extend nearly to center of disk, there being only a small area of small paxillæ.

The paxillæ of sides of rays are not in such regular rows and are not easily differentiated from the midradial ones. About 3 or 3½ transverse series of paxillæ correspond to 2 superomarginal plates at base of ray (usually 5 in *californicus*), about 5 at middle of ray, and 6 or 7 near tip. Opposite suture between second and third superomarginal plates about 12 or 13 paxillæ can be counted across ray to same point on opposite side (18 to 20 in *californicus*). Large paxillæ at base of rays with 15 to 18 peripheral and 10 to 15 central spinelets, which are much longer than in *californicus*, terete, with rounded or clavate tips. Tabulum of paxilla fairly broad so that both central and peripheral spinelets appear spaced, giving the whole an open flori-form appearance. Farther along ray, 1 to 6 central spinelets to a paxilla, and upwards to 15 or 18 peripheral. At very end of ray the paxillæ are much smaller.

Superomarginal plates 32 to a ray, without enlarged spinelets or tubercles. General surface covered with short spinelets, delicate except along median transverse line where they are cla-

vate to thimble-shaped, increasing in size toward upper end of plate (same spinelets are markedly squamiform in *californicus*).

Armature of inferomarginal plates very similar to that of *californicus*, there being usually 2 or 3 marginal spines obliquely placed, and, in a line, 3 more spaced, smaller, spines along aboral edge of plate. The auxiliary lateral spines situated just adoral to the regular lateral spines on each plate are longer than the same spines of *californicus*.

Adambulacral furrow spines 3 or 4, similar to those of *californicus*. First actinal series with 2 spines, the aboral being much the longer, tapering, slightly flattened, bluntly pointed, longer and slenderer than the corresponding spine of *californicus*. The adoral member is about as long as the furrow spine which stands vis-à-vis. Outer or second actinal series usually consists of 3 slender untapered spines somewhat shorter than furrow spines, and standing in a fairly regular row. Near base of furrow 2 or 3 very small spinelets sometimes stand on outer end of plate.

Mouth spines similar to those of *californicus*, but the marginal series stand slightly spaced from the intermediate spines, so that inner end of combined plates is broader and the 3 series, superficial, intermediate and marginal, are more clearly evident. All spines are slenderer and a trifle longer than in *californicus*. Marginal spines, about 7 between tooth and inner end of first adambulacral plate; and about 6 or 7 more minute spinelets continue the series two-thirds distance to outer end of plate.

Madreporic body concealed by paxillæ, situated as in *californicus* and crossed by sinuous striæ; tiny, spiniform knobs on ridges of *californicus* apparently lacking.

Color in alcohol, bleached yellowish to whitish; color in life unknown.

Type, No. 21927, U. S. Nat. Mus. Type locality, vicinity of Santa Barbara Islands, in 150 fathoms. The vertical range is 67 to 162 fathoms, and the species extends south to Lower California at least, and north to the latitude of Monterey Bay.

Remarks.—This species differs from *A. fragilis* Verrill in having numerous actinal adambulacral spines and shorter rays.

A. regalis Gray, a short-rayed form, also has but one actinal adambulacral spine, scarcely longer than longest furrow spine. *A. verrilli* de Loriol differs from *ornatissimus* in having a different inferomarginal and adambulacral armature. The superomarginal plates of *verrilli* carry small tubercles forming a single longitudinal series. *A. rubidus* de Loriol is allied to *articulatus* (Say), having broad superomarginal plates, a smaller disk than *ornatissimus*, and with rays broader at tip, paxillæ with shorter spinelets, and adambulacral plates with much smaller spinelets — 3 small ones in actinal series.

Family LUIDIIDÆ (Sladen) Verrill.

Genus *Luidia* Forbes.

Luidia Forbes, Mem. Wern. Soc., VIII, 1839, 123.

There are three species of *Luidia* occurring off the California coast. In literature two names occur — *Luidia foliolata* Grube¹ and *L. californica* Perrier.² According to Ludwig the latter name is a nomen nudum; hence it need not further be considered. Ludwig³ further states that Grube gives California as the locality of *foliolata*. I have not been able to consult Grube's description, but from the fact that Sladen thinks *foliolata* may not be distinct from *brevispina*, I have considered that the name must apply (if not actually to *brevispina*) to a common, shallow water *Luidia* (Southern Alaska to San Diego, and Mazatlan?) which is closely related to *brevispina*. This form I have compared with specimens of *L. brevispina*, and it is perfectly distinct. If the name *foliolata* does not apply to it, it is a new form.

The other 2 species are evidently new and the more evident characters of the 3 forms are contrasted in the following synopsis.

¹Ueber einige neue Seesterne des Breslauer zoologischen Museums < 43 Jahresber. d. Schlesisch. Gesellsch. f. vaterländ. Kultur, Breslau, 1866, 59. (*Fide* Ludwig.)

²Étude sur la répartition géographiques des Astérides. < Nouv. Archiv Mus. Hist. Nat. Paris, II ser. I, 1878, 35, 91. (*Fide* Ludwig.)

³Mem. Mus. Comp. Zool., XXXII, 1905, 80, footnote.

- a. Lateral abactinal paxillæ with a quadrate or subquadrate tabulum.
 b. No pedicellariæ; abactinal surface drab gray or greenish gray in life*Luidia foliolata*.
 bb. Pedicellariæ (bivalved) on inferomarginal plates (abactinal end) and on superomarginal paxillæ, and trivalved upright pedicellariæ on actinal intermediate plates; abactinal surface reddish in life, sometimes mottled with lighter*Luidia ludwigi*.
 aa. Paxillæ with stellate crown; granuliform abactinal 2-jawed pedicellariæ; slender 2-jawed actinal intermediate pedicellariæ; rather prominent lateral spines.....*Luidia asthenosoma*.

LUIDIA LUDWIGI Fisher, new species.

Rays 5. $R = 107$ mm.; $r = 13$ mm. $R = 8.2r$. Breadth of ray at base, 15 mm.

Rays slender, very gradually tapering to a pointed extremity; interbrachial arcs acute; general form depressed as in other species of genus, but abactinal surface well arched; sides of ray rounded; abactinal area with 3 or 4 regular series of quadrate paxillæ on each side, the superomarginal with small 2- and 3-jawed pedicellariæ; inferomarginal plates rather narrow, arched, with 1 to 3, *usually* 2, lateral spines, and 3-6 actinal spinules larger than spinelets of general surface, and on upper end a pedicellaria similar to that of adjacent paxilla; actinal intermediate plates of interradian areas and proximal half of ray each with a rather prominent 3-jawed pedicellaria; adambulacral plates with a curved furrow spine, 3 actinal spines and 1 or 2 smaller spinules.

Abactinal paxillar area rather crowded; paxillæ of 4 or 5 lateral regular series, quadrate; fourth, fifth, or sixth series (according to size of specimen) with many subcircular or not obviously quadrate paxillæ; superomarginal paxillæ slightly smaller than those of adjacent series; paxillæ thence decreasing in size toward mid-radial area where they are arranged without regularity and are roundish or irregular in outline. In some small specimens paxillæ are not so obviously quadrate in lateral series, being subcircular in outline, but nevertheless arranged regularly. Crown of spinelets not so flat as in *foliolata* but rather convex especially in small examples; supero-

marginal paxillæ with about 35 short clavate spinelets in a radiating coördinate group, and most of them also with a small 2-jawed valvate pedicellaria, slightly longer than spinelets; next series with about 40 spinelets, those in center of tabulum stouter than the peripheral, as in superomarginal paxillæ; small mid-radial paxillæ with about 20 spinelets.

Inferomarginal plates relatively narrower than in *foliolata* (*i. e.*, with reference to transverse axis of plate); fasciolar grooves deep, and wider (with reference to long axis of ray) than same dimension of special raised ridges of inferomarginals. Outer or abactinal end of each plate with a 2-jawed pedicellaria similar to that of adjacent superomarginal paxilla, and with 1 or 2, usually 2, tapering sharp spines, of which sometimes the inner, sometimes the outer, is the longer; the longer (about 4 mm.) equal to about width of its plate; more rarely 3 shorter subequal spines in transverse series on outer end of plate; spines forming a prominent marginal fringe to ray; on actinal surface of plate, 3 to 6 much shorter spinules form a transverse series in line with lateral spines, or a zigzag, or even double series, while margin of plate bears slender terete spinelets, becoming more capillary in fasciolar grooves.

Adambulacral armature consisting of a curved sabre-shaped furrow spine, and on actinal surface 3 tapering bluntly pointed spines, of which 1, the longest, stands behind furrow spine and the other 2 form a slightly oblique longitudinal series just behind first actinal spine; or 2 spines, the adoral the shorter, stand in a longitudinal series just behind furrow spine, and the third just outside of the aboral (longer) spine of the series; 1 to 3 small slender spinelets occur on outer part of plate, frequently 3 at base of ray forming a longitudinal series, or 1 on adoral edge of plate, back of outer adoral spine.

Actinal intermediate plates of interradial region and proximal half of ray paxilliform, surmounted by a prominent 3-jawed pedicellaria which is surrounded at base by numerous slender spinelets in a calyx-like whorl. Each pedicellaria is conical and 1.5 to 2 times as high as its width at base.

Mouth plates narrow, with 6 or 7 marginal spines and 7 or 8 superficial ones, forming together a double series on the raised

exposed surface of plate parallel with median suture. Inner spine of superficial series largest, and like the rest, slender, pointed, tapering. All spines decrease in size toward outer end of plate. Innermost marginal spine situated nearer peristome than is the enlarged inner superficial spine.

Madreporic body between second and third lateral rows of paxillæ, and hidden by them.

Type, No. 21928, U. S. Nat. Mus. Type locality, Albatross Station 2970, vicinity of Santa Barbara Islands, in 29 fathoms, on fine gray sand and mud.

Remarks. — This species has the general form of *L. lorioli* Meissner (Mazatlan), but has longer arms, which are more attenuate distally. *L. ludwigi* lacks the conspicuous sharp spinules which are present in many of the lateral abactinal paxillæ of *lorioli*, and the latter has no abactinal pedicellariæ, such as are very characteristic of the present species. Another character which separates *ludwigi* from both *lorioli* and *bellonæ* Lütken is the presence of prominent pedicellariæ on the actinal intermediate plates of interradial region and proximal half of ray. Details of adambulacral armature differ in all three forms. *L. ludwigi* differs from *L. quinaria* in having much longer narrower rays, no scattered and abundant abactinal pedicellariæ over the midradial region, and in having 3-jawed, not 2-jawed, actinal pedicellariæ. The abactinal pedicellariæ of *quinaria* are low, and of the bivalved form of some Goniasteridæ. The adambulacral plates also have 2-jawed pedicellariæ in *quinaria*.

Named for Prof. Hubert Ludwig.

LUIDIA ASTHENOSOMA Fisher, new species.

This fragile creature bears a close resemblance to *L. sarsi* Düben and Koren, of northern Europe and the Mediterranean, and may be looked upon as a north Pacific representative of that species. None of the specimens are as large as *L. sarsi* is known to grow. The California species differs from *sarsi* in having very small, abactinal, 2-jawed (rarely 3-jawed), granuliform pedicellariæ scattered along the medioradial area, with larger ones, sometimes, on the regular lateral paxillæ, and on upper end of inferomarginal plates. The inferomarginal spines

are longer, the adambulacral armature and minor details of paxillæ are different.

Rays 5. $R = 86$ mm.; $r = 9$ mm.; $R = 9.5r$. Breadth of ray at base, 10 to 11 mm.

Rays long, narrow, pointed, very gently tapering, with a slightly convex abactinal surface usually sunken along midradial line. General form much flattened; sides of rays rounded; inferomarginal plates narrow, not encroaching much upon actinal area, but forming rather the margin of ray; ambulacral furrow wide and shallow; tube feet long, in 2 series; actinal and marginal spines rather long and bristling, the adambulacral armature forming 2 series continuous with that of inferomarginal plates; actinal intermediate plates usually with a rather short, 2-jawed, blunt, papilliform pedicellaria.

Abactinal paxillæ with a stellate crown; those of superomarginal series larger than rest, and each corresponding to an inferomarginal plate, to upper end of which it is closely juxtaposed. Crown of superomarginal paxilla longitudinally oval (as in *sarsi*), the others subcircular. Adjacent to superomarginal paxillæ are about 2 regular series of lateral abactinal paxillæ, about 2 of which correspond to 1 superomarginal paxilla. Paxillæ diminish in size very rapidly toward median line of ray and become less regular in arrangement as they approach it. Superomarginal paxilla has slightly convex tabulum armed with about 30 slender denticulate spinelets, of which about 10 are scattered on surface of tabulum and the remainder about the periphery, the whole forming a diverging group. The superomarginal and other lateral paxillæ sometimes have a blunt 2-jawed pedicellaria similar to but larger than those scattered over the midradial area (see below). The adjacent paxillæ have about 12 peripheral and 3 to 5 central spinelets, while those in midradial region have about 10 peripheral and 3 or 4 central, very much smaller, spinelets, the whole paxilla being notably smaller. Many of small paxillæ of midradial area also bear in center of tabulum, surrounded usually by a few small peripheral spinelets, a small obovoid 2-jawed valvate pedicellaria, resembling a split granule. Viewed from above, the pedicellaria is elliptical in shape when closed. Each jaw is .

hollowed on inner face and occasionally is larger, springing from a very low paxilla and emerging between the others. Rarely there are 3 jaws. Jaws of pedicellariæ much thicker and more robust than any paxilla spines.

Inferomarginal plates relatively very narrow, transversely arched, encroaching but slightly upon actinal surface, forming rounded margin to ray; chord of width equal to 1.5 times that of adambulacral and actinal intermediate plates combined. Fasciolar grooves deep and wide, slightly wider (*i. e.*, measured on long axis of ray) than corresponding dimension of specialized elevated ridge of plate. Each plate with a transverse series of 3 robust, tapering, sharp spines, of which the outer is often slightly the longest, but frequently the middle one, or the 2 are subequal; inner (actinal) spine of series is sometimes much slenderer than other 2, and only one half or two thirds length of longest spine; latter attains a length of 5.5 mm. or slightly over one half width of abactinal paxillar area, or nearly twice width of plate (*i. e.*, chord of width). General surface of plate covered with slender almost capillary spinelets which become finer in fasciolar grooves; and upper end of plate sometimes bears a pedicellaria similar to those of abactinal surface.

Adambulacral plates with a slender sabre-shaped furrow spine, and forming a linear series with it on actinal surface, 2 slender tapering pointed spines, the inner of which is the stouter and slightly the longer. A couple of very slender spinelets stand on adoral side of outermost spine, which decreases in size toward extremity of ray more rapidly than the inner.

On most of the actinal intermediate plates of proximal two thirds of ray is a small 2-jawed pedicellaria accompanied by 2 or 3 capillary spinelets; when former is absent its place is taken by about 3 to 5 capillary spinelets; jaws of pedicellaria blunt, oblong to obovate, 0.5 mm. high; 3 or 4 pedicellariæ in interradiial region, but very few spinelets.

Mouth-plates more like those of *Astropecten* than most species of *Luidia*. Exposed surface of combined plates, ovoid, prominent; suture between plates fairly wide. Armature consisting of a slightly tapering, bluntly pointed tooth and back of

that on margin a large 2-jawed pedicellaria nearly as long as tooth. Two shorter spines may take the place of the pedicellaria. In line with the tooth a series of about 10 superficial spinelets follows edge of suture, decreasing in size toward outer end of plate; and along curved margin adjacent to first ambulacral are 4 or 5 slender spinelets, the second from inner end of series often the longest. This series is separated from the superficial by a shallow groove.

Color in life, reddish brown (burnt Sienna) on abactinal surface; marginal spines lighter, often whitish; actinal surface whitish.

Type, No. 21929, U. S. Nat. Mus. Type locality, Albatross Station 3148, off Central California in 47 fathoms, on brown mud.

Family ECHINASTERIDÆ Verrill.

Genus *Henricia*¹ Gray.

Henricia Gray, Ann. and Mag. Nat. Hist., Ser. 1, VI, 1840, 184.

Type, *Asterias sanguinolenta* O. F. Müller.

Linckia Forbes, non Nardo, Mem. Wern. Soc. VIII, 1839, 120.

Cribrella Forbes, non Agassiz, Brit. Starfishes, 1841, 106.

Cribrella Lütken, Grönl. Echinod., 1857, 30; and most authors since then.

Echinaster M. & T. Syst. Ast., 1842, 22 (pars).

Henricia Bell, Ann. and Mag. Nat. Hist., Ser. 6, VI, 1890, 472.

HENRICIA ASPERA Fisher, new species.

Rays 5. $R = 100$ mm.; $r = 15$ mm.; $R = 6.6r$. Breadth of ray at base, 14 mm.

Disk small, rays slender, usually not swollen at base. Abactinal skeleton forming an open meshwork, the individual plates

¹ *Cribrella* Ag., the name long used for this genus, is a synonym of *Linckia* Nardo. Forbes appropriated Agassiz's name and transferred it to a different group, that is, to the genus which Gray had previously named *Henricia*. *Cribrella* Forbes drops out of nomenclature both because it is a synonym of *Henricia* and more especially as it is a homonym of *Cribrella* Agassiz. The *Cribrella* of Agassiz was proposed (Mem. Soc. Sci. Nat. Neuchâtel t. 1, 1835. 191) as a substitute name for *Linckia* Nardo, the latter being now in use. Consequently *Cribrella* Ag. has no status other than as a synonym of *Linckia*.

indistinguishable and spinelets very short granuliform, not arranged in evident pseudopaxillæ as in *leviuscula*. Meshes roundish quadrate, or irregularly polygonal, more open in some examples than in others, containing sometimes 1 or 2 small secondary ossicles with a few granuliform spinelets. Meshes usually considerably wider than enclosing trabeculæ, and with 5 to 12 papulæ on proximal two-thirds of ray, 5 to 7 distally (but fewer in small specimens). Spinelets not crowded, but spaced, short, sharp, much slenderer, and fewer than in *leviuscula*, often reduced to mere granuliform sharp elevations on plate and more or less obscured by a tight thin skin; arranged along ridges irregularly, but in not over three rows, often in only one irregular series. These rows are interrupted, dividing the spinelets and granules into groups probably corresponding to underlying plates, although no divisions are evident. There are commonly 5 to 15 spinelets in one of these groups, but in some specimens they are so obscured by the superficial membranes that only the very tips of the spinelets are visible. They are invisible to the naked eye, and are seen with difficulty under a strong glass. Division into groups more evident on sides of ray.

Marginal plates regularly arranged. Superomarginal series departing from interradiial angle about midway between dorsal center of disk and inner angle of jaw-plates; occasionally rather irregular near interbrachial angle; plates sometimes transversely elongated, with 10 to 12 spinelets. Inferomarginals slightly larger or exactly equal to superomarginals; 1 or 2 rows of intermarginal plates on basal fifth of ray; also 1 or 2 rows of actinal intermediate plates, 2 extending about one fifth length of ray, and 1 series for one half length, beyond which point inferomarginals and adambulacrals are in contact. Inter- and inframarginal papulæ; 1 to 6 in an area. Marginal plates also form fairly regular transverse series with adambulacrals, although latter are more numerous than former.

Adambulacral plates with 1 small spine deep in furrow; on some plates, especially in large specimens, a second may be present just above it and in line. On actinal surface 2 larger spines stand in an oblique transverse series on furrow margin

(frequently a group of 3); and behind them 3 or 4 much shorter graduated spinelets in a single zig-zag series, all more or less united basally by membrane. Armature varies greatly, sometimes 2 transverse series of spines being present, and the spines themselves vary in shape from slender cylindrical tapering to thick, clavate and blunt. Armature generally has appearance of being in a single series and rather sparse. The outer spinelets of some specimens (those which have very minute spinelets generally) are buried in membrane and all but invisible.

Madreporic body variable — usually subtubercular, roundish, with coarse striations.

Color in life: Abactinal surface deep chrome yellow; papular areas deep saffron yellow; actinal surface pale Indian yellow.

Type, No. 21930, U. S. Nat. Mus. Type locality, Albacross Station 3052, off Oregon in 48 fathoms, on "coral," broken shells and rocky bottom.

HENRICIA POLYACANTHA Fisher, new species.

Rays 5. $R = 66$ mm.; $r = 11$ mm.; $R = 6r$. Breadth of ray at base, 13 mm.

Rays moderately to decidedly slender, very flexible, tapering gradually to bluntly pointed, upturned tip; abactinal surface usually collapsed more or less; disk rather small; adambulacral plates at base of ray with 30 to 40 actinal spinelets, and in furrow, instead of the usual single spinelet, 2 to 6 such spinelets grouped or in a vertical series; always more than 1 furrow spinelet; at base of ray always more than 3.

Abactinal and lateral surfaces of rays covered with small, evenly-spaced pseudopaxillæ, leaving papular areas considerably larger than the plates; papulæ 1 to an area, large. Without aid of a glass the papular areas appear roundish. Paxillæ more or less elongated in one direction; convex, covered with exceedingly small spinelets, which are numerous, but vary greatly in number, according to the size of pseudopaxilla; 10 to 40 is the usual number. Paxillæ form a more or less evident median radial line along ray.

External to adambulacral plates is a regular series of actinal intermediate plates, and separated from the latter by a regular series of papulæ is a row of smaller inferomarginals. Sometimes a superomarginal series can be distinguished just above the inferomarginals, especially on outer part of ray, where the 2 series are fairly regular. At base of ray the serial arrangement is broken up and 2 or 3 additional series of small intermediate plates are interpolated. The "marginal plates" are larger than dorsolateral pseudopaxillæ.

Adambulacral plates separated by a distinct suture. Armature very dense, consisting of many spinelets, as follows: (1) on furrow face of plates 2 to 6 small sabre-shaped spinelets in a vertical series, or more irregularly in 2 series. The number varies in different individuals. Usually there are 5 or 6 at base of ray and 2 or 3 to each plate beyond middle. Occasionally specimens have more than three on plates of distal portion of arm. (2) On actinal surface of plate are 30 to 40 slender pointed spinelets arranged in 3 or 4 transverse series on inner half of plate, but too crowded on outer half to form rows. Even the inner spinelets are often without regularity. Spinelets decrease rapidly in length and calibre from the furrow outward, the outer spinelets being sharper than the inner and about the same size as those on other actinal plates.

Madreporic body prominent, tubercular, situated midway between center of disk and interbrachial angle, there being small spinelets scattered on the surface. Striations coarse, irregularly radiating.

Type, No. 21931, U. S. Nat. Mus. Type locality, Albatross Station 2936, off Dan Diego, Cal., in 359 fathoms, on mud.

Family SOLASTERIDÆ Perrier.

Genus *Crossaster* Müller & Troschel.

Crossaster Müller & Troschel, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1840, 103.

- a. Marginal plates of two kinds in a single linear series — conspicuous transversely oriented, prominently spinous, paxilliform plates alternating with 1 or 2 low longitudinally placed plates with

short spinelets; proximal marginal plates strictly actinal in position; adambulacral plates with usually four actinal spines. Papulæ very conspicuous; abactinal skeleton more open.

Crossaster alternatus.

- aa. Marginal plates of one kind, viz.: conspicuous transversely oriented paxilliform plates which are strictly marginal in position; adambulacral plates with 2 or 3 actinal spines. Abactinal skeleton less open *Crossaster borealis.*

CROSSASTER ALTERNATUS Fisher, new species.

Rays 10. $R = 63$ mm.; $r = 24$; $R = 2.6r$. A larger specimen taken between San Diego and San Clemente (500 fathoms) in 1904 measures as follows: $R = 100$ mm.; $r = 34$ mm.; $R = 2.9r$. Breadth of ray at base, 23 mm.

General form flattened; abactinal surface of disk slightly convex, capable of inflation, but flattened on central part; abactinal surface of rays slightly rounded; margins well rounded; actinal surface nearly flat; interbranchial angles rather acute; abactinal skeleton open reticulate, the ossicles slenderer than in *Crossaster papposus*; papulæ large; paxillæ small, well-spaced; marginal plates characteristic, more prominently spinous transversely placed plates alternating with (usually 2) longitudinally oriented plates with very short spinelets; marginal plates actinal in position on basal half of ray; actinal interradial areas small, with few plates set fairly close together; a single series of very small intermediate plates extending to end of ray; adambulacral plates with 4 to 8 furrow spinules and a transverse series of 4 actinal spinules.

Abactinal integument rather thin but tough and pliable, parchment-like, quite opaque and obscuring the ossicles unless dried. Skeleton open and forming a net-work with fairly wide meshes, which are irregular and largest on disk; connecting ossicles slender, often irregular; enclosed within meshes, small free irregular ossicles; these often absent, but usually present on disk and most numerous near its center. Paxillæ with a 2- to 4-slender-lobed base and a low stout pedicel surmounted by usually 4 or 5 rough, delicate tapering, pointed, spinelets enclosed in a delicate membraneous sac, which fits tightly about

each spinule for about half its length, leaving only its basal part obscured. In consequence of the open character of skeleton, paxillæ are well spaced, but are much smaller and more numerous than in *Crossaster papposus*. They are largest and most widely spaced midway between center of disk and margin on radial areas, thence rapidly diminishing in size toward extremity of ray and less toward center of disk. A bare sulcus leads from each interradial angle half way to center of disk. These bare areas are about 1 mm. wide and are paved solidly with ossicles which are the upper edge of the incomplete calcareous interbrachial partition. At the inner end of this bare area, in 1 interradius is the madreporic body surrounded by several paxillæ; in the other radii several slightly larger paxillæ hold a similar position. Papulæ large, partially obscuring the small paxillæ; absent from bare interradial areas; 2 to 7 or 8 to each mesh of skeleton on rays and as many as 15 on disk, or even more where meshes are incomplete. Papulæ commonly 3 mm. long, pointed. In the interradia a number of the abactinal plates are actinal in position because the marginal plates are drawn inward toward the mouth. Thus in the type the distance between marginal plates and interradial angle is 6 to 8 mm., consequently the dorsal integument with plates and papulæ is drawn onto actinal surface.

Marginal plates conspicuous; about 14 or 15 prominent, rather widely spaced, *transversely* oriented, paxilliform plates seem to represent the inferomarginal series, and between each of these, in the same linear series, are 1 to 3, usually 2, *longitudinally* oriented, much lower and slightly smaller plates, which may represent the superomarginal series, although now forming a single series with inferomarginals. Prominent marginals become more conspicuous toward tip of ray, acquiring a heavy, compressed pedicel often higher than its width at top, and very paxilliform in appearance, bearing 2 transverse rows of about 8 to 16 long, tapering needle-like spinules, which increase in length but decrease in number toward extremity of ray. Beyond proximal fourth of ray there are two well-defined series of these spinules, of which the adoral spinules are the shorter, and in the other series about 3 skin-covered spin-

ules become much larger than the rest and have very fine points. Distally the spinules form 2 palmate series, but there is more or less variation in their numbers. The non-prominent longitudinally oriented plates vary considerably in size, and decrease markedly in size distad, whereas the others become more prominent. Except at base of ray, they are not nearly so high as transverse plates and are rounded to elliptical-oblong, bearing upwards to 25 very short spinelets in about 3 or 4 longitudinal series. At tip of ray these plates are very small, bearing a group of 5 or more delicate spinelets.

Actinal interradiial areas small, with small, closely-placed, paxilliform plates bearing 4 to 10 spinelets, which are more delicate than those of abactinal paxillæ, although the latter are of about the same size. Interradiial paxillæ about 10 to 20 in number. Proceeding along ray almost to its tip is an inconspicuous series of very small actinal intermediate plates, often rather widely separated, a plate usually opposite each adambulacral plate, and distally bearing only a single small spinelet, or none at all, proximally with 2 to 5 spinelets.

Adambulacral plates with a palmate furrow series proximally of 6 to 8, distally of 4 or 5, very delicate, tapering sharp skin-covered spinules united for about a third their length by a web. Mesial spinules longest (about one-third width of plate in length) thence decreasing in length toward either end of series. On actinal surface of plate a transverse comb of 4 or 5 slender, needle-like, sharp spines, the 2 or 3 mesial much the longest, the inner usually slightly longer than furrow spinules, often much longer; outermost spine usually nearly equal to the longest, which exceeds in length width of plate. These spines, like those of furrow series, invested in membrane, which forms vane-like lateral expansions (causing the spinule to appear broad and flat near base) and unites them in a common web by their bases. On distal part of ray the large adambulacral spines are similar in size and appearance to the larger inferomarginal spines, already described.

Mouth-plates of the usual shape, rather prominent actinally. Each plate with 3 long slightly tapering pointed spines at inner end, these decreasing in size outward, so that third spine is

about one half length of innermost; thence series is continued to end of plate in 7 or 8 much shorter spines resembling those of first adambulacral plate. All spines skin-covered and united basally by a web. On actinal surface, parallel with median suture and slightly nearer it than free margin, is a comb of 2 to 8 skin-covered sometimes basally webbed spinules similar to but smaller than corresponding series of first inferomarginal.

Madreporic body irregularly circular or oval, situated about midway between center of disk and margin; convex, irregularly and centrifugally striated; about 3 mm. in diameter.

Color in life: "salmon pink."

Young: Young specimens agree very well with the large examples, except that the papulæ are less numerous, and there is a slight reduction in number of spines of interradial, marginal and adambulacral plates, as well as fewer intraradial and marginal plates. In small specimens there is more often only one superomarginal plate interpolated between the transversely oriented inferomarginals, and the former are slightly more superior in position, at base of ray, than in adults. Adambulacrals commonly with 3 to 5 furrow spinules proximally, and about 5 actinal. Usually only 1 or 2 *large* papulæ to a mesh; abactinal spinelets not fewer in number than in adults.

Type, No. 21932, U. S. Nat. Mus. Type locality, Albatross Station 2839, Santa Barbara Islands, Cal., in 414 fathoms, on gray sand.

CROSSASTER BOREALIS Fisher, new species.

Rays 9 to 12. $R = 140$ mm.; $r = 47$ mm. $R = 3r$. Breadth of ray at base, 23 mm.

Related to *C. australis* Perrier. General form much as in preceding species, but disk usually more arched, and commonly slightly sunken in middle; marginal plates prominent, paxilliform, transversely oriented, spaced; not of two kinds as in the preceding species; situated on margin of ray and disk, not proximally encroaching on actinal surface to any great extent; interradial areas small, paved with small roundish close-set plates bearing very few spinelets; a single series of *small* scat-

tered intermediate plates extending nearly to tip of ray; abactinal skeleton similar to that of preceding species, but slightly less open, *i. e.*, meshes somewhat smaller; paxillæ small, spaced, typically arranged with more or less regularity on disk, in series parallel with median radial; anal aperture prominent.

Abactinal integument entirely obscuring underlying skeleton, unless dried or treated with caustic potash. Paxillæ small, spaced, with a low tabulum surmounted by 1 to 6 slender blunt or pointed, tapering spinelets. In life these spinelets are thick, short and stubby, owing to a membranous investment, and are usually 3 or 4 to each paxilla. In center of disk and along distal half of ray, paxillæ irregularly arranged, but between these two areas an arrangement in longitudinal rows more or less evident. Base of paxillæ with 3 or 4 slender unequal lobes impinging upon those of neighboring paxillæ or connected by short irregular ossicles; latter not numerous; near center of disk there are 1 or 2 isolated ossicles in many of the meshes. Anus surrounded by 4 or 5 large paxillæ. As in preceding species a very narrow bare sulcus extends from interradiial angle about half way to center of disk. Papulæ prominent, but usually not quite so large as in preceding species, about 3 to 10 to a mesh on disk, 1 to 3 in distal half of ray where skeleton is closer.

Marginal plates, about 30 to each side of a ray, prominent, confined to side wall of ray, paxilliform with fairly high pedicels (relatively about as in *papposus*), bearing 2 vertical or transverse palmate series of 6 to 9 stout tapering pointed skin-covered spines, the mesial of which are the longest. Sometimes there is 1 main series and 2 or 3 smaller spines stand adorally out of the series, or there may be a second adoral series of less conspicuous spinules, but few in number. Spines of proximal plates shorter than rest, except near tip of ray.

Actinal interradiial areas rather small, about 35 to 40 plates to each area. Plates obscured by integument which has fine furrows or wrinkles leading from interradambulacral sulcuses to marginal plates. Plates appear spaced, each bearing 1 to 4 short stubby papilliform spinelets, very delicate when dried. Plates arranged irregularly in rows, between the wrinkles. A

series of very small widely spaced actinal intermediate plates extends over three fourth length of ray. They bear usually 1 or 2 stumpy spinelets, or are spineless.

Adambulacral plates with (1) a palmate furrow series of 5 or 6 (distally 3 or 4) slender tapering skin-covered spinelets (united for about half their length by a web) of which the 2 or 3 mesial are subequal, the laterals much shorter. These spinelets are of about same length as in preceding species. (2) On actinal surface a transverse series of 4 (3 on smaller examples, varying to 2 and 5) much longer, slender, terete, blunt, skin-covered spines, the second or third usually longest (exceeding in length the width of plate), the outer about one half length of inner (where there are 3 spines); when 2 spines only are present they are subequal and long.

Mouth plates just a trifle narrower than in preceding species. Free margin with a webbed series of about 11 spinelets increasing in length toward inner end of each plate to 2 or 3 enlarged spines, the innermost stoutest. On actinal surface of plate near inner end of each is a stout, though slender, spine. Sometimes instead of this a small one stands on outer end of plates, or there may be 2 or 3 small spines.

Madreporic body variable in size, similar to that of preceding species, and, like it, situated at inner end of an interradiol fasciole. Two or 3 large paxillæ stand near it.

Type, No. 21933, U. S. Nat. Mus. Type locality, Albatross Station 2858, east of Kadiak Island in 230 fathoms, on blue mud and gravel; also found in Bering Sea, in 987 fathoms, on green mud.

Family PYCNOPODIIDÆ¹ Stimpson (restr.).

Rathbunaster Fisher, new genus.

Rathbunaster Fisher, new genus of Pycnopodiidæ. (Type, *R. californicus* Fisher, new species.)

Near *Pycnopodia* Stimpson, but differing in having a smaller disk, with the rays constricted at base and easily detachable;

¹ Used by Stimpson (Proc. Bost. Soc. Nat. Hist., VIII, 1862, 261), as synonymous with Asteriidæ of modern authors. As here employed it includes *Pycnopodia*, *Rathbunaster* and possibly also *Anasterias*, although I have not examined that genus.

in the entire absence of rudimentary annular or calcareous ridges at base of ray, in the abortion of alternate superomarginal plates beyond base of ray, and in the small widely spaced inferomarginals each bearing a slender spine; in the greater prominence of the adambulacral plates which are placed on the same level with the inferomarginals (and each with a single spine as in *Pycnopodia*); in the less crowded condition of the ambulacral ossicles.

The circular isolated plates on abactinal surface of rays are more numerous than in *Pycnopodia* and each bears a wreathed spine, whereas in *Pycnopodia* spines are rare on abactinal plates of arm. There are no large bivalved pedicellariæ as in *Pycnopodia*. Tube-feet quadriserial except at extremity and base of ray where they are biserial. Ambulacral plates being less crowded, the tube feet are really intermediate in arrangement between the biserial and quadriserial type. Mouth plates are more prominent than in *Pycnopodia* and approach in form the type common to *Brisingidæ*. Actinostome wide, like the *Brisingidæ*.

Named for Dr. Richard Rathbun.

RATHBUNASTER CALIFORNICUS Fisher, new species.

Rays 17 (varying from 13 to 17). $R = 155$ mm. (variable); $r = 23$ mm. $R = 6.7r$ (variable). Breadth of ray at base, 9 to 11 mm.

Disk nearly flat, circular; rays long, slender, *Brisinga*-like, deciduous, more or less constricted at base, adjacent to disk. Abactinal integument thin, translucent on rays, thicker on disk; abactinal skeleton reduced to small circular plates, widely spaced, each bearing a slender needle-like spine heavily wreathed with pedicellariæ; a single superomarginal spine to each plate, widely spaced; a single inferomarginal spine to each plate, twice as numerous as superomarginals; a single long slender adambulacral spine to each plate. Numerous long vermiform papulæ.

Disk resembling that of a *Brisinga* in general form, only larger, the rays being very insecurely connected and therefore readily broken off. Rays in general form suggesting those of

Freyella. Abactinal surface depressed, collapsed on account of the utter absence of any sort of rigidity. On disk, small roundish plates imbedded in membrane are spaced about 2 to 3 mm. apart, each plate being .5 to 1.25 mm. in diameter, and they are slightly more crowded toward center of disk than near periphery; on ray, plates are rather more widely spaced, and about 4 irregular longitudinal series are sometimes evident, although often no serial arrangement is present. These small plates are a trifle convex in center, and bear a single very delicate needle-like spinule, most of which are encircled about the middle or nearer tip by a very elegant wreath of minute crossed pedicellariæ. This wreath consists of a circular expansion of membrane, the upper surface being thickly beset with pedicellariæ, the lower naked. These wreaths are a little larger, and more crowded near center of disk. Scattered between the primary plates are minute grains. Papular pores pierce abactinal integument, the papulæ being long slender, vermiform, and arranged in groups of 2 or 3 up to 10 or 12. On disk they appear very crowded. Intermarginal papulæ present, more or less grouped.

Marginal spines longer and stouter than abactinal and bearing more prominent wreaths of pedicellariæ. Inferomarginal plates small, spaced (not in contact), closely appressed to adambulacral plates, to every 4 or 5 of which there is 1 inferomarginal. Spine borne on a ventral boss of plate, on about same level with adambulacral spines, not much more ventrally as in *Pycnopodia helianthoides*. Just above each alternate inferomarginal, a somewhat larger superomarginal bears a single subequal wreathed spine. These plates touch the inferomarginals and are elongated transversely. Opposite the remaining inferomarginals they are very small and rudimentary, reduced to a tiny ossicle devoid of a spinelet, and wholly invisible until skin is dried. Near base of ray *each* inferomarginal has a spiniferous superomarginal adjacent to it, but soon the alternate superomarginals, as noted above, lose their spine and atrophy. Comparatively few of the inferomarginal spines have a forciform pointed pedicellaria at their base .75 mm. in length. This may stand on plate near base of spine.

Adambulacral plates placed obliquely as in *Pycnopodia helianthoides*, but not so crowded. They are not sunken within furrow as in that species, but are on same level with inferomarginal plates and define true margin of furrow. Each plate bears a single spinule, slightly shorter and much slenderer than inferomarginal spine. No pedicellariæ on either spines or plates.

Mouth plates small, each with a marginal spine pointing across mouth of furrow, another over actinostome, and usually 2 upright spines, subequal to furrow spines, on actinal surface near suture — 1 placed behind the other. Furrow spines may bear 1 or 2 small forficiform pedicellariæ but usually they do not; several, instead, being found on inner angle of plate.

Ambulacral furrow wide and shallow; ambulacral plates not so crowded as in *Pycnopodia helianthoides*. Ambulacral pores in 4 rows, except at very base of furrow, and on terminal third or fourth of ray, where there are but 2 rows. Tube-feet large, rather crowded. At base of furrow they are very evidently in only 2 rows and resemble those of *Brisinga*. Soon the plates become a little more crowded and a not very marked quadri-serial arrangement of the feet then becomes evident. Actinostome very wide, 24 mm. on a disk 44 mm. in diameter.

Madreporic body small, situated near interradi- al angle; distant about its own diameter from edge of disk. Striations radial.

In this species the gonads open to the exterior near base of rays. There is one gonad on either side of ray, much as in *Pycnopodia*.

Type, No. 21934, U. S. Nat. Mus. Type locality, Alb- tross Station 2925, off San Diego, Cal., in 339 fathoms, on mud.