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XV.—*Natural History Notes from H.M. Indian Marine Survey Steamer 'Investigator,' Commander C. F. Oldham, R.N., commanding.*—Series II., No. 7. *An Account of the Collection of Deep-sea Asteroidea.* By A. ALCOCK, M.B., Surgeon-Captain I.M.S., late Naturalist to the Survey.

[Plates IV.–VI.]

§ 1. *Introduction.*

THE Starfishes to be described in the sequel have been dredged since the year 1885, all in water over 100 fathoms, most in water over 200 fathoms, and very nearly half in water over 1000 fathoms deep. A large collection of littoral and shallow-water forms has also been made, but these are not here considered. If it be thought objectionable to have separated the deep-water from the shallow-water forms, it may be urged in justification that within the limits of Indian seas, so far as our experience at present goes, there is no instance of the two sections overlapping, and, on another ground, that almost nothing has been published, and nothing else is promised, about the extremely interesting Asteroidea of the deeper waters of India. Of the basins into which these waters may conveniently be divided the Bay of Bengal proper—the basin best explored by the dredge so far—gives us the smallest number of unknown species. Beyond the

limits of the 30-fathom line it would seem as if the overwhelmingly muddy bottom of the Bay presented conditions specially unfavourable to the existence of starfishes; and after passing this limit we usually dredge nothing until we reach true bathybial conditions in the middle of the Bay. At 561 fathoms on the Andaman side, however, we have met with *Brisinga*, and at about 500–700 fathoms, opposite to the Godávári and Kistna Deltas, on a bottom of hardening clay that seems to be a special habitat for *Flabellum* (*japonicum* and *laciniatum*), *Bathyactis*, *Phormosoma*, and Spatangoids, *Pentagonaster* again appears. When we come to the middle of the Bay, where *Globigerina*-ooze is accumulating, we find forms that are familiar to deep-sea explorers all the world over, namely *Pararchaster*, *Dytaster*, *Porcellanaster*, *Styracaster*, *Hyphalaster*, *Paragonaster*, *Zoroaster*, *Marsipaster*, *Hymenaster*, and *Freyella*.

The enclosed basin of the Andaman Sea in its moderate depths appears to be peculiarly favourable to starfish life, though of its greatest depths—600 to 1200 fathoms—we know nothing. The calcareous sand and ooze (coral, *Globigerina*, and Pteropod) accumulating between 200 and 300 fathoms seems to afford to Asteroids, as to Ophiuroids and Echinoids, an optimum of development. Not only is there abundance, but there is also variety. Though our dredgings have been few, they have brought in twenty-one species, of which sixteen (including three remarkable generic types) are new to science. The species belong to the following genera:—*Pseudarchaster*, *Porcellanaster*, *Astropecten*, *Pentagonaster*, *Dorigona*, *Nymphaster* (common), *Anthenoides*, *Palmipes*, *Chataster*, *Zoroaster* (common), *Cribrella*, *Pedicellaster*, *Stolasterias*, *Brisinga*, *Persephonaster* (near *Plutonaster*), *Dipsacaster* (an *Astropectinoid*), *Mitteliphaster* (near *Calliaster*), and *Dictyaster* (near *Plectaster*).

Concerning the Laccadive Sea our limited zoological knowledge is almost entirely confined to the depths (700 to 1200 fathoms) in the immediate vicinity of the atolls. The Gulf of Manaar may here be very naturally included. The calcareous bottoms of these basins seem to be very favourable to starfishes, and we have in a few hauls found representatives of eighteen species of the following genera:—*Pararchaster*, *Pontaster* (very common), *Porcellanaster*, *Pentagonaster*, *Nymphaster*, *Mediaster*, *Zoroaster* (common), *Brisinga*, and *Persephonaster*.

Our observations have done but little to illustrate the habits of life of the deep-sea Asteroidea. Like some of the common reef-forms they must sometimes live in swarms, as,

for instance, *Zoroaster carinatus*, of which over a score have been taken at one haul, *Pontaster hispidus*, of which about fifty have been dredged at the same time, and *Nymphaster florifer*, of which a hundred and fifty have come up on the tangle-bar. Like their shallow-water relatives they seem to subsist largely on mollusks, the shells of which, along with the chitinous remains of prawns and amphipods, are often to be found in their stomachs; but some of the characteristic bathybial forms, as *Pararchaster*, *Pontaster*, *Porcellanaster*, *Styracaster*, and *Hyphalaster*, appear to gorge themselves with *Globigerina*-ooze. A curious case of symbiosis, which has been observed too often to be a merely accidental association, occurs between *Dictyaster xenophilus* and an annelid.

Some of the species noticed in this paper have already been described in joint papers by Professor Wood-Mason and myself upon the recent dredging-operations of the 'Investigator'; but owing to the discovery of further material in the examination of the collections of former years, I have found it necessary to amend the diagnoses of *Persephonaster* and *Dictyaster*, and I have redescribed *Dytaster anacanthus*, *Persephonaster croceus*, *Persephonaster rhodopeplus*, *Dictyaster xenophilus*, and *Asterias mazophorus*, and have more fully described three species of *Brisinga*, namely *B. insularum*, *B. andamanica*, and *B. bengalensis*, which before were merely named.

I have to express my great obligations to Mr. Sladen's classical volumes on the 'Challenger' Asteroidea, to which I owe guidance on every point. Mr. Sladen's classification is followed throughout, in the conviction that it is the expression of natural relations.

## § 2. List of the Asteroidea, with Descriptions of the Species believed to be new.

### Family Archasteridæ.

#### PARARCHASTER, Sladen.

##### 1. *Pararchaster semisquamatus*, Sladen.

*Pararchaster semisquamatus*, Sladen, 'Challenger' Asteroidea, p. 7, pl. ii. figs. 1 and 2, pl. iv. figs. 7 and 8; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 428.

Bay of Bengal, on a bottom of *Globigerina*-ooze, in 1664 fathoms.

Colour uniform salmon-red.

2. *Pararchaster Huddlestonii*, sp. n.

Rays 5.  $R=11 r$ .  $R$ =about 170 millim. in the type specimen.

Disk very small; rays depressed, very long, tapering.

Abactinal surface covered with small, rather distant, unequal-sized nodular plates, each of which bears a single erect acute spine or spinelet, the spines on the disk being very stout and measuring in the type specimen 5 to 8 millim. in length, while the spinelets on the rays are small and slender and decrease in length from about 2 millim. near the base to less than a millim. at the periphery of the ray.

Supero-marginal plates more than 60, entirely lateral and slightly oblique in position, elongate, oval, tumid; each with a central tubercle bearing a stout acute spine with a basal circlet of spinelets, one of which is sometimes considerably enlarged, especially in the interbrachial region; the odd interbrachial plate is in the form of a salient eminence, upon which stands a spike of preeminent size with a basal circlet of spinelets larger than those on the other plates.

Infero-marginal plates alternate with the supero-marginals and very oblique, elongate, pyriform, tumid; each bears usually three stout sharp spines in an oblique series, the most abactinal being the largest and often having at its base a pair of spinelets; in the interbrachial arc the spines, especially those of the odd plate, are a good deal aborted. The intervals between the infero-marginal plates throughout the ray are occupied each by a large multivalve or pectinate pedicellaria.

Adambulacral plates large, broad, tumid, each with a furrow-series of six to eight compressed obtuse spinelets in a semicircular comb, and with three spinelets obliquely placed on its actinal surface, the two of these nearest the furrow being of conspicuous size.

Mouth-plates large, each with a furrow-series of six or seven spinelets, increasing in size from periphery to centre, and with a suture-series of three much larger spinelets.

Actinal interradial areas very small, not extending beyond the second or third marginal plate; the intervals between the plates occupied by large multivalve (pectinate) pedicellariæ, but the plates are otherwise quite unarmed usually.

Anus subcentral. Madreporiform plate large, subcircular, flat, with fine radial striations.

Ambulacral furrow wide; tube-feet very large, with a small sucker at point.

Papulæ confined to rudely stelliform areas at the very base

of the rays, reaching to the level of the fourth marginal plate.

Bay of Bengal, Carpenter's Ridge, 1520 fathoms, *Globigerina-ooze*.

3. *Pararchaster violaceus*, sp. n.

Rays 5.  $R=9-10 r$ .  $R$ =about 100 millim. in the type specimen.

Disk very small; rays depressed, very long, tapering.

Abactinal surface covered with close-set nodular plates of unequal size, each of which bears from two to four minute capillary spinelets, visible only with a lens on the rays, but plain to the naked eye on the disk, where a few in the centre become distinct spines.

Supero-marginal plates more than 35, entirely lateral and slightly oblique, elongate, rudely oval, tumid; each with a central tubercle, bearing a very stout and sharp spine surrounded at its base by three to five spinelets, one or two of which are usually large; the odd interbrachial plate is a salient eminence which supports a spike of preeminent size rising out of a circle of large spinelets.

Infero-marginal plates alternate with the supero-marginals and oblique, elongate, pyriform, tumid; each with two stout sharp spines, of which the upper is nearly equal in size to and the lower about half the size of the supero-marginal spine, and with several distant spinelets; in the interbrachial arcs the spaces between the plates to the number of four are occupied each by a large pectinate pedicellaria.

Adambulacral plates large, broad, tumid; each with a furrow-series of seven or eight obtuse spinelets in a semi-circular comb, and actinally with two large spinelets. Mouth-plates large, each with a furrow-series of seven or eight spinelets, increasing in size from periphery to centre, and with a suture-series of two much larger spinelets.

Actinal interradial areas extremely small, with apparently in each area only two pairs of distantly spinate plates and a large pectinate pedicellaria between each pair.

Anus subcentral and very distinct. Madreporiform plate rather large, strongly convex, with close radial striations.

Ambulacral furrow narrow.

Papulae confined to oval areas quite at the base of the rays, reaching only to the level of the second marginal plate.

Colours in the fresh state delicate pink, with the disk violet owing to the mud contained in the stomach and its caeca.

Laccadive Sea, 1200 fathoms, coral and *Globigerina*-ooze.

PONTASTER, Sladen.

4. *Pontaster mimicus*, Sladen.

*Pontaster mimicus*, Sladen, 'Challenger' Asteroidea, p. 48, pl. vi. figs. 1 and 2, pl. vii. figs. 5 and 6.

Laccadive Sea, 1000 fathoms, olive mud.

5. *Pontaster cribellum*, sp. n.

Rays 5.  $R=5r$ .  $R=45$  millim. in the type specimen.

Very closely related to *P. subtuberculatus*, Sladen, from the South Pacific Ocean.

No pedicellariæ of any kind present.

Disk of moderate size; rays rather short.

Abactinal surface covered with small paxillæ formed of from six to twelve uniformly minute spiniform granules, three or four round the madreporiform body, and one in each inter-radius having about twenty granules.

Marginal plates uniformly covered with similar granules.

Supero-marginal plates about 21, broad, tumid, almost entirely abactinal in position, articulating rather obliquely with one another; each with a central eminence supporting a single stout sharp spine.

Infero-marginal plates broad, tumid, alternating with the supero-marginals in the basal half of the ray, coinciding with them in the distal half; each with a stout sharp spine at its upper (abactinal) end.

Adambulacral plates distant, broad, each with a furrow-series of about twelve spinelets, standing in an almost circular palisade round a single large actinal spine. Mouth-plates large, each with a furrow-series of six or seven spinelets, of which the most central (adoral) is many times larger than any of the others and slightly larger even than the large actinal spine of the plate, and with a suture-series of small spinelets.

Actinal interradial areas small, not extending beyond the third adambulacral plate, and carrying only about six finely spinate plates.

Anus central, distinct. Madreporiform plate small, situated midway between the centre and the margin of the disk, and outside a very big paxilla.

Papularia small and compact, with only five or six papulae in each.

Colour in the fresh state delicate pink.

Laccadive Sea, 1200 fathoms, coral and *Globigerina*-ooze.

6. *Pontaster hispidus*, Alcock and Wood-Mason.

*Pontaster hispidus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 428.

This species is very closely related both to *P. forcipatus*, Sladen, and to *P. mimicus*, Sladen, but especially to *P. forcipatus*, var. *echinata*, Sladen, from the southern limit of the Indian Ocean.

Abundant on the green mud of the Laccadive Sea at about 1000 fathoms.

7. *Pontaster pilosus*, sp. n.

Also allied to *P. mimicus*.

Rays 5. R=about 6 r. R=70 millim. in the type specimen.

Disk of moderate size; rays rather long.

Abactinal surface covered with densely crowded spinose paxillae of two kinds in nearly equal proportions, the one kind crowned with about eight spinelets of uniform size, the other kind bearing also a central spine—these, seen in mass, producing a shaggy appearance.

Marginal plates extremely tumid, uniformly invested with capillary spinelets.

Supero-marginal plates 30 to 35, forming a broad abactinal border to the disk and rays, each with a large spine quite on its inferior (actinad) margin. [In *P. hispidus* the spine is quite on the superior (abactinad) margin of the plate.]

Infero-marginal plates alternate with the supero-marginals nearly to the tip of the ray, each with a large spine at its superior (abactinad) margin, and with from one to three much smaller and slenderer spines vertically beneath it.

The distant adambulacral plates are so convex marginally as almost to meet from opposite sides across the furrow; each has a furrow-series of about eight spinelets upstanding in a semicircle around a large actinal spine, which is nearly as big as the spines of the corresponding supero-marginal plate; outside the actinal spine an irregular row of capillary spinelets completes the circle with the furrow spinelets. The mouth-plates are hardly modified from this type, but, like the first

two or three adambulacral plates, they bear two large actinal spines, and the most central (adoral) furrow-spine is conspicuously enlarged.

The actinal interradial areas form small crescents, the horns of which touch the proximal end of the third infero-marginal plates; each area carries 21 to 24 small plates in three concentric rows, the plates being closely covered with capillary spinelets, which occasionally fall into the semblance of a pectiniform pedicellaria, and sometimes bearing also a central spine.

Anus subcentral. Madreporiform plate small, placed about midway between the centre and the margin of the disk.

Papularia small and compact, each with about 10 papulæ.

No true pedicellariæ.

Gulf of Manaar, 597 fathoms, green mud.

### DYTASTER, Sladen.

#### 8. *Dytaster exilis*, Sladen.

*Dytaster exilis*, Sladen, 'Challenger' Asteroidea, p. 65, pl. ii. figs. 3 and 4, pl. iv. figs. 9 and 10; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 429.

This species has several times been met with in the Bay of Bengal between 1748 and 1924 fathoms on *Globigerina*-ooze.

#### 9. *Dytaster anacanthus*, Alcock and Wood-Mason.

*Dytaster anacanthus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 429.

Rays 5. R=about 6 r. R=82 millim. in the type specimen.

Disk small, irregularly inflated; rays long, narrow, rigid, tapering; interbrachial arcs rather acute.

Abactinal surface densely crowded with small paxillæ formed of narrow tabulæ capped with numerous close-set granules or papilliform spinelets, those in the centre of the disk and in a narrow band along the middle of the rays being smaller than those elsewhere, and those on the rays being disposed in obliquely transverse rows on each side of this median band.

The supero-marginal plates, 40 to 45 in number, are entirely vertical and lateral in position, almost perfectly square, except in the interbrachial arcs, where their vertical diameter is greater, and are uniformly covered with papilliform granules without any enlarged spines or tubercles.



The infero-marginal plates correspond in number, size, and shape with their exactly superposed fellows of the upper marginal series; they are uniformly covered with papilliform granules, and, except in the apical third of the ray, each bears near the middle of its distal (aboral) margin a long fine accumbent spine, and often another, and occasionally two other, similar but smaller spines vertically below the first.

Adambulacral plates long and large, fairly coinciding base to base with the infero-marginals, each with a straight furrow-comb of 6 to 8 equal obtuse spinelets, and actinally with a dense mass of smaller spinelets which usually fall into three fairly distinct longitudinal series. Mouth-plates very prominent, with widely open sutures, and with the most central (adoral) furrow spine enormously enlarged; actinally each plate is thickly covered with spinelets in a triserial arrangement.

Actinal interradial areas narrow, but extending to the eleventh or twelfth infero-marginal plate, and bearing thickly spinulate plates, the spinelets of which have a tendency to fall into pedicellaria-like clumps.

Anus distinct, central, forming a longish chink-like vent to a short broad intestine. Madreporiform plate placed near the margin of the disk and much concealed by paxillæ.

Colour in the fresh state uniform light rose-madder.

Bay of Bengal, 1748 fathoms, *Globigerina*-ooze and pumice.

The determination of the relations of this species has always given me great trouble. Of described and figured bathybial starfishes it comes nearest to *Psilaster gracilis*, Sladen ('Challenger' Asteroidea, p. 230, pl. xli. figs. 5 and 6, pl. xlii. figs. 9-11), which Mr. Sladen states to be so far different from all its congeners that he only places it with them with hesitation. As far as mere external characters go, our species seems to agree with *Psilaster gracilis* in almost every detail; but I have satisfied myself by dissection that our species has an alimentary canal with both ends opening to the exterior, and for the present I leave it with *Dytaster*.

#### PERSEPHONASTER, Alcock and Wood-Mason.

Close akin to *Plutonaster*, Sladen.

Disk large, flat; rays of moderate length, rigid.

Marginal plates more or less covered with papilliform spinelets and bearing each one or many strong rigid spines: the supero-marginals, which form a broad massive border on

the abactinal surface of the disk and rays, directly superposed to the infero-marginals, plate to plate.

Abaetinal surface covered with close-set paxillæ, which on the rays are arranged in curved transverse rows without any enlarged median series; papulæ distributed everywhere between the paxillæ.

Actinal intermediate areas large, extending far along the ray; the plates closely covered with coarse spinelets.

Adambulacral plates with a furrow-series of obtuse, compressed, slightly radiating spinelets, and actinally with two longitudinal series of coarse papilliform spinelets.

All the spinelets on the actinal surface of the animal are covered with membrane and are grooved, somewhat resembling pedicellariæ to the casual view.

Anus distinct, subcentral. Madreporiform body small, concealed, distant from the margin of the disk.

No true pedicellariæ are present.

The generative glands have the usual position in the inter-brachial arcs.

The ambulacral furrow is remarkably wide.

This genus was first defined in the *Ann. & Mag. Nat. Hist.*, Dec. 1891, p. 430. The examination of further material now permits more precision in the definition.

10. *Persephonaster croceus*, Alcock and Wood-Mason.  
(Pl. IV. figs. 1, 2.)

*Persephonaster croceus*, *Ann. & Mag. Nat. Hist.*, Dec. 1891, p. 430.

Rays 5.  $R=4.5 r$ .  $R=95$  millim. in the  
type specimen.

Disk and rays quite rigid, their abactinal surface covered with close-set spinose paxillæ, which become small and very crowded towards the subcentral anal aperture, and are arranged in transverse series on the rays; a few incipient pedicellariæ adjoin the marginal plates on the disk; the whole abactinal surface is perforated by close-set papulæ.

The very massive supero-marginal plates number 31, and are directly superposed on the infero-marginals, plate to plate; each is coarsely granular in the centre and finely spinulate at the edges, and each bears two sharp rigid spines, one at the abactinal, the other near the actinal end, the former being the smaller and often bifid.

The massive infero-marginal plates correspond, plate to plate, with the supero-marginals; they are uniformly covered with papilliform granules, which are largest in the middle of the plate, and each bears near its upper (abactinal) end a

sharp rigid spine, beneath which is an obliquely vertical row of three or four very slender accumbent spines.

Adambulacral plates with the furrow-margin slightly convex, and armed with a comb of six or seven longish compressed spinelets; actually each carries two longitudinal series of small inflated membrane-clad spinelets, which are grooved down the middle like a barley-corn, four in each series. Mouth-plates small, tumid, with a close suture; each with a furrow-series of about seven spinelets, the most central (adoral) of which is of enormous relative size, and with two longitudinal series of close barleycorn spinelets.

Actinal interradial areas large, the intermediate plates extending to the thirteenth or fourteenth infero-marginal; all are closely covered with barleycorn spinelets, which in the plates adjoining the adambulacrals fall into clumps resembling multivalve pedicellariæ.

Madreporiform plate small and inconspicuous, placed about two diameters from the margin of the disk.

Ambulacral groove extremely broad; tube-feet large, conical. The spirally coiled sacculated intestine opens at a distinct subcentral vent.

Colour in the fresh state olive-yellow, marginal plates pink, tube-feet red.

Gulf of Manaar, 738 fathoms, green mud.

This species, like the rest, seems to resemble *Psilaster patagiatus*, Sladen ('Challenger' Asteroidea, p. 232, pl. xli. figs. 3 and 4, pl. vii. figs. 11 and 12), which Mr. Sladen considers to be an abnormal Astropectinoid of Archasteroid affinities, and quite unlike any other species of *Psilaster*.

#### 11. *Persephonaster rhodopeplus*, Alcock and Wood-Mason.

*Persephonaster rhodopeplus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 431.

Rays 5.  $R=3.5r$ .  $R$  = about 65 millim. in the type specimen.

Disk and rays quite rigid, their abactinal surface covered with very close-set tabulate paxillæ surmounted by numerous uniform flat-topped granules; the paxillæ are very small and crowded towards the subcentral anal aperture, and on the rays fall into transverse curved rows; the whole abactinal surface is perforated by close-set papulæ.

The supero-marginal plates number about 28, and are directly superposed on the infero-marginals, plate to plate; they are covered with granules, which are coarse and distant in the middle of the plate, and are armed with sharp rigid spines—those in the interbrachia with one, those along the

rays with one, or with two or three in a vertical series; at the base of the rays each plate usually bears on its extreme abactinal edge one or two incipient pedicellariæ.

The infero-marginal plates correspond, plate to plate, with the supero-marginals; they are almost smooth in the middle and are covered with papilliform granules round the edge, and are armed with from two to four stout accumbent spines in a median vertical series, the most abactinal being the largest.

Adambulacral plates with a strongly convex furrow-margin armed with six to eight short, truncated, longitudinally-grooved spinelets, and actinally with two longitudinal series of similar spinelets, about five in each series; these spinelets are sometimes almost clavate. Mouth-plates small, very narrow, with the suture widely open; each with a furrow-series of about ten spinelets, of which the most central (adoral) is much enlarged, and with a single suture-series of eight or nine barleycorn spinelets.

Actinal interradial areas large, the intermediate plates extending to about the eighteenth infero-marginal; in the interradial areas each plate carries a pedicellaria-like clump of from six to eight truncate or clavate grooved spinelets, and along the rays each usually carries two short longitudinal series of similar spinelets.

Madreporiform plate small and inconspicuous or quite concealed; placed about midway between margin and centre.

Ambulacral groove very broad; tube-feet large, conical.

The intestine is similar to that of *P. croceus* and opens by a long narrow vent.

Colour in the fresh state "crushed strawberry," with sometimes a golden suffusion; marginal plates pink, tube-feet blood-red.

Laccadive Sea and Gulf of Manaar, 738 to 902 fathoms, green mud.

In a very young specimen a granular epiproctal tube is observed.

## 12. *Persephonaster cælochiles*, sp. n.

Rays 5.  $R=4.75 r$ .  $R=117$  millim. in the type specimen.

Disk thin, flat, flexible; rays very broad at base, but tapering to a fine point, thin and flat, with a remarkably broad ambulacral furrow.

Abactinal surface with close-set paxillæ consisting of a slender cylindrical column crowned by a thick brush of capillary spinelets; the paxillæ of the disk small and irregu-

larly placed, those on the rays in beautifully regular transverse rows; the whole abactinal surface closely perforated with papulae.

Supero-marginal plates 42, superposed on the infero-marginals, plate to plate; almost entirely abactinal in position; closely covered with membrane-clad granules, and bearing at the actinal end each a stout procurrent spine.

Infero-marginal plates corresponding, plate to plate, with the supero-marginals, covered with similar granules, and armed with an obliquely vertical series of, usually, three stout procurrent spines.

The adambulacral plates are practically within the furrow, lying far below (*i. e.* above in the normal position of the animal in life) the level of the infero-marginals; they are distant *inter se*, and their slightly convex furrow-margin bears a comb of, usually, six long needle-like spinelets, while on the actinal surface there are two longitudinal rows of inflated membrane-clad barleycorn spinelets. Mouth-plates long and large, extremely tumid actinally; each with a furrow-series of seven or eight spinelets, the most central (adoral) of which is of enormous relative size, with a suture-series of ten or eleven spinelets, of which the most central is enlarged, and with a few scattered granules between.

Actinal interradial areas narrow, but long, the intermediate plates reaching in a discontinuous series to the twenty-third infero-marginal, and those along the ray lying in a furrow between the adambulacral on the one side and the infero-marginals on the other; each plate with a clump of barleycorn spinelets.

Madreporiform plate small, somewhat concealed by paxillae; placed midway between margin and centre.

Anus central, distinct, receiving the termination of a wide intestine.

Ambulacral groove of great width, its width being two fifths that of the ray; tube-feet very large, conical, in two rows.

Andaman Sea, 230 to 250 fathoms.

This species is readily distinguished by the actinal hollowing of the rays and by the flexibility of the disk.

#### PSEUDARCHASTER, Sladen.

13. *Pseudarchaster mosaicus*, Alcock and Wood-Mason.

*Pseudarchaster mosaicus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 432.

Andaman Sea, 188 to 220 fathoms, green mud.

## Family Porcellanasteridæ.

## PORCELLANASTER, Wyville Thomson.

14. *Porcellanaster cæruleus*, Wyville Thomson.

*Porcellanaster cæruleus*, Wyville Thomson, Voy. Chall. Atlantic, vol. i. p. 378, figs. 97 and 98; Sladen, 'Challenger' Asteroidea, p. 134, pl. xx.; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, pp. 433 and 434.

Andaman Sea, 683 fathoms, blue mud; Laccadive Sea, 738 fathoms, green mud; and Bay of Bengal, 1664 to 1748 fathoms, *Globigerina*-ooze.

## STYRACASTER, Sladen.

15. *Styracaster horridus*, Sladen.

*Styracaster horridus*, Sladen, 'Challenger' Asteroidea, p. 150, pl. xxiii. figs. 5-7, pl. xxvii. figs. 17-20; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 434.

Bay of Bengal, 1748 and 1803 fathoms, *Globigerina*-ooze and pumice.

16. *Styracaster armatus*, Sladen.

*Styracaster armatus*, Sladen, 'Challenger' Asteroidea, p. 153, pl. xxiv. figs. 1-4, pl. xxviii. figs. 1-4.

Bay of Bengal, 1840 and 1924 fathoms, *Globigerina*-ooze.

17. *Styracaster clavipes*, Alcock and Wood-Mason.

*Styracaster clavipes*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 434.

Bay of Bengal, 1748 fathoms, *Globigerina*-ooze and pumice.

## HYPHALASTER, Sladen.

18. *Hypenthalaster tara*, Alcock and Wood-Mason.

*Hypenthalaster tara*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 434.

Bay of Bengal, 1748 and 1997 fathoms, *Globigerina*-ooze and pumice.

## Family Astropectinidæ.

ASTROPECTEN, Linck.

19. *Astropecten*, sp.

A small *Astropecten*, which I think is undescribed, occurs in the Andaman Sea at about 250 fathoms.

## DIPSACASTER, gen. nov.

Disk large, with flat rigid rays of moderate length. Abactinal surface of disk and rays with compact definitely arranged paxillæ and numerous intervening papulæ.

Marginal plates with highly developed ridges and fasciolar channels; the infero-marginals with enlarged spines.

Actinal interradial areas large, with numerous intermediate plates extending far along the ray, and bearing compact rosettes of spinelets.

Adambulacral plates with a palmate or pectinate furrow-series of spinelets, and actinally with several series of spinelets arranged in rosette-like groups.

Madreporiform plate large but concealed.

No anus exists, and though a minute pore is present in the centre of the disk, it has no communication with the lumen of the intestine. No pedicellariæ.

20. *Dipsacaster Sladeni*, sp. n. (Pl. V. figs. 3, 4.)

Rays 5.  $R=3$  to  $3\cdot3$  r.  $R=110$  millim. in the type specimen.

Disk large, quite flat; rays very broad, quite flat, bluntly pointed; interbrachial arcs wide.

Abactinal surface densely covered with paxillæ which have broad bases, long slender cylindrical pedicles, and a glomerular crown of crowded capillary spinelets; the paxillæ are arranged with beautiful regularity in close series of chevrons, the angles of the chevrons pointing to and converging at the centre of the disk.

The marginal plates have the form of great salient cubical blocks, separated from one another by deep trenches; they are densely covered with papillary granules, which at the edges become capillary spinelets that stretch across and completely fill up the trenches.

The supero-marginal plates number 32 (exclusive of the terminal plate); they are without any enlarged spines or tubercles; they are entirely abactinal in position, forming a

broad border to the abactinal surface of the disk and rays. Beyond them, when viewed abactinally, project the infero-marginals for about one fifth of their extent, so that from this view the disk and rays have a double-festooned border—an inner broad border formed by the supero-marginal plates, and an outer narrower fringe formed by the uncovered projecting ends of the infero-marginal plates.

The infero-marginal plates correspond, plate to plate, with the supero-marginals; each carries on its projecting abactinal end a tuft of enlarged spinelets, of which about three, usually in an obliquely vertical row, are particularly large; in the interbrachial arcs, as far as the sixth plate, there are usually from two to four additional enlarged spines in a vertical row down the middle of each plate.

The adambulacral plates are large and distant, each bears a palmate furrow-series of about eight long needle-like spinelets, and actinally a radiating rosette-like or paxilla-like group of about twelve very much shorter spinelets. Except that the mouth-plates are a little larger and have slightly larger spines, they are not much modified from the adambulacral type.

The actinal interradial areas are very large; on the disk each area carries about ninety strongly carinated plates arranged in slightly oblique rows; and on the rays similar plates extend in a double series to about the tenth, and in a single series to about the twentieth infero-marginal. In the undenuded state each plate has the appearance of a very large compact and beautifully expanded glomerular paxilla, owing to the fact that the central carina of the plate bears a multitude of stiff radiating spinelets arranged like the florets of a composite flower.

Madreporiform plate very large, entirely concealed by enlarged paxillæ, placed a little nearer to the margin than to the centre. There is a central pore, anal in position, but having, as is seen by dissection, no connexion with the gut.

The tube-feet, which are in two rows, have a simple papillary point.

Andaman Sea, 250 fathoms.

I beg to name this fine species after Mr. Percy Sladen.

#### Family *Pentagonasteridæ*.

*PENTAGONASTER*, Linck, Sladen.

21. *Pentagonaster investigatoris*, sp. n.

$R=1.6 r$ .  $R=82.5$  millim.

Disk pentagonal, much inflated in the radial, very concave



in the interradial areas, flexible; rays very short and broad, flat, pointed, rigid, upturned at the tip.

Abactinal surface covered with uniformly small round tabular plates, which are distinctly isolated from one another and are fringed with a single row of flat squamous membrane-clad granules flush with the general surface, but are otherwise naked, except that some of the plates (perhaps one fourth) bear a very excentric or quite marginal broadly bilobed pedicellaria. Papulae long, crowded everywhere, except in a narrow band down the middle of each interradial area, where the plates are in close apposition.

Marginal plates 17 in each series from mid-interbrachium to tip of ray, quadrangular, fringed with squamous granules like the abactinal plates, and occasionally bearing a deciduous bilobed pedicellaria; the supero-marginals with a small central patch of deciduous granules, the infero-marginals with a much larger similar patch; at the very tip of the rays these patches of granules are placed on distinct elevations.

Adambulacral plates with a furrow-series of 6 or 7 coarse prism-shaped spinelets, and actinally with (i.) a longitudinal series of three or four large coarse distant granules, one or two of which in a series are often replaced by a bivalve pedicellaria; and (ii.) numerous distant conical granules, arranged in two irregular rows, but sometimes only in one. Mouth-plates large, with the furrow spinelets chisel-shaped, the most central (adoral) one being enlarged.

Actinal interradial areas very large, continued to the tip of the ray; the intermediate plates are rather closely covered with small rounded granules which are more or less deciduous; many of those nearest the actinostome carry one or two rather broadly bilobed pedicellariae.

Anus excentric. Madreporiform plate of moderate size, placed a third of the way from the centre to the margin, with fine radial striations.

Colour in life brilliant orange.

Bay of Bengal, off the Kistna Delta, 678 fathoms, brown mud.

## 22. *Pentagonaster arcuatus*, Sladen.

*Pentagonaster arcuatus*, Sladen, 'Challenger' Asteroidea, p. 277, pl. lii. figs. 1 and 2, pl. xviii. figs. 5 and 6.

I am not quite certain about this determination, although our species conforms exactly to Mr. Sladen's description, and although the habitat supports it—the 'Challenger' specimen being dredged in the green mud of the Japanese Sea at

345 fathoms, and our specimen being dredged in the green mud of the Andaman Sea at 271 fathoms.

23. *Pentagonaster intermedius*, Perrier.

*Pentagonaster intermedius*, Perrier. Nouv. Archiv. du Mus. d'Hist. Nat. sér. ii. tom. vi., 1883, p. 243, pl. v. fig. 5.

From the Laccadive Sea, off Minnikoy, 1200 fathoms, coral and *Globigerina*-ooze.

Colour in the fresh state salmon-red.

24. *Pentagonaster pulvinus*, sp. n.

Rays 5.  $R=2.2r$ .  $R=33$  millim. in the type specimen.

Near *Pentagonaster mirabilis*, Perrier (Arch. Zool. expér. vol. v., 1876, p. 40).

Disk pentagonal, much inflated abactinally and hollowed actinally; rays relatively long and narrow, blunt-pointed, strongly upcurved in the distal half. The strongly convex abactinal surface of disk and rays is covered with hexagonal or polygonal plates, so close-set that, although their boundaries are quite definite, no papulae are visible on denudation nor any papular pores, and all closely covered with angular granules which show a distinctly paxilliform arrangement; the basal interradial plates are more than twice the size of any of the other abactinal plates.

Marginal plates 17 in the upper, 19 in the lower series, measured from mid-interbrachium to tip of ray, all very closely and uniformly covered with granules except the terminal six to eight in the supero-marginal series, which have a central smooth oval boss.

Adambulacral plates with a furrow-comb of about seven nearly equal-sized lamellar spinelets, and actinally with two longitudinal rows of granules, and between these and the furrow a row of three coarse spinelets, the adcentral (adoral) of which is often replaced by a pedicellaria with two spathulate valves.

Actinal surface deeply concave; the actinal interradial areas are large; the actinal intermediate plates extend to the fourteenth infero-marginal, they are large and roughly quadrangular, and are so closely covered with granules that their limits are not easily discerned.

Anus very indistinct. Madreporiform plate small and also very indistinct; it lies outside a much larger basal interradial plate, and is inconspicuous not merely because it is small,

but also because its coarse discontinuous vermicular erosions give it a granular appearance much like that of an ordinary plate.

Colour in the fresh state salmon-red.

Laccadive Sea, off Minnikoy, 1200 fathoms, coral and *Globigerina*-ooze.

#### MILTELIPHASTER, gen. nov.

Allied to *Calliaster*, Gray.

Rays 5, moderately long.

Abactinal surface of disk and rays covered with a close mosaic of round or hexagonal naked plates, which (like the marginal, adambulacral, and actinal interradial plates) have a fringe of squamous membrane-clad granules lying flush with the surface of the plate, and often carry a single large spike or a large pedicellaria; papulæ conspicuous between the abactinal plates.

Marginal plates large, naked, armed with one or two great spines, which may be sharp or may end in swollen bifid or multifid points; sometimes with a pedicellaria also.

Adambulacral plates with a close comb of furrow-spines, and actinally with (two) great spines which end in swollen multifid points; sometimes with a pedicellaria also.

Actinal interradial areas large, some of the plates with great spines swollen and multifid at tip, or with a pedicellaria.

Madreporiform plate small, nearer to the centre than to the margin of the disk. Anus distinct.

The most characteristic feature of the species upon which this genus is, not without hesitation, established is the curious form of the large spines of the under surface; they end in swollen bifid or multifid points, and, recalling as they do the long spines of certain Cidaroids, may be called ineipiently florigerous.

#### 25. *Milteliphaster Wood-Masoni*, sp. n. (Pl. VI. figs. 5-7.)

Rays 5.  $R = 3.6 r$ .  $R = 80$  millim. in the type specimen.

Disk rather large, very thin, rigid, flat, with slight central and radial abactinal convexities; rays rather long, broad at base, thin, rigid, tapering and gently curving upwards from base to tip, the tip being turned right over.

Abactinal surface closely covered with quite smooth, naked, circular, oval, or hexagonal plates, which are fringed

with a single close series of small squamous membrane-clad granules lying nearly flush with the general surface; the central plates and the mid-radial plates to a point about halfway along the ray are much enlarged, and usually bear a central large coarse erect spine from 5 to 8 millim. in length, and often also a large excentric pedicellaria formed of two short-stalked spoons or obovate leaves; the plates elsewhere are small and occasionally carry a pedicellaria, but never a spine; papulae emerge everywhere between the plates, but much more numerously in the centre and along the margin of the disk.

Marginal plates quite smooth, edged like the abactinal plates with squamous granules.

The supero-marginal plates number 20, excluding the globular terminal plate, and are entirely lateral and vertical throughout; they are tumid, and each carries at its abactinal end a large coarse sharp spine, from 5 to 9 millim. long, standing rigidly outwards almost at right angles to the ray; at the tip of the ray the plates have two spines; many of the plates have also one of the large pedicellariae formed of two spoons or obovate leaves.

The infero-marginals correspond plate to plate with the supero-marginals in the interbrachial arcs, but not in the distal half of the ray; each bears on a central eroded eminence one or two, occasionally three, coarse spines, not quite so long as those of the supero-marginal series, and differing from them in having the points bifid or trifid; a few of the plates carry also one of the large obovate pedicellariae.

The adambulacral plates, which, in addition to the edging of squamous membrane-clad granules, have a distantly granular surface, bear a furrow-comb of eight to ten close truncate spinelets, and actually a transversely arranged pair of large spines (Pl. VI. fig. 7) equal in length to those of the infero-marginal series, and, somewhat like them, ending in swollen multifid points not unlike the long spines of *Dorocidaris bracteata* or of *Goniocidaris florigera*; a few of the plates have also one of the large pedicellariae. Mouth-plates with the central (adoral) furrow-spine enlarged—4 millim. long in the type specimen—and each with one large “florigerous” spine actually.

Actinal interradial areas large, extending to the eighth infero-marginal plate; the actual intermediate plates are arranged in concentric chevrons or semicircles, in addition to the edging of squamous granules they often have an incomplete second marginal series of granules, and occa-

sionally either a central large "florigerous" spine or a large obovate pedicellaria.

Anus central. Madreporiform plate small, radially striated, placed a little nearer to the centre than to the margin.

Colour in life a network of cinnabar-red on a yellow ground abactinally.

Andaman Sea, 230 to 290 fathoms.

I have named this magnificent species after its discoverer.

### DORIGONA, Gray.

#### 26. *Dorigona pentaphylla*, sp. n.

A magnificent species, very near to *Dorigona longimaua*, Möbius.

Rays 5.  $R=3.25r$ .  $R=115$  millim. in the type specimen.

Disk large, flat, pentagonal; rays long, broad at base, tapering. All the plates—actinal, marginal, and abactinal—except the adambulacral perfectly smooth and edged with foliaceous granules lying flush with the general surface.

Abactinal surface of the rays entirely occupied by the supero-marginal plates, which from the seventh onward meet across the ray; abactinal surface of the disk covered with hexagonal plates, of which those in a broadly oval petal-shaped area in each radius are distant regular hexagons—in the mid-radial line of predominant size—with long tentacle-like papulæ standing near the angles, while those in a triangular area in each interradius are crowded irregular hexagons without any papulæ intervening.

The marginal plates number about 30 in each series, measured from mid-interbrachium to tip of ray; they are broad massive squares and form a broad margin on both surfaces; the supero-marginals from and including the seventh meet across the ray in a zigzag suture; the infero-marginals are smaller than the supero-marginals and alternate with them, except in the interbrachia, where the two series nearly correspond.

The adambulacral plates are small; each has a semicircular furrow-series of small foliaceous spinelets—ten or eleven in number in the basal half, eight to six in number in the apical half of the ray—of which those at the ends of the series are thickened, while actinally there are three irregular longitudinal rows of depressed granules; most of the plates near the actinostomal end have a central bivalve or trivalve pedi-

cellaria. On the mouth-plates the furrow spines become more prism-shaped.

Actinal interradiial areas very large, the intermediate plates extending to about the fourteenth infero-marginal; the plates, which number about 250 in each area, are arranged in about nine chevrons, and decrease conspicuously in size from actinostome to margin and from ambulacrum to mid-interbrachium.

Madreporiform plate pentagonal, with fine radial striations, placed not quite a third of the way from the centre to the margin of the disk.

Tube-feet with a broad sucker.

Colour in alcohol ivory-white, the papular areas combining to form a beautifully symmetrical, dark-coloured, five-petal flower.

Andaman Sea, 271 fathoms.

#### NYMPHASTER, Sladen.

##### 27. *Nymphaster florifer*, sp. n.

Rays 5.  $R=3r$ .  $R=32$  millim. in the type specimen.

Disk pentagonal, large, very thin and flat; rays of moderate length, very narrow and flat, quadrangular in section; interbrachial arcs wide.

Abactinal surface of the disk displaying in the centre and in the radial areas a large and particularly beautiful and conspicuous rosette of hexagonal paxilliform plates, each inflated petal-shaped segment of the rosette consisting of seven longitudinal rows of plates, of which those in the middle row—coinciding with the mid-radial axis—are of predominant size; the interradiial (interpetaloid) areas are small and triangular and are clothed with small irregularly pentagonal or subcircular plates.

The abactinal surface of the rays, between the plates of the supero-marginal series, is occupied chiefly by a continuation of the large plates, now become rather irregular in shape, of the middle row of the petals, with on each side a discontinuous row of platelets.

The hexagonal plates of the rosette are true paxillæ and consist of a raised tabulum bearing in the centre from one to six (usually two or three) and round the margin from twelve to sixteen flat-topped bacillary granules; the irregular plates of the interradiial (interpetaloid) areas and of the rays are merely covered with minute granules.

The marginal plates are large and rectangular and are uniformly covered with small granules, without any other armature; many of them bear an entrenched pedicellaria, found only on denudation; they number about twenty-two in each series, which correspond plate to plate; the supero-marginals do not meet across the ray even at its very tip.

The adambulacral plates have a pectinate furrow-series of seven to eight long fine spinelets of nearly equal size, the proximal (adoral) one of the series alone being diminutive, and actually a row of from three to five papillary spinelets, and outside these a row of four or five granules. Mouth-plates small, the conjoint pair nearly circular in outline, the armature hardly differing from the adambulacral type except that the granules are more numerous.

Actinal interradial areas large, each area carrying about sixty irregularly quadrangular plates arranged in chevron series; all of these plates are granular like the marginal plates, and many of those nearest the ambulacrum have an entrenched pedicellaria.

Madreporiform plate small but conspicuous, placed very much nearer to the centre than to the margin of the disk.

The papulae are found only in the rosette of the abactinal surface, where they stand with great regularity at the angles of the hexagonal plates.

Andaman Sea, 130 to 250 fathoms.

This species much resembles *Nymphaster bipunctus*, Sladen.

In young specimens  $R = \text{about } 2.2 r$ , the interbrachial arcs are not so wide as they are in the adult, the apical plates are conspicuously large, and the marginal plates number eight or nine in each series.

### 28. *Nymphaster protentus*, Sladen.

*Nymphaster protentus*, Sladen, 'Challenger' Asteroidea, p. 303, pl. 1. figs. 3 and 4, pl. liii. figs. 9 and 10.

Andaman Sea, 220 to 250 fathoms.

### 29. *Nymphaster basilicus*, Sladen.

*Nymphaster basilicus*, Sladen, 'Challenger' Asteroidea, p. 308, pl. lvii. figs. 8 and 9.

Two fine specimens, one from the Laccadive Sea, 1370 fathoms, coral-mud, the other from the Gulf of Manaar, 597 fathoms, green mud.

This species, as Mr. Sladen observes, appears to be very near *Dorigona ternalis*, E. Perrier.

30. *Nymphaster nora*, sp. n.

Rays 5.  $R=6.3 r$ .  $R=120$  millim. in the type specimen.

Disk small, flat, pentagonal; rays very long and slender and tapering, quadrangular in section, but at the tip cylindrical; interbrachial arcs wide.

Abactinal area of the rays entirely occupied by the supero-marginal plates, which from the fifth onwards meet across the ray; abactinal area of the disk covered with hexagonal paxilliform plates, which consist of a slightly raised tabulum closely covered with angular many-faceted granules, of which six to nine form a central group and twelve to sixteen a marginal ring; of these plates the basal interradians are the largest, but those in the radial areas, especially those in the mid-radial line, are also very large; papulae are found in the radial areas only, emerging at the angles of the plates.

The marginal plates number about 40 in each series, they are quadrangular and massive, and are closely covered with angular granules without any other armature; each supero-marginal articulates with two infero-marginals unequally.

The supero-marginals of opposite sides, from the fifth onward, meet across the ray, plate to plate, in a straight suture; each plate presents a broad abactinal plane and a narrow lateral plane, and at the junction of these two planes an inflated angle; the cap-like terminal plate bears five spines in a half hoop.

The infero-marginals are smaller than the supero-marginals; their lateral surface, except in the interbrachium, is twice the breadth of the actinal surface, and the angle at which the two surfaces meet is so inflated that the rays, whether viewed actinally or abactinally, seem to have beaded or festooned borders.

The large adambulacral plates completely close the furrow, the distantly isolated pairs of tube-feet emerging from semi-circular gaps which, by the close apposition of the plates of opposite sides, become isolated circular holes. Each adambulacral plate is, in fact, rudely L-shaped, the broad horizontal limbs of the L's meeting across the furrow, and the much restricted concavities of the L's forming the gaps which, by the apposition of the plates, are converted into closed chambers; actinally the plates are closely covered with granules, while on the furrow-edge each plate has about twelve long compressed spinelets arranged (except in the case of a few plates close to the actinostome) in two divergent



series so as to form a circular palisade round each isolated pair of tube-feet.

Actinal interradial areas large, the irregularly quadrangular and closely granular intermediate plates being arranged in concentric chevrons and numbering about fifty in each area.

Madreporiform plate very small, with coarse radiating striations; placed close to the centre, encircled by three much larger plates, the adcentral of which—the largest of all—is a basal interradial.

Andaman Sea, 490 fathoms.

#### PARAGONASTER, Sladen.

##### 31. *Paragonaster tenuiradiis*, sp. n.

Rays 5.  $R=4.5 r$ .  $R=40$  millim. in the type specimen.

Disk small, pentagonal; rays long, extremely slender, oval in section, rigid.

The abactinal area of the small disk bears large crowded paxilliform plates arranged in regular chevrons and closely covered with angular flat-topped granules, the mid-radial plates being the largest and the mid-interradial plates the smallest of all; the narrow abactinal surface of the rays bears a single series of narrow granular plates intervening between the supero-marginal plates of opposite sides.

The marginal plates, which are large and closely covered with angular granules, number over twenty-five in each series; the supero-marginals, which are a good deal larger than the infero-marginals, are almost entirely lateral on the disk, but largely abactinal on the rays, where those of opposite sides are separated only by a narrow series of abactinal plates; the infero-marginals alternate (more markedly in the distal half of the ray, less markedly in the interbrachia) with the supero-marginals, and those in the interbrachia bear a median vertical series of two to four small spines or spinelets.

The adambulacral plates bear a semicircular marginal series of nine or ten radiating spinelets encircling a few distant actinally-placed spinelets, of which one, standing close to the middle of the marginal series, is more conspicuous than the rest. Mouth-plates prominent actinally, with a close furrow-series of ten or eleven spinelets and a single suture-series of nine or ten spinelets.

Actinal interradial areas small, barely reaching to the third infero-marginal plate; in each area there are about thirty minute scale-like plates bearing distant papilliform granules.

Madreporiform plate completely hidden. Anus central.

Colour in the fresh state pale yellowish pink.

Bay of Bengal, 1748 fathoms, *Globigerina*-ooze and pumice.

### 32. *Paragonaster*, sp.

*Paragonaster*, sp., Ann. & Mag. Nat. Hist., Dec. 1891, p. 436.

A specimen too much mutilated for description was taken with the above; it is characterized by having the papulae in distinctly circumscribed papularia, over which the paxillae are singularly large and prominent.

## MEDIASTER, Stimpson.

### 33. *Mediaster roseus*, sp. n.

*Mediaster*, sp., Ann. & Mag. Nat. Hist., Jan. 1891, p. 13.

Rays 5.  $R=4r$ .  $R=42$  millim. in the type specimen.

Disk small, flat; rays flat, tapering, rigid.

Abactinal surface of the disk covered with paxilliform plates which in the centre and interradii are small, irregular in shape, and crowded together, but which in the radial areas are large and regularly hexagonal and are arranged in regular longitudinal parallel rows; the plates are surmounted by large flat-topped hexagonal granules of unequal size, which fit close together to form a mosaic for each separate plate; abactinal surface of the rays formed principally by the supero-marginal plates, which, however, are separated throughout the ray by at least three rows of small irregularly hexagonal paxilliform plates.

Marginal plates massive, closely covered with hexagonal flat-topped granules, and forming on both aspects a very broad border to the disk and rays; they number thirty-five in each series, and the two series correspond plate to plate; the infero-marginals of the interbrachia have a median vertical series of distant papilliform spinelets or pedicellariae.

The large adambulacral plates have each a radiating furrow-series of seven or eight flattened prismatic spinelets, slightly decreasing in size in each series from the ends to the middle, and actually three unequal longitudinal series of close prismatic granules. Mouth-plates narrow and elongate, each with a furrow-series and a suture-series of coarse papilliform spinelets, which increase in size from periphery to centre.

Actinal interradial areas small, semielliptical in shape, reaching to the third infero-marginal plate; about thirty plates in each area, of which those in the row nearest the ambulacrum are much the largest; all the plates are closely covered with prismatic granules, grouped, except in the particularly large adoral pair of plates, in paxilla-form.

Anus central but indistinct. Madreporiform plate almost completely hidden, rather nearer to the marginal plates than to the centre.

Ambulacral furrow narrow.

Colour in the fresh state light pink.

Laccadive Sea, 740 fathoms, coral-mud.

This species appears to be closely related to *Astrogonium fallax*, Perrier (Ann. Sci. Nat. tom. xix., 1885). Guided by the work of Mr. Sladen and by the description and figures in the 'Boston Journal of Natural History,' vol. vi., 1857, p. 530, pl. xxiii., I have placed it, though not without misgiving, in Stimpson's Pacific genus.

#### ANTHENOIDES, Perrier.

##### 34. *Anthenoides sarissa*, sp. n.

Rays 5.  $R=2.5 r$ .  $R=46$  millim. in the type specimen.

Disk large, flexible, inflatable, especially in the interradial areas; rays moderately long, rigid, broad at base, but quickly becoming narrow and then tapering.

The abactinal surface of the disk and of the rays, except at the extreme tip, where the supero-marginal plates meet across, is cased by flat plates which are covered with a finely and distantly granulose membrane; these plates are of two kinds and of two modes of disposition:—(i.) large stellate or somewhat polygonal plates arranged in series radiating from the centre of the disk, and (ii.) small or minute platelets inlaid everywhere between the large plates. Papulæ emerge in the seams between the plates everywhere except in a narrow band in each interradius.

The marginal plates, which number about 20 in each series, are large and finely and distantly granular. The supero-marginals form a very broad bevelled margin to the disk in the interradia and a narrower margin to the rays, except in the distal third of the latter, where they nearly meet across the ray; except for one, two, or three small inconstant papilliform pedicellariæ occurring on the extreme distal edge

of the plates of the apical half of the ray they are unarmed, but the cap-like terminal plate has a fringe of five spinelets. The infero-marginals, which correspond plate to plate with the supero-marginals, have each a strong lateral bulge on which stands a horizontal series of three (sometimes only two) spines, but in the apical half of the rays there is only one spine, placed on the extreme distal edge of the plate.

The small adambulacral plates have each a palmate furrow-series of six or seven spinelets, and almost in serial continuity with these, and to the central (adoral) side of them, a pedicellaria with two long spoon-shaped valves; actually each plate has near its distal end an eminence on which stands a stout spine longer than the plate itself and usually longer than any of the infero-marginal spines, in addition to two or three pustules; on the mouth-plates, which are extremely prominent actually, the spine and pedicellaria are usually absent, and only the pustular granules present, but the central (adoral) furrow-spines are much enlarged.

The actinal interradial areas are very large, reaching to the sixth or seventh infero-marginal (thirteenth or fourteenth adambulacral) plates; each area bears eighty to ninety large plates arranged in concentric chevrons; all the plates are covered with a distantly granular membrane, and some or all of them (but most constantly those of the series next the ambulacrum) bear one or more papilliform pedicellariæ; the plates of the second series from the ambulacrum are of superior size.

Anus central, distinct. Madreporiform plate large, with fine radial striations; placed rather nearer to the centre than to the margin.

Ambulacral furrow wide; tube-feet with a terminal sucker.  
Andaman Sea, 130 to 250 fathoms.

### Family Asterinidæ.

#### PALMIPES, Linck.

##### 35. *Palmipes pellucidus*, sp. n.

Rays 5.  $R=1.5 r$ .  $R=48$  millim. in the type specimen.

Form a curvilinear pentagon with bluntly rounded angles; flat, very thin and leaf-like, membranous, semitransparent.

Abactinal surface with regular longitudinal and oblique rows of scale-like rhomboid or subhexagonal plates, which gradually diminish in size from the centre to the margin; all the plates are covered with distant erect spicules and bear

each a central tuft of capillary spinelets, the tufts and their constituent spinelets being enlarged in a mid-radial row. The papulæ are in *four* rows, two on each side of the mid-radial line, the inner row on each side extending from the centre of the disk to the tip of the ray, and the outer extending continuously only about halfway along the ray, and thence onward in a broken series. In young specimens there are only two rows of papulæ, one on each side of the mid-radial line.

The papular pores, like the papulæ themselves, are of two kinds; all are encircled by a close palisade of spinelets, but from three to six of the pores of the inner two rows are much enlarged, to give exit each to a singularly long papula, and these are encircled by spinelets of superior length; the small pores give exit each to a small short papula.

The marginal plates, which lie in alternation with the oblique rows of abactinal plates, are minute, and each is edged with a tuft of spinelets and each has a very minute scale-like platelet at its base.

The adambulacral plates have each a palmate furrow-series of six spinelets and actually an oblique or curved series of three or four capillary spinelets; the mouth-plates have a furrow-series of eight or nine spinelets which increase in size adorally and a suture-series of five or six capillary spinelets.

The actinal plates are in regular longitudinal and oblique rows, and diminish in size from the actinostome to the margin; each plate carries a radiating marginal series of capillary spinelets, four in a series near the actinostome, three elsewhere.

Colour in life pellucid hyaline grey.

Andaman Sea, 112 fathoms, blue mud.

### Family Linckiidae.

#### CHÆTASTER, M. & T.

##### 36. *Chætaster*, sp.

In our collection there is a small broken specimen of an undoubted *Chætaster* which I do not at present venture to describe. In appearance it corresponds with the figure of *Chætaster munitus*, Möbius ('Neue Seesterne des Hamburger und Kieler Museums,' pl. i. figs. 1 and 2), and, so far as the description (*op. cit.* p. 3) of that species goes (a description which, however, is certainly incomplete), it corresponds with it exactly. With Professor Möbius's form I should have identified our species, had not *Chætaster munitus*, Möbius,

been pronounced by Mr. Sladen to be merely a synonym of *Nectria ocellifera* (Lamarck).

The single specimen is from the Andaman Sea, 238 to 290 fathoms.

### Family Zoroasteridæ.

ZOROASTER, Wyville Thomson.

#### 37. *Zoroaster Alfredi*, sp. n.

Rays 5.  $R=9r$ .  $R$ =about 190 millim. in the type specimen.

Disk small, hemispherical, tumid above the tumid rays; rays long, narrow, tapering, subcylindrical to cylindrical.

Abactinal surface of disk with large distant, subhexagonal, or substellate primary radials and interradials surrounding a large dorso-central plate, and with numerous small intervening plates; all the plates are closely covered with simple or grooved or bifid membrane-clad spinelets, and the large hollows between neighbouring plates contain each a group of papulæ and a group of pedicellariæ, one of which is of conspicuous size, being about as big as a grape-stone.

The rays have a longitudinal mid-radial row of large subhexagonal plates co-serial with the large primary plate of the apical system, and on each side of it and parallel with it six (in the interbrachia seven, at the end of the rays five) rows of smaller plates, which also form transversely parallel series, the lowest row articulating with the cramped adambulacral plates; all these plates are closely covered with simple or grooved membrane-clad spinelets and pedicellariæ, and bear a centrally-placed spine, which is small, erect, and often obsolescent in the plates of the abactinal rows, but large and acumbent in the four lower rows on each side, gradually increasing in size from above downwards; the large hollow intervals between neighbouring plates, which, in consequence of the symmetry of the plates themselves, also fall into longitudinally and transversely parallel series, contain groups of pedicellariæ, one of which in each group is conspicuously enlarged, and (except between the lowermost two rows of plates) from one to three papulæ.

The adambulacral plates extend vertically far upwards into the furrow, and the whole system is so cramped that the two middle tube-feet of each row are quite perceptibly atrophied by pressure; every alternate plate has a strongly salient intra-ambulacral ridge, upon which stands a row of three or

four large spinelets, each with a large pedicellaria and often also a bunch of small pedicellariæ attached by ligament to its base, and which, deep in the roof of the furrow, bifurcates to give origin to a pair of large bunches of pedicellariæ, twelve to twenty in each bunch; all the adambulacral plates are covered with spinelets and small pedicellariæ on their narrow actinal edge.

Madreporiform plate large, with coarsish radial striations.

Colour in the fresh state "deep salmon-colour throughout, spines a little paler" (*G. M. Giles*).

Bay of Bengal, 1300 to 1380 fathoms, *Globigerina*-ooze.

This large and very beautiful species is readily distinguished by the extraordinary development of its pedicellariæ, especially by the two large cæspitose masses of these organs which are borne on every alternate adambulacral plate between the bases of the tube-feet, and by the large pedicellariæ (much more conspicuous than any of the spines except those on the plates of the two most actinal rows) arranged in regular longitudinal and transverse parallel series along the rays.

It was named by Messrs. Wood-Mason and Giles after Commander Alfred Carpenter, R.N.

### 38. *Zoroaster Barathri*, sp. n.

Rays 5.  $R=16 r$ .  $R$ =about 180 millim. in the type specimen.

Disk extremely small, not differentiated from the bases of the rays, tumid; rays extremely long and finely tapering, semicylindrical.

Abactinal surface of disk with large, close-set, subhexagonal primary radials and interradials surrounding an apical mass formed of a dorso-central and radial underbasal plates, all of equal size; all the plates are very closely covered with capillary spines, and the small depressions which intervene between the plates are perforated for one or two papulæ and bear from one to three pedicellariæ, of which one is sometimes slightly enlarged.

The rays have a longitudinal mid-radial row of large tumid hexagonal plates coserial with the large primary radial, and on each side of it six (in the interbrachia seven, at the end of the rays five) parallel rows of smaller plates, very close-set, the lowest row abutting on the adambulacrals; these plates also fall into close-set transversely parallel series, and all are densely covered with capillary spines that become gradually longer and more slender in each successive row from the

abactinal to the actinal surface; the plates of the lowest (most actinad) two or three rows bear each one or two centrally-placed spines which are of slightly superior size. The small intervals between the angles of the closely apposed plates give exit, except between the two lowermost (most actinad) rows, each to a papula, and (on the plates) between every two papulæ is a pedicellaria.

The adambulacral plates are short and do not extend far up into the furrow; each plate bears on its actinal edge a transverse row of two or three large sabre-shaped spinelets, of which the innermost often carries a large pedicellaria, and every alternate plate has also a prominent intra-ambulacral ridge, on which stand two more spines, of which the outer carries a pedicellaria almost as large and conspicuous as a tube-foot and the inner a small cluster of small pedicellariæ. The mouth-plates bear each two series of long needle-like spines.

Tube-feet quadriserial.

Madreporiform plate very small and much hidden, with a deep, coarse, vermicular sculpture like a peach-stone.

Bay of Bengal, 1520 fathoms, *Globigerina*-ooze.

This fine species is recognized (i.) by its extremely small disk not differentiated from the bases of the rays, and (ii.) by the close capillary spinulation of the plates, which gives the animal a uniformly hairy appearance when dried. It appears to be more nearly related to *Zoroaster longicauda*, Perrier, than to any other described species.

### 39. *Zoroaster planus*, sp. n.

Rays 5. R=16 r. R=210 millim. in the type specimen.

Disk extremely small, depressed; rays extremely long and finely tapering, semicylindrical, depressed.

Abactinal surface of disk with slightly enlarged, close-set, subhexagonal, primary radials and interradials surrounding a mass composed of a dorso-central and radial under-basal plates all of equal size; all the plates are rather closely covered with capillary spinelets, and the dorso-central and the radial plates carry in addition a stout conical fluted spine; the narrow intervals between neighbouring plates each with one papula and often with a single large pedicellaria.

The rays have a longitudinal mid-radial row of large tumid plates, each of which bears, besides the capillary spinelets, a central stout, conical, fluted spine much like a pedicellaria;



on each side of this row are six (seven in the interbrachia, five at the end of the rays) very close parallel rows of smaller plates, the lowest row articulating with the adambulacrals; these plates, which also fall into transversely parallel series, are rather distantly covered with capillary spinelets, the central one of which in each plate (except in the row immediately adjoining the large mid-radial series) becomes a long slender spine that gradually increases in size in each successive row from the abactinal to the actinal surface. The narrow intervals between the angles of neighbouring plates give passage (except between the two lowermost rows of plates) each to one papula, and (on the plates) between the papulae is a rather large pedicellaria.

The adambulacrals plates are short and do not extend far upwards within the furrow; each plate bears on its actinal edge two transversely placed spinelets and occasionally a pedicellaria, and every alternate plate has a prominent intra-ambulacrals ridge on which is borne a row of three spinelets, the innermost being furnished with a cluster of eight small pedicellariae, and the one next the innermost with a single large pedicellaria. The mouth-plates are armed with large needle-like spines.

Tube-feet quadriserial.

Madreporiform plate large, tumid, and conspicuous, with a coarse peach-stone sculpture.

Colour in life salmon-red.

Laccadive Sea, 1200 fathoms, coral and *Globigerina*-ooze.

This species is very like *Z. Barathri*, from which it is easily distinguished, (i.) by the flattened disk very definitely delimited from the bases of the rays; (ii.) by the large salient madreporiform plate; and (iii.) by the large spinelet borne centrally on every plate except the basal interradials and the plates of the row immediately adjoining the mid-radial row on each side.

#### 40. *Zoroaster angulatus*, sp. n.

Rays 5. R=12 to 13 r. R=148 millim. in the type specimen.

Disk small, high, flat-topped; rays long and tapering, high, compressed, and strongly keeled abactinally.

Abactinal surface of disk with close-set, large, tumid, stellate primary radials and basals surrounding a very large tumid dorso-central plate and a ring of small depressed radial under-basals; all the plates bearing distant capillary

spinelets and small marginal pedicellariæ, and the crevices between the plates giving exit to scattered distant papulæ.

The rays with a longitudinal mid-radial row of very large tumid vertebra-shaped plates co-serial with the primary radial, each bearing a central globular or squatly conical spine; and on each side of this mid-radial row seven (in the distal half of the ray six) parallel rows of much smaller tumid octagonal plates, the lowermost of which articulates with the adambulacrals; these plates, which also fall into transversely parallel series, all bear distant capillary spinelets and small marginal pedicellariæ, and all but those in the row immediately adjoining the mid-radial row have a central long needle-like spine, which is largest in the plates of the row adjoining the adambulacrals. The pin-hole intervals between the angles of neighbouring plates (except between the two lowermost rows of plates) are just large enough to give exit to a single small papula.

Adambulacral plates small, almost cylindrical; each plate bears on its actinal surface either three or four long sharp spinelets in two transverse series, one of the spinelets which adjoins the furrow often furnished with one or two small pedicellariæ; every alternate plate has a prominent intra-ambulacral ridge, on which stands a row of two or three long spinelets, of which the innermost bears a cluster of from six to ten small pedicellariæ and the outermost a single large pedicellaria. The mouth-plates are armed with needle-like spines similar to those of the other adambulacral plates.

Tube-feet quadriserial, but the two middle feet of each row reduced in size.

Madreporiform plate very small, not half the size of the basal plate, outside of which it lies almost hidden by overhanging spinelets.

Gulf of Manaar, 597 fathoms, green mud; Laccadive Sea, 705 fathoms, coarse coral shingle.

This species is distinguished, (i.) by the high but flat-topped disk, with its tumid stellate primary plates sparsely covered with spinelets; (ii.) by the strongly carinated rays, pentagonal in section, with their median row of large vertebra-shaped plates; and (iii.) by the broad cylindrical adambulacral plates with their two transverse series of actinal spinelets.

In a young specimen the disk, with its relatively enormous tumid apical plates, recalls the appearance of the Ophiuroid *Ophiomastus*; the relatively short rays ( $R=8r$ ) end in a large inflated, helmet-like, two-horned plate, and the tube-feet are biserial.

41. *Zoroaster carinatus*, sp. n.

Rays 5. R=about 10 r. R=about 90 millim. in the type specimen.

Disk small, hemispherical, higher than the rays; rays semicylindrical, strongly carinated, tapering in the distal half, but not much diminishing in the basal half.

Abactinal surface of disk with close-set, large, tumid, stellate, primary radials and basals surrounding a very prominent dorso-central plate and a ring of small depressed under-basals; all the plates are densely covered with thorn-like spinelets, which are enlarged in the middle of the plate; isolated papulae surround the plates, and a few small scattered pedicellariae occur.

Rays with a median longitudinal row of very large and tumid stellate plates, closely covered with spinelets, of which those in a tuft in the middle of each plate are enlarged. On each side of this median row is a depressed discontinuous series of very small irregular platelets, below which are five parallel rows of close-set tumid octagonal plates; all these are closely covered with thorn-like spinelets, and those of the four lower rows have also a long slender median spine. The minute apertures between the angles of neighbouring plates (except between those of the two lowermost rows) give exit to a single papula, and close to every papula is a small pedicellaria.

Adambulacral plates small, cylindrical, each with a transverse series of two (rarely three) long slender spinelets; every alternate plate has a prominent intra-ambulacral ridge bearing a row of two or (usually) three similar but larger spinelets, one of which, within the furrow, has occasionally a small pedicellaria, or sometimes two. Mouth-plates with long spinelets like those of the ordinary adambulacrals.

Tube-feet quadriserial.

Madreporiform plate very small, hardly one third the size of the basal plate outside of which it lies.

Colour in life brick-red.

Andaman Sea, 130 to 250 fathoms.

This species, which is one of the commonest starfishes met with in the Andaman Sea between 200 and 300 fathoms, is characterized, (i.) by the dense thorny armature of the very tumid apical plates, each of which has a central tuft of enlarged spinelets; (ii.) by the strong carination of the rays, which is due partly to the tufts of enlarged spinelets of the tumid mid-radial row of plates and partly to the sinking of

the small plates on each side of this prominent mid-radial row; and (iii.) by the paucity of pedicellariæ, even the spines of the adambulacral plates being oftener without these organs than with them.

In the young stage ( $R=6.5 r$ ) the apical and abactinal mid-radial plates are extremely prominent, the tip of the rays is capped by a large, inflated, spiny terminal plate, and the tube-feet are but indistinctly quadriserial.

42. *Zoroaster Gilesii*, sp. n.

Rays 5.  $R$ =about 8  $r$ .  $R=70$  millim.

Disk comparatively large, low, flat or very gently convex, very distinctly delimited from the rays (above which it is not much elevated) by a complete ring of massive semiglobular plates; abactinally it is encased in concentric series of these great semiglobular plates (with or without small sunken plates intervening) in the following order:—a dorso-central, five basal interradials, five primary radials (the largest of all), and twenty-five marginal plates, of which one succeeds each primary radial and four close in each interradial area. All the plates are covered with capillary spinelets with a few coarser spinelets interspersed, and the intervals between the plates are occupied by papulæ and rather numerous large pedicellariæ.

The rays are rigid, broadish, and flat, with a gentle abactinal convexity, and are encased in thirteen longitudinal parallel series of small and very close-set tumid plates, which also stand in obliquely transverse parallel series. These plates have the following arrangement:—(i.) a mid-radial row of suboctagonal slightly imbricating plates lying in a furrow between two rows of distant papulæ (which two rows of papulæ are the only papulæ present on the rays), flanked on each side by (ii.) six rows of very close-set bead-like plates, of which the upper (abactinad) three rows are much the larger, the lower (actinad) three rows consisting of minute plates so crowded together as to appear at first sight like a single row. All these plates are covered with coarse spinelets, which are larger and denser in the three lower (actinad) rows, and those of the mid-radial and three upper (abactinad) rows on each side have also a small coarse spine centrally, and on each suture margin a largish pedicellaria, while those of the three lower rows have each a long lanceolate spine.

Adambulacral plates small and short, but extending high up into the furrow; each plate has two transversely placed

spinelets, and every alternate plate has a prominent intra-ambulacral ridge bearing a row of three spines, the innermost of which carries a single large pedicellaria. Mouth-plates armed with spines similar to those of the ordinary adambulacrals.

Tube-feet quadriserial.

Madreporiform plate small and much hidden by neighbouring spinelets, with obsolescent sculpture.

Colour in life "red ochre" (*G. M. Giles*).

Andaman Sea, 490 to 500 fathoms.

#### 43. *Zoroaster squameus*, sp. n.

Rays 5. R=about 11 *r*. R=135 millim. in the type specimen.

Disk pentagonal, flat-topped, distinctly delimited from the rays by a circumferential series of large tumid plates; its abactinal surface bears concentric series of massive tumid stellate plates—a dorso-central, five basal interradials, five primary radials (the largest of all), and twenty-five marginals arranged as in *Z. Gilesii*; all these plates bear distant deciduous granules, and the intervals between them display papulæ and numerous small pedicellariæ.

Rays long, tapering, compressed, strongly convex abactinally, with thirteen to fifteen parallel longitudinal rows of plates (which also fall into transversely parallel series), each row, with the exception of the mid-radial row, strongly imbricate over the row below. The following is their arrangement:—(i.) a mid-radial row of non-imbricate plates, hardly enlarged, and flush with the surface of the ray; flanked on each side by (ii.) six or seven rows of scale-like plates which overlap one another from above like tiles on a roof, those of the upper four rows being the more massive and conspicuous, those of the lower two or three rows being thin and crushed up beneath one another. The mid-radial row of plates appears to be quite smooth and unarmed; the plates of the three or four upper (abactinad) rows on each side are quite smooth, but bear each a more or less deciduous procumbent median spine, and in the distal half of the ray some marginal pedicellariæ; the plates of the three lower (actinad) rows on each side are very closely covered with acumbent scale-like spinelets, with a long procumbent, needle-like, deciduous median spine. Papulæ occur, accompanied each by a pedicellaria, in an incompletely double row on each side of the mid-radial row of plates; and between the second and

third row of plates throughout the ray, and between the third and fourth row of plates in the basal fourth of the ray, there are minute perforations (seen only in the dried specimen) which appear to be too small for the passage of papulæ.

Adambulacral plates very small, but extending high up into the furrow; each plate has two short transverse series of spinelets, and every alternate plate has a prominent intra-ambulacral ridge bearing three stout spinelets, of which the innermost is furnished with a large pedicellaria emerging from a cluster of small pedicellariæ. Mouth-plates with long needle-like spines and large clusters of pedicellariæ.

Tube-feet quadriserial.

Madreporiform plate very small, with coarse peach-stone sculpturing.

Colour in life orange-pink.

Laccadive Sea, 1043 fathoms, green mud.

#### 44. *Zoroaster zea*, sp. n.

Rays 5. R=about 12 *r*. R=144 millim. in the type specimen.

Disk semicircular, flat-topped, well raised above the rays, from which it is delimited by a circumferential series of massive oval or substellate plates, arranged exactly as in *Z. Gilesii* and *Z. squameus*, with small plates intervening. All the plates are quite smooth and membrane-clad, but the small intervening plates bear each a small coarse spine; the intervals between the plates show distant papulæ and pedicellariæ, the last often in pairs.

Rays long, rigid, subcylindrical, tapering, with thirteen longitudinal parallel series of Indian-corn-like or bead-like membrane-clad plates, which also fall into transversely parallel series. A single ray, viewed abactinally, has much the appearance of a seed-spike of maize. The plates are disposed as follows:—(i.) a mid-radial row of slightly enlarged plates, flanked on each side by a deep furrow, in which lies (ii.) a discontinuous row of minute platelets concealed by membrane, and only revealed either by a small pedicellaria or by a coarse spikelet which they sometimes bear; and outside these (iii.) six rows of plates, decreasing in size and inclining to imbricate actinally, of which the three abactinad rows are, like the mid-radial row, quite naked and unarmed, while the three actinad rows are thickly covered with membrane-clad squamous spinelets and bear a median spine and sometimes a marginal pedicellaria. Long papulæ

are found in a close double row in the furrow on each side of the mid-radial series of plates; minute perforations occur between some of the other rows of plates, but they are only visible with a lens, and seem to be far too small to give exit to papulæ.

The adambulacral plates are covered with flat foliaceous spinelets; every alternate plate has a prominent intra-ambulacral ridge bearing a row of three sabre-shaped spines, and deep within the furrow a slender spinelet furnished with several pedicellariæ, one of which is large. Mouth-plates with stout spinelets and clusters of pedicellariæ.

Tube-feet quadriserial.

Madreporiform plate small—half the size of a basal inter-radial plate—but tumid and conspicuous, with coarse radial striations.

Gulf of Manaar, 597 fathoms, green mud; Laccadive Sea, 1200 fathoms, coral and *Globigerina*-ooze.

In a youngish specimen (R=65 millim.) R=about 8 r; the mid-radial plates are relatively larger; the rays terminate in a rather inflated bilobed plate fringed with spines; and the papulæ, which are in a double row on each side of the mid-radial series of plates, extend only about halfway along the rays.

*Zoroaster Gilesii*, *Z. squameus*, and *Z. zea* form a very well-defined group within the genus *Zoroaster*, and, along with *Z. Sigsbeei*, Perrier (Nouv. Archiv. du Mus. sér. ii. vol. vi., 1883, p. 195, pl. iii. fig. 2), may perhaps be conveniently recognized as a subgenus. The following characters are common to the first three species, and, as far as can be judged from the rather brief though very succinct description of Professor Perrier and from the phototype figure, appear to be shared by the last:—(i.) the disk is very distinctly demarcated from the rays abactinally by massive plates which form a circumferential series—one plate at the base of each ray and four in each interradius; (ii.) the rays are particularly rigid, with the longitudinal mid-radial row of plates neither conspicuously large nor very prominent, and the papulæ of the rays are more or less restricted to two single or double rows, one on each side of the mid-radial row of plates [in *Z. Sigsbeei* the papular orifices seem to have been only doubtfully recognized (*tom. et loc. cit.*)]; (iii.) the three actinad rows of plates are much crushed together (? *Z. Sigsbeei*), and are always more densely covered with spinelets and more conspicuously armed than the plates of the abactinad rows,

which last are often quite smooth and unarmed; (iv.) the anal aperture is very distinct.

This subgenus shows an interesting series of gradations between *Zoroaster*, Wyville Thomson, and *Cnemidaster*, Sladen. At the true *Zoroaster* extreme is *Zoroaster Gilesii*, with all the plates spinate and armed, with numerous pedicellariæ, and with a broad ambulacrum and four rows of tube-feet. Near the *Cnemidaster* extreme comes, as Mr. Sladen has already pointed out, *Z. Sigsbeeii*, with the abactinad plates smooth and unarmed and only the actinad plates spinate, with few pedicellariæ, and with crowded tube-feet which only in the basal part of the ray are quadriserial. While between the two come (i.) *Z. squameus*, with the abactinad plates granular or quite smooth and their armature reduced to one deciduous spinelet, and (ii.) *Z. zea*, in which the abactinad plates are quite smooth and unarmed and the pedicellariæ reduced in size and number.

### Family Pterasteridæ.

#### MARSIPASTER, Sladen.

##### 45. *Marsipaster hirsutus*, Sladen.

*Marsipaster hirsutus*, Sladen, 'Challenger' Asteroidea, p. 487, pl. lxxviii. figs. 3 and 4, pl. lxxix. figs. 4 and 6; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 437.

Bay of Bengal, 1997 fathoms, *Globigerina*-ooze and pumice.

#### HYMENASTER, Wyville Thomson.

##### 46. *Hymenaster nobilis*, Wyville Thomson.

*Hymenaster nobilis*, Wyville Thomson, Journ. Linn. Soc., Zool. vol. xiii. p. 73, fig. 11; Sladen, 'Challenger' Asteroidea, p. 495, pl. lxxxvii. figs. 1-3; and Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 438.

Bay of Bengal, 1748 fathoms, *Globigerina*-ooze and pumice.

### Family Echinasteridæ.

#### CRIBRELLA, Agassiz, Forbes.

##### 47. *Cribrella præstans*, Sladen.

*Cribrella præstans*, Sladen, 'Challenger' Asteroidea, p. 545, pl. xevi. fig. 7, pl. xeviii. figs. 7 and 8.

Four specimens from the Andaman Sea, 240 to 480



fathoms, on bottoms of green mud or of coral and *Globigerina*-ooze, only differing from the described type, which was dredged by the 'Challenger' in the Indian Ocean off the Crozet Islands, in having the disk relatively smaller. In one specimen the rays are most remarkably inflated in their basal fourth.

DICTYASTER, Alcock and Wood-Mason.

Rays 5.

Disk large, quite flat actinally, but slightly inflated abactinally, as are the broad rays; both disk and rays are invested throughout by a thick, smooth, coriaceous membrane, beneath which is a reticulum of plates.

Abactinal surface with coarse irregular plates, some or all of which bear coarse spinelets, and forming an irregular wide-meshed network, the meshes being occupied by large groups of papulæ.

Supero-marginal plates absent or inconspicuous; infero-marginals conspicuous and bearing one or more stout spines; the group of papulæ extend downwards as far as the infero-marginal plates.

Actinal interradial areas large, the smooth intermediate plates extending to the tip of the rays.

Adambulacral armature in the form of a double furrow-palisade.

Tube-feet in a double row, their tip ending in a sucker.

Madreporiform plate small, single. Anus subcentral. No pedicellariæ.

This genus appears to be nearest related to *Plectaster*; it is instituted for the reception of two Andaman forms, *Dictyaster xenophilus*, from deep water, and *Dictyaster Wood-Masoni*, a littoral form recently discovered in Prof. Wood-Mason's rich Andaman collection.

48. *Dictyaster xenophilus*, Alcock and Wood-Mason.  
(Pl. V. figs. 8, 9.)

*Dictyaster xenophilus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 433.

Rays 5.  $R=2.5r$ .

Disk large and, like the short broad rays, flat actinally, and often a little inflated abactinally; both disk and rays are everywhere invested in a thick leathery membrane which covers all the plates and their spines—abactinal, actinal, and adambulacral.

The narrow salient abactinal plates form a very wide-meshed network, the sunken meshes of which are occupied by large grouped masses of papulæ; all the plates carry coarse spines, either solitary or in rows of two or three.

The supero-marginal plates hardly differ from the ordinary abactinal plates in form and armature, but they constitute a fairly well-defined border to the rays.

The infero-marginals are separated from one another by an interval equal in length to the plates themselves; they are distinct laminæ, with their surface horizontal and with a sharp edge that projects laterally and bears a horizontal comb of three to five (usually three) coarse spines. The space between the two series of plates is occupied by papulæ in large isolated groups.

Adambulacral plates small, each with two, but near the actinostome often three, narrow ligulate spines along and almost within the furrow, and on the margin of the furrow with one much larger broadly ligulate spine, the truncated end of which is usually bilobed or trilobed; so that the narrow ambulacral groove is bounded on each side by a double palisade of ligulate spines, those of the outer series being about half as numerous but about twice as big as those of the inner series. Mouth-plates with a furrow-series of from four to six ligulate spines, increasing in size from the periphery to the centre, and actinally with two of the broadly ligulate spines, placed transversely.

Actinal interradiar areas large; the plates, which are quite smooth and which are separated from one another by intervals equal in breadth to the plates themselves, extend nearly to the tip of the ray.

Madreporiform plate situated almost in an interbrachial arc, very finely and closely striated. Anus subcentral, surrounded by blunt spinelets.

Tube-feet in a double row, ending in a sucker.

Colour in the fresh state chestnut-brown.

A symbiotic Chætopod is often found on the actinal inter-radiar areas, on which also it often lays its eggs.

Andaman Sea, 170 to 290 fathoms.

#### Family *Pedicellasteridæ*.

*PEDICELLASTER*, Sars.

49. *Pedicellaster atratus*, sp. n.

Rays 5.  $R=11$  *r*.  $R$ =about 100 millim. in the type specimen.

Disk extremely small, circular (button-like), abactinally

delimited from the rays, with which it is flush, by a groove that passes across the base of each ray. Rays long, semi-cylindrical, constricted laterally, as well as somewhat depressed, near their junction with the disk.

Abactinal surface closely covered with partly imbricate cruciform plates which have no particular arrangement on the disk, but which on the rays stand in beautifully regular longitudinally and transversely parallel rows forming a quadrangular network of great symmetry. There are from twelve to fourteen longitudinal rows of plates on each ray between the adambulacrals. All the plates are embedded in a continuous membrane, and each plate carries at the decussation of its cross-pieces a stout erect spinelet. The membrane that closes over the quadrangular meshes between the plates is thickly studded with large pedicellariæ and is perforated by papulæ—one to three in each mesh.

Marginal plates quite undifferentiated.

There are no actinal plates, the actinal surface of the rays being almost entirely taken up by the broad ambulacral furrow.

The adambulacral plates are very small; each plate carries two long cylindrical truncated spines placed transversely, the outer spine being about twice the length and four times the thickness of the inner one, and usually having external to its base a large pedicellaria.

Although the ambulacral furrow is so broad the tube-feet are biserial.

Madreporiform plate small, radially striated, placed near the margin of the disk.

Colour uniform jet-black.

Andaman Sea, 240 to 220 fathoms, coral-sand and foraminiferal ooze; Bay of Bengal, 290 fathoms.

### Family Asteroiidae.

#### ASTERIAS, Linn.

##### Subgen. STOLASTERIAS, Sladen.

#### 50. *Asterias mazophorus*, Alcock and Wood-Mason.

*Asterias mazophorus*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 436.

Rays 5.  $R=11r$ .  $R=115$  millim. in the type specimen.

Disk extremely small, circular (button-like), delimited abactinally from the rays, beneath the level of which it is

sunk, by a deep groove passing across the base of every ray. Rays long, semicylindrical, much constricted laterally at the junction with the disk, and very deciduous.

Abactinal surface of the disk with a reticulum of plates embedded in tough membrane; each plate bears a large spine with its base sheathed in a globular fleshy mass closely covered with minute pedicellariæ; the meshes between the plates are perforated by papulæ in groups; numerous large pedicellariæ fill the interbrachial arcs and extend nearly to the actinostome.

Abactinal surface of the rays with five beautifully regular parallel rows of partly imbricating plates that may best be described as compositely cruciform—that is to say, each composite plate is made up of two cross series of tightly imbricating platelets. The outermost row of plates on each side forms a distinct supero-marginal series. All the plates are embedded in a tough membrane, and each plate of the midradial and supero-marginal rows, and in large specimens each plate of the other two rows also, bears at the decussation of its composite cross-pieces a large spine with its base ensheathed in a globular fleshy mass closely covered with pedicellariæ; other large pedicellariæ lie scattered over the plates. The quadrangular meshes between the plates are filled with papulæ in oval plots of from five to nine.

Marginal plates distinct; the supero-marginals, which otherwise resemble the abactinal plates, are distinguished by their mainly vertical direction, their long outer limbs forming a high vertical palisade along the sides of the ray; the broad intervals of the palisade are filled by papulæ in groups. The infero-marginals are simply oblong plates of small size lying at right angles to the long vertical limb of the supero-marginals, and having a considerable lateral horizontal bulge; each carries two strong horizontally-directed spines, one above and behind the other, the upper being the larger and exactly resembling the abactinal spines in form and in its ensheathing fleshy pedicellaria-covered base, the lower being quite simple.

Adambulacral plates very small, but extending up into the furrow; each carries a pair of spines placed transversely, and almost every alternate plate has inside the furrow a large pedicellaria.

The adambulacral plates are separated from the infero-marginals by a single row of small narrow plates distant almost their whole length apart, the long intervals between the plates being filled each with a large papula encircled by

pedicellariæ. Mouth-plates ambulacral, each with two large spines.

Madreporiform body placed in the middle of a large basal (interradial) plate.

Anal aperture indistinct.

Tube-feet quadriserial, ending in a sucker.

Colour in the fresh state deep orange-yellow, with large chestnut-brown blotches.

Andaman Sea, 120 to 250 fathoms.

This is a very remarkable and interesting form, and has repeatedly led me on to difficult and uncertain ground. Its affinities, unlike those of some of its fellows of the Stolasterian alliance, appear to be more Stichasteroid and Zoroasteroid than Brisingoid.

### Family Brisingidæ.

#### BRISINGA, Asbjornsen.

51. *Brisinga insularum*, Alcock and Wood-Mason.

*Brisinga insularum*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 439.

Allied to *B. coronata*, Sars.

#### Rays 13.

Disk comparatively large (its diameter being 44 millim. in the type specimen), with vertical edge; rays not extremely deciduous (six of them still being firmly attached to the disk in the type specimen), but fragile, inflated and broadened in the basal (ovarian) region.

Abactinal surface of the disk invested by a tough opaque membrane, closely covered with coarse granules which form a base each for a tuft of minute spinelets.

Abactinal surface of the rays covered with a very delicate transparent membrane, which in the basal part of the rays is strengthened by from thirteen to seventeen sinuous, very salient, transverse ridges, armed with strongly spinate plates and covered with microscopic pedicellariæ. In the intervals between these ridges, as throughout the ray at regular close intervals, occur broad, slightly raised, felt-like, transverse bands of microscopic pedicellariæ.

The vertebra-like adambulacral plates have the following armature:—(i.) abactino-marginally, on a distinct but closely fused platelet, a needle-like spine ten to twelve times as long as the plate itself; (ii.) actino-marginally, a similar spine four to five times as long as the plate; (iii.) on the furrow-

margin, one at each end of the plate, two spinelets as long as the plate; (iv.) deep within the furrow, on a distal epiphysis, a spinelet which stretches across the furrow to overlap with its fellow of the opposite plate and separate the pairs of tubefect from one another. All these spines are hyaline, fluted, and invested in membranous sacs which are closely felted with pedicellariæ.

Actinostome large (25 millim. in diameter in the type specimen). Mouth-plates of moderate size, each plate distinctly formed of two fused adambulacrals, of which they bear the furrow and cross-furrow spinelets unchanged and the actino-marginal spines but little modified.

Madreporiform plate rather large, excavated centrally and divided by a deep groove into two halves, with fine radial striations, placed close to the margin of the disk.

Colour in the fresh state bright cinnabar-red.

Laccadive Sea, 1043 fathoms, green mud with foraminifera.

This species is characterized by its large disk with tough membrane and coarse tufts of spinelets, and by the great length and coarseness of its spinature.

## 52. *Brisinga andamanica*, Alcock and Wood-Mason.

*Brisinga andamanica*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 439.

Rays 15.  $R=27r$ .

Disk of moderate size (its diameter being 38 millim. in the type specimen), with vertical edge; rays very deciduous, but not fragile, long, slender, a little depressed, but not inflated in the ovarian region.

Abactinal surface of the disk much as in *B. insularum*, but the membrane is not so tough, and the tufts of spinelets and the tubercles on which they stand are not so coarse.

Abactinal surface of the rays covered with a very delicate transparent membrane, which in the proximal third of the ray is strengthened by about forty-five rather distant cross bands or half-bands of feebly developed spiny plates. In the intervals between these bands, as throughout the whole ray at regular intervals, occur very narrow felted bands of microscopic pedicellariæ.

The vertebra-like adambulacral plates have the following armature:—(i.) abactino-marginally a spine about six times as long as the plate; (ii.) actino-marginally a spine about four times as long as the plate; (iii.) a single furrow spinelet, placed at the adoral end, about equal in length to the plate; (iv.) deep within the furrow, on a distal epiphysis, a cross-

furrow spine separating the pairs of tube-feet. All these spines are hyaline, fluted, and invested in sacs formed of membrane and felted microscopic pedicellariæ.

Actinostome large (25 millim. in diameter in the type specimen). Mouth-plates small, each plate formed of two adambulacrals, with the furrow and cross-furrow spinelets unchanged and the actinal spines not much modified; the most adoral actinal spine is enlarged and is often united with its fellow of the same pair in a common membranous investment.

Madreporiform plate rather small, excavated centrally, with fine radial striations, marginal in position.

Colour in the fresh state bright cinnabar-red.

Andaman Sea, 405 fathoms, green mud.

This species stands intermediate between *B. insularum* and the next species, *B. bengalensis*; it is well characterized by the extensive development along the rays of feeble calcareous plates.

53. *Brisinga bengalensis*, Alcock and Wood-Mason.

*Brisinga bengalensis*, Ann. & Mag. Nat. Hist., Dec. 1891, p. 439.

Rays 14.  $R=25 r$ .

Disk small (its diameter being 30 millim. in the type specimen), depressed centrally, with a strongly bevelled abactinal margin; rays very deciduous, but not otherwise very fragile, long, slender, hardly inflated in the ovarian region.

Abactinal surface of the disk much as in *B. andamanica*; abactinal surface of the rays covered with a very delicate transparent membrane, which in the basal ninth of the ray is strengthened by about twenty close cross bands or half-bands of spiny plates that are not very much more salient than the cross bands of felted pedicellariæ that occur throughout the ray.

The vertebra-like adambulacral plates have the following armature:—(i.) abactino-marginally a spine about five or six times as long as the plate; (ii.) actino-marginally a spine twice to two and a half times as long as the plate; (iii.) two furrow-spinelets not quite half as long as the plate; (iv.) deep within the furrow, on a distal epiphysis, a cross-furrow spine not quite as long as the plate, separating the tube-feet. All these are hyaline, fluted, and clothed with membrane and felted pedicellariæ.

Actinostome very large (21 millim. in diameter in the type

specimen). Mouth-plates very small, each being distinctly formed of two fused adambulacrals, of which it carries the furrow-spinelets and cross-furrow spinelets unchanged; of the two actinal spines the adoral one is remarkable in being united with the corresponding spine of the fellow mouth-plate in a common membranous sac, so that each pair of mouth-plates appears to possess in this situation but one large ligulate spine between them.

Madreporiform plate large, salient, marginal, marked with fine but deep radial striations.

Colour in the fresh state bright cinnabar-red.

Bay of Bengal, 561 fathoms, grey mud.

This species is well characterized by the small disk with its bevelled edge; by the slenderness of the rays and by their short and very delicate spinature; and by the union in a common investing membrane of the two large actinal spines of each pair of mouth-plates.

#### 54. *Brisinga Gunnii*, sp. n.

##### Rays 14-15.

Disk remarkably thin, its abactinal margin slightly bevelled; rays both very deciduous and very fragile, slender, not inflated in the ovarian region.

Disk covered abactinally with a very thin semitransparent membrane bearing small tufts of spinelets, of which the central in each tuft is sufficiently elongated to give *en masse* a downy appearance to the disk. In one of these specimens midway between the centre and the margin is a pair of large spines covered with microscopic pedicellariæ.

Rays covered with a membrane of extreme delicacy, which in the basal part of the ray is strengthened by from twenty to thirty very contorted calcareous ridges, these standing far out on each side like hoops, but becoming inconspicuous or quite obsolete abactinally. In the intervals between the ridges are narrow felted bands of pedicellariæ, which also occur in the region beyond the ridges, though, owing to excessive denudation, their exact disposition is not determinable.

The vertebra-like adambulacral plates have the following armature:—(i.) abactino-marginally a spine about six times as long as the plate; (ii.) actino-marginally a spine about two and a half times as long as the plate; (iii.) a single furrow-spinelet about as long as the plate; (iv.) deep within the furrow, on a distal epiphysis, a cross-furrow spine about



as long as the plate, separating the pairs of tube-feet. All these are hyaline, fluted, and invested in a felt of membrane and microscopic pedicellariæ.

Actinostome large. Mouth-plates very small; each plate is made up of two adambulacral so incompletely fused that in place of the usual groove there is a ligamentous symphysis between the two plates, and each bears the usual furrow and cross-furrow spinelets unchanged and the actinal spine not much changed—only diminished in size in the distal (aboral) plate.

Madreporiform plate marginal, small, deeply cross-fissured, radially striated. A membranous (epiproctal?) appendage is found on the disk excentrically.

Colours in the fresh state dull reddish ochre.

Off the Konkan Coast, 559 fathoms, green sand.

This species is well characterized by the strong contortion of the calcareous ridges at the base of the rays and their hoop-like lateral elevation; by the incomplete fusion and partially ligamentous union between the two adambulacral elements that make up a mouth-plate; and by the curious membranous epiproctal (?) appendage.

FREYELLA, Perrier.

55. *Freyella tuberculata*, Sladen.

*Freyella tuberculata*, Sladen, 'Challenger' Asteroidea, p. 638, pl. cxvii. figs. 1-3.

Bay of Bengal, 1840 fathoms, *Globigerina*-ooze.

56. *Freyella benthophila*, Sladen.

*Freyella benthophila*, Sladen, 'Challenger' Asteroidea, p. 641, pl. cxi. figs. 5-8; and in Wood-Mason and Alcock, "Indian Deep-sea Dredging," Ann. & Mag. Nat. Hist., Dec. 1891, p. 440.

Bay of Bengal, 1520 to 1997 fathoms, usually on *Globigerina*-ooze.

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XVI.—*Report upon the Myriopoda of the 'Challenger' Expedition, with Remarks upon the Fauna of Bermuda.* By R. I. POCKOCK, of the British Museum (Natural History).

[Plate IX.]

SINCE marine biological research was the main object of the cruise of the 'Challenger,' and the capture and preservation of terrestrial forms but a pastime, so to speak, of the zoologists