

were quite unexplored, and Nipal, it should be remembered, is still, with the exception of a very small tract in the lower hills around Katmandu, inaccessible to Europeans.

“Apart from their intrinsic merit as admirable representations of the Himalaya avifauna, these drawings have an especial value for two reasons. In the first place, they have Mr. Hodgson’s generic and specific names on them in his own handwriting, and therefore prevent any question as to the species to which these names refer. This is important, because, as is well known, several of Mr. Hodgson’s names were printed in British-Museum Catalogues without descriptions, and mistakes were in some cases made by the naturalists, who endeavoured to identify the species without having access to the original types. In the second place, it must not be forgotten that Mr. Hodgson is to this day the only naturalist who has had the opportunity of making large ornithological collections in Nipal, and, as he has never published his observations in full, the notes attached to the present collection form the only record of Nepalese ornithology in existence. It is moreover quite possible, owing to the great destruction of forests in the Lower Himalayas of late years, that no such collections as were made by Mr. Hodgson will ever again be brought together in the same area.

“For the last twelve years the drawings have been lent to Mr. A. O. Hume, and their value is admirably shown by his frequent references to them in the volumes of ‘Stray Feathers’ and in his work on the ‘Nests and Eggs of Indian Birds.’ All that is known of the nidification and zoology of several Indian Birds is contained in these sheets. Mr. Hume has added to the value of the drawings, and greatly facilitated their arrangement by numbering them in accordance with the numbers in Jerdon’s ‘Birds of India’ and with the more complete list published in ‘Stray Feathers,’ vol. viii. p. 81.”

Mr. Blanford concluded his remarks by recommending that the drawings should be carefully mounted and arranged, and bound in twelve volumes.

The following papers were read:—

1. Contributions to the Systematic Arrangement of the Asteroidea.—II. The Species of *Oreaster*. By F. JEFFREY BELL, M.A., Sec.R.M.S., Professor of Comparative Anatomy in King’s College.

[Received January 16, 1884.]

Introductory.

In addition to the fine series of specimens of *Oreaster* collected by Dr. Coppinger during the voyage of H.M.S. ‘Alert’ in the Australian seas, the Trustees of the British Museum have lately acquired by purchase some magnificent specimens from Dr. Bolsius of Billiton, and others, less remarkable, from various collectors.

These additions have, as may be supposed, led me to a careful study of the generic and specific characters of these forms; a work in which, unfortunately, one has been able to gain but little assistance from preceding naturalists. The only writer who stands in the front rank of the students of *Oreaster* is Dr. Lütken¹, and of his work, unhappily, I have been unable to make as full a use as I should have done had he written in a language whose literature was rich enough to justify the time necessary for learning it, or in case I had understood a language which, when all is told, is not spoken by a population exceeding one half that of this metropolis.

I have, however, this satisfactory reflection, that in all, or nearly all, the cases in which I have been able to understand him, there is complete agreement between us.

In the course of the paper I make use of some technical terms, which are either new or have been but little used; and in so doing I fear I shall bring on myself the wrath of Mr. Lyman for forcing the reader to undergo a certain amount of "sawdust swallowing"²; but I shall, I believe, thereby adopt a method which is not only approved by the philosopher and logician³, and adopted by experts in every branch of art and science, but one which will aid in the two objects that ought now to be very dear to all zoologists—(α) the condensation and assimilation of our technical descriptions, and (β) the preparation for a systematic method of formulation, by means of which intellectual operations may be rendered more easy and more rapid⁴.

It is convenient to have a single term for the line which divides the dorsal surface of the arm into two halves; where this line is most apparent it has the form of a ridge, and I propose therefore to speak of it as the *lophial* line, and of its spines as the *lophial* spines. The five, often prominent, spines which are found at the proximal end of the *lophial* lines may be called the *apical* spines, while the term *apical region* may be well applied to the area contained by the lines which join them to one another.

I have seen no reason for departing from the use of the definite terms *superomarginal* and *inferomarginal* for the upper and lower series of marginal plates; nor can I propose any change in the terms for the adambulacral spinulation (*monacanthid*, *diplocanthid*, and *triplocanthid*) which I suggested in the first of these "Contributions⁵."

Before commencing a systematic study of the species of this genus it is necessary to make oneself acquainted with the character of the modifications which the species undergo during growth. Not only is it necessary to do this for the purpose of correctly discriminating specific forms, but it would appear to be the mode

¹ Videnskabelige Meddelelser (Copenhagen), 1859, 1864, 1871.

² See his Introduction to his Report on the Ophiurids of the 'Challenger.'

³ See Mill, *Logic*, 4th ed. ii. pp. 245–6.

⁴ Cf. Owen, *Phil. Trans.* 1850, pp. 496–497; and Allman, *Rep. Brit. Assoc.* 1863, p. 352.

⁵ *P. Z. S.* 1881, p. 499.

best adapted for arriving at some clearer ideas as to the relations of the species among themselves, and the history of an ancient generic group.

First of all, we may well expect some differences in external appearance, in the relations of the greater to the lesser radii, and in the width and proportions of the arms, the moment we know that specimens may attain to a spread of 400 millims. or more, or attain to a height of 120 millims.; while, however, we shall find growth-differences in some, we shall in others, such as *O. nodulosus*, be struck rather by the constancy of proportions in the post-larval stages of development.

Our experience of other long-armed forms, such as *Linckia* or *Ophidiaster*, might lead us to ask, Does *Oreaster*, like these genera, tend to lose its arms, and does it, like them, reproduce itself asexually, or exhibit any other mode of heteractinism? Heteractinic conditions are exceedingly rare among Oreasters, and it follows therefore that the dangers to which the species are exposed are slight, its skeletal structures are very strong, or its power of active or passive defence very great.

As to the danger we know but little; as to the skeletal structure, we know that it is eminently reticulated on the upper surface; and, now, as to the organs of defence, we know that many of the species are well provided with marginal or dorsal spines of considerable length, and that, in some cases, the proper ventral plates are very spinous.

To a certain extent these spines present us with very definite characters. We can, for example, always safely discriminate between *O. lincki* and *O. nodosus*, by examining the free ends of the arms, the sides of which in the former are constantly, and in the latter are never, provided with outstanding spines. So, again, the species described by Perrier under the name of *O. alveolatus* may, as it seems, be certainly separated from *O. lincki*, owing to the fact that the infero-marginal plates bear well or fairly developed spines.

For the purposes of this investigation we shall, perhaps, do well to study attentively one of the species of the genus in which the spinous armature is well developed—*O. armatus*: three specimens, in which R is respectively equal to 23.5, 37, and 85 millims., have at the proximal end of the middle line of each arm a spine measuring 1, 3, and 14 millim. respectively. In (*a*) the marginal plates rarely exhibit any break in their regular granulation; when they do so, we find a naked papilla just projecting beyond the level of the granular investment; no spines are developed in the spaces between the middle lines of each ray; in the centre of the disk is a spine which is about equal in size to those which mark the end of the arms; the other spines along the middle line are nothing more than mere papilliform processes. On the ventral plates spines are developed indeed, but they are as yet only rounded projections which are just beginning to be distinguishable from the investing granules of the ossicles which bear them.

In the next specimen (*β*) the spines of such marginal plates as

bear them are all distinct, the spines along the middle line of the arms are beginning to grow up, but only one interrarial spine is as yet developed; the spines on the ventral surface are now more regularly arranged.

In the third or largest specimen (γ) all the spines—those on the distal marginal plates, those on the middle line of the arm, the central portion of the disk, and those that lie between the interrarial lines—are all long, strong, sharp, and prominent.

It is clear, therefore, that we have here to do with a condition in which the spines increase in size and number during the growth of their possessor; this is to be insisted on, inasmuch as it is not a condition which always obtains. In some species of *Linckia* we find that the spines diminish in size as the form grows larger; but in that case we also see that increase in size is accompanied by consolidation of the skeletal plates—or, where spines are wanting and plates are not very strong, arms are often found to have been broken off or injured.

The study of individual development and the consideration that the larger the form the greater its need of defence, lead to the supposition that the least modified *Oreaster* will be found to be one that is not specially spinose. This consideration gains in force when we know that a form with feebly developed spines such as *O. nodulosus* has in the most striking fashion the characters of the younger repeated in the older individuals.

In the arrangement, therefore, of the species of the genus, we shall have to commence with those which have the spines least well developed. Next to the non-spinous condition of such a form as *O. nodulosus*, we should probably place those in which a few spines are developed at the proximal end of the arm to defend, so far as may be, the more central, and thereby more precious, portion of the internal organs. The next line of defence is probably that of the free end of the arms, next the ventral plates, and lastly the dorsal surface.

On the other hand, we have in *Oreaster occidentalis* an example of a species in which the marginal spines disappear during growth.

Not only have we evidence of this in Prof. Verrill's original description of the species, but more convincing proofs are afforded by the three specimens in the collection of the British Museum: the smallest of these, one presented and named by Mr. Verrill, never has *more than five* of the superomarginal plates on either side of any arm *without spines*; and a few are also to be found on the infero-marginal spines. The smaller specimen described by Verrill has "from one to four (upper plates) that bear small, short, stout, bluntconical spines near the end of the rays;" this is very much the condition in which I find a specimen collected by Mr. Lockington in San Francisco Bay. The larger specimen described by Verrill had no spines on the superomarginal plates; while a yet larger specimen collected by Lockington has on the terminal plate of some of the rays three minute processes, distinctly smaller than those of the other specimen from the same collector.

When we oppose these facts to those which we have already learnt as to the growth-changes in *O. armatus*, we are met at once by the obvious reflection that the very conditions of the case are exactly reversed. In the one we have the progressive growth; in the other the as marked decline in the size of the spines. When we go further and seek, as we are bound to do, for some explanation, we find that, firstly, the explanation will probably be of this character: Corresponding to the differences in the growth-characters of the spines, there are differences in (α) the length of the free and unprotected portion of the arms, which have become proportionately shorter as the means of defence has been lost; or (β) there has been a consolidation of the skeletal plates, which, becoming thereby stronger, are the better able to withstand attacks from without.

Either of these structural characters could be easily enough investigated and demonstrated by a cabinet naturalist; but in the case now being studied there is not either that concentration or consolidation, which nations as well as individuals have to suffer, when their means of offence or defence are diminished or insufficient.

An explanation must therefore be found in a study of living specimens, with a view to see whether they are provided either with protective colourings or offensive odours; or in the examination of the environment of the Starfish, and the possible absence of creatures strong enough to prey on it. Should the latter be the case, the comparatively rich development of spines in the younger forms would be explained as due to the influence of heredity.

In the classification and description of the species of *Oreaster* it will, for the future, be necessary to bear in mind the two opposing conditions represented by *O. armatus* and *O. occidentalis* respectively, and to endeavour to supplement the technical zoological description of the adult by a history of the growth of the species; for Starfishes, as for birds or monera, the life-history is an essential factor in an intelligent arrangement.

Speculations and considerations such as have here been briefly sketched will not be barren of result if they direct the student of living forms to the closer observation of environment, and to the conviction that faunal lists and lists of collections have a scientific value far above that of a mere catalogue, if to a knowledge of the existence of a given species we can add something of its relations to those other forms with which it lives, and on which it is as dependent as are they on it. In this way some of the dangers of specialization may be diminished if not averted.

I. List of the apparently distinct Species of *Oreaster*.

1. *affinis*, M. Tr.¹ p. 46.
2. *alveolatus*, Perrier,² p. 243. B.M.
3. *armatus*, Perrier, p. 251. B.M.
4. *australis*, Lütken,³ 1871, p. 252.

¹ M. Tr.= 'System der Asteriden' by Müller and Troschel.

² Perrier=Revision des Stellérides par E. Perrier.

³ Lütken=Videnskabelige Meddelelser, distinguished by the year.

5. *carinatus*, M. Tr. p. 49.
6. *chinensis*, M. Tr. p. 46. B.M.
7. *dorsatus*, M. Tr. p. 49 (s. v. *clavatus*). B.M.
8. *forcipulosus*, Lützk., 1864, p. 156.
9. *gracilis*, Lützk., 1871, p. 260. B.M.
10. *granulosus*, Perr. p. 236. B.M.
11. *hedemanni*, Lützk., 1871, p. 255.
12. *hiulcus*, M. Tr. p. 48.
13. *lincki*, Lützk., 1864, p. 156. B.M.
14. *mammillatus*, M. Tr. p. 48. B.M.
15. *nodosus*, M. Tr. p. 47 (s. v. *turritus*). B.M.
16. *nodosus* (Gray), Ann. N. H. (1), vi. p. 277. B.M.
17. *nodulosus*, Perr. p. 237. B.M.
18. *occidentalis*, Verrill, Trans. Conn. Acad. I. ii. p. 278. B.M.
19. *orientalis*, M. Tr. p. 128. B.M.
20. *regulus*, M. Tr. p. 51.
21. *reinhardtii*, Lützk., 1864, p. 160.
22. *reticulatus*, M. Tr. p. 45. B.M.
23. *superbus*, Möbius, Abh. Geb. Naturw. Hamburg, iv. 2. p. 3.
24. *tuberculatus*, M. Tr. p. 46.
25. *valvulatus*, M. Tr., Arch. f. Nat. 1843, p. 115.
26. *verrucosus*, M. Tr. p. 49.
27. *westermanni*, Lützk., 1871, p. 257.

II. List of the more important Synonyms.

1. *aculeatus*, M. Tr. p. 50 = *reticulatus*.
2. *clavatus*, M. Tr. p. 49 = *dorsatus*.
3. *clouei*, Perrier, Ann. Sc. Nat. (v.), xii. p. 271 = *nodosus*¹.
4. *franklini*, Gray, Ann. N. H. vi. p. 277 = *nodosus*.
5. *gigas*, Linnæus, Mus. Tessin. p. 114 = *reticulatus*.
6. *lapidarius*, Grube, Arch. f. Nat. 1857, p. 342 = *reticulatus*.
7. *mammosus*, Perrier, Ann. Sc. Nat. (5) xii. p. 270 = *nodosus*.
8. *micHELINI*, Perrier, Rev. Stel. p. 252 = *armatus*.
9. *muricatus*, Gray, Ann. N. H. vi. p. 277 = *lincki*.
10. *nodosus*, Gray, ibid. p. 277 = *grayi* (Bell).
11. *obtusangulus*, M. Tr. p. 51 = *Goniaster obtusangulus*.
12. *sebæ*, De Blainville, Man. d'Actinol. p. 238 = *reticulatus*.
13. *turritus*, M. Tr. p. 47 = *nodosus*.

It will, I think, be found on examination that *Oreaster regulus*, M. Tr. = *O. dorsatus*; that *O. verrucosus*, M. Tr., stands very near *O. nodosus*; and that *O. tuberculatus*, M. Tr., is at most a varietal form of *O. mammillatus*.

Limits of the Genus.—It will be seen that I here include the species to which Dr. Gray gave the name of *armatus*, and for which he proposed the generic term *Nidorellia*. With *Nidorellia* Prof. Perrier has associated the form to which Dr. Gray gave the peculiarly inelegant appellation of *Paulia horrida*; and it has therefore

¹ Prof. Perrier's decision as communicated to me by letter.

been necessary to make a close inquiry into the structural characters of an *Oreaster* (e. g. *O. nodosus*), *Nidorellia armata*, and *Paulia horrida*.

One of the leading distinctions of the family Goniasteridæ is the solidity and strength of those ossicles which Gaudry has called interambulacral ; among the members of the family in which the "tergal ossicles" are reticulated, *Oreaster*, as exhibited by *O. nodosus*, stands out conspicuously ; and we have, therefore, in the first place, to speak of the genus as a Goniasterid in which the tergal ossicles are always so reticulated that pore-areas more or less extensive are observable among them.

So far the definition applies to *Nidorellia* as much as to *Oreaster* ; but it could only be applied to *Paulia* by saying that the reticular character is obscured or destroyed by the investing granulation.

Secondly, among the Goniasterids, we find that the two outermost rows of interambulacral plates take on a special development, and form a well-defined margin to the side of the Starfish. These plates may or may not be armed with spinous or tubercular prominences, and they may or may not have smaller plates intercalated among them. In *Oreaster* such plates are never intercalated, the investing granules do not project from their side so as to separate the ossicles from one another, nor are they ever limited to the base, but always pass some way up the sides of the spines or tubercles, when such are developed.

This statement is as true of *Nidorellia armata* as of *O. nodosus*, but it does not apply to *Paulia*.

It would seem to follow, therefore, that Lütken was justified in regarding *N. armata* as an *Oreaster*, and that the return by Perrier to Gray's original view was a retrograde step. For the present, the characters and relations of *Paulia* may be put on one side as well as the exact position of *O. obtusatus*, which must be removed from its original generic position in consequence of the presence of intercalated smaller plates among the marginal ossicles.

The species of this genus fall into two well-marked groups, in one of which large tubercles may be, but spines are never, developed ; in the other a certain number of spines are constantly present, and they may be both large and numerous. Intermediate to these stand such as have the lophial spines reduced or absent, but others developed on various parts of the skeleton. The two chief divisions may be distinguished as those of the *inermes* and *armati* ; and in each the species may be separated according to the number of rows of spines which are typically and most generally developed on the adambulacral plates. In no case do we find a Monacanthid arrangement.

The following series commences with the unarmed, and ends with the triplacanthid well-armed forms.

A. INERMES.

MONACANTHIDA.

0.

DIPLACANTHIDA.

australis.
forcipulosus.
nodulosus.
mammillatus.
valvulatus.

TRIPLACANTHIDA.

granulosus.

B. Intermediate forms with small spines on plates
of various orders.

DIPLACANTHIDA.

chinensis.
decipiens.

C. ARMATI.

MONACANTHIDA.

0.

DIPLACANTHIDA.

a. Lophial spines alone developed.

nodosus.
hiulcus.

β. Lophial aided by lateral spines.

hedemanni.

γ. Lophial and superomarginal spines.

lincki.

δ. Inferomarginal spines also.

alveolatus.
reinhartdi.

ε. Ventral spines also.

productus.
affinis.

ζ. Dorsal spines also.

luetkeni.
occidentalis.
dorsatus.
reticulatus.
armatus.

TRIPLACANTHIDA.

 α . Lophial and ventral spines.*westermanni*. β . Marginal spines also developed.*superbus*. γ . Dorsal spines also developed.*gracilis*.*grayi*.*orientalis*.*troscheli*.*muelleri*.

In the case of such species as I have been able to see I have given a fresh description; where specimens have been wanting, I have, in the case of Dr. Lütken's forms, copied his Latin diagnoses, and for other species I have drawn up brief diagnoses based on the descriptions of preceding writers.

OREASTER AUSTRALIS.

Oreaster australis, Lütken, Vidensk. Med. 1871, p. 263 (Australia).

"*Dorsum altum; brachia angusta, acuta, elongata; radius stellæ major minorem triplum fere æquat; tessellæ marginales c. 21; dorsales angulorum a margine paulum remotæ; tubercula minuta singula in tessellis marginis ventralibus plerumque adsunt, in marginalibus dorsi angulorum vero perpauca, brachiorum crebriora; in tessellis dorsalibus propriis plerumque adsunt, regulariter disposita, series quinas in brachiis formantia, media tuberculis c. 13-14 majoribus gaudente; intimum seriei cujuscunque omnium maximum; areæ poriferæ confluentes, poris numerosissimis; tessellæ ventrales propriæ granulatione obtectæ, haud conspicuæ, granula minuta pedicellariasque numerosissimas lineares elongatas gerunt; papillæ ambulacrales internæ nonæ, externæ ternæ (rarius quaternæ); papillæ orales ori proximæ series singulas (non ut fieri solet duplices) formant.*

Hab. ad oras Australiæ (Novæ Hollandiæ)."

OREASTER FORCIPULOSUS.

Oreaster forcipulosus, Lütken, Vidensk. Med. 1864, p. 156.

"*Brachia angusta, acuminata; radius stellæ major minorem duplum æquat; dorsum deplanatum nodosum; tubercula vel spinæ omnino nullæ in tessellis marginalibus, dorsalibus, ventralibusve, pedicellariæ valvatæ maximæ numerosissimæ (7-15) vero in omnibus hisce tessellis; areæ poriferæ sexseriatæ, sat distinctæ, poris c. 20; papillæ ambulacrales externæ 3 (2-4)."*

West Africa.

OREASTER NODULOSUS.

Pentaceros nodulosus, Perrier, Rev. Stell. p. 237.

$R=2.3r$. Disk moderately elevated, arms of moderate width, tapering gradually. The lophial and apical spines absent, and their place taken by the enlargement of the ossicles into convex rounded bodies.

About 17 marginal plates in either series; it is only in the more distal regions that the inferomarginals take any share in forming the sides of the arms. Neither series are spinose.

Adambulacral spinulation diplacanthid, the spines blunt; in the inner row there are ordinarily seven spines, of which the median are the more prominent; in the outer row there are two or three larger spines, one of which is often, when only two are developed, much larger than the other; these spines have a direction a little oblique to the longitudinal axis of the arm. Between the outer and inner rows a well-developed forcipiform pedicellaria is placed. Beyond the outer row there are irregularly shaped separate granules, which appear, at first, to afford indications of a third row of adambulacral spines.

The ventral ossicles are often distinguishable from one another owing to the larger size of the granules in the centre than at the edge of the ossicle; sessile valvular pedicellariæ are richly developed among the granules. Large and coarse granules are also to be observed on the marginal plates, on which, however, pedicellariæ are only rarely developed.

The upper surface, both of the disk and of the arms, is delicately reticulated. The pore-areas are well separated from one another, and are, in all the more proximal parts of the arm, of some size, and contain more than twenty pores.

The areas of the two lower series along the sides of the arms sometimes become fused at certain points; the lower series extend into the space between every pair of superomarginal plates. The granulation on the nodal points is rather more delicate than on the ventral surface, and the sessile pedicellariæ are exceedingly small.

Nearly all the ossicles along the lophial line are enlarged; some are more so than the rest, and two or three generally attain to considerable prominence; those which flank the apical region are large and rounded, and are, like the rest, covered with a close-set investment of rather large flat granules. A few pedicellariæ are to be observed among the granules of the apical region, where no spine or protuberance of any kind is developed. The madreporite forms an elongated oval whose longer axis is directed downwards, and is placed just outside the boundary of the apical region.

Colour (dry) dirty yellow, probably deep yellow in life.

Measurements:—

$R=53$; $r=21.5$; breadth of arm at base 18.

$R=70$; $r=30$; breadth of arm at base 29.

Hab. West Australia (Dick Hartog's Island).

OREASTER MAMMILLATUS.

Oreaster mammillatus, M. Tr. Syst. Ast. p. 48.

$R=2.7r$. Disk moderately elevated, the elevation not confined to the central portion; arms moderate, rather narrow than wide. Lophial line marked by the greater size, and consequent prominence of some of its ossicles; no spines, however, are developed thereon.

About 18 superomarginal and 20 inferomarginal plates; the latter are confined to the ventral surface; the former are, ordinarily, obtusely conical, and the free end is bare of granules, but there is no reason for supposing that these have the functions of spines; similar blunt tubercular growths are to be found on the more proximal inferomarginals.

Adambulacral spinulation diplacanthid; six well-formed spines, not sharp at their tips, and longer mesially than laterally, occupy the inner row; in the outer there are two or three stout short spines; when there are three, the middle one is generally the stoutest.

The arrangement of the ossicles of the ventral face is a little obscured by the coarse granulation by which they are covered; here and there, and especially towards the edges of the disk, some of the granules come to form quite distinct tubercles; the granulation on the marginal plates is sufficiently coarse.

From the nodal points of the ossicles of the back there arise tubercular processes, hardly one of which deserves to be called spinous; the pore-areas between are considerable, not always distinctly separated from one another; three rows are ordinarily to be detected along the side of the arms, and of these the lowest is the most extensive. The ossicles on the apical region are swollen and tubercular.

The madreporite is irregularly shield-shaped, and placed nearly halfway between the centre and the edge of the disk.

Colour, stony grey.

Measurements:— R 118, r 44; greatest breadth of arm 46.

Hab. Red Sea; Mauritius.

OREASTER VALVULATUS.

For a careful description of this form from New Holland, see the account given by Müller and Troschel; it appears to be most remarkable for its long valvular pedicellariæ.

OREASTER GRANULOSUS.

Pentaceros granulosus, Gray, P. Z. S. 1847, p. 75.

A triplacanthid unarmed species with the disk depressed, and the habit as much of *Goniodiscus* as of *Oreaster*.

$R=2.2r$. Disk depressed; arms rather wide at their base, and not very acute at their tip; lophial ossicles not prominent, and apical spines, as indeed all spines, completely wanting.

About 14 supero- and infero-marginal plates; both sets take part in forming the sides of the arms, are well developed in proportion to the general size of the Starfish, but are always without any spines whatsoever.

Adambulacral spinulation essentially triplacanthid, but care is required in determining the characters of the third row. The plates which carry the spines are strongly convex towards the ambulacral groove; six spines in each innermost series, of which the median are distinctly the longest; none are particularly delicate. In the middle row there is generally only one spine, which is then of considerable stoutness; sometimes a smaller is added to it; those of the third row are most conspicuous when they form a process about half as prominent as the median spine; sometimes it is difficult to distinguish them from the granulation of the disk.

The arrangement of the ventral ossicles may be made out, as the granules which invest them are loosely packed and are of some size; the granules on the marginal plates are much more closely set, are smaller, and form a more regular pavement; the granules are very numerous on the dorsal aspect, tending to be convex, but differing a good deal in size and shape; the poriferous areas are small, as the ossicles are individually large; the lophial series of ossicles have their long axes set at right angles to the long axis of the arm; on either side another series of ossicles reaches to the ends of the arms, while another proceeds about halfway down; some three or four ossicles form a short series outside these last; so that the whole disk is marked by regular rows of convex ossicles. The madreporic plate, as so frequently happens in this genus, is not far from the apical region, is of a moderate size, and fairly prominent.

Colour, when first dried, probably brownish.

Measurements:— $R=60, 46, 45, 41$; $r=29, 22, 19, 18$; greatest width of arm 19, 18.

Hab. Australia (Swan River; Fremantle).

OREASTER CHINENSIS.

Pentaceros chinensis, Gray, Ann. N. H. vi. p. 276.

Oreaster chinensis, M. Tr. Syst. Ast. p. 46.

The type of Gray's species is now lying before me, and it answers so well to the description given by Müller and Troschel that I feel confident that Mr. Edgar Smith took a correct view when he attached to its board the words, "The same, I believe, as *Oreaster chinensis*, Müller and Troschel."

It will be convenient to give here a diagnosis of the species, couched in similar terms to the others here described.

$R=2.7r$. Disk rather high, arms pretty wide at their base, narrowing towards the tip; lophial ossicles without spines, save the apical, which are rounded and knob-like; four spinous projections within the apical region.

18 plates in either marginal series; the inferior quite ventral in position, and not set regularly (in the middle line of the arm) below the superior; in the angle of the arm one or more of the superomarginals may be provided with short but sharp spinous projections; all or nearly all the inferomarginals bear short spinous processes; bare of granules.

The diplacanthid arrangement of the adambulacral spinulation is obscured by the elongation, in places, of the granules which cover the adjacent plates; seven short spines, of which the median are a little longer than those to the sides, are developed in the inner row; in the outer there are ordinarily four, not long, but fairly stout, spines; the forcipiform pedicellaria is developed between the spines of each plate. The arrangement of the ventral plates can be made out underneath the granules of various sizes and shapes by which they are closely invested; a few valvular pedicellariæ can be made out among them. The granules on the inferomarginals are rather more, and those on the superomarginal much more delicate.

The poriferous areæ are not large, and are sharply separated from one another; three rows extend along the greater part of each side of the arm; on the sloping sides of the disk a few of the ossicles have spiniform projections which are bare of granules; the granulation of the dorsal surface is by no means coarse, and no pedicellariæ seem to be developed on it. Madreporic plate an elongated oval.

Colour (dry) dead white.

Measurements:— $R=68$; $r=25$; width of arms at base 24.

Hab. China.

OREASTER DECIPIENS, sp. nov.

A species with the closest external and general resemblance to *O. chinensis*, but distinguished from it by characters to which, in the present condition of our knowledge, we must give the value of specific attributes.

Thus, though it is larger than *O. chinensis*, it is far less richly provided with spines on the marginal plates; there are more spines in the inner, and as a rule, fewer in the outer row of adambulacral spines. In addition to this the disk is quite flat, while $r : R = 1 : 3.4$, in place of the much lower ratio of $1 : 2.7$, which obtains with *O. chinensis*, and the number of marginal plates is much greater.

Taking into consideration all these differences it seems that we must regard the specimens as belonging to a different species.

$R=3.4r$. Disk not high; arms rather narrow, tapering regularly. Lophial ossicles without spines, save the apical, which are well developed, and are very prominent on the unarmed disk. There are no spines within the apical region.

About 25 marginal plates in either series; both take part in forming the sides of the arms, are pretty stout, a little convex; only the more distal inferomarginals bear spines, and these are distributed with great irregularity; they are longer and more prominent than in *O. chinensis*; there are no spines at all on the superomarginal plates.

Just as in *O. chinensis*, the adambulacral spinulation appears in places to be triplacanthid owing to the elongation of the adjacent granules; it is, however, really of a diplacanthid character.

There are 9 spines in the inner row, and they are exceedingly delicate; none are long, but the median are much longer than the lateral ones. Between each plate stands a forcipiform pedicellaria.

In the outer row there are ordinarily two very well-developed spines, though, here and there, three are to be detected.

None of the ventral plates bear spines; some of the granules on the more proximal of them are larger than the rest, and form very distinct aggregates. The valvular pedicellariæ scattered among them are small and not very numerous. The poriferous areæ on the dorsal surface are arranged in three very regular rows along either side of the arms; the areæ are not very large, and the pores are not numerous. The granules on the upper are larger than those on the ventral surface, and have no pedicellariæ scattered among them. Towards the end of the arm the lophial ossicles may project a little, but they never develop spines. Madreporic plate set just between two of the apical spines, irregularly lozenge-shaped, not large.

The integument is much thicker than in most species of the genus, and the specimen has the dead-white colour which we can imagine *O. chinensis* would have had had it been preserved in spirit.

Measurements:— $R=116$; $r=35$; greatest breadth of arm 28.

Hab. Billiton.

OREASTER NODOSUS.

Pentaceros turritus, Perrier, Rev. Stel. p. 240.

Asterias nodosa, Linnæus, Syst. Nat. ed. xii. p. 1100 (pars).

Prof. Perrier prefers Linck's name to that of Linnæus, whom, indeed, he abstains from directly quoting, his only reference being to Gmelin's edition of the 'Systema Naturæ.'

$R=2.5r$ to $3r$. Disk considerably elongated; arms long, rather narrow. Lophial line well marked, with prominent rounded projections; the apical spines very prominent, and a central one typically developed.

About 30 superomarginal, and one or two more inferomarginal plates; both sets obscure, and without any spines, the lower altogether confined to the actinal side.

Adambulacral spinulation diplacanthid; ordinarily seven spines in the inner row, of which two or three in the middle are distinctly longer than those at their sides. In the outer row three spines, about twice as stout as those of the inner row; between the two rows there stands a well-developed forcipiform pedicellaria.

The separate ventral ossicles are a good deal obscured by the coarse granulation with which they are covered; the only region in which there can be said to be a distinctly serial disposition of the plates is that which extends along the side of the ambulacral groove. Many of the investing granules are more than a millimetre in length along their longest axis, and the sessile valvular pedicellariæ are very numerous represented. A similar coarse granulation is found on the marginal plates; but any resemblance to *O. lincki* is opposed by the development of a very large number of pedicellariæ¹.

The upper surface might almost be said to be one mass of pedi-

¹ Have we not here another example of the kind of balance that obtains between the development of spines and of pedicellariæ? Cf. the case of *Asterias glacialis*, Zool. Anz. 1882, p. 283.

cellariæ, for they not only cover the reticulating bars of the dorsal ossicles, but invade also the poriferous areas; the granules, of ordinary character, are confined to the knobs and spines, the tips of which, however, they do not cover. Along the lophial line the projections are always rather tubercular than spinous, but the five spines at the angle of the apex and the central spine within are exceedingly well developed and rather acutely pointed. A few rounded tubercles, similar in character to those of the lophial line, are developed at the sides of the disk. In dried specimens the disk rises up in an altogether turritiform fashion. Madreporite small, rather obscure, on one of the sides of the disk.

Colour (dried) greyish sandy.

Hab. Indian Ocean generally.

Measurements :—

R	165	130	118	100
r	62	44	46	37
Height of disk.....	58	45	31	27
Length of longest spine ..	15	14	21	18

It is to be observed that there are some not unimportant variations in the characters of the spines: those of the lophial line are sometimes sharp, are not always blunt; the apical spines appear to be liable to early division into two or three secondary apices, or they may give off a spur or projection, and, lastly, the processes at the sides of the disk may become quite sharp.

OREASTER HIULCUS.

Oreaster hiulcus, M. Tr. Syst. Ast. p. 48.

The most important difference between this species and the preceding would appear to be the character of the granulation of the dorsal ossicles and the much feebler development of pedicellariæ.

Müller and Troschel, who alone (Syst. Ast. p. 48) have given a satisfactory account of the species, give the habitat as the Indian Ocean; Prof. Perrier would appear to know of it only as from Zanzibar and Mauritius.

OREASTER HEDEMANNI, Lütken.

O. hedemanni, Lütken, Vidensk. Med. 1871, p. 263.

“*Dorsum sat altum, brachia triangularia, mediocria, acuta; radius stellæ major minorem duplum et dimidium æquat; tessellæ marginales utrinque c. 15, dorsales ventralibus magnitudine æquales, parte externa brachiorum forsitan excepta haud alternantes et in peripheria stellæ formanda æqualiter participes; nonnullæ (dorsales sc. 5, ventrales 5-6, ad angulos stellæ sitæ, nec non 1 vel 2 versus apices brachiorum locum tenentes) tubercula minuta gerunt; arcæ poriferae regulares, sejunctæ, poris numero mediocri, juxta tesselas marginales maximæ; tubercula dorsualia quinque sat magna apice nuda, spatiis diametros basales æquantibus inter se separata, tuberculum centrale mediocri circumdant; series fere*

continua tuberculorum similium 7-9, versus apices brachiorum descrentium, carinas brachiorum coronat; minora 1-3 in lateribus brachiorum series duplices utrinque formant; ad angulos stellæ vulgo nulla; tessellæ ventrales propriæ sat magnæ, sejunctæ, granula majuscula, tuberculis haud intermixta, gerunt; pedicellariæ lineares elongatæ in vicinis ambulacrorum, rariores in dorsalibus tuberculis destitutis, conspiciuntur; papillæ ambulacrales internæ 7, externæ 2 (rarius 1 v. 3), complanatæ; orales series duplices formant, internas 12, externas 5 numerantes. Hab. ad oras insulæ indicæ Billiton (specimen junior?)."

OREASTER LINCKI.

Asterias lincki, De Bl. Dict. Sci. Nat. lx. p. 219.

Pentaceros muricatus, Perrier, Rev. Stel. p. 239¹.

R=3 r. Disk moderately high; arm moderately wide, not at all acutely pointed. Lophial spines well developed, the apical very prominent; a spine or two sometimes developed within the apical region.

About 18 marginal plates; the superomarginals alone form the sides of the arms, and are alone provided with spines; these are confined to the distal end, and vary considerably; from one to four may be developed, and in some specimens they are twice as long as they are in others.

Adambulacral spinulation diplacanthid; in the inner row eight poorly developed spines, in the outer two, which are much stouter, for each plate; the tips of the latter are often marked by several shallow grooves; as so frequently happens, a forcipiform pedicellaria is developed between each inner group of adambulacral spines.

The separate ventral ossicles are hardly, if at all, to be made out under the exceedingly coarse granulation by which they are covered; the separate granules vary considerably in size, and a few valvular pedicellariæ are scattered among them. The granules on the marginal plates are hardly less coarse. The dorsal surface is rendered markedly reticulate by the great size and close approximation of the poriferous areas, two of which pass along each side of every arm; in the middle of the arm the second of these may equal in length as much as half the whole height of the arm; sometimes the connecting processes of the ossicles become very delicate, when the whole side of the arm appears to form a huge poriferous area. Spines are very irregularly developed at the angle of the areas; sometimes they are distributed so regularly that one may almost speak of a regular row of spines running on either side of the lophial series; in other cases they are completely absent. This happens sometimes also to the spines of the lophial ridge itself, but they are ordinarily very well developed, as are, too, the apical spines and the spines that stand below them on the sloping sides of the disk. The granulation on the dorsal spines and ossicles is very coarse and extends sometimes quite

¹ M. Perrier here adopts the name of Linck; a course in which, I regret, I cannot follow him.

to the tips of the spines. Madreporic plate rather small, not conspicuous.

Colour (when dry)—lower surface reddish, upper reddish where the granules are developed, with grey poriferous areas; in some cases the dried specimens are almost white, but this may be due to the mode of drying.

The above description has been drawn up from a set of five specimens, which were collected at the same time and place (between tide-marks, at the Mozambique, in May 1882) by Dr. Coppinger, H.M.S. 'Alert', and illustrate the exactness of the statement of Dr. von Martens:—"Alle diese Variationen kreuzen sich so sehr durcheinander, dass man darnach keine irgendwie bestimmbaren Lokalvarietäten aufstellen kann"¹. The variations are so marked that it seems to be impossible to follow Dr. von Martens in establishing definite "varieties." The exact state of the case is, I think, this. The strength of the marginal and ventral plates, with their coarse granulation, is sufficient for the safety of the Starfish; the spines are additional defences that are not constantly needed, and are developed more according to the conditions of individual environment than in obedience to the necessities of the species. They are organs which have begun to disappear, and their importance to their possessor may be judged of by the extent to which they vary in number and size on the different arms of one and the same individual. The species stands midway between *O. alveolatus*, in which inferomarginal spines are also developed, and *O. nodosus*, in which there are no marginal spines at all.

Hab. Indian Ocean (Mauritius, Timor).

R.....	110	95	80	64
r.....	40	34	28	26
Greatest breadth of arm	35	34	31	26

OREASTER ALVEOLATUS.

Pentaceros alveolatus, Perrier, Rev. Stell. p. 243.

At first sight this species has the most remarkable resemblance to *O. lincki*, but it is at once to be distinguished from it by the constant possession of inferomarginal spines.

$R=2.7r$. Disk very high, lophial line well marked; lophial spines well developed; apical very prominent. The arms diminish but little in breadth from the proximal to the distal end.

About 21 marginal plates; at the angles the inferomarginals form the sides, while the superomarginals are rather obscure, and these inferomarginals are provided with rather short spines; the superomarginals gradually become larger, and oust the inferior plates from any share in forming the sides of the arms, while they develop prominent spines; towards the tip of the arm spines, or spinous tubercles, reappear on the inferomarginal plates.

Adambulacral spinulation diplacanthid; five or six spines in the inner row, not remarkably delicate; those of the outer row pretty stout and arranged by twos or threes. A spiniform pedicellaria is

¹ Arch. für Naturg. xxxii. 1866, p. 79.

ordinarily developed between the successive sets of spines. The ventral plates are thickly covered with granules irregular in, but often remarkable for, their size; moderately-sized valvular pedicellariæ will be found pretty numerous scattered among them. Large granules and pedicellariæ are developed on the inferomarginal plates; the granules on the superomarginals are not quite as coarse, and pedicellariæ there appear to be wanting.

The poriferous areæ on the dorsal surface are very abundant and of large size; the ossicles are elongated and narrow, and are set at right angles to the long axis of the arm. The well-developed lophial ossicles are frequently blunt at their tips, and then appear to be covered with granules; when the tips are sharp they are bare of granules; the apical spines are very prominent, the contained area free of spines, the arms surrounded by a well-marked granulation; valvular pedicellariæ are to be here and there detected on the dorsal surface. The madreporic plate is of an irregular shape.

Colour (dry) brownish or light grey, the lophial spines rather darker than the rest.

Measurements:— $R=100, 104$; $r=37.5, 38$; greatest breadth of arm 31, 33.

Hab. New Caledonia.

OREASTER REINHARDTI.

Oreaster reinhardti, Lütken, Vid. Med. 1864, p. 159.

“*O. reinhardti* differt ab *O. linckii* brachiis crassioribus, spinis dorsi paucioribus et minoribus, areis poriferis superioribus haud confluentibus, in seriebus duabus alternantibus vero dispositis, papillis ambulacralibus internis 4–5 (non 6–7) minus gracilibus, pedicellariis interpositis hisce minoribus (non illas superantibus).”

Nicobar Islands.

OREASTER PRODUCTUS.

$R=4r$ to $4.6r$; disk flat, lophial spines not strongly developed; spinous tubercle on both supero- and inferomarginal plates; on the latter there may be two or three on each; spines also developed on the ventral plates. The arms long, not wide at their base, tapering somewhat rapidly; superomarginals about 35, inferomarginals one or two less, groove of division obscure, angles between the plates with, at the angles of the arms, a few (less than ten) pores; these diminish in number at the sides, and disappear towards the ends of the arms. Even in a specimen where $R=150$ mm. we find that the superomarginals may be without any spinous tubercles; these, when they are developed, are not large, nor are they regularly set on all the plates; the inferomarginals, at the angles of the arms, may be armed with five or six small spines, one of which is often more prominent than the rest; as they pass outwards the spines diminish in number, though they may increase in size; on the distal half of the arm there is only one spine on a plate.

Adambulacral spinulation diplacanthid; spines of inner row eight to ten, the median the longest, all very delicate; spines of outer row

four, well developed. All the ventral spines on the disk with one or two spinous tubercles; owing to the narrowness of the arm only one row extends along the side of the adambulacral spines, and the plates at the distal end of this are without spines.

The pore-areas of the dorsal side are distinctly marked, but vary considerably in size and form; the apical region has no central spine, and the most prominent spine of the row along the lophial line is not at all high; none of the spines along the lophial line are especially prominent, and they are not always separated from one another by equal distances; at the distal end of the arm they may become rounded tubercles. Madreporic tubercle moderate, just outside the apical region, lozenge-shaped.

Colour (in alcohol) creamy yellow.

$R=148$, 220 . $r=32$, 53.5 . Breadth of arm at base 32 , 50 .

Hab. Billiton.

OREASTER LUETKENI, sp. nov.

A diplacanthid form, with the appearance, were it not for the shallowness of its disk, of *O. reticulatus*. Supero- and inferomarginal spines; the ventral plates without spines, but most abundantly provided with pedicellariæ.

$R=2.4r$. Disk not elevated: arms, where distinct from the disk, rapidly tapering; most of the supero- and of the inferomarginal plates provided with spines; of the lophial series the apical spines are alone well developed; short, but quite distinct spines developed at all the angles of the poriferous area.

There are about 21 plates in either series along the side of the arm, but the whole of the side of the arm is occupied by the superior set. The disposition of the spines on these plates is exceedingly irregular: only about half of the plates are spiniferous; spines on the inferomarginals are rarer and much less developed. In both series plates without spines will be found to carry, perhaps as many as three, pedicellariæ.

Of the adambulacral spines the inner row has 3 for each plate; these are not very delicate, nor are they exceedingly different in length; between each set is an elongated forcipiform pedicellaria. The outer row has, as a rule, two pretty stout spines on each plate. The ventral plates are remarkably distinct from one another, the granules often larger, the valvular pedicellariæ of some size, numerous, especially in the neighbourhood of the ambulacra. The ventral plates which extend along the lower side of the arm often intervene between the inner edges of the inferomarginal plates. The whole of the dorsal surface is rough with spines; the pore-areas are, on the back, very distinct, and generally triangular; they are specially large along the sides of the arms, the pores large; the granulation is rather coarse and the granules reach very nearly to the tip of the spines and spinous tubercles. Madreporic plate large, irregular in shape.

Measurements:— $R=117$; $r=48$; greatest breadth of arm 3.5 .

Colour, brownish (in alcohol).

Hab. Billiton.

OREASTER OCCIDENTALIS.

O. occidentalis, Verrill, Trans. Conn. Acad. I. ii. (1867), p. 278.

$R=2.5$ to $2.17 r$. Disk not high; arms not wide, tapering pretty rapidly. Lophial line not prominent, some of the ossicles provided with short, sharp, inconspicuous spinous processes. There are some spines within the apical region.

About 22 superomarginal and 20 inferomarginal plates in the largest specimen examined; the latter would not seem to be completely confined to the ventral aspect, though in the process of drying they may often be drawn thither. Both sets of plates are fairly well developed, and are richly covered with granules; on the whole they are perhaps more indistinct than in any other species of the genus. From among the granules there stands up on a few of the plates of either series a very small and inconspicuous spinous process, and the disposition of these spines differs on different arms and on different sides of the same arm.

Adambulacral spinulation diplacanthid; about seven or eight spines ordinarily developed in the inner row; these are not so strong as are two out of the three which are developed in the outer row, where the third, if present, seems to be always smaller than the other two.

The whole of the ventral surface proper is closely covered by large and coarse granules, not a few of which become almost spinous in character; among these only a few pedicellariæ are developed.

The poriferous areæ are arranged in three fairly regular rows along the sides of the middle line of the arm; the areæ of the innermost are the smallest and those of the outermost the largest in extent; at most of the nodes formed by the reticulating dorsal ossicles a small spinous process is developed, but in the adult this is nearly always inconspicuous. The granulation on these ossicles is rather coarse, though by no means so coarse as on the ventral surface, but it always leaves bare the spinous process.

The madreporite is triangularly cordiform, the apex being directed towards the apical region, just outside which it is placed.

Colour in alcohol said by Verrill to be greyish brown: it has something of the same colour when dried.

As has been pointed out in the introduction to this paper, this species undergoes during the later stages of its growth some very considerable changes in the characters of its spinulation; the spines in the younger being very much better developed than in the older forms.

Measurements:—

R	90	115	148
r	39	53	59
Breadth of arm at base	37	46	45

Hab. Western coast of Central and Northern America.

OREASTER DORSATUS.

Pentaceros dorsatus, Perrier, Rev. Stell. p. 245 ; but substitute the following for the inexact synonymy there given :—

1753. *Asterias dorsata*¹, Linnæus, Mus. Tessin. p. 114, pl. ix. 2.

1758. Seba, Thesaurus, iii. pl. v. 7, 8, pl. vi. 1, 2.

1766. *Asterias nodosa*, Linnæus, Syst. Nat. p. 1100 (*pars*).

1842. *Oreaster clavatus*, M. Tr. Syst. Ast. p. 49.

1864. *Oreaster dorsatus*, Lütken, Vidensk. Med. p. 161.

This species has been so admirably diagnosed by Müller and Troschel that had I not here the object of giving original and similarly constituted definitions of such species as I have seen, I should gladly content myself with referring the student to their description.

$R=2.2r$. Upper surface, in dried specimen, almost flat ; arms not acutely pointed. Lophial line and spines distinct, the apical not especially prominent ; spines developed within the apical region.

About 12 supero- and 14 inferomarginal spines, the latter distally, but not proximally taking a share in the formation of the side of the arm. Both sets are provided with spines ; on the upper plates these spines are of some size, and frequently two are developed ; these are set one above the other so as to lie at right angles to and not parallel with the long axis of the arm. Two spines are likewise often developed on the inferomarginal plates ; these spines are sometimes of a fair size, but are frequently rather tubercular than spinous.

Adambulacral spinulation diplacanthid ; three strong and often subequal spines in the inner, and one very stout, with rounded tip, in the outer row.

The separate ventral ossicles are quite easily made out under the rather coarse granulation by which they are invested ; the row of ossicles running along the side of the adambulacral series is without spines, but those outside this, of which there are four in the proximal and two in the most distal region, are provided with one and sometimes with two rounded spinous projections.

The upper, like the lower surface, is well provided with spines, and here again two are frequently found to be developed on the free surface of one and the same ossicle. The lophial ossicles are large ; as large indeed, if not larger than, the more proximal superomarginals ;

¹ The only foundation for the statement of Müller and Troschel, reiterated by Perrier, that in the Mus. Tessin. Linnæus called this species *A. stellata*, is the fact that the word *stellata* is the first in the definition of the species. As the work is rare (the copy from which I took this note was one which I saw, by the kindness of Professor Lindström, in the admirable Library of the Royal Academy of Sciences at Stockholm), I think it well to give in full what Linnæus said :—

"*Dorsata*. *Asterias stellata*, radiis convexis longitudinaliter elevatis. Tab. ix. fig. 2.

Locus : India.

Stella spithami diametro. Radii quinque, obtusi, versus basin dilatati, dorso admodum convexi, adpersi undique mucronibus obtusiusculis remotis.

Subtus plana, adpersa punctis prominulis ; rima cineta papillis subulatis, tenuissimis."

spines are not developed on all, though they are on most of the ossicles; and we frequently find, though without any definite regularity, that two, or it may be three, spines are developed. When this happens the spines are so set side by side as to lie across the long axis of the arm; they are not large, but their free end is always bare of granules. The ossicles extend almost to the centre of the disk.

In addition to the lophial spines a number of others, almost if not quite as large as they, are also developed; a definite row runs down either side of the lophial line, and in the wider portion of the disk two other rows of spine-bearing ossicles are less distinctly developed. The pore-areas are extensive, but not sharply distinguished from one another, and the individual pores are large. The close granulation of the superior ossicles and the intermediate pore-areas is hardly less coarse than that of the lower surface. The madreporite is of moderate size, irregularly elliptical, and about its own long diameter from the centre of the disk. Notwithstanding the statement of Müller and Troschel, I venture to think that a perfect specimen would present at any rate a few pedicellariæ.

Colour (when dry): the distal parts of the arms light, the proximal brown, above; the whole greyish brown below. The specimen here under description is stated to have had the "tops of prickles scarlet-red, upper surface tile-red."

It was collected by Mr. Darwin at St. Iago, Cape Verde Islands.

Measurements:— $R=95$; $r=42$; breadth of arm at base 41 millim.

OREASTER RETICULATUS.

Pentaceros reticulatus, Perrier, Rev. Stell. p. 246, where see the complicated synonymy, and therein make the following corrections and additions.—

Insert "1766, *Asterias reticulata*, Linn. Syst. Nat. ed. x. p. 1099."

Add "page, p. 14," to "Retzius (1805)."

After "(1840) *reticulatus*," add "*aculeatus*, p. 277."

Add to reference to Grube in Archiv of 1857,—"*Nova Acta Ac. L. C. xxvii. (1860), p. 17*;" and delete the words "*et Oreaster gigas*."

Correct page of reference to Lütken (1859) to "p. 64."

For "1862, *Oreaster tuberosus*, Belm,"—read "1859, *Oreaster tuberosus*, Möbius, Neue Seesterne, p. 6, in Abhandl. Geb. Naturw. (Hamburg), iv. p. 2. The specific name was suggested by Prof. Behn."

Complete reference to Agassiz,—"*no. 9 (1869), p. 307*."

The numerous names given to this species will afford some indication of its variability; it will perhaps be most convenient to commence with an account of a large almost perfect (though dried) specimen.

R is about equal to $2r$. Disk exceedingly high; arms rapidly tapering from their base, rounded, not carinated, so that the lophial line is very indistinct; spines developed within the apical region.

Sides of the arms formed by the superomarginal plates only: of these there are rather more than 20 on either side of each arm; they are regularly provided with long strong spines, which are nearly always rather acute, and only become distinctly shorter near the distal end of the arm. The inferomarginal plates are not quite so numerous as the superomarginal; they are almost without exception provided with one, and in some cases with more than one, spine; these vary a little in size, but are always much smaller than those on the upper plates.

Adambulacral spinulation diplacanthid, three inner and one outer being the ordinary arrangement; the inner are quite small, the outer of fair size, and not sharp at their tips. The whole of the ventral surface is spinous, owing to the rich development and the regular distribution of the spines which are found on it; there are as many as six rows in the proximal and three in the distal region; the spines would seem to be carried on separate ossicles, and while each ossicle has one, it may sometimes have two or three large spines, or a larger number of smaller ones; speaking generally, the larger spines are the more proximal. Between the spines are found coarse, separate granules, and a fair number of sessile bivalved pedicellariæ.

In the specimen under description the bases of the ossicles are particularly thick, except along the lophial line; a large number of the pore-areas have the form of an equilateral triangle, and are quite distinct from one another; as a rule the best-developed spines of the dorsal surface are those which are found on the nodes of the reticulations; between these somewhat smaller ones are not unfrequently developed; the spines along the lophial line are, on the whole, rather stouter than the rest, but they are by no means conspicuously so. There are no prominent spines on the apical portion of the disk; and the madreporite is of moderate size and somewhat irregular shape.

Colour dark brown; but other specimens are white.

Measurements:— $R=186$; $r=86$; height of disk 116 millim.

Hab. "West Indies;" two small specimens in the Museum collection are from Fremantle, Australia.

Owing, no doubt, to the great size to which this species attains, many of the incompletely grown forms have been regarded as representatives of distinct species; nor has this, as it seems, been the only cause of the many names given to it. The *O. lapidarius* of Grube is no doubt a remarkable form at first sight, but the appearance is to be explained by the dried and injured condition of the specimen.

OREASTER ARMATUS.

Pentaceros (Nidorellia) armata, Gray, Ann. N. H. vi.

Oreaster armatus, M. Tr. Syst. Ast. p. 52.

Nidorellia armata, Perrier, Rev. Stell. p. 251.

Nidorellia michelini, Perrier, Rev. Stell. p. 252.

The conception of the limits of a genus vary, of course, considerably, but the close study of this species seems to show that M. Perrier has elevated into generic what are only specific cha-

racters. He speaks, for example, of the difference of the form of the body between *N. armata* and any species of the genus *Oreaster*, as he regards it. But a comparatively insignificant difference in the value of $\frac{R}{r}$ is not even a subgeneric character. The second point of difference is, in Prof. Perrier's words, "le peu de saillie des ossicules dorsaux qui sont à peine distinctes," but they are, at any rate, just as clear as they are in *O. granulosus*, and, indeed, they are much more so, while there are specimens of *O. gracilis* in which the lophial line is no more distinct. M. Perrier proceeds, "Les aires porifères sont larges, confluentes et paraissent même parfois envahir toute l'étendue du disque." In young specimens the poriferous areæ are much more distinctly marked off than in *O. alveolatus*; if there is any disadvantage to the side of *O. armatus* with respect to its alveolation, when adult, it is no doubt to be correlated with its better development of long defensive spines. It is not always the case that the spines of species of true Oreasters, according to M. Perrier—take, for example, his own species *O. alveolatus*—are always free of granules at their tip; we find so many intermediate stages between a complete investment and an almost complete absence of granules that this character, again, must not be regarded as having, at the utmost, more than a specific character.

The species may be defined in the following terms:—

$R = 1.7r$ to $2.1r$. Disk not high, arms very short, interbrachial angles rounded; lophial and apical spines very strong, intermediate spines and spines on marginal plates exceedingly well developed; spines likewise developed on the ventral plates.

Nine plates in the supero- and nine in the inferomarginal series; the latter all bear spines, which are short in the angles and of a moderate size near the distal ends of the arms; the three or four spines found on the distal plates of the superomarginals are much larger; the superomarginals are greatly elongated from above downwards in the angles of the arms, where they almost shut off the inferomarginals from any share in forming the sides of the arm; further out the plates become shorter, but the penultimate is very large and convex.

Ambulacral spinulation diplacanthid; three or four fairly developed spines in the lower, and one much larger in the outer row. The ventral ossicles covered with rather coarse granules, and each having, rising from its centre, a blunt stout spine; some large valvular pedicellariæ are developed on these plates; the granules on the inferomarginals are only a little less coarse than those on the ventral ossicles, but the greater number of those on the superomarginals are much more delicate; pedicellariæ are only feebly developed. With increasing size the boundaries between the poriferous areæ become largely obliterated; just at the interradian angles, however, the ossicles are stouter in older than in younger specimens.

The lophial spines are strong and sharp in the adult; between them some few spines may become developed; and in the centre of the apical region there is a spine as long or nearly as long as the apical. A few pedicellariæ are developed on the dorsal surface, the

general granulation of which is rather delicate. In the adult the shield-shaped madreporic plate is covered with granules.

Colour (in spirit) creamy white or white.

Measurements:—

R.	24	*27	47	*48	84
r	16	16.5	22	23	50
Length of longest spine.	1.5	3	3.1	6	15

The two specimens whose admeasurements are marked with an asterisk were determined by M. Perrier as examples of his species *N. michelini*; but there can hardly be any doubt that within the limits of a millimetre or two differences may always obtain in the development of defensive spines, and the two species may well be united.

Hab. W. coast Central America; Sandwich Islands.

OREASTER WESTERMANNI.

Oreaster westermanni, Lütken, Vidensk. Med. 1871, p. 264.

“*Dorsum deplanatum fere, brachia longissima, radio stellæ majore minorem triplum quinta parte superante; tessellæ marginales admodum convexæ, alternantes c. 30; dorsuales, tuberculis 1–4 minutis obsitæ, solæ (apice brachiorum excepta) ipsum marginem stellæ formant; areæ poriferæ triangulares, sæpe confluentes, poris numerosissimis; tubercula numerosissima mediocria obtusa in nodis trabecularum, in parte centrali stellæ et basali brachiorum conica vel cylindrica fere, in parte terminali brachiorum crassiora, convexa, approximata, tessellasque marginales fere æquantia, series quinas in brachiis formant, media c. 30 numerante; tubercula 5 duplicia paullo modo majora et parum inter cetera conspicua partem centralem stellæ circumdant; tessellæ ventrales propriæ tuberculiformes, minutæ, numerosæ, propter granula obtegentia haud conspicuæ, præter granula singulam (prope ambulacra duplicem vel triplicem) spinam crassam obtusam gerunt; papillæ ambulacrales triseriatæ, internæ nonæ graciles, ceteræ crassæ, obtusæ, ternæ (rarius binæ vel quaternæ); pedicellariæ valvulatæ minutæ raræ prope ambulacra. Hab. ad oras Bengalæ.*”

OREASTER SUPERBUS.

Oreaster superbus, Möbius, Neue Seesterne, p. 5; Abh. Geb. Naturw. Hamburg, Bd. iv. Abth. ii.

The figures of Möbius show that this is a really remarkable species, on account of the knobbed character of its spines, and the apparently restricted size of the poriferous areas.

It would seem that R is about equal to 4 r; the lophial line distinguished by the presence of knobbed processes, somewhat irregularly, but always closely, arranged. Some of the more proximal superomarginals bear knobbed spines, and the infero-marginals till about the middle of the arm have two, whereof the

outer is thicker than the inner. The ventral plates each bear a spine; the ambulacral spinulation is triplacanthid. $R=200$ millim.

Hab. Sumatra.

OREASTER GRACILIS.

Oreaster gracilis, Lütken, Vidensk. Medd. 1871, p. 260.

As there is in the British Museum collection a specimen the spread of which must exceed the largest of Dr. Lütken's specimens by more than 50 millim., it may be convenient to give an account of it.

$R=2.87r$. Disk not elevated; arms narrow at their base, slender in proportion to the disk; lophial line well marked, but not projecting; the apical spines of moderate height, and a smaller central spine.

About 30 superomarginal and inferomarginal plates; the greater number of these are large, and both sets take part in forming the sides of the arm. In the angles of the arm they are elongated from above downwards; further out the upper are longest in the direction of the long axis of the arm, while the lower are squarish. In the specimen under description the two inferomarginals in the angle of the arm are always, and the corresponding superomarginals are sometimes, provided with bluntly conical spinous projections; inconspicuous tubercular projections are developed on a few of the quite distal superomarginal plates.

Adambulacral spinulation triplacanthid; in the innermost row ordinarily nine rather delicate spines, of which the median are the longest: the middle and outer rows have generally two spines each; these are stouter than the inner spines, and those of the median are a little stronger than those of the outer row. The ventral plates are quite distinct from one another, the covering granulation being so arranged that each ossicle seems to have its proper investment; on the actinal surface of the disk these ossicles seem to have no definite arrangement; along the greater part of the arm there runs but a single row of ossicles between the ambulacrum and the inferomarginal plates; these ventral ossicles are all of the same size, and the larger may be often seen to have pushed their way into the slight space between two succeeding inferomarginal plates. Fair-sized pedicellariæ are developed on some of the ossicles that lie nearest to the adambulacral plates.

The marginal plates are very regularly granulated, and appear to be altogether devoid of pedicellariæ. The granulation on the upper surface is still more delicate; the general appearance of this aspect of the disk is well stated in the words of Lütken, "Dorsum disci regulariter reticulatum, areis poriferis trigonis, nodis trabecularum tuberculiferis;" but of this specimen it is hardly correct to add "tuberculis minutis."

In the face of the fact that this is a larger specimen than either examined by Dr. Lütken, and that the tubercles at the nodal points of the reticulating ossicles are, so far as one can judge, better developed than in his specimens, the question arises as to the extent

to which one may suppose that the spines vary in length and strength.

The first explanation that one would be led to give would probably be to some such effect as this. The specimen now under consideration is larger than Dr. Lütken's specimens because it is better provided with spines, and has therefore had less difficulty in maintaining its existence.

On the other hand, we do not and never can know what Dr. Lütken's specimens might have accomplished in the way of growth had they not fallen victims to the zeal of a collector.

All, then, that we can say is, that of known specimens of *Oreaster gracilis* the largest has the spines best developed.

This statement does not, of course, exclude the possibility of smaller specimens being also well provided with spines: if it did it could never be allowed to pass by one who had gone over the collection in the British Museum. Inasmuch as it tacitly allows that small specimens may be well provided with spines on the dorsal aspect of the disk, it raises the next question as to whether that difference is one of race, of sex, or of an indefinite variability, not yet seized upon to the profit of the species. In other words, it raises questions which are beyond the ken of the cabinet naturalist, but not questions which cannot be satisfactorily investigated by those who are fortunate enough, as are some of our Australian fellow-subjects, to have these creatures living in their own seas.

One will perhaps be pardoned the apparent truism if attention is directed to the fact that while a systematist measures spines by millimetres, a Starfish may have them scattered in great abundance over his whole body—in other words, accurate measurements must always be used in an intelligent fashion, note being made of the fact that a difference in length which, when measured by the ruler, may amount only to $\frac{1}{2}$ a millimetre, comes to be a matter of importance to a creature which numbers these spines by hundreds.

In the investigation of the spinulation of Starfishes there is, surely, a wide field for the study of those mechanical causes with which the zoologist is concerned.

OREASTER GRAYI, sp. nov.

Pentaceros nodosa, Gray, Ann. N. H. vi. p. 277 (1841).

As we use Linnæus's name *nodosus* for the species which he no doubt so first named, we have to find another name for Gray's species.

The following description is based on a specimen considerably larger than Gray's "type," which was obtained from Billiton:—

R=2.2 r. Disk not high; arms very broad, even at the distal end; lophial ossicles with large tubercles in the place of more or less sharp spines; the apical spines not disproportionately large. A few spines within the apical region.

The superomarginal plates alone form the sides of the arm, they are about 17 in number; the inferomarginals are more numerous by one or two; of the former, some of the more distal are provided

with rounded tubercles very similar to those which are found on the lophial line; there are no spines of any sort on the inferomarginals.

The spines of the adambulacral plates in the dried specimen have been for the most part lost, as have also the granules on the ventral plates. In the "type" the inner row has five not particularly delicate spines; those of the next row form a pretty stout pair, and outside these there is a set of smaller and more irregularly disposed spines. The ventral plates, which are distinct from one another, are covered by large granules, among which may be discerned a fair number of valvular pedicellariæ of various sizes.

On comparing the smaller and the larger specimen (which give respectively the following admeasurements— $R=52, 76$; $r=23, 34$; breadth of arm at base $23.5, 36.5$) we see that the leading differences between them are—(1) the smaller sometimes has spines on the inferomarginal plates, which themselves take some share in forming the sides of the arms; (2) the number of marginal plates is smaller; and (3) nearly all the superomarginals carry nodose spines or tubercles.

We have therefore in this species a growth-character which differs from that which ordinarily obtains in this genus; but it is one which can be explained by reference to the small size and rare distribution of the poriferous arææ, coupled with the considerable size and resisting power of the ossicles of which the skeleton is here composed.

OREASTER ORIENTALIS.

Oreaster orientalis, M. Tr. p. 128.

Three dried specimens of this species, the first representatives of it in the British Museum, have recently been acquired from the Chinese Court in the late Fisheries Exhibition, and I am able therefore to give an independent description of a species which has never been mentioned since the time of Müller and Troschel.

A triplacanthid form, with a high disk and the general habit of *O. reticulatus*, but with dorsal spines much less well developed and ventral spines altogether absent.

$R=2.5 r$. Disk elevated; arms narrow at their base, slender in portion to the disk. Lophial line well marked, but spines not long; apical spines prominent, a few short spines within the apical region.

From about 20 to 25 marginal plates, the boundaries between which are not always as well marked as in most species of the genus; both sets take part in forming the sides of the arm; in the angles of the arm both sets bear spines, rather short and sharp; further out the spines are smaller and less regularly developed; they are, however, absent from the upper, and generally present on the distal lower plates. Adambulacral spinulation triplacanthid; eight (nine *testibus* Müller & Tröschel) delicate short spines in the innermost row, each set separated by a forcipiform pedicellaria; five much stouter in the middle, and two to four in the outermost row. With advance in size the boundaries between the ventral plates become obscured; the granules are closely packed and large, but always remain flat, and never become produced into spinous processes;

valvular pedicellariæ are, on the other hand, pretty numerous, and are especially rich along the sides of the ambulacra. The marginal plates are very regularly granulated, and small valvular pedicellariæ are not unfrequently developed. The granulation on the upper surface is more delicate. The pore-areæ are very regular, triangular, and of moderate size; at the nodal points spines or spinous tubercles are always developed; and we have here one of the rare cases of the development of dorsal without ventral spines.

Colour (dry) more or less white.

Measurements:—

R.....	133	115	110
r.....	52	37 ¹	42
Greatest breadth of arm....	35	24	25

Hab. China (Swatow).

OREASTER TROSCHLI, sp. nov.

A triplacanthid form, most nearly allied to *O. orientalis*, but distinguished from it by the following characters:—There are not more than three spines in the second row of adambulacral spines on each plate; the spines are, as a rule, developed only on the distal marginal plates, and those that do not carry spines bear a number of valvular pedicellariæ.

$R=3r$. Disk not elevated; arms distinct, not wide at their base, and tapering very gradually. A median dorsal row of fairly well-developed spines; the five apical spines very strong; most of the angles of the poriferous areæ on the disk are provided with spines; there are no spines on the ventral plates.

About 25 superomarginal and 27 inferomarginal plates; the latter are confined to the abactinal aspect, save at the end of the arm. The superomarginals are very high in the angles, but are shorter along the sides of the arms; in exceptional cases a spine or two may be developed on them in the proximal, but, as a rule, they are confined to the distal half of the arm. They are often well developed sharp processes. Owing to the position of the terminal superomarginals, the two last spines are set quite on the abactinal surface. The spines on the inferomarginals are rare and small; but these, as well as the non-spinose superomarginals, are richly provided with pedicellariæ.

Adambulacral spines in three rows; the innermost delicate, short, about ten in number; in the middle row there are two or three stout spines, and in the outermost two or three, not quite so regularly developed as the rest. The immediate buccal armature is formed by the elongation and strengthening of the spines of the lowest row. The ventral ossicles are fairly distinct from one another, and are very richly provided with pedicellariæ. A considerable number of pedicellariæ are likewise developed on the abactinal aspect of the disk and arms; like all those in this species, they are sessile and valvular.

The pore-areæ are large and numerous, so that the reticulation of

¹ Shrunk in drying.

the dorsal ossicles is very well marked ; three rows of pore-areas extend along the greater part of each side of the arm. Madreporic body rather obscure, small, irregularly oval, surrounded by an impressed line. Granules cover all the plates, are small and regular, save on the ventral plates, where they are larger and more irregular.

Colour (in alcohol) yellowish white.

$R=140$ millim. ; $r=47$ millim.

Hab. Billiton.

I have dedicated this species to the memory of the late Professor Troschel, who, with Johannes Müller, was the author of the 'System der Asteriden.'

OREASTER MUELLERI, sp. nov.

A triplacanthid form allied to *O. orientalis*, but distinguished from it by the following characters :—There are only two or three, and not as many as five, spines in the second adambulacral row ; nearly all the marginal plates, whether superior or inferior, carry spines ; the pedicellariæ on the ventral plates are not numerous.

$R=2.5 r$. Disk rather high ; arms rather wide at their base, and stout for all their distance ; spines at the sides half or more than half as high as those of the median row, the apical spines well developed. Spines richly developed on the disk. No spines on the ventral plates.

About twenty marginal plates in either series, the lower completely confined to the abactinal aspect, save just at the end of the arm. The superomarginals considerably excavated superiorly, so that their upper edge is triangular ; the spines on the upper are more prominent than those on the lower plates, and are developed on nearly all ; those on the inferomarginals are occasionally double. There are no pedicellariæ on the marginal plates.

Adambulacral spines in three rows ; in the innermost eight delicate spines, of which the outer in each set are remarkably small ; each set is separated from its neighbour by a forcipiform pedicellaria ; in the middle row two, sometimes three, much stouter spines ; in the outermost row two or three, not quite as stout ; these spines decrease in number on the distal plates. The immediate buccal armature appears to be formed by the elongation of the spines of the lowest row. The ventral plates are best distinguished from one another by the large size of some of the tubercles on each plate ; of these there may be four or more, which may form a rosette. A fairly large number of valvular pedicellariæ are developed, especially in the neighbourhood of the ambulacra.

The pore-areas are large and numerous, when of a definite form triangular, but at the sides of the arm the reticulation of the skeleton is not as distinct as it is on the disk.

Madreporic body irregular in form. Granules unequal, forming a mosaic, never reaching to the tips of the spines. Pedicellariæ on the dorsal surface small, forcipiform.

Colour (in alcohol) creamy white.

$R=98$; $r=38$; breadth of arm at base 34.

Hab. Billiton.

OREASTER.

Species incertæ.

From the island of Mauritius (through M. de Robillard) came two specimens of a brick-red colour, which have at first sight a very close resemblance to *O. reticulatus*; further investigation, however, not only shows that the species are distinct from that form (though neither of them are *O. affinis*), but also, and this is the curious point, striking as is their general resemblance to one another, they do not belong to the same species.

Species α .—Adambulacral spinulation triplacanthid, the spines in the middle row remarkably strong, two on each plate; superomarginal plates about 16, but only the distal plates with well-developed spines; spines developed on the rather more numerous inferomarginals, without any marked irregularity, but they are never so long, or so strong, or so sharp as in *O. reticulatus*. Granules on the ventral plates coarse and large, sometimes, but rarely, forming short spines. Dorsal surface and general form not unlike that of *O. reticulatus*.

Species β .—Adambulacral spinulation diplacanthid, and always two outer spines for each plate: about 16 superomarginal and inferomarginal plates; the latter with fairly developed spines in the angles of the arm; the former occasionally with small spines at the angles, but with spines only well developed quite at the distal end. The numerous spines developed among the granules of the ventral plates are not so strong, and are far less regularly arranged than in *O. reticulatus*.

Complete accounts of these two species must be based on fuller material, and especially on specimens preserved in spirit. In addition to these two species there is yet another from Mauritius, which is represented by two badly preserved specimens; this third species, which likewise appears to be new, has the general form of *O. lincki*, but has lateral rows of spines not unlike those that are found in *O. dorsatus*.

Just as I had come to the conclusion to issue the incomplete notices of these apparently new species, I received a copy of the first part of the 'Catalogue Raisonné'¹, which I owe to the kindness of its accomplished author. In the second part of that essay, soon no doubt to be published, we shall probably obtain some more information as to these forms.

OREASTER CARINATUS.

Oreaster carinatus, M. Tr. p. 49.

A diplacanthid form with a well-marked lophial ridge and tubercles on both series of marginal plates and on the ventral plates; it seems to stand nearest *O. productus* (n. sp.), but our information with regard to it is very slight.

¹ "Catal. Raison. des Échinodermes recueillis par M. V. de Robillard à l'île Maurice," par P. de Lorient (Mém. Soc. Phys. Genève, xxviii. no. 8).



Bell, F. J. 1884. "Contributions to the Systematic Arrangement of the Asteroidea.-II. The Species of Oreaster." *Proceedings of the Zoological Society of London* 1884, 57-87. <https://doi.org/10.1111/j.1096-3642.1884.tb02810.x>.

View This Item Online: <https://www.biodiversitylibrary.org/item/96832>

DOI: <https://doi.org/10.1111/j.1096-3642.1884.tb02810.x>

Permalink: <https://www.biodiversitylibrary.org/partpdf/73132>

Holding Institution

Natural History Museum Library, London

Sponsored by

Natural History Museum Library, London

Copyright & Reuse

Copyright Status: Public domain. The BHL considers that this work is no longer under copyright protection.

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.