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THE CAMBRIAN FAUNAS OF NORTH-EASTERN AUSTRALIA.

PART 4: EARLY CAMBRIAN ECHINODERMS SIMILAR TO THE LARVAL STAGES OF RECENT FORMS.

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(Plates I-IV.)

Summary: In the lowest zone of the Middle Cambrian of Queensland two species of unattached echinoderms occur in vast numbers. One of these, bilaterally symmetrical, corresponds morphologically to the dipleurula stage in the larval history of the phylum. The other agrees with the radially symmetrical form that, in ontogeny, usually succeeds that stage. Stereom structures are more simple than is usual for the echinoderms; but a change in skeletal structures by the adoption of fibrous spherulitic growth provides an explanation for the metamorphosis in echinoderm ontogeny and the attainment of pentamerous form. Some observations are offered upon the inter-relationships of the major groups of the phylum.

From the Lower Cambrian to the Ozarkian echinoderms are richly present in the sequence of Western Queensland. Very often the ossicles are packed so closely, with relatively little of the calcareous cement, that they form echinodermal limestones as fully organic as the typical crinoidal limestones of later periods. Such limestones often are of great thickness as well as of wide extent. Usually, however, as with later limestones, the plates are so closely adpressed that the surface features of individuals or the form of the whole skeleton is not to be determined. Yet from quite a number of horizons, from late Lower Cambrian to Ozarkian, united ossicles of normal pelmatozoans have been obtained. These will be described at some later date. Meanwhile this record is given of two members that are not pelmatozoans but belong to quite a new group. They occur in vast numbers and in considerable perfection; and they have features of unusual interest for morphological and phylogenetic studies in the phylum.

THE MATERIAL AND ITS AGE.

The specimens were collected in 1939 by Mr. Edgar Riek* and myself on Thornton station in the far north-west of Queensland (lat. 19° 30'S.: long. 138° 55'E.). During this field period a wonderfully rich assemblage of Cambrian fossils (sponges, brachiopods, molluscs, trilobites and echinoderms) was obtained from measured horizons throughout the whole range of the Middle Cambrian and part of the Lower Cambrian. When described they will amplify considerably the stratal and faunal notes given in previous parts of this publication. A summary has been published elsewhere (Whitehouse 1940, p. 45) of the stratal succession, with a record of a few of the trilobite horizons.

*I take this opportunity of expressing my thanks to Mr. Riek for his very great assistance both during the field work and in later activities.

Essentially in North-Western Queensland the sequence is of limestone. Occasionally chert beds (some of them original, siliceous sediments, others being later replacements of the limestones) occur as prominent bands in the section. Around Thornton the sediments belong to the upper part of the Lower Cambrian and the lower part of the Middle Cambrian. The pertinent portion of the sequence for the present purpose is shown graphically in figure 1.

The Middle Cambrian limestones in this region are over 800 feet in thickness. Through the first 150 feet the trilobite genus *Xystridura* occurs, often in very great abundance. Immediately below are beds with *Redlichia* but with very little else—only echinoderm ossicles, *Orthotheca* and *Helcionella*. Actually the two trilobite genera overlap for two feet in their ranges. In the *Xystridura* beds a number of new trilobite genera appear, particularly towards the top of the stage, all of them Middle Cambrian types—for instance *Pagetia* and *Lyriaspis*. Other rich Middle Cambrian faunas (with *Nepea* and *Amphoton*) appear in the immediately succeeding beds. Such relationships, together with the mesonacid affinities of *Redlichia* and some as yet unpublished work upon the agnostids, suggest that the incoming of *Xystridura* may best be regarded as the beginning of the Middle Cambrian. *Redlichia*, on this reading, dies out at the beginning of that division.*

Both echinoderms now to be described have been found only in the early part of the *Xystridura* zone. They have been collected on hills adjoining the left bank of the Thornton River, one mile south of the present Thornton homestead. *Cymbionites* appears first in the basal beds of the zone (about ten feet above the river flats) and lasts until the initial two feet of the second limestone (bed E of figure 1). Thus, on present evidence, it ranges through forty feet of strata. At its final appearance it occurs in colossal numbers. The limestone is closely packed with complete specimens of the echinoderm, weathering out beautifully upon the surface. A flat-lying, slabby limestone with specimens crowded as richly as in pl. I, fig. 1, and as well preserved, may be traced continuously around the contour of these hills. Following it is like walking over thickly strewn, embedded marbles. The fecundity of this species is astonishing.

* In previous parts of this publication, when no sequence of the beds had been traced in the field (collections having been made at sporadic localities), a zonal nomenclature was used based solely upon the palaeontological evidence. Now, however, a continuous section has been traced through the whole of the Middle Cambrian limestones and collections carefully have been made. The succession of trilobites and other forms thus has been established by direct observation so that some revision of the zonal scale is desirable. The trilobite stages of previous nomenclature are of unequal value. Some of them need to be modified. For instance the association of *Nepea* and *Amphoton* occurs at intervals through a very large part of the Middle Cambrian and seems to have mainly a facies significance. There are, however, few changes to be made. For the present, until this evidence can be presented in detail, Middle Cambrian beds vertically as far as the horizon with *Dinesus* may be placed in the one zone—a *Xystridura* zone.

Twenty-four feet above this rich band occurs the bed, five feet thick, with *Peridionites*. This is packed almost as tightly with specimens as the other (pl. I, fig. 2) and they, too, weather out in relief. *Peridionites*, so far as is known, is restricted to this bed. Between the two rich horizons are other echinodermal limestones greatly crowded with ossicles that, however, do not stand out with naturally etched surfaces. Thus what echinodermal types occur in them is unknown. They may be largely of normal pelmatozoans; for definite, conjoined, pelmatozoan ossicles occur throughout this range, from the beds with *Redlichia* to the *Peridionites* band.

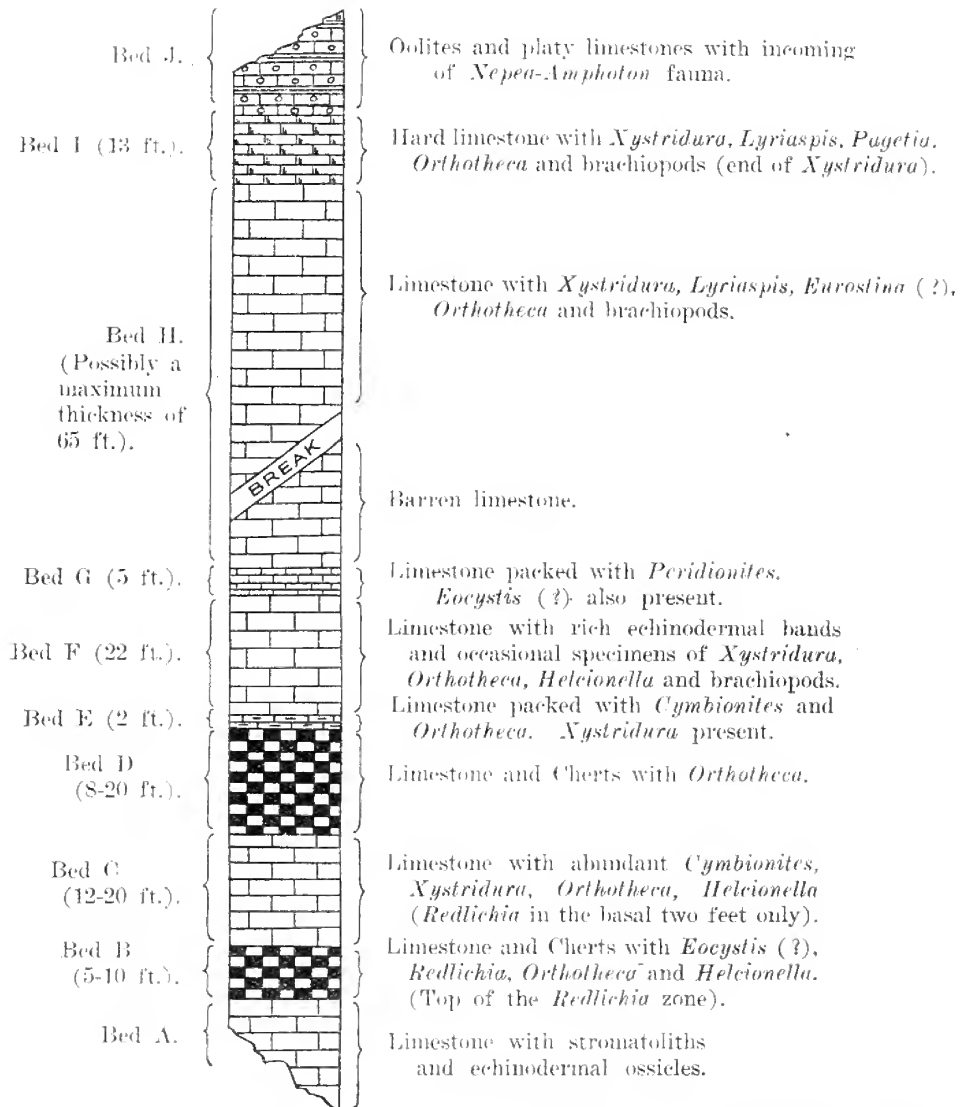


Fig. 1.—The succession of beds in the *Xystridura* zone (basal Middle Cambrian) on Thornton Station, showing the echinoderm horizons.

These are the only collections that yet have been made from the beds so that all collected specimens, including types, are lodged in the Geology Department of the University of Queensland. Examples of both forms will, however, be placed in the Queensland Museum, and slabs with *Cymbionites* are being sent to the Australian Museum, the British Museum, the Sedgwick Museum and the American Museum of Natural History.

STATE OF PRESERVATION.

The plates of the theca in each species are preserved as crystalline calcite, each plate being one optically continuous crystal. There has been, however, some late silicification, so that both outer and inner surfaces, to a varying depth, have been silicified. This is most marked in *Cymbionites craticula*, the outer skin of which commonly has the familiar multiple rosettes of beekite. In complete specimens some silicification of the articulating surfaces has gone on, so that specimens such as that of pl. II, fig. 11 are quite common, in which outer and inner surfaces of the theca and the articulating surfaces of the plates have been converted to silica and stand out, while the non-silicified remainder has dissolved away.

The lower limestone (bed A in figure 1), of the *Redlichia* zone, often has numerous grains of coarse, quartz sand, suggesting some current action. In the basal limestone of the *Xystridura* zone (bed C) the trilobite fragments, occurring in enormous numbers, are broken into pieces, the shattered parts being tightly packed in several bands. *Cymbionites*, in this bed, occurs more frequently as isolated plates than as complete specimens (pl. I, fig. 3). In the later limestone band the specimens are complete (pl. I, fig. 1), and isolated plates are very rare. In the *Peridionites* band, where separate plates are prolific (pl. I, fig. 2), complete thecae are found only occasionally. Both echinoderms have very firm sutures. Turbulent conditions, breaking shells and skeletons, seem thus to have alternated with quiet phases during the deposition of these limestones.

DESCRIPTION OF THE SPECIES.

PHYLUM ECHINODERMATA KLEIN, 1734.

Sub-Phylum HAPLOZOA nov.*

In this new division are placed such early, unattached echinoderms that have a skeleton composed of few plates, forming a theca about an unrestricted calyx. Bilaterally and radially symmetrical members are known; and since they have differing micro-structures, and since bilaterally and radially

* ἀπλός simple, ζῶον living creature.

symmetrical stages are separate and distinct in the early ontogeny of living echinoderms these two groups, the Cyamoidea and the Cycloidea that must have each only a few members, are for convenience regarded as separate classes.

Class **CYAMOIDEA** nov.

The bilaterally symmetrical members of the group, with a small, pouch-like or bean-shaped theca (*κύαμος*, a bean) composed of five plates. The stereom is not formed of prismatic fibres.

Family **PERIDIONITIDAE** nov.

Genus **PERIDIONITES** nov.*

Genotype: *Peridionites navicula* sp. nov.

Diagnosis: Unattached echinoderms with a skeleton composed of a reniform theca that is bilaterally symmetrical about two planes, is closed aborally, and consists of five plates—an apical plate (dorso-centrale), two end plates and two medio-lateral plates, the latter being bounded by the converging end plates.

PERIDIONITES NAVICULA sp. nov.

(Pl. I, fig. 2; Pl. II, figs. 1-9.)

Description: The individuals are small, pouch-like structures, laterally compressed and sub-semi-circular in outline. They are bilaterally symmetrical about both the sagittal and transverse planes. There are five, massive, calcareous plates in the theca, enclosing a calyx that has the maximum width and length of the theca. The outer surfaces of the plates are unornamented and the articulating surfaces are smooth. The stereom is not fibrous but has radiating and rather irregular pores.

The two end plates, at the limits of the sagittal axis, are similar and are the largest plates of the theca. They are rhomboidal in lateral view, subtriangular in transverse section, and have slightly curved outer edges. On each the ventral face has three shallow depressions, separated one from another by two radial grooves. The largest of these (the Axial Depression) is subovate and occupies most of the surface, continuing to the outer edge of the theca. Towards the centre of the theca this is flanked by two similar, smaller, subtriangular pans (the Lateral Depressions). The inner surface of the plate is faceted about a median, channelled ridge, the two facets being the articulating surfaces for the medio-lateral plates. The dorsal or aboral surface, where the apical plate adjoins, is smooth and subtriangular.

The medio-lateral plates are subtriangular, with the free edges prominently arched. Such a plate has a cuneate section adjacent to the theca *calyx*.

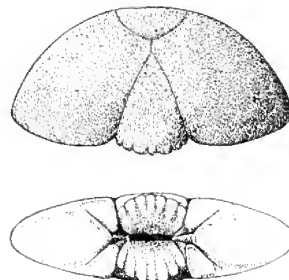


Fig. 2.—Lateral and ventral diagrams of *Peridionites navicula* ($\times 5$).

* *πηρίδιον*, a small pouch.

where the inner face is radially grooved. Between the medio-lateral plates and the inter-facet ridges of the end plates is the relatively deep, central portion of the calyx, the Central Fossa.

The apical plate (or dorso-centrale) is a small, wedge-shaped structure with smooth, curved surfaces. No trace has been found upon it of any place of attachment for the theca.

There is no evidence of any tegmen.

The calyx thus is divisible longitudinally into five sections symmetrically arranged—the anterior axial depression, the paired antero-lateral depressions, the central fossa, the paired postero-lateral depressions and the posterior axial depression. The symmetry is such that, from the skeleton alone, no distinction can be made between anterior and posterior structures, the two ends being precisely similar. The central fossa is moderately excavated for some depth and then, towards its base where the medio-lateral plates come closely together, becomes slot-like by the development of a narrow, aboral, tongue-shaped cavity, the Central Cleft. The grooves on the inner surfaces of the medio-lateral plates and the bounding grooves of the lateral depressions together form a system of radiating channels around the main portion of the central fossa.

Variation: Thirty-six complete or almost complete thecae have been examined and many hundred isolated plates. There is a considerable variation in the lateral outline of the theca, as is shown by the figured specimens. Usually the vertical axis is shorter, occasionally considerably shorter, than the sagittal, but some forms in this are equidimensional. The majority of the specimens are markedly compressed in the transverse plane, with a sub-fastigate outer edge. But there are a few forms more obese and with a broadly arched edge. Nevertheless there is no marked division into two or more definite types, so that advisedly all are retained in the one, variable species.

In the more compressed forms the central fossa is an elongate structure, but in the more obese forms it is broadly ovate in oral view. The number of grooves on the inner surfaces of the medio-lateral plates is not fixed, so that there is a slight variation in the number of radiating grooves around the central fossa.

Dimensions: For comparison the length of the sagittal axis of each suitable, complete specimen is stated in millimetres with the transverse and vertical dimensions given, for each specimen, as a percentage of this. Such dimensions for six specimens are as follows:—

Catalogue Number.	Sagittal Axis.	Transverse Axis.	Vertical Axis.	Reference (if figures).
F. 5399	9.4	56	45	Pl. II, fig. 1
5400	9.4	78	42	Pl. II, fig. 2
5401	10.0	77	42	Pl. II, fig. 3
5402	8.8	85	40	Pl. II, fig. 4
5403	9.2	57	38	Pl. II, fig. 5
5404	11.0	55	33	Pl. II, fig. 7 (holotype)

Interpretation: From the foregoing observations the following conclusions may be drawn about the body of the species:

1. The body was segmented, five segments being recognisable.
2. About the transverse plane there was a perfect symmetry in the outward form of the segments, and there was an equally perfect symmetry of the body parts about the sagittal plane.
3. The soft parts were seated in eight regions corresponding to the eight depressions of the calyx, that in the central fossa being the most voluminous.
4. All openings that the species may have had (oral, anal and hydroporal) were on the one side (ventral) of the body. The other side (dorsal) was arched.
5. The radiating channels around the central fossa indicate a set of radiating structures, most probably muscular ligaments by which the body was attached in the calyx.

The bilateral symmetry of the calyx, and thereby of the form of the body, together with the arched dorsum and the ventral placing of essential openings, are reminiscent strongly of structures in the larval form (dipleurula stage) of present-day echinoderms. One difference only is noticeable—hydropores, if present, must have been ventral in position. The comparison may be taken much closer. Some other structures that are claimed as essential in the Dipleurula or ancestral form of the echinoderms (see, for example, Bather 1900, p. 4) are:

1. A pre-oral lobe.
2. A coelom divided into paired anterior and paired posterior portions.
3. An uncoiled intestine with possibly an enlargement to form a stomach.

The paired lateral depressions of *Peridionites* indicate the presence of anterior and posterior paired, soft structures of similar form, and suggest that they may have been the place of lodgment of the four, paired, coelomic sacs. Axially beyond these were equal, laterally unpaired structures, seated in the axial depressions. One of these corresponds in position with the pre-oral lobe. The other is a posterior lobe; and from the symmetry a post-anal lobe is suggested, thereby implying the presence of an anus. The most bulky portions of the body were centrally placed, and a stomach is indicated. Dorsal to this was a narrow, elevated portion of the body seated in the central cleft. In the echinoids, asteroids and ophiuroids the genitalia are borne in an aboral sinus, so that a similar function may be suggested, tentatively, for this aboral pouch. Suggestively, therefore, the structure of the body is interpreted as follows:

The animal, whose form would be of the type shown in figure 3, was segmented into five regions and provided with both mouth and anus as well as with an uncoiled intestine increasing medially to form a stomach. There were pre-oral and post-anal lobes of equal size, seated in the axial depressions. Paired coelomic sacs, two anterior and two posterior and all of equal size, were

present on the lateral depressions. The stomach was situated in the central fossa, this region of the body being attached to the inner, calical surface of the theca by a series of muscles. The hydrocoel, if present, would have been in the central fossa. But if it were present it must have been different from those of present day echinoderm larvae; for it would have been symmetrical (present forms are unsymmetrical or unpaired) and the hydropore would have

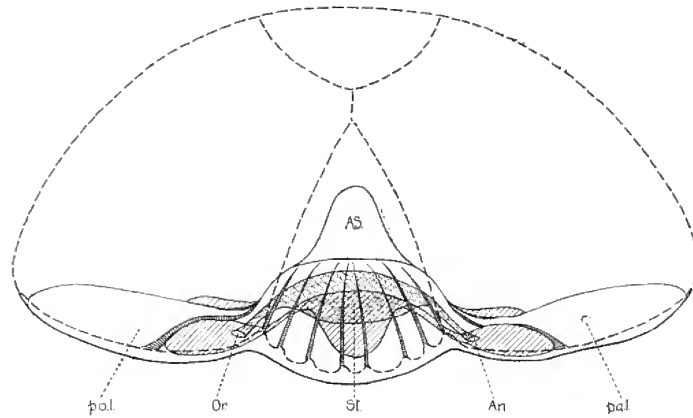


Fig. 3.—Interpretation of the soft structures of *Peridionites navicula*. Stippled area, the digestive tract. Lightly ruled area, the coelomic sacs. Heavily ruled areas, the muscles. *As.*, aboral (? genital) sinus; *An.*, anus; *Or.*, mouth; *p.o.l.*, pre-oral lobe; *p.a.l.*, post-anal lobe; *St.*, stomach. The presence of median coelomic sacs is questionable.

been on the ventral side. A symmetrical hydrocoel divided into two sacs is, of course, claimed usually as a feature of the theoretical Dipleurula. But the impossibility of there being a dorsal pore raises the question of whether in this form a water vascular system was present. Possibly there was, in the central fossa, a median pair of coelomic sacs that had not, at this stage, been modified to form a hydrocoel although, more likely perhaps, there may have been no median, coelomic sacs. Aborally was a pouch (the aboral sinus) containing the genitalia.

From such premises the Cyamoidea have claims to include the ancestral, dipleurural form of the phylum. It is doubtful whether *Peridionites* itself, a form of the littoral benthos with very thick plates, is a primitive member of the class. Somewhat simpler forms yet may be expected from the Lower Cambrian or even older rocks. Yet from the perfection of its segmentation it possibly is not far removed from the direct lineage of the Dipleurula.

Class **CYCLOIDEA** nov.

The radially symmetrical members of the group, with a small, cup-like theca (*κύκλος*, a circle), composed of five radially disposed plates with possibly an apical plate.

Family CYMBIONITIDAE nov.

Genus **CYMBIONITES** nov.*Genotype: *Cymbionites craticula* sp. nov.

Diagnosis: Unattached echinoderms with a skeleton typically composed of five equal, thick, curved, wedge-like plates united laterally and apically to form a cup-shaped theca arranged about a fluted, crater-like calyx. A membranous theca probably was present.

CYMBIONITES CRATICULA sp. nov.

(Pl. I, figs. 1 and 3; pl. II, figs. 10-24; pl. III; pl. IV.)

Description: The skeleton typically is composed of five, similar, very massive, wedge-shaped plates, the stereom of which consists of uniform fibres arranged in spherulitic form. Each plate is convex externally, has flat, smooth, articulating surfaces and a flat or slightly convex calical surface. In combination the plates form a theca with a smooth, uniformly rounded, external surface varying from hemispherical to thimble-like and even barrel-like or saucer-like in form. The theca is rigid, with the plates strongly adherent in spite of the lack of any articulating furrows, and sutures are not visible except on weathered specimens. The calyx varies considerably in form due to the variation in the angle made by the calical surfaces of the plates with the horizontal plane. In some types it is shallow, almost saucer-shaped. In others it is deep and crateriform. According to the straightness or curvature of the calical slope the calyx may be regularly conical or bell-shaped. The surface of the calyx is fluted by fine, straight channels that vary considerably in number. The plates in any one specimen are not always equal in size. A transverse section beyond the region of the calyx frequently reveals the presence of a small, additional and central, pentagonal plate (fig. 6c), not shown on the surface, being completely enveloped by the five radial plates. Other small, adventitious radial plates are sometimes present, either extending across the thecal radius or else limited to the central region. The calical edge is scalloped and bears a faint circum-oral groove suggesting that a membranous integument was present forming a tegmen.

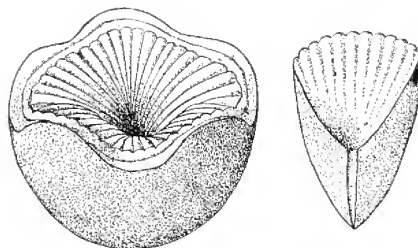


Fig. 4.—The general form of *Cymbionites craticula* and one radial plate ($\times 3$).

Variation: From the specific description, from the figures, from the measurements that are given, and from the arrangement of fibres described below, it will be seen that, in spite of the essential simplicity of the form, this is a very variable species. Several thousand specimens have been examined;

* *κυμβίον*, a small cup.

but there seems no justification for regarding them as of more than one species. There is no uniformity of shape, although the hemispherical, capsular form is most frequent, and the number of plates is not always five, as is indicated in the following chapter. There seems to be variation also in the size attained by the adults. A diameter of approximately 12 mm. is so common that this may be regarded as the normal size of the fully grown form; but quite a number of specimens reach a diameter of 18 mm. There is such a host of still smaller specimens that considerable latitude in the size of the adults seems likely.

Dimensions: In this species the maximum transverse diameter is the standard chosen and is stated in millimetres. The length of the vertical axis and the depth of the calyx are stated as percentages of this. Such measurements for twelve specimens are as follows:

Catalogue Number.	Transverse Diameter.	Vertical Axis.	Depth of Calyx.	Reference (if figured).
F. 5409	14.3	97	39	Pl. II, fig. 12
5410	12.6	49	8	Pl. II, fig. 13
5411	11.5	104	57	Pl. II, fig. 14
5412	11.0	80	36	Pl. II, fig. 15
5413	11.5	104	56	Pl. II, fig. 16
5414	10.4	95	52	Pl. II, fig. 17
5415	8.3	127	..	Pl. II, fig. 18
5416	8.7	82	47	Pl. II, fig. 19
5417	8.6	76	35	Pl. II, fig. 20
5418	8.0	107	62	Pl. II, fig. 21
5419	8.0	114	80	Pl. II, fig. 22
5420	10.5	67	43	Pl. II, fig. 24

Interpretation: From such observations the following conclusions may be drawn about the soft parts:

1. The body was seated in a radially symmetrical calyx that was closed aborally.
2. Such symmetry that the body parts had was pentamerous but some variation from the pentamerous form occurred.
3. All essential openings of the body were ventral (oral) in position.
4. The calyx was fluted with grooves that possibly indicated the seating of muscles.

The great thickness of the plates and the close sutures render it impossible that there was an anal pore in the dorsal region. Thus either no anus was present, as in some present-day larval forms, or else (as in the crinoids) it had emerged on the oral side.

THE STRUCTURE OF THE STEREOM.

The fabric of the skeleton in *Peridionites navicula* is massive, non-fibrous calcite, each plate an optical unit with self-contained cleavage, and with the substance pierced by many, irregular, radially elongate and radially directed pores. Presumably the pores indicate that the plates were infiltrated by mesodermal tissue that was not sufficiently arranged in stromal form to develop spicular secretion. No trace has been seen in microsections of concentric arrangements that suggest growth lines.

In contrast the stereom of *Cymbionites craticula* is formed of packed, but intermittently inupinging prismatic fibres (see pl. IV, figs. 3,4), between which is a meshwork of calcite in optical continuity with the fibres. The fibres of each plate are of uniform diameter (approximately $12\ \mu$) and they unite as the one crystal of calcite having the characteristic cleavage pattern. But there are some significant departures, in the direction of decreased specialisation, from the stereom structures of living species. In such later forms an ossicle microscopically is a unit, the fibres being so arranged that in pattern each plate is a discrete entity. In *Cymbionites* the prisms of one plate have a definite relationship with those of adjoining plates; and there is a uniform, simple grouping for the theca as a whole (see pl. II, fig. 10 and text-fig. 5).

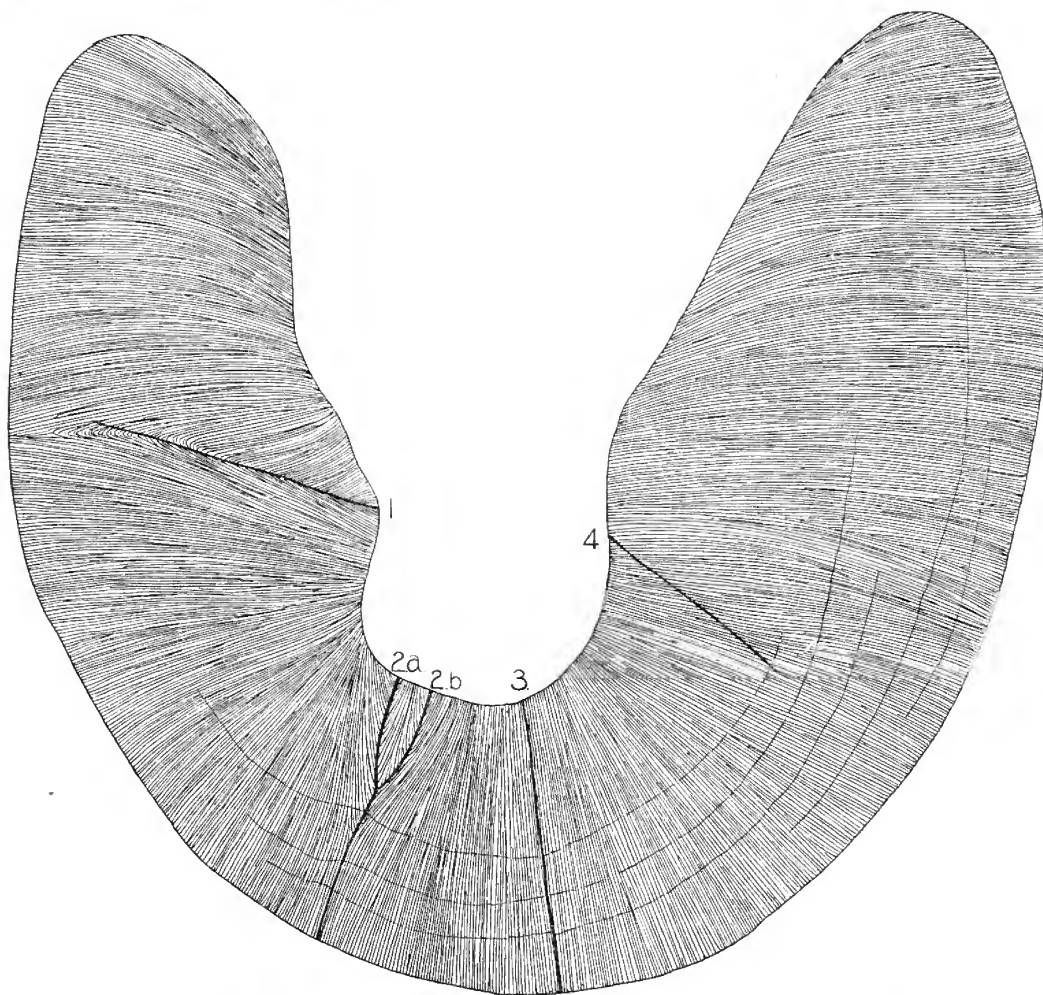


Fig. 5.—*Cymbionites craticula*. Semi-diagrammatic figure of plate II, fig. 10 (a vertical section), to show the unity of the fibrous arrangement throughout the whole skeleton, and the relationship of sutures to the fibres. Sutures nos. 2 and 3 are concordant; no. 1 is slightly discordant; and no. 4 is wholly discordant. The discordant sutures do not continue to the outer margin. Between the two branches of no. 2 is a subsidiary, internal plate, formed by a complete, minor tuft.

The fibres are arranged in two patterns—plumose, when they spread radially and arcuately from an axis; and tufted, when they arise at the calical margin and diverge as a uniformly spreading bundle (see plates III and IV). The fibres in a bundle slowly increase in number towards the limits of the tuft or plume by a process of branching or insertion of new fibres. Typically there is one plume or one tuft to a plate; and when the fibres, spreading outwards, reach the suture between an adjacent plate the individual prisms are matched symmetrically by the fibres of that adjoining ossicle (pl. IV, fig. 2). In tufted forms the fibres radially outwards become parallel to the sutures; but nearer the calyx, where they approach at slight angles, the individual structures are seen generally to be in apparent continuity, about this acute angle, from one plate to the next.

In all this there is a certain unity, or rather there is an alternative pattern according to the fibres being tufted or plumose. That is to say, there is one distinct bundle of prisms to each plate; and the bundle of one plate is a unit, visually separable from the adjacent bundle, even though some individual fibres seem symmetrically to cross the sutures. Actually, however, forms that keep strictly to this mode are rare. Among the more noticeable departures from type the following are significant:

1. Very occasionally (pl. III, fig. 3) the axis of a plume is the vertical axis of the theca; in which mode the theca may form one great bundle and apparently is not divided into plates by sutures.
2. Two or more tufts, or rarely two plumes, may occur within one plate (pl. III, fig. 2).
3. The radiating fibres of adjacent plates may meet symmetrically but the suture between may not strictly conform to this plane of symmetry (pl. II, fig. 10).
4. It may happen (pl. III, fig. 4) that a suture is aligned obliquely and discordantly across very straight prisms that continue their course unaffected by the suture. In the specimen illustrated one suture only is of this type. The other sutures of the theca are normal.
5. Well defined sutures may start at the inner wall, bounding a plume or tuft, but they disappear before reaching the outer wall, so that a plate does not separate (pl. IV, fig. 1).

From these vagaries it is obvious that there is generally a correspondence between the formation of sutures (and so of plates) and the natural division of the theca into unit bundles of fibres. But since the sutures do not always follow strictly the division planes between the bundles, and since also they are not always complete, they and the plating are evidently subsidiary in development to the arrangement of the fibres.

The tufted and the plumose forms denote two types of thecal growth. In the former the increase is outwards from the calyx; and the fibres are arranged normal to the growth lines—that is to the growing surface (see pl. II, fig. 10). Plumose forms presumably indicate that increase took place not only outwardly but also inwardly, in the direction of the calical wall. Where all

plates of the theca have plumose fibres the axes of the several plumes are at the same distance from the calical wall. Furthermore the axes of the plumes are relatively close to the calyx; so that increase in this direction was uniform but less than outwards growth (text-fig. 6D).

One curious circumstance is at present difficult to explain. In spite of the uniform pattern in any one theca the plates are individual crystals of calcite. Even in that remarkable type, No. 4 just mentioned, where the suture cuts obliquely across continuous fibres, a section under crossed nicols shows that on opposite sides of the suture the calcite extinguishes differently. The deduction from such evidence seems again to be that development of the sutures, and the welding of the fibres of each plate into the one crystal unit were subsidiary to the production of the fibrous form. And yet the specimen just illustrated is one of the largest thecae; and presumably in earlier stages of growth it had the usual crystal relationships. If so, as it increases in size, the individual fibres, continuous as units across the suture, divided at that plane in their crystal affinities—the one portion growing in optical continuity with its lateral neighbours, and the other, across the suture, having a corresponding relationship with its adjacent fibres. It is somewhat analogous though not of course homologous with the phenomenon of twinning in crystals.

A related feature that also as yet is unexplained is that occasionally circumscribed patches occur within one plate that optically are foreign to it but are in accord with the properties of an adjacent plate.

Realising what lack of uniformity there is in the grouping of the fibres it is not to be wondered at that the form of the theca varies to the degree that has been recorded in the description of the species.

Two far-reaching conclusions may be drawn from a study of the microstructures. The first is that the fibres of a growing skeleton are aggregated precisely in the mode of spherulitic growth. That is to say, they follow the system of growth of a developing mass of inorganic, needle-like crystals of constant composition in a viscous medium. The second is that this growth is the primary cause of the symmetry of the skeleton, and that the symmetry of body parts is evolved in response.

The factors and forms of spherulitic growth have been analysed very clearly by Bryan (1941); and Bryan and Hill (1941) have shown, as a corollary, that in at least one group of relatively simple organisms with a fibrous crystalline skeleton, the hexacorals, skeletal growth is in accord with these principles. From Bryan's studies it is shown that the radiating, prismatic crystals of a spherulite grow in one of three modes—tufted, plumose or strictly radially—forming a distinct pattern that varies among spherulites but is constant for the one specimen. Bryan has pointed out, further, that a compound spherulite, growing about a spherical surface without interference from neighbouring structures, assumes naturally the form of a pentagonal dodecahedron superimposed upon a

spherical surface; and many of his specimens correspond, with some modification, to this ideal form. From this it follows that the majority of sections through such a structure will show a pentagonal arrangement of segments—as indeed is apparent from published figures (for example Bryan 1934, pl. 8; and 1941, pl. 3).

The typical pentagonal arrangement of tufts and plumes in the theca of *Cymbionites*, even though the form is subglobular and not spherical, are, by comparison, almost ideally grouped in spherulitic form. But in inorganic, spherulitic growth, although the pentagonal form is typical, specimens with fewer or more segments are common. Similar also are the skeletons of *Cymbionites*. There may be five tufts or plumes in a complete transverse section (the typical form), giving rise to five plates; there may be more than five bundles but still only five plates; there may be as many as seven fully

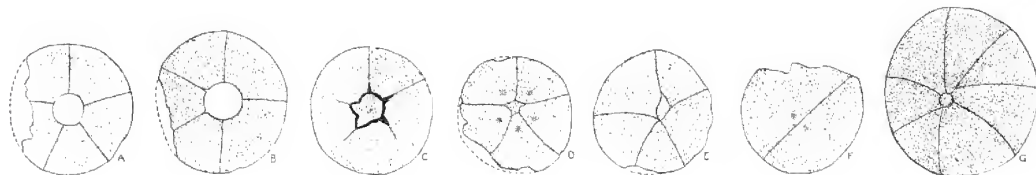


Fig. 6.—Drawings made from microslides across the theca of *Cymbionites craticula* to show variations in plating. A, a transverse section through the base of the calyx, with five subequal, tufted plates. B, similar to the preceding but with the plates unequal. C, a section beyond the calyx with a well-developed centrale but with only two sutures persisting to the outer margin. D, a plumose form with five subequal plates and a small centrale; the axes of the plumes, denoted by asterisks, are uniformly arranged around the main axis (microphotographs of this slide are shown as pl. IV, figs. 2, 3 and 4). E, a tufted form with a sixth plate. F, a vertical, tangential section through a plumose form. G, a transverse section, beyond the calyx, of the specimen shown in pl. II, fig. 23, showing seven unequal radial plates and a centrale. All sections except F are transverse sections and the magnification of each is slightly under two diameters.

developed radial plates in the cycle, each corresponding to a bundle (fig. 6G); the cycle may start with more than five plates but in outward growth be reduced to five by the crowding out of minor plates (pl. II, fig. 10); or, as a limiting condition in the other direction, only one bundle may be present in the theca and no subdivision into plates. Such a wide limit of variation, which is illustrated on the accompanying plates and text figures, is more in accord with ordinary, spherulitic growth than with a strictly biological control, which latter influence, if dominant, would determine the symmetry and the number of plates according to some organic constant.

And so the conclusion almost inexorably arises that the radial symmetry of the Cycloidea is due to spherulitic growth, determined by the condition that the skeleton is composed of uniform, acicular crystals growing in a relatively free medium (the mesoderm); and that the division of the theca into plates was occasioned by this mode of growth. As a corollary it appears that any corresponding pentamerism of body parts is not primary but has been induced

by the symmetry imposed by the spherulitic form. However, since *Peridionites* already had a longitudinal pentamerism of body parts this correspondence may have developed very quickly and naturally by a simple torsion of body structures.

In genesis, therefore, *Peridionites* and *Cymbionites* are diametrically opposed. In the former acicular fibres do not occur, and the skeleton conforms to the structures determined by the symmetry of the body. In *Cymbionites*, with fibrous growth, the spherulitic form develops, becomes the control, and the body is adaptive.

One factor may be important as a control. Both *Peridionites* and *Cymbionites* have unusually thick plates for an echinoderm. Were spherulitic growth to be initiated in a group with thin plates it is perhaps difficult to conceive that the process could control the growth. That in these forms, apparently, it did so may be related to the relatively great mass of the skeletal parts.

If the logical implications of spherulitic growth are taken to their limit one peculiar coincidence emerges, depending upon Bryan's demonstration that the ideal form of such a spherulite is a pentagonal dodecahedron. It is mentioned without emphasis as an interesting possibility that scarcely can be more than interesting while only the one genus of Cycloidea is known. A pentagonal dodecahedron has twelve sides; and about any axis through the mid point of a face this resolves itself into two polar faces and, between them, two cycles each of five faces. If spherulitic growth were the control in building the skeleton and the oral pole of the body became such an axis, the natural form of the skeleton would be of eleven plates—a centrale, a first cycle of five plates (the radials), and a second similiar cycle (terminals). The twelfth plate, by need of an oral, polar opening, would not appear.

Such a skeleton, modified in the dicyclic erinoids by the presence of a third cycle of plates, does happen to be the form assumed immediately after metamorphosis by all classes of living echinoderms that have an interlocking skeleton. Thus, since the features of spherulitic growth are so closely simulated or realised in *Cymbionites*, it may be that this form of the test also is a related feature. Cycloidea accordingly may include other genera with thinner plates, with a well developed centrale, and with a second cycle.

In the light of the finer, stereomic structures of *Cymbionites* two features of echinoderm morphology deserve investigation. There are, within the phylum, two contrasted but sporadically operating tendencies, one to increase the number of plates in any system, and the other to reduce the number. The former is exemplified by the remarkably variable plates around the dorso-centrale in *Uintacrinus*, so clearly described by Springer (1901), and by the more regular plates in the centre of the apical disc of Saleniidae. Sometimes the need for this increase is functional, as for instance with the anal plates of erinoids; but such an explanation seems inadequate for the two

examples quoted. Springer (1901, p. 35) suggested that something analogous to the variability of *Uintacrinus* might be expected at earlier periods (*Uintacrinus* is a Cretaceous erinoid). To casual appearances that prediction is realised with *Cymbionites*, in which the variation is due to the vagaries of spherulitic growth. It is a matter worthy of some attention whether, in such forms as *Salenia* and *Uintacrinus*, the multiplication of plates around the aboral pole is likewise due to modifications in the grouping of the fibres of the stereom.

In the reverse direction are such features as the formation of compound ambulacral plates in the diademoid echinoids, the syzygy of erinoids, and the remarkable reduction of the skeleton in *Tiarechinus* and its allies. Many of these economies seem to be effected in response to functional requirements; but how the mode of fusion operates (possibly it may be by new groupings of stereom units) does not seem to have been investigated.

Microscopic studies on these lines might even lead to some clarity in the vexed problem of the significance of monocyclic, diyclic and pseudomonocyclic forms among the erinoids.

COMPARATIVE ONTOGENY.

After passing through preliminary blastula and gastrula stages the developing echinoderm, in all groups of the Eleutherozoa, attains a pelagic, bilaterally symmetrical form. There are individual differences in the arrangement of the ciliated bands and the arms that may arise to support them, but the general pattern is the same. This was established long ago by Müller (1853) who gave a series of names (*Pluteus*, *Auricularia*, *Bipinnaria* and *Brachiolaria*) to the several variants. Later the pluteus form was found to be shared by both echinoids and ophiuroids; and Mortensen (1898) separated the two by the new terms *Echinopluteus* and *Ophiopluteus*. Semon, in 1888, proposed one embracing term *Dipleurula*, for these generally similar bilateral larvae.

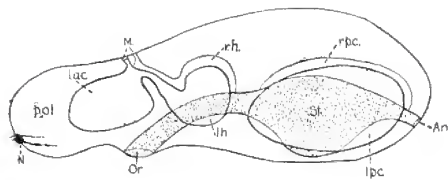


Fig. 7.—The hypothetical *Dipleurula* (after Bather). *Or.*, mouth; *St.*, stomach; *An.*, anus; *N.*, nerve centre; *p.o.l.*, pre-oral lobe; *M.*, Hydropores; *l.a.c.*, left anterior coelom; *l.h.*, left hydrocoel; *r.h.*, right hydrocoel; *l.p.c.*, left posterior coelom; *r.p.c.*, right posterior coelom.

The *Dipleurula*, regarded as a consequent ancestral type, has been interpreted by earlier authors (e.g. Bather), and accepted, as a form with the following feature (fig. 7). The body was symmetrical about the sagittal plane and had the ventral side concave. The mouth and anus were present on the ventral side and probably there was an enlargement of the intestine to form a simple stomach. The coelom was divided into paired vessels, the anterior pair being connected to the dorsal surface by a pore or a pair of pores, and

continued posteriorly into sacs that were modified to form a paired hydrocoel. The posterior coelomic vessels were separated from the anterior. There was a

pre-oral lobe differentiated as a sense organ, with cilia and a nerve centre from which two gangliated nerves ran symmetrically backwards.

The known larval types (auricularia, bipinnaria, etc.) depart from this generalised form in several ways. Sometimes, for instance, the anterior coelom is not paired, and never is there a perfect pairing of the hydrocoel—the left sac is more developed and sometimes alone is present. In echinoids and ophiuroids the long "arms" of the larvae are supported by a bilaterally arranged skeletal framework.

The perfect symmetry of *Peridionites* suggests that it was closer to the ideal than are the dipleurulan stages of present-day species. It may even be more primitive since, as already noted, it is doubtful whether there was a modification of the medium coelomic sacs to serve as a hydrocoel*.

From the dipleurulan stage the larvae of living species change to the radial adult by a remarkable metamorphosis. On the way, occasionally, it is found that the ciliated bands of the larva are rearranged from a bilateral alignment into five separate rings. This is shown most clearly in the pupa stage of the ontogeny of certain holothurians (see fig. 8); and it seems to

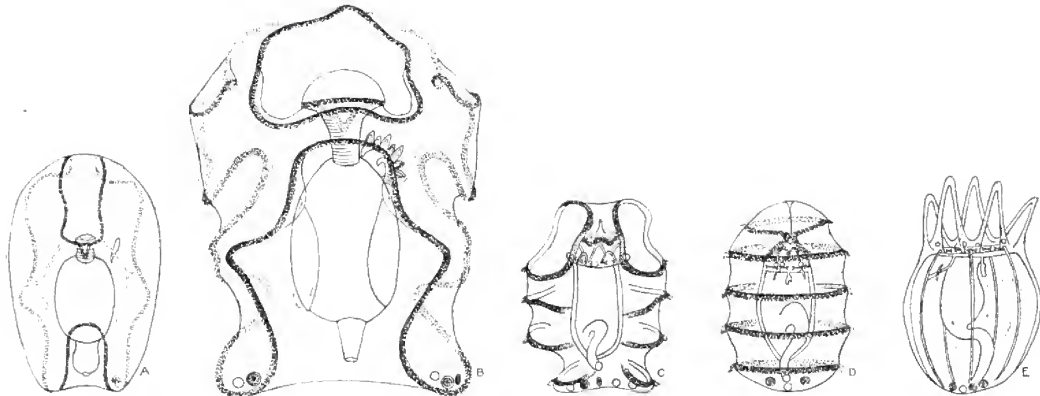


Fig. 8.—Stages in the ontogeny of the holothurian *Synapta digitata* (after Semon). A and B are in the dipleurulan stage; C is transitional to the pupa stage; D is an early form of the pupa stage; and E is the free pentactula stage.

suggest that there are five natural divisions (segments) of the body corresponding to the five ciliated regions. If so the five segments of *Peridionites* become even more significant. It is worthy of note that both the segments of *Peridionites* and the ciliated rings of the larvae are so arranged that two are pre-oral and three post-oral.

In the crinoids the only free larval stage that yet has been found is with *Antedon*. In this the body is bilaterally symmetrical, as with the dipleurula, and the mouth is at a ventral concavity. But five ciliated rings are present,

* It is interesting to recall that MacBride (1918) artificially has reared larvae without a water vascular system.

so that probably it is at relatively a higher stage of development than typical dipleurulan larvae. Furthermore incipient stem ossicles occur within it. In the late dipleurulan (brachiolaria) stage of certain asteroids a "sucking disc" develops on the pre-oral lobe by which probably the larva could be attached. Great stress has been placed upon this process by many authorities as being homologous with the fixation of the erinoid larvae (in those forms by a stem). But Bury (1895, p. 93) doubted if there is any homology and Mortensen (1921, p. 239) states that the sucking disc is purely "a secondary adaptation."

In metamorphosis the change is abrupt. The bilaterally symmetrical form is replaced by one that is radial. The body parts rearrange themselves around a new axis. In those forms (echinoids and ophiuroids) in which previously there was a bilateral skeleton this skeleton is not merely modified.

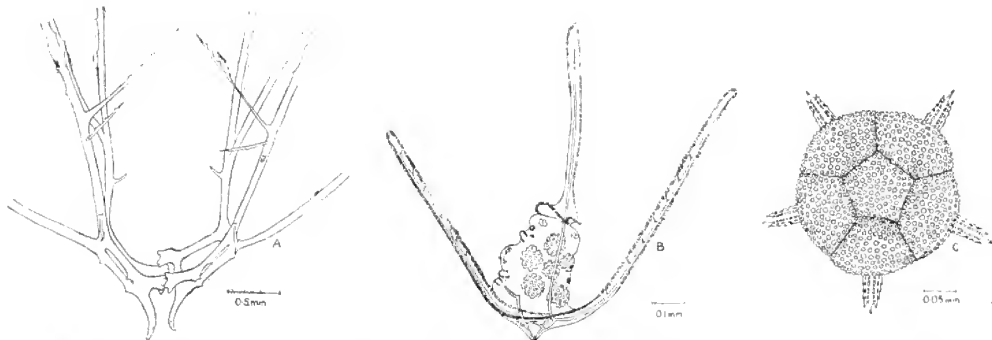


Fig. 9.—Skeletal forms in ophiuroid larvae. A, the bilateral skeleton of an ophiopluteus (dipleurula stage). B, a phase during metamorphosis with the bilateral skeleton not wholly resorbed and the radial skeleton beginning to form. C, the skeleton of a form in the pentaactula stage. (A and B after Mortensen; C after Chadwick.)

It is resorbed and a new skeleton conforming to the radial plan appears in its place (fig. 9). To this first radial stage Semon (1888) gave the name Pentaactula. In the comatulid erinoids it is fixed. In all other recent forms that have been investigated it is free.

The holothuroids of course have no continuous skeleton, but in all other groups of the Eleutherozoa the skeleton in the pentaactula stage is similar. It consists of eleven plates (fig. 9c)—a dorso-centrale, five radials and five terminals. There are certain class differences in the appearance of these plates that Sladen (1884) thought might have a phylogenetic significance. In the echinoids, except for the dorso-centrale which is replaced by the periproct, the initial plates are emphasised to form the genital and ocular plates and constitute the apical disc in the corona of the fully developed adult. In certain early asteroids, notably the genus *Hudsonaster* (see Schuchert, 1915), the eleven initial plates are retained as an almost equally accentuated apical system; but generally in the asteroids and the ophiuroids, as the skeleton grows by the addition of the many other plates, the initial eleven cease to be a recognisable, circumscribed group.

From these agreements an adult form with a skeleton corresponding with that of the larval free pentactula should occur in early strata. *Cymbionites* virtually is this. It has a cycle of five radial plates, there is a spasmodically appearing dorso-centrale, and all plates are united into a simple, free, capsule-like theca. A cycle of five terminals does not develop; but the spherulitic growth of the skeleton is such that it is likely that other and closely similar genera have arisen in which the full complement of eleven plates occurs. The Cycloidea, represented at present solely by *Cymbionites*, have a claim to represent the ancestral, free pentactula comparable with that of the Cyamoidea to be the early dipleurula; and since in ontogeny the free pentactula is the starting point in the development of asteroids, ophiuroids and echinoids, so in phylogeny the Cycloidea may be regarded, I would suggest, as the immediate common ancestor of these three classes.

In ontogeny, as already noted, the change from dipleurula to pentactula is abrupt, the skeleton elements of the two having nothing in common. The difference between the skeletons of *Peridionites* and *Cymbionites* is comparably great. In the former there is no fibrous form and the skeleton is moulded to the bilateral body. In the latter fibrous elements develop, spherulitic growth is initiated, takes control and produces a radial, pentamerous skeleton to which the body is adapted, modified by necessity with considerable rearrangement of parts. If Cyamoidea and Cycloidea correctly are interpreted as representing the dipleurula and pentactula stages, then in this there is a simple explanation of the abrupt metamorphosis in echinoderm ontogeny. All that was needed was a change from non-fibrous to fibrous calcite as the skeletal element—or, in other words, a more formal arrangement of the cells in the mesenchyme so that regular, fibrous secretion was possible.

The pentactula larva of crinoids, as represented by *Antedon*, is fixed firmly by a stalk. Such an attached pentactula was called Pentactaea by Semon (1888) who claimed that an early form of this type would be the ancestor of all modern echinoderms, a claim that these new discoveries to a large extent refute. But the stem in *Antedon* starts to develop in the previous larval stage—the pelagic, bilateral larva with ciliated rings. The attachment of the crinoids thus appears to date from a stage at the close of its dipleurulan history; and pentamerous, radial growth may be considered to have developed parallel to the Cycloidea and, presumably, in an analogous spherulitic mode.

ASPECTS OF PHYLOGENY.

The long-desired reconciliation between the ontogeny and palaeontology of the echinoderms was not possible so long as all the earliest and supposedly the most primitive genera were attached. An unattached, radially symmetrical body of simple plating, such as occurs in early growth stages, was not known. The majority of those who wrote were satisfied that, whereas some unknown, unattached, bilaterally symmetrical echinoderm (the Dipleurula) must have

existed, an unattached radial form was not necessary. Free radial types, so ran the argument, must come after the fixed ("radial symmetry being, it would appear, a consequence of fixation"—Bather, 1900, p. 9). Semon (1888), so far as I can discover, seems first to have enunciated this idea which, developed by other specialists, has come to be regarded almost as a law of echinodermal development. Accordingly fixed forms like those of the early Palaeozoic were taken to be the primitive types from which the unattached echinoderms have evolved. The presence of free, radial, larval stages was dismissed with such specious arguments as: "changes that, in phylogeny, must have succeeded fixation now precede it" (Bather, 1900, p. 9); or else it was implied that a fixed stage had been suppressed in the ontogeny of echinoids, ophiuroids and holothuroids by a process of accelerated development. Considerable reliance, accordingly, was placed upon the temporarily attached stage through which some asteroids go. This was a weak point in argument; for, as already noted, some experienced specialists believe that this transient attachment is in no wise homologous with the fixation of the erinoids.

It is somewhat surprising to realise that a fixed ancestry was considered essential for any radial symmetry. The most perfect of all radial animals and plants, the Radiolaria and the Diatoms, pass through no fixed stage. Among the Coelenterata it is only the pelagic types, the medusae, that attain the perfect radial form.

At its best the reasoning was illogical. Bury (1895), it should be remembered, sounded a note of caution but was hardly heard. In an incisive essay he justly affirmed that if all present-day echinoderms were derived from fixed forms then ontogeny is misleading; and the obligation still was with palaeontologists (as indeed it has been ever since) to establish a fixed ancestry.

However the needs for this tortuous type of phylogeny are removed when two free, fossil forms are known, almost as early as echinoderms have been recorded, agreeing morphologically with the dipleurula and free pentactula stages. Not only individually are they pertinently comparable with ontogenetic stages; but the simple, spherulitic growth of the radial form (*Cymbionites*) indicates that the attainment of radial, pentamerous symmetry was independent of fixed conditions.

One other argument, hitherto unassailable but, in the light of this new evidence, of questionable validity, must be noted. It was, perhaps, most clearly expressed by Bather (1900, p. 8) in the words: "By a remarkable metamorphosis, varying in its detail but presenting some common features in the different classes, the almost bilaterally symmetric larva is transformed into the almost radially symmetric adult. This metamorphosis undoubtedly represents the changes that occurred in the early history of the classes; and the extraordinary difficulties of interpretation are due to the enormous compression of that history, the elimination in some cases of unnecessary stages, and the unequal

acceleration of others.' This metamorphosis is one of the most striking and abrupt changes in the ontogeny of invertebrates, and hitherto it has not received a satisfactory explanation. But the changes, already assessed, that took place by the development of spherulitic growth were themselves abrupt so that there may be now no need to postulate an "enormous compression" or an "elimination of unnecessary stages" in phylogeny.

Thus, if these two forms are correctly interpreted, the palaeontological evidence and the succession in ontogeny no longer are at variance. Early fossil forms corresponding to the essential larval stages are known and an explanation of the abrupt change in metamorphosis is available; so that the ontogeny of a species may be claimed as a true epitome of the phylogeny of its group. Based upon what is known of larval stages and is summarised in the preceding chapter the consequences of this would be expressed as follows.

Asteroidea, Ophiuroidea and Echinoidea are derived from Cycloidea and they, in previous sequence, came from Cyamoidea. The Crinoidea arose from Cyamoidea at about the stage when it was evolving into the cycloids. About Holothuroidea, that have no interlocking skeleton, no comments are possible from the evidence of these fossils. In 1911, it should be noted, Walcott described as holothuroids a number of new genera and species from the Middle Cambrian of British Columbia. Some comment arose about the correctness of the biological grouping of these forms. A. H. Clark (1912) accepted the forms as holothurians and published an interesting restoration of one of them, *Eldonia ludwigi*. However in the same year H. L. Clark (1912) refused to accept them as echinoderms. More recently Cronis and McCormack (1932), though non-committal in their writings (p. 127) about the echinodermal nature of these forms, nevertheless implied in their evolutionary diagram (p. 135) that they were holothurians. I do not propose to enter into this controversy other than to remark that *Eldonia*, as restored by A. H. Clark, is a form that would fit neatly the calyx of such an echinoderm as *Cymbionites*, so that some relationship might be considered; although just as easily, from that restoration, it could be claimed as a coelenterate. It may be pertinent, also, to recall a suggestion made by Bell (1891) that since the holothurians are non-calicular and do not have gonads arranged pentamerally they may have departed rather early from the common stock. The other great groups of echinoderms are all extinct and of them we have no ontogenetic knowledge; but from other evidence they, too, may be brought into conspectus.

The Cystida, Blastoidea, Edrioasteroidea and Crinoidea are related by the common bonds of firm attachment and radial symmetry. Even in such irregularly plated genera as *Aristocystis* and *Sinocystis* the first (aboral) plates are a regular cycle suggesting that, whatever be their subsequent history, these forms began as radial types. It would be idle to enter into a discussion of the interrelations of these classes. As a related group they may be regarded, from the evidence of the crinoids, their one surviving member, as having arisen from the developing echinodermal stock in the closing phase of the dipleurulan period.

If the class Machaeridia, established by Withers (1926), be correctly placed in the echinoderms, as the evidence seems satisfactorily to suggest, its closest affinities are with the Carpoidea (Jaekel, 1900), as Bather (1926 and 1929) has noted. Each group is bilaterally and not radially symmetrical, and with each there has been some speculation whether, accordingly, it could represent the long-sought Dipleurula*. Neither, of course, truly is a dipleurulan type, for each is multi-plated beyond what is expected of such a form. But they may be related to Cyamoidea, interpreting that as the dipleurulan group. The Machaeridia, being longitudinally plated by a succession of similar structures, are suggestively more segmented than *Peridionites*; so that conceivably they arose either from very primitive cyamoids or they are a collateral branch from an even less specialised, segmented form with echinodermal characters only incipient—either that or their greater segmentation is secondarily derived.

It is customary to place the Carpoidea in the Pelmatozoa, and thereto Bather (1929) has allotted the recently established Machaeridia. But not only have these two groups no sign of the radial arrangement that, in some degree, is found in ordinary pelmatozoans, but if they were attached at all their attachment was different. Withers has noted that the proximal plates in the skeleton or test of Machaeridia are slightly modified, and a hint was given that thereby they might have been attached. But the figures do not suggest attachment and all specimens that were described were isolated. The carpoids have a long "stem" that often is similar to the whole skeleton of a machaeridian, but it tapers and, so far as I am aware, no such structure has been figured showing one of these forms anchored to a foreign body. Maybe in many forms it was only a tail-like feature.

In such manner these two groups differ from all other echinoderms and were better kept distinct. Tentatively I suggest that they represent a separate group (a sub-phylum it would have to be) for which the term HOMALOZOA (*ὁμαλός* flat, *ζῶον* living creature) would be appropriate.

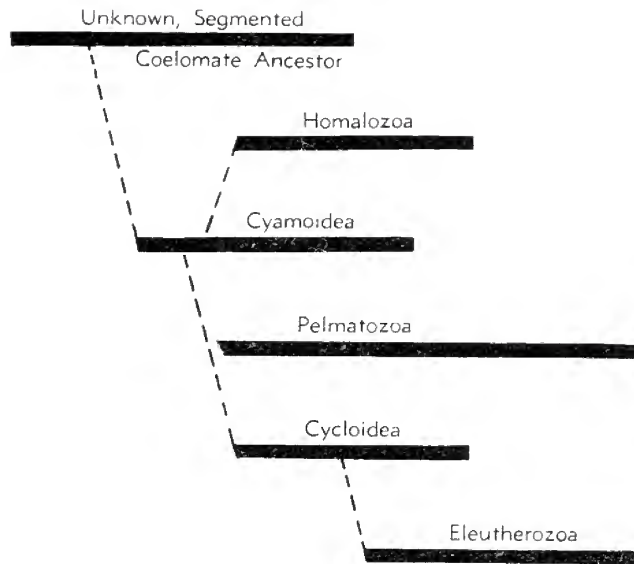
Graphically these ideas are embodied in the accompanying diagram.

There still is, in the vertical range of the unattached echinoderms, a hiatus that makes perfect palaeontological accord impossible. But this is readily to be understood when one considers the great rarity of early Palaeozoic Eleutherozoa, the fact that for all these years Cyamoidea and Cycloidea have remained undiscovered, and that it was only a few years ago that Ordovician echinoids

* See Walther (1886) and Haeckel (1896) for the Carpoidea and Bather (1926 and 1929) for the Machaeridia. In passing it may be noted that Fritsch (1909, p. 797) suggested that an Ordovician fossil from Bohemia, the *Furca bohémica* of Barrande, was the larval stage of a crinoid: but Jaekel (*vide* Mortensen, 1921, p. 233) places that form as an arthropod and not an echinoderm.

were discovered in relatively well-searched Britain.* One may venture to suppose that other and later cycloids eventually will be found, and maybe earlier eleutherozoans, to reduce this gap in sequence. The great wealth of echinodermal limestones in the Cambrian of Queensland itself offers some hope of this.

Two other aspects remain that require only brief mention—the origin of the cyamoids and the relationship to primitive Chordata. The perfect segmentation of *Peridionites* (and incidentally the even more numerous segments of *Machaeridia*) suggests that its ancestors were well-segmented, coelomate creatures. What they were it is not possible to say. The annelids fulfil such requirements, but there are difficulties about an annelid ancestry (particularly in essential differences in segmentation of the ovum in Annelida and Echinodermata).



The primitive chordate *Balanoglossus* and its relatives have a larval form (Tornaria) named by Müller and of the same type as the *Dipleurula*. Many authors have thought that thereby there might be some common ancestor to both the early chordates and the echinoderms. The discovery of *Peridionites* does not bring these two groups very much closer; for *Peridionites* still is a typical echinoderm in its skeletal structures and so is not a member of a common ancestral group.

* *Myriastiches gigas*, an English echinoid, was recorded as long ago as 1899 by Sollas from a single specimen; but it does not seem to have been recognised as Ordovician until 1934, when Bather and Spencer described a second Ordovician species from Great Britain—*Autechinus grayae* from Girvan (Scotland).

CONCLUSIONS.

1. Two early Middle Cambrian echinoderms are described, each of them unattached and having a skeleton composed of very few plates with typical, unit calcite cleavage.

2. One (*Peridionites*), of the new class Cyamoidea, is bilaterally symmetrical, having a calyx of five precisely arranged plates without a fibrous structure. There is ample evidence that the body was arranged in five segments with perfectly paired structures.

3. In the arrangements of its parts *Peridionites* corresponds remarkably well with the hypothetical Dipleurula, though in some features it may be even more primitive than was expected of the Dipleurula. A reconstruction of the body parts is possible and is shown in text figure 3.

4. The other (*Cymbionites*), of the new class Cycloidea, is radially symmetrical, with a theca composed of five very variably arranged plates with sometimes small accessory plates (centrals and radials).

5. *Cymbionites* corresponds with the free pentaactula stage in the ontogeny of the Eleutherozoa, although the five terminal plates do not occur.

6. The skeleton of *Cymbionites* is formed of radial fibres arranged according to the mode and variations of spherulitic growth. The formation of the plates clearly is subsidiary to the spherulitic pattern; and so it is suggested that the form of the skeleton and the pentamerism of its parts were determined by the almost inorganic control of typical, spherulitic increase, and that the body adapted itself to this new mode.

7. By this change, through spherulitic growth, an explanation is offered of the metamorphosis in echinoderm ontogeny—being due to the cells of the mesoderm developing in such fashion that multi-spicular secretion was possible.

8. It is believed that the relatively great mass of the skeleton in these forms favoured the spherulitic mode when fibrous secretion began. Also since pentamerism was a consequence of this mode of growth, and since *Peridionites* already had five definite segments, a torsion to adapt the two independent pentamerous developments (body and skeleton) may be the explanation of the torsion of body parts during metamorphosis in ontogeny. Thus to the unusual coincidence of these factors (massive skeleton and independent pentamerism of body and skeleton), it is suggested, are due the unique features of the metamorphosis of the echinoderms.

9. An attached stage in the phylogeny of the Eleutherozoa generally has been postulated although without confirmation in ontogeny. The existence of these two early forms and their correspondence, morphologically, with the two chief larval stages, makes it unnecessary to require an attached stage in the ancestry of the Eleutherozoa.

10. From comparative studies it is suggested that the Homalozoa (that is, Machaeridia and Carpoidea) were derived from early Cyamoidea or from an even more primitive group; and that Pelmatozoa (Cystida, Blastoidea, Edrioasteroidea and Crinoidea) arose from Cyamoidea at about the stage of transition to Cycloidea.

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EXPLANATION OF PLATES.

PLATE I.

(All figures natural size.)

- Fig. 1. *Cymbionites craticula* sp. nov. Limestone showing the concentration of individuals. Complete specimens are seen in ventral, lateral and dorsal views. A natural transverse section, through the lower part of the calyx, is shown in the centre of the photograph, with five plates of approximately equal size.
- Fig. 2. *Peridionites navicula* sp. nov. Limestone showing isolated plates of the species, most of them end plates. Two plates of *Eocystis* (?) sp. also are to be seen.
- Fig. 3. *Cymbionites craticula* sp. nov. A specimen showing isolated plates, each of them typically wedge-shaped.

PLATE II.

(All figures natural size unless otherwise stated.)

- Figs. 1-9. *Peridionites navicula* sp. nov. 1a, b, lateral and ventral views of a typical complete specimen. 2, 3 and 4, lateral views of three specimens of a rather taller type. 5, ventral view of a more obese form. 6, a typical specimen with the apical plate missing. 7a, b, a specimen similar to fig. 6 with the sutures of the medio-lateral plate etched; 7b is an enlargement ($\times 2$) of this specimen, the *holotype*. 8a, b, ventral view of another specimen (8b is enlarged two diameters). 9a, b, microphotographs through a complete specimen. 9a (magnified 9 diameters) illustrates the general form. The black dots indicate the outline of the Central Cleft. The irregularly porous nature of the skeleton may be seen, the pores aligned generally in a radial fashion. Figure 9b is a greater magnification (enlarged 30 diameters) of that portion of 9a within the four white dots. The irregular pores of the skeleton may be noticed.
- Figs. 10-24. *Cymbionites craticula* sp. nov. 10, an almost vertical microsection (enlarged 13 diameters) through the calyx. The following features should be noticed (see also text-fig. 5):
- i. The unity of the fibrous development throughout the skeleton.
 - ii. The grouping of the plates according to the tufts.
 - iii. The crowding out of a small plate near the base of the calyx by the growth of neighbouring tufts.
 - iv. The discordance between the two uppermost sutures and the fibres—that on the left discordant only towards the outer edge, that on the right continuously discordant.
 - v. The cessation of the upper, right suture in outwards development.
 - vi. The well developed growth lines.
- Fig. 11 is a naturally etched specimen, the silicified margins of the outer and inner walls, as well as the five sutures, stand out in natural relief.
- Figs 12-22 (a and b) show ventral and lateral views of eleven specimens, illustrating the variation in shape. Fig. 12 is the *holotype*.
- Fig. 23 is a ventral view ($\times 2$) of a form with seven radial plates and a centrale.
- Fig. 24 ($\times 2$) is a ventral view of a slightly etched specimen showing that the sutures correspond sometimes with the crests and sometimes with the dips in the scalloped margin of the calyx.

PLATE III.

Cymbionites craticula sp. nov.

Four microphotographs of transverse sections through plates of the theca.

- Fig. 1. Section of one plate near the calical wall (the bounding sutures are at the top and bottom left corners). The fibres occur as a simple tuft contained within the limits of the plate. ($\times 25$ diameters.)
- Fig. 2. A specimen in similar aspect to fig. 1, but with the fibres arranged in a double tuft. ($\times 50$ diameters.)
- Fig. 3. A section dorsal to the calyx showing fibres arranged in one plume that forms the whole theca. Sutures are not developed. ($\times 25$ diameters.)
- Fig. 4. A section dorsal to the calyx and midway to the outer edge, showing a suture discordant with the fibres. Although the fibres are continuous across the suture they have differing optical properties on either side. ($\times 50$ diameters.)

PLATE IV.

Cymbionites craticula sp. nov.

Four microphotographs of transverse sections through plates of the theca.

- Fig. 1. A specimen with plumose growth, showing a small plate starting to develop with very strong sutures bounding a small plume, but the sutures soon cease and the plate does not separate. ($\times 25$ diameters.)
- Fig. 2. A section across the specimen illustrated in text fig. 7D, showing two plumes separated by a suture. The radial, plumose growth is very well illustrated, and also the typical symmetry of fibres across a suture. ($\times 50$ diameters.)
- Fig. 3. The centre portion of the plume of fig. 2 enlarged 230 diameters, showing the fibres and the interstitial meshwork.
- Fig. 4. Another portion of the same slide enlarged 750 diameters, in which there are transverse and longitudinal sections of the fibres, and in which the relations to the interstitial meshwork can be seen.

I am greatly indebted to Professor H. J. Wilkinson who made the microphotographs and to Mr. E. V. Robinson who photographed the exteriors of the specimens.

The specimens illustrated in text-figures and on plates bear the following numbers in the catalogue of the Department of Geology, the University of Queensland:

Peridionites navicula:

Plate I, fig. 2 (5398).

Plate II, fig. 1 (5399), fig. 2 (5400), fig. 3 (5401), fig. 4 (5402), fig. 5 (5403),
fig. 6 (5405), fig. 7 (5404—holotype), fig. 8 (5406), fig. 9 (5407).

Cymbionites craticula:

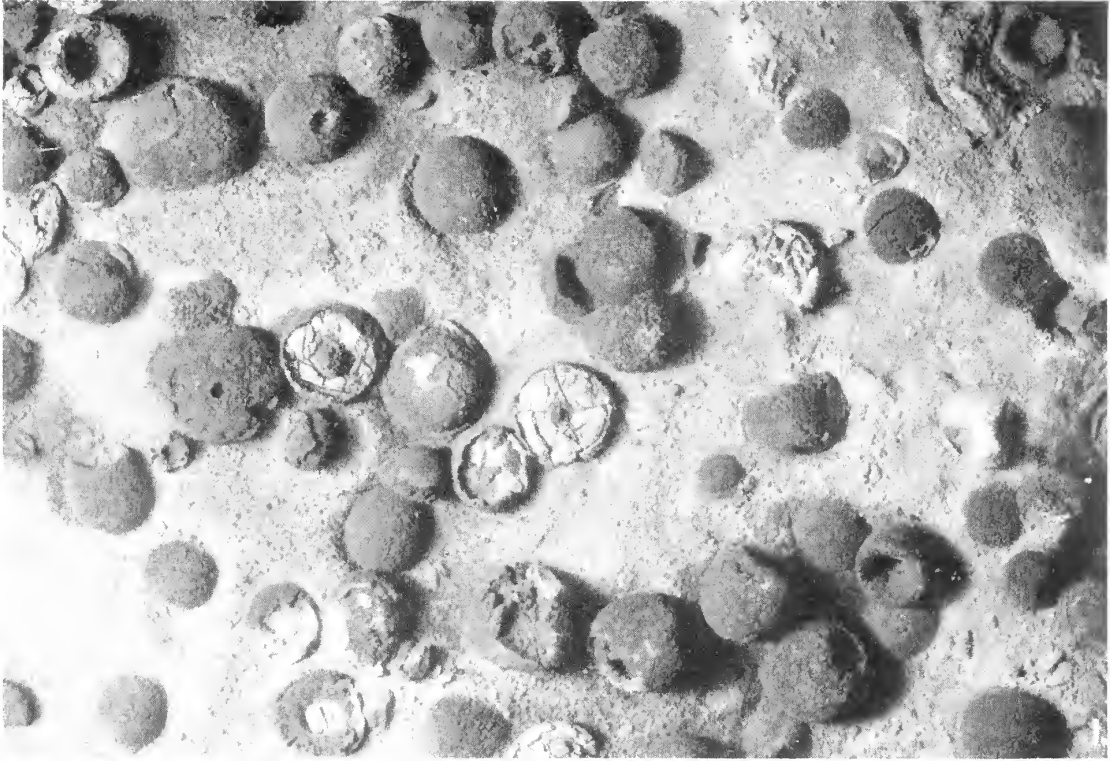
Plate I, fig. 1 (5408), fig. 3 (5421).

Plate II, fig. 10 (5422), fig. 11 (5423), fig. 12 (5409—holotype), fig. 13 (5410),
fig. 14 (5411), fig. 15 (5412), fig. 16 (5413), fig. 17 (5414), fig. 18 (5415),
fig. 19 (5416), fig. 20 (5417), fig. 21 (5418), fig. 22 (5419), fig. 23 (5435),
fig. 24 (5420).

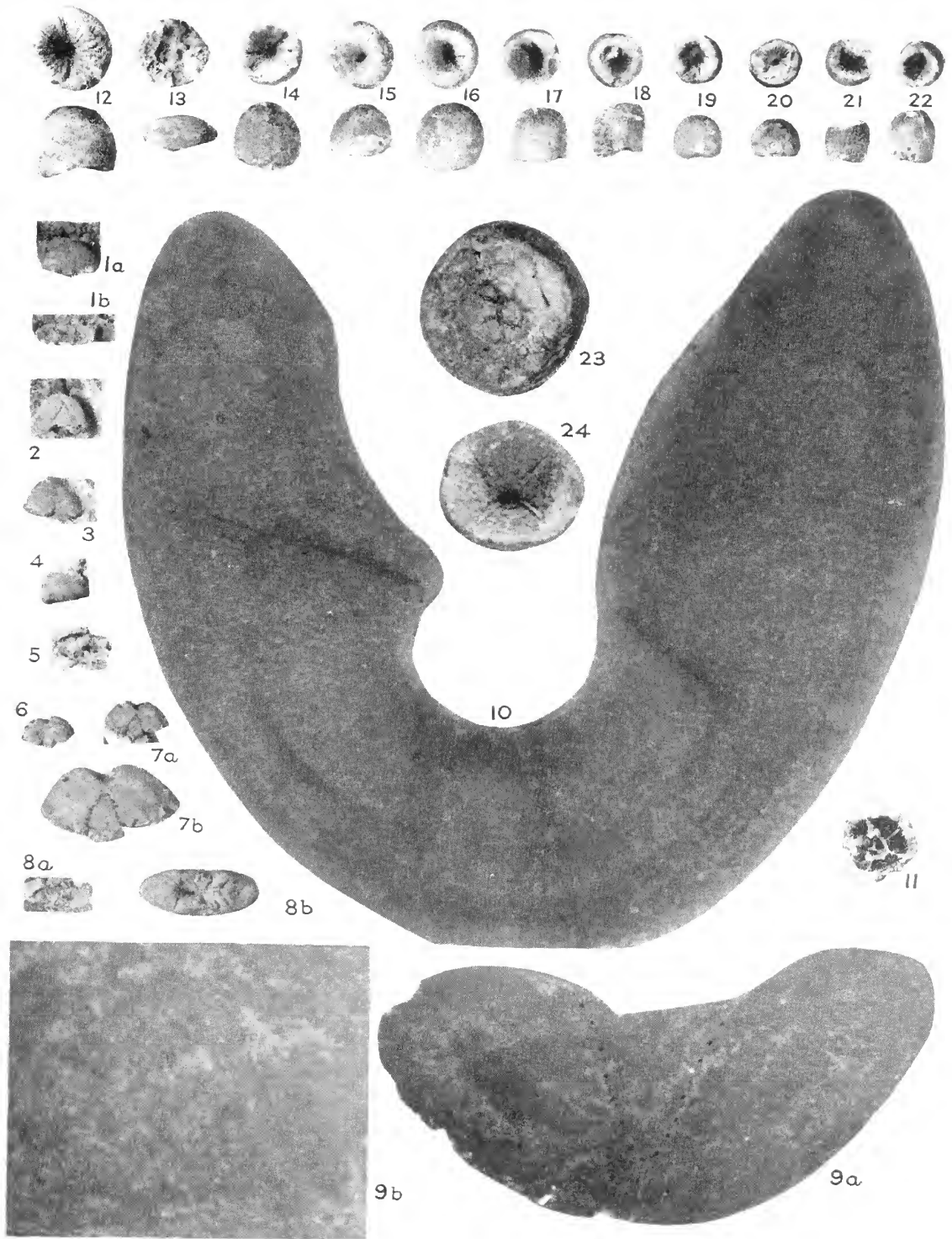
Plate III, fig. 1 (5424), fig. 2 (5425), fig. 3 (5426), fig. 4 (5427).

Plate IV, fig. 1 (5428), figs. 2, 3 and 4 (5429).

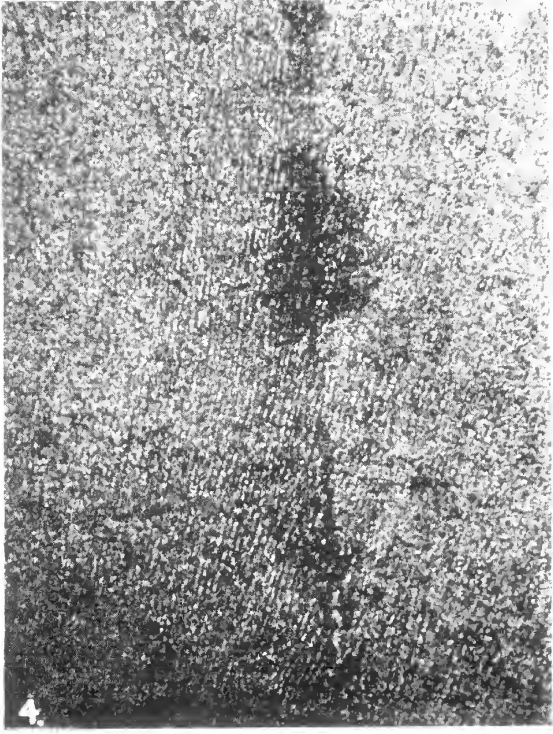
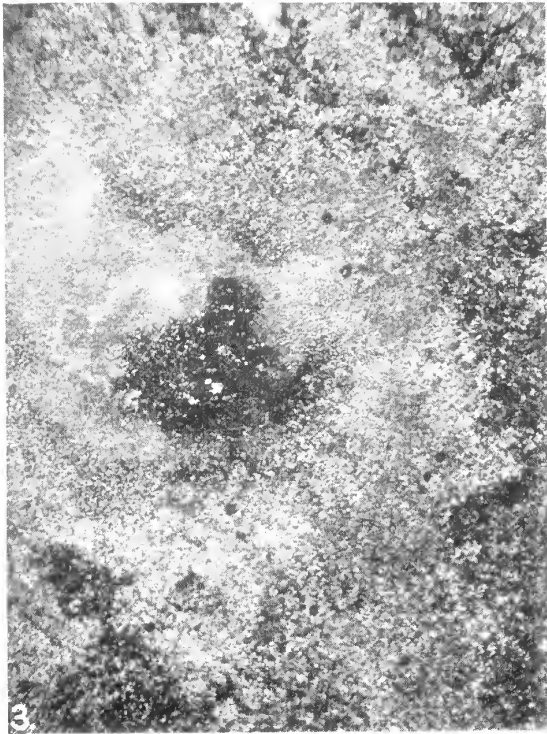
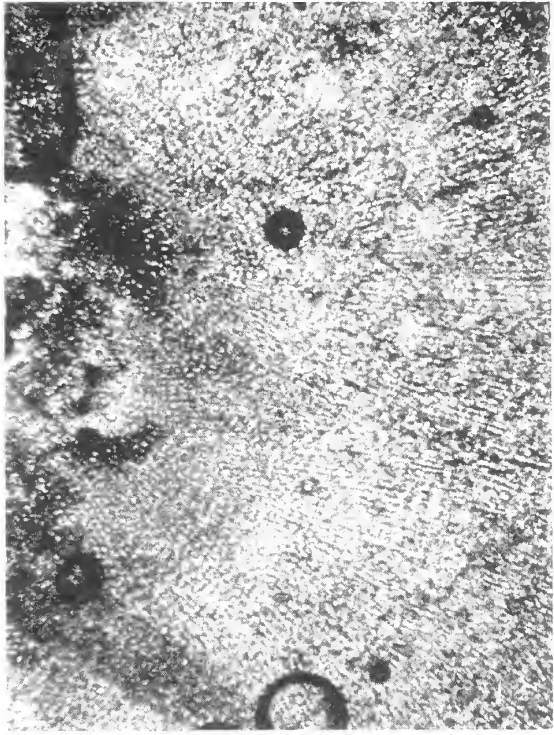
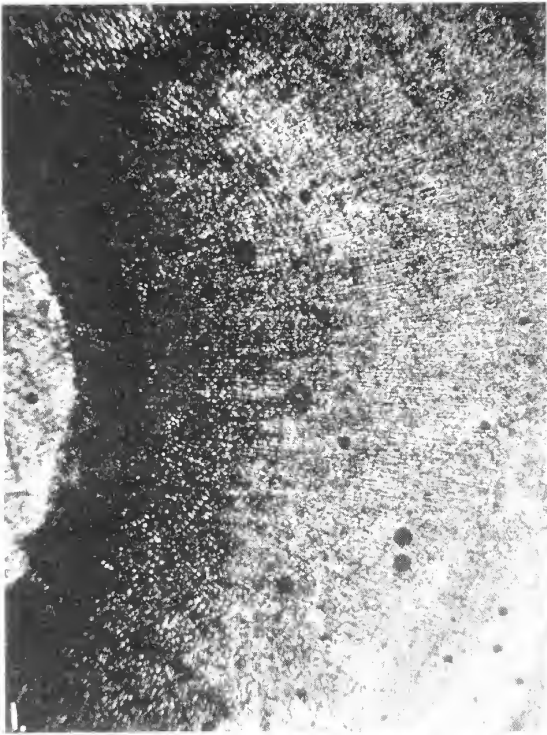
Text-fig. 6A (5430), 6B (5424), 6C (5431), 6D (5429), 6E (5433), 6F (5434),
6G (5435).



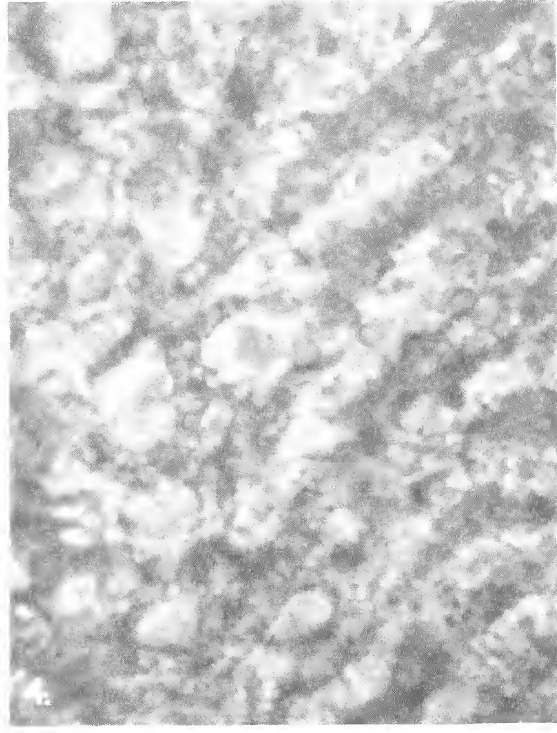
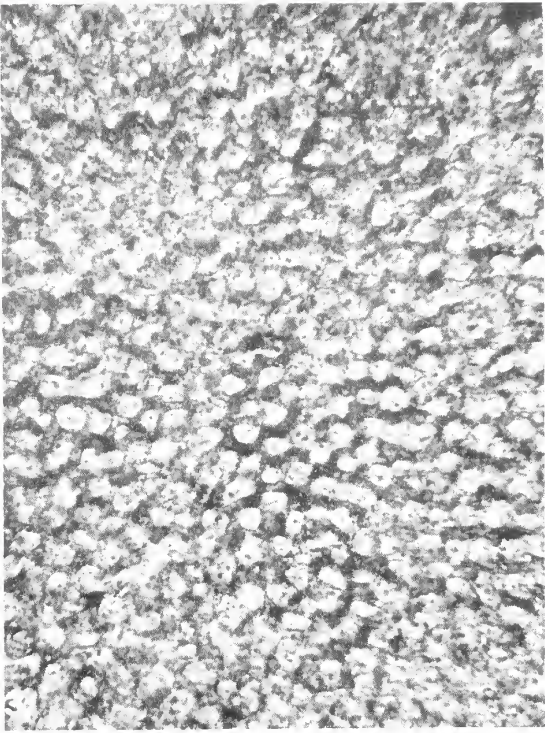
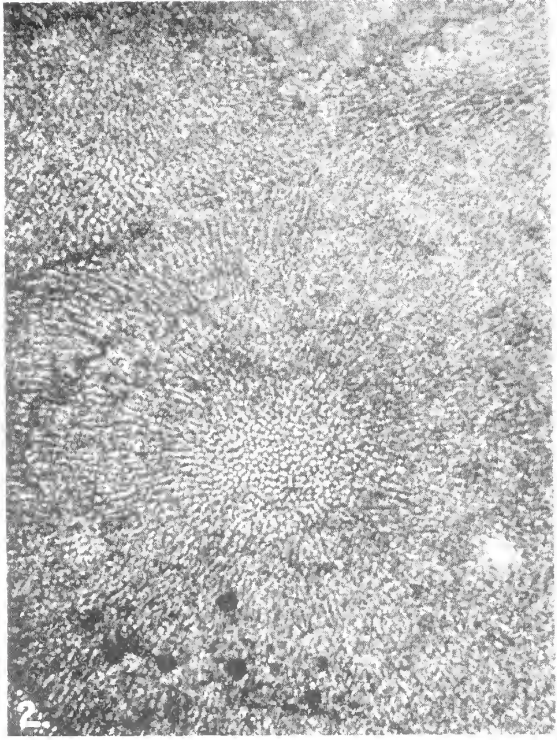














A QUEENSLAND FOSSIL AMPHIBIAN.

BY H. A. LONGMAN (DIRECTOR).

(Plate V.)

With Notes by F. W. Whitehouse, Ph.D., D.Sc., on the Age of the Beds.

A small fragment of bone discovered by Mr. John Wadley in the sandstones on the Brisbane River, below Lowood, is of unusual interest as it represents the first vertebrate remains to be found in these extensive deposits. The writer has at times searched over large areas of these sandstones, hoping for signs of vertebrate remains, but without success. It is pleasant to pay a tribute to Mr. Wadley's enthusiasm, to which this discovery is due. Persistent searching by him in the same locality, however, has failed to reveal additional material, although further attempts will be made.

The actual spot in which the fragment was found in situ was in the bed of the Brisbane River nearly a mile below Lowood Station and near the flood gauge.

The fragment was embedded in a large mass of sandstone, and the smooth surface exposed resembled portion of a rib. When this was carefully removed from the matrix, however, the hidden contours proved significant and the fragment was found to be portion of an amphibian jaw. The rib-like exposed surface proved to be the oral border. The dorsal aspect of the fragment showed characteristic sculpturing, whilst the flat lower surface contained the abraded remains of twenty alveoli.

AUSTROPELOR WADLEYI, genus and species new.

The fragment as exposed consists of three conjoined pieces. The maximum length is 99 mm., breadth 28 mm., and the dorso-ventral thickness 25 mm. Evidently the fragment was partly macerated before fossilisation, as all the teeth are lost. Even the body of the fragment is somewhat abraded, and it is most unfortunate that the alveolar cavities give no evidence of the actual teeth.

The alveoli are small and closely set, with a maximum diameter of 4 mm. The fragment is considered to be from the right side of the upper jaw, and it obviously represents only a small section of the dental arcade.

Figure 1 of Plate V shows the lower surface of this maxillary fragment with the somewhat obscure alveoli. Figure 2 gives a supero-lateral aspect, the fragment being tilted to show the external or labial surface and the abraded sculpturing of the cranial roof.

The outer surface, although abraded, shows two prominent straight grooves. One of these is situated on the labial border and occupies most of its area. The second, which is not so prominent, is on the upper surface adjoining the lateral border and running parallel to it. Both these grooves are quite shallow anteriorly, where they are merged in the plane of the less prominent sculpturing. They apparently correspond with lateral portions of the lyrate system of mucous or sensory canals between the orbits and narial openings which are characteristic of many Stegocephalians (*Mastodonsaurus*, *Capitosaurus*, *Lyrocephalus*, *Trematosaurus*, etc.). From the published researches of A. P. Bystrow, G. Save-Soderbergh, F. Broili and J. Schröder and others it is evident that considerable significance may be attached to the structure of these lateral line canals in well-preserved crania. Although so fragmentary, the evidence for canals in the Lowood fossil seems to be definite, but no precise comparisons can be made between it and well-known genera.

The labial groove, which appears to have a distinctive feature, is relatively deep and is almost V-shaped in section at its strongest development. If placed in a reversed position, the fossil might be interpreted as a fragment from the left maxilla, and the grooves would then be seen as becoming gradually merged in the posterior and not the anterior plane of the surface.

On the median border of the upper surface the contours are disrupted for two-thirds of the length where the fragment was broken off from the cranial roof. The remaining third presents a smooth surface which apparently represents the narial opening. The choanae may have been of the somewhat elongated type figured by F. Broili and J. Schröder in their reconstruction of *Capitosaurus haughtoni*.¹

The actual curve of the fragment suggests an arc with a radius of twenty inches. The cranial contours of fossil amphibia, ranging from elongated to triangular or almost circular outlines, are too variable to postulate the shape of the head from so small a fragment. It is obvious, however, that this Lowood fossil represents a very large species. It is suggested that a complete adult skull would be about two feet in length.

Austropelor wadleyi is tentatively placed in the Family Capitosauridae of the Stegocephali. Reg. No. F. 2628. Type fragment in Queensland Museum.

The bone was exhibited at a meeting of the Royal Society of Queensland on 26th June, 1940.

Previous Records.—Very few fossil amphibians have been found in Australia.

Bothriceps australis from the Hawkesbury beds of New South Wales was described by Huxley in 1859.² A second species *Bothriceps major*, from Airly, N.S.W., was subsequently recorded by A. Smith Woodward.³

¹ F. Broili u. J. Schröder, 1937, Sitz. der Bayer. Ak. Wiss., München, Heft 11, p. 111.

² Huxley, 1859, Quart. Journ. Geol. Soc., Vol. XV, p. 647.

³ A. Smith Woodward, 1909, Rec. Geol. Surv., N.S.W., Vol. VIII, pp. 317-319.

In 1886 the late Professor W. J. Stephens recorded a pectoral plate from Cockatoo Island, which he tentatively associated with *Mastodonsaurus*. He also described *Platyceps wilkinsoni*, a "Baby Labyrinthodont" from the Hawkesbury Series near Gosford.⁴

The most significant labyrinthodont remains yet discovered in Australia were secured by the late B. Dunstan, Queensland Government Geologist, from St. Peters quarry, near Sydney, N.S.W., Wianamatta shales. This very large specimen was sent to London. In a brief comment D. M. S. Watson notes that this labyrinthodont "is, so far as can be seen from a short inspection, a typical *Cyclotosaurus* which marks a definite evolutionary stage of the *Stereospondyli*, always of Upper Triassic age in Europe."⁵

Age.—I am greatly indebted to Dr. F. W. Whitehouse, Hon. Palaeontologist, for the following notes:—

THE AGE OF THE BONE-BEARING SANDSTONE AT LOWOOD.

By F. W. WHITEHOUSE, Ph.D., D.Sc.

"In south-eastern Queensland there is a very extensive development of Mesozoic sediments that fall naturally into several series. The nomenclature of these at present is slightly involved since there has been a progressive subdivision of earlier-named groups sometimes without a clear statement of what restriction a later author had intended for the older names. A full discussion and analysis of these things will be given by the writer in a forthcoming publication. Meanwhile the following stratigraphical succession expresses best the progression locally from the early Triassic or even late Permian (Kinbombi Series) to the Aptian division of the Lower Cretaceous (Roma Series).

- Roma Series (Whitehouse 1926).
- Blythesdale Series (Jack 1895).
- Walloon Series (Cameron 1907).
- Marburg Series (Reid 1921).
- Bundamba Series (Cameron 1907).
- Ipswich Series (Jack 1886).
- Esk Series (Reid 1923).
- Kinbombi Series (Reid 1925).

"The bone-bearing sandstone occurs in beds that have been mapped by Mr. J. H. Reid* as the Marburg Series—that is a little above the middle of this sedimentary column. The latest series (the Roma Series) alone is of marine origin and has a rich Aptian fauna. The Blythesdale flora is rich but undescribed, probably of lowest Cretaceous (pre-Aptian) age.

⁴ W. J. Stephens, 1886, Pr. Linn. Soc., N.S.W., Vol. I (2), pp. 931-940; loc. cit pp. 1175-1192, and 1887, Vol. II (2), pp. 156-158.

⁵ D. M. S. Watson, 1918. Rep. Brit. Ann. Ad. Sci., 1917, p. 115.

* Reid, J. H. 1921. "Geology of the Walloon-Rosewood Coalfield." *Qd. Gort. Mining J.*, XXII, p. 224.

“Only one species of plant (a giant *Nilssonia*) is known in the Kinbombi Series which mainly is a group of andesitic boulder beds. The Esk and Ipswich Series have wonderfully rich Triassic floras as well as abundant insect faunas. In earlier times, by comparison with Europe (where Triassic beds earlier than the Rhaetic are almost barren of plants), the flora of the Ipswich Series was regarded as Rhaetic. But now, when here in Queensland we know of rich floras almost continuously downwards to the Permian, the basis of such a definite age determination is open to question. However, judging from stratal thicknesses and by comparison with the African and Argentine floral evidence, the Esk and Ipswich Series together must continue the succession upwards to near the top of the Triassic.

“Between these Triassic and Cretaceous groups lie the three series, the Bundamba, Marburg and Walloon, with very few species of plants. In an outlier of what appears to be the Bundamba Series at Durikai is a *Sagenopteris* flora (*Sagenopteris rhoifolia* Presl. sp., *Otozamites feistmanteli* Zigno, and *Phlebopteris alethopteroides* Eth. fil.), definitely Jurassic. The described floras of the Walloon and Marburg Series (in their restricted senses) are very meagre although, near Bymount in the western regions, there is a very rich undescribed flora of the Walloon. Until this and certain other floras (of the Blythesdale Series most notably) are described a definite age pronouncement would be premature. Sufficient it is to say that these three series (Bundamba, Marburg and Walloon) are Jurassic in age and that the Marburg Series which has this bone bed may be placed tentatively about the middle of the period.

“It may be appropriate to record that it is in the succeeding series (the Walloon) that the most striking evidences of vertebrate life in our lacustrine Mesozoic beds has been obtained—the dinosaur *Rhoetosaurus brownei* Longman from Durham Downs north of Roma, and the abundant dinosaur footprints in a coal mine at Lanefield. All four non-marine series, from Bundamba to Blythesdale, cover an enormous area in Queensland, outcropping as a continuous eastern, marginal fringe to the Great Artesian Basin. Except for the Blythesdale Series they occur also in smaller basins nearer the coast. There is considerable promise therefore of future discoveries of Jurassic and early Cretaceous land and fresh-water vertebrates in Queensland.

“For purposes of comparison it may be well to record that the Mesozoic sediments of the Sydney area with several described vertebrates (the Narrabeen, Hawkesbury and Wianamatta Series) are all Triassic and so are earlier than the bone bed at Lowood.”



Fig. 1.—*Austropolor wadleyi*. Lower surface of jaw fragment with remains of alveoli.



Fig. 2.—*Austropolor wadleyi*. Supero-lateral view of jaw fragment.



A REVISION OF THE GENUS *ANOPLODACTYLUS* TOGETHER WITH A NEW SPECIES FROM QUEENSLAND.

BY G. WILLIAMS, M.Sc., QUEEN'S UNIVERSITY, BELFAST.

(Text-figures 1-5.)

The interesting Pycnogonid, which forms the third species of *Anoplodactylus* recorded from the Australian coast, was collected by Mr. Melbourne Ward. For the opportunity of describing this specimen my thanks are due to Professor T. Thomson Flynn, to whom I am also indebted for much helpful criticism and for the use of his extensive literature.

The Genus *Anoplodactylus* (Wilson) established in 1878 now includes 39 named species and two forms which are referable to the genus but which have not received specific names. One of these, found off the south coast of Japan, was too immature for specific diagnosis (Ohshima). The other, taken near Yé, Burma, is stated to resemble closely *A. petiolatus*. Calman hesitated to extend the already wide distribution of *A. petiolatus* or to establish a new closely-related species on the evidence of but one specimen.

Cole in 1904 established the genus *Halosoma* but this has not retained its generic rank, having been transformed by Loman (1912) into a subgenus of *Anoplodactylus*. Seven members of this subgenus are now known, occurring in widely separated regions, viz.:

1. *Anoplodactylus* (*Halosoma*) *virid-intestinalis* Cole 1904, from the Californian coast.
2. *Anoplodactylus* (*Halosoma*) *lappa* Böhm 1879, from the coast of Mozambique.
3. *Anoplodactylus* (*Halosoma*) *exiguus* Dohrn 1881, from the Mediterranean Sea.
4. *Anoplodactylus* (*Halosoma*) *robustus* Dohrn 1881, from the Mediterranean Sea.
5. *Anoplodactylus* (*Halosoma*) *anarthrus* Loman 1908, from the Timor Sea.
6. *Anoplodactylus* (*Halosoma*) *haswelli* Flynn 1918, from Port Jackson, Australia.
7. *Anoplodactylus* (*Halosoma*) *derjugini* Losina-Losinsky 1929, from the Sea of Japan.

Of the above, numbers 2, 3 and 5 were transferred to the genus *Anoplodactylus* by Loman in 1912 and number 4 by Losina-Losinsky in 1929. In tabulating the known species of *Halosoma*, however, Losina-Losinsky omitted

Flynn's species *A. haswelli* (1918). Of the remaining species, eight, including the genotype *A. lentus* (Wilson 1878), have been recorded from North American waters and two from those of South America, although one example in each case is the widespread species *A. petiolatus*. Nine species are known from Africa, but of these one is again *A. petiolatus* from the Algerian coast and another *A. saxatilis* from Port Said, the latter species also occurring off the Indian coast. Only three species (including the new species described below) have been taken in Australian waters and of these one, *A. plumulariae* (von Lendenfeld 1883) is only known from immature forms. Eight species are recorded from the waters of India and the Malay Archipelago and one from near Japan.

The members of the genus *Anoplodactylus* appear to be mainly warm water forms, the great majority having been taken in tropical or subtropical regions (Fig. 1). The European species show the greatest extension into colder latitudes and the known distribution of the most northerly species (*A. petiolatus*) is particularly interesting. Stevensen (1933) has recorded *A. petiolatus* from as far north as 69° and it may be that this northern extension has been made possible by the warmer waters of the Gulf Stream Drift. It is of interest also to note that this northerly region from which *A. petiolatus* has been taken closely corresponds to the isotherm of maximum positive anomaly, where the air temperature may be as much as 40° F. above the mean temperature for that latitude.

LIST OF KNOWN ANOPLODACTYLUS SPECIES AND KEY TO THEIR DISTRIBUTION.

<i>A. lentus</i> (genotype) (Wilson) 1878 .. A.	<i>A. investigatoris</i> (Calman) 1923 .. A. n.
<i>A. petiolatus</i> (Kroyer) 1844 .. N.	<i>A. cribellatus</i> (Calman) 1923 .. A. c.
<i>A. typhlops</i> (Sars) 1891 .. M.	<i>A. species like petiolatus</i> (Calman) 1923 A. s.
<i>A. pygmaeus</i> (Hodge) 1864 .. L.	<i>A. insignis</i> (Hoek) 1881 .. H.
<i>A. (Halosoma) robustus</i> (Dohrn) 1881 O.	<i>A. insignis bermudensis</i> (Cole) 1904 .. E.
<i>A. angulatus</i> (Dohrn) 1881 .. P.	<i>A. oculatus</i> (Carpenter) 1904 .. I.
<i>A. virescens</i> (Hodge) 1864 .. K.	<i>A. (Halosoma) exiguus</i> (Dohrn) 1881.. Q.
<i>A. stylops</i> (Loman) 1908 .. A. st.	<i>A. portus</i> (Calman) 1927 .. Y.
<i>A. digitatus</i> (Bohm) 1879 .. A. b. (re-described by Loman 1908)	<i>A. neglecta</i> (Hoek) 1898 .. W.
<i>A. brevicollis</i> (Loman) 1908 .. A. j.	<i>A. plumulariae</i> (von Lendenfeld) 1883 A. pl.
<i>A. versluysi</i> (Loman) 1908 .. A. v.	<i>A. massiliensis</i> (Bouvier) 1916 .. J.
<i>A. (Halosoma) anarthrus</i> (Loman) 1908 A. a.	<i>A. maritimus</i> (Hodgson) 1915 .. F.
<i>A. (Halosoma) tubiferus</i> (Haswell) 1884 A. t.	<i>A. californicus</i> (Hall) 1915 .. B.
<i>A. gestiens</i> (Ortmann) 1891 .. A. g.	<i>A. parvus</i> (Giltay) 1934 .. D.
<i>A. aculeatus</i> (Mobius) 1902 .. V.	<i>A. Species</i> (immature) (Ohshima) 1933 A. sp.
<i>A. spinosus</i> (Mobius) 1902 .. U.	<i>A. (Halosoma) derjugini</i> (Losina-Losinsky) 1929 .. A. d.
<i>A. erectus</i> (Cole) 1904 .. C.	<i>A. (Halosoma) virid-intestinalis</i> (Cole) 1904 .. G.
<i>A. pulcher</i> (Carpenter) 1907 .. A. p.	<i>A. (Halosoma) lappa</i> (Bohm) 1879 .. R.
<i>A. pelagicus</i> (Flynn) 1928 .. T.	<i>A. longicollis</i> (Williams) 1939 .. A. q.
<i>A. polignaci</i> (Bouvier) 1914 .. S.	<i>A. (Halosoma) haswelli</i> (Flynn) 1918 A. h.
<i>A. saxatilis</i> (Calman) 1923 .. Z.	

ANOPLODACTYLUS LONGICOLLIS sp. nov.

Locality.—“Lindeman Island, Whitsunday Passage, Queensland, Australia. Among bushy algae and hydroids. (M. Ward).” 2♂.

Description.—Body elongated and slender, the lateral processes separated by about twice their diameter, last two segments practically coalesced, the suture line being barely visible. Ocular tubercle very large, pointed and directed forwards. Proboscis dilated in its proximal third and slightly swollen at tip. Abdomen considerably longer than last pair of lateral processes, directed vertically.

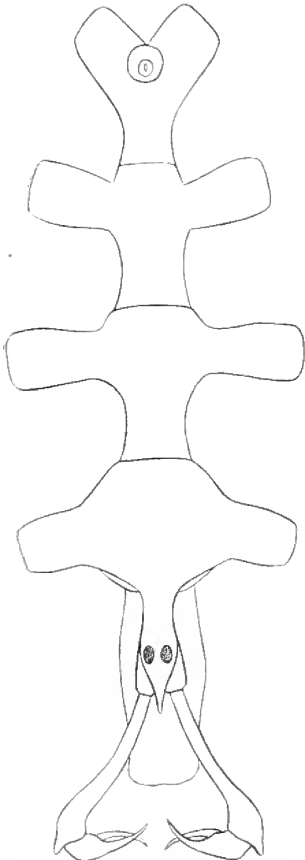


Fig. 2.—*Anoplodactylus longicollis*, sp. n., Male. Dorsal view, legs omitted ($\times 33\frac{1}{2}$).

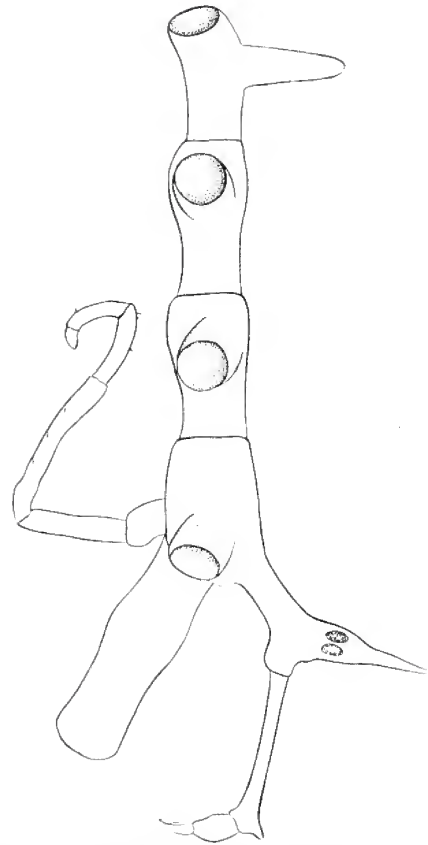


Fig. 3.—*Anoplodactylus longicollis*, sp. n., Male. From the right side, legs omitted ($\times 33\frac{1}{2}$).

Chelophores fairly slender, scape long but not equal to length of cephalic segment owing to the length of the neck. Fingers delicate, very strongly curved distally, with a few scattered spines.

Legs slender, second coxa not quite as long as first and third together. Femur equal to first tibia and provided with a long terminal process ending in a long spine. First tibia longer than second tibia, also provided with spinous

terminal process, the latter being much shorter than that of the femur. Propodus with well marked basal projection bearing one large unpaired spine followed by one pair. Sole of propodus with a series of smaller spines extending nearly to base of claw. Claw long and slender, auxiliaries very small. Second coxa of last three legs with small bluntly pointed process. First leg bluntly rounded in this region but with no distinct process. Femora of all legs with two large eribriform gland openings, symmetrically placed on each side of middle of femur. Ovigera six jointed of the characteristic *Anoplodactylus* form, third joint longest, sixth joint smallest, with a few spines but no terminal claw.

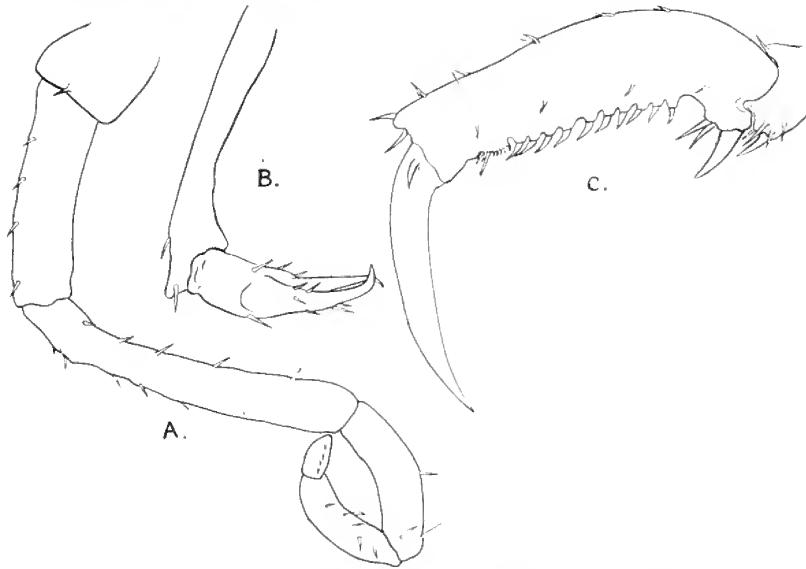


Fig. 4.—*Anoplodactylus longicollis* sp. n., Male.
 A. Right Oviger ($\times 57\frac{1}{2}$).
 B. Right Chelophore ($\times 66\frac{2}{3}$).
 C. Tarsus and Propodus of first right leg ($\times 62\frac{2}{3}$).

MEASUREMENTS, IN MM.

Length of proboscis (from the side)	0.82
Greatest width of proboscis	0.29
Length of trunk	1.9
Length of abdomen	0.36
Length of scape of chelophore	0.61
Height of ocular tubercle (from dorsal base of chelophore)	0.51
Fourth right leg:—		
First coxa	0.364
Second coxa	0.666
Third coxa	0.375
Femur	1.51
First tibia	1.51
Second tibia	1.41
Tarsus and propodus	0.82
Length of great claw	0.54

(The measurements of the tarsus and propodus and of the great claw are taken from the first leg as these regions are foreshortened in the microscopic preparation of the fourth leg.)

Remarks.—*Anoplodactylus longicollis* is related to *A. cribellatus* (Calman 1923, p. 285) and *A. oculatus* (Carpenter 1905). There is a very strong resemblance to the latter, particularly in the neck region, in the shape and size of the ocular tubercle, and also in the form of the proboscis. The resemblance to *A. cribellatus* is not so close although the widely separated lateral processes and the fusion of the last two segments is common to both. The three species differ from each other in the following points. The lateral processes are more widely separated in *A. longicollis* than in *A. cribellatus* or *A. oculatus*. The proportion of the limb joints is different in all three species. The heel of the propodus

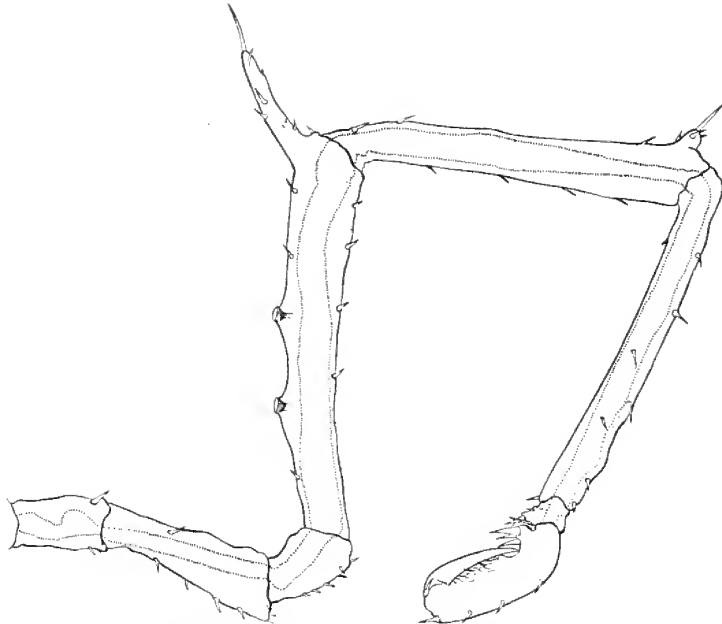


Fig. 5.—*Anoplodactylus longicollis*, sp. n., Male. Fourth right leg ($\times 32$).

in *A. longicollis* has only one unpaired spine whereas in the other two species there are two. The femoral cement gland openings are very large and only two in number in *A. longicollis* while there are five in *A. oculatus* and fifteen in *A. cribellatus*. There is no end claw to the oviger in either *A. longicollis* or *A. cribellatus*. Carpenter figures and describes one in the case of *A. oculatus*. I believe this to be the only case on record of an *Anoplodactylus* species possessing such a structure. The scape of the chelophore is considerably shorter than the cephalic segment in *A. longicollis*, whilst in *A. oculatus* and *A. cribellatus* the reverse is the case. The genital process is distinct as a definite process in *A. oculatus*, in *A. longicollis* it is a pointed hump. The process at the distal end of the femur is present in *A. oculatus* and *A. longicollis*, although it is better developed in the latter. *A. cribellatus* has no such process. Neither *A. oculatus* or *A. cribellatus* shows any process comparable to that found at the extremity of the first tibia in *A. longicollis*.

Type in Queensland Museum, Reg. No. W. 974.

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NEW SPECIES OF LEPIDOPTERA FROM THE BARNARD COLLECTION.

BY A. JEFFERIS TURNER, M.D., F.R.E.S.

The large and valuable collection of lepidoptera made by the late Mr. W. B. Barnard has recently been presented to the Queensland Museum by his family. Mr. Barnard, who was a skilled, zealous, and untiring collector of this group of insects, has added much to our knowledge by prolonged collecting in the far north of the Cape York Peninsula, West Australia, and Tasmania, as well as in Southern and Western Queensland. The arranging of this great collection will be a long task, and is certain to reveal a large number of hitherto unknown species. A first instalment of these is the subject of the present article.

The types of the species here described are in the Queensland Museum.

Fam. NOTODONTIDAE.

PHIRERASPIS RECTILINEA n. sp.

rectilineus, straight-lined.

♂ ♀. 54-60 mm. Head and thorax fuscous mixed with whitish hairs. Palpi $1\frac{1}{4}$; pale brown. Antennae ochreous-grey whitish; pectinations in male 10. in female without pectinations, but shortly ciliated. Abdomen brownish-ochreous, at apex fuscous. Legs fuscous; tarsi with whitish rings. Forewings elongate-oval, costa gently arched, apex rounded, very oblique; fuscous with blackish lines; a sub-basal line with a posterior median tooth, not quite reaching dorsum; antemedian from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum, indented beneath costa, otherwise straight; a very slender irregularly dentate median line; postmedian from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, slightly sinuate, finely dentate; subterminal finely dentate, strongly sinuate; cilia fuscous. Hindwings with termen rounded; whitish-grey; on dorsum suffused with brownish-ochreous; cilia grey, apices whitish.

Very similar to *P. polioxutha* Turn., but the forewings are darker; antemedian line straight, and the antennae of female not pectinate.

Queensland: Injune in November; two specimens.

Gen. NYCTEROPA nov.

νυκτερωπος, dusky.

Tongue well developed. Palpi porrect or slightly ascending, much thickened with rough scales; terminal joint concealed. Antennae of male bipectinate, apex simple. Thorax with a short dense posterior crest. Abdomen without crests. Posterior tibiae with middle spurs. Forewings with 2 from shortly before angle, 3 and 4 connate from angle, 5 from middle of cell, 6 from

near end of areole, 7, 8, 9 stalked from areole, 10 separate from areole, 11 from four-fifths, free. Hindwings with 2 from four-fifths, 5 from slightly above middle, 6 and 7 long-stalked, 12 parallel to and near cell, but not closely approximated. Apparently near *Destolmia*.

NYCTEROPA SUBOVALIS n. sp.

subovalis, somewhat oval.

♂. 42 mm. Head and thorax fuscous. Palpi 2; fuscous. Antennae grey; pectinations in male 2, extreme apex simple. Abdomen grey-whitish. Legs fuscous sprinkled, and tarsi ringed, with whitish; posterior pair mostly whitish. Forewings suboval, narrow towards base, strongly dilated posteriorly, costa moderately arched, apex rounded, termen obliquely rounded; grey with dark fuscous lines and irroration; two short transverse lines from costa near base; two curved antemedian lines at one-fourth diverging towards dorsum; a small round pale orbicular spot precedes the second; a median line with a posterior tooth above dorsum; a sinuate postmedian line at two-thirds, followed by fine streaks on veins to termen; cilia fuscous mixed with whitish. Hindwings with termen rounded; whitish with a pale fuscous apical suffusion extending on termen to middle; cilia as forewings.

♂. 44-48 mm. Antennae simple. Abdomen brownish-fuscous; apices of segments ochreous-whitish. Posterior legs mostly fuscous. Forewings broader at base, costa more strongly arched near base; fuscous with patchy whitish suffusion and dark fuscous markings; one or both basal lines absent; first antemedian line well marked, indented above dorsum, second slender and sometimes obsolete, preceded or interrupted by a small circular pale orbicular spot; postmedian slender or partly obsolete preceded by a pale oval reniform spot; basal, midcostal, and mid-dorsal areas suffused with whitish; a slender dentate whitish subterminal line sometimes more strongly marked, preceding a fuscous terminal band crossed by dark fuscous streaks on veins. Hindwings and cilia fuscous.

Although sexual diversity is unusual in this group, there is no reasonable doubt that these are one species.

Queensland: Injune in March and April; one male and three females. One of the latter is the type.

GALLABA SUBVIRIDIS n. sp.

subviridis, partly green.

♂. 56 mm. Head and thorax fuscous sparsely sprinkled with ochreous-whitish. Palpi $3\frac{1}{2}$; second joint long, broad, densely scaled, expanded beneath towards apex; second joint short, cylindrical, obtuse; fuscous, second joint whitish-ochreous beneath except apex. Antennae ochreous-grey-whitish; pectinations in male 6, fuscous. Abdomen pale fuscous, apices of segments whitish-ochreous. Legs whitish-ochreous; anterior pair fuscous. Forewings suboblong,

costa moderately arched, apex rounded-rectangular, termen rounded, scarcely oblique; fuscous rather sparsely and very unevenly sprinkled with green scales, which are more numerous towards base; orbicular median, consisting of a small white dark-centred ring; reniform slightly beyond, more faintly outlined, transversely compressed, with an acute costal angle, incomplete dorsally; costal edge above orbicular whitish, with a small patch of green irroration beneath; several obscure whitish spots on dorsum and apical fourth of costa; a series of minute whitish dots in a line angled inwards from apex to tornus; a terminal series of similar dots extending into cilia; cilia between dots fuscous. Hindwings with termen rounded; pale fuscous; towards base ochreous-whitish; cilia as forewings but whitish on dorsum.

In spite of its green scales this species is very obscure and certainly cryptic.

North Queensland: Kuranda in April.

Fam. LARENTIADAE.

POECHLASTHENA ISCHNOPIRICA n. sp.

ισχοφρικος, narrowly rippled.

♀. 21-24 mm. Head pale grey; face and palpi fuscous-brown. Antennae, thorax, and abdomen pale grey. Legs whitish; anterior pair fuscous or grey. Forewings triangular, costa slightly arched, apex pointed, termen moderately oblique; whitish-grey with numerous fine rippled transverse lines of slightly darker grey; in posterior half of wing these are usually marked by fuscous points where they cross veins; a fuscous discal dot before middle; cilia whitish-grey. Hindwings with termen rounded; as forewings.

On a casual inspection this might be mistaken for *Cidaria microcyma* or even for one of the *Sterrhidae*. It is interesting as the only indigenous species of the genus recorded from West Australia. The only other species known from that State is the widespread *P. pulchra*.

West Australia: Busselton in February; Denmark in March and April; ten specimens.

TEPHROCLYSTIA APHANES n. sp.

ἀφανης, obscure.

♀. 17-18 mm. Head grey. Palpi one and a half; grey. Antennae grey. Thorax and abdomen fuscous. Legs grey-whitish; anterior pair fuscous. Forewings elongate-triangular, costa nearly straight, apex rounded, termen rounded, oblique; fuscous-grey with some darker scales; a series of costal strigulae terminating in a fuscous dot at three-fourths followed by another at seven-eighths; from these proceed two whitish lines ending before and on tornus, the first irregularly waved, the second dentate; a dark fuscous median discal dot and

another above tornus; a fuscous terminal line; cilia grey-whitish with pale fuscous bars. Hindwings with termen gently rounded; colour and cilia as forewings; several short fuscous lines from dorsum.

Apart from its neuration this may be distinguished from similarly obscure species of *Chloroclystis* by its discal dots.

Queensland: Toowoomba in February; three specimens.

XANTHORHOE EMMELOPIS n. sp.

ἔμμελωπις, harmonious.

♂. 28 mm. Head, palpi, and thorax fuscous. Antennae fuscous; pectinations in male 12. Abdomen grey; apices of segments fuscous. Legs fuscous; posterior pair grey. Forewings triangular, costa gently arched, apex round-pointed, termen slightly rounded, oblique; whitish with many rippled lines and suffusion fuscous; a small dark basal patch containning two whitish transverse lines; beyond this a narrow whitish fascia bisected by a fuscous line; median band broad on costa, narrower on dorsum, anterior edge from one-third costa to one-third dorsum, slightly curved outwards, posterior edge from three-fourths costa, slightly dentate, transverse to middle, where it forms an acute tooth, thence inwards to two-thirds dorsum; this band contains three rippled transverse lines and a median dot; there follows a narrow whitish fascia bisected by a slender fuscous line; a fine dentate whitish subterminal line followed by interneural fuscous streaks; a terminal series of triangular blackish dots; cilia fuscous with obscure whitish bars. Hindwings with termen scarcely rounded, dentate; whitish with very fine fuscous strigulae on dorsum; a faint fuscous subterminal line and a stronger terminal line; cilia whitish with an obscure fuscous median line.

West Australia; Denmark in April; one specimen.

Fam. STERRHIDAE.

EOIS TRISSOMITA n. sp.

τρισομιτος, with three threads.

♀. 13-14 mm. Head brownish; fillet whitish; face and palpi fuscous. Thorax and abdomen brownish. Legs pale brownish. Forewings narrowly elongate, costa straight almost to apex, apex pointed, termen slightly rounded, oblique; pale brownish with fuscous markings; an ill defined spot on costa at one-third; another at two-thirds giving rise to a sinuate line ending on mid-dorsum; a similar but less defined line shortly beyond and parallel; a third fainter parallel subterminal line; cilia pale brownish with median fuscous line. Hindwings with termen rounded; as forewings but lines antemedian, postmedian, and subterminal.

The forewings are much narrower than is usual in this genus, the wing-shape resembling that of a *Gymnoscelis*. It is unfortunate that we do not know the structural characters of the male.

Queensland: Injune in August and October; three specimens.

SCOPULA LOXOGRAPHIA n. sp.

λοξογραφος, obliquely marked.

♂ ♀. 24-28 mm. Head and palpi dark fuscous. Antennae in male grey, in female fuscous; ciliations in male 1. Thorax and abdomen whitish sprinkled with grey. Legs grey; posterior pair grey-whitish; posterior tibiae in male smooth, slightly swollen, not quite as long as femora, without spurs, tarsi slightly longer than tibiae; posterior tibiae in female with two pairs of spurs. Forewings elongate-triangular, costa slightly arched, apex pointed, termen nearly straight, oblique; whitish sparsely sprinkled with grey; a thick dark fuscous line from one-third dorsum to apex, nearly straight, costal edge rather suffused, terminal edge sharply defined; a slender fuscous line from mid-dorsum, roughly parallel, to termen beneath apex, followed by two suffused grey lines; a fuscous terminal line; cilia whitish. Hindwings with termen rounded; colour as forewings; a straight dark fuscous transverse median line; a slender parallel fuscous line from two-thirds dorsum to apex, followed by two grey lines; terminal line and cilia as forewings. In many examples the wings are more grey and have no blackish lines, all being slender and slightly waved.

Queensland: Injune in August, September, October, and April (W. B. Barnard); a fine series. Cunnamulla in February (N. Geary) one female of the grey form with the lines less strongly marked. This species is exceptional in the genus in having a double areole. In other respects it appears to be a typical *Scopula*.

ANISODES RHODOBAPTA n. sp.

ροδοβαπτος, rosy-tinged.

♂ ♀. 25-28 mm. Head ochreous-whitish; upper part of face fuscous-erimson. Palpi in male 2, in female two and a half, terminal joint in male one and a half, in female two-thirds; fuscous-erimson, beneath whitish. Antennae whitish; pectinations in male 10, apical fourth simple. Thorax pale, ochreous-grey. Abdomen pale ochreous-grey with a few fuscous scales, sides rosy-tinged. Legs ochreous-whitish; anterior and middle pairs rosy-tinged. Forewings triangular, costa slightly arched, apex round-pointed, termen slightly rounded, slightly oblique; ochreous-whitish rather densely sprinkled with grey and fuscous-erimson scales; five or six fuscous dots in basal area; discal dot faintly indicated; postmedian indicated by a faint grey shade, sometimes with a few fuscous points; subterminal by a series of fuscous dots on veins; cilia grey-whitish. Hindwings with termen strongly rounded; as forewings, but with a white discal dot outlined with fuscous.

North Queensland: Cape York in October and November; three specimens.

ANISODES LECHRIOSTROPHIA n. sp.

λεχριοστροφος, obliquely banded.

♂ ♀. 36-38 mm. Head grey-whitish; upper part of face grey. Palpi in male one and a quarter, in female 2, terminal joint in male one-third, in female two-thirds; whitish. Antennae grey-whitish; pectinations in male 12, apical

third simple. Thorax and abdomen grey-whitish with a few scattered dark fuscous scales. Legs ochreous-whitish; anterior pair dull rosy-purple anteriorly; posterior femora of male with a dense fuscous-purple crest of scales on apex of dorsum; posterior tibiae of male without middle spurs. Forewings triangular, costa straight almost to apex, apex round-pointed, termen rounded, slightly crenulate, slightly oblique; grey-whitish with a few dark fuscous scales and a minute discal dot; a broadly suffused pale grey line from two-fifths dorsum towards apex, but near end curved to three-fourths costa; a series of blackish dots on veins in a similarly suffused subterminal line, that on vein 5 displaced inwards; a terminal series of blackish dots on veins; cilia whitish. Hindwings with termen rounded, slightly crenulate; as forewings, but with a faint sub-basal line and second line median.

North Queensland: Cape York in October and June; three specimens.

PISORACA STICTA n. sp.

στυκτος, speckled.

♂ ♀. 26-27 mm. Head grey-whitish; upper part of face fuscous. Palpi in male one and a half, in female 2, terminal joint in male one-half, in female two-thirds; fuscous, beneath whitish. Antennae grey-whitish; pectinations in male 8, terminal fourth simple. Thorax and abdomen grey-whitish. Legs whitish; anterior pair crimson-grey. Forewings triangular, costa straight, apex round-pointed, termen slightly rounded, oblique; grey-whitish rather densely sprinkled with grey; sometimes a few grey dots in basal area; discal dot faint or absent; postmedian line ill defined, sinuate, subterminal faint, irregularly dentate with a few darker dots; a terminal series of dots between veins; cilia whitish. Hindwings with termen strongly rounded; as forewings.

North Queensland: Cape York in October and May; three specimens.

Fam. GEOMETRIDAE.

IDIOCHROA RUFIFRONS n. sp.

rufifrons, with reddish face.

♀. 22-30 mm. Head green on crown; fillet white; face and palpi dark red. Antennae white; pectinations in female 4, apical sixth simple. Thorax green. Abdomen grey; dorsum of first two segments green; median whitish dots on third, fourth, and fifth segments. Legs whitish; anterior coxae and femora reddish; anterior tibiae and tarsi grey. Forewings triangular, costa moderately arched, apex round-pointed, termen nearly straight, oblique; rather dark green; sometimes a pale subterminal line, slightly dentate, obsolete towards costa, with an anterior tooth above dorsum; cilia grey. Hindwings with termen slightly rounded, tornus prominent, colour and cilia as forewings; subterminal line indistinct.

Queensland: Injune in November, February, and April; five specimens.

CHILOROCOMA CYCLOSEMA n. sp.

κυκλοσημος, with a circular mark.

♀. 20 mm. Head greyish-brown; fillet and antennae white. Palpi not extending beyond face; whitish. Thorax green. Abdomen whitish; dorsum green towards base. Legs pale pink; posterior pair whitish. Forewings triangular, costa straight almost to apex, apex pointed, termen slightly rounded, slightly oblique; green; a greyish-brown streak from base of costa to apex, separated except at base and apex from costal edge by a white streak; antemedian line obsolete; a faint dentate whitish postmedian line; cilia whitish. Hindwings with termen rounded, tornus prominent; as forewings but with a rather large greyish-brown circular discal spot. Allied to *C. melocrossa* Meyr. but much smaller and distinguished by the discal spot of the hindwings.

New South Wales: Brunswick Heads in January: one specimen.

GELASMA SELENOSEMA n. sp.

σεληνοσημος, with lunate markings.

♂ ♀. 28-30 mm. Head green; fillet white; face reddish-orange. Palpi in male 1 and a half, terminal joint very short, in female 2 and a half, terminal joint as long as second; pale ochreous. Antennae white towards base, green towards apex; pectinations in male 4, green, apical two-fifths simple. Thorax green. Abdomen green on dorsum; beneath white. Legs whitish; anterior pair ochreous-tinted with green coxae; posterior tibiae in male dilated, with hair-tuft; all spurs present but short. Forewings triangular, costa straight to two-thirds, thence gently arched, apex pointed, termen almost straight, slightly oblique; green; costal edge in male ochreous from near base to middle, in female ochreous to beyond middle, thence whitish to apex; lines slender, whitish, composed of small lunules or half-loops; antemedian from one-fourth costa to two-fifths dorsum; consisting of three lunules convex posteriorly; postmedian from three-fourths costa to two-thirds dorsum, somewhat outwardly curved, lunules numerous and smaller, convex anteriorly, their junctions dentate posteriorly; termen edged very narrowly with fuscous; cilia whitish. Hindwings angled on vein 4, straight above and beneath; as forewings but without antemedian line.

North Queensland: Cape York in October and November: five specimens.

Gen. ECNOMOPHLEBIA nov.

εκνομοφλεβιος, unusually veined.

♂. Face smooth. Tongue well developed. Palpi moderately long, smooth, slender, obliquely ascending, projecting slightly beyond face. Antennae in male simple, minutely ciliated. Thorax and abdomen without crests. Under-surface of thorax and femora smooth. Posterior tibiae of male shorter and more slender than middle pair; tibiae without middle spurs, terminal spurs short. Forewings with 2 from two-thirds, 3 and 4 separate, 5 from above middle, 6 from upper angle, connate with 7, 8, 9, 10, which are stalked. 7

separating before 10, 11 from near end of cell, anastomosing strongly with 10. Hindwings with cell short (less than one-third), discocellulars strongly oblique, 2 from near angle, 3 and 4 stalked, 5 well developed, arising one-fourth of the distance between 6 and 4, 6 and 7 stalked, 12 anastomosing with cell from near base to near apex, thence strongly diverging.

An anomalous genus. In the hindwing 5 is typically Geometrid, but for the long anastomosis of 12 with the cell, which is, so far as I know, unique in this family.

ECNOMOPHLEBLA ARGYROSPILA n. sp.

ἀργυροσπίλος, silver-spotted.

♂. 28 mm. Head pale brown; fillet white; face ochreous except on margins. Palpi one and a quarter; pale ochreous. Antennae white. Thorax greenish-yellow, anteriorly pale brown. Abdomen greenish-yellow. Legs whitish-ochreous. Forewings triangular, costa moderately arched, apex round-pointed, termen rounded, oblique; pale greenish-yellow with numerous silvery spots outlined with pale brown; these appear to be irregularly dispersed and some are confluent, they are most dense in median area, where a double series form a band beyond middle, towards termen they are rather larger and more irregular in outline; a terminal series of brown dots between veins; cilia whitish. Hindwings with short projecting teeth on veins 3 and 6; colour and markings as forewings.

North Queensland: Cape York in November; one specimen.

TERPNA PAMMIGES n. sp.

παμμυγής, all-blended.

♂. 30 mm. Head green with some fuscous scales on vertex; lower edge of face whitish, edged above by a dark fuscous line. Palpi 1 and a quarter; fuscous, base of second and apex of terminal joint whitish. Antennae dark fuscous. Thorax dark fuscous; patagia partly green. Abdomen dark fuscous with some pinkish scales; beneath ochreous-whitish. Legs dark fuscous with ochreous-whitish rings. Middle femora pinkish sprinkled with dark fuscous; posterior pair ochreous-whitish with a few fuscous scales. Forewings broadly triangular, costa slightly arched, apex pointed, termen slightly rounded, scarcely oblique, crenulate; dark fuscous mixed with green, whitish, and pinkish; pinkish scales limited to veins in basal and central areas and as strigulae on basal part of costa; costal edge mostly fuscous with whitish dots beyond middle; base of wing mostly green towards costa and fuscous towards dorsum; markings fuscous; antemedian line obscure, rather broad, suffused, interrupted, outwardly curved from one-fifth costa to one-third dorsum; discal spot obscurely indicated by a fine transversely oval ring; postmedian from two-thirds costa to two-thirds dorsum, outwardly curved to below middle, thence strongly sinuate, otherwise as antemedian; a very faint whitish dentate subterminal line broadly edged anteriorly with fuscous; short intermural streaks

running to termen; cilia whitish mixed with fuscous. Hindwings with termen strongly rounded, crenulate; as forewings with less fuscous and more pinkish and whitish suffusion; no antemedian line nor discal spot. Underside ochreous-whitish with fuscous markings and strigulae; pinkish scales only on veins; discal spot in forewings rounded in hindwings reduced to a very fine linear mark; both wings with a broad interrupted subterminal band not reaching tornus.

Queensland: Injune in April; one specimen.

Fam. NOCTUIDAE.

Subfam. ACRONYCTINAE.

Gen. MACROPRORA nov.

μακροπρωρος, with long prow.

Face with strong smooth rounded-conical projection. Tongue present. Palpi long, porrect. Antennae in male very minutely ciliated. Thorax with strong posterior crest. Abdomen with a series of dorsal crests. Hindwings with 5 obsolescent from slightly below middle. Allied to *Euplexia*.

MACROPRORA CHIONOBOLA n. sp.

χιονοβολος, snow-beaten.

♂ ♀. 30-34 mm. Head snow-white; two blackish dots between antennae and three on face below middle. Palpi $2\frac{1}{2}$; blackish, base and apex white. Antennae fuscous. Thorax with large rounded posterior crest; blackish mixed with white. Abdomen with dorsal crests on first four segments, that on third large; fuscous sprinkled with whitish, crests dark fuscous. Legs blackish with white rings. Forewings elongate-triangular, costa slightly arched, apex pointed, termen slightly rounded, slightly oblique; fuscous with snow-white and blackish markings; an oblique sub-basal series of partly confluent white dots; a blackish streak on fold giving off short filaments above and beneath; a series of short oblique blackish streaks separated by white dots on costa; orbicular and reniform slenderly outlined with whitish and blackish, in centre grey; an interrupted white subterminal line almost confluent with an irregular series of white terminal dots; cilia white with fuscous bars. Hindwings with termen rounded, slightly wavy; ochreous-grey-whitish; a subterminal line and terminal band fuscous; cilia as forewings.

Queensland: Injune in November and February; four specimens.

NAMANGANA POLYMITA n. sp.

πολυμιτος, with many threads.

♀. 30-32 mm. Head and thorax whitish mixed with fuscous, appearing grey. Palpi $1\frac{1}{2}$; whitish mixed with fuscous. Antennae grey. Abdomen whitish-grey; tuft grey. Legs whitish mixed with fuscous; anterior and middle tibiae dark fuscous with whitish rings. Forewings elongate-triangular, costa

straight, apex rectangular, termen slightly rounded, slightly oblique; whitish with fuscous irroration, appearing grey; markings dark fuscous; many fine longitudinal streaks; one from base to postmedian line; six or seven running into termen, the second from costa arising in disc at $3/5$ and cutting through postmedian line, the third from this line, the others shorter; an oblique streak from $\frac{1}{4}$ costa prolonged towards antemedian line; antemedian outwardly oblique from midcosta, curved in disc and indented above dorsum, on which it ends at $3/5$; cilia fuscous with fine whitish bars. Hindwings with termen sinuate; whitish suffused with grey posteriorly; cilia white with sub-basal grey line.

Queensland: Injune in November, December, and March; four specimens.

Gen. STONYCHOTA nov.

στονυχότης, clawed.

Face with a sharp vertical corneous ridge truncate at apex and slightly produced at angles. Tongue present. Palpi rather long, porrect. Thorax with strong posterior crest. Abdomen with a small basal dorsal crest. Anterior tibiae with a strong anterior terminal claw. Neuration normal.

Well characterised by the frontal projection and tibial claw. Not near any Australian genus.

STONYCHOTA ANGUSTULA n. sp.

angustulus, rather narrow.

♀. 26-28 mm. Head and thorax fuscous sprinkled with white; tegulae mostly white. Palpi 2; grey. Antennae grey. Abdomen pale grey. Legs fuscous with some whitish scales; posterior pair ochreous-whitish. Forewings narrowly triangular, costa almost straight, apex pointed, termen rounded, slightly sinuate, oblique; fuscous unevenly sprinkled with white, darker towards costa; a broad median basal area and another smaller on tornus white; a dark dorsal area reaching beyond fold; sometimes a brown pretornal spot; veins partly outlined with fuscous; a fuscous terminal line; cilia fuscous sprinkled with white. Hindwings with termen rounded and sinuate; grey; cilia pale grey, apices whitish.

Queensland: Injune in January, February, and March; four specimens.

Subfam. ERASTRIANAE.

CORGATHA OCHROBAPTA n. sp.

ὠχροβάπτος, pale-suffused.

♂. 19-20 mm. Head white. Palpi $2\frac{1}{2}$; reddish-brown. Antennae grey; ciliations in male 2. Thorax whitish-grey. Abdomen reddish-brown; two basal segments whitish-grey. Legs ochreous. Forewings elongate-triangular, costa

straight almost to apex, apex pointed, termen sinuate, oblique; whitish-grey; costa narrowly reddish; a fuscous discal dot; a broad reddish dorsal blotch from $1/3$ to termen, traversed by pale postmedian and terminal lines; a small reddish terminal patch beneath apex and above middle; cilia whitish-ochreous with reddish bars. Hindwings with termen rounded; reddish with whitish suffusion at base and in middle; a pale postmedian line; cilia reddish, bases whitish-ochreous.

Queensland: Injune in November and April; two specimens.

Subfam. OPHIDERINAE.

CRYSIPRORA OXYMETOPA n. sp.

ὄξυμετωπος, with sharp-pointed forehead.

♂ ♀. 32-36 mm. Face with a long conical projection covered with scales, ending in a sharp corneous spike. Head and thorax fuscous mixed with white, appearing grey. Palpi nearly 2, ascending; fuscous mixed with white. Antennae grey; in male bipectinate to $7/8$, pectinations 2. Abdomen grey. Legs fuscous sprinkled and tarsi annulated with white. Forewings narrowly triangular, costa straight nearly to apex, apex rounded, termen rounded, oblique, erenulate; fuscous sprinkled with white, appearing grey; markings blackish; antemedian from $\frac{1}{4}$ costa very obliquely outwards, angled at $1/3$, thence dentate to $1/3$ dorsum; postmedian outwardly oblique from $3/5$ costa, bent twice to form a large quadrangular projection, thence dentate to $\frac{3}{4}$ dorsum, above dorsum edged with white posteriorly; an oblique line from midcosta joins this above middle; longitudinal streaks in disc more or less developed; cilia white with fuscous bars. Hindwings with termen rounded and slightly erenulate; grey; paler towards base; cilia white.

Queensland: Injune in January, February, and March; four specimens.

Fam. LASIOCAMPIDAE.

EREMONOMA PORPHYRICA n. sp.

πορφυρικος, purple.

♂. 34 mm. Head grey. Palpi 1; grey, towards base whitish. Antennae grey; pectinations in male 8. Thorax grey with a suffused central purple-reddish spot. Abdomen purple-reddish. Legs grey. Forewings elongate-triangular, costa straight to $\frac{3}{4}$, apex pointed, termen straight, oblique; pale grey; cilia pale grey. Hindwings with termen strongly rounded; purple-reddish; cilia purple-reddish.

♀. 38-42 mm. Uniformly grey. The forewings are darker and their apices more pointed than in *E. holopolia*.

Queensland: Injune in February, April, and May; four specimens received from Mr. W. B. Barnard.

EREMONOMA PLINTHICA n. sp.

πλωθικος, brick-red.

♂. 25-28 mm. Head, thorax, abdomen, and legs whitish-grey. Palpi 1; pale grey. Antennae grey; ciliations in male 5. Forewings elongate-triangular, costa straight, apex pointed, termen rounded, oblique; whitish-grey very thinly sprinkled with fuscous-purple; cilia whitish-grey. Hindwings with termen strongly rounded; brick-red; cilia brick-red.

♀. 30 mm. Uniform grey sparsely sprinkled with fuscous. Forewings with apices more rounded.

West Australia: Carnarvon in June (M. Carnaby); four specimens received from Mr. W. B. Barnard. Type in Queensland Museum.

PORELA EUTHYERGES n. sp.

εὐθυεργης, accurately wrought.

♂. 40 mm. ♀. 52 mm. Head and thorax fuscous finely sprinkled with whitish. Palpi 1; fuscous. Antennae fuscous; pectinations in male 10, in female 1, brownish-ochreous. Abdomen grey. Legs fuscous sprinkled with whitish. Forewings elongate-triangular, costa straight to three-fourths, thence arched, apex rounded, termen rounded, slightly oblique; fuscous sprinkled with whitish; markings blackish; a slightly waved transverse line from one-fifth costa to one-third dorsum; a circular discal spot before middle, white outlined with blackish; a line from two-thirds costa to two-thirds dorsum, where it approaches first line, obtusely angled above middle, thence incurved; a fine dentate subterminal line partly edged anteriorly with whitish; cilia white with fuscous bars in male, in female fuscous. Hindwings with termen strongly rounded; grey; a darker suffused median line; a narrow whitish terminal fascia suffused anteriorly, sharply edged and dentate posteriorly; a suffused subterminal fuscous line; cilia as forewings.

Nearest *P. notabilis* Wlk., which may be distinguished by the uniformly whitish hindwings.

Queensland: Injune in March (W. B. Barnard); two specimens. New South Wales: Murrurundi in October (Dr. B. L. Middleton). Type in Queensland Museum.

Fam. LIMACODIDAE.

Ecnomoctena sciobaphes n. sp.

σκιοβαφης, shaded.

♂ 24, ♀ 30 mm. Head and thorax fuscous with some whitish scales: face brownish. Palpi in male 1, in female $1\frac{1}{2}$, fuscous mixed with whitish. Antennae in male unipectinate to $\frac{3}{5}$, pale brownish; in female fuscous, simple. Abdomen grey. Legs fuscous sprinkled and tarsi annulated with whitish. Forewings elongate-triangular, costa straight to near apex, apex rounded, termen slightly rounded, slightly oblique; fuscous suffused with whitish, appearing grey; a narrow transverse median discal spot outlined with fuscous; a dark fuscous postmedian line from $\frac{2}{3}$ costa, transverse to middle, there angled inwards beneath discal spot and sinuate to mid-dorsum; a finely dentate fuscous subterminal line; a fuscous terminal line; cilia fuscous mixed with whitish. Hindwings with termen strongly rounded; brownish-grey; cilia as forewings.

Queensland: Injune in November and February; two specimens. The type is a female.

NEW ICHTHYOLOGICAL RECORDS.

BY TOM C. MARSHALL.

The Queensland Museum is fortunate in having a public who are aware of the need of securing specimens of unusual interest and who respond readily to calls for material from certain localities. Space does not permit me to mention our numerous donors of specimens, but foremost among our many honorary collectors are Mr. George Coates of Townsville, Alderman W. R. Howard of Wynnum and Fisheries Inspector W. Hiddens (late of Brisbane and now of Townsville). No less than one hundred and fifty-one specimens of fishes were collected and presented by Mr. George Coates for the year ending December, 1940. Many of these were new records or rare material and form the basis of these notes. Our thanks are due to these "friends of the Museum" for their unstinting help and interest in their State Museum and its collections.

Family CLUPEIDAE.

CLUPEA (HARENGULA) KONINGSBERGERI M. Web. & de Beau.

Clupea (Harengula) koningsbergerei Max Weber and L. F. de Beaufort. Akad. Verhand. Amsterdam 17, No. 3, 1912, p. 14.

Clupea (Harengula) koningsbergerei M. Weber and de Beaufort. Fishes Indo-Austr. Arch. 2, 1913, p. 72.

Harengula maccullochi Whitley. Rec. Aust. Mus. 18, 1931, p. 143, fig. 2. Type locality Port Headland, North-Western Australia.

Eight specimens, from West Molle Island, Cape Cleveland and Low Isles, the largest measuring 165 mm. in total length. New record for Queensland.

CLUPEA (HARENGULA) ATRICAUDA Gthr.

Clupea atricauda Gunther. Cat. Fish. Brit. Mus. 7, 1868, p. 426.

Three examples in the collection, the largest 115 mm. in total length. Labelled "Queensland Coast." Collected by K. Broadbent. New record for Australia.

Family ARIIDAE.

TACHYSURUS PROXIMUS (Ogilby).

Arius proximus Ogilby. Proc. Linn. Soc. N.S.W. 23, 1898, p. 280.

Tachysurus (Pararius) proximus Whitley. Aust. Zool. 9, 1940, p. 409, fig. 16.

Two specimens presented by G. Coates. One from Cape Pallarenda, N. Qld., is 14 inches in total length. The other is from the Bohle River, near Townsville, and is 15 inches in total length. The latter was carrying 14 juveniles in its mouth when captured, disgorging them when laid on the beach. They each measured 70 mm. in total length. (No. 7142). New record for Queensland.

Family OPHICHTHYIDAE.

PISODONOPHIS CANCRIVORUS (Rich.).

Ophisurus cancrivorus Richardson. Zool. Voy. Erebus and Terror, Fish. 1848, p. 97, pl. 50, figs. 6-9.

Two specimens, 12 inches in total length, from Bowen, Nth. Qld. Presented by the late E. H. Rainford. (No. 4407). New record for Queensland.

MALVOLIOPHIS PINGUIS (Gthr.).

Ophichthys pinguis Günther. In Breckley, Cruise Curacoa, 1873, p. 430, pl. 35.

Ten specimens from various localities in South Queensland, the most northerly being Yeppoon. The largest, which measures $16\frac{1}{4}$ inches in total length, was presented by Mr. E. Baird, who captured it at Caloundra. (No. 4864). New record for Queensland.

Family SYNODONTIDAE.

SAURIDA GRACILIS (Quoy & Gaimard).

Saurus gracilis Quoy and Gaimard. Voy. Uranie, Physic. Zool. 1824, p. 224.

In the old collection of the museum is a specimen of 225 mm. in total length, from Moreton Bay. (No. 427). New record for Queensland.

Family SYNGNATHIDAE.

SYNGNATHUS TIGRIS Castelnau.

Syngnathus tigris Castelnau. Proc. Linn. Soc. N.S.W., 3, 1879, p. 397.

Several in the collection, all from Moreton Bay, the largest measuring $9\frac{1}{2}$ inches in total length. New record for Queensland.

Family BELONIDAE.

TYLOSURUS LEIURUS (Blkr.).

Belon leirus Bleeker. Nat. Tijdschr. Ned. Indie, 1, 1850, p. 94.

Four specimens captured off Townsville and presented by G. Coates. The largest, from Cape Cleveland, measures 32 inches in total length. (No. 5981). New record for Australia.

Family MELANOTAENIIDAE.

AMNERIS RUBROSTRIATA (Ramsay & Ogilby).

Nematoentris rubrostriatus Ramsay and Ogilby. Proc. Linn. Soc. N.S.W. (2) 1, 1886, p. 14. Strickland River, Papua.

Twenty examples of this handsome species were forwarded to the Museum from Townsville by Mr. G. Coates, who obtained them in the Leichhardt Creek, near Townsville. The largest measures $5\frac{1}{2}$ inches in total length. Five were received alive and placed in the Museum's aquarium on 11th November, 1940, where, with the exception of one, they are still thriving. New record for Australia.

Family POLYNEMIDAE.

POLYNEMUS HEPTADACTYLUS Cuv. & Val.

Polynemus heptadactylus Cuvier and Valenciennes. Hist. Nat. Poissons, 3, 1829, p. 390.

Mr. W. R. Howard presented two specimens which were caught at St Helena, Moreton Bay, the larger one measuring $11\frac{1}{2}$ inches in total length (Nos. 4719-20). A third example was received from G. Coates. Locality Cape Cleveland, North Queensland. (No. 5639). New record for Australia.

Family SPHYRAENIDAE.

SPHYRAENA JELLO Cuv. & Val.

Sphyraena jello Cuvier and Valenciennes. Hist. Nat. Poissons, 3, 1829, p. 349.

A twenty-four inch specimen from Stradbroke Island, Moreton Bay. Presented by Mr. W. R. Howard (No. 5126). Two others from Cape Cleveland, near Townsville, were collected by G. Coates. They measure 19 inches and $14\frac{1}{2}$ inches in total length. (Nos. 5977, 6129). New record for Australia.

Family HOLOCENTRIDAE.

HOLOCENTRUM CORNUTUM Blkr.

Holocentrum cornutum Bleeker. Nat. Tijdschr. Ned. Indie, 5, 1853, p. 240.

I obtained three examples of this handsome species on the coral reefs off Curacoa Island, Palm Group, North Queensland. The largest was $6\frac{1}{4}$ inches in total length. New record for Australia. (Nos. 6441, 5861-2).

HOLOCENTRUM DIADEMA Lacc.

Holocentrus diadema Lacépède. Hist. Nat. Poissons, 5, 1803, p. 372, 374 (*vide* Weber and de Beaufort).

Two specimens are in the collection. They are labelled "Old Collection." Locality:—"Coast of Queensland." They measure $4\frac{1}{4}$ and $5\frac{3}{4}$ inches. New record for Australia.

MYRIPRISTIS MURDJAN (Forsk.)

Sciaena murdjan Forskal. Descript. Animal. 1775, p. 48.

A $6\frac{1}{4}$ inch specimen was collected by me off Curacoa Island, North Queensland (No. 5868). A second example was obtained on Keeper Reef, North Queensland, by G. Coates (No. 6987), length $2\frac{1}{2}$ inches. New record for Australia.

Family SERRANIDAE.

Subfamily EPINEPHELINAE.

EPINEPHELUS FARIO (*Thunb.*).

Perca fario Thunberg. Kon. Vet. Acad. Nya. Handl. 14, 1793, p. 296, pl. 9.

One example, 14 inches in total length, from Lodestone Reef, N.Q., was collected by G. Coates. (No. 5539). New record for Australia.

CEPHALOPHOLIS ROGA (Forsk.).

Red-flushed Rock Cod.

Perca roga Forskal. Descript. Animal. 1775, p. 38.

A fine, large specimen of this fish was received from G. Coates, who captured it on Wheeler Reef, North Queensland. Total length 19 inches. The colours, when received in ice at Brisbane, were:—Blackish-brown, very little paler below; a scarlet-red flush showing through between the scales from back to belly; beneath the maxillary, the mouth-parts, in the throat and beneath the gill-covers bright scarlet; the blackish spinous dorsal tipped with dark scarlet; other fins and caudal blackish. (No. 7063). New record for Australia.

Family PRIACANTHIDAE.

PRIACANTHUS TAYENUS Rich.

Priacanthus tayenus Richardson. Rep. Ichth. China, Rep. 15th meeting Brit. Assoc. (1845) 1846, p. 237.

Two specimens measuring 10 and 11 inches in total length, have D. X/12: distinct rich dark brown spots in ventrals. Caudals crescentic, with the lobes much produced. They are from Magnetic Island, North Queensland, presented by G. Coates. (Nos. 6617, 6769). New record for Australia.

Family APOGONIDAE.

APOGON RUPPELLII Gthr.

Apogon ruppellii Gunther. Cat. Fish. Brit. Mus. 1, 1859, p. 236.

Three specimens are in the old collection of the Museum, labelled "Cape York." Three others were collected by me at Prince of Wales Island, Cape York. They measure 3½ inches each in total length. (Nos. 6540-2). New record for Queensland.

Family CARANGIDAE.

Subfamily CARANGINAE.

CARANX (CARANX) MELAMPYGUS Cuv. & Val.

Caranx melampygus Cuvier and Valenciennes. Hist. Nat. Poiss. 9, 1833, p. 116.

Caranx melampygus McCulloch. Mem. Qld. Mus. 8, 1924, p. 70, pl. 11, fig. 2. Port Moresby, Papua.

Two specimens from Magnetic Island, North Queensland, the larger one 12¾ inches in total length, collected by G. Coates (Nos. 6654, 7007). A third one is from Noosa, South Queensland, presented by L. Kesteven (No. 6955). These three examples agree well with McCulloch's description and plate but I am only able to find seven dorsal spines, preceded by a strong procumbent one in all three specimens. New record for Australia.

CARANX (SELAR) MATE Cuv. & Val.

Caranx mate Cuvier and Valenciennes. Hist. Nat. Poissons, 9, 1833, p. 54.

Caranx mate Weber and de Beaufort. Fishes Indo-Aust. Arch. 6, 1931, p. 207.

Three specimens, one from the Barnard Group, collected by the late Dr. W. E. J. Paradise, (No. 4084), the other two from Magnetic Island, North Queensland. Lengths 11 inches. Collected by G. Coates. (Nos. 7060-1). Their

colour on arrival in ice at Brisbane was:—Beautiful light greenish-blue iridescence above; dark-bluish on head; sides and below silvery-white; eight or nine very obscure broad grey transverse bars on body; dorsals tinged yellowish; pectorals almost hyaline; ventrals and anal white; caudal canary-yellow; a dense black blotch on the scapula. McCulloch¹ recorded this species from Broome, Northwestern Australia, under the name of *C. affinis*. New record for Queensland.

Subfamily CHORINEMINAE.

CHORINEMUS TOLOOPARAH (Rupp.).

Lichia tolooparah Ruppell. Atl. Fische Rot. Meer 1828, p. 91.

Seven examples are in the collection. They are from various localities on the Queensland coast, from Moreton Bay to the Gulf of Carpentaria. The largest is $8\frac{3}{4}$ inches in total length and is from Cape Cleveland, Nth. Qld. Collected by G. Coates. New record for Australia.

Subfamily SERIOLINAE.

SERIOLA NIGROFASCIATA (Rupp.).

Nomeus nigrofasciatus Ruppell. Atl. Reise N. Afrika 1826-1831, p. 82 (*vide* Fowler).

Two examples, one being from Moreton Bay; total length 12 inches, collected by J. D. Ogilby; the other from Cape Cleveland, North Queensland; total length $15\frac{1}{2}$ inches. Collected by G. Coates. (Nos. 3072, 6035). New record for Australia.

SERIOLA DUMERILI (Risso).

Caranx dumerili Risso. Ichthyol. Nice. 1810, p. 175.

A large specimen, 33 inches in total length, was caught off Mooloolaba, South Queensland, and presented by Mr. F. Z. Eager. (No. 6709). A new record for Australia.

Family LUTJANIDAE.

Subfamily LUTJANINAE.

PARACAESIO PEDLEYI McCull. & Waite.

Paracaesio pedleyi McCulloch and Waite. Trans. Roy. Soc. Sth. Aust. 40, 1916, p. 440, pl. 42.

Several specimens are in the collection from localities in South Queensland, from Moreton Bay to Mooloolaba. The largest measures 15 inches. New record for Queensland.

CAESIO DIGRAMMA Blkr.

Caesio digramma Bleeker. Ned. Tijdschr. Dierk. 2, 1865, p. 180.

Mr. G. Coates collected a specimen 9 inches in total length, in the Whitsunday Passage. (No. 6254). New record for Australia.

LUTJANUS JANTHINUROPTERUS (Blkr.).

Mesoprion janthinuropterus Bleeker. Nat. Tijdschr. Ned. Indie. 3, 1852, p. 751.

Three specimens from the reefs adjacent to Townsville were collected by G. Coates. The largest, which measured 13 inches in total length, is from Cordelia Rocks. (Nos. 6564, 6655, 5287). New record for Queensland.

¹McCulloch. Biol. Res. "Endeavour" 3, pt. 3, 1915, p. 130.

Subfamily NEMIPTERINÆ.

SCOLOPSIS BILINEATUS (Bloch).

Anthias bilineatus Bloch. Ausland. Fische. 7, 1793, p. 3.

Several examples of this handsome species were collected by me at Curacoa Island, Palm Group, North Queensland, the largest measuring $7\frac{3}{4}$ inches (Nos. 5892-4). Others are in the collection, one from Murray Island, Torres Strait, and others from the reefs off Townsville, collected by G. Coates. Life colours of my specimens were:—Olive-green above, mostly over head to about 3rd dorsal spine; snout golden-brown; beneath soft dorsal light blue; sides of body very pale green; belly white, tinged pale green; a broad white stripe, bordered on each edge with a narrow red line, runs from the mouth backwards and upwards to the second dorsal ray; spinous dorsal to 9th spine light cadmium (except at the bases of the last 5 spines) followed by a black-red blotch on the terminal half of the last spine and first 3 rays; last 6 rays and membranes clear white, which colour runs forward beneath the black-red blotch and the yellow spinous dorsal to the base of the 4th dorsal spine; pectorals hyaline, tinged yellow; ventrals white, the anterior edge pale orange; anal with the 3 spines and the first 2 rays black, the next membrane white, edged red; rest of fin hyaline; a golden-brown saddle, tinged red, over the caudal peduncle; caudal pale reddish-brown. Eye with pupil black and with an orange patch anteriorly and posteriorly, rest green and silver. New record for Australia.

SCOLOPSIS CANCELLATUS Cuv. & Val.

Scolopsides cancellatus Cuvier and Valenciennes. Hist. Nat. Poissons, 5, 1830, p. 351.

I collected three specimens of this species at Palm Islands, North Queensland, and Yorke Island, Torres Strait, the largest being $6\frac{1}{4}$ inches in total length. New record for Australia.

Subfamily POMADASYNÆ.

PLECTORHYNCHUS CELEBICUS Blkr.

Plectorhynchus celebicus Bleeker. Ned. Tijdschr. Dierk. 4, (1872) 1873, p. 285.

Mr. G. Coates collected two at Magnetic Island, North Queensland. They measure 13 and $13\frac{1}{2}$ inches in total length. There is also an old mounted specimen, $7\frac{3}{4}$ inches in total length from "Queensland Coast" in the collection. (Nos. 6288, 6768). New record for Australia.

PLECTORHYNCHUS PUNCTATISSIMUS (Playfair).

Diagramma punctatissimum Playfair. Proc. Zool. Soc. London, 1867, p. 851, pl. 40.

A specimen collected at Rib Reef by G. Coates agrees very well with Playfair's description and plate. Total length $22\frac{1}{2}$ inches. (No. 6822). New record for Australia.

PLECTORHYNCHUS GOLDMANNI (Blkr.).

Diagramma goldmanni Bleeker. Nat. Tijdschr. Ned. Indie. 4, 1853, p. 602.

One specimen, $24\frac{1}{2}$ inches in total length. Collected by G. Coates at Cape Cleveland, North Queensland. (No. 6749). New record for Australia.

PLECTORHYNCHUS SCHOTAF Forsk.

Sciaena abu-mgaterin schotaf Forskal. Deser. Animal. 1775, p. 51.

Diagramma griseum Day. Fishes of India, 1878-88, p. 81, pl. 21, fig. 2.

Plectorhynchus schotaf Fowler. Bull. 100, U.S. Nat. Mus. Vol. 11, 1931, p. 255.

A specimen $8\frac{3}{4}$ inches in total length agrees well with Day's figure and Fowler's description. It is from Prince of Wales Island, Torres Strait; collected T. C. Marshall (No. 6496). It has 89 scales above the lateral line between its origin and hypural joint and 19 above the lateral line and the base of the fourth dorsal spine. Colour in formalin uniform slaty-brown, with ventral, anal and caudal fins darker; lips and throat pinkish-white. When fresh the colour was somewhat similar, there being no trace of any spots or bands.

Fowler has included *P. reticulatus* McCulloch¹ in the synonymy of this species. It is not impossible that with further specimens they may prove to be the same species but on account of the much smaller scales and uniform coloration and other minor differences I prefer to keep them, provisionally, apart.

POMADASYS ARGYREUS (Cuv. & Val.).

Pristipoma argyreum Cuvier and Valenciennes. Hist. Nat. Poissons, 9, 1833, p. 485.

One specimen, 3 inches in total length, from off Bowen, North Queensland. (No. 3180). New record for Australia.

Subfamily LETHRININAE.

LETHRINUS VARIEGATUS Cuv. & Val.

Lethrinus variegatus Cuvier and Valenciennes. Hist. Nat. Poissons, 6, 1830, p. 287.

Two specimens were forwarded by G. Coates. They are from Lodestone Reef and John Brewer Reef, Nth. Qld., and measure 11 inches in total length. (Nos. 5416, 6764). New record for Australia.

LETHRINUS MAHSENA (Forsk.).

Yellow-tailed Emperor.

Sciaena mahsena Forskal. Deser. Animal, 1775, p. 52.

Six examples of this common northern species are in the collection. The largest, which measures 17 inches in total length, was collected on Hopkinson Reef, off Cape Cleveland by G. Coates. (No. 6026). Mr. G. Roberts of Palm Island notes:—"This fish attains to at least 20 inches and is commonly found along the edges of all the reefs in the Palm Island Group." Commonly called "Snapper."

LETHRINUS ORNATUS Cuv. & Val.

Lethrinus ornatus Cuvier and Valenciennes. Hist. Nat. Poissons, 6, 1830, p. 310.

Lethrinus ornatus De Vis. Proc. Linn. Soc. N.S.W. 9, 1884, p. 458.

Lethrinus ornatus Weber and de Beaufort. Fish Indo-Austr. Arch. 7, 1936, p. 447.

Lethrinus devisianus Whitley. Rec. Austr. Mus. 17, 1929, p. 122 (on De Vis).

A specimen from Keeper Reef, Nth. Qld., presented by G. Coates, measures 13 inches in total length (No. 5423). The type of De Vis' *L. ornatus* is apparently lost, but his description suggests that Weber & de Beaufort are correct in placing that species in the synonymy of the above.

¹ McCulloch, Biol. Res. Endeavour, 4, pt. 4, 1916, p. 185, pl. 53 (*nee* Gunther).

Family PEMIPHERIDAE.

PEMPHERIS KLUNZINGERI McCulloch.

Pempheris klunzingeri McCulloch. Zool. Res. Endeavour, 1, pt. 1, Dec. 1911, p. 47 (on Klunzinger).

A perfect specimen of this apparently rare fish was taken from the stomach of an *Epinephelus* which was caught off Salamander Rocks, Nth. Qld. It measures $5\frac{1}{2}$ inches in total length. Presented by G. Coates. (No. 6307). New record for Queensland.

Family SCIAENIDAE.

PSEUDOSCIAENA DIACANTHUS (Lacé.).

Lutjanus diacanthus Lacépède. Hist. Nat. Poiss. 4, 1802; pp. 195, 240.

A fine specimen 16 inches in total length was caught off the Townsville Beach and presented by G. Coates (No. 7085). Apparently the species is common in North Queensland waters for Mr. Coates states:—"No. 7085 is, as far as I can see, one of the common jew-fish caught locally. I have caught them up to fifty pounds in weight and have seen one nearly one hundred pounds. Have seen as many as forty (7 to 30 lbs.) caught in one night by three men on hand-lines." New record for Australia.

SCIAENA DUSSUMIERI (Cuv. & Val.).

Umbrina dussumieri Cuvier and Valenciennes. Hist. Nat. Poiss. 9, 1833, p. 481.

Eight specimens of this small species are in the collection, five having been collected in the vicinity of Townsville by G. Coates; one from Yeppoon, collected by me, and two from "Queensland Coast," collected by Capt. Hoult. The largest example of the series is $9\frac{1}{2}$ inches in total length. New record for Australia.

Family MULLIDAE.

UPENEUS SIGNATUS Gthr.

Upeneus signatus Gunther. Ann. Mag. Nat. Hist. (3) 20, 1867, p. 59.

Upeneus signatus Tosh. Parliam. Rept. Marine Dept. Qld. 1902-3 (1903), p. 3, pl. 3, fig. 2. (Southport, Sth. Qld.)

Pseudupeneus signatus McCulloch. Check-list of Fish Rec. from Aust., Mem. Aust. Mus. 5, 1929-30, p. 223.

Several specimens from Moreton Bay and Caloundra, South Queensland. The largest is 12 inches in total length, and is from Moreton Bay. Collected by Mr. C. O'Connell. (No. 4146).

Apparently Tosh first noted the species from Queensland, but his record was overlooked in the check-list by McCulloch.

PARUPENEUS SPILURUS (Blkr.).

Upeneus spilurus Bleeker. Nat. Tijdschr. Ned. Indie. 6, 1854, p. 395.

One specimen, 10 inches in total length, taken at Magnetic Island, Nth. Qld., by G. Coates. (No. 6947). New record for Queensland.

Family KYPHOSIDAE.

KYPHOSUS VAIGIENSIS (Quoy & Gaimard).

Pimelepterus vaigiensis Quoy and Gaimard. Voy. Uranie, Zool. 1824, p. 396, pl. 62, fig. 4.

Two examples were obtained by G. Coates, one at Upstart Bay, Nth. Qld. and the other at Magnetic Island, Nth. Qld. Total lengths 11 inches and 9 inches respectively. (Nos. 6696, 6813). New record for Australia.

Family CHAETODONTIDAE.

HOLACANTHUS (CHAETODONTOPLUS) PERSONIFER McCull.

Holacanthus personifer McCulloch. Rec. West. Aust. Mus. 1, pt. 3, 1914, p. 221, pl. 31.

Chaetodontoplus conspicillatus Ogilby. Mem. Qld. Mus. 3, 1915, p. 114 (*nec* Waite).

Five specimens in the collection, from South Queensland and Moreton Bay, the largest being 10½ inches in total length. (No. 4538).

Although my specimens vary somewhat in colour from *C. personifer* they agree much better with that species than with *C. conspicillatus*.¹ One specimen shows variation from the others in that it lacks the yellow spots on the face, otherwise they are alike. In all five the caudal was clear canary yellow, sharply defined on the caudal peduncle from the jet-black body. In life the head is violet-purple with bright yellow spots, and the edges of the soft dorsal and anal are narrowly edged with violet. In all five the caudal is truncate and the pectorals are shorter than the ventrals. New record for Queensland.

Family THUNNIDAE.

GYMNOSARDA NUDA Gthr.

“Scaleless Tunny.”

Pelamys nuda Gunther. Cat. Fish. Brit. Mus. 2, 1860, p. 368.

Gymnosarda nuda Kishinouye. Jour. Coll. Agric. Tokyo, 8, No. 3, 1923, p. 426, pl. 22, fig. 37.

A specimen forwarded from Townsville is evidently this supposedly rare species and agrees very well with Kishinouye's external description and his plate, except that in the Townsville specimen the pectoral is 5.6 and the head 3.86 in the total length, which is 32 inches from tip of snout to end of median caudal ray. The colour has evidently been dark bluish above, greyish-white on the belly, with the fins blackish or greyish and the tips of the dorsal and anal whitish; the seven dorsal finlets were evidently blue in life and the seven anal ones, now creamy-fawn, were probably yellow. (No. 6583). Caught by Mr. H. Miller.

I am unable to find any reference to the species since Kishinouye noted it in 1923, stating that it is “known from the tropical regions of Indo-Pacific waters.” Fowler does not mention the species in his “Fishes of Oceania” nor does Day in his “Fishes of India.”

¹ Waite. Aust. Mus. Mem. 4, “Thetis Exp.” 1, Fishes, 1899, p. 87, pl. 15.

The species is common in North Queensland as evinced by the remarks of Mr. Miller, a fisherman familiar with our other allied species. In discussing the Yellow-fin and this species with Mr. G. Coates, he stated that the Scaleless Tunny (*G. nuda*) "is much more plentiful and the largest fish was 50 lbs., but averaged much smaller." He has "seen quite good shoals" and "has caught a large number all told. Several times caught a dozen or so. . . . Are great fighters and so far have all been caught on outer reefs . . . selling quality same as Yellow-fin" (*Neothunnus macropterus*). Mr. Hole, another fisherman who fishes the Mackerel, (*S. commersoni*) from Gladstone to Townsville, states "Scaleless Tunny are fairly plentiful and the largest fish caught was 90 pounds. Mostly caught on outer reefs." New record for Australia.

ACANTHOCYBIUM SOLANDRI (Cuv. & Val.).

Wahoo.

Cybiium solandri Cuvier and Valenciennes. Hist. Nat. Poiss. 8, 1831, p. 192.

The presence of this species on our coast has only been made known since the advent of the big game fishing clubs. They have proved from many captures that it is a fairly common fish in South Queensland waters, but apparently becoming rare in the north. A head is in the collection, taken from a thirty-five pound example caught off John Brewer Reef near Townsville by G. Coates. (No. 6075).

Family SIGANIDAE.

SIGANUS SPINUS (Linn.).

Sparus spinus Linnaeus. Syst. Nat. ed. 10, Vol. 1, 1758, p. 281 (*vide* Fowler).

Three specimens from the reefs off Townsville, collected by G. Coates. Total lengths, 5, 6½ and 6½ inches. (Nos. 6308-9, 6023). New record for Australia.

SIGANUS PUNCTATUS (Schneider).

Amphacanthus punctatus Schneider. Syst. Ichth. Bloch. 1801, p. 210.

Siganus capricornensis Whitley. Austr. Zool. 4, pt. 4, 1926, p. 231, pl. 33.

Several specimens in the collection. They range from the Capricorns to Cape York, the largest being two collected on Keeper Reef, off Townsville, by G. Coates. Total lengths 17 and 18 inches. (Nos. 6783-4). The species is most variable in colour, ranging from a ground colour of dark brown with lighter brown spots to clear blue, blue-green or green and spotted with light or dark yellow all over head, body and dorsal and anal spines and rays: pectorals and anal without spots.

Family TEUTHIDAE.

TEUTHIS TRIOSTEGUS (Linn.).

Chaetodon triostegus Linnaeus. Syst. Nat. ed. 10, 1758, p. 274, ed. 12, 1766, p. 463.

Acanthurus hirundo Bennett. Fishes of Ceylon, 1828, pl. 11.

Teuthisroughtoni Whitley. Rec. Austr. Mus. 16, 1928, p. 233, pl. 16, fig. 1.

Six specimens of this distinctively marked species are in the collection. One (6¾ inches in total length) from Moreton Bay, the others from the reefs off Townsville. Presented by G. Coates. (Nos. 6017-8; 6299-6302). The largest of these measures 7 inches. I can see no reason for considering *T.roughtoni*

to be distinct from *T. triostegus*. Whitley bases his species on the difference in colour, for he states "Near *Teuthis triostegus* (Linn.), but that species has no subhorizontal dark stripe separating the darker ground colour from the cream ventral area." Of *Acanthurus hirundo* Bennett he says "Bennett's figure of *Acanthurus hirundo* shows faint indications of the dividing stripes, but differs in the disposition of the body stripes." This is surely "splitting hairs," as a glance at Bennett's plate will show. The dark sub-horizontal stripe of which he speaks is in varying stages of clearness in my specimens and in one it is practically absent.

Bennett's figure differs from my specimens in that the second stripe, which extends from the pectoral origin to the first dorsal spine, is curved forward. This is obviously due to the artist's faulty drawing, which shows the first dorsal spine too far in advance of the pectoral origin.

PRIONURUS MICROLEPIDOTUS Lacé.

Prionurus microlepidotus Lacépède. Ann. Mus. d'hist. Nat. 4, 1804, p. 205 (vernac.) and 211 (*vide* McCulloch).

Two specimens in the collection, one 6½ inches, the other 9 inches in total length. Both are from Moreton Bay, the latter presented by Alderman W. R. Howard. (No. 4882). New record for Queensland.

NASO LITURATUS (Forster).

Harpurus lituratus Forster. Descrip. Anim. ed. Licht. (1844) p. 218 (*vide* Herre).

Naso lituratus Herre. Phil. Jour. Sci. 34, 1927, No. 4, p. 464, pl. 16, fig. 1.

One specimen, 10 inches in total length, from Raine Island, Torres Strait, presented by Dr. J. R. Tosh in 1914, has been identified as this species. New record for Australia. (No. 1719).

Family SYNAPTURIDAE.

SYNAPTURA SETIFER Paradise.

Synaptura setifer Paradise. Mem. Qld. Mus. 9, 1, Apl. 28, 1927, p. 101, fig. 3. Port Darwin, N. Terr.

Four specimens from Cape Cleveland, near Townsville, North Queensland. Collected by G. Coates. The total lengths are from 4½ to 6½ inches. (Nos. 6120-3; 6192; 6887). New record for Queensland.

Family POMACENTRIDAE.

POMACENTRUS VIOLESCENS (Bkr.).

Pristotis violescens Bleeker. Jour. Ind. Arch., 2, 1848, p. 637.

Thirty-five specimens from West Molle Island, Whitsunday Passage, North Queensland, the largest 2 inches in total length, and another ten specimens from Esk Island, Palm Group, North Queensland, the largest being 2 inches. The life colours were:—General colour brownish-black, grey on belly; posterior half of soft dorsal, anal and entire caudal fin cadmium-yellow; caudal produced on both lobes to a black attenuated ray; spines and rays of the fins black, the membranes lighter; pupil of eye surrounded by a wide red ring. They showed little or no variation. New record for Australia.

Family LABRIDAE.

HALICHOERES MELANURUS (Blkr.).

Julis (Halichoeres) melanurus Bleeker. Nat. Tijdschr. Ned. Indie, 2, 1851, p. 251 (fide Fowler).

I collected one example of this species at Yorke Island, Torres Strait. It measures $2\frac{1}{2}$ inches in total length. (No. 6382). New record for Australia.

HALICHOERES HOEVENII Blkr.

Julis (Halichoeres) hoevenii Bleeker. Nat. Tijdschr. Ned. Indie, 2, 1851, p. 250 (fide Fowler).

Six specimens from Yorke Island, Torres Strait, collected T. C. Marshall, each $2\frac{1}{2}$ inches in total length. (No. 6377). New record for Australia.

LABRICHTHYS CYANOTAENIA Blkr.

Tube-lip.

Labrichthys cyanotaenia Bleeker. Nat. Tijdschr. Ned. Indie, 6, 1854, p. 331.

Labrichthys cyanotaenia Herre. Fishes of Crane Pacific Exp. Field Mus. Nat. Hist. U.S.A. 21, pub. 353, 1936, p. 304.

One example from Palm Island, North Queensland, collected T. C. Marshall. Total length, $4\frac{3}{4}$ inches. Two others from the reefs off Townsville, collected by G. Coates. Total length, 4 and $4\frac{1}{2}$ inches. New record for Australia.

Herre mentions in his description the curious lips of this labrid, remarking on the fact that that feature has never been adequately noticed by any who have mentioned the species. It is clearly seen in all my specimens.



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