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FOREWORD

Since the first major Symposium on Echinoderm Biology was held in London in 1966, sponsored by the Royal Zoological Society, at least six subsequent meetings have been organised by echinodermologists. These have been held in Washington D.C., U.S.A. (2), Rovinj, Yugoslavia (1), Sydney, Australia (1), London (1); the last two meetings (Sydney and London), within the same year (1978), and Brussels, Belgium. Also, at least four meetings are known to have been held in U.S.S.R. Such has been the surge of interest in the study of echinoderms over the past decade, that there is now a demand for the organisation of regular, and more frequent, meetings. The international representation at these meetings indicates the enormous involvement and co-operation which now exists between colleagues working in this exciting field, the world over.

It is more than evident that the satisfaction and pleasure expressed by Professor Norman Millott, in his foreword to the first Symposium volume (1967), at the resurgence of interest in Echinoderm Biology has been clearly justified and can continue so to be.

This volume presents twelve of the forty-one contributions offered at the Echinoderm Conference, Sydney, 1978. The papers are representative of the wide coverage of topics dealt with during the Conference, including echinoderm palaeontology, physiology, reproduction, ecology, behaviour and taxonomy.

To the speakers and chairmen, and to all those who attended the Sydney Conference, I convey my thanks. I must also thank my Technical Officer, Ms Jan Marshall, and Dr Susan Oldfield (Queen's Fellow at The Australian Museum, February, 1977-1979) for their unstinting assistance in the organisation of the Conference. Thanks are also due to the Department of State Fisheries (N.S.W.), Taronga Park Zoo, McWilliams Wines Pty, Leo Buring Wines Pty, Qantas Airways Ltd, and Trans-Australia Airlines (T.A.A.). To The Australian Museum Society (TAMS) I extend a special thanks for assistance.

This Conference could not have been held without the tremendous support and encouragement afforded to the organiser by Dr D. J. G. Griffin, Director, The Australian Museum, and the very generous financial support of the Trustees of the Museum, to both of whom I offer my very sincere thanks.

DECEMBER 1979

FRANCIS W. E. ROWE

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7. INTER-RELATIONSHIPS OF RECENT STALKED, NON-ISOCRINID CRINOIDEA

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SUMMARY

Outlines are given of the body form in the extant families of the stalked crinoid orders Millericrinida and Bourgueticrinida with particular notes on the few taxa exhibiting secondary arm branching.

The recent nominal species of the Bourgueticrinida are listed in a table, together with their distributions and an indication of the size range of the often limited known material. The wisdom of division of these taxa into more than the one family Bathycrinidae is questioned, in view of recent observations on ontogeny and variation, particularly with regard to the stalk attachment.

A new record of a particularly relevant species, *Porphyrocrinus thalassae* Roux, is included, with a photograph showing the secondary arm branching.

INTRODUCTION

Apart from the aberrant Holopodidae (order Cyrtocrinida), the remaining recent non-Isocrinid taxa of stalked Crinoidea are referable to two orders — the family Hyocrinidae to the Millericrinida and the remainder to the Bourgueticrinida. Most of these species are remarkable among recent crinoids for the conspicuous part the basal plates play in making up the calyx of the adult.

SYSTEMATIC ACCOUNT

The Hyocrinidae have thin-walled cup-shaped calyces, surmounted by the arms, which are more or less widely-spaced, approximately cylindrical in cross-section and unbranched in most genera, including *Hyocrinus*. However, *Calamocrinus diomedae* from near the Galapagos Islands, representative of a monotypic genus, has irregularly-branching arms, evidently formed by elaboration of up to five of the original pinnules on each side of a primary arm into secondary arms, themselves bearing pinnules. This kind of augmentation of arm number contrasts with the multiplication by what is called 'adolescent autotomy' at proximal syzygies followed by regeneration, with the first new ossicle becoming an axillary, found throughout the Comatulida. The single exception in this order is *Comatula rotalaria* Lamarck, from northern Australia, in which the second brachial of each of the ten primary arms of the post-pentacrinoid gradually transforms itself into a symmetrical axillary by modification of its appendage into an arm instead of a pinnule. Similar arm multiplication also occurs in some Isocrinida.

The species of the Bourgueticrinida differ from the Hyocrinidae in having the calyx more compact and thick-walled, bearing closely approximating arms lacking pinnules on usually the first six to ten brachials. The nominal species currently recognised are listed in Table 1. However, some of these names are very likely to prove to be synonymous since many are abyssal and many are only known from incomplete specimens often of a limited size range, so that inadequate allowance has often been made for very wide geographical distributions and for growth changes when naming supposedly new taxa.

The first five genera in Table 1 have been referred to the family Bathycrinidae, three of them: *Rhizocrinus*, *Conocrinus* and *Democrinus*, having five simple arms while *Bathycrinus* and

*Monachocrinus** have ten arms, the second post-radial ossicle being a primary axillary. All have the arm bases aligned vertically when in the non-feeding position with a marked lateral flange on each side, beyond which basal part the muscular and non-muscular joints between the brachials normally alternate regularly. The calyx ranges in form from conical to narrow vase-shaped and the stalk is xenomorphic with some of the topmost columnals discoidal, their joint faces more or less smooth and not yet modified into the oval synarthries found between the succeeding more elongated columnals, the alignment between the synarthrial joints being twisted from one to the next through nearly 90°. The distal part of the stalk, when known, bears irregular rhizoid-like jointed appendages for attachment, though in a few cases, notably *Democrinus brevis* A. H. Clark (see A. M. Clark, 1977) the rhizoid system is more or less completely replaced by an irregular flattened expansion at the end of the stalk.

In 1907, A. H. Clark proposed a new family Phrynocrinidae for *Phrynocrinus nudus* from SE of Japan, a species with all the columnals fairly short and twisted so that successive joints appear alternately wide and narrow when seen in one plane, distal attachment is solely by an expanded terminal plate, the calyx is markedly flared above bearing almost cylindrical arms which leave exposed the relatively large disc or tegmen and which often have several successive muscular joints easily outnumbering the non-muscular joints by about 4:1. Judging from what is left of the three least broken post-radial series of the holotype, the five primary arms branch irregularly at least once, these three having axillaries at brachials 13, 20 and 25 respectively, all preceded by pinnules. It is likely that this development of secondary arms is by modification from pinnules, as in *Calamocrinus*.

Subsequent discoveries of recent Bourgueticrinida have tended to blur the distinction between Phrynocrinidae and Bathyrcrinidae.

In 1973, I described an Atlantic species, *Zeuctocrinus gisleni*, referring this new genus to the Phrynocrinidae, on account of its low, flared calyx, rounded arm bases and the similar form of the stalk to that of *Phrynocrinus nudus* with synarthrial joints throughout (at least in larger specimens), though unfortunately the stalk attachment is unknown. However, smaller specimens of *Zeuctocrinus* than the holotype of *Z. gisleni*, show that earlier in the ontogeny the upper columnals are much shorter and the distal ones relatively longer. Possibly the same will prove to be true of *P. nudus*, when a better range of specimens is available. *Z. gisleni* parallels *Bathyrcrinus* in having a primary axillary — normally the second post-radial ossicle — and ten arms and also shows the same relatively high frequency of non-muscular joints in the arms as *Bathyrcrinus*, only a few proximal brachials having muscular joints at both ends.

In 1912, A. H. Clark described *Naumachocrinus hawaiiensis*, a species with stalk attachment

*In 1970 I noted that A. H. Clark's figure of the holotype of *Monachocrinus sexradiatus* (1923) appeared to show muscular joints at both ends of brachials 3, 6 and 9, as characteristic of *Bathyrcrinus*, where *Monachocrinus* is diagnosed by Gislén (1938) as having complete alternation of muscular and ligamentary joints. However, thanks to Dr. Madsen, I have been able to see the holotype and find that only one arm out of those remaining has muscular joints at both ends of brachial 3 and its condition beyond brachial 5 is unknown due to breakage. Nevertheless, the joint sequence hardly seems of generic weight unsupported. Other distinctions cited by Gislén are the fusion of the basal ring in *Bathyrcrinus*, while some specimens at least of *Monachocrinus* (e.g. the paratype of *M. sexradiatus* but not the holotype) show distinct interbasal sutures, and the profile of the calyx showing an angle between the basal and radial rings in *Bathyrcrinus* but a straight line or smooth curve in *Monachocrinus*. The importance of the latter was stressed by Macurda & Meyer (1976). It seems to me likely that fusion of the basal ring may be correlated with a higher incidence of autotomy between the two rings and so be more frequent in *Bathyrcrinus*. The subsequent regeneration of the radial ring and arms would result in at least temporary discontinuity of the profile. Conversely, some specimens of *Bathyrcrinus* do show smooth profiles, along the radii if not also the interradial, either by slight constriction of one or the other ring near the junction point or by an even flaring of both rings. The second is true of the specimen of *B. australis* shown in Döderlein's pl. 5, fig. 1 and pl. 6, fig. 7 (1912), which incidentally also shows distinct interbasal sutures as photographed in toluol in pl. 6. I consider therefore that the generic distinction of *Monachocrinus* from *Bathyrcrinus* is ill-founded.

similar to that of *Phrynocrinus*, prompting him to refer the genus to the Phrynocrinidae although he said that the upper part of the stalk resembled that of *Rhizocrinus* (now *Democrinus*) *weberi* and the calyx is almost perfectly cylindrical with extraordinarily long radials but a basal ring no higher than the discoidal uppermost columnal just below it (see A. M. Clark, 1973, Fig. 6h). The arms are unknown.

A fourth genus — *Porphyrocrinus* — has also been referred to the family Phrynocrinidae, after considerable deliberation by Gislén (1925), because the type-species, *P. verrucosus* from Indonesia, has simple arms, proximally flanged and concealing the tegmen, the calyx is almost cylindrical and the proximal columnals are discoidal. The stalk attachment is unknown. Consequently there is very little superficial resemblance to *Phrynocrinus*, though more to *Naumachocrinus*. However, in 1973 I described a similar species from the SW Indian Ocean, *Porphyrocrinus polyarthra*, from a specimen retaining the distal part of the stalk, showing that attachment is by a lobed terminal expanded plate. Even so, the anomalies between *Porphyrocrinus* and *Naumachocrinus*, on the one hand, and *Phrynocrinus* on the other, seemed to me so great that I proposed a third family, Porphyrocrinidae, intermediate between the two others, characterized by the stalk attachment of the Phrynocrinidae and the calyx form of the Bathyrcrinidae.

Subsequently, two factors affecting the validity of this third family and perhaps even of the Phrynocrinidae, have become evident.

Recently both Roux and I have independently found a new bourgueticrinid which he described as *Porphyrocrinus thalassae* in 1977. Smaller specimens of this species (upper stalk diameter c.3 mm) have simple arms but the larger ones (s.d. c.4 mm) have the first pinnule, on the right side of the eighth brachial (Br_8) modified into a secondary arm and may also have the first pinnule of the left side (on Br_{10}) similarly modified, converting these two ossicles into rather lop-sided axillaries. Possibly at a larger size still the secondary arms achieve equality with the primary ones and adopt a plane tangential to the vertical axis instead of being inclined obliquely like the pinnules; the axillaries would then become more nearly symmetrical. Since the holotypes of the other species of *Porphyrocrinus* were smaller, it is not unlikely that they too may show a similar augmentation in arm number with growth.

Secondly, re-examination of the type material of *Democrinus brevis*, brought home to me in 1977 the great variation in stalk attachment shown by different species of undoubted Bathyrcrinidae, *D. brevis* showing expanded terminal plates in contrast to both *D. parfaiti*, the type-species of *Democrinus*, and some West Indian specimens which I have attributed to *D. conifer*, which consistently have slender branching rhizoids terminating the stalk. Macurda (in Meyer, Messing and Macurda, 1978) believes that *D. brevis* and *conifer* intergrade. Also McKnight (1977) has described a bathyrcrinid stalk from the Kermadec Islands which terminates in both an expanded plate and rhizoids. Gislén's 1927 diagnosis of the Bathyrcrinidae as having stalks attached by rhizoids needs modification. As indicated in Table 1, in about a third of the nominal species of Bathyrcrinidae the distal part of the stalk is unknown.

Hopefully, the current increase in the amount of deep-water biological collecting and the number of specialists interested in these animals may soon result in some degree of clarification of the inter-relationships of these recent Bourgueticrinida.

NOTE ON AN UNRECORDED SPECIMEN OF *PORPHYROCRINUS THALASSAE*
ROUX***Porphyrocrinus thalassae* Roux**

Fig. 1

Porphyrocrinus thalassae Roux, 1977: 34-38, 50-54, fig. 1B, pl. 1, figs. 1-5.**MATERIAL EXAMINED:** 'Discovery' station 8511/2, 41°49'N, 11°06'W (NW of Spain), 2574-2584 metres; 1 specimen.**REMARKS:** Only the uppermost 30 columnals remain, measuring 15 mm. The first 20 are discoidal, the height of the uppermost one being 0.3 mm, while the thirtieth is 1.5 mm high. Stalk diameter at the top is 4.1 mm and at the bottom 3.2 mm.

The basal ring height is 1.0 mm radially, 2.0 mm interradially. The radial ring is 1.4 mm high radially. The total calyx height is 2.4 mm radially and 2.8 mm interradially. The top of the basal ring is slightly constricted after a slight expansion so that both top and bottom are 4.1 mm in diameter. The top of the radial ring is 5.2 mm in diameter. The interbasal sutures are not distinguishable, the undulating basiradial suture only after removal of the skin but the interradi al sutures are more easily visible.

The first eight post-radial ossicles are joined in pairs by non-muscular joints, 1+2, 3+4, 5+6, 7+8ax., Br₈ bearing a secondary arm on the right. Two rays, C and E, have another secondary arm on the left of Br₁₀. Four of the arms from Br₈ have the first brachial divided longitudinally; non-muscular joints mostly alternate with muscular ones from 2+3 onwards so that the first pinnule is on the outer side of Br₃. The primary arms have their first pinnule on the right of Br₁₂. This consists of 13 very elongated pinnulars with a short gonad from segments 2-5; the length is 11.5 mm. The longest arm remaining is a secondary one; it measures 60 mm and consists of 50 brachials; probably c.20 mm is lost. Some of the more distal brachials have a muscular joint at both ends. The dark brown tegmen is widely exposed between the bases of the primary arms; it extends to about Br₆.

The numerology of the ossicles is debatable but, as the additional arms are clearly secondary, the first eight post-radial ones are not a true division series and are better counted as brachials. The numerology used by A. H. Clark in 1907 in describing *Phrynocrinus nudus* was that of Carpenter, counting the ossicles on both sides of the ligamentary joints as forming a single brachial. Translating to Clark's later method of counting, as now generally adopted, the joints of the holotype of *P. nudus* are as follows:

1+2, 3, 4+5, 6, 7+8, 9, 10, 11, 12+13, 14, 15+16, 17, 18, 19+20, 21, 22, 23, 24+25ax.

1+2, 3, 4+5, 6, 7, 8, 9, 10, 11, 12, 13+14, 15, 16, 17+

1+2, 3, 4, 5+6, 7, 8+9, 10, 11, 12+13, 14, 15+16, 17, 18, 19+20ax.

1+2, 3, 4+5, 6, 7+8, 9, 10+11, 12, 13, 14+15, 16, 17, 18+

1+2, 3, 4+5, 6, 7, 8, 9+10, 11, 12, 13ax.

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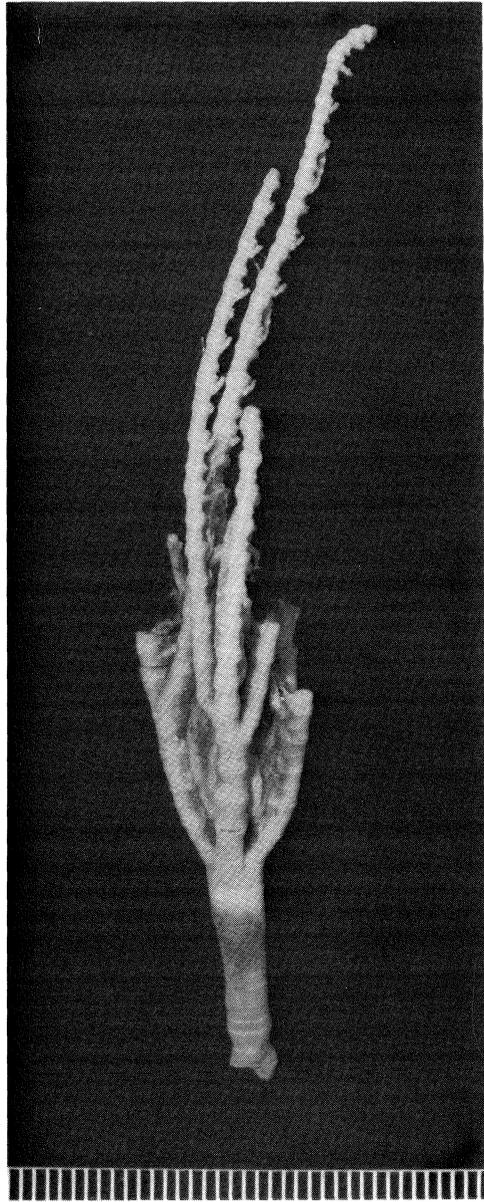


Fig. 1. *Porphyrocrinus thalassae* Roux, 'Discovery' st. 8511/2, showing the secondary arm branching. The calyx has been partially bleached to clarify the sutures.

Table 1. Species of recent Bourgueticrinida, showing the occurrence of the distal part of the stalk and of at least part of the arms beyond the first brachial, entries in brackets indicating broken and incomplete or regenerating parts in the recorded material. The first column gives an approximate estimate of the size range, this measurement has not always been cited and entries with '?' '??' signify the degree of guesswork involved.

	Proximal stalk diameter: approx. range (mm)	Distal Stalk	Arms beyond Br ₁	Depth Range	Geographical range
<i>Bathycrinus aldrichianus</i> W.T.	0.5-0.75	+	+	3320-5850	Mid-Atlantic
<i>australis</i> (A.H.C.)	1.0-2.0	+	+	1730-8210	Southern Ocean
<i>australocrucis</i> McK.	1.0	+	+	693-838	New Zealand
<i>carpenteri</i> (D. & K.)	0.75-1.25	+	+	1360-2810	Arctic N. Atlantic
<i>complanatus</i> A.H.C.	? 1.25-2.0?	+	+	2840	Bering Sea
<i>equatorialis</i> A.H.C.	? 1.0 ?	?	-	4220	Mid-Pacific
<i>gracilis</i> W.T.	0.25-0.75	-	+	4450-5010	NE Atlantic
<i>pacificus</i> A.H.C.	? 1.0 ?	(+)	+	1650	S Japan
<i>woodmasoni</i> A.H.C.	—	-	-	2770	Bay of Bengal
<i>Monachocrinus aotearoa</i> McK.	1.25	+	+	1060-2150	New Zealand
<i>caribbeus</i> (A.H.C.)	? 0.5 ?	-	-	1260	West Indies
<i>mortenseni</i> Gislén	0.25	-	+	1000	New Caledonia
<i>paradoxus</i> (A.H.C.)	? 0.5 ?	(+)	+	2370	Bay of Bengal
<i>perrieri</i> (K. & V.)	0.25	-	(+)	1620-4600	Azores, S. Africa
<i>recuperatus</i> (Perr.)	1.25-1.75	-	+	2300-4260	Azores, Morocco
<i>sexradiatus</i> A.H.C.	0.5	+	+	2075	Iceland
<i>Rhizocrinus lofotensis</i> Sars	0.5-1.0	+	+	140-3475	N Atlantic
<i>minimus</i> (Död.)	0.25	-	(+)	1300	East Indies
<i>Conocrinus cabiochi</i> Roux	1.0	-	-	1975-2070	Bay of Biscay
<i>cherbonnieri</i> Roux	0.5	-	-	330-510	Bay of Biscay
<i>Democrinus aoteanus</i> McK.	1.0	+	+	650-945	New Zealand
<i>brevis</i> (A.H.C.)	1.5-1.75	+	+	540	West Indies
<i>chuni</i> (Död.)	0.25-1.25	+	+	410-1800	E & S Africa
<i>conifer</i> (A.H.C.)	1.75	-	-	160-1750	Brazil
<i>globularis</i> Gislén	1.25	-	-	290	East Indies
<i>japonicus</i> Gislén	1.25	+	+	140-170	S Japan

<i>nodipes</i> (Död.)	0.25	+	+	1160-1570	East Indies
<i>parfaiti</i> Perr.	1.0-1.5	+	+	600-4260	NE Atlantic
<i>poculum</i> (Död.)	0.25	(+)	-	1570	East Indies
<i>rawsoni</i> (Pourt.)	1.5	(+)	+	70-650	West Indies
<i>weberi</i> (Död.)	0.5-4.25	+	+	110-2050	
<i>Phrynocrinus nudus</i> A.H.C.	4.0-6.0	+	+	600-1190	SE Japan
<i>Naumachocrinus hawaiiensis</i> A.H.C.	1.5	+	-	930-1300	Hawaiian Is.
<i>Zeuctocrinus gisleni</i> A.M.C.	0.75-2.75	-	+	2110-2575	NE Atlantic
<i>Porphyrocrinus incrassatus</i> Gislén	0.75	+	(+)	1300-2400	E Atlantic
<i>polyarthra</i> A.M.C.	1.0-1.25	+	(+)	400	SW Indian Ocean
<i>thalassae</i> Roux	2.0-4.0	-	+	2110-2580	Bay of Biscay
<i>verrucosus</i> Gislén	1.5	-	+	345	East Indies

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