

GENERIC DIAGNOSES FOR SOME BURROWING BIVALVES
OF THE AUSTRALIAN PERMIAN

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ABSTRACT

The differing classifications of some burrowing bivalves of the Australian Permian by Newell (1956) and Dickins (1963) are reviewed. Morphological details not considered by these authors, such as dentition and musculature, support Dickins in his recognition of a number of genera, rather than Newell, who regarded only a few as valid. Generic diagnoses are given for *Megadesmus* Sowerby, *Astartila* Dana, *Pyramus* Dana, *Myonia* Dana, *Notomya* M'Coy, and *Pachymyonia* Dun. Two new genera are erected, *Globicarina*, with type species *Globicarina grossula* sp. n. and *Vacunella*, with type species *Allorisma curvatum* Morris. The latter species has been referred to *Chaenomya* by authors, but detailed comparison with topotypes of *C. leavenworthensis* show important differences in shape, posterior gape and musculature. The interrelationships between the genera are outlined.

INTRODUCTION

The Permian bivalve genera *Megadesmus*, *Myonia* and their allies were large sediment-burrowing shells especially characteristic of the marine faunas that lived in cold waters close to the ice-sheets of Gondwana. They are most abundant in eastern Australia, but occur widely, especially in the Sakmarian (basal Permian) of India, Pakistan (Waagen, 1891; Reed, 1932, 1936) and perhaps Brazil (Reed, 1930) and Argentine (Harrington, 1955; Dickins, 1963) when the ice-sheets of Gondwana were at their maximum extent. They have also been reported from the middle Permian of New Zealand (Waterhouse, 1963, 1964; Waterhouse and Vella, 1965) and from the Kazanian of Siberia (Popov, 1958). Much attention was focused on these shells in the early days of geological and palaeontological exploration in Australia, and the following taxa have been erected:

- Megadesmus* Sowerby 1838
- Pachydomus* Morris 1845
- Pyramus* Dana 1847
- Cleobis* Dana 1847
- Astartila* Dana 1847

- Myonia* Dana 1847
- Notomya* M'Coy 1847
- Maeonia* Dana 1849
- Pyramia* Dana 1849
- Clarkia* de Koninck 1877
- Pachymyonia* Dun 1932

Of these names *Pachydomus* was erected by Morris as a substitute for *Megadesmus* Sowerby (1838) not *Megadesma* Bowdich (1822). *Pyramia* and *Maeonia* are variant spellings of *Pyramus* and *Myonia*, introduced without cause. The type species of *Clarkia* de Koninck is *Pyramus myiformis* Dana, which is also the type species of *Pyramus*, so that *Clarkia* is an objective synonym of *Pyramus*.

Other allied shells have been referred to *Edmondia* de Koninck (1844) and to *Chaenomya* Meek (1865). With the exception of these latter forms the entire group has been revised recently by Newell (1956) after examining specimens in museums in Great Britain, Australia and the United States, where most of the types are kept. Newell considered that the early workers had subdivided the group excessively and recognised only 4 genera as valid:

1. *Pachydomus* Morris (= *Megadesmus* Sowerby, *Astartila* Dana)
2. *Myonia* Dana (= *Maeonia* Dana, *Pachymyonia* Dun)
3. *Pyramus* Dana (= *Notomya* M'Coy, *Pyramia* Dana, *Clarkia* de Koninck)
4. *Cleobis* Dana

All 4 were stated to have an identical hinge, with a tooth in each valve. *Pachydomus cuneatus*, the supposed type of *Pachydomus*, was characterised by its lack of an umbonal carina or posterior gape, *Myonia elongata* by its umbonal carina, *Pyramus myiformis* by its pallial sinus and *Cleobis* by its slight posterior gape and thin shell, although Newell (1956: 11, 13) noted that this genus might in fact be a large *Pachydomus*.

The other worker who has recently expressed views on the group is Dickins, working more especially on forms from Western Australia, but also on collections from eastern Australia. Dickins (1956, 1957, 1961, 1963) subdivided the group much more closely than Newell, and also used subgenera to indicate affinities between different taxa. His conclusions may be summarised as follows:

Following the decisions of the 1953 International Commission of the Zoological Nomenclature *Megadesmus* Sowerby (1838) is recognised as a valid genus, and not a homonym of *Megadesma* Bowdich, or senior synonym of *Pachydomus* (see also Vokes, 1956). The type species of *Megadesmus*, *M. globosus* Sowerby, cited by Woodward (1856) as the type of *Pachydomus* Morris (= *Megadesmus* J. Sowerby), is considered by Dickins (1963) to be congeneric with *Cleobis grandis*, the type of *Cleobis*. *Astartila* is recognised as a genus or subgenus of *Megadesmus*; *Pachymyonia* is distinguished from *Myonia* by its strongly carinate posterior umbonal ridge, and treated as a genus or subgenus. *Notomya* is considered to be distinct from *Pyramus*. The bivalve genera *Edmondia* and *Chaenomya* were also recognised in the Australian Permian.

In summary Dickins recognised the

following genera:

Megadesmus Sowerby (= *Cleobis* Dana, *Pachydomus* Morris)
Myonia Dana (= *Maeonia* Dana)
Pyramus Dana (= *Pyramia* Dana, *Clarkia* de Koninck)
Astartila Dana (or subgenus of *Megadesmus*)
Notomya M'Coy
Pachymyonia Dun (or subgenus of *Myonia*)
Edmondia de Koninck
Chaenomya Meek

Hill and Woods (1964: 20), presumably following Dickins for they acknowledged his help in their introduction, used the taxa *Chaenomya*, *Astartila*, *Myonia* and *Pyramus*, and treated *Cleobis* as a subgenus of *Megadesmus*.

In assessing the validity of these genera (apart from *Edmondia* and *Chaenomya*) Dickins used virtually the same criteria as Newell - that is, mainly shell shape, gape, and pallial sinus, though he did place more stress on shell size, and shell thickness, and definition of muscle scars. He also qualified Newell's report of a tooth in each valve, considering that only the right valve has a tooth. Allowing for these minor differences it would thus seem that Newell and Dickins differ considerably over the significance of what are almost the same criteria, and that the decision as to the validity of the various genera must be an arbitrary one, that will possibly vary according to each worker in the field, or one that requires considerable statistical analysis to reveal subtle differences over which agreement can be reached.

It has been found however that in most of these genera objective criteria are readily available which support an initial grouping according to shape, much as outlined by Dickins. These criteria lie in the hinge and musculature, which appear to differ consistently from genus to genus (as recognised herein). A compound illustration (Fig. 1) shows various generalized morphological features of use in

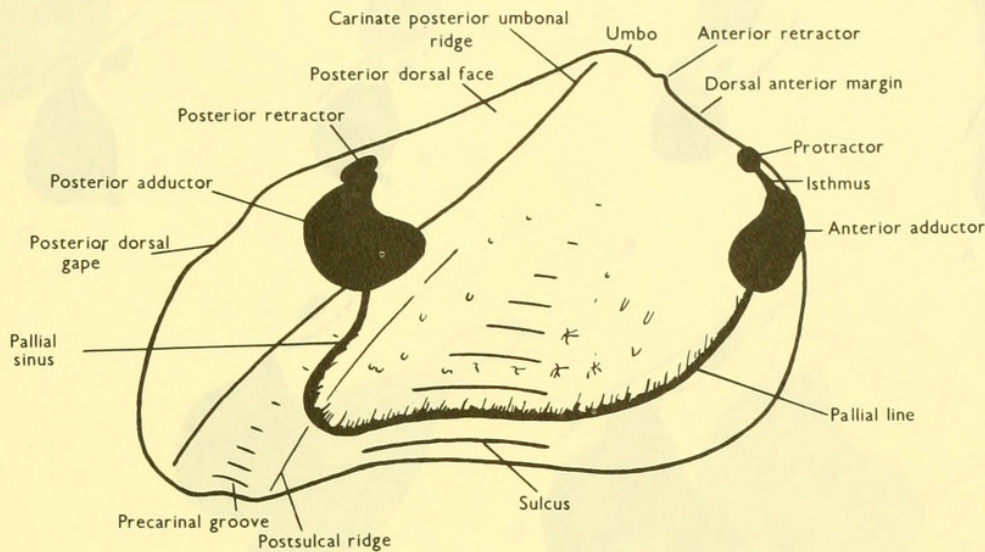


FIG. 1. Internal mould of right valve, generalised to show various morphological features of *Myonia*, *Megadesmus* and their allies. The shell outline and ctenidial markings are taken from the lectotype of *Myonia valida*, the other features are compounded from various genera.

characterising these bivalves, and Figs. 2 and 3 show how the muscle scars differ in each genus. The criteria were gathered partly from plaster duplicates made of all available types at the British Museum (Natural History), London; Sedgwick Museum, Cambridge; Smithsonian Institution, Washington; and the Australian Museum, Sydney, as well as by examination of large suites of Australian and New Zealand fossils at the Bureau of Mineral Resources, Canberra; the Australian Museum, Sydney; and New Zealand Geological Survey, Lower Hutt, with further specimens contributed by other institutions as recorded in the acknowledgments. The following account outlines generic diagnoses, based chiefly on the type species, and supplemented where necessary from allied species.

Genus MEGADESMUS Sowerby 1838

Type Species. *M. globosus* Sowerby

(1838), designated by Woodward (1856). Stoliczka (1871) later selected *Megadesmus cuneatus* as type, but this is invalid. The sole specimen figured by Sowerby (1838, Pl. 3, Fig. 1, 2) is designated lectotype (L 61043, British Museum, Natural History).

Synonymy. *Pachydomus* Morris (1845). *Cleobis* Dana (1847) with type species *C. grandis* Dana is externally identical.

Diagnosis. Moderately large, oval, thin to thick shelled inflated species with faintly prosogyrous umbones, and shallow anterior depression or sulcus on the lower flanks of the shell, concave forward in outline throughout its height (or extent). Dorsal posterior margin concave in outline, and no posterior umbonal ridge or posterior gape. Ligament opisthodontic, parinvicular, supported by nymphs, set in moderately defined posterior depression. Internal details poorly known in type species.

In externally similar species *Edmondia*

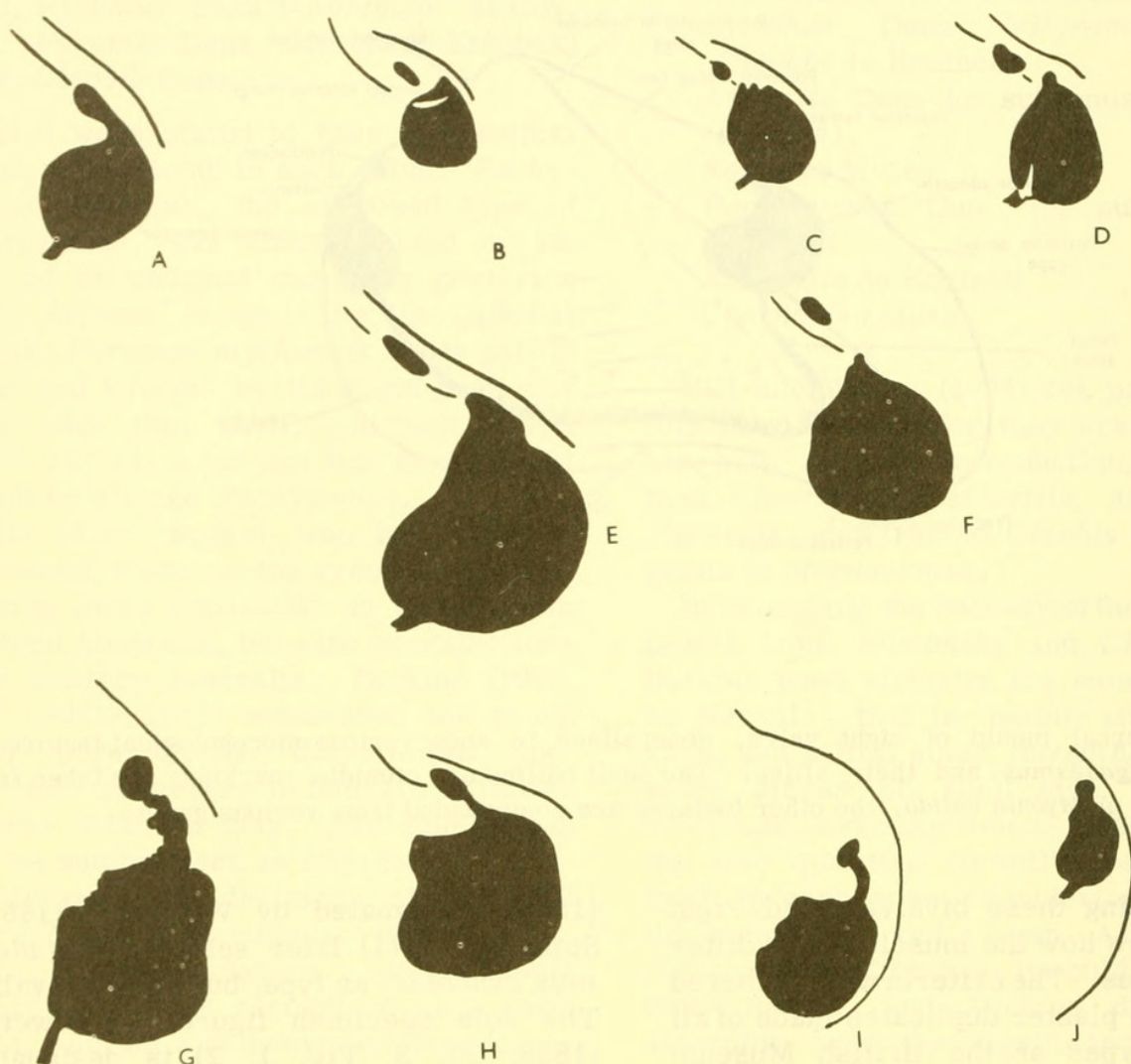


FIG. 2. Sketches of anterior adductor and protractor impressions on internal moulds of the right valve, slightly below natural size. A. *Megadesmus nobilissimus* (de Koninck). B. *Astartila intrepida* Dana (from the specimen figured as *Pachydomus ovalis* M'Coy). The large adductor has a sharp bend in its surface. C. *Pyramus myiformis* Dana, from a paratype. D. *Notomya securiformis* M'Coy, from lectotype - the adductor is raised near the posterior ventral margin. E. *Globicarina grossula* n. sp. from holotype, F 21750, Australian Museum. F. *Globicarina* n. sp. (Farley beds) from F 53, Australian Museum. G. *Myonia elongata* Dana, from *M. valida* Dana, lectotype. H. *Pachymyonia* sp. n., TM 3806, New Zealand Geological Survey. I. *Vacunella curvata* (Morris) from F 197, Australian Museum. J. *Chaenomya leavenworthensis* (Meek and Hayden) from photographs of type, and USNM 32985, Smithsonian Institution.

The line to the right indicates the anterior margin of the shell, and the line to the left the umbo-ridge. Angles of observation differ slightly, to show the position of the muscle scars most clearly in each instance. Where necessary, details observed on well preserved left valves have been transposed into details of right valves.

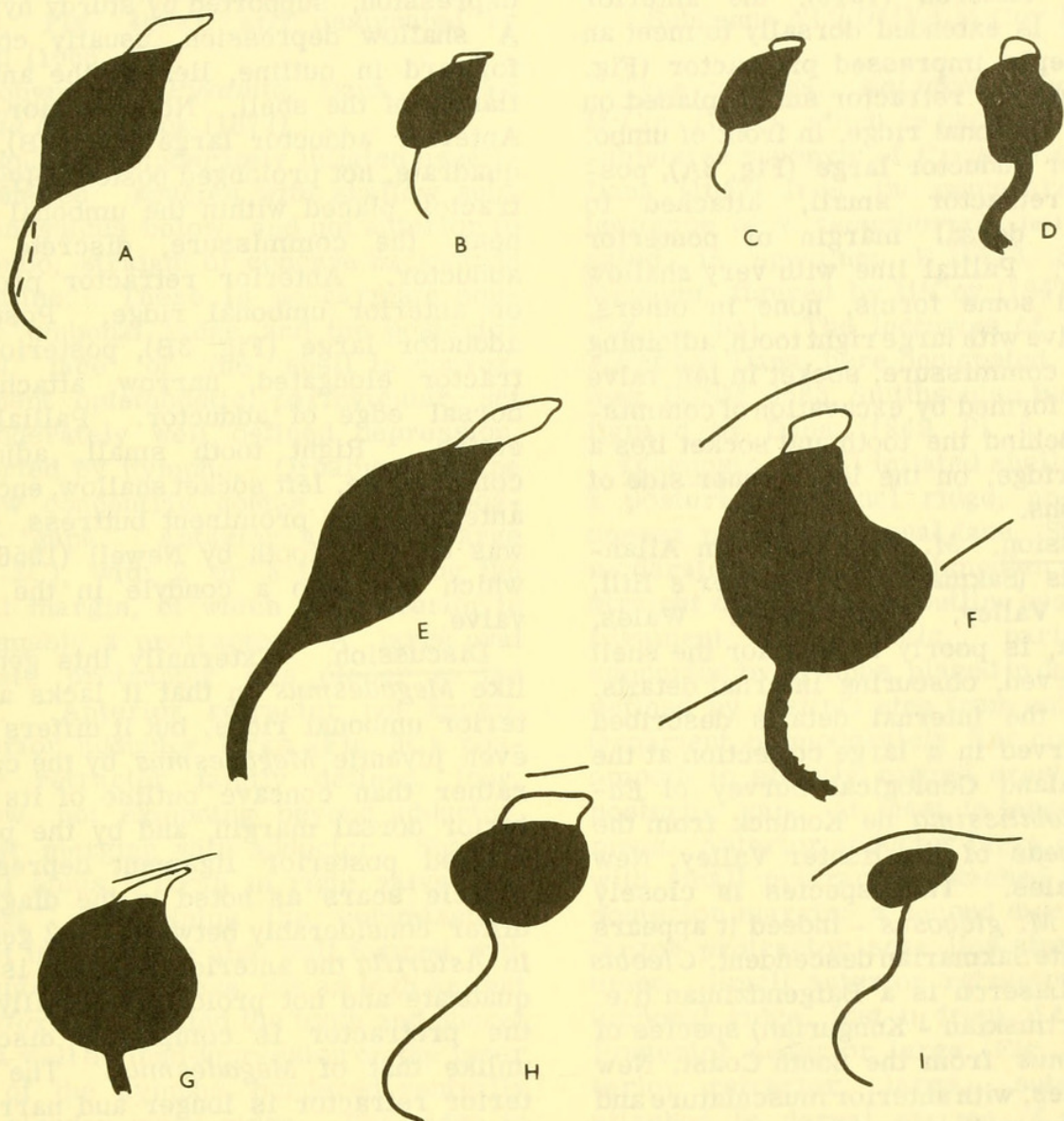


FIG. 3. Sketches of posterior adductor and retractor impressions with posterior part of pallial line, on internal moulds of right valve, slightly below natural size. A. *Megadesmus nobilissimus* (de Koninck), from specimens at Geology Department, Australian National University, Canberra, with the outlines of 2 pallial lines from different specimens, one with a shallow sinus, one without. Retractor slightly uncertain. B. *Astartila intrepida* Dana from *A. cytherea* Dana. C. *Pyramus myiformis* Dana, from lectotype. Retractor not seen. D. *Notomya securiformis* M'Coy, from lectotype. E. *Globicarina grossula* n. sp. from holotype, F 21750, Australian Museum, outline of scars and pallial line speculative. F. *Myonia elongata* Dana, from lectotype of *M. valida* Dana. G. *Pachymyonia morrisii* (Etheridge), from F 26275, Australian Museum, H. *Vacunella curvata* (Morris) from F 197 and F 30077, Australian Museum, highly speculative, and possibly quite inaccurate. I. *Chaenomya leavenworthensis* (Meek and Hayden) sketched from figure of type.

The line above the muscle scars indicates the dorsal margin, the line below indicates the position of the posterior carina. Angles of observation differ slightly, to show the musculature clearly. Where necessary, the details observed on well preserved left valves have been transposed to right valves.

nobilissima de Koninck (1877) and *Cleobis robusta* Laseron (1910), the anterior adductor is extended dorsally to meet an oval deeply impressed protractor (Fig. 2A). Anterior retractor small, placed on anterior umbonal ridge, in front of umbo. Posterior adductor large (Fig. 3A), posterior retractor small, attached to anterior dorsal margin of posterior adductor. Pallial line with very shallow sinus in some forms, none in others. Right valve with large right tooth, adjoining anterior commissure, socket in left valve shallow, formed by excavation of commissure. Behind the tooth and socket lies a narrow ridge, on the lower inner side of the nymphs.

Discussion. *M. globosus* from Allandale beds (Sakmarian) at Harper's Hill, Hunter Valley, New South Wales, Australia, is poorly known, for the shell is preserved, obscuring internal details. Most of the internal details described are observed in a large collection at the New Zealand Geological Survey of *Edmondia nobilissima* de Koninck from the Farley beds of the Hunter Valley, New South Wales. This species is closely allied to *M. globosus* - indeed it appears to be a late Sakmarian descendent. *Cleobis robusta* Laseron is a Baigendzinian (i.e. upper Artinskian - Kungurian) species of *Megadesmus* from the South Coast, New South Wales, with anterior musculature and pallial line well preserved. Queensland *Megadesmus* also show the hinge and musculature well.

Genus *ASTARTILA* Dana 1847

Type species. *A. intrepida* Dana (1847), designated by Stoliczka (1871). The lectotype is figured by Dana (1849, Pl. 3, Fig. 5, 5a), USNM 3594, Smithsonian Institution, as indicated by Fletcher (1929, caption to Pl. 26, Fig. 6).

Diagnosis. Small thin to thick shelled inflated species of suboval shape, with strongly prosogyrous umbones and the posterior dorsal margin convex in outline. No posterior umbonal ridge is differentiated. No lunule. Ligament opistho-

detic, parinvicular, not set in any defined depression, supported by sturdy nymphs. A shallow depression, usually concave forward in outline, lies on the anterior flanks of the shell. No posterior gape. Anterior adductor large (Fig. 2B), subquadrate, not prolonged posteriorly. Protractor placed within the umbonal ridge near the commissure, discrete from adductor. Anterior retractor probably on anterior umbonal ridge. Posterior adductor large (Fig. 3B), posterior retractor elongated, narrow, attached to dorsal edge of adductor. Pallial line entire. Right tooth small, adjoining commissure, left socket shallow, enclosed anteriorly by prominent buttress, which was called a tooth by Newell (1956) and which fits into a condyle in the right valve.

Discussion. Externally this genus is like *Megadesmus* in that it lacks a posterior umbonal ridge, but it differs from even juvenile *Megadesmus* by the convex rather than concave outline of its posterior dorsal margin, and by the poorly defined posterior ligament depression. Muscle scars as noted in the diagnosis differ considerably between the 2 genera. In *Astartila* the anterior adductor is subquadrate and not prolonged dorsally, and the protractor is completely discrete, unlike that of *Megadesmus*. The posterior retractor is longer and narrower in *Astartila* and a pallial sinus is never developed. Furthermore the dentition differs, for the anterior buttress of the left socket is not found in *Megadesmus*.

The diagnosis is based on plaster duplicates of the type and of the other *Astartila* species described by Dana from the same locality at Wollongong, New South Wales, Australia, all of which are probably conspecific, as noted by Newell (1956).

Genus *PYRAMUS* Dana 1847

Type species. *Pyramus myiformis* Dana (1847), designated by Newell (1956). Woodward (1856) noted only the species *ellipticus* Dana (1847) after the name *Pyramus*, but did not specify that it was

to be considered the type. The lectotype is USNM 3587, figured by Dana (1849, Pl. 6, Fig. 4a-c), and designated by Newell (1956, p 9).

Synonymy. *Pyramia* Dana (1849); *Clarkia* de Koninck (1877).

Diagnosis. Moderately inflated usually thin-shelled species with shallow submedian sulcus below, and not anterior to the umbo, straight or concave backwards in outline. There is no carinate posterior umbonal ridge and the posterior dorsal face of the shell is convex. Ligament opisthodic, parinvicular, set in moderately well defined depression, supported by nymphs. Ornament of fine narrow concentric costae. Slight posterior gape. Anterior adductor large (Fig. 2C), with 2 or 3 lobes along the dorsal margin, of which the posterior is presumably a protractor. A large oval discrete protractor lies closer to the umbo. Anterior retractor not known. Posterior adductor large (Fig. 3C), posterior retractor faintly defined, long, narrow, not extending beyond adductor, almost merging with adductor. Shallow pallial sinus. Tooth in right valve well formed, not joining the commissure. Socket in left valve also well formed, with low anterior buttress, not as high as that of *Astartila*. Behind the tooth and socket lies a well defined depression on the inner side of the nymphs, bordered ventrally by a slender inner ridge. The ridge is possibly homologous to the inner ridge of *Edmondia*, but is much lower.

Discussion. The diagnosis is based on plaster moulds, rubber moulds, and photographs of the lectotype and paratypes collected and described by Dana (1847, 1849). In spite of the good preservation, the posterior retractor is scarcely to be distinguished from the posterior adductor. Neither Newell (1956) or Dickins (1961) questioned the validity of *Pyramus*: it is easily distinguished from *Astartila* and *Megadesmus* by its elongated outline, and its medianly placed sulcus. As is here shown, the tooth and socket are better formed than in these genera and are independent of the commissure, and the

musculature also differs.

Subgenus *NOTOMYA* M'Coy 1847

Type species. *Notomya securiformis* M'Coy (1847), which is probably a junior subjective synonym of *Pyramus ellipticus* Dana (1847) from the same area. The lectotype of *N. securiformis*, here designated, is specimen E 10776, Sedgwick Museum, figured by M'Coy (1847, Pl. 15, Fig. 5, 5a). The lectotype of *Pyramus ellipticus* Dana, here designated, is specimen USNM 3583, Smithsonian Institution, figured by Dana (1849, Pl. 6, Fig. 5a).

Diagnosis. Well inflated shells without a posterior umbonal ridge, and with a convex posterior dorsal face. Shallow to moderately deep submedian sulcus, straight or concave in outline posteriorly. Ligament opisthodic, parinvicular, supported by nymphs, placed in depression defined by distinct step from outer shell. Ornament of moderately fine costae with smooth to slightly ragged crests. Slight posterior gape, at least in larger specimens. Anterior adductor large (Fig. 2D), with small protractor attached to dorsal posterior margin; a second discrete oval larger protractor scar lies closer to the umbo. Small anterior retractor lies on umbonal ridge, just in front of the umbo. Posterior adductor large (Fig. 3D), posterior retractor large, subquadrate, attached to dorsal margin of adductor. Pallial sinus shallow. Tooth in right valve and socket in left valve comparatively well formed, not in contact with commissure. The depression on the inner side of the nymphs behind the tooth and socket, seen in *N. clavata* M'Coy, slightly shallower than in *Pyramus myiformis*, and the ventral ridge more massive.

Discussion. The diagnosis is based on plaster duplicates of the types of *Notomya securiformis* M'Coy and *N. clavata* M'Coy, here considered a synonym, and *Pyramus ellipticus* Dana, supplemented by observations on the types and other specimens of *Megadesmus cuneatus* Sowerby and *P. antiquatus* Sowerby, here held to belong to *Notomya*.

Newell (1956) considered *N. securiformis* to be not only congeneric, but conspecific with *Pyramus myiformis*. Dickins (1961) placed the 2 in different genera, and distinguished them by the greater inflation and thicker shell and deeper muscle scars of *Notomya*. I would not regard these differences as of generic significance in themselves, but there might be supporting evidence in the musculature and perhaps the definition of the inner ridge behind the tooth and socket. Unfortunately the musculature is not fully resolved for *Pyramus*, nor the variation in appearance of the inner side of the nymphs in *Pyramus* or *Notomya*. I therefore take the cautious viewpoint of considering *Notomya* to be a subgenus of *Pyramus*, rather than a full genus. They are obviously closely allied by shape and dentition, and the chief difference seems to lie only in the size and shape of the posterior retractor.

Genus **GLOBICARINA** gen. nov.

Type species. *Globicarina grossula* n. sp., here designated.

Diagnosis. Very large inflated species, with strongly incurved weakly prosogyrous umbones, and a shallow depression on the flank of the shell, placed near the anterior margin and concave forward in outline. A weakly to well defined posterior umbonal ridge is present, and a concave posterior dorsal face. Ligament opisthodontic, parinvicular, supported by moderately sturdy nymphs, contained in a moderately well defined posterior depression. Slight or negligible posterior gape. Ornament of low costae, shell thin. Anterior musculature (Fig. 2E, F) much as in *Notomya*; anterior adductor large, with moderately large protractor attached to its dorsal posterior margin, a second large discrete protractor lies nearer the umbo, within the umbonal ridge, as in *Astartila*. Anterior retractor pit tiny, set on anterior umbonal ridge. Posterior adductor large (Fig. 3E), posterior retractor impression poorly known, possibly attached to dorsal margin of posterior adductor as a long

large scar. Posterior part of pallial line not known to me. Tooth in right valve well formed, discrete from commissure, to judge from a New Zealand specimen. Inner side of nymph with shallow depression and very low ridge.

Discussion. *Megadesmus cuneatus* Sowerby, here referred to *Notomya*, has anterior musculature almost identical with that of *Globicarina grossula*, the only difference being that the anterior protractor is larger in *Globicarina*, and the posterior protractor tends to lie within the umbonal ridge, and not on it. *Globicarina* also has a somewhat similar well formed tooth in the right valve. Differences from *Notomya* are found externally in its anterior, not median sulcus, and in its posterior umbonal ridge and concave posterior dorsal face. Internally the anterior musculature differs slightly, and the posterior retractor seems to be larger and longer.

In many respects *Globicarina grossula* resembles *Megadesmus globosus* - both are well inflated shells, with an anterior sulcus and strongly incurved umbones. But *Megadesmus* lacks a posterior umbonal ridge, and internal differences of musculature and probably of the hinge are considerable.

GLOBICARINA GROSSULA sp. n.

Figs. 4, 5

Holotype. Specimen F 21750, Australian Museum, from middle Permian (Artinskian - Kungurian) beds of South Coast, New South Wales.

Diagnosis. Large elongated *Globicarina* with anterior umbones and deeply concave anterior margin. Distinguished from a species of the Lower Artinskian or upper Sakmarian Farley beds of New South Wales by its greater length and less carinate posterior umbonal ridge.

Discussion. The species will be fully described and illustrated in a forthcoming paleontological bulletin of the New Zealand Geological Survey. A number of specimens are present at the Australian Museum from Permian localities along

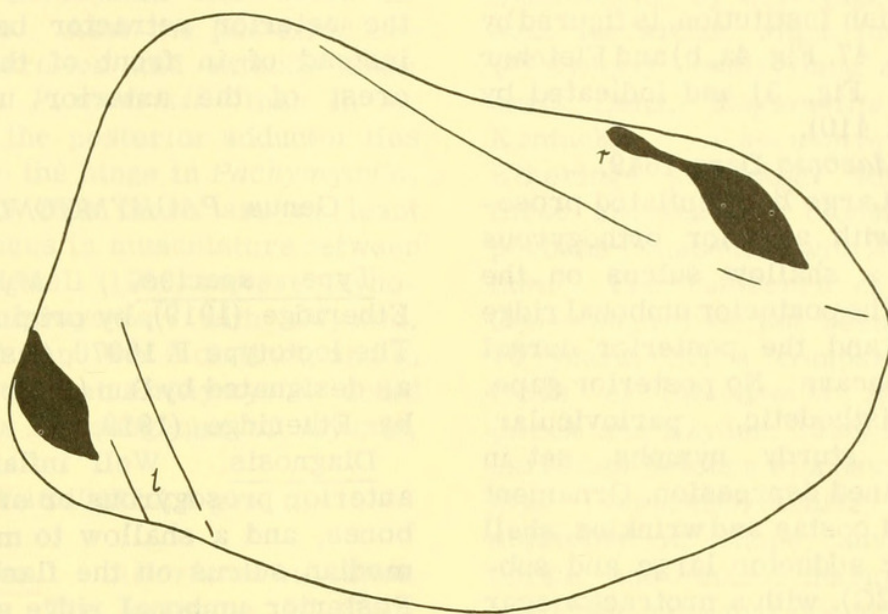


FIG. 4. Outline of left valve of *Globicarina grossula* n. sp. with muscle scars, holotype F 21750, Australian Museum, x 0.5 approx. Lateral view. l = depression or sulcus on shell surface; r = posterior retractor.

the South Coast. Previously some have been confused with *Cleobis grandis*, but *C. grandis* lacks a well developed posterior umbonal ridge, and has a less anterior umbo. It is probable that differences of musculature and hinge are also considerable - but internal details are not known for *C. grandis*.

Genus *MYONIA* Dana 1847

Type species. *Myonia elongata* Dana (1847) (= *Myonia valida* Dana, 1847), designated by Newell (1956). The lectotype of *M. elongata*, USNM 3584, Smithsonian Institution is figured by Dana (1849, Pl. 47, Fig. 2) and Fletcher (1932, Pl. 47,

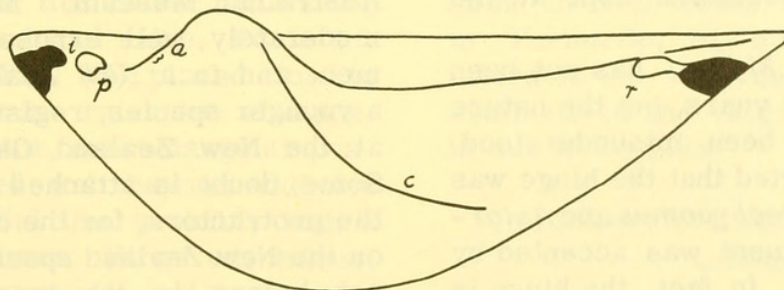


FIG. 5. Dorsal outline and muscle scars of left valve of *Globicarina grossula* n. sp. holotype 21750, Australian Museum, x 0.5 approx. a = anterior retractor scar; c = posterior umbonal ridge; i = anterior protractor scar attached to anterior adductor; p = posterior protractor scar; r = posterior retractor.

Fig. 2), and indicated by Fletcher (1932: 409). The lectotype of *M. valida*, USNM 3665, Smithsonian Institution, is figured by Dana (1849, Pl. 47, Fig. 4a, b) and Fletcher (1932, Pl. 48, Fig. 3) and indicated by Fletcher (1932: 410).

Synonymy. *Maeonia* Dana 1849.

Diagnosis. Large little inflated prosocline shells with anterior orthogyrous umbones, and a shallow sulcus on the median flank. The posterior umbonal ridge is prominent, and the posterior dorsal face usually concave. No posterior gape. Ligament opisthodontic, parinvicular, supported by sturdy nymphs, set in moderately defined depression. Ornament of even-crested costae and wrinkles, shell thin. Anterior adductor large and subquadrate (Fig. 2G), with a protractor scar at its dorsal margin, adjoining a second protractor - in some shells the second protractor is almost discrete. Anterior retractor below umbonal ridge on outer flank of shell, at least in the lectotype of *M. valida*. Posterior adductor large (Fig. 3F), posterior retractor well formed, subquadrate, attached to dorsal margin of adductor, in some shells almost discrete. Pallial line entire. Hinge edentulous, with concave commissural face bordered ventrally by low ridge.

Discussion. The diagnosis is based on plaster duplicates of *M. elongata* and *M. valida* described by Dana (1849). Details of the hinge, not well shown in these specimens, are seen in various New Zealand specimens (e.g. TM 3815, 3816) of *M. elongata* and in specimens kept at the Australian Museum.

The validity of *Myonia* has not been questioned in recent years, but the nature of the hinge has been misunderstood. Newell (1956) reported that the hinge was identical to that of *Pachydomus* and *Astartila*, and this statement was accepted by Dickins (1963: 48). In fact, the hinge is edentulous. Etheridge (1892) reported that the hinge was edentulous in well exposed specimens of *Myonia carinata* and Fletcher (1932) also stated that the hinge was edentulous. The genus is thus readily

separated from the preceding genera, and is further distinguished by the position of the anterior retractor below the umbo, instead of in front of the umbo on the crest of the anterior umbonal ridge.

Genus *PACHYMYONIA* Dun 1932

Type species. *Myonia morrisii* Etheridge (1919), by original designation. The lectotype F 16978, Australia Museum, as designated by Dun (1932: 412), is figured by Etheridge (1919, Pl. 28, Fig. 7, 8).

Diagnosis. Well inflated shells with anterior prosogyrous or orthogyrous umbones, and a shallow to moderately deep median sulcus on the flanks of the shell. Posterior umbonal ridge sharply angular in cross-profile, and the posterior dorsal face flat or concave. Ornament of low costae and wrinkles. Shell thick in type species, but thin in related species. Ligament opisthodontic, parinvicular, supported by sturdy nymphs, set in moderately defined depression. Anterior adductor large (Fig. 2H), its dorsal margin extended posteriorly towards well defined protractor; seemingly no second protractor. Anterior retractor set in umbonal ridge. Posterior adductor placed very close to hinge, well in from carina, posterior retractor narrow, elongated (Fig. 3G). Pallial line entire. Hinge edentulous.

Discussion. The diagnosis is based on the type species, with internal details of the hinge well shown in F 26275 at the Australian Museum. Muscle scars are moderately well exposed in this specimen, and in a New Zealand specimen of a younger species, registered as TM 3806 at the New Zealand Geological Survey. Some doubt is attached to the nature of the protractors, for the diagnosis is based on the New Zealand specimen, which does not belong to the type species. The protractors are a little more obscure on F 26275. It may be that the second anterior protractor is present, as in *Myonia*, but is almost fused to the adductor. F 26275 does have a pit on the umbonal

ridge, suggestive of an anterior retractor, whereas that of *Myonia* lies below the umbonal ridge. Also the posterior retractor is narrower and extends more anteriorly in *P. morrisii* than in *M. elongata*, and the posterior adductor lies much closer to the hinge in *Pachymyonia*. It thus seems that there are at least minor differences in musculature between the 2 taxa. Newell (1956) however synonymised *Pachymyonia* with *Myonia*. Dickins (1957) kept the 2 distinct, and in 1963, suggested that *Pachymyonia* could be treated as a subgenus of *Myonia*.

Genus *VACUNELLA* gen. n.

Type species. *Allorisma curvatum* Morris (1845). The lectotype, PL 3692, British Museum here designated, is figured by Morris (1845, Pl. 10, Fig. 1).

Diagnosis. Inflated shells with anterior orthogyrous umbones, and a shallow depression near the anterior margin in some forms and below the umbo in others. Posterior umbonal ridge well rounded in cross-profile, posterior dorsal face concave. Moderately wide posterior dorsal gape. Ornament of concentric wrinkles, costae and very fine pustules. Shell thin, of simple platy structure. Ligament opisthodontic, parinvicular, supported by sturdy nymphs, contained in moderately defined depression. Anterior adductor (Fig. 2I) placed close to anterior ventral extremity, attached by attenuated portion of isthmus to deeply impressed protractor. Anterior retractor lies closer to the umbo on the anterior umbonal ridge. Posterior adductor large (Fig. 3H), placed close to the hinge, posterior retractor elongate, attached to adductor, subrectangular posteriorly, extended well beyond adductor anteriorly. Pallial line probably with a large shallow sinus. Hinge edentulous, thickened under nymphs and in front of umbo.

Discussion. The diagnosis is based on Morris' type specimen, and on a large suite of specimens at the Australian Museum, of which F 197 and F 30077 are most useful.

Allorisma curvatum was referred to *Chaenomya*? by Etheridge (1892), together with its allies, which include *Homomya* (*Platymya*) *audax* Dana and *H. glendonensis* Dana, *Sanguinolites etheridgei* de Koninck, *Chaenomya* ? *bowenensis* Etheridge and other forms. Most of these species are closely allied to and perhaps conspecific with *Allorisma curvatum*. The reference of the species to *Chaenomya* has not been challenged for 70 years, but a comparison with topotypes of *Chaenomya leavenworthensis* (Meek and Hayden, 1858) suggests that *A. curvatum* belongs to a new genus. *Chaenomya leavenworthensis* differs considerably in shape, having subparallel dorsal and ventral margins, and a huge posterior gape that occupies the maximum width of the shell. By contrast *A. curvatum* is a more inflated shell, with a more rounded ventral margin, the maximum width near mid-length and a relatively small posterior dorsal gape. It is much less adapted for burrowing, looking like a *Pleuromya*, whereas *Chaenomya* looks like *Panopea*. Also the pustules are much finer (15-20 in 1 mm) in *A. curvatum*, compared with 2 or 3 in 1 mm in *Chaenomya*. The hinge and shell structure are much the same in both types, but the musculature differs. The anterior adductor lies much higher on the shell in *Chaenomya* (Fig. 2J), and is elongated vertically, and adjoins a deeply impressed rounded protractor, without being prolonged. The sinus is probably much the same in both forms but is poorly known in *Vacunella*, and the posterior musculature is not well shown in *Chaenomya* available to me (Fig. 3I), nor very clear in this new genus.

INTERRELATIONSHIPS BETWEEN GENERA

The genera described above fall into 2 or perhaps 3 natural groups. The largest group, with the genera *Megadesmus*, *Astartila*, *Pyramus*, *Notomya*, and *Globicarina* is characterised by the presence of a tooth in the right valve and socket in

the left. These genera are referred to the Edmondiidae King (1850) by Dickins (1961, 1963), and to a distinct family, the Pachydomidae, by Fischer (1887), Newell (1956), and Müller (1958). The ridge on the inner side of the nymphs of the Australian genera is reminiscent of the inner plate of *Edmondia*, but *Edmondia* lacks the tooth and socket of *Megadesmus*, *Astartila*, *Pyramus*, *Notomya* and *Globicarina*. Two subdivisions are seen in the Pachydomids, one with *Astartila* and *Megadesmus*, which differ from each other in many respects, and a second more closely knit group, with similar dentition and anterior musculature, *Pyramus*, *Notomya*, and *Globicarina*. Another group of genera is *Myonia* and *Pachymyonia*. These have edentulous hinges, and so are more closely similar to *Edmondia*. The relationship of the new genus *Vacunella* is more problematical. It may represent a rather unexpected loss of specialization by the Carboniferous-Permian genus *Chaenomya*, with gain of ventricosity, reduction in posterior gape, and change in method of valve rotation, as shown by the different muscle scars. Or it may represent a divergence from pre-*Myonia* stock, with the gain of a pallial sinus and posterior gape, in becoming adapted to a burrowing habit.

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RESUMEN

DIAGNOSIS GENERICA DE ALGUNOS BIVALVOS EXCAVADORES DEL PERMICO DE AUSTRALIA

Se revisan las clasificaciones de Newell (1956) y de Dickins (1963), para algunos bivalvos permicos australianos. Detalles morfológicos no considerados por esos autores, tales como dentición y musculatura, apoyan el reconocimiento que hizo Dickins de cierto número de géneros, antes que la de Newell quien reconoce validez a unos pocos. Se dan las diagnosis genéricas para *Megadesmus* Sowerby, *Astartila* Dana, *Pyramus* Dana, *Myonia* Dana, *Notomya* McCoy, y *Pachynomya* Dun. Se crean dos nuevos géneros, *Globicarina* con la especie *Globicarina grossula* n. sp. como tipo, y *Vacunella* con *Allorisma curvatum* Morris. La última especie fué referida por los autores a *Chaenomya*, pero comparaciones detalladas con topotipos de *C. laevenworthensis* muestran importantes diferencias en forma, porción hiente anterior y musculatura. Se delinean las interrelaciones entre los géneros.



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