COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

BULLETIN No. 41.

LOWER PERMIAN PELECYPODS AND GASTROPODS FROM THE CARNARVON BASIN, WESTERN AUSTRALIA

BY

J. M. DICKINS.

Issued under the Authority of Senator the Hon. W. H. Spooner, Minister for National Development.

By Authority:
A. J. ARTHUR, Commonwealth Government Printer, Canberra.
(Printed in Australia.)

357/57.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

BULLETIN No. 41.

LOWER PERMIAN PELECYPODS AND GASTROPODS FROM THE CARNARVON BASIN, WESTERN AUSTRALIA

BY

J. M. DICKINS.

Issued under the Authority of Senator the Hon. W. H. Spooner, Minister for National Development.

By Authority:
A. J. ARTHUR, Commonwealth Government Printer, Canberra.
(Printed in Australia.)

357/57.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

Minister : SENATOR THE HON. W. H. SPOONER, M.M.

Secretary : H. G. RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

Director : P. B. NYE, O.B.E.

Deputy Director : J. M. RAYNER.

This Bulletin was prepared in the Geological Section.

Chief Geologist : N. H. FISHER.

Issued 31st July, 1957.

CONTENTS.

PRAEUNDULOMYA, A NEW GENUS OF PELECYPODS FROM THE PERMIAN ROCKS OF THE CARNARVON BASIN, WESTERN AUSTRALIA.

SUMMARY.

A new genus, *Praeundulomya,* has been erected to embrace forms from the Lower Permian rocks of Western Australia. The type species, *P. concentrica,* is described.

Species of the new genus are known from the Lyons Group, the Coyrie Formation, and the Bulgadoo Shale, in the Carnarvon Basin.

Praeundulomya is related to *Allorisma*-like forms such as *Edmondia sulcata* (Phillips), and is probably ancestral to *Undulomya* Fletcher.

INTRODUCTION.

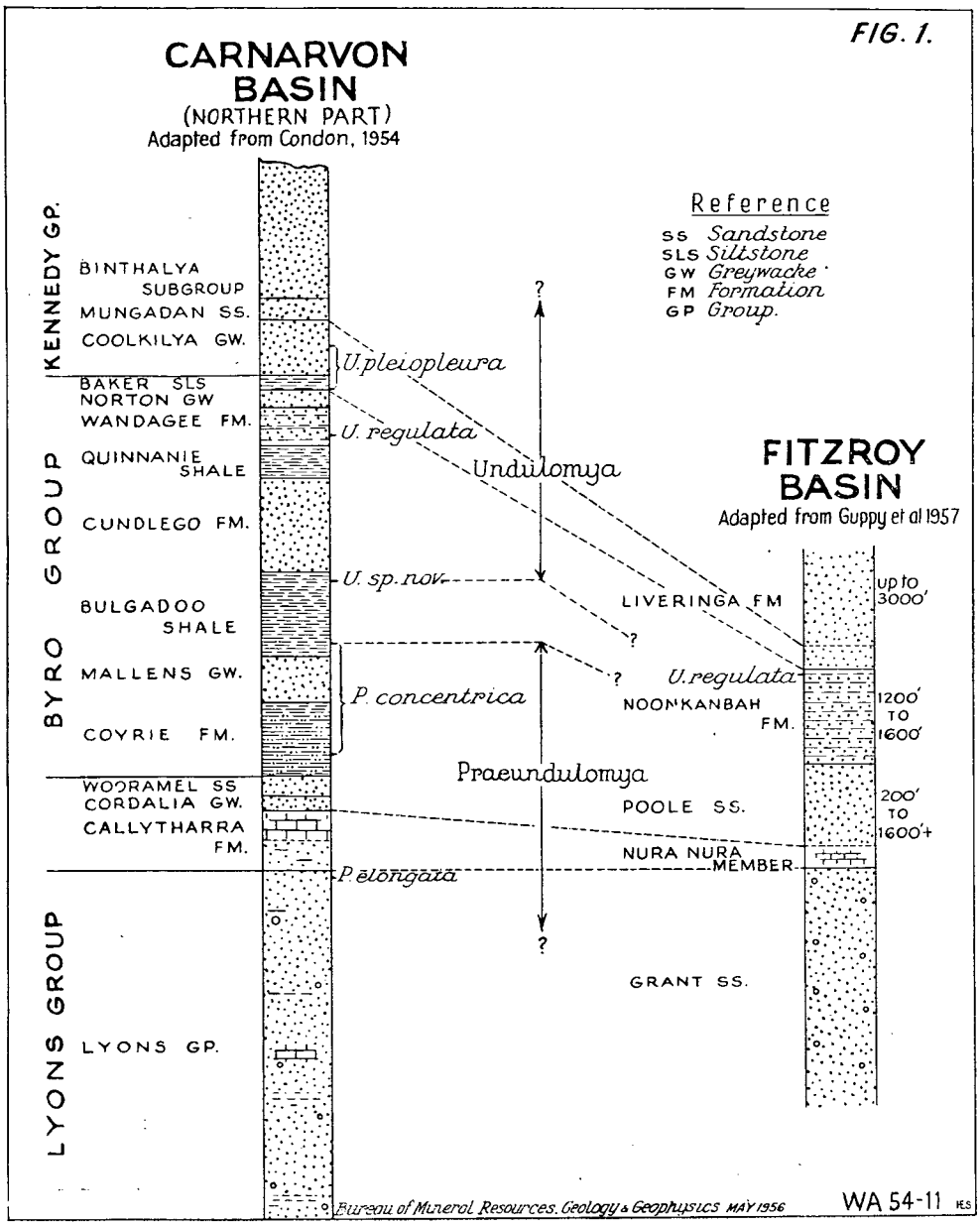
In 1946 Fletcher (p. 398) described a new genus *Undulomya,* with two species, from the Permian rocks of Western Australia. Both species, *U. rugulata* Fletcher (1946, p. 400, pl. 34, figs. 2 and 3; pl. 35, fig. 6) and *U. pleiopleura* Fletcher (1946, p. 399, pl. 34, fig. 1; pl. 35, figs. 1-5), are characterized by having V-shaped rugae or coarse ribs, an edentulous hinge with an elongated flattened ligament area running backwards from the umbo and two distinct furrows separated by a ridge, immediately below the ligament area and running from the umbo towards the posterior margin.

In 1956 another specimen of *Undulomya pleiopleura* from the Norton Greywacke or the Baker Formation of the Carnarvon Basin was described and figured; and it was suggested, on the basis of the shape and the presence of radiating lines of granules on the external surface, that the genus should be placed in the family Arcomyidae rather than in the Pholadomyidae (Dickins, 1956, p. 28, pl. 4, figs. 6-8).

In recent collections from Western Australia there are forms which, although closely related to *Undulomya* and previously considered to belong to *Undulomya* (Dickins in Hill, 1955, p. 100, and Dickins, 1956, p. 28), are distinguished by the presence of concentric rugae, the absence of V-shaped rugae, and the two posterior radiating grooves are less well developed. These forms occur in formations older than those containing *Undulomya* and a new genus is proposed for their reception. A new species of this genus occurs in the Lyons Group, but another species from the Coyrie Formation and the Bulgadoo Shale of the Carnarvon Basin will be used as a type because the material is better. The new genus and the type species are described here so that the name can be used in the description of the Lyons Group fauna.

STRATIGRAPHICAL DISTRIBUTION OF UNDULOMYA AND PRAEUNDULOMYA.

Fletcher (1946, p. 395) recorded *Undulomya rugulata* from the Wandagee Formation (*Calceolispongia* Stage of Teichert, 1941) and from the top beds of the Noonkanbah Formation at Mt. Marmion in the Fitzroy Basin. He recorded *Undulomya pleiopleura,* the type species, from the Coolkilya Sandstone of



Teichert (1950) (approximately Baker Formation plus Coolkilya Greywacke of Condon, 1954). In the Carnarvon Basin, in addition, at least one undescribed species of *Undulomya* occurs. It is found in the top beds of the Bulgadoo Shale, west of Moogooree Homestead. *Praeundulomya concentrica* sp. nov., the type of the new genus, occurs in the Coyrie Formation and the Bulgadoo Shale of the Carnarvon Basin. *Praeundulomya elongata* sp. nov., described in the following paper, is at present known only from the top part of the Lyons Group.

SYSTEMATIC DESCRIPTION.

Fam. ARCOMYIDAE Fischer.

Genus PRAEUNDULOMYA gen. nov.*

Type Species: Praeundulomya concentrica sp. nov.

Diagnosis: Shell similar in shape to *Undulomya,* distinguished by the presence of concentric rugae instead of V-shaped rugae. Posterior furrows

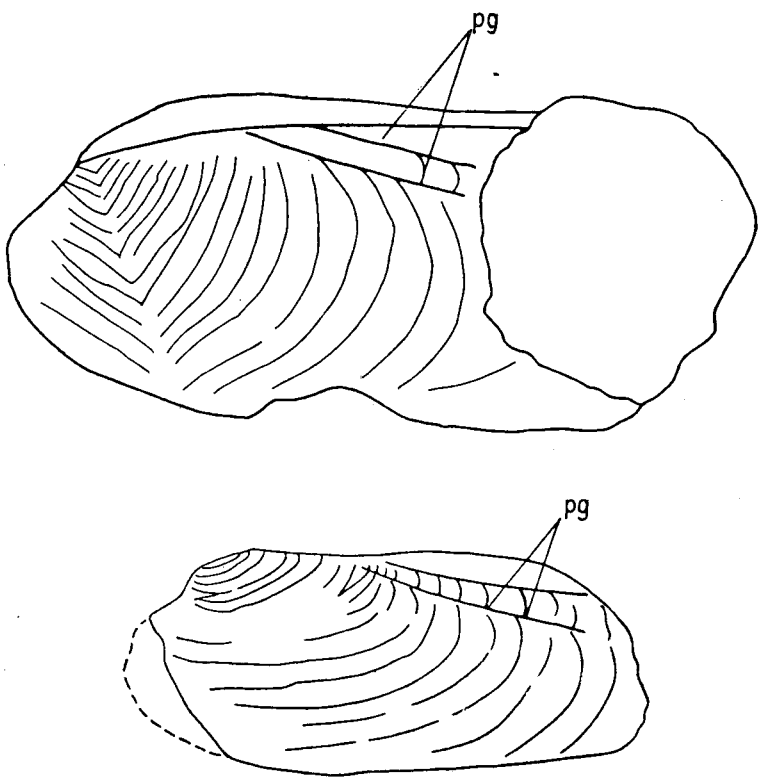


Fig. 2.—Shape and ribbing of *Praeundulomya* and *Undulomya.* Above: *U. pleiopleura* Fletcher. x1. Below: *P. concentrica* Dickins. pg = posterior groove. x1.

* *Prae,* before ; *Undulomya,* a genus of shells.

and ridge not as distinctly developed. Valves gape slightly at back; hinge edentulous, with elongated flattened ligament area extending backwards from umbo and widening and then narrowing towards rear of shell. Shell thin.

Discussion: The new genus occurs earlier than *Undulomya* and is no doubt ancestral to it. On the other hand it is more closely related to some Carboniferous *Allorisma*-like forms, especially *Edmondia sulcata* (Phillips) 1836 (Hind, 1899, p. 318) than is *Undulomya,* and it is probably intermediate. In *Edmondia sulcata* as figured by Hind the shape of the shell and the structure of the hinge are similar and the external surface is granulated. Although the rugae are of a similar character they diminish in number towards the rear and no posterior furrows or ridges appear to be present.

Fletcher (1946, p. 399, 400) has already suggested that *Sanguinolites insolitus* Thomas (1928, p. 228, pl. 6, figs. 6 and 7) from the Upper Palaeozoic of Peru may be related to *Undulomya.* The Peruvian species appears to belong to the genus *Praeundulomya.* The shape and the posterior grooves and ridge are similar and the ribbing corresponds to that of an incomplete *Praeundulomya. Sanguinolites kashmiricus* Reed (1932, p. 37, pl. 8, figs. 1-4a) from the Agglomeratic Slate of Kashmir may also belong to the new genus.

PRAEUNDULOMYA CONCENTRICA sp. nov.

(Plate 1, figs. 1-11, text fig. 2.)

Holotype: C.P.C. 2193, Coyrie Formation, type section.

Diagnosis: Shell not greatly produced in front of umbos; rugae or ribs and growth lines not parallel. Ribs increase in number towards the rear in such a way that in some specimens continuous ribs coming from the front truncate a number of ribs on the back part of the shell.

Description: Holotype (a bivalved shell): Umbos prosogyre, rising only slightly above the cardinal margin, almost touching. Behind the umbos the cardinal margin is straight and almost parallel to the ventral margin. The ligament is lodged in an elongated area behind the umbos, the ligament area extending for the full length of the cardinal margin. At the front end the ligament lies tucked under the umbos; posteriorly it broadens and apparently thins out towards the rear. In front of the umbos the cardinal margin is rounded and a distinct lunule is marked off from the rest of the shell.

The ligament area is bounded externally by a ridge, below which are two grooves, separated by a rounded ridge, which run from the umbo to the dorsal part of the posterior margin. The valves are more tumid towards the front, and the shell is tapered towards the back; there appears to have been a slight gape at the rear.

External Ornament—Left Valve: The early ribs are small, concentric and constant in number; seven or more such ribs are visible. In the more mature part of the shell (i.e. in the middle part of the shell) more ribs are added at the back than at the front so that a single rib at the front runs continuously to the rear,

where it encloses between it and the previous continuous rib four or five ribs. Towards the outside of the shell the ribs or rugae at the front run continuously to the back without cutting off extra ribs at the back, but in the front the ribs are concentric, whereas at the back the ribs transgress the growth lines and so approach the cardinal margin more rapidly than the growth lines. More ribs, which have no counterpart at the front, are added at the back part of the shell.

External ornament—Right valve: The ribbing of the right valve differs in that fewer ribs are inserted at the rear in the middle part of the shell.

Paratypes: Juvenile specimens show growth stages in the development of the shell. The ribs are concentric and parallel to the growth-lines and the posterior radiating grooves are poorly developed, and thus young shells resemble, much more closely than mature shells, the *Allorisma*-like forms of the Carboniferous.

The granulation of the external surface varies in different parts of the shell: at the back the granules form rows radiating from the umbo, but in other parts of the shell the granules are scattered irregularly.

DIMENSIONS (IN MM.).

—	Length.	Height.	Thickness.	Distance of Umbo from Front.
Holotype (both valves)	68 (estimated)	32	23	9 (estimated)
Paratype A (both valves)	74	29 (estimated)	22	8
Paratype B (right valve)	9	4	15	2
Paratype C (right valve)	22	10	2.5	4
Paratype E (both valves)	+110	63	38	24

Occurrence: P. concentrica is represented in the present collection by a large number of specimens from the Coyrie Formation and the Bulgadoo Shale.

Holotype and Paratype A—C.P.C.* 2193 and 2194—5 miles south-west of Moogooree Homestead, 5½ miles south-east by east of Donnelly's Well, 355 feet above base of Coyrie Formation, type section. Paratypes B & C—C.P.C. 2195 and 2196—same locality as holotype, 402-455 feet above base of Coyrie Formation. Paratypes D & E—C.P.C. 2197 and 2198—same locality and formation, 20 feet higher than holotype. Paratypes F & G—C.P.C. 2199 and 2200—same as for holotype. Specimens from Budgadoo Shale, B.M.R. Reg. No. F.20,836, 2 miles south-east of Donnelly's Well, about 100 feet above base of formation.

Discussion: Some specimens attain a large size, and in the late growth stages of these shells the posterior radiating grooves lose their distinctive character.

The ribbing varies somewhat in different shells and in some the truncation of the rear ribs in the middle part of the mature shell is not as distinct as in the holotype. The truncation is more distinct in left valves than in right valves.

* C.P.C.—Commonwealth Palaeontological Collection, housed in the Bureau of Mineral Resources, Canberra.

Apparently the shell was very thin, as it is rare to find the original shell material preserved; most of the specimens are internal or external impressions.

Praeundulomya concentrica appears to have affinities with *Sanguinolites insolitus* Thomas (1928, p. 228, pl. 6, figures 6-7), but Thomas's figures do not allow a satisfactory comparison. *P. concentrica* can be distinguished from *P. elongata,* a new species from the Lyons Group described in the next paper, in the following ways: the ratio of height to length is greater; *P. concentrica* tapers towards the rear whereas *P. elongata* is more evenly convex from front to rear; from the front *P. concentrica* is more tumid; in the middle part of mature shells *P. elongata* never has a large number of ribs at the rear truncated by continuous ribs; the posterior radiating grooves are more prominent in *P. concentrica.*

PELECYPODS AND GASTROPODS FROM THE LYONS GROUP, CARNARVON BASIN, WESTERN AUSTRALIA.

SUMMARY.

Seventeen species are described and figured—thirteen species of pelecypods belonging to twelve genera and four species of gastropods belonging to four genera. Of the pelecypods only two are referred to described species, and of the gastropods only one. The fauna can be called the "*Eurydesma* fauna"; it is found to have affinities with faunas with *Eurydesma* from South Africa, India, Eastern Australia, and South America. An examination of the occurrences of *Eurydesma* in the Carnarvon Basin and elsewhere indicates that where this form is found in great abundance it is associated with cold shallow-water sediments; frequently it occurs near the base of marine sequences. The shell structure of *Eurydesma* and *Deltopecten* and the hinge structure of *Deltopecten* are described and illustrated. It is considered that a new family, the Deltopectinidae, is required for the reception of *Deltopecten* and allied forms. Although the species described show a closer relationship to Upper Carboniferous species than do the faunas in the Carnarvon Basin found higher in the sequence, it is considered that the evidence as a whole indicates that the fauna is of a Lower Permian (Sakmarian) age.

INTRODUCTION.

The material described has been collected during a geological survey carried out since 1948 in the Carnarvon Basin by the Bureau of Mineral Resources. The collections thus represent the results of a comprehensive survey carried out over eight consecutive years. Condon (1954) has described the stratigraphy of the northern part of the area in some detail, and generalized stratigraphical columns are given by Thomas and Dickins (1954) and Dickins (1956). Several papers on the stratigraphy of the area are being prepared at present.

Since 1953 the Carnarvon Basin has been drilled in the search for oil.

The Lyons Group* is the oldest sequence containing marine Permian fossils and rests unconformably on earlier Palaeozoic or Precambrian rocks. The correlation, the character, and the manner of occurrence of the marine fossils are to be considered in detail in a separate paper by J. M. Dickins and G. A. Thomas, and only a summary account is included here. Although the Lyons Group crops out over a wide area and in many places is very thick (Condon, 1954, p. 40, records a section of 4,600 feet in the Williambury area) marine fossils occur at only a few places. Not only are the few fossiliferous horizons separated by non-fossiliferous strata in vertical section, but horizontally the fossil beds do not persist very far, except in the top fossiliferous beds of the Lyons Group. Where fossils do occur, however, large numbers of individuals may be present. Compared with the brachiopods, the molluscs, especially the pelecypods, predominate in number of species and in number of individuals. Up to the present no ammonoids have been collected.

The marine fauna of the Lyons Group forms a single assemblage: all the identifiable species present in the lowermost horizon, with one exception, are present in the topmost beds. Although certain forms are known only from the Lyons Group many continue into the Callytharra Formation, and there is no sharp faunal break to indicate that the top of the Lyons Group is definitely older than the Callytharra Formation. The Callytharra Formation is known to be of lowermost Artinskian age (see Thomas and Dickins, 1954). Indirect evidence of the age is given by the occurrence of Sakmarian ammonoids (Teichert and Glenister, 1952) in the Holmwood Shale of the Irwin River area of Western Australia, which recent field work shows to be probably correlable with the topmost part of the Lyons Group in the Callytharra Springs area.

The fauna as a whole does not appear to be contemporaneous with the Upper Carboniferous forms in other parts of the world; it is intermediate between those of the Upper Carboniferous and those of the Artinskian and younger Permian. For these reasons it is not considered likely that any of the marine fossils of the Lyons Group are of Carboniferous age, although at

* M. A. Condon (personal communication) states that the formation below the Callytharra Formation in the Callytharra Springs area, which is here included in the Lyons Group, should not be so included. This formation, which will be named in a forthcoming publication, includes all the marine fossils described here from Callytharra Springs and Gap Pool.

present the evidence is not conclusive. The specimens described in this paper are all from the upper part of the Lyons Group and are thus referred without hesitation to the Lower Permian.

In the Carnarvon Basin the marine horizons in the Lyons Group are intimately associated and interbedded with deposits of glacial origin.

Among the Permian faunas from Western Australia, it is the fauna from below the Callytharra Formation that is most closely related to that from the Permian rocks of eastern Australia. In Western Australia in Artinskian time, the early fauna was gradually replaced by a fauna related to that of Timor, South-East Asia, and India, whereas eastern Australia was apparently partly isolated and the main development was an indigenous one based on the earlier fauna.

Only a single mollusc (*Nuculana lyonsensis,* Dickins, 1956, p. 8, plate 1, figs. 7-9) has been described from the Lyons Group. The following additional forms are described in the present paper:—

Pelecypoda—		
Fam. Nuculanidae	..	*Nuculana darwini* (de Koninck) 1877.
Fam. Modiolopsidae	..	*Stutchburia variabilis* sp. nov.
Fam. Edmondiidae	..	*Astartila condoni* sp. nov.
		Astartila? obscura sp. nov.
		Pachydomus? sp.
Fam. ?	..	*Pachymyonia occidentalis* sp. nov.
		Chaenomya sp. nov.
Fam. Leiopteriidae	..	*Leiopteria? carrandibbiensis* sp. nov.
Fam. Eurydesmidae	..	*Eurydesma playfordi* sp. nov.
Fam. Arcomyidae	..	*Praeundulomya elongata* sp. nov.
Fam. Trigoniidae	..	*Schizodus crespinae* sp. nov.
Fam. Deltopectinidae	..	*Deltopecten lyonsensis* sp. nov.
Fam. Aviculopectinidae	..	*Aviculopecten tenuicollis* (Dana) 1847.
Gastropoda—		
Fam. Pleurotomariidae	..	*Mourlonia? lyndonensis* sp. nov.
		Ptychomphalina umariensis (Reed) 1928.
Fam. Euomphalidae	..	*Keeneia carnarvonensis* sp. nov.
		Platyschisma? sp. nov.

PALAEOECOLOGY OF EURYDESMA.

An examination of the recorded occurrences of *Eurydesma* shows how frequently the names "*Eurydesma*-beds", "*Eurydesma*-zone", &c., are used, indicating that where *Eurydesma* is found it frequently occurs in great numbers or forms a conspicuous part of the fauna. An examination of the occurrences also shows that where *Eurydesma* is found in large numbers it is frequently found in coarse sediments—sand-size or coarser. It is also often reported

from near the base of marine sequences. This is true of the Carnarvon Basin except that it is not clear that the occurrences are near the base of marine sequences.

The known occurrences of *Eurydesma* are plotted on the accompanying sketch map of the Carnarvon Basin. A single species, *Eurydesma playfordi* sp. nov., is present at all localities except possibly at the Lyndon River locality, where the material is insufficient for a specific determination.

In New South Wales, David (1950, p. 338) describes the presence of a large number of *Eurydesma* associated with conglomerates containing glacial erratics in the Allandale of the Hunter Valley. Such an occurrence is figured in David's Plate 32. Near Cranky Corner, sandstone with occasional boulders, densely packed with *Eurydesma* and other forms, is recorded in the Allandale Stage. On the north coast of New South Wales a limestone is referred to as the "*Eurydesma*-limestone".

In Tasmania, Banks (1952, p. 67) states "In most areas of the Permian in Tasmania there is a zone low in the sequence which is comparatively rich in *Eurydesma* spp.". At Maria Island and elsewhere this zone is found closely associated with underlying glacial beds. Voisey (1938) had also previously recorded such occurrences. In Queensland "*Eurydesma* beds" are also recorded in the lower part of the sequence (see David, 1950).

In India, Waagen (1891) and Reed (1936) record numbers of *Eurydesma* in the Salt Range associated with boulder beds and conglomerates containing glacially striated pebbles. In Kashmir *Eurydesma* is associated with conglomeratic deposits (Reed, 1932). In South America Harrington (1955) records large numbers of *Eurydesma* from the Bonete Formation associated with the glacial deposits in the underlying Sauce Grande Formation.

In the Carnarvon Basin *Eurydesma* is associated with comparatively coarse sediments. In the Callytharra Springs/Gap Pool area *Eurydesma playfordi* is contained in a fine to medium sand, often very silty and sometimes calcareous. Many coarse to very coarse grains are present, with pebbles up to an inch or more in diameter. The sands are lenticular with large numbers of *Eurydesma,* the whole having the form of a shell bank. Also contained in these lenses are thirteen other species of molluscs, one brachiopod, several crinoids, a few bryozoa, and wood fragments—some more than an inch in diameter. On the Gascoyne River, west of Jimba Jimba Homestead, numerous *Eurydesma* occur with the gastropod *Keeneia carnarvonensis* sp. nov., the brachiopod *Trigonotreta* sp. nov., and wood fragments, in a fine arkosic conglomerate with pebbles up to half an inch across. Many of the grains are composed of fresh felspar. Sediments containing *Eurydesma playfordi* near Baracooda Pool vary from a fine to medium sand to a sandy limestone, but scattered throughout are coarse to very coarse grains and pebbles. Other fossils present at this locality are *Deltopecten lyonsensis, Trigonotreta* sp. nov., and Fenestellidae. On the Lyndon River the sediment is a very silty or clayey medium to coarse sand with many pebbles and containing seven species of molluscs, one brachiopod, *Trigonotreta* sp. nov., a few species of crinoids, and bryozoa.

Another feature of the occurrences in the Carnarvon Basin is the predominance of molluscs. Sloan (1955), in a study of the palaeoecology of Pennsylvanian marine shales, uses a faunal index of brachiopods/brachiopods + molluscs as an indicator of depth. On this basis the occurrences with *Eurydesma* would have a very low faunal index, indicating shallow water. These lines of evidence indicate that *Eurydesma* lived in shallow-water near-shore marine conditions.

In the accompanying map showing the outcrop of the Lyons Group and the occurrence of *Eurydesma* in the Carnarvon Basin, *Eurydesma* is found close to the periphery of the present outcrop of Permian sediments. The eastern boundary of the Permian rocks is formed by the Lyons Group, which rests unconformably on earlier Palaeozoic or Precambrian rocks to the east.

In Australia it has been common for beds near the base of marine sequences in widely separated basins to be correlated because they contain abundant *Eurydesma* of the same or similar species: for example, the "*Eurydesma*-beds" of Tasmania have been correlated with the "*Eurydesma*-beds" of the "Lower Marine" of the Hunter Valley. The present analysis shows that care is necessary in using such a correlation. Locally indeed and perhaps within a basin, the correlation may be quite valid, but it needs to be used very cautiously for accurate interbasinal correlation.

Not only, however, is *Eurydesma* closely associated with near-shore deposits, but it is almost everywhere associated with glacial deposits. As shown above, species of *Eurydesma* are interbedded with deposits of glacial origin in New South Wales and Western Australia and are closely associated, if not interbedded, with glacial deposits in Tasmania, the Salt Range, and South America. *Eurydesma* is also associated with glacial deposits in South Africa and at Umaria in Peninsular India. The only area where *Eurydesma* is not known to be associated with such deposits is in the Agglomeratic Slate of Kashmir, and even here it is possible that sediments of glacial origin are present.

It can be concluded that the presence of *Eurydesma* in large numbers indicates cold, shallow water conditions.

SYSTEMATIC DESCRIPTIONS.

Class PELECYPODA.
Fam. NUCULANIDAE Stoliczka
Genus NUCULANA Link.

Type Species: Arca rostrata Chemnitz (1784, p. 206, pl. 55, figs. 550 and 551.)

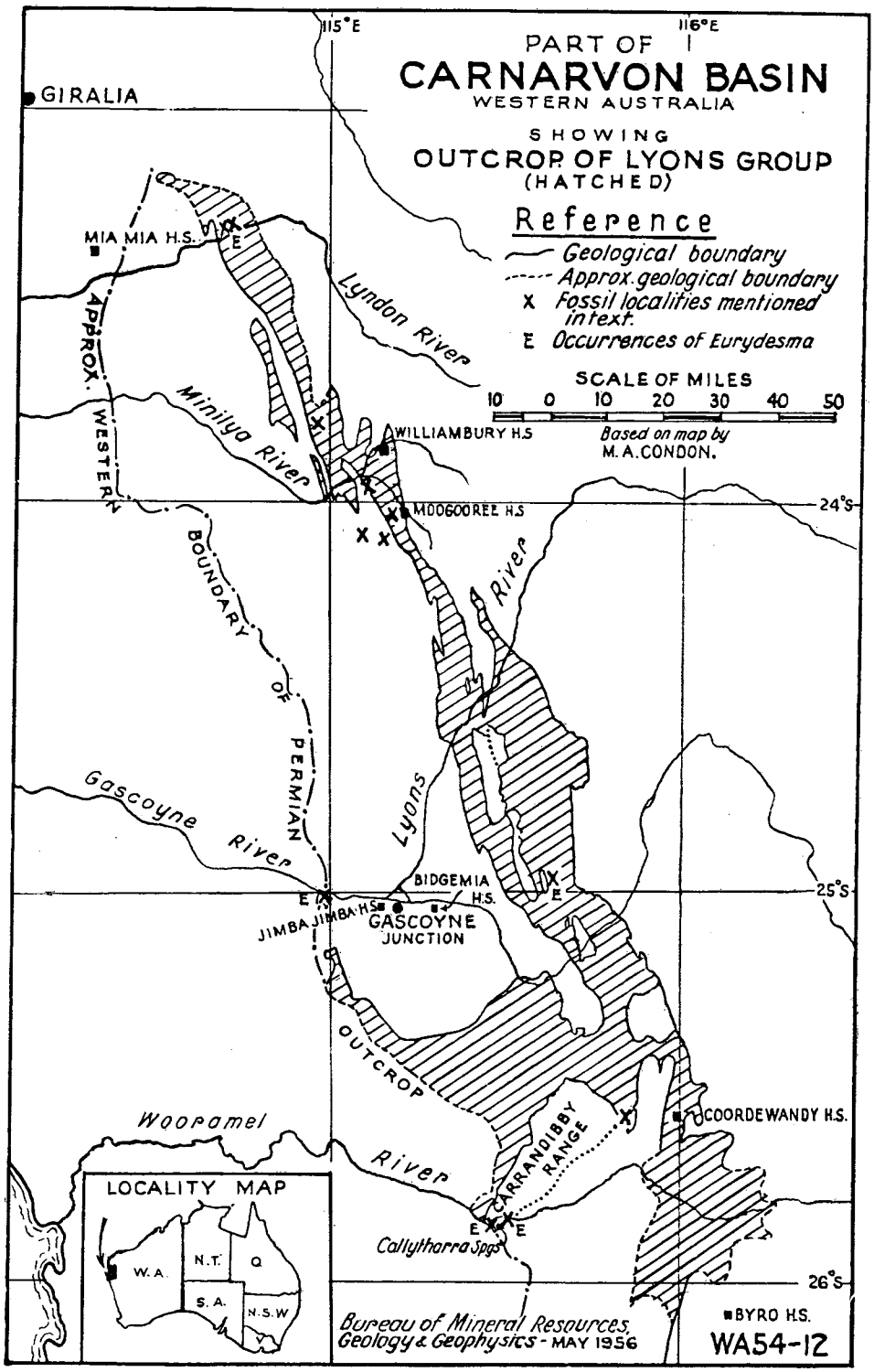
NUCULANA DARWINI (de Koninck) 1877.
(Pl. II, figs. 1-6.)

1877. *Tellinomya darwini* de Koninck, p. 147, pl. 16, fig. 9.

1945. *Nuculana darwini*, Fletcher, p. 306, pl. 21, figs. 1-2, pl. 22, figs. 1-2.

Holotype: Destroyed in Garden Palace Fire, 1882.

Neotype: F.41409, Australian Museum Collection, designated by Fletcher (1945, p. 306).


PART OF
CARNARVON BASIN
WESTERN AUSTRALIA
SHOWING
OUTCROP OF LYONS GROUP
(HATCHED)
Reference
Geological boundary
Approx. geological boundary
X Fossil localities mentioned in text.
E Occurrences of Eurydesma
SCALE OF MILES
10 0 10 20 30 40 50
Based on map by
M. A. CONDON.
115°E
116°E
24°S
25°S
26°S
GIRALIA
MIA MIA H.S.
APPROX. WESTERN BOUNDARY OF PERMIAN OUTCROP
Lyndon River
Miniliya River
WILLIAMBURY H.S
MOOGOOREE H.S
Lyons River
Gascoyne River
BIDGEMIA H.S.
JIMBA JIMBA H.S
GASCOYNE JUNCTION
Woopamel River
CARRANDIBBY RANGE
Callytharra Spgs
COORDEWANDY H.S.
BYRO H.S.
LOCALITY MAP
W.A.
N.T.
Q
S.A.
N.S.W.
Bureau of Mineral Resources, Geology & Geophysics - MAY 1956
WA54-12

Description: Umbos not very sharp and directed slightly towards the back; the margin of the shell in front of the umbo forms a uniform oval. The external surface of the shell is uniformly convex except for the area dorsal and posterior to the posterior rounded umbonal ridge, which is relatively flattened. The external surface is covered by more than twenty very fine concentric ribs. The pallial line is simple; the posterior adductor is situated on and elongated along the posterior umbonal ridge. The anterior edge of the muscle is deeply impressed. The anterior adductor is oval, elongated in a dorso-ventral direction, and situated high on the flanks of the valve. The pedal scar is not clearly visible but appears to be between the dorsal end of the anterior adductor and the umbo. The dentition is not shown in detail in any of the shells, but taxodont teeth are visible in Hypotype D. The umbonal angle is variable, as shown in dimensions, but in all specimens it is obtuse as compared with certain other species, such as for example *N. thomasi* Dickins.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.	Umbonal Angle.
Hypotype A (right valve)	7.5	4.5	1	126°
Hypotype B (internal left valve)	7.0	4.5	1.5	123°
Hypotype C (right valve)	7.5	4	1	129°
Hypotype D (internal bivalve)	8.0	4.5	2.5	130°

Occurrence: Hypotypes A-D—C.P.C. 2201, 2202, 2203 and 2204 respectively —1 mile west of Callytharra Springs, Byro Station, top 15 feet of the Lyons Group. Other specimens also occur at the same locality, 12 feet below the Hypotype horizon (more than 30 specimens).

Discussion: The specimens described are from a single locality where they are of a uniformly small size. Although they are consistently smaller than the neotype they agree closely in the proportion of the dimensions, the shape, and the character of the external ribbing. The umbonal angle of both is also similar and possible differences may be due to variation. As shown in the dimensions, this character varies considerably in the Western Australian specimens. A lesser number of ribs would be expected in smaller shells. In New South Wales *N. darwini* occurs in the Branxton Stage of the Upper Marine Beds (= Branxton Sub-group of the Maitland Group (Hanlon in Hill, 1955, p. 94)) of the Hunter Valley.

Nuculana thomasi Dickins (1956, p. 10, plate 1, figures 1, 2, 10) has a more upright umbo, the umbonal angle is less, and the anterior part of the shell is less inflated than in *N. darwini*. In *N. basedowi* Eth. fil. (1907, p. 8, plate 6, figure 6), on the other hand, the anterior part of the shell is more inflated and the umbo is more distinctly directed towards the back. Both *N. thomasi* and *N. basedowi* occur much higher in the Permian sequence in Western Australia.

The specimens show some resemblance to forms assigned to *N. bellistriata* (Stevens) (1858, p. 261), first described from the Pennsylvanian of the United States of America, but also recorded from Permian rocks.

Fam. Modiolopsidae.

Genus Stutchburia Etheridge Junr. 1900.

Type Species: Orthonota? costata Morris (1845, p. 273, plate 11, figure 1) by original designation of Etheridge Junr. (1900, p. 180). The family position of this genus has been discussed by Dickins (1956, p. 13).

Stutchburia variabilis sp. nov.

(Plate II, figures 7-14.)

Holotype: C.P.C. 2205, 1-4/5th miles from Callytharra Springs. Top bed of Lyons Group.

Diagnosis: Rather elongated transversely with greatest thickness of valve nearer rear of shell than front—about half-way between umbo and rear. Anterior adductor approximately parallel to front part of ventral margin: buttress ridge set at about 45° to cardinal margin. Rounded ridge from umbo to posterior margin forms distinct area on posterior dorsal part of shell. Posterior radial ribbing variable; in some specimens confined to dorsal flanks, in others extending down over ventral flanks, and in some specimens possibly absent altogether.

Description: Holotype: (internal impression of a left valve). The anterior adductor scar is oval and the pallial line simple. The posterior adductor and the pedal scar are not visible. The ligament is deep-set. A very wide, shallow sulcus runs from the umbo towards the ventral margin about midway between the anterior adductor scar and the rounded posterior ridge, forming a slight sinuation of the cardinal margin.

Paratypes: The external ornament is composed of fine concentric growth-lines, and, in most cases where the ornament is visible, of ribs radiating backwards from the umbo.

In Paratype A, an external impression of a right valve, no radiating ribs are visible, with the possible exception of the ridge bounding the escutcheon.

Paratype E shows the escutcheon and radial ribbing.

The escutcheon is bounded by a sharp ridge. In addition to this ridge two ribs radiate out from the umbo to the posterior margin. In Paratype F at least five ribs in addition to the ridge bounding the escutcheon are present. The ribs are not closely spaced and extend well down on the ventral flanks of the specimen. Two faint ribs are visible in Paratype D.

In none of the specimens is it possible to see whether a lunule is present.

DIMENSIONS (in mm.).

	Length.	Height.	Thickness.
Holotype (internal impression of a left valve)	70	27	10
Paratype A (external impression of a right valve) ..	67 (estimated)	33	10 (estimated)
Paratype B (internal impression of left valve)	43	21	8
Paratype C (internal impression of right valve) ..	..	35	12
Paratype D (internal impression of right valve) ..	62 (estimated)	31	11
Paratype E (bivalved specimen)	28	14	12
Paratype F (left valve)	..	14	4

Occurrence: Holotype and Paratype A (same piece of rock)—C.P.C. 2205 and 2206—1-4/5 miles slightly south of west of Callytharra Springs, Byro Station, top bed of Lyons Group. Paratypes B-F—C.P.C. 2207, 2208, 2209, 2210, and 2211 respectively—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. Other localities: About 3 miles north-east of Round Hill Well, 1 mile west of Kialawibri Creek road crossing, Winning Station; top part of Lyons Group. Two and one-half miles slightly south of south-east of South Branch Well, 9½ miles south-south-east of Williambury Homestead; top beds of Lyons Group. A total of more than fifteen specimens.

One specimen, possibly two, of *S. variabilis* also occur in the top beds of the Callytharra Formation, about six miles south-south-east of Plant Well, Coordewandy Station.

Discussion: All the specimens included in this species are united by their similar dimensions and their possession of a distinct rounded posterior umbonal ridge and a median sulcus. The number of ribs, however, varies considerably, although the spacing of the ribs does not alter significantly. *S. variabilis* appears to be most closely related to *Stutchburia? randsi* (Eth. fil.) (1892, p. 275, plate 14, figure 14) from the Permian Gympie beds of Queensland. Etheridge, however, makes no mention in his description of the median sulcus, the distinct posterior umbonal ridge, or the greatest tumidity being near the rear of the shell, and these characters will serve to differentiate the two species. Also in Etheridge's figure the ribs of *S.? randsi* are shown closer together than in *S. variabilis*. The type species *S. costata* (Morris) (1845, p. 273, plate 11, figure 1) from the Permian Upper Marine beds of New South Wales differs from the Western Australian species in possessing a greater number of more closely spaced ribs. Another closely related species is *Stutchburia? biplex* (de Koninck) (1877, p. 282, plate 19, figure 1), also from the Upper Marine beds of New South Wales. *S. variabilis* is readily distinguished from *S. muderongensis* Dickins (1956, p. 14, plate 1, figures 12-17), the only other species of *Stutchburia* described from Western Australia. *S. muderongensis* differs in shape and entirely lacks posterior radial ribbing and a median sulcus.

Fam. EDMONDIIDAE King 1849.

Hind (1898, p. 253) places the genera *Cardiomorpha* de Koninck (1844, p. 101), *Edmondia* de Koninck (1844, p. 66), *Scaldia* de Ryckholt (1852, p. 67), and *Sedgwickia* McCoy (1844, p. 61) in the family Edmondiidae. He considered that *Broeckia* de Koninck (1885, p. 19) was a synonym of *Edmondia*. To these must be added *Astartila* Dana (1847, p. 155) and possibly *Pachydomus* Morris (1845, p. 271). The position of *Cleobis* Dana (1847, p. 154) and *Pyramus* Dana (1847, p. 156) will depend upon the choice of type species for these two genera.

The members of this family are characterized by an oval shape, no lunule distinctly marked off from the rest of the shell, an opisthodetic external ligament, and a hinge either edentulous or with a single blunt tooth.

The relationships of the genera within the family are not altogether clear, because the characters of some of the type species of the genera are not fully known. For instance, the hinge of *Isocardia unioniformis* Phillips (1836, p. 209, plate 5, figure 18), the type of *Edmondia*, is not known with certainty. The relationship of *Astartila* and *Cardiomorpha* has been dealt with previously (Dickins, 1956, p. 16).

Genus ASTARTILA Dana 1847.

Type Species: Astartila intrepida Dana (1847, p. 155; 1849, p. 689, plate 3, figure 5) formally designated by Dickins (1956, p. 16). This species, however, has previously been named as type by Stoliczka (1871, p. 275).

ASTARTILA CONDONI sp. nov.

(Plate III., figures 7-11.)

Holotype: C.P.C. 2212, one mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: Astartilid shell with external ornament of coarse concentric ribs or rugae. Only a few ribs added posteriorly; ribs increasing in size towards the rear. Beak distinctly prosogyre: greatest convexity of the shell is about one-third of the shell-length from the rear.

Description: Holotype (a left valve): No distinct lunule is present although in front of the umbo there is a flattish smooth area on which no rugae but only fine lines of growth are present. Over the main part of the shell the number of rugae is constant. Near the ventral margin, however, two ribs are added at about one-third of the shell-length from the front. Twenty ribs are visible altogether. The shell has a humped appearance because the greatest convexity is towards the rear and the umbo is pointed distinctly towards the front.

Paratypes (internal impressions of right and left valve): The anterior adductor muscle scar is oval, elongated dorso-ventrally with the pedal muscle slightly above and towards the rear. The pedal muscle scar is elongated parallel to the dorsal margin, in front of the umbo. A shallow groove runs down in front of the umbo towards the lower margin, but dies out before reaching

the lower side of the anterior adductor muscle. The pallial line is not visible. The posterior adductor muscle is oval and situated on the slightly flattened area dorsal to the rounded crest running from the umbo to the posterior margin. In Paratype A, a left valve, a shallow groove occurs in the cardinal margin immediately behind the umbo, and in Paratype B, a right valve, the impression of a tooth-like projection lies in the corresponding position.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.	Distance of Greatest Convexity from Rear.
Holotype	38	30	14	16
Paratype A	50 (estimated)	36 (estimated)	13	18 (estimated)
Paratype B	..	33	12	..

Occurrence: Holotype C.P.C. 2212—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. Paratypes A and B—C.P.C. 2213 and 2214—3 miles west of Moogooree Homestead, 1,250 feet below top of Lyons Group, which is here about 3,500 feet thick (M. A. Condon, personal communication). The species is represented only by the three specimens described in this paper.

Discussion: Shells of this species could easily be confused with small specimens of *Pachydomus?* sp. which they closely resemble in shape. In *A. condoni,* however, no thick hinge plate is developed as in specimens of *Pachydomus?* sp. of similar size, and the two posterior ridges on the internal impressions of *Pachydomus?* sp. are not present. The shape of the hinge-plate is also different. This species is readily distinguished from *Astartila blatchfordi* (Hosking) (1931, p. 30, plate 7, figures 4a-b; 5), and *Astartila fletcheri* Dickins (1956, p. 17, plate 2, figures 8-9) by its different shape. In both these species the number of rugae increases markedly by intercalation towards the rear, differing from *A. condoni.* The new species shows some resemblance to the shell described as *Astartila ovalis* (McCoy) 1847 by Reed (1932, p. 54, plate 7, figure 6) from the Lower Permian Agglomeratic Slate of Kashmir. The shape is similar in both but unfortunately Reed's data do not allow a comparison of the important convexity of the shell. The new species does not closely resemble McCoy's original figures of *Astartila ovalis* (McCoy) (1847, plate 14, figure 4).

A. condoni has been placed in the genus *Astartila* because of its general resemblance in shape, size, and nature of the rugae, to *A. blatchfordi* and *A. fletcheri. Edmondia, Scaldia,* and *Pachydomus* apparently have a well-developed hinge-plate. If this is so, the poor development of the hinge-plate in *A. condoni* would separate it from these genera.

The species has been named after Mr. M. A. Condon, Assistant Chief Geologist of the Bureau of Mineral Resources, who collected a number of the specimens described in this paper.

ASTARTILA? OBSCURA sp. nov.

(Plate III., figures 1-6.)

Holotype: C.P.C. 2215, 1 mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: An *Astartila*-shaped shell without rugae and with a comparatively smooth external surface. Umbo very prominent; very distinct posterior umbonal ridge.

Description: Holotype (a bivalved shell): Umbo prosogyre, very distinct, rising high above the hinge-line and at the back forming a distinct rounded umbonal ridge or shoulder; at the front there is no distinct umbonal ridge, but the umbo passes gradually into the anterior lobe of the shell. The anterior lobe projects distinctly in front of the umbo and apparently no distinctly marked off lunule is present. The anterior, ventral and posterior margins form a smooth arc of a circle. No rugae are present, but only low rounded ridges and grooves formed by the concentric growth-lines. These do not increase in number towards the back of the shell, but increase in width over the body of the shell and then diminish in width towards the posterior margin where the shell narrows again. The ligament is opisthodetic and external. The musculature and dentition are not shown.

DIMENSIONS (in mm.).

—	Height.	Length.	Thickness.	Height of Umbo above Hinge-line.
Holotype (bivalve)	36	33 (estimated)	24 (two valves)	9
Paratype A (left valve)	46	44 (estimated)	14	10 (estimated)
Paratype B (left valve)	42	40	12	..

Occurrence: The species is represented by at least six specimens from one locality. None of the specimens is complete.

Holotype, Paratype A. and B—C.P.C. 2215, 2216 and 2217 respectively—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group.

Discussion: From the present material it is not clear to what genus this species belongs, but on the grounds of its general similarity in external appearance to a number of Eastern Australian members of the genus *Astartila* it is doubtfully referred to this genus.

The species appears to be most closely related to *Edmondia nobilissima* de Koninck (1877, p. 269, plate 20, figure 2) from the Farley Stage of the Permian of New South Wales. At first it was considered that the Western Australian specimens should be referred to this species, but specimens from the Farley Stage kindly lent through the courtesy of Mr. H. O. Fletcher, of the Australian Museum, Sydney, show that the Western Australian specimens belong to a new species. Besides being larger, the New South Wales specimens are less tumid and no distinct posterior umbonal ridge is present.

The dimensions of a specimen of *Edmondia nobilissima* from the Farley Stage are (in mm.)—

AUSTRALIAN MUSEUM No. 6586.

—	Height.	Length.	Thickness.	Height of Umbo above Hinge-line.
(Left valve)	82	80	18	15

Genus PACHYDOMUS Morris, 1845.

Type Species: Megadesmus cuneata J. de C. Sowerby (1838, p. 15, plate 1, figure 3), by subsequent designation of Stoliczka (1871, p. 274).

Discussion: the name *Pachydomus* was proposed by Morris (1845, p. 271) to replace *Megadesmus* J. de C. Sowerby (1838, p. 15) this generic title, according to Morris, having been previously used " by Bowdich for a genus of fluviatile *Conchifera* ". Four species were described by Sowerby and were available for subsequent designation as type of the genus—*Megadesmus globosa* (p. 15, plate 3, figures 1-2), *M. antiquata* (p. 15, plate 1, figure 2), *M. cuneata* (p. 15, plate 1, figure 3) and *M. laevis* (p. 15, plate 1, figure 1). An examination of a plastc-type of Sowerby's figured specimen of *M. cuneata,* kindly supplied by the British Museum (Natural History), suggests that if this species is selected as type of *Pachydomus, Notomya* McCoy (1847, p. 303) may become a synonym of *Pachydomus,* and a new generic name may be required for forms like *M. globosa* which are less elongated laterally and more inflated.

PACHYDOMUS? sp.

(Plate IV., figures 1-4; text-figure 3.)

Description: A large transversely elongated shell; the umbo is tumid and prominent, turned towards the front, and dominates the anterior part of the shell. The anterior margin does not extend far in front of the umbo, which stands well above the hinge-line. The greatest convexity of the shell is about midway between the anterior and posterior margins. The anterior adductor muscle is oval, elongated dorso-ventrally, and is situated in the corner formed by the junction of the anterior and ventral margins. The pallial line leaves

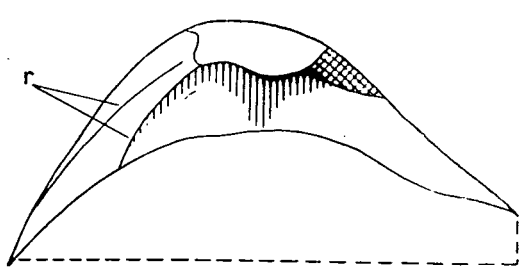


Fig. 3.—*Pachydomus*? sp. Impression of inside of hinge-plate showing posterior ridges (see also Pl. IV., fig. 2). x1.

the anterior adductor at about its midpoint. The posterior adductor muscle and the posterior part of the pallial line are not visible. The hinge is composed of a thickened hinge-plate, but the detailed character of the hinge is not visible. Inside the hinge-plate at the posterior end, however, are two grooves which show as ridges on the impression. The ridges radiate from the umbo, the posterior one being more rounded than the anterior. Externally the shell is smooth or with low rounded rugae and fine concentric lines of growth.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Figured specimen (right valve)	75	63	21
C.P.C. 2219 (left valve)	64	48	20
C.P.C. 2220 (left valve)	67	53 (estimated)	20

Occurrence: Figured specimen—C.P.C. 2218—3 miles west of Moogooree Homestead, 1,250 feet below top of Lyons Group. C.P.C. 2219 and 2220—about 3¾ miles north-east of Round Hill Well, 700 feet west of Kialawibri Creek road crossing, Winning Station, top part of Lyons Group. Four specimens from locality of figured specimen and nine from Winning Station.

Discussion: Most of the specimens of this species are incomplete and the details of the hinge are not shown. The Western Australian shells have been compared with a plaster cast of the holotype of *P. globosa* (J. de C. Sowerby) (1838, plate 3, figures 1-2) from the Permian of the Hunter River valley of New South Wales, which has been kindly provided by the British Museum (Natural History), London. *Pachydomus?* sp. is smaller, but the external shape and ornament are similar. The beak of the holotype of *P. globosa* is sharper but the position and character are similar.

Fam. ?

Genus PACHYMYONIA Dun 1932.

Type Species: Maeonia morrisii Etheridge Junr. (1919, p. 186, Plate 28, figures 7, 8), by original designation of Dun (1932, p. 411).

Discussion: The relationship of *Pachymyonia* and *Myonia* (= *Maeonia*) Dana 1844, a closely related genus, both originally described from the Permian of New South Wales, to other elongated posteriorly carinate Middle and Upper Palaeozoic genera is not clear. *Sanguinolites angustatus* (Phillips) 1836 (= *S. discors* McCoy 1844), the type of *Sanguinolites* McCoy 1844 (see Dickins, 1956, p. 20), is an elongated form with a posterior carina (Hind, 1900, pl. 40, figures 1, 2), and appears to differ sufficiently in shape from *Pachymyonia morrisii,* the type of *Pachymyonia,* and shells included in *Myonia* (see Fletcher, 1932) for *Pachymyonia* and *Myonia* to stand as separate genera. The character of the hinge does not appear to be known with certainty in any of these shells.

Pachymyonia morrisii and shells included by Fletcher in *Myonia* (= *Maeonia*) differ in shape from typical species of *Sphenotus* Hall (1885, p. xxxiii) and cannot be assigned to this genus. Judged from the original figure of *Cypricardia cymbaeformis* J. de C. Sowerby (1839, p. 602, plate 3, figure 10), the type species of *Goniophora* Phillips (1848, p. 264), the Australian type species also cannot be placed in this genus.

In place of the family name Caelonotidae used by Hind (see Dickins, 1956, p. 20) a new family name Sanguinolitidae could be erected for the reception of *Sanguinolites* and closely related genera. *Pachymyonia* would probably belong in this family, but since the relationship of *Pachymyonia* to *Sanguinolites* is not clear, the position is left open in this paper.

PACHYMYONIA OCCIDENTALIS sp. nov.

(Plate IV, figures 5-9.)

Holotype: C.P.C. 2221. One mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: Shell not particularly transversely elongated but strongly inflated and with a very distinct carina running from the umbo back towards the junction of the posterior and ventral margins.

Description: Holotype (a bivalved specimen): Shell rather inequilateral but apparently equivalved. Umbos not particularly prominent; turned towards the front. Anterior and ventral margins are rounded and merge imperceptibly. The posterior margin, however, is straighter and meets the ventral margin in a sharp angle where the carina reaches the outside of the shell. The carina is one of the most distinctive features of the shell, which it divides into two parts—an anterior gently rounded part and a posterior flattened part. The anterior part is ornamented with concentric rugae less than 1 mm. high with about four rugae in 6 mm. Fine concentric growth-lines are also visible. In the right valve is the impression of fine radiating ornament, about five radiating lines per millimetre. The posterior flattened part is smooth except for concentric growth-lines. The shell appears to gape front and back.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Holotype (bivalved specimen)	30	19	18
Paratype (right valve)	27	18	8.5

Occurrence: Known only from holotype and paratype—C.P.C. 2221 and 2222 respectively, 1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group.

Discussion: Pachymyonia occidentalis sp. nov. is the first species of this genus described from Western Australia. It can be readily distinguished by its shape from the two species—*P. morrisii* (Etheridge) and *P. etheridgei* Dun (1932, p. 412, plate 51, figures 2-3, plate 52, figure 6)—which have been

described from New South Wales. Like both these species, however, it has a very distinct carina and the valves are very inflated. The two specimens are impressions and no shell material has been preserved.

Fam. ?

Genus CHAENOMYA Meek 1865.*

Type Species: Allorisma? leavenworthensis Meek and Hayden (1858, p. 263) by original designation of Meek (1865, p. 42).

Discussion: Chaenomya is closely related to *Allorisma* King, from which it can be separated by a more prominent posterior gape and the distinct recurving of the back part of the dorsal margin. It resembles *Allorisma* in possessing a pallial sinus, in the granulation of the external surface, and in its general shape. Among recognized families, both *Chaenomya* and *Allorisma* come closest to the Caelonotidae of McCoy and Hind, for which it is suggested the name Sanguinolitidae can be substituted if the name Caelonotidae is not suitable (see Dickins, 1956, p. 20). The granulation, the pallial sinus, and the gape of the shell, however, set aside *Chaenomya* and *Allorisma* as distinct from other members of this family.

CHAENOMYA sp. nov.

(Plate IV, figures 10-12.)

Description: Transversely elongated, anterior margin rounded, passing gradually into the ventral margin. Posterior margin truncated, passing rather more abruptly into the ventral and cardinal margins. Anterior part of cardinal margin in front of the umbo concave and distinct from the umbo. Posterior part of the cardinal margin also slightly concave and reflexed so that the back part rises slightly above the umbos. Shell gaping at the rear. The external surface is covered by rugae with a rough bark-like appearance under the hand lens. Thirteen rugae are visible on the left valve of the figured specimen. At the rear the growth-lines form small lamellae directed backwards. No lunule is present and the structure of the hinge and the musculature are not shown, although apparently the ligament was opisthodetic and external.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Figured specimen..	28	16	11

Occurrence: More than six specimens. Figured specimen—C.P.C. 2223—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group.

Discussion: Although a number of specimens of this species are present in the collections, none is complete, and the species has not been named or types chosen in the hope that the collection of additional material will allow more

* The paper is published under the authorship of Meek and Hayden, but in the text this genus is attributed to Meek. In the Introduction it is stated that Meek is responsible for the family and generic descriptions.

satisfactory types to be chosen. Amongst the forms present in about the same stratigraphic position, *Chaenomya* sp. nov. is most likely to be mistaken for incomplete specimens of *Praeundulomya elongata* sp. nov. Although the two are similar anteriorly, they are quite different in the ribbing and the shape of the posterior part of the shell. *Chaenomya* sp. nov. also lacks an elongated flat ligament area and the posterior grooves.

The Western Australian specimens are sufficiently close to the type species *C. leavenworthensis* to be placed in the same genus. The new species, however, can be readily distinguished by its greater relative elongation.

Fam. LEIOPTERIIDAE.

Genus LEIOPTERIA Hall 1883.

Type Species: Leiopteria dekayi Hall (1883, plate 19, figure 1: Plate 20, figures 16-18 (19 in error): 1884, p. 164, plate 88, figures 5-10). Manner of designation not known.

Discussion: Hall in his diagnosis of *Leiopteria* (1884, p. xiii) gives two examples, *L. dekayi* and *L. rafinesquii,* which, on the basis of Hall's descriptions and figures, appear to be closely related. Shimer and Shrock (1944, p. 383) give *L. dekayi* as the type.

The new species is placed only with doubt in the genus, as probably it is edentulous whereas typically (Newell, personal communication) *Leiopteria* has cardinal and lateral teeth, and in shape it differs rather considerably from *L. dekayi* in being more oblique and having the cardinal margin extending in a straight line in front of the umbo.

The relationship between the new species and *Merismopteria* Etheridge (1892, p. 271) and between *Merismopteria* and *Leiopteria* is not clear, and possibly the new species should be placed in *Merismopteria* rather than *Leiopteria.* According to Etheridge *Merismopteria* is distinguished by having only lateral teeth and having the anterior muscle behind a deep clavicle. An examination of specimens from New South Wales shows that the anterior muscle does occur behind the clavicle, and not in front, as apparently for instance in *Dozierella* Newell (1940, p. 284). In *L? carrandibbiensis* sp. nov., although the position of the anterior muscle is not clear, it does not appear to be located behind the clavicle. *M. macroptera* (Morris) (1845, p. 276, plate 13, figures 2,3) the type of *Merismopteria,* may also differ from the new species in its larger size and lesser obliquity, and in having a posterior lateral tooth or teeth. Unfortunately, as yet it has not been possible to trace Morris's specimen of *M. macroptera.*

LEIOPTERIA? CARRANDIBBIENSIS sp. nov.

(Plate IV., figures 13-17; text figure 4.)

Holotype: C.P.C. 2224. One mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: Shell oblique, pterioid in shape, apparently edentulous. Left valve slightly more convex than right. A small vertical ridge ("clavicle")

present under the anterior end of the umbo. Hinge composed of an elongated ligament area with a number of fine longitudinal ligament grooves. External ornament of thin concentric lamellae.

Description: Holotype (a bivalved specimen with most of right valve embedded in matrix). Shell pterioid and oblique, with the posterior ear flat and well marked off from the body of the shell and with the margin joining the hinge-line at an acute angle. Anterior ear rounded in outline and with the margin joining the hinge-line at an obtuse angle; marked off from the body of the shell by a shallow groove. Musculature anisomyarian with the posterior adductor below the posterior end of the hinge-line on the back part of the umbonal crest. Shell thin, less than 1 mm. thick, with a prismatic outer ostracum and an extremely thin ?nacreous inner ostracum. The prisms are set at right angles to the surface of the shell and are not visible to the naked eye, measuring about 0.04 mm. in width. The external surface is ornamented with fine concentric lamellae directed at a slight angle towards the outside of the shell. The lamellae are less than 1 mm. high and range from less than 1 mm. apart near the umbo to more than 1 mm. near the posterior ventral margin. The number of lamellae increases towards the rear by irregular division.

Paratypes: The ligament in both valves is lodged in a narrow elongated external amphidetic ligament area, which is broadest beneath the umbo and narrows gradually behind the umbo and rapidly in front. On the ligament area are a number of parallel longitudinal ligament grooves. The grooves are not chevron-shaped as described in *Dozierella* by Newell (1940, p. 282, text figure 5). In paratype A at least four grooves are visible in each valve immediately below the umbos.

The umbos are prosogyre and project only slightly above the hinge-line. The umbo of the left valve is slightly more prominent than that of the right, and the left valve is more convex than the right.

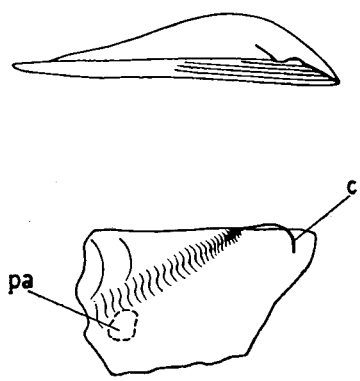


Fig. 4. — *Leiopteria? carrandibbiensis* Dickins. Above: Ligament area of paratype A. x4. (see also Pl. IV., fig. 17.) Below: Internal structure of paratype B. x2. c = clavicle; pa = posterior adductor (see also Pl. IV., fig 15).

Paratype B shows a rounded posterior adductor scar below the posterior end of the hinge-margin and immediately below the sulcus separating the posterior ear from the body of the shell. In front of the umbo is a small but distinct buttress ridge or clavicle running from the hinge-margin downward into the body of the shell. It is not possible to see the relationship of the anterior muscle to this ridge.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.	Angle Between Elongation of Shell and Hinge-line.
Holotype (left valve only)	32	23	5	35°
Paratype A (bivalve)	16 (estimated)	10 (estimated)	Left valve 3.5 Right valve 2.5	33°
Paratype C (right valve)	21 (estimated)	13 (estimated)	3.5	34°

Occurrence: Holotype and Paratypes A, B and C—C.P.C. 2224, 2225, 2226, and 2227 respectively—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. More than 20 specimens.

Discussion: Although more than 20 specimens of this species are available, the material does not show the complete nature of the hinge or the muscle pattern. The adductor muscle scars are very superficial and the anterior muscle is not shown in any of the specimens. Serial sectioning has not shown the presence of either lateral or cardinal teeth, and the hinge may be edentulous.

In Permian rocks shells closely related to the Western Australian species seem to occur at widely separated points, both geographically and stratigraphically. *L? carrandibbiensis* is closely related to *Leiopteria? dutoiti* Harrington (1955, p. 120, plate 24, figures 5:11) and to *Leiopteria bonaerensis* Harrington (1955, p. 120, plate 24, figure 10) from the Bonete Formation of Argentina, which Harrington considers to be of Permian age. It differs from the former by a greater angle of obliquity and from the latter by the absence of the furrow behind the umbo.

Leiopteria? carrandibbiensis in its shape also resembles "*Avicula*" *sublunulata* (de Koninck) (1877, p. 307, plate 26, figure 4) from the Permian of Muree, New South Wales.

The Western Australian species also resembles "*Avicula*" *chidruensis* (Waagen) (1881, p. 290, plate 20, figures 8-10) from the Upper Productus Limestone of the Salt Range of India.

Fam. Eurydesmidae Reed 1932.

Genus Eurydesma Morris 1845.

Type Species: Eurydesma cordata Morris 1845, p. 276, plate 12) by monotypy.

Synonym: Leiomyalina Frech (1891, p. 201).

Discussion: After a considerable discussion of its relationships Etheridge and Dun (1910, p. 66) place the genus *Eurydesma* in the family *Pteriidae*. As they point out, there are some resemblances to *Meleagrina* Lamarck 1819, *Maccoyella* Eth. fil. 1892, and *Buchia* Rouillier 1845 (= *Aucella* Keyserling 1846), which at that time were all placed in the family *Pteriidae*. *Eurydesma* however, differs considerably from all of these, particularly in the possession of a concealed ligament, the absence of a ligament pit or chondrophore on the ligamental area, and the presence of a distinct dental process, and also in other characters such as the muscle pattern and the shell structure. *Eurydesma* also differs considerably from members of the family *Myalinidae* and from the Triassic genera *Pergamidia* Bittner 1891 and *Timoria* Krumbeck 1924. For these reasons *Eurydesma* is placed in a distinct family, the Eurydesmidae, a name first used by Reed (1932, p. 50).

A large number of specimens have been available for the present study and a number of thin sections have been made to show the shell structure. Three shell layers can be distinguished: the outer and inner ostracum and hypostracum. A detailed account is given in the description of *Eurydesma playfordi* sp. nov.

EURYDESMA PLAYFORDI sp. nov.

(Plate V, figures 1-11, pl. X figures 1-2, 5, textfigures 5, 6.)

Holotype: C.P.C. 2228, 1 mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: Medium-sized *Eurydesma* with beak placed anteriorly and only moderately flexed towards the front: anterior margin not markedly concave. Right dental process well developed.

Description: Holotype (a right valve); Shell circular in shape with a straight cardinal margin. The dorsal part of the anterior margin is broadly concave with umbo placed anteriorly and pointed slightly towards the front. When the shell is held with the cardinal margin horizontal the anterior lobe only projects slightly in front of the umbo. The shell is greatly thickened near the umbo and the external surface is ornamented only by concentric growth lines. Internally the hinge has been eroded slightly before final incorporation in sediment, the matrix being removed from the hinge area in the laboratory. The dental process is well developed and projects distinctly into the cavity of the left valve. Immediately in front of the dental process is a deep sinus. The ligament was lodged in a single groove which extends backwards from the front of the umbo: the groove is narrow at the front, broadens rapidly, and then narrows and disappears towards the back of the cardinal margin. The groove bears a number of fine longitudinal lines, but because of the slightly eroded condition of the shell it can be seen that these correspond to growth layers in the rest of the shell, indicating that a single ligament was present.

Paratypes: In the left valve there is no groove for the dental process of the right valve, which simply projects into the shell cavity immediately beneath the anterior end of the ligament groove. No sinus is present in the left valve,

but a smaller dental process than in the right valve fits over the sinus of the right when the two valves are in apposition. This dental process of the left valve gives the shell the appearance of being slightly inequivalved, although the convexity of the two valves does not differ significantly.

The retractor muscles are similar to those described by Etheridge and Dun (1910, p. 60). In the left valve two or more larger impressions at the top are elongated and run parallel to the cardinal margin. The lower impressions are smaller and run downwards—first towards the back and then towards the front; all the impressions together form an S-shape.

In larger shells the anterior lobe projects further in front of the umbo.

The adductor muscle is not clearly shown on any of the specimens, although what appears to be the adductor muscle is shown in Paratype F slightly in front of and below the umbo. According to Morris (1845, p. 276) and Etheridge and

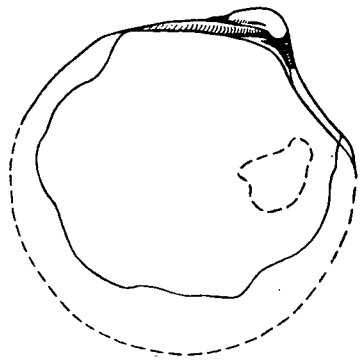


Fig. 5—*Eurydesma playfordi* Dickins. Inside of paratype F, showing possible mark of adductor muscle. x1. (see also Pl. V, fig. 4.)

Dun (1910, p. 58) the adductor muscle scar is found more or less anteriorly. On the basis of the present material it must be concluded that the adductor muscle scar is superficial.

Shell Structure: Three shell layers are preserved, the outer ostracum, the inner ostracum, and the hypostracum (Newell, 1937, p. 24). The outer ostracum is of variable structure in different parts of the same valve and in different left valves and different right valves. In the left valve the structure of the outer ostracum varies from homogenous to lamellar and in some places it it possible to distinguish faint lamellae in the predominantly homogeneous structure. The lamellae slope at an angle of about 15° to the inner ostracum away from the margin of the shell. In the right valve the outer ostracum varies from homogeneous to lamellar and complex lamellar. This layer is composed of calcite, which extinguishes under crossed nicols at right angles to the length of the lamellae. The inner ostracum in both valves is composed of very thin homogenous layers. It has an irregular extinction, is fine-grained, and at present is composed of calcite. Probably the inner ostracum was originally composed of an aragonitic nacre.

Towards the outside of the shell the inner ostracum thins and disappears so that only the outer ostracum remains. The inner ostracum is greatly thickened towards the umbo. The hypostracum appears to be fibrous with the fibres running approximately parallel to the inner and outer surface of the layer.

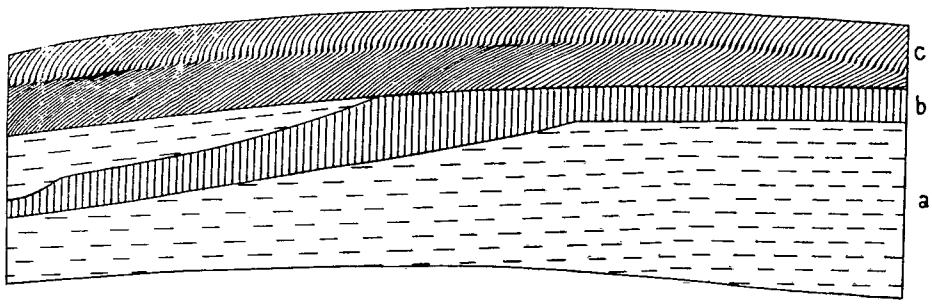


Fig. 6—*E. playfordi.* Shell structure of paratype H, a right valve: cross-section approximately parallel to hinge. x 22. (see also Pl. X, fig. 1.) a = inner ostracum; b = hypostracum; c = outer ostracum.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Holotype (right valve)	47	45	17
Paratype C (left valve)	64	66	21
Paratype D (right valve)	70	73	30
Paratype E (bivalve, measurement of left valve) ..	76	78	32

Occurrence: Eurydesma playfordi is represented in the collection by a large number of specimens. Holotype and Paratypes A-H—C.P.C. 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235 and 2236 respectively—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group.

Paratype I—C.P.C. 2237—about 10½ miles west of Jimba Jimba Homestead, top of Lyons Group.

Other Occurrences: About 1 mile north of Gap Pool—same horizon as holotype locality; $4^3/_{10}$ miles east-south-east of Baracooda Pool, Arthur River, Bidgemia Station, top of upper part of Lyons Group.

Eurydesma playfordi probably also occurs three miles north-east of Round Hill Well, one mile west of Kialawibri Creek road crossing, Winning Station, Lyndon River area, in the top part of the Lyons Group.

Discussion: The shape of the valves varies somewhat. In some specimens, especially the larger specimens, the anterior lobe is more distinct. In the sharpness and prominence of the umbo, a character that is important for a comparison with *E. mytiloides* (Reed) 1932, there is little variation.

Eurydesma playfordi appears to be most closely related to *Eurydesma mytiloides* (Reed) (1932, p. 50, pl. 11, figures 1-3b), which was first described from the Agglomeratic Slate of Kashmir and later described by Reed from the

Speckled Sandstone of the Salt Range (1936, p. 18, plate 3, figures 1, 2). The Western Australian species differs mainly in having a more rounded and less prominent umbo. Harrington (1955, p. 124, plate 25, figures 5-8) has also described *E. mytiloides* (Reed) (1932) from the Bonete Formation of Argentina. Harrington's material, however, does not appear to be well preserved.

Eurydesma playfordi also appears to be closely related to *Eurydesma hobartense* (Johnston) (1887, p. 16) especially the first figured specimen (Johnston, 1888, plate 16, figure 2), and the specimen figured by Etheridge and Dun (1910, plate 18, figures 2, 3), but *E. hobartense* has a more distinct anterior lobe than *E. playfordi.*

The species is named after Mr. P. E. Playford, of West Australian Petroleum Pty. Ltd., who collected many of the specimens.

Fam. ARCOMYIDAE Fischer.

Genus PRAEUNDULOMYA Dickins 1957.

Type Species: Praeundulomya concentrica Dickins (this volume, p. 10, plate 1, figures 1-11) by original designation.

PRAEUNDULOMYA ELONGATA sp. nov.

(Plate VI., figures 10-14; text figure 7.)

Holotype: C.P.C. 2238. One mile west of Callytharra Springs, top 15 feet of Lyons Group.

Diagnosis: Shell distinctly produced in front of the umbos. Ribbing predominantly concentric over whole external surface and only a few extra ribs added at the rear. Ligament area not distinctly tucked under umbos at front. Posterior grooves and ridge only poorly developed.

Description: Holotype (a bivalved shell): The external ornament is composed of rugae which are almost parallel to the outer margins of the shell and run continuously from the front to the back. As distinct from *P. concentrica* Dickins no rugae at the rear lack counterparts at the front which are cut off by the ventral margin. Where additional ribs or rugae are present behind the

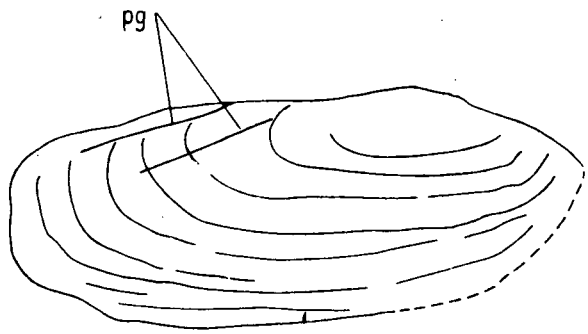


Fig. 7—*Praeundulomya elongata* Dickins. Shape and ribbing of right valve x1. pg = posterior groove (see also Pl. VI. fig. 12).

umbo, nowhere is more than one rib formed between two consecutively continuous ribs. The shell has a slight gape, front and back. The umbos are rounded, inrolled towards the front, non-contiguous, and do not project markedly above the hinge-line. The ligament is opisthodetic, external, lodged in an area which extends to the rear of the cardinal margin. At the front end the area has the form of a shallow groove which the umbos do not distinctly overhang and towards the rear widens slightly and flattens. The two posterior grooves and the separating ridge, which are characteristic of *Praeundulomya,* are only poorly developed, especially the lower groove, only a suggestion of which is present. The shell is rather evenly convex from front to rear with the greatest tumidity at about the middle of the shell. No lunule is visible.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.	Distance of Umbo from Front.
Holotype (both valves)	78	31	20	19
Paratype A (both valves)	97 (estimated)	40	24	20 (estimated)
Paratype B (both valves)	..	24	16	18

Occurrence: Holotype and Paratypes A and B—C.P.C. 2238, 2239 and 2240 respectively—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. Three specimens and a number of fragments.

Discussion: P. elongata occurs considerably lower in the sequence than the type species *P. concentrica.* It is distinguished by its greater relative elongation, greater prolongation in front of the umbo, less specialized external ornament, lesser development of the posterior grooves and ridge, and different convexity. *P. elongata* resembles more closely young forms of *P. concentrica* than mature forms and is apparently more closely related to the *Allorisma*-like ancestral stock.

Sanguinolites kashmiricus Reed (1932, p. 37, Plate 8, figures 1-4a), from the Agglomeratic Slate of Kashmir, may be related to *P. elongata,* which it resembles in shape and the character of the ligament. Reed, however, makes no mention of posterior grooves or addition of rugae behind the umbo between the continuous rugae running from front to rear. The shell from the Speckled Sandstone of the Salt Range, India, which has been referred by Waagen to *Sanguinolites tenisoni* (1891, p. 128, Plate 5, figures 6a-c) may also be related to *P. elongata* rather than *Allorisma?* sp. nov. as previously suggested (Dickins, 1956, p. 22). It is doubtful if Waagen's figured specimen should be referred to *Sanguinolites tenisoni* de Koninck (1877, p. 263, Plate 17, figure 5) (see also Reed, 1932, p. 38).

Fam. TRIGONIIDAE Lamarck.

Genus SCHIZODUS Murchison and De Verneuil 1844.*

Type Species: Axinus obscurus J. de C. Sowerby (1821, p. 12, p. 314) by designation of de Verneuil (1845, p. 308).

* Originally attributed by courtesy to Professor W. King.

SCHIZODUS CRESPINAE sp. nov.

(Plate VI., figures 1-6.)

Holotype: C.P.C. 2241. One mile west of Kialawibri Creek road crossing, Winning Station, upper part of Lyons Group.

Diagnosis: Shell small, compared with other Australian Permian species. Valves inflated and external surface gently rounded; a rounded carina divides the shell into two parts. Nearly as high as long.

Description: Holotype (a right valve): Shell rounded-triangular, umbo inclined slightly towards the front. No distinct lunule visible but an escutcheon is formed by a groove for the reception of the external opisthodetic ligament. Two, possibly three, cardinal teeth—a small projection from the front part of the cardinal margin may represent an anterior cardinal tooth (5a). The centrally placed cardinal tooth (3a) is robust and wedge-shaped, inclined towards the front, bounded in front by a groove for the anterior cardinal of the left valve and behind from the posterior cardinal by a groove for the second cardinal tooth of the left valve. The posterior cardinal (3b) is slender, inclined towards the rear and separated from the cardinal margin by a groove. The external surface is ornamented by a large number of fine concentric ribs.

Paratype A (a left valve): The shell shows in addition the dentition of the left valve. The anterior cardinal (4a) is formed as a projection of the anterior part of the hinge-line. The second cardinal (2b) is robust and wedge-shaped, inclined slightly towards the back. A posterior cardinal (4b) may be represented by a small projection running parallel and joined to the posterior part of the hinge-line.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Holotype	14	13 (estimated)	5
Paratype A	14 (estimated)	13.5	5
Paratype B	8	7.5	1.5

Occurrence: Holotype and Paratypes A and B—C.P.C. 2241, 2242, and 2243 respectively—about 3 miles north-east of Round Hill Well, 1 mile west of Kialawibri Creek road crossing, Winning Station, upper part of Lyons Group. Three specimens.

Discussion: *S. crespinae* is an interesting species, as on one hand it rather differs from the only other described schizodid from the Permian of Western Australia, *S. kennedyensis* Dickins (1956, p. 30, Plate 5, figures 1-10), which occurs very much higher in the sequence; and on the other hand it is apparently more closely related to *S. harii* Miller (1892, p. 701, Plate 20, figures 1-3) from the Upper Pennsylvanian rocks of the United States. It differs, however, slightly in shape and in the details of the dentition—the hinge-plate of the left

valve of *S. harii* is more elongated and there is apparently no indication of a posterior cardinal (4b) and in the right valve the posterior cardinal (3b) is poorly developed as compared with that of *S. crespinae.*

S. crespinae is thus apparently related to Upper Carboniferous forms; such a relationship is not entirely unexpected in a species from the Lyons Group.

Newell (1940) and Cox (1951) have recently discussed the status of *Schizodus* and other Upper Palaeozoic and Triassic Trigoniids and have pointed out how unsatisfactory is our knowledge of the structure, especially the hinge, of many of these shells. Cox restricts *Schizodus* to forms with reduced dentition and introduces a new genus *Eoschizodus* for Middle and Upper Palaeozoic forms with the full Trigoniid dentition $\frac{L}{R}\ \frac{3a\ :\ 3b}{4a\ :\ 2b\ :\ 4b}$. On this basis *S. crespinae* would belong to *Eoschizodus* rather than *Schizodus* as restricted by Cox. *S. crespinae,* however, is apparently rather distinct from *Megladon truncatus* Goldfuss 1837, the type of *Eoschizodus* (see Cox, 1951, text-figure 1).

The species is named after Miss I. Crespin, palaeontologist of the Bureau of Mineral Resources.

Fam. Deltopectinidae nov.

Diagnosis: Pectinoid shells characterized by the presence of an elongated ligament area without a distinctly marked-off central chondrophore as in the Aviculopectinidae Etheridge Jnr., 1906 emend. Newell 1937, or the chevron-shaped ligament grooves characteristic of the Pterinopectinidae Newell 1937. Distinct longitudinal ridges are present on the ligament area. The external ornament is composed basically of prominent radiating ribs with the ribs of the two valves interlocking along the exterior margin. In some forms secondary or more complex patterns are developed on the large radiating ribs.

Discussion: At present this family is represented by a single genus *Deltopecten.* It is considered that this genus shows such distinctive characteristics that it should be placed in a family separate from the Aviculopectinidae and the Pterinopectinidae in the sense of Newell (1937). Unfortunately the exact standing of *Aviculopecten* McCoy, 1851, is not without uncertainty as the hinge of the type species, *A. planoradiatus* McCoy, is not known (Newell, 1937, p. 45).

Genus Deltopecten Eth. Fil., 1892.

Type Species: Pecten illawarensis Morris (1845, p. 277, Plate 14, figure 3) by original designation of Etheridge, Junr. (1892, p. 269).

Diagnosis: Ribbing comparatively simple, composed basically of prominent radiating ribs; smaller secondary ribs may be developed between the large primary ribs. Right valve less convex than left, but not as markedly inequivalve as is characteristic of the Aviculopectinidae.

Discussion: It is unfortunate that Etheridge chose *Pecten illawarensis* as type of this genus as this species is an unsatisfactory type for a number of reasons. First the types, housed in the Sedgwick Museum, Cambridge, are

poor specimens. Secondly there is doubt about the type locality: although Morris stated his specimens were from Illawarra, later authors (Dana, 1849; Etheridge and Dun, 1906) have suggested that this species does not occur at Illawarra. The relationship of *D. illawarensis* (Morris) and *D. mitchelli* (Etheridge and Dun) also presents difficulties.

An examination of Etheridge and Dun's figured specimens of *D. illawarensis* and *D. mitchelli* in the Australian Museum, Sydney, shows that both have the same type of hinge. The hinge of *D. mitchelli* is shown clearly in one of the specimens figured by Etheridge and Dun (1906, Plate 1, figure 3), although it cannot be seen in Etheridge and Dun's figure. The front part of the hinge of this shell is figured here (Plate 8, figure 10) in a photograph kindly supplied by H. O. Fletcher of the Australian Museum. The hinge of another specimen of *D. mitchelli* from Allandale, New South Wales, is also figured. Etheridge and Dun's specimen is an internal impression of a left valve with only a small amount of shell matter remaining. The hinge is composed of an elongated bow-shaped ligament area, widest under the umbo; no chonodrophore or distinctly marked ligament pit is present, but on the area are a number of ridges and grooves which run parallel to the lower boundary of the area and run off the area along its dorsal or upper side. The ridges may represent growth ridges rather than reflecting the presence of ligament grooves. The hinge is apparently identical with that described for *D. mitchelli* by Kegel (1953).

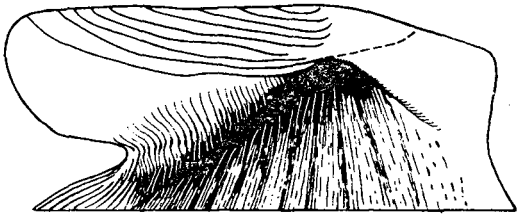


Fig. 8—*Deltopecten mitchelli* Etheridge and Dun. Hinge of specimen Aust. Mus. F26, 435 from Allandale, N.S.W. x1. (see also Pl. VIII, fig. 8.)

No chevron grooves are present such as are described by Newell (1937) in the Pterinopectinidae.

At the Australian Museum it was possible to remove the matrix from the front part of the hinge of one of the specimens figured by Etheridge and Dun as *D. illawarensis* (1906, Plate 2, figure 2). This revealed a bow-shaped area with ridges and grooves running parallel to the ventral margin, similar to that in *D. mitchelli.* A photograph of this hinge has also been kindly supplied by H. O. Fletcher and is reproduced here (Plate 8, figure 9).

This type of hinge is also found in two new species of *Deltopecten* from Western Australia, *D. lyonsensis* from the Lyons Group, described in this paper, and an undescribed species from the Callytharra Formation. In the undescribed species from the Callytharra Formation the ligament area is slightly deeper beneath the umbo, but there is no distinctly marked ligament

pit. It may have been a depression of this type to which Etheridge referred when he was describing specimens from Queensland as *Deltopecten illawarensis* (1892, p. 269):

> The area is exceedingly broad and strong, especially beneath the umbones, where it is excavated into a pseudo-cartilage pit of a deltoid or roughly triangular form . . . the whole area is coarsely transversely striated or grooved.

Unfortunately these features are not clear in Etheridge's figure (Plate 43, figure 2). This description does not accord well with the type of hinge described for *Aviculopecten* by Newell (1937) or with the hinge of species from Eastern and Western Australia which have the "*Aviculopectinid*" type of hinge, for example, the specimen of "*Deltopecten*" *leniusculus* (Dana) figured by Etheridge and Dun (1906, Plate 4) or "*Deltopecten*" *farleyensis* (Etheridge and Dun) (1906, Plate 13, figure 6). It can be concluded, then, that *Deltopecten* has a hinge distinct from that found in *Pterinopecten* and that generally thought to occur in *Aviculopecten*.

When dealing with the hinge of *Aviculopecten* in his monograph on the Late Palaeozoic Pectinacea of North America, Newell (1937, p. 45) considered that *Aviculopecten planoradiatus* McCoy, the type species, so closely resembled *A. occidentalis* Shumard that it could be assumed the two had a similar hinge. Before the hinge of *Aviculopecten* can be definitely ascertained, however, it is necessary to know the structure of the hinge of *A. planoradiatus*, especially as Newell points out that the ornament of the two is different.

Besides *D. illawarensis* and *D. mitchelli*, a number of other species from eastern Australia in the Australian Museum collections have the *Deltopecten* type of hinge. For the present I place them in the genus *Deltopecten*, although later work may show that they should be divided into a number of genera related to *Deltopecten*. They include *Deltopecten squamuliferus* (Morris) (1845, p. 278, Plate 14, figure 1), *Deltopecten multicostatus* (Fletcher) (1929, p. 8, Plate 2), *Deltopecten media* (Laseron) (1910, p. 203, Plate 15, figure 1), *Deltopecten* cf. *giganteus* Chao (Fletcher, 1929, p. 20, Plate 11) and *Deltopecten limaeformis* (Morris) (1845, p. 277, Plate 13, figure 1). The hinge of a specimen identified in the Australian Museum as *Aviculopecten media* is figured in Plate 7, figures 6-7. The basic ornament of all these species is coarse radiating ribs of a single order. In some species a complexity is superimposed on this basic pattern, such as in *D. illawarensis* where secondary ribs may develop between primary ones, and *D. multicostatus* where the primary ribs, although retaining their main character, are covered with a number of fine ribs running parallel to the main ribs.

DELTOPECTIN LYONSENSIS sp. nov.

(Plate VII., figures 1-5 and 9; Plate VIII., figures 11-13; Plate IX., figure 12; Plate X., figures 3-4, text-figure 9.)

Holotype: C.P.C. 2244, 1 mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group.

Diagnosis: Biconvex with right valve less convex than the left; very similar to *D. illawarensis* and *D. mitchelli* but distinguished by the more slender character of the ligament area. Also differs from *D. illawarensis* in having a lesser number of ribs and lacking the posterior fold of the specimen figured by Etheridge and Dun (1906, Plate 2, figure 2). The fold is not clearly shown in the figure.

Description: Holotype (a right valve): The shell is rounded, approximately acline with the ribs bent slightly towards the front. The anterior ear is prominent and much larger than the posterior; it is separated from the body of the shell by a groove and a sinus and is ornamented by four or possibly five simple radiating ribs and concentric growth filae. Nodes are formed where the filae cross the ribs. The posterior ear is flat and is separated from the body of the shell by a shallow sulcus. The body of the shell is ornamented by 27 large primary radial ribs and several smaller secondary ribs intercalated between the larger ribs. These ribs are crossed by concentric growth-lines. The area is bow-shaped and extends for about the full length of the hinge. No chondrophore or distinct ligament pit is present and the area has seven shallow grooves which are parallel to the lower margin of the area and run off it on the upper side both in front and behind the umbo.

Paratypes: Paratype B is a left valve. The anterior ear is larger than the posterior ear and ornamented by six or seven simple radiating ribs and growth filae forming nodes where the two cross. The ear is separated from the body of the shell by a shallow groove. The posterior ear is similar to that of the right valve, with no distinct sinus in the outline, the posterior part joining smoothly with the body of the shell. Twenty-six primary ribs and two secondary ribs are visible. Sufficient of the hinge is revealed to show that it is similar in character to that of the right valve.

In Paratype C, a right valve, 27 primary ribs and eight secondary ribs are visible.

Shell Structure—Paratypes F-H: The main layer of the shell is composed of concentric interlocking lamellae which are arranged parallel to the external surfaces of this layer, i.e. parallel to the pronounced grooves on the outside and the shallower grooves on the inside. In most cases this is the only shell layer preserved. Thin sections of these shells have been examined by Mrs. A. Beck, lately a petrologist of the Bureau, who was unable to detect the presence of secondary lamellae. Refractive index tests show the lamellae are composed of calcite. Under crossed nicols the lamellae do not extinguish as a whole, but irregularly. It is possible that this layer was originally composed of aragonite and that although the secondary lamellae have not been preserved the coarser primary lamellae are still visible.

In one of the sections of a right valve there is a thin layer on the outside of the crossed lamellar layer composed of calcite prisms which are vertical to the external surface and under crossed nicols extinguish at right angles to the

length of the prism. Whether this represents an outer shell layer or is adventitious is not clear. If indeed this prismatic layer represents the outer ostracum then its absence in most of the shells examined could be explained by its thinness. In another section there is a comparatively thin layer of coarsely crystalline calcite on the inside of the lamellar layer which may represent originally aragonitic hypostracum.

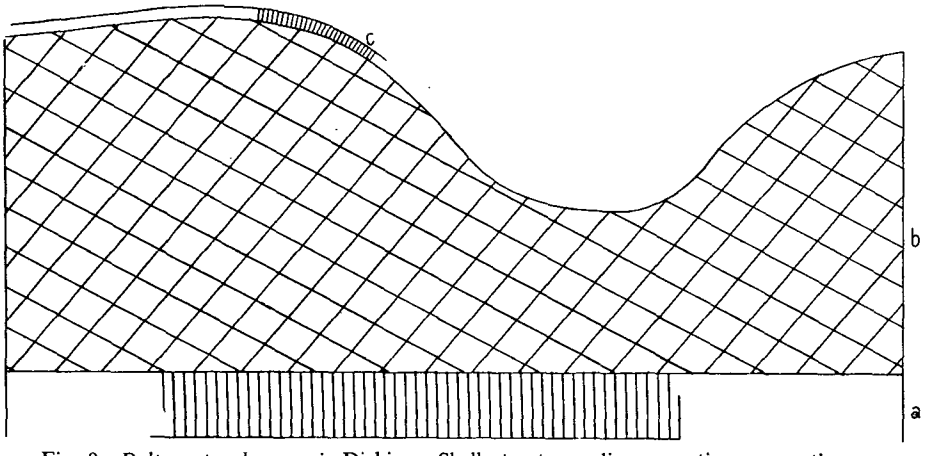


Fig. 9—*Deltopecten lyonsensis* Dickins. Shell structure—diagrammatic cross-section approx. parallel to hinge. x26. a = hypostracum?; b = main shell layer; c = prismatic layer.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Holotype (right valve)	76	74	12
Paratype A (left valve)	92	88	22
Paratype B (left valve)	79	74	14
Paratype C (right valve)	76	74 (estimated)	11
Paratype D (right valve)	73	68 (estimated)	..
Paratype E (bivalve)	63 (estimated)	56 (estimated)	Left valve 17 Right valve 14

Occurrence: D. lyonsensis is the most common form in the Lyons Group. It is present at almost all localities where marine fossils occur and ranges throughout the sequence from the lowest known marine fossiliferous horizon to the topmost. It is not known from the Callytharra Formation.

Holotypes and Paratypes A-G—C.P.C. 2244, 2245, 2246, 2247, 2248, 2249, 2250 and 2251 respectively—about 3 miles north-east of Round Hill, 1 mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group. Paratype H—C.P.C. 2252—4 and 3/10 miles south-east by east of Baracooda Pool, Arthur River, Bidgemia Station; upper part of Lyons Group.

Discussion: Right valves vary in convexity but are always less convex than left valves of the same shell. The ribbing also varies considerably; in some specimens secondary ribs are almost absent whereas in others there are a considerable number. The internal surface of the shell is more or less smooth, but towards the ventral margin the ribs become more pronounced on the inside and in life the two valves were interlocking. Muscle impressions are not visible in any of the present material.

D. lyonsensis is closely related to *D. illawarensis* and *D. mitchelli* from the Permian rocks of eastern Australia. In New South Wales the occurrence of these two species is only well authenticated in beds of "Lower Marine" age, although Morris (1845) in his original description of *D. illawarensis* states that his specimens were from Illawarra, i.e. in beds of "Upper Marine" age. *D. lyonsensis* differs from the two eastern Australian species chiefly in the more slender development of the hinge.

Aviculopecten cf. *mitchelli* Reed (1932, p. 45, Plate 12, figures 1, 1a) is also related to *D. lyonsensis.* It is larger, however, than the specimens from the Lyons Group and may be more closely related to the undescribed species from the Callytharra Formation.

Fam. Aviculopectinidae Eth. Fil., 1906,

emend. Newell, 1937.

Newell (1937, p. 43) recognizes two subdivisions in this family, the subfamilies Aviculopectininae and the Pseudomonotinae. It appears, however, that the Pseudomonotid forms of the Permian were the forerunners of a number of Mesozoic forms including the genera *Claraia* (Bittner, 1901) and *Entomonotis* (Marwick, 1934) of the Triassic, and *Meleagrinella* (Whitfield, 1885) (=*Echinotis* (Marwick, 1934)) and *Maccoyella* Eth. fil., 1892, of the Jurassic and Cretaceous, which have been commonly placed in the family Pteriidae, but which from morphology and descent are related to the Aviculopectinidae rather than the Pteriidae. It seems desirable, therefore, to raise the Pseudomonotinae to family rank for the inclusion of both Upper Palaeozoic and Mesozoic forms.

Genus Aviculopecten McCoy, 1851.

Type Species: Aviculopecten planoradiatus McCoy (1851, p. 171) by subsequent designation of Hind (1903, p. 66).

Discussion: Newell (1937, p. 44) has described very fully the type of *Aviculopecten* McCoy. Unfortunately, as he points out, important characters, including the hinge of *A. planoradiatus,* remain unknown.

AVICULOPECTEN TENUICOLLIS (Dana), 1847.

(Plate VI, figures 7-9.)

1847—*Pecten tenuicollis* Dana, p. 160.

1849—*Pecten tenuicollis,* Dana, p. 705, Plate 9, figures 7-7a.

1906—*Aviculopecten tenuicollis,* Etheridge and Dun, p. 13, Plate 13, figures 10-12, Plate 14, figure 5.

Description: Hypotype A. External impression of a left valve. The hinge-line is straight and the ligament area is not shown. Both ears are distinctly separated from the body of the shell, the anterior ear by a groove. The margin of the posterior ear meets the cardinal margin with an only slightly rounded acute angle. Radial ribs are present over the body of the shell and the ears, but on the ears the ribs are less distinct. On the body of the shell the number of ribs increases by intercalation in ranks—near the umbos secondary ribs appear between the primary ribs, and about one third to one half of the distance from the umbo to the ventral margin tertiary ribs appear, one between each primary and secondary. In a few places towards the outside of the shell there is a suggestion of a fourth rank. The radiating ribs are crossed by very fine concentric filae; where the filae cross the ribs they bend slightly towards the outside of the shell and where they cross the grooves they bend slightly back towards the umbo. Hypotype B, an incomplete left valve, differs mainly from Hypotype A in having relatively thicker primary ribs and in the more irregular addition of ribs.

DIMENSIONS (in mm.).

—	Length.	Height.	Thickness.
Hypotype A	17	18	3
Hypotype B	17	18	4

Occurrence: Hypotype A—C.P.C. 2253—3 miles west of Moogooree Homestead, 1,250 feet below top of Lyons Group. Hypotype B—C.P.C. 2254—1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. Three specimens, one from near Moogooree and two from near Callytharra Springs.

Discussion: The Western Australian specimens show a close similarity to those placed in *A. tenuicollis* by Dana (1849) and Etheridge and Dun (1906). They are also very similar to *A. sprenti* Johnston (1887, p. 9; 1888, p. 127, Plate 14, figure 11). From an examination of specimens of *A. tenuicollis* and *A. sprenti* in the Australian Museum, Sydney, including specimens figured by Etheridge and Dun, it seems possible that only one species is represented: for example the specimen figured by them (1906, Plate 2, figure 7) as *A. sprenti* is almost identical in shape with the specimen (Plate 13, figure 12) figured as *A. tenuicollis.*

Both species also show similarity to growth stages of *A. subquinquelineatus* (McCoy) (1847, p. 298, Plate 17, figure 1), but unfortunately none of the specimens of *A. subquinquelineatus* in the Australian Museum show the growth stages well enough to be able to determine whether or not *A. tenuicollis* and *A. sprenti* represent young forms of *A. subquinquelineatus*.

Class GASTROPODA.

Fam. PLEUROTOMARIIDAE D'Orbigny.

Genus MOURLONIA de Koninck, 1883.

Type Species: Helix carinatus J. Sowerby (1812, p. 34, Plate 10, upper and lower figure) by original designation of de Koninck.

MOURLONIA? LYNDONENSIS sp. nov.

(Plate VIII, figures 1-5.)

Holotype: C.P.C. 2255. 1 mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group.

Diagnosis: Pleurotomariid gastropods with slit-band (selenizone) bounded on either side by a carina, distinct parallel ornament, spire turbinate and cross section oval; an umbilicus is present.

Description: Holotype: The spire is low and turbinate and made up of five whorls. The sutures are distinct, situated just below the slit-band (selenizone), the slit-band being situated at about the middle of the outer part of the whorl, near the periphery. The slit-band is bordered on either side by a distinct carina. The length of the slit is not visible and the growth lines are not clear enough to show the shape of the outer lip, but apparently the slit was less than one eighth of the length of the last whorl. The whorl is oval in cross-section and the surface is ornamented with parallel (revolving) and transverse lines or lirae. On the last whorl in the youngest part of the shell preserved, eight lirae are visible, the fourth and fifth from the slit band being the largest, and the first, sixth, and eighth being smaller than the others. About eighteen lirae are visible below the slit-band. The transverse ornament is poorly preserved and is apparently parallel to the growth-lines. A wide conical umbilicus is present.

Paratypes: Two paratypes have five whorls, and Paratype C, the largest specimen, has six whorls. The ornament also varies. On the last whorl in the youngest part of the shell, Paratype A has six or seven parallel lirae, the largest being the third from the slit-band; Paratype B has seven lirae with the third and fifth from the slit-band larger than the others; and Paratype C has eight with the third and the fifth larger than the others. The transverse lirae are only poorly developed and on the top part of the whorl swing backwards in an arc from the suture towards the slit-band.

DIMENSIONS (in mm.).

—	Height.	Width.	Apical Angle.
Holotype	8	11	75°
Paratype A	7	11	About 66°
Paratype B	10	14	84°
Paratype C	12	17 (estimated)	77°

Occurrence: Holotype and Paratypes A, B and C—C.P.C. 2255, 2256, 2257 and 2258 respectively—about three miles north-east of Round Hill Well, one mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group. Twelve specimens.

Discussion: M.? lyndonensis is not known to resemble closely any described species. It differs considerably from the type species *Helix carinatus* Sowerby, 1812 and for this reason is only doubtfully placed in the genus *Mourlonia.* In *M.? lyndonensis* the parallel ornament is more prominent, the slit-band is delimited on either side by a carina, and a distinct umbilicus is present. Whether these differences are of a generic character is problematical.

Genus PTYCHOMPHALINA Fischer, 1885.*

Type Species: Helix? striatus J. Sowerby (1817, p. 159, Plate 171, figure 1) by monotypy—see Knight (1941, p. 286).

Discussion: Thomas (1940, p. 58) proposes that *Ptychomphalina* Fischer (=*Ptychomphalus* de Koninck) should be placed in synonymy with *Mourlonia* de Koninck, as he considers that the types of the two genera belong to a single genus. He states that Fischer (1885, p. 850) "appears to imply that the only distinction is the possession by *Mourlonia* of an umbilicus, a character which taken alone cannot be considered of generic value". The description and figures of the types of *Helix? striatus* J. Sowerby and *Helix carinatus* J. Sowerby in Knight 1941 show, however, that not only does the character of the umbilicus differ in the two, but there are also other important differences, particularly the absence of revolving ornament and the presence of strong transverse ornament in *Helix? striatus* J. Sowerby, the type of *Ptychomphalina.*

PTYCHOMPHALINA UMARIENSIS (Reed) 1928.

(Plate IX., figures 1-5.)

1928 *Pleurotomaria umariensis* Reed, p. 389, Plate 34, figure 12; Plate 35, figures 11-13.

Description: The number of whorls varies according to size, five being the most common number. The whorl size increases rapidly so that the last whorl is about one-third or more of the total height of the spire. The slit is not deep

* Originally attributed by courtesy to Professor E. Bayle.

and gives rise to a prominent slit-band (selenizone) which is sub-median in position and bounded on either side by well-marked carinae or lirae; the band is ornamented by distinct curved lunulae. Below the slit-band is a third lira which is visible in all well preserved specimens; no other parallel ornament is visible. The shape of the outer lip is shown by the prominent transverse growth-lines; the growth-lines leave the suture at about 90° and swing backwards to the slit-band at about 45°; after leaving the slit-band they swing forward to the third lira and then backwards to the parietal or columellar lip. The upper part of the whorl is flattish and the base is more rounded; the mouth is sub-circular and the columellar lip almost straight. The shell has no umbilicus, and thin callus is present on the columellar lip inside the aperture. The suture is distinct and is situated just below the third lira in the second last whorl in mature individuals; in preceding whorls and in small specimens the suture appears to be at or below the third lira.

DIMENSIONS (in mm.).

—	Height.	Width.	Apical Angle.
Hypotype A	10	7	39°
Hypotype B	8	5.5	38°
Hypotype C	8	6	43°
C.P.C. 2262	11	..	38° (estimated)
C.P.C. 2263	11 (estimated)	8	39°

Occurrence: Hypotypes A, B, and C—C.P.C. 2259, 2260 and 2261 respectively—and C.P.C. 2262 and 2263, about 3 miles north-east of Round Hill Well, 1 mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group.

Other localities, 1 mile west of Callytharra Springs, Byro Station, top 15 feet of Lyons Group. Twelve specimens from hypotype locality and a large number from near Callytharra Springs.

Discussion: The Western Australian specimens appear to agree with the Indian specimens in every essential respect. In addition to Reed's description and figures the author has been able to use for comparison specimens of *Ptychomphalina umariensis* collected by Professor S. W. Carey of the University of Tasmania from Umaria, India.

An important character distinguishing *P. umariensis* from the type species of *Ptychomphalina* is the possession of a third lira, with which is associated a marked forward swing of the growth-lines between the slit-band and the third lira. This character is shared also by *P. morrisiana* (McCoy) (1847, p. 17, figure 3) from the Permian of eastern Australia, and possibly by *P. articiformis* (Wanner) (1922, p. 25, Plate 151, figure 11) from the Permian Basleo beds of Timor. It is possible that the possession of a third lira and associated differences should constitute a generic difference.

Amongst described forms *P. umariensis* appears to be most closely related to *Ptychomphalina morrisiana.* This species, however, may be readily distinguished by a more convex whorl section with which is associated a greater apical angle. In addition the transverse ornament is less well developed. Through the courtesy of the Australian Museum it has been possible to borrow specimens of *P. morrisiana* from Gerringong and Illawarra, New South Wales, i.e. from the Gerringong Volcanics (= "Upper Marine"). Two of these specimens, Australian Museum No. F21250 from Illawarra, are figured for comparison (Plate 8, figures 6, 7) and the dimensions are tabulated below:—

—	Height.	Width.	Apical Angle.
A.	8	6	50°
B.	8	6	54°

Fam. EUOMPHALIDAE De Koninck.

Genus KEENEIA Eth. Fil., 1902.

Type Species: Keeneia platyschismoides Etheridge Junr. (1902, p. 199, Plate 32, Plate 33, figures 3-5) by designation of Etheridge (1902, p. 198).

Discussion: Both *Keeneia* and *Platyschisma* McCoy are characterized by the possession of a distinct sinus in the outer lip. In *Platyschisma,* however, the sinus is higher on the whorl than in *Keeneia* and the two differ in shape; in both the sinus is situated near the periphery of the outer lip. *Euomphalus* has a slight sinus in the outer lip (Knight, 1941, p. 122), so that, taking the other characters also into consideration, *Keeneia* and *Platyschisma* do not seem to be out of place in the family *Euomphalidae.*

Knight (in Branson, 1948, p. 702—personal communication) suggests that *K. platyschismoides* is a synonym of *K. ocula* (J. Sowerby) (1838, p. 15, Plate 2, figures 3-4). However, before this can be accepted, it is necessary to show that *K. platyschismoides* is a mature form of the shell represented by the type of *K. ocula.* In Sowerby's figures of *K. ocula* the shape is different from that of the type of *K. platyschismoides* and the shape and angle of the aperture appear to be different.

Etheridge (1902, p. 198) states that *K. ocula* should be excluded from the genus *Keeneia.* However, an examination of the type specimen of *K. platyschismoides* in the Australian Museum, Sydney, shows that the structure of the "band" is similar to that shown in Sowerby's figure of *K. ocula.* The growth-lines cross the "bands" without sharp interruption, the "band" being formed by the regular backward swinging of the growth-line at the top part of the "band" and the forward swinging at the bottom part. In the position of the sinus on the lower part of the aperture *K. ocula* resembles *Keeneia* and not *Platyschisma.* For these reasons it is suggested *K. ocula* should be placed in the genus *Keeneia.*

KEENEIA CARNARVONENSIS sp. nov.

(Plate IX, figures 9-11.)

Holotype: C.P.C. 2264. 1 mile west of Kialawibri Creek road crossing; upper part of Lyons Group.

Diagnosis: Small *Keeneia* with periphery slightly but distinctly above lowest part of whorl. Aperture more rounded than in *K. platyschismoides* or *K. ocula.*

Description: Holotype: Spire flat and made up of four whorls. The suture is shallow and the upper part of the whorl is broadly convex with a shoulder slightly below the suture. The base of the whorl is flatly convex; at the umbilical shoulder the umbilicus is wide but narrows rapidly. The aperture is oval in shape with a sinus formed at the periphery. The outer lip swings backwards from the suture at an angle of about 45°; on reaching the periphery it swings forward again and straightens out, running over the umbilical shoulder into the umbilicus. In the umbilicus the inner lip is thickened and swings first towards the outer lip and back again to form a reversed S before meeting the base of the previous whorl. Little or no callus is visible over the previous whorl. The upper part of the shell has been weathered so that in the main the ornament is only shown on the lower part of the shell. The ornament is composed of transverse growth-lines parallel to the outline of the aperture, and faint revolving lirae on the base of the last whorl.

DIMENSIONS (in mm.).

—	Height.	Width.	Apical Angle.
Holotype	11	21	About 118°
Paratype	11	21	About 120°

Occurrence: Holotype—C.P.C. 2264—about 3 miles north-east of Round Hill Well, 1 mile west of Kialawibri Creek road crossing, Winning Station; upper part of Lyons Group. Paratype—C.P.C. 2265—at rabbit-proof fence, 3.4 miles south of Coyango Well, Williambury Station; 800 feet stratigraphically below top of Lyons Group.

Other localities—about 10½ miles west of Jimba Jimba Homestead, top of Lyons Group. Three specimens, one from each locality.

Discussion: Although the present collections contain only three specimens of this species, the characters are sufficiently distinctive to allow the establishment of a new species. *K. carnarvonensis* is closely related to the only two described species of *Keeneia, K. ocula* and *K. platyschisomoides;* but it is even more closely related to an undescribed species from the Permian Allandale Stage, Allandale, New South Wales. A specimen of this species lent by the Australian Museum is figured for comparison (Plate 9, figures 6-8). Like

K. carnarvonensis the sinus and the periphery are higher above the lowest part of the whorl than in *K. ocula* or *K. platyschismoides* and the aperture is more rounded.

Genus PLATYSCHISMA McCoy, 1844.

Type Species: Ampullaria helicoides J. de C. Sowerby (1826, p. 40) by subsequent designation of de Koninck (1881, p. 107)—see Knight (1941, p. 259).

PLATYSCHISMA? sp. nov.

(Plate VIII, figure 8.)

Description: A moderately high spire composed of four or more whorls and with distinct sutures; the top part of the spire is not preserved. The whorls are rounded, slightly more convex on the top than on the base. The internal impression shows prominent transverse grooves at intervals parallel to the growth lines, i.e., swinging backwards from the suture towards the periphery, and below the periphery swinging forwards again.

DIMENSIONS (in mm.).

—	Height.	Width.	Apical Angle.
Figured specimen C.P.C. 2266	35	44	85°
C.P.C. 2267	23	29	91° (estimated)

Occurrence: C.P.C. 2266 and C.P.C. 2267 at rabbit-proof fence, 3.4 miles south of Coyango Well, Williambury Station, 800 feet stratigraphically below top of Lyons Group. Two specimens.

Discussion: The material on hand at present does not allow a satisfactory generic or specific determination. It is sufficient, however, to indicate that a new species is present, which is related to *Platyschisma rotundatum* Morris (1845, p. 286, Plate 18, figure 2) from the Permian of New South Wales. Like *P. rotundatum,* it has a moderately high spire; the whorls are rounded and transverse grooves occur. The Western Australian species differs, however, in the shape of the spire and the dimensions of the whorls.

ACKNOWLEDGMENTS.

The help of officers of the Australian Museum, especially Mr. H. O. Fletcher, in making collections available for examination and in the loan of specimens and the preparation of photographs is gratefully acknowledged. Plaster casts have been kindly supplied by the Royal Scottish Museum, Edinburgh, and the British Museum (Natural History), London.

POSTSCRIPT.

Since this paper has gone to press a recent paper has come to hand: Newell, N. D., Chronic, J., Roberts, T. G., Upper Paleozoic of Peru, *Mem. geol. Soc. Amer.,* 58, 1953. In this paper Chronic describes a new genus *Peruvispira* of the family Pleurotomariidae from the Lower Permian. Although Chronic (p. 139) does not indicate the presence of a third carina either in his diagnosis or description, such a structure appears to be present in the holotype of *Peruvispira delicata* Chronic 1949, the type species, as shown in Pl. 28, fig. 11a. On this basis and also the grounds of the similarity in general shape, ornamentation and character of the slit-band, it appears likely that both *Pytchomphalina umariensis* (Reed) 1928 and *Ptychomphalina morrisiana* (McCoy) 1847 of this Bulletin should be referred to *Peruvispira* Chronic 1949.

REFERENCES.

BANKS, M. A., 1952.—Permian, Triassic and Jurassic Rocks in Tasmania. *Congr. geol. int. XIXme sess., Alger:* Symp. on Gondwanaland, 63-68.

BRANSON, C. C., 1948.—Bibliographic Index of Permian Invertebrates. *Mem. geol. Soc. Amer.*, 26.

CHEMNITZ, J. A., 1784.—NEUES SYSTEMATISCHES CONCHYLIEN-CABINET, Vol. 8. Nurnberg (not seen).

CONDON, M. A., 1954.—Progress Report on the Geology of the Carnarvon Basin. *Bur. Min. Resour. Aust. Rep.* 15.

COX, L. R., 1951.—The Lamellibranch Genus *Schizodus* and other Palaeozoic Myophoriidae. *Geol. Mag.*, 88 (5), 362-371.

DANA, J. D., 1847.—Description of Fossils from Australia. *Amer. J. Sci.*, 54, 151-160.

DANA, J. D., 1849.—*In* United States Exploring Expedition during the years 1838, 1840, 1841, under the command of Charles Wilkes N.S.W.; 10, Geology, 681-713.

DAVID, T. W. E., ed. BROWNE, W. R., 1950.—THE GEOLOGY OF THE COMMONWEALTH OF AUSTRALIA, Vol. 1. London, Arnold.

DICKINS, J. M., 1956.—Permian Pelecypods from the Carnarvon Basin, Western Australia. *Bur. Min. Resour. Aust. Bull.* 29.

DUN, W. S., 1932.—The Lower Marine Forms of *Myonia*, with Notes on a Proposed New Genus, *Pachymyonia*. *Rec. Aust. Mus.*, 18, 411-414.

ETHERIDGE, R., Junr., 1892.—In Jack, R. L. and Etheridge, R., Junr., GEOLOGY AND PALAEONTOLOGY OF QUEENSLAND AND NEW GUINEA. Brisbane and London.

ETHERIDGE, R., Junr., 1900.—Little Known and Undescribed Permo-Carboniferous Pelecypoda in the Australian Museum. *Rec. Aust. Mus.*, 3, 178-187.

ETHERIDGE, R., Junr., 1902.—A New Permo-Carboniferous Genus (*Keeneia*) of Pleurotomariidae, and *Straparollus* in New South Wales. *Rec. Aust. Mus.*, 4, 195-200.

ETHERIDGE, R., Junr., 1907.—Official Contributions to the Palaeontology of South Australia. *S. Aust. Parl. Pap.*, 55 (1906) Supp., 1-21.

ETHERIDGE, R., Junr., 1919.—Palaeontologia Novae Cambriae Meridionalis—Occasional Descriptions of New South Wales Fossils—No. 7. *Rec. Aust. Mus.*, 12, 183-192.

ETHERIDGE, R., Junr., and DUN, W. S., 1906.—A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales, Vol. II.—Pelecypoda. Part I.—The Palaeopectens. *Mem. geol. Surv. N.S.W., Palaeont.*, 5, 1-39.

ETHERIDGE, R., Junr., and DUN, W. S., 1910.—Idem, Part II.—*Eurydesma*. *Ibid.*, 5, 41-75,

FISCHER, P., 1880-1887.—MANUEL DE CONCHYLIOLOGIE ET DE PALÉONTOLOGIE CONCHYLIOLOGIQUE. Paris, Masson.

FLETCHER, H. O., 1929a.—Contributions on the Permo-Carboniferous Aviculopectinidae of New South Wales. *Rec. Aust. Mus.*, 17, 1-34.

FLETCHER, H. O., 1929b.—A Revision of the genus *Astartila*. *Ibid.*, 17, 53-75.

FLETCHER, H. O., 1932.—A Revision of the Genus *Myonia*, with Notes on Allied Genera from the Permo-Carboniferous of New South Wales. *Ibid.*, 18, 389-409.

FLETCHER, H. O., 1945.—A New Genus *Glyptoleda* and Revision of the Genus *Nuculana* from the Permian of Australia. *Ibid.*, 21, 293-312.

FLETCHER, H. O., 1946.—New Lamellibranchia from the Upper Permian of Western Australia. *Ibid.*, 21, 395-405.

FRECH, F., 1891.—Die Devonischen Aviculiden Deutschlands. *Abh. geol. Specialkarte Preuss.*, 9 (3) (not seen).

GUPPY, D. J., LINDNER, A. W., RATTIGAN, J. H., and CASEY, J. N., 1957.—The Geology of the Fitzroy Basin, W.A. *Bur. Min. Resour. Aust. Bull.* 36 (in press).

HALL, J., 1883.—*Natural History of New York, Palaeontology*, Vol. 5, Part I. Lamellibranchia I., Monomyaria. Plates and Explanations.

HALL, J., 1884.—*Ibid.*, Vol. 5, Part I. Lamellibranchia I., Monomyaria. Text and additional Plates and Explanations.

HALL, J., 1885.—*Ibid.*, Vol. 5, Part I. Lamellibranchia II. Dimyaria.

HARRINGTON, H. J., 1955.—The Permian *Eurydesma* Fauna of Eastern Argentina. *J. Paleont.*, 29 (1), 112-128.

HILL, D., 1955.—Contributions to the Correlation and Fauna of the Permian in Australia and New Zealand. *J. geol. Soc. Aust.*, 2, 83-107.

HIND, W., 1898.—A Monograph of the British Carboniferous Lamellibranchiata, Part III. *Palaeontogr. Soc. Monogr.*, 62.

HIND, W., 1899.—*Ibid.*, Part IV., 63.

HIND, W., 1900.—*Ibid.*, Part V., 64.

HIND, W., 1903.—*Ibid.*, Vol. II., Part II., 67.

HOSKING, L. F. V., 1931.—Fossils from the Wooramel District, Western Australia. *J. Roy. Soc. W. Aust.*, 17, 15-52.

JOHNSTON, R. M., 1887.—Contribution to the Palaeontology of the Upper Palaeozoic Rocks of Tasmania. *Pap. Roy. Soc. Tas.*, 1886, 4-18.

JOHNSTON, R. M., 1888.—SYSTEMATIC ACCOUNT OF THE GEOLOGY OF TASMANIA. Hobart, Government Printer.

KEGEL, W., 1953.—Sobre "*Aviculopecten mitchelli*" Etheridge & Dun. *Argent., Dep. nac. Prod. Min., Div. Geol. Min., Not. prelim. Est.*, 66, 1-6.

KNIGHT, J. B., 1941.—Palaeozoic Gastropod Genotypes. *Spec. Pap. geol. Soc. Amer.*, 32.

KONINCK, L. G. DE, 1844.—DESCRIPTION DES ANIMAUX FOSSILS DU TERRAIN CARBONIFÈRE DE BELGIQUE, Liége.

KONINCK, L. G. DE, 1877.—Recherches sur les fossiles paléozoiques de la Nouvelle-Galles du Sud (Australie). *Mem. Soc. roy. Sci. Liége*, 2, 6; (Translation: *Mem. geol. Surv. N.S.W. Palaeont.*, 6.)

KONINCK, L. G. DE, 1881.—Faune du calcaire carbonifère de la Belgique, 3e partie, Gasteropodes. *Ann. Mus. Hist. nat. Belg., Ser. Paléont.*, 6.

KONINCK, L. G. DE, 1883.—*Ibid.*, 4e Partie, Gasteropodes, 8.

KONINCK, L. G. DE, 1885.—*Ibid.*, 5e partie, Lamellibranches, 11.

LASERON, C. F., 1910.—Palaeontology of the Lower Shoalhaven River. *J. Roy. Soc. N.S.W.*, 44, 190-225.

MCCOY, F., 1844.—A SYNOPSIS OF THE CARBONIFEROUS LIMESTONE FOSSILS OF IRELAND. Dublin.

MCCOY, F., 1847.—On the Fossil Botany and Zoology of the Rocks Associated with Coal of Australia. *Ann. Mag. nat. Hist.*, ser. 1, 20, 145-157, 226-236, 298-312.

MCCOY, F., 1851.—*Ann. Mag. nat. Hist.*, Ser. 2, 7 (not seen).

MEEK, F. B., and HAYDEN, F. V., 1858.—Descriptions of New Organic Remains collected in Nebraska Territory, together with some remarks on the Black Hills and portions of the surrounding country. *Proc. Acad. nat. Sci. Phila.*, 41-59.

MEEK, F. B., and HAYDEN, F. V., 1865.—Palaeontology of the Upper Missouri. *Smithson. Contr. Knowl.*, 14, 1-135.

MILLER, S. A., 1892.—Indiana, Geology and Natural History, Palaeontology. *Dep. geol. nat. Resour., Ann. Rep.*, 17, 611-705.

MORRIS, J., 1845.—Descriptions of Fossils, *in* Strzelecki, P. de, PHYSICAL DESCRIPTION OF NEW SOUTH WALES AND VAN DIEMEN'S LAND, London, 270-291.

NEWELL, N. D., 1937.—Late Paleozoic Pelecypods: Pectinacea. *Geol. Surv. Kansas*, 10, 10-23.

NEWELL, N. D., 1940.—Invertebrate Fauna of the Late Permian Whitehorse Sandstone. *Bull. geol. Soc. Amer.*, 51 (2), 261-323.

NEWELL, N. D., 1942.—Late Paleozoic Pelecypods: Mytilacea. *Geol. Surv. Kansas*, 10 (2), 1-115

PHILLIPS, J., 1836.—GEOLOGY OF YORKSHIRE, Part 2 (not seen).

PHILLIPS, J., 1848.—*Mem. geol. Surv. U.K.*, 2 (1) (not seen).

REED, F. R. C., 1928.—A Permo-Carboniferous Marine Fauna from the Umaria Coal Field. *Rec. geol. Surv. India*, 60, 367-398.

REED, F. R. C., 1932.—New Fossils from the Agglomeratic Slate of Kashmir. *Palaeont. Indica*, N.S., 20, 1.

REED, F. R. C., 1936.—Some Fossils from the *Eurydesma* and *Conularia* beds (Punjabian) of the Salt Range. *Ibid.*, N.S., 23, 1.

RYCKHOLT, P. DE, 1852.—MELANGES PALÉONTOLOGIQUES, Ière Partie (not seen).

SHIMER, H. W., and SHROCK, R. R., 1944.—INDEX FOSSILS OF NORTH AMERICA. N.Y., Wiley.

SLOAN, R. E., 1955.—Paleoecology of the Pennsylvanian Marine Shales of Palo Pinto County, Texas. *J. Geol.*, 63 (5), 412-428.

SOWERBY, J., 1812.—THE MINERAL CONCHOLOGY OF GREAT BRITAIN. Lond., 1 (not seen).

SOWERBY, J., 1817.—*Ibid.*, 2 (not seen).

SOWERBY, J., 1838.—Fossils, in T. L. Mitchell, THREE EXPEDITIONS INTO THE INTERIOR OF AUSTRALIA, 15.

SOWERBY, J. DE C., 1821.—THE MINERAL CONCHOLOGY OF GREAT BRITAIN. London, 4 (not seen).

SOWERBY, J. DE C., 1826.—*Ibid.*, 6 (not seen).

SOWERBY, J. DE C., 1839.—Fossil Shells in the lowest bed of the old Red Sandstone. In R. I. Murchison, THE SILURIAN SYSTEM.

STOLICZKA, F., 1871.—Cretaceous Fauna of Southern India. The Pelecypoda, with a Review of all known Genera of this class, Fossil and Recent. *Palaeont. Indica*, ser. 6, 3.

TEICHERT, C., 1941.—Upper Palaeozoic of Western Australia: Correlation and Palaeogeography. *Bull. Amer. Ass. Petrol. Geol.*, 25 (3), 371-415.

TEICHERT, C., 1950.—Some Recent Additions to the Stratigraphy of Western Australia. *Ibid.*, 34 (9), 1781-1794.

TEICHERT, C., and GLENISTER, B. F., 1952.—Lower Permian Ammonoids from the Irwin River Basin, Western Australia. *J. Paleont.*, 26 (1), 12-23.

THOMAS, E. G., 1940.—Revision of the Scottish Carboniferous Pleurotomariidae. *Trans. geol. Soc., Glasgow*, 21 (1), 30-72.

THOMAS, G. A., and DICKINS, J. M., 1954.—Correlation and Age of the Marine Permian Formations of Western Australia. *Aust. J. Sci.*, 16 (6), 219-223.

THOMAS, H. D., 1928.—An Upper Carboniferous Fauna from the Amotape Mts., Peru. *Geol. Mag.*, 65, 146-152, 215-223, 289-300.

VERNEUIL, E. DE, 1845.—Mollusques. *In* R. I. Muchison, E. de Verneuil and A. de Keyserling, GÉOLOGIE DE LA RUSSIE D'EUROPE, Vol. 2, Part 2, 37-376. John Murray, London, and Bertrand, Paris.

VERNEUIL, E. DE, and MURCHISON. R. I., 1844.—Note sur les equivalents du systeme permien en Europe. *Bull. Soc. géol. Fr.*, ser. 2, 1, 475-517.

VOISEY, A H., 1938.—Permian of Tasmania. *Proc. Linn. Soc. N.S.W.*, 63, 309.

WAAGEN, W., 1881.—Salt Range Fossils, Part 3, Pelecypods. *Palaeont. Indica*, ser. 13, 1, 185-328.

WAAGEN, W., 1891.—Salt Range Fossils. *Palaeont. Indica*, ser. 13, 4 (2), 89-242.

WANNER, C., 1922.—Die Gastropoden und Lamellibranchiaten der Dyas von Timor. *Palaeont. Timor*, 11 (18).

PLATE I.

FIGS. 1-11—*Praeundulomya concentrica* Dickins, gen. et sp. nov. .. .. Page 10

Figs. 1-4—Holotype x 1. 1. Left valve. 2. Dorsal view. 3. Right valve (see also Text-fig. 2). 4. Front view.

Fig. 5—Paratype C, immature specimen x 2.

Fig. 6—Paratype B, an immature specimen x 4.

Fig. 7—Paratype F, showing mature ornament in middle part of shell x 1.

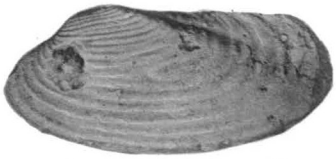
Fig. 8—Paratype E, a large specimen x ½.

Figs. 9-10—Paratype D, two parts of an external impression showing the granulation of the surface x 8.

Fig. 11—Paratype G, showing the structure of the hinge x 1.

(Photographs in the plates, except Plate VIII., figs. 9 and 10, taken by G. T. Reid, photographer of the Bureau of Mineral Resources, Geological Section, in collaboration with the author.)


1


5


6


2

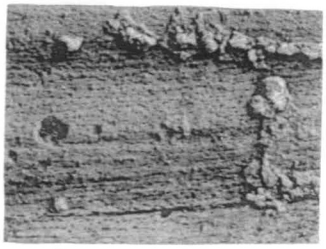

7


3


8


4


9


10


11

PLATE II.

FIGS. 1-6—*Nuculana darwini* (de Koninck) x 4 .. .. Page 18

Figs. 1-2—Hypotype D, showing shape and muscle pattern.
Figs. 3-4—Hypotype A. 3. Side view. 4. Dorsal view.
Fig. 5.—Hypotype B.
Fig. 6—Hypotype C.

FIGS. 7-14—*Stutchburia variabilis* Dickins, sp. nov. x. 1 .. .. . Page 21

Figs. 7-9—Holotype. 7. Side view. 8. Dorsal view. 9. Front view.
Fig. 10—Paratype A, an external impression of a right valve.
Figs. 11, 12—Paratype E, lateral and dorsal views.
Fig. 13—Paratype B.
Fig. 14—Paratype F.


1


3


5


2


4


6


7


8


9


10


11


12


13

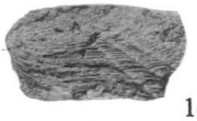

14

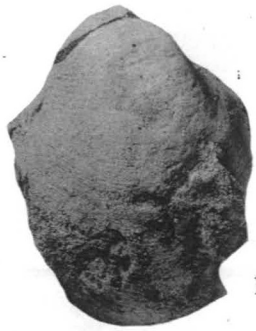
PLATE III.

FIGS. 1-6—*Astartila? obscura* Dickins, sp. nov. x 1 .. .. Page 25

Fig. 1—Paratype A.
Figs. 2-5—Holotype, front view, left valve, right valve, dorsal view.
Fig. 6—Paratype B, an incomplete left valve.

FIGS. 7-11—*Astartila condoni* Dickins, sp. nov. x 1 .. .. Page 23

Figs. 7-8—Paratype B, front and side views.
Figs. 9-10—Holotype, side and dorsal views.
Fig. 11—Paratype A.

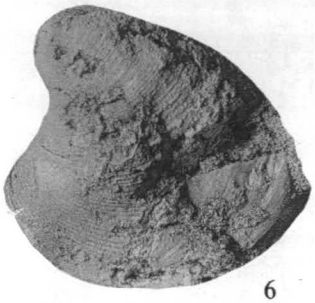

1


2


3


4


5


6


7


8


9


10

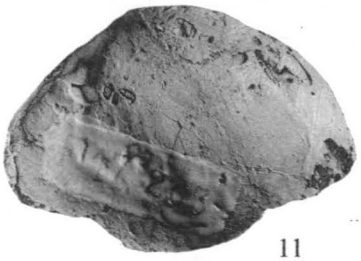

11

PLATE IV.

FIGS. 1-4—*Pachydomus?* sp. x ½ .. .. Page 26

Type No. C.P.C. 2218, an internal impression of a left valve.
Fig. 1—Dorsal view.
Fig. 2—Impression of inside of hinge plate (see also Text-fig. 3).
Fig. 3—Front view.
Fig. 4—Side view.

FIGS. 5-9—*Pachymyonia occidentalis* Dickins, sp. nov. x 1 .. .. .. Page 28

Figs. 5-8—Holotype. 5. Dorsal view. 6. Right valve. 7. Left valve. 8. Front view.
Fig. 9—Paratype.

FIGS. 10-12—*Chaenomya* sp. nov. x 1 .. .. Page 29

Type No. C.P.C. 2223.
Fig. 10—Right valve.
Fig. 11—Dorsal view.
Fig. 12—Left valve.

FIGS. 13-17—*Leiopteria? carrandibbiensis* Dickins, sp. nov. .. .. .. Page 30

Fig. 13—Paratype C x 1.
Fig. 14—Holotype x 1.
Fig. 15—Paratype B, showing the internal structure x 2 (see also Text-fig. 4).
Figs. 16-17—Paratype A. 16. Dorsal view x 3. 17. Dorso-lateral view to show ligament area x 4 (see also Text-fig. 4).

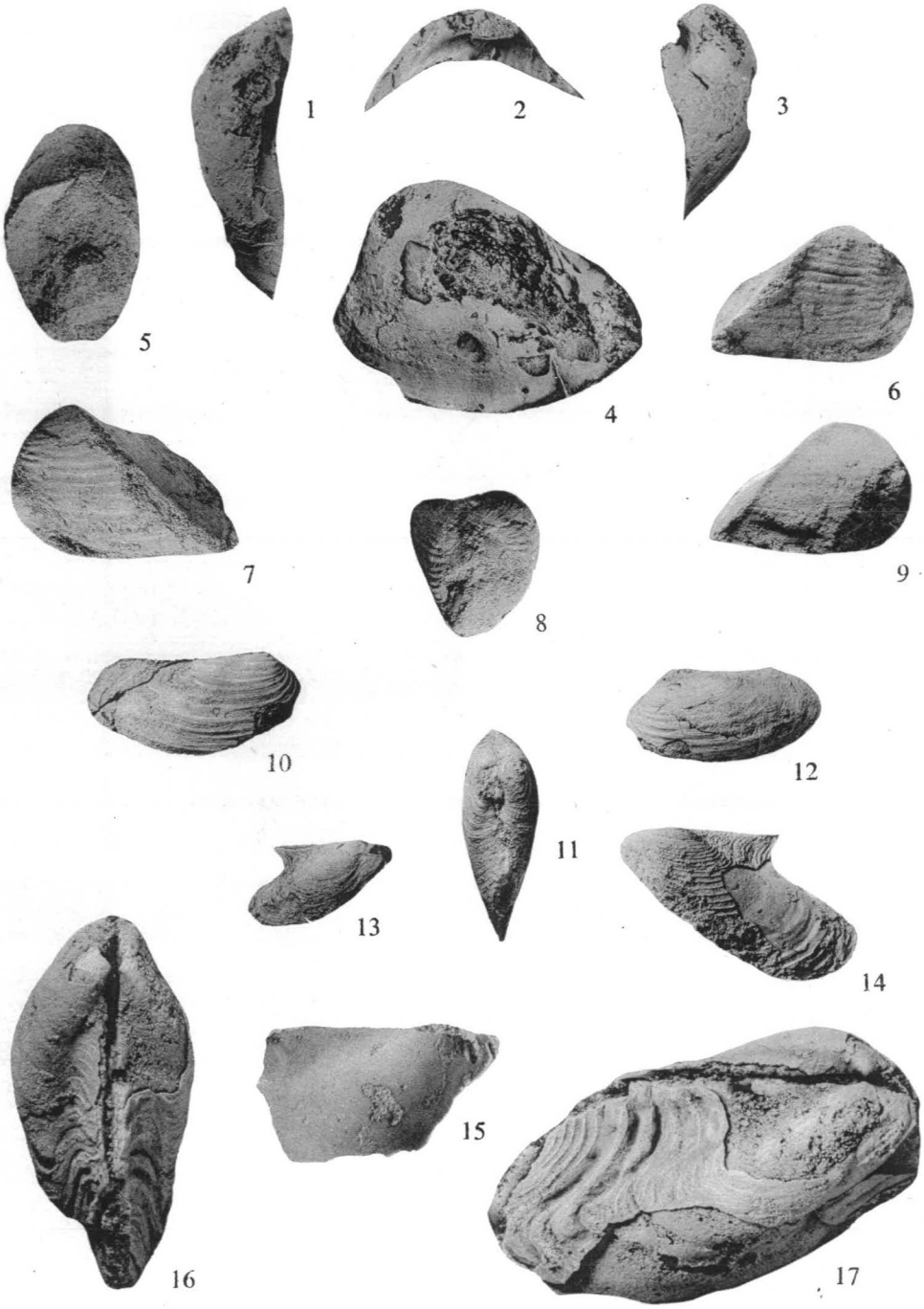

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

PLATE V.

FIGS. 1-11—*Eurydesma playfordi* Dickins, sp. nov. .. .. Page 33

Fig. 1—Paratype A x ½.

Fig. 2—Paratype C x ½.

Fig. 3—Paratype E, a slightly crushed specimen x ½.

Fig. 4—Paratype F, inside of a left valve showing an impression which may be the mark of the adductor muscle x 1 (see also Text-fig. 5). Fig. 5. Paratype I., showing muscular impressions near umbo x 1.

Figs. 6-7—Paratype D x ½.

Figs. 8-10—Holotype, internal, external and dorsal views x 1.

Fig. 11—Paratype B, front view of a bivalved specimen x 1.

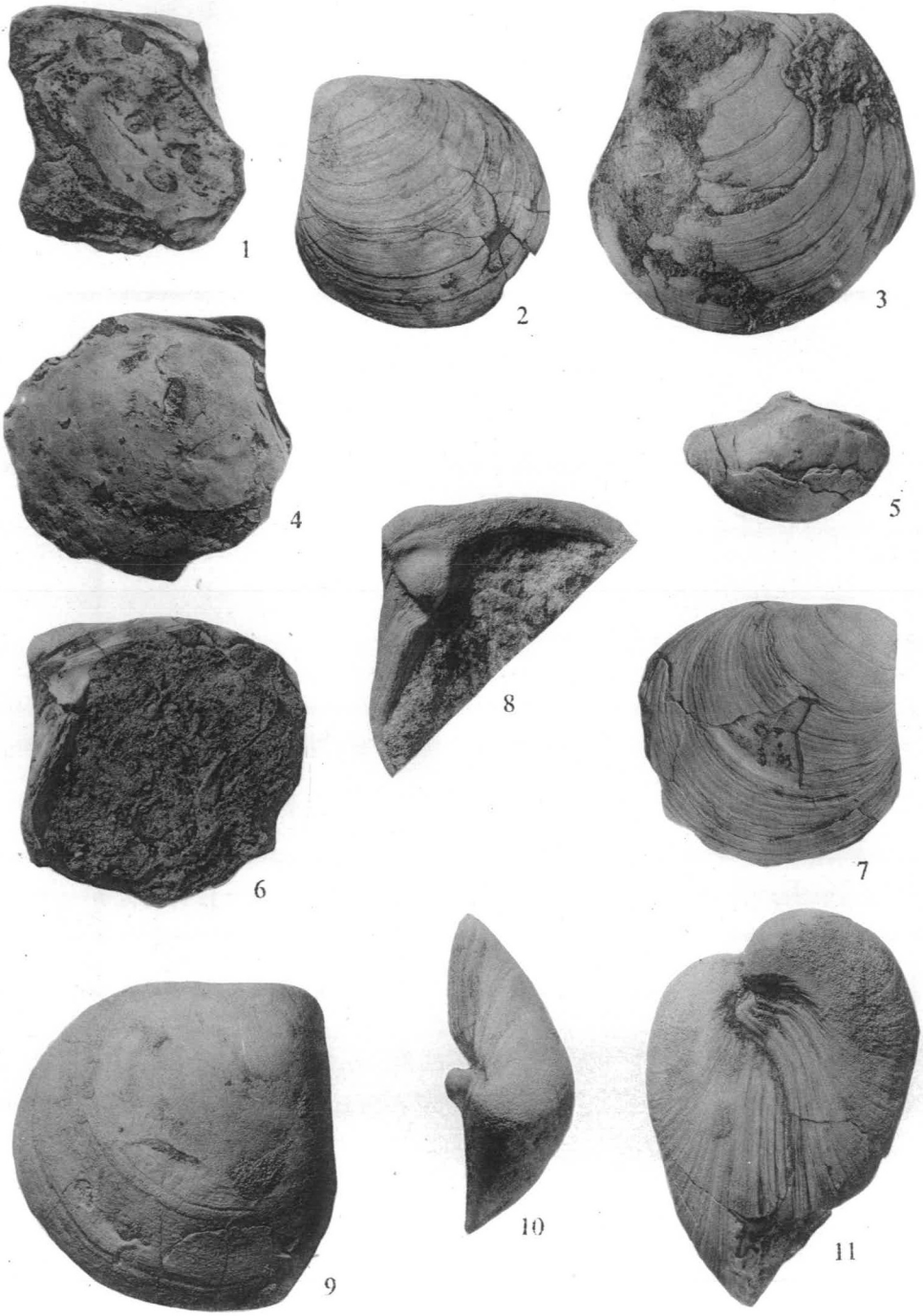

1
2
3
4
5
6
7
8
9
10
11

PLATE VI.

FIGS. 1-6—*Schizodus crespinae* Dickins sp. nov. .. .. Page 38

Figs. 1-3—Holotype. 1. Side view x 2. 2. Dorsal view x 2. 3. Hinge structure x 4.
Figs. 4-6—Paratype A. 4. Front view x 2. 5. Side view x 2. 6. Hinge structure x 4.

FIGS. 7-9—*Aviculopecten tenuicollis* (McCoy) x 2 .. .. Page 45

Fig. 7-8—Latex mould of Hypotype A, side and front views.
Fig. 9—Hypotype B, side view.

FIGS. 10-14—*Praeundulomya elongata* Dickins, sp. nov. x 1 .. .. .. Page 36

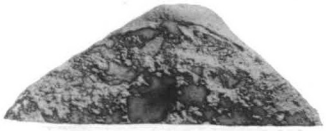
Figs. 10-13—Holotype. 10. Dorsal view. 11. Front view. 12. Right valve (see also Text-fig. 7). 13. Left valve with shell tilted slightly towards the side.
Fig. 14—Paratype B; the lower posterior groove can be seen in the right valve.


1


2


4


5


3


6


7


8


9


10


11


12


13

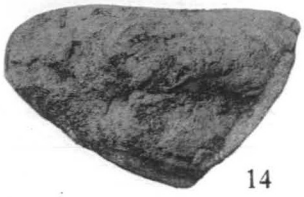

14

PLATE VII.

FIGS. 1-5 and 9—*Deltopecten lyonsensis* Dickins sp. nov. .. .. .. Page 41

Figs. 1-3—Holotype. 1. Side view x ½. 2. Front view x ½. 3. Hinge x 2.
Fig. 4—Paratype C x ½.
Fig. 5—Paratype E, a bivalved specimen, dorsal view x ½.
Fig. 9—Paratype D x ½.

FIGS. 6-7—*Deltopecten media?* (Laseron) .. .. Page 41

Australian Museum No. F.24,054, from Berrara, N.S.W.
Fig. 6—Inside of shell x 1.
Fig. 7.—Hinge x 2.

FIG. 8—*Deltopecten mitchelli* (Etheridge and Dun) .. .. Page 40

Australian Museum No. F.26,435, from Allandale, N.S.W., showing hinge structure x 1 (see also Text-fig. 8).


1

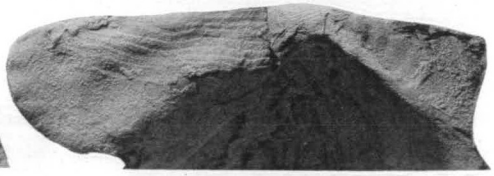

2

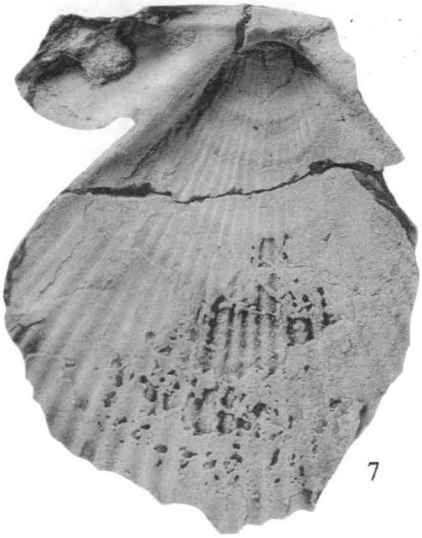

4


5


3


6


8


7


9

PLATE VIII.

FIGS. 1-5—*Mourlonia? lyndonensis* Dickins, sp. nov. x 2 .. .. .. Page 46
Figs. 1-4—Holotype.
Fig. 5—Paratype B.

FIGS. 6-7—*Ptychomphalina morrisiana* (McCoy) x 4 .. .. Page 49
Australian Museum No. F.21,250, from Illawarra, N.S.W.
Fig. 6—Specimen B.
Fig. 7—Specimen A.

FIG. 8—*Platyschisma?* sp. .. .. Page 51
Type No. C.P.C. 2266 x 1.

FIG. 9—*Deltopecten illawarensis* (Morris) .. .. Page 40
Australian Museum No. F.35,332; from road cutting near Allandale Railway Station, N.S.W.; hinge of left valve of specimen figured by Etheridge & Dun (1906, pl. 2, fig. 2) x 1 approx.
(Photograph by Australian Museum.)

FIG. 10—*Deltopecten mitchelli* (Etheridge and Dun) .. .. .. Page 40
Australian Museum No. F.35,333, from road cutting near Allandale Railway Station, N.S.W., impression of hinge of left valve figured by Etheridge and Dun (1906, pl. 1, fig. 3) x 1 approx.
(Photograph by Australian Museum.)

FIGS. 11-13—*Deltopecten lyonsensis* Dickins, sp. nov. x ½ approx. .. .. Page 41
Fig. 11—Paratype B.
Figs. 12-13—Paratype A, front and side views.


1


2


3

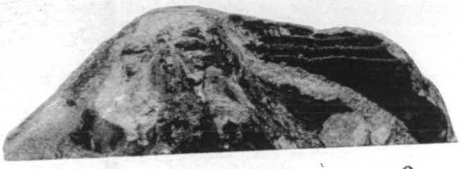

4

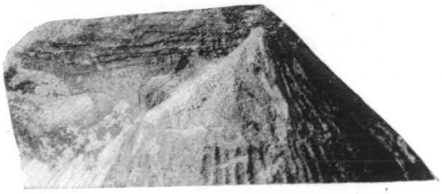

5

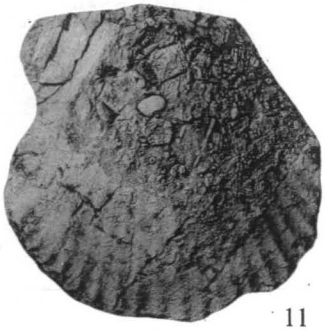

6


8


7


9


10


11


12

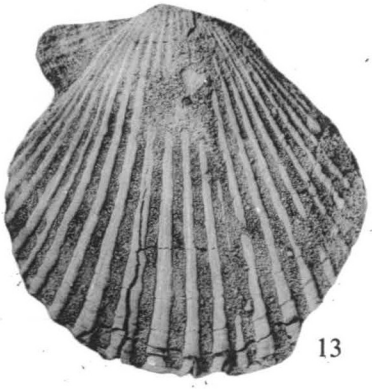

13

PLATE IX.

FIGS. 1-5—*Ptychomphalina umariensis* (Reed) x 4 .. .. Page 47
Figs. 1-3—Hypotype A.
Fig. 4—Hypotype C.
Fig. 5—Hypotype B.

FIGS. 6-8—*Keeneia* sp. nov. x 1 .. .. Page 50
Australian Museum No. F.27,531 from Allandale, N.S.W.

FIGS. 9-11—*Keeneia carnarvonensis* Dickins, sp. nov. x 2 .. .. .. Page 50
Figs. 9-11—Holotype.

FIG. 12—*Deltopecten lyonsensis* Dickins, sp. nov. .. .. Page 41
Paratype H, cross-section of shell approx. parallel to the hinge line, showing the main shell layer x 26.

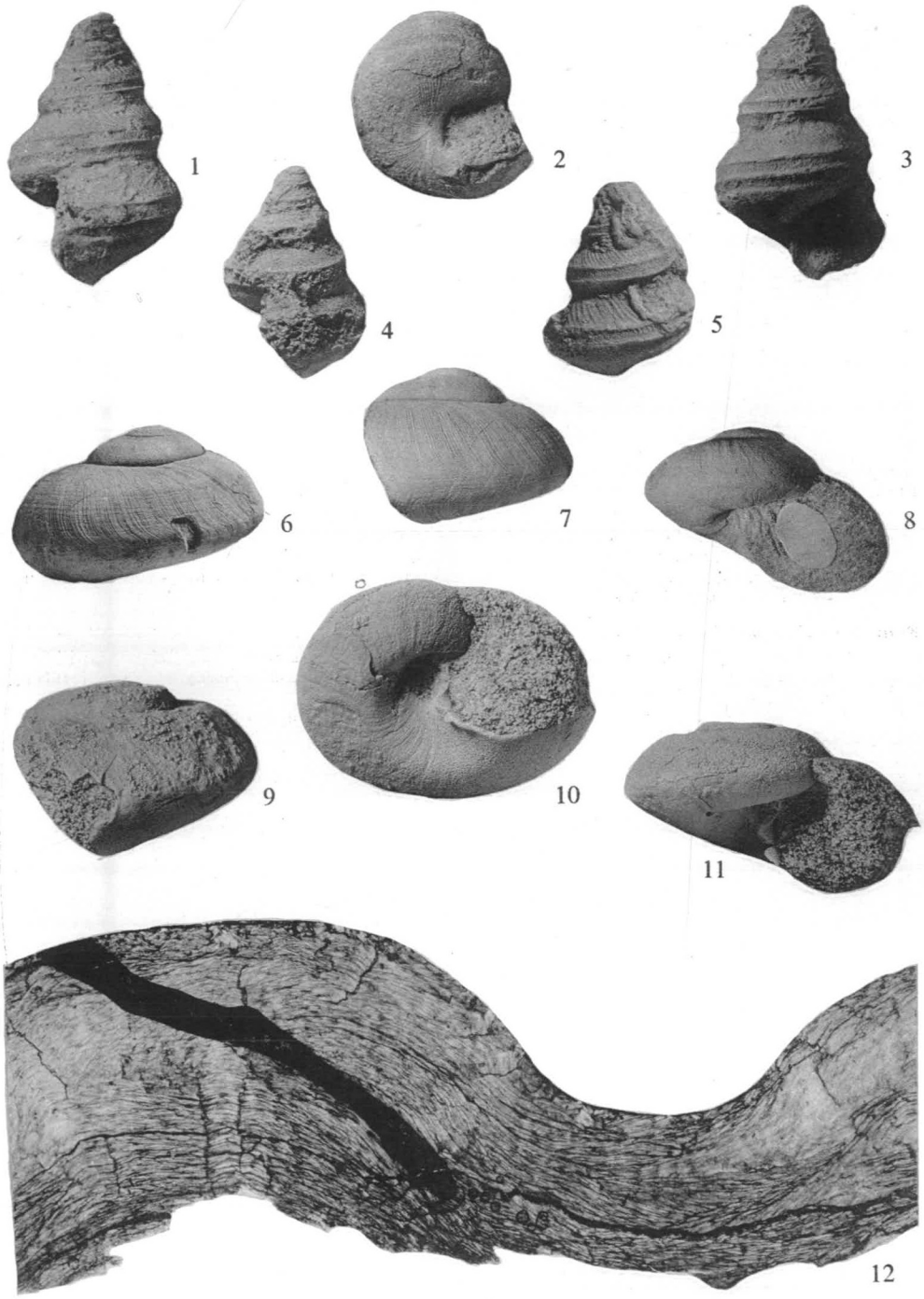

1
2
3
4
5
6
7
8
9
10
11
12

PLATE X.

FIGS. 1-2 and 5—*Eurydesma playfordi* Dickins, sp. nov. .. .. .. Page 35

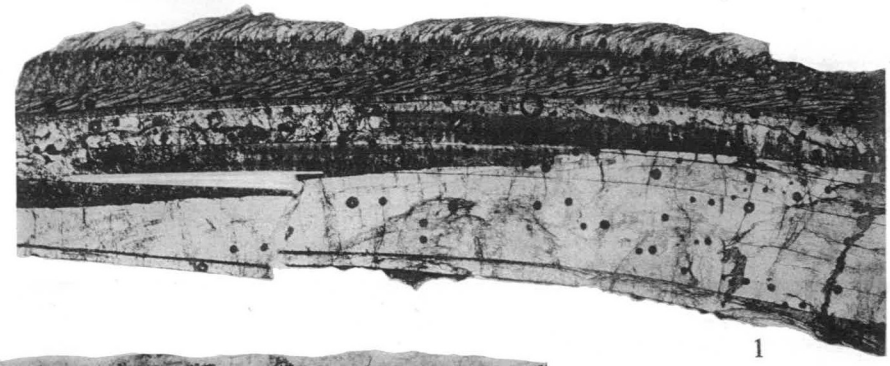
Figs. 1-2—Paratype H, a right valve. 1. Cross section of the shell, approx. parallel to the hinge, outside margin of the shell on the left x 22 (see also Text-fig. 6).
2. Another cross section of the shell, x 26.

Fig. 5—Paratype G, a left valve; cross section approx. parallel to hinge, near margin which is to the right x 26.

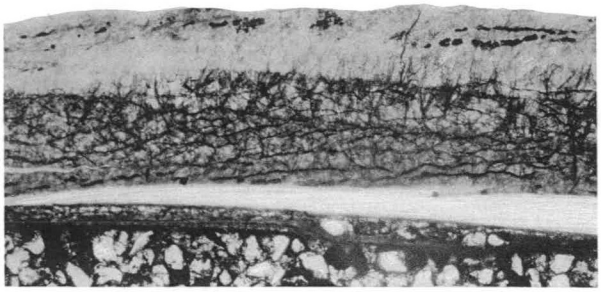
FIGS. 3-4—*Deltopecten lyonsensis* Dickins, sp. nov. .. .. Page 42

Fig. 3—Paratype G, a right valve, cross section of shell approx. parallel to the hinge and near margin which is to the left. A thin outer prismatic layer is shown faintly in the top right hand corner x 22.

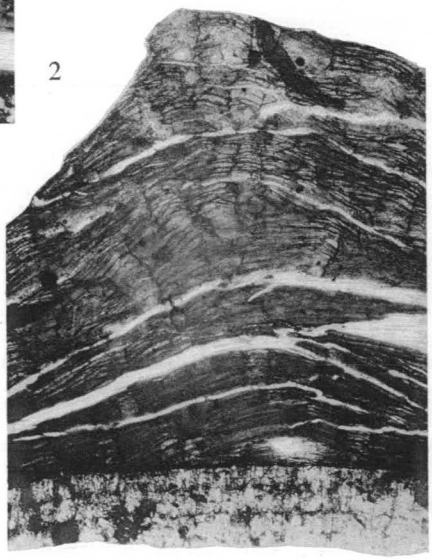
Fig. 4—Paratype F, cross section approx. parallel to the hinge showing the main and internal layer x 22.



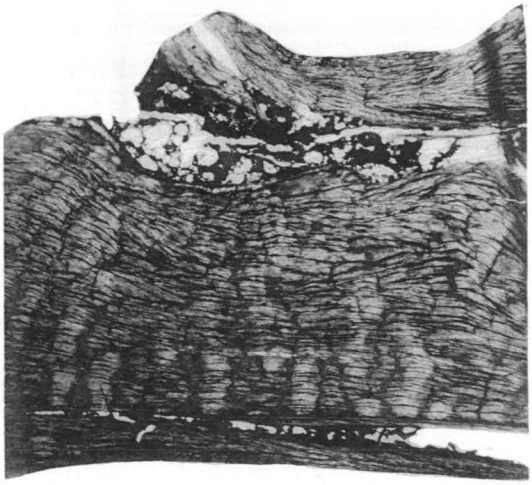
1



2



4



3

5