STUDIES ON WESTERN AUSTRALIAN PERMIAN BRACHIOPODS 10. FAUNAS FROM THE WOORAMEL GROUP, CARNARVON BASIN

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Archbold, N. W., 1991:12:31. Studies on Western Australian Permian brachiopods 10. Faunas from the Wooramel Group, Carnarvon Basin. *Proceedings of the Royal Society of Victoria* 103 (2): 55–66. ISSN 0035-9211.

The brachiopod faunas from the One Gum and Billidee Formations of the Wooramel Group are reviewed and described. The new species *Neochonetes (Sommeriella) hockingi* is described and the *Strophalosia jimbaensis* zone is proposed for the faunas described herein. The age of the *Strophalosia jimbaensis* zone is discussed, with an Aktastinian (Early Artinskian) age being preferred.

FOR MANY years there has been considerable debate about the stratigraphical and age significance of the Early Permian marine faunas from the Wooramel Group of the Carnarvon Basin. This study investigates the relatively small collections of variably preserved specimens from the dominantly arenaceous sections of the Wooramel Group sequence. A larger fauna from the Jimba Jimba Calcarenite Member will be documented elsewhere, in view of some confusion over the recognition of this unit in the field (cf. Condon 1967, Hocking et al. 1987).

STRATIGRAPHY

The Permian stratigraphy of the Carnarvon Basin was extensively described by Condon (1967) on the basis of mapping by Bureau of Mineral Resources field parties, and was reviewed and revised by Hocking et al. (1987) on the basis of mapping by Geological Survey of Western Australia field parties. Only the pertinent stratigraphy concerning the Wooramel Group is summarised herein.

The Wooramel Group was defined by Konecki et al. (1958: 28) as the predominantly arenaceous sequence, with few marine fossils, above the surface of the disconformity on top of the Callytharra Formation and conformably below the Byro Group. They divided the Group into three formations (the Nunnery Sandstone, One Gum Formation and Keogh Formation in ascending order) in the type locality region on the Wooramel River, Byro Sub-Basin. The Wooramel Group interval of sediments had previously been recognised by such workers as Condit (1935), Condit et al. (1936), Raggatt (1936), Teichert (1952) and Condon (1954). McWhae et al. (1958) had access to the manuscript of Konecki et al. (1958) and were the first to cite the names of the formations proposed by Konecki et al.

Other formations in the Wooramel Group were named or described by Condon (1954, 1962a, 1962b, 1965) and in McWhae et al. (1958). Substantial simplification and revisions of the terminology of the Wooramel Group were proposed by van de Graaff et al. (1977) and Hocking et al. (1980). The collections described in the present study come from the One Gum Formation, Byro Sub-Basin (*sensu* Konecki et al. 1958, also Dickins 1956) and the Billidee Formation of the Merlinleigh Sub-Basin (*sensu* Hocking et al. 1987). For convenience, these two stratigraphical names are used in this study.

PREVIOUS FAUNAL STUDIES

Most faunal studies involving the Wooramel Group assemblages have been based on field observations or unpublished palaeontological reports (e.g. see Condon 1962a, 1967, Dickins 1956, Cockbain 1979). On the basis of material observed and collected by Bureau of Mineral Resources field parties during the 1950s, Dickins (1963) was able to demonstrate that the bulk of the Wooramel Group was characterised by "rather unsatisfactory" material that appeared to be "closer to the older Fossil Cliff/ Nura Nura assemblage than to the younger fauna of the Byro Group" (Dickins 1963: 14). This was to characterise Stage C marine faunas of the Western Australian Permian sequences which were "marked by the absence rather than the presence of a marine fauna" (Dickins 1963: 20).

Dickins (1963: 14) also drew attention to the small bivalve and brachiopod fauna in the top-most beds of the Wooramel Group which is identical with the fauna found in the immediately overlying Byro Group, reflecting "the deepening of the basin and the initial development of more definite off-shore marine conditions in those places". This fauna, found in the top of the Keogh and Billidee Formations, was included in Stage D by Dickins (1963). The occurrence of the ammonoids *Neocrimites* sp. and *Bamyaniceras* sp. in beds high in the Billidee Formation (Cockbain 1980) also links this fauna with the lowest fauna of the Byro Group, generally regarded as being early Baigendzhinian in age.

While there is little disagreement as to the age of the uppermost Wooramel Group faunas, this is not the case for the bulk of the Wooramel Group. Dickins (1963) considered that the close relationship of his Stage C assemblages with those of his Stage B assemblages indicated an age for Stage C of Early Artinskian (Aktastinian). He considered Stage C to be immediately younger than the Sterlitamakian fauna of the underlying Callytharra Formation with, by implication, the disconformity between the two stratigraphical units representing a very minor interval of time.

However, the discovery of a specimen of the ammonoid *Pseudoschistoceras* from beds near the top of the Cordalia Sandstone (a lateral equivalent of the Nunnery Sandstone) resulted in Cockbain (1980) considering the entire Wooramel Group to be of early Baigendzhinian age. *Pseudoschistoceras* is generally considered to indicate a Baigendzhinian age (Glenister et al. 1983) but is only known from three described localities and is listed from the Kungurian by Bogoslovskaya (1988), indicating that it's full stratigraphical range may not be fully understood. Runnegar (1969) and Waterhouse (1970) regarded the recognition of Stage C as unwarranted and so merged it with Stage B. As a result Cockbain (1980: 104) considered that Stage B had a "fairly long time range and occurs at a number of shelly horizons, often of limited extent, and hence cannot be used for detailed biostratigraphical correlation".

AGE OF WOORAMEL GROUP

The fossils figured and described herein include the following:

?*Streptorhynchus* sp.
Permorthotetes sp.
Neochonetes (Sommeriella) hockingi sp. nov.
Strophalosia jimbaensis Archbold, 1986
Aulosteges sp.
Fusispirifer sp.
Neospirifer sp.
?*Cleiothyridina* sp.
?*Aviculopecten* sp.

While the preservation of specimens as natural ferruginous casts and internal and external moulds is of variable quality, the overall affinity of the fauna is closer to that of the Callytharra Formation than to that of the overlying fauna of the Madeline/Coyrie Formation. Nevertheless the Wooramel Group species are distinctive, and of particular importance are species of *Neochonetes (Sommeriella)* and *Strophalosia*. Chonetid brachiopods evolved rapidly during the Permian in Western Australia (e.g. see Archbold 1981) and are invaluable for correlation, while *Strophalosia* species are also important for biostratigraphy (e.g. see Clarke 1990).

A formal zone is proposed herein for Wooramel Group faunas, namely the *Strophalosia jimbaensis* zone, based on a species that is found in both the One Gum and Billidee Formations. The species is also present in the Jimba Jimba Calcarenite where the distinctive species *Globiella flexuosa* (Waterhouse) is also found (Archbold 1983). The Jimba Jimba fauna, currently being investigated by me, appears to be related to that of the Callytharra Formation but is distinct at the species level, adding support to the biostratigraphical recognition of Stage C of Dickins (1963).

In view of the relatively close relationship of many of the Wooramel Group species to those from the Callytharra Formation (see comparisons below), I agree with Dickins (1963) that the disconformity between the two units does not represent a major break in time (perhaps just the late Sterlitamakian). As a result, not withstanding the significance of the occurrence of the ammonoid *Pseudoschistoceras* sp., I prefer an Aktastinian age assignment for the Wooramel Group. Comparison of a few species of the fauna with forms from Sterlitamakian or Aktastinian horizons elsewhere also strengthens the proposed Aktastinian age.

COLLECTIONS AND LOCALITIES

All specimens are registered with the Geological Survey of Western Australia (GSWA F), Perth or with the Commonwealth Palaeontological Collections (CPC) of the Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Specimens were found at the following localities:

Geological Survey of Western Australia locality 94217, from a solitary peak west of Mt Sandiman–Moogooree Road about 12 km north of Mt Sandiman Homestead, Kennedy Range 1:250,000 sheet. Photo reference, Kennedy Range 1968: Run 3, Photo 214, Point 547. From midway up hill where two coquina bands outcrop. Lower band with *Neochonetes (Sommeriella)* and upper (2 m higher) with *Strophalosia*. Billidee Formation.

Bureau of Mineral Resources locality WB 9, 1.25 miles (2 km) on a bearing of 285° from Keogh Hill. Base of One Gum Formation.

Bureau of Mineral Resources locality WB 69, 2.24 miles (3.5 km) on a bearing of 258° from Keogh Hill. Base of One Gum Formation.

Bureau of Mineral Resources locality 7864, 0427, Glenburgh Run 13A, Photo 5009, 2.4 km on a bearing of 276° from Keogh Hill. Base of One Gum Formation.

SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA
Order STROPHOMENIDA Öpik, 1934
Suborder ORTHOTETIDINA Waagen, 1884
Superfamily ORTHOTETACEA Waagen, 1884
Family STREPTORHYNCHIDAE Stehli, 1954

Genus **Streptorhynchus** King, 1850

Type species. Terebratulites pelargonatus Schlotheim, 1816.

?**Streptorhynchus** sp.

Fig. 1C

Comments. A single specimen (CPC 24502) of a ferruginous cast of a dorsal valve exterior (specimen 24 mm wide, 26 mm long) may represent the occurrence of *Streptorhynchus* or a related genus in the basal One Gum Formation assemblage (locality BMR 7864, 0427). The specimen

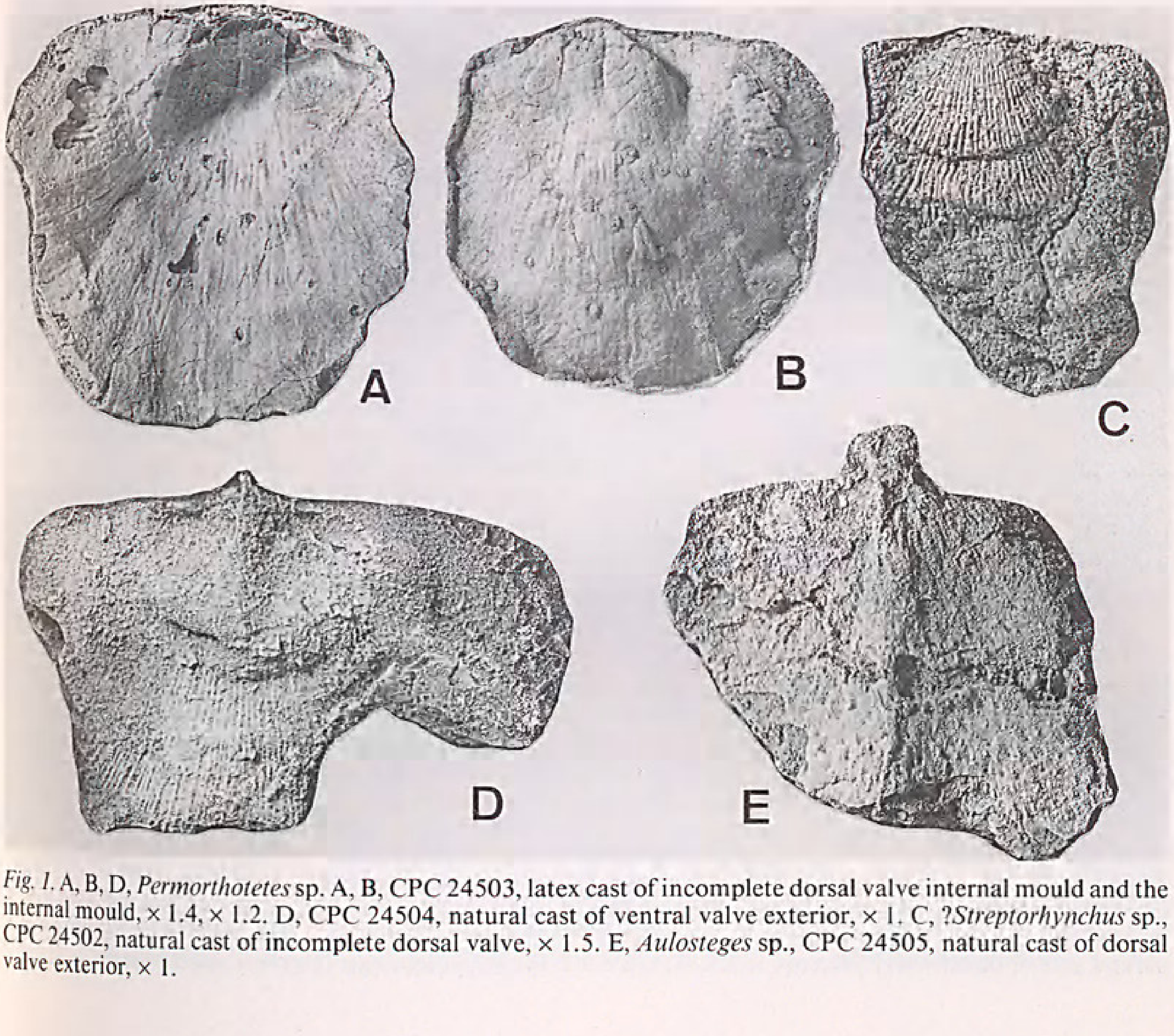


Fig. 1. A, B, D, *Permorthotetes* sp. A, B, CPC 24503, latex cast of incomplete dorsal valve internal mould and the internal mould, × 1.4, × 1.2. D, CPC 24504, natural cast of ventral valve exterior, × 1. C, ?*Streptorhynchus* sp., CPC 24502, natural cast of incomplete dorsal valve, × 1.5. E, *Aulosteges* sp., CPC 24505, natural cast of dorsal valve exterior, × 1.

possesses distinct concentric growth interruptions as in *Arctitreta plicatilis* (Hosking) as described by Thomas (1958), but indicates a larger species than the Callytharra species. Costellae number 8 to 12 per 5 mm and increase predominantly by intercalation although rare bifurcation does occur. Costellae are gently rounded and broaden anteriorly, and hence are not flattened as in *Arctitreta plicatilis* but rather resemble those of *Streptorhynchus crassimurus* Thomas, 1958 from the late Baigendzhinian Noonkanbah Formation, Canning Basin.

Family ORTHOTETIDAE Waagen, 1884
Subfamily ORTHOTETINAE Waagen, 1884

Genus **Permorthotetes** Thomas, 1958

Type species. Permorthotetes callytharrensis Thomas, 1958.

Permorthotetes sp.

Fig. 1A, B, D

Permorthotetes sp.—Thomas 1958: 107.—Condon 1962a: 11.—Condon 1967: 102.
Orthotetacea nov. gen.—Konecki et al. 1958: 33.

Material. One incomplete mould of a dorsal valve (CPC 24503) from locality BMR 7864, 0427, width 38.5+ mm, length 42+ mm; and one natural cast of a ventral valve exterior (CPC 24504) from locality BMR WB 9, width 67+ mm, length 42 mm.

Comments. Two specimens are consistent with the identification of *Permorthotetes* from the basal One Gum Formation. The dorsal valve internal mould reveals an uneven convex profile and a low median ridge bisecting the muscle field. The cardinal process is unknown. The ventral valve external ferruginous cast is large, wrinkled, irregularly gently convex posteriorly and flat anteriorly. Costellae are fine (about 7 to 8 per 5 mm at 30 to 40 mm from umbo) and increase by intercalation. Intercostal troughs are wider than costellae. A comparison with *Permorthotetes callytharrensis* Thomas, 1958 is suggested but better material is required for detailed comparisons.

Order CHONETIDA Nalivkin, 1979
Suborder CHONETIDINA Muir-Wood, 1955
Superfamily CHONETACEA Bronn, 1862
Family RUGOSOCHONETIDAE Muir-Wood, 1962
Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus **Neochonetes** Muir-Wood, 1962
Subgenus **Neochonetes (Sommeriella)** Archbold, 1982

Type species. Chonetes prattii Davidson, 1859.

Comments. The subgeneric name *Sommeria* Archbold, 1981 was replaced by the name *Sommeriella* by Archbold, 1982. The recognition of subgenera within the large and widely understood genus *Neochonetes* was discussed by Archbold (1981).

Neochonetes hockingi sp. nov.

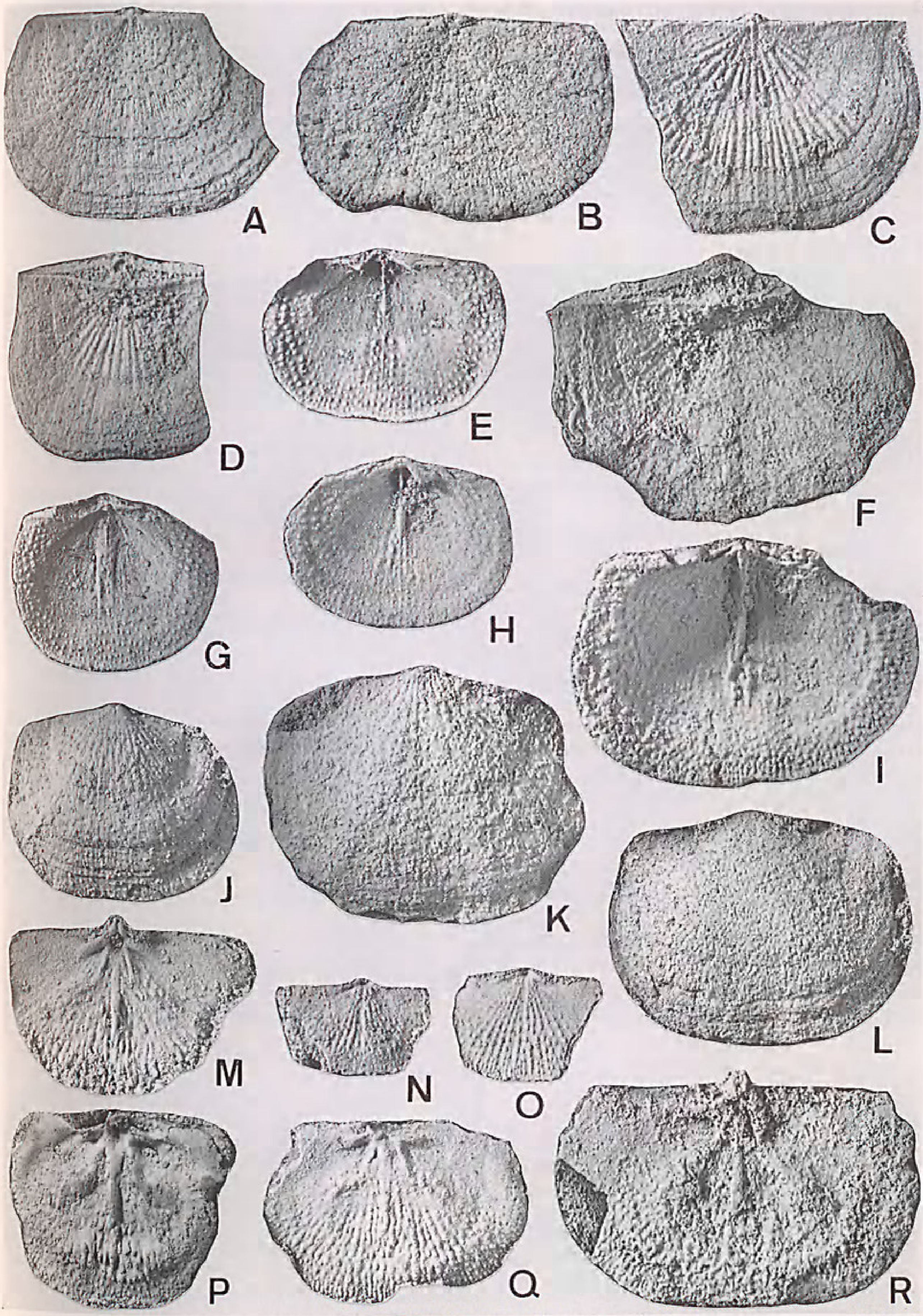
Fig. 2A–R

Etymology. Named for geologist Roger M. Hocking, discoverer of the chonetid band which yielded the species.

Holotype. GSWA F11247, a natural ferruginous cast of a ventral valve exterior showing the external ornament, from GSWA locality 94217, Billidee Formation, collected by Dr S. K. Skwarko, Geological Survey of Western Australia.

Paratypes. GSWA F43818–F43820, two natural casts of dorsal valve exteriors and one external mould of a dorsal valve; GSWA F43821, F43822, two natural casts of shells; GSWA F43823–F43826, four natural casts of ventral valve interiors; GSWA F43827, F43828, two natural casts of ventral valve exteriors; and GSWA F43829–F43834, five natural casts of dorsal valve interiors and one natural internal mould of a

Fig. 2. Neochonetes (Sommeriella) hockingi sp. nov. A, GSWA F43818, natural cast of dorsal valve exterior, × 3.5. B, GSWA F43819, latex cast of dorsal valve exterior, × 3.5. C, GSWA F43820, natural cast of dorsal valve exterior, × 3.5. D, GSWA F43821, natural cast of shell in dorsal view, × 3.5. E, GSWA F43823, natural cast of ventral valve interior, × 3.5. F, GSWA F43822, natural cast of shell in dorsal view, × 3.5. G, GSWA F43824, natural cast of ventral valve interior, × 3.5. H, GSWA F43825, natural cast ventral valve interior, × 3.5. I, GSWA F43826, natural cast of ventral valve interior, × 3.5. J, GSWA F11247, holotype, natural cast of ventral valve exterior, × 3.5. K, GSWA F43827, natural cast of ventral valve exterior, × 3.5. L, GSWA F43828, natural cast of worn ventral valve exterior, × 3.5. M, GSWA F43829, natural cast of dorsal valve interior, × 3.5. N, GSWA F43830, natural cast of juvenile dorsal valve interior, × 3.5. O, GSWA F43831, natural cast of juvenile dorsal valve interior, × 3.5. P, GSWA F43832, latex cast of dorsal valve internal mould, × 3.5. Q, GSWA F43833, natural cast of dorsal valve interior, × 3.5. R, GSWA F43834, natural cast of dorsal valve interior, × 3.5.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dorsal valve; same locality and collector as holotype.

Size ranges. Maximum width 5.7–14.9 mm; hinge width 5.5–14.2 mm; ventral length 6.5–10.6 mm; dorsal length 4.3–9.3 mm.

Diagnosis. Small *Neochonetes (Sommeriella).* Ventral sulcus weakly developed; dorsal fold low but distinct. External ornament of fine capillae, on average numbering 3 per mm at 6 mm from umbones.

Description. Length of shell just over two-thirds of maximum width. Maximum width just anterior of shell mid-length; hinge width less than maximum width. Ventral valve evenly convex. Sulcus low, broadening anteriorly, arising close to umbo. Dorsal valve gently concave with low median fold often poorly developed. Interareas low, chilidium and pseudodeltidium poorly known. Ornament of capillae increasing by bifurcation and intercalation. Growth lines fine, more pronounced anteriorly.

Casts of worn ventral valves show external ornament poorly; those of worn dorsal valves show progressive absence of growth lines and presence of fine pseudocapillate ornament (5–6 per mm at 6 mm from umbo) reflecting internal subsurface shell structure. Ventral hinge spines poorly known, appear to project at 40° to 45°.

Ventral interior with distinct median septum, over half valve length at maturity, arising under ventral umbo. Parallel vascular trunks usually distinct adjacent to septum. Adductor scars indistinct; diductors large, prominent, gently striated. Remainder of valve floor papillose. Teeth small, sharp.

Cardinal process internally bilobate, externally poorly known. Dorsal median septum distinct, up to 0.6 times valve length. Ontogeny of dorsal septum reveals absence in juveniles, presence well to the anterior of alveolus in submaturity but fused with lateral septa and anterior of alveolus at maturity. Sockets distinct with pronounced inner socket ridges. Brachial ridges raised and papillose at maturity. Radiating rows of papillae in anterior of dorsal valve.

Discussion. Neochonetes (Sommeriella) hockingi is distinguished from most other Western Australian representatives of the subgenus by its distinctive small size and low ventral sulcus. *N. (S.) robustus* Archbold, 1981 from the early Baigendzhinian Madeline Formation, Carnarvon Basin, is a slightly larger species with a distinctive rounded outline and is more concavo-convex than *N. (S.) hockingi.* The sulcus of *N. (S.) robustus* is virtually absent. The new species shares features with *N. (S.) arabicus* (Hudson & Sudbury, 1959) from the Sterlitamakian to Aktastinian or younger Lusaba Limestone of Oman, an even smaller species with similar dorsal exterior and interior to those of *N. (S.) hockingi.* The Oman species is the smallest representative of *Neochonetes (Sommeriella)* known at present (Archbold & Burrett 1990).

Order Productida Sarycheva & Sokolskaya, 1959
Suborder Strophalosiidina Waterhouse, 1975
Superfamily Strophalosiacea Schuchert, 1913
Family Strophalosiidae Schuchert, 1913
Subfamily Strophalosiinae Schuchert, 1913

Genus **Strophalosia** King, 1844

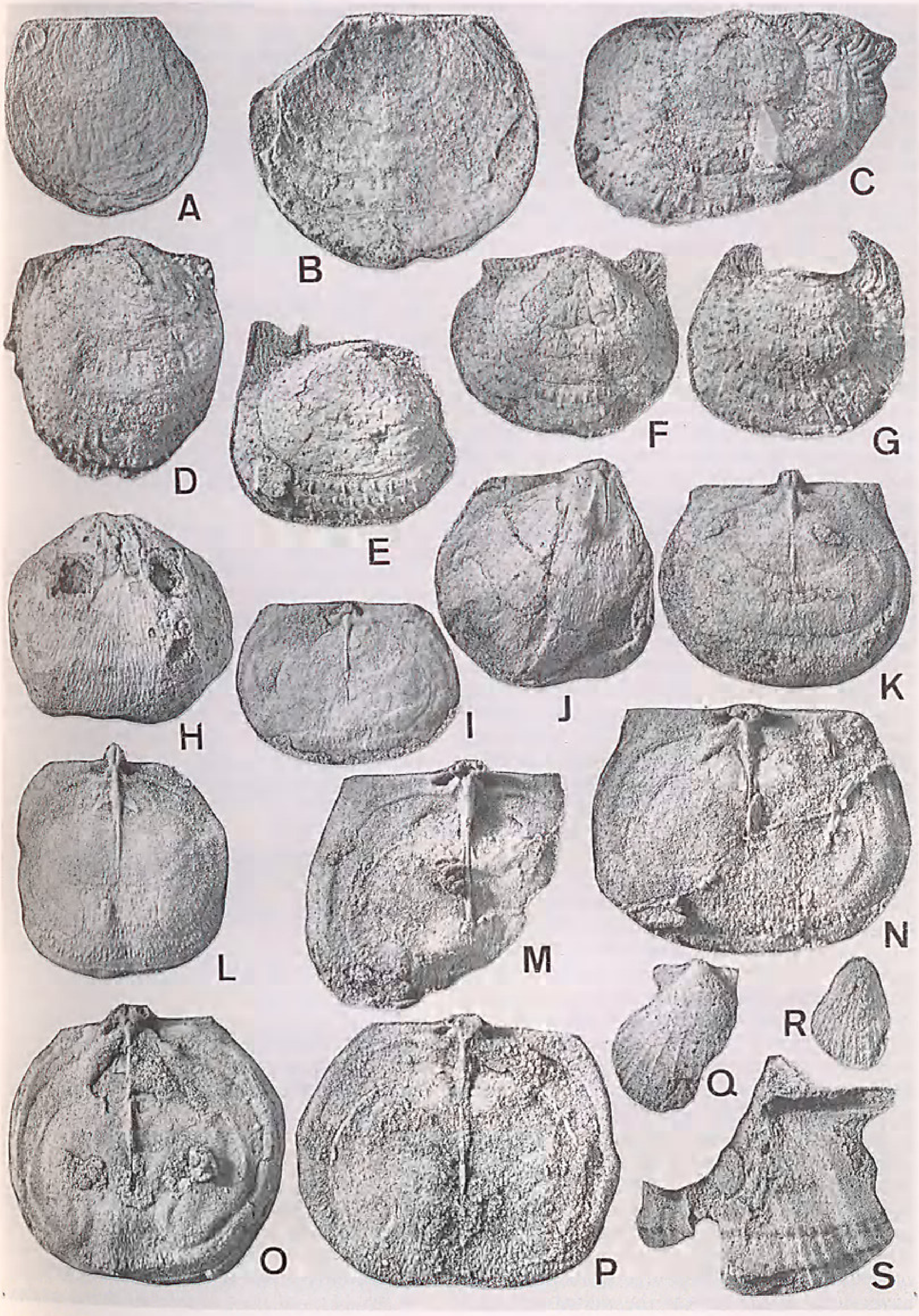
Type species. Strophalosia gerardi King, 1846.

Strophalosia jimbaensis Archbold, 1986

Fig. 3A–P

Strophalosia nov. sp.—Konecki et al. 1958: 33.
Strophalosia sp.—Condon 1963a: 11.—Condon 1967: 114.—McGann 1976: 47.

Fig. 3. A–P, *Strophalosia jimbaensis* Archbold. A, GSWA F43835, natural cast of dorsal exterior, × 1.3. B, GSWA F43836, natural cast of dorsal valve exterior, × 1.3. C, GSWA F43837, latex cast of ventral valve external mould, × 1.3. D, GSWA F43838, latex cast of ventral valve external mould, × 1.3. E, GSWA F43839, latex cast of ventral valve external mould, × 1.3. F, GSWA F43840, latex cast of ventral valve external mould, × 1.3. G, GSWA F43841, latex cast of ventral valve external mould, × 1.3. H, GSWA F43842, internal mould of ventral valve, × 1.3. I, GSWA F43844, latex cast of dorsal valve internal mould, × 1.3. J, GSWA F43843, latex mould from natural cast of dorsal valve interior, × 1.3. K, GSWA F43845, latex cast of dorsal valve internal mould, × 1.3. L, GSWA F43846, latex cast of dorsal valve internal mould, × 1.3. M, GSWA F43847, latex cast of dorsal valve internal mould, × 1.3. N, GSWA F43848, latex cast of dorsal valve internal mould, × 1.3. O, GSWA F43849, latex cast of dorsal valve internal mould, × 1.3. P, GSWA F43850, latex cast of dorsal valve internal mould, × 1.3. Q, R?, *Aviculopecten* sp., GSWA F43852, F43853, two small specimens, both incomplete, × 1. S, *Fusispirifer* sp., GSWA F43851, incomplete internal mould of ventral valve, × 1.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Strophalosia jimbaensis Archbold 1986: 102–104, fig. 2A–G.

Strophalosia sp. cf. *S. jimbaensis*.—Archbold 1986: 104, fig. 2H–O.

Material. GSWA F43835–43850, two natural ferruginous casts of dorsal valve exteriors, five external moulds of ventral valves, one internal mould of a ventral valve, one natural cast of a ventral valve interior and seven internal moulds of dorsal valves, all from GSWA locality 94217, Billidee Formation, collected by Dr S. K. Skwarko, Geological Survey of Western Australia.

Size ranges. Maximum width 25.4–40.2 mm; hinge width 19.2–28.2 mm; ventral length 20.6–29.4 mm; dorsal length 19.6–32.6 mm.

Diagnosis. Medium to large sized *Strophalosia* with moderately convex ventral valve and concave dorsal valve. Dorsal valve with well defined dimples, growth lamellae and radial capillae, no spines. Ventral valve with hinge spines, two rows on ears, numerous scattered suberect body spines and a shallow median sulcus or flattening.

Comments. Dickins (in Konecki et al. 1958: 33) was the first to recognise "*Strophalosia* nov. sp., resembling a species from the Callytharra Formation" in the basal One Gum Formation assemblage. Eight specimens from the assemblage were figured by Archbold (1986, fig. 2H–O) who compared them with the Jimba Jimba Calcarenite species *Strophalosia jimbaensis*. Different styles of preservation between the type specimens of *S. jimbaensis* and the One Gum specimens prevented unequivocal assignment of the latter to *S. jimbaensis*.

The well preserved new suite of specimens from the Billidee Formation serves to unite the two collections discussed above and provides additional information on details of the ventral exterior spines and the dorsal interior and cardinal process. Spines on the ventral ears are in two rows and curve back towards the umbo; they are in excess of 8.5 mm in length. Body spines are in rough concentric rows and project laterally and anteriorly near the exterior perimeter of the ventral valve. The dorsal interior possesses a thin median septum about half the valve length at submaturity, but at maturity a thickened median septum is some two-thirds the valve length. Large brachial ridges become prominent at full maturity. The cardinal process is relatively small, bilobed internally and spike-like at submaturity when it projects posteriorly beyond the hinge line of the dorsal valve. At maturity, the cardinal process is broader and more massive, approaches a quadrilobed state internally and projects internally in the plane of the dorsal interarea.

Several other species of *Strophalosia* have been described since the erection of *S. jimbaensis* by Archbold (1986). *Strophalosia perfecta* Waterhouse & Rao (1989) from the Early Permian of the Bap Formation, Rajasthan is a much smaller species than *S. jimbaensis*, suggesting comparison with the Western Australian Sterlitamakian species *S. irwinensis* Coleman (see Archbold 1986). *S. concentrica* Clarke, 1990 from the Early Permian of Tasmania is a distinct small to medium sized globose species that does not warrant close comparison with *S. jimbaensis*. *S? vollosovitschi* (Fredericks, 1931) as recorded by Abramov & Grigor'eva (1988: 104, pl. 1, figs 23–25, pl. 2, figs 1, 2, 7) from Verkhoyan'ya, northeast Siberia is a large species apparently lacking distinct dorsal external dimples.

Strophalosia is a characteristic genus of the Early Permian (Asselian–Sakmarian) of Australia (Archbold 1986, Clarke 1990) although ranging younger in Western Australia with the species *S. jimbaensis*. The genus is unknown in the well known Baigendzhinian faunas of the Carnarvon and Canning Basins, although a very rare species (2 specimens?) is known from the early Baigendzhinian fauna of the Mingenew Formation of the Perth Basin (Archbold 1988). The Mingenew species possesses distinctive smaller dorsal exterior dimples than those of *S. jimbaensis*.

Superfamily AULOSTEGACEA Muir-Wood & Cooper, 1960

Family AULOSTEGIDAE Muir-Wood & Cooper, 1960

Subfamily AULOSTEGINAE Muir-Wood & Cooper, 1960

Genus **Aulosteges** von Helmersen, 1847

Type species. Orthis wangenheimi de Verneuil, 1845 (= *Aulosteges variabilis* von Helmersen, 1847).

Aulosteges sp.

Fig. 1E

Comments. A single natural cast of the exterior of a dorsal valve (CPC 24505) from BMR locality WB 9, basal One Gum Formation, indicates the presence of *Aulosteges* s.l. in the assemblage, on the basis of its distinct, low dorsal median fold. The specimen shows distinct dimples and a few spine bases but is inadequate for detailed comparison with other Western Australian species described by Coleman (1957).

Order SPIRIFERIDA Waagen, 1883
Suborder SPIRIFERIDINA Waagen, 1883
Superfamily SPIRIFERACEA King, 1846
Family SPIRIFERIDAE King, 1846
Subfamily NEOSPIRIFERINAE Waterhouse, 1968

Genus **Fusispirifer** Waterhouse, 1966

Type species. Spirifer nitiensis Diener, 1897.

Comments. Fusispirifer was reviewed by Archbold & Thomas (1987) who discussed the subfamilial placing of the genus and its palaeogeographical distribution. An additional species of *Furispirifer* from the Western Australian Permian was described by Archbold & Skwarko (1988).

Fusispirifer sp.

Fig. 3S, 4A–G, L.

Material. CPC 19894–19897, three ventral valve internal moulds and one external mould of a ventral valve from BMR locality WB 69, basal One Gum Formation. CPC 24506–24509, two natural casts of juvenile ventral valve interiors and two incomplete external moulds of ventral valves from BMR locality 7864 0427, basal One Gum Formation. GSWA F43851 (formerly F11060/1), incomplete internal mould of a ventral valve from GSWA locality 94217, Billidee Formation.

Comments. Fusispirifer is abundant in the Permian of Western Australia (Archbold & Thomas 1987) and the present material indicates the presence of the genus in the Wooramel assemblages. The species is characterised by coarse costae and lateral plications that are variable but usually well developed on juvenile specimens but are poorly developed on the flanks of mature specimens. The Callytharra Formation species *F. carnarvonensis* possesses lower and usually finer ventral valve costae and very subdued lateral flank plications when compared with the material to hand. The younger *F. byroensis* (Glauert) (see Archbold & Thomas 1987) is a distinct flattish species readily distinguished from the Wooramel Group species.

A distinctive internal feature of the Wooramel species is the large, relatively wide ventral muscle field recalling that of the large species *F. wandageensis* from the late Early Permian Wandagee Formation. The Wooramel specimens are closest to *F. carnarvonensis* from the Callytharra Formation but are distinct from that species and with the collection of additional material, particularly dorsal valves, will require the recognition of a new species.

Genus **Neospirifer** Fredericks, 1924

Type species. Spirifer fasciger von Keyserling, 1846.

Neospirifer sp.

Fig. 4H–J

Neospirifer sp.—Konecki et al. 1958: 33.—Condon 1962a: 11.—Condon 1967: 114.—McGann 1976: 51.

Neospirifer sp. B.—Archbold & Thomas 1986: 150, fig. 14 B, C.

Material. One natural cast of a ventral valve interior and one incomplete external mould of a ventral valve (CPC 19898–19899) from BMR locality 7864 0427, and one incomplete external mould of a ventral valve (CPC 24362) from BMR locality WB 69; all from the basal One Gum Formation.

Comments. As noted by Archbold & Thomas (1986: 150), the Wooramel *Neospirifer* species is related to the Western Australian *N. hardmani–N. plicatus* group of *Neospirifer* and appears to represent an intermediate species between the Callytharra and Madeline Formation species. The new material includes a fragment of a mature ventral valve (CPC 19899) which recalls specimens of an undescribed species of *Neospirifer* from the Aktastinian High Cliff Sandstone of the Perth Basin.

Order ATHYRIDIDA Dagys, 1974
Suborder ATHYRIDIDINA Boucot, Johnson & Staton, 1964
Superfamily ATHYRIDACEA M'Coy, 1844
Family ATHYRIDIDAE M'Coy, 1844
Subfamily ATHYRIDINAE M'Coy, 1844

Genus **Cleiothyridina** Buckman, 1906

Type species. Atrypa pectinifera Sowerby, 1840.

?**Cleiothyridina** sp.

Fig. 4K

Comments. A single specimen (CPC 24510) of an incomplete natural cast of a juvenile ventral valve interior from BMR locality 7864 0427 may represent an athyrid such as *Cleiothyridina*, judging from what appear to be traces of vascu-

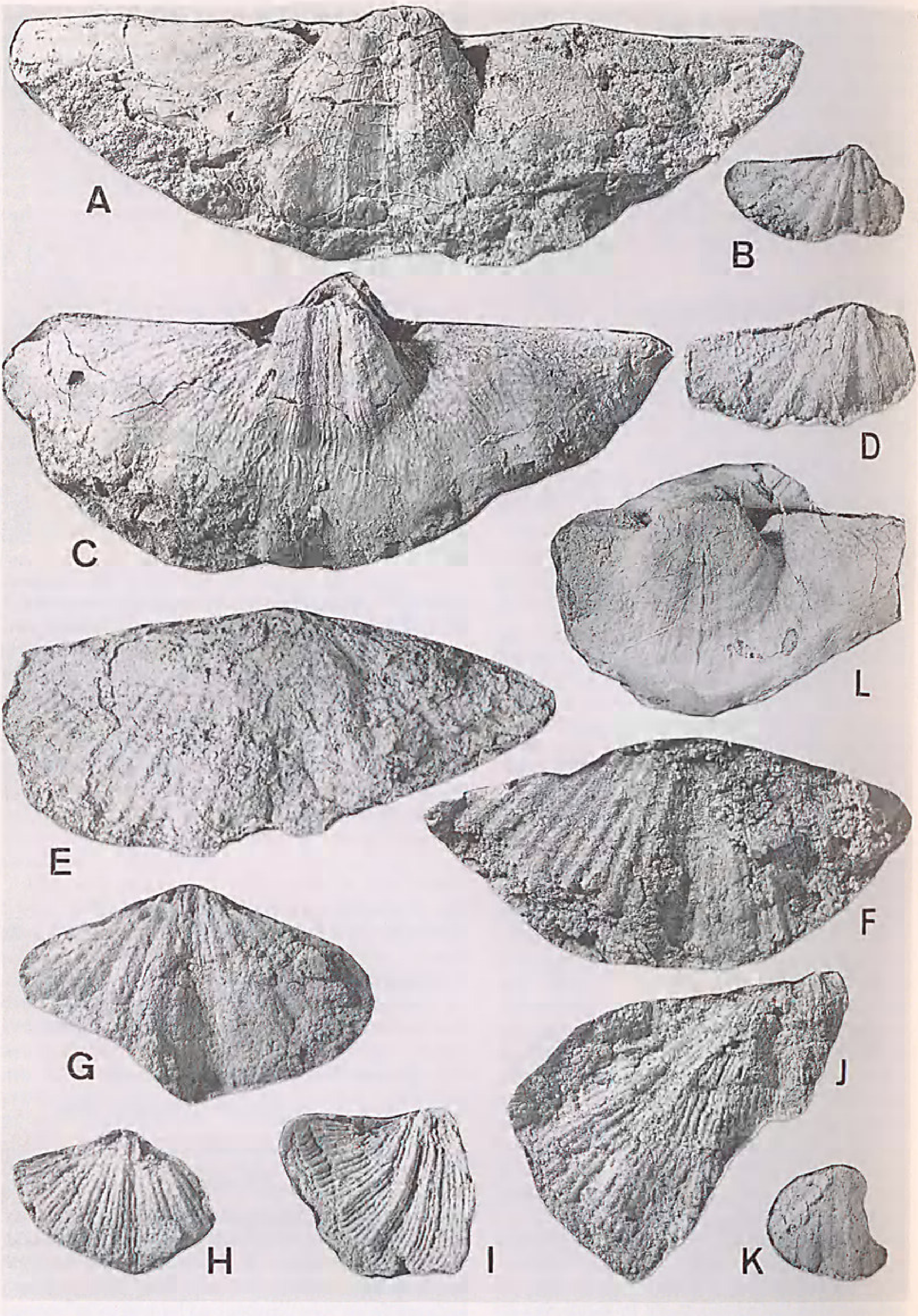
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Fig. 4. A–G, L, *Fusispirifer* sp. A, CPC 19894, internal mould of ventral valve, × 1. B, CPC 24506, latex cast of natural cast of juvenile ventral valve interior, × 1.5. D, CPC 24507, latex cast of natural cast of juvenile ventral valve interior, × 1.5. C, CPC 19895, internal mould of ventral valve, × 1. E, CPC 19896, latex cast of ventral valve external mould, × 1. F, CPC 24508, latex cast of ventral valve external mould, × 1. G, CPC 24509, latex cast of ventral valve external mould, × 1; note that lateral valve extremities are not preserved. L, CPC 19897, internal mould of ventral valve, × 1. H–J, *Neospirifer* sp. H, CPC 19898, latex cast of natural cast of juvenile ventral valve interior, × 1.5. I, CPC 24362, latex cast of ventral valve external mould, × 1. J, CPC 19899, latex cast of incomplete ventral valve external mould, × 1.2. K, ?*Cleiothyridina* sp., latex cast of natural cast of ?juvenile ventral valve interior, × 1.5.

lar impressions. The specimen is inadequate for detailed comment.

Phylum MOLLUSCA
Class BIVALVIA

Comments. For completeness, two small fragmentary specimens (GSWA F43852–43853) from GSWA locality 94217 are figured (Fig. 3Q–R). Judging from descriptions and illustrations of Western Australian Permian Bivalvia provided by Dickins (1963), both specimens probably represent pectinaceans referrable to *Aviculopecten, Etheripecten* or a closely related genus and appear close to forms from the Callytharra Formation.

ACKNOWLEDGEMENTS

Dr S. K. Skwarko, Geological Survey of Western Australia, and Dr J. M. Dickins, Bureau of Mineral Resources, Geology & Geophysics, are thanked for the loan and collection of specimens and the provision of locality data. Ms C. Hansen and Ms P. Storer typed the manuscript. A Royal Society of Victoria Study Grant assisted with the cost of photography, and my work on Late Palaeozoic brachiopod faunas of Western Australia is supported by the Australian Research Council (Project A 38930315).

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