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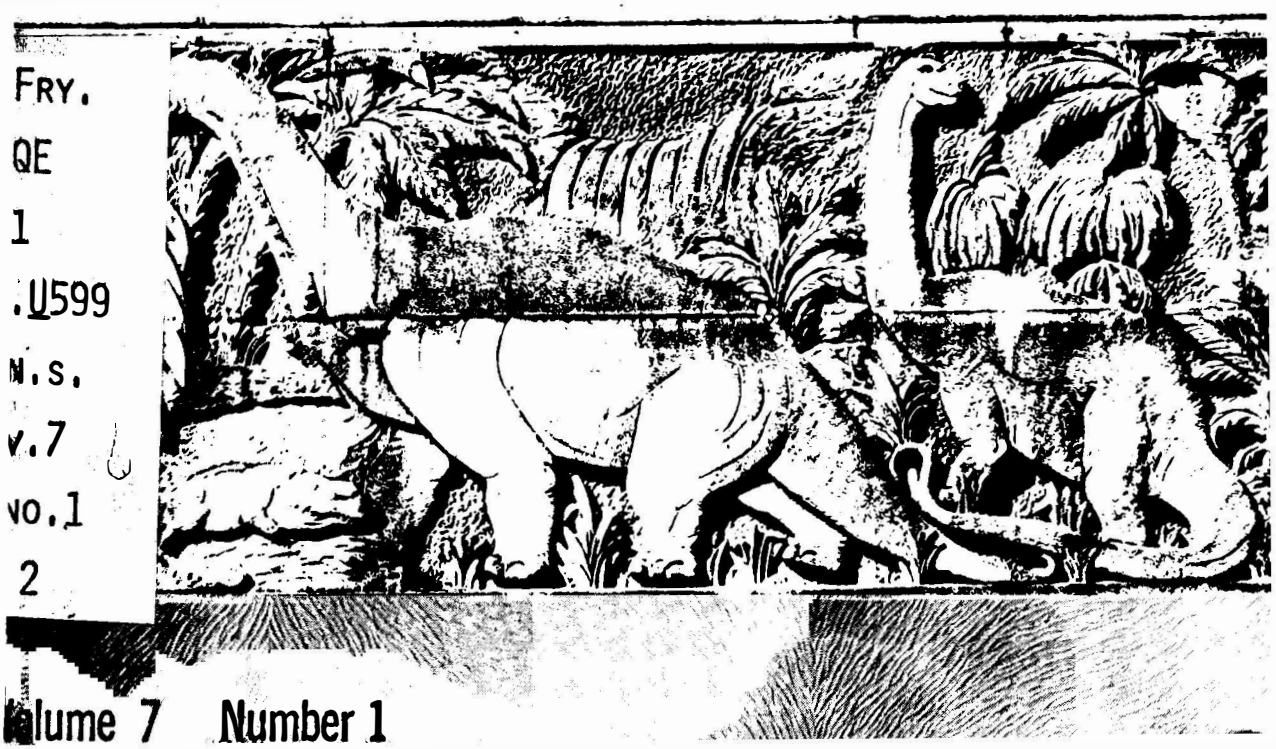



lume 7 Number 1

# NEW PERMIAN AND TRIASSIC BRACHIOPOD TAXA

*by* **J.B. Waterhouse**

ABSTRACT. The following taxa are proposed, described, and discussed for Permian and Triassic Brachiopoda: *Costachonetes* gen. nov., type species *Chonetes uralica pygmaea* Loczy; *Quinquenella* gen. nov., type species *Quinquenella glabra* sp. nov., both in Chonetacea; *Echinalosia kalikotei* sp. nov. of Strophalosiacea; *Megasteges* gen. nov., type species *Megasteges nepalensis* sp. nov.; *Platyconcha* gen. nov., type species *Platyconcha grandis* sp. nov., both of Aulostegacea; *Lamnimargus* gen. nov., type species *Marginifera himalayensis* Diener; *Transennatia* gen. nov., type species *Productus gratiosus* Waagen; *Striatospica* gen. nov., type species *Striatifera kayseri* Chao; *Fusiproductus* gen. nov., type species *Linoproductus fusiformis* Huang; *Auriculispina* gen. nov., type species *Cancrinella levis* Maxwell; *Chianella* gen. nov., type species *Avonia chianensis* Chao; all in Productacea; and *Alipunctifera* gen. nov., type species *Spiriferina kaihikuana* Trechmann of Spiriferinacea. Genus *Yakovlevia* Frederiks is referred to a new subfamily Yakovleviinae within Linoproductidae Stehli; *Stepanoviella* Zavodowsky to Stepanoviellinae subfam. nov. within Anidanthidae Waterhouse; *Clavigera* Hector to Clavigeridae fam. nov. within Athyridacea; *Pterospirifer* Dunbar to Pterospiriferinae subfam. nov. within Paeckelmanellidae Ivanova; *Reticulariina* Frederiks to Reticulariinae subfam. nov., and *Punctospirifer* North to Punctospiriferinae subfam. nov., both in Spiriferinidae.

## INTRODUCTION

This study names various Permian and Triassic brachiopod genera, subfamilies, and families that are critical to Permian correlations, especially in south-east Asia, and to the Permian-Triassic boundary.

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## SYSTEMATIC DESCRIPTIONS

Phylum BRACHIOPODA
Suborder CHONETOIDEA Muir-Wood 1955
Superfamily CHONETACEA Bronn 1862
Family CHONETIDAE Bronn 1862
Subfamily ANOPLIINAE Muir-Wood 1962
Genus COSTACHONETES gen. nov.

Lat. *costa* – rib, *Chonetes* – brachiopod name.

*Type species. Chonetes pygmaea* as *Chonetes uralica* Möller var. *pygmaea* Loczy 1899, text fig. 13, 14. Penchi and Taiyuan Groups, China. Late Carboniferous, and Asselian Stage, Early Permian.

*Diagnosis.* Small Chonetacea, ventral valve swollen medianly, with minute ventral sinus over umbo or extending for length of shell, dorsal valve deeply depressed medianly. Ears well developed, ornament on both valves of branching costellae, row of ventral hinge spines, and numerous body spines. Interior as recorded by Chao (1928, p.20), with median dorsal septum.

*Discussion.* In shape this genus is close to *Chonetina* Krotow 1888 (type species *Chonetella artiensis* Krotow 1885), but has strong radial ornament, a median dorsal septum, and narrow median ventral groove. *Chonetinetes* Cooper & Grant 1969, type species *C. reversus* Cooper & Grant 1969, is a smooth genus of similar shape, with well formed short median septum in each valve. No body spines have been recorded. *Striochonetes* Waterhouse & Piyasin 1970 is ribbed and almost identical in shape but lacks hinge spines.

?Subfamily RETIOCHONETINAE Muir-Wood 1962
Genus QUINQUENELLA gen. nov.

Lat. *quinque* – five.

*Type species. Quinquenella glabra* sp. nov.

*Diagnosis.* Small subquadrate chonetid with smooth exterior and row of oblique hinge spines, shallow or no ventral sulcus. Ventral median septum, dorsal valve with short median septum and long accessory septa, short lateral septa.

*Discussion.* Externally, *Micraphelia* Cooper & Grant 1969 is similar, but the dorsal interior of the type species *M. scitula* Cooper & Grant 1969 (pl. 5, fig. 12) has an elevated brachial area of dissimilar shape, bounded by ridges converging more on the septum. The elevated nature may simply reflect ontogeny, but this will require further study. There are no lateral or accessory septa.

*Undulella* Cooper & Grant 1969 differs in having a different shaped brachial shield, and deep pit in the anterior median part of the visceral disc. It

lacks lateral and accessory septa from the dorsal valve. *Lissochonetes* Dunbar & Condra 1932, *Mesolobus* Dunbar & Condra 1932, and *Quadrochonetes* Stehli 1954 all are larger, differ in outline, and have lateral but no accessory septa.

*Quinquenella glabra* sp. nov.
Pl. 1, fig. 1-3

Lat. *glaber* – smooth.

*Holotype.* Specimen 711, from locality 1407, pl. 1, fig. 3.

*Material and locality.* Two small (immature) and 7 large (mature?) ventral valves, 4 small and 6 large dorsal valves and 6 large specimens with valves conjoined, from locality 1407, 6 km northwest from Popa, northwest Nepal. (These and other localities were collected by the writer in 1973, and will be described with more complete documentation in a forthcoming work). Chhidruan Substage, Punjabian Stage, Middle Permian.

*Diagnosis.* Small smooth shells, without sulcus or fold.

*Dimensions in mm.*

| Specimen | Width | Length | Height | Valve |
|---|---|---|---|---|
| 701 | 10 | 6.5 | 1.7 | Ventral |
| 705 | 11.5 | 7.2 | ?1.5 | Dorsal |
| 711 | 9.5 | 6.2 | 1.3 | Dorsal |

*Description.* Shells small, transverse, ventral umbo low and not incurved, broad, angle close to 160°. Interarea low, cardinal extremities at maximum width of shell, with minute acute ears, margin retracted in front, then rounding forward into long anterior margin. Dorsal valve concave, with very low interarea and broad notothyrium. Venter arched, slightly flattened towards anterior, no sulcus or fold in either valve. Row of hinge spines in ventral valve; both valves smooth apart from fine growth lamellae and increments, apparently 10-12 per mm.

Teeth, median septum extending nearly two thirds the length of ventral valve, thick posteriorly, thin in front. Diductors small, lightly impressed, venter marked by fine pits and pustules posteriorly over inner ears, 1-2 per mm, somewhat radially aligned.

Cardinal process not preserved. Sockets small, enclosed within ridge. Median septum short, low, anteriorly placed, not connected to cardinal process. Paralleled by two long accessory septa bounding inner edges of brachial shield, brachial shield also bordered postero-laterally by two short ridges or lateral septa. Adductors small, apparently two pairs, with bulge between continuing forward laterally. Brachial shields depressed, bordered by shallow groove anteriorly. Hinge ridge. Posterior shell smooth, but most of the floor marked by pustular ridges, 2-3 per mm, becoming more pustular in larger specimens.

Small shells 6-7 mm wide have no median septum, and pustules are arranged regularly over the valve with no ridges. Inner adductors raised, apparent outer adductors depressed with no ridges. Shell at 10 mm width possesses low median septum, round inner adductors, no other adductors clearly defined, no lateral septa.

*Resemblances.* Specimens ascribed to *Chonetes vishnu* Salter 1865 from the Productus Shales of the Himalayas by Diener (1897, pl. 2, fig. 5,7) have a narrow deep ventral sulcus, and, according to Diener (1915, p. 84) in recording a specimen from the Zewan beds at Mandakpal, Kashmir, sharply incised external grooves laterally and on the ears. But one figured specimen (Diener, 1897, pl. 5, fig. 9) shows two well developed accessory septa in the dorsal valve.

Order PRODUCTIDA Sarytcheva and Sokolskaya 1959
Suborder STROPHALOSIIDINA suborder nov.
Superfamily STROPHALOSIACEA Schuchert 1913
Family STROPHALOSIIDAE Schuchert 1913
Genus ECHINALOSIA Waterhouse 1967

*Type species. Strophalosia maxwelli* Waterhouse 1964.

*Discussion.* The species described below is distinguished by the ornament of very fine spines on both valves, with conspicuous pits and pustules on the dorsal valve, and by the heavy internal marginal ridge around both valves. Typical *Echinalosia* Waterhouse 1967 has coarser ventral spines, including some to many recumbent spines, is less thickened in the dorsal valve near the trail, and has fewer dorsal pits and pustules. The internal marginal ridge is much more subdued in *Echinalosia* than in the new species. These differences may be of more than specific significance, but further investigation is required, together with evaluation of the generic limits of the ill-defined genus *Pseudostrophalosia* Clarke 1972, type species *Strophalosia brittoni* Maxwell 1954, which could prove to be allied.

*Echinalosia kalikotei* sp. nov.
Pl. 1, fig. 4-7

1966 ?*Marginifera* sp. Waterhouse, p. 17, pl. 3, fig. 5, part, not fig. 3, 4.

Named after Mr. Kalikote, supervisor of Nepal Research Centre, Katmandu.

*Holotype.* Specimen 266, pl. 1, fig. 4, 6.

*Material.* Two ventral valves, 2 dorsal valves, 2 specimens with valves conjoined from locality 1232, 0.5 km west of third pass from Mugu to Popa; 78 ventral valves, 46 dorsal valves and 11 specimens with valves conjoined from locality 1275, in gully 4 km northwest from Popa; 6 ventral valves, 11 dorsal valves, and 19 specimens with valves conjoined from locality 1297, 5 km northwest of

Popa; Dolpo District, northwest Nepal. Chhidruan Substage, Punjabian Stage, Middle Permian.

*Diagnosis.* Moderately large shells with variable development of sulcus and fold, obtuse extremities, spines dense and fine on both valves. Interareas relatively low, ventral adductor scars long. Internal marginal ridges thick and high.

*Dimensions in mm.*

| Specimen | Width | Length | Height | Hinge |
|---|---|---|---|---|
| 275 | 29 | 22.5 | 13 | 21.5 |

*Description.* Shell of moderately large size for strophalosiids, shape varies from usually subrounded, to ovally transverse or elongate, often asymmetrical in outline. Ventral umbo massive with large cicatrix on many shells, posterior walls concave posteriorly, diverging at 85° to generally 100-110° forwards. Dorsal neanic portion pustular and flat or faintly convex and laminated. Interareas well developed, longitudinally striated, delthyrium and notothyrium narrow, ventral interarea not very high, in plane of posterior commissure; dorsal interarea at right angle approximately. Cardinal extremities bluntly angular, obtuse, close to 100-120°. Maximum width varies in position, generally between mid-length and anterior third of shell length. Ventral ears slightly differentiated on some specimens, as a less convex part behind posterior walls. Dorsal ears gently concave, at different angle to disc. Venter either fully rounded, or with median flattening, or shallow sulcus; dorsal valve deeply concave, and curving abruptly into long trail at right angles, with low median dorsal fold on many specimens over anterior disc and trail. Some specimens have two or three broad anterior rugae up to 5 mm wide.

Both valves covered by minute spines, semirecumbent, 0.5 to 0.7 mm in diameter on ventral valve, alternating in quincunx, about 1 to 1.5 mm apart along rows, and 1 mm between rows anteriorly. Spines on dorsal valve generally erect, 0.5 mm in diameter, spaced erratically along concentric rows. Short radial ridges and capillae conspicuous on anterior dorsal valve, especially trail, 6 in 1 mm, irregularly spaced. Pits conspicuous over dorsal disc. Both valves marked by growth increments, about 30-32 in 1.5 to 2 mm, suggesting that more conspicuous growth lamellae formed at monthly intervals, and that shells entered maturity and developed trail after one year, and lived about two years.

Ventral teeth. Posterior wall thick. Adductor platform generally elongated, subdivided in many shells by median ridge, relatively smooth, impressed posteriorly into posterior wall, but often almost at floor level anteriorly; lateral margins straight or wavy. In some shells posterior small adductor set marked by low ridges pointing diagonally forwards and inwards. Diductor scars clearly impressed, scored by sublongitudinal grooves extending a little in front of adductors. Marginal ridge encircles valve from teeth, very high and sometimes crenulated across ears, persists around disc, but may subdivide into three or four ridges anteriorly. Remainder of floor with small pits, subelongate in some specimens at early maturity.

Cardinal process strophalosiid, in plane of posterior disc, with median

shaft of variable width and lateral claws of variable prominence. Median septum high and wide posteriorly, extending to about mid-length or just beyond. Adductor scars of posterior triangular impressed pair, and suboval, elongate anterior raised pair, both sets smooth. Two well defined depressions lie immediately in front. Dental socket ridges pass apparently into brachial ridges which encurve forward to enclose narrow shield-shaped areas, ending at raised parts in front of septum. Marginal ridge commences as hinge ridge each side of sockets, curves completely around disc, high across ears. Trail at right angles, forming geniculation at start of trail. Shell thickened in this region.

*Resemblances. Strophalosia? bajkurica* Ustritsky (in Ustritsky & Chernyak, 1963, p. 96, pl. 24, fig. 2; pl. 25, fig. 1, 2) is similar in essential detail, and may prove closely allied. Unfortunately its ventral ornament and variation are not well known. The species occurs in the Baikur Suite of Taimyr Peninsular. It differs in having heavier thickening of the ventral posterior wall, and the dorsal valve appears to be more thickened, with a flatter disc internally, and a more concave disc externally.

Superfamily AULOSTEGACEA Muir-Wood & Cooper 1960
(ex F. Aulostegidae Muir-Wood & Cooper 1960)
Family AULOSTEGIDAE Muir-Wood & Cooper 1960
Subfamily AULOSTEGINAE Muir-Wood & Cooper 1960
Genus MEGASTEGES gen. nov.

Greek *megas* – large, *stege* – chamber.

*Type species. Megasteges nepalensis* sp. nov.

*Diagnosis.* Large shells, ventral valve asymmetrically sulcate, with high interarea, elytridium, ornament of large sessile or erect spines. Dorsal valve convex near hinge, concave anteriorly, geniculate, semi-wedge shaped, ornamented by pustules with minute erect spines. Ventral muscle field with long narrow adductors surrounded laterally and anteriorly by huge diductors. Cardinal process supported by two anterior septa and median septum, dendritic adductors.

*Discussion.* The genus is allied to *Aulosteges* von Helmerson 1847, from which it differs chiefly by the lack of rhizoid spines over the dorsal as well as ventral valve, and different ventral musculature. *Wyatkina* Frederiks 1931 is closer to the new genus in general shape and especially the geniculate dorsal valve, but lacks dorsal spines. *Taeniothaerus* Whitehouse 1928 is distinguished by the lower ventral interarea and finer ventral spines, and lateral rather than anterior lateral diductors.

*Megasteges nepalensis* sp. nov.
Pl. 1, fig. 8-10

*Material.* Four mature ventral valves, 12 ventral valves, 9 dorsal valves and one specimen with valves conjoined from locality 1275 in gully 4 km northwest

from Popa, Dolpo region, northwest Nepal. Chhidruan Substage, Punjabian Stage, Middle Permian.

*Holotype.* Specimen 314, pl. 1, fig. 10.

*Diagnosis.* Large shells with ventral interarea inclined 45° from commissure, sulcus of moderate depth.

*Dimensions in mm.*

| Specimen | Width | Length | Height |
|---|---|---|---|
| 314 | 48 | +58 | 28 |

*Description.* Shell large, variable in shape and often asymmetrical. Ventral umbo irregular, prolonged posteriorly to varying degree, or blunt, with high posterior walls, concave in outline, and also varying in length and inclination. Cardinal extremities generally bluntly obtuse. Ventral cardinal interarea high, in some shells almost at right angles to commissure, but generally sloping back ventrally, weakly concave, surface poorly known, crossed by horizontal and vertical striae, deltidium elevated as double ridge with narrow median groove. Dorsal valve gently convex posteriorly, concave around anterior disc, and curving abruptly into geniculate trail. Low or no interarea. Ventral sulcus commences up to 10 mm in front of umbonal tip, moderately deep and persistent with gently rounded floor, dorsal fold developed over anterior disc and persists over trail. Ventral spines cover entire valve, with sturdy bases, 0.5 to 0.7 mm in diameter and 2.5 mm long, approximately in quincunx, rows 1 mm apart and spines up to 3 mm apart along rows, sometimes rows and spines denser in bands. No known specialised patches. Anteriorly some spine bases swollen, and spines pressed against shell. Dorsal spines very fine, less than 0.5 mm in diameter, and appear to cover the valve as scattered rows in quincunx, with small slightly or non-swollen bases. Prominent growth increments about 0.7 mm apart, with about 6-7 finer increments between.

Delthyrium masked internally, bordered by two ridges along edge near hinge. Adductor platform long, moderately raised, narrow, with ridges and grooves directed posterolaterally, subdivided along mid-line by groove. Diductor impressions large, anteriorly placed, and, at least in mature shells, fusing in front of the adductors, scored by ridges and grooves radiating laterally forward. Posterior walls thickened, bearing well spaced pits, elongated over lateral walls and lateral disc.

Cardinal process large, suberect, with two anterior lateral supports. Median septum arises in between, narrow, persisting well forward for 0.75 length of disc. Adductor scars with posterior lateral, suboval highly dendritic pair and anterior inner small subrounded pair, slightly raised, smooth in early maturity, marked by ridges radiating posterolaterally. Brachial ridges arise at edge of adductors, form subquadrate loop, converge on anterior end of septum. Floor of valve finely pitted with several rows of small pustules over geniculation, where shell moderately thickened.

*Resemblances.* *Aulosteges dalhousei* Davidson 1862 (p. 33, pl. 2, fig. 7) from the Zewan beds of Kashmir, and similar specimens from the Kalabagh Member of the Salt Range, Pakistan, figured by Waagen (1884, pl. 63, fig. 1) may be allied, but are smaller and more transverse. Judged from descriptions by Davidson (1862) the dorsal valve of *dalhousei* is similar to that of the new species. Allied specimens were figured from the Basleo beds of Timor by Broili (1916, pl. 118, fig. 8) and Hamlet (1928, pl. 4, fig. 4). *Aulosteges fairbridgei* Coleman 1957 (pl. 2, fig. 5-12) from the Hardman Member and Port Keats Group of Western Australia is very close to the new species apart from having a more incurved ventral umbo, and lateral rather than anteriorly placed diductors.

Amongst Himalayan material the closest is that compared by Diener (1903, pl. 8, fig. 13-14) to *Aulosteges gigas* Nechaev 1894. It is similar in shape, but lacks a ventral sulcus, and has a lower more curved ventral interarea than in the new species.

## Family WAAGENOCONCHIDAE Muir-Wood & Cooper 1960
## (ex Subfamily Waagenoconchinae Muir-Wood & Cooper 1960)
## Genus PLATYCONCHA gen. nov.

Lat. *plata* – dish, *concha* – shell.

*Type species.* *Platyconcha grandis* sp. nov.

*Diagnosis.* Large Waagenoconchid shells, ventral valve gently convex, numerous fine spines; dorsal valve gently concave without spines, otherwise like *Waagenoconcha.* Ventral interior with dendritic adductors, large striated diductors. Dorsal interior with bilobed cardinal process, low median septum, smooth adductors.

*Discussion.* The genus is close to *Waagenoconcha* Chao 1927, but lacks dorsal spines.

### *Platyconcha grandis* sp. nov.
### Pl. 2, fig. 1-4

Lat. *grandis* – large.

*Holotype.* Specimen 380, from locality 1466, pl. 2, fig. 3.

*Material.* A dorsal valve from locality 1295, 10 m stratigraphically below 1275 (see above), 4 km northwest of Popa; 8 ventral valves and 2 dorsal valves from locality 1466, Crystal Mountain, 3 km north from Shay Gompa; 15 ventral valves and one dorsal valve from locality 1464, 60 feet stratigraphically below 1466; Dolpo District, northwest Nepal. Chhidruan Substage, Punjabian Stage, Middle Permian.

*Diagnosis.* Large, little inflated shells with large ventral muscle scars, shallow ventral sulcus, gently concave dorsal valve.

*Dimensions in mm.*

| Specimen | Locality | Width | Length | Height | Valve |
|---|---|---|---|---|---|
| 371 | 1464 | 66 | 61 | 20 | Ventral |
| 380 | 1466 | 68 | 53 | 6.5 | Dorsal |

*Description.* Shells large, ovally transverse in outline, ventral valve gently convex, maximum width close to midlength, dorsal valve gently concave. Ventral umbo massive, not incurved, hinge from half to two thirds maximum width, cardinal extremities well rounded, umbonal slopes low and convex in outline and section, with narrow poorly differentiated ears. Dorsal ears not differentiated, and trail curves imperceptibly from disc. Ventral centre generally weakly convex, or flattened, or very slightly sulcate, one or two individuals have better defined sulcus. Dorsal valve correspondingly may have very gentle fold, or median flattening.

Ventral spines cover the valve, small and close-set over umbo, about 1 mm apart along rows just over 1 mm apart, stronger over lateral-posterior shell, 1.5 to 2 mm apart, with bases opening into interior; in rows, more or less in quincunx, 1-2 mm between rows, up to 2 mm between spines anteriorly, but not very well known. Shell comparatively smooth apart from spines, and spine-bases small.

Dorsal valve covered by close-set dimples and ridges imparting cellular pattern, crossed by growth increments, about 8 in 1 mm. Density of dimples varies in bands 3-6 mm long; often 6-8 rows of dimples in each band, some dimples slightly elongated, up to 1.5 mm long. Preservation not allowing comparative counts of growth increments. No spines.

Ventral adductor platform long and narrow, subdivided by median groove which may be striated, platform generally smooth, becoming dendritic posteriorly in late maturity. Diductor scars huge, weakly impressed, extending a little in front of adductors, posterior umbonal region thickened, anterior shell pitted in maturity, pits elongate near anterior margin in some individuals. Low marginal ridge may cross ears and encircle all or part of disc.

Cardinal process bifid with deep median groove on ventral face. Septum commences just in front as very low ridge and extends to about mid-length. Anterior adductor scars smooth, raised, rounded. No posterior hinge ridge. Further detail not exposed.

*Resemblances.* No other species appears to be similar. Mid-Permian Arctic species of *Waagenoconcha* approach the new form in shape and size, but have dorsal spines.

Suborder PRODUCTIDINA Waagen 1883
Superfamily PRODUCTACEA Gray 1840
Family MARGINIFERIDAE Stehli 1954
Subfamily PAUCIMARGINIFERIDAE Muir-Wood & Cooper 1960
emend. Waterhouse 1970b
Genus LAMNIMARGUS gen. nov.

Lat. *lamni* – sheet, *margo* – edge.

*Type species. Marginifera himalayensis* Diener 1899. Lectotype, specimen figured by Diener (1899, pl. 2, fig. 5), designated by Muir-Wood (1941, p. 20) from *Lamnimargus himalayensis* Zone, Spiti; widespread in Himalayas. Kalabaghian Substage, Punjabian Stage, Middle Permian.

*Diagnosis.* Shell transverse with wide ears, semigeniculate trail, reticulate ornament over disc of both valves, spines restricted to ventral valve, in hinge row, ear cluster, six halteroid spines, and rare over disc. Ventral interior has somewhat striated adductors, diductors, marginal ridge, with anterior flange or curtain in some individuals. Dorsal interior with cardinal process, septum, divided adductors, marginal ridge, and one or two flanges in some individuals, two-three rows of moderately prominent and numerous pustules over anterior disc.

*Discussion.* The species *himalayensis* is clearly distinguished from *Marginifera* by its reticulate ornament, and Waterhouse (1970b) pointed out a close similarity externally to *Retimarginifera* Waterhouse 1970b apart from the presence of a cluster of spines over the ears. The difference appeared to be confirmed by the difference in shell structure between *himalayensis* and the type species of *Retimarginifera.* Internally, *himalayensis* occasionally displays two or three trails arising from the marginal ridge in both valves, and this has not been observed so far for *Retimarginifera.*

Grunt & Dimetriev (1973) assigned Diener's species to *Probolionia* Cooper 1957, a genus which has as many as 40 to 50 multiple trails arising from the dorsal marginal ridge, and there is clearly some similarity between the two. However, the reticulate ornament is less defined in *Probolionia,* and, so far as is known, *Probolionia* does not have a cluster of ventral ear spines nor a ventral marginal ridge, nor ventral false trails (Cooper, 1957; Muir-Wood & Cooper, 1960).

Family RETARIIDAE Muir-Wood & Cooper 1960
Subfamily TYLOPLECTINAE Termier & Termier 1970
Genus TRANSENNATIA gen. nov.

Lat. *transenna* – net, lattice.

*Type species. Productus gratiosus* Waagen 1884. Lectotype, here designated, specimen figured by Waagen (1884, pl. 72, fig. 3), from Cephalopod bed,

Chhidru, Salt Range, Pakistan. Punjabian Stage, Middle Permian.

*Diagnosis.* Small brachiopods with thick disc, well defined ears, and reticulate ornament with branching radial costae. Spines limited to ventral valve, in one or two umbonal rows, hinge row; crowded on inner ears, scattered over venter and trail. Interior poorly known, presumably retariid.

*Discussion.* The reticulate ornament with branching costae has invited comparison with species of *Costiferina* Muir-Wood & Cooper 1960 (see Reed, 1931; Waterhouse, 1966), but the small size and different spine pattern show that *gratiosus* belongs to a different genus. In *Costiferina* the spines form a hinge row, and row on the umbonal slope, and are scattered over the venter and trail, with single large halteroid spines on the inner ears of some specimens. But *Costiferina* has no cluster of spines on the inner ears. *Thamnosia* Cooper & Grant 1969 and *Thuleproductus* Sarytcheva & Waterhouse 1972 are closer in this respect, but these genera have numerous ear spines on both valves, and spines on the ventral umbonal slopes of *Thuleproductus* are differentiated into two orders.

Family LINOPRODUCTIDAE Stehli 1954
Subfamily LINOPRODUCTINAE Stehli 1954
Genus STRIATOSPICA gen. nov.

Lat. *stria* – line, *spica* – point.

*Type species. Striatifera kayseri* Chao 1927. Holotype, specimen figured by Chao (1927, pl. 13, fig. 9), by original designation, from *Lyttonia* bed of Kiangsi, south China. Djulfian Stage, Middle Permian.

*Diagnosis.* Subquadrate shells with wide hinge, small alate ears, geniculate trail. Ornament of very fine even costellae on both valves crossed by low growth rugae. Spines sturdy, limited to hinge row, passing across ears of ventral valve.

*Discussion.* The genus represents a late Middle Permian specialised form of Linoproductinid with reduced spinose ornament, readily distinguished from *Linoproductus* by the paucity of spines.

Subfamily YAKOVLEVIINAE subfam. nov.

*Name genus. Yakovlevia* Frederiks 1925, type species *Yakovlevia kaluzinensis* Frederiks 1925, from Cape Kalouzin Formation, Sikhote Alin. Kungurian Stage, Middle Permian.

*Diagnosis.* Transverse and geniculate closely costellate shells with wide hinge and well-formed ears, ventral valve with up to 6 large halteroid spines, hinge row and scattered body spines, none on dorsal valve. Ventral adductors smooth, striate or lobate; cardinal process sessile, trilobate; marginal ridges absent or weakly developed.

*Discussion.* Waterhouse & Piyasin (1970) showed that *Yakovlevia* and allies *Muirwoodia* Likharev 1947 and *Duartia* Mendes 1959 do not belong to the Paucispiniferinae Muir-Wood & Cooper 1960 as classed by Muir-Wood & Cooper (1960) and Muir-Wood in Moore (1965). *Paucispinifera* Muir-Wood & Cooper 1960 has strong marginal ridges, and a cardinal process allied to that of *Marginifera* Waagen 1884 and especially *Kozlowskia* Frederiks 1933. The genus *Paucispinifera* and the subfamily which is based on it are closer to the Marginiferidae than to the Linoproductidae. *Yakovlevia* and allies are closer to the Linoproductidae in fine costellate ornament, but have different muscle scars and a few special halteroid spines.

Family ANIDANTHIDAE Waterhouse 1968
(ex Anidanthinae Waterhouse 1968)
Subfamily ANIDANTHINAE Waterhouse 1968
Genus FUSIPRODUCTUS gen. nov.

Lat. *fusus* – stretched out, *Productus,* brachiopod name.

*Type species. Linoproductus fusiformis* Huang 1932. Lectotype, specimen figured by Huang (1932, pl. 3, fig. 11), here designated, from Kuiechow, China. Djulfian Stage, late Middle Permian.

*Diagnosis.* Shells small, with ventral valve highly enrolled, wide, convex to subtubular ventral ears, ornament of costellae, with single cardinal spine, no ventral body spines.

*Discussion.* The genus is somewhat similar to *Anidanthus* Whitehouse 1928 and related members of the Anidanthinae, *Megousia* Muir-Wood & Cooper 1960, and *Kuvelousia* Waterhouse 1968, but has an extraordinary shape, and large ventral ears. The large ears of *Anidanthus* and *Kuvelousia* appear to belong chiefly to the dorsal valve. Moreover, ventral spines are more common over the body disc of these genera. The enrolled shape delineates a most characteristic genus, but the dorsal valve is still virtually unknown.

Subfamily STEPANOVIELLINAE subfam. nov.

*Name genus. Stepanoviella* Zavodowsky 1960, type species *S. paracurvata* Zavodowsky 1960. Kazanian Stage, Middle Permian of northeast Siberia.

*Diagnosis.* Concavo-convex shells with costellate ornament on both valves, body spines, auricular spines and hinge spines over ventral valve, without swollen bases; dorsal valve without strong concentric ornament. Ventral adductors subquadrate to subrectangular, not dendritic or lobate.

*Discussion.* The subfamily includes *Stepanoviella* Zavodowsky 1960, *Globiella* Muir-Wood & Cooper 1960 (type species *Productus hemisphaerium* Kutorga; see Waterhouse, 1970a, p. 45), *Auriculispina* gen. nov. (see below) and

*?Chianella* gen. nov. (see below). It is allied to the Anidanthinae Waterhouse 1968, and Monticuliferinae Muir-Wood & Cooper 1960 in possessing smooth ventral adductors, unlike the dendritic adductors found in Linoproductinae. The Stepanoviellinae are distinguished from the Monticuliferinae by the lack of swollen spine bases, and from the Anidanthinae by the lack of strong concentric ornament on the dorsal valve.

## Genus AURICULISPINA gen. nov.

Lat. *auris* – ear, *spina* – thorn.

*Type species. Cancrinella levis* Maxwell 1964. Holotype, specimen UQF 18706 figured by Maxwell (1964, pl. 6, fig. 16) by original designation, from basal Burnett Formation, Yarrol Basin, Queensland. Asselian Stage, Early Permian.

*Diagnosis.* Concavo-convex shells with costellate ornament, low concentric ornament on both valves, scattered ventral body spines with slightly elongated, not swollen bases, and cluster of spines over ventral ears. No dorsal spines. Ventral adductors smooth, subrectangular, diductors large, striate. Dorsal cardinal process, median septum broad, double posteriorly, adductors two pair, striate.

*Discussion.* The species *levis* Maxwell 1964 is distinguished from *Cancrinella* Frederiks 1928 by the smooth or striate rather than dendritic ventral adductor scars, and burst of spines over the ventral ears. *Stepanoviella* Zavodowsky 1968 is close in internal detail, but has a more globular venter, without the burst of ventral ear spines or concentric ornament.

## Genus CHIANELLA gen. nov.

*Type species. Avonia chianensis* Chao 1927. Holotype, specimen figured by Chao (1927, pl. 13, fig. 13), by original designation, from Hsiaokiang Limestone, Kwiangsi, China. Kungurian Stage, Middle Permian.

*Diagnosis.* Small shells with moderately long hinge, well defined ears, flattish disk curving rapidly into long trail. Ornament on both valves of sturdy broad costae, increasing by bifurcation and intercalation, fine erect spines over both valves, with poorly developed row along hinge margin of ventral valve. Concentric wrinkles developed especially on dorsal flanks.

*Discussion.* This is a poorly known genus, readily distinguished from *Avonia* Thomas 1914 and related forms to which Chao (1927) had initially referred the species, by its costate ornament. In shape and radial ornament it somewhat approaches *Anidanthus* Whitehouse 1928 and allies of the Anidanthinae Waterhouse 1968, but lacks the strong concentric ornament on the dorsal valve found in these genera. It may prove allied to *Stepanoviella* Zavodowsky

1968 and *Globiella* Muir-Wood & Cooper 1960, but is more transverse, with scattered fine body spines, and less flexuous costae.

Order ATHYRIDA Rzhonsnitskaya 1960
Suborder ATHYRIDIDINA Boucot, Johnson, & Staton 1964
Superfamily ATHYRIDACEA M'Coy 1844
Family CLAVIGERIDAE fam. nov.

*Name genus. Clavigera* Hector 1879. Type species *C. bisulcata* Hector (in Thomson 1913). ?Rhaetian and Norian Stages, Late Triassic, New Zealand and New Caledonia.

*Diagnosis.* Athyridaceans with ventral sulcus, dorsal fold, surface with growth increments only, well developed interareas, tiny foramen later infilled. Ventral interior with short median septum, plates reaching floor of valve, muscle field placed in front, striated, adductors elongated; genital pits not pinnate or linear. Dorsal interior with more or less spirigerellid cardinal plate and laminate process, crural plates, no tabellae, low median septum, spiralia laterally directed, with long jugal arms, short stem and v-shaped jugal apex (see text-fig 1, and Trechmann, 1918, fig. 4, p. 233). Shell impunctate.

*Discussion.* The familial and superfamilial relationships of *Clavigera* Hector 1879 from the New Zealand Triassic were obscure to Pitrat in Moore (1965, p. 727), although Marwick (1952), Trechmann (1918) and Hector (1879) had indicated its Athyrid affinities. Examination of type and other New Zealand material confirms that *Clavigera* is Athyridacean. Its dorsal valve possesses an interior very close to that of *Spirigerella* and allies, including the high cardinal plate and laminated cardinal process supported on a massive posterior pillar. A jugum lies between the spiralia. The ventral plates and muscle field are also somewhat Athyridacean. A tiny foramen is present in some *Clavigera* shells, but appears to have been filled in many large individuals (Trechmann, 1918, p. 233). Cardinal interareas are well developed, as if *Clavigera* represented a strophic descendent of non-strophic shells, a most unusual trend, as discussed by Rudwick (1959, p. 21). *Majkopella* Moisseiev in Dagys 1962 is related.

Genus CLAVIGERA Hector 1879
Pl. 2, fig. 5-7; text-fig. 1

*Type species. Clavigera bisulcata* Hector (in Thomson, 1913). Holotype, specimen figured by Hector in Thomas (1913, pl. 1, fig. 1). From Benmore Sandstone, GS 371, 2 km north of Benmore Railway cutting, Southland, Late Triassic.

*Description.* Shell transversely subpentagonal in outline, with well formed interareas, delthyrium closed by striated plate. Tiny foramen in small shells, not seen in mature individuals. Ventral sulcus bordered by high ridges, dorsal fold high with broad flat crest. Surface smooth apart from scattered inconspicuous growth increments.

Ventral teeth low and broad, supported by plates extending to floor of valve, converging inwards; adminicula if present poorly differentiated. Low median septum lies between dental plates, passing down posterior wall, and persisting a little anteriorly. Small muscle scars lie each side, probably from muscles attached to part of cardinal process. Adductors inconspicuous, diductor scars broad, striated longitudinally. Posterior thickening heavy.

Dorsal interior with very high athyrid-spirigerellid laterally laminated cardinal process, above elevated cardinal plate with concave surface bordered by crural plates. No tabellae. Low median septum at base, striated somewhat diffuse adductors, placed under floor of fold. Spiralia laterally oriented, jugum present with two forward prongs, not contributing to spire. Shell moderately thickened.

Order SPIRIFERIDA Waagen 1883
Suborder SPIRIFERIDINA Waagen 1883
Superfamily SPIRIFERACEA Waagen 1883
Family PAECKELMANELLIDAE Ivanova 1972
Subfamily PTEROSPIRIFERINAE subfam. nov.

*Name genus. Pterospirifer* Dunbar 1955; type species *Spirifer alatus* Schlotheim 1813, from lower Zechstein, Germany. Kungurian Stage, Middle Permian.

*Diagnosis.* Transverse shells with wide hinge, ventral sulcus, dorsal fold, both valves plicate, micro-ornament of radial capillae and predominant concentric laminae, no pustules. Ventral interior with dental and adminicular plates, no median septum. Dorsal interior with cardinal process, low crural plates, no tabellae, low median ridge.

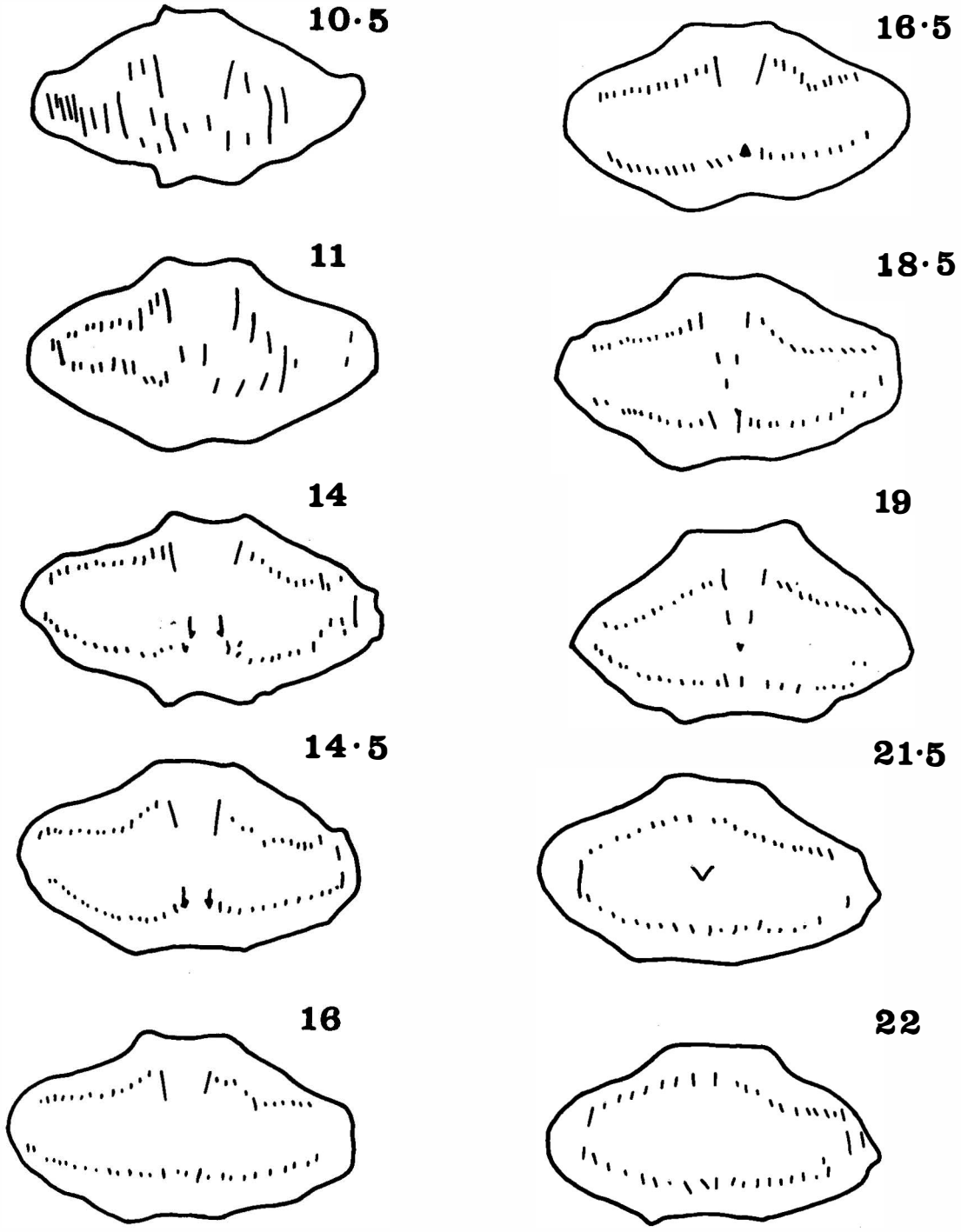
*Discussion.* This subfamily is distinguished from Paeckelmanellinae Ivanova 1972 by lack of ventral medium septum and from Licharewiinae Slusareva 1958 by lack of pustules and predominance of concentric laminae. *Alispirifer* Campbell 1960 is closely related.

Superfamily SPIRIFERINACEA Davidson 1884
Family SPIRIFERINIDAE Davidson 1884
Subfamily RETICULARIININAE subfam. nov.

*Name genus. Reticulariina* Frederiks 1916, type species *Spirifer spinosus* Norwood and Pratten 1885, from Mississippian of Illinois, United States. Carboniferous.

*Diagnosis.* Micro-ornament of large spines with irregular concentric lamellae. Punctate. Ventral valve with median septum, dental plates, adminicula; dorsal valve with low septum, crural plates and tabellae.

*Discussion.* Distinguished from Spiriferininae by thick short spines and from Laballinae by lack of spondylium. *Altiplecus* Stehli 1954 is related. *Mentzeliopsis* Trechmann 1918 is similar but impunctate.




Text-fig. 1 *Clavigera bisulcata* Hector, serial sections of internal mould BR 1297, from Winton Stream, Benmore. Dorsal valve on top, looking posteriorly, distance from ventral umbonal tip indicated in mm. x 1. Slices retained at New Zealand Geological Survey, Lower Hutt.

## Subfamily PUNCTOSPIRIFERINAE subfam. nov.

*Name genus. Punctospirifer* North 1920, type species *P. scabricosta* North, from Viséan Stage of England. Carboniferous.

*Diagnosis.* Micro-ornament of radial capillae and concentric lamellae. Punctate. Ventral interior with median septum, dental plates, adminicula; dorsal interior with low septum, crural plates. Presence of dorsal tabellae not certain.

*Discussion.* Other genera in the subfamily include *Ziganella* Nalivkin 1960, *Liriplica* Campbell 1961, possibly *Dimegelasma* Cooper 1942 and *?Alipunctifera* gen. nov. (see below). *Ziganella* is said to lack a ventral medium septum but its maturity is not established.

## Genus ALIPUNCTIFERA gen. nov.

Lat. *ala* – wing, *puncta* – pore, *fero* – to bear.

*Type species. Spiriferina kaihikuana* Trechmann 1918. Lectotype, sole specimen figured by Trechmann (1918, pl. 24, fig. 15), designated by Marwick (1952, p. 36). From Southland, New Zealand. Ladinian Stage, Middle Triassic.

*Diagnosis.* Shell transverse with alate cardinal extremities; delthyrium open, cardinal areas moderately high, striated parallel to hinge. Ventral sulcus deep, well defined, fold high, plicae well defined. Long growth lamellae at intervals, micro-ornament of fine concentric growth increments, traces of radials, and no spines. Shell finely punctate.

Ventral interior with teeth supported by dental plates and adminicula, high median septum; narrow adductors, striated broad diductors, heavy posterior thickening, with pits. Hinge not denticulate.

Dorsal valve with laminated cardinal process, low crural plates, low median septum, faintly impressed adductors. Large specimens have low posterior ridges, which may be traces of calcified tabellae. Laterally directed spiralia.

*Discussion.* Synonymy of the species is provided by Marwick (1952, p. 36). The new form is distinguished from *Spiriferina* d'Orbigny 1847 by its alate shape, and lack of prominent external spines. Another Triassic genus, *Rastelligera* Hector 1879, is moderately similar but has a strongly denticulate hinge, amongst other differences. The Permian genus *Paeckelmanella* Likharev 1934 is close in many respects, but has a denticulate hinge, low costa along the sulcus, and impunctate shell.

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## PLATE EXPLANATIONS

### Plate 1

Fig. 1-3 *Quinquenella glabra* gen. et sp. nov. from loc. 1407, northwest Nepal, x 3. 1, block with ventral valves, internal mould and two external moulds, specimens 701, 864 and 865. 2, dorsal interior, specimen 705. 3, dorsal interior, with patches of unleached calcite, specimen 711, holotype.

Fig. 4-7 *Echinalosia kalikotei* sp. nov. from loc. 1275, northwest Nepal, x 1. 4, 6, ventral and dorsal aspects of holotype, specimen 266. 5, interior of ventral valve, specimen 202 from loc. 1232. 7, dorsal aspect of internal mould, specimen 561 from loc. 1297.

Fig. 8-10 *Megasteges nepalensis* gen. et sp. nov. from loc. 1275, northwest Nepal, x 1. 8, dorsal external mould, specimen 311. 9, ventral internal mould, specimen 318. 10, dorsal aspect of holotype, specimen 314.

### Plate 2

Fig. 1-4 *Platyconcha grandis* gen. et sp. nov. from northwest Nepal, x 1. 1, dorsal external mould, specimen 357 from loc. 1295. 2, ventral internal mould, specimen 371 from loc. 1464. 3, dorsal external mould, holotype, specimen 380 from loc. 1466. 4, ventral internal mould, specimen 368 from loc. 1464.

Fig. 5-7 *Clavigera bisulcata* Hector, x 1.5, BR 1295, from GS loc. 435, "*Psiloidea* beds", Eighty-eight Valley, Nelson, showing dorsal exterior and part of septate ventral umbo, and interarea as mould. 6, ventral interior, BR 1300, from GS 196, Eighty-eight Valley, Nelson. 7, internal mould of ventral valve, broken laterally, BR 1296, from GS loc. 366, Main branch, Taylor's Creek, Hokonui Hills, Southland, New Zealand.

**PLATE 1**


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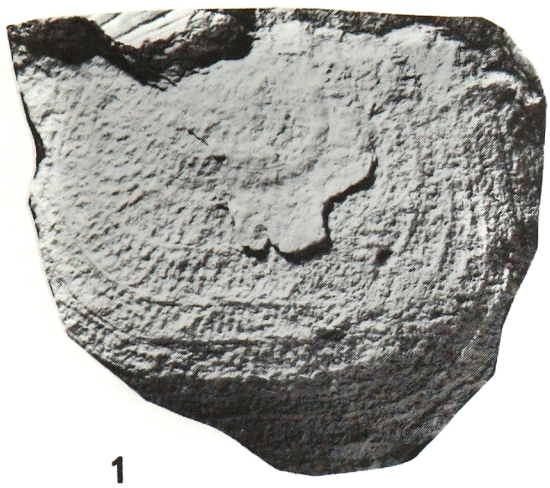
**PLATE 2**



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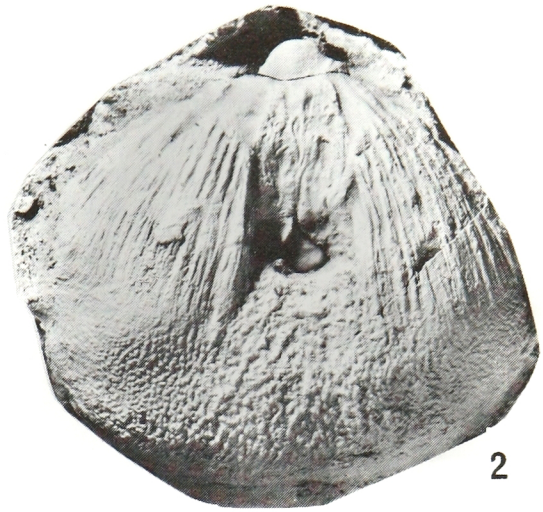

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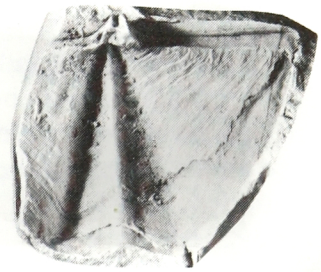

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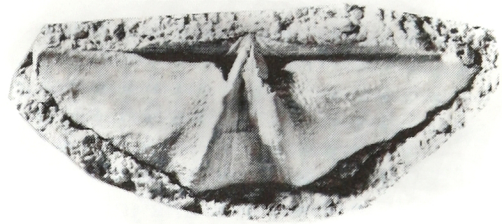

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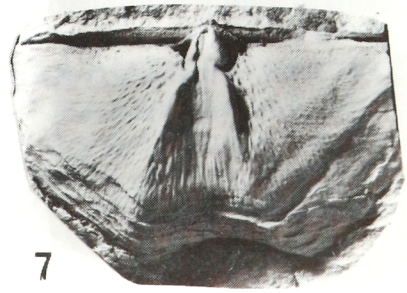

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References should be cited in the list of references, in alphabetical order of author's names, as follows:

CAMPBELL, K.S.W. (Ed.) 1969. *Stratigraphy and palaeontology: essays in honour of Dorothy Hill.* Aust. Nat. Univ. Press, Canberra.

DAWSON, J.B. 1967. Geochemistry and origin of kimberlite; in WYLLIE, P.J. (Ed.), *Ultramafic and related rocks:* 269-278. Wiley, New York.

JONES, O.A., & STEVENS, N.C. 1967. Notes on the geology of the University Experimental Mine. *Pap. Dep. Geol. Univ. Qd,* 6: 99-108.

Note: (a) Periodical titles (*italicized*) are to conform with the *'World List of Scientific Periodicals'* (4th Ed.); (b) the ampersand (&) is to be used as conjunctive in joint-author citations.

## TABLES

Tables should be either drafted or typed on an electric typewriter using *italic typeface*, not underlining, for words requiring italicization. Tables must not exceed single page size (13 x 20 cm) when printed. Submit originals, together with one photocopy of each at the correct size for publication.

## ILLUSTRATIONS (TEXT-FIGS, PLATES)

Illustrations are to be submitted as originals, together with one photocopy of each at the size for publication. The number of each illustration should be pencilled on back of original. Fold-outs or double-page spreads cannot normally be allowed.

Maps and other line-drawn or stippled diagrams (designated text-figs)

should be professionally drafted in black ink, preferably on good-quality white card. They should be suitable for reproduction either within or fully occupying a page (13 x 20 cm), allowing space for caption at bottom; for this purpose, the original should be 1.5 or 2 times the size at which it is ultimately to be printed, and no characters should be less than 1 mm high when reduced. Where scale is important (as it usually is), a linear metric scale is to be drafted on to each text-fig. Avoid awkwardly shaped diagrams, and give careful thought to the best possible use of the page size (or portion thereof) for illustrations.

Photographs (e.g. of fossils, micrographs) are to be grouped carefully and economically as Plates, 13 x 20 cm in overall dimensions (the actual size of half-tone reproduction). Photographs, of good definition and glossy finish, should be mounted on strong white card. Each is to be given an arabic number (consecutive figures within an individual plate): self-adhesive or 'Letraset' numbers (3 mm high) are to be inserted at bottom right-hand corner of figures on a composite plate. No other characters are to appear on the original plate (apart from arrows which may appropriately emphasize particular features); magnifications are to be specified on typed plate explanations. Lines should not be drawn around the plates or between figures to indicate groupings.

Appropriate textual positions of tables and text-figs should be pencilled in margin of typescript.

## STRATIGRAPHIC NOMENCLATURE

Any newly proposed stratigraphic names should have prior approval of the Stratigraphic Nomenclature Committee, Geological Society of Australia; and their definitions should conform with the provisions of the Australian Code of Stratigraphic Nomenclature (*J. geol. Soc. Aust.*, 20 (*1*): 105-112).

## REPRINTS, PROOFS

Each author (or joint author) will receive 25 free copies of his paper. Further copies and all reprints ordered by others will be charged according to a scale forwarded with author's proofs. Reprint orders and proofs must be returned promptly to the Editors. Changes other than correction of typographical errors shall not normally be allowed at proof stage.

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