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Graptolite Zonation in the late Wenlock (Early Silurian), with a New Graptolite-Brachiopod Fauna from New South Wales

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ABSTRACT. The Panuara Formation at Cobblers Creek near Orange, New South Wales, Australia has yielded a graptolite-brachiopod fauna assigned to the *sherrardae* sub-Biozone (late Wenlock: Early Silurian). The *sherrardae* sub-Biozone as defined here is equivalent to the *praedeubeli* sub-Biozone, and is the lowest part of the *ludensis* Biozone. The *ludensis* Biozone is reappraised following restudy of the type specimens of *Monograptus ludensis*, which are shown to exhibit growth stages from the *deubeli* to the *gerhardi* condition.

The graptolite fauna consists of *Gothograptus chainos* Lenz, *G. marsupium* Lenz, *Pristiograptus jaegeri* Holland, Rickards & Warren, *Pristiograptus dubius* (Suess), *Monograptus ludensis* (Murchison), *Monograptus moorsi* n.sp., *Monograptus* sp. and *Lobograptus sherrardae* (Sherwin). The limited shelly fauna includes the brachiopods *Plectodonta brownae* n.sp., *Bracteoleptaena pannucea* n.sp. and *?Lissatrypa*.

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Silurian strata in the vicinity of the New South Wales central western city of Orange have yielded important and abundant graptolite faunas (e.g., Sherrard, 1954; Packham & Stevens, 1955; Sherwin, 1971a, 1982; Jenkins, 1978, 1986; Rickards, Packham, Wright & Williamson, 1995) as well as abundant shelly fossils (see Pickett, 1982). The small but significant fauna of graptolites and shelly fossils, from Silurian exposures in Cobblers Creek, a tributary of Panuara Rivulet (Fig. 1) described here, was discovered by Ray Smith (1966)

during mapping of the Mandurama-Panuara district, south of Mount Canobolus; the locality is about 30 km roughly SSW of Orange (Fig. 1). Our initial collections were made by Henry Moors, Norman Savage and Tony Wright in about 1963; further collections were made by Barrie Rickards, Penny Williamson and Wright in 1989, and again by Wright in 1996. The graptolites are described by Rickards, and the brachiopods by Wright; trilobite identifications are by Andrew Sandford of the Museum of Victoria, Melbourne, Australia.

Geological setting

On the Molong-Wellington High (Pickett, 1982), abundant shallow marine Silurian faunas occur in well known limestone sequences such as are developed in the Borenore, Cheesemans Creek, Quarry Creek and Four Mile Creek areas (Rickards *et al.*, 1995). Closely associated with these limestones are important graptolitic sequences; Rickards *et al.* (1995) summarised previous work on these Llandoverly, to at least Ludlow, faunas.

During pioneering work in the region (Stevens, 1953), the Silurian strata yielding these Cobblers Creek and other graptolite faunas were named the Panuara Formation (see also Packham & Stevens [1955] and Smith [1966]). In the recent re-mapping of the Bathurst 1:250,000 sheet by the Geological Survey of NSW and the Australian Geological Survey Organisation (Pogson & Wyborn, 1994), the detailed stratigraphic terminology introduced by Jenkins (1978) for exposures in the Panuara area, some 3 km north of our Cobblers Creek locality, was followed. Rickards *et al.* (1995) noted some problems in the usage of this terminology, so we use the older lithostratigraphic name Panuara Formation here.

The fossils were collected from grey to tan shales and siltstones, and fine sands which are almost certainly distal turbidites. These beds dip at 62° degrees towards 328° in Cobblers Creek, at grid reference 799 891 on the Canowindra 8630-I & IV 1:50,000 topographic sheet. Hand-specimens often exhibit scale slumping and scouring, and consist mostly of interbedded brown, often bioturbated mudstone and fine greyish graptolitic or radiolarian siltstone to gritty sandstone. Some bedding planes are strewn with quartz grains and flakes of white mica up to about 1 mm in size. In order of abundance, the fauna consists of graptolites, radiolarians, "articulate" brachiopods, ostracodes, trilobites, and rare cystoid plates, phosphatic brachiopods and hyolithids.

Shelly material (almost invariably moulds) occurs rarely, scattered on bedding planes; one bedding surface exhibits an encrusting bottom fauna. Most of the shells are transported, separate valves, although conjoined valves of *Plectodonta* (in the "butterfly" configuration) do occur; some *Bracteoleptaena* valves are broken. Para-autochthonous moulds of trilobites are rare; taxa identified by Andrew Sandford include ?*Latiproetus* and ?*Maurotarion*. The graptolites are often current-aligned and occur with or without other, less abundant but usually complete, macrofossils. Preservation of the graptolites is generally excellent, with periderm in all but weathered specimens; many are uncompressed. Most graptolites and brachiopods in the fauna are slightly tectonically deformed.

In terms of biogeography, the cosmopolitan Cobblers Creek brachiopod genera support the Old World connection previously indicated for the region (Rong *et al.*, 1995). The plankton-dominated fauna is clearly deepwater (at least outer shelf) and close to the limit of tolerance for the shelly benthos.

Biostratigraphic horizon of the Cobblers Creek graptolites

Smith (1966) assigned this graptolite fauna to the Melbournian stage, based on his identification of "Varieties of *Monograptus tumescens*". As discussed by Brown *et al.* (1968), the term Melbournian (Gregory, 1903) was broadly defined, but was later restricted to part of the Ludlow (Late Silurian, see VandenBerg *et al.*, 1976: 58); it is irrelevant here as it has been discarded in recent discussions of Victorian Silurian biostratigraphy (e.g., VandenBerg *et al.*, 1976; Rickards & Sandford, in press).

Our collections can be referred unequivocally to what has been called by most workers the *ludensis* Biozone of the late Wenlock (Early Silurian) (see Rickards, 1995; Koren' *et al.*, 1996); subdivision of this Biozone has been discussed by many authors (see Rickards *et al.*, 1995 for summary). The presence of *Lobograptus sherrardae* (Sherwin), especially those extreme variants which approach quite closely to *Pristiograptus idoneus* (Koren') (see section on Evolution) at Cobblers Creek, in association with *M. ludensis* ("*praedeubeli*" and *ludensis* growth stages), indicates a level low in the *ludensis* Biozone or in what we prefer to call the *sherrardae* sub-Biozone (see below). Equally, the absence of *M. deubeli*, recorded from the Quarry Creek district (Rickards *et al.*, 1995) some 20 km away, indirectly supports an early *ludensis* age for our fauna. *Gothograptus chainos* and *G. marsupium* were first described by Lenz (1993b) from the latest part of the *lundgreni-testis* Biozone in the Canadian Arctic but, at Cobblers Creek, these species occur with a distinct *ludensis* assemblage; these two species thus appear to range up into the *sherrardae* sub-Biozone, low in the *ludensis* Biozone.

The lowest part of the *ludensis* Biozone has been variously labelled by different authors: *praedeubeli* (Jaeger, 1991), *sherrardae (praedeubeli)* (Koren', 1992), *ludensis praedeubeli* (Lenz, 1993a) and *sherrardae praedeubeli* (Lenz, 1994b). It seems to us that the most sensible label for this assemblage biozone is the *sherrardae* sub-Biozone of the *ludensis* Biozone. This then avoids problems that may arise with respect to *M. praedeubeli* (see discussion under the *M. ludensis* problem).

Few Australian graptolite faunas can be compared with this assemblage; *ludensis* zone faunas are well known from Quarry Creek (Rickards *et al.*, 1995), but there is surprisingly little taxonomic similarity, and we conclude that our Cobblers Creek fauna is slightly older.

From the Forbes district of New South Wales, Sherwin (1975) described Silurian faunas belonging to the *sherrardae* sub-Biozone as do the Cobblers Creek fauna and, where taxa are similar, they are discussed in the taxonomic section. The association of "*dubius*"-type monograptids, *Lobograptus sherrardae* and retiolitids in the Forbes fauna is reminiscent of the fauna discussed here.

The emerging, updated account of the Silurian graptolites of Victoria (Rickards & Sandford, in press) offers excellent prospects for establishing correlations between New South Wales and Victoria on the basis of graptolite faunas. However, there is no clear equivalent of the Cobblers Creek

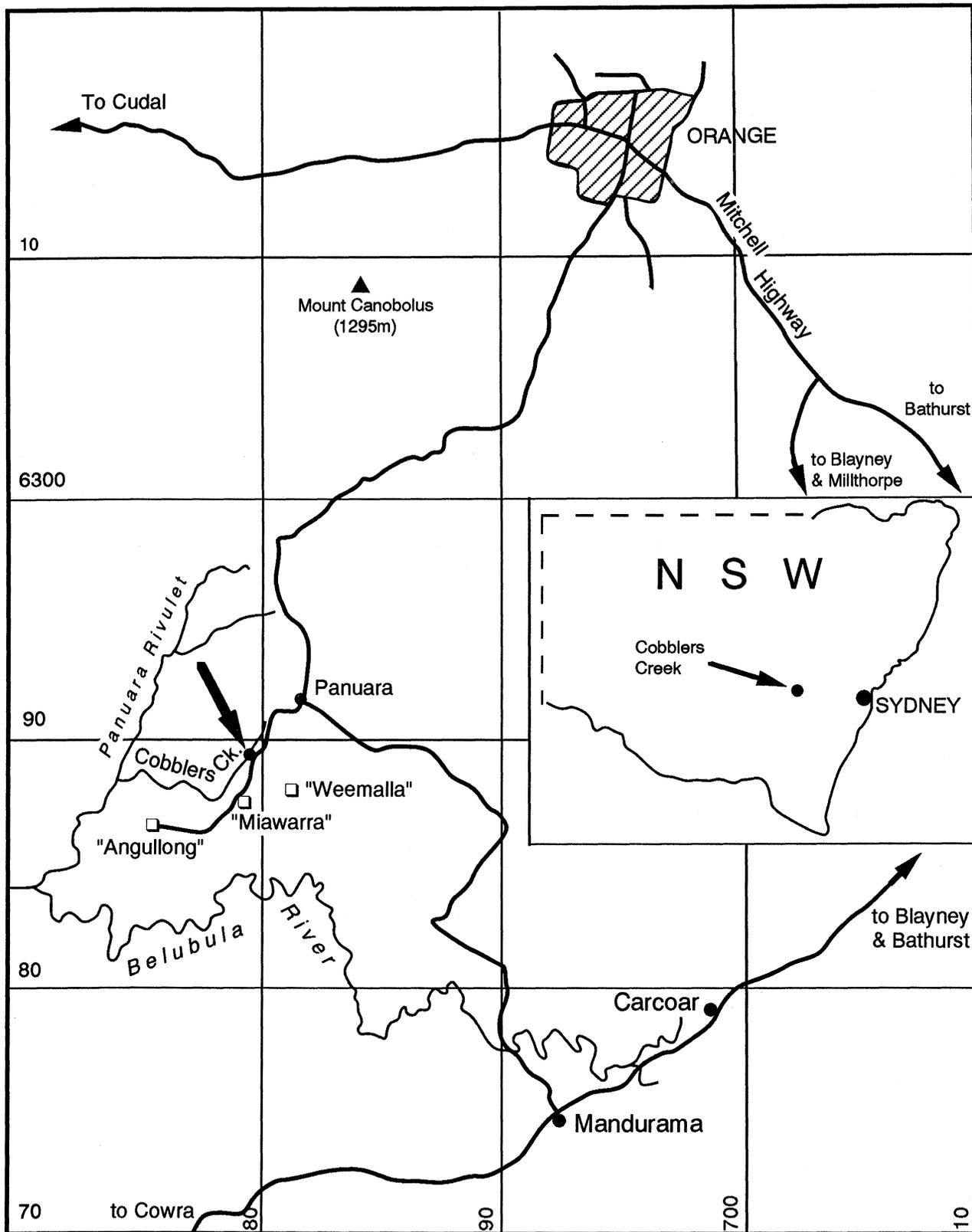


Fig. 1. Sketch topographic map for the Cobblers Creek locality; grid spacing 10 km.

fauna in Victoria. Garratt (1975) recognised and listed a probable *nassa* zone graptolite fauna from the Anderson Creek Formation in Victoria which included *Gothograptus nassa* (Holm), *Monograptus flemingii* Salter, *M. cf. ludensis* (Murchison) and *Pristiograptus cf. jaegeri* Holland, Rickards & Warren. Rickards & Sandford (in press) state that the formation has a suspected range of low Wenlock to high Wenlock (possibly including the very base of the *ludensis* Biozone), thus approximately confirming Garratt's age for the assemblage.

In the New South Wales context, the occurrence of shelly fossils with graptolites at Cobblers Creek provides more information on the local ranges of these Silurian shelly forms, as well as contributing to the solution of the problem that exists in differentiating Wenlock from Ludlow shelly faunas in Eastern Australia. The parlous state of knowledge reflected by the range chart given by Sherwin (in Pickett, 1982; fig. 10) listed 6 brachiopod taxa for the *lundgreni-testis* to *ludensis* interval; more recent data have been summarised by Strusz & Garratt (in press).

The occurrence in the Cobblers Creek fauna of *Plectodonta* extends the range of the genus well below the Pridoli range cited by Cocks & Rong (1989) for *Plectodonta bipartita* (Chapman), most species of the genus being Devonian. *Bracteoleptaena* has not been previously reported from Australia, although species assigned to the genus indicate generic ranges from Ashgill to Wenlock in Europe (Temple, 1965, 1968; Havlicek, 1967; Cocks, 1978); the late Wenlock age for the Cobblers Creek fauna does not conflict with this range. Other members of the shelly fauna (e.g., *?Lissatrypa* sp. and the trilobites) are too tentatively known to be of stratigraphic value; species of *Lissatrypa* are known from the Llandovery at Heathcote, Victoria (Öpik, 1953) up to the Early Devonian (e.g., Philip, 1962; in the Boola Beds, Tyers, Victoria). From the Nandan facies of Guangxi, Xu Hankui (1977, 1979) described a Middle Devonian brachiopod fauna characterised by diminutive genera including notanopliids, but also two species of *Plectodonta* and an atrypid *Holynatrypa mirabilis*; the latter bears some gross resemblance to the form described below as *?Lissatrypa*.

Evolution of Cobblers Creek graptolites

Koren' & Urbanek (1994) suggested a possible evolutionary origin of *Lobograptus sherrardae* from *Pristiograptus idoneus* (Koren'). We support this suggestion in that some of the straighter members of our collection of *L. sherrardae* are very close to *P. idoneus*, but differ in still having the rounding of th 1. Material described by Lenz (1995) must also be very close to this plexus but, as he rightly said, it is distinguishable from *P. idoneus* in having a lappetted th 1, and from *L. sherrardae* in its straight rhabdosome and small sicula.

It is clear from our record of *Monograptus moorsi* n.sp. and *Monograptus* sp. that there is more to resolve in the evolution of *Monograptus* s.st. at this stratigraphic level. At one time it was considered that the genus was absent from the *ludensis* Biozone, but it is clear that at least the

flemingii group continues, rarely and locally (see Rickards *et al.*, 1995). *Monograptus moorsi* cannot be readily placed in any previously described species grouping, so elucidation of its evolution must await further records.

Pristiograptus jaegeri may be important in the early evolution of the *ludensis* group. *Pristiograptus dubius* (Suess) is usually considered the likely ancestor of the *ludensis* group (Rickards *et al.*, 1977; Koren' & Urbanek, 1994); however, recent work suggests that there is some difficulty in distinguishing *P. jaegeri* from *M. praedeubeli* Jaeger, 1991 (but see section on the *ludensis* problem below). For example, some (perhaps all) material referred by Lenz (1994c) to *M. praedeubeli* is unquestionably referable to *P. jaegeri*. The latter species has only occasionally a rounded aperture to th 1, and the derivation of *M. ludensis*, including its early growth stage (*M. "praedeubeli"*), from *P. jaegeri* requires that this feature became dominant and that the sicula curved ventrally instead of being quite straight. Little else is needed. Thus it is possible that *M. ludensis* evolved only indirectly from *P. dubius* via the morphologically and stratigraphically intermediate species *P. jaegeri*.

The *Monograptus ludensis* Problem

Some controversy has continued over the taxonomy of the *ludensis* species group (Jaeger, 1991; Rickards *et al.*, 1995) ever since Holland *et al.* (1969) first revised the group. We have taken the opportunity raised by our Cobblers Creek records of *M. ludensis* to re-examine the type series of the species (British Geological Survey Museum number 6584), originally figured by Murchison (1839, plate 26, fig. 2 [*non* fig. 1]); the specimen BGSM 6584a was selected as holotype by Holland *et al.* (1969).

There are at least 80 current-oriented specimens of a monotypic assemblage on the type slab (BGSM 6584) and another slab (BGSM 6582). Preservation is in full relief and there is no tectonic deformation of the sandy nodule from which the two pieces were derived. Holland *et al.* (1969) figured only their selected lectotype from the type series, but further preparation by us has revealed further rhabdosomes with excellently-preserved proximal ends which are figured herein (Figs 4A–C,E).

The first point to recognise is that Figs 4A–E represent a growth series, and that each step in that series is represented by numerous specimens. Earlier growth stages (Fig. 4A) are narrower and have less thecal overlap, although the thecal spacing remains the same and th 1 is distinctly rounded. This is the form which equates with *Monograptus praedeubeli* Jaeger in some recent papers (Jaeger, 1990, 1991; Koren', 1992; Lenz, 1995). Later growth stages show that the thecal tubes continue to grow and that there is a tendency, visible even as early as Fig. 4B, for the ventral thecal lip to grow more distally than ventrally—to change direction, in fact. Figure 4B conforms approximately to *M. vulgaris* Wood, 1900 (which Holland *et al.* [1969] placed in synonymy with *M. ludensis*) and Figs 4C–D approach the change to what has been described as *M. gerhardi* Kühne (see Kühne, 1955; Jaeger, 1991;

Gutiérrez-Marco *et al.*, 1996). In short, the syntype series of *M. ludensis* embraces several "species" increasingly being used to characterise subdivisions of the old *M. ludensis* Biozone (see, for example, Koren, 1992; Rickards *et al.*, 1995). Fortunately, these subdivisions of the *ludensis* Biozone do not depend solely upon *M. praedeubeli* and *M. gerhardi* and, whatever the taxonomic complexities of the *M. ludensis* group, the current three subdivisions of the *ludensis* Biozone seem quite workable (see Rickards *et al.*, 1995: fig. 4; Rickards, 1995: fig. 5).

Two further matters arise from our revision of the types. The first concerns the growth stage potential in differing depositional realms. There is some suggestion that records of this species group from shelf deposits, such as in Shropshire (U.K.) and parts of central Europe and the Canadian Arctic, conform fairly closely to Jaeger's concept of *M. praedeubeli*, whereas contemporaneous down-slope, offshore deposits, such as are seen in Wales and the Lake district, yield the full growth series as seen on the type slab of *M. ludensis*. Thus, the Much Wenlock Limestone Formation of the Ludlow district (Holland *et al.*, 1969) yields *M. ludensis* close to the *M. praedeubeli* stage, whereas deposits of the same age in Wales and the Lake district yield this form as well as all growth stages up to and including *M. gerhardi*. In contrast, Lenz (1994b, 1994c, 1995) did not record *M. gerhardi*. Furthermore, these down-slope deposits yield very large and long specimens, well over 2 mm broad and up to 140 mm long, not seen in shelf occurrences of the species group.

The second matter concerns the supposed biostratigraphic value of *M. praedeubeli*, *M. ludensis* and *M. gerhardi*. The three forms are supposed to follow each other in time, with *praedeubeli* first, then *ludensis*, and finally *gerhardi* (possibly reaching into the *nilssoni* Biozone), but with considerable overlap between them. This might work if only individual shelf sequences are considered but, if offshore, deeper-water deposits are considered (as in the case of the type collections of *M. ludensis*), it is immediately clear that *M. praedeubeli* is an early growth stage of, and technically a junior synonym of, *M. ludensis*. One compromise on this issue, suggested provisionally by Rickards *et al.* (1995), was that three subspecies (*ludensis praedeubeli*, *l. ludensis* and *l. gerhardi*) be recognised until the palaeogeography and precise correlation were more refined, when the question can be reassessed, including the possibility of ecophenotypic variation. Our preferred subzonal scheme for this *ludensis* Biozone is threefold: *sherrardae*, followed by *deubeli* and *gerhardi* (highest). Justifications of the two major changes are that the first name avoids problems generated by the *praedeubeli-ludensis* relationship and the second name permits retention of the long-ranging *ludensis* for the higher level biozone.

Monograptus gerhardi is a rather different matter from *M. praedeubeli* in this context because it does seem, on current evidence, that the stratigraphically later forms of the *ludensis* group do reach the *gerhardi* condition more commonly. The procedural suggestion by Rickards *et al.* (1995) does at least have the merit of recording the growth stages identified in any particular section. Future work will then gradually test whether

these taxa are stratigraphically viable forms or not. For example, the current distinction in some papers, such as Lenz (1994b,c, 1995), of a *praedeubeli* Biozone overlain by a *ludensis* Biozone is suspect. Note that in Lenz (1994b, 1994c, 1995) the ranges of the recorded *praedeubeli* and *ludensis* in particular sections are more or less the same, with the former appearing slightly earlier in some sections, and the latter appearing slightly earlier in others. *M. gerhardi* was not recorded.

The relationship between *P. jaegeri* and *M. praedeubeli* is discussed here in the section on evolution, but is relevant in that the very earliest records of *M. praedeubeli* recorded by Lenz (1995) may be close to the origin of the latter from *P. jaegeri*, and the full *M. ludensis* range of growth may not have been developed. That is admittedly speculative, and for future work to examine; but *M. praedeubeli* of Lenz (1995) is here referred to *M. ludensis*.

Systematic palaeontology

Type material is deposited at the Australian Museum, Sydney (AMF), the British Geological Survey Museum, and at the Museum of Victoria, Melbourne (NMV). A selection of comparative material is lodged in the Sedgwick Museum, Cambridge.

In this section, no new terms are proposed. The calculation of thecal spacing follows the method of Packham (1962) in which measurements for 1–3 thecae are extrapolated to give thecae per millimetre. This, we maintain, gives a more clear indication of thecal spacing changes along the rhabdosome than other methods and, in particular, gives a figure more easily compared with traditional measurement (which counts the number of thecae per unit length) than does the method of Howe (1983). The diagnoses given refer to the Cobblers Creek material, and are not a synthetic species abstract. Comparisons of Cobblers Creek biocharacters are made, as appropriate, with type and other material. Cobblers Creek material is deformed by a cleavage at a high angle to the bedding. In the descriptions corrections are made for this, unless otherwise indicated.

Class Graptolithina Bronn, 1849

Note that the date for Bronn's first mention of the class has been commonly given as 1846; our research shows that the date of publication was 1849.

Order Graptoloidea Lapworth, 1873

Family Plectograptidae

Boucek & Münch, 1952

Subfamily Gothograptinae

Obut & Zaslavskaya, 1986

Gothograptus Frech, 1897

Type species. *Retiolites nassa* Holm, 1890; Late Wenlock *nassa* Zone, Eske Beds, Gotland, Sweden; by original designation.

Gothograptus chainos Lenz, 1993b

Figs 5A–B

- 1993b *Gothograptus chainos*, new species; 17–18, pl. 7, figs 1–12.
 1994a *Gothograptus chainos* Lenz, 1993b; Lenz, 858, pl. 5.1–8

Material examined. Numerous fragmentary specimens. Figured specimens AMF 81782 and NMV 146877.

Diagnosis. Small gothograptid up to 5 mm long and 0.70–0.90 mm wide, comprising only clathrial elements. Corona bowl-shaped, rounded. Thecal apertures alternating, 10 in 10 mm. Apertural regions thickened in some specimens, but no thecal hoods. Nema free, at least for most of rhabdosomal length. Clathrial meshwork of subpolygonal spaces, occasionally square or rounded; usually 4 sets of meshes, arranged in linear fashion, on the free “wall” of each theca.

Remarks. Although not so well preserved, these specimens closely resemble those illustrated by Lenz (1993b) in all dimensions and overall appearance. It is the dominant retiolitid at the locality, most rock fragments having a few complete or fragmentary specimens. It differs from the other retiolitid in the assemblage, the more robust *G. marsupium*, which is described below. The latter species certainly reaches a dorso-ventral width of 2.0 mm, has an ovate rather than parallel-sided rhabdosome, and has inwardly-sloping “supra-genicular” walls; in all of these features it differs from *G. chainos*.

Gothograptus marsupium Lenz, 1993b

Fig. 5C

- 1993b *Gothograptus marsupium*, new species; Lenz, 18–19, pl. 10, figs 1–9; pl. 11, figs 1–8.
 1994d *Gothograptus* n.sp.; Lenz, pl. 4, figs B,F,G.
 1995 *Gothograptus* sp.; Rickards *et al.*, 41, figs 18K–L, 20J.

Material. Figured specimen AMF 92265, and some possible fragments.

Diagnosis. Gothograptid with rhabdosome up to 3 mm long and 2 mm broad, with conspicuous thecae outlined by clathrial elements; “supragenicular” wall inward-sloping, no “genicular” hood present; thecal spacing 11–13 in 10 mm; rhabdosome narrows a little distally; virgula present; all clathrial elements fine, providing a squarish meshwork, interspersed with even finer reticular threads.

Remarks. Although fragmentary, our specimens are identical in structure and dimensions to the originals of Lenz (1993b), except that the pouch-like thecal profiles are not so clear. Rickards *et al.* (1995) misleadingly described the thecae of *Gothograptus* as “strongly keeled” when they were, in fact, referring to the “supragenicular” walls and geniculum. Those Quarry Creek specimens are from the *ludensis* Biozone, as is the material described here from Cobblers Creek. Lenz (1993b) recorded *G. marsupium* from the *lundgreni-testis* level, but in New South Wales the species occurs in the *ludensis* Biozone.

Pristiograptus Jaekel, 1889

Type species. *Pristiograptus frequens* Jaekel, 1889; Ludlow, glacial drift boulders, North Germany; by original designation.

Pristiograptus jaegeri

Holland, Rickards & Warren, 1969

Figs 2A–B, 5F–I

- pars 1900 *Monograptus vulgaris* Wood, 455–6, text-fig. 10a (non 10b, pl. 256, fig. 2).
 non 1900 *Monograptus vulgaris* var. b Wood, 457, pl. 25, fig. 3.
 non 1911 *Monograptus vulgaris* var. *curtus* Elles & Wood, 379, pl. 37, fig. 11.
 pars 1911 *Monograptus vulgaris* Wood; Elles & Wood, 378–379, text-fig. 248a (non 248b, pl. 37, fig. 2).
 ?1935a *Monograptus vulgaris* Wood; Decker, 443–444, figs 32–4.
 ?1935b *Monograptus vulgaris* Wood; Decker, 309.
 ?pars 1944 *Pristiograptus vulgaris vulgaris* (Wood); Příbyl, text-fig. 2L (non 2M), 22–23.
 ?1947 *Monograptus vulgaris* Wood; Ruedemann, 490, pl. 84, figs 22–24.
 ?1948 *Pristiograptus* cf. *vulgaris vulgaris* (Wood, 1900); Příbyl, 78.
 non 1960 *Monograptus vulgaris* var. *ashlandensis* Berry, 1163, fig. 2H.
 1963 *Monograptus vulgaris* Wood; Holland, Lawson & Walmsley, 104, 136, 157.
 1969 *Pristiograptus jaegeri* n.sp.; Holland, Rickards & Warren, 668–671; pl. 130, fig. 1; text-figs 2k–r, 3f.
 1974 *Monograptus* (*Pristiograptus*) aff. *jaegeri* Holland, Rickards & Warren; Cuerda, 328–330; pl. 3, figs 1–8; pl. 4, figs 1–4.
 1975 *Pristiograptus jaegeri* Holland, Rickards & Warren; Berry & Murphy, 71–73; text-fig. 21a; pl. 8, fig. 3.
 1994b *Pristiograptus dubius dubius* (Suess); Lenz, 1420, figs 2A–D.
 pars 1994b “*Pristiograptus*” *praedeubeli* (Jaeger); Lenz, 1420, figs 2E–G, 3A–E.
 1995 *Pristiograptus jaegeri* Holland, Rickards & Warren, 1969; Rickards *et al.*, 41–2, figs 22F–G, 24A–G.

Material. AMF 81780, 81792, 92253–4, 92267 and NMV 146878; the material is variously deformed, some specimens being little deformed, some in low relief.

Diagnosis. *Pristiograptus* with straight rhabdosome, including the proximal end, up to 30 mm long. Proximal dorso-ventral width 0.65–0.70 mm, gradually reaching 1.30–1.50 mm more distally. Proximal thecal spacing about 15 in 10 mm, and distally as low as 10 in 10 mm. Thecal overlap 1/2 proximally, changing to 2/3 distally.

Description. The above diagnostic figures are corrected for tectonic deformation. Thecal spacing, for example,

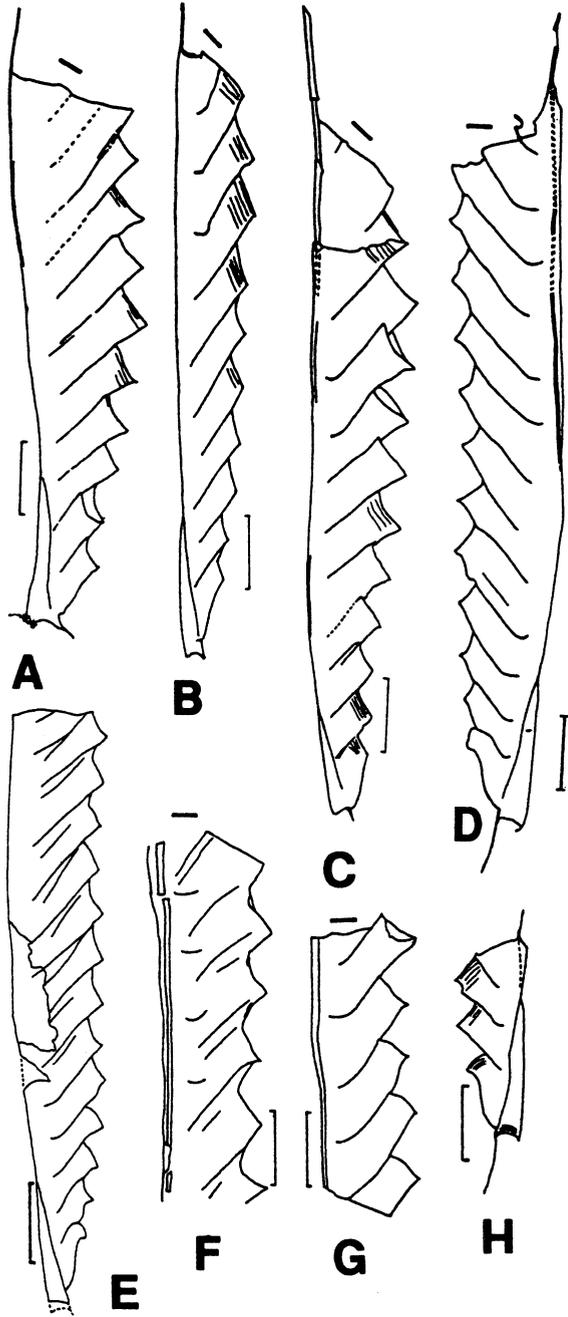


Fig. 2. A–B, *Pristiograptus jaegeri* Holland *et al.*, 1969, respectively AMF 92253–4, showing the effect of tectonic deformation on dorso-ventral width and thecal overlap in extreme cases (A). C, *Pristiograptus dubius* (Suess), NMV 146884. D–H, *Monograptus ludensis* (Murchison), respectively AMF 92255–6, AMF 92258–60. Lineation caused by tectonic deformation shown by short heavy bar; scale bars 1 mm, all approximately $\times 10$.

varies from 13 in 10 mm to 19 in 10 mm at the proximal end, but specimens at 45° to the lineation have 15–16 in 10 mm. The sicular length is also affected but, in undeformed specimens or when corrected, is 2 mm long; its apex reaches to just above the aperture of th 2. The proximal end is quite straight in almost all specimens; even those specimens normal to the lineation show no increase in rhabdosomal curvature. The first theca shows a very slight rounding of the aperture in a small number of specimens.

Remarks. The thecal spacing is slightly higher than in the type series described by Holland *et al.* (1969) from Shropshire and Wales, the latter ranging from 12–8 in 10 mm. However, all other measurements are the same and the overall aspect, especially the straight proximal end, are identical. The Cobblers Creek specimens are very similar to the Quarry Creek material (Rickards *et al.*, 1995).

Jaeger (1991) considered one specimen of the type series (Holland *et al.*, 1969, text-fig. 2m) of *P. jaegeri* a synonym of *M. praedeubeli* Jaeger but, as pointed out by Rickards *et al.* (1995), this is unlikely because **most** specimens in an assemblage of *M. praedeubeli* have a rounded aperture to th 1, whereas in the type series of *P. jaegeri* rounding of th 1 is rare. Furthermore, it should be pointed out that *P. jaegeri* has priority over *M. praedeubeli*.

Jaeger (1991: 327) was also of the opinion that, based on an examination of three specimens of *P. jaegeri*, that it was a junior synonym of *P. dubius*. This is certainly wrong, as is well exemplified by the Cobblers Creek collection of at least 100 specimens; all are quite straight proximally with no sign of the characteristic slight ventral curvature of *P. dubius*. Comparison of Figs 2A–B and 2C shows the differences between our recorded specimens of *P. jaegeri* (which are abundant) and *P. dubius* which are quite rare at Cobblers Creek. In addition to the question of curvature of the rhabdosome, the sicula is longer and differently positioned in *P. jaegeri*.

The species figured by Lenz (1994b) from the Canadian Arctic as "*Pristiograptus*" *praedeubeli* (Jaeger) seems to us to be classical *P. jaegeri* in that there is little or no rounding of the aperture of th 1. Furthermore, the other dimensions resemble the type material closely, more closely even than our Cobblers Creek material.

These problems of identification highlight the rapid evolutionary diversions taking place in the *ludensis* Biozone, especially amongst this species group. The global range of *P. jaegeri* (see Holland *et al.*, 1969) is late *lundgreni* to *nilssoni* Biozones, although it is rare in the latter biozone.

An evolutionary origin of *M. praedeubeli* (= *M. ludensis praedeubeli* of Rickards *et al.*, 1995) from *P. jaegeri* at the base of the *ludensis* Biozone seems very likely.

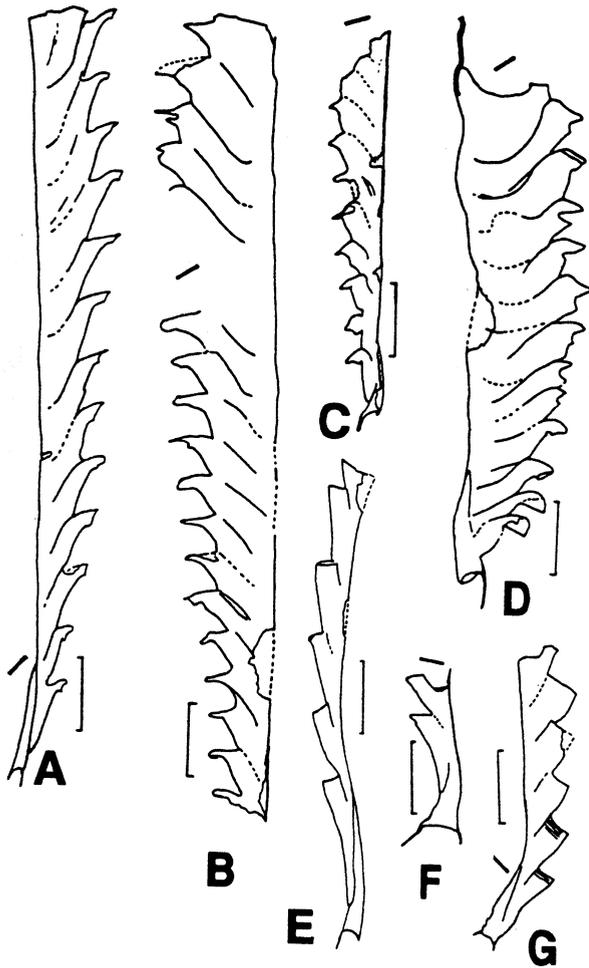


Fig. 3. A–C, *Monograptus moorsi* n.sp., respectively AMF 92261 (holotype), AMF 92262–3. **D**, *Monograptus* sp., AMF 92264. **E–G**, *Lobograptus sherrardae* (Sherwin), respectively NMV 146883, NMV 146875 and NMV 146882. Lineation caused by tectonic deformation shown by short heavy bar; scale bars 1 mm, all approximately $\times 10$.

Pristiograptus dubius (Suess, 1851)

Figs 2C, 5D–E

1851 *Graptolithus dubius* Suess: 115, pl. 9, figs 5a,b.

Material. AMF 81781, 92266.

Remarks. This species has been discussed briefly above; it occurs very rarely in the fauna.

Monograptus Geinitz, 1852

Type species. *Lomatoceras priodon* Bronn, 1835; Étage E, Bohemia; designated by Bassler (1915).

Monograptus ludensis (Murchison, 1839)

Figs 2D–H, 4A–E, 5J

1839 *Graptolithus ludensis* Murchison, 694, pl. 26, fig. 2 (non fig. 1); for a full synonymy, see Rickards *et al.* (1995).

1990 *Monograptus praedeubeli* n.sp.; Barca & Jaeger, figs 11/11–12.

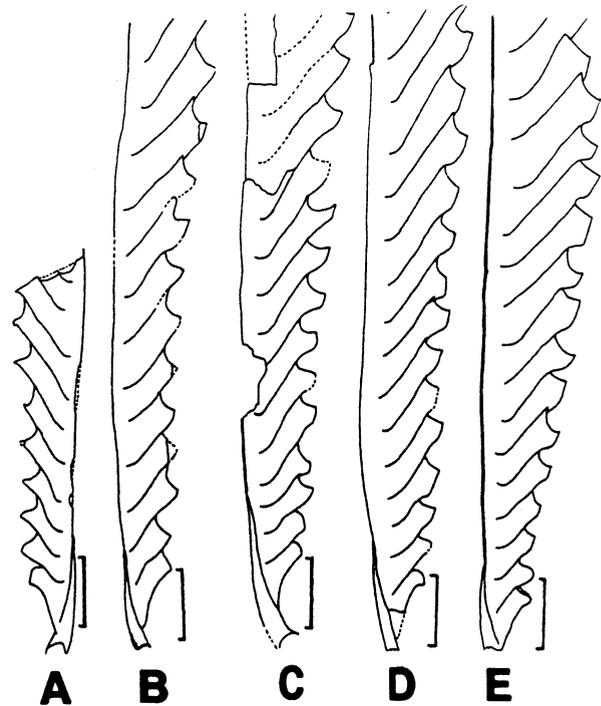


Fig. 4. A–E, *Monograptus ludensis* (Murchison), a growth series selected from Murchison's type slab, British Geological Survey Museum no. 6582/4; **A**, "praedeubeli" growth stage; **B**, same, but with some further growth of thecae and slightly distal turning of the free ventral wall (incipient "gerhardi" stage, essentially the *ludensis* or *vulgaris* growth stage); **C**, further growth stage showing increased dorso-ventral width, length of thecae, and further development of *gerhardi* condition; **D**, lectotype 6584a, with moderately advanced "gerhardi" condition; **E**, an example of the most robust specimens on the slab, which may reach 50 mm in length; all specimens tectonised, in full relief; scale bars 1 mm, approximately $\times 10$.

1995 *Colonograptus? ludensis* (Murchison); Lenz, 1385, figs 9D–I, 11N,O,W,X.

1995 *Colonograptus? praedeubeli* (Jaeger); Lenz, 1385–6, figs 9P–R, 11A–D.

1996 *Colonograptus ludensis* (Murchison, 1839); Lenz *et al.*: 1396, figs 3P,Q, 4M–R.

Material. Numerous well-preserved specimens, being only second in abundance to *P. jaegeri* (see above section entitled "The *Monograptus ludensis* problem"). Figured specimens are: AMF 81791, 92255–6, 92258–60; several specimens from the type slab BGSM 6582/4, including the lectotype 6582a.

Description. The Cobblers Creek specimens have a rounded th 1, occasionally th 2 to some extent, and exhibit only the *praedeubeli* and *ludensis* growth stages (see discussion above on *ludensis* problem). Sicular length 1.80–2.40 mm; apex usually about the level of the aperture of th2. The dorso-ventral stipe width reaches 1.30–1.50 mm, and the thecal spacing is 13–11 in 10 mm. The thecal apertural regions are sometimes slightly concave just below the apertural lip.

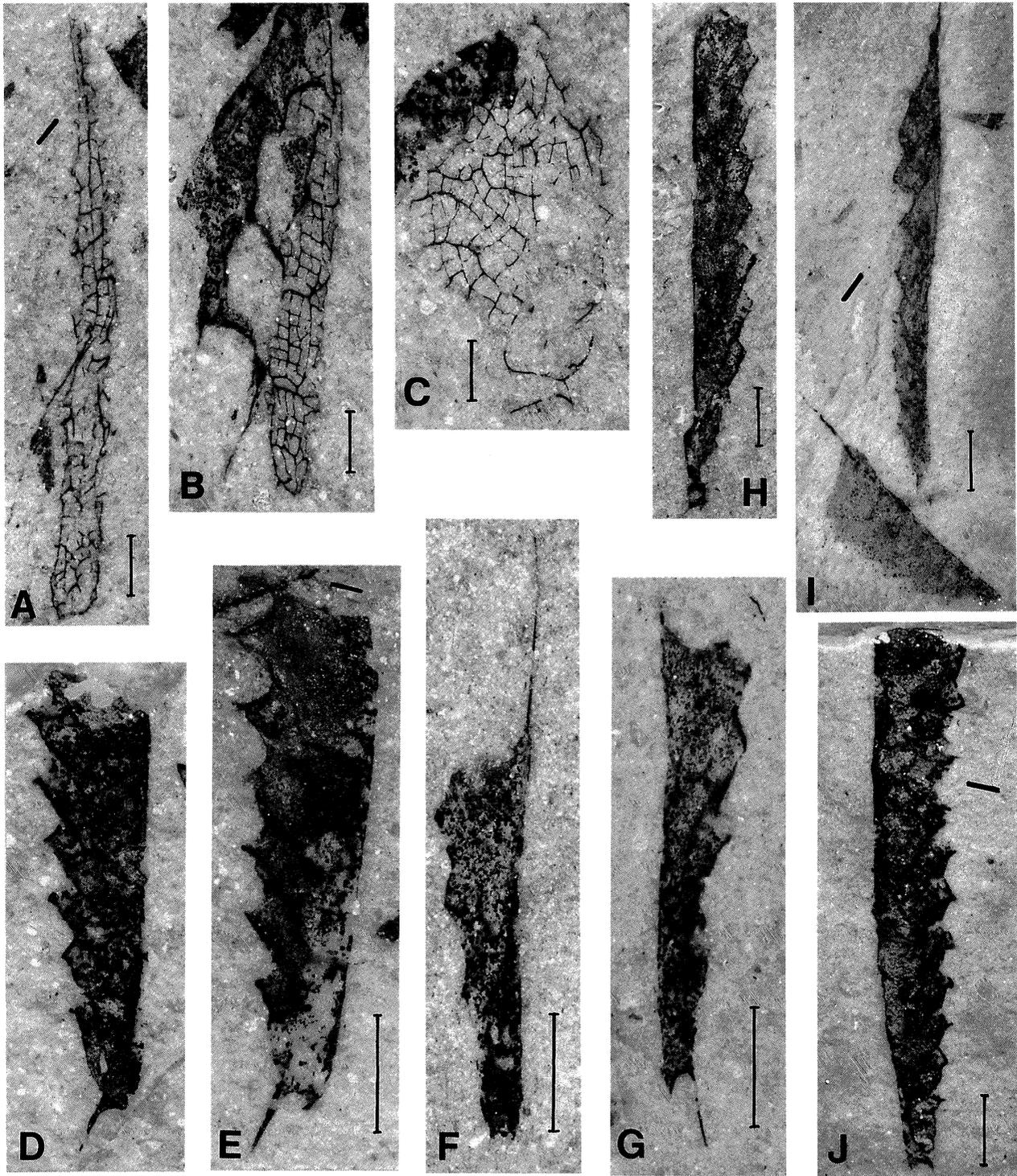


Fig. 5. A–B, *Gothograptus chainos* Lenz, respectively NMV 146877 and AMF 81782, profile and subapertural views. C, *Gothograptus marsupium* Lenz, AMF 92265. D–E, *Pristiograptus dubius* (Suess), respectively AMF 92266 and AMF 81781. F–I, *Pristiograptus jaegeri* Holland *et al.*, 1969, respectively AMF 81792, AMF 92267, NMV 146878 and AMF 81780; I, shows the extreme tectonic deformation seen on some surfaces. J, *Monograptus ludensis* (Murchison), AMF 81791. Lineation caused by tectonic deformation shown by short heavy bar; scale bars 1 mm, all approximately $\times 10$.

Remarks. A diagnosis for this species was given by Rickards *et al.* (1995). The relationship of *M. ludensis* to *M. praedeubeli*, *M. vulgaris* Wood, *M. gerhardi* and *P. jaegeri* is discussed above in the sections on the

ludensis problem and on the evolution of some Cobblers Creek graptolites. The latter specimens closely resemble the type series of Murchison and differ only in that they show a slight concavity just below the apertural lip.

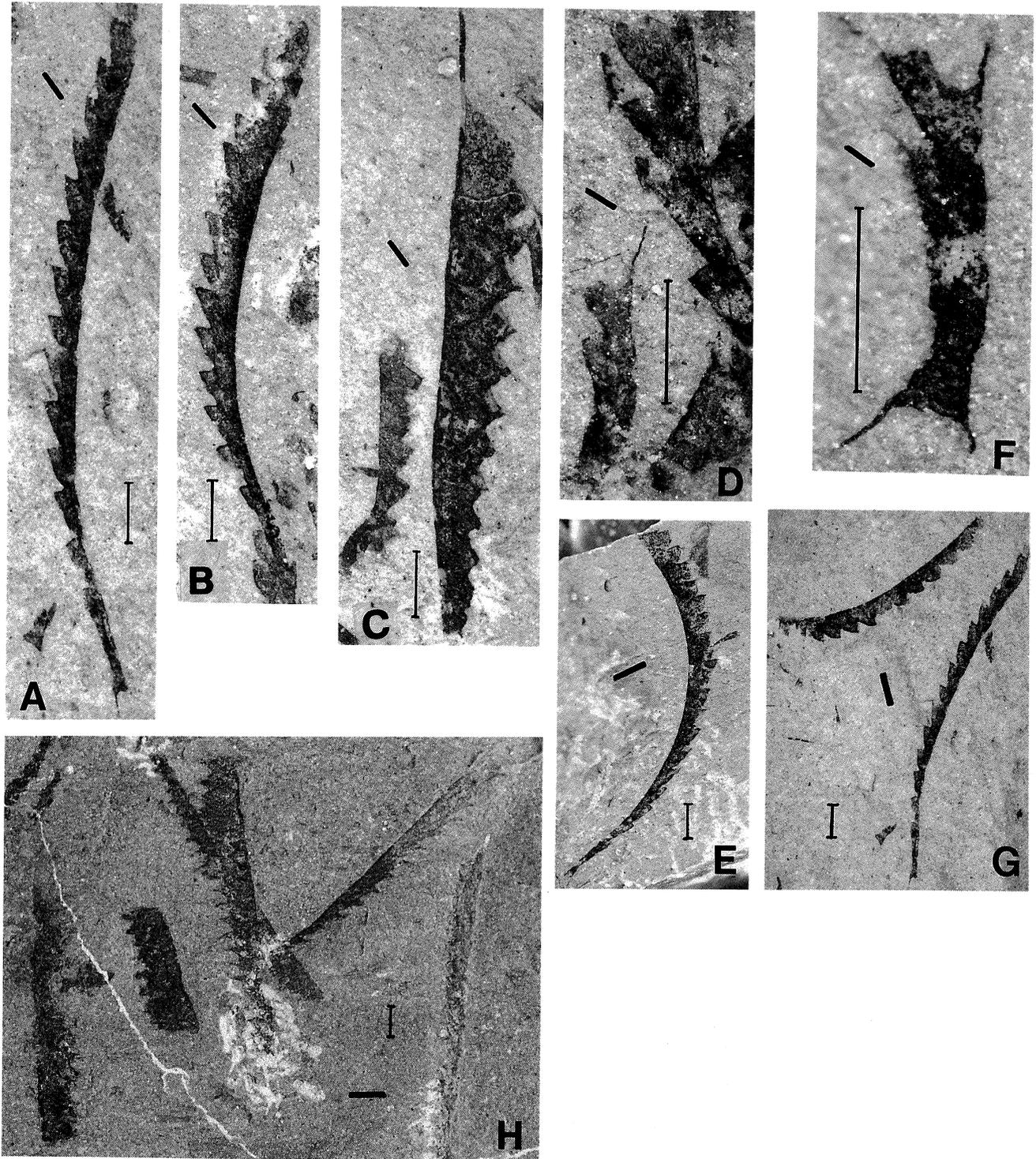


Fig. 6. A–G, *Lobograptus sherrardae* (Sherwin); **A**, NMV 146879, with typical proximal end somewhat attenuated by stretching; **B**, NMV 146880, more distal thecae; **C**, NMV 146881, proximal end made more robust by stretching, associated with specimen of *P. dubius* (Suess); **D**, NMV 146885, proximal end showing curved sicula, nema, together with a fragment of distal thecae; **E**, NMV 146886, specimen with increased curvature as a result of stretching; **F**, NMV 146876, showing characteristically curved sicula with flared sicular aperture, and completion of th 2 before growth of th 3; **G**, NMV 146799, relative deformation of two adjacent specimens. **H**, *Monograptus moorsi* n.sp., holotype AMF 92261 (diagonal specimen; see also Fig. 3A) associated with AMF 92262 (central upright specimen; see also Fig. 3B) and other fragmentary specimens of the same species. Direction of tectonic stretching indicated by short bar; scale bar 1 mm.

Monograptus moorsi n.sp.

Figs 3A–C, 6H

Material. HOLOTYPE AMF 92261; figured PARATYPES AMF 92262–3 and other specimens are known with certainty only on the same slab as the holotype.

Derivation of name. The species is named for Dr Henry Moors, in recognition of his work on Australian graptolites.

Diagnosis. Almost straight *Monograptus*, at least 10 mm long; distal dorso-ventral width up to 1.30 mm, gradually expanding from a proximal dorso-ventral width of 0.40 mm. Thecal spacing about 16–17 in 10 mm proximally, 14 in 10 mm distally. Thecal overlap about 1/2 proximally, 2/3 distally. Thecal hook occupies almost 1/2 rhabdosomal width proximally, and as little as 1/4 distally. Hook pronounced, but without strong retroversion. Sricula about 1.30 mm long, reaching to above level of the hook of th 1.

Description. The rhabdosome is more or less straight at the proximal end, the sicula providing a conspicuous dorsal addition (Fig. 3A). The virgella is thickened and robust in one specimen (Fig. 3C) but is fine and straight in others (e.g., Fig. 3A). Its apex is seen a little way along the hook of th 1. Proximal thecal hooks suggest more retroversion more than distal hooks and they occupy a greater proportion of the rhabdosomal width. As the thecal overlap increases distally, so the ratio of thecal hook to stipe width falls. The nature of the thecal hooks is uncertain. It seems that both dorsal and ventral walls are involved in the hooks but, on the more distal thecae, the most distal part of each hook has a curiously flattened appearance. This may indicate the presence of paired lappets on distal thecae, rather than dorsal wall retroversion.

Remarks. *Monograptus moorsi* is distinct from the *flemingii* group as the hooks are different, lacking the clear retroversion and thecal spinosity, and in having narrow, straight proximal ends with a sicular apex positioned more proximally. *Monograptus moorsi* differs from *M. ex. gr. flemingii* recorded from the *ludensis* Biozone at Quarry Creek (Rickards *et al.*, 1995) in having a higher thecal spacing (16–14 in 10 mm compared with 12–10 in 10 mm) as well as on the general grounds just stated. Thus *M. moorsi* represents a new record of *Monograptus* s.s. for the *ludensis* Biozone, as only forms of the *M. flemingii* group have been previously recorded (see Rickards *et al.*, 1995: 9).

Monograptus moorsi differs from *M. uncinatus* Tullberg in having a less retroverted hook and a much higher thecal spacing, whereas the proximal end in *M. uncinatus* tends to have a slight ventral curvature and is more robust.

Monograptus insperatus Koren¹, which occurs in the *ludensis* Biozone of Peshkaut, Kirghizia and the same horizon in Victoria (see Rickards & Sandford, in press), has paired thecal lappets and is more robust, with a ventrally curved sicula. The thecal spacing of *M. moorsi* is about twice that of *M. insperatus*.

Monograptus sp.

Fig. 3D

Material. A single specimen, AMF 92264 a, b.

Description. The rhabdosome is 6 mm long, and has a maximum dorso-ventral width of 1.50 mm achieved at a length of 3 mm. However, the specimen is clearly tectonically deformed, as indicated not only by the lineation on the bedding surface but also by the undulating dorsal margin and nema. The sicula is 1.50 mm long, slightly curved ventrally, although this curvature is exaggerated by deformation. Thecal overlap is considerable, being at least 1/2 proximally and 3/4 distally. The thecae are clearly hooked, but the nature of the hook is obscure. The first two thecae appear to have the dorsal margin strongly retroverted, and there is a clear indication of this in the most distal thecae. Other thecae suggest that the ventral margin is also retroverted; in other words, the thecal hook is of *priodon* style. However, there is a slight suggestion that on thecae 5–9 lappets may be present, although this may be an artefact of preservation. In brief, the thecae are strongly hooked but the nature of the hook cannot yet be ascertained. Thecal spacing (deformed) is 20 in 10 mm, suggesting (allowing for deformation of the specimen) an original spacing of about 16 in 10 mm.

Remarks. The overall appearance and measurements are similar to *Monograptus banksi* Rickards *et al.*, 1995, but the latter is more robust and has a strongly curved sicula. *Monograptus dalejensis dalejensis* of Rickards *et al.*, 1995 is similarly distinct from *M. sp.* It is possible that *M. sp.* is related to the *M. flemingii* group, and may be the proximal end of the *M. ex. gr. flemingii* described by Rickards *et al.* (1995) from the *ludensis* Biozone at Quarry Creek, but the deformation of *M. sp.* does not allow us to be certain about this. Another possible comparison is with *M. insperatus* from the *ludensis* Biozone of Peshkaut, Kirghizia. The same species has been recorded from Victoria (Rickards & Sandford, in press). The thecal spacing in *M. insperatus* is much less than in *M. sp.* and the two are similar only in overall dimensions and rhabdosomal shape.

For the moment it is clearly advisable to leave the Cobblers Creek specimen in open nomenclature, whilst noting that it is yet another record from the *ludensis* Biozone as the evolutionary diversity increases after the *nassa/dubius* evolutionary low point.

Lobograptus Urbanek, 1958

Type species. *Monograptus scanicus* Tullberg, 1883; Cardiolaskiffern (Ludlow), Marianelund, Scania, Sweden; by original designation.

Lobograptus sherrardae (Sherwin, 1974)

Figs 3E–G, 6A–G

- 1971b *Monograptus* spp. D, E; Sherwin, 167–171, pl. 17, figs 2,5,7.
 1974 *Pristiograptus sherrardae* n.sp.; Sherwin, 231, pl. 2, figs 1–10, text-fig. 3a–e.
 1978 *Pristiograptus etheringtoni* n.sp.; Lenz, 635, pl. 2, figs B–F, text-figs 1.4–6.
 1980 *Monograptus?* aff. *deubeli* Jaeger; Lenz, 635, pl. 6, figs 1,3.
 1988 *Monograptus sherrardae* Sherwin; Koren' & Rinenburg, 12, pl. 1, figs 13–15,18.
 1992 *Lobograptus? sherrardae* (Sherwin, 1974); Koren'; 31–32, pl. 3, figs 4–5; pl. 4, figs 3–6.
 ?1994c *Lobograptus? sherrardae* (Sherwin); Lenz, 1780, figs 3a, 4a–c.
 1994c *Lobograptus?* aff. *sherrardae* (Sherwin); Lenz, 1780–1, figs 3b–h, 4d–f, 4m–n.
 1995 *Lobograptus? angustus* n.sp.; Lenz, 1387–1388, figs 10A,B, 11T–V.

Material. The ten figured specimens are NMV 146875–6, 146879–83, 146885–7.

Diagnosis. *Lobograptus* with dorsally curved rhabdosome; curvature gentle to moderate, except at the extreme proximal end where the ventrally curved sicula imparts a ventral curvature to the rhabdosome as a whole. Sicular apex near or just above th 1 aperture; sicular aperture flared, with conspicuous virgella; sicular length approximately 2 mm; th 1 apertures slightly rounded in profile as a result of lateral lappets; thecal overlap 1/3 proximally, 1/2 distally; all thecae subsequent to th 1 have pristiograptid apertures. Distal dorso-ventral width 0.75 mm. Thecal spacing about 12 in 10 mm distally, and 15 in 10 mm proximally.

Remarks. The Cobblers Creek specimens are identical to Sherwin's original material from the Forbes district, N.S.W., except that the thecal spacing may be slightly higher (12–15 compared to 11–14). However, there is clearly some variation when global records are considered. For example, Koren' (1992) cited 9–13 in 10 mm, and Lenz (1994b) 11–13 in 10 mm proximally. Lenz's (1994b) specimens appear to be rather more robust proximally than Sherwin's or our material; indeed, his specimens described as *L?* aff. *sherrardae* seem closer to the N.S.W specimens. *L?* aff. *sherrardae sensu* Lenz (1994b) seem to show some tendencies towards *L?* *claudiae* Koren', although it lacks the thecal apertural isolation of *L?* *claudiae*; Lenz later named his Canadian form *L?* *angustus*. Clearly there is some variation in this species group, and possibly some of that variation may prove to be valuable stratigraphically.

Phylum Brachiopoda

Class Strophomenata Williams *et al.*, 1996

Order Strophomenida Öpik, 1934

Family Plectambonitacea Jones, 1928

Plectodonta Kozłowski, 1929

Type species. *Plectodonta mariae* Kozłowski, 1929, from the Borschov Horizon, Mitkov Beds (Pridolí), Podolia, Ukraine (Cocks & Rong, 1989); by original designation.

Remarks. The oldest species accepted by Cocks & Rong (1989) in *Plectodonta* is the Ludlow-Pridolí *Plectodonta thuringica* Schmidt, 1939; thus it is important to note the Wenlock age of the species described here, and that *P. bipartita* (Chapman, 1913) occurs (as *P. davidi* Mitchell, 1923) in the Rainbow Hill Marl Member (Ludlow) in the Yass district of New South Wales, immediately above the occurrence of *Bohemograptus*. Several of the Silurian species assigned to *Plectodonta* by Havlicek (1967) and Cocks & Rong (1989) are Australian. The Devonian occurrence of the genus in Australia is well documented (e.g., Philip, 1962).

Plectodonta brownae n.sp.

Figs 7A–O, ?8A–C

Material. HOLOTYPE: conjoined valves AMF 99584a–b PARATYPES: conjoined valves AMF 99614, 99587; brachial valves AMF 99586, AMF 99589, NMV 146098; pedicle valves AMF 99591–3, AMF 99594–5, AMF 99615–6; NMV 146100.

Derivation of name. For the late Dr Ida Alison Browne (née Brown), in recognition of her contribution to understanding of middle Palaeozoic geology of New South Wales (e.g., Brown, 1941; Browne, 1959; Brown & Sherrard, 1952).

Diagnosis. *Plectodonta* with resupinate brachial valve, internally characterised by several short radial ridges posterolateral of the main septa (especially in smaller shells), and numerous low and rare large papillae. Sculpture parvicostellate, with up to about 15 primary ribs separated by 4–5 secondary costellae; up to 7.3 mm wide and 4.2 mm long.

Description. Transversely semi-oval, concavo-convex shells; resupinate brachial valve initially gently convex, becoming gently concave, pedicle valve convex throughout. Hingeline straight, and weakly denticulate for less than half shell width. Parvicostellate sculpture, with up to about 15 primary ribs separated by 4–5 secondary costellae, and often impressed internally; primary ribs appear by intercalation. Maximum width 7.3 mm, maximum length 4.2 mm.

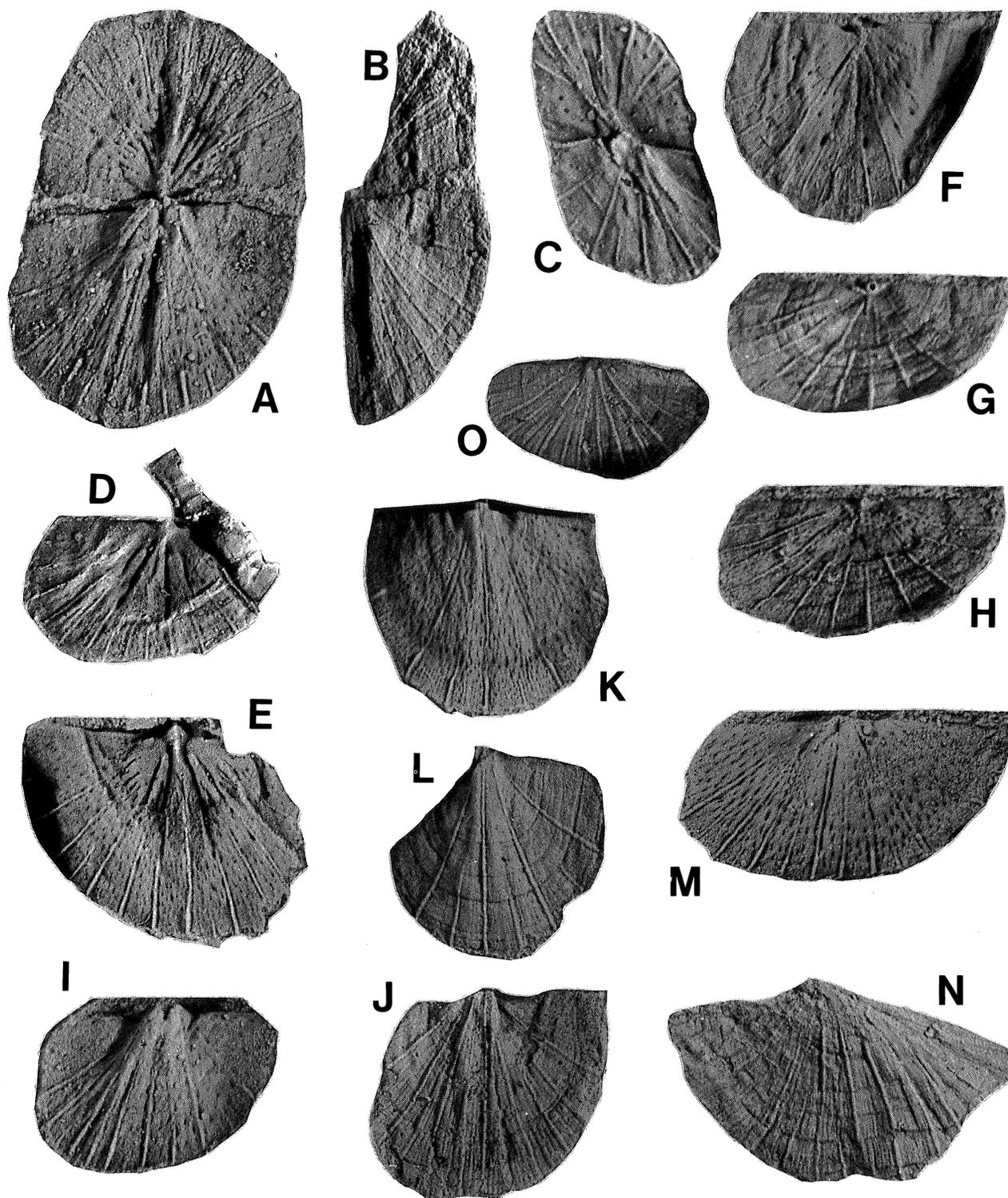


Fig. 7. A–O, *Plectodonta brownae* n.sp. A–B, AMF 99584, holotype brachial internal and latex cast of external surfaces, $\times 10$; C–O, all paratypes, all internal moulds unless otherwise stated: C, AMF 99587, conjoined valves, $\times 20$; D, AMF 99614, brachial valve, with incomplete pedicle detached, $\times 12$; E, NMV 146098, brachial valve, $\times 10$; F, AMF 99586, brachial valve, $\times 10$; G–H, AMF 99588, brachial valve and external cast, $\times 12$; I, AMF 99592, pedicle valve, $\times 12$; J, AMF 99591, external cast, pedicle valve, $\times 12$; K–L, AMF 99593, pedicle valve and external cast, $\times 10$; M, AMF 99594, pedicle valve, $\times 10$; N, AMF 99615, external pedicle cast, $\times 12$; O, AMF 99616, external pedicle cast, $\times 12$.

Brachial interior finely papillate; external radial sculpture strongly impressed, especially near margin. Muscle field slightly elevated; adductor scars large and flabellate in mature specimens, with lobes separated by prominent radial ridges of varied lengths; medially short, with faint ridge anteriorly. Narrow medial groove arises in pit at front of essentially bilobed cardinal process, and becomes weaker anteriorly. Sockets low and set at high angle to hingeline, with low rounded socket ridges. The two major septa are gently convex outwards from just in front of cardinalia, diverging from medial line at about 20°, to just past mid-length and, beyond the “lophophore platform”, are almost straight for anterior half of length where they are located just medially of the traces of the first costellae lateral to the medial costella. Each major septum is flanked and paralleled by one, or rarely more, almost straight secondary septa set at about 60° to the hingeline, and reaching to about half the length of the longer septa; in one specimen, the space between the major and secondary septa is occupied by a short ridge. These are, in turn, flanked posterolaterally by about 4–5 smaller radial ridges described above; posteromedial part of lophophore platform finely papillate.

Pedicle valve also bears widespread imprint of external sculpture, but is more papillate than brachial valve. Muscle scars divided posteriorly by short, narrow myophragm, anterior of which the muscle field bifurcates; adductor scars not clearly differentiated. Delthyrium apparently open, teeth stout.

Remarks. The brachial valves exhibit what Philip (1962) called the “lophophore platform”, which lacks papillae.

The small plectambonitaceans (whose dimensions, given above, must be used with discretion as all specimens are deformed) in this collection fall into three groups:

i The majority of the material is assigned to *P. brownae* n.sp. This species differs from *P. bipartita* (Chapman, 1913) in size and the number of primary ribs, as well as the accessory brachial septa. It also lacks the coarse papillae seen outside the brachial muscle field of both *P. bipartita* and *P. mariae*. Another species from New South Wales, described as *Stropheodonta davidi* by Mitchell (1923: pl. xli, figs 19–21), was re-illustrated by Brown (1948: pl. XIV, figs 1–4) and assigned to *Plectodonta*. Savage (1974) suggested that the species is a junior synonym of *P. bipartita*.

ii. Four specimens (AMF 99585, 99588, 99590, NMV 146099) in the collection lack secondary costellae, but are assigned to *Plectodonta* sp. (Figs 8D–G) as denticulation has been observed along the hinge line of this sparse material. Fine, almost linear features between the primary costellae (as in Figs 8E–G) are caused by parallel clay particles. Only further material can establish the relationships of this form to *P. brownae*.

iii. Two further parvicostellate specimens have a relatively large number of primary costellae (NMV 146101–2, Figs 8A–C) for their valve size. They are here assigned tentatively to *P. brownae*, as they exhibit about 15 costellae at a width of 4.8 mm (NMV 146101)

and ca 12 costellae at width of 4.7 mm (NMV 146102).

Comparisons. Other comparable Australian forms include: “*Plectodonta* n.sp.” of Talent (1965), which lacks the parvicostellate sculpture of *P. brownae* n.sp.; and *P. bipartita* from the Late Silurian of the Melbourne district (Talent, 1965). Both *P. bipartita* and *P. davidi* lack the accessory septa which characterise the brachial valve of *P. brownae*. *Sowerbyella? plebia* Talent, 1965 from Heathcote, Victoria (assigned by Cocks & Rong to *Plectodonta*) appears to lack both a denticulate hingeline and the characteristic brachial septa. Both Philip (1962) and Savage (1974) figured specimens with a prominent marginal zone, showing prominent papillae and impression of sculpture, lacking in *P. brownae*, on the interior of valves of *Plectodonta bipartita*.

Mitchell (1923) described a number of new species of small plectambonitaceans from the Yass district of New South Wales, including *Stropheodonta davidi*, *Stropheodonta minuta*, *Stropheodonta tarloensis* and *Stropheodonta striato-costata*. Savage (1974) considered the first and last of these taxa to be synonyms of *P. bipartita*; material examined (AMF 27218, 28745, 28748) is parvicostellate (with 22–25 primary costellae) and has a gently sulcate brachial valve. The status and, indeed, the original location and stratigraphic horizons of Mitchell’s other species is somewhat obscure. *Stropheodonta tarloensis* Mitchell does not appear to be a plectodontid. *Stropheodonta minuta* Mitchell is coarsely ribbed, and quite unlike *pannucea*. *Stropheodonta davidi* Mitchell appears to develop a bema in large specimens; this feature would exclude it from *Plectodonta*. Mitchell’s (1923: 472, pl. 42, fig. 31) figured pedicle valve of *Stropheodonta striatopunctata* was described as having very numerous radials including fine striae, “numerous fine punctures on the very mildly convex valve, with a short slit-like septum”; this form is indeterminate.

Another similar species assigned to *Plectodonta* by Cocks & Rong (1989) is *P. sanglangensis* Xian (in Xian & Jiang, 1978: Eifelian; Guizhou province, China). This tiny species (about 4.5 mm wide and 2.5 mm long; Xian, 1978, pl. 97, figs 2,3) exhibits 7 primary costellae and lacks the small posterior septa characteristic of *P. brownae*, as do other species of *Plectodonta* listed by Cocks & Rong (1989).

Plectodonta sp.

Figs 8D–G

Material. AMF 99585, 99588, 99590; NMV 146099.

Remarks. The listed specimens lack secondary costellae, have a small dimple-like protegular node on the subsequently concave brachial valve, and appear to lack the extra short, irregular brachial septa outside the normal two. As preservation is excellent, the lack of secondary costellae does not seem to result from adverse preservation; otherwise they are indistinguishable from *P. brownae*. This material is referred to *Plectodonta* as it shows a denticulate hinge line and paired brachial septa.

Family Ellipsostrophiidae Havlicek, 1967

Bracteoleptaena Havlicek, 1963

Type species. *Strophomena bracteola* Barrande, 1879, from the Wenlock Liten Formation, Borek near Suchomasty, Czech Republic; by original designation.

Remarks. Our species is clearly very close to the type species of *Bracteoleptaena* which, when erected, included the type species; subsequently, *Platymena polonica* Temple, 1965 was assigned to the genus by Temple (1968) and Cocks (1978). The latter species was chosen as type species of *Paromalomena* Rong. According to Chang (1981) this genus was established in 1979; however, Dr L. R. M. Cocks (pers. comm.) has kindly informed me that the name appeared in Rong (1979) only in a faunal list and a caption to an illustration and was, therefore, a *nomen nudum*. The genus was eventually formalised by Rong (1984).

Bracteoleptaena pannucea n.sp.

Figs 9A–K

Material. HOLOTYPE AMF 99603 a–b; PARATYPES AMF 92269, 99604–99612, 99631–3, ?99613.

Derivation of name. *Pannuceus* (L.), meaning wrinkled.

Diagnosis. *Bracteoleptaena* with plano-convex, non-sulcate shell, costellae poorly developed to lacking posterolaterally; weak dorsally-directed trail on mature pedicle valves. Dental lamellae short, sockets small and widely spaced; papillae in brachial valve restricted to outer part of adductor field.

Description. Shell very gently plano-convex with no sulcus, tongue or apophragm; elongate to transverse semi-oval in outline, with short alae. Both valves with an initial convex portion, but almost flat thereafter; mature pedicle valve weakly flexed dorsally at margins. Brachial interarea steeply hypercline, pedicle interarea steeply apsacline; both interareas flat and low. Width up to 15 mm, length about 8 mm. Radial sculpture ranges from absent, to weak, low costellae (posterolateral regions smooth); well-defined prottegular node, growth lines and weak rugae on both valves.

Brachial interior with slender socket ridges at less than 45° to the hingeline, and an elongate adductor field consisting of two elevated, elongate-oval scars divided by a slender medial furrow over most of length and a shallow depression posteriorly. Cardinalia crudely bilobed. Papillae on outer parts of adductor field, but sparse outside that region.

Pedicle valve dominated by the deeply conical, anteriorly-shallowing muscle field which reaches to about 1/3 of valve length; narrow, well-developed, slightly raised, elongate-oval central adductor field reaches to about anterior end of muscle field; larger diductor scars, showing prominent growth lines, are mostly located on flanks of muscle pit and bounded

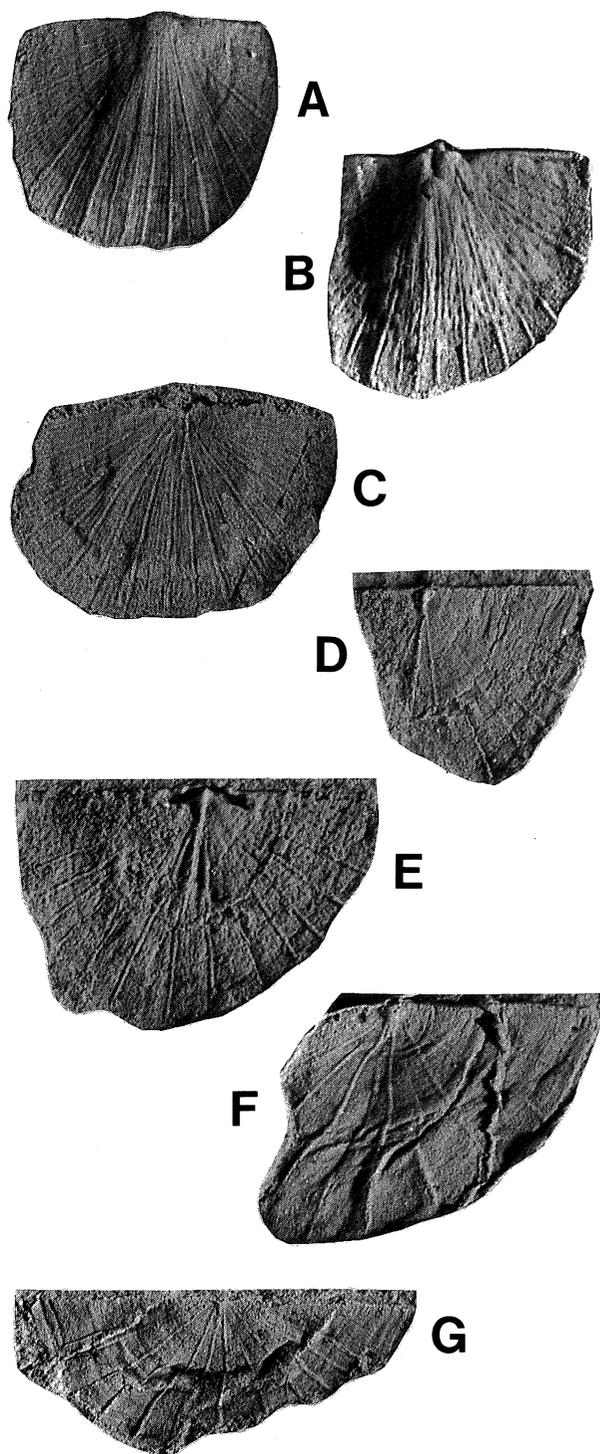


Fig. 8. A–C, *Plectodonta brownae*? A–B, NMV 146101, pedicle internal mould and latex cast of external surface, both $\times 10$; C, NMV 146102, latex cast of pedicle valve, $\times 10$. D–G, *Plectodonta* sp. D–E, AMF 99585, latex cast of external surface of brachial valve, and brachial internal mould, both $\times 10$; F, latex cast of external surface of pedicle valve, AMF 99590, $\times 10$; G, latex cast of external surface of pedicle valve, NMV 146099, $\times 8$.

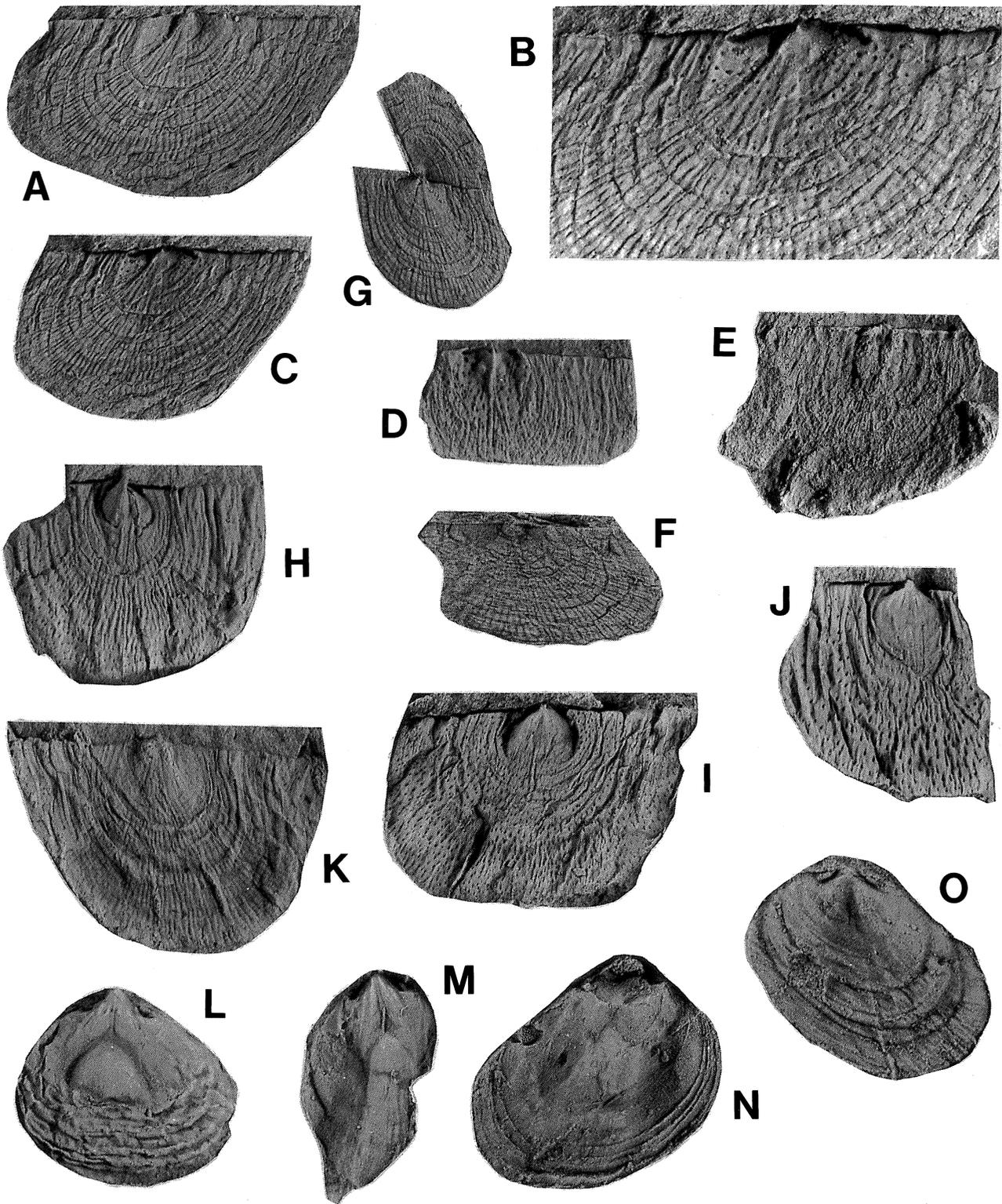


Fig. 9. A–K, *Bracteoleptaena pannucea* n.sp. A–C, AMF 99603, holotype brachial valve; **A**, internal mould $\times 5$; **B**, posteromedial portion of **A**, showing sockets and weak, papillate muscle-bounding ridges, $\times 10$; **C**, latex cast of external surface, $\times 5$; D–J, paratypes: **D**, AMF 99607, brachial internal mould demonstrating elevated adductor muscle scars, and bounding furrows, $\times 6$; **E**, AMF 99605, latex cast of brachial internal showing socket plates and elevated muscle scars, $\times 5$; **F**, AMF 99604, external cast of brachial valve, $\times 6$; **G**, AMF 99632, external cast of displaced pair of valves, $\times 5$; **H**, AMF 99606, pedicle internal mould, $\times 5$; **I**, AMF 99608, pedicle internal mould, $\times 4$; **J**, AMF 99629, pedicle internal mould, $\times 6$; **K**, AMF 99631, latex cast of pedicle exterior, $\times 5$. L–O, *Lissatrypa?* sp. L–N, pedicle internal moulds, all $\times 6$; **L**, AMF 99596, **M**, AMF 99599, **N**, AMF 99598; **O**, AMF 99600, brachial internal mould, possibly of this species, $\times 6$.

laterally by low ridges which curve medially at anterior end of lobate scars. Short dental lamellae diverge at 45° to hingeline. Open delthyrium encloses apical angle of about 90°, possible foramen.

Remarks. This species assigned to the Ellipsostrophiidae rather than the Leptaenidae as it lacks the characteristic apophragm (Kelly, 1967) of the latter family. Much of our material seems to have undergone soft-sediment compaction, suggesting a thin, fragile shell which fractured due to sediment loading.

Previously described representatives of the genus are from Europe (Ashgill-Wenlock: Cocks, 1978) and China (Fu, 1975; Fu, 1982; Chang, 1981).

Comparisons. *Platymena polonica*, assigned by Temple (1968) and Cocks (1978) to *Bracteoleptaena*, has long, thin dental plates set at a higher angle to the hingeline than our material; this species has also been recorded from Dabashan Mountain, in the Yangtze Gorge region, China (Fu, 1975: 113) and Hubei (Chang 1981). Fu (1982: 123, pl. 35, figs 23,24) referred this species to *Paromalomena* Rong, 1984, in descriptions of faunas from northwest China. Chang (1981: 562) described *P. polonica* (pl. 1, fig. 29) and *P. hubeiensis* Chang (pl. 1, figs 34–36) from the Ashgill *Hirnantia* fauna of Hubei Province.

Bracteoleptaena pannucea differs from *B. bracteola* (Barrande, 1879) in lacking an anterior trail, in having less well-developed rugae, and having better developed muscle-bounding ridges in the pedicle valve. The less well known *B. degenera* Havlicek, 1967 is distinguished from *B. pannucea* by its prominent trail and partly parvicostellate sculpture.

Order Spiriferida Waagen, 1883

Superfamily Atrypacea Gill, 1871

Family Lissatrypidae Twenhofel, 1914

Lissatrypa Twenhofel, 1914

Type species. *Lissatrypa atheroidea* Twenhofel, 1914, from the Llandovery of Anticosti Island; by original designation.

?*Lissatrypa* sp.

Figs 9L–O

Material. AMF 99596–99 (pedicle valves), AMF 99600–1 (brachial valves).

Remarks. Pedicle valves in our collections display the characteristics of this vexatious genus (see Strusz, 1982). Important Australian species ascribed to this genus include *Lissatrypa tyro* (Öpik, 1953) and *L. lenticulata* Philip, 1962. The only reasonably preserved brachial valve in the collections may not be conspecific with the pedicle valves, as it has a dorsal sulcus and more “atrypid” cardinalia (Fig. 9M). *Lissatrypa lenticulata* differs from *L. tyro* in having a stronger “shoe-lifter” process in the pedicle valve, and a more massive hinge plate; both species have a sulcate pedicle valve.

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