Silicified shallow-water ostracodes from the Early Carboniferous of South China

EWA OLEMPSKA

Olempska, E. 1999. Silicified shallow-water ostracodes from the Early Carboniferous of South China. — *Acta Palaeontologica Polonica* **44**, 4, 383–436.

Well preserved silicified ostracodes have been found in a presumably allochthonous detrital limestone lens within argillaceous limestones of the Muhua Formation of the Muhua section in Guizhou Province, South China. Some 32 species have been identified and assigned to 24 genera. *Houhongfeiella microspinosa* gen. et sp. n., *Gortanella ruggierii* sp. n., *Coryellina grammi* sp. n., *Coryellina advenoides* sp. n., *Guerichiella coeni* sp. n., *Knightina jiqiangi* sp. n., *Hypotetragona*? *sinica* sp. n., *Cavellina robinsoni* sp. n., *Cavellina guizhouensis* sp. n., *Sulcella jonesi* sp. n., *Bairdia cheni* sp. n., and *Bairdiacypris wangi* sp. n. are proposed. Similarity at the generic level exists between ostracode faunas of the Early Carboniferous formations of China, Australia, Europe, Asia and North America. Unlike the ostracodes from the underlying nodular limestones of the Wangyou Formation that represent the basinal 'Thuringian ecotype' fauna, the ostracode assemblage of the studied interval belongs to the 'Eifelian ecotype' and is indicative of a well-oxygenated, normal salinity, high-energy shallow-water environment. The term calcified internal rim is proposed for the internal structure developed along the free margin in some palaeocopid ostracodes. It differs from the calcified inner lamella of podocopids mainly in the lack of marginal pore canals, lack of vestibulae and lack of clear separation from the outer lamella.

Key words: Ostracoda, taxonomy, morphology, palaeoecology, Early Carboniferous, South China.

Ewa Olempska [olempska@twarda.pan.pl], Instytut Paleobiologii PAN, ul. Twarda 51/55, PL-00-818 Warszawa, Poland.

Introduction

Late Devonian–Early Carboniferous marine sedimentary rocks are widely exposed in South China and were systematically studied by Chinese palaeontologists well over half a century ago. One of the most interesting localities where fossils are still poorly known is the section near Muhua village. Since the recommendation of the Muhua section as one of the final candidates for the stratotype of the Devonian–Carboniferous boundary (Ziegler & Sandberg 1984), several papers have dealt with the stratigraphy and/or palaeontology of this section (Wang & Yin 1984; Hou *et al.* 1984, 1985; Ziegler

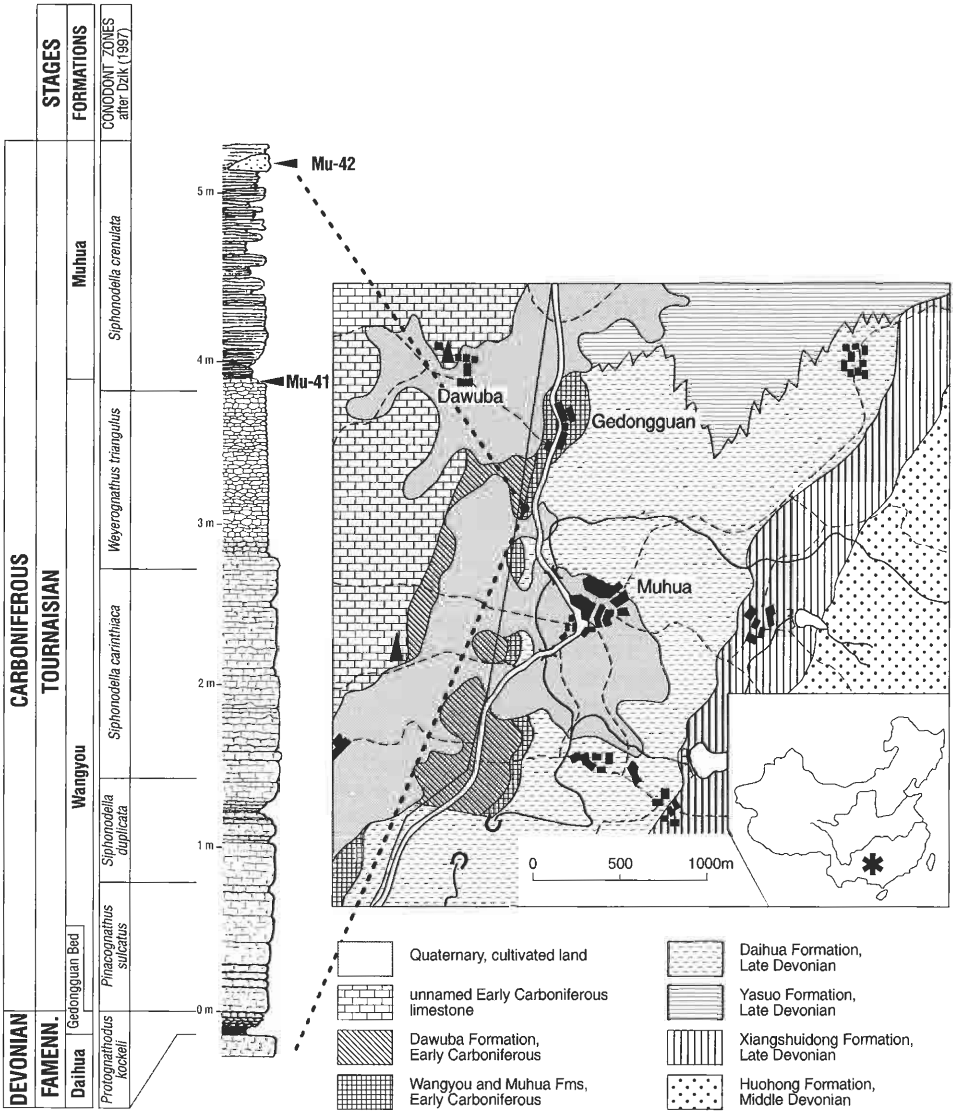


Fig. 1. Muhua section with conodont zonation (Dzik 1997) and location of the studied area and samples.

et al. 1988; Ji & Chen 1987; Ji *et al.* 1989; Dzik 1997). The Muhua section is situated close to the Muhua village (lat. 25°46'0"N, long. 106°23'0"E) in the south part of the Guizhou province, 50 km south of Huishui, the main town of this area (Fig. 1). The ostracodes described herein come from a detrital limestone lens (sample Mu-42; Fig. 1) within argillaceous limestone of the Muhua Formation from this section.

Discovery of abundant, well-preserved, silicified ostracode carapaces and dissociated valves in insoluble residue of the Mu-42 sample provided an opportunity to gain some new insights into the nature and significance of these fossils in the Muhua section, to complete the faunal list, to revise some previous works, and to examine the geographic distributions of the various species. These collections have made it possible to make known the ostracode fauna of this unit for the first time. The collection described herein was submitted to me by Jerzy Dzik (Institute of Paleobiology, Warsaw), who sampled the Muhua section in 1994 during his expedition to China (see Dzik 1997).

Associated with the ostracodes in insoluble acid residues are various fossils including agglutinated foraminifers, sponges, brachiopods, trilobites, echinoids, conodonts, and fish scales and teeth (see Baliński 1999).

If not indicated otherwise, the figured specimens are from the late Tournaisian Muhua Formation, Muhua section, Guizhou Province, South China. The material studied is reposited in the Institute of Paleobiology PAN, Warsaw (abbreviated ZPAL).

Geologic and stratigraphic setting

Upper Devonian limestones of the Daihua Formation occur at the base of the Muhua section (Fig. 1) and are overlain by the Wangyou Formation with the Gedongguan bed in the lowermost part. The Gedongguan bed consists of grey lenticular limestones and yellow grey marlstones. The Devonian–Carboniferous boundary is located at the top of this interval. Probably there is a slight sedimentary break between the Daihua Formation and the Gedongguan bed (Hou *et al.* 1985). The rest of the Wangyou Formation is composed mainly of a grey thin- to medium-bedded and nodular limestone with *Gattendorfia* ammonoid fauna. The overlying Muhua Formation consists of a sequence of argillaceous limestones (Hou *et al.* 1985; Dzik 1997). Conodonts from the Wangyou and Muhua Formations were studied by Hou *et al.* (1985) and Dzik (1997). The overlying Dawuba Formation (old name 'Yanguan Formation') is a series of black shales, silty shales intercalated with silstone, cherts and rare phosphatic nodules in the lower part, and medium- to thin-bedded dense marls with calcareous and siliceous shales in the upper part. It varies from 130 to 230 m in thickness. The basal shale of the Dawuba Formation yielded a spore assemblage, which may be correlated with the CM spore zone (*Schopfites claviger–Auroraspora macra* Zone) of the late Tournaisian (Hou *et al.* 1985).

The described ostracode assemblage is from a detrital limestone lens (sample Mu-42) in the upper part of the Muhua Formation. Conodonts occur rarely in sample Mu-42, and the most abundant is *Pseudopolygnathus primus* Branson & Mehl, 1934. One specimen of *Mestognathus* sp., probably representing a new species, is also present (Baliński 1999). The appearance of *Mestognathus,* according to von Bitter *et al.* (1986), has generally been thought to coincide with, and define, the base of the Viséan. The conodonts and ostracodes suggest a late Tournaisian age for the upper part of the Muhua Formation.

Previous work

During the past twenty years, knowledge of the Late Devonian–Early Carboniferous ostracode fauna from South China has increased greatly. The Late Devonian (Frasnian) ostracodes from Hunan province were described by Zhang (1995), and those from the Frasnian/Famennian transition beds in Hunan by Casier *et al.* (1997). Coen (1989) studied ostracodes of the Devonian–Carboniferous transition beds from the section at Baihupo (Dushan, Guizhou). Recently, Coen (1996) described ostracodes from coeval beds of central Hunan and Wang (1988a) from Nanbiancun, Guilin. The Early Carboniferous ostracodes from Hunan were studied by Zhang (1985), and the Early Carboniferous ostracodes of the 'Thuringian ecotype' from the Wangyou Formation in Nandan of Guangxi were described by Wang (1988b). The Early Carboniferous kirkbyids and bairdiids from Guilin, Guangxi, were reported by Becker & Wang (1992). Wang (1988c) discussed the paleoecological significance of Late Palaeozoic ostracode associations from South China.

There is only one report on Carboniferous ostracodes from the Muhua section (Ji & Chen 1987). These authors identified five ostracode species belonging to the *Bairdia–Rectonaria* biofacies from the Muhua Formation (Lower *Siphonodella crenulata* Zone). Two new genera from the Muhua Formation were described by Olempska (1998a, b).

Material and methods

The ostracode fauna from sample Mu-42 is both abundant and well preserved. More than 1800 carapaces and 2500 valves were collected. Ostracode shells are fully replaced by silica. The interiors of closed carapaces are infilled by calcite. Specimens have been thin sectioned in order to evaluate the nature of their valve margin. The ostracode assemblage is rich in juvenile specimens as well as species with small and large adult shells. Specimens of *Bairdia* and paraparchitaceans, represented by large specimens (exceeding 3 mm in length) are usually crushed. Despite silicification some details of the shell structure can be studied in thin sections and on polished sections with a scanning electron microscope. For study of free margin structure under the SEM, specimens from Muhua were embedded in plastic resin, sectioned, polished, and subsequently etched with 4% HCl for about four seconds before coating.

Palaeoecological remarks

In the upper part of the nodular limestone Wangyou Formation (sample Mu-41), silicified ostracodes of the 'Thuringian ecotype' and poorly preserved pyritized moulds of entomozoaceans were found (Fig. 1). Thuringian-type ostracodes inhabited low-energy environments and rather deep, calm, cold and oxygen deficient biotopes (Olempska 1997). The benthic assemblage from sample Mu-41 contains species of *Rectonaria* Gründel, 1961, *Aurigerites* Roundy, 1926, *Rectoplacera* Blumenstengel, 1965, *Acratia* Delo, 1930, *Ampuloides* Polenova, 1952, *Praepilatina* Polenova, 1970, *Bairdia* McCoy, 1844, and *Amphissites* Girty, 1910. It is similar to the fauna described from the Early Carboniferous of Muhua by Ji & Chen (1987). Entomozoaceans are represented by *Maternella* (*Zagoroundella*) cf. *schindewolfi* (Kummerow, 1939), *Maternella* sp., and *Franklinella* sp. A description of the 'Thuringian-ecotype' assemblage is beyond the scope of this study.

Rocks of the Wangyou and Muhua Formations represent quiet water environments with a predominance of planktonic or nektonic fauna (Hou *et al.* 1985). According to Ji & Chen (1987), the presence of *Bairdia* and ostracodes of 'Thuringian ecotype' suggest slope or basin margin environments for the Muhua Formation.

The ostracode assemblage from sample Mu-42 clearly represents the 'Eifelian ecotype' of Becker (in Bandel & Becker 1975). This ecotype is characteristic of high-energy palaeoenvironments. The ostracode assemblage from the studied interval is similar in generic composition to marine near-shore to shallow off-shore ostracode assemblages described by Bless (1983) from the Late Devonian–Early Carboniferous of Europe.

The ostracode assemblage is characterised by the joint occurrence of the smooth-shelled podocopids *Bairdia* McCoy, 1844, *Bairdiacypris* Bradfield, 1935, *Acratia* Delo, 1930, large paraparchitaceans (*Shivaella* Sohn, 1971, *Shishaella* Sohn, 1971), abundant cavellinids (*Cavellina* Coryell, 1928, *Sulcella* Coryell & Sample, 1932, *Houhongfeiella* gen. n., *Muhuaella* Olempska, 1998) as well as the primitiopsids *Coryellina* Bradfield, 1935 and *Guerichiella* Adamczak, 1968. Several other ostracode species belonging to *Malnina* Jones, 1989, *Amphissites* Girty, 1910, *Kirkbya* Jones, 1895, *Knightina* Kellett, 1933, *Hollinella* Coryell, 1928, *Gortanella* Ruggieri, 1966, *Libumella* Rozhdestvenskaja, 1959, and *Editella* Olempska, 1998 (see Olempska 1998b), occasionally occur.

The most important components of this assemblage are primitiopsaceans (two *Coryellina* and one *Guerichiella* species) that account 40% of the relative abundance. Cavellinids (*Cavellina, Houhongfeiella, Sulcella,* and *Muhuaella* species) constitute 28% of all specimens. Bairdiidids, represented by five species of *Bairdia,* one of *Bairdiacypris,* and one of *Acratia,* constitute 10% of the specimens. Palaeocopids (beyrichiaceans, hollinaceans, kirkbyaceans) and paraparchitaceans constitute almost 20% of the assemblage.

Studies on both Recent and Carboniferous species of *Bairdia* (Kornicker 1961; Kaesler 1982) indicate that they are most abundant in stable shallow offshore environments of normal marine salinity. Acratiidae and Bairdiidae occur also in deeper, low-energy environments. Kirkbyaceans seem to have lived in all environments (near-shore to deep-sea). Large, smooth-shelled paraparchitaceans (*Shivaella*) are typical of very shallow to shallow euryhaline environments and were probably crawlers (Melnyk & Maddocks 1988). During the Devonian and Carboniferous, paraparchitaceans occurred with bairdiaceans, presumably under normal marine conditions (Crasquin-Soleau 1997; Sohn & Sando 1987). *Hollinella* was a marine, nectobentonic representative of shallow- to very-shallow water marine faunas (Melnyk & Maddocks 1988). *Malnina* was a nearshore taxon according to Jones (1989). Members of the Cavellinidae were adapted to relatively nearshore as well as offshore environments (Melnik & Maddocks 1988).

The diversity and abundance of the ostracode fauna, the presence of bairdiids, the presence of highly ornamented forms (*Amphissites, Kirkbya, Malnina*), and large smooth-shelled paraparchitaceans all suggest a normal-salinity, shallow-marine environment. The Muhua fauna as a whole (trilobites, echinoderms, brachiopods, corals and bryozoans) is indicative of normal marine salinity and confirms a marine shelf environment. According to von Bitter *et al.* (1986), species of the conodont *Mestognathus* are characteristic of Carboniferous near-shore environments and were apparently restricted in their palaeogeographic occurrence to a narrow equatorial belt lying between 40°S and 25°N.

The Muhua shallow water ostracode assemblage from sample Mu-42 is a mix of two ostracode associations recognised by Wang (1988c) in the Late Palaeozoic of South China: a 'palaeocopid association' with predominance of palaeocopids and cavellinids and a 'smooth-podocopid association' with dominance of bairdiaceans, common kirkbyaceans and paraparchitaceans, usually with carapaces larger than 1 mm. The ostracodes of the 'palaeocopid association' occupied shallow-water, near-shore (inner shelf) environments and 'smooth-podocopid accociations' might have mainly inhabited shallow water but off-shore (outer shelf) regions (Wang 1988c).

In summary, the Wangyou and Muhua Formations represent a quiet water environment with a predominance of planktonic or nektonic fauna (Hou *et al.* 1985). Sample Mu-42 yielded shallow-water ostracodes. The skeletal debris of the limestone lens was probably transported down slope into a deeper-water, basin-slope environment. The presence of very well preserved small specimens with fine surface morphology suggests that they were not transported far from their original deposition site.

Palaeobiogeographical remarks

The Yangtze Block, according to the best data available, was located near Australia during most of the Palaeozoic. Rifting must have begun by the Middle Devonian, but it was not until the Late Triassic/Early Jurassic Indosinian orogeny that South China eventually joined Asia (Scotese & McKerrow 1990). Another scheme associates South China, North China and Tarim, Kolyma, and Borneo in the hypothetical Pacifica continent (Zhang 1984; Streel 1986).

Most of the studied ostracode taxa are referred to cosmopolitan genera found in nearly all the major Early Carboniferous provinces. Some genera have a more restricted distribution. For example, *Malnina* is unique to South China and Australia (northern Gondwana), where shallow-water palaeocopid ostracodes have been investigated (Jones 1989). Analysis of the geographic distribution of taxa occurring in the Muhua Formation shows that there is little affinity (only two species in common) between Muhua and the Early Carboniferous ostracodes of Kolyma and Omolon (Buschmina 1975; Buschmina *et al.* 1986). The investigations of Coen (1996) on ostracodes from the Devonian–Carboniferous boundary in Hunan also did not confirm similarities between these two areas. Coen (1996) suggested the general Euramerican affinities of the South Chinese ostracode fauna. These interpretations conflict with Conil *et al.* (1988), who postulated a strong similarity of the foraminifer and stromatoporoid faunas of South China, Kolyma, and Omolon.

Crasquin-Soleau & Lethiers (1993) showed that dispersion of Early Carboniferous species could be controlled by palaeocurrents. Specimens may have been swept on rafts of floating algae along east-west and west-east currents.

Internal morphology of the free margin of ostracode valves

The structure of the internal morphology of the free margin and development of the outer and inner lamella were discussed by Zalanyi (1929), Sylvester-Bradley (1941), Kesling (1951), Harding (1965), Hartmann (1966), Kornicker (1969), Benson (1975), Oertli (1975), Okada (1982), Keyser (1990), and Adamczak & Becker (1991), among others.

The structure and position on the free margin of valves indicate that the calcified part of the inner lamella strengthens the carapace and seals up the domicilium (Benson 1975; Adamczak & Becker 1991). According to Hartmann (1966) the marginal calcification of the inner lamella improved the stability of the valves and enabled the production of marginal pore canals, which provided the free margins with sense organs.

The presence of a calcified inner lamella (duplicature) is generally assumed to be a character peculiar only to Podocopina, and, as a rule, it occurs in its advanced representatives (Scott 1961b). However, Swain (1962) noted the presence of well-developed, calcified inner lamellae in the Ordovician species *Platyrhomboides virginiensis* Kraft, 1962 and *Acanthoscapha champlainensis* Swain, 1962. Also, Schallreuter (1968a, b) and Knüpfer (1968b) expressed the opinion that the duplicature was present in some

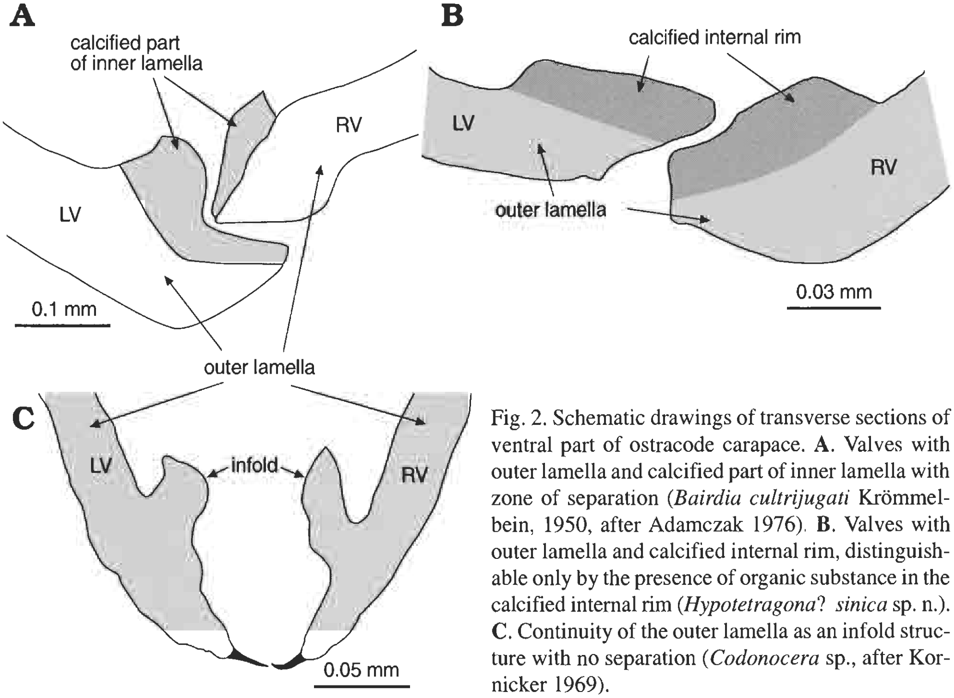


Fig. 2. Schematic drawings of transverse sections of ventral part of ostracode carapace. **A**. Valves with outer lamella and calcified part of inner lamella with zone of separation (*Bairdia cultrijugati* Krömmelbein, 1950, after Adamczak 1976). **B**. Valves with outer lamella and calcified internal rim, distinguishable only by the presence of organic substance in the calcified internal rim (*Hypotetragona*? *sinica* sp. n.). **C**. Continuity of the outer lamella as an infold structure with no separation (*Codonocera* sp., after Kornicker 1969).

Ordovician Podocopina. Adamczak & Becker (1991) claimed that the pre-Devonian Podocopina lack a duplicature, which appeared for the first time simultaneously in different families during the Early or Middle Devonian (e.g., in Pachydomellidae and Bairdiocyprididae).

From the early 1960s, the presence of a narrow internal calcified structure ('calcified inner lamella' according to many authors) of nearly equal width, without vestibulae and marginal pore canals, was noted in many Palaeozoic taxa traditionally assigned to Palaeocopida (Sohn 1961a, 1969, 1971, 1972; Adamczak 1961; Pollard 1966; Knüpfer 1968a; Gramm 1976, 1984a, b, c, 1988, 1991; Schallreuter 1968a; Kozur 1993).

I propose the term calcified internal rim for an internal structure developed along the free margin that is equal in width, and closely linked to the outer lamella. The structure is often recognisable in thin sections by its brownish colour owing to organic substances. This structure occurs in some Palaeocopida and was often referred to previously as a calcified inner lamella (Gramm 1984a, b; 1988, 1991; Sohn 1961a, 1983, 1988). Calcified internal rim differs from calcified inner lamella (which is characteristic only for members of Podocopina), in lacking a clear zone of separation, lack of vestibulae and absence of marginal pore canals (Fig. 2).

From the Muhua section the calcified internal rim was observed in some representatives of Primitiopsacea Swartz, 1936, Knoxitacea Egorov, 1950, and doubtfully in Paraparchitacea Scott, 1959. In all of these cases the structure is recognisable in single valves and broken carapaces in SEM photomicrographs and also by its brownish colour (owing to organic substance) in thin sections in transmitted light.

Gramm's (1988) descriptive terms (homogenous free margin, epibolic free margin, isoplatic inner lamella, mesoplatic inner lamella) applied to various types of internal

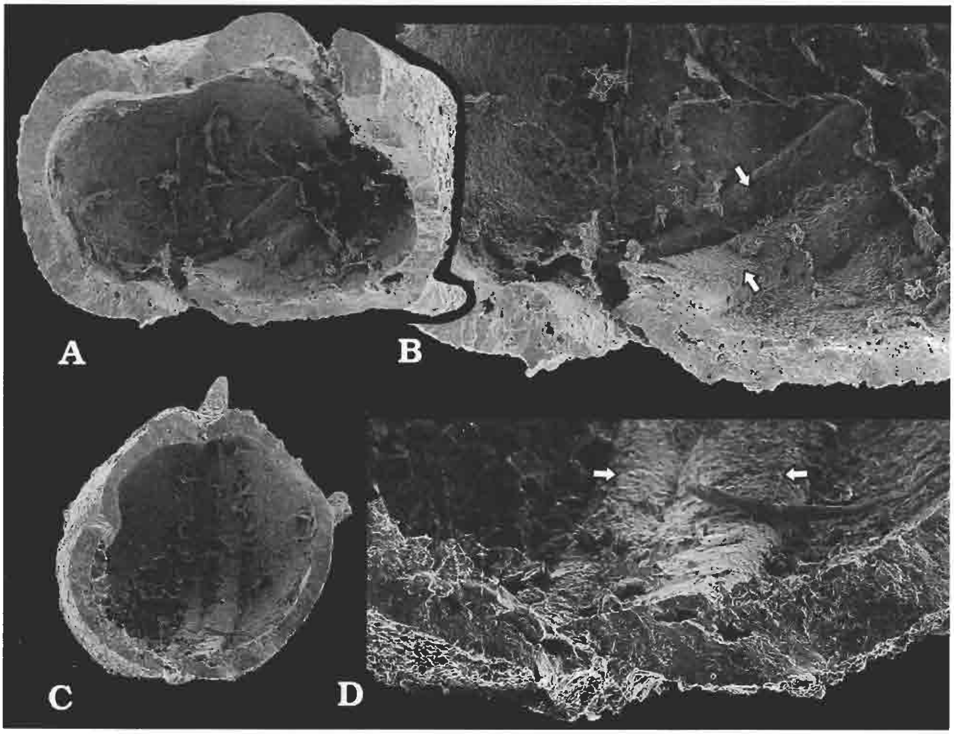


Fig. 3. **A**, **B**. *Coryellina advenoides* sp. n., ZPAL O.XLV/147. **A**. Internal view of broken specimen. **B**. Detail of ventral margin, calcified internal rim in ventral and posterior part of the carapace indicated by arrows. **C**, **D**. *Coryellina grammi* sp. n., ZPAL O.XLV/136. **C**. Internal view of broken specimen. **D**. Detail of ventral margin, calcified internal rim in ventral and posterior part of the carapace indicated by arrows. **A**, × 90; **B**, × 180; **C**, × 60; **D**, × 240.

free margin structures are not accepted here, because the differences between them are not clear.

Calcified internal rim in the Primitiopsacea (Figs 3, 4, 5, 6, 11J, 12H, I). — Although representatives of Primitiopsacea lack calcified inner lamella, Gramm (1984a, b; 1988) suggested that a duplicature with inner lamella equal in width is present in *Coryellina* Bradfield, 1935 and *Selebratina* Polenova, 1953. In thin sections in reflected light this structure was distinguished from the outer lamella by its darker colour (Gramm 1984a).

More than 1000 separate valves and broken carapaces of two *Coryellina* species (*C. advenoides* sp. n., *C. grammi* sp. n.) from Muhua exhibit a well-developed, calcified internal rim (Figs 3, 11, 12) very similar to that described by Gramm (1984a, b). However, in transverse sections the discontinuity between the outer lamella and calcified internal rim is expressed only in a brownish coloration of the rim (Figs 4, 5). A honey-brown layer (its colour probably derived from contained organic substances) is visible on the free margin and in the hinge area. The calcified internal rim played an important role for closing the valves, because a contact groove is impressed in the internal rim of the larger right valve (Fig. 4). In *C. advenoides* the internal rim varies slightly in width from 60–70 µm in right valves and 55–65 µm in left valves. In *C. grammi* it is slightly

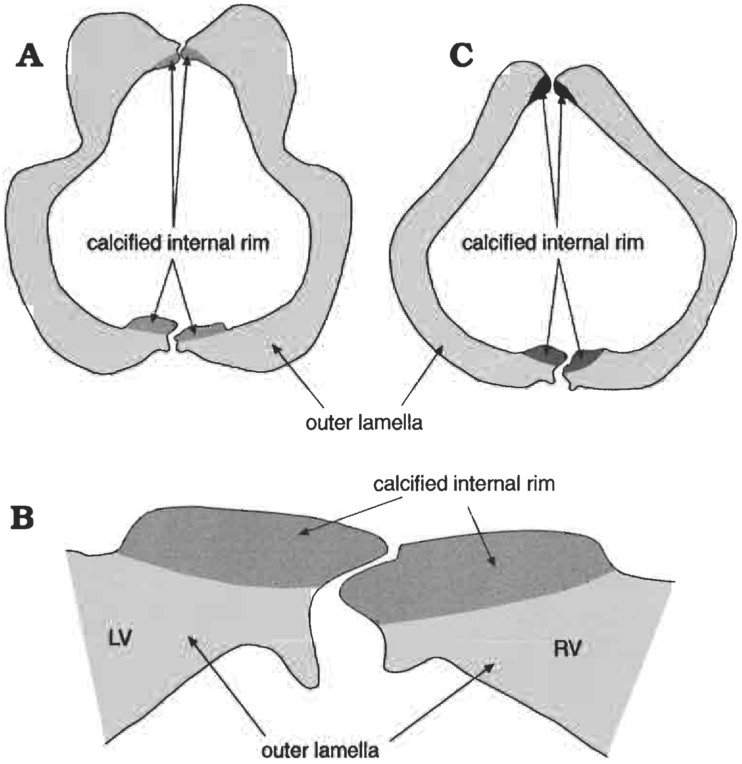


Fig. 4. **A**, **B**. *Coryellina advenoides* sp. n. **A**. Schematic drawing of transverse section of the carapace. **B**. Detail of ventral margin of the same specimen. **C**. *Coryellina grammi* sp. n., schematic drawing of transverse section of the carapace. Not to scale.

narrower (55 to 65 µm, measured in the middle part of the ventral margin and is of nearly equal width) in adult specimens. The thickness of the internal rim in *C. grammi* is about 27–30 µm. The thickness of the outer lamella, measured in mid-height of the valve, is about 60–65 µm. No marginal pore canals have been found.

For comparison, several specimens of *Coryellina sanctacrucensis* Olempska, 1979 and *Selebratina* sp. from the Late Devonian and Early Carboniferous of the Holy Cross Mountains, Poland (see Olempska 1979) were sectioned. The specimens are slightly silicified and were macerated in Na_2SO_4. In thin sections examined in transmitted light, the construction of the free margin appears to be similar to that in Chinese *Coryellina* species. However, the arrangements of crystallites is not visible – only a clear zone of discontinuity separates the two layers (Fig. 6).

Calcified internal rim in the Knoxitidae (= Geisinidae) (Figs 2B, 7, 8, 15H, I, M, N). — The presence of a narrow 'calcified inner lamella' of even width along free margins in *Geisina* Johnson, 1936 was noted (not illustrated) for the first time by Sohn (1961a). Pollard (1966) described the presence of a wide, thickened rim in *Geisina arcuata* (Bean, 1836), which runs internally around the contact margin of both valves. In the thickened rim of the right valve there is a ridge and groove to accommodate the overlapped edge of the left valve. This rim, according to Pollard (1966), may represent remains of the duplicature.

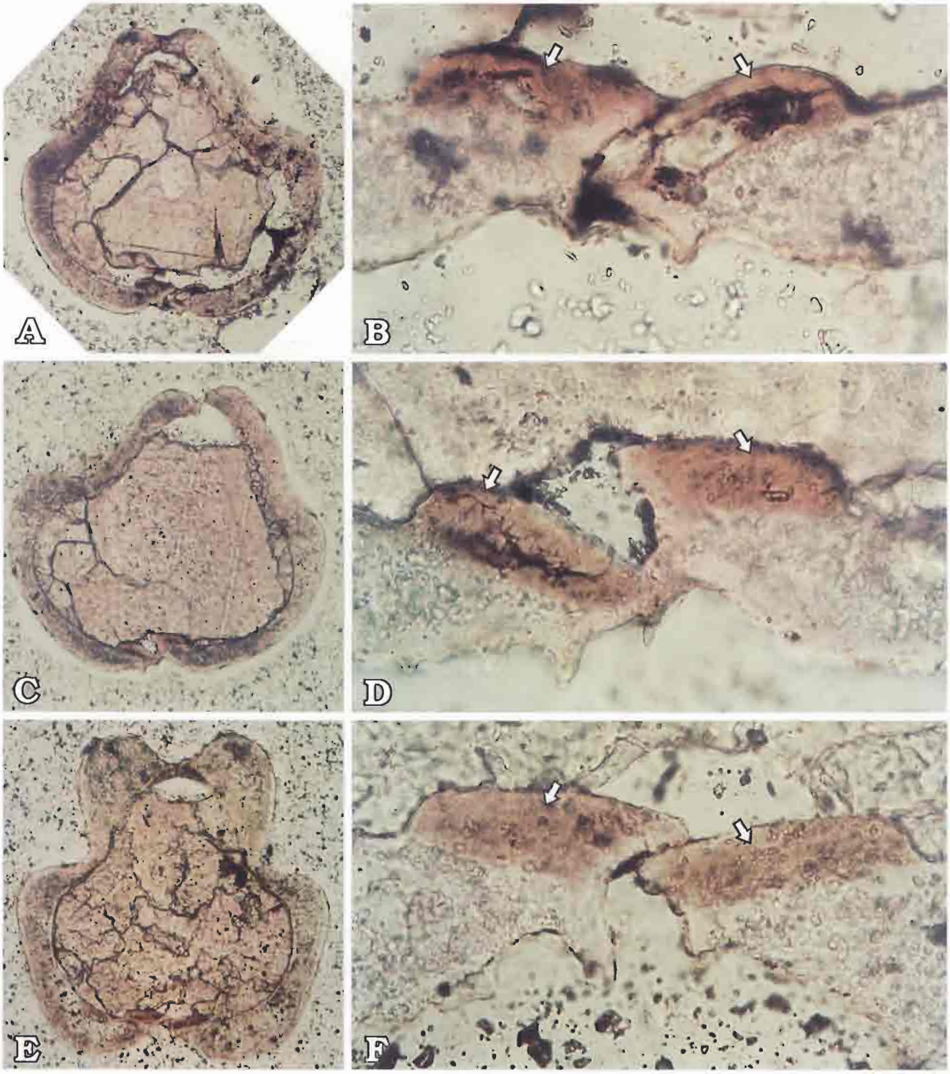


Fig. 5. Thin sections. **A–D**. *Coryellina grammi* sp. n. **A**, **C**. Transverse section of the carapaces. **B**, **D**. Details of ventral margin of A and C respectively. Right valves on the right (**A**, **B**, ZPAL O.XLV/137; **C**, **D**, ZPAL O.XLV/138). **E**, **F**. *Coryellina advenoides* sp. n. **E**. Transverse section of the carapace. **F**. Detail of ventral margin; ZPAL O.XLV/148. The calcified internal rim indicated by arrows. **A**, **C**, **E**, × 70; **B**, **D**, **F**, × 350.

Adamczak (1961) also described 'calcified inner lamella' in *Knoxiella accepta* Polenova, 1952 and Kozur (1990) illustrated a 'calcified inner lamella' of equal width in *Italogeisina transita* Kozur, 1990 from the Permian of Hungary. A similar structure is also visible in *Hypotetragona* sp. illustrated by Fohrer (1991: pl. 10: 6). Knüpfer (1968a) also observed an 'inner lamella' in some representatives of Knoxitidae and Glyptopleuridae Girty, 1910.

A calcified internal rim is present in more than 250 valves and broken carapaces of two *Hypotetragona* species [*H.*? *sinica* sp. n., *H.*? *angulata* (Posner, 1951)] examined from the Muhua section (Figs 7, 15). When this structure has been observed under the SEM, it is represented by a layer of nearly equal width, but slightly wider in posteroventral part (Fig. 7). In *H.*? *sinica* it is 97–105 μm wide in the middle of the ventral margin of the left valve and 115–125 μm wide in the posteroventral part. In the right valve, where the contact groove is impressed in the internal rim, it is 100–120 μm wide. In thin sections through the carapaces this brown-coloured layer (Fig. 8) is almost the same thickness as the outer lamella. Marginal pore canals are not visible in transmitted light.

Contact structures in the Paraparchitacea (Fig 16). — The presence of a narrow 'calcified inner lamella' of approximately the same width around the free margin was shown by Sohn (1971, 1972, 1983), Sohn & Sando (1987), Gramm & Ivanov (1975), and Gramm (1984a) in several genera of Paraparchitacea.

Williams & Vannier (1995) claimed that the presence of a calcified inner lamella in the Paraparchitacea, is not visible in sections or single valves figured by Sohn (1971, 1972). Two representatives of Paraparchitacea, *Shivaella armstrongiana* (Jones & Kirkby, 1886) and *Shishaella* sp., from the Muhua section are preserved mostly as separate valves with clearly visible free margin contact structures (Fig. 16). These structures consist of a distinct list (125–180 μm in width) in the right valve and a terminating ridge in the left valve. They are relatively narrow with respect to the size of the valves (over 3 mm).

Calcified inner lamella in the Bairdiacea (Figs 26–29). — This superfamily is characterised by a strongly calcified inner lamella, commonly with vestibules. In the Palaeozoic representatives of this superfamily a distinct calcified inner lamella was illustrated in the Middle Devonian *Bairdia cultrijugati* Krömmelbein, 1950 by Adamczak (1976) and Adamczak & Becker (1991). An inner lamella in Carboniferous species of *Bairdia* was illustrated by Gramm (1984a) and in Permian ones by Sohn (1954).

A calcified inner lamella that is wide at both ends, slightly narrower ventrally, and with well-marked vestibulae in anterior and posterior ends may be observed in *Bairdia* species and *Bairdiacypris wangi* sp. n. from Muhua. The sinusoidal contact groove (= contact depression of Adamczak 1976) impressed in the inner lamella of the larger left valves is clearly visible in *B. cestriensis* Ulrich, 1891, *B. cheni* sp. n., and *B.* sp. The contact groove in *Bairdiacypris wangi* is weakly developed only in the middle part of the inner lamella of the left valve. The inner lamella may be slightly darker in some specimens when compared with the remaining part of the shell.

Calcified inner lamella in the Cytheracea (Fig. 24). — A calcified inner lamella was discovered in poorly preserved specimens of the Early Carboniferous ostracode *Editia germanica* by Knüpfer (1967). Gramm & Egorov (1986) recognised the presence of a duplicature with narrow vestibulae at both ends in three species of *Editia* Brayer, 1952 and one species of *Adeditia* Gramm & Egorov, 1986 from the Viséan of the Novgorod region. In *Proeditia cristata* Buschmina, 1979 from the Late Devonian of the Kolyma Basin, Buschmina (1979) noted (but did not illustrate) a duplicature of equal width throughout the length from the anterior to posterior cardinal corners.

Specimens of *Editella dawubaensis* Olempska, 1998 (see Olempska 1998b), from the Muhua section clearly possess a calcified inner lamella that is wide at the anterior and slightly narrower at the posterior end (Olempska 1998b, and this paper Fig. 24). A vestibulum is present at the anterior end, whereas at the posterior it is poorly visible. In the calcified inner lamella of the larger left valve there is an impressed, crenulated contact groove that is narrow along the posterior and ventral margins and wider at the anterior end. Marginal pore canals are not visible.

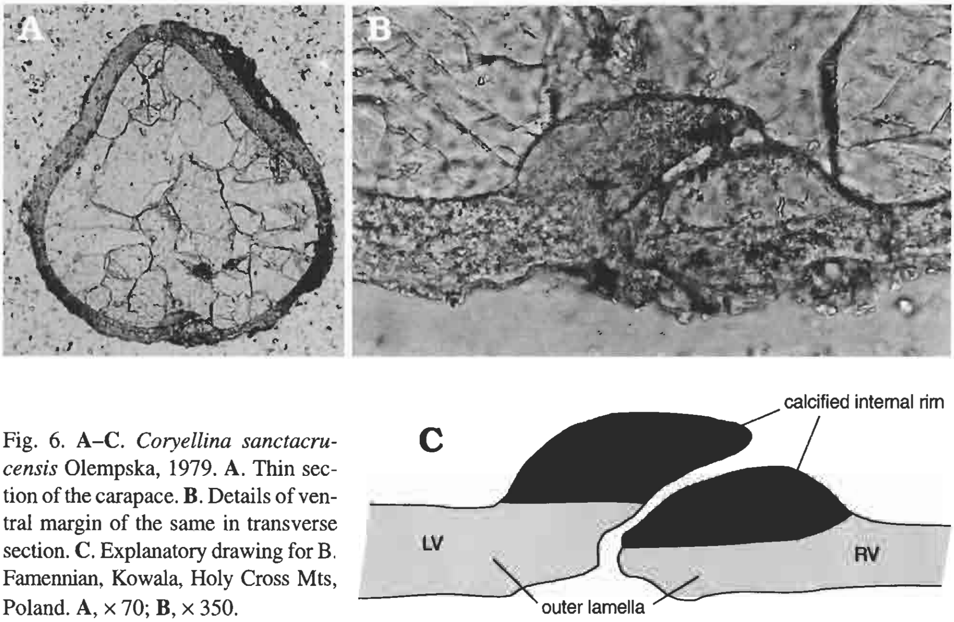


Fig. 6. **A–C**. *Coryellina sanctacrucensis* Olempska, 1979. **A**. Thin section of the carapace. **B**. Details of ventral margin of the same in transverse section. **C**. Explanatory drawing for B. Famennian, Kowala, Holy Cross Mts, Poland. **A**, × 70; **B**, × 350.

Discussion. — Okada (1982) demonstrated in Recent Podocopida that both the outer and inner lamellae consist of two layers of cuticle (epicuticle and procuticle) linked with a single layer of epidermal cells. If the procuticle of the inner lamella is not calcified (or very slightly calcified), it has no chance to be preserved in fossils.

The presence of a duplicature in the sense of Moore (1961) as a part of the inner lamella is accepted by many authors (Kesling 1951; Scott 1961a; Oertli 1975; Sohn, 1970; Adamczak & Becker 1991). According to Scott (1961a), the duplicature is attached to the outer lamella by an adhesive strip of chitin; the proximal line of contact is referred to as the line of concrescence. According to Adamczak (1976) and Adamczak & Becker (1991), the inner lamella, as seen in the Devonian species of *Bairdia*, produced a doubling of the distal portion of the free margin of the ostracode valve (Fig. 2A). This means that the epithelium (covering the animal body) was, at the valve edge, deflected inwardly and calcified, forming a solid structure (Adamczak & Becker 1991).

In most of the fossil Podocopina the calcified portion of the inner lamella stands out very clearly in thin sections. Where it is thick and highly calcified the inner lamella is recognisable by its structure and different crystallisation. The crystallites of the calcareous inner lamella join at more or less acute angles in the so-called zone of fusion (Oertli 1975; Adamczak 1976; Adamczak & Becker 1991).

Harding (1965) stated that there is no fusion between the inner and outer lamellae in Recent ostracodes, and the cuticle forms one continuous sheet, soft in some places and hard in others, according to the functional needs. According to him, the idea of complete separation of the two laminae by a zone of concrescence is erroneous. The dark line, often visible between two lamellae, may be a radial pore canal, or it may be a boundary between cuticle hardened in different ways – perhaps by calcification on one side and by sclerotisation on the other (Harding 1965). Kornicker's (1969) investiga-

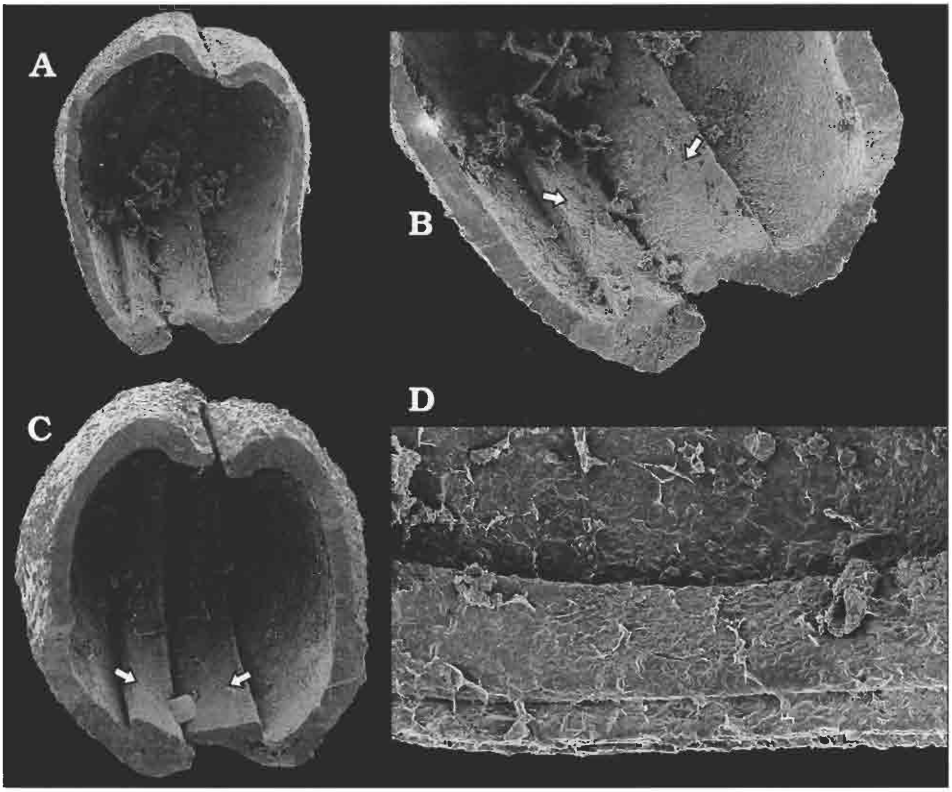


Fig. 7. **A–D**. *Hypotetragona*? *sinica* sp. n. **A**, **B**. Internal view of broken specimen, calcified internal rim in ventral and posterior end of the carapace indicated by arrows; ZPAL O.XLV/174. **C**. Internal view of broken specimen, calcified internal rim indicated by arrows, posterior part of carapace; ZPAL O.XLV/175. **D**. Details of the calcified internal rim in RV; ZPAL O.XLV/172. **A**, × 56; **B**, × 126; **C**, × 84; **D**, × 210.

tions of the free margin in Recent Myodocopida gave strong support to Harding's idea. Kornicker (1969) introduced the term infold to denote the continuous structure of the free margin and defined it as a part of the shell and not part of the 'inner lamella' (Fig. 2C). According to Benson (1975) the concept of the continuity of the outer lamella as an infold with no separation is more likely and confirmed by scanning electron microscopy of broken sections in this region.

Authors disagree as to whether the internal calcified marginal structure present in some genera of the Palaeocopida represents a calcified part of the inner lamella. Adamczak & Becker (1991) were of the opinion that the structures of the free margin in carapaces of *Coryellina* cannot be interpreted as a duplicature. They instead interpreted the thickenings of the free margin as being comparable to the infold structure described by Kornicker (1969). Gramm (1988: pl. 3: 10, 12) published SEM-micrographs of etched sections of *Coryellina advena* and noted the differences in structure between the fine-grained outer lamella and the bubble-like 'calcified inner lamella'. According to him, differences in the structure provided evidence for the presence of an inner lamella in *Coryellina* and *Selebratina*. An EDAX analysis of etched sections of *Coryellina grammi* and *C. advenoides* from Muhua indicates differences similar to those noted by

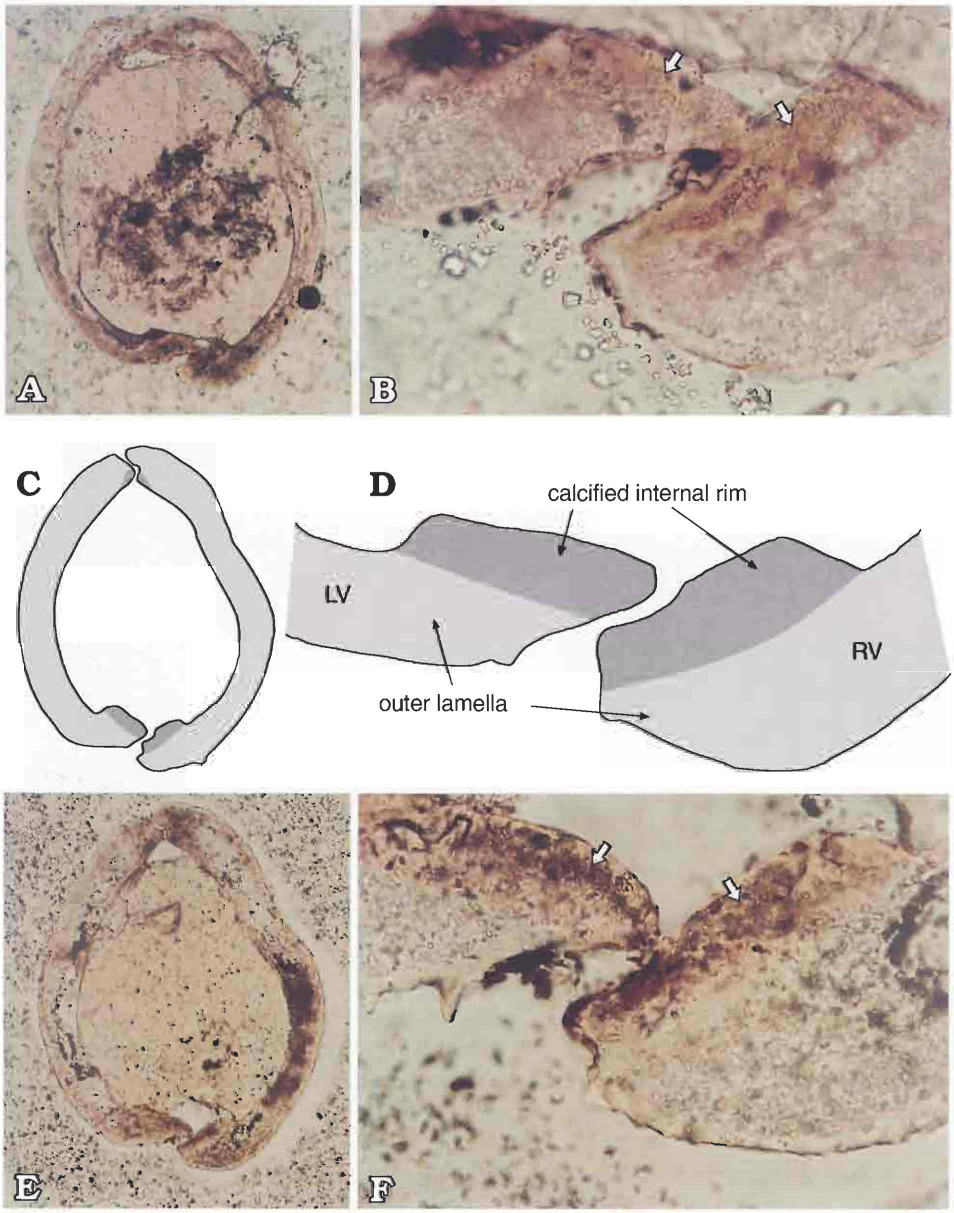


Fig. 8. **A**–**F**. *Hypotetragona*? *sinica* sp. n. **A**. Thin section of the carapace in transverse section. **B**. Details of ventral margin. **C**, **D**. Explanatory drawings for A and B. **E**. Thin section of the carapace in transverse section. **F**. Details of ventral margin. Calcified internal rim indicated by arrows. **A**–**D**, ZPAL O.XLV/176; **E**, **F**, ZPAL O.XLV/177. **A**, **E**, × 70; **B**, **F**, × 350.

Gramm in the structure of the outer lamella and calcified internal rim. They apparently resulted from the presence of organic substance in the internal rim. This does not mean that a zone of fusion similar to that as in Podocopina is present.

Although the described calcified internal rim appears to be structure distinctly different from the calcified part of the inner lamella, the lack of sufficiently well-preserved existing material (mostly silicified) does not allow us to demonstrate with certainty that it does not represent part of the inner lamella.

Taxonomical consequences. — The classification of groups with a calcified internal rim is debated. Henningsmoen (1953: p. 188) defined Palaeocopida as ostracodes with 'apparently no calcareous inner lamella', and Scott (1961b) in the diagnosis of the order Palaeocopida noted 'calcareous inner lamella absent'.

However, there has been a tendency to erect separate suprageneric taxa for ostracodes with a 'calcified inner lamella' (Sohn 1969, 1983, 1988; Gramm 1984a, 1988, 1991). Gramm (1984a), followed by Sohn (1988), erected the new suborder Parapodocopina for some straight-backed Ordovician to Permian ostracodes that have a 'calcified inner lamella', but did not state to what higher taxon this new suborder should belong.

According to Sohn (1971, 1983) and Gramm (in Gramm & Ivanov 1975), Paraparchitacea should be placed within Podocopida. Whatley *et al.* (1993) placed Paraparchitacea within the order Leiocopa and this opinion is followed here.

Although the importance of the calcified internal rim both in phylogeny and systematics should not be ignored, its classificatory value as the main diagnostic feature is not clear.

The calcified internal rim is actually specific only to some genera or lineages. Its taxonomic value is less important than the type of dimorphism, hinge structure, or adductorial muscle field, and its use is more restricted in this paper.

Systematic palaeontology

The following abbreviations are used in the descriptions: C, carapace; S1, anterior sulcus; L1, anterior lobe; S2, adductorial sulcus; L2, median lobe; L3, posterior lobe; RV, right valve; LV, left valve.

Class Ostracoda Latreille, 1802

Order Palaeocopida Henningsmoen, 1953

Superfamily Beyrichiacea Matthew, 1886

Beyrichiacea *incertae familiae*

Genus *Malnina* Jones, 1989

Type species: *Malnina spinosa* Jones,1989.

Malnina sp.

Fig. 9A–D.

Material. — Three right valves, partly damaged.

Description. — Lateral outline preplete. Dorsal margin straight; ventral margin gently curved. Greatest length at about mid-height of valve; greatest height in anterior part. Anterior and posterior margins rounded. Acroidal spine distinct, at anterodorsal cardinal corner. L3 low, with long conical spine. L2 small, poorly developed. S2 very shallow. Crumina in anteroventral part. Adductorial muscle field smooth. Free margin with small spines. Surface granulose.

Remarks. — *Malnina* sp. from the Muhua section represents a second species of *Malnina*. It differs from *Malnina spinosa* Jones, 1989, from the latest Tournaisian–early Viséan of the Bonaparte Basin, Australia (Jones 1989) in having a granulose surface, a thinner and longer posterodorsal spine, and a shallow adductorial sulcus.

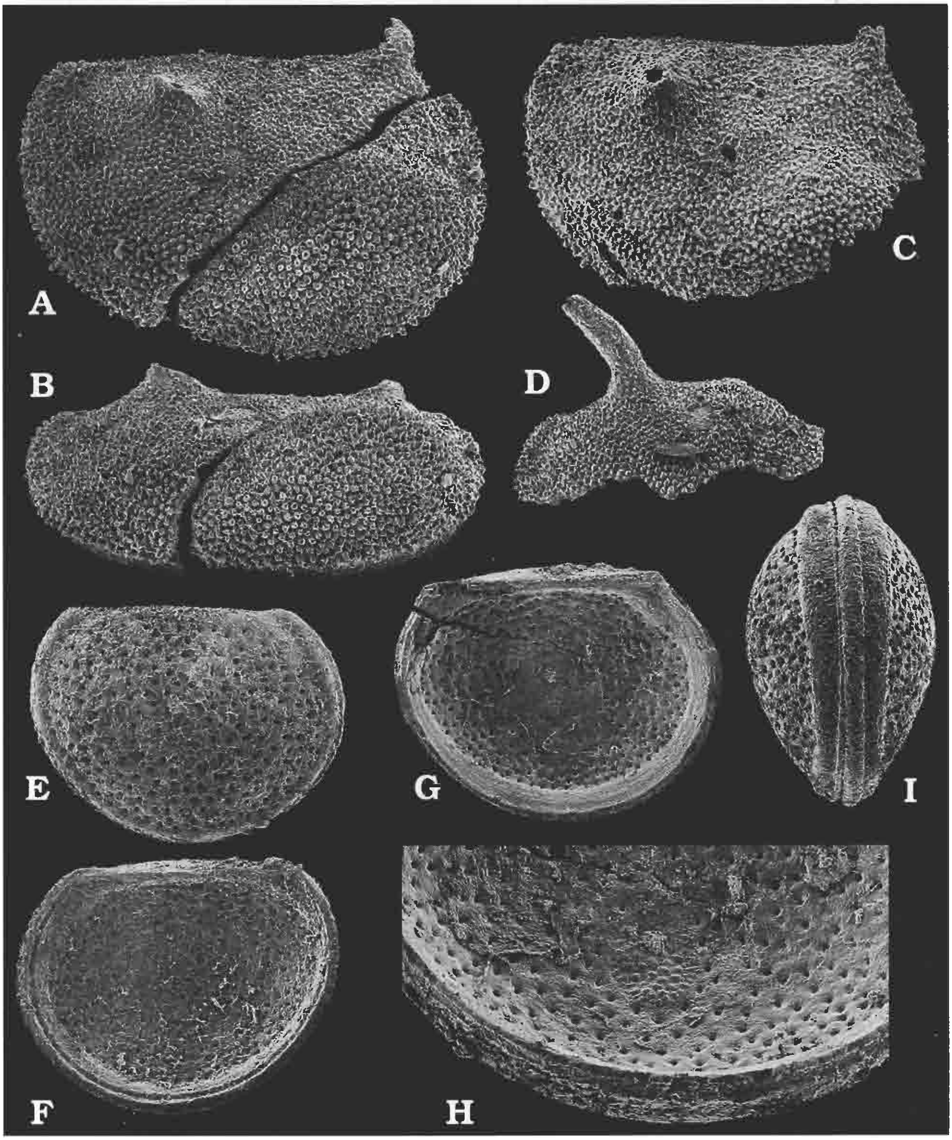


Fig. 9. **A–D**. *Malnina* sp. **A**, **B**. RV in lateral and oblique views; ZPAL O.XLV/113. **C**. RV in lateral view; ZPAL O.XLV/114. **D**. RV, damaged in lateral view; ZPAL O.XLV/115. **E–H**. *Libumella bonapartensis* Jones, 1989. **E**. Carapace in left lateral view; ZPAL O.XLV/116. **F**. RV in lateral internal view; ZPAL O.XLV/117. **G**. LV in lateral internal view. **H**. Same specimen with details of adductor muscle scar; ZPAL O.XLV/118. **I**. Carapace in ventral view; ZPAL O.XLV/119. All × 48 except for **H** which is × 96.

Superfamily Hollinacea Swartz, 1936
Family Hollinellidae Bless & Jordan, 1971
Genus *Hollinella* Coryell, 1928 emend. Kellett 1929

Type species: *Hollinella dentata* Coryell, 1928.

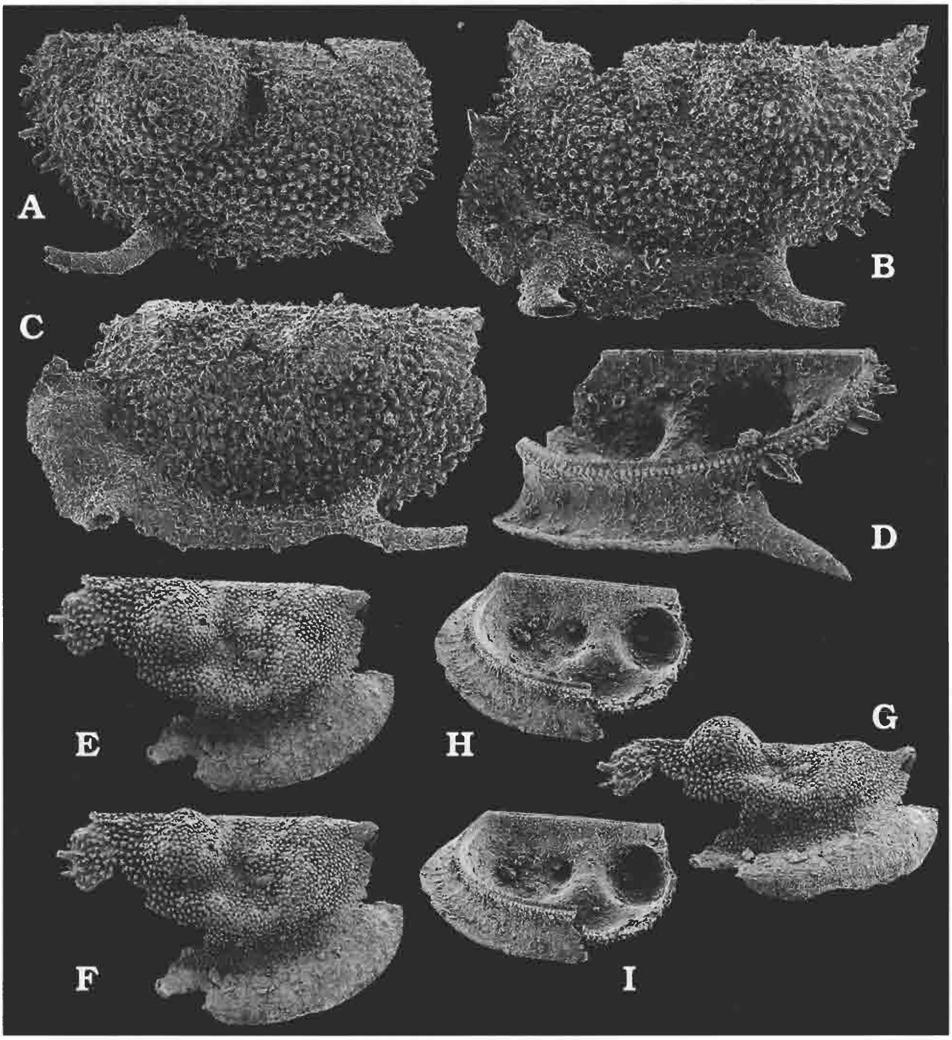


Fig. 10. **A–D**. *Gortanella ruggierii* sp. n. **A**. RV in lateral view; ZPAL O.XLV/120. **B**. Holotype, LV in lateral view; ZPAL O.XLV/121. **C**. LV in lateral view; ZPAL O.XLV/122. **D**. RV, damaged in internal view; ZPAL O.XLV/123. All × 48. **E–I**. *Hollinella* sp. **E**, **F**. Stereo-pair of heteromorphic RV in lateral view. **G**. Same specimen in oblique view; ZPAL O.XLV/124. **H**, **I**. Stereo-pair of tecnomorphic RV in oblique internal view; ZPAL O.XLV/125. All × 24.

Hollinella sp.

Fig. 10E–I.

Material. — 17 valves, all partly damaged.

Description. — Lateral outline subrectangular. L3 large and bulbous, rising to or slightly above hinge line. L2 a small node, separated from L3 by moderately deep S2. S2 reaches mid-height of carapace. L1 low, confluent with ventral lobe; ventral lobe distinct, extending from L3 to L1, subparallel to ventral margin. Velum developed as broad incurved frill in females, and slightly narrower, not incurved, frill in males. Velum runs from anterodorsal corner to posteroventral part of free margin, ending abruptly with spur. One or more rows of spines present along posterior margin. Marginal structure as row of small tubercles. Surface granulose.

Remarks. — Specimens from the Muhua section are not assigned to any of the subgenera because there are no juvenile forms and the material is too poorly preserved to be described in detail. The adventral structure in Muhua specimens is similar to that of *Hollinella (Hollinella) ulrichi* (Knight, 1928) from the Late Carboniferous of Carnic Alps (Fohrer 1991).

Genus *Gortanella* Ruggieri, 1966

Type species: *Gortanella regina* Ruggieri, 1966.

Gortanella ruggierii sp. n.

Fig. 10A–D.
Holotype: ZPAL O. XLV/121 (Fig. 10B).
Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.
Type locality: Muhua, Guizhou province, South China.
Derivation of the name: In honour of Guiliano Ruggieri, the author of the genus.

Diagnosis. — *Gortanella ruggierii* differs from other species of this genus in having L2 as small node and a large and bulbous L3. It differs from *G. regina* Ruggieri, 1966 in having a more elongate carapace, larger L3, papillose surface, and shorter ventral spines. From *G. rumjancevae* Kotchetova, 1992 it differs in lacking a ventral lobe.

Material. — 27 valves, some of them damaged.

Description. — Lateral outline preplete. L2 small, poorly developed; L3 large and bulbous, rising abruptly from surface shell. S2 is short, not very deep. Juvenile forms with two long curved spines, in anteroventral and in posteroventral region, both curving posteriorly. Adult and pre-adult carapaces with adventral structure as wide frill, extending from mid-height of the anterior margin and terminating in posteroventral end with long spine. Anteroventral spine also present. Small spine at anterodorsal part of frill. Acroidal spines in anterior and posterior cardinal corners. Marginal structure occurs as row of tubercles. Surface papillose.

Remarks. — *Gortanella ruggierii* sp. n. is the oldest recorded species of *Gortanella. G. regina* is known from the Late Carboniferous of the Eastern Alps (Ruggieri 1966) and Late Carboniferous of the Carnic Alps (Fohrer 1991), and *G. rumjancevae* is known from the Early/Middle Carboniferous of Central Tien Shan (Kulagina *et al.* 1992).

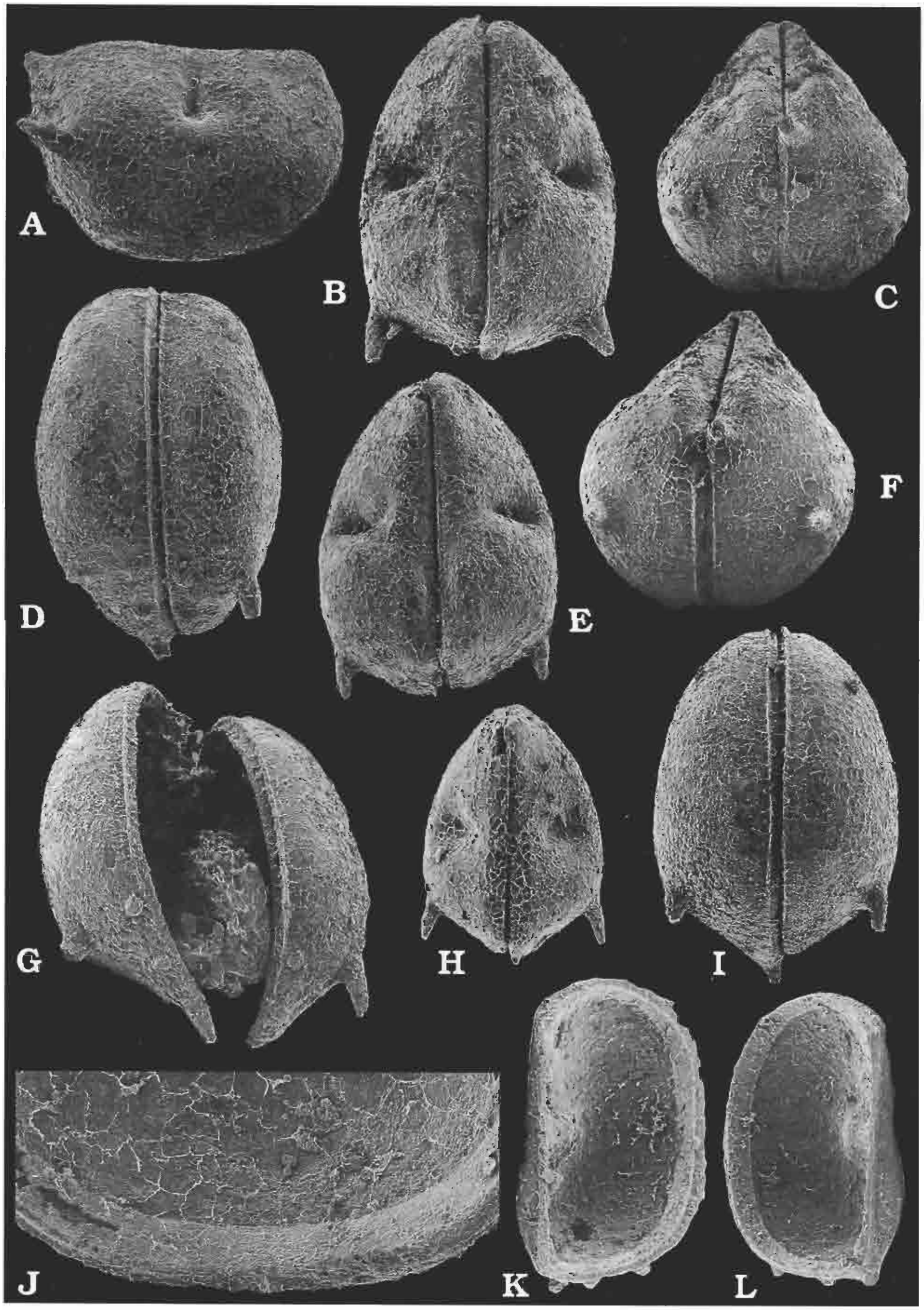
Superfamily Primitiopsacea Swartz, 1936

Remarks. — See Adamczak (1968), Melnikova (1979), Polenova (1982), Adamczak & Becker (1983), and Wang (1979, 1982) for discussion of the scope of the superfamily. The perimarginal structure (in the form of ridge or tubercles) appears in heteromorphs and is unique for primitiopsids. The sexual character of this structure was proposed by Sohn (1962) in *Coryellina* Bradfield, 1935. Its function is only speculative. According to Adamczak & Coen (1992), it may have served as an organ of luminescence for 'species recognition'. Perimarginal structures in heteromorphs appear in the Ordovician genus *Leiocyamus* Martinsson, 1956 and survived until the Permian genus *Coryellina* Bradfield, 1935.

The recognition by Coen (1985) and Adamczak & Coen (1992) of a triple-tuberculate perimarginal structure in *Kielcella ardunnensis* Adamczak & Coen, 1992 and presence of a perimarginal structure in the form of a ridge in the closely related *Kielcella dorsi* Adamczak, 1968, indicates that the form of the perimarginal structure is variable within a genus and is not generically or supragenerically fixed. The recognition of a triplete-tuberculate perimarginal structure in *Guerichiella coeni* sp. n. (Fig. 13) confirms the observations of Adamczak & Coen (1992). All known species of *Guerichiella*

→

Fig. 11. **A–L.** *Coryellina grammi* sp. n. **A.** Holotype, heteromorphic RV in lateral view; ZPAL O.XLV/126. **B, C.** Heteromorphic carapace in dorsal and posterior views; ZPAL O.XLV/127. **D.** Heteromorphic carapace in ventral view; ZPAL O.XLV/128. **E, F.** Tecnomorphic carapace in dorsal and posterior views; ZPAL



O XLV/129. **G**. Heteromorphic half-open carapace in ventral view; ZPAL O.XLV/130. **H**. Juvenile carapace in dorsal view; ZPAL O.XLV/131. **I**. Tecnomorphic carapace in ventral view; ZPAL O.XLV/132. **J**. Internal view of ventral margin showing details of internal rim; ZPAL O.XLV/133. **K**. LV in oblique internal view; ZPAL O.XLV/134. **L**. RV in oblique internal view; ZPAL O.XLV/135. All × 60 except for **J** which is × 120.

have a perimarginal structure in the form of a ridge. In *G. coeni* sp. n. it is visible as a transitional stage of the perimarginal structure from marginal ridge to tubercles.

Family Primitiopsidae Swartz, 1936

Genus *Coryellina* Bradfield, 1935

Type species: *Coryellina capax* Bradfield, 1935.

Remarks. — The genus has a wide geographic distribution, being recorded from North America, Western and Eastern Europe, Asia, China, and Australia, in the Devonian, Carboniferous and Permian. The perimarginal structure in *Coryellina* is in the form of three, or rarely two, distinct tubercles usually present along the posterior margin of heteromorphic valves.

Coryellina grammi sp. n.

Figs 3C, D; 4C; 5A–D; 11.

Holotype: ZPAL O. XLV/126 (Fig. 11A).

Type horizon : Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou province, South China.

Derivation of the name: In memory of the late Dr. Mendel Gramm.

Diagnosis. — Differs from most known species of *Coryellina* by the presence of two perimarginal tubercles. From *C. advenoides* sp. n. it is distinguished by an elongate S2, and lack of posterodorsal hump. It is similar in outline to *C. ventricornis* (Jones & Kirkby, 1886) occurring in the Viséan of Great Britain, but differs in having two perimarginal tubercles. *C. grammi* is also similar in outline to *Coryellina obesa* Wei, 1983 (Lower Carboniferous of Sichuan Province, China), but the perimarginal structure has not been described in that species.

Material. — 160 carapaces and almost 1000 valves.

Description. — Lateral outline subrhomboidal. Dorsal margin straight, hinge line channelled in posterior half. Free margin gently rounded. Valves nearly equal, RV slightly larger. Carapace strongly inflated in ventral part. S2 narrow, deep, not extending to mid-height, shallowing toward dorsal margin. Small acroidal spine developed in posterocardinal corner of RV. Small process, present at anterior cardinal angle of RV, fits into corresponding socket in LV. Admarginal spines present in posterior part, at mid-height. Heteromorphs with two perimarginal tubercles near posterior margin on each valve. Free margin with single marginal ridge. Hinge of RV composed of indistinct median groove, anterior and posterior teeth, and anterior and posterior furcal sockets. LV hinge structure is composed of median list, anterior and posterior sockets, and anterior and posterior tooth-like projections, which are terminations of internal rim. Tecnomorphic valves are distinguished by lack of perimarginal tubercles. Calcified internal rim of equal width, reaching from anterior to posterior cardinal corners.

Coryellina advenoides sp. n.

Figs 3A, B; 4A, B; 5E, F; 12.

Holotype: ZPAL O. XLV/139 (Fig. 12A).

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou province, South China.

Derivation of the name: For its resemblance to *Coryellina advena* Schneider & Tkatscheva, 1972.

Diagnosis. — *C. advenoides* sp. n. is very similar to *C. advena* Schneider & Tkatscheva, 1972 in the development of adductorial pit and in strongly inflated posterodorsal part of carapace, but differs from the latter in having two perimarginal tubercles in heteromorphs and the lack of a small ridge around the adductorial pit. *C. advenoides* differs from *C. grammi* sp. n. by its more inflated carapace, an oval S2 and hump in posterodorsal part of carapace, and more deeply depressed valve contact line.

Material. — 35 carapaces and more than 300 valves of heteromorphs and tecnomorphs.

Description. — Carapace preplete in lateral view; strongly inflated and of relatively small size (up to 0.7 mm long). Valves nearly equal, RV slightly larger. Hinge-line straight and long, strongly depressed in posterior half. Valve contact line strongly depressed ventrally. Hump in posterodorsal area. Large,

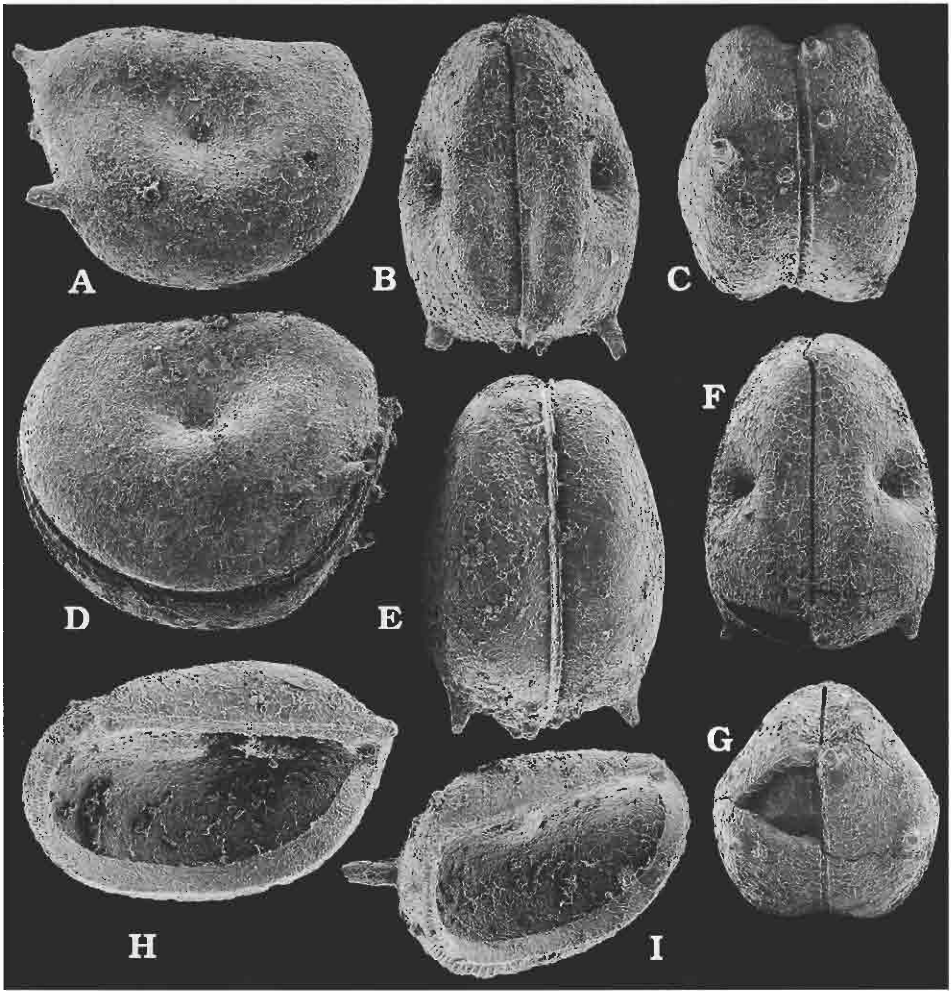


Fig. 12. **A–I.** *Coryellina advenoides* sp. n. **A**. Holotype, heteromorphic carapace in right lateral view; ZPAL O.XLV/139. **B**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/140. **C**. Heteromorphic carapace in posterior view; ZPAL O.XLV/141. **D**. Heteromorphic carapace in left lateral view; ZPAL O.XLV/142. **E**. Heteromorphic carapace in ventral view; ZPAL O.XLV/143. **F**, **G**. Tecnomorphic carapace in dorsal and posterior views; ZPAL O.XLV/144. **H**. RV in oblique internal view; ZPAL O.XLV/145. **I**. LV in oblique internal view; ZPAL O.XLV/146. All × 60.

oval adductorial pit occurs as deep depression slightly above mid-height. A small process at anterior cardinal angle of RV fits into a corresponding socket in LV. Acroidal spine developed in posterocardinal corner of RV. Heteromorphs with two perimarginal tubercles near the posterior margin. Admarginal spine occurs in posterior part near mid-height of each valve. Surface smooth. Hinge structure as in *C. grammi* sp. n. Calcified internal rim of equal width along free margin. Tecnomorphs distinguished from heteromorphs by absence of perimarginal tubercles, smaller posterodorsal hump and smaller ventral depression of valve contact line.

Remarks. — In their original description Schneider & Tkatscheva (1972) did not mention the presence of perimarginal tubercles in *C. advena,* but on the illustration of this species in Gramm (1984a: pl. 12: 8) three perimarginal tubercles are visible.

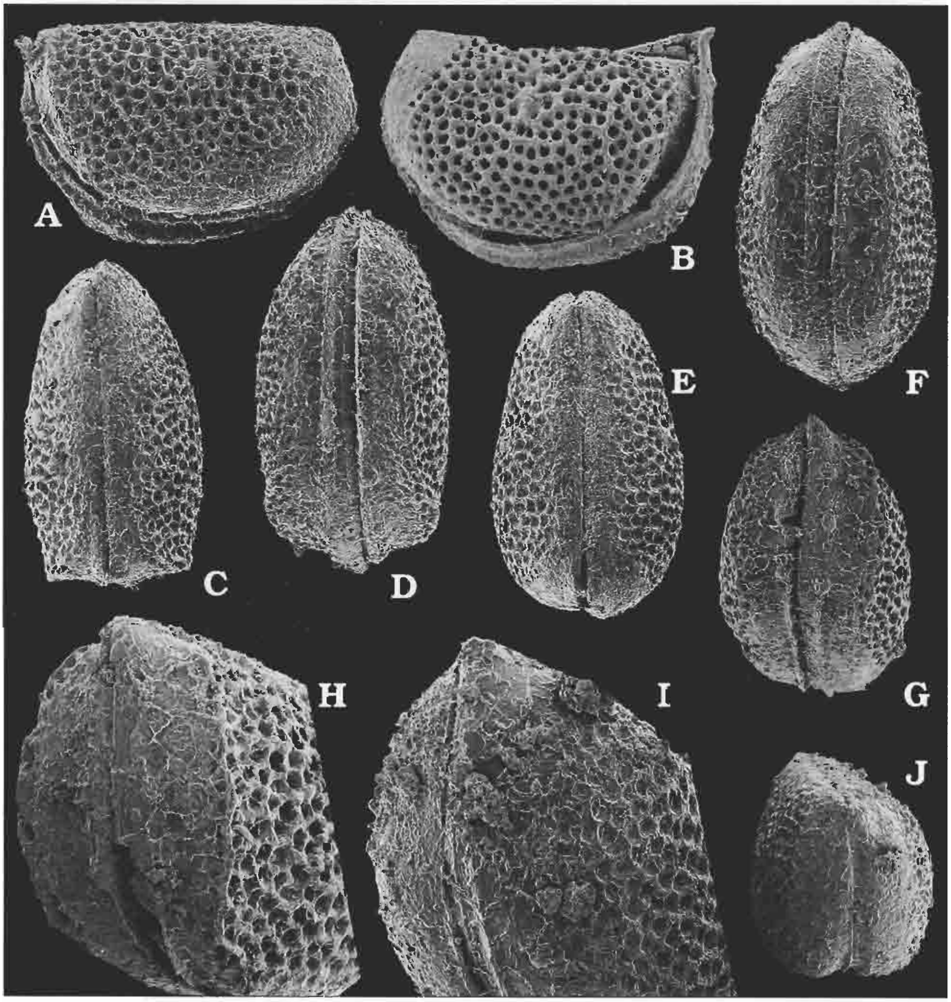


Fig. 13. **A–J**. *Guerichiella coeni* sp. n. **A**. Holotype, heteromorphic carapace in right lateral view; ZPAL O.XLV/149. **B**. Heteromorphic carapace in left lateral view; ZPAL O.XLV/150. **C**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/151. **D**. Heteromorphic carapace in ventral view; ZPAL O.XLV/152. **E**. Tecnomorphic carapace in dorsal view; ZPAL O.XLV/153. **F**. Tecnomorphic carapace in ventral view; ZPAL O.XLV/154. **G**. Heteromorphic carapace in posterior view; ZPAL O.XLV/155. **H**. Heteromorphic carapace in posterior view; ZPAL O.XLV/156. **I**. Tecnomorphic carapace in oblique posterior view; ZPAL O.XLV/157. **J**. Tecnomorphic carapace in posterior view; ZPAL O.XLV/158. All × 72 except for **H** and **I** which are × 120.

Guerichiella Adamczak, 1968

Type species: *Guerichiella meridiensis* Adamczak, 1968.

Remarks. — Previous discoveries of this genus include species with the perimarginal structure as a semicircular ridge along the posterior part of the heteromorphic valves. *Guerichiella coeni* sp. n. is the only known species of the genus with a perimarginal structure in the form of tubercles. *Selebratina serotina* Jones, 1989 and Primitiopsacean sp. A, described by Jones (1989) from the Early Carboniferous of north-western Australia, probably belong to this genus.

Guerichiella coeni sp. n.

Fig. 13.

Holotype: ZPAL O. XLV/149 (Fig. 13A).

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou province, South China.

Derivation of the name: In honour of Dr. Michel Coen from Louvain, Belgium.

Diagnosis. — *Guerichiella coeni* sp. n. differs from other representatives of *Guerichiella* in having perimarginal tubercles in heteromorphs.

Material. — 150 carapaces of heteromorphs and tecnomorphs and more than 100 valves.

Description. — This is a small species with adults up to 0.65 mm in length. Lateral outline preplete. Anterior cardinal angle slightly greater than posterior. Greatest width about mid-length. Dorsal margin straight and long; ventral margin nearly straight in middle part; anterior margin equally rounded; posterior truncated posteroventrally. RV slightly larger, overlap insignificant. Acroidal process small, located at posterocardinal corner of RV. Adductorial muscle spot small, located above mid-height. Adventral structure a rounded flange parallel to ventral margin, becoming sharp flange in posterior part, runs almost parallel to posterior margin. Three perimarginal tubercles occur near the posterior margin in heteromorphs forming a continuation of marginal ridge. Posterior part of heteromorphs carapace flattened: in tecnomorphs posterior part of carapace inflated. Surface with coarse reticulae except for smooth areas along dorsum, posterior end, and ventral margin. Hinge of primitiopsid type. Contact groove parallel to free margin of larger RV. Shell wall very thin.

Tecnomorphs distinguished from heteromorphs by lack of perimarginal tubercles, traces of adventral flange, and swollen posterior part of carapace.

Superfamily Kirkbyacea Ulrich & Bassler, 1906

Family Kirkbyidae Ulrich & Bassler, 1906

Genus *Kirkbya* Jones, 1859

Type species: *Dithyrocaris permiana* Jones, 1850.

Kirkbya sp.

Fig. 14G, H.

Material. — Five valves.

Description. — Carapace relatively large, elongate. Dorsal margin somewhat convex, subparallel to ventral margin. Anterior margin rounded, posterior ventrally truncated. Poorly developed posterior shoulder, anterior lobe obsolete; kirkbyan pit obscure. Carina thick, separated from marginal ridge by four rows of reticulae. Surface reticulate.

Remarks. — This species differs from other species of the genus by poorly developed kirkbyan pit and poorly developed posterior shoulder.

Genus *Knightina* Kellett, 1933

Type species: *Amphissites allerismoides* Knight, 1928.

Knightina jiqiangi sp. n.

Fig. 14C–F.

Holotype: ZPAL O.XLV/161 (Fig. 14C, D).

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou province, South China.

Derivation of the name: In honour of Dr. Ji Qiang from Chinese Academy of Geological Sciences.

Diagnosis. — *Knightina jiqiangi* sp. n. is somewhat similar to *K. hungarica* Kozur, 1985 from the Permian of Hungary and to *K. votadiniae* Robinson, 1978 from the late Viséan–Namurian of Great Britain but differs in having a poorly developed kirkbyan pit and prominent posterior shoulder.

Material. — 35 valves and 10 carapaces.

Description. — Carapace small, subrectangular, elongate in outline. Dorsal margin straight, subparallel to ventral margin. Anterior and posterior margins rounded, posterior somewhat truncated ventrally. Greatest length at mid-height, greatest height in posterior three-quarters of length. Posterior shoulder prominent, continuing down the valve flank as bend. Cardinal angles obtuse. Kirkbyan pit poorly developed. Carina narrow, separated from marginal ridge by three rows of reticulae. Surface with medium-sized reticulae.

Family Amphissitidae Knight, 1928

Genus *Amphissites* Girty, 1910

Subgenus *Amphissites* (*Amphissites*) Girty, 1910

Type species: *Amphissites rugosus* Girty, 1910.

Amphissites (Amphissites) centronotus (Ulrich & Bassler, 1906)

Fig. 14A, B.

Kirkbya centronota Ulrich & Bassler, 1906: p. 159, pl. 11:16, 17.

Amphissites (Amphissites) centronotus (Ulrich & Bassler, 1906); Becker & Wang 1992: p. 12, pl. 1:5.

Amphissites centronotus (Ulrich & Bassler, 1906); Crasquin-Soleau 1997: p. 51, pl. 2: 9–11 (with full synonymy list).

Material. — Seven valves and one juvenile carapace.

Description. — *Amphissites (A.)* species with moderately large globular central node, flanked by carinae extending from dorsal carina, reaching to just below central node. Deep kirkbyid muscle scar pit below mid-height of valve, located at base of central node. Surface reticulate.

Remarks. — There are many forms described from Europe, Asia, N-America and China as *A. centronotus*, which may belong to a closely related but yet different species.

Occurrence. — Carboniferous–Permian; N. America, N. Spain, Carnic Alps, Hungary, Great Britain, Russia, Japan, South China.

Suborder uncertain

Superfamily Knoxitacea Egorov, 1950

Remarks. — The taxonomic position of the natural group of taxa, including straight-backed ostracodes with sexual dimorphism characterised by inflation of female carapaces but without inner partition (limen) and often with calcified internal rim, is still open to interpretation. Lethiers (1981), Abushik (1990), and Crasquin-Soleau (1997) assigned knoxitids and geisinids to the family Knoxitidae Egorov, 1950. Adamczak's (1991) investigation of *Kloedenella* Ulrich & Bassler, 1908, the nominate genus of the Kloedenellacea, demonstrated the presence of a brood chamber, separated from the rest of the domicilium by an inner partition (limen). Thus the superfamily Kloedenellacea is restricted by Adamczak (1991) to genera of this type (kloedenellid type) of sexual dimorphism. In the superfamily Knoxitacea the limen is absent and is restricted to those taxa with sexual dimorphism characterised by an inflated posterior part of female carapaces and lacking limen (knoxitids, glyptopleurids, beyrichiopsids).

Family Knoxitidae Egorov, 1950 (= Geisinidae Sohn, 1961)

Genus *Hypotetragona* Morey, 1935

Type species: *Hypotetragona impolita* Morey, 1935.

Remarks. — *Hypotetragona* species from the Muhua section are similar to several taxa assigned to poorly known and widely interpreted genera: *Hypotetragona*, *Jonesina* Ulrich & Bassler, 1909, *Geffenina* Coryell & Sohn, 1938, and *Geisina* Johnson, 1936. Therefore, they are only questionably assigned to *Hypotetragona*. Most of these genera are in need of revision.

Hypotetragona? *sinica* sp. n.

Figs 7A–D; 8; 15A–I.

Holotype: ZPAL O.XLV/165 (Fig. 15A).

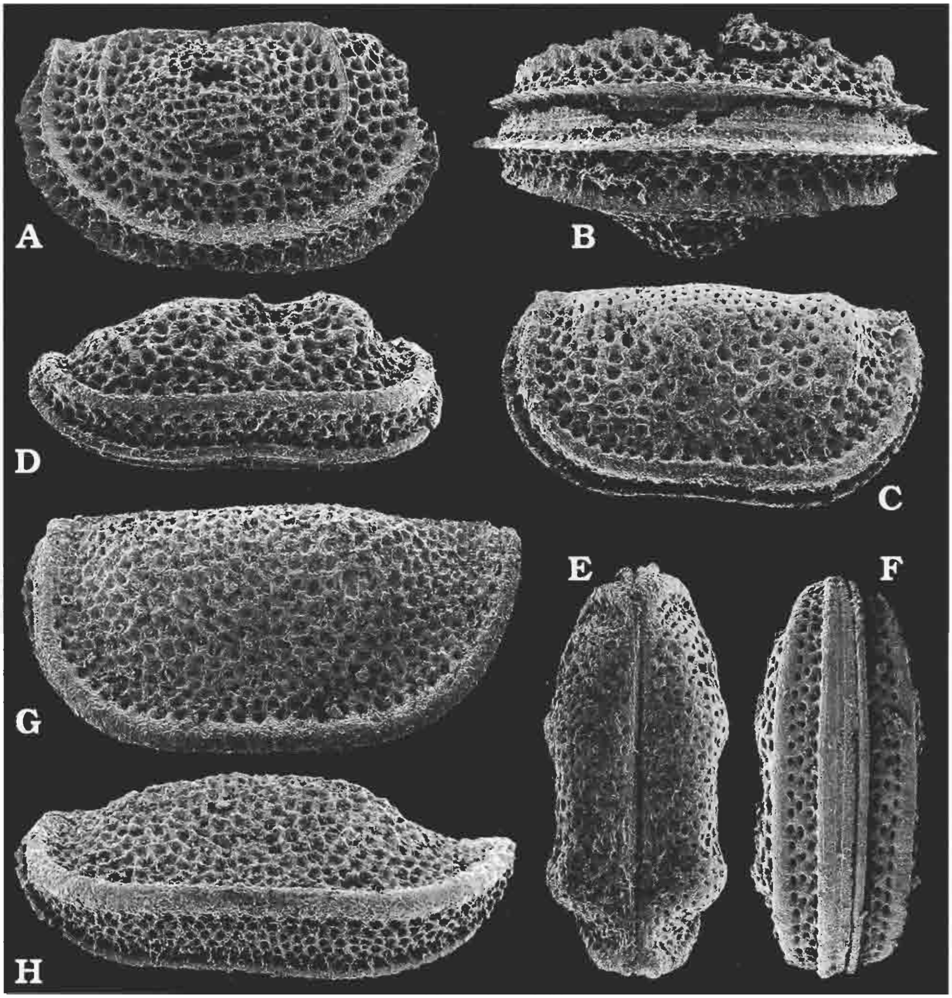


Fig. 14. **A**, **B**. *Amphissites (A.) centronotus* (Ulrich & Bassler, 1906). **A**. Carapace in right lateral view; ZPAL O.XLV/159. **B**. Carapace in ventral view; ZPAL O.XLV/160. **C–F**. *Knightina jiqiangi* sp. n. **C**, **D**. Holotype, LV in lateral and oblique views; ZPAL O.XLV/161. **E**. Carapace in dorsal view; ZPAL O.XLV/162. **F**. Carapace in ventral view; ZPAL O.XLV/163. **G**, **H**. *Kirkbya* sp. LV in lateral and oblique views; ZPAL O.XLV/164. **A**, **B**, **G**, **H**, × 48; **C–F**, × 60.

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.
Type locality: Muhua, Guizhou, South China.
Derivation of the name: From China, country of origin.

Diagnosis. — *Hypotetragona*? *sinica* sp. n. differs from *Hypotetragona*? *angulata* (Posner, 1951) by its shorter carapace, narrow S2 and lack of anterodorsal depression. It differs from other species of the genus in having a weakly developed preadductorial node, and a narrow short sulcus.

Material. — 200 carapaces and more than 200 valves.

Description. — Valves up to 1.1 mm in length. Subquadrate in lateral outline. Dorsal margin straight, ventral gently curved. Hinge line channelled in posterior part. Greatest length in mid-height. Greatest width in posterior part. Valves nearly equal, RV larger and slightly overlaps LV. S2 narrow, short, vertically elongate in front of midlength, not reaching mid-height. Preadductorial node small, indistinct. Stragular process present in RV. Heteromorphs with strongly swollen posterior part, tecnomorphs of nearly equal width in anterior and posterior ends. Pre-adult dimorphism present. Hinge structure of kloedenellid type. RV hinge structure with hinge list in posterior part, reaching S2, and depression below stragulum (Fig. 15F). LV with median groove reaching S2, and ridge in anterior part, which is a continuation of ventral bar (Fig. 15G). Limen absent. Adductor muscle field not visible. Calcified internal rim of nearly equal width (see discussion on p. 391; Figs 7A–D, 15H, I). Contact groove impressed in internal rim of RV (Fig. 15H). Surface smooth or indistinctly pitted.

Remarks. — *H.*? *sinica* is similar in lateral outline to *Jonesina* cf. *maccoyi* Roth & Skinner, 1930, *sensu* Crasquin (1985) from the late Tournaisian–early Viséan of western Canada, and to *Hypotetragona* sp. illustrated by Adamczak (1991: pl. 2: 20, 21) from the Early Carboniferous of Australia (Tournaisian Laurel Formation, in the Canning Basin according to Dr. P. J. Jones).

Hypotetragona? *angulata* (Posner, 1951)

Fig. 15J–N.

Jonesina(?) *angulata* Posner, 1951: p. 34, pl. 5: 3.

Material. — 28 carapaces and 43 valves.

Description. — Carapace subrectangular in lateral view. Dorsal margin straight in tecnomorphs; in heteromorphs straight in anterior half, slightly convex in posterior half, rising above hinge line. Hinge line strongly depressed in posterior half in heteromorphs and slightly depressed in tecnomorphs. RV larger and slightly overlaps LV. Greatest length above midheight, greatest height just behind S2. Anterior and posterior margins rounded, posterior somewhat ventrally truncated; ventral margin gently convex. S2 a subtriangular depression terminated by round, deep pit. Preadductorial node low, passing smoothly anteriorly into valve surface. Short depression in anterodorsal part, below stragular process in RV and LV. Stragular process in anterior part of dorsal margin of RV. Heteromorphs with strongly inflated carapace in posterior part; pre-adult dimorphism present. Tecnomorphs uniformly convex. Calcified internal rim relatively wide and of nearly equal width. Contact groove impressed in calcified internal rim of RV. Hinge structure of kloedenellid type. RV hinge structure consists of hinge list in posterior part and depression below stragulum in anterior part. LV with median groove reaching S2, and ridge in anterior part, which is a continuation of ventral bar. Limen absent. Adductor muscle field not visible. Surface smooth, but may be faintly ornamented with fine striae.

Remarks. — *H.*? *angulata* is distinguished from *Hypotetragona*? *sinica* by its more elongate carapace, the presence of an anterodorsal depression, and deep S2. This species appears closely related to *Geffenina*? *aspinifera* Green, 1963 from the Banff Formation (Early Carboniferous) of Alberta, Canada (Green 1963).

Occurrence. — Early Carboniferous of Moscow Basin (Russian Platform).

Knoxiella Egorov, 1950

Type species: *Knoxiella semilukiana* Egorov, 1950.

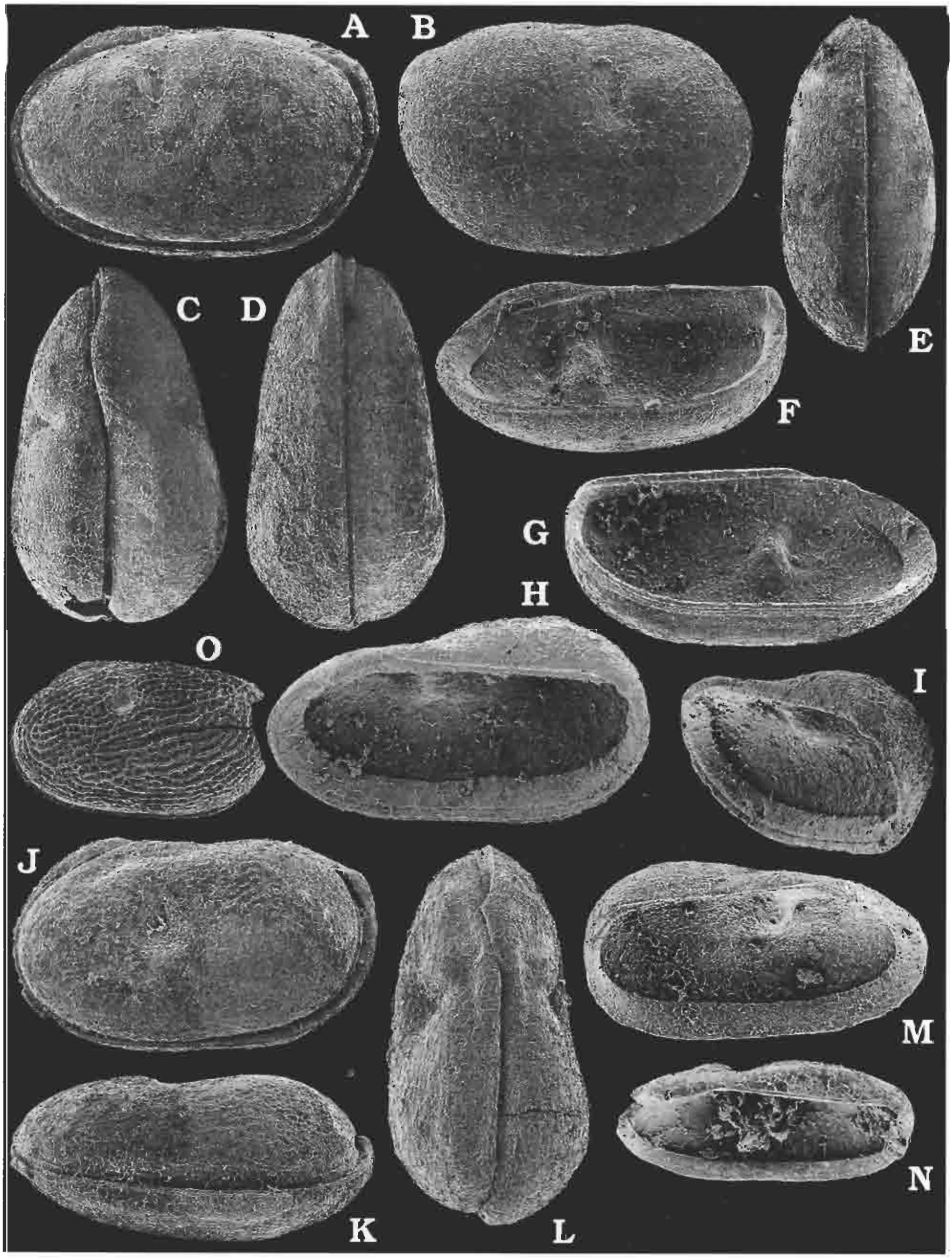
Knoxiella? sp.

Fig. 15O.

Description and remarks. — One specimen of *Knoxiella* has been found in the present material. The material is too poorly preserved to be described in detail, although it is sufficient to state that the lateral outline is suboblong, dorsal margin long and straight, S2 short, and L2 poorly developed. Surface reticulate with muri strongly developed and parallel to the lateral axis of the valve.

→

Fig. 15. **A–I.** *Hypotetragona*? *sinica* sp. n. **A**. Holotype, heteromorphic carapace in left lateral view; ZPAL O.XLV/165. **B**. Heteromorphic carapace in right lateral view; ZPAL O.XLV/166. **C**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/167. **D**. Heteromorphic carapace in ventral view; ZPAL O.XLV/168. **E**. Tecnomorphic carapace in ventral view; ZPAL O.XLV/169. **F**. Heteromorphic RV in oblique internal view;



ZPAL O.XLV/170. **G**. Heteromorphic LV in oblique internal view; ZPAL O.XLV/171. **H**. RV in oblique internal view; ZPAL O.XLV/172. **I**. RV in oblique internal view; ZPAL O.XLV/173. **J–N**. *Hypotetragona*? *angulata* (Posner, 1951). **J**, **K**. Heteromorphic carapace in left lateral and oblique views; ZPAL O.XLV/178. **L**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/179. **M**. LV in oblique internal view; ZPAL O.XLV/180. **N**. Juvenile RV in oblique internal view; ZPAL O.XLV/181. **O**. *Knoxiella* sp. LV in lateral view; ZPAL O.XLV/182. All × 48.

Order Leiocopa Schallreuter, 1973

Superfamily Aparchitacea Jones, 1901

Family Aparchitidae Jones, 1901

Genus *Libumella* Rozhdestvenskaya, 1959

Type species: *Libumella discoides* Rozhdestvenskaya, 1959.

Remarks. — The Early Carboniferous species belonging to *Libumella* are known from western Canada, northern England, France, Germany, the southern Urals, north-western Australia (listed by Jones 1989), and southern China. Sexual dimorphism in *Libumella* species is unknown, but Robinson (1978) noted possible sex-dimorphism in *Libumella reticulata* Robinson, 1978 from Upper Asbian (Viséan) of Great Britain.

Libumella bonapartensis Jones, 1989

Fig. 9E–I.
Libumella bonapartensis Jones, 1989: p. 22, pl. 1: 1–10, text-fig. 13.

Material. — Three carapaces and 18 valves.

Description. — Carapace subcircular in lateral view. Hinge line straight, slightly depressed and shorter than greatest length. Ventral margin convex, passing smoothly into anterior and posterior margins. Greatest width just in front of mid-length. Adventral structure distinct and relatively broad with plication in larger, right valve. RV overlapping LV along entire free margin. Central adductorial muscle field poorly visible on outside of shell. Inside the subcircular muscle scar is located at mid-height and consists of numerous individual scars (Fig. 9H).

Right hinge with list; left hinge with hinge groove. Valve surface ornamented with deep punctae. Inside, valves minutely pitted. RV possess contact groove along free margin. Dimorphism unknown.

Remarks. — This species is distinguished from *Libumella reticulata* Robinson, 1978 (junior homonym of *L. reticulata* Copeland, 1962) by its broad smooth adventral structure.

Occurrence. — Tournaisian?–Viséan of Australia, Tournaisian of South China.

Superfamily Paraparchitacea Scott, 1959

Family Paraparchitidae Scott, 1959

Remarks. — See discussion on p. 392.

Genus *Shivaella* Sohn, 1971

Type species: *Shivaella suppetia* Sohn, 1971.

Shivaella armstrongiana (Jones & Kirkby, 1886)

Fig. 16A–C.
Leperditia armstrongiana Jones & Kirkby, 1886: p. 253, pl. 7: 1a, b.
Paraparchites armstrongianus (Jones & Kirkby, 1886); Latham 1932: p. 356, text-fig. 4.
Shivaella armstrongiana (Jones & Kirkby, 1886); Sohn 1971: p. 9.
Shivaella armstrongiana (Jones & Kirkby, 1886); Buschmina 1975: p. 33, pl. 4: 6.
Shivaella armstrongiana (Jones & Kirkby, 1886); Buschmina 1986: p. 133, pl. 30: 4.

Material. — 32 valves and eight carapaces.

Description. — Lateral outline distinctly preplete; carapace elongate, up to 1.6 mm long. Dorsal margin straight and long; ventral margin convex. Anterior margin broadly rounded; posterior narrowly rounded. Greatest length above mid-height, greatest height in anterior part. Lateral surface moderately convex. Hinge not incised. LV slightly larger, overlap RV along free margins. Hinge structure as groove in RV and list in LV. Dorsoposterior spines on both valves, removed from posterior margin twice their distance from dorsal margin. Internally, round adductorial muscle spot located at or slightly in front of mid-length. It consists of numerous individual scars. Contact structure occurs as terminating ridge in LV and distinct list in RV. Sexual dimorphism not observed. Surface of valve smooth.

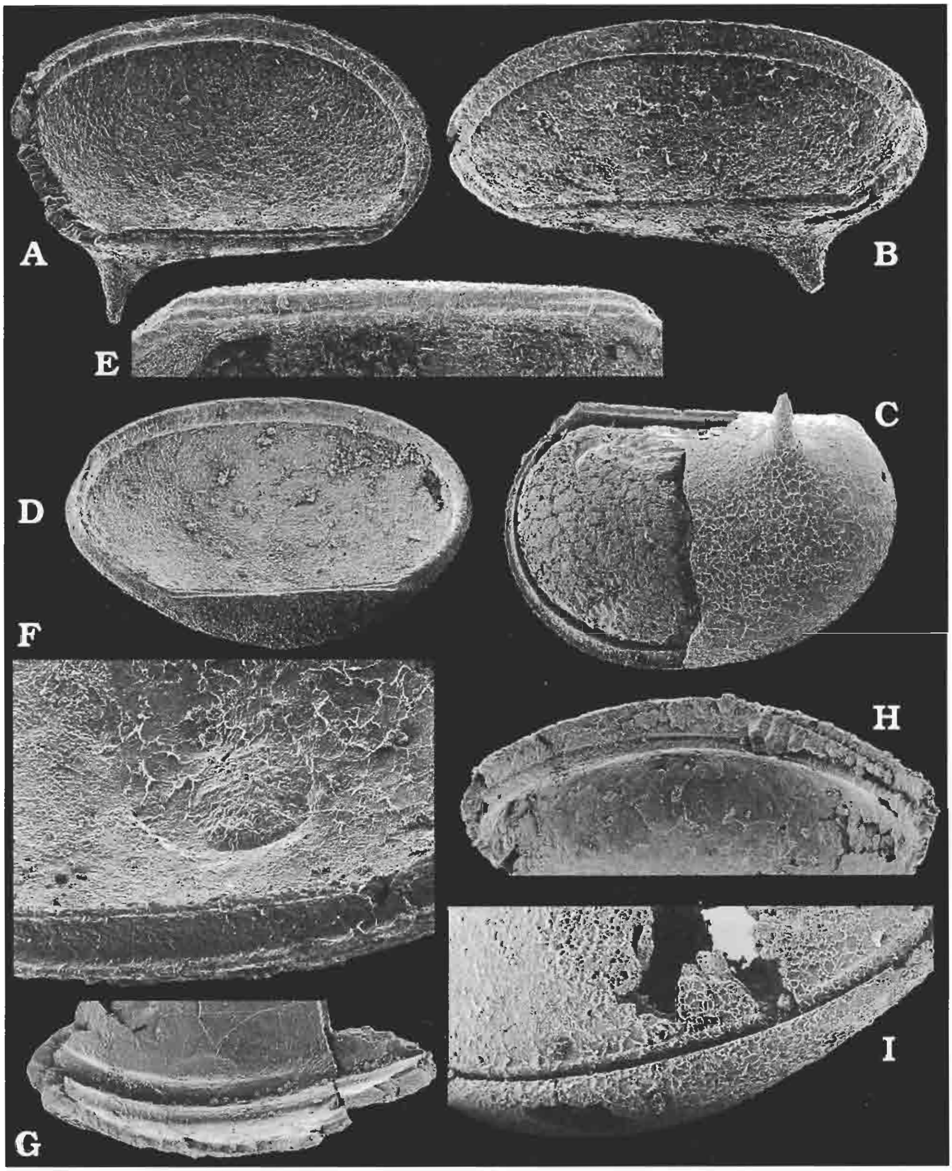


Fig. 16. **A–C**. *Shivaella armstrongiana* (Jones & Kirkby, 1886). **A**. RV in internal oblique lateral view, showing free margin structures; ZPAL O.XLV/183. **B**. RV in internal oblique lateral view, showing free margin structures; ZPAL O.XLV/184. **C**. Carapace in left lateral view; ZPAL O.XLV/185. **D–I**. *Shishaella* sp. **D**. RV in oblique internal view. **E**. Same specimen with details of hinge structure; ZPAL O.XLV/186. **F**. Details of adductorial muscle field; ZPAL O.XLV/187. **G**. Internal view of margin structures; ZPAL O.XLV/188. **H**. Details of margin in LV; ZPAL O.XLV/189. **I**. Close-up of marginal structures in latero-ventral view; ZPAL O.XLV/190. **A–C, E, I**, × 48; **D**, × 24; **F**, × 96; **G**, × 72; **H**, × 45.

Remarks. — According to Sohn (1971), *Shivaella armstrongiana* described by Posner (1951) represents *Shivaella* sp.

Occurrence. — Early Carboniferous of Great Britain; late Tournaisian of Western Siberia and Early Carboniferous of the Kolyma massif.

Genus *Shishaella* Sohn, 1971

Type species: *Paraparchites nicklesi* var. *cyclopea* Girty, 1910.

Shishaella sp.

Fig. 16D–I.

Material. — 20 damaged specimens.

Description. — Large, sub-circular carapace, more than 3 mm in greatest length. Dorsal margin straight; ventral rounded. Hinge line relatively short. Obtuse cardinal angles. RV overreaches slightly above hinge line. LV larger. Small dorsoposterior spine on RV, close to dorsal margin. Hinge structure, a median groove in RV (Fig. 16E) and list in LV. Adductorial muscle spot circular, consisting of many secondary scars in a quite compact field; elongate ridge (mandibular scar?) located anteroventrally to adductor scar (Fig. 16F). Contact structures occurs as terminating ridge with small depression behind it in LV and contact list in RV (Fig. 16G, H). Surface smooth.

Remarks. — This species is similar to *Shishaella moreyi* Sohn, 1975 in the position of spine. The adductorial muscle field is similar to that in *Paraparchites minax* Ivanov, 1975 (in Gramm & Ivanov 1975). The species from Muhua is similar to many species described from N-America (Sohn 1971, 1972), Carboniferous of Siberia (Buschmina 1986) and the Middle Carboniferous *Shishaella* species of South Urals (Kotschetkova 1983).

Order Platycopida Sars, 1866
Superfamily Cytherellacea Sars, 1866
Family Cavellinidae Egorov, 1950

Remarks. — The classification of fossil cavellinids in general is far from stable. Adamczak (1991) considered that the suborder Platycopina has a closer affinity to the palaeocopes rather than podocopes. Recently Cavellinidae were assigned to the order Podocopida (suborder Platycopina, superfamily Kloedenellacea) by Whatley *et al.* (1993). Sohn (1968) suggested that the Cavellinidae be considered as a superfamily in the Platycopina – the Cavellinacea – and that the Cytherellidae be raised to coordinate superfamily – the Cytherellacea. The Cavellinacea differ from the Cytherellacea in that the former has an aggregate muscle-scar pattern and the latter a biserial muscle-scar pattern (Sohn 1968). Adamczak (1991) regards cavellinids as a subfamily of the Cytherellidae.

Genus *Cavellina* Coryell, 1928

Type species: *Cavellina pulchella* Coryell, 1928.

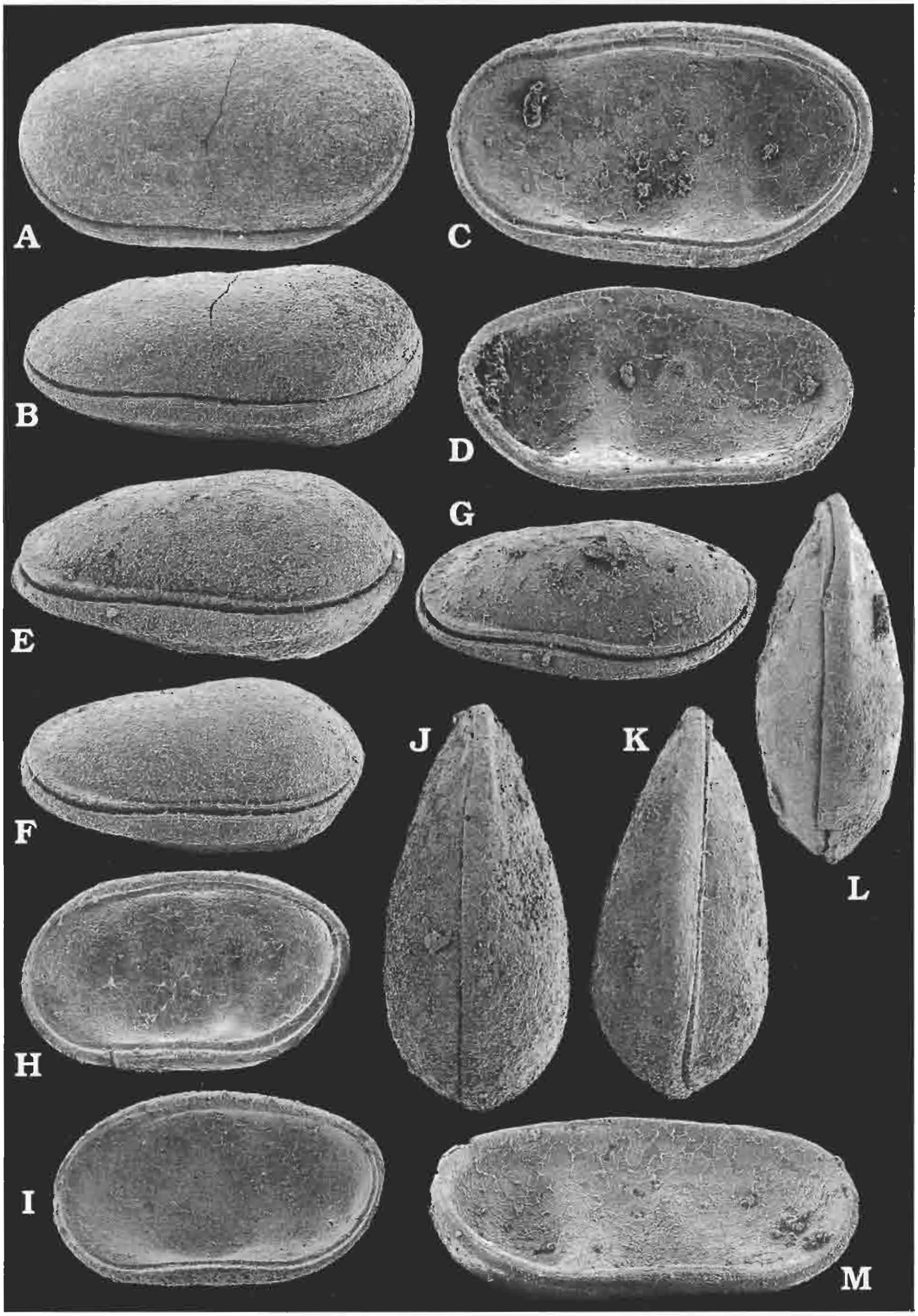
Remarks. —Because shells of *Cavellina* generally, lack distinctive features, it is difficult to determine specific characters. The lateral and dorsal outlines and shape of the overlap along the dorsum and venter are used to discriminate species. Shaver (1953) discussed the ontogenetic development and sexual dimorphism of *Cytherella* Jones, 1849 and *Cavellina* Coryell, 1928. Gramm & Egorov (1972) described separate receptacles for eggs in the females of *Cavellina lovatica* Zaspelova, 1959 from the Late Devonian of Novgorod region. In the cavellinids from the Muhua section, the separate egg compartments are not visible.

Cavellina robinsoni sp. n.

Fig. 17.

Holotype: ZPAL O.XLV/211 (Fig. 17A, B).

Fig. 17. **A–M**. *Cavellina robinsoni* sp. n. **A**, **B**. Holotype, heteromorphic carapace in left lateral and oblique views; ZPAL O.XLV/211. **C**. Heteromorphic RV in internal view; ZPAL O.XLV/212. **D**. Heteromorphic LV in internal lateral view; ZPAL O.XLV/213. **E**. Pre-adult heteromorphic carapace in oblique left view; ZPAL O.XLV/214. **F**. Pre-adult heteromorphic carapace in oblique left view; ZPAL O.XLV/215. **G**. Tecnomorphic carapace in oblique left view; ZPAL O.XLV/216. **H**. Pre-adult heteromorphic RV in internal view; ZPAL O.XLV/217.



I. Tecnomorphic RV in internal view; ZPAL O.XLV/218. **J**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/219. **K**. Heteromorphic carapace in ventral view; ZPAL O.XLV/220. **L**. Tecnomorphic carapace in dorsal view; ZPAL O.XLV/221. **M**. Heteromorphic LV in oblique internal view; ZPAL O.XLV/222. All × 48.

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.
Type locality: Muhua, Guizhou, China.
Derivation of the name: In honour of Dr. Eric Robinson from Great Britain.

Diagnosis. — *Cavellina robinsoni* sp. n. is distinguished from *C. guizhouensis* sp. n. by its compressed anterior part of carapace and presence of plication in RV.

Material. — 300 carapaces and 220 valves.

Description. — Carapace ovate-elongate in lateral outline. Dorsal and ventral margins subparallel; dorsal slightly arched, ventral almost straight. Anterior margin rounded, posterior ventrally truncated. Carapace slightly compressed anteriorly and swollen posteriorly. RV larger, overlaps smaller LV all round. RV with marginal plication along anterior and ventral margins, LV with small admarginal ridge. Greatest height in posterior part, greatest length at mid-height. Greatest width in heteromorphs in posterior part; in tecnomorphs slightly behind mid-length. Stragulum strongly reduced. Sexual dimorphism present in last 3 instars. Surface smooth. Holosolenic contact condition well developed. Chamber for egg care bounded anteriorly by vertical limen (Fig. 17C, D, H, M). Limen in younger instars poorly developed. Brood chamber larger in LV. Adductor muscle field oval, composed of many scars, and located internally on small elevation.

Remarks. — This species is similar in lateral and dorsal outline to *Cavellina subreniformis* (Jones, Kirkby & Brady, 1884), *Cavellina attenuata* (Jones & Kirkby, 1886) from the Carboniferous of Britain and to *Cavellina ovatoelongata* Přibyl, 1962 from the Upper Carboniferous of north-central Czech Republic.

Cavellina guizhouensis sp. n.

Fig. 18.
Holotype: ZPAL O.XLV/223 (Fig. 18A, B).
Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.
Type locality: Muhua, Guizhou, China.
Derivation of name: From Guizhou province.

Diagnosis. — *Cavellina guizhouensis* sp. n. differs from other species of the genus in having carapace nearly equal in width at anterior and posterior ends.

Material. — 200 carapaces and 110 valves.

Description. — Carapace ovate-elongate in lateral outline, ovate in dorsal outline. Dorsal margin slightly arched, ventral almost straight. Anterior and posterior margins rounded, posterior ventrally truncated. Posterior end slightly higher than anterior. Greatest height behind mid-length; greatest length in mid-height. RV overlap LV all round, overlap greatest dorsally and ventrally. Heteromorphs only slightly swollen posteriorly. Tecnomorphs nearly of equal width in anterior and posterior ends. Stragulum weakly developed. Surface smooth. Adductor muscle field contains many scars, located on small internal elevation (Fig. 18K). Holosolenic contact condition well developed. Sexual dimorphism in last three instars. Limen well developed, reaching from venter almost or entirely to dorsum (Fig. 18E, F).

Remarks. — This species is similar in lateral and dorsal outline to *Cavellina valida* (Jones, Kirkby & Brady, 1884), but differs from the latter illustrated by Robinson (1978: pl. 2: 2) in having smaller truncation of posteroventral margin. *C. guizhuensis* differs from *C. robinsoni* in the nearly equal width of tecnomorphs, and lack of plication along anterior and ventral margins of RV.

Cavellina benniei (Jones, Kirkby & Brady, 1884)

Fig. 19.
Cytherella benniei Jones, Kirkby & Brady, 1884: p.70, pl. 6: 3-5, 7, pl. 7: 12.
Cavellina benniei var. *intermedia* (Jones, Kirkby & Brady, 1884); Posner 1951: p. 83, pl. 18: 3.
Cavellina benniei (Jones, Kirkby & Brady, 1884); Robinson 1978: p. 132, pl. 2: 1.

Material. — 24 carapaces and ten valves.

Description. — Relatively small *Cavellina* species, adults reaching up to 0.9 mm in length. Elongate-subquadrate in lateral outline. Dorsal and ventral margins subparallel. Greatest height in poste-

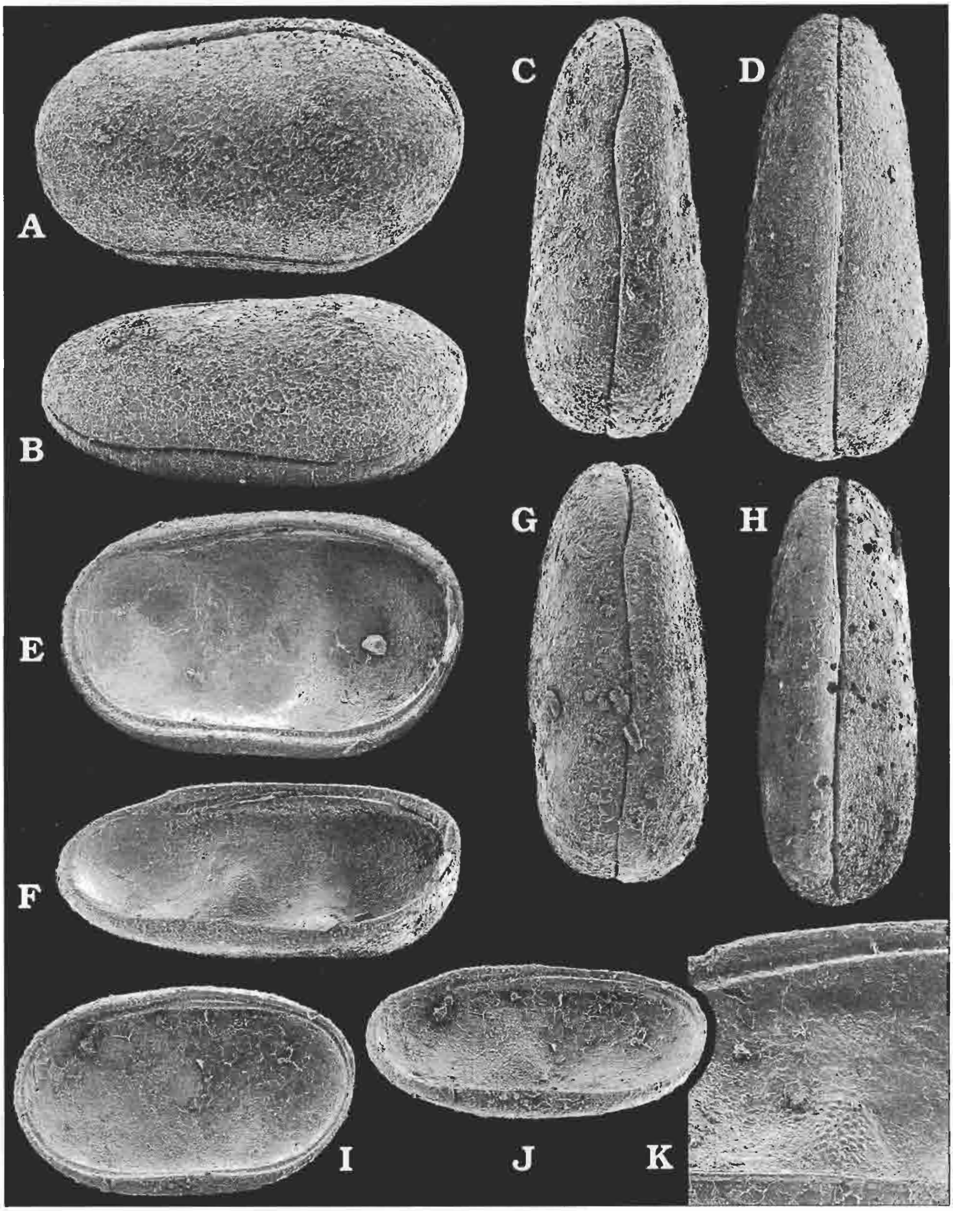


Fig. 18. **A–K**. *Cavellina guizhouensis* sp. n. **A**, **B**. Holotype, carapace in left lateral and oblique views; ZPAL O.XLV/223. **C**, **D**. Heteromorphic carapace in dorsal and ventral views; ZPAL O.XLV/224. **E**, **F**. Heteromorphic RV in lateral and oblique internal views; ZPAL O.XLV/225. **G**. Tecnomorphic carapace in dorsal view; ZPAL O.XLV/226. **H**. Tecnomorphic carapace in ventral view; ZPAL O.XLV/227. **I**, **J**. Tecnomorphic RV in lateral and oblique internal views; ZPAL O.XLV/228. **K**. Details of adductorial muscle scar; ZPAL O.XLV/229. All × 48 except for **K** which is × 96.

rior part. Greatest width in heteromorphic carapaces in posterior part, tecnomorphs almost uniformly convex. Surface smooth. Heteromorphs with well developed limen, reaching up to 3/4 of height.

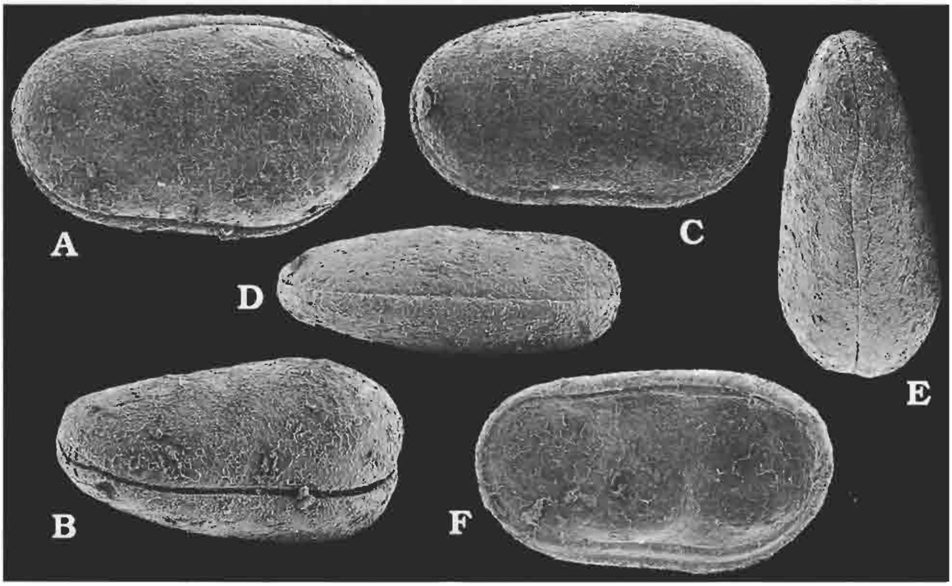


Fig. 19. **A–F.** *Cavellina benniei* (Jones, Kirkby & Brady, 1884). **A, B.** Heteromorphic carapace in left lateral and oblique views; ZPAL O.XLV/230. **C, D.** Tecnomorphic carapace in left lateral and oblique views; ZPAL O.XLV/231. **E.** Heteromorphic carapace in dorsal view; ZPAL O.XLV/232. **F.** Heteromorphic RV in internal view; ZPAL O.XLV/233. All × 48.

Adductorial muscle field composed of many scars, located internally at small elevation. RV larger, overlaps LV all round.

Remarks. — This species differs from other *Cavellina* species from Muhua in having a more elongate lateral outline and smaller dimensions.

Occurrence. — Late Viséan of Great Britain and Viséan of Moscow Basin.

Genus *Sulcella* Coryell & Sample, 1932

Type species: *Sulcella sulcata* Coryell & Sample, 1932.

Sulcella jonesi sp. n.

Fig. 20.
Holotype: ZPAL O.XLV/234 (Fig. 20A, B).
Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.
Type locality: Muhua, Guizhou, China.
Derivation of the name: In honour of Dr. Peter J. Jones from Canberra, Australia.

Diagnosis. — *Sulcella jonesi* sp. n. differs from other species of the genus in having a slightly arched dorsal margin, concave ventral margin, multiserial muscle scar, and plication along anterior and ventral margin of larger RV.

Material. — 18 carapaces and seven valves.

Description. — Lateral outline subrectangular. Dorsal margin slightly arched, ventral concave in central part. Greatest height in anterior part, greatest length at mid-height. Greatest width in tecnomorphs posterior to subcentral pit; greatest width of heteromorphs almost at posterior part. Adductorial pit round, shallow. Vertical sulcus slightly developed on ventroposterior portion of heteromorphs. Surface smooth. Holosolenic contact condition well developed. Limen well developed.

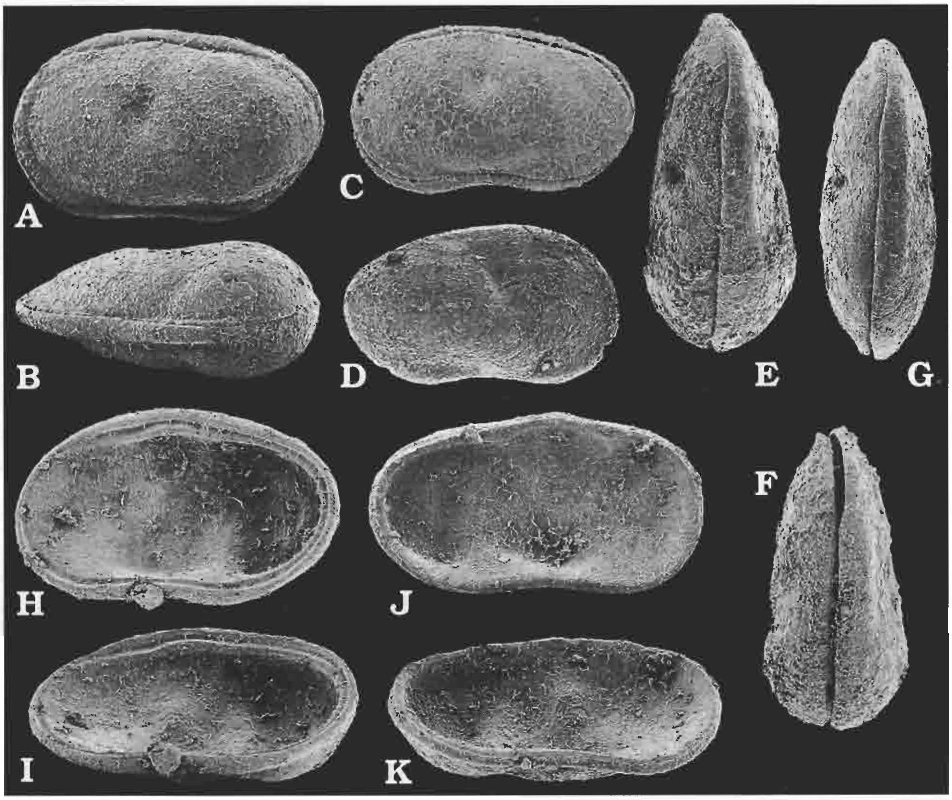


Fig. 20. **A–K**. *Sulcella jonesi* sp. n. **A, B**. Holotype, heteromorphic carapace in left lateral and oblique views; ZPAL O.XLV/234. **C**. Tecnomorphic carapace in left lateral view; ZPAL O.XLV/235. **D**. Tecnomorphic carapace in right lateral view; ZPAL O.XLV/236. **E**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/237. **F**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/238. **G**. Tecnomorphic carapace in dorsal view; ZPAL O.XLV/239. **H, I**. Heteromorphic RV in lateral and oblique internal views; ZPAL O.XLV/240. **J, K**. Heteromorphic LV in lateral and oblique internal views; ZPAL O.XLV/241. All × 48.

Remarks. — This species is similar to species described as *Uchtovia definita* Li, 1987 from the Lower Carboniferous of Chouniukou Formation in Jingyuan, Gansu (Li 1987).

Genus *Houhongfeiella* n.

Type species: *Houhongfeiella microspinosa* sp. n.

Derivation of the name: In honour of Prof. Hou Hongfei from Institute of Geology of Chinese Academy of Geological Sciences, Beijing, People's Republic of China.

Diagnosis. — A cavellinid genus with weak sulcal depression, centroventral lobe terminating in small spine and poorly developed vertical sulcus on ventroposterior portion of heteromorph. Surface smooth.

Discussion. — *Houhongfeiella* gen. n. is similar to *Sulcella* Coryell & Sample, 1932, but differs in presence of a centroventral lobe, shallower adductorial depression and almost straight dorsal margin. It is also similar to *Borovitchella* Gramm, 1985, but is distinguished from that genus by its weaker sulcal depression, aggregate muscle scars, and presence of a posteroventral spine. From *Muhuaella* Olempska, 1998 (see Olempska 1998a), it differs in the nature of marginal structures, more cavellinid

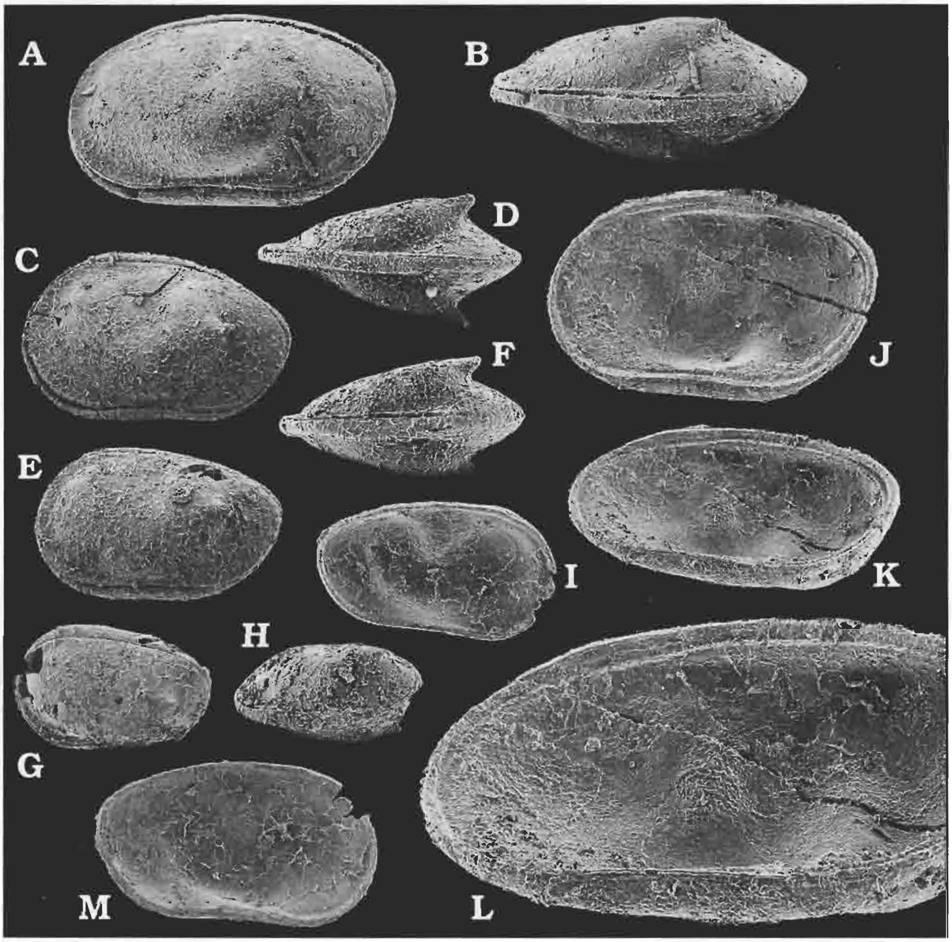


Fig. 21. **A–M**. *Houhongfeiella microspinosa* sp. n. **A**, **B**. Holotype, heteromorphic carapace in left lateral and oblique views; ZPAL O.XLV/242. **C**, **D**. Tecnomorphic carapace in left lateral and ventral views; ZPAL O.XLV/243. **E**, **F**. Tecnomorphic carapace in lateral and ventral views; ZPAL O.XLV/244. **G**, **H**. Tecnomorphic juvenile carapace in left lateral and oblique views; ZPAL O.XLV/245. **I**. Tecnomorphic carapace in right lateral view; ZPAL O.XLV/246. **J–L**. Heteromorphic RV in lateral and oblique internal views with details of adductorial muscle scar; ZPAL O.XLV/247. **M**. Tecnomorphic LV in internal view; ZPAL O.XLV/248. All × 48 except for **L** which is × 90.

outline, shallow adductorial pit, and very shallow posteroventral depression. From *Alatacavellina* Wang, 1982, it differs in the presence of centroventral lobe terminating in spine and is separated from posterior part by a shallow vertical furrow in the place of limen.

The new genus is similar also in the presence of subcentral pit and lateral outline of the carapace to *Reubenella* Sohn, 1968 from the Triassic of Israel (Sohn 1968), but differs in having a smooth surface and well-developed centroventral lobe.

Houhongfeiella microspinosa sp. n.

Fig. 21.

Holotype: ZPAL O.XLV/242 (Fig. 21A, B).

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou, China.

Derivation of the name: From Greek μikpos (micros) – small and Latin spinatus – spiny, referring to the small spine on each valve.

Diagnosis. — As for the genus.

Material. — 128 carapaces and 100 valves.

Description. — Lateral outline ovate – suboblong. Dorsal margin slightly convex, ventral slightly concave in the middle. Anterior margin rounded, posterior somewhat truncated ventrally. S2 weak, as shallow pit. Ventral lobe well developed, terminated in small spine. RV with plication along anterior and ventral margin. LV with small admarginal ridge. Surface smooth. Heteromorphs with inflated posterior part of carapace. Limen well developed. Adductor muscle spot located on small elevation and consisting of many scars. Holosolenic contact condition well developed.

Remarks. — This species is similar in presence of posteroventral furrow to some species described as *Cavellina* (*C. songziensis* Sun & Lin, 1988 from the Early Carboniferous of Hubei Province, China , and to *C. sinensis* Hou, 1955 from the Late Devonian of Hupeh Province, China).

Genus *Muhuaella* Olempska, 1998

Type species: *Muhuaella spinosa* Olempska, 1998 (see Olempska 1998a).

Muhuaella spinosa Olempska, 1998

Fig. 22.

Muhuaella spinosa Olempska 1998a: p. 35–38, pl. 25 (36): 1–6, pl. 25 (38): 1–5.

Material. — 33 carapaces and 35 valves.

Description. — Lateral outline subrectangular. Dorsal margin almost straight, ventral concave in central part. Greatest height in anterior part, greatest length at mid-height. Greatest width in heteromorphs in posterior part, in tecnomorphs just behind sulcus. Adductorial sulcus a relatively large but shallow depression. Ventral lobe strongly inflated, terminating in spine, small in adult specimens, and relatively large in tecnomorphs and early instars. RV and LV with rim-like structure along anterior and ventral margin, with depression separating it from valve surface. Stragulum reduced. Posteroventral furrow well developed. Young instars with anterodorsal acroidal spine on RV. Surface smooth. Holosolenic contact condition well developed. Aggregate adductor muscle scar of cavellinid type, located on elevation. Limen well developed, reaching mid-height. Brood chamber larger in LV.

Remarks. — The presence of the continuous groove on the inner margins of the RV in the representatives of this genus suggests assignment it to the Cavellinidae and not to *Kloedenellitina* Egorov, 1950, which is similar externally. *Muhuaella spinosa* is similar, in lateral outline, to *Kloedenellitina hunanensis* Zhang, 1985 described from the Early Carboniferous from Shaodong, Hunan (Zhang 1985); it is distinguished by the presence of a spine at the end of the posteroventral lobe and a deep depression enclosed by a wide rim along the free margin.

M. spinosa is similar in morphology to *Kloedenellitina triceratina* Tschigova, 1960 illustrated by Coen (1989) from D–C transitional beds from Baihupo section (Guizhou, South China), but differs in the presence of a rim around the margins and the presence of posteroventral spine. The internal morphology of *K. triceratina* is unknown.

The presence of an acroidal spine in the anterodorsal part of RV was described in young instars of *Kloedenellitina modesta* Tschigova & Kotschetkova, 1986 by Buschmina *et al.* (1986).

Order Podocopida G.W. Müller, 1894

Suborder Metacopina Sylvester-Bradley, 1961

Superfamily Healdiacea Harlton, 1933

Family Healdiidae Harlton, 1933

Genus *Healdia* Roundy, 1926

Type species: *Healdia simplex* Roundy, 1926.

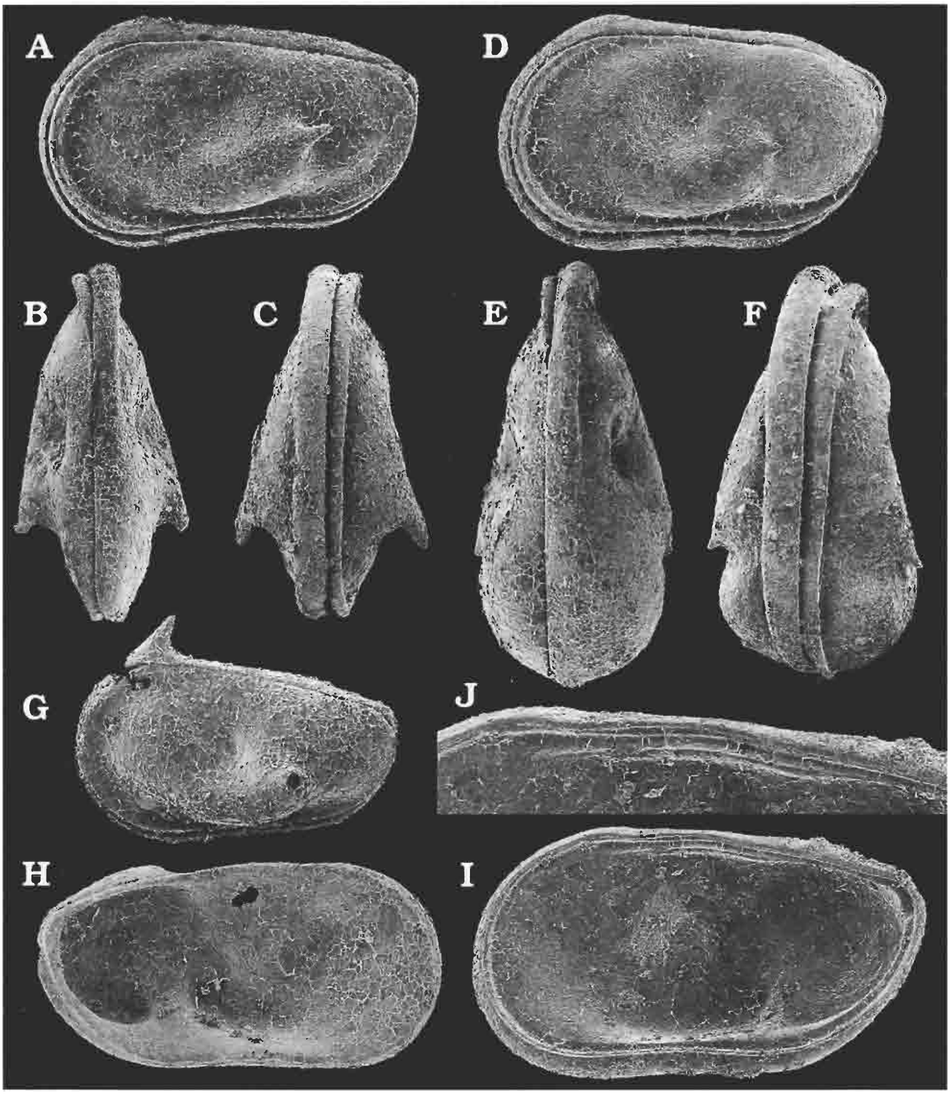


Fig. 22. **A–J**. *Muhuaella spinosa* Olempska, 1998. **A**. Tecnomorphic carapace in left lateral view; ZPAL O.XLV/104. **B**. Tecnomorphic carapace in dorsal view; ZPAL O.XLV/102. **C**. Tecnomorphic carapace in ventral view; ZPAL O.XLV/106. **D**. Holotype, heteromorphic carapace in left lateral view; ZPAL O.XLV/101. **E**. Heteromorphic carapace in dorsal view; ZPAL O.XLV/103. **F**. Heteromorphic carapace in ventral view; ZPAL O.XLV/105. **G**. Juvenile carapace in left lateral view; ZPAL O.XLV/110. **H**. Heteromorphic LV in internal view; ZPAL O.XLV/108. **I**, **J**. Heteromorphic RV in internal view with details of hinge structure; ZPAL O.XLV/112. All × 48 except for **J** which is × 87.

Healdia? sp.

Fig. 23.

Material. — 100 carapaces and 18 valves.

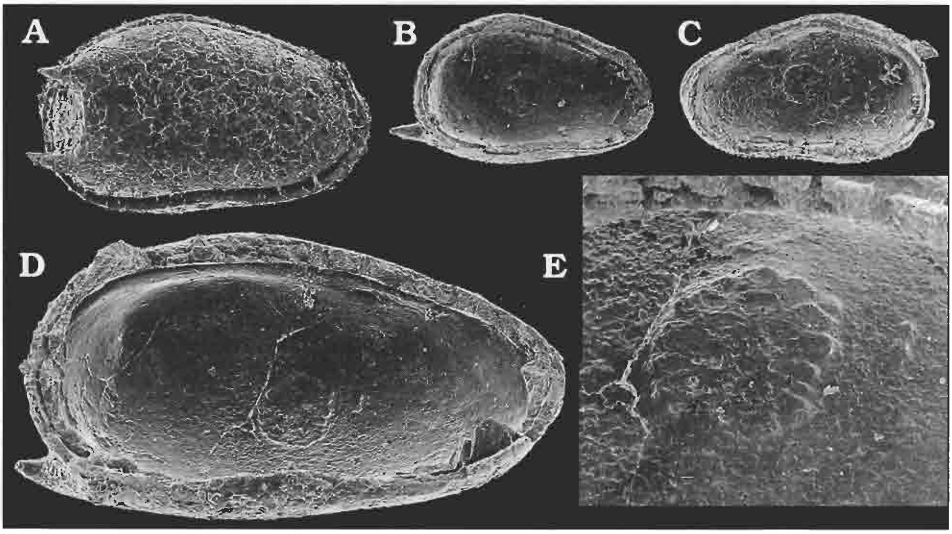


Fig. 23. **A–E.** *Healdia* sp. **A.** Carapace in right lateral view; ZPAL O.XLV/249. **B.** LV in internal view; ZPAL O.XLV/250. **C.** RV in internal view; ZPAL O.XLV/251. **D, E.** LV in internal view with details of adductorial muscle scar; ZPAL O.XLV/252. **A–C**, × 72; **D**, × 120; **E**, × 300.

Description. — A small species, with adults up to 0.56 mm in length. Subovate in lateral outline. Greatest height in posterior part; greatest width and length in central part. LV slightly larger than RV. Dorsal margin gently arched; ventral margin nearly straight. Anterior and posterior margins rounded, anterior more narrowly rounded. Vertical ridge in posterior part, terminated dorsally and ventrally by posteriorly directed spines. Adductor muscle field relatively large and of healdid type (Fig. 23E). Holosolenic contact groove well developed in LV. Duplicature absent. Surface smooth.

Remarks. — There are some specimens which have small poorly preserved pits in the posterior end, and it is possible that this species may represent *Cribroconcha* Cooper, 1941 or a species of *Healdia.*

Suborder Podocopina Sars, 1866
Superfamily Cytheracea Baird, 1850

Remarks. — This superfamily is very poorly represented in the Palaeozoic but became dominant in the Mesozoic and the Cainozoic.

Family Editiidae Knüpfer, 1967

Remarks. — Originally *Editia* Brayer, 1952 was referred to Kirkbyidae (Brayer 1952; Samoilova & Smirnova 1958; Gründel 1965; Ivanova *et al.* 1975). Later it was assigned to palaeocopids of uncertain position (Sohn 1961b; Green 1963). An adductor muscle spot characteristic for Cytheracea and the presence of an inner lamella and merodont hinge was discovered by Knüpfer (1967) in the Early Carboniferous species *Editia germanica* Knüpfer, 1967. Gramm & Egorov (1986) proposed that the subfamily Editiinae Knüpfer, 1967, a highly aberrant group previously referred to the Bythocytheridae by Knüpfer (1967), and Gramm (1975), should be regarded as a separate family of the Cytheracea (Editiidae) with only two genera: *Editia* and *Adeditia* Gramm & Egorov, 1986. Schornikov (1988) agreed with Gramm & Egorov (1986) and placed the remaining taxa previously refered to the Editiinae in the Bythocytheridae. Gramm (1992) erected the new family Adeditiidae for the sole genus *Adeditia*, which he distinguished from Editiidae by a slight difference in the adductorial muscle field and the lack of sieve-pores. In the 'Russian Manual', Abushik (1990) classified *Editia* as a mem-

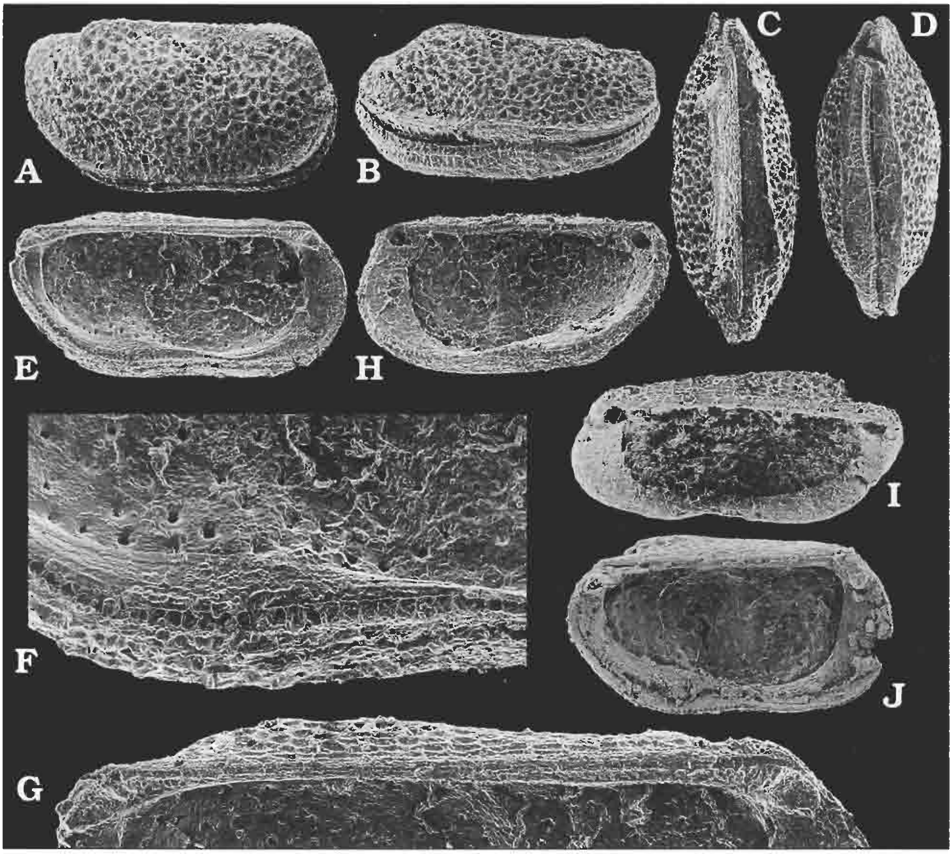


Fig. 24. **A–J**. *Editella dawubaensis* Olempska, 1998. **A**, **B**. Carapace in right lateral and oblique views; ZPAL O.XLV/202. **C**. Carapace in dorsal view; ZPAL O.XLV/203. **D**. Carapace in ventral view; ZPAL O.XLV/204. **E–G**. LV in internal view showing details of contact groove and hinge structure; ZPAL O.XLV/207. **H**. RV in internal view; ZPAL O.XLV/206. **I** . RV in internal oblique view; ZPAL O.XLV/209. **J**. LV in internal view; ZPAL O.XLV/205. All × 72 except for **F** which is × 240, and **G**, × 180.

ber of the superfamily Amphissitacea Knight, 1928 (family Knightinidae Sohn, 1970) without discussion concerning the presence of the inner lamella and the character of the adductor muscle spot. In *Proeditia* Buschmina, 1979 (type species *P. cristata*) described from the Late Devonian of Kolyma Basin, Buschmina (1979) noted (but did not illustrate) the presence of an inner lamella of equal-width. Therefore its assignment to Editiidae is not clear.

Sieve-pores in species of *Editia* were described by Gramm (1977) and Gramm & Egorov (1986).

Genus *Editiella* Olempska, 1998

Type species: *Editiella dawubaensis* Olempska, 1998 (see Olempska 1998b).

Editiella dawubaensis Olempska, 1998

Fig. 24.

Editella dawubaensis Olempska 1998b: p. 39–42, pl. 25 (40): 1–4, pl. 25 (42): 1–3.

Material. — Nine carapaces and six valves.

Description. — Carapace fragile, subrectangular in lateral view. Dorsal margin long and straight, hinge slightly depressed. Ventral margin slightly sinuate in middle. Anterior margin broadly rounded

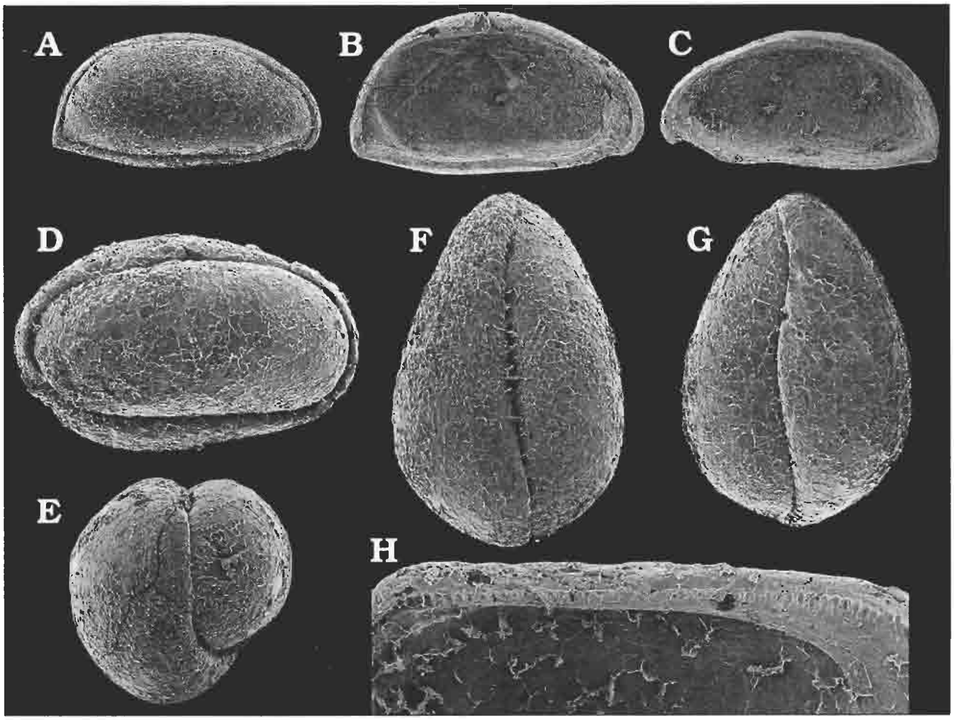


Fig. 25. **A–C.** *Acratia deloi* Geis, 1932. **A.** Carapace in right lateral view; ZPAL O.XLV/253. **B.** LV in internal view; ZPAL O.XLV/254. **C.** RV in internal view; ZPAL O.XLV/255. **D–H.** *Microcheilinella* sp. aff. *M. subcorbuloides* (Jones & Kirkby, 1886). **D.** Carapace in right lateral view; ZPAL O.XLV/256. **E.** Carapace in anterior view; ZPAL O.XLV/257. **F.** Carapace in dorsal view; ZPAL O.XLV/258. **G.** Carapace in ventral view; ZPAL O.XLV/259. **H.** Detail of hinge structure; ZPAL O.XLV/260. All × 60 except for **H** which is × 120.

with extremity at mid-height, posterior ventrally truncated. Maximum height at the posterior cardinal angle; maximum length above mid-height. In dorsal view greatest width in posterior half. LV larger. Poorly developed eye tubercle present just below anterior cardinal angle. Dorsal ridge extends from eye tubercle, subparallel to dorsal margin to 3/4 of total length, diverges posteroventrally and terminates at 1/3 of height. Dorsum outlined by the ridge is flattened and slightly depressed. The area between the dorsal ridge and the hinge line and between submarginal ridge and margin is finely reticulate; remainder of the lateral surface reticulate with moderately large fossae. Sexual dimorphism not observed, however there are differences in lateral outline among valves.

Calcareous inner lamella wide at end margins. Anterior vestibulum shallow, posterior absent. Hinge merodont (Fig. 24G). Central muscle scar includes 5 adductors in a vertical row, located at anterior part of internal vertical ridge (Fig. 24H); slightly above, one round dorsal muscle scar is visible. Normal-pore (sieve?) canals can be seen as pits on the interior surface. Crenulated contact groove in LV.

Remarks. — *Editiella dawubaensis* differs from other species of *Editia* in the lack of ridges on the lateral surface. It is most similar, in outline and absence of ridges, to *Editia* cf. *kiselensis* (Posner in Tschigova 1960) from the Tournaisian of Great Britain illustrated by Robinson (1978: pl. 7: 9). The latter differs from *E. dawubaensis* in having a poorly developed dorsal ridge in the median part of the valve. *E. dawubaensis* differs from *Editia kiselensis* illustrated by Ivanova *et al.* (1975) in the lack of a ridge parallel to the free margin and a poorly developed eye tubercle.

The described species is similar in outline and presence of dorsoposterior ridge, to *Editia albertensis* Green, 1963 from the Lower Mississippian of Alberta (Green 1963) but differs in the absence of anterior and anteroventral carinae.

Superfamily Bairdiacea Sars, 1888

Family Bairdiidae Sars, 1888

Genus *Acratia* Delo, 1930

Type species: *Acratia typica* Delo, 1930.

Acratia deloi Geis, 1932

Fig. 25A–C.
Acratia deloi Geis, 1932: p. 183, pl. 26: 3.
Acratia deloi Geis, 1932; Sohn 1975: pl. 3: 33–39.

Material. — 100 carapaces and 30 valves.

Description. — Carapace medium-sized, subtrapeziform in lateral outline. Dorsal margin strongly arched; ventral margin straight; greatest length close to ventral margin; greatest height about mid-length, sloping to posterior end with steeper angle than to anterior end. Anteroventral beak and notch visible. Anterior margin narrowly curved, posterior end pointed close to ventral margin. LV (larger) overreaches RV (smaller) all around, overlap greatest ventrally. Carapace in dorsal view moderately biconvex, greatest width subcentral. Hinge simple, ridge-groove. Carapace surface smooth. Inner lamella slightly calcified, poorly visible only in RV. Vestibule absent. Adductor muscle field not visible.

Occurrence. — Salem limestone, Mississippian of Indiana.

Genus *Bairdia* McCoy, 1844

Type species: *Bairdia curta* McCoy, 1844.

Bairdia cestriensis Ulrich, 1891

Figs 26A–E, 27.
Bairdia cestriensis Ulrich, 1891: p. 210, pl. 17: 6, 7.
Orthobairdia cestriensis (Ulrich 1891); Sohn 1960: p. 65, pl. 3: 24–27 (here additional synonymy).
Orthobairdia cestriensis (Ulrich, 1891); Sohn 1969: p. 52, pl. 8: 1–9.
Bairdia cestriensis Ulrich, 1891; Wang 1988: p. 236, pl. 60: 1–6.

Material. — 130 carapaces and 80 valves.

Description. — Carapace large, adults up to 3 mm long; subrectangular in lateral view. Dorsal margin long and almost straight, runs parallel to ventral margin; ventral margin very gently sinuate. Posteriodorsal slope much steeper than anterodorsal slope. Anterior margin rounded; posterior pointed below mid-height. Greatest height at about one-third length. Greatest thickness located near mid-length. LV slightly larger than RV. Bow-shaped projection small. Surface smooth. Surface internally smooth; inner lamella wide and thick with sigmoidal contact groove in LV (Fig. 26C). Vestibules open. Adductor muscle-scar pattern very large, arranged in bairdiid pattern, and situated at mid-length of valve. Left hinge has median list with accommodation depressions in anterior and posterior ends of ventral bar. Right hinge has median groove with thickenings at ends of ventral bar.

Remarks. — *Bairdia praesinuosa* Buschmina, 1975 from the Early Carboniferous of Kolyma massif may also be conspecific with *B. cestriensis*. This species is similar in outline to *Bairdia fragosa* Morey, 1935, illustrated by Wang (1988a) from the Wangyou Formation in Nandan of Guangxi.

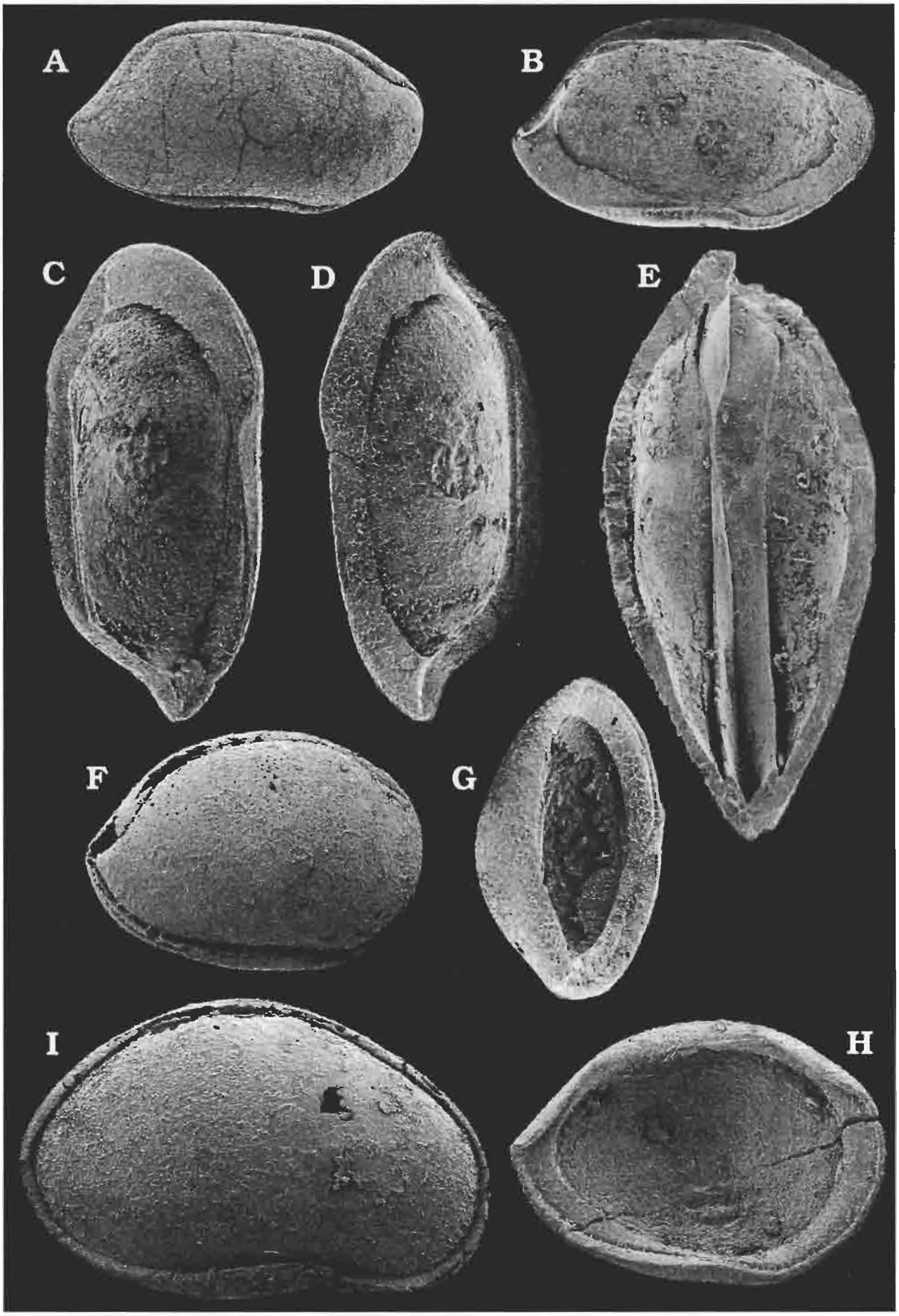
Occurrence. — Mississippian of N-America, Early Carboniferous of South China.

Bairdia cheni sp. n.

Fig. 28.
Holotype: ZPAL O.XLV/274 (Fig. 28A).
Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

→

Fig. 26. **A–E.** *Bairdia cestriensis* Ulrich, 1891. **A.** Carapace in right lateral view; ZPAL O.XLV/261. **B.** LV in internal view; ZPAL O.XLV/262. **C.** LV in oblique internal view; ZPAL O.XLV/263. **D.** RV in oblique internal view; ZPAL O.XLV/264. **E.** Internal view of broken specimen showing close-up structures and inner lamella; ZPAL O.XLV/265. **F–H.** *Bairdia* sp. **F.** Carapace in right lateral view; ZPAL O.XLV/270. **G.** LV in



oblique internal view; ZPAL O.XLV/271. **H**. LV in internal view; ZPAL O.XLV/272. **I**. *Bairdiocypris alia* Buschmina, 1977. Carapace in right lateral view; ZPAL O.XLV/273. All × 24 except for **A** and **B** which are × 12.

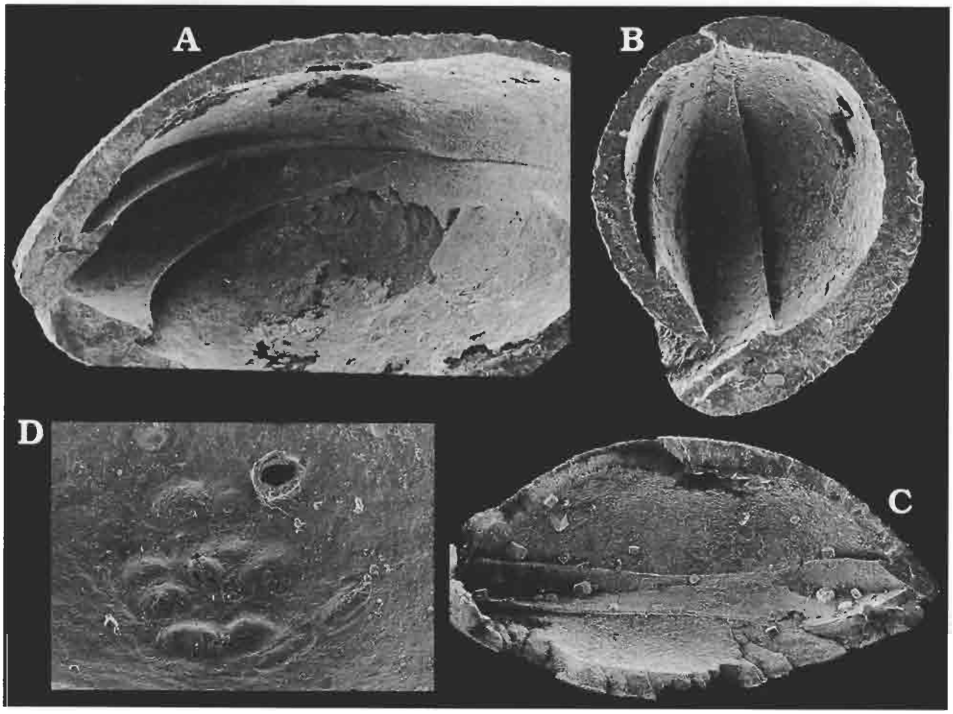


Fig. 27. **A–D.** *Bairdia cestriensis* Ulrich, 1891. **A.** Internal view of broken specimen, anterodorsal part of inner lamella indicated by an arrow; ZPAL O.XLV/266. **B.** Internal view of broken specimen, showing posterior end of carapace; ZPAL O.XLV/267. **C.** Internal view of broken specimen, showing inner lamella; ZPAL O.XLV/268. **D.** Details of adductorial muscle field; ZPAL O.XLV/269. **A,** ×48; **B,** ×60; **C,** ×30; **D,** × 120.

Type locality: Muhua, Guizhou, South China.

Derivation of the name: In honour of Dr. Chen Xuan-zhong from Guangxi Team of Oil Geology.

Diagnosis. — *Bairdia cheni* sp. n. is similar, in lateral outline and pitted surface, to *Cryptobairdia berniciana* Robinson, 1978 from the Viséan of Great Britain and to *B. lucidaformis* Buschmina, 1977 from the Tournaisian of Karaganda Basin, but differs from them in having greatest width in posterior part of carapace.

Material. — 17 carapaces and 25 valves.

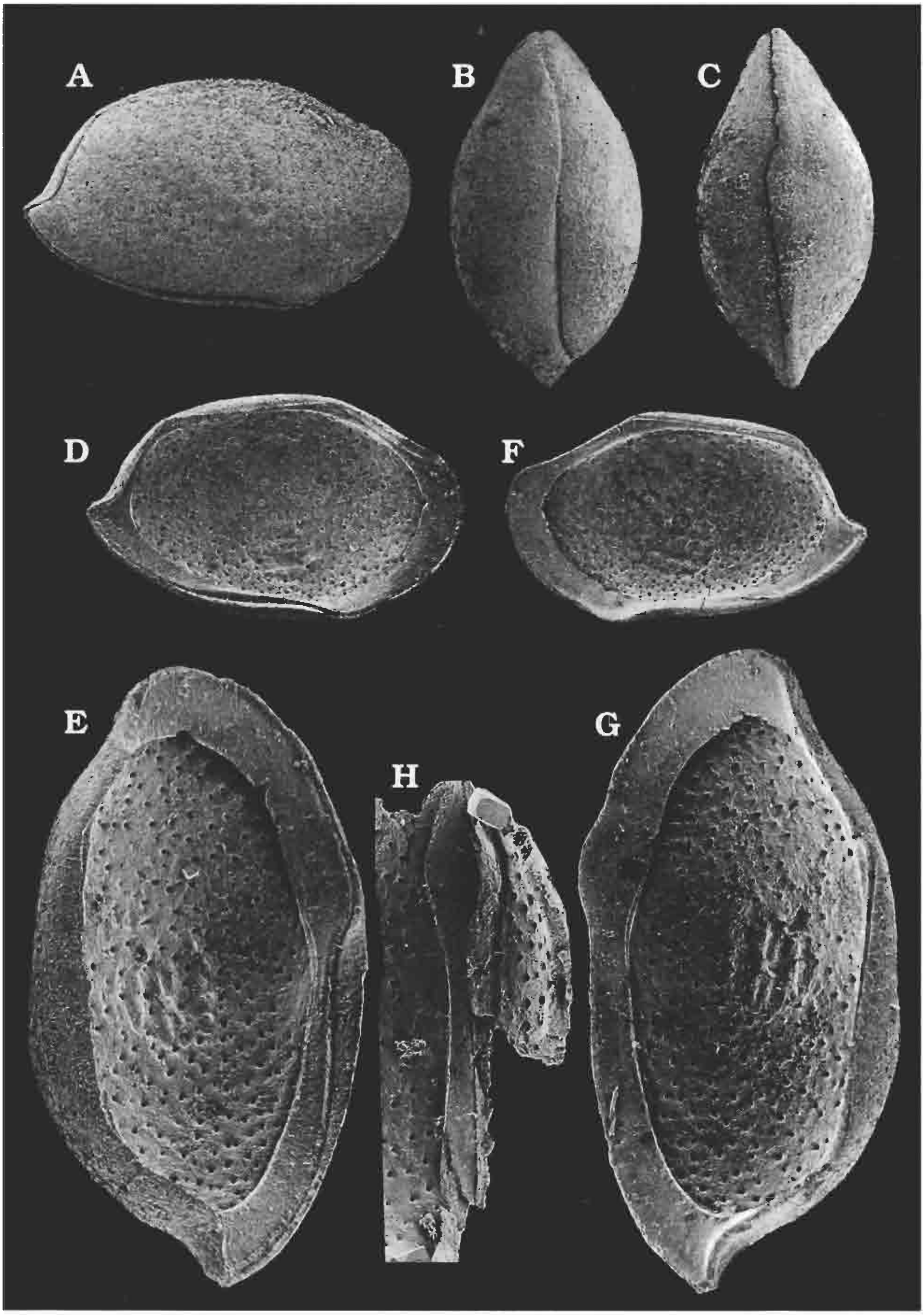
Description. — Carapace large, adults up to 2.0 mm long, moderately convex. Dorsal margin broadly arched; ventral margin nearly straight. Posterodorsal slope steeper than anterodorsal slope. Rounded anterior and acuminated posterior margin. Hinge line slightly depressed. Greatest height and thickness located at about mid-length. Greatest width in posterior part. Bow-shaped projection small. Surface finely pitted. Interior surface of valves pitted. Inner lamella of nearly equal size, with sinuate contact groove in larger LV. Adductorial muscle spot large, of bairdid type. Hinge structure a median list with accommodation depressions in anterior and posterior ends of ventral bar in LV and median groove with thickenings at ends of ventral bar in RV.

Bairdia bicornis Jones & Kirkby, 1879

Fig. 29G.

→

Fig. 28. **A–H.** *Bairdia cheni* sp. n. **A.** Holotype, carapace in right lateral view; ZPAL O.XLV/274. **B.** Carapace in dorsal view; ZPAL O.XLV/275. **C.** Carapace in ventral view; ZPAL O.XLV/276. **D, E.** LV in lateral and



oblique internal views showing inner lamella and contact structures; ZPAL O.XLV/277. **F–G**. RV in lateral and oblique internal views showing inner lamella; ZPAL O.XLV/278 . **H**. Internal view of broken specimen showing close-up ventral structures and inner lamella; ZPAL O.XLV/279. **A–D**, **F**, × 18; **E**, **G**, **H**, × 30.

Bairdia curta McCoy var. *bicornis* Jones & Kirkby, 1879: p. 568, pl. 28: 7.
Rectobairdia bicornis (Jones & Kirkby, 1879); Robinson 1979: p. 152, pl. 12: 5.

Material. — Three carapaces.

Description. — Carapace medium sized, elongate in lateral outline. Dorsal margin convex; greatest height at mid-length. Dorsoanterior and dorsoposterior margins slightly concave, sloping to carapace ends with subequal angles. Ventral margin slightly convex. Anterior and posterior ends highly acuminate, curving dorsally. Posterior end more spine-like than anterior, pointed above mid-height. LV overreaches RV all around. Carapace in dorsal view elongate, greatest width subcentral. Carapace surface smooth.

Remarks. — This species appears conspecific with *Rectobairdia bicornis* (Jones & Kirkby, 1879) illustrated by Robinson (1978) from the Viséan of Great Britain (originally a subspecies of *Bairdia curta* McCoy). It is also similar in lateral outline to *Acanthoscapha prodigiosa* Buschmina, 1979 from the Late Devonian of Kolyma Basin (Buschmina 1979).

Occurrence. — Upper Asbian (Viséan) of Great Britain.

Bairdia nanbiancunensis Wang, 1988

Fig. 29H.
Bairdia nanbiancunensis Wang, 1988: p. 239, pl. 60: 9–12.
Bairdia sp.; Coen 1989: pl. 2: 2, 3.

Material. — Three carapaces.

Description. — Carapace ellipsoidal in lateral outline. Dorsal and ventral margins convex. Anterior margin narrowly rounded, posterior pointed slightly below mid-height. Greatest height in median part. Carapace surface smooth.

Remarks. — This species is similar in lateral outline to *B. jonesi* Posner, 1951 from Viséan of the Moscow Basin.

Occurrence. — Middle Tournaisian (*S. crenulata* Zone) at Nanbiancum, Guilin; D–C transitional beds at Baihupo, Guizhou, China. This species is also present in the Tournaisian Laurel Formation of the Canning Basin, Western Australia (Jones unpublished).

Bairdia sp.

Fig. 26F–H.

Material. — Three carapaces and ten valves.

Description. — Carapace small, up to 1.2 mm long. Dorsal margin broadly arched; ventral margin slightly convex. Anterior margin broadly rounded, posterior pointed below mid-height. Greatest height at mid-length. Posterodorsal slope slightly steeper than anterodorsal slope. LV larger than RV, overreaches all around. Bow-shaped projection small. Carapace in dorsal view moderately biconvex, greatest width central. Carapace surface smooth. Internally, inner lamella is of nearly equal width. Small vestibulum in anterior end. Contact depression in LV sigmoidal, close to margin in anterior part, and centrally located in posterior part (Fig. 26G).

Remarks. — This species is different from other *Bairdia* species from Muhua in having different lateral outline and smaller carapace size, nearly equal width of inner lamella, and indistinctly pitted surface. It is similar in outline to *Bairdia seminalis* Knight, 1928 from the Pennsylvanian of Missouri and to *Bairdia gibbosa* Payne, 1937 from the late Pennsylvanian of Indiana.

Genus *Bairdiacypris* Bradfield, 1935

Type species: *Bairdiacypris deloi* Bradfield, 1935.

Remarks. — Sohn (1983) regarded *Fabalicypris* Cooper, 1946 as a junior subjective synonym of *Bairdiacypris*. The ventroanterior offset of the larger valve was supposed to be diagnostic of *Fabalicypris,* but because of variation in this feature it is inadequate to differentiate the two genera.

Bairdiacypris wangi sp. n.

Fig. 29A–F.
Bairdiacypris? sp. 1.; Wang 1988: p. 232, pl. 58: 15–16.

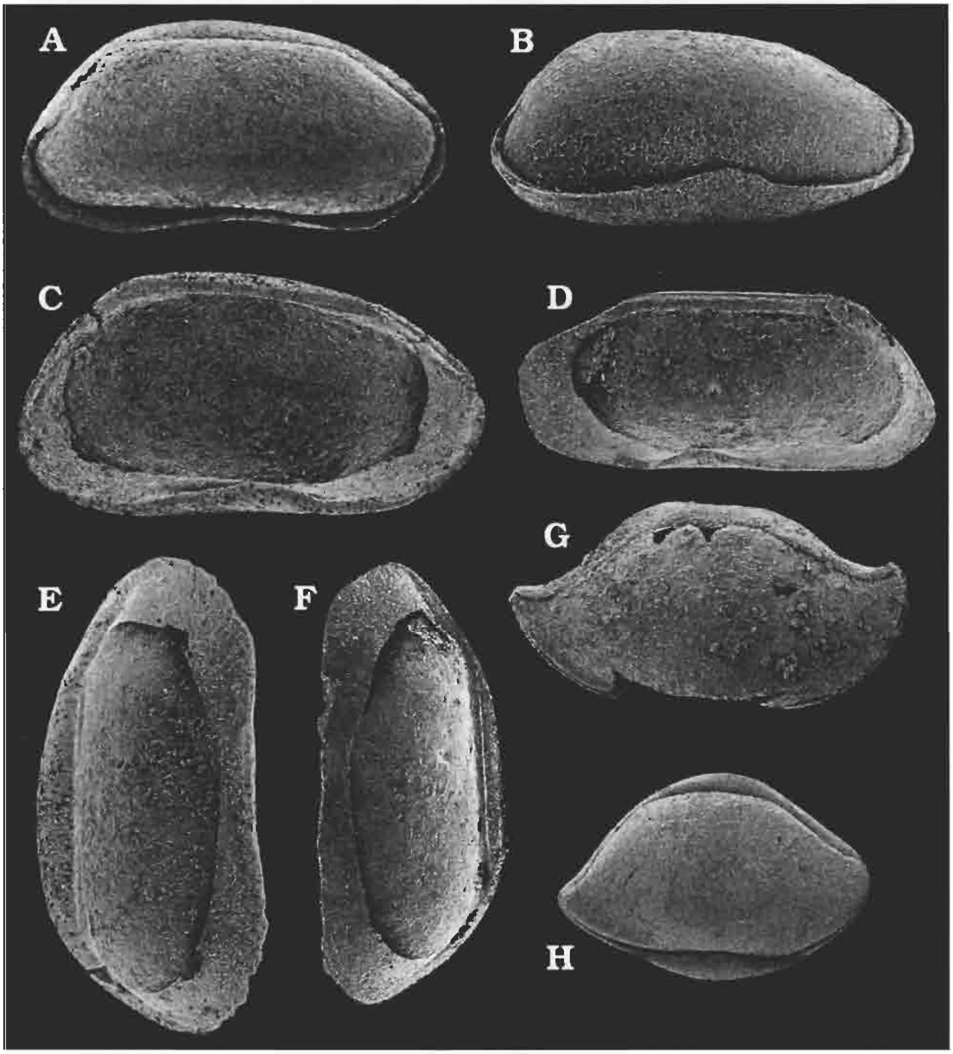


Fig. 29. **A–F**. *Bairdiacypris wangi* sp. n. **A**, **B**. Holotype, carapace in right lateral and oblique views; ZPAL O.XLV/280. **C**. LV in internal view; ZPAL O.XLV/281. **D**. RV in internal view; ZPAL O.XLV/282. **E**. LV in oblique internal view; ZPAL O.XLV/283. **F**. RV in oblique internal view; ZPAL O.XLV/284. **G**. *Bairdia bicornis* Jones & Kirkby, 1879. Carapace in right lateral view; ZPAL O.XLV/285. **H**. *Bairdia nanbiancunensis* Wang, 1988. Carapace in right lateral view; ZPAL O.XLV/286. All × 18.

Holotype: ZPAL O.XLV/280 (Fig. 29A, B).

Type horizon: Early Carboniferous, late Tournaisian, Muhua Formation.

Type locality: Muhua, Guizhou, South China.

Derivation of the name: In honour of Dr Wang Shang-qi from Nanking Institute of Geology and Palaeontology, Academia Sinica, Nanking.

Diagnosis. — *Bairdiacypris wangi* sp. n. differs from other species of genus in having a long, almost straight dorsal margin and slightly concave ventral margin.

Material. — 12 carapaces and 20 valves.

Description. — Carapace relatively large, up to 2.0 mm in length. Dorsal margin nearly straight in middle part, ventral widely concave in middle part. Anterior and posterior margins rounded, posterior narrower. Anterodorsal slope almost straight; posterodorsal slope gently arched, much steeper than anterior. LV larger and overlaps RV on all margins. Hinge of bairdiid type. Adductor muscle spot of bairdiid type. Inner lamella wide on both ends, narrower in ventral part. Contact groove in LV poorly developed (Fig. 29E). Surface smooth.

Remarks. — This species appears conspecific with *Bairdiacypris* ? sp. 1 described by Wang (1988b) from the *Siphonodella crenulata* Zone of Nanbiacun.

Occurrence. — Early Carboniferous of Nanbiacun (Guilin), South China.

Superfamily Bairdiocypridacea Shaver, 1961

Family Bairdiocyprididae Shaver, 1961

Genus *Bairdiocypris* Kegel, 1932

Type species: *Bythocypris (Bairdiocypris) gerolsteinensis* Kegel, 1932.

Bairdiocypris alia Buschmina, 1977

Fig. 26I.

Bairdiocypris alia Buschmina, 1977: p. 114, pl. 27: 6.
Bairdiocypris alia Buschmina, 1977; Wang 1988: p. 221, pl. 57: 1–2.

Material. — Four carapaces and three valves.

Description. — Carapace subtriangular in lateral outline. Dorsal margin broadly convex; ventral margin slightly concave. Greatest height at mid-length; greatest width slightly behind mid-length. Anterior and posterior margins rounded, posterior more narrowly rounded. Posterior slope steeper than anterior. LV overreaches all around, slightly more mid-ventrally. Bow-shaped projection small. Adductor muscle spot round, composed of many scars. Stop ridges absent. Inner lamella absent. Carapace surface smooth.

Remarks. — This species is similar in outline to *Bairdiocypris* sp. from the Tournaisian of the Karaganda Basin (Buchmina 1977). It is also similar in outline to *Bairdiocypris fomikhaensis* Buschmina, 1968 from the Early Carboniferous of the Kuznetsk Basin (Buschmina 1968), from which it differs in its more elongate outline.

Occurrence. — Late Tournaisian of Kazakhstan. Nanbiancun, Guilin, China, *Siphonodella duplicata* Zone.

Family Pachydomellidae Berdan & Sohn, 1961

Genus *Microcheilinella* Geis, 1933

Type species: *Microcheilus distortus* Geis, 1932.

Microcheilinella sp. aff. *M. subcorbuloides* (Jones & Kirkby, 1886)

Fig. 25D–H.

Material. — More than 100 carapaces and 70 valves.

Description. — Lateral outline suboblong, very tumid, in dorsal view asymmetrically ovoid. Dorsal margin gently arched in LV, nearly straight in RV; ventral margin nearly straight. Anterior and posterior ends rounded. Valves strongly asymmetrical. LV larger and overlaps smaller RV along ventral, posterior, and anterior margins; maximum overlap along ventral margin. Maximum width posterior to mid-length. Hinge margin in depression. Bow-shaped projections strongly developed. Surface of shell smooth. Hinge merodont (Fig. 25H). Muscle-scar pattern not visible. Calcified part of inner lamella absent. Short contact groove along anterior and posterior margins in LV, reduced along ventral margin. Internal ridge in anterodorsal part not reaching mid-height. In some larger specimens there are visible small openings of normal pore canals on the interior surface of shells.

Remarks. — *Microcheilinella* species are very poor in distinctive features. The hinge and internal structures are unknown in most of the species. The species from Muhua is a form very close in lateral outline to *M. subcorbuloides*, but only closed carapaces of the latter are known. The species from Muhua is also similar in outline to *M. inaequalis* Buschmina, 1977 from the late Tournaisian of the Karaganda Basin (Buschmina 1977) and Tournaisian of the Omolon Massif (Buschmina *et al.* 1986). *M. subcorbuloides* described by Posner (1951) is less tumid. This species differs from *Microcheilinella distorta* Geis, 1932 in having a less elongate lateral outline. In lateral outline it is also similar to *Microcheilinella* sp. 1 from the Late Carboniferous of Carnic Alps (Fohrer 1991), to *Microcheilinella* sp. from the Lower Mississippian, Banf Formation of Alberta (Green 1963: pl. 17: 19, 23), and to *Microcheilinella obesa* Cooper, 1941 from the Carboniferous of Illinois.

The internal morphology and discussion of species of *Microcheilinella* from the Muhua section will be given in a later publication (Olempska in preparation).

Acknowledgements

I would like to thank Professor Jerzy Dzik (Instytut Paleobiologii, Warsaw) for the material he placed at my disposal. All fossils described herein were collected during his expedition to China in 1994 organised in collaboration with Zhao Yuanlon of the Guizhou Institute of Technology and financed by the State Committee for Scientific Research, Poland (Project no. 6PO4D 04608 to Jerzy Dzik). I am deeply grateful to Dr. Peter J. Jones (The Australian National University, Canberra), who carefully read the manuscript and made many very helpful comments., and to Professor Hou Hongfei (Institute of Geology, Beijing), for help in completing the Muhua literature. I would like to thank Dr. Robert Lundin (Arizona State University, Tempe) and Dr. Larry Knox (Tennessee Technological University, Cookeville), who kindly revised the manuscript.

References

Abushik, A.F. (Abušik, A.F.) 1990. Superfamily Amphissitacea Knight, 1928 [in Russian]. *In:* B.S. Sokolov (ed.), *Practical Manual on Microfauna of USSR 4, Palaeozoic Ostracoda*, 112–113. Nedra, Leningrad.

Adamczak, F. 1961. On the genus *Poloniella* Gürich (Ostracoda). — *Acta Palaeontologica Polonica* **6**, 283–320.

Adamczak, F. 1968. Palaeocopa and Platycopa (Ostracoda) from Middle Devonian rocks in the Holy Cross Mountains, Poland. — *Stockholm Contributions in Geology* **17**, 1–109.

Adamczak, F. 1976. Middle Devonian Podocopida (Ostracoda) from Poland; their morphology, systematics and occurrence. — *Senckenbergiana lethaea* **57**, 265–467.

Adamczak, F. 1991. Kloedenellids: morphology and relation to non-myodocopide ostracodes. — *Journal of Paleontology* **65**, 255–267.

Adamczak, F.J. & Becker, G. 1983. Devonian Primitiopsidae (Ostracoda) from Spain and their morphological connections. — *Senckenbergiana lethaea* **64**, 267–293.

Adamczak, F.J. & Becker, G. 1991. Free margin of valves in early podocopines (Ostracoda). — *Senckenbergiana lethaea* **71**, 203–219.

Adamczak, F. & Coen, M. 1992. Perimarginal and antral structures in some primitiopsides (Palaeocopina, Ostracoda). — *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* **6**, 321–336.

Baliński, A. 1999. Brachiopods and conodonts from the Early Carboniferous of South China. — *Acta Palaeontologica Polonica* **44**, 437–451.

Bandel, K. & Becker, G. 1975. Ostracoden aus paläozoischen pelagischen Kalken der Karnischen Alpen (Silurium bis Unterkarbon). — *Senckenbergiana lethaea* **56**, 1–84.

Becker, G. & Wang Shang-qi 1992. Kirkbyacea and Bairdiacea (Ostracoda) from the Palaeozoic of China. — *Palaeontographica A* **224**, 1–54.

Benson, R. 1975. Morphologic stability in Ostracoda. — *Bulletins of American Paleontology* **65**, 13–46.

Bless, M.J.M. 1983. Late Devonian and Carboniferous ostracode assemblages and their relationship to the depositional environment. — *Bulletin de la Société belge de Géologie* **92**, 31–53.

Brayer, R.C. 1952. Salem Ostracoda of Missouri. — *Journal of Paleontology* **26**, 162–174.

Buschmina, L.S. (Bušmina, L.S.) 1968. *Early Carboniferous Ostracoda of the Kuznetsk Basin* [in Russian]. 128 pp. Nauka, Moskva.

Buschmina, L.S. (Bušmina, L.S.) 1975. Early Carboniferous ostracodes of Kolymian Massifs [in Russian]. — *Trudy Instituta geologii i geofiziki SO AN SSSR* **219**, 5–103.

Buschmina, L.S. (Bušmina, L.S.) 1977. Tournaisian ostracodes from the Karaganda Basin [in Russian]. — *Trudy Instituta geologii i geofiziki SO AN SSSR* **345**, 95–136.

Buschmina, L.S. (Bušmina, L.S.) 1979. Upper-Devonian ostracodes of the Central Kolyma Basin [in Russian]. *In:* K.W. Simakov (ed.), *XIV Pacific Science Congress. Field Excursion Guidebook for tour IX. Biostratigraphy and fauna of the Devonian–Carboniferous boundary deposits*, supplement 5, 5–70, Magadan 1979.

Buschmina, L.S. (Bušmina, L.S.) 1986. Lower Carboniferous Paraparchitidae in the south of western Siberia [in Russian]. — *Trudy Instituta geologii i geofiziki SO AN SSSR* **651**, 111–135.

Buschmina, L.S., Kotschetkova, N.M., & Tschigova, W.A. (Bušmina, L.S., Kočetkova, N.M., & Cižova, W.A.) 1986. Ostracodes of the Devonian–Carboniferous transition deposits of the Omolon Massif [in Russian]. — *Trudy Instituta geologii i geofiziki SO AN SSSR* **651**, 16–41.

Casier, J.-G., Lethiers, F., & Hou, H. 1997. Ostracodes from the Frasnian/Famennian transition beds in the Lijiaping section (Hunan, southern China). — *Comptes rendus hebdomadaires des séances de l'Academie des Sciences, Paris. Sciences de la terre et des planétes/ Earth & Planetary Sciences* **325**, 433–438.

Coen, M. 1985. Ostracodes givétiens de l'Ardenne. — *Mémoires de l'Institut Géologique de l'Université de Louvain* **32**, 1–48.

Coen, M. 1989. Ostracodes of the Devonian–Carboniferous transition beds of South China. — *Bulletin de la Société belge de Géologie* **98**, 311–317.

Coen, M. 1996. Ostracodes from the Frasnian to Viséan deposits of central Hunan, South China. *In:* M. Coen, L. Hance, & H.F. Hou (eds), Papers on the Devonian–Carboniferous transition beds of Central Hunan, South China. — *Mémoires de l'Institut Géologique de l'Université de Louvain* **36**, 55–72.

Conil, R., De Putter, T., Hou, H.F., Wei, J.Y., & Wu, X.H. 1988. Contribution á l'étude des foraminiféres du strunien et du Dinantien de la Chine sud-orientale. — *Bulletin de la Société belge de Géologie* **97**, 47–61.

Crasquin, S. 1985. Zonation par les ostracodes dans le Mississippien de l'Ouest Canadien. — *Revue de Paleobiologie* **4**, 43–52.

Crasquin-Soleau, S. 1997. First Upper Palaeozoic ostracodes from British Colombia (Canada): Harper Ranch Group. — *Palaeontographica A* **244**, 37–84.

Crasquin-Soleau, S. & Lethiers, F. 1993. Distribution provinciale des ostracodes dinantiens: implications paléocourantologiques en Europe. — *Bulletin de la Societe géologique de France* **164**, 155–163.

Dzik, J. 1997. Emergence and succession of Carboniferous conodont and ammonoid communities in the Polish part of the Variscan sea. — *Acta Palaeontologica Polonica* **42**, 57–170.

Fohrer, B. 1991. Verkieselte Flachwasser-Ostracoden und ihre Begleitfauna und -flora aus dem Oberkarbon der Karnischen Alpen (Nassfeld-Region, Kärnten, Österreich). — *Abhandlungen der Geologischen Bundesanstalt* **46**, 1–107.

Gramm, M.N. 1975. Marine Triassic Cytheracea (Ostracoda) from South Primorye (Soviet Far East). — *Palaeontographica A* **151**, 102–11

Gramm, M.N. 1976. The interrelation between the Palaeozoic ostracodes *Roundyella* and *Scrobicula.* — *Geologiska Föreningens i Stockholm Förhandlingar* **98**, 217–226.

Gramm, M.N. 1977. Sieve pores in the Palaeozoic ostracodes of the genus *Editia* [in Russian]. — *Paleontologičeskij žurnal* **1**, 151–154.

Gramm, M.N. 1984a. *Internal Structures in Palaeozoic Ostracod Carapaces* [in Russian], 1–71. AN SSSR, Nauka, Leningrad.

Gramm, M.N. 1984b. Morphophysiological basis of change in ostracod faunas [in Russian]. — *Paleontologičeskij žurnal* **3**, 50–63.

Gramm, M.N. 1984c. Janischewskyidae n. fam. and the duplicature of Palaeozoic ostracodes. — *Lethaia* **17**, 125–132.

Gramm, M.N. 1988. The free margin contact structures in some 'palaeocopid' ostracodes and their bearing on classification. *In:* T. Hanai, N. Ikeya, & K. Ishizaki (eds), Evolutionary biology of Ostracoda. — *Developments in palaeontology and stratigraphy* **11**, 159–174, Tokyo (Elsevier).

Gramm, M.N. 1991. Internal structures of the Devonian ostracode genera *Indivisia* and *Akidellina*, and their significance for classification. On the problem of Kloedenellacea [in Russian]. — *Paleontologičeskij žurnal* **2**, 45–55.

Gramm, M.N. 1992. Borovitchellidae (Platycopina) and Adeditiidae (Podocopina, Cytheracea) – the new families of Carboniferous ostracodes [in Russian]. — *Paleontologičeskij žurnal* **4**, 82–85.

Gramm, M.N. & Egorov, G.I. 1972. Late Devonian *Cavellina* (Ostracoda) with separate receptacles for eggs. — *Nature* **238**, 5362, 267–268.

Gramm, M.N. & Egorov, G.I. 1986. Early Carboniferous Editiidae (Ostracoda) and remarks on phylogeny of Cytheracea [in Russian]. — *Paleontologičeskij žurnal* **2**, 50–60.

Gramm, M.N. & Ivanov, V.K. 1975. The ostracod *Paraparchites minax* Ivanov, sp. nov. from the Permian of the U.S.S.R., and its muscle-scar field. — *Palaeontology* **18**, 551–561.

Green, R. 1963. Lower Mississippian ostracodes from the Banff Formation, Alberta. — *Research Council of Alberta, Bulletin* **11**, 1–237.

Gründel, J. 1965. Zur Kenntnis der Kirkbyacea (Ostracoda). — *Freiberger Forschungshefte C* **182**, 49–61.

Harding, J.P. 1965. Crustacea cuticle with reference to the ostracod carapace. *In:* H.S. Puri (ed.), Ostracodes as ecological and palaeontological indicators. — *Publicazioni della Stazione Zoologica di Napoli* **33** (supplemento), 9–31.

Hartmann, G. 1966. Ostracoda. *In:* H.G. Bronns (ed.), *Klassen und Ordnungen des Tierreichs. B. 5: Arthropoda 4*, 1–216. Leipzig.

Henningsmoen, G. 1953. Classification of Palaeozoic straight-hinged ostracodes. — *Norsk Geologisk Tidsskrift* **31**, 185–288.

Hou Hong-fei, Ji Qiang, Xiong Jian-fei, & Wu Xiang-he 1984. A possible stratotype of Devonian–Carboniferous boundary in Guizhou province, South China. *In:* E. Paproth & M. Streel (eds), The Devonian–Carboniferous Boundary. — *Courier Forschungsinstitut Senckenberg* **67**, 193–205.

Hou Hongfei, Ji Qiang, Wu Xianghe, Xiong Jianfei, Wang Shitao, Gao Lianda, Sheng Huaibin, Wei Jiayong, & Turner, S. 1985. *Muhua sections of Devonian–Carboniferous boundary beds*, 1–226. Geological Publishing House, Beijing.

Ivanova, N.O., Kotschetkova, N.M., Stepanaitys, N.E., & Tkatscheva, I.D. (Ivanova, N.O., Kočetkova, N.M., Stepanaitys, N.E, & Tkačeva, I.D.) 1975. Ostracoda [in Russian]. *In:* Paleontological Atlas of the Early Carboniferous strata of the Urals. — *Trudy WNIGRI* **383**, 131–238.

Ji Qiang & Chen Xuan-zhong 1987. Ostracodes from the Muhua Formation, Changshun County, Guizhou. — *Acta Micropalaeontologica Sinica* **4**, 225–230.

Ji Qiang, Wang Zengji, Sheng Huaibin, Hou Jingpeng, Feng Rulin, Wei Jiayong, Wang Shitao, Wang Hougdi, Xiang Liwen, & Fu Guomin 1989. *The Dapoushang Section. An Excellent Section for the Devonian–Carboniferous Boundary Stratotype in China.* 165 pp. Science Press, Beijing.

Jones, P.J. 1968. Upper Devonian Ostracoda and Eridostraca from the Bonaparte Gulf Basin, North-western Australia. — *Bulletin of Bureau of Mineral Resources, Geology and Geophysics* **99**, 1–93.

Jones, P.J. 1989. Lower Carboniferous Ostracoda (Beyrichicopida & Kirkbyocopa) from the Bonaparte Basin, north-western Australia. — *Bureau of Mineral Resources, Geology and Geophysics, Bulletin* **228**, 1–97.

Kaesler, R.L. 1982. Ostracoda as environmental indicators in late Pennsylvanian subsurface shales. — *Proceedings of the 3rd North American Paleontological Convention* **1**, 275–280.

Kesling, R.V. 1951. Terminology of ostracod carapaces. — *Contributions from the Museum of Paleontology University of Michigan* **9**, 93–171.

Keyser, D. 1990. Morphological changes and function of the inner lamella of podocopid Ostracoda. *In:* R. Whatley & C. Maybury (eds), *Ostracoda and Global Events*, 401–410. Chapman & Hall, London.

Knüpfer, J. 1967. *Editia germanica* sp. n., eine neue Ostracodenart aus dem Unterkarbon im Norden der DDR und zur Taxonomie der Familie Bythocytheridae Sars 1926. — *Berichte der deutschen Geselischaft für geologische Wissenschaften, Reihe A (Geologie und Paläontologie)* **12**, 193–200.

Knüpfer, J. 1968a. Einige neue Ostracoden aus dem Unterkarbon und zur Stellung der Kloedenellacea Ulrich & Bassler, 1908. — *Berichte der deutschen Geselischaft für geologische Wissenschaften, Reihe A (Geologie und Paläontologie)* **13**, 215–223.

Knüpfer, J. 1968b. Ostracoden aus dem Oberen Ordovizium Thüringens. — *Freiberger Forschungshefte C* **234**, 5–29.

Kornicker, L.S. 1961. Ecology and taxonomy of Recent Bairdiinae (Ostracoda). — *Micropaleontology* **7**, 55–70.

Kornicker, L.S. 1969. Relationship between the free and attached margins of the myodocopid ostracod shell. *In:* J.W. Neale (ed.), *The Taxonomy, Morphology and Ecology of Recent Ostracoda*, 109–135. Oliver & Boyd, Edinburgh.

Kotschetkova, N.M. (Kočetkova, N.M.) 1983. *Ostracoda from the Middle Carboniferous of the Southern Ural Mountains* [in Russian]. 119 pp. Nauka, Moskva.

Kozur, H. 1990. Neue Ostracoden-Arten aus dem Oberen Mittelkarbon (Höheres Moskovian), Mittel- und Oberperm des Bükk-Gebirges (N-Ungarn). — *Geologische-Paläontologische Mitteilungen, Innsbruck* **2**, 1–145.

Kozur, H. 1993. Relation between late Palaeozoic–Triassic Kirkbyacea and Cretaceous–Recent Punciacea (Ostracoda). *In:* K.G. McKenzie & P.J. Jones (eds), *Ostracoda in the Earth and Life Sciences*, 91–106. Proceedings of the 11th International Symposium on Ostracoda Warrnambool /Victoria/Australia /8–12 July 1991, A.A. Balkema /Rotterdam/Brookfield.

Kulagina, E.I., Rumyantseva, Z.S., Pazukhin, V.N., & Kotchetova, N.N. (Kulagina, E.I., Rumânceva, Z.S., Pazuhin, V.N., & Kočetova, N.N.) 1992. *Lower/Middle Carboniferous Boundary in the South Urals And Central Tien Shan* [in Russian]. 112 pp. Nauka, Moskva.

Lethiers, F. 1981. Ostracodes du Devonien terminal de L'Ouest du Canada: systématique, biostratigraphie et paléoécologie. — *Geobios, mémoire spécial* **5**, 1–236.

Li Zu-wang 1987. Record of ostracodes from the Lower carboniferous Chouniukou Formation in Jingyuan, Gansu. — *Acta Micropalaeontologica Sinica* **4**, 313–328.

Melnyk, D.H. & Maddocks, R.F. 1988. Ostracode biostratigraphy of the permo-Carboniferous of Central and North-Central Texas, part I: paleoenvironmental framework. — *Micropaleontology* **34**, 1–20.

Melnikova, L.M. 1979. Phylogenetic questions concerning the superfamily Primitiopsacea (Ostracoda) and some of its Ordovician representatives from Central Siberia [in Russian]. — *Paleontologičeskij žurnal* **4**, 47–59.

Moore, R.C. 1961. Glossary of morphological terms applied to Ostracoda. *In:* R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3, Crustacea, Ostracoda*, Q47–56. Geological Society of America and Kansas University Press, Lawrence.

Oertli, H.J. 1975. The conservation of ostracode tests – observations made under the scanning electron microscope. *In:* F.M. Swain (ed.), Biology and Paleobiology of Ostracoda. A Symposium University of Delaware 14–17 August 1972. — *Bulletin of American Paleontology* **65**, 549–575.

Okada, Y. 1982. Structure and cuticle formation of the reticulated carapace of the ostracode *Bicornucythere bisanensis*. — *Lethaia* **15**, 85–101.

Olempska, E. 1979. Middle to Upper Devonian Ostracoda from the Southern Holy Cross Mountains, Poland. — *Palaeontologia Polonica* **40**, 57–162.

Olempska, E. 1997. Changes in benthic ostracod assemblages across the Devonian–Carboniferous boundary in the Holy Cross Mountains, Poland. — *Acta Palaeotologica Polonica* **42**, 291–332.

Olempska, E. 1998a. On *Muhuaella spinosa* gen. et sp. nov. — *A Stereo-Atlas of Ostracod Shells* **25** (8), 35–38, London.

Olempska, E. 1998b. On *Editella dawubaensis* gen. et sp. nov. — *A Stereo-Atlas of Ostracod Shells* **25** (9), 39–42, London.

Polenova, E.N. 1982. On the systematics of Primitiopsacea and the taxonomic position of the Graviidae (Ostracoda) [in Russian]. — *Voprosy mikropaleontologii* **25**, 130–140.

Pollard, J.E. 1966. A non-marine ostracod fauna from the Coal Measures of Durham and Northumberland. — *Palaeontology* **9**, 667–697.

Posner, V.M. 1951. Lower Carboniferous ostracodes from the western flank of the Moscow Basin [in Russian]. — *Vsesouznyj Naučno-Issledovatel'skij Geologo-Razvedočnyj Neftânoj Institut, Trudy* **56**, 5–108.

Robinson, E. 1978. The Carboniferous. *In:* R. Bate & E. Robinson (eds), A stratigraphical index of British Ostracoda. — *Geological Journal Special Issue* **8**, 121–166. Seel House Press, Liverpool.

Ruggieri, G. 1966. Nuovo genere di ostracode del Carbonifero Superiore delle Alpi Carniche. — *Rivista Italiana di Paleontologia e Stratigrafia* **72**, 1–8.

Samoilova, R.B. & Smirnova, R.F. 1958. Family Kirkbyidae Ulrich *et* Bassler, 1923 [in Russian]. *In:* New ostracode genera and species — *Vsesouznyj Naučno-Issledovatel'skij Geologo-Razvedočnyj Neftânoj Institut, Trudy* **115** (Mikrofauna SSSR: 9), 255–256.

Schallreuter, R. 1968a. Ordovizische Ostracoden mit geradem Schlossrand und konkaven Ventralrand. — *Wissenschaftliche Zeitschrift der Ernst Moritz-Arndt-Universität Greiswald, Jahrang 17, Matematisch--naturwissenchaftliche Reihe 1/2*, 127–152.

Schallreuter, R. 1968b. Ordovizische Podocopida (Ostracoda): Beecherellidae. — *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **131**, 82–97.

Schneider, G.F. & Tkatscheva, I.D. (Sneider, G.F. & Tkačeva, I.D.) 1972. New Tournaisian ostracode species *Coryellina advena* of the Timan and South Urals [in Russian]. — *Paleontologičeskij žurnal* **2**, 150–151.

Schornikov, E.I. 1988. The pathways of morphological evolution of Bythocytheridae. *In:* T. Hanai, N. Ikeya, & K. Ishizaki (eds), *Evolutionary Biology on Ostracoda*, 951–965. Proceedings of the Ninth International Symposium on Ostracoda, Kodansha Ltd., Tokyo.

Scotese, C.R. & McKerrow, W.S. 1990. Revised world maps and introduction. *In:* W.S. McKerrow & C.R. Scotese (eds), Palaeozoic Palaeogeography and Biogeography. — *Geological Society, Memoir* **12**, 1–21.

Scott, H.W. 1961a. Shell morphology of Ostracoda. *In:* R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part Q Arthropoda 3, Crustacea, Ostracoda*, Q21–37. Geological Society of America and Kansas University Press, Lawrence.

Scott, H.W. 1961b. Order Palaeocopida Henningsmoen, 1953. *In:* R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3, Crustacea, Ostracoda*, Q110–194. Geological Society of America and Kansas University Press. Lawrence.

Shaver, R.H. 1953. Ontogeny and sexual dimorphism in *Cytherella bulbata*. — *Journal of Paleontology* **27**, 471–480.

Sohn, I.G. 1954. Ostracoda from the Permian of the Glass Mountains, Texas. — *Geological Survey Professional Paper A* **264**, 1–24.

Sohn, I.G. 1961a. Family Geisinidae Sohn, n. fam *In:* R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3, Crustacea, Ostracoda*, Q182–184. Geological Society of America and Kansas University Press, Lawrence.

Sohn, I.G. 1961b. Palaeocopida, Suborder and Family Uncertain. *In:* R.C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3, Crustacea, Ostracoda*, Q195–197. Geological Society of America and Kansas University Press, Lawrence.

Sohn, I.G. 1962. Stratigraphic significance of the Palaeozoic ostracode genus *Coryellina* Bradfield, 1935. — *Journal of Paleontology* **36**, 1201–1213.

Sohn, I.G. 1968. Triassic ostracodes from Makhtesh Ramon, Israel. — *Bulletin, Geological Survey, State of Israel* **44**, 1–71.

Sohn, I.G. 1969. Revision of some Girty's invertebrate fossils from the Fayetteville Shale (Mississippian) of Arkansas and Oklahoma – Ostracodes. — *Geological Survey Professional Paper* F **606**, 40–55.

Sohn, I.G. 1970. Early Tertiary ostracodes from West Pakistan. — *Pakistan Geological Survey, Palaeontologica Pakistanica* **3**, 1–91.

Sohn, I.G. 1971. New Late Mississippian ostracode genera and species from Northern Alaska. A revision of the Paraparchitacea. — *Geological Survey Professional Paper A* **711**, 1–24.

Sohn, I.G. 1972. Late Palaeozoic ostracode species from the conterminous United States. A revision of the Paraparchitacea. — *Geological Survey Professional Paper B* **711**, 1–15.

Sohn, I.G. 1977. *Paraparchites mazonensis* n. sp. (Ostracoda) from Middle Pennsylvanian ironstone concretions of Illinois. — *Fieldiana Geology* **37**, 43–59.

Sohn, I.G. 1983. Ostracodes of the 'Winifrede Limestone' (Middle Pennsylvanian) in the region of the proposed Pennsylvanian system stratotype, West Virginia. — *Bulletins of American Paleontology* **84** (316), 5–53.

Sohn, I.G. 1988. Revision of the Late Mississippian new ostracode genera in Coryell and Johnson 1939. — *Micropaleontology* **34**, 52–62.

Sohn, I.G. & Sando, W.J. 1987. Paleobathymetric significance of ostracodes from the Paine Member of the Lodgepole Limestone (Early Mississippian), Northeast Utah. — *U.S. Geological Survey Bulletin* **1690**, 1–7.

Streel, M. 1986. Miospore contribution to the Upper Famennian–Strunian event stratigraphy. — *Annales de la Société Géologique de Belgique* **109**, 75–92.

Swain, F.M. 1962. Early Middle Ordovician Ostracoda of Eastern United States. — *Journal of Paleontology* **36**, 719–744.

Sylvester-Bradley, P.C. 1941. The shell structure of the Ostracoda and its application to their palaeontological investigation. — *Annals and Magazine of Natural History*, series 11, **8**, 1–33.

Von Bitter, P.H., Sandberg, Ch.A., & Orchard, M.J. 1986. Phylogeny, speciation, and palaeoecology of the Early Carboniferous (Mississippian) conodont genus *Mestognathus*. — *Royal Ontario Museum, Life Sciences, Contributions* **143**, 1–115.

Wang Shang-qi 1979. On the classification of the superfamily Primitiopsacea. *Proceedings of the VII International Symposium on Ostracodes. Taxonomy, Biostratigraphy and Distribution of Ostracodes*, 35–39. Serbian Geological Society, Beograd.

Wang Shang-qi 1982. On the classification of Primitiopsacea (Ostracoda). — *Acta Palaeontologica Sinica* **21**, 207–216.

Wang Shang-qi 1988a. Ostracodes. *In:* Yu Chang-min (ed.), *Devonian–Carboniferous boundary in Nanbiancun, Guilin, China – aspects and records*, 209–364. Science Press, Beijing, China.

Wang Shang-qi 1988b. Ostracode faunas from the Early Carboniferous Wangyou Formation in Nandan of Guangxi and their paleoecotype. — *Memoires of Nanjing Institute of Geology and Palaeontology, Academia Sinica* **24**, 269–313.

Wang Shang-qi 1988c. Late Palaeozoic ostracode associations from South China and their paleoecological significances. — *Acta Palaeotologica Sinica* **27**, 91–102.

Wang Cheng-yuan & Yin Bao-an 1984. Conodont zonation of Early Lower Carboniferous and Devonian–Carboniferous boundary in pelagic facies, South China. — *Acta Palaeontologica Sinica* **23**, 224–238.

Whatley, R.C., Siveter, D.J., & Boomer, I.D. 1993. Arthropoda (Crustacea: Ostracoda). *In:* M.J. Benton (ed.), *The Fossil Record 2*, 343–356. Chapman & Hall, London.

Williams, M. & Vannier, J.M.C. 1995. Middle Ordovician Aparchitidae and Schmidtellidae: the significance of 'featureless' ostracodes. — *Journal of Micropalaeontology* **14**, 7–24.

Zalanyi, B. 1929. Morphosystematische Studien über fossile Muschelkrebse. — *Geologica Hungarica, Series Palaeontologica* **5**, 1–152.

Zhang Jin-jian 1985. Some new Early Carboniferous ostracodes from Shaodong, Hunan. — *Acta Micropalaeontologica Sinica* **2**, 351–360.

Zhang Jin-jian 1995. Ostracodes from the Shetianqiao Formation (Upper Devonian), Xiangxiang County, Hunan (in China). — *Acta Micropalaeontologica Sinica* **12**, 167–187.

Zhang, Z.K. 1984. Sino-Korean block and Yangtze block as part of the Pacifica continent in the late Palaeozoic. — *Bulletin of the Chinese Academy of Geological Sciences* **9**, 45–54.

Ziegler, W. & Sandberg, Ch. 1984. Important candidate sections for stratotype of conodont based Devonian–Carboniferous boundary. *In:* E. Paproth & M. Streel (eds), The Devonian–Carboniferous Boundary. — *Courier Forschungsinstitut Senckenberg* **67**, 231–239.

Ziegler, W., Ji Qiang, & Wang Chengyuan 1988. Devonian–Carboniferous boundary – final candidates for a stratotype section. — *Courier Forschungsinstitut Senckenberg* **100**, 15–19.

Skrzemionkowane płytkowodne małżoraczki z wczesnego karbonu południowych Chin

EWA OLEMPSKA

Streszczenie

Profil osadów późnego dewonu i wczesnego karbonu (turneju) w odsłonięciu Muhua, w prowincji Guizhou, w południowych Chinach, reprezentuje niskoenergetyczne środowisko z dominacją fauny planktonicznej i nektonicznej (Hou *et al.* 1985).

W soczewce wapieni w górnej części Formacji Muhua znaleziono bogaty zespół skrzemionkowanych płytkowodnych małżoraczków turnejskich. Ogółem oznaczono 32 gatunki, z których 12 jest nowych, oraz wyróżniono 3 nowe rodzaje. Opisany zespół reprezentuje tzw. „eifelski ekotyp" małżoraczkowy, wskazujący na środowisko płytkowodne, dobrze natlenione o normalnym zasoleniu. Prawdopodobnie jest to zespół allochtoniczny, przeniesiony wzdłuż skłonu basenu na miejsce depozycji w środowisku głębszym. W odróżnieniu od opisanego zespołu, fauna małżoraczkowa w niższej części profilu reprezentuje tzw. „turyngijski ekotyp" małżoraczkowy z przewagą kolczastych podokopidów, wsazujący na spokojne środowisko głębszego morza.

W pracy przedyskutowano występowanie, budowę oraz znaczenie dla taksonomii wewnętrznych struktur dotychczas określanych jako „zwapniała blaszka wewnętrzna", występujących wzdłuż brzegu wolnego u niektórych małżoraczków tradycyjnie zaliczanych do rzędu Palaeocopida Henningsmoen, 1953. Dla struktur tych wprowadzono nowy termin „zwapniała obręcz wewnętrzna", uznając, że nie jest to struktura analogiczna do „zwapniałej blaszki wewnętrznej" występujacej u małżoraczków z rzędu Podocopida Müller, 1894. Opisana struktura ma więc mniejsze znaczenie dla taksonomii paleozoicznych paleokopidów niż to było dotychczas uznawane przez niektórych badaczy.