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A monograph of the Bradoriid arthropods from the Lower Cambrian of SW China

Hou Xian-guang, David J. Siveter, Mark Williams and Feng Xiang-hong

ABSTRACT: This paper evaluates the taxonomy, biostratigraphy, and palaeogeographical significance of the Cambrian bradoriid arthropods of China, the majority of which occur in the lower Cambrian of SW China. Of bradoriid faunas world-wide, Chinese occurrences yield the greatest number of specimens and a comparatively high diversity at all taxonomic levels. Nevertheless, taxonomic diversity is much less than previously supposed. Some 80 bradoriid genera and nearly 300 species have been proposed on the basis of Chinese material. By contrast, in our study, which encompasses all of the important Chinese bradoriid faunas, we recognise only 16 genera and 21 species, including those treated under open nomenclature. Interpretation of deformed specimens as discrete species and lack of application of the rules of the International Code of Zoological Nomenclature resulted in taxonomic splitting and a proliferation of names. There are an additional 12 poorly known monotypic genera of uncertain systematic status that are listed but not treated further herein. One phosphatocopid species, a group originally thought closely related to the Bradoriida, is also described.

Most Chinese bradoriid material is known from Yunnan Province; the group also occurs in Guizhou, Henan, Hubei, Hunan, Liaoning, Qinghai, Shaanxi, Sichuan, Xinjiang and Zhejiang provinces. The first bradoriids occur just below the *Abadiella* trilobite Biozone. They are most prolific and diverse in the Qiongzhusian Stage, constituting the most abundant animal group; the succeeding Canglangpuian Stage contains fewer individuals and species. A previously proposed bradoriid biozonal scheme lacks rigour and is of little practical value: of the five supposed biozones, two correspond to trilobite zones and three are based on taxa that herein are considered to belong to a single species.

Palaeogeographically the bradoriids occur in the Middle and especially the Western subprovinces of the Cambrian of the SW China (Yangtze) Platform. Almost all of the bradoriid genera and species are endemic to that region. The palaeogeographical links with other bradoriid faunas are mostly within the Redlichiid trilobite Realm, with areas such as N China, Australia and parts of central Asia.

KEY WORDS: biostratigraphy, Bradoriida, palaeogeography, systematics

Bradoriids are small bivalved arthropods known from Cambrian and lower Ordovician rocks (e.g. Siveter *et al.* 1996; Melnikova *et al.* 1997; Siveter & Williams 1997; Williams & Siveter 1998). Adults are less than 1 mm to over 18 mm long. Bradoriids are particularly abundant in the lower Cambrian strata of China, where they occur in the Western and Middle subprovinces of the Yangtze Platform. They are known from Guizhou, Henan, Hubei, Hunan, Liaoning, Qinghai, Shaanxi, Sichuan, Xinjiang, Zhejiang and especially Yunnan provinces (Fig. 1; see also Appendix 1 for a list of localities). The bradoriid material found in this region is the most abundant and amongst the taxonomically most diverse in the world.

In SW China several bradoriid genera occur with the oldest trilobite *Abadiella*, and locally bradoriids occur at even lower levels. Bradoriids are the most abundant animals in the lower Cambrian Qiongzhusian Stage in SW China, with many more individuals than trilobites and other fossils; they reach great abundance in the *Eoredlichia–Wutingaspis* and *Yunnanocephalus–Malungia* biozones. They are much less abundant in taxa and individuals in the succeeding Canglangpuian and higher stages. Although these bradoriid faunas hold biostratigraphical potential, the previously proposed five bradoriid 'zones' for the lower Cambrian of SW China (Huo *et al.* 1991) are herein shown to be spurious.

Multitudes of bradoriid taxa have been based on Chinese material (see Huo & Shu 1985; Shu 1990a; Huo *et al.* 1991) and the bradoriid faunas of China would seem to be the most diverse in the world. However, our studies suggest that this diversity has been greatly overestimated. Of some 80 genera and nearly 300 species erected on material from China, in our study, which embraces all of the important Chinese bradoriid faunas, we recognise only 16 genera and 21 species.

The Order Bradoriida of Raymond (1935) embraced essentially what are now recognised as two distinct groups of Cambrian bivalved arthropods, namely the Bradoriida *s.s.* and the Phosphatocopida Müller, 1964. For the sake of completeness, treatment of the single Chinese phosphatocopid taxon for which modern data are known, namely *Dabashanella hemicyclica* Huo, Shu & Fu *in* Huo *et al.* 1983b, is also included herein. The differences in the shell morphology of the bradoriids and phosphatocopids have been detailed by Siveter & Williams (1997) and Williams & Siveter (1998).

In their bivalved form, general valve morphology and overall size range bradoriids and phosphatocopids are similar to ostracod crustaceans, and have traditionally been assigned to that group by most authors (e.g. see Müller 1964, 1979; Kozur 1974; Jones & McKenzie 1980; Zhang & Pratt 1993; Hinz-Schallreuter 1993a, b, c, 1998, 1999). Based on their shell morphology they have also been regarded as unrelated to the Ostracoda (e.g. Öpik 1968; Fleming 1973), or to be related to the conchostracan (e.g. Ulrich & Bassler 1931) or malacostracan (e.g. Raymond 1935) crustaceans. However, Hou *et al.* (1996; see also Shu *et al.* 1999) presented evidence from preserved soft anatomy of the Chinese genus *Kunmingella*

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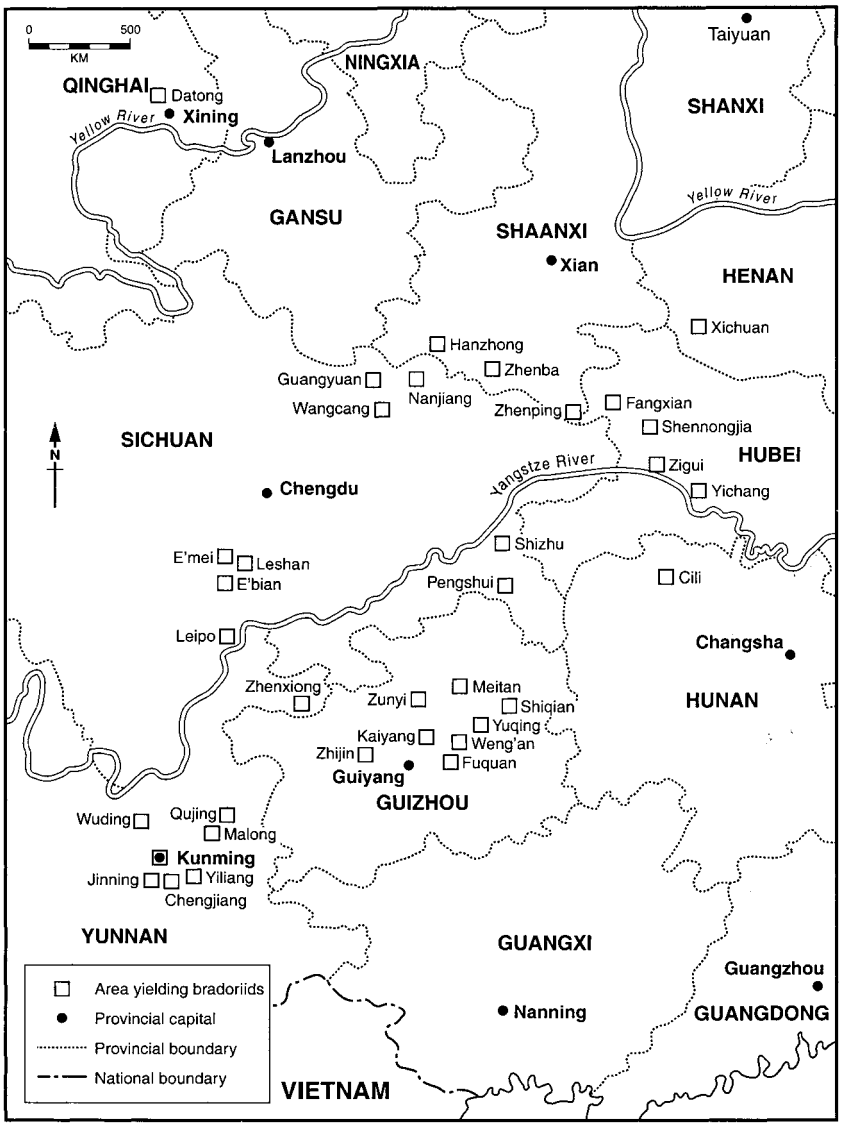

Figure 1 The bradoriid-bearing localities of SW and central China. Bradoriids also occur in the Cambrian of NW China in Liaoning Province and in the westernmost Xinjiang Province of China (not shown).

Huo, 1956 which indicates that such typical bradoriids belong outside the Crustacea *s.s.* and endorses the notion that they are not the same group as the phosphatocopids. Based on their preserved soft anatomy (see, for example, Müller 1979) the phosphatocopids are considered to be a sister group to the Crustacea *s.s.* (i.e. Eucrustacea; see, for example, Walossek & Müller 1997, 1998; Walossek 1999).

1. Material, methods and terminology

Most of the material studied in this contribution was collected by Hou Xian-guang after 1980. A few specimens, especially of *Tsunyiella luna* Zhang, 1974 from Guizhou, were collected by staff of the Institute of Geology and Palaeontology, Nanjing, in the 1970s. Most of the specimens featured herein are housed at the Research Centre for Chengjiang Biota, Yunnan University, Kunming (RCCBYU). Other important Chinese bradoriid collections are in the Museum of the Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing (NIGPAS); the Yunnan Institute of Geological Sciences, Kunming (YIGSK); the Chengdu Institute of Geology and Mineral Resources, Chengdu (CIGMR); the Geological College of Chengdu (GCC); the Department of Geology, Northwest University, Xian (NWUX); and the United States National Museum, Washington D.C. (USNM). In addition, a small collection of bradoriid specimens from Yunnan are housed at the Oxford University Museum. Where possible, we have examined the relevant Chinese type bradoriid material (for example that housed in Nanjing, Kunming and Washington), but in other instances our observations are based on illustrations in pertinent publications.

Almost all of the material was prepared mechanically, on rock slabs, using needles and a 'Vibrotool'. Such specimens were photographed with 'Aristophot' equipment using the methods of Siveter (1990). A few valves were obtained by acid digestion of rocks, and are illustrated by scanning electron microscopy.

The terminology used herein to describe the morphology of bradoriid and phosphatocopid shells (see Fig. 2) follows Siveter & Williams (1997) and Williams & Siveter (1998). In theory, the term 'lobe' is used for elongate lobal structures, and 'node' for rounded lobal structures. In some species the same lobal structure can be node-like in some individuals and lobe-like in others; that notwithstanding, in such cases consistency of the use of either lobe or node is maintained for each species description.

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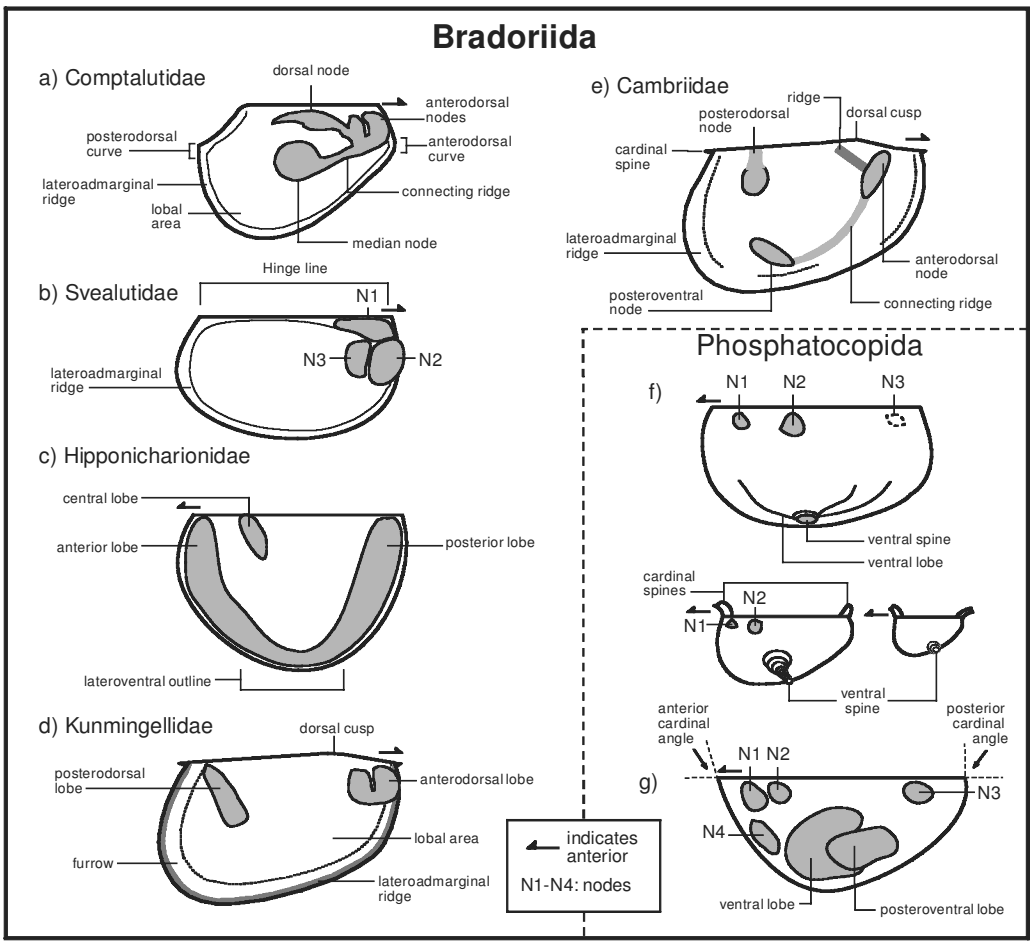

Figure 2 Terminology for the shells of bradoriids (a–e) and phosphatocopids (f, g); lateral views of valves, based on the following genera: (a) *Comptaluta*; (b) *Anabarochilina*; (c) *Hipponicharion*; (d) *Kunmingella*; (e) *Shangsiella*; (f) *Vestrogothia*; (g) *Cyclotron*. Lobal structures (lobes and nodes) are shaded.

A set of Chinese publications pertinent to the description of Bradoriida in this paper is deposited in the British Library at Boston Spa, under supplementary publication number SUP 90941.

2. History of research

Walcott (1905) was the first to document such material when he assigned a few specimens from Zhenping County in Shaanxi Province to six species of the genus *Bradoria* Matthew, 1899. Later, Mansuy (1912) described bradoriids from Yiliang County, Yunnan Province, and Ho (1942, p. 101) found bradoriids, which were identified as *Bradoria* by Yang Zui-yi (Zhongshan University), throughout a 100–200 m thick shale sequence in the Maotianshan area, Chengjiang County, Yunnan Province. However, it was Huo Shi-cheng (1956, 1965) who made the first primary systematic study of some of the lower Cambrian bradoriids of SW China. He described several new taxa from scattered (and in some cases currently unlocated) localities in southern Shaanxi and eastern Yunnan provinces.

Since 1974 many studies have documented Cambrian bradoriids and phosphatocopids from China, especially from the lower Cambrian of SW China. They include the work of Zhang (1974), Lee (1975), Li *et al.* (1975), Lin (1978, 1979), Sun (1978), Yin (1978), Tan (1980), Li (1981, 1983, 1985), Zhang (1981), Jiang (1982, 1984), Huo & Shu (1982, 1983, 1984, 1985), Huo *et al.* (1983a, 1983b, 1991), Jiang & Xiao (1985), Zhou (1985), Xiao & Zhao (1986), Zhang (1986, 1987), Cui *et al.* (1987), Hou (1987c), Tong (1987), Tan & Li (1988), Huo & Cui (1989), Zhao (1989a, 1989b), Shu (1990a, 1990b), Zhang & Pratt (1993), Hou & Bergström (1991), Hou *et al.* (1996) and Shu *et al.* (1999). Some of the bradoriids featured in these papers were systematically collected, but many were obtained by chance during the course of various mapping and other geological investigations. Notwithstanding these papers, the lower Cambrian bradoriid faunas of SW China were still poorly known in modern terms (see Hinz-Schallreuter 1999). Many of the species and genera recognised were created on the basis of no more than a few, often poorly preserved or deformed and inadequately illustrated specimens, with brief text, and often without regard to the biological species concept or the application of the rules of the International Code of Zoological Nomenclature. The result has been a proliferation of generic and specific names, the validity of many of which is questionable, and a false picture of very high species diversity.

The three monographs published on Chinese bradoriids since 1974 (Huo & Shu 1985; Shu 1990a; Huo *et al.* 1991) have substantially added to the number of taxa created. Huo & Shu's (1985) paper essentially copied descriptions and illustrations of all previously published Chinese bradoriids, and added 12 new genera and 90 new species. Huo *et al.*'s (1991)

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paper, encompassing some 80 genera and approaching 300 species, is essentially a duplication of Huo & Shu (1985) with additional genera and species. Shu's (1990a) work on the Bradoriida from Zhejiang, Hunan and Shaanxi provinces, which included new material recovered from insoluble residues from limestones, also contained tens of new genera and species, many of which were based on fragmentary and indifferently preserved material. His specimen of *Tuzoia* Walcott, 1912 is in fact a mis-identified tail-shield of the trilobitomorph arthropod *Retifacies abnormalis* Hou *et al*., 1989 (see Hou & Bergström 1997). His two new superfamilies and four new families were established on the basis of only brief definitions. His new bradoriid superfamily Haoiacea was mentioned only in the classification list in the English abstract and not in the systematics (Shu 1990a, p. 79, cf. p. 40), where it was replaced by the superfamily Hipponicharionacea Sylvester-Bradley, 1961. He cited species and generic names and established taxa on the basis of material in an unpublished Master's thesis by Tong and some of these names have been attributed to Shu (1990a) by some subsequent authors (e.g. Hinz-Schallreuter 1993a). Within his classification of the 'subclass Bradoriida' (Shu 1990a, pp. 34, 40, 41) he placed all of the Cambrian bivalved arthropods including the Ostracoda; we consider that his major taxa, such as his orders Lipabdomida and Abdomida (see also Huo & Shu 1985; Huo *et al.* 1991), which he thought to be ancestral to the ostracods and the phyllocarids respectively, are not sustainable.

Thus, although the lower Cambrian bradoriids of SW China are not uncommon, their study has often been characterised by a lack of rigour (Müller & Hinz 1993). Their restudy, with the aid of newly collected and well-illustrated material, has become a prerequisite to the elucidation of their morphologies, systematics, biostratigraphy and palaeogeographical significance. Thus, in 1980 Hou Xian-guang systematically collected bradoriids at sections at Gaoqiao, Sichuan Province and Qiongzhusi in Kunming City, Yunnan Province. Further systematic collecting was undertaken at sections in Yunnan Province in 1984: at Meishucun in Jinning County, at Dapotou, Hongjiachong and Maotianshan in Chengjiang County, at Kebaocun in Yiliang County, and also Shapushan and Shishan in Wuding County. This fieldwork yielded large numbers of diverse bradoriids, including material from some localities where previously (see Huo *et al.* 1983a, b; Huo & Shu 1985) the presence of only *Kunmingella douvillei* (Mansuy, 1912) had been reported. It was also during the course of this fieldwork that the first soft-bodied fossils of the lower Cambrian Chengjiang Konservat-Lagerstätte were discovered by Hou Xian-guang, at Maotianshan in Chengjiang County and Meishucun in Jinning County (e.g. Zhang & Hou 1985; Hou 1987a, b; Hou & Sun 1988; see Hou & Bergström 1997).

3. Stratigraphy, localities and facies

The Chinese bradoriid localities mentioned in the text, in Guizhou, Henan, Hubei, Hunan, Qinghai, Shaanxi, Sichuan and Yunnan provinces, are shown in Figure 1 and listed in Appendix 1. Bradoriids are also known from the lower Cambrian of Liaoning Province in NE China (see *Alutella* below) and from Xinjiang Province in westernmost China (see *Liangshanella, Tsunyiella* and *Dabashanella* below).

The western part of the Cambrian of the SW China ('Yangtze') Platform is termed the Western Subprovince (Fig. 3). It includes lower Cambrian bradoriid-bearing deposits at Hanzhong City in Shaanxi Province, Guangyuan City, Leshan City and E'mei County in Sichuan Province, and Chengjiang, Jinning and Wuding counties and Kunming City in Yunnan Province. The Western Subprovince contains abundant bradoriids and trilobites and is the standard area for the lower Cambrian stratigraphy and biostratigraphy of China (e.g. Zhou & Yuan 1980; Luo *et al.* 1994). The lower Cambrian in this area is characterised by detrital deposits and was traditionally divided, in ascending order, into the Qiongzhusi (Chiungchussu), Canglangpu (Tsanglangpu) and Longwangmiao (Lungwangmiao) formations. The Yuhucun Formation was formerly included within the Precambrian, but with the finds and study of small shelly fossils the upper part of that formation is now placed in the lower Cambrian. The Western Subprovince has yielded the most abundant and diverse bradoriid faunas in China (e.g. *Hanchiangella minor* Huo, 1956, *Kunyangella cheni* Huo, 1965, *Emeiella venusta* Lee, 1975 and *Kunmingella douvillei*).

The Middle Subprovince of the SW China Platform lies E of the Western Subprovince (Figs 1, 3). It is characterised by shallow shelf deposits in which, compared to the Western Subprovince, bradoriids are much reduced in numbers of genera and species, with *Tsunyiella luna* being a typical species. The Middle Subprovince includes bradoriid-bearing Cambrian deposits at Zhenba and Zhenping counties in Shaanxi Province, Zigui County in Hubei Province, Pengshui and Shizhu counties in Sichuan Province, and Zunyi (= Tsunyi) City and Yuqing County in Guizhou Province. Both the lithofacies and biofacies of the lower Cambrian differ between areas of the Middle Subprovince, a fact reflected in the application of different stratigraphical nomenclatures. In western Hubei and eastern Sichuan the lower Cambrian strata are, in ascending order, the Shuijingtuo, Shipai, Tianheban and Shilungdong formations. The stratigraphical nomenclature of the lower Cambrian of Guizhou Province differs from that of the other areas of the Middle Subprovince (see Fig. 3).

In the northern area of the SW China Platform the lithofacies and biofacies of certain lower Cambrian sections, such as those in Zhenba and Zhenping counties of Shaanxi Province and in Xichuan County in southwestern Henan Province, embrace clastics and carbonates and thus differ from those of the Western and Middle subprovinces. Such sections may represent a special palaeogeographical area within the SW China Platform. Deposits in Zhenba County are characterised by the bradoriids *Kunmingella douvillei* and *Alutella* cf. *A. nakamurai* Kobayashi & Kato, 1951 and those in Xichuan County by species of *Alutella* Kobayashi & Kato, 1951 and *Liangshanella* Huo, 1956.

4. Biostratigraphy

The stratigraphical range of bradoriid species of the lower Cambrian of SW China is given in Figure 4. The stratigraphical distribution of these bradoriids is in part elucidated by their occurrence in five key sections, collections from which were made by Hou Xian-guang (Figs 5–9, sections also detailed in Appendix 2): Shapushan section in Wuding County, Qiongzhusi section in Kunming City, Maotianshan section in Chengjiang County and Meishucun section in Jinning County, Yunnan Province; and Gaopo section in Gaoqiao, E'mei County, Sichuan Province. Collectively these sections contain nearly all of the bradoriid species described in this paper.

Beginning with the occurrence of the first small shelly fossil assemblage, the lower Cambrian of the SW China Platform is divided into 14 biozones. The lowest three biozones are based on small shelly fossils, the succeeding 11 biozones are based on trilobites (Zhou & Yuan 1980). *Abadiella*, the oldest trilobite in the whole *Redlichia* trilobite faunal region, gives its name to

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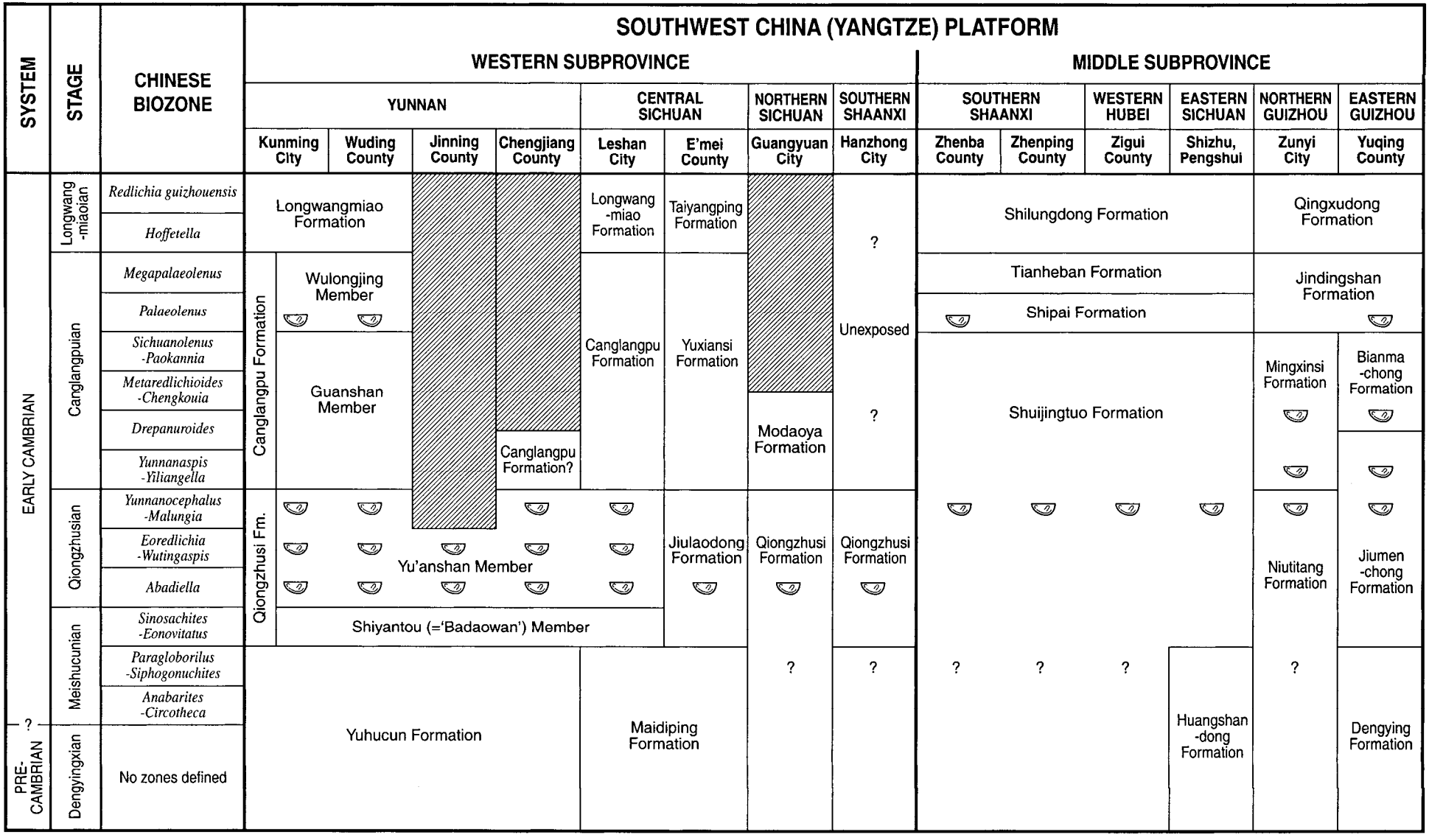

Figure 3 Stratigraphy of bradoriid-bearing lower Cambrian areas of the SW China Platform (see Luo *et al.* 1994); the icon represents the presence of bradoriid faunas; the records of the phosphatocopid *Dabashanella* are not plotted.

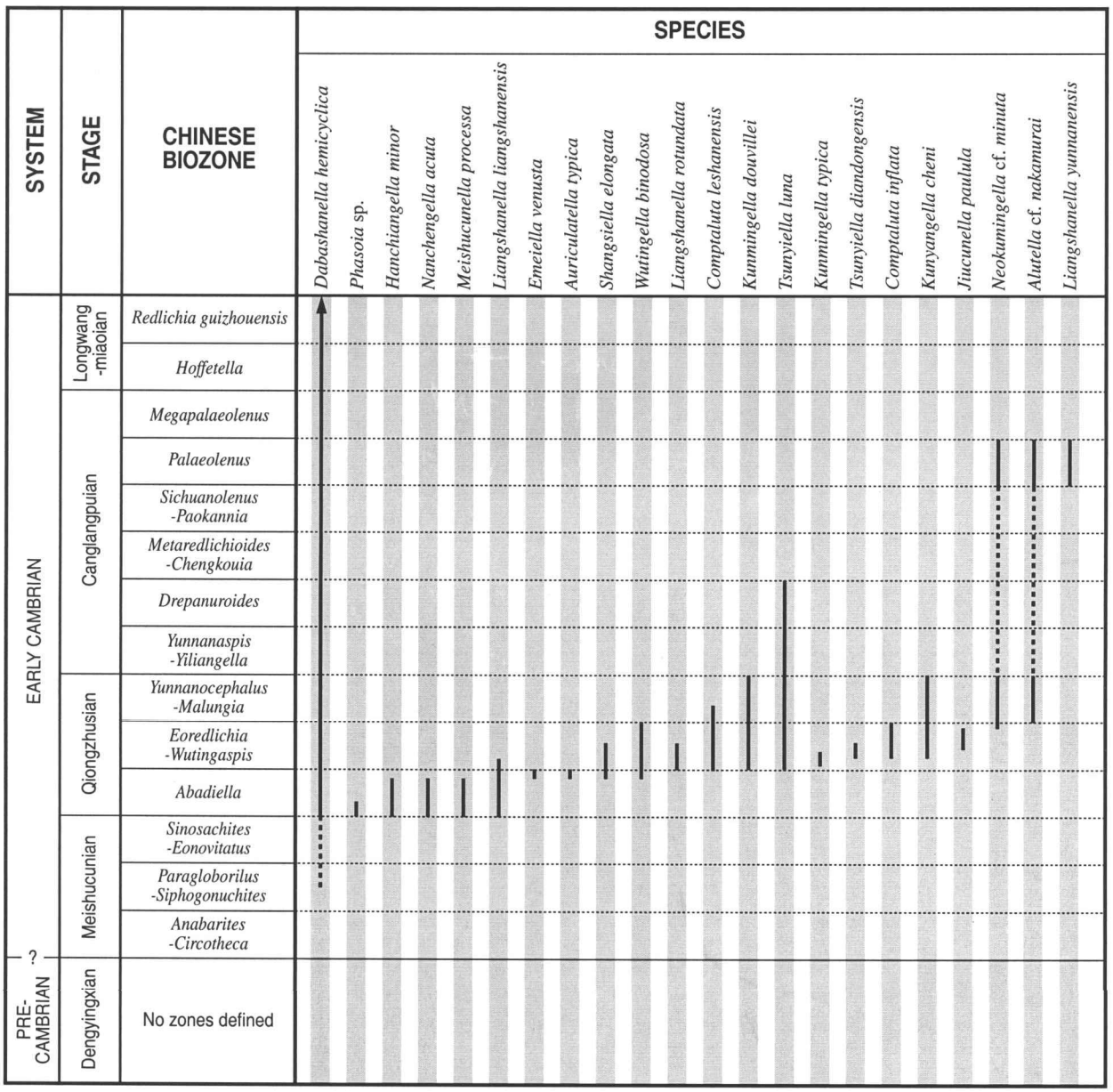

Figure 4 Stratigraphical distribution of bradoriids and the phosphatocopid *Dabashanella hemicyclica* within the lower Cambrian of SW China; a dotted line indicates inferred occurrence; the questionable occurrence of *D. hemicyclica* in rocks of possible Meishucunian age is based on records of *Xinjiangella venustois* Jiang & Xiao, 1985 and

the fourth biozone. The latter appears to correspond to a very short time interval and in Yunnan Province is represented by less than 3 m of sediment.

Huo & Shu (1985, pp. 52–9; see also Huo *et al.* 1991, pp. 60–63) introduced, in ascending order, the following bradoriid biozones for the Yu'anshan Member, Qiongzhusi Formation, of Yunnan Province: *Hanchiangella* and *Nanchengella*; *Hanchungella* and *Emeiella*; *Pseudokunmingella* and *Kunmingella* (*Angustacostatella*) *angustacostata*; *Kunmingella* (*Validocostatella*) *maotianshanensis*; and *Kunmingella* (*Validocostatella*) *acuta*. However, these biozones are of little practical value. Notwithstanding the fact that at a few localities *Nanchengella* occurs a little earlier in the succession than *Abadiella*, in general both *Hanchiangella* and *Nanchengella* have the same stratigraphical distribution as the *Abadiella* Biozone. With regard to the so-called *Hanchungella* and *Emeiella* Biozone, herein *Hanchungella* is regarded as a junior synonym of *Liangshanella*; moreover, sequences in E'mei County, Sichuan Province, and Chengjiang, Jinning and Wuding counties, Yunnan Province, show that the bradoriids *Emeiella* and *Auriculatella* have approximately the same stratigraphical range as the trilobite *Tsunyidiscus*, extending a few metres through the Yu'anshan Member of the Qiongzhusi Formation. Furthermore, all of the taxa on which Huo & Shu based their three youngest 'biozones' are herein considered to belong to a single species, namely *Kunmingella douvillei*.

In Yunnan Province *Abadiella* occurs at levels associated with the bradoriids *Nanchengella acuta* Huo, 1956, *Hanchiangella minor* Huo, 1956, *Liangshanella liangshanensis* Huo, 1956, *Meishucunella processa* Jiang, 1982 and *Phasoia* sp. In the Shapushan section of Yunnan Province (Fig. 5), *N. acuta* occurs at level W1, just below *Abadiella* which appears at level W2. *N. acuta, H. minor*, *M. processa* and *Phasoia* sp. disappear from the stratigraphic record more or less at the same time as *Abadiella*, while *L. liangshanensis* continues into the lower part of the overlying *Eoredlichia–Wutingaspis* Biozone.

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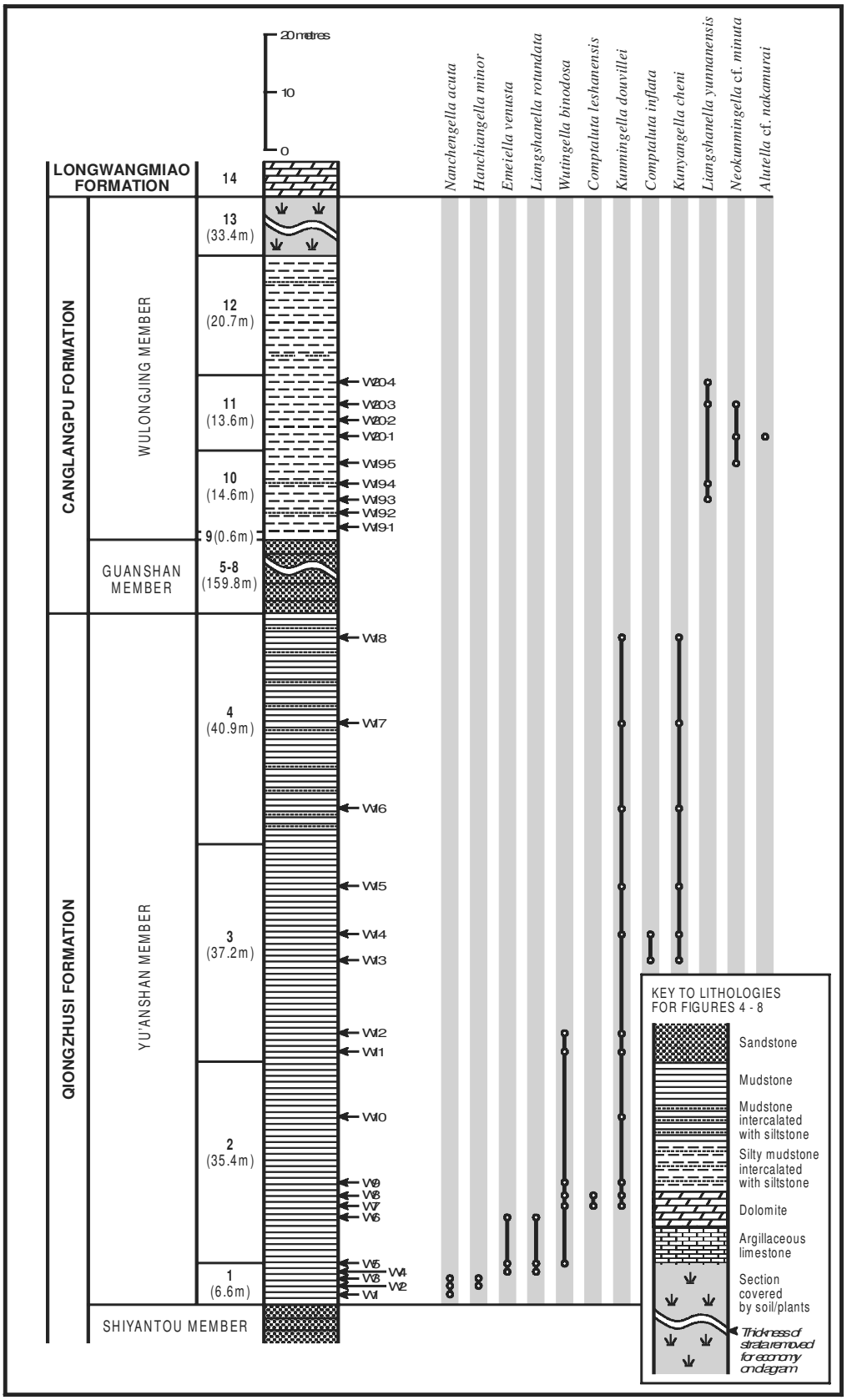

Figure 5 Lithostratigraphy and occurrence of bradoriids in the Shapushan section, Wuding County, Yunnan Province; position of sampled horizons is approximate; horizons W2 and W3 also yielded the trilobite *Abadiella*; horizon W6 has the trilobite *Tsunyidiscus aclis* and the large bivalved arthropod *Isoxys auritus*; horizons W19-1 and W19-2 have abundant trilobites and *I. auritus*.

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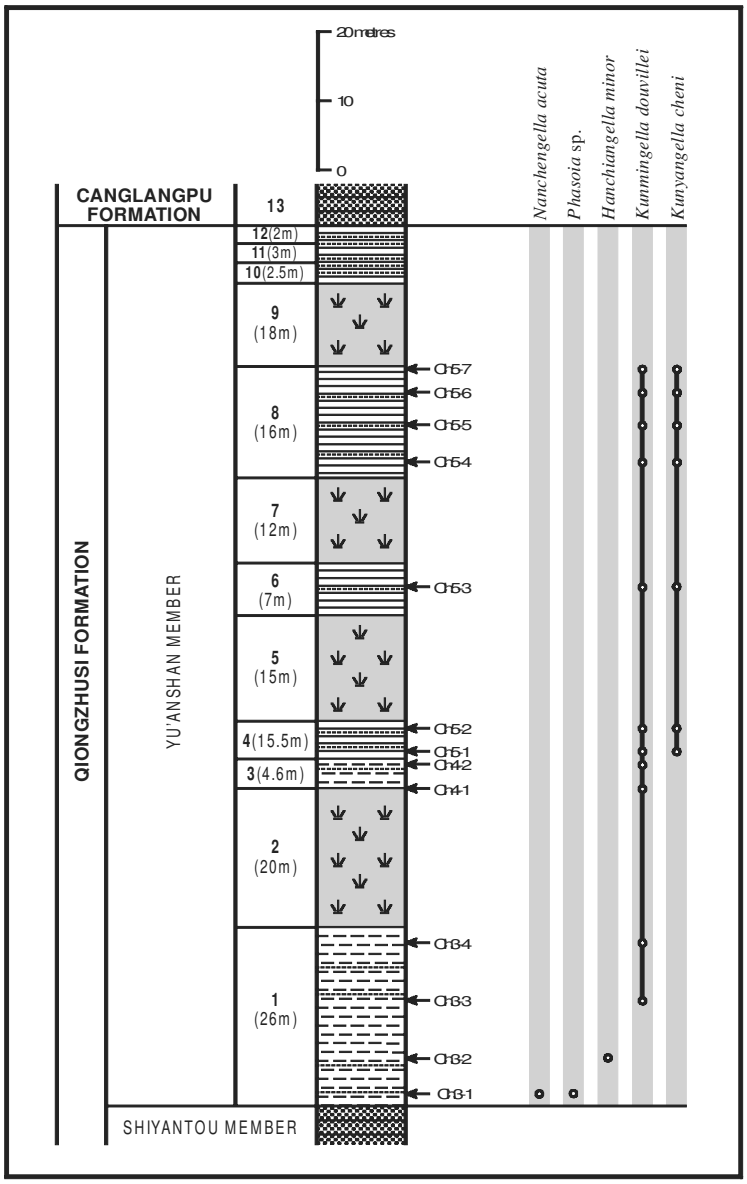

Figure 6 Lithostratigraphy and occurrence of bradoriids in the Qiongzhusi section, Kunming City, Yunnan Province; position of sampled horizons is approximate; key for lithologies as for Figure 5; the section also yields the trilobites *Abadiella* (horizon Ch3-1), *Eoredlichia intermedia* (horizons Ch5-1, Ch5-2, Ch5-4 and Ch5-5) and *Yunnanocephalus yunnanensis* (horizon Ch5-7), the large bivalved arthropod *Chuandianella ovata* (horizons Ch5-1 to Ch5-6) and hyolithids (horizons Ch5-1 to Ch5-5).

Abadiella is succeeded by the trilobite *Tsunyidiscus* and the bradoriid *Emeiella venusta* Lee, 1975. In the sections at Gaoqiao in Sichuan Province (Fig. 9) and Liangshan and Yuanshan in Shaanxi Province the bradoriid *Auriculatella typica* Tan, 1980 is associated with *E. venusta* and *Tsunyidiscus*. *Shangsiella elongata* Lee, 1975 occurs at approximately the same level, but only at Changjianggou, Guangyuan City, Sichuan Province, and extends into the overlying *Eoredlichia–Wutingaspis* Biozone.

In the sections at Shapushan, Yunnan Province, and at Gaoqiao, Sichuan Province, the bradoriid *Wutingella binodosa* Zhang, 1974 occurs stratigraphically with and above *E. venusta*, into the upper part of the Qiongzhusi Formation, where it disappears. The overall ranges of the bradoriids *Kunmingella douvillei* and *Kunyangella cheni* are similar and span approximately the *Eoredlichia–Wutingaspis* and *Yunnanocephalus–Malungia* trilobite biozones. *K. douvillei* appears shortly above the uppermost occurrence of *E. venusta* and below the lower part of the stratigraphical range of *Eoredlichia*. In Yunnan Province *K. douvillei* first appears about 14 m (Qiongzhusi section; Fig. 6) and 7 m (Maotianshan section; Fig. 7) above the base of the *Abadiella* Biozone and disappears near the top of the Qiongzhusian Stage. *K. cheni* makes its lowest stratigraphical appearance in the *Eoredlichia–Wutingaspis* Biozone, but below *Eoredlichia* itself, and ranges to the top of the Qiongzhusi Formation.

The bradoriids *Comptaluta leshanensis* (Lee, 1975) and *K. douvillei* first appear at the same level in the Shapushan section (Fig. 5), about 15 m above the base of the *Abadiella* Biozone. *C. leshanensis* occurs at a similar level in the Fandian section in Leshan City, Sichuan Province (see Lee 1975); at Maotianshan (Fig. 7) it is found only in the upper part of the Qiongzhusi Formation. Both *C. leshanensis* and *K. douvillei* range from the *Eoredlichia–Wutingaspis* Biozone into the *Yunnanocephalus-Malungia* Biozone. The bradoriids *Comptaluta inflata* Zhang, 1974, *Jiucunella paulula* Hou & Bergström, 1991, *Liangshanella rotundata* (Huo 1956), *Tsunyiella diandongensis* Tong *in* Huo & Shu 1985 and *Kunmingella typica* Huo

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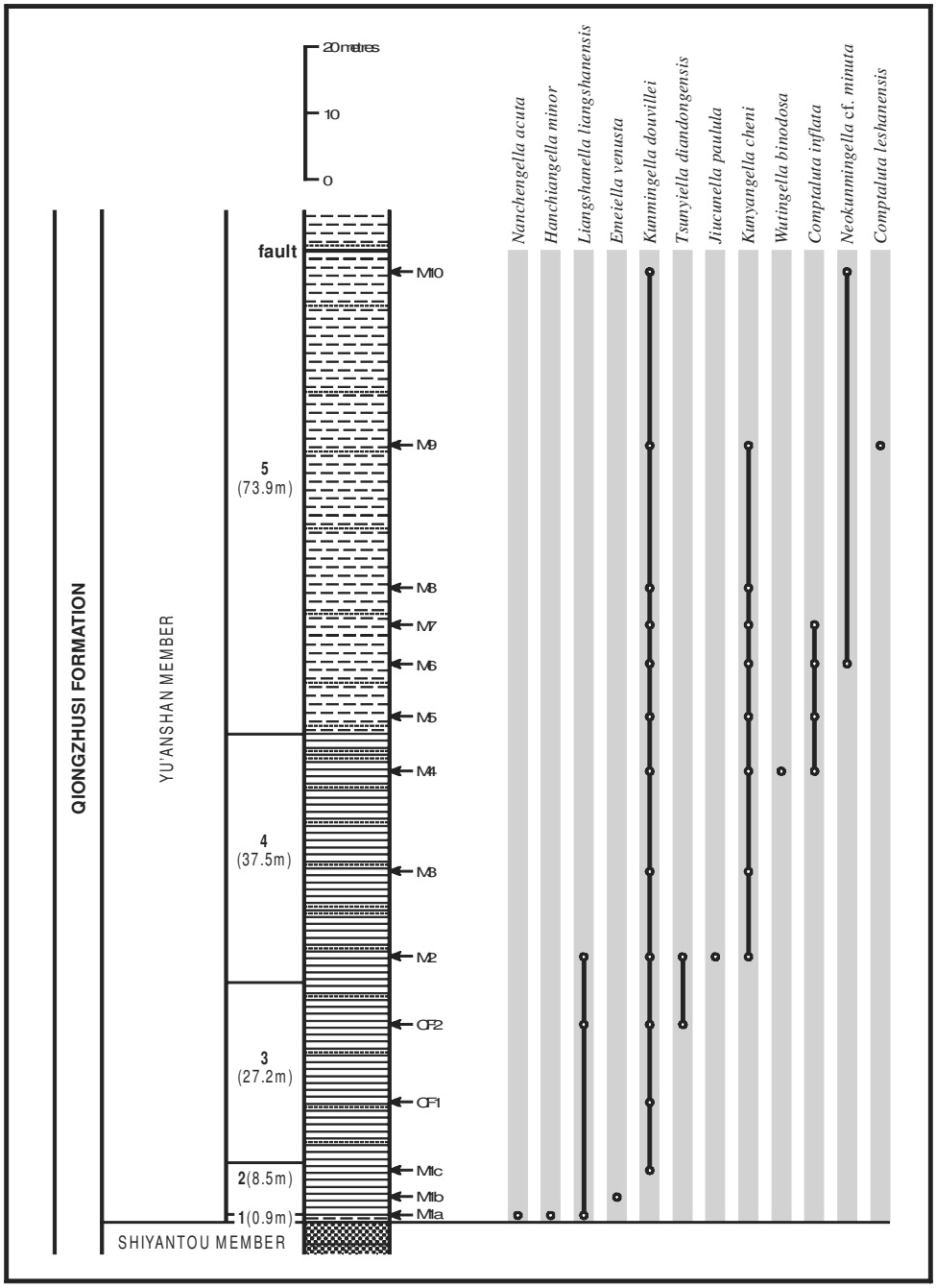

Figure 7 Lithostratigraphy and occurrence of bradoriids in the Maotianshan section, Chengjiang County, Yunnan Province; position of sampled horizons is approximate; key for lithologies as for Figure 5; the section also yields the trilobites *Abadiella* (horizon M1a), *Tsunyidiscus aclis* (horizon M1b), *Eoredlichia intermedia* (horizons M2 to M7, M9, M10) and *Yunnanocephalus yunnanensis* (horizons M2, M5, M6), and the large bivalved arthropod *Chuandianella ovata* (horizon M7).

& Shu, 1985 are confined to the *Eoredlichia–Wutingaspis* Biozone.

Four species have long stratigraphical ranges. In Yunnan Province the bradoriid *Neokunmingella* cf. *N. minuta* Zhang, 1974 is found in the middle part of the Qiongzhusi Formation at the Maotianshan (Fig. 7), Shishan and Kebaocun sections, in the top of the Qiongzhusi Formation at the Yaoying section and in the upper part of the Canglangpu Formation at the Shapushan (Fig. 5) and Shijiangjun sections. The lowest stratigraphical occurrence of the bradoriid *Alutella* cf. *A. nakamurai* Kobayashi & Kato, 1951 is in a black limestone of the Shuijingtuo Formation in Zhenba County, Shaanxi Province, at a level roughly corresponding to the middle part of the Yu'anshan Member of the Qiongzhusi Formation; it also occurs in the *Palaeolenus* Biozone within the Canglangpu Formation at Kunming City and in Wuding County, Yunnan Province. The bradoriid *Tsunyiella luna* Zhang, 1974 is widely distributed in the Middle Subprovince of the SW China Platform, and occurs from the *Eoredlichia–Wutingaspis* Biozone to the top of the *Drepanuroides* Biozone. The phosphatocopid *Dabashanella hemicyclica* Huo *et al.*, 1983 perhaps occurs as low as the upper part of the Meishucunian Stage (Jiang & Xiao 1985), and is also reported from the middle Cambrian Maojiagou Formation in Datong County, Qinghai Province (Huo *et al.* 1991). The bradoriid *Liangshanella yunnanensis* Zhang, 1974 is found only in the *Palaeolenus* Biozone.

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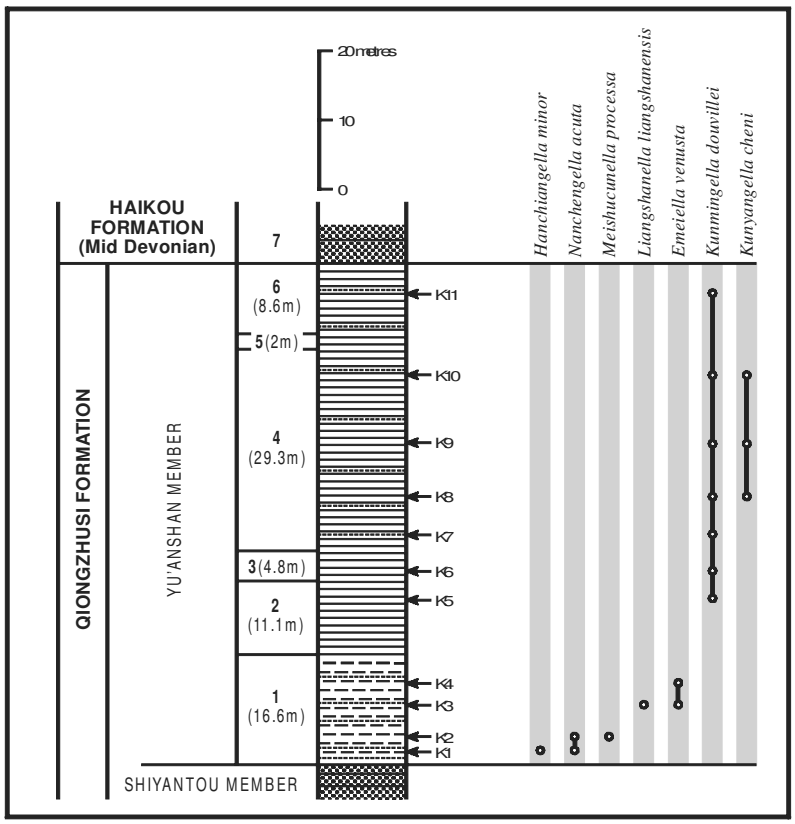

Figure 8 Lithostratigraphy and occurrence of bradoriids in the Meishucun section, Jinning County, Yunnan Province (stratigraphy after Luo *et al.* 1994); position of sampled horizons is approximate; key for lithologies as for Figure 5; horizon K2 also yields the trilobite *Abadiella.*

5. Palaeogeography

During early and mid-Cambrian times, SW China is thought to have formed part of a discrete South China Plate lying at low latitudes to the NE of the Gondwana palaeocontinent (Fig. 10). The area lay within the Redlichiid trilobite biogeographical Realm, whose faunas also characterise the Cambrian of N China, Australia, SE Asia and parts of central Asia (McKerrow *et al.* 1992). To the W, the Cambrian faunas of North America (including Greenland), southern Britain and

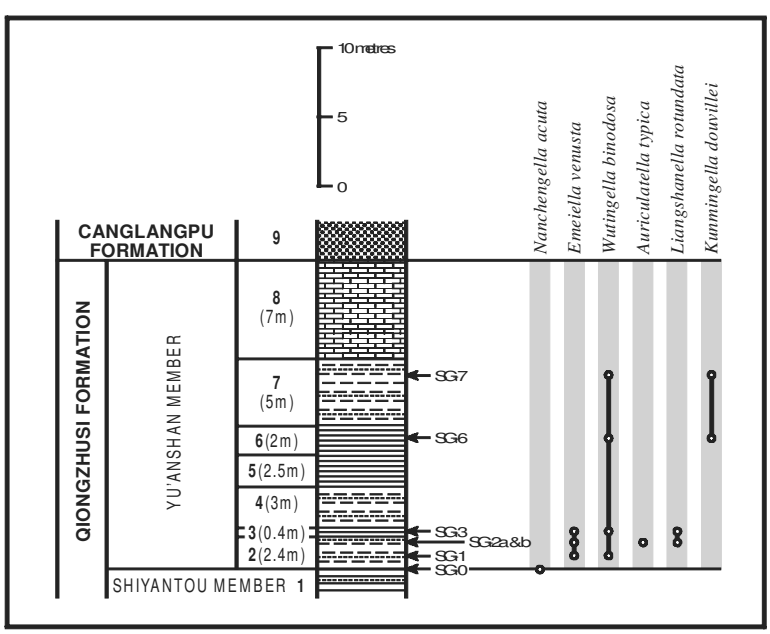

Figure 9 Lithostratigraphy and occurrence of bradoriids in the Gaopo section, Gaoqiao, E'mei County, Sichuan Province; position of sampled horizons is approximate; key for lithologies as for Figure 5; the section also yields the large bivalved arthropod *Chuandianella ovata* (horizons SG-1, SG-2b and SG-3) and the trilobites *Abadiella* (close to horizon SG-O) and *Tsunyidiscus aclis* (horizons SG-1, SG-2a); horizon SG-2a also contains hyolithids.

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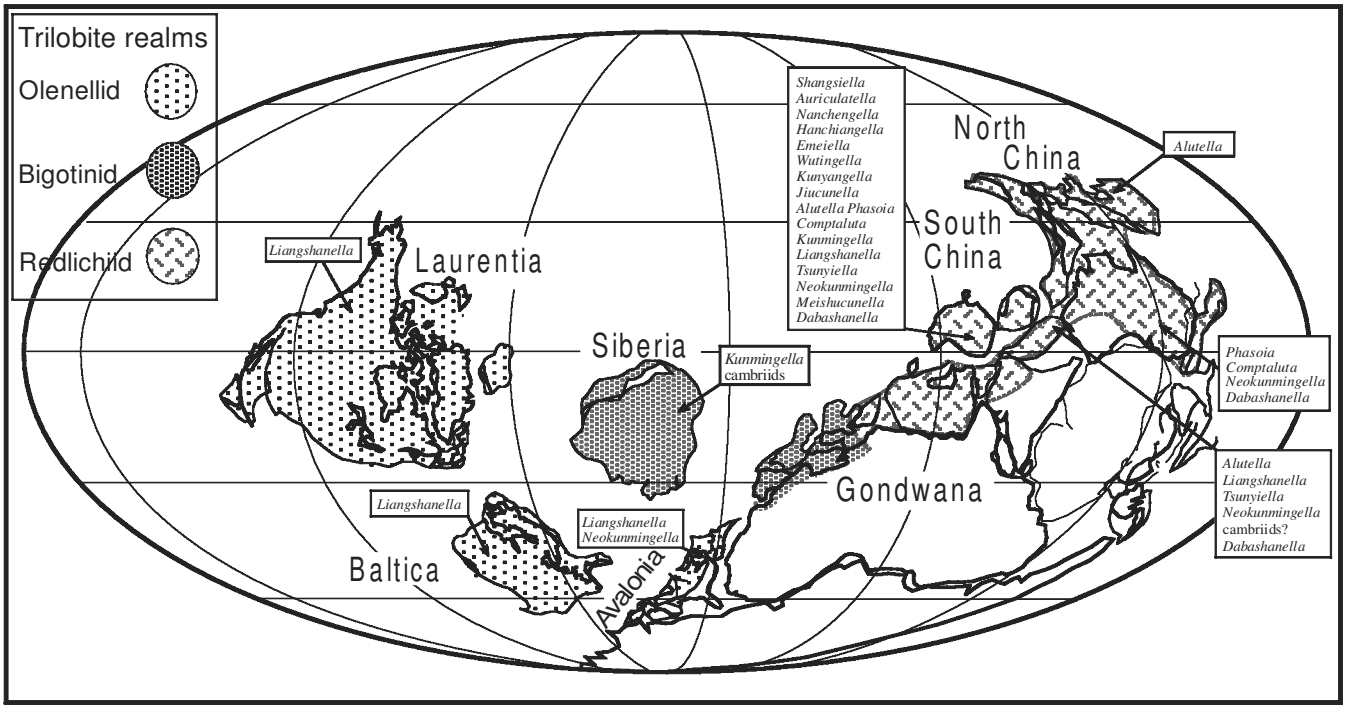

Figure 10 Distribution of those Chinese bradoriid and phosphatocopid (*Dabashanella* only) genera detailed herein, on a palaeogeographical map (from McKerrow *et al.* 1992) for the early Cambrian (Botomian–Toyonian stages).

Scandinavia, respectively representative of the faunas of palaeocontinental Laurentia, Avalonia and Baltica, were characterised by trilobites that distinguish an Olenellid biogeographical Realm. Intervening areas, such as Siberia and North Africa, are distinguished by trilobites of the Bigotinid Realm (Fig. 10).

The distribution of early Cambrian bradoriids is, in general, strongly provincial and was clearly affected by palaeogeography, latitude and mode of life. Thus, amongst presumed benthonic-shelf marine bradoriids within the Olenellid trilobite realm, Siveter & Williams (1997) were able to differentiate low-latitude cratonic, Laurentian faunas typified by *Walcottella* and *Dielymella*, from high-latitude Avalonia and Baltica faunas typified by *Bradoria*, *Beyrichona* and *Hipponicharion*. In contrast, the widespread cambriid bradoriids and the large bivalved arthropod *Isoxys* have a distribution which encompasses the Olenellid, Redlichiid and Bigotinid trilobite realms, but which is clearly limited to tropical regions of the Cambrian world (Siveter *et al.* 1996; Williams *et al.* 1996).

Within SW China the low diversity of bradoriid faunas in the Middle Subprovince compared to that of the Western Subprovince probably relates to different marine facies rather than to any significant difference in palaeogeographical factors. Thus, a number of genera and species are common to both areas, including *Kunmingella* (*K. douvillei*), *Liangshanella* (*L. rotundata, L. yunnanensis,* ?*L. liangshanensis*), *Tsunyiella* (*T. luna*), the phosphatocopid *Dabashanella* (*D. hemicyclica*), and possibly *Emeiella* and *Neokunmingella*. However, taken as a whole, of the 16 genera of Chinese bradoriids identified in this study, many are endemic to southern China, including *Shangsiella*, *Auriculatella*, *Emeiella*, *Hanchiangella*, *Nanchengella*, *Wutingella*, *Kunyangella*, *Jiucunella* and *Meishucunella*. The closest biogeographical links with other bradoriid faunas are within the Redlichiid Realm, such as those faunas of northern China, Australia and parts of central Asia (Kazakhstan, Kirghizia and eastern Trans-Baikal; for additional information see Melnikova *et al.* 1997). *Alutella* is particularly widespread, occurring in all of these major regions except Australia (see Kobayashi & Kato 1951; Melnikova *et al.* 1997), though it is closely related to the Australian *Quetopsis* (see Hinz-Schallreuter 1999). *Comptaluta*, *Neokunmingella* and *Phasoia* occur in southern China and Australia, the Chinese species *Phasoia* sp. and *Comptaluta leshanensis* being very similar to their Australian counterparts *Phasoia rogerensis* and *Comptaluta hartmanni* (see Hinz-Schallreuter 1993c, 1999). In addition to *Alutella*, *Tsunyiella* and a possible cambriid occur in north-eastern central Kazakhstan, and *Liangshanella* is possibly present in the eastern Trans-Baikal region (Melnikova *et al.* 1997). These distributions confirm the strong affinities of Cambrian faunas between the southern China–Tarim–Kazakhstan regions (see McKerrow *et al.* 1992; Shu & Chen 1994).

Palaeobiogeographical ties with the Bigotinid trilobite Realm are much weaker, the Siberian occurrences of *Kunmingella* and the widespread cambriids being the chief links (Fig. 10; see Melnikova *et al.* 1997). Partly this reflects the paucity of lower Cambrian bradoriid faunas known from Siberia and North Africa. Of the southern Chinese genera we have studied, only *Liangshanella* and *Neokunmingella* occur amongst the numerous bradoriid faunas of the Olenellid Realm (Fig. 10). *Liangshanella* appears to have been cosmopolitan throughout much of the early Cambrian marine world, occurring along the margins of Laurentia (Burgess Shale; Siveter & Williams 1997), and in Avalonia (Shropshire, England), and Baltica (southern Sweden; Williams & Siveter 1998, specimens referred to *Ovaluta*). This follows a pattern of distribution for other svealutid bradoriids, including *Anabarochilina*, which suggests a highly mobile, possibly pelagic mode of life (see Siveter *et al.* 1993; Siveter & Williams 1997) and the ability to inhabit tropical (Laurentia, South China Plate) and temperate (Avalonia, Baltica) Cambrian shelf seas.

The hipponicharionid *Neokunmingella* also occurs in the Olenellid Realm, appearing in Avalonia (Shropshire, England)

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during mid Cambrian times (Williams & Siveter 1998). Hipponicharionids occur widely, with representatives in North America (Siveter & Williams 1997), North Africa and Antarctica (Hinz-Schallreuter 1993b), southern Britain (Williams & Siveter 1998), Scandinavia (Siveter *et al.* 1994b) and China. The widespread early Cambrian distribution of representatives of such bradoriid families as the Svealutidae, Hipponicharionidae and Cambriidae suggests significant evolution and dispersal prior to their first appearance in the geological record.

Among the southern Chinese phosphatocopids, only *Dabashanella* occurs in the faunas we have studied. The rich falitid, vestrogothiid and hesslandonid phosphatocopid faunas of southern Britain and Scandinavia (e.g. Hinz-Schallreuter 1993a, b; Williams & Siveter 1998) are unrecorded from China, though most of these do not have their major diversification until the mid to late Cambrian, and thus lie outside the time range of the Chinese faunas we have studied. Within the Redlichiid Realm *Dabashanella* also occurs in Australia (Fleming 1973) and southern Kazakhstan (Melnikova *et al.* 1997) and may have been present among the Olenellid Realm faunas of the early Cambrian of southern Britain (see Williams & Siveter 1998, pl. 6, figs 9, 10). As with the svealutid bradoriids, the widespread distribution of *Dabashanella*, which includes occurrences in the Qinghai, Henan, and Xinjiang provinces of China, suggests a relatively mobile mode of life.

6. Systematic palaeontology

Order Bradoriida Raymond, 1935

Remarks. Traditionally most authors have considered that the bradoriids are ostracods or ostracod-like animals and that they represent the Cambrian record of that group. The Order Bradoriida of Raymond (1935) embraces essentially what are now recognised as two distinct groups of Cambrian bivalved arthropods, namely the Bradoriida *s.s.* and the Phosphatocopida Müller, 1964.

Rare, exceptionally well-preserved specimens with soft anatomy indicate that typical bradoriids belong outside the Crustacea *s.s.* (Hou *et al.* 1996; see also Shu *et al.* 1999) and the phosphatocopids are a sister group to the Crustacea *s.s.* (i.e. Eucrustacea; see, for example, Walossek & Müller 1997, 1998, and Walossek 1999). In the absence of soft part preservation, bradoriid and phosphatocopid taxonomy is necessarily based on gross carapace morphology. Carapace composition was the original criterion for distinguishing bradoriids from phosphatocopids (Müller 1964, 1979) but now appears to have been discredited (Hinz-Schallreuter 1993b; Siveter & Williams 1995; Siveter *et al.* 1996; Siveter & Williams 1997; Williams & Siveter 1998); many Bradoriida are now known to have a phosphatic carapace (Siveter & Williams 1997). Bradoriid carapaces can be relatively large (adults up to 18 mm long), are postplete (though not exclusively so), have ornament of granulostriation, reticulation, punctation and nodes, lack an interdorsum, and rarely have a mineralised inner lamella. Bradoriid carapaces typically have a dorsal hinge-line, but there is no evidence for complex articulating hinge structures between the two valves, which, for example, are present in other small bivalved arthropods such as the ostracods. Phosphatocopids are typically small (adults *c.* 1–5 mm long), preplete, smooth, and often possess an interdorsum and well-preserved inner lamella. Lobal morphology of the shell, which varies widely both in bradoriids and phosphatocopids, is used as a basis for familial and subfamilial classification within both groups (e.g. Hinz-Schallreuter 1993b; Siveter *et al.* 1996; Siveter & Williams 1997; Williams & Siveter 1998).

Walcott (1905) erected six bradoriid species based on material from a limestone boulder recovered from river drift 1·6 km S of Chön-p'ing-hién, on the Nan-kiang River, Zhenping County, Shaanxi Province. He considered the material to be of middle Cambrian age (although it is probably from the lower Cambrian), probably from the lower part of the Ki-sin-ling Limestone. Because his six species were each based on a single specimen from an allochthonous boulder, we refrain from providing a formal redescription of his taxa, but discuss each species in the relevant sections of the text. Thus, *Bradoria bergeroni, Bradoria stereope, Bradoria enyo* and *Bradoria fragilis* are briefly discussed within the bradoriid family Svealutidae, and *Bradoria woodi* and *Bradoria eris* within the section detailing the Comptalutidae. Some of the specimens which formed the basis of *Zhenpingella* Lee, 1975 (?junior synonym *Zhongbaoella* Huo & Shu 1982; see also Huo & Shu 1985; Huo *et al.* 1991), from the lower Cambrian Shuijingtuo Formation of Zhongbao, Zhenping County, might be related to Walcott's species. A firm assignment requires re-examination of Lee's material.

Family Kunmingellidae Huo & Shu, 1985

Diagnosis. Medium-sized (adults *c.* 3·5–5·5 mm long), postplete or amplete Bradoriida, carapace generally with well-defined hinge-line. Lateroadmarginal ridge narrow, entire between cardinal corners, situated close to and paralleling valve margin, demarcated from convex lateral surface by a shallow continuous furrow. Anterodorsal lobe weakly to well developed, subovate-elongate, in some cases divided by a narrow furrow into posterior and more elevated anterior parts. Posterior lobe subovate to elongate, straight or crescent-shaped. Dorsal connecting lobe (linking anterior and posterior lobes) and mid-ventral node may also be present. Anterior to the posterior lobe there may be a weak to moderately developed shallow sulcal depression. Valves smooth or granulose.

Remarks. The Kunmingellidae contains the genera *Kunmingella* Huo, 1956, *Emeiella* Lee, 1975, *Hanchiangella* Huo, 1956 and *Nanchengella* Huo, 1956. The record of *Kunmingella* sp. from the lower Cambrian of Siberia (Melnikova *et al.* 1997) represents the only known non-Chinese occurrence of this family.

Genus *Kunmingella* Huo, 1956

1956 *Kunmingella* gen. nov.; Huo, p. 434.
1965 *Kunmingella* Huo; Huo, p. 292.
1974 *Parakunmingella* (gen. nov.); Zhang, p. 109.
?1974 *Malongella* (gen. nov.); Zhang, p. 109.
1975 *Kunmingella* Huo, 1956; Lee, p. 52.
1982 *Kunmingella* Huo, 1956; Huo & Shu, p. 324.
1982 *Pseudokunmingella* gen. nov.; Huo & Shu, p. 325.
1983b *Kunmingella* Huo; Huo & Shu *in* Huo *et al.*, p. 56.
1983b *Kunmingella* (*Validocostatella*) Huo & Shu subgen. nov.; Huo & Shu *in* Huo *et al.*, p. 59.
1983b *Kunmingella* (*Angustacostatella*) Huo & Shu subgen. nov.; Huo & Shu *in* Huo *et al.*, p. 60.
1983 *Kunmingella* Huo, 1956; Li, p. 10.
1985 *Kunmingella* Huo 1956; Huo & Shu, p. 101.
1985 *Kunmingella* (*Angustacostatella*) Huo & Shu 1983; Huo & Shu, p. 101.
1985 *Kunmingella* (*Validocostatella*) Huo & Shu; Huo & Shu, p. 106.
1985 *Kunmingella* (*Spinokunmingella*) Huo & Shu (subgen. nov.); Huo & Shu, p. 113.
1985 *Parakunmingella* Chang; Huo & Shu, p. 115.

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1985 *Pseudokunmingella* Huo & Shu 1982; Huo & Shu, p. 117.
1988 *Kunmingella* Huo, 1956; Tan & Li, p. 22.
1988 *Kunmingella* (*Angustacostatella*) Huo & Shu, 1983; Tan & Li, p. 23.
1988 *Kunmingella* (*Cryptocostatella*) Tan & Li (subgen. nov.); Tan & Li, p. 23.
1988 *Bicostatella* Tan & Li (gen. nov.); Tan & Li, p. 24.
1988 *Pseudobicostatella* Tan & Li (gen. nov.); Tan & Li, p. 25.
?1990a *Kunmingelloides* gen. nov.; Tong *in* Shu, p. 54.
?1990a *Kunmingella* Huo; Shu, p. 55.
1991 *Kunmingella* Huo, 1956; Huo *et al*., p. 122.
1991 *Kunmingella* (*Angustacostatella*) Huo & Shu 1983; Huo *et al*., p. 123.
1991 *Kunmingella* (*Validocostatella*) Huo & Shu 1983; Huo *et al*., p. 128.
1991 *Kunmingella* (*Spinokunmingella*) Huo & Shu, 1985; Huo *et al*., p. 133.
1991 *Parakunmingella* Chang, 1974; Huo *et al*., p. 134.
1991 *Pseudokunmingella* Huo & Shu, 1982; Huo *et al*., p. 136.
1999 *Kunmingella* Huo, 1956; Luo *et al*., p. 69.

Type species. By original designation: *Kunmingella maxima* Huo, 1956 (senior subjective synonym: *Bradoria douvillei* Mansuy, 1912). From Kebaocun section, Yiliang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Kunmingellids with broad anterodorsal lobe, which in typical late-stage instars is divided by a subvertical furrow into posterior and much more inflated (node-like) anterior parts. Posterior lobe elongate, straight to weakly crescentic, tapering, extends from just behind valve centre to terminate immediately in front of posterior cardinal corner. Broad, shallow sulcal depression occurs between anterodorsal and posterior lobes, is deepest mid-dorsally. Lateroadmarginal ridge narrow, low, entire between cardinal corners. Valves smooth to finely granulose. Long posteroventral spine may occur.

Remarks. *Parakunmingella* Zhang, 1974 (type species *Parakunmingella malongensis* Zhang, 1974) and *Pseudokunmingella* Huo & Shu, 1982 (type species *Pseudokunmingella fandianensis* Huo & Shu, 1982) were distinguished from *Kunmingella* principally by having the anterior lobe divided into anterior and posterior parts by a vertical furrow. However, as the latter feature is also found in *Kunmingella* (e.g. Fig. 11a–e, h, i) we consider that these genera are synonymous. The redundant nature of *Pseudokunmingella* is further demonstrated by the fact that subsequently Huo & Shu (1985, p. 101) referred the type species of *Kunmingella*, *K. maxima*, to *Pseudokunmingella* and 'designated' a new type species, namely *K. Validocostatella maotianshanensis*, for *Kunmingella*. *Parakunmingella* was also distinguished by having a very short posterior lobe; however, based on our *Kunmingella* material, such variation is due to intraspecific and preservational differences (see also Li 1983, p. 12). Except for the occurrence of fine reticulation on its valves, the morphology of *Kunmingelloides* Tong, 1990 (type species *Kunmingelloides bulbosus* Tong *in* Shu, 1990a) seems to lie within the range of variation of *Kunmingella* and, therefore, these two genera may also be synonymous. *Malongella* Zhang, 1974 (type species *Malongella bituberculata* Zhang, 1974) is another possible synonym (see below, under *Kunmingella typica* Huo & Shu, 1985).

Huo & Shu (*in* Huo *et al*. 1983b; Huo & Shu 1985) used posterior lobal morphology to distinguish their subgenera *Kunmingella* (*Validocostatella*) and *Kunmingella* (*Angustacostatella*). They considered that *K.* (*Angustacostatella*) demonstrated evolution towards an increasingly elongate, postplete valve shape with reduction in length and increased convexity of the posterior lobe. We consider that such lobal differences lie within the range of variation shown in the type species *Kunmigella douvillei*. We also consider that the possession of a ventral spine, which was used to establish *Kunmingella* (*Spinokunmingella*) Huo & Shu, 1985, is insufficient on which to establish a separate subgenus.

Tan & Li's (1988) taxa *Kunmingella* (*Cryptocostatella*) (type species *Kunmingella* (*Cryptocostatella*) *shannanensis*), *Bicostatella* (type species *Bicostatella xibeiensis*) and *Pseudobicostatella* (type species *Pseudobicostatella minuta*) were each based on only one or two poorly preserved specimens from Shaanxi Province. In our opinion they represent deformed valves of *Kunmingella*.

Occurrence. Shaanxi, Sichuan and Yunnan provinces, SW China; lower Cambrian.

Kunmingella douvillei (Mansuy, 1912)
(Figs 11a–k, 12a–j, 13a–h)

1912 *Bradoria douvillei* sp. nov.; Mansuy, p. 22, pl. 1, fig. 8.
1931 *Aluta douvillei* (Mansuy); Ulrich & Bassler, p. 61, pl. 4, fig. 17.
1956 *Kunmingella maxima* sp. nov.; Huo, p. 435, pl. 2, figs 7, 8.
1956 *Kunmingella parva* sp. nov., Huo, p. 435, pl. 2, fig. 9.
1956 *Kunmingella douvillei* (Mansuy); Huo, p. 436, pl. 2, figs 10–13.
1965 *Kunmingella douvillei* (Mansuy); Huo, p. 292, pl. 1, fig. 1.
1965 *Kunmingella intermedia* sp. nov.; Huo, p. 292, pl. 1, figs 2–4.
1965 *Kunmingella sui* sp. nov.; Huo, p. 293, pl. 1, fig. 5.
1974 *Parakunmingella malongensis* (gen. et sp. nov.); Zhang, p. 109, pl. 43, fig. 8.
?1974 *Kunmingella longa* (sp. nov.); Zhang, p. 110, pl. 43, fig. 12.
?1974 *Kunmingella maxima* Huo; Zhang, pl. 110, pl. 43, fig. 13.
?1975 *Kunmingella repsis* Lee 1972 sp. nov. (*sic*); Lee, p. 52, pl. 4, fig. 13.
?1975 *Kunmingella wudingensis* Lee, 1972 sp. nov. (*sic*); Lee, p. 52, pl. 4, figs 14, 15.
?1975 *Kunmingella intermedia* Huo, 1965; Lee, p. 53, pl. 4, fig. 16.
?1975 *Kunmingella micronicostata* Lee, sp. nov.; Lee, p. 53, pl. 4, figs 17–19.
1980 *Kunmingella douvillei* (Mansuy); Tan, p. 189, pl. 21, fig. 12.
1982 *Kunmingella intermedia* Huo; Huo & Shu, p. 324, pl. 1, figs 6–9.
?1982 *Kunmingella leshanensis* sp. nov.; Huo & Shu, p. 324, pl. 1, fig. 10.
1982 *Pseudokunmingella fandianensis* gen. et sp. nov.; Huo & Shu, p. 325, pl. 1, fig. 13, ?figs 11, 12.
1983 *Kunmingella maxima* Huo, 1956; Li, p. 10, pl. 1, fig. 19.
1983 *Kunmingella douvillei* (Mansuy); Li, p. 11, pl. 2, fig. 1.
?1983 *Kunmingella intermedia* Huo, 1956; Li, p. 11, pl. 2, fig. 2.
1983 *Kunmingella leshanensis* Li (sp. nov.); Li, p. 11, pl. 2, fig. 3.
1983 *Kunmingella longa* Chang, 1974; Li, p. 11, pl. 2, fig. 4.
1983 *Kunmingella malongensis* (Chang, 1974); Li, p. 12, pl. 2, fig. 5.
?1983 *Kunmingella micronicostata* Lee, 1975; Li, p. 12, pl. 2, fig. 6.
1983 *Kunmingella parva parva* Huo, 1956; Li, p. 12, pl. 2, fig. 7.

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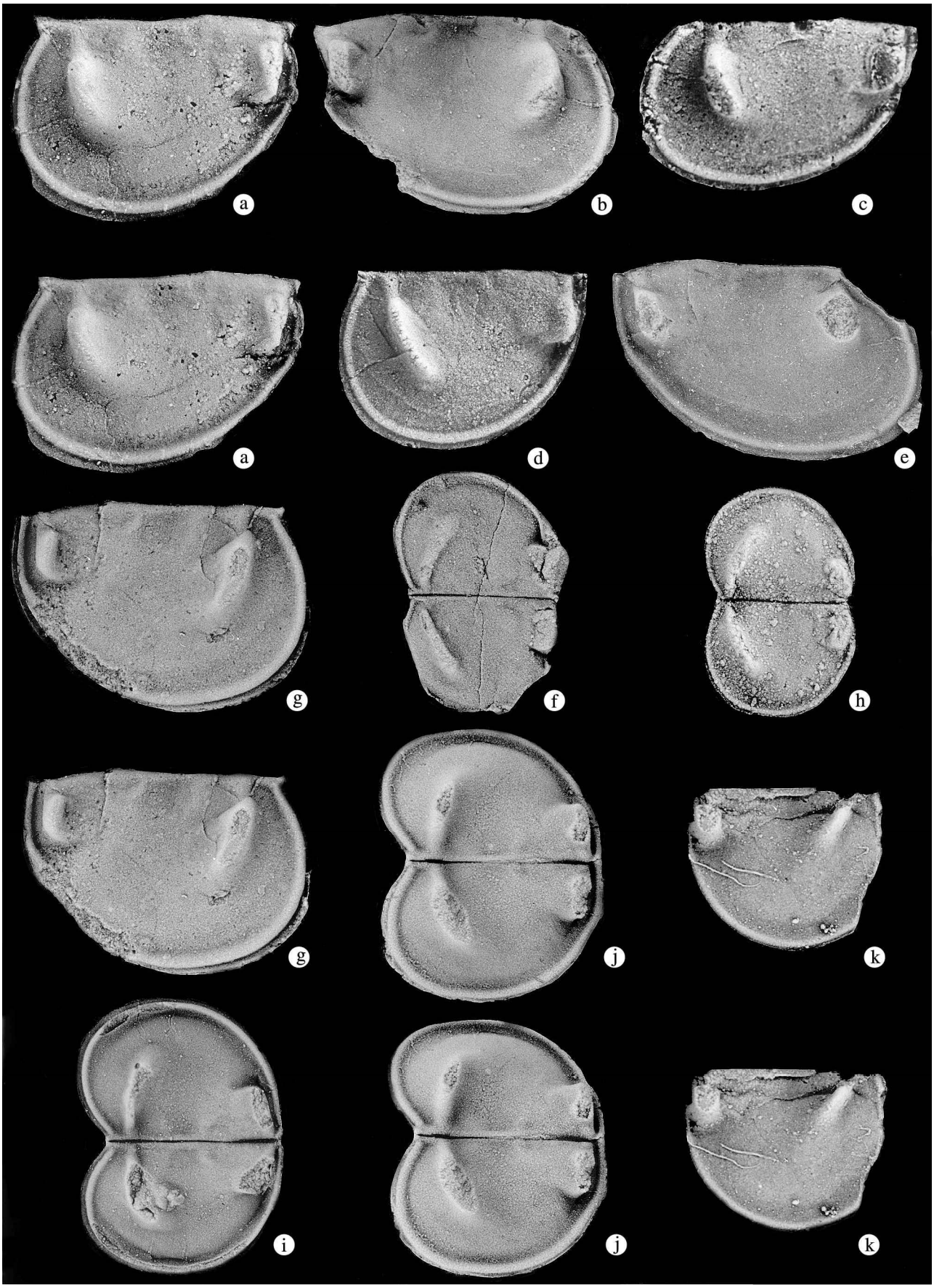

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1983 *Kunmingella parva elongata* Huo & Peng; Li, p. 12, pl. 2, fig. 8.
1983 *Kunmingella retangulata* Li (sp. nov.); Li, p. 13, pl. 2, fig. 9.
?1983 *Kunmingella repsis* Lee, 1975; Li, p. 13, pl. 2, fig. 10.
1983 *Kunmingella sichuanensis* Li (sp. nov.); Li, p. 13, pl. 2, figs 11–13.
1983 *Kunmingella suae* Huo, 1965 (*sic*); Li, p. 14, pl. 2, fig. 14.
?1983 *Kunmingella wudingensis* Lee, 1975; Li, p. 14, pl. 2, fig. 15.
1983b *Kunmingella* (*Validocostatella*) *maotianshanensis* Huo & Shu subgen. et sp. nov.; Huo & Shu *in* Huo *et al.*, p. 59, pl. 4, figs 7–15.
1983b *Kunmingella* (*Validocostatella*) *guanshanensis* Huo & Shu subgen. et sp. nov.; Huo & Shu *in* Huo *et al.*, p. 59, pl. 3, figs 1–6.
?1983b *Kunmingella* (*Validocostatella*) *acuta* Huo & Shu subgen. et sp. nov.; Huo & Shu *in* Huo *et al.*, p. 60, pl. 3, figs 7–10.
1983b *Kunmingella* (*Angustacostatella*) *angustacostata* Huo & Shu subgen. et sp. nov.; Huo & Shu *in* Huo *et al.*, p. 61, pl. 4, figs 1–6.
1983b *Kunmingella* (*Angustacostatella*) *qiongzhusiensis* Huo & Shu subgen. et sp. nov.; Huo & Shu *in* Huo *et al.*, p. 61, pl. 3, figs 11–15.
?1983b *Kunmingella zhuazhuayanensis* Huo & Shu sp. nov.; Huo & Shu *in* Huo *et al.*, p. 62, pl. 3, figs 16–19.
1984 *Pseudokunmingella fuxianensis* sp. nov.; Huo & Shu, p. 242, pl. 1, fig. 10.
1984 *Kunmingella* (*Angustacostatella*) *angustacostata* Huo & Shu; Huo & Shu, p. 242, pl. 1, figs 7–9.
1984 *Kunmingella* (*Validocostatella*) *maotianshanensis* Huo & Shu; Huo & Shu, p. 242, pl. 1, figs 5–6.
1985 *Kunmingella* (*Angustacostatella*) *angustacostata* Huo & Shu; Huo & Shu, p. 101, pl. 9, figs 1–6.
1985 *Kunmingella* (*Angustacostatella*) *parva* Huo; Huo & Shu, p. 102, pl. 9, fig. 14.
?1985 *Kunmingella* (*Angustacostatella*) *leshanensis* Huo & Shu; Huo & Shu, p. 102, pl. 9, fig. 13.
1985 *Kunmingella* (*Angustacostatella*) *wudingensis* Lee; Huo & Shu, p. 103, pl. 9, figs 7, 8.
1985 *Kunmingella* (*Angustacostatella*) *micronicostata* Lee; Huo & Shu, p. 103, pl. 9, fig. 10, ?fig. 11.
?1985 *Kunmingella* (*Angustacostatella*) *repsis* Lee; Huo & Shu, p. 103, pl. 9, fig. 9.
?1985 *Kunmingella* (*Angustacostatella*) *longa* Chang; Huo & Shu, p. 104, pl. 9, fig. 12.
?1985 *Kunmingella* (*Angustacostatella*) *asilla* Huo & Shu (sp. nov.); Huo & Shu, p. 104, pl. 9, figs 15, 16.
?1985 *Kunmingella* (*Angustacostatella*) *tenocostata* Huo & Shu (sp. nov.); Huo & Shu, p. 104, pl. 10, figs 1–3.
?1985 *Kunmingella* (*Angustacostatella*) *ovata* Huo & Shu (sp. nov.); Huo & Shu, p. 105, pl. 13, fig. 19.
1985 *Kunmingella* (*Angustacostatella*) *qiongzhusiensis* Huo & Shu; Huo & Shu, p. 106, pl. 10, figs 4, 5.
1985 *Kunmingella* (*Validocostatella*) *maotianshanensis* Huo & Shu; Huo & Shu, p. 106, pl. 10, figs 8–11.
1985 *Kunmingella* (*Validocostatella*) *diandongensis* Huo & Shu (sp. nov.); Huo & Shu, p. 106, pl. 11, figs 1–10.
?1985 *Kunmingella* (*Validocostatella*) *dezeensis* Huo & Shu (sp. nov.); Huo & Shu, p. 107, pl. 12, figs 1–7.
?1985 *Kunmingella* (*Validocostatella*) *costata* Huo & Shu (sp. nov.); Huo & Shu, p. 108, pl. 10, figs 12–14.
?1985 *Kunmingella* (*Validocostatella*) *fusulus* Huo & Shu (sp. nov.); Huo & Shu, p. 109, pl. 11, figs 11–15.
1985 *Kunmingella* (*Validocostatella*) *douvillei* (Mansuy); Huo & Shu, p. 110, pl. 13, figs 11–16.
?1985 *Kunmingella* (*Validocostatella*) *zhuazhuayanensis* Huo & Shu; Huo & Shu, p. 110, pl. 10, figs 6, 7.
1985 *Kunmingella* (*Validocostatella*) *guanshanensis* Huo & Shu; Huo & Shu, p. 110, pl. 12, figs 8–12.
?1985 *Kunmingella* (*Validocostatella*) *acuta* Huo & Shu; Huo & Shu, p. 111, pl. 12, figs 13, 14.
1985 *Kunmingella* (*Validocostatella*) *intermedia* Huo; Huo & Shu, p. 111, pl. 13, fig. 17.
1985 *Kunmingella* (*Validocostatella*) *sui* Huo; Huo & Shu, p. 111, pl. 13, fig. 18.
?1985 *Kunmingella* (*Validocostatella*) cf. *maotianshanensis* Huo & Shu; Huo & Shu, p. 112, pl. 14, figs 1–4.
?1985 *Kunmingella* (*Validocostatella*) *costata leipoensis* Huo & Shu subsp. nov.; Huo & Shu, p. 112, pl. 14, figs 5–7.
?1985 *Kunmingella* (*Validocostatella*) *jinshajiangensis* Huo & Shu (sp. nov.); Huo & Shu, p. 113, pl. 14, fig. 8.
?1985 *Parakunmingella malongensis* Chang; Huo & Shu, p. 115, pl. 14, figs 15, 16.
1985 *Parakunmingella dadiyakouensis* Huo & Shu (sp. nov.); Huo & Shu, p. 115, pl. 14, figs 9, 10.
1985 *Parakunmingella venusta* Huo & Shu (sp. nov.); Huo & Shu, p. 116, pl. 14, figs 11, 12.
1985 *Parakunmingella chengjiangensis* Huo & Shu (sp. nov.); Huo & Shu, p. 116, pl. 14, figs 13, 14.
1985 *Pseudokunmingella fandianensis* Huo & Shu; Huo & Shu, p. 117, pl. 16, figs 1–4.
1985 *Pseudokunmingella qujingensis* Huo & Shu (sp. nov.); Huo & Shu, p. 118, pl. 15, figs 1–5.
?1985 *Pseudokunmingella zhanyiensis* Huo & Shu (sp. nov.); Huo & Shu, p. 118, pl. 15, figs 6–10.
1985 *Pseudokunmingella fuxianensis* Huo & Shu (sp. nov.); Huo & Shu, p. 119, pl. 15, figs 11–16.
?1985 *Pseudokunmingella emeiensis* Huo & Shu (sp. nov.); Huo & Shu, p. 120, pl. 16, figs 5–8.
1988 *Kunmingella* (*Angustacostatella*) *bimarginata* Tan & Li (sp. nov.); Tan & Li, p. 22, pl. 2, figs 14, 15.
1988 *Kunmingella* (*Angustacostatella*) *jingyangensis* Tan & Li (sp. nov.); Tan & Li, p. 23, pl. 2, figs 1–3.
1988 *Kunmingella* (*Cryptocostatella*) *shannanensis* Tan & Li (subgen. et sp. nov.); Tan & Li, p. 23, pl. 2, fig. 7.

Figure 11 *Kunmingella douvillei* (Mansuy, 1912); Qiongzhusi Formation, lower Cambrian. (a–f) Qiongzhusi section, Kunming City, Yunnan Province; (g–i) Meishucun section, Jinning County, Yunnan Province; (k) Gaopo section in Gaoqiao, E'mei County, Sichuan Province; all light photographs, ×12.

(a) RCCBYU 00001 (field coll. Ch4-2), right valve, lateral view (stereo-pair); (b) RCCBYU 00002 (field coll. Ch5-2), anteriorly incomplete left valve, lateral view; (c) RCCBYU 00003 (field coll. Ch4-2), right valve, lateral view; (d) RCCBYU 00004 (field coll. Ch4-2), right valve, lateral view; (e) RCCBYU 00005 (field coll. Ch5-2), posterodorsally incomplete left valve, lateral view; (f) RCCBYU 00006 (field coll. Ch4-2), open carapace, lateral view; (g) RCCBYU 00007 (field coll. K10), left valve, lateral view (stereo-pair); (h) RCCBYU 00009 (field coll. K7), open carapace, lateral view; (i) RCCBYU 00010 (field coll. K7), open carapace, lateral view; (j) RCCBYU 00008 (field coll. K10), open carapace, lateral view (stereo-pair); (k) RCCBYU 00011 (field coll. SG-7), posteriorly incomplete left valve, lateral view (stereo-pair).

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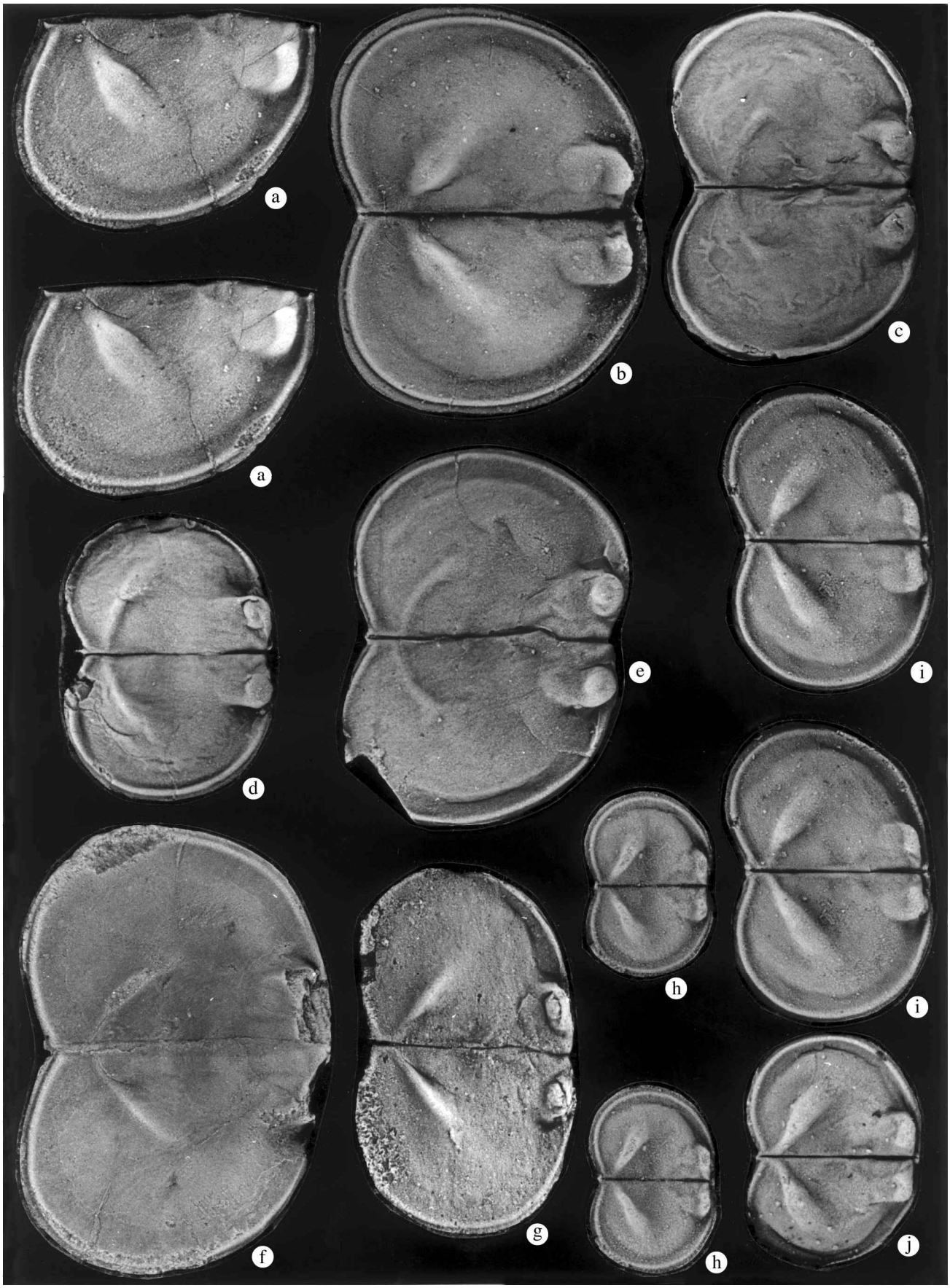

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1988 *Bicostatella xibeiensis* Tan & Li (gen. et sp. nov.), Tan & Li, p. 24, pl. 2, fig. 5.
1988 *Bicostatella longa* Tan & Li (gen et sp. nov.); Tan & Li, p. 24, pl. 2, fig. 6.
1988 *Pseudobicostatella minuta* Tan & Li (gen. et sp. nov.); Tan & Li, p. 25, pl. 2, fig. 8.
?1990a *Kunmingelloides bulbosus* Tong (gen. et sp. nov.); Tong *in* Shu, p. 54, pl. 9, figs 1–11.
?1990a *Kunmingella xiaoyangensis* sp. nov.; Shu, p. 55, pl. 9, figs 12–16.
?1990a *Kunmingella fusina zhenbaensis* subsp. nov.; Shu, p. 56, pl. 10, figs 1–5.
1991 *Kunmingella* (*Angustacostatella*) *angustacostata* Huo & Shu; Huo *et al.*, p. 123, pl. 18, figs 1–4.
1991 *Kunmingella* (*Angustacostatella*) *parva* Huo; Huo *et al.*, p. 123, pl. 18, fig. 14.
1991 *Kunmingella* (*Angustacostatella*) *micronicostata* Lee; Huo *et al.*, p. 123, pl. 18, figs 5, 6.
?1991 *Kunmingella* (*Angustacostatella*) *wudingensis* Lee; Huo *et al.*, p. 123, pl. 18, figs 7, 8.
?1991 *Kunmingella* (*Angustacostatella*) *longa* Zhang; Huo *et al.*, p. 124, pl. 18, fig. 9.
?1991 *Kunmingella* (*Angustacostatella*) *leshanensis* Huo & Shu; Huo *et al.*, p. 124, pl. 18, fig. 10.
?1991 *Kunmingella* (*Angustacostatella*) *repsis* Lee; Huo *et al.*, p. 125, pl. 18, fig. 11.
?1991 *Kunmingella* (*Angustacostatella*) *asilla* Huo & Shu; Huo *et al.*, p. 125, pl. 18, figs 12, 13.
?1991 *Kunmingella* (*Angustacostatella*) *tenocostata* Huo & Shu; Huo *et al.*, Shu & Cui, p. 125, pl. 18, figs 15, 16.
?1991 *Kunmingella* (*Angustacostatella*) *bulbosa* Tong (sp. nov.); Tong *in* Huo *et al.*, p. 126, pl. 19, figs 1–11.
?1991 *Kunmingella* (*Angustacostatella*) *elongata* Tong (sp. nov.); Tong *in* Huo *et al.*, p. 127, pl. 19, figs 12–15.
?1991 *Kunmingella* (*Angustacostatella*) *ovata* Huo & Shu; Huo *et al.*, p. 127, pl. 20, fig. 1.
1991 *Kunmingella* (*Angustacostatella*) *qiongzhusiensis* Huo & Shu; Huo *et al.*, p. 128, pl. 20, figs 2, 3.
1991 *Kunmingella* (*Validocostatella*) *maotianshanensis* Huo & Shu; Huo *et al.*, p. 128, pl. 20, figs 4–7.
1991 *Kunmingella* (*Validocostatella*) *diandongensis* Huo & Shu; Huo *et al.*, p. 128, pl. 20, figs 8–11.
?1991 *Kunmingella* (*Validocostatella*) *dezeensis* Huo & Shu; Huo *et al.*, p. 129, pl. 20, figs 12–15.
?1991 *Kunmingella* (*Validocostatella*) *costata* Huo & Shu; Huo *et al.*, p. 129, pl. 21, figs 1–3.
?1991 *Kunmingella* (*Validocostatella*) *fusulus* Huo & Shu; Huo *et al.*, p. 130, pl. 21, figs 4–8.
1991 *Kunmingella* (*Validocostatella*) *douvillei* (Mansuy); Huo *et al.*, p. 130, pl. 21, figs 9–14.
?1991 *Kunmingella* (*Validocostatella*) *zhuazhuayanensis* Huo & Shu; Huo *et al.*, p. 131, pl. 21, figs 15, 16.
1991 *Kunmingella* (*Validocostatella*) *guanshanensis* Huo & Shu; Huo *et al.*, p. 131, pl. 22, figs 1–4.
1991 *Kunmingella* (*Validocostatella*) *sui* Huo; Huo *et al.*, p. 131, pl. 22, fig. 5.
1991 *Kunmingella* (*Validocostatella*) *intermedia* Huo; Huo *et al.*, p. 132, pl. 22, fig. 6.
?1991 *Kunmingella* (*Validocostatella*) *acuta* Huo & Shu; Huo *et al.*, p. 132, pl. 22, figs 7, 8.
?1991 *Kunmingella* (*Validocostatella*) cf. *maotianshanensis* Huo & Shu; Huo *et al.*, p. 132, pl. 22, figs 9–12.
?1991 *Kunmingella* (*Validocostatella*) *costata leipoensis* Huo & Shu; Huo *et al.*, p. 132, pl. 22, figs 13–15.
1991 *Parakunmingella malongensis* Chang; Huo *et al.*, p. 134, pl. 22, figs 16, ?17.
1991 *Parakunmingella dadiyakouensis* Huo & Shu; Huo *et al.*, p. 134, pl. 22, figs 18, 19.
1991 *Parakunmingella venusta* Huo & Shu; Huo *et al.*, p. 135, pl. 23, figs 11, 12.
1991 *Parakunmingella chengjiangensis* Huo & Shu; Huo *et al.*, p. 135, pl. 23, figs 13, 14.
1991 *Pseudokunmingella fandianensis* Huo & Shu; Huo *et al.*, p. 136, pl. 24, figs 6–9.
?1991 *Pseudokunmingella zhanyiensis* Huo & Shu; Huo *et al.*, p. 136, pl. 23, figs 15–18.
1991 *Pseudokunmingella qujingensis* Huo & Shu; Huo *et al.*, p. 137, pl. 24, figs 1–5.
1991 *Pseudokunmingella fuxianensis* Huo & Shu; Huo *et al.*, p. 137, pl. 24, figs 10–15.
?1991 *Pseudokunmingella emeiensis* Huo & Shu; Huo *et al.*, p. 137, pl. 25, figs 15–17.
1994 *Kunmingella guanshanensis* Huo & Shu; Luo *et al.*, p. 168, pl. 5, figs 8, 9.
1994 *Kunmingella diandongensis* Huo & Shu; Luo *et al.*, p. 168, pl. 5, figs 10, 11.
1994 *Kunmingella douvillei* (Mansuy); Luo *et al.*, p. 168, pl. 5, figs 12, 13.
1994 *Kunmingella diandongensis*; Shu & Chen, fig. 5d.
1994 *Kunmingella xiaovangensis* Shu & Chen, fig. 5e.
1996 *Kunmingella douvillei* (Mansuy, 1912); Hou *et al.*, figs 3–5.
1999 *Kunmingella guanshanensis* Huo & Shu, 1983; Luo *et al.*, p. 70, pl. 14, fig. 9, pl. 15, figs 1–7.
1999 *Kunmingella angustacostata* Huo & Shu, 1983; Luo *et al.*, p. 71, pl. 14, fig. 10.
1999 *Parakunmingella malongensis* Chang, 1974; Luo *et al.*, p. 71, pl. 14, fig. 11.

Syntypes. Carapaces and valves on a slab of mudstone, Mansuy 1912, p. 22, pl. 1, fig. 8. Kebaocun section, Yiliang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian. The repository for this material is unknown. It does not appear to be in Lyon or Paris (Jean Vannier, pers. comm.).

Material. Several thousand specimens from sections at Dapotou, Fengkoushao, Hongjiachong, Maotianshan and Xiaolantian in Chengjiang County, and hundreds of specimens from Meishucun in Jinning County, Qiongzhusi in Kunming

Figure 12 *Kunmingella douvillei* (Mansuy, 1912); Qiongzhusi Formation, lower Cambrian. (a, d, e, i, j) Maotianshan section (western slope), Chengjiang County, Yunnan Province; (c, g, h) Maotianshan section (northwestern slope), Chengjiang County, Yunnan Province; (b) Dapotou section, Chengjiang County, Yunnan Province; (f) Hongjiachong section, Chengjiang County, Yunnan Province; all light photographs, ×12.
(a) RCCBYU 00012 (field coll. M2), right valve, lateral view (stereo-pair); (b) RCCBYU 00020 (field coll. DP), open carapace, lateral view; (c) RCCBYU 00017 (field coll. CF2), open carapace, lateral view; (d) RCCBYU 00013 (field coll. M2), open carapace, lateral view; (e) RCCBYU 00014 (field coll. M2), open carapace, lateral view; (f) RCCBYU 00021 (field coll. H2-1), open carapace, lateral view; (g) RCCBYU 00018 (field coll. CF1), open carapace, lateral view; (h) RCCBYU 00019 (field coll. CF5), open carapace, lateral view (stereo-pair); (i) RCCBYU 00015 (field coll. M2), open carapace, lateral view (stereo-pair); (j) RCCBYU 00016 (field coll. M2), open carapace, lateral view.

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City and Shapushan and Shishan in Wuding County, Yunnan Province. About twenty specimens from Kebaocun section, Yiliang County and ten specimens from Siqitian section, Malong County, Yunnan Province. Ten specimens from the Fandian section, Leshan City, and a few valves from Gaoqiao in E'mei County, Sichuan Province.

Measurements. Our specimens range in length from 1·76–5·24 mm.

Diagnosis. As for the genus, but lacking a posteroventral spine.

Description. Valves postplete throughout ontogeny. Lobation well developed, even in small juveniles. Anterodorsal lobe is short, elongate, becomes broadly U-shaped in late-stage instars; posterior lobe is elongate, straight to weakly curved, posterodorsally tapering, extends from just posterior of valve centre to immediately in front of posterior cardinal corner. Broad, shallow sulcal depression, deepest mid-dorsally, occurs between anterodorsal and posterior lobes. Lateroadmarginal ridge narrow, low, situated close to valve margin, entire between cardinal corners. Between lateroadmarginal ridge and convex lobal surface is a broad shallow continuous depression. Valve surface is smooth or has small, closely spaced granules. Hinge-line well developed; nature of junction of valves unknown.

The soft part anatomy of *K. douvillei* is described by Hou *et al.* (1996) and Shu *et al.* (1999).

Remarks. *K. douvillei* is the most common species of the Chengjiang fauna, accounting for over 80% of recovered individuals (Hou & Bergström 1991). Nevertheless, specimens with preserved soft anatomy are extremely rare (see Hou *et al.* 1996). Our collections demonstrate that *K. douvillei* has a wide range of intraspecific and preservational variation in carapace morphology (Figs 11–13) and that particular variants do not cluster stratigraphically. In specimens which have undergone minimum compression, the anterior lobe is strongly inflated and U-shaped (e.g. Fig. 12b); however, in somewhat flattened valves only the more strongly inflated anterior portion of the lobe is well preserved (e.g. Fig. 11a, b, e–h, k). Similarly, in valves which preserve their original convexity the posterior lobe is broad (e.g. Fig. 12a), but in other specimens it is narrow and ridge-like (e.g. Fig. 12f). The posterior lobe also displays considerable intraspecific variation in shape (straight to curved), orientation (in its angle with the dorsal margin) and length. If worn, the posterior lobe may be virtually absent (e.g. Fig. 13d) or preserved as only the more strongly inflated part of the lobe (e.g. Fig. 13e). Some of our flattened specimens show the posterior lobe only as a subcircular node (e.g. Fig. 13b; cf. *Kunmingelloides bulbosus* Tong *in* Shu 1990a); however, as they co-occur with more typical specimens and do not cluster at particular stratigraphic horizons, they, too, are regarded as intraspecific variants.

We consider that almost 50 taxa are synonyms or probable synonyms of *K. douvillei*. All of these species have been based on a few specimens, many on one or two often deformed and juvenile specimens. In some cases the material was from an unspecified locality. Moreover, most of these species have been poorly illustrated, and few authors have attempted comparison with the relevant type species, and in some cases no type specimen was given (e.g. see Huo 1956, 1965; Huo *et al.* 1983b; Huo & Shu 1985; Shu 1990a; Huo *et al.* 1991; Zhang 1974; Lee 1975). For example, of the species of *Kunmingella* established by Huo (1956, e.g. *K. parva*; 1965), none was based on more than three specimens and some were based on juveniles. The three specimens on which Huo (1965) erected *Kunmingella intermedia* and the anteriorly incomplete left valve on which he based *Kunmingella sui* are referable to *K. douvillei*.

The type species *Parakunmingella malongensis* Zhang, 1974, based on a left valve with a reduced posterior lobe (which is merely a preservational feature), is referable to *K. douvillei*. *Kunmingella longa* Zhang, 1974 (based on a deformed right valve) and the deformed specimen which Zhang (1974) referred to *K. maxima* may also be referable to *K. douvillei*.

Lee (1975) established three additional *Kunmingella* species on the basis of a few specimens. His three figured valves of *Kunmingella micronicostata,* from Fandian section, Sichuan Province, appear to be flattened *Kunmingella douvillei* specimens, as does the deformed left valve from Yaoying section, Yunnan Province, on which he based *K. repsis*. The two valves from Yaoying section, on which he based *K. wudingensis*, are very poorly preserved, but are possibly also referable to *K. douvillei*. The material that Huo & Shu (1982) described under *Kunmingella intermedia* Huo and *Kunmingella leshanensis* sp. nov., from Fandian section, Sichuan Province, consists of only a few poorly preserved specimens. Their single specimen of *K. leshanensis* has its dorsal margin obscured by matrix, but is probably a left valve of *K. douvillei*. Their three figured specimens of the type species *Pseudokunmingella fandianensis* (for which no holotype was selected) are deformed internal and external moulds of carapaces, of which at least one (*op. cit.*, pl. 1, fig. 13) is referable to *K. douvillei*.

The six *Kunmingella* species, from Yunnan and Guizhou provinces, erected by Huo & Shu (*in* Huo *et al.* 1983b) were distinguished on the basis of minor differences in valve shape and anterior and posterior lobal morphology. Of these, the type species *K.* (*Validocostatella*) *maotianshanensis* (for lectotype designation see Huo *et al.* 1991) and *K.* (*Validocostatella*) *guanshanensis*, and also the type species *K.* (*Angustacostatella*) *angustacostata* (no type specimen designated) and *K.* (*Angustacostatella*) *qiongzhuensis*, are indistinguishable from *K. douvillei*. *K.* (*Angustacostatella*) *acuta* and *K. zhuazhuayanensis*, based on incomplete or deformed specimens, may also be synonymous with *K. douvillei*.

Of the fourteen species of *Kunmingella* described from several parts of SW China by Li (1983), most are simply descriptions and illustrations repeated from previously published works. We consider that this material, together with the two species that he established in that paper (*K. leshanensis* and *K. rectangulata*), can be assigned to *K. douvillei*.

Huo & Shu (1985) described 36 species and subspecies of *Kunmingella*, *Parakunmingella* and *Pseudokunmingella,* including 18 new. Many of their figured specimens are incomplete and poorly preserved. Their descriptions offered little or no

Figure 13 *Kunmingella douvillei* (Mansuy, 1912); Qiongzhusi Formation, lower Cambrian. (a, c, f) Shapushan section, Wuding County, Yunnan Province; (b, d) Siqitian section, Malong County, Yunnan Province; (e) Kebaocun section, Yiliang County, Yunnan Province; (g) Ma'anshan section, Chengjiang County, Yunnan Province; (h) Fandian section, Leshan City, Sichuan Province; all light photographs; (a–f, h) ×12, (g) ×4.

(a) RCCBYU 00022 (field coll. W8), open carapace, lateral view; (b) RCCBYU 00023 (field coll. EY201), open carapace, lateral view; (c) RCCBYU 00024 (field coll. W8), right valve, lateral view; (d) RCCBYU 00025 (field coll. EY201), right valve, lateral view; (e) RCCBYU 00026 (field coll. EY153), right valve, lateral view; (f) RCCBYU 00027 (field coll. W11), open carapace, lateral view (stereo-pair); (g) RCCBYU 00028 (field coll. Ma'anshan), several valves on mudstone; (h) RCCBYU 00029 (field coll. Fan23), open carapace, lateral view.

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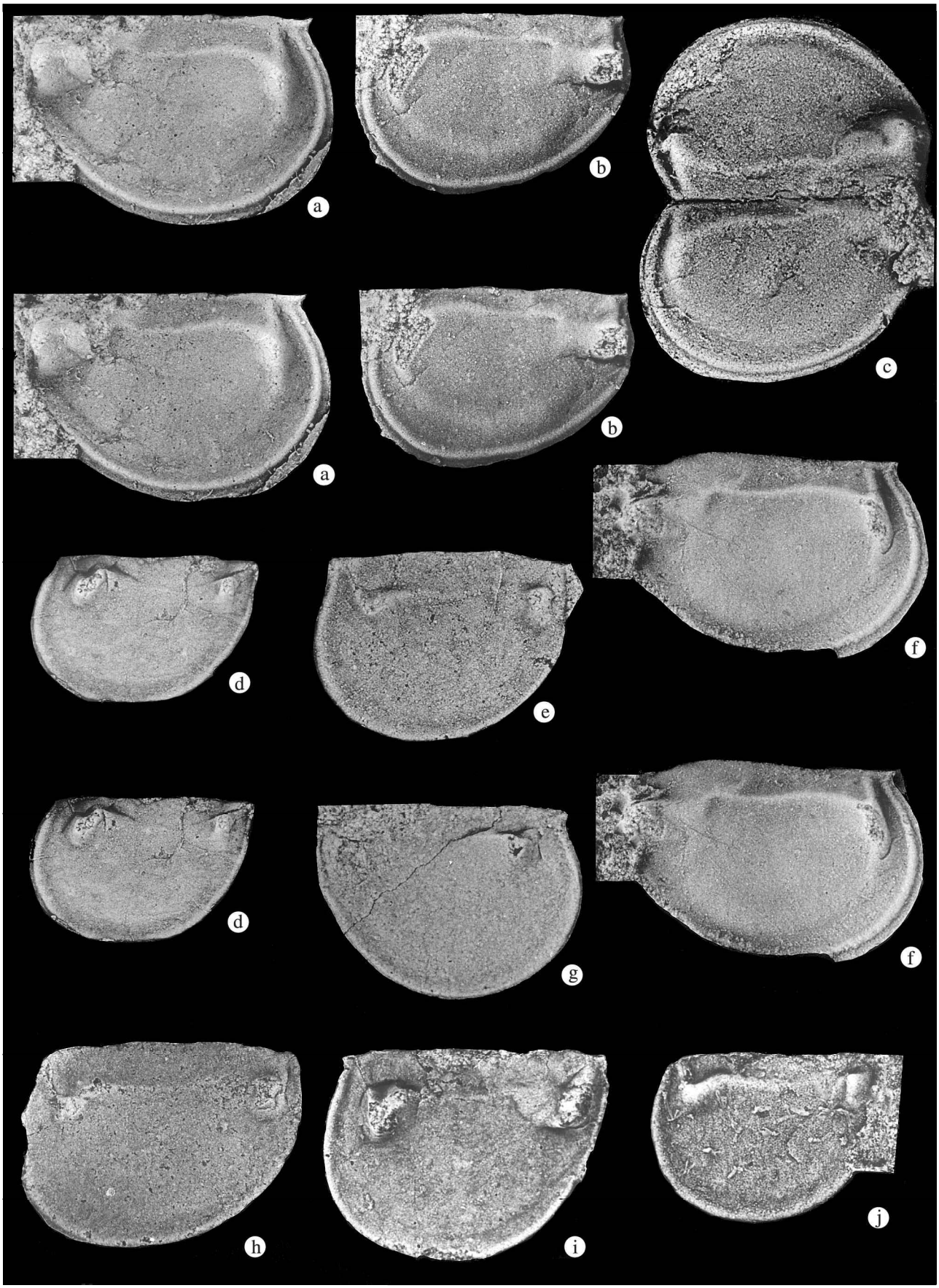

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comparison with the appropriate type species and in the case of some species (e.g. *K.* (*Angustacostatella*) *asilla*) a type specimen was not designated. We consider that all of these taxa except *Kunmingella* (*Spinokunmingella*) *typica* and *Kunmingella* (*Spinokunmingella*) *rectospina* (see below) are synonyms or possible synonyms of *K. douvillei*. Huo & Shu (1985) distinguished their species on the basis of what we recognise to be intraspecific and preservational differences. These include variation in posterior and anterior lobal morphology, valve shape, and the shape of the lateroadmarginal ridge.

Based on material from Zhenba County, Shaanxi Province, Tan & Li (1988) established two new genera, one new subgenus and six new species of kunmingellids; each species was based on 1–3 poorly preserved specimens. The differences used to distinguish these species are in most cases due to differential preservation of especially the anterior and posterior lobes, and we regard the species as synonymous with *K. douvillei*.

Kunmingella xiaoyangensis Shu, 1990 was based on specimens recovered from acid residues from Xiaoyangba Section, Zhenba County, Shaanxi Province. Its lobal morphology falls within the range of variation of *K. douvillei*. Like the possibly conspecific *Kunmingelloides bulbosus* (also from Xiaoyangba Section), *K. xiaoyangensis* differs from *K. douvillei* in having finely reticulate valves. The affinity of the weakly lobate *Kunmingella fusina zhenbaensis* Shu, 1990, which was based on only a few poorly preserved valves, is uncertain.

Nearly all of the taxa and illustrations featured in Huo *et al.* (1991) are reproduced from Huo & Shu 1985. *Kunmingella* (*Angustacostatella*) *bulbosa* Tong, 1991 and *Kunmingella* (*Angustacostatella*) *elongata* Tong, 1991 both have generally similar lobation to *K. douvillei*, but in addition are finely reticulate.

Occurrence. Western and Middle subprovinces. Sections in E'mei County (Huo & Shu 1985; Huo *et al.* 1991; herein), Fandian section, Leshan City (Lee 1975; Huo & Shu 1982, 1985; Li 1983; Huo *et al.* 1991; herein), Zhuazhuayan section, Leipo County (Huo & Shu 1985; Huo *et al.* 1991) and Nanjiang County (Huo & Shu 1985; Huo *et al.* 1991), Sichuan Province; Xiaoyangba section, Zhenba County, Shaanxi Province (Tan & Li 1988; Shu 1990a; Huo *et al.* 1991); Wuding County (Zhang 1974; Lee 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991; herein), Qujing City (Huo & Shu 1985), Qiongzhusi section, Kunming City (Huo *et al.* 1983b; Huo & Shu 1985; herein), Meishucun section, Jinning County (Huo 1965; Jiang 1982, 1984; Huo & Shu 1985; Huo *et al.* 1991; herein), sections in Chengjiang (Huo *et al.* 1983b; Huo *et al.* 1991; herein) and Malong counties (Zhang 1974; Li 1983; herein) and Kebaocun section, Yiliang County (Mansuy 1912; see also Ulrich & Bassler 1931; Huo 1956; Li 1983; Huo & Shu 1985; Huo *et al.* 1991; and herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Eoredlichia–Wutingaspis* and *Yunnanocephalus–Malungia* biozones.

Kunmingella typica Huo & Shu, 1985
(Fig. 25h, i)

?1974 *Malongella bituberculata* (gen. et sp. nov.); Zhang, p. 108, pl. 43, fig. 4

1985 *Kunmingella (Spinokunmingella) typica* Huo & Shu (subgen. et sp. nov.); Huo & Shu, p. 113, pl. 13, figs 1–5.

1985 *Kunmingella (Spinokunmingella) rectospina* Huo & Shu (subgen. et sp. nov.); Huo & Shu, p. 114, pl. 13, figs 6–10.

1991 *Kunmingella* (*Spinokunmingella*) *typica* Huo & Shu; Huo *et al.*, p. 133, pl. 23, figs 1–5.

1991 *Kunmingella* (*Spinokunmingella*) *rectospina* Huo & Shu; Huo *et al.*, p. 133, pl. 23, figs 6–10.

Holotype. A juvenile open carapace, NWUX D83078; Huo & Shu 1985, pl. 13, fig. 1. Maotianshan section, Chengjiang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Material. Three specimens from Kuangshan section, Malong County and one specimen from Xiaolantian section, Chengjiang County, Yunnan Province.

Measurements. Based on the illustration in Huo & Shu (1985, pl. 13, fig. 1), the holotype carapace is 3·1 mm long. Our specimens are up to 5·5 mm long.

Diagnosis. Species of *Kunmingella* with a posteroventral spine.

Description. Valves amplete, adults typically greater than 5 mm in length. Lateroadmarginal ridge low and narrow, situated close to valve margin, entire between cardinal corners. Between lateroadmarginal ridge and weakly convex lobal area is a broad shallow continuous depression. Lobation comprises an anterodorsal lobe, separated from a short, weak, ridge-like posterodorsal lobe by a broad sulcal depression. Each valve has a long, straight to slightly curved posteroventral spine that projects posteroventrally.

Remarks. *K. typica* is distinguished from the type species by the presence of the spine. We do not consider that this represents a dimorphic feature or any other type of possible intraspecific variation of *K. douvillei*, because the spine is known from only a few of the thousands of *Kunmingella* specimens we have examined.

Huo & Shu (1985; see also Huo *et al.* 1991) distinguished *K. typica* from *K. rectospina* on details of the morphology of the posteroventral spine, a difference we consider is intraspecific.

The type species *Malongella bituberculata* Zhang, 1974, which was based on only one poorly preserved valve from Siqitian section, Malong County, may be a senior synonym of *K. typica*. Zhang's illustration (1974, pl. 43, fig. 4) shows the possible base of a posteroventral spine.

Occurrence. Western Subprovince. Kuangshan section (herein), Malong County; and Xiaolantian (herein) and

Figure 14 *Emeiella venusta* Lee, 1975: Qiongzhusi Formation, lower Cambrian. (a–c, f) Gaopo section in Gaoqiao, E'mei County, Sichuan Province; (d, e) Maotianshan section, Chengjiang County, Yunnan Province; (g, h) Shapushan section, Wuding County, Yunnan Province; (i, j) Meishucun section, Jinning County, Yunnan Province; all light photographs, ×12.

(a) RCCBYU 00030 (field coll. SG2), left valve, lateral view (stereo-pair); (b) RCCBYU 00031 (field coll. SG2), right valve, lateral view (stereo-pair); (c) RCCBYU 00032 (field coll. SG2), open carapace, lateral view; (d) RCCBYU 00034 (field coll. M1b), right valve, lateral view (stereo-pair); (e) RCCBYU 00035 (field coll. M1b), right valve, lateral view; (f) RCCBYU 00033 (field coll. SG2), anteroventrally incomplete left valve, lateral view (stereo-pair); (g) RCCBYU 00036 (field coll. W4), left valve, lateral view; (h) RCCBYU 00037 (field coll. W4), right valve, lateral view; (i) RCCBYU 00038 (field coll. K3), right valve, lateral view; (j) RCCBYU 00039 (field coll. K4), right valve, lateral view.

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Maotianshan sections (Huo & Shu 1985), Chengjiang County, Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Eoredlichia–Wutingaspis* Biozone.

Genus *Emeiella* Lee, 1975

1975 *Emeiella* Lee, gen. nov.; Lee, p. 53.
?1978 *Songlinella* Yin (gen. nov.); Yin, p. 384.
1980 *Emeiella* Lee, 1975; Tan, p. 187.
1981 *Emeiella* Lee, 1975; Li, p. 72.
1983b *Emeiella* Lee; Huo *et al.*, p. 56.
1983 *Emeiella* Lee, 1975; Li, p. 7.
1985 *Emeiella* Lee 1975; Huo & Shu, p. 125.
?1985 *Emeiellopsis* Huo & Shu (gen. nov.); Huo & Shu, p. 130.
?1985 *Songlinella* Yin, 1978; Huo & Shu, p. 132.
1991 *Emeiella* Lee, 1975; Huo *et al.*, p. 142.
?1991 *Emeiellopsis* Huo & Shu, 1985; Huo *et al.*, p. 146.
?1991 *Songlinella* Yin, 1978; Huo *et al.*, p. 147.

Type species. By original designation: *Emeiella venusta* Lee, 1975. From Yuxiansi section, E'mei County, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Kunmingellids with a well-developed anterodorsal lobe divided by a subvertical furrow into anterior and posterior parts; a very narrow, weakly sinuous, dorsal connecting ridge; and a short, ridge-like posterodorsal lobe which subparallels the posterior margin and is node-like at its junction with the connecting ridge. Lateroadmarginal ridge is low and narrow, and is entire between cardinal corners.

Remarks. *Emeiella* differs from *Kunmingella* in its possession of a dorsal connecting ridge and shorter, more posteriorly situated posterior lobe that subparallels the posterior margin.

Songlinella Yin, 1978 (type species *Songlinella songlinensis* Yin, 1978) and *Emeiellopsis* Huo & Shu, 1985 (type species *Emeiellopsis orthoformis* Huo & Shu, 1985) are possible junior synonyms of *Emeiella*. *Songlinella* is purported to differ from *Emeiella* in its lack of a dorsal connecting ridge. However, in the type species, *E. venusta*, the dorsal connecting ridge is fully developed only in specimens longer than 3·5 mm (e.g. see Fig. 14a–c, f) and, additionally, the connecting ridge is often absent due to abrasion. Thus, we consider that *Songlinella* is possibly based on juvenile or abraided material of *Emeiella*. *Emeiellopsis* is supposed to be distinguished from *Emeiella* and *Songlinella* by its posterior lobal morphology. However, based on their illustrations, the species which Huo & Shu (1985) erected within *Emeiellopsis* (*E. orthoformis* and *E. badaowanensis*), *Emeiella* (e.g. *E. wudingensis* and *E. sapushanensis*) and *Songlinella* (e.g. *S. badaowanensis*) are based on specimens that appear to show only minor preservational differences in posterior lobe morphology. Furthermore, we have identified a similar range of morphological variation in the posterior lobe of our material of *E. venusta* (see Fig. 14a–j).

Occurrence. Shaanxi, Sichuan and Yunnan provinces, SW China; lower Cambrian.

Emeiella venusta Lee, 1975
(Fig. 14a–j)

1975 *Emeiella venusta* Lee, gen. et sp. nov.; Lee, p. 54, pl. 4, figs 20, 21.
1975 *Emeiella obesadorsata* Lee, gen. et sp. nov.; Lee, p. 54, pl. 4, fig. 23.
1975 *Emeiella planata* Lee, gen. et sp. nov.; Lee, p. 55, pl. 4, fig. 24.
1975 *Emeiella zhangshanensis* Lee, sp. nov.; Lee, p. 55, pl. 4, fig. 22.
?1978 *Songlinella songlinensis* Yin (gen. et sp. nov.); Yin, p. 384, pl. 143, fig. 5.
?1978 *Songlinella zunyiensis* Yin (gen. et sp. nov.); Yin, p. 384, pl. 143, fig. 4.
1980 *Emeiella obesadorsata* Lee; Tan, p. 187, pl. 21, fig. 8.
1980 *Emeiella zhangshanensis* Lee; Tan, p. 187, pl. 21, fig. 9.
1980 *Emeiella triacuta* Tan, (sp. nov.); Tan, p. 187, pl. 21, fig. 10.
1981 *Emeiella* sp.; Li, p. 72, pl. 2, figs 10, 11.
1983b *Emeiella sapushanensis* Huo & Shu sp. nov.; *in* Huo *et al.*, p. 56, pl. 5, figs 1–3.
1983 *Emeiella venusta* Lee, 1975; Li, p. 7, pl. 1, fig. 1.
1983 *Emeiella obesadorsata* Lee, 1975; Li, p. 7, pl. 1, fig. 2.
1983 *Emeiella planata* Lee, 1975; Li, p. 8, pl. 1, fig. 3.
1983 *Emeiella zhangshanensis* Lee, 1975; Li, p. 8, pl. 1, fig. 4.
1985 *Emeiella venusta* Lee; Huo & Shu, p. 125, pl. 5, figs 1–3.
1985 *Emeiella obesadorsata* Lee; Huo & Shu, p. 126, pl. 5, figs 4, 5.
1985 *Emeiella planata* Lee; Huo & Shu, p. 126, pl. 5, fig. 6.
1985 *Emeiella zhangshanensis* Li; Huo & Shu, p. 126, pl. 6, fig. 1.
1985 *Emeiella* sp. Lee; Huo & Shu, p. 127, pl. 5, fig. 9.
1985 *Emeiella triacuta* Tan; Huo & Shu, p.127, pl. 5, fig. 10.
1985 *Emeiella sapushanensis* Huo & Shu; Huo & Shu, p. 127, pl. 5, figs 11, 12.
1985 *Emeiella shaanxiensis* Huo & Shu sp. nov.; Huo & Shu, p. 127, pl. 5, figs 7, 8.
1985 *Emeiella liangshanensis* Huo & Shu sp. nov.; Huo & Shu, p. 128, pl. 6, figs 4–6.
1985 *Emeiella wudingensis* Huo & Shu sp. nov.; Huo & Shu, p. 129, pl. 6, fig. 2.
?1985 *Emeiella orthoformis* Huo & Shu sp. nov.; Huo & Shu, p. 129, pl. 6, fig. 3.
1985 *Emeiella rigida* Huo & Shu sp. nov.; Huo & Shu, p. 130, pl. 6, figs 7, 8.
1985 *Emeiellopsis orthoformis* Huo & Shu (gen. et sp. nov.); Huo & Shu, p. 130, pl. 6, figs 9–11.
1985 *Emeiellopsis badaowanensis* Huo & Shu (gen. et sp. nov.); Huo & Shu, p. 131, pl. 6, figs 12–16.
?1985 *Songlinella songlinensis* Yin; Huo & Shu, p. 132, pl. 7, fig. 3, ?figs 1, 2.
?1985 *Songlinella zunyiensis* Yin; Huo & Shu, p. 132, pl. 7, fig. 4.
?1985 *Songlinella meishucunensis* (sp. nov.), Huo & Shu, p. 133, pl. 7, figs 5–8.
?1985 *Songlinella yunnanensis* Huo & Shu (sp. nov.); Huo & Shu, p. 133, pl. 7, fig. 9.
?1985 *Songlinella stellaris* Huo & Shu (sp. nov.); Huo & Shu, p. 134, pl. 8, figs 3–8.
?1985 *Songlinella badaowanensis* Huo & Shu (sp. nov.), Huo & Shu, p. 135, pl. 7, figs 10–12.
?1985 *Songlinella tenuis* Huo & Shu (sp. nov.), Huo & Shu, p. 135, pl. 8, figs 1, 2.
1991 *Emeiella venusta* Lee; Huo *et al.*, p. 142, pl. 26, figs 1–3.
1991 *Emeiella obesadorsata* Lee; Huo *et al.*, p. 143, pl. 26, figs 4, 5.
1991 *Emeiella planata* Lee; Huo *et al.*, p. 143, pl. 26, fig. 6.
1991 *Emeiella shaanxiensis* Huo & Shu; Huo *et al.*, p. 143, pl. 26, figs 7, 8.
1991 *Emeiella* sp.; Huo *et al.*, p. 143, pl. 26, fig. 9.
1991 *Emeiella zhangshanensis* Lee; Huo *et al.*, p. 144, pl. 27, fig. 1.
1991 *Emeiella wudingensis* Huo & Shu; Huo *et al.*, p. 144, pl. 27, fig. 2.
?1991 *Emeiella orthoformis* Huo & Shu; Huo *et al.*, p. 145, pl. 27, fig. 3.
1991 *Emeiella liangshanensis* Huo & Shu; Huo *et al.*, p. 145, pl. 27, figs 4, 6.

1991 *Emeiella rigida* Huo & Shu; Huo *et al*., p. 145, pl. 27, figs 7, 8.
1991 *Emeiella triacuta* Tan; Huo *et al*., p. 146, pl. 27, fig. 16.
1991 *Emeiella sapushanensis* Huo & Shu; Huo *et al*., p.146, pl. 27, figs 17, 18.
1991 *Emeiellopsis orthoformis* Huo & Shu; Huo *et al*., p.146, pl. 27, figs 9–11.
1991 *Emeiellopsis badaowanensis* Huo & Shu; Huo *et al*., p. 147, pl. 27, figs 12–15.
?1991 *Songlinella songlinensis* Yin; Huo *et al*., p. 147, pl. 28, fig. 3, ? figs 1, 2.
?1991 *Songlinella zunyiensis* Yin; Huo *et al*., p. 148, pl. 28, fig. 4.
?1991 *Songlinella meishucunensis* Huo & Shu; Huo *et al*., p. 148, pl. 28, figs 5–7.
?1991 *Songlinella yunnanensis* Huo & Shu; Huo *et al*., p. 148, pl. 28, fig. 8.
?1991 *Songlinella badaowanensis* Huo & Shu; Huo *et al*., p. 149, pl. 28, figs 9, 10.
?1991 *Songlinella stellaris* Huo & Shu; Huo *et al*., p. 149, pl. 28, figs 11–14.
?1991 *Songlinella tenuis* Huo & Shu; Huo *et al*., p. 149, pl. 29, figs 1, 2.

Holotype. A carapace, CIGMR no. SO15; Lee, 1975, p. 54, pl. 4, fig. 21. Yuxiansi section, E'mei County, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Material. About 100 specimens from Gaoqiao, E'mei County, Sichuan Province; 20 specimens from Meishucun section in Jinning County, Hongjiachon and Maotianshan sections in Chengjiang County and Shapushan section in Wuding County, Yunnan Province.

Measurements. Based on the illustration in Lee (1975, pl. 4, fig. 21), the holotype carapace is 4·8 mm long. Our specimens are 3·29–4·38 mm long.

Diagnosis. As for the genus.

Description. Valves postplete throughout ontogeny. Lateroadmarginal ridge is low and narrow, entire between cardinal corners, and situated close to valve margin. Between lateroadmarginal ridge and weakly convex lobal area is a broad, shallow, continuous depression. Lobation (fully developed in specimens longer than 3·5 mm) comprises: a broad anterodorsal lobe divided by a narrow subvertical furrow; and a short, ridge-like posterodorsal lobe that subparallels the posterior margin, and terminates immediately in front of the posterior cardinal corner, and which is node-like at its junction with the narrow, weakly sinuous, dorsal connecting ridge. Hinge-line well developed; nature of junction of valves unknown.

Remarks. Our material of *E. venusta* clearly demonstrates a wide range of preservational and intraspecific morphological variation, particularly of lobation. However, the variation is not discontinuous and variants do not cluster at particular stratigraphic intervals. In larger (more than 4 mm long) specimens of *E. venusta,* which appear to have undergone minimum compression, the anterodorsal lobe is strongly inflated and clearly divided into two parts by a subvertical furrow (see Fig. 14a, c). In partially flattened or smaller (juvenile) specimens, only the anterior part of the anterodorsal lobe is well preserved and is often subcircular in shape (see Fig. 14b, d, i, j; cf. *Kunmingella*). In markedly flattened specimens, the anterodorsal lobe may be very attenuated (see Fig. 14e, g, h). Similarly the posterodorsal lobe is relatively long in large specimens which preserve their original convexity (Fig. 14a), but is smaller and subcircular in compressed and smaller (juvenile) specimens (Fig. 14d, e, g, h). The connecting ridge is fully developed only in specimens longer than 4 mm (Fig. 14a, c, f) and is absent or very weakly developed in specimens smaller than 3·5 mm long (Fig. 14d). Recognition of this ontogenetic variation of the connecting ridge is particularly important as previous authors have used its absence to distinguish numerous taxa that we believe are synonyms of *E. venusta* (see below).

There are at least 19 previously established species (11 referred to *Emeiella*, six to *Songlinella* and two to *Emeiellopsis*), all from the same general stratigraphical level, which we consider are synonyms or possible synonyms of *E. venusta.* Each of these species is based on only a few specimens, which in some cases is only one or two deformed and/or juvenile valves. For example, in addition to the type species *E. venusta*, Lee (1975) distinguished an additional three species of *Emeiella*, each based on a single specimen from E'mei County and purportedly differentiated on the basis of minor differences in valve and lobal shape. From his illustrations (1975, pl. 4, figs 20–24; see also Li 1983, pl. 1, figs 1–4) we consider these differences to be intraspecific.

The two specimens from Songlin section, Guizhou Province, which Yin (1978) used to erect *Songlinella songlinensis* and *Songlinella zunyiensis* apparently lack a connecting ridge; however, they may simply represent juvenile or abraided material of *E. venusta.* We consider that the *Emeiella* material which Tan (1980) and Li (1983) described from E'mei County, Sichuan Province, is conspecific with *E. venusta.*

Based on their illustrations, we believe that as many as 12 species established by Huo & Shu (1985) may simply represent ontogenetic and preservational differences in lobal and lateral valve shape of a single species. *Emeiella shaanxiensis*, *Emeiella liangshanensis*, *Emeiella wudingensis*, *Emeiella rigida* and *Emeiellopsis orthoformis* and *Emeiellopsis badaowanensis* are indistinguishable from *E. venusta.* Their illustration of *Emeiella orthoformis* (1985, pl. 6, fig. 3) shows an incomplete and abraded possible *E. venusta.* The five species that they established within *Songlinella* (1985, pl. 7, figs 5–12, pl. 8, figs 1–8), based on material from Yunnan Province, include juveniles, adults and abraded specimens which appear to lack a fully developed connecting ridge; however, in all other respects these taxa are identical to *E. venusta.*

Occurrence. Western Subprovince and also possibly the Middle Subprovince. Liangshan section, Hanzhong City, Shaanxi Province (Huo & Shu 1985); Yuxiansi section (Lee 1975; Li 1981, 1983; Huo & Shu 1985; Huo *et al.* 1991) and Gaopo section, Gaoqiao (Lee 1975; Tan 1980; Li 1983; Huo & Shu 1985; Huo *et al.* 1991; herein), E'mei County, Sichuan Province; Shapushan section, Wuding County (Huo & Shu 1985; Huo *et al.* 1991; herein), Meishucun section, Jinning County (Huo & Shu 1985; Huo *et al.* 1991; herein), and Maotianshan (Huo & Shu 1985; Huo *et al* 1991; herein), Hongjiachong (herein) and Dapotou (herein) sections, Chengjiang County, Yunnan Province. Possibly occurs also at the Songlin section, Zunyi City, Guizhou Province. Qiongzhusi Formation, lower Cambrian; lower part of the *Eoredlichia–Wutingaspis* Biozone.

Genus *Hanchiangella* Huo, 1956

1956 *Hanchiangella* gen. nov.; Huo, p. 436.
1956 *Shensiella* gen. nov.; Huo, p. 440.
1983a *Hanchiangella* Huo 1956; Huo *et al*., p. 94.
1985 *Hanchiangella* Huo, 1956; Huo & Shu, p. 139.
1985 *Shensiella* Huo 1956; Huo & Shu, p. 143.
1987c *Hanchiangella* Huo, 1956; Hou, p. 542.
1991 *Hanchiangella* Huo, 1956; Huo *et al*., p. 152.
1991 *Shensiella* Huo, 1956; Huo *et al*., p. 156.

Type species. By original designation: *Hanchiangella minor* Huo, 1956. From Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

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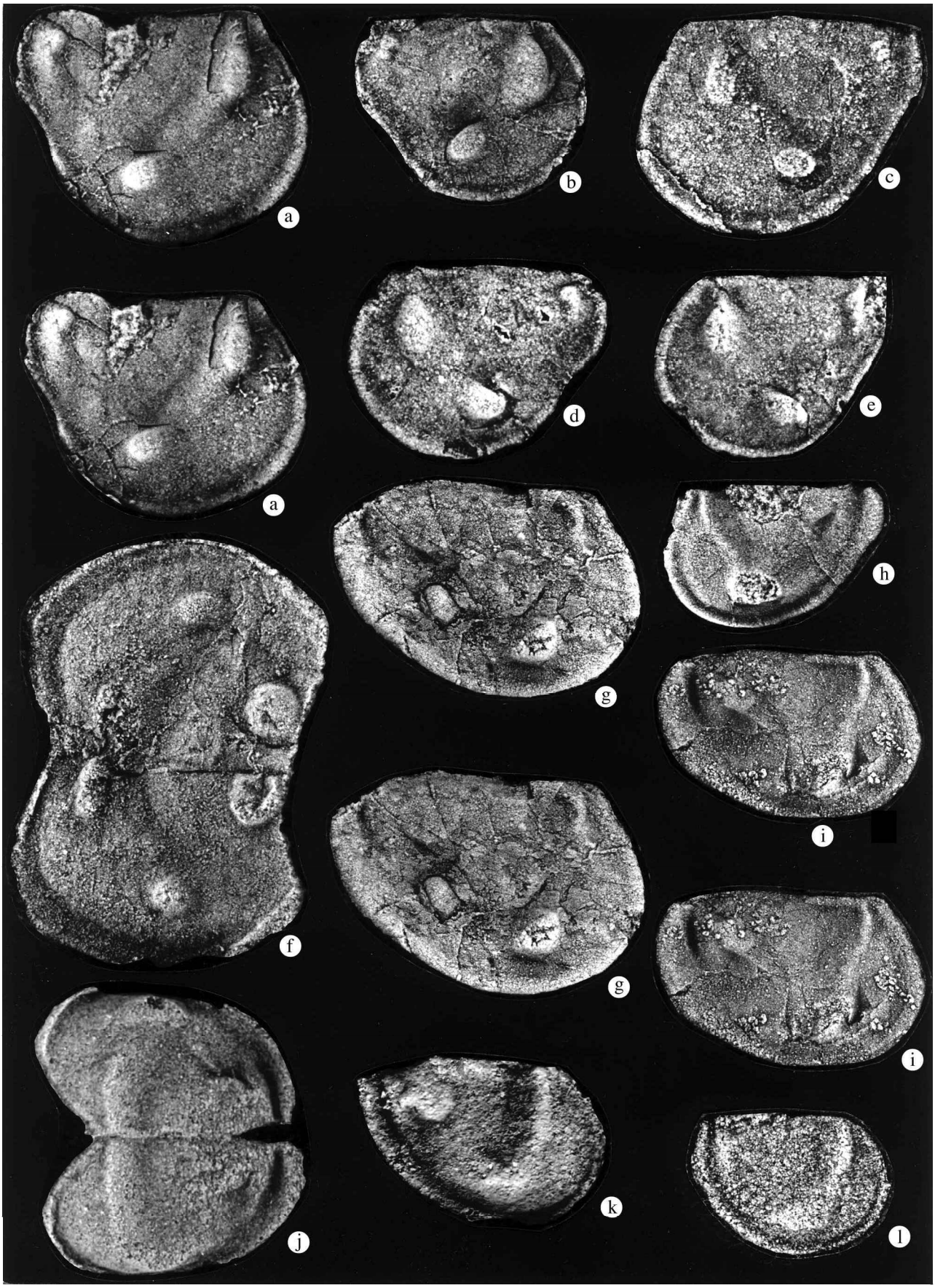

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Diagnosis. Postplete, trilobate kunmingellids with subovate anterodorsal lobe, subovate mid-ventral node, and curved, subovate to elongate posterodorsal lobe. Sulcal depression anterior of posterodorsal lobe is narrow, indistinct and weakly sigmoidal. Lateroadmarginal ridge demarcated from lateral valve surface by a furrow. Lateral outline of anteroventral part of free margin gently concave.

Remarks. *Hanchiangella* differs from *Kunmingella* and *Emeiella* in being trilobate, by having the lateral outline of the anteroventral part of the free margin gently concave, and by being smaller.

Huo (1956) established the genera *Hanchiangella* and *Shensiella* based on a small number of specimens from the Liangshan section, Hanzhong City, Shaanxi Province. He distinguished *Shensiella* from *Hanchiangella* on the basis that its anterodorsal node was divided into two parts by a furrow. Our analysis of specimens of the type species *Hanchiangella minor* shows that the lobe may also have such a feature; indeed, as a result of differential compaction the shape of the anterodorsal lobe can vary from subovate to U-shaped even between the conjoined valves of a carapace (Fig. 15f). We have also noted marked ontogentic changes in lobation within *Hanchiangella minor*. Thus, we regard *Hanchiangella* and *Shensiella* as synonymous.

On account of the early first stratigraphic occurrence of *Hanchiangella* it has often been considered as a primitive bradoriid (see Huo & Shu 1983, 1985; Huo *et al.* 1991). Huo & Shu (1985, see text-fig. 3–2) and Huo *et al.* (1991) identified what they regarded as an evolutionary continuum in their new species and subspecies of *Hanchiangella* and *Shensiella,* with those taxa with four lobes (*Shensiella crassa*) evolving to those with three (*Hanchiangella minor sulcus*) and, finally, two lobes (*Hanchiangella minor*). They distinguished *Hanchiangella minor interceda* as a probable intermediate between forms with three and two lobes. They interpreted this purported fusion of lobes to represent the amalgamation of four original body segments. However, they did not have any evidence from soft parts with which to substantiate their proposal (an idea, indeed, which cannot be supported based on preserved soft parts; see Hou *et al.* 1996; Shu *et al.* 1999). Moreover, we believe that all of their relevant species and subspecies are synonyms of *H. minor*.

Occurrence. Shaanxi, Sichuan and Yunnan provinces, SW China; lower Cambrian. *Hanchiangella* is associated with the earliest Chinese trilobite *Abadiella*.

Hanchiangella minor Huo, 1956
(Fig. 15a–f)

1956 *Hanchiangella minor* sp. nov.; Huo, p. 437, pl. 3, figs 1–4.
1956 *Hanchiangella minor* var. *sulcus*, nov.; Huo, p. 437, pl. 3, fig. 5.
1956 *Hanchiangella subquinquata* sp. nov.; Huo, p. 438, pl. 3, figs 6, 7.
1956 *Hanchiangella alta* sp. nov.; Huo, p. 438, pl. 3, figs 8, 9.
1956 *Hanchiangella robusta* sp. nov.; Huo, p. 439, pl. 3, figs 10, 11.
1956 *Hanchiangella tenuis* sp. nov.; Huo, p. 439, pl. 3, figs 12, 13.
1956 *Shensiella crassa* sp. nov., Huo; p. 440, pl. 3, figs 14, 15.
1956 *Shensiella subquadrata* sp. nov.; Huo, p. 441, pl. 3, figs 16, 17.
1974 *Shensiella crassa* Huo; Zhang, p. 108, pl. 43, fig. 5.
1974 *Hanchiangella minor* Huo; Zhang, p. 110, pl. 43, fig. 15.
1975 *Hanchiangella minor* Huo; Li *et al.*, p. 133, pl. 6, figs 1–4.
1975 *Hanchiangella minor* var. *sulcus* Huo; Li *et al.*, p. 133, pl. 6, fig. 5.
1975 *Hanchiangella subquingquata* Huo; Li *et al.*, p. 133, pl. 6, figs 6, 7.
1975 *Hanchiangella robusta* Huo; Li *et al.*, p. 133, pl. 6, figs 10, 11.
1975 *Hanchiangella tenuis* Huo; Li *et al.*, p. 134, pl. 6, figs 12, 13.
1975 *Shensiella crassa* Huo; Li *et al.*, p. 134, pl. 5, figs 7, 8.
1975 *Shensiella subquadrata* Huo; Li *et al.*, p. 134, pl. 5, figs 9, 10.
1982 *Hanchiangella tenuis* Huo, 1956; Jiang, p. 212, pl. 29, fig. 5.
1983a *Hanchiangella minor wudingensis* subsp. nov.; Huo & Tong *in* Huo *et al.*, p. 94, pl. 1, figs 1–3.
1985 *Hanchiangella minor* Huo; Huo & Shu, p. 139, pl. 1, figs 1, 2.
1985 *Hanchiangella minor wudingensis* Huo & Tong; Huo & Shu, p. 139, pl. 1, figs 3, 4.
1985 *Hanchiangella minor sulca* Huo; Huo & Shu, p. 139, pl. 1, fig. 5.
1985 *Hanchiangella minor interceda* (subsp. nov.); Huo & Shu, p. 140, pl. 1, fig. 6.
1985 *Hanchiangella minima* Huo & Peng; Huo & Shu, p. 140, pl. 1, fig. 14.
1985 *Hanchiangella subquinquata* Huo; Huo & Shu, p. 141, pl. 1, figs 7, 8.
1985 *Hanchiangella alta* Huo; Huo & Shu, p. 141, pl. 1, fig 10.
1985 *Hanchiangella robusta* Huo; Huo & Shu, p. 141, pl. 1, fig. 9.
1985 *Hanchiangella tenuis* Huo; Huo & Shu, p. 141, pl. 1, fig. 13.
1985 *Hanchiangella hanchiangensis* (sp. nov.); Huo & Shu, p. 142, pl. 1, figs 11, 12.

Figure 15 (a–f) *Hanchiangella minor* Huo, 1956: Qiongzhusi Formation, lower Cambrian. (a–e) Shapushan section, Wuding County, Yunnan Province; (f) Meishucun section, Jinning County, Yunnan Province; all light photographs, ×15.

(a) RCCBYU 00040 (field coll. W3), left valve, lateral view (stereo-pair); (b) RCCBYU 00041 (field coll. W3), left valve, lateral view; (c) RCCBYU 00042 (field coll. W3), right valve, lateral view; (d) RCCBYU 00043 (field coll. W3), right valve, lateral view; (e) RCCBYU 00044 (field coll. W3), right valve, lateral view; (f) RCCBYU 00045 (field coll. K1), anteriorly incomplete open carapace, lateral view.

(g–l) *Nanchengella acuta* Huo, 1956: Qiongzhusi Formation, lower Cambrian. (g) Maotianshan section, Chengjiang County, Yunnan Province; (h, i) Meishucun section, Jinning County, Yunnan Province; (j–l) Gaopo section in Gaoqiao, E'mei County, Sichuan Province; all light photographs; (g–k) ×11, (l) ×13.

(g) RCCBYU 00046 (field coll. M1a), left valve, lateral view (stereo-pair); (h) RCCBYU 00047 (field coll. K1), right valve, lateral view; (i) RCCBYU 00048 (field coll. K1), left valve, lateral view (stereo-pair); (j) RCCBYU 00049, (field coll. SG-0), open carapace, lateral view; (k) RCCBYU 00050 (field coll. SG-0), left valve, lateral view; (l) RCCBYU 00051 (field coll. SG-0), left valve, lateral view.

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1985 *Hanchiangella longa* (sp. nov.); Huo & Shu, p. 142, pl. 1, figs 15–18.
1985 *Shensiella crassa* Huo; Huo & Shu, p. 143, pl. 1, figs 19, 20.
1985 *Shensiella subquadrata* Huo; Huo & Shu, p. 144, pl. 1, figs 21, 22.
1987c *Hanchiangella wudingensis* Huo & Tong; Hou, p. 542, pl. 2, figs 1–8.
?1987c *Hanchiangella* sp. indet., Hou, p. 544, pl. 2, fig. 9.
1991 *Hanchiangella minor* Huo; Huo *et al.*, p. 152, pl. 31, figs 1, 2.
1991 *Hanchiangella minor wudingensis* Huo & Tong; Huo *et al.*, p. 152, pl. 31, figs 3, 4.
1991 *Hanchiangella minor sulca* Huo; Huo *et al.*, p. 153, pl. 31, fig. 5.
1991 *Hanchiangella minor interceda* Huo & Shu; Huo *et al.*, p. 153, pl.31, fig. 6.
1991 *Hanchiangella minima* Huo & Peng; Huo *et al.*, p. 153, pl. 31 fig. 14.
1991 *Hanchiangella subquinquata* Huo; Huo *et al.*, p. 154, pl. 31, figs 7, 8.
1991 *Hanchiangella alta* Huo; Huo *et al.*, p. 154, pl. 31, fig. 10.
1991 *Hanchiangella robusta* Huo; Huo *et al.*, p. 154, pl. 31, fig. 9.
1991 *Hanchiangella hanchiangensis* Huo & Shu; Huo *et al.*, p. 156, pl. 31, figs 11, 12.
1991 *Hanchiangella tenuis* Huo; Huo *et al.*, p. 156, pl. 31, fig. 13.
1991 *Hanchiangella longa* Huo & Shu; Huo *et al.*, p. 156, pl. 31, figs 15–18.
1991 *Shensiella crassa* Huo; Huo *et al.*, p. 156, pl. 31, figs 19, 20.
1991 *Shensiella subquadrata* Huo; Huo *et al.*, p. 156, pl. 31, figs 21, 22.
1994 *Hanchiangella minor*; Shu & Chen, fig. 5c.

Holotype. A juvenile carapace, NIGPAS no. 8616; Huo 1956, p. 437, pl. 3, fig. 1. Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian, *Abadiella* Biozone.

Material. Several tens of specimens from Shishan section, Wuding County and a few specimens from Meishucun section, Jinning County, Maotianshan section, Chengjiang County and Qiongzhusi section in Kunming City, Yunnan Province.

Measurements. Based on the illustration in Huo (1956, pl. 3, fig. 1), the holotype carapace is 2·6 mm long. Our specimens are 2·61–3·43 mm long.

Diagnosis. As for the genus

Description. Valves postplete, lateral outline of anteroventral part of free margin concave. Anterior cardinal corner less obtuse than posterior cardinal corner. Lateroadmarginal ridge low and narrow, entire between cardinal corners, and is situated close to valve margin. Between lateroadmarginal ridge and weakly convex lobal surface is a shallow, continuous depression. Lobation comprises a subovate anterodorsal lobe, a subovate mid-ventral node, and a curved subovate, vertically elongated posterodorsal lobe that terminates immediately in front of posterior cardinal corner. Sulcal depression anterior of posterodorsal lobe is narrow, indistinct and sigmoidal. Hinge-line well developed; nature of junction of valves unknown.

Remarks. We consider that the eleven taxa of *Hanchiangella* and *Shensiella* which were erected by Huo (1956) and Huo & Shu (1985), together with *H. minor wudingensis* Huo & Tong (*in* Huo *et al.* 1983a), are synonyms of a single species, namely *H. minor*. Many of these taxa were based on only one or two specimens, and the material of ten of them (all except *H. minor wudingensis*, from Yunnan Province) comes from the same general stratigraphic level and location in Shaanxi Province as *H. minor*. The taxa in question display only slight differences in valve outline, valve convexity and size, and size of the lobes/nodes; such variation can be accounted for by ontogenetic and/or preservational (e.g. compaction) factors. *H. minor*, *H. minor sulcus* and *H. minor interceda* appear to be based on juvenile specimens (Huo 1956, pl. 3, figs 1–5; Huo & Shu 1985, pl. 1, fig. 6; cf. Fig. 15b, e). The specimens used by Huo (1956) to establish *Shensiella crassa, S. subquadrata, Hanchiangella robusta,* and *H. alta* appear to be adults. *Hanchiangella tenuis*, *H. subquinquata* and *H. hanjiangensis* are based on flattened adult and juvenile specimens (Huo 1956, pl. 3, figs 6, 7, 12, 13; Huo & Shu 1985, pl. 1, figs 11, 12). *H. longa* Huo & Shu, 1985 (pl. 1, figs 15–18) was based on juveniles and adults.

The material which Huo & Shu (1985, pl. 1, fig. 14) treated under the binomen *Hanchiangella minima* Huo & Tong (an unpublished manuscript name) appears to be conspecific with *H. minor*.

Occurrence. Western Subprovince. Liangshan section, Hanzhong City, Shaanxi Province (Huo 1956; Zhang 1974; Li *et al.* 1975; Huo & Shu 1985; Huo *et al.* 1991); Zhengyuan section, Wangcang County, Sichuan Province (Huo & Shu 1985; Huo *et al.* 1991); Shishan and Shapushan sections, Wuding County (Huo *et al.* 1983a; Hou 1987c; Huo *et al.* 1991; herein), Meishucun section, Jinning County (Jiang 1982; Huo & Shu 1985; Huo *et al.* 1991; herein), Qiongzhusi section in Kunming City (herein) and Maotianshan section, Chengjiang County (Hou 1987c), Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Abadiella* Biozone.

Genus *Nanchengella* Huo, 1956

1956 *Nanchengella* gen. nov.; Huo, p. 431.
1982 *Bajiella* Jiang (gen. nov.); Jiang, p. 213.
1983a *Nanchengella* Huo 1956; Huo *et al.*, p. 96.
?1983 *Laogongshania* Li (gen. nov.); Li, p. 18.
1985 *Nanchengella* Huo 1956; Huo & Shu, p. 120.
?1985 *Laogongshania* Li 1983; Huo & Shu, p. 166.
1987c *Nanchengella* Huo, 1956; Hou, p. 540.
1991 *Nanchengella* Huo, 1956; Huo *et al.*, p. 138.
?1991 *Laogongshania* Li, 1983; Huo *et al.*, p. 176.

Type species. By original designation: *Nanchengella acuta* Huo, 1956. From Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Kunmingellid with an elongate, postplete carapace. Anterodorsal lobe subovate and weakly developed. Posterior lobe ridge-like, weakly sigmoidal, connects with subovate mid-ventral node via a connecting ridge. Lateroadmarginal ridge demarcated from valve surface by a furrow.

Remarks. *Nanchengella* differs from *Kunmingella* and *Emeiella* by being trilobate. It differs from *Hanchiangella* by being more elongate, by having a stronger connecting ridge between the posterior lobe and the mid-ventral node, and by lacking a concave lateral outline to the anteroventral part of the free margin.

Based on published illustrations, we consider that *Bajiella* Jiang, 1982 (type species *Bajiella dalongtonensis* Jiang, 1982, from Jinning County, Yunnan Province) and also possibly the monotypic *Laogongshania* Li, 1983 (type species *Laogongshania elliptica* Li, 1983, from E'bian County, Sichuan Province) are synonyms of *Nanchengella*. Huo & Shu (1985) and Huo *et al.* (1991) distinguished *Laogongshania* from *Nanchengella* by what they interpreted as a bifurcated anterior node

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and by its supposed discrete posterior lobe and mid-ventral node. Similar variation in our specimens of the type species *N. acuta*, is clearly a result of differential compaction (see Fig. 15g, j).

Occurrence. Shaanxi, Sichuan and Yunnan provinces, SW China; lower Cambrian. *Nanchengella* co-occurs with *Hanchiangella* and the oldest Chinese trilobite *Abadiella*.

Nanchengella acuta Huo, 1956
(Fig. 15g–l)

1956 *Nanchengella acuta* sp. nov.; Huo, p. 431, pl. 1, figs 9–11.
?1956 *Nanchengella lui* sp. nov.; Huo, p. 432, pl. 1, figs 12, 13.
1956 *Nanchengella elongata* sp, nov.; Huo, p. 433, pl. 2, figs 1, 2.
1956 *Nanchengella major* sp. nov.; Huo, p. 433, pl. 2, fig. 3, ? fig. 4.
1956 *Nanchengella minima* sp. nov.; Huo, p. 434, pl. 2, figs 5, 6.
1974 *Nanchengella elongata* Huo; Zhang, p. 109, pl. 43, fig. 9.
1974 *Nanchengella acuta* Huo; Zhang, p. 110, pl. 43, fig. 14.
1975 *Nanchengella acuta* Huo; Li *et al*., p. 131, pl. 4, figs 9–11.
?1975 *Nanchengella lui* Huo; Li *et al*., p. 132, pl. 5, figs 12, 13.
1975 *Nanchengella elongata* Huo; Li *et al*., p. 132, pl. 5, figs 1, 2.
1975 *Nanchengella major* Huo; Li *et al*., p. 132, pl. 5, fig. 3, ? fig. 4.
1975 *Nanchengella minima* Huo; Li *et al*., p. 132, pl. 5, figs 5, 6.
1982 *Bajiella dalongtanensis* Jiang gen. et sp. nov.; Jiang, p. 213, pl. 29, figs 2–4.
?1983a *Nanchengella microcostata* sp. nov.; Huo & Tong *in* Huo *et al*., p. 96, pl. 1, fig. 4.
?1983a *Nanchengella yunnanensis* sp. nov.; Huo & Tong *in* Huo *et al*., p. 96, pl. 1, figs 9, 10.
?1983a *Nanchengella diandongensis* sp. nov.; Huo & Tong *in* Huo *et al*., p. 96, pl. 1, figs 5, 6.
?1983a *Nanchengella elongata kunyangensis* subsp. nov.; Huo & Tong *in* Huo *et al*., p. 97, pl. 1, figs 7, 8.
?1983a *Nanchengella planata* subsp. nov.; Huo & Shu *in* Huo *et al*., p. 97, pl. 1, figs 11, 12.
?1983 *Laogongshania elliptica* Li (gen. et sp. nov.); Li, p. 19, pl. 3, fig. 16.
1984 *Bajiella dalongtanensis* Jiang; Jiang, p. 149, pl. 17, fig. 2.
1984 *Nanchengella elongata* Huo; Huo & Shu, p. 241, pl. 1, fig. 4.
1985 *Nanchengella acuta* Huo; Huo & Shu, p. 121, pl. 2, figs 1, 2.
?1985 *Nanchengella lui* Huo; Huo & Shu, p. 121, pl. 2, figs 3, 4.
?1985 *Nanchengella elongata* Huo; Huo & Shu, p. 121, pl. 2, figs 5, 6.
?1985 *Nanchengella elongata kunyangensis* Huo & Tong; Huo & Shu, p. 122, pl. 2, figs 7, 8.
?1985 *Nanchengella major* Huo; Huo & Shu, p. 122, pl. 2, fig. 9.
?1985 *Nanchengella minima* Huo; Huo & Shu, p. 123, pl. 2, figs 10, 11.
?1985 *Nanchengella planata* Huo & Shu; Huo & Shu, p. 123, pl. 3, figs 1, 2.
?1985 *Nanchengella microcostata* Huo & Tong; Huo & Shu, p. 123, pl. 2, fig. 14.
?1985 *Nanchengella yunnanensis* Huo & Tong; Huo & Shu, p. 123, pl. 2, figs 16, 17.
?1985 *Nanchengella diandongensis* Huo & Tong; Huo & Shu, p.124, pl. 2, figs 12, 13.
?1985 *Nanchengella diandongensis emeiensis* (subsp. nov.); Huo & Shu, p. 124, pl. 2, fig. 15.
?1985 *Nanchengella bituberculata* (sp. nov.); Huo & Shu, p. 125, pl. 3, fig. 3.
?1985 *Laogongshania elliptica* Li; Huo & Shu, p. 166, pl. 28, fig. 5.
1987c *Nanchengella jinningensis* sp. nov.; Hou, p. 541, pl. 1, figs 4–12.
1991 *Nanchengella acuta* Huo; Huo *et al*., p. 139, pl. 25, figs 1, 2.
?1991 *Nanchengella lui* Huo; Huo *et al*., p. 139, pl. 25, figs 3, 4.
?1991 *Nanchengella elongata* Huo; Huo *et al*., p. 139, pl. 25, figs 5, 6.
?1991 *Nanchengella elongata kunyangensis* Huo & Tong; Huo *et al*., p. 140, pl. 25, figs 7, 8.
?1991 *Nanchengella major* Huo; Huo *et al*., p. 140, pl. 25, fig. 9.
?1991 *Nanchengella minima* Huo; Huo *et al*., p. 140, pl. 25, figs 10, 11.
?1991 *Nanchengella diandongensis* Huo & Tong; Huo *et al*., p. 141, pl. 25, figs 12, 13.
?1991 *Nanchengella microcostata* Huo & Tong; Huo *et al*., p. 141, pl. 25, fig. 14.
?1991 *Nanchengella planata* Huo & Shu; Huo *et al*., p. 141, pl. 26, figs 10, 11.
?1991 *Nanchengella bituberculata* Huo & Shu; Huo *et al*., p. 141, pl. 26, fig. 12.
?1991 *Laogongshania elliptica* Li; Huo *et al*., p. 176, pl. 36, fig. 10.
1994 *Nanchengella dalongtanensis* (Jiang); Luo, Jiang & Tang, p. 168, pl. 5, figs 3, 4.

Lectotype. Designated Huo *et al*., 1991; a juvenile carapace, NIGPAS no. 8599; Huo 1956, pl. 1, fig. 10. Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

Material. Several dozen specimens from Gaopo section in Gaoqiao, E'mei County, Sichuan Province and Meishucun section, Jinning County, Yunnan Province. Ten specimens in total from Shapushan section, Wuding County, Qiongzhusi section in Kunming City and Maotianshan section, Chengjiang County, Yunnan Province.

Measurements. Based on the illustrations in Huo (1956, pl. 1, fig. 10) the lectotype is 3·3 mm long. Two additional syntype specimens of Huo are 3·7 mm long (NIGPAS no. 8600) and 3·1 mm long (NIGPAS no. 8601). Our specimens are 2·71–5·09 mm long.

Diagnosis. As for the genus.

Description. Valves postplete; lateral outline of free margin convex throughout. Lateroadmarginal ridge is narrow and low, entire between cardinal corners, and is situated close to valve margin. It is demarcated from the lateral valve surface by a narrow, shallow furrow. Lobal surface convex. Lobation comprises a subovate, weakly developed anterodorsal lobe, and ridge-like, weakly sigmoidal posterior lobe that in some specimens connects with a subovate mid-ventral node. Broad sulcal depression occurs anterior to posterior lobe. Hinge-line well developed; nature of junction of valves uncertain.

Remarks. Our specimens from Sichuan and Yunnan provinces are morphologically indistinguishable from Huo's (1956) figured material of *N. acuta*.

We consider that all of the other twelve species and subspecies that have been referred to *Nanchengella* are synonyms or probable synonyms of *N. acuta*. They comprise four taxa

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based on material from the same section as the type material of *N. acuta*, at Liangshan, Hanzhong City, Shaanxi Province (Huo 1956), five taxa from Meishucun section, Jinning County, Yunnan Province (Huo & Tong *in* Huo *et al.* 1983a; Hou 1987), and three from Gaopo section in Gaoqiao, E'mei County, Sichuan Province (Huo & Shu *in* Huo *et al.* 1983a; Huo & Shu 1985). In our opinion the differences in valve size, lobation and in the lateroadmarginal ridge that have been used to differentiate these various taxa are probably due to ontogenetic and preservational (e.g. compactional) factors.

The four additional *Nanchengella* species erected by Huo (1956) were each based on only one or two specimens and were distinguished from the type species only by their larger overall size or length (*N. major* and *N. elongata*), smaller size (*N. minima*) or minor lobal differences (*N. lui*). Similarly, the four species and subspecies of *Nanchengella* (*N. microcostata*, *N. yunnanensis*, *N. diandongensis*, *N. elongata kunyangensis*) established by Huo & Tong (*in* Huo *et al.* 1983a) and *N. planata* Huo & Shu (*in* Huo *et al.* 1983a) were each based on only one or two specimens and differentiated from the type species by only minor lobal differences.

Based on only two deformed specimens, Huo & Shu (1985) erected the 'geographical subspecies' *N. diandongensis emeiensis,* which they distinguished by its larger size and ventral node, and the species *N. bituberculata*, which they distinguished by having its anterior node divided by a transverse groove. As noted above, the latter feature varies markedly as a product of differential compression and should not be used to distinguish kunmingellid taxa.

Shu (1990b, p. 321) considered that nine of the above subspecies and species, including the type species *N. acuta*, were synonomous with *N. elongata*, and represented the equivalent of four ontogenetic stages of that species.

Occurrence. Western Subprovince. Liangshan section, Hanzhong City, Shaanxi Province (Huo 1956; Zhang 1974; Li *et al.* 1975; Huo *et al.* 1983a, 1991; Huo & Shu 1985); Gaopo section in Gaoqiao, E'mei County (Huo *et al.* 1983a, 1991; Huo & Shu 1985; herein) and Laogongshan section, E'bian County (Li 1983; Huo & Shu 1985; Huo *et al.* 1991), Sichuan Province; Meishucun section, Jinning County (Jiang 1982, 1984; Huo *et al.* 1983a, 1991; Huo & Shu 1985; Hou 1987c; herein), Shapushan, Wuding County (Hou 1987c; herein), Qiongzhusi section in Kunming (herein) and Maotianshan section, Chengjiang County (herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Abadiella* Biozone.

Family Cambriidae Lee, 1975

1975 Cambridae (*sic*) Lee, fam. nov.; Lee, p. 43.
1983 Cambridae (*sic*) Lee, 1975; Li, p. 18.
1985 Sangsiellidae (*sic*) Li (n. fam.); Li, p. 86.
1985 Cambriidae Lee 1975; Huo & Shu, p. 153.
1991 Cambriidae Lee, 1975; Huo *et al.*, p. 168.
1996 Cambriidae Li, 1975 (*sic*); Siveter *et al.*, p. 116.

Diagnosis. (After Siveter *et al.* 1996). Subamplete to postplete Bradoriida with a medium to large carapace (adult species are from 6 mm up to 17·5 mm long), a broad cusp on the anterior part of the dorsal margin, two to three subcircular to elongate ovate nodes, a ventrally situated narrow to broad arcuate connecting ridge and a lateroadmarginal ridge which is entire between the cardinal corners.

Remarks. The type species *Cambria sibirica* Neckaja & Ivanova, 1956 and other coeval Russian taxa have recently been rehabilitated (Williams *et al.* 1994; Siveter *et al.* 1994a; Melnikova *et al.* 1997). Features of the cambriid carapace, additional to those given in the diagnosis, include: fine, closely spaced granulose ornament (in which individual granules are larger on the lobes); and, in some taxa, the presence of an anastomosing network of fine ridges on the lateral surface below the main lobal area (see Siveter *et al.* 1996; Vannier *et al.* 1997).

The lower Cambrian Chinese genera *Shangsiella* Lee, 1975 and *Auriculatella* Tan, 1980 have typical cambriid morphology (see Siveter *et al.* 1996). *Chuanbeiella* Huo & Peng (*in* Huo & Shu), 1985 and *Paracambria* Huo & Shu, 1985 are junior synonyms of *Shangsiella* (see below). Placement of *Guangyuanella* Zhang, 1974 in the Cambriidae requires examination of additional, more diagnostic material than the single specimen figured by Zhang (1974; see also Huo & Shu 1985, pl. 27, fig. 13 and Huo *et al.* 1991, pl. 37, fig. 14).

Kunmingellids resemble cambriids in overall valve shape, in having a lateroadmarginal ridge that is entire between the cardinal corners, and by possessing a cusp in the anterodorsal valve outline. They differ by lacking a ventrally situated arcuate connecting ridge and by having anterior lobation that overreaches the anterior margin (Fig. 2).

Genus *Shangsiella* Lee, 1975

?1974 *Guangyuanella* (gen. nov.); Zhang, p. 108.
1975 *Shangsiella* Lee, gen. nov.; Lee, p. 62.
1983 *Shangsiella* Lee, 1975; Li, p. 19.
1985 *Shangsiella* Lee, 1975; Huo & Shu, p. 154.
1985 *Chuanbeiella* gen. nov.; Huo & Peng *in* Huo & Shu, p. 155.
1985 *Paracambria* (gen. nov.); Huo & Shu, p. 160.
?1985 *Antihipponicharion* gen. nov.; Huo & Shu, p. 162.
1991 *Paracambria* Huo & Shu, 1985; Huo *et al.*, p. 168.
?1991 *Antihipponicharion* Huo & Shu, 1985; Huo *et al.*, p. 171.
1991 *Shangsiella* Lee, 1975; Huo *et al.*, p. 173.
1991 *Chuanbeiella* Huo & Peng, 1985; Huo *et al.*, p. 174.

Type species. By original designation: *Shangsiella elongata* Lee, 1975. From Changjianggou section, Guangyuan City, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Medium-sized (adults *c.* 6–7 mm long), postplete cambriids with relatively short, arcuate connecting ridge joining subovate to elongate anterodorsal and posteroventral

Figure 16 (a–g) *Shangsiella elongata* Lee, 1975: Qiongzhusi Formation, lower Cambrian. Changjianggou section, Guangyuan City, Sichuan Province; all light photographs; (a, c–e, g) ×9, (b) ×8.5, (f) ×8.25.

(a) RCCBYU 00138, left valve, lateral view (stereo-pair); (b) RCCBYU 00139, left valve, lateral view; (c) RCCBYU 00140, right valve, lateral view; (d) RCCBYU 00141, open carapace, lateral view (stereo-pair); (e) RCCBYU 00142, open carapace, lateral view (stereo-pair); (f) RCCBYU 00143, open carapace, lateral view; (g) RCCBYU 00144, open carapace, lateral view.

(h–j) *Auriculatella typica* Tan, 1980: Qiongzhusi Formation, lower Cambrian. Gaopo section in Gaoqiao, E'mei County, Sichuan Province: all light photographs; (h, j) ×8.75, (i) ×8.25.

(h) RCCBYU 00146 (field coll. SG-2), right valve, lateral view; (i) RCCBYU 00147 (field coll. SG-2), right valve, lateral view (stereo-pair); (j) RCCBYU 00145 (field coll. SG-2), anteriorly incomplete left valve, lateral view (stereo-pair).

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nodes. A short ridge extends from anterodorsal node to posterior side of cusp in dorsal outline. Posterodorsal node short, isolate and ridge-like, is oriented perpendicular to the dorsal margin and terminates ventrally in a subcircular inflation. Lateroadmarginal ridge entire between cardinal corners. Ornament of small, closely spaced granules in well-preserved specimens.

Remarks. Although resembling *Shangsiella*, the monotypic *Guangyuanella* (type species *G. tianjingshanensis* Zhang, 1974) from the Luomiaozhen section of Guangyuan City, Sichuan Province, is poorly preserved and best restricted to its type specimen.

Based on specimens from the type locality of *Shangsiella*, Huo & Shu (1985) established three bradoriid genera, namely *Chuanbeiella*, *Paracambria* and *Antihipponicharion,* that we consider to be synonyms or possible synonyms of *Shangsiella*. *Chuanbeiella* was differentiated from *Shangsiella* principally by having a straight dorsal margin, but figures of *Chuanbeiella* in Huo & Shu (1985, pl. 27, figs 1–4, 6, 7) illustrate only open carapaces which are identical to our open carapaces of *Shangsiella* (see Fig. 16d–g). In such specimens the dorsal outline always appears nearly straight (see also the carapace of the cambriid *Petrianna* Siveter *et al.* 1996, fig. 6j) as the dorsal cusps of the two opposing valves suffer post-mortem compression during flattening, effectively cancelling each other out. Based on comparison of our valves and carapaces of *Shangsiella* with those figures of specimens in Huo & Shu (1985) referred to *Chuanbeiella*, we cannot identify any further differences in the position of the connecting ridge or other lobal features.

Specimens referred to *Paracambria* by Huo & Shu (1985, pl. 28, figs 1–3) are single, apparently flattened valves, whose valve shape and lobation is nonetheless identical to that of *Shangsiella*. Perceived variation in the position of the connecting ridge and development of the anterodorsal node is probably a product of compression (cf. Huo & Shu 1985, p. 160).

The monotypic *Antihipponicharion* (type species *A. navis* Huo & Shu, 1985, pl. 28, fig. 4) is based on a deformed left valve of ?*Shangsiella* and was figured in oblique dorsal orientation.

Some of the specimens from the type locality of *Shangsiella* referred to two species of *Cambria* Neckaja & Ivanova by Huo & Shu (1984, p. 243; 1985, pp. 158, 159) might be referable to *Shangsiella*. Thus, *Cambria chinensis* (Huo & Shu 1984, pl. 1, figs, 7, 8; not pl. 2, figs 7, 8 as the plate explanations were transposed) has lobal morphology similar to *S. elongata*, but is distinguished by the much more prominent development of its lateroadmarginal ridge anteriorly.

Occurrence. Sichuan Province (Lee 1975; Huo & Shu 1985; Huo *et al*. 1991; herein), SW China; lower Cambrian.

Shangsiella elongata Lee, 1975
(Fig. 16a–g)

1975 *Shangsiella elongata* Lee, gen et sp. nov.; Lee, p. 63, pl. 2, fig. 8.
1975 *Shangsiella longa* (*sic*) Lee, gen. et sp. nov.; pl. 2, fig. 8 (cited in error as *S. longa*).
?1975 *Shangsiella hypsista* Lee, sp. nov.; Lee, p. 63, pl. 2, fig. 7.
1975 *Shangsiella alata* Lee, sp. nov.; Lee, p. 64, pl. 2, fig. 15.
1983 *Shangsiella elongata* Lee, 1975; Li, p. 19, pl. 4, fig. 1.
1983 *Shangsiella alata* Lee, 1975; Li, p. 19, pl. 4, fig. 7.
1983 *Shangsiella changjianggouensis* Huo & Peng; Li, p. 19, pl. 4, fig. 2.
1983 *Shangsiella distincta* Huo & Peng; Li, p. 20, pl. 4, fig. 8.
1983 *Shangsiella shangsiensis* Huo & Peng; Li, p. 20, pl. 4, figs 3, 4.
?1983 *Shangsiella hypsista* Lee 1975; Li, p. 20, pl. 4, fig. 5.
1985 *Shangsiella elongata* Lee; Huo & Shu, p. 154, pl. 27, fig. 5.
?1985 *Shangsiella hypsista* Lee; Huo & Shu, p. 154, pl. 26, fig. 1.
1985 *Shangsiella changjianggouensis* Huo & Peng sp. nov.; Huo & Peng *in* Huo & Shu, p. 155, pl. 26, figs 2–8.
1985 *Chuanbeiella distincta* Huo & Peng gen et sp. nov.; Huo & Peng *in* Huo & Shu, p. 156, pl. 27, figs 3, 4.
?1985 *Chuanbeiella gigantea* Huo & Peng gen et sp. nov.; Huo & Peng *in* Huo & Shu, p. 156, pl. 27, figs 6, 7.
1985 *Chuanbeiella alata* (Lee); Huo & Shu, p. 157, pl. 26, fig. 9.
?1985 *Chuanbeiella guangyuanensis* sp. nov.; Huo & Shu, p. 157, pl. 27, figs 1, 2.
?1985 *Paracambria typica* gen. et sp. nov.; Huo & Shu, p. 160, pl. 25, figs 8–13.
?1985 *Paracambria longa* gen et sp. nov.; Huo & Shu, p. 161, pl. 28, figs 1–3.
?1985 *Paracambria zhaoi* gen. et sp. nov.; Huo & Shu, p. 161, pl. 27, figs 8–12.
?1985 *Paracambria* aff. *zhaoi* Huo & Shu, p. 162, pl. 25, fig. 14.
?1991 *Paracambria typica* Huo & Shu; Huo *et al*., p. 168, pl. 33, figs 8–12.
?1991 *Paracambria longa* Huo & Shu; Huo *et al*., p. 169, pl. 32, figs 12–14.
?1991 *Paracambria zhaoi* Huo & Shu; Huo *et al*., p. 169, pl. 33, figs 14–18.
?1991 *Paracambria* aff. *zhaoi* Huo & Shu; Huo *et al*., p. 169, pl. 33, fig. 13.
1991 *Shangsiella elongata* Lee; Huo *et al*., p. 173, pl. 35, fig. 5.
?1991 *Shangsiella hypsista* Lee; Huo *et al*., p. 174, pl. 35, fig. 6.
1991 *Shangsiella changjianggouensis* Huo & Peng; Huo *et al*., p. 174, pl. 35, figs 7–15.
1991 *Chuanbeiella distincta* Huo & Peng; Huo *et al*., p. 175, pl. 36, figs 1, 2.
?1991 *Chuanbeiella gigantea* Huo & Peng; Huo *et al*., p. 175, pl. 36, figs 6, 7.
?1991 *Chuanbeiella guangyuanensis* Huo & Shu; Huo *et al*., p. 176, pl. 36, figs 3, 4.
1991 *Chuanbeiella alata* (Lee); Huo *et al*., p. 176, pl. 36, fig. 5.

Holotype. External mould of a left valve, CIGMR no. SO35; Lee, 1975, pl. 2, fig. 8. Changjianggou section, Guangyuan City, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Material. More than 100 specimens from the type locality.

Measurements. Based on the illustration in Lee (1975, pl. 2, fig. 8), the holotype is 6·1 mm long. Our specimens are 3·57–6·7 mm long.

Diagnosis. *Shangsiella* with short, arcuate connecting ridge joining sub-ovate to elongate anterodorsal and posteroventral nodes. A short ridge extends from the anterodorsal node to the posterior side of the dorsal margin cusp. Short, isolate, ridge-like posterodorsal node terminates ventrally in a subcircular inflation.

Description. Valves postplete, cusp on dorsal margin is posterior to anterodorsal node. Lateroadmarginal ridge situated adjacent to the valve margin, entire between cardinal corners. Between lateroadmarginal ridge and weakly convex lobal surface is a weak, broad continuous depression. Lobation well developed even in small juveniles (see Fig. 16d). It comprises: subequally sized subovate to elongate anterodorsal and posteroventral nodes joined by an arcuate connecting ridge; a straight dorsal ridge extending from the anterodorsal lobal area towards the posterior part of the dorsal margin; and an

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elongate posterodorsal node oriented perpendicular to the dorsal margin and terminated ventrally in a subcircular inflation. Hinge-line well developed; nature of junction of valves unknown. Short posterocardinal and anterocardinal spines (always broken to their base). Entire shell surface finely and densely granulose.

Remarks. Our specimens, from the type locality, are identical with Lee's (1975, pl. 2, fig. 8) figure of *S. elongata*. They show variation in the degree of development of the various nodes, but the relative positioning of those nodes is constant. Thus, for example, the subcircular inflation at the ventral end of the posterodorsal node may be well developed (Fig. 16a, b) or weak (Fig. 16c). The short ridge extending from the anterodorsal node to the posterior side of the dorsal margin cusp may also vary from well developed (Fig. 16a, b, d, e, g) to weak (Fig. 16c). Similarly the connecting ridge may be narrow (e.g. Fig. 16e) or broad (Fig. 16c, d). Often the ventral margin of the valve is compressed and in such specimens the connecting ridge and posteroventral node may be situated very close to the edge of the valve (see Fig. 16c, e). Some valves also have a shrivelled appearance and these may be exuviae (see Fig. 16f).

Ten species have been described, all based on material from the type locality, which we consider may be synonyms of *S. elongata*. Lee (1975) appears to have had only three specimens of *Shangsiella* though he referred these to three separate species: *S. elongata*, *S. hypista* and *S. alata*. Because his specimen of *S. hypista* (*op. cit.*, pl. 2, fig. 7; see also Li 1983, pl. 4, fig. 5) is laterally compressed, accounting for its reduced length, we are uncertain whether it is conspecific with *S. elongata*. Despite the fact that Huo & Shu (1985, p. 157) later chose to refer *S. alata* to *Chuanbeiella* Huo & Peng (see also below), apart from its more prominent connecting ridge (see Lee 1975, pl. 2, fig. 15), there is no difference in the position of its nodes or valve shape by which to distinguish it from *S. elongata*, and we consider it conspecific.

Of the four *Shangsiella* species attributed to Huo & Peng by Li (1983, pp. 19, 20), illustrations in that paper indicate that *S. distincta*, *S. shangsiensis* and *S. changjianggouensis* are identical to *S. elongata* (compare with our figures of *S. elongata*, Fig. 16). However, the small *Shangsiella minima* (see Li 1983, p. 20, pl. 4, fig. 6) is too incompletely preserved to be referred to *S. elongata* with any certainty. One of these species, *S. distincta*, was later referred to the genus *Chuanbeiella* (*in* Huo & Shu 1985), together with three additional species, *C. gigantea*, *C. guangyuanensis* and *C. alata*, the latter already discussed above. These species were distinguished on the basis of superficial differences in valve outline and lobation (see Huo & Shu, 1985, pp. 156, 157, cf. pl. 27, figs 1–4, 6, 7). For example, their figured specimen of *C. distincta*, a repeat of that figured by Li (1983, pl. 4, fig. 8), lacks the straight dorsal ridge extending from the anterodorsal node towards the posterior part of the dorsal margin (see also fig. 8-67 in Huo & Shu 1985). However, the degree of development of this feature varies intraspecifically in our specimens of *S. elongata* (see above). Indeed, based on Huo & Shu's (1985) illustrations, differences between the two valves of a single carapace can often be as great as differences between individual specimens, and this is typified by their figures of *C. gigantea* (*op. cit.*, pl. 27, figs 6, 7).

Specimens referred to the type species *Paracambria typica*, *P. longa, P. zhaoi* and *P.* aff. *zhaoi* (see Huo & Shu 1985, pp. 160–62) appear to have the valve shape and lobation of *Shangsiella*. Some of their figured specimens might be conspecific with *S. elongata,* particularly those referred to *P. longa* (*op. cit.*, pl. 28, figs 1, 2, ?3), but a firm assignment requires investigation of the actual specimens.

Occurrence. Western Subprovince. Changjianggou section, Guangyuan City, Sichuan Province (Lee 1975; Huo & Shu 1985; herein). Qiongzhusi Formation, lower Cambrian; upper *Abadiella* to middle *Eoredlichia–Wutingaspis* trilobite biozones.

Genus *Auriculatella* Tan, 1980

1980 *Auriculatella* gen. nov.; Tan, p. 189.
1981 *Auriculatella* Tan; Li, p. 73.
1983 *Auriculatella* Tan, 1980; Li, p. 18.
1985 *Auriculatella* Tan, 1980; Huo & Shu, p. 163.
1991 *Auriculatella* Tan, 1980; Huo *et al.*, p. 171.

Type species. By original designation: *Auriculatella typica* Tan, 1980. From Gaopo section in Gaoqiao, E'mei County, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Medium sized (adults 6–7 mm long), weakly postplete cambriids with short, arcuate connecting ridge joining subequally sized subovate to arcuate anterocentral and posterocentral nodes. A short ridge extends from the anterocentral node to connect with a third subcircular node which is situated immediately ventral of the dorsal margin cusp. Lateroadmarginal ridge entire between cardinal corners, in adults situated about 0·8 mm from the valve margin. Ornament of small, closely spaced granules in well-preserved specimens.

Remarks. *Auriculatella* is distinguished from the Laurentian (Greenland) *Petrianna* Siveter *et al.*, 1996 by being less postplete, in the position and shape of its nodes and by lacking the anastomosing network of fine ridges on the lateral surface which characterise that genus. It differs from the Siberian *Cambria* Neckaja & Ivanova, 1956 by the greater extent of its connecting ridge and more prominent nodes, but in other respects is similar. From *Shangsiella* it differs in the position and shape of its nodes and lateroadmarginal ridge (see also Siveter *et al.* 1996, fig. 4). For additional comments see Generic Remarks for *Shangsiella*.

Occurrence. Shaanxi (Huo & Shu 1985) and Sichuan (Tan 1980) provinces, SW China; lower Cambrian.

Auriculatella typica Tan, 1980
(Fig. 16h–j)

1980 *Auriculatella typica* gen. et sp. nov.; Tan, p. 190, pl. 21, figs 13–15.
1981 *Auriculatella zhangshanensis* sp. nov.; Li, p. 73, pl. 1, figs 1–7.
1983 *Auriculatella zhangshanensis* Li, 1981; Li, p. 18, pl. 3, fig. 15.
1985 *Auriculatella typica* Tan; Huo & Shu, p. 163, pl. 24, fig. 4.
1985 *Auriculatella zhangshanensis* Lee; Huo & Shu, p. 163, pl. 24, figs 1–3.
1985 *Auriculatella typica shaanxiensis* subsp. nov.; Huo & Shu, p. 164, pl. 24, figs 7–9.
1985 *Auriculatella acuta* (sp. nov.); Huo & Shu, p. 165 (*partim*), pl. 24, fig. 6; *non* fig. 5 (= ?*Auriculatella*).
1991 *Auriculatella typica* Tan; Huo *et al.*, p. 171, pl. 34, fig. 4.
1991 *Auriculatella acuta* Huo & Shu; Huo *et al.*, p. 172 (*partim*), pl. 34, fig. 5; *non* fig. 6 (= ?*Auriculatella*).
1991 *Auriculatella zhangshanensis* Lee; Huo *et al.*, p. 172, pl. 34, figs 7–9.
1991 *Auriculatella typica shaanxiensis* Huo & Shu; Huo *et al.*, p. 172, pl. 35, figs 1–3.
1996 *Auriculatella* sp.; Siveter *et al.*, fig. 6b.

Holotype. A left valve, GCC no. Em68OS15; Tan 1980, pl. 21, fig. 13. Gaopo section in Gaoqiao, E'mei County, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Material. Ten specimens from the type locality.

Measurements. According to the illustration in Tan (1980, pl. 21, fig. 13), the holotype is 6·4 mm long. Our specimens are 5·1–6·9 mm long.

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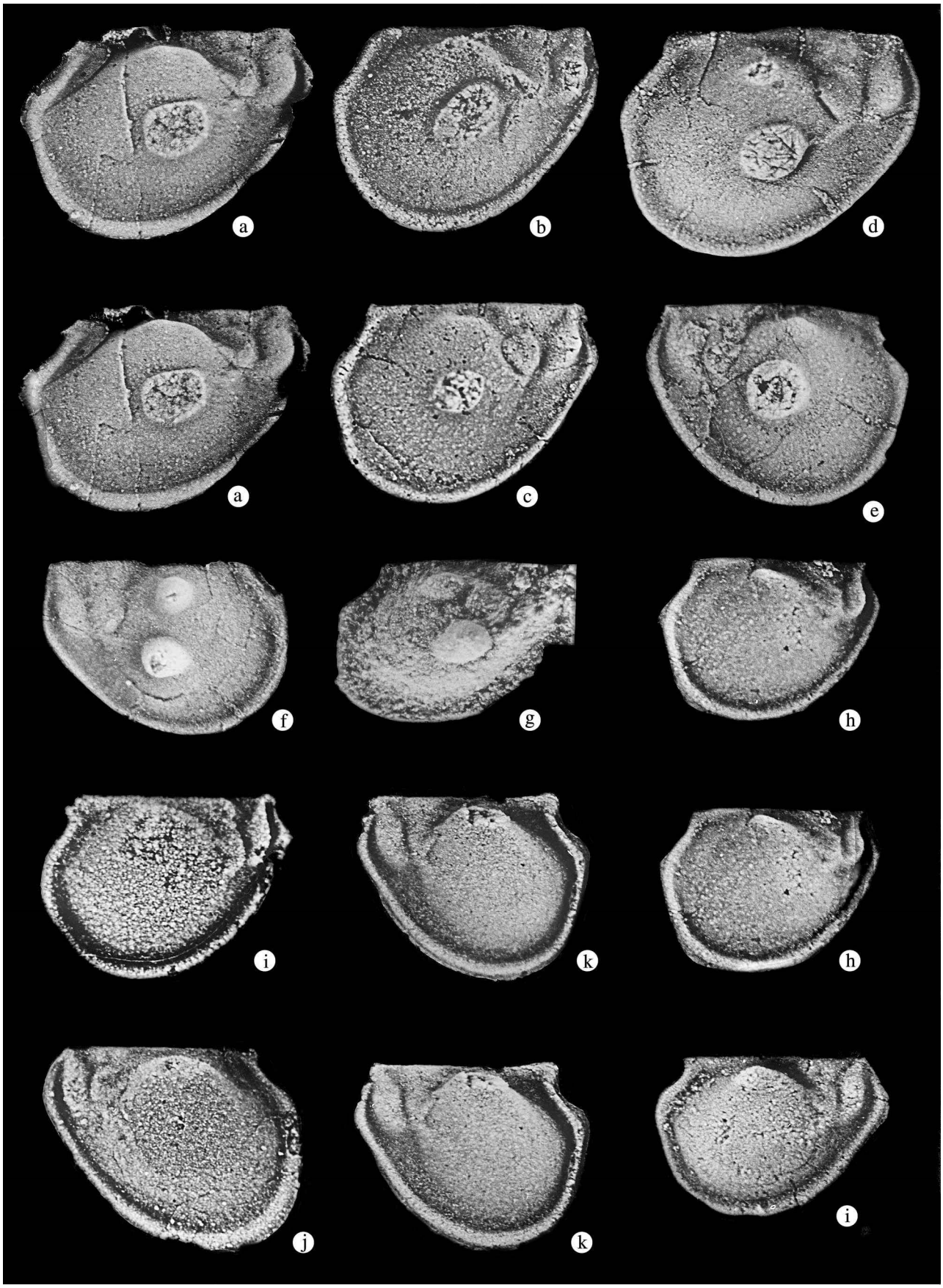

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Diagnosis. As for the genus.

Description. Valves weakly postplete, cusp on dorsal margin is posterior to anterocentral node. Lateroadmarginal ridge entire between cardinal corners, in adults situated about 0·8 mm from the valve margin (see Fig. 16i). The intervening area between the ridge and the valve margin forms a broad raised rim often with striae that are parallel to the valve margin. Lobation well developed, in juveniles occupying more of the valve surface than in larger valves and adults. Lobation comprises subequally sized subovate to arcuate anterocentral and posterocentral nodes conjoined by an arcuate connecting ridge, and a third, more diffuse subcircular node situated immediately ventral to the dorsal cusp. Nature of dorsal hinge uncertain. Entire shell surface finely and densely granulose.

Remarks. The area between the lateroadmarginal ridge and the valve margin, which reaches a maximum width ventrally and posteriorly of about 0·8 mm, is probably the external expression of the doublure. A similar (homologous?) feature is noted in representatives of the lower-middle Cambrian bivalved arthropod *Isoxys* (see Williams *et al.* 1996).

A. typica was based on three specimens from the Gaopo section in Gaoqiao, E'mei County, Sichuan Province. The identical (conspecific) *A. zhangshanensis* (see Li 1981, p. 73, pl. 1, figs 1–7; see also Huo & Shu, 1985, p. 163, pl. 24, fig. 4) is based on topotype material.

Three additional species and subspecies have been referred to *Auriculatella* (Huo & Shu, 1985, pp. 163–5), based on specimens from the Liangshan and Yuanshan sections, Hanzhong City, Shaanxi Province. Of these, illustrations in Huo & Shu (1985) indicate that: *A. typica shaanxiensis* is identical to *A. typica*; the deformed specimen on which *A. allocota* is based (*op. cit.*, pl. 24, fig. 10) is too poorly preserved to be reliably identified as a separate taxon and should be restricted to its type; whilst *A. acuta* is based on a small juvenile of *A. typica* (2·6 mm long, *op. cit.*, pl. 24, fig. 6) and a poorly preserved adult valve (6·3 mm long, *op. cit.*, pl. 24, fig. 5) of ?*Auriculatella*.

Occurrence. Western Subprovince. Gaopo section in Gaoqiao, E'mei County, Sichuan Province (Tan 1980; Li 1981, 1983; Huo & Shu 1988; Huo *et al.* 1991; herein); Liangshan and Yuanshan sections, Hanzhong City, Shaanxi Province (Huo & Shu 1985; Huo *et al.* 1991). Qiongzhusi Formation, lower Cambrian; the upper part of the *Abadiella* trilobite Biozone.

Family Comptalutidae Öpik, 1968

1968 Comptalutidae nov.; Öpik, p. 27.
1980 Comptalutidae Öpik 1968; Jones & McKenzie, p. 209.
1980 Oepikalutidae nov.; Jones & McKenzie, p. 211.
1999 Oepikalutidae Jones & McKenzie; Hinz-Schallreuter, p. 27.

Diagnosis. Small (adults *c.* 2–2·5 mm long) strongly postplete Bradoriida with a well-defined hinge-line. Cardinal corners weakly to moderately spicate. Lateroadmarginal ridge entire between cardinal corners, situated close to, and paralleling, valve margin. Lateroadmarginal ridge demarcated from convex lobal surface by a continuous furrow, and generally broadest posteriorly. Lobal surface moderately to strongly inflated, dorsally may be expanded to form a bulbous node, or more rarely a discrete subcircular node. Anterodorsal lobation may be well developed, comprises one or more lobes or nodes and a sulcus. Lobes or nodes are ventrally confluent with strongly inflated lobal area. They may be conjoined by connecting ridges. Ornament smooth, reticulate or punctate.

Remarks. Jones & McKenzie (1980) distinguished their Family Oepikalutidae (type species of the type genus: *Oepikaluta dissuta* Jones & McKenzie, 1980), which they refer to the Phosphatocopida Müller, 1964, by their phosphatic carapaces and possession of 'sub-spicate' dorsal margins. Several recent studies show that carapace composition is an unreliable criterion by which to distinguish Bradoriida and Phosphatocopida (see Hinz-Schallreuter 1993, 1999; Siveter *et al.* 1996; Hou *et al.* 1996; Siveter & Williams 1997) and 'spicate' processes at the posterior and anterior dorsal margins are features possessed by bradoriids, phosphatocopids and other bivalved arthropod groups including the Ostracoda. We consider that genera referred to the Oepikalutidae by Jones & McKenzie (*Oepikaluta*, *Zepaera* and *Flemingopsis* [=*Flemingia*]) are closely related to the bradoriid Family Comptalutidae by the characters of carapace size, shape, possession of a lateroadmarginal ridge and (often strongly) convex lobal area, and by possessing lobation concentrated anteriorly and mid-dorsally. Comptalutids differ from oepikalutids only in the detailed morphology of the anterodorsal lobation but we do not consider these differences to be worthy of familial distinction.

Hinz-Schallreuter (1999) adopted a similar approach, referring all of the above comptalutid and oepikalutid genera to the Family Oepikalutidae (though Öpik's Family Comptalutidae is the senior synonym). She assigns *Flemingopsis* and *Oepikaluta* to the subfamily Oepikalutinae, and *Comptaluta* and *Zepaera* to the subfamily Comptalutinae. She also identifies the new subfamilies Phasoiinae (type and only genus *Phasoia*) and Quetopsinae (type and only genus *Quetopsis*). Because of the dearth of well-illustrated publications of Chinese taxa, she rightly notes (*op. cit.*, p. 28) the difficulty of assigning those genera (e.g. *Yaoyingella*, *Kunyangella*, *Alutella* and *Wutingella*) to this subfamilial scheme. Our evaluation of the Chinese faunas indicates that *Yaoyingella* Zhang, 1974 is a junior synonym of *Comptaluta* (see below). *Wutingella* Zhang, 1974 (type species *W. binodosa*), by its possession of conjoined elongate dorsal and anterior lobes, appears to be a

Figure 18 (a–g) *Comptaluta leshanensis* (Lee, 1975): Qiongzhusi Formation, lower Cambrian. (a–f) Shapushan section, Wuding County, Yunnan Province; (g) Maotianshan section, Chengjiang County, Yunnan Province; all light photographs, ×23.

(a) RCCBYU 00052 (field coll. W7), right valve, lateral view (stereo-pair); (b) RCCBYU 00053 (field coll. W7), right valve, lateral view; (c) RCCBYU 00055 (field coll. W7), right valve, lateral view; (d) RCCBYU 00054 (field coll. W7), right valve, lateral view; (e) RCCBYU 00056 (field coll. W7), left valve, lateral view; (f) RCCBYU 00057 (field coll. W7), left valve, lateral view; (g) RCCBYU 00058 (field coll. M9), anteroventrally incomplete right valve, lateral view.

(h–l) *Comptaluta inflata* Zhang, 1974: Qiongzhusi Formation, lower Cambrian. (h–k) Shapushan section, Wuding County, Yunnan Province; (l) Shishan section, Wuding County, Yunnan Province; all light photographs, ×23.

(h) RCCBYU 00059 (field coll. W13), right valve, lateral view (stereo-pair); (i) RCCBYU 00060 (field coll. W14), right valve, lateral view; (j) RCCBYU 00061 (field coll. W14), left valve, lateral view; (k) RCCBYU 00062 (field coll. W14), left valve, lateral view (stereo-pair); (l) RCCBYU 00063 (field coll. SH-5) right valve, lateral view.

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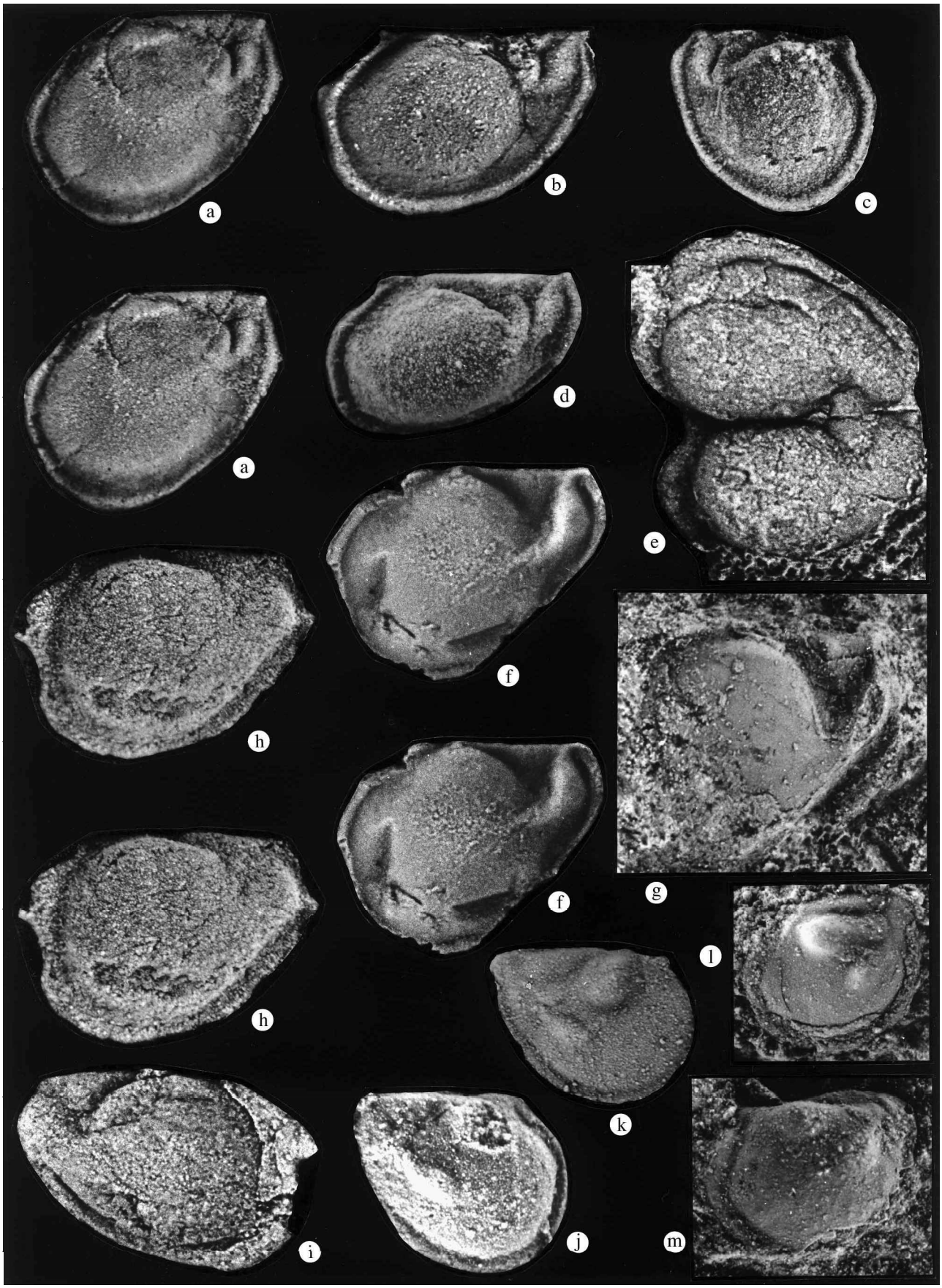

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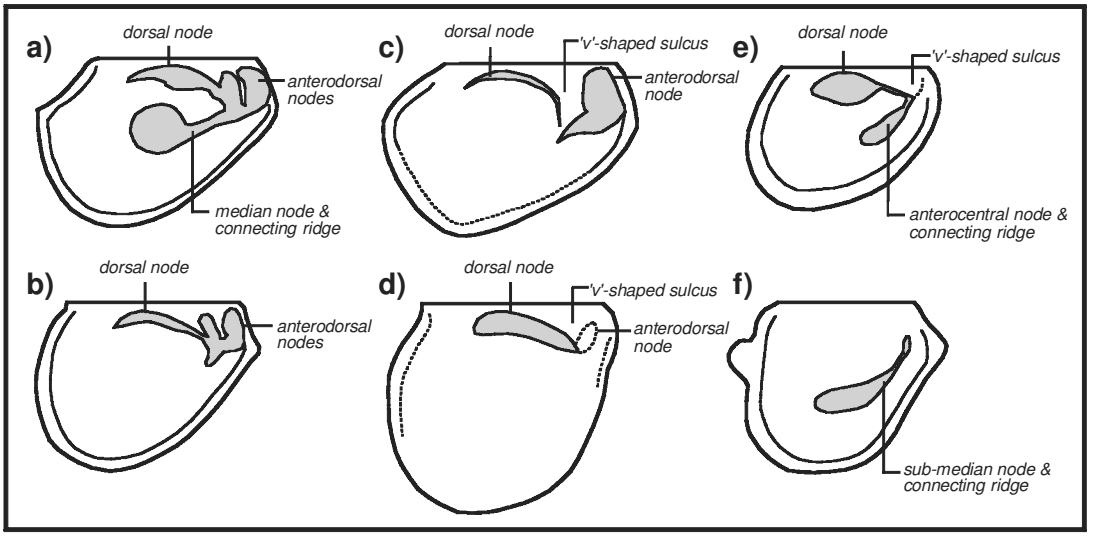

Figure 17 Lobal features (shaded areas) of comptalutid genera, based on lateral views: (a) *Comptaluta leshanensis* (Lee, 1975); (b) *Comptaluta inflata* Zhang, 1974; (c) *Alutella* cf. *A. nakamurai* Kobayashi & Kato, 1951; (d) *Kunyangella cheni* Huo, 1965; (e) *Wutingella binodosa* Zhang, 1974; (f) *Jiucunella paulula* Hou & Bergström, 1991.

comptalutinid (see Fig. 17). *Kunyangella* Huo, 1965 (type species *K. cheni*) approaches the more simple lobal morphology of Hinz-Schallreuter's *Quetopsis*, though its dorsal lobation is more distinct. More difficult is the placement of *Alutella* Kobayashi & Kato, 1951. Hinz-Schallreuter (1999) suggests that the specimens of *Alutella nakamurai* figured by Huo *et al.* (1991) might be *Quetopsis*. The more abraded of our specimens of *A.* cf. *nakamurai* (from Wuding County, Yunnan Province) do indeed approach the simple lobal morphology of *Quetopsis*, but better-preserved conspecific specimens (from Zhenba County, Shaanxi Province) have lobation which is more clearly related to *Comptaluta* (see Figs 17, 18e–i), except that the lobes are not conjoined (see discussion of *A.* cf. *nakamurai* below). *Jiucunella* Hou & Bergström, 1991 (type species *J. paulula*), possesses features typical of the Comptalutidae (see below), but, as with *Kunyangella* and *Alutella* is not readily assignable to any of the four subfamilies discussed by Hinz-Schallreuter (1999).

Many of the genera herein referred to the Comptalutidae were placed in the Alutidae Huo, 1956 by Huo & Shu (1985), but the type species of that family, *Aluta flexilis* Matthew, 1896 is a *nomen dubium* (see Öpik 1968; Siveter & Williams 1997).

Bradoria eris Walcott, 1905 was based on a single incomplete right valve (holotype, USNM 56496) with a submedian node and well-developed lateroadmarginal ridge. The valve resembles some comptalutids like *Jiucunella*, but is too incomplete for a positive referal. Öpik (1968) also considered *B. eris* to be a comptalutid.

Subfamily Comptalutinae Öpik, 1968

Diagnosis. Comptalutidae with anterodorsally concentrated lobation, the lobes being conjoined by connecting ridges.

Genus *Comptaluta* Öpik, 1968

1968 *Comptaluta* nov.; Öpik, 1968, p. 29.
1974 *Yaoyingella* (gen. nov.); Zhang, p. 108.
1975 *Leshanella* Lee, gen. nov.; Lee, p. 57.
1985 *Leshanella* Lee, 1975; Huo & Shu, p. 70.
1985 *Yaoyingella* Chang (*sic*); Huo & Shu, p. 75.
1991 *Leshanella* Lee, 1975; Huo *et al.*, p. 89.
1991 *Yaoyingella* Chang, 1974; Huo *et al.*, p. 91.
1999 *Comptaluta* Öpik, 1968; Hinz-Schallreuter, p. 29.

Figure 19 (a–d) *Comptaluta inflata* Zhang, 1974: Qiongzhusi Formation, lower Cambrian. (a–c) Maotianshan section, Chengjiang County, Yunnan Province; (d) Jianbaobaoshan section, W of Dapotou village, Chengjiang County, Yunnan province; all light photographs, ×23.

(a) RCCBYU 00064 (field coll. M7), right valve, lateral view (stereo-pair); (b) RCCBYU 00065 (field coll. M5), right valve, lateral view; (c) RCCBYU 00066 (field coll. M5), left valve, lateral view; (d) RCCBYU 00067 (field coll. DJ-3), right valve, lateral view.

(e–i) *Alutella* cf. *A. nakamurai* Kobayashi & Kato, 1951: (e) Canglangpu Formation, lower Cambrian, Qiongzhuzi section, Kunming City, Yunnan Province; (f, g) Shuijingtuo Formation, lower Cambrian, Jingyang section, Zhenba County, Shaanxi Province; (h, i) Canglangpu Formation, lower Cambrian, Shapushan section, Wuding County, Yunnan Province; all light photographs; (e, f) ×21, (g, i) ×18, (h) ×20.

(e) RCCBYU 00068 (field coll. QZS), open carapace, lateral view; (f) RCCBYU 00071 (field coll. HE-6), right valve, lateral view (stereo-pair); (g) RCCBYU 00072 (field coll. HE-6), right valve, lateral view; (h) RCCBYU 00069 (field coll. W20-1), right valve, lateral view (stereo-pair); (i) RCCBYU 00070 (field coll. W20-1), left valve, lateral view.

(j–m) *Wutingella binodosa* (Zhang, 1974): Qiongzhusi Formation, lower Cambrian. (j, l, m) Gaopo section in Gaoqiao, E'mei County, Sichuan Province; (k) Shapushan section, Wuding County, Yunnan Province; all light photographs, ×23.

(j) RCCBYU 00074 (field coll. SG-6), left valve, lateral view; (k) RCCBYU 00076 (field coll. W11), left valve, lateral view; (l) RCCBYU 00073 (field coll. SG-6), right valve, lateral view; (m) RCCBYU 00075 (field coll. SG-7), right valve, lateral view.

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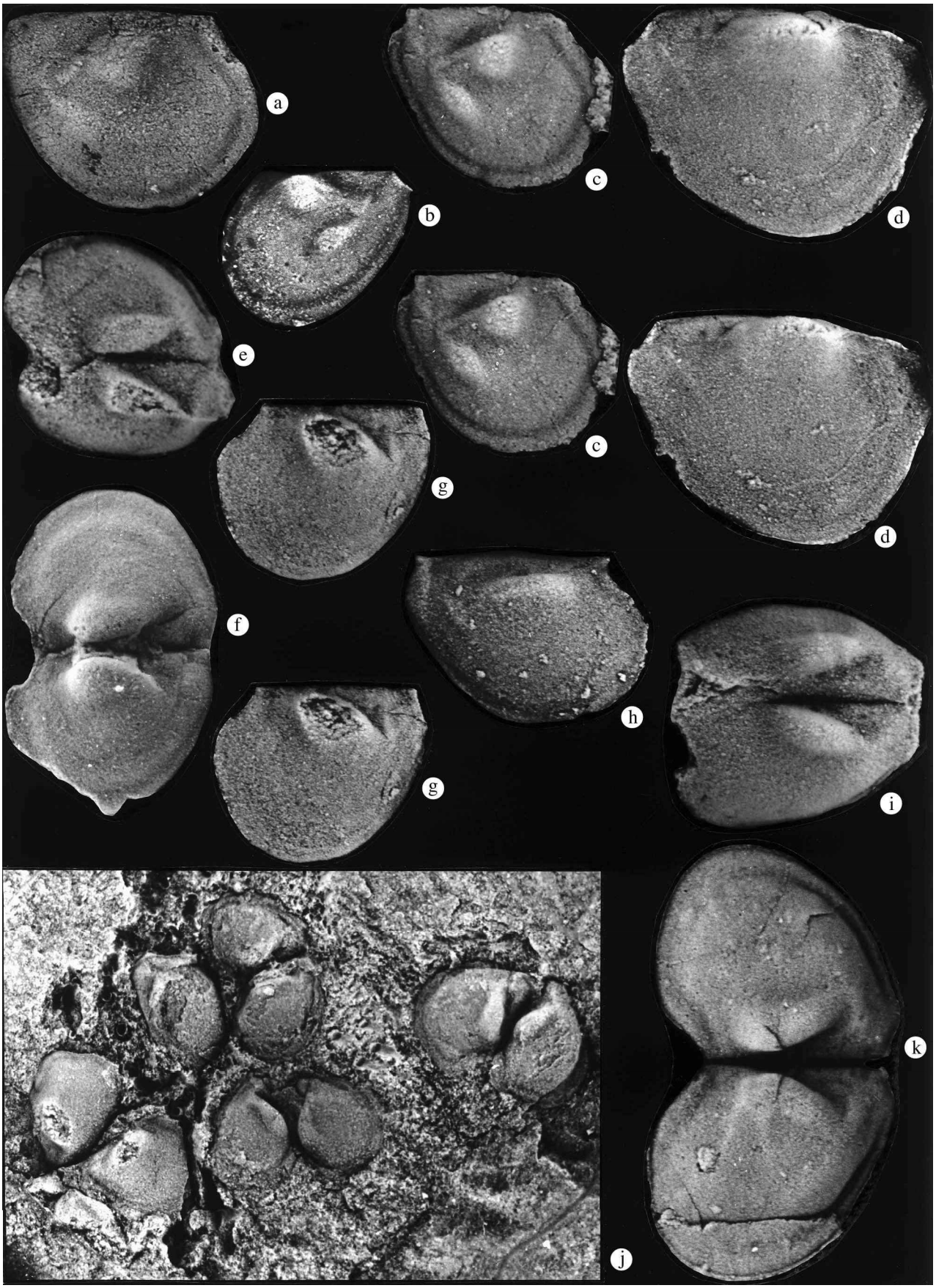

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Type species. By original designation: *Comptaluta calcarata* Öpik, 1968. From Queensland, Australia; Yelvertoft Beds, 'Middle Cambrian (Ordian)' of Öpik (1968).

Diagnosis. Comptalutids with postplete valves having a weak to marked posterodorsal and anterodorsal curve in the lateral outline of the valve. Lateral outline is fairly straight between these curves and the cardinal corners, ventrally is convex to strongly convex. Two, subovate anterodorsal nodes, separated by a narrow sulcus, are conjoined ventrally by a ridge, by which they are also confluent with the strongly convex lobal area. Narrow sulcus posterior of the anterodorsal nodes. Dorsal part of lobal area inflated to form a weak and indistinct to well-developed subcircular mid-dorsal node. When developed, large, subcircular median node is conjoined with anterodorsal nodes by a short connecting ridge. Lateroadmarginal ridge tubulose and entire between cardinal corners, demarcated from the lobal surface by a well-developed, narrow continuous furrow.

Remarks. The Chinese *Yaoyingella* was originally based on an anteroventrally deformed right valve from the Yaoying section, Wuding County, Yunnan Province (see Zhang 1974). Though most of Öpik's (1968) figured specimens of his genus *Comptaluta* are flattened, two well-preserved specimens (*op. cit*., pl. 4, figs 3, 4a, 4b) show that in lateral outline, size, possession of an entire lateroadmarginal ridge, convex lobal surface, and lobation conjoined by connecting ridges, *Comptaluta* is identical to *Yaoyingella*. This observation is confirmed by the specimens of *Comptaluta* figured by Hinz-Schallreuter (1999).

In its lateral outline and anterodorsal lobation *Comptaluta* also resembles the type bradoriid, the North American *Bradoria scrutator* Matthew, 1899 (see Siveter & Williams 1997, pl. 1).

The anterodorsal lobation of *Comptaluta* resembles that of some kunmingellids, whose anterodorsal lobe is divided by a subvertical depression into posterior and more strongly developed anterior portions, but which are connected ventrally. In *Yaoyingella* there are two adjacent, yet virtually discrete anterodorsal nodes, which are connected ventrally by a narrow ridge. Analogous to kunmingellids, the anteriormost anterodorsal node is the most strongly developed.

Leshanella Lee, 1975 (type species *L. leshanensis* Lee, 1975), based on material from the Fandian section, Leshan County, Sichuan Province, differs from *Comptaluta* only by possessing a well-developed subcircular median node. We consider this to be a specific rather than a generic difference (see below).

We are unsure of the affinities of *Leshanella calcaria* Lee, 1975 and (the abraded?) *Leshanella qianzhongensis* Shu *in* Huo & Shu 1985, both of which appear to have been based on poorly preserved specimens.

Occurrence. Sichuan (Lee 1975) and Yunnan (Zhang 1974) provinces, SW China; lower Cambrian. 'Middle Cambrian (Ordian)' of Öpik (1968), Australia (see also Hinz-Schallreuter 1999).

Comptaluta inflata (Zhang, 1974)
(Figs 18h–l, 19a–d)

1974 *Yaoyingella inflata* (gen. et sp. nov.); Zhang, p. 109, pl. 43, fig. 7.
1985 *Yaoyingella inflata* Chang (*sic*); Huo & Shu, p. 75, pl. 8, fig. 12.
1991 *Yaoyingella inflata* Chang (*sic*); Huo *et al*., p. 91, pl. 8, fig. 1.

Holotype. A right valve, NIGPAS no. 21678; Zhang, 1974, pl. 43, fig. 7. Yaoying section, Wuding County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Material. Several hundred specimens from Wuding County and several tens of specimens from Chengjiang County, Yunnan Province.

Measurements. The holotype is 2·2 mm long (measured by Hou X-g, 1981). Our specimens range from 1·67–2·05 mm in length.

Diagnosis. Species of *Comptaluta* without median node. Mid-dorsal node weakly to moderately well developed and ridge-like. Anterior-most of two anterodorsal nodes is largest.

Description. Valves postplete and small, adults typically 2 mm long. Lateral valve outline with a posterodorsal and anterodorsal curve; outline is fairly straight between these curves and the cardinal corners, ventrally is convex to strongly convex. Anterior-most of two anterodorsal nodes is largest. Anterior nodes are confluent with strongly inflated lobal area. Dorsal part of lobal area inflated to form a weak to moderately well-developed ridge-like mid-dorsal node. Lateroadmarginal ridge tubulose and entire between cardinal corners, demarcated from the lobal surface by a narrow, deep, well-developed furrow.

Remarks. *C. inflata* is distinguishable from all other species of *Comptaluta*, including the Australian *C. hartmanni* Hinz-Schallreuter, 1999 and the type species *C. calcarata* by lacking a median node and/or connecting ridge from this area to the dorsal lobation (see Fig. 17).

Since its original description no new specimens of *C. inflata* have been figured (e.g. see Huo & Shu, 1985, p. 75; Huo *et al*. 1991, p. 91). However, well-preserved specimens of *C. inflata* are abundant in the Yu'anshan Member of the Qiongzhusi Formation in Yunnan Province (Figs 18, 19). These display variation in the lateral outline, such that the posterodorsal curve can be very pronounced (e.g. Fig. 18k, l) or very weak

Figure 20 (a–c) *Wutingella binodosa* Zhang, 1974: Qiongzhusi Formation, lower Cambrian. (a, b) Shapushan section, Wuding County, Yunnan Province; (c) Shishan section, Wuding County, Yunnan Province; all light photographs, ×23.

(a) RCCBYU 00077 (field coll. W9), left valve, lateral view; (b) RCCBYU 00078 (field coll. W11), right valve, lateral view; (c) RCCBYU 00079 (field coll. Sh9), left valve, lateral view (stereo-pair).

(d–k) *Kunyangella cheni* Huo, 1965: Qiongzhusi Formation, lower Cambrian, Yunnan Province. (d, f) Shishan section, Wuding County; (e) Maotianshan section, Chengjiang County, Yunnan Province; (g, h) Shapushan section, Wuding County; (i, k) Meishucun section, Jinning County; (j) Qiongzhusi section, Kunming City; all light photographs; (d–j, k) ×23, (j) ×10.

(d) RCCBYU 00080 (field coll. Sh6), left valve, lateral view (stereo-pair); (e) RCCBYU 00082 (field coll. M3), open carapace, lateral view; (f) RCCBYU 00081 (field coll. Sh8), open carapace, lateral view; (g) RCCBYU 00083 (field coll. W13), right valve, lateral view (stereo-pair); (h) RCCBYU 00084 (field coll. W14), left valve, lateral view; (i) RCCBYU 00085 (field coll. K10), partially open carapace, dorsal view; (j) RCCBYU 00087 (field coll. Ch5–4), carapaces and valves on rock slab; (k) RCCBYU 00086 (field coll. K10), open carapace, lateral view.

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(Figs 18i, 19a). Similarly, the valve outline varies from typically postplete to more elongate postplete (see Fig. 19d). A similar range of shape variation was noted for the type bradoriid, the North American *Bradoria scrutator* Matthew, 1889 (see Siveter & Williams 1997, pl. 1 and text-fig. 8).

Occurrence. Western Subprovince. Shapushan (herein) and Yaoying sections (Zhang 1974; Huo & Shu 1985; Huo *et al.* 1991; herein), Wuding County, and Maotianshan and Dapotou sections, Chengjiang County (herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; middle to upper *Eoredlichia–Wutingaspis* trilobite Biozone.

Comptaluta leshanensis (Lee, 1975)
(Fig. 18a–g)

1975 *Leshanella leshanensis* Lee, gen. et sp. nov.; Lee, p. 58, pl. 5, figs 9–14.
1975 *Leshanella pachydorsa* Lee, sp. nov.; Lee, p. 59, pl. 5, figs 15, 16.
1975 *Leshanella bulbosa* Lee, sp. nov.; Lee, p. 59, pl. 5, fig. 17.
1983 *Leshanella leshanensis* Lee, 1975; Li, p. 14, pl. 2, fig. 18.
1983 *Leshanella bulbosa* Lee, 1975; Li, p. 15, pl. 2, fig. 19.
1983 *Leshanella pachydorsa* Lee, 1975; Li, p. 15, pl. 2, figs 20, 21.
1985 *Leshanella leshanensis* Lee; Huo & Shu, p. 71, pl. 23, fig. 9.
1985 *Leshanella pachydorsa* Lee; Huo & Shu, p. 71, pl. 23, figs 10, 11.
1985 *Leshanella bulbosa* Lee; Huo & Shu, p. 71, pl. 23, fig. 12.
1991 *Leshanella leshanensis* Lee; Huo *et al.*, p. 89, pl. 7, fig. 9.
1991 *Leshanella pachydorsa* Lee; Huo *et al.*, p. 89, pl. 7, figs 10, 11.
1991 *Leshanella bulbosa* Lee; Huo *et al.*, p. 90, pl. 7, fig. 12.

Holotype. A left valve, CIGMR no. SO27; Lee, 1975, pl. 5, fig. 14. Fandian section, Leshan County, Sichuan Province; Qiongzhusi Formation, lower Cambrian.

Material. Several hundred specimens from Wuding County and several tens of specimens from Chengjiang County, Yunnan Province.

Measurements. Based on the illustration in Lee (1975, pl. 5, fig. 14), the holotype is 2·4 mm long. Our specimens range from 1·86–2·38 mm in length.

Diagnosis. Species of *Comptaluta* with well-developed subcircular median node which is joined to the anterodorsal nodes by a narrow, short connecting ridge. Mid-dorsal node well developed, sometimes as a discrete subcircular node. Anterior-most of the two anterior nodes is largest.

Description. Valves postplete and small sized, adults typically 2–2·4 mm long. Lateral valve outline with posterodorsal and anterodorsal curves; outline is fairly straight between these curves and the cardinal corners, ventrally is convex to strongly convex. Anterodorsal nodes joined ventrally by a narrow connecting ridge that ventrally is confluent with strongly inflated lobal area, and with large, subcircular median node. Dorsal part of lobal area inflated to form a well-developed, sometimes discrete subcircular mid-dorsal node. Lateroadmarginal ridge tubulose and entire between cardinal corners, demarcated from the lobal surface by a narrow, deep, well-developed furrow.

Remarks. The size range of our specimens of *C. leshanensis* indicate that overall this species is larger than *C. inflata*. *C. leshanensis* closely resembles the Australian *C. hartmanni*, but appears to have a more pronounced median node.

In some specimens of *C. leshanensis* the median and mid-dorsal nodes appear to have greater relief (Fig. 18f, g). Thus, the mid-dorsal node ranges from a bulbous to ridge-like dorsal inflation of the lobal area (e.g. Figs 18a–c), through specimens which have a more discrete node (e.g. Fig. 18d, e), to specimens with a fully discrete, subcircular node (e.g. Fig. 18f, g). In some instances this may partly be the product of the degree of convexity of the lobal area, thus, in less inflated specimens the nodes may stand more proudly. In our material from Yunnan Province, we consider these differences to be due to intraspecific variation, as particular variants do not cluster at particular stratigraphic horizons.

Based on published illustrations, specimens from the Fandian section, Leshan County, Sichuan Province, referred to *Leshanella pachydorsa* by Lee (1975) may be conspecific with *C. leshanensis*. Despite possessing a very bulbous median node, *Leshanella bulbosa* Lee, 1975 also appears indistinguishable from *C. leshanensis*.

Occurrence. Western Subprovince. Fandian section, Leshan County, Sichuan Province (Lee 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991); Maotianshan, Dapotou, Jianbaobaoshan and Hongjiachong sections, Chengjiang County, and Shishan, Shapushan and Yaoying sections, Wuding County, Yunnan Province (herein). Qiongzhusi Formation, lower Cambrian; *Eoredlichia–Wutingaspis* to middle *Yunnanocephalus–Malungia* trilobite biozones.

Genus *Wutingella* Zhang, 1974

1974 *Wutingella* (gen nov.); Zhang, p. 109.
1975 *Gaoqiaoella* Lee, gen. nov.; Lee, p. 56.
1981 *Gaoqiaoella* Lee, 1975; Li, p. 72.
1983 *Gaoqiaoella* Lee, 1975; Li, p. 8.
1985 *Gaoqiaoella* Lee, 1975; Huo & Shu, p. 69.
1985 *Wutingella* Chang (*sic*); Huo & Shu, p. 75.
1991 *Wutingella* Chang, 1974 (*sic*); Huo *et al.*, p. 77.
1991 *Gaoqiaoella* Lee, 1975; Huo *et al.*, p. 87.

Type species. By original designation: *Wutingella binodosa* Zhang, 1974. From Yaoying section, Wuding County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Comptalutids with postplete valves having large subovate mid-dorsal node and smaller sub-ovate anterocentral node conjoined by a narrow, V-shaped connecting ridge. Anterodorsal V-shaped sulcus narrow and deep, demarcates the dorsal margin of the mid-dorsal node and part of the connecting ridge from the more inflated anterodorsal corner. Posterodorsal curve in lateral valve outline; no discernible anterior or anterodorsal curve in outline. Lateroadmarginal ridge broadest ventrally and posteriorly, demarcated from the lateral valve surface by a furrow.

Remarks. *Wutingella* is similar to *Comptaluta* in possessing confluent subdorsal and anterocentral nodes. It differs from *Comptaluta* by lacking a marked anterior curve in the lateral valve outline and by absence of a distinct anterodorsal node.

The type species *Gaoqiaoella superadunata* Lee, 1975, has identical morphology to *W. binodosa* and we consider that lobal differences used to distinguish *Gaoqiaoella* as a separate compatulitid genus (Lee 1975; also Li 1981; Huo & Shu 1985; Huo *et al.* 1991) are preservational. Thus, in our material of *Wutingella* from the Qiongzhusi Formation, lobal variation and the absence of a connecting ridge between the lobes are due largely to valve abrasion or flattening (see remarks for *Wutingella binodosa* below, and Fig. 20).

In lateral outline and possession of a bulbous mid-dorsal node, *Wutingella* most closely resembles *Kunyangella* Huo, 1965. *Kunyangella* differs from *Wutingella* by having a weakly defined lateroadmarginal ridge and by lacking an anterocentral node (see Fig. 17).

Occurrence. Sichuan (herein) and Yunnan (Zhang 1974 and herein) provinces, SW China; lower Cambrian.

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Wutingella binodosa Zhang, 1974
(Figs 19j–m, 20a–c)

1974 *Wutingella binodosa* (gen. et sp. nov.); Zhang, p. 109, pl. 43, fig. 10.
1975 *Gaoqiaoella superadunata* Lee, gen. et sp. nov.; Lee, p. 56, pl. 5, figs 4, 6, 8.
1975 *Gaoqiaoella subadunata* Lee, sp. nov.; Lee, p. 57, pl. 5, figs 1–3, 5, 7.
1981 *Gaoqiaoella subadunata* Lee, 1975; Li, p. 72, pl. 1, figs 8, 9.
1981 *Gaoqiaoella bidunata* sp. nov.; Li, p. 72, pl. 2, figs 1–6.
1981 *Gaoqiaoella monosis* sp. nov.; Li, p. 72, pl. 2, figs 7–9.
1983 *Gaoqiaoella superadunata* Lee, 1975; Li, p. 8, pl. 1, fig. 5.
1983 *Gaoqiaoella biadunata* Li, 1981; Li, p. 8, pl. 1, figs 9, 10.
1983 *Gaoqiaoella monosis* Li, 1981; Li, p. 9, pl. 1, figs 7, 8.
1983 *Gaoqiaoella subadunata* Lee, 1975; Li, p. 9, pl. 1, fig. 6.
1985 *Gaoqiaoella superadunata* Lee; Huo & Shu, p. 69, pl. 23, fig. 1.
1985 *Gaoqiasella subadunata* Lee (*sic*); Huo & Shu, p. 69, pl. 23, fig. 2.
1985 *Gaoqiaoella biadunata* Lee (*sic*); Huo & Shu, p. 70, pl. 23, figs 6–8.
1985 *Gaoqiaoella monosis* Lee (*sic*); Huo & Shu, p. 70, pl. 23, figs 3–5.
1985 *Wutingella binodosa* Chang (*sic*); Huo & Shu, p. 75, pl. 8, fig. 10.
1991 *Wutingella binodosa* Chang (*sic*); Huo *et al*., p. 78, pl. 3, fig. 10.
1991 *Gaoqiaoella superadunata* Lee; Huo *et al*., p. 87, pl. 7, fig. 1.
1991 *Gaoqiaoella subadunata* Lee; Huo *et al*., p. 88, pl. 7, fig. 2.
1991 *Gaoqiaoella monosis* Li; Huo *et al*., p. 88, pl. 7, figs 3–5.
1991 *Gaoqiaoella biadunata* Li; Huo *et al*., p. 88, pl. 7, figs 6–8.

Holotype. Dissociated left and right valves of a ?juvenile carapace, NIGPAS no. 21680; Zhang, 1974, pl. 43, fig. 10. Yaoying section, Wuding County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Material. More than 100 specimens from the Gaopo section in Gaoqiao, E'mei County, Sichuan Province, and Shapushan section, Wuding County, Yunnan Province. Also, a few specimens from the Yaoying section, Wuding County, and Maotianshan section, Chengjiang County, Yunnan Province.

Measurements. The length of the ?carapace of the holotype is 1·5 mm long (measured Hou X-g, 1981). Our specimens are 1·43–2·0 mm long.

Diagnosis. Species of *Wutingella* with large subovate mid-dorsal node and a smaller subovate anterocentral node which are conjoined by a narrow, V-shaped connecting ridge. Anterodorsal sulcus narrow and deep. Lateroadmarginal ridge broadest ventrally and posteriorly, demarcated from the lateral valve surface by a furrow.

Description. Valves small and postplete, adults typically 2 mm long. Posterodorsal curve in lateral valve outline; no discernible anterior or anterodorsal curve in outline. Lobal area moderately convex, with large subovate mid-dorsal node and smaller sub-ovate mid-anterior node which are conjoined by a narrow, V-shaped connecting ridge (see particularly Fig. 20b, c). Anterodorsal V-shaped sulcus narrow, deep, and demarcating the dorsal margin of the mid-dorsal node and part of the connecting ridge from the more inflated anterodorsal corner. Lateroadmarginal ridge moderately well developed, broadest ventrally and posteriorly, demarcated from the lateral valve surface by a furrow.

Remarks. In our material of *W. binodosa* from the Qiongzhusi Formation, lobal variation and the absence of the connecting ridge is largely due to abrasion or flattening. Typically, abraded specimens lack the connecting ridge and have reduced lobation (see Fig. 19j, l, m).

As noted above, the relative position, number and morphology of the nodes in *G. superadunata* are the same as that of *W. binodosa* and the species are regarded as synomyms. We also consider differences in lobation identified by Lee (1975) and Li (1981; see also Huo & Shu 1985; Huo *et al*. 1991) in his three other (conspecific) species referred to *Gaoqiaoella* to be preservational. Thus, *G. subadunata* and *G. monosis* lack the connecting ridge and/or have reduced lobation because of abrasion of the valves (for example, clearly evident from Huo & Shu 1985, pl. 23, figs 2–5), whilst variation in the lobation of *G. biadunata* is again due to valve abrasion (*op. cit*. pl. 23, figs 6–8). In none of the specimens figured by the above authors does the number, position or overall morphology of the nodes exceed that of the intraspecific variation displayed by our specimens of *W. binodosa*.

The smallest specimens of *W. binodosa* we identify already have the typical lobation of adults (e.g. Figs 19k, 20b).

Occurrence. Western Subprovince. Fandian section, Leshan City and Gaopo section in Gaoqiao, E'mei County, Sichuan Province (Lee 1975; Li 1981, 1983; Huo & Shu 1985; Huo *et al*. 1991; herein). Yaoying, Shapushan and Shishan sections, Wuding County (Zhang 1974, 1983; Huo & Shu 1985; Huo *et al*. 1991; herein) and Maotianshan section, Chengjiang County (herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; stratigraphic interval between the upper part of the *Abadiella* and *Eoredlichia–Wutingaspis* trilobite biozones and the *Eoredlichia–Wutingaspis* trilobite Biozone.

Subfamily Phasoiinae Hinz-Schallreuter, 1999

Remarks. Phasoiinids are comptalutids distinguished by having lobes that form a loop on the lateral valve surface. For further discussion of the subfamily and of the type genus *Phasoia*, see Hinz-Schalleuter (1999).

Genus *Phasoia* Hinz-Schallreuter, 1993

non 1943 *Ophiosema*; Romieux (= Lepidoptera).
1968 *Ophiosema* nov.; Öpik, p. 27.
1985 *Ophiosema* Öpik; Huo & Shu, p. 76.
1991 *Ophiosema* Öpik, 1968; Huo *et al*., p. 103.
1993c *Phasoia* n. g. n. sp.; Hinz-Schallreuter, p. 321.
1999 *Phasoia* Hinz-Schallreuter 1993; Hinz-Schallreuter, p. 36.

Type species. By original designation: *Ophiosema spicatum* Öpik, 1968. From Queensland, Australia; Yelvertoft Beds, 'Middle Cambrian (Ordian) of Öpik (1968)'.

Remarks. *Bradoria woodi* Walcott, 1905 (holotype: USNM no. 56494; see Fig. 21m) has the lateral shape (including a bend in the lateral outline mid-posteriorly), lateroadmarginal ridge and anterodorsal lobation of a comptalutid. Its possession of a lobal loop on the lateral surface suggests a relationship to *Phasoia*, but a more positive assignment requires analysis of additional specimens (see also Öpik 1968, p. 26).

Occurrence. Yunnan Province (herein), SW China, and Guangdong Province, S China (Zhang 1986); lower Cambrian. Queensland, Australia; 'Middle Cambrian (Ordian)' of Öpik (1968) (see also Hinz-Schallreuter 1999).

Phasoia sp.
(Fig. 24m)

Material and measurement. One right valve, 2·75 mm long, from the Qiongzhusi Formation, associated with the bradoriid *Nanchengella acuta* and the trilobite *Abadiella*.

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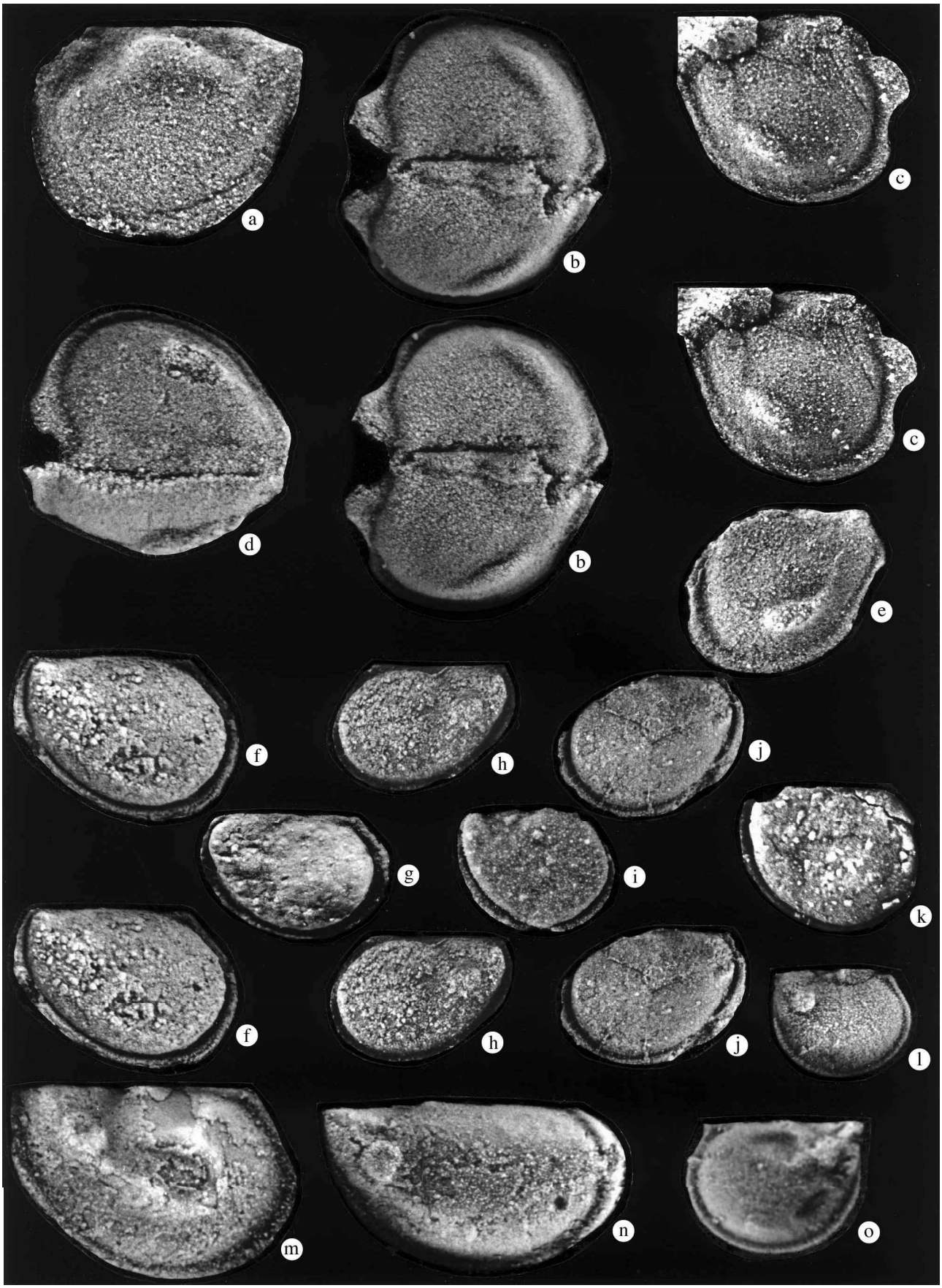

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Remarks. The specimen from Yunnan most closely resembles *Phasoia rogerensis* Hinz-Schallreuter, 1993, but is too poorly preserved to be referred to that species with any certainty.

Occurrence. Western Subprovince. Qiongzhusi section, Kunming City, Yunnan Province. Qiongzhusi Formation, lower Cambrian; lower part of the *Abadiella* trilobite Biozone.

Family Comptalutidae, subfamily uncertain

Genus *Kunyangella* Huo, 1965

1965 *Kunyangella* gen. nov.; Huo, p. 293.
1975 *Kunyiangella* (*sic*) Huo; Lee, p. 49.
1985 *Kunyangella* Huo, 1965; Huo & Shu, p. 72.
1991 *Kunyangella* Huo, 1965; Huo *et al*., p. 85.

Type species. By original designation: *Kunyangella cheni* Huo, 1965. From Jinning (Kunyang) County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Postplete comptalutids with bulbous to arcuate mid-dorsal node, but no other nodes or lobes. Lateroadmarginal ridge weakly developed but entire between cardinal corners, demarcated from the lateral valve surface by a weak furrow.

Remarks. In lateral outline and possession of a bulbous mid-dorsal node *Kunyangella* most closely resembles *Wutingella* Zhang, 1974. It differs from other comptalutids (including *Wutingella*) by having a very weakly defined lateroadmarginal ridge and by lacking anterodorsal or anterocentral lobation (see Fig. 17).

Occurrence. Yunnan Province (Huo 1965) and possibly from Sichuan Province (Huo & Shu 1985), SW China; lower Cambrian.

Kunyangella cheni Huo, 1965
(Figs 20d–k, 21a)

1965 *Kunyangella cheni* sp. nov.; Huo, p. 293, pl. 1, fig. 6.
1974 *Kunyangella cheni* Huo; Zhang, p. 107, pl. 43, fig. 3.
1975 *Kunyiangella acuta* Lee, 1972 sp. nov. (*sic*); Lee, p. 49, pl. 4, fig. 12.
1983 *Kunyangella cheni* Huo, 1965; Li, p. 14, pl. 2, fig. 16.
1983 *Kunyangella acuta* Lee, 1975; Li, p. 14, pl. 2, fig. 17.
1985 *Kunyangella cheni* Huo; Huo & Shu, p. 73, pl. 19, figs 17, 18.
1985 *Kunyangella* acuta* Lee (*sic*); Huo & Shu, p. 73, pl. 19, fig. 21.
1985 *Kunyangella cheni zhangshanensis* (subsp. nov.); Huo & Shu, p. 73, pl. 19, figs 22, 23.
1985 *Kunyangella tongi* (sp. nov.); Huo & Shu, p. 74, pl. 19, figs 19, ?fig. 20 (dorsal margin of valve obscured by rock).
1991 *Kunyangella cheni* Huo; Huo *et al*., p. 86, pl. 6, figs 12, 13.
1991 *Kunyangella tongi* Huo & Shu; Huo *et al*., p. 86, pl. 6, fig. 14, ?fig. 15.
1991 *Kunyangella acuta* Lee; Huo *et al*., p. 86, pl. 6, fig. 16.
?1991 *Kunyangella cheni zhangshanensis* Huo & Shu; Huo *et al*., p. 87, pl. 6, figs 17, 18.

Holotype. External mould of a (juvenile?) left valve, NWUX no. 0006; Huo, 1965, pl. 1. fig. 6. Jinning County, Yunnan Province; Qiongzhusi Formation, lower Cambrian. The holotype was wrongly cited as the specimen of pl. 19, fig. 17 by Huo & Shu (1985, p. 73, pl. 19, fig. 18; see also Huo *et al.* 1991, p. 86, pl. 6, fig. 14).

Material. More than 100 specimens from the Shapushan, Shishan and Yaoying sections, Wuding County, the Qiongzhusi section in Kunming City, the Meishucun section, Jinning County, and the Maotianshan, Dapotou and Jianbaobaoshan sections, Chengjiang County, Yunnan Province.

Measurements. Based on the illustration in Huo (1965, pl. 1, fig. 6), the holotype is 1·7 mm long. Our specimens are 1·67–2·38 mm in length.

Diagnosis. Species of *Kunyangella* with bulbous, elongate to arcuate mid-dorsal node, and a weakly developed lateroadmarginal ridge demarcated from the lateral valve surface by a weak furrow.

Description. Valves postplete and small sized (adults *c*. 2–2·4 mm long). Lateral valve outline with a posterodorsal curve and weak anterodorsal curve. Lateral outline between these curves and the cardinal corners is fairly straight to weakly concave, ventrally is rounded and convex to strongly convex. Bulbous mid-dorsal node is elongate to arcuate, oriented sub-parallel to the dorsal margin. Weak, V-shaped depression developed anterior of node, may demarcate a very weak anterodorsal node. Lateroadmarginal ridge entire between cardinal corners, weakly developed, demarcated from the lateral valve surface by a furrow. Valves smooth.

Figure 21 (a) *Kunyangella cheni* Huo, 1965: Qiongzhusi Formation, lower Cambrian; Maotianshan section, Chengjiang County, Yunnan Province; RCCBYU 00148 (field coll. M7), right valve, lateral view; light photograph, ×23.

(b–e) *Jiucunella paulula* Hou & Bergström, 1991: Qiongzhusi Formation, lower Cambrian. (b, c, e) Maotianshan section, Chengjiang County, Yunnan Province; (d) Hongjiachong section, Chengjiang County, Yunnan Province; all light photographs, ×26.

(b) RCCBYU 00088 (field coll. M2), partially open carapace, lateral view (stereo-pair); (c) RCCBYU 00089 (field coll. M2), left valve, lateral view (stereo-pair); (d) RCCBYU 00090 (field coll. H2-2), partially open carapace, lateral view; (e) RCCBYU 00091 (field coll. M2), right valve, lateral view.

(f–k) *Liangshanella yunnanensis* Zhang, 1974: Canglangpu Formation, lower Cambrian. (f, i) Shapushan section, Wuding County, Yunnan Province; (g, h, j, k) Shijiangjun section, Wuding County, Yunnan Province; all light photographs, ×23.

(f) RCCBYU 00092 (field coll. W20-4), left valve, lateral view (stereo-pair); (g) RCCBYU 00097 (field coll. SJ-1), left valve, lateral view; (h) RCCBYU 00094 (field coll. SJ-1), right valve, lateral view (stereo-pair); (i) RCCBYU 00093 (field coll. W20–4), left valve, lateral view; (j) RCCBYU 00095 (field coll. SJ-1), posterodorsally incomplete right valve, lateral view (stereo-pair); (k) RCCBYU 00096 (field coll. SJ-1), left valve, lateral view.

(l–o) *'Bradoria'* species of Walcott, 1905; all from a single limestone boulder, river drift, 1·6 km S of Chön-p'ing-hién, Nan-kiang River, Zhenping County, Shaanxi Province; lower Cambrian (Walcott considered the material to be middle Cambrian, probably from the lower part of the Ki-sin-ling Limestone); all light photographs, ×27.

(l) USNM 56497 holotype of *'Bradoria' enyo* Walcott, 1905, left valve, lateral view; (m) USNM 56494 holotype of *'Bradoria' woodi* Walcott, 1905, left valve, lateral view; (n) USNM 56493 holotype of *'Bradoria' bergeroni* Walcott, 1905, left valve, lateral view; (o) USNM 56498 holotype of *'Bradoria' stereope* Walcott, 1905, right valve, lateral view.

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Remarks. The V-shaped depression is developed only in well-preserved specimens. We believe that variation in the shape of the dorsal node from arcuate (e.g. Figs 20h, k, 21a) to more bulbous (Fig. 20d–g, i) is due to the convexity of the lobal area. Thus, where the latter is more flattened, either due to compression or original morphology, the dorsal node is more arcuate. We also note slight variation in the shape of the valve outline (as end members compare Fig. 20h, k, though note that Fig. 20h is a slightly oblique view), but this is never sufficient to distinguish discrete species (cf. Huo & Shu 1985). For these reasons, we believe that the open carapace referred to *K. acuta* by Lee (1975) and at least one of the two specimens referred to *K. tongi* by Huo & Shu (1985, p. 74, pl. 19, fig. 19, ?fig. 20) are conspecific with *K. cheni*.

Because of poor preservation, we are uncertain of the affinity of a specimen from the Gaopo section at Gaoqiao, E'mei County, Sichuan Province referred to *K. cheni zhangshanensis* (see Huo & Shu 1985, p. 73, pl. 19, figs 22, 23).

Occurrence. Western Subprovince. Qiongzhusi section, Kunming City (Lee 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991; herein); Meishucun section, Jinning County (Huo 1965; Zhang 1974; Lee 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991; herein); Shapushan and Shishan sections, Wuding County (Huo & Shu 1985; herein); Maotianshan, Dapotou and Jianbaobaoshan sections, Chengjiang County (herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Eoredlichia–Wutingaspis* and *Yunnanocephalus–Malungia* trilobite biozones.

Genus *Alutella* Kobayashi & Kato, 1951

Type species. By original designation: *Alutella nakamurai* Kobayashi & Kato, 1951. From Sanshilipu section, Jinxian County, Liaoning Province; Mantou Formation, lower Cambrian.

Remarks. The type species *A. nakamurai* was based on a single specimen from Liaoning Province, NE China. Well-preserved conspecific specimens from the Beishan section of Jinxian County, near the type locality, exhibit the typical comptalutid lateral outline, lateroadmarginal ridge, well-developed anterodorsal lobation and inflated lobal area (see Cui & Wang *in* Huo *et al.* 1991, pl. 10, figs 1–7, 9–11; herein Fig. 16).

The Chinese genera *Houlongdongella* Lee, 1975, *Yaxianella* Lin, 1979, *Hainanella* Huo & Zhang *in* Huo *et al.* 1983, *Tianduella* Huo & Zhang *in* Huo *et al.* 1983, *Guangdongella* Zhang, 1986, *Liella* Cui & Huo *in* Huo & Shu 1985, *Qingquanella* Cui & Huo *in* Huo & Shu 1985 and *Wushiella* Xiao & Zhao, 1986 have very similar morphology to *Alutella*. Their taxonomic status is in need of further investigation. The ontogeny of *Alutella* is inadequately known, but larger specimens and adults of the Australian *Zepaera* Fleming, 1973 (see also Jones & McKenzie 1980, fig. 5D–H) and *Flemingopsis* Jones & McKenzie, 1980 appear to be very similar.

Alutella differs from *Comptaluta* by having a broad anterodorsal sulcus, single anterodorsal node and absence of connecting ridges. Well-preserved specimens of *Alutella* are distinguishable from *Quetopsis* Hinz-Schallreuter, 1999 by their more developed lobation (see remarks for the Family Comptalutidae).

Occurrence. Liaoning Province, NE China (Kobayashi & Kato 1951; Cui & Wang *in* Huo *et al.* 1991), and Shaanxi and Yunnan provinces (herein), SW China; also the east Trans-Baikal Region of the former Soviet Union (see Melnikova *et al.* 1997, figs 1, 2, pl. 3, figs 8, 9). Lower Cambrian.

Alutella cf. *A. nakamurai* Kobayashi & Kato, 1951 (Fig. 19e–i)

Material. About ten specimens from the Shishan section, Wuding County and three from the Qiongzhusi section in Kunming City, Yunnan Province; three specimens from Zhenba County, Shaanxi Province.

Measurements. Our valves are 2·4–2·9 mm in length.

Description. Valves postplete and small sized (not greater than 3 mm long). Lateral valve outline with a posterodorsal curve and a more pronounced anterior curve; outline is fairly straight between these curves and the cardinal corners, ventrally is convex to strongly convex. Anterodorsal node and sulcus weakly to well developed; anterodorsal node ventrally confluent with inflated lobal area. Lateroadmarginal ridge entire and moderately well developed, demarcated from the lobal surface by a furrow.

Remarks. Well-preserved specimens from limestones in Zhenba County, Shaanxi Province show a distinct V-shaped anterodorsal sulcus (see Fig. 19f, g) whilst younger specimens from clastic rocks in Kunming and Wuding County, Yunnan Province are more abraded and show poorly developed anterodorsal lobation (see Fig. 19e, h, i). The latter specimens resemble those referred to *Quetopsis* by Hinz-Schallreuter (1999).

Occurrence. Western Subprovince: Qiongzhusi section in Kunming City and Shishan section, Wuding County, Yunnan Province (herein); Canglangpu Formation, lower Cambrian, *Palaeolenus* trilobite Biozone. Middle Subprovince: Zhenba County, Shaanxi Province (herein); lower Cambrian, Shuijingtou Formation, *Yunnanocephalus–Malungia* trilobite Biozone.

Genus *Jiucunella* Hou & Bergström, 1991

1991 *Jiucunella* gen. nov.; Hou & Bergström, p. 186.

Type species. By original designation: *Jiucunella paulula* Hou & Bergström, 1991. From Maotianshan section, Chengjiang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. Small (adults typically less than 2 mm long) postplete comptalutids with small subovate sub-median node extended anteriorly as a narrow (connecting?) ridge. No other lobes or sulci. Marked anterodorsal curve in the lateral valve outline. Lateroadmarginal ridge well developed, widening mid-posteriorly to form a triangular extension at position of the posterodorsal curve in the lateral valve outline of other comptalutids. Lateroadmarginal ridge entire between cardinal corners, demarcated from the lateral valve surface by a furrow.

Remarks. *Jiucunella* resembles other comptalutids in size, shape, convex lobal area, possession of an entire lateroadmarginal ridge and development of anterior lobation. It differs by lacking mid-dorsal or anterodorsal lobation and by its possession of a triangular extension to the lateroadmarginal ridge mid-posteriorly.

The ridge which rises anterodorsally from the sub-median lobe of *Jiucunella* is homologous to the connecting ridge between the median or anterocentral, and anterodorsal nodes of other comptaulitds.

Occurrence. Chengjiang County, Yunnan Province (Hou & Bergström 1991); lower Cambrian.

Jiucunella paulula Hou & Bergström, 1991 (Fig. 21b–e)

1991 *Jiucunella paulula* Hou & Bergström; p. 186, pl. 1, fig. 5a–c.

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Holotype. An open carapace, NIGPAS no. 110823; Hou & Bergström 1991, pl. 1, fig. 5a. On a rock slab with three syntype carapaces. Maotianshan section, Chengjiang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Material. About 100 specimens from the Maotianshan section associated with soft-bodied fossils, and mostly preserved as clusters of carapaces; a few specimens from the Jianbaobaoshan section, W of Dapotou village, Chengjiang County, Yunnan Province.

Measurements. The holotype carapace (see Hou & Bergström 1991) is 1·5 mm long. Our specimens are 1·39–1·85 mm in length.

Diagnosis. As for the genus, which is monospecific.

Description. Valves postplete, small (adults typically less than 2 mm long), and non-sulcate. Lobal area moderately convex, possessing a small subovate sub-median situated node which is extended antero-dorsally as a narrow ridge. Lateroadmarginal ridge well developed, widening mid-posteriorly to form a triangular extension. Ridge demarcated from the lateral valve surface by a furrow. Valves smooth.

Remarks. Although occurring in strata with soft-bodied 'Chengjiang Lagerstätte' fossils at Maotianshan, Chengjiang County, *J. paulula* are preserved as clusters of poorly preserved carapaces without soft parts.

Occurrence. Western Subprovince. Maotianshan and Jianbaobaoshan sections, Chengjiang County, Yunnan Province (Hou & Bergström 1991; herein). Qiongzhusi Formation, lower Cambrian; the middle part of the *Eoredlichia–Wutingaspis* trilobite Biozone.

Family Svealutidae Öpik, 1968

1968 Svealutidae nov. Öpik, p. 31 (*partim*), *non Alutella* Kobayashi & Kato, 1951 (= Comptalutidae Öpik, 1968), *non Carnarvonia* Walcott, 1912 (= a non-bradoriid bivalved arthropod).
1980 Svealutidae Öpik, 1968; Jones & McKenzie, p. 207.
1985 Tsunyiellidae Huo & Shu (*in* litt.); Li, p. 88.
1985 Tsunyiellinae (subfam. nov.); Huo & Shu, p. 80 (*partim*).
1987 Svealutidae Öpik, 1968; Zhang, p. 14.
1987 Liangshanellidae fam. nov.; Hou, p. 538 (*partim*).
1989a Liangshanellidae fam. nov.; Zhao, p. 470.
1991 Liangshanellidae Hou (fam. nov.); Huo *et al.*, p. 113 (*partim*).
1993b Svealutidae Öpik, 1961 (*sic*); Hinz-Schallreuter, p. 431.
1997 Svealutidae Öpik, 1968; Siveter & Williams, p. 51.
1998 Svealutidae Öpik, 1968; Williams & Siveter, p. 20.

Diagnosis. (After Siveter & Williams 1997). Small to large (adults *c*. 2–10 mm long), elongate, subamplete to postplete Bradoriida. Dorsal margin straight or gently curved anterodorsally, hinge-line well developed. Lateroadmarginal ridge entire between cardinal corners, often widest mid-posteriorly, demarcated from lateral surface by a furrow. Up to four, mid-anterior to anterodorsally situated nodes. Valves smooth and evenly convex.

Remarks. *Anabarochilina* Abushik, 1960, *Tsunyiella* Zhang, 1974 and *Liangshanella* Huo, 1956 are typical svealutids (see Siveter & Williams 1997; Williams & Siveter 1998). Several taxa which have been referred to the Alutidae Huo, 1956 (e.g. see Huo 1956; Huo & Shu 1985; Huo *et al.* 1991) may also belong to the Svealutidae. *Aluta* Matthew, 1896 is a *nomen dubium* (see Siveter & Williams 1997).

Bradoria bergeroni Walcott, 1905 (holotype USNM 56493, see Fig. 21n) has the elongate amplete lateral shape, well-developed lateroadmarginal ridge and anterodorsal lobation of typical svealutids. It closely resembles *Anabarochilina* (for which see Siveter *et al.* 1993), but a more positive referral requires additional specimens.

Genus *Liangshanella* Huo, 1956

1956 *Liangshanella* gen. nov.; Huo, p. 427.
1956 *Hanchungella* gen. nov.; Huo, p. 429.
1965 *Liangshanella* Huo; Huo, p. 294.
1975 *Liangshanella* Huo, 1956; Lee, p. 46.
1975 *Hanchungella* Huo, 1956; Lee, p. 47.
1982 *Liangshanella* Huo, 1956; Huo & Shu, p. 323.
1982 *Hanchungella* Huo, 1956; Huo & Shu, p. 323.
1983a *Hanchungella* Huo 1956; Huo *et al.*, p. 98.
1983 *Hanchungella* Huo, 1956; Li, p. 9.
1985 *Liangshanella* Huo; Huo & Shu, p. 76.
1985 *Hanchungella* Huo 1956; Huo & Shu, p. 144.
1986 *Liangshanella* Huo, 1956; Xiao & Zhao, p. 79.
1987c *Liangshanella* Huo, 1956; Hou, p. 539.
1987 *Ovaluta* gen. nov.; Zhang, p. 14.
1991 *Liangshanella* Huo, 1956; Huo *et al.*, p. 113.
1991 *Hanchungella* Huo, 1956; Huo *et al.*, p. 156.
1997 *Liangshanella* Huo, 1956; Siveter & Williams, p. 53.
1998 *Ovaluta* Zhang, 1987; Williams & Siveter, p. 23.

Type species. By original designation: *Liangshanella liangshanensis* Huo, 1956. From Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

Diagnosis. (Modified from Siveter & Williams 1997). Small to medium-sized subovate svealutids (adults *c*. 1·8–7 mm long) with equivalved, postplete carapace. Dorsal margin straight. Lateroadmarginal ridge entire between cardinal corners, and separated from lateral valve surface by a furrow. Anterodorsal node ranges from well developed to virtually lacking.

Remarks. We consider that *Liangshanella* and *Hanchungella* Huo, 1956 (type species: *Hanchungella rotundata* Huo, 1956), both of which are based on specimens from a section at Liangshan in Shaanxi Province, are synonymous. We regard the supposed difference which Huo (1956) used to establish these genera, that the anterior cardinal angle is either acute (*Liangshanella*) or a right angle (*Hanchungella*), is due to deformation (see also Huo & Shu 1985; Huo *et al.* 1991). Conjoined valves of the type material of *Liangshanella* preserve a range of anterior cardinal angles (Huo 1956, pl. 1, figs 1, 2). We consider that the other differences in nodal morphology between the respective type species of these two genera, are of species, rather than generic level.

We regard *Ovaluta* Zhang, 1987 (type species: *Aluta usualis* Shu *in* Huo *et al.* 1983b; from the Niutitang Formation, Fuquan County, Guizhou Province) as a junior synonym of *Liangshanella*. Huo *et al.* (1991) considered *Ovaluta* to be a synonym of *Aluta* Matthew, 1896; however, *Aluta* should be regarded as a *nomen dubium* (Siveter & Williams 1997). The Chinese literature contains many lower Cambrian species described under *Aluta* that, in most cases, differ from each other only by slight differences in the size and position of the anterodorsal node (or nodes?). Without access to all this material it is uncertain whether such variation is species diagnostic or merely reflects preservational factors.

The five specimens from Zhongbao section, Shaanxi Province, that Huo & Shu (1982) described as *Liangshanella chiehi* Huo, *Liangshanella obesa* Huo, *Hanchungella bulbosa luohebaensis* subsp. nov., *Hanchungella recta* sp. nov. and

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Hanchungella alta sp. nov. are too poorly preserved to be referred with certainty to *Liangshanella*. Indeed, Huo & Shu (1985, p. 148, pl. 3, fig. 18; see also Huo *et al.* 1991, p. 160) were also clearly doubtful about the preservational quality of these specimens as they incorrectly designated a 'new' holotype for *H. alta* on the grounds that the original holotype was incomplete.

Two small (0·5 mm long), acid-residue specimens from Wushi County, Xinjiang Province, on which *Xinjiangella squamiformis* Xiao & Zhao, 1986 was based, might be small juveniles of *Liangshanella* (see also Huo *et al.* 1991, p. 116). *Liangshanella lubrica* Qian & Zhang, 1983, established on the basis of two specimens from acid residues of lower Cambrian limestones from Gujingwan, Zhenping County, may represent *Liangshanella* material. We regard the poorly preserved *Liangshanella*? *kalpinensis* Zhang, 1981 (see also Huo *et al.* 1991) as a *nomen dubium*.

The shrivelled valve of *Bradoria fragilis* Walcott, 1905 (holotype, USNM 56495) might be the exuvia of a *Liangshanella*; however, its poor state of preservation precludes a firm assignment and the species should be restricted to its type. *Bradoria stereope* Walcott, 1905 (holotype USNM 56498; see Fig. 21o) and *B. enyo* Walcott, 1905 (holotype USNM 56497; see Fig. 21l), which may be conspecific, also possibly represent a small species of *Liangshanella,* perhaps closely related to *L. yunnanensis*. *B. stereope* differs from *B. enyo* only by (presumably post-mortem) flattening of the valve mid-dorsally and anteroventrally. Additional specimens are needed for a firm assignment to be made.

A centrally situated, subcircular set of numerous small pits, apparently representing a muscle scar, is known from the middle Cambrian Burgess Shale *Liangshanella burgessensis* Siveter & Williams, 1997. This is a unique case of the possible presence of an adductor muscle scar in a bradoriid.

Occurrence. Shaanxi, Sichuan, Yunnan, Guizhou, Hennan and possibly Xinjiang provinces, China; lower Cambrian. Also occurs in the lower Cambrian (Comley 'Series') and possibly middle Cambrian (St David's 'Series') of Britain (*Ovaluta* of Williams & Siveter 1998); the lower Cambrian of the eastern Trans-Baikal region (cf. *Bradoria*? *sayutinae* Melnikova, 1988; see Melnikova *et al.* 1997); the middle Cambrian of British Columbia, Alberta and Utah, North America (Siveter & Williams 1997); and possibly the lower Cambrian of Scandinavia (see Williams & Siveter 1998).

Liangshanella liangshanensis Huo, 1956
(Fig. 23g–j)

1956 *Liangshanella liangshanensis* sp. nov.; Huo, p. 427, pl. 1, figs 1, 2.
?1956 *Liangshanella obesa* sp. nov.; Huo, p. 428, pl. 1, fig. 3.
?1956 *Liangshanella chiehi* sp. nov.; Huo, p. 428, pl. 1, fig. 4.
?1965 *Liangshanella chiehi* Huo; Huo, pp. 294, 301, pl. 1, fig. 7.
1974 *Liangshanella liangshanensis* Huo; Zhang, p. 111, pl. 43, fig. 17.
?1975 *Liangshanella orbicularis* Lee sp. nov.; Lee, p. 46, pl. 4, figs 1–4.
1975 *Liangshanella liangshanensis* Huo; Li *et al.*, p. 130, pl. 4, figs 1, 2.
?1975 *Liangshanella obesa* Huo; Li *et al.*, p. 130, pl. 4, fig. 3.
?1975 *Liangshanella chiehi* Huo; Li *et al.*, p. 130, pl. 4, fig. 4.
?1983 *Liangshanella chichi* Huo (*sic.*); Li, p. 15, pl. 3, fig. 4.
?1983 *Liangshanella orbicularis* Lee, 1975; Li, p. 16, pl. 3, fig. 6.
1985 *Liangshanella liangshanensis* Huo; Huo & Shu, p. 77, pl. 18, figs 10, 11, ?12 & 13.
?1985 *Liangshanella obesa* Huo; Huo & Shu, p. 77, pl. 19, figs 1, 2.
?1985 *Liangshanella chiehi* Huo; Huo & Shu, p. 77, pl. 19, figs 3, 4.
?1985 *Liangshanella minuta* Shu sp. nov.; Shu *in* Huo & Shu, p. 78, pl. 19, figs 5–8.
?1985 *Liangshanella striata* Huo & Shu (sp. nov.); Huo & Shu, p. 78, pl. 19, figs 9, 10.
?1985 *Liangshanella jinningensis* Huo & Shu (sp. nov.); Huo & Shu, p. 79, pl. 19, figs 11–13.
?1985 *Liangshanella orbicularis* Lee; Huo & Shu, p. 79, pl. 19, figs 14, 15.
?1986 *Liangshanella wushiensis* Zhao & Xiao (sp. nov.); Zhao & Xiao *in* Xiao & Zhao, p. 79, pl. 2, fig. 3.
1987 *Liangshanella liangshanensis* Huo; Hou, p. 539, pl. 1, figs 1–3.
?1989 *Liangshanella* sp.; Huo & Cui, p. 79, pl. 1, fig. 7.
1991 *Liangshanella liangshanensis* Huo; Huo *et al.*, p. 113, pl. 15, figs 8, 9, ?6 & 7.
?1991 *Liangshanella obesa* Huo; Huo *et al.*, p. 114, pl. 15, figs 1, 2.
?1991 *Liangshanella chiehi* Huo; Huo *et al.*, p. 114, pl. 15, figs 3, 4.
?1991 *Liangshanella minuta* Shu; Huo *et al.*, p. 114, pl. 15, figs 10–13.
?1991 *Liangshanella striata* Huo & Shu; Huo *et al.*, p. 115, pl. 15, figs 14, 15.
?1991 *Liangshanella jinningensis* Huo & Shu; Huo *et al.*, p. 115, pl. 15, figs 16–18.
?1991 *Liangshanella similis* Cui (sp. nov.); Cui *in* Huo *et al.*, p. 115, pl. 15, figs 19, 20.
?1991 *Liangshanella wushiensis* Xiao & Zhao (*sic.*); Huo *et al.*, p. 116, pl. 15, fig. 22.
?1991 *Liangshanella orbicularis* Lee; Huo *et al.*, p. 117, pl. 15, figs 25, 26.

Figure 22 (a–c) *Tsunyiella diandongensis* Tong *in* Huo & Shu 1985: Qiongzhusi Formation, lower Cambrian, (a) Maotianshan section (northwestern slope), Chengjiang County, Yunnan Province; (b, c) Maotianshan section (western slope), Chengjiang County, Yunnan Province; all light photographs, ×10.

(a) RCCBYU 00098 (field coll. CF2), open carapace, lateral view; (b) RCCBYU 00099 (field coll. M2), open carapace, lateral view; (c) RCCBYU 00100 (field coll. M2), open carapace, lateral view.

(d–j) *Tsunyiella luna* Zhang, 1974: (d–h) Mingxinsu and Mingxinsi formations, Jindingshan section, Zunyi City, Guizhou Province; (i, j) Shuijingtuo Formation, Shizhu and Penshui Counties, Sichuan Province; all light photographs; (d) ×11, (e–j) ×10.

(d) RCCBYU 00101 (field coll. AAE386), open carapace, lateral view (stereo-pair); (e) RCCBYU 00102 (field coll. AAE385), right valve, lateral view (stereo-pair); (f) RCCBYU 00103 (field coll. AAE386), deformed open carapace, lateral view; (g) RCCBYU 00104 (field coll. AAE386), open carapace, lateral view; (h) RCCBYU 00105 (field coll. AAE385), open carapace, lateral view; (i) RCCBYU 00106 (field coll. KC2–3), right valve; (j) RCCBYU 00107 (field coll. KC2–3), left valve, lateral view.

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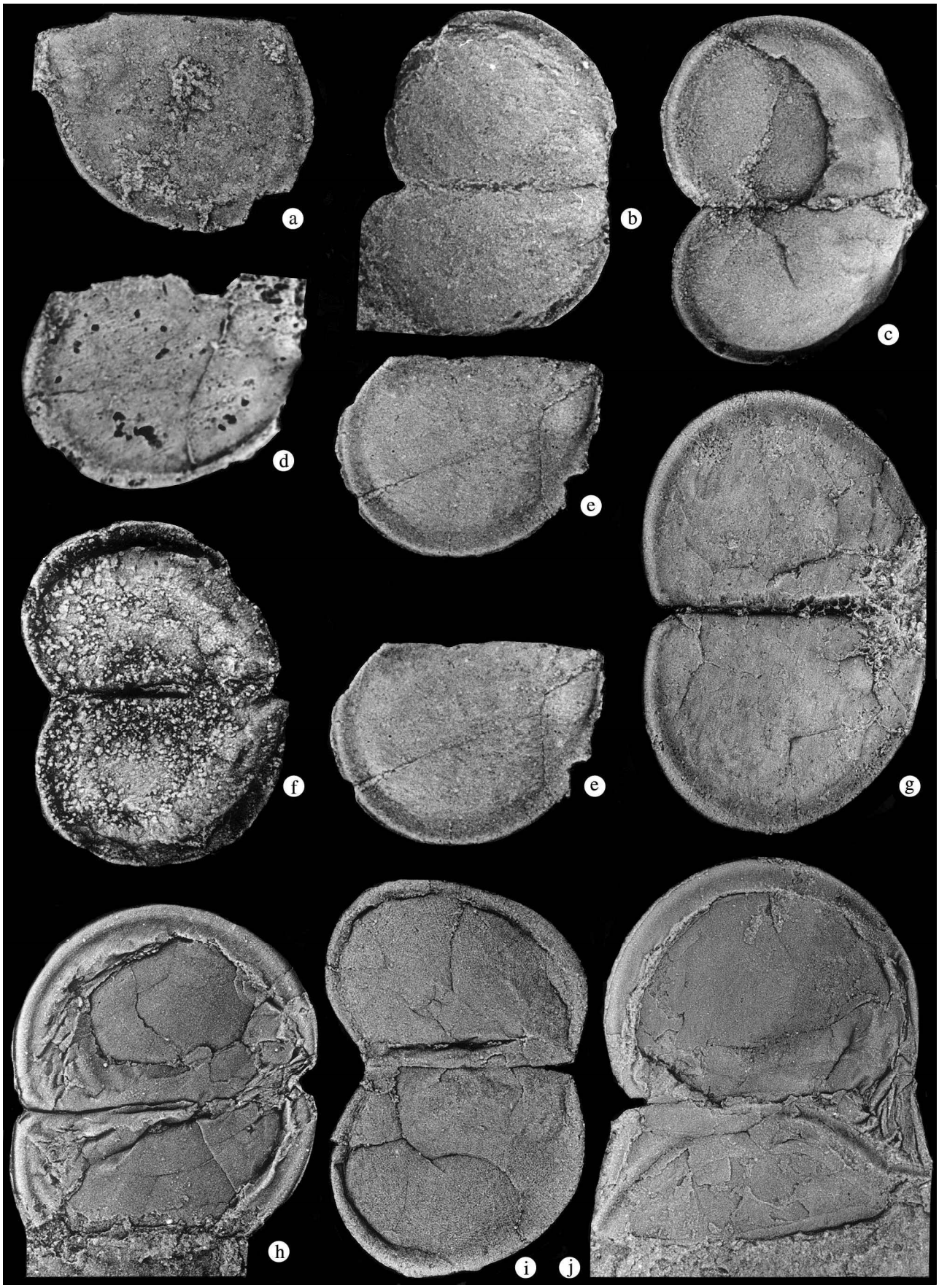

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Syntypes. Two juvenile carapaces, NIGPAS nos 8591 and 8592; Huo, 1956, pl. 1, figs 1, 2 (see also Huo & Shu 1985, pl. 18, figs 10, 11). Liangshan section, Hanzhong City, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

Material. Our material consists of a few specimens from Maotianshan and Xiaolantian sections, Chengjiang County and Meisuchun, Jinning County, Yunnan Province; and two specimens from Changjianggou Section, Guangyuan City, Sichuan Province.

Measurements. According to the illustrations given in Huo (1956, pl. 1, figs 1, 2), the syntypes are 3·8 mm (NIGPAS no. 8591) and 3·4 mm (NIGPAS8592) long. Our specimens range up to 7·1 mm long.

Diagnosis. Large *Liangshanella* species with a very weakly developed subcircular anterodorsal node.

Description. Equivalved carapace with postplete valves. Dorsal margin straight, hinge-line well developed. Lobate area rather flat. Lateroadmarginal ridge entire between cardinal corners and separated from lateral valve surface by a distinct furrow. Anterior cardinal angle less than posterior cardinal angle. Anterodorsal node subcircular, very weakly developed.

Remarks. Huo (1956) erected *L. liangshanensis, L. obesa* and *L. chiehi* based on single specimens from Shaanxi Province. The purported differences between these species, in valve outline and width of the lateroadmarginal ridge, may simply be the result of preservational factors.

L. orbicularis Lee, 1975, from Yuxiansi section, E'mei County, Sichuan Province, is possibly a synomyn of *L. liangshanensis*. Its supposed different ('subcircular') valve outline is consistent with the variation in valve shape in our specimens of *L. liangshanella* (e.g. see conjoined valves, Fig. 23i). Of the three *Liangshanella* species established in Huo & Shu (1985), it appears that the small *L. minuta* Shu and its associate from the Meishucun section, the larger *L. jinningensis* Huo & Shu, may represent instars of a single species, and that the 3–4 irregular concentric lines used to distinguish the type and only specimen of *L. striata* Huo & Shu, from Yuanshan section, Hanzhong City, Shaanxi Province, is probably due to compression or post-mortem valve shrinkage (similar features are common in the thin, apparently flexible carapaces of many bradoriids; see Siveter & Williams 1997).

Liangshanella similis Cui, 1991 was based on three specimens (including one figured as *Liangshanella* sp. by Huo & Cui 1989) from Wushi County, Xinjiang Province. The species was purported to differ from *L. liangshanella* in valve height and anterior cardinal angle, differences that we consider of doubtful diagnostic value at the species level. The smooth, acid-residue specimen (1·3 mm long) from Wushi County, erected as *Liangshanella wushiensis* Zhao & Xiao (*in* Xiao & Zhao 1986), may belong to *Liangshanella*.

Occurrence. Liangshan (Huo 1956; Zhang 1974; Li *et al.* 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991), Yuanshan and Huashan (Huo & Shu 1985; Huo *et al.* 1991) sections, Hanzhong City, Shaanxi Province; Changjianggou Section, Guangyuan City, Sichuan Province (herein); and Meishucun section, Jinning County (Huo & Shu 1985; Hou 1987c; Huo *et al.* 1991; herein), sections in Kunming City (Huo 1965; Huo & Shu 1985; Huo *et al.* 1991) and Maotianshan and Xiaolantian sections, Chengjiang County (Hou 1987c; Huo *et al.* 1991; herein), Yunnan Province. Possibly also at Yuxiansi section, E'mei County, and Fandian section, Leshan City, Sichuan Province (Lee 1975; Li 1983; Huo & Shu 1985; Huo *et al.* 1991); and the Weiganping section, Fuquan County, Guizhou Province (Huo & Shu 1985; Huo *et al.* 1991). All these confirmed and possible occurrences are from the Qiongzhusi Formation and correlatives, lower Cambrian; *Abadiella* Biozone and the lower part of the *Eoredlichia–Wutingaspis* Biozone. Possibly also in Wushi County, Xinjiang Province (Xiao & Zhao 1986; Huo & Cui 1989; Huo *et al.* 1991); Yurtus and Xiaoerbulag formations, lower Cambrian.

Liangshanella rotundata (Huo, 1956)
(Fig. 23a–f)

1956 *Hanchungella rotundata* sp. nov.; Huo, p. 429, pl. 1, fig. 5.
?1956 *Hanchungella shangliangshanensis* sp. nov.; Huo, p. 429, pl. 1, fig. 6.
?1956 *Hanchungella angusta* sp. nov.; Huo, p. 430, pl. 1, fig. 7.
?1956 *Hanchungella giganta* sp. nov.; Huo, p. 430, pl. 1, fig. 8.
1974 *Hanchungella rotundata* Huo; Zhang, p. 109, pl. 43, fig. 11.
?1975 *Hanchungella toculata* Lee, sp. nov.; Lee, p. 47, pl. 4, figs 5, 6.
?1975 *Hanchungella leshanensis* Lee, sp. nov.; Lee, p. 48, pl. 4, figs 7–9.
?1975 *Hanchungella bulbosa* Lee, sp. nov.; Lee, p. 48, pl. 4, fig. 10.
?1975 *Hanchungella semicircinata* Lee, sp. nov.; Lee p. 49, pl. 4, fig. 11.
1975 *Hanchungella rotundata* Huo; Li *et al.*, p. 130, pl. 4, fig. 5.
?1975 *Hanchungella shangliangshanensis* Huo; Li *et al.*, p. 131, pl. 4, fig. 6.
?1975 *Hanchungella angusta* Huo; Li *et al.*, p. 131, pl. 4, fig. 7.

Figure 23 (a–f) *Liangshanella rotundata* (Huo, 1956): Qiongzhusi Formation, lower Cambrian. (a) Shapushan section, Wuding County, Yunnan Province; (b, c, e) Gaopo section in Gaoqiao, E'mei County, Sichuan Province; (d) Maotianshan section, Chengjiang County, Yunnan Province; (f) Meishucun section, Jinning County, Yunnan Province; all light photographs; (a, f) ×15, (b, c, e) ×16, (d) ×14.

(a) RCCBYU 00108 (field coll. W5), left valve, lateral view; (b) RCCBYU 00110 (field coll. SG-2), open carapace, lateral view; (c) RCCBYU 00111 (field coll. SG-2), open carapace, lateral view; (d) RCCBYU 00109 (field coll. M1-a), fragmentary right valve (in carbonaceous shale), lateral view; (e) RCCBYU 00112 (field coll. SG-3), right valve, lateral view (stereo-pair); (f) RCCBYU 00113 (field coll. K3), open carapace (in carbonaceous shale), lateral view.

(g–j) *Liangshanella liangshanensis* Huo, 1956: Qiongzhusi Formation, lower Cambrian. (g, h) Maotianshan section (northwestern slope), Chengjiang County, Yunnan Province; (i) Changjianggou section, Guangyuan City, Sichuan Province; (j) Xiaolantian section, Chengjiang County, Yunnan Province; all light photographs, ×8.

(g) RCCBYU 00114 (field coll. CF5), open carapace, lateral view; (h) RCCBYU 00115 (field coll. CF3), open carapace, lateral view; (i) RCCBYU 00117, open carapace, lateral view; (j) RCCBYU 00116 (field coll. XL1), incomplete open carapace, lateral view.

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?1975 *Hanchungella giganta* Huo; Li *et al.*, p. 131, pl. 4, fig. 8.
1980 *Nanchungella rotundata* Huo, 1956; Tan, p. 188, pl. 21, fig. 11.
?1981 *Hanchungella toculata* Lee, 1975; Li, p. 71, pl. 2, fig. 12.
?1982 *Hanchungella alta* sp. nov.; Huo & Shu, p. 324, pl. 1, fig. 5.
?1983a *Hanchungella rotundata* Huo; Huo *et al.*, p. 98, pl. 1, figs 13–15.
?1983a *Hanchungella angusta yunnanensis* Huo & Shu subsp. nov.; Huo & Shu *in* Huo *et al.*, p. 98, pl. 1, figs 16, 17.
?1983 *Hanchungella bulbosa* Lee; Li, p. 9, pl. 1, fig. 11.
?1983 *Hanchungella leshanensis* Lee; Li, p. 9, pl. 1, fig. 14.
?1983 *Hanchungella semicircinata* Lee; Li, p. 9, pl. 1, fig. 12.
?1983 *Hanchungella toculata* Lee; Li, p. 10, pl. 1, fig. 13.
1985 *Hanchungela rotundata* Huo; Huo & Shu, p. 144, pl. 3, fig. 4, ?figs 5–7.
?1985 *Hanchungella shangliangshanensis* Huo; Huo & Shu, p. 145, pl. 3, figs 8–10.
?1985 *Hanchungella angusta* Huo; Huo & Shu, p. 145, pl. 3, fig. 11.
?1985 *Hanchungella angusta yunnanensis* Huo & Shu; Huo & Shu, p. 145, pl. 3, figs 13, 14.
?1985 *Hanchungella giganta* Huo; Huo & Shu, p. 146, pl. 3, fig. 12.
?1985 *Hanchungella toculata* Lee; Huo & Shu, p. 146, pl. 3, fig. 16.
?1985 *Hanchungella toculata tenuis* Huo & Shu (subsp. nov.); Huo & Shu, p. 146, pl. 4, figs 10–12.
?1985 *Hanchungella leshanensis* Lee; Huo & Shu, p. 147, pl. 4, fig. 1–4.
?1985 *Hanchungella bulbosa* Lee; Huo & Shu, p. 147, pl. 4, figs 5–9.
?1985 *Hanchungella semicircinata* Lee; Huo & Shu, p. 147, pl. 3, fig. 15.
?1985 *Hanchungella alta* Huo & Shu; Huo & Shu, p. 148, pl. 3, fig. 18.
?1985 *Hanchungella sphenis* Huo & Shu (sp. nov.); Huo & Shu, p. 148, pl. 4, fig. 13.
?1985 *Hanchungella emeiensis* Huo & Shu (sp. nov.); Huo & Shu, p. 149, pl. 4, figs 16–19.
?1985 *Hanchungella u-formis* Huo & Shu (sp. nov.); Huo & Shu, p. 149, pl. 4, figs 14, 15.
1991 *Hanchungella rotundata* Huo; Huo *et al.*, p. 157, pl. 30, fig. 4, ?figs 5, 6.
?1991 *Hanchungella leshanensis* Lee; Huo *et al.*, p. 157, pl. 30, figs 1–3.
?1991 *Hanchungella bulbosa* Lee; Huo *et al.*, p. 157, pl. 30, figs 7–9.
?1991 *Hanchungella shangliangshanensis* Huo; Huo *et al.*, p. 158, pl. 30, figs 10–12.
?1991 *Hanchungella angusta* Huo; Huo *et al.*, p. 158, pl. 30, fig. 13.
?1991 *Hanchungella u-formis* Huo & Shu; Huo *et al.*, p. 158, pl. 30, figs 14, 15.
?1991 *Hanchungella sphensis* Huo & Shu; Huo *et al.*, p. 159, pl. 30, fig. 16.
?1991 *Hanchungella emeiensis* Huo & Shu; Huo *et al.*, p.159, pl.30, figs 17, 18.
?1991 *Hanchungella alta* Huo & Shu; Huo *et al.*, p. 159, pl. 30, fig. 19.
?1991 *Hanchungella toculata* Lee; Huo *et al.*, p. 160, pl. 29, fig. 8.
?1991 *Hanchungella toculata tenuis* Huo & Shu; Huo *et al.*, p. 160, pl. 30, figs 20, 21.
?1991 *Hanchungella giganta* Huo; Huo *et al.*, p. 161, pl. 29, fig. 10.
?1991 *Hanchungella semicircinata* Lee; Huo *et al.*, p. 161, pl. 29, fig. 11.

Holotype. A right valve, NIGPAS no. 8595; Huo, 1956, p. 429, pl. 1, fig. 5. Liangshan section, Hanzhong County, Shaanxi Province; Qiongzhusi Formation, lower Cambrian.

Material. Our material consists of several tens of specimens from Gaopo section in Gaoqiao, E'mei County, Sichuan Province, and about ten specimens from Meishucun section, Jinning County, Shapushan section, Wuding County and Maotianshan section, Chengjiang County, Yunnan Province.

Measurements. According to the illustration in Huo (1956, pl. 1, fig. 5), the holotype is 3·1 mm long. Our specimens are up to 3 mm long.

Diagnosis. Small *Liangshanella* with a weak anterodorsal node.

Description. Valves postplete, dorsal margin straight. Distinct furrow separates rather flat, lateral valve surface from narrow lateroadmarginal ridge that is entire between cardinal corners. Posterior cardinal angle greater than anterior cardinal angle. Small, indistinct anterodorsal node: other lobal features lacking.

Remarks. *L. rotundata* differs from *L. liangshanensis* in its consistently smaller size. The middle Cambrian *L. burgessensis* (see Siveter & Williams 1997) differs from *L. rotundata* only by the possession of a possible adductor muscle scar. *L. rotundata* is purported to be found in many localities in SW China, but it is difficult to be sure that these various occurrences represent conspecific material.

We consider that the supposed differences, in shape and size, by which Huo (1956; see also Huo & Shu 1985; Huo *et al.* 1991) established *Hanchungella rotundata, H. shangliangshanensis*, *H. angusta* and *H. giganta* (each of which was based on single specimens from Liangshan section, Shaanxi Province), are due to preservational or ontogenetic reasons and that, therefore, these taxa are synonymous. Although Huo (1956) identified a possible articulating hinge structure in his specimen of *H. shangliangshanensis*, a feature which would be unique in bradoriids (see Hou *et al.* 1996; Siveter & Williams 1997; Williams & Siveter 1998), in later descriptions of the taxon (Huo & Shu 1985; Huo *et al.* 1991) this feature was not mentioned and remains unconfirmed.

The four *Hanchungella* species established by Lee (1975), each on the basis of one or a few specimens from sections at Yuxiansi and Leshan City, Sichuan Province, also appear to be probable synonyms of *L. rotundata*. The supposed T-shaped anterodorsal node described for *H. toculata* appears to be due to compression (cf. Lee 1975, pl. 4, figs 5, 6). Differences identified for his other species, *H. leshanensis, H. bulbosa* and *H. semicircinata*, are minor, intraspecific or preservational variation in valve shape and the shape and convexity of the anterodorsal node. We recognise similar variation, particularly in the degree of development of the anterodorsal node, in our specimens of *L. rotundata* from Yunnan (Fig. 23a–f). *H. angusta yunnanensis* Huo & Shu 1983, based on two deformed specimens from Meishucun section, Yunnan Province, and differentiated by having an elliptical anterior node, is a similar case, and is also a probable synonym of *L. rotundata*.

Huo & Shu (1985) established four *Hanchungella* taxa, each of which we consider as possible synonyms of *L. rotundata*. Their *H. toculata tenuis* (from the Meishucun section) was, like *H. toculata,* also purported to have a T-shaped anterior node but was distinguished by having a curved dorsal margin and longer anterodorsal node. Both the latter features vary in our material of *L. rotundata* and, more importantly, the T-shaped anterodorsal node is not evident in their figures of *H. toculata tenuis* (*op. cit.* pl. 4, figs 10–12, text-fig. 8-57). The

other three species were all distinguished primarily on the basis of variation in the shape of the anterodorsal node. For example, *H. emeiensis*, from E'mei County, Sichuan Province and Liangshan section, Shaanxi Province, was distinguished by its elongate, oval anterodorsal node paralleling the anterior margin. However, the outline of this node clearly varies (intraspecifically and preservationally) between all four figured specimens of *H. emeiensis*, and even between the left and right valves of the holotype carapace (Huo & Shu 1985, pl. 4, figs 16–19, text-fig. 8-60). *H. sphenis* and *H. u-formis* were each based on single specimens from Liangshan and Meishucun sections respectively (Huo & Shu 1985, pl. 4, figs 13–15, text-fig. 8-59).

Occurrence. Western Subprovince. Liangshan section, Hanzhong County (Huo 1956; Zhang 1974; Li *et al.* 1975; Tan 1980; Huo & Shu 1985; Huo *et al.* 1991), Shaanxi Province; Meishucun section, Jinning County (herein; see also Jiang 1982; Huo *et al.* 1983a, 1991; Huo & Shu 1985), Shapushan section, Wuding County (herein) and Maotianshan section, Chengjiang County, Yunnan Province.; Gaopo section in Gaoqiao (herein; see also Li 1981; Huo & Shu 1985; Huo *et al.* 1991), E'mei County, Sichuan Province. Possibly also at Zhongbao section, Zhenping County, Shaanxi Province (Huo & Shu 1982, 1985; Huo *et al.* 1991); Yuxiansi section (Lee 1975; Li 1981; Huo & Shu 1985; Huo *et al.* 1991), E'mei County and Fandian section (Lee 1975; Huo *et al.* 1983a, 1991; Huo & Shu 1985), Leshan City, Sichuan Province. All these confirmed and possible occurrences are from the Qiongzhusi Formation and correlatives, lower Cambrian; the lower part of the *Eoredlichia–Wutingaspis* Biozone.

Liangshanella yunnanensis Zhang, 1974
(Fig. 21f–k)

1974 *Liangshanella yunannensis* (sp. nov.); Zhang, p. 111, pl. 43, fig. 18.
?1983b *Aluta usualis* sp. nov.; Shu *in* Huo *et al.*, p. 63, pl. 5, figs 4–11.
?1985 *Aluta usualis* Shu 1983; Huo & Shu, p. 63, pl. 20, figs 12–15.
?1985 *Aluta aulaca* Shu (sp. nov.); Shu *in* Huo & Shu, p. 64, pl. 21, figs 1–4.
?1985 *Aluta bimarginata* Shu (sp. nov.); Shu *in* Huo & Shu, p. 65, pl. 20, fig. 16.
?1985 *Aluta postprotusa* Shu (sp. nov.); Shu *in* Huo & Shu, p. 65, pl. 20, figs 17, 18.
?1987 *Ovaluta usualis* (Shu) 1983; Zhang, p. 15, figs 11A, 11B.
?1987 *Ovaluta henanensis* sp. nov.; Zhang, p. 15, figs 11C–E.
?1991 *Aluta usualis* Shu; Huo *et al.*, p. 69, pl. 1, figs 4–8.
?1991 *Aluta aulaca* Shu; Huo *et al.*, p. 70, pl. 1, figs 14, 15.
?1991 *Aluta postprotusa* Shu; Huo *et al.*, p. 70, pl. 1, figs 12, 13.
?1991 *Aluta bimarginata* Shu; Huo *et al.*, p. 72, pl. 2, fig. 7.
?1991 *Aluta henanensis* (Zhang); Huo *et al.*, p. 71, pl. 2, figs 1–4.

Holotype. A right valve, NIGPAS no. 21683; Zhang 1974, p. 111, pl. 43, fig. 18. Shijiangjun section, Wuding County, Yunnan Province; Canglangpu Formation, lower Cambrian, *Palaeolenus* Biozone.

Material. About 100 specimens from Shapushan and Shijiangjun sections, Wuding County, Yunnan Province.

Measurements. The holotype is 1·5 mm long (measured by Hou X-g, 1981). Our specimens are up to 1·78 mm long.

Diagnosis. Small *Liangshanella* with modestly developed anterodorsal node and very slight overreach of lobal area above dorsal margin.

Description. Valves small, postplete, with subovate lateral outline. Lobal area gently convex overall, its dorsal margin is straight to very slightly curved in lateral view. Lateroadmarginal ridge narrow, entire between cardinal corners, separated from lobal area by distinct, narrow furrow. Lobation comprises only a modestly developed anterodorsal node.

Remarks. Much of our material is from the same section in Wuding County, Yunnan Province, from which Zhang (1974) obtained his material of *L. yunnanensis*. Almost all of our specimens have the anterodorsal node in a similar position to that of the holotype of *L. yunnanensis* and that of *L. henanensis* (Zhang, 1987) from Henan Province, that is, adjacent to the anterior cardinal corner. However, a few specimens (e.g. Fig. 21g) also show a weak and slightly more anteromedially positioned node (an arrangement which is similar to the morphology of the type material of *'A'. usualis* Shu *in* Huo *et al.* 1983b). For the present we regard this as intraspecific variation.

Both the type material of *'A'. usualis* Shu *in* Huo *et al.* 1983b from the lower Cambrian of Guizhou Province, and material from the Shuigoukou Formation of Henan Province that Zhang (1987) assigned to that species, are similar to, or conspecific with, material described herein under *L. yunnanensis*. *Aluta aulaca* from Liangshan section, Hanzhong City, Shaanxi Province and *Aluta bimarginata* and *Aluta postprotusa* from Weiganping Section, Fuquan County, Guizhou Province (all Shu *in* Huo & Shu 1985) may also be junior synonyms of *'A'. usualis*.

The lower Cambrian *Liangshanella salopiensis* (Cobbold *in* Cobbold & Pocock 1934) from Britain differs from *L. yunnanensis* and allied species in lacking an anterodorsal node.

Occurrence. Shapushan (herein) and Shijiangjun (Zhang 1974; herein) sections, Wuding County, Yunnan Province; Canglangpu Formation, lower Cambrian *Palaeolenus* Biozone. Possibly occurs also at the Naozizhai section, Xichuan County, Henan Province (Shuigoukou Formation, *Palaeolenus* Biozone; Zhang 1987; Huo *et al.* 1991) and at the Weiganping section, Fuquan County, Guizhou Province (Niutitang Formation; Huo *et al.* 1983b; Huo & Shu 1985; Huo *et al.* 1991).

Genus *Tsunyiella* Zhang, 1974

1974 *Tsunyiella* Chang, p. 107.
1978 *Majiashanella* Lin (gen. nov.); Lin, p. 141.
1978 *Tsunyiella* Chang; Yin, p. 383.
1983a *Tsunyiella* Chang; Huo *et al.*, p. 98.
1983a *Tsunyiella* (*Anaulaca*) subgen. nov.; Shu & Cui *in* Huo *et al.*, p. 102.
1985 *Tsunyiella* Chang 1964 (*sic.*); Huo & Shu, p. 80.
1985 *Anaulaca* Shu & Cui; Huo & Shu, p. 85.
?1985 *Varitsunyiella* gen. nov.; Cui & Huo *in* Huo & Shu, p. 88.
?1988 *Sulcatella* (gen. nov.); Tan & Li, p. 22.
1991 *Tsunyiella* Chang, 1964 (*sic.*); Huo *et al.*, p. 78.
1991 *Varitsunyiella* Cui & Huo, 1985; Huo *et al.*, p. 84.

Type species. By original designation: *Tsunyiella luna* Zhang, 1974. From the Jindingshan section, Zunyi (Tsunyi) City, Guizhou Province; Mingxinsi Formation, lower Cambrian.

Diagnosis. Medium-sized (adults *c*. 5 mm long), postplete to amplete svealutids with three or four nodes anterodorsally and a narrow lateroadmarginal ridge which is entire between cardinal corners.

Remarks. *Tsunyiella* was made available with a formal description in 1974, with a designated and illustrated type specimen. Previously Zhang had illustrated the same specimen, under the nomen nudum *Tsunyiella luna*, in an unpublished 1964 geological excursion booklet. *Tsunyiella* is characteristic of the middle subprovince of the SW China platform in

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Guizhou and Hubei provinces. Its valves are often preserved flattened, commonly resulting in deformation (and in some cases virtual loss) of the anterodorsal nodes (e.g. Huo *et al.* 1991, pl. 5, figs 8–12, pl. 6, figs 1, 3, 4, 7).

Herein *Anaulaca* Shu & Cui (*in* Huo *et al.*, 1983a; type species *Anaulaca elongata* Shu *in* Huo *et al.*, 1983a), established on specimens from Guizhou and Hubei provinces, is considered synonymous with *Tsunyiella*. *Varitsunyiella* Cui & Huo (*in* Huo & Shu, 1985; type species *Varitsunyiella stipitiformis* Cui & Huo, 1985), established on limited, poorly preserved material from Hubei province, is another possible synonym. These genera were purported to differ from *Tsunyiella* by having a single ridge for the anterodorsal node (*Varitsunyiella*), rather than a U-shaped anterodorsal node, and by the absence of the anterodorsal furrow (*Anaulaca*), characteristics that we ascribe to preservational factors.

Anabarochilina appears to differ from *Tsunyiella* in its more amplete, elongate lateral shape and in its greater valve convexity. However, the differences are slight and may, in part, be preservational; additional study may indicate that these two genera are synonyms.

Restudy of the type and other material of *Majiashanella* Lin, 1978 (type species: *Majiashanella ziguiensis* Lin, 1978) which was established on the basis of flattened specimens from black shales from the Yemaomian section, Zigui County, Hubei Province, has indicated that it is a junior synonym of *Tsunyiella* (see Huo & Shu 1985, p. 85; Huo *et al.* 1991, p. 78). The same is possibly true of *Sulcatella* Tan & Li, 1988 (type species *Sulcatella typica* Tan & Li, 1988) which was erected on the basis of a single specimen from Zhenba County, Shaanxi Province.

The deformed specimens that formed the basis of *Aluta shipaiensis* Cui (*in* Huo & Cui 1989), from the Shipai section, Yichang City, Hubei Province and *Aluta nanjiangensis* Cui (*in* Huo *et al.* 1991), from Wushi County, Xinjiang Province, are possibly *Tsunyiella*. The specimen from Xiaoyangba section, Zhenba County, Shaanxi Province, which was used to erect *Tsunyiella intermedia* Tong (*in* Huo *et al.* 1991) appears to more closely resemble *Zhenpingella* Lee, 1975.

Occurrence. Guizhou, Sichuan, Hubei and Yunnan provinces, SW China and Xinjiang Province, W China; lower Cambrian.

Tsunyiella luna Zhang, 1974
(Fig. 22d–j)

1974 *Tsunyiella luna* Chang; p. 107, pl. 43, fig. 1.
1974 *Tsunyiella striata* (sp. nov.), Chang; p. 107, pl. 43, fig. 2.
1978 *Tsunyiella luna* Chang; Yin, p. 383, pl. 143, figs 1, 2.
1978 *Tsunyiella striata* Chang; Yin, p. 383, pl. 143, fig. 3.
1978 *Tsunyiella shiqianensis* sp. nov.; Yin, p. 383, pl. 143, fig. 8.
1978 *Majiashanella ziguiensis* Lin (gen. et sp. nov.); Lin, p. 141, pl. 18, figs 5–7.
1978 *Majiashanella yangtziensis* Lin (gen. et sp. nov.); Lin, p. 142, pl. 18, figs 1–3.
1978 *Majiashanella vicina* Lin (gen. et sp. nov.); Lin, p. 142, pl. 18. fig. 4.
1978 *Majiashanella hubeiensis* Lin (gen. et sp. nov.); Lin, p. 142, pl. 18, fig. 8.
1983 *Tsunyiella luna* Chang, 1964 (*sic.*); Li, p. 17, pl. 3, fig. 13.
1983 *Tsunyiella striata* Chang, 1974; Li, p. 17, pl. 3, fig. 14.
1983a *Tsunyiella wenganensis* Shu sp. nov.; Shu *in* Huo *et al.*, p. 98, pl. 2, figs 1–3.
1983a *Tsunyiella niutitangensis* Shu & Cui sp. nov.; Shu & Cui *in* Huo *et al.*, p. 99, pl. 2, figs 4–6.
1983a *Tsunyiella zunyiensis* Shu sp. nov.; Shu *in* Huo *et al.*, p. 100, pl. 2, fig.7.
1983a *Tsunyiella zunyiensis yichangensis* Huo & Cui subsp. nov.; Huo & Cui *in* Huo *et al.*, p. 100, pl. 2, figs 8, 9.
1983a *Tsunyiella xianrenqiaoensis* Huo & Cui sp. nov.; Huo & Cui *in* Huo *et al.*, p. 100, pl. 2, figs 10, 11.
1983a *Tsunyiella luna huangshandongensis* Huo & Cui subsp. nov.; Huo & Cui *in* Huo *et al.*, p. 101, pl. 2, figs 12, 13.
1983a *Tsunyiella xiakouensis* Huo & Cui sp. nov.; Huo & Cui *in* Huo *et al.*, p. 102, pl. 2, figs 14, 15.
1983a *Tsunyiella (Anaulaca) elongata* Shu subgen. et sp. nov.; Shu *in* Huo *et al.*, p. 103, pl. 2, fig. 16.
1983a *Tsunyiella (Anaulaca) acuta* Shu subgen. et sp. nov.; Shu *in* Huo *et al.*, p. 103, pl. 1, fig. 18.
1983a *Tsunyiella (Anaulaca) songlinensis* Shu subgen. et sp. nov.; Shu *in* Huo *et al.*, p. 103, pl. 2, fig. 17.
1983a *Tsunyiella (Anaulaca) liantuoensis* Huo & Cui subgen. et sp. nov.; Huo & Cui *in* Huo *et al.*, p. 104, pl. 1, fig. 20.
1983a *Tsunyiella (Anaulaca) tianzhushanensis* Huo & Cui subgen. et sp. nov.; Huo & Cui *in* Huo *et al.*, p. 104, pl. 1, fig. 19.
1985 *Tsunyiella luna* Chang, Huo & Shu, p. 80, pl. 17, figs 1, 2.
1985 *Tsunyiella striata* Chang, Huo & Shu, p. 80, pl. 17, fig. 12.
1985 *Tsunyiella luna huangshandongensis* Huo & Cui; Huo & Shu, p. 81, pl. 18, figs 1, 2.
1985 *Tsunyiella wenganensis* Shu 1983; Huo & Shu, p. 81, pl. 17, figs 8, 9.
1985 *Tsunyiella niutitangensis* Shu & Cui; Huo & Shu, p. 82, pl. 17, figs 5, 7.
1985 *Tsunyiella zunyiensis* Shu; Huo & Shu, p. 82, pl. 16, fig. 12.
1985 *Tsunyiella zunyiensis yichangensis* Huo & Cui; Huo & Shu, p. 82, pl. 17, fig. 13.
1985 *Tsunyiella xianrenqiaoensis* Huo & Cui; Huo & Shu, p. 83, pl. 17, figs 10, 11.
1985 *Tsunyiella xiakouensis* Huo & Cui; Huo & Shu, p. 83, pl. 17, figs 3, 4.
1985 *Tsunyiella hemicyclica* Shu (sp. nov.); Shu *in* Huo & Shu, p. 83, pl. 16, figs 10, 11.
1985 *Tsunyiella niutitangensis ziguiensis* (Lin); Huo & Shu, p. 85, pl. 22, figs 13–15.
1985 *Tsunyiella luna hubeiensis* (Lin); Huo & Shu, p. 85, pl. 22, fig. 16.
1985 *Anaulaca elongata* Shu; Huo & Shu, p. 86, pl. 18 fig. 5.
1985 *Anaulaca acuta* Shu; Huo & Shu, p. 86, pl. 18, fig. 7.
1985 *Anaulaca songlinensis* Shu; Huo & Shu, p. 86, pl. 18, fig. 6.
1985 *Anaulaca shiqianensis* (Yin); Huo & Shu, p. 87, pl. 18, fig. 4.
1985 *Anaulaca liantuoensis* Huo & Cui; Huo & Shu, p. 87, pl. 18, fig. 8.
1985 *Anaulaca tianzhushanensis* Huo & Cui; Huo & Shu, p. 87, pl. 18, fig. 9.
?1985 *Varitsunyiella stipitiformis* Cui & Huo gen. et sp. nov.; Cui & Huo *in* Huo & Shu, p. 88, pl. 28, figs 6–8.
?1985 *Varitsunyiella miaoheensis* Cui & Huo gen. et sp. nov.; Cui & Huo *in* Huo & Shu, p. 89, pl. 28, figs 9, 10.
?1988 *Sulcatella typica* Tan & Li (gen. et sp. nov.); Tan & Li, p. 22, pl. 2, fig. 4.
1989 *Tsunyiella luna huangshandongensis* Huo & Cui; Huo & Cui, p. 78, pl. 1, figs 2–4.
1989 *Tsunyiella xianrenqiaoensis* Huo & Cui; Huo & Cui, p. 79, pl. 1, figs 8–10.

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1989 *Tsunyiella luna* Chang; Huo & Cui, p. 81, pl. 1, figs 15–17.
1991 *Tsunyiella luna* Chang; Huo *et al*., p. 78, pl. 4, figs 1–4.
1991 *Tsunyiella luna huangshandongensis* Huo & Cui; Huo *et al*., p. 79, pl. 3, figs 13–17.
?1991 *Tsunyiella epicharis* (sp. nov.); Huo *et al*., p. 79, pl. 3, fig. 12.
1991 *Tsunyiella xiakouensis* Huo & Cui; Huo *et al*., p. 80, pl. 4, figs 5, 6.
1991 *Tsunyiella striata* Chang; Huo *et al*., p. 80, pl. 4, fig. 7.
1991 *Tsunyiella zunyiensis* Shu; Huo *et al*., p. 80, pl. 4, fig. 8.
1991 *Tsunyiella wenganensis* Shu; Huo *et al*., p. 81, pl. 4, figs 10, 11.
1991 *Tsunyiella niutitangensis* Shu & Cui; Huo *et al*., p. 81, pl. 4, fig. 12.
?1991 *Tsunyiella dichotoma* (sp. nov.); Huo *et al*., p. 82, pl. 4, fig. 13.
1991 *Tsunyiella luna ziguiensis* (Lin); Huo *et al*., p. 82, pl. 5, figs 6, 8, 10, 12.
1991 *Tsunyiella luna hubeiensis* (Lin); Huo *et al*., p. 83, pl. 5, figs 7, 9, 11, 13.
1991 *Tsunyiella xianrenqiaoensis* Huo & Cui; Huo *et al*., p. 83, pl. 6, figs 1–3.
1991 *Tsunyiella elongata* Shu; Huo *et al*., p. 83, pl. 6, fig. 4.
1991 *Tsunyiella liantuoensis* Huo & Cui; Huo *et al*., p. 84, pl. 6, fig. 11.
1991 *Tsunyiella* sp.; Huo *et al*., p. 84, pl. 6, fig. 5.
?1991 *Varitsunyiella stipitiformis* Cui & Huo; Huo *et al*., p. 85, pl. 6, figs 7, 8.
?1991 *Varitsunyiella miaoheensis* Cui & Huo; Huo *et al*., p. 85, pl. 6, figs 9, 10.
1994 *Tsunyiella luna*; Huo, Shu & Chen, fig. 5n.
1997 *Tsunyiella* sp.; Vannier, Williams & Siveter, p. 178, fig. 8.

Holotype. A carapace, NIGPAS no. 21673; left valve figured Zhang 1974, pl. 43, fig. 1 (see also Huo & Shu 1985, pl. 17, fig. 1). Jindingshan section, Zunyi City, Guizhou Province; Mingxinsi Formation, lower Cambrian.

Material. Dozens of specimens from Jindingshan section, Zunyi City, and a few from Yuqing County and Baimadong section, Kaiyang County, Guizhou Province; also a few specimens from Shizhu County and Gaoqiao section, Pengshui County, Sichuan Province.

Measurements. The holotype is 4·7 mm long (measured by Hou X-g, 1981). Our specimens are 3·43–5·28 mm long.

Diagnosis. Species of *Tsunyiella* with three nodes anterodorsally.

Description. Valves postplete to amplete; the only lobal structures are three small nodes clustered anterodorsally. Anterior-most node nestles in angle between dorsal and anterior valve margins; behind and slightly lower is second node, typically divided by narrow subvertical furrow to give node an overall horseshoe-shape; third and smallest node has weakly conical shape, is virtually isolated, occurs almost at dorsal margin immediately behind other nodes. Lateroadmarginal ridge narrow, low, gently rounded edge, entire between cardinal corners, demarcated from lateral surface by narrow furrow. Valves smooth; both cardinal corners typically have tiny spine-like extensions.

Remarks. *Tsunyiella* specimens display a wide range of variation in general valve appearance and nodal shape and prominence (Fig. 22a–j), much of which results from post-mortem deformation. For example, the prominence of the cluster of anterodorsal nodes can be much reduced by flattening (cf. Fig. 22b, c) and many valves have a wrinkled appearance (Fig 22d, g), which in many cases is subconcentrically arranged. Such variation, especially wrinkling, is common in many bradoriids and Cambrian bivalved arthropods and probably results from post-mortem shrinkage or compression of what is a thin-shelled carapace; some wrinkled valves may represent exuviae (see Williams *et al*. 1996; Siveter & Williams 1997; Williams & Siveter 1998). Even in rocks that have apparently undergone minimal tectonic deformation, some valves of *Tsunyiella* display evidence of shear-like structures (Fig. 22f). A few valves show remains of a fine network of anastomosing ridges (Fig. 22a), presumed to be a manifestation of the circulatory system (Vannier *et al*. 1997).

Based on what we interpret as preservational variation, a large number of Chinese bradoriid taxa are herein considered synonyms of *Tsunyiella luna*. These include *T. striata* Chang, which was based on a single, flattened concentrically wrinkled carapace (see Yin 1978, pl. 143, fig. 3) from the Baimadong section, Kaiyang County, Guizhou Province (cf. Zhang 1974, pl. 43, fig. 2; Huo & Shu 1983, p. 85; Huo & Shu 1985, pp. 20, 81; Huo *et al*. 1991 pp. 17, 80; see also *Tsunyiella* sp. of Huo *et al*. 1991, pl. 6, fig. 5).

That the original specimens of *Majiashanella ziguiensis* Lin, 1978 (junior synonyn of *T. luna*) do not show an anterodorsal node because of compression is endorsed by later finds of specimens from the type locality that have an anterodorsal node (Huo *et al*. 1991). Some of Lin's (1978) other *Majiashanella* material was subsequently assigned to subspecies of *T. luna* by Huo *et al*. (1991), who also concluded, but without appropriate evidence, that some of these subspecies might represent sexual dimorphs of one species. We have no evidence for sexual dimorphism in our specimens of *T. luna*.

We consider that all of the 12 species and subspecies of *Tsunyiella* erected in Huo *et al*. (1983a), many of which were established on the basis of a single specimen, are synonymous with *T. luna*. These species were distinguished from *T. luna* on what we consider to be combinations of minor intraspecific differences in valve outline, nodal morphology and preservation.

Huo & Shu (1985) redescribed and re-illustrated virtually all established species of *Tsunyiella*. They also raised *Tsunyiella* (*Anaulaca*) Shu & Cui, 1983 to generic rank, to which they assigned six species. That genus and many of its species were not recognised by Huo *et al*. (1991). The poorly preserved specimens which formed the basis of *Varitsunyiella stipitiformis* Cui & Huo and *Varitsunyiella miaoheensis* Cui & Huo (in Huo & Shu 1985) are also possibly referable to *T. luna*.

The two *Tsunyiella* species erected by Huo *et al*. (1991), *T. epicharis* and *T. dichotoma*, were each based on single specimens, from Hubei Province, Shipai and Qingquan sections respectively; both specimens possibly represent incomplete, flattened specimens of *T. luna*. Huo *et al*.'s (1991) monograph did not feature *T. shiqianensis*, *T. zunyiensis yichangensis*, *T.* (*Anaulaca*) *acuta*, *T.* (*A.*) *songlinensis*, *T.* (*A.*) *tianzhushanensis* or *T. hemicyclica*.

Occurrence. Middle Subprovince and NW China. Jindingshan section, Zunyi City, Baimadong section, Keiyang County, and Weng'an County, Guizhou Province; Niutitang and Mingxinsu formations (Zhang 1974; Yin 1978; Li 1983; Huo *et al*. 1983a, 1991; Huo & Shu 1985; herein). Yaoshang section, Shiqian County, Guizhou Province; Jiumenchong Formation (Yin 1978; Huo & Shu 1985; Huo *et al*. 1991). Yemaomian section, Zigui County, Huangshandong and Shipai sections, Yichang City, and Qingquan section in Shennongjia area, Hubei Province; Shuijingtou Formation (Lin 1978; Huo *et al*. 1985; Huo & Shu 1983a, 1991). Shizhu County and Pengshui County (herein), Sichuan Province; Shuijingtuo Formation. Wushi County, Xinjiang Province; lower part of the Xiaoerbulag Formation (Huo & Cui 1989; Huo *et*

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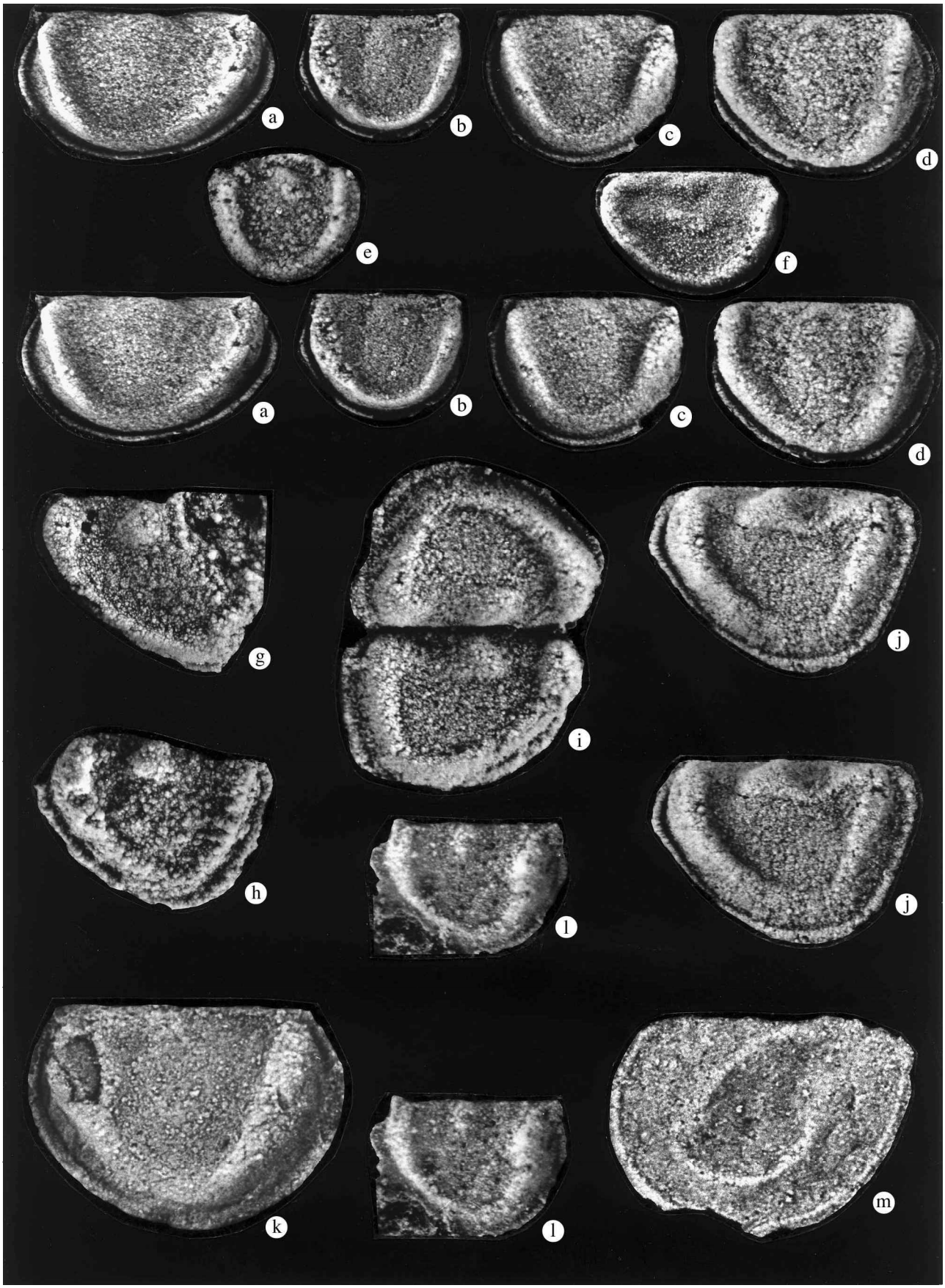

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al. 1991). Lower Cambrian; from the *Eoredlichia–Wutingaspis* to *Drepanuroides* biozones.

Tsunyiella diandongensis Tong *in* Huo & Shu, 1985
(Fig. 22a–c)

1985 *Tsunyiella luna diandongensis* Tong subsp. nov.; Tong *in* Huo & Shu, p. 84, pl. 28, fig. 12.
1991 *Tsunyiella luna diandongensis* Tong; Huo *et al.*, p. 81, pl. 4, fig. 9.

Holotype. A carapace, NWUX no. D83001; Huo & Shu 1985, pl. 28, fig. 12. Lufeng Section, Yiliang County, Yunnan Province; Qiongzhusi Formation, lower Cambrian.

Material. Our material consists of about 20 specimens from Maotianshan section, Chengjiang County, Yunnan Province.

Measurements. According to the illustration in Huo & Shu (1985, pl. 28, fig. 12), the holotype is 6·0 mm long. Our specimens are 4·8–5·0 mm long.

Diagnosis. Species of *Tsunyiella* with four nodes.

Description. As for *T. luna*, plus the occurrence of a small, weakly developed node just in front of mid-centre and just above mid-height, and a confluent very fine ridge. Latter connected to anterodorsal U-shaped node.

Remarks. *T. diandongensis* differs from *T. luna*, in having a fourth node and associated fine ridge. Tong (*in* Huo & Shu 1985) did not recognise the presence of this more centrally placed node in the single, somewhat compressed and wrinkled specimen on which he based his taxon. *Tsunyiella zhijinensis* Yin (1978, pl. 143, fig. 6; see also Huo & Shu 1985, pl. 16, fig. 9; Huo *et al.* 1991, pl. 3, fig. 19), from the Dayuan section, Zhijin County, Guizhou Province, also has a similarly placed node but the only specimen is too ill-preserved to permit a more detailed comparison with *T. diandongensis*.

Occurrence. Western Subprovince. Lufeng, Yiliang County (Huo & Shu, 1985) and Maotianshan, Chengjiang County (herein), Yunnan Province. Qiongzhusi Formation, lower Cambrian; *Eoredlichia–Wutingaspis* Biozone.

Family Hipponicharionidae Sylvester-Bradley, 1961

Diagnosis. (After Siveter & Williams 1997). Small to medium-sized (adults *c.* 2–6 mm long), subamplete to slightly postplete Bradoriida with subtriangular lateral outline, straight dorsal margin and well-developed hinge-line. Tri- to multilobate; anterior and posterior lobes may be discrete or ventrally fused to form broad connecting lobe. Trilobate forms have small, sinusoidal central lobe situated adjacent to dorsal margin and anteriorly of valve mid-length. Multilobate forms with up to seven ventrally confluent lobes. Lateroadmarginal ridge entire.

Remarks. The Hipponicharionidae include trilobate and multilobate forms (see Siveter & Williams 1997; Williams & Siveter 1998). Herein we follow the convention of treating hipponicharionids with the Bradoriida, though in valve shape, lobation, and possession of a straight dorsal margin and discrete hinge-line they clearly resemble palaeocope ostracodes. However, without evidence from soft parts it is impossible to confirm that they truly are a separate group. Hipponicharionids differ from typical palaeocopes by being non-dimorphic, by having a phosphatic component to their carapace composition, and by being, in most cases, larger.

Genus *Neokunmingella* Zhang, 1974

1974 *Neokunmingella* (gen. nov.); Zhang, p. 110.
?1983b *Parahipponicharion* Shu gen. nov.; Shu *in* Huo *et al.*, p. 66.
?1985 *Parahipponicharion* Shu 1983; Huo & Shu, p. 150.
?1990a *Pseudobeyrichona* gen. nov.; Shu, p. 47.
?1991 *Parahipponicharion* Shu, 1983; Huo *et al.*, p. 163.
1993c *Cambraechmina* n. g.; Hinz-Schallreuter, p. 316.
1998 *Neokunmingella* Zhang, 1974; Williams & Siveter, p. 19.

Type species. By original designation: *Neokunmingella minuta* Zhang, 1974. From Shijiangjun section, Wuding County, Yunnan Province; Wulongjing Member, Canglangpu Formation, lower Cambrian.

Diagnosis. (After Williams & Siveter 1998). Small hipponicharionids (adults *c.* 1–2·5 mm long) with confluent anterior and posterior lobes, a discrete, subovate to arcuate centrodorsal lobe which is subparallel to the dorsal margin, and a lateroadmarginal ridge which is entire between cardinal corners.

Remarks. *Neokunmingella* differs from *Hipponicharion* Matthew, 1886 (North America and Britain) and the morphologically closer *Wimanicharion* Hinz-Schallreuter, 1993 (Scandinavia and ?North America) by its smaller size and in having its centrodorsal lobe oriented subparallel to, rather than perpendicular to, the dorsal margin (see Siveter *et al.* 1994b; Siveter & Williams 1997; Williams & Siveter 1998). It further differs from *Hipponicharion* by having confluent anterior and posterior lobes.

We regard the Australian genus *Cambraechmina* Hinz-Schallreuter, 1993 as a synonym of *Neokunmingella*. In size and lobation, *Parahipponicharion* Shu, 1983 (type species *Parahipponicharion huoi* Shu *in* Huo *et al.* 1983b, from Weiganping section, Fuquan County, Guizhou Province; see also Huo & Shu 1985, p. 150, pl. 22, figs 8–12) and *Pseudobeyrichona* Shu,

Figure 24 (a–l) *Neokunmingella* cf. *N. minuta* Zhang, 1974: Qiongzhusi and Canglangpu Formations, lower Cambrian. (a–c, k) Shijiangjun section, Wuding County, Yunnan Province; (d, f) Shapushan section, Wuding County, Yunnan Province; (e) Shishan section, Wuding County, Yunnan Province; (g, h) Kebaocun section, Yiliang County, Yunnan Province; (i, j) Maotianshan section, Chengjiang County, Yunnan Province; (l) Yaoying section, Wuding County, Yunnan Province; all light photographs, ×25.

(a) RCCBYU 00118 (field coll. SJ-2), right valve, lateral view (stereo-pair); (b) RCCBYU 00119 (field coll. SJ-2), left valve, lateral view (stereo-pair); (c) RCCBYU 00120 (field coll. SJ-2), left valve, lateral view (stereo-pair); (d) RCCBYU 00122 (field coll. W19–5), left valve, lateral view (stereo-pair); (e) RCCBYU 00124 (field coll. SH4), right valve?, lateral view; (f) RCCBYU 00123 (field coll. W19–5), left valve, lateral view; (g) RCCBYU 00125 (field coll. Y3), fragmentary left valve, lateral view; (h) RCCBYU 00126 (field coll. Y3), left valve, lateral view; (i) RCCBYU 00129 (field coll. M6), open carapace, lateral view (anterior to right); (j) RCCBYU 00128 (field coll. M6), left valve, lateral view (stereo-pair); (k) RCCBYU 00121 (field coll. SJ-2), left valve, lateral view; (l) RCCBYU 00129 (field coll. Yao-2), left valve, lateral view (stereo-pair).

(m) *Phasoia* sp.: Qiongzhusi Formation, lower Cambrian; Qiongzhusi section, Kunming City, Yunnan Province; light photograph, ×20; RCCBYU 00130 (field coll. CH3–1), right valve, lateral view.

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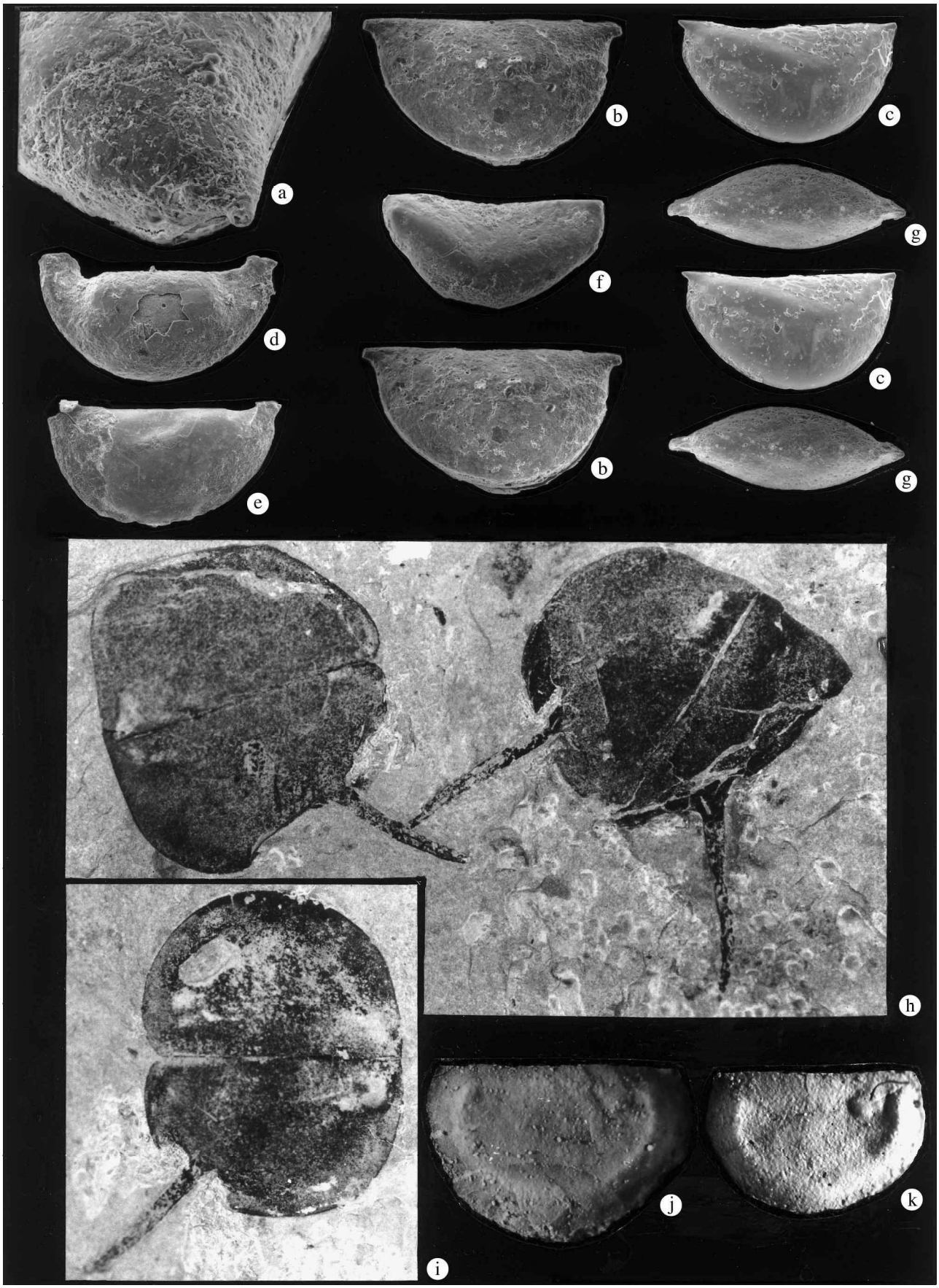

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1990 (type species *Pseudobeyrichona longquanxiensis* Cui *in* Shu 1990a, from Shaanxi Province: possible senior synonym, *Beyrichona longquanxiensis* Cui *in* Cui *et al.* 1987, from Pengshui County, Sichuan Province) are morphologically very similar to *Neokunmingella* and probably represent junior synonyms.

Neokunmingella resembles *Meishucunella* Jiang, 1982 but the type species, *Meishucunella processa* Jiang, 1982 (see below), has its node anterodorsally rather than centrodorsally placed.

Neokunmingella? sp. of Williams & Siveter (1998), described from a single valve from Shropshire, England, can now be assigned with certainty to *Neokunmingella*.

Occurrence. Yunnan and possibly Guizhou, Shaanxi and Sichuan provinces, SW China; lower Cambrian. Also the middle Cambrian (St David's 'Series') of England (Williams & Siveter 1998).

Neokunmingella cf. *N. minuta* Zhang, 1974
(Fig. 24a–l)

Material. Our material comprises: about 100 specimens from Shapushan and Shijiangjun sections, more than ten specimens from Shishan section, and a few specimens from Yaoying section, Wuding County; about 100 specimens from Maotianshan section, Chengjiang County; and a few specimens from Kebaocun section, Yiliang County; all Yunnan Province.

Measurements. The holotype of *N. minuta* (NIGPAS no. 21682; Zhang 1974, pl. 43, fig. 16) is 1·5 mm long (measured by Hou X-g, 1981). Our specimens of *N.* cf. *minuta* are up to 2·2 mm long.

Description. Valves small, postplete, length greater than height. Narrow, distinct lateroadmarginal ridge entire between cardinal corners. Ridge-like, confluent anterior and posterior lobes, subparallel to lateroadmarginal ridge, are less elevated mid-ventrally, forming saddle-like depression. Discrete central lobe, relatively small, weak to well developed, subovate to arcuate and situated close to and subparallel to the dorsal margin.

Remarks. The holotype of *N. minuta* shows a tiny node anteriorly on the valve. None of our specimens from many localities, including topotype material, displays this node, which we conclude may represent matrix or a preservational feature. An anterior node was also purported to occur in the four species of the possible synonym *Parahipponicharion*, which Shu (*in* Huo *et al.* 1983b; *in* Huo & Shu 1985; see also Huo *et al.* 1991) described on the basis of five poorly preserved specimens from Fuquan County, Guizhou Province, but it is not obvious in his illustrations. Some *Parahipponicharion* material may be conspecific with the *N.* cf. *minuta* of this paper, but confirmation awaits additional studies. Because of the uncertainty about the presence of an anterior node in the type material of *N. minuta* we prefer at present to refer our material to that species with a *confer*.

In our material from Yunnan Province the central lobe varies in prominence. In juveniles and presumed adults from Shijiangjun (Fig. 24a–c, k) and Shapushan (Fig. 24d, f) sections it is weak; in specimens from Shishan (Fig. 24e), Kebaocun (Fig. 24g, h), Yaoying (Fig. 24l) and especially Maotianshan (Fig. 24i, j) sections it is well developed.

The British *Neokunmingella* species (Williams & Siveter 1998) differs from the Chinese species in lacking a depression at the site of the mid-ventral confluence of the anterior and posterior lobes.

Occurrence. Western and possibly Middle subprovinces. Maotianshan section, Chengjiang County, Kebaocun section, Yiliang County and Shishan and Yaoying sections, Wuding County, Yunnan Province; Qiongzhusi Formation, upper part of the *Eoredlichia–Wutingaspis* and *Yunnanocephalus–Malungia* biozones. Shapushan and Shijiangjun sections, Wuding County, Yunnan Province (Zhang 1974; herein); Canglangpu Formation, *Palaeolenus* Biozone. Also possibly occurs in Guizhou, Shaanxi and Sichuan provinces.

? Family Hipponicharionidae
Genus *Meishucunella* Jiang, 1982

1982 *Meishucunella* Jiang (gen. nov.); Jiang, p. 212.
1983b *Meishucunella* Jiang; Huo *et al.*, p. 67.
1984 *Meishucunella* Jiang; Jiang, p. 59.
1985 *Meishucunella* Jiang; Huo & Shu, p. 152.
1991 *Meishucunella* Jiang, 1982; Huo *et al.*, p. 165.

Type species. By original designation: *Meishucunella processus* Jiang, 1982, p. 213, pl. 29, fig. 1. From Meishucun section, Jinning County, Yunnan Province; Yuanshan Member, Qiongzhusi Formation, lower Cambrian.

Diagnosis. Small, weakly postplete, elongate Bradoriida with confluent anterior and posterior lobes forming a U-shaped lobal ridge subparallel and close to the free margin, entire between cardinal corners. Area between lobal ridge and straight dorsal margin is concave, with small round node anterodorsally. Lateroadmarginal ridge very weakly developed or lacking.

Remarks. *Meishucunella* appears to be most similar to *Neokunmingella*, from which it differs especially in having an anterodorsal (rather than centrodorsal) node. Its rather elongate shape also contrasts with the subtriangular shape typical of adults of hipponicharionid genera such as *Neokunmingella*. Until more material is available and its morphology becomes better resolved (e.g. presence of a lateroadmarginal ridge is unconfirmed) the familial assignment of *Meishucunella* remains uncertain.

Occurrence. Yunnan Province, SW China; lower Cambrian.

Figure 25 (a–g) *Dabashanella hemicyclica* Huo, Shu & Fu, 1983: Shuigoukou Formation, lower Cambrian; Naozizhai section, Xichuan County, Henan Province; all scanning electron micrographs; (a) ×180, (b–g) ×60.
(a) RCCBYU 00131, detail of cardinal spine; (b) RCCBYU 00132, carapace, lateral view (stereo-pair); (c) RCCBYU 00133, carapace, lateral view (stereo-pair); (d) RCCBYU 00134, carapace, lateral view; (e) RCCBYU 00135, carapace, lateral view; (f) RCCBYU 00136, carapace, lateral view; (g) RCCBYU 00137, carapace, dorsal view (stereo-pair).
(h, i) *Kunmingella typica* Huo & Shu, 1985: Qiongzhusi Formation, lower Cambrian; Kuangshan section, Malong County, Yunnan Province; both light photographs; (h, i) ×12.
(h) RCCBYU 00149, slab containing two open carapaces, lateral view (specimen on the left is orientated with its anterior to lower left; specimen on the right is orientated with its anterior to upper right); (i) RCCBYU 00150, open carapace, lateral view (anterior is to the right).
(j, k) *Meishucunella processa* Jiang, 1982: Qiongzhusi Formation, lower Cambrian; Meishucun section, Jinning County, Yunnan Province; both light photographs; (j) ×19, (k) ×15.
(j) YIGSK Jf23, right valve, lateral view; (k) YIGSK Babu 64 (holotype), right valve, lateral view.

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Meishucunella processa Jiang, 1982
(Fig. 25j, k)

1982 *Meishucunella processus* Jiang; p. 213, pl. 29, fig. 1.
?1983b *Meishucunella tuberculata* Huo & Shu sp. nov.; Huo & Shu *in* Huo *et al.*, p. 67, pl. 6, figs 1, 2.
?1983b *Meishucunella typica* Huo & Shu sp. nov.; Huo & Shu *in* Huo *et al.*, p. 67, pl. 6, figs 3–5.
1984 *Meishucunella processus* Jiang; Jiang, p. 59, 149, pl. 17, fig. 1.
1985 *Meishucunella processus* Jiang; Huo & Shu, p. 152, pl. 22, fig. 1.
?1985 *Meishucunella tuberculata* Huo & Shu; Huo & Shu, p. 153, pl. 22, figs 4, 5.
?1985 *Meishucunella typica* Huo & Shu; Huo & Shu, p. 153, pl. 22, figs 2, 3.
1991 *Meishucunella processus* Jiang; Huo *et al.*, p. 165, pl. 32, fig. 1.
?1991 *Meishucunella typica* Huo & Shu; Huo *et al.*, p. 166, pl. 32, figs 2, 3.
?1991 *Meishucunella tuberculata* Huo & Shu; Huo *et al.*, p. 166, pl. 32, figs 4, 5.
1994 *Meishucunella processa*; Shu & Chen, fig. 5a.
1994 *Meishucunella processus* Jiang; Luo, Jiang & Tang, p. 168, pl. 5, figs 1, 2.

Holotype. A right valve, YIGSK no. Babu 64; Jiang 1982, p. 213, pl. 29, fig. 1. Meishucun section, Jinning County, Yunnan Province; Yuanshan Member, Qiongzhusi Formation, lower Cambrian, *Abadiella* Biozone.

Material. The holotype and paratype specimens.

Measurements. The holotype is 2·6 mm long and 1·6 mm high. The paratype YIGSK Jf23 is 2·3 mm long and 1·6 mm high.

Diagnosis. As for the genus.

Remarks. Both *M. tuberculata* and *M. typica* (both Huo & Shu 1983; refigured *in* Huo & Shu 1985; and Huo *et al.* 1991), also from the Qiongzhusi Formation at Meishucun, are possibly junior synomyms of *M. processa*.

Occurrence. Western Subprovince. Meishucun section, Jinning County, Yunnan Province (Jiang 1982). Qiongzhusi Formation, lower Cambrian; *Abadiella* Biozone.

Order Phosphatocopida Müller, 1964
Family Dabashanellidae Zhao, 1989a

Remarks. This family was erected by Zhao (1989a) and not by Huo *et al.* as claimed in Huo *et al.* (1991).

A detailed analysis of the mainly Scandinavian material of phosphatocopids with preserved soft anatomy ('Orsten' specimens) is not yet published, though several thousand specimens are now available for comparative study (see Müller & Walossek 1985). Distinctions between the various phosphatocopid families (e.g. Hesslandonidae, Vestrogothiidae, Falitidae, Dabashanellidae) are still based mainly on shell taxonomy and remain poorly constrained, and for this reason we have not given a diagnosis for the Family Dabashanellidae. However, in terms of carapace morphology, the principle difference between dabashanellids and the other major phosphatocopid families (for a discussion of which, see Williams & Siveter 1998, p. 27; see also Fig. 2) is their univalved carapace and absence of lobation.

Genus *Dabashanella* Huo, Shu & Fu, 1983

1983b *Dabashanella* gen. nov.; Huo, Shu & Fu *in* Huo *et al.*, p. 68.
1983b *Xiaoyangbaella* gen. nov.; Huo, Shu & Fu *in* Huo , Shu, Zhang, Cui & Tong, p. 69.
1985 *Xinjiangella* (gen. nov.); Jiang & Xiao *in* Huo & Shu, p. 184.
1986 *Xinjiangella* Jiang & Xiao, 1985; Xiao & Zhao, p. 79.
1986 *Dabashanella* Huo, Shu & Fu, 1983; Xiao & Zhao, p. 81.
1986 *Xiaoyangbaella* Huo, Shu, Fu, 1983; Xiao & Zhao, p. 82.
1986 *Naviformella* Zhao & Xiao (gen. nov.); *in* Xiao & Zhao, p. 83.
1986 *Selliformella* Zhao & Xiao (gen. nov.); *in* Xiao & Zhao, p. 83.
1986 *Palaeomeishucunella* Zhao & Xiao (gen. nov.); *in* Xiao & Zhao, p. 84.
1987 *Phaseolella* gen. nov.; Zhang, p. 16.
1987 *Dabashanella* Huo, Shu, Fu, 1983; Tong, p. 433.
1987 *Paraphaseolella* gen. nov.; Tong, p. 434.
1988 *Xiaoyangbaella* Huo, Shu & Fu, 1983; Tan & Li, p. 25.
1988 *Dabashanella* Huo, Shu & Fu, 1983; Tan & Li, p. 26.
1988 *Naviformella* Zhao & Xiao, 1986; Tan & Li, p. 27.
1988 *Paranaviformella* (gen. nov.); Tan & Li, p. 27.
?1988 *Zhenbaella* (gen. nov.); Tan & Li, p. 28.
1988 *Jingyangella* (gen. nov.); Tan & Li, p. 29.
1989a *Pseudindiana* gen. nov.; Zhao, p. 470.
1990a *Eohesslandona* gen. nov.; Shu, p. 65.
1990a *Dabashanella* Huo, Shu & Fu; Shu, p. 67.
?1990a *Pseudodabashanella* gen. nov.; Shu, p. 69.
?1990a *Paradabashanella* gen. nov.; Shu, p. 70.
1991 *Dabashanella* Huo, Shu & Fu, 1983; Huo *et al.*, p. 178.
1991 *Phaseolella* (Zhang), 1987; Huo *et al.*, p. 180.

Type species. By original designation: *Dabashanella hemicyclica* Huo, Shu & Fu *in* Huo *et al.* 1983b. From Xiaoyangba section, Zhenba County, Shaanxi Province; Shuijingtuo Formation, lower Cambrian.

Diagnosis. Very small (adults typically less than 1 mm long), amplete to weakly preplete phosphatocopids. Dorsal outline straight, outline between cardinal corners evenly convex so that overall valve shape in lateral view is semicircular. Carapace univalved, position of 'hinge' marked by no more than a dorsal curve in the carapace; no interdorsum. Cardinal corners with well-developed short processes. Valves typically smooth and non-lobate. Duplicature well developed.

Remarks. The valves of *Dabashanella* were evidently weakly mineralised, susceptible to post-mortem plastic deformation, and therefore many specimens are deformed. Typically this manifests as a strong concave dorsal curvature of the carapace, possibly resulting from post-mortem shrinkage (e.g. see specimens of *Phaseolella curvata* figured by Zhang 1987, fig. 13A–E; herein see Fig. 25f). At its maximum extent, this may result in the development of cusps at the cardinal corners (e.g. see *Paranaviformella* and *Jingyangella*, both Tan & Li 1988). Such deformed specimens commonly co-occur with well-preserved *Dabashanella* amongst our collections and there seems to be no justification for the pantheon of preservational variants that have been identified as discrete genera (see below).

Although poorly illustrated, *Xiaoyangbaella* Huo, Shu & Fu *in* Huo *et al.* 1983 (see also Huo & Shu 1985, pl. 28, figs 16, 17) is evidently a junior synonym of *Dabashanella* and was not discussed as a separate genus by Huo *et al.* (1991). We also concur with Zhao (1989b) and Huo *et al.* (1991), who considered *Xinjiangella* Jiang & Xiao, 1985, *Palaeomeishucunella* Zhao & Xiao, 1986 and *Phaseolella* Zhang, 1987 to be junior synonyms of *Dabashanella* (see also discussion above). We believe that the genera *Naviformella* and *Selliformella* (both Zhao & Xiao 1987), *Paraphaseolella* Tong, 1987, *Eohesslandona* Shu, 1990, and *Paranaviformella*, *Jingyangella* and prob-

ably *Zhenbaella* (all Tan & Li 1988) are all based on deformed (shrunken?) specimens of *Dabashanella*. Similarly deformed specimens occur as a component of our collections of *Dabashanella hemicyclica*. They include forms which resemble *Paranaviformella* (see Fig. 25d, e) and *Phaseolella* (Fig. 25f). Specimens referred to *Xinjiangella reniformis* Jiang & Xiao (see Huo & Shu 1985, pl. 36, fig. 7), *Phaseolella* (Zhang 1987, fig. 13; see also Huo *et al.* 1991, pl. 37, figs 4–8), and *Dabashanella* Huo, Shu & Fu, 1983 (Zhao 1989a, fig. 6, 1989b, figs 10–13, 16) show similar deformation.

Based on their illustrations, *Indiana sipa* Fleming (1973, p. 6, pl. 1, figs 1–3), *Indiana? sipa* Fleming (Jones & McKenzie 1980, p. 217, fig. 8A–D) and *Dielymella*? *dubia* Jones & McKenzie (1980, p. 217, fig. 8E–I), from the 'middle Cambrian' of the Georgina Basin, Queensland, Australia, appear referable to *Dabashanella* (see Zhao 1989a, pp. 467, 470; Zhang 1987, p. 16). We concur with Zhao's (1989b, p. 414, table 1) referal of *Indiana? sipa* Fleming of Zhao & Xiao (*in* Xiao & Zhao 1986) and *Mononotella*? *lentiformis* Zhao & Xiao (*in* Xiao & Zhao 1986, pp. 85, 86) to *Dabashanella*.

Specimens from the type Xiaoyangba section, Zhenba County, Shaanxi Province were referred to Shu's (1990, pp. 69, 70, pl. 10, figs 7–10, 13–17) new genera *Pseudodabashanella* and *Paradabashanella*. Shu's figured specimens appear broken along the free and dorsal margins and are somewhat irregular in outline. Nevertheless, they compare with previously figured *Dabashanella* (see Xiao & Zhao 1986, pl. 2, figs 6, 9, 10; Zhao 1989b, pl. 1, fig. 16) and are probable junior synonyms of *Dabashanella*.

An incomplete specimen from Datong County, Qinghai Province referred to *Dabashanella* sp. by Huo *et al.* (1991, p. 180, pl. 45, fig. 13) shows a median node and weak reticulate ornament. Its relationship to *Dabashanella* needs verifying.

The phosphatocopid specimen figured by Williams & Siveter (1998, pl. 6, figs 9, 10) from the Comley Limestone, Lower Cambrian (Protolenid–Strenuellid trilobite Biozone) of Shropshire, England is very similar to the Chinese and Australian *Dabashanella*. It differs by possessing reticulostriate ornament and by having a gently arched dorsal outline in lateral view.

Occurrence. Shaanxi, Sichuan, Henan, Qinghai and Xinjiang provinces, China (Huo *et al.* 1983b, 1991; Huo & Shu 1985; Xiao & Zhao 1986; Cui *et al.* 1987; Zhang 1987; Tan & Li 1988; Zhao 1989a, b; Shu 1990a); western Queensland, Australia (Fleming 1973; Jones & McKenzie 1980); possibly from Shropshire, England (Williams & Siveter 1998). Lower Cambrian of China and ?England, and 'Middle Cambrian (Ordian)' of Öpik (1968), Australia.

Dabashanella hemicyclica Huo, Shu & Fu, 1983
(Fig. 25a–g)

1983b *Dabashanella hemicyclica* gen. et sp. nov.; Huo, Shu & Fu *in* Huo *et al.*, p. 68, pl. 5, figs 18–20.
1983b *Dabashanella retroswinga* gen. et sp. nov.; Huo, Shu & Fu *in* Huo *et al.*, p. 69, pl. 5, figs 14–17.
1983b *Xiaoyangbaella zhenbaensis* gen. et sp. nov.; Huo, Shu & Fu *in* Huo *et al.*, p. 69, pl. 5, figs 21, 22.
1985 *Dabashanella hemicyclica* Huo, Shu & Fu; Huo & Shu, p. 175, pl. 28, figs 18–20.
1985 *Dabashanella retroswinga* Huo, Shu & Fu; Huo & Shu, p. 175, pl. 28, figs 13–15.
1985 *Xiaoyangbaella zhenbaensis* Huo, Shu & Fu; Huo & Shu, p. 175, pl. 28, figs 16, 17.
1985 *Xinjiangella venustois* (gen. et sp. nov.); Jiang & Xiao *in* Huo & Shu, p. 184, pl. 36, figs 1–6, 9 (*non* pl. 1, figs 6, 9).
1985 *Xinjiangella reniformis* (gen. et sp. nov.); Jiang & Xiao *in* Huo & Shu, p. 185, pl. 36, figs 7, 8 (*non* pl. 1, figs 7, 8).
1986 *Xinjiangella venustois* Jiang & Xiao, 1985; Xiao & Zhao, p. 79, pl. 1, figs 5, 6.
1986 *Xinjiangella dorsonodis* Zhao & Xiao (sp. nov.); *in* Xiao & Zhao, p. 80, pl. 1, fig. 7.
1986 *Xinjiangella squamiformis* Xiao & Zhao (sp. nov.); Xiao & Zhao, p. 81, pl. 1, figs 18, 19.
1986 *Dabashanella hemicyclica* Huo, Shu & Fu, 1983; Xiao & Zhao, p. 81, pl. 1, figs 8, 11.
1986 *Dabashanella conica* Zhao & Xiao (sp. nov.); *in* Xiao & Zhao, p. 82, pl. 1, fig. 9.
1986 *Xiaoyangbaella nudata* Zhao & Xiao (sp. nov.); *in* Xiao & Zhao, p. 82, pl. 2, figs 5–10.
1986 *Naviformella antiquata* Zhao & Xiao (gen. et sp. nov.); *in* Xiao & Zhao, p. 83, pl. 2, fig. 4.
1986 *Selliformella reniformis* (Jiang & Xiao, 1985); Xiao & Zhao, p. 83, pl. 2, figs 11–15.
1986 *Palaeomeishucunella xibeiensis* Zhao & Xiao (gen. et sp. nov.); *in* Xiao & Zhao, p. 84, pl. 1, figs 12, 14, 15.
1986 *Palaeomeishucunella xibeiensis elongata* Zhao & Xiao (gen. et sp. nov.); *in* Xiao & Zhao, p. 84, pl. 1, figs 16, 17.
1986 *Indiana*? *sipa* Fleming, 1973; Xiao & Zhao, p. 85, pl. 1, fig. 10.
1986 *Mononotella*? *lentiformis* Zhao & Xiao (sp. nov.); *in* Xiao & Zhao, p. 86, pl. 2, figs 1, 2.
1987 *Phaseolella dimorpha* sp. nov.; Zhang, p. 16, fig. 12A–W.
1987 *Phaseolella curvata* sp. nov.; Zhang, p. 18, fig. 13A–E.
1987 *Dabashanella retroswinga* Huo, Shu & Fu; Cui, Zhang, Tong & Huo, p. 75, pl. 1, figs 18–21.
1987 *Dabashanella retroswinga* Huo, Shu & Fu, 1983; emend. nov., Tong, p. 433, pl. 1, figs 3–10, pl. 2, figs 1–18.
1987 *Dabashanella hemicyclica* Huo, Shu & Fu, 1983; emend. nov., Tong, p. 434, pl. 1, figs 11–16.
1987 *Paraphaseolella typica* gen. et sp. nov.; Tong, p. 434, pl. 1, figs 1–2, pl. 2, figs 19–22.
1988 *Xiaoyangbaella obesa* (sp. nov.); Tan & Li, p. 26, pl. 1, fig. 15.
1988 *Xiaoyangbaella allocota* (sp. nov.); Tan & Li, p. 26, pl. 2, fig. 20.
1988 *Dabashanella elongata* (sp. nov.); Tan & Li, p. 26, pl. 2, fig. 16.
1988 *Dabashanella shanxiensis* (sp. nov.); Tan & Li, p. 27, pl. 1, figs 6, 7.
1988 *Naviformella zhenbaensis* (sp. nov.); Tan & Li, p. 27, pl. 1, fig. 5.
1988 *Paranaviformella lubrica* (gen. et sp. nov.); Tan & Li, p. 28, pl. 1, figs 8–11.
?1988 *Zhenbaella acuta* (gen. et sp. nov.); Tan & Li, p. 28, pl. 1, fig. 12.
?1988 *Zhenbaella simplex* (gen. et sp. nov.); Tan & Li, p. 29, pl. 1, fig. 13.
?1988 *Zhenbaella angusta* (gen et sp. nov.); Tan & Li, p. 29, pl. 1, fig. 14.
1988 *Jingyangella euryacantha* (gen. et sp. nov.); Tan & Li, p. 30, pl. 1, figs 1–4.
1989a *Dabashanella hemicyclica* Huo, Shu & Fu, 1983; Zhao, p. 472, pl. 1, figs 1, 2.
1989a *Naviformella antiquata* Zhao & Xiao, 1986; Zhao, p. 473, pl. 1, fig. 5.
1989a *Dabashanella reniformis* (Jiang & Xiao, 1985); Zhao, p. 473, pl. 1, fig. 6.
?1989a *Dabashanella squamiformis* (Xiao & Zhao, 1986); Zhao, p. 473, pl. 1, fig. 7.

1989b *Dabashanella hemicyclica* Huo, Shu & Fu; Zhao, p. 418, pl. 1, figs 5–9.
1989b *Dabashanella reniformis* (Jiang & Xiao); Zhao, p. 418, pl. 1, figs 10–12.
1989b *Dabashanella curvata* (Zhang); Zhao, p. 418, pl. 1, fig. 13.
1989b *Dabashanella hemicyclica* Huo, Shu & Fu; Zhao, p. 418, pl. 1, fig. 16.
1989b *Hesslandona antiquata* Zhao & Xiao (*sic*); Zhao, p. 418, pl. 1, fig. 17.
1989b *Hesslandona nudata* Zhao & Xiao (*sic*); Zhao, p. 418, pl. 1, fig. 18.
1989b *Hesslandona curvata* (Zhang); Zhao, p. 418, pl. 1, fig. 19.
1990a *Eohesslandona usualis* gen. et sp. nov.; Shu, p. 66, pl. 13, figs 1–3.
1990a *Dabahsnaella hemicyclica* Huo, Shu & Fu; Shu, p. 67, pl. 11, figs 9–24.
1990a *Dabashanella retroswinga* Huo, Shu & Fu; Shu, p. 67, pl. 14, fig. 10.
1990a *Dabashanella tenuis* sp. nov.; Shu, p. 67, pl. 11, figs 1–8, 25.
?1990a *Dabashanella erecta* sp. nov.; Shu, p. 68, pl. 10, figs 11, 12.
?1990a *Pseudodabashanella striata* gen. et sp. nov.; Shu, p. 69, pl. 10, figs 7–10.
?1990a *Paradabashanella elongata* gen. et sp. nov.; Shu, p. 70, pl. 10, figs 13–17.
1990b *Eohesslandona usualis* Shu, 1987 (*sic*); Shu, p. 328, pl. 3, figs 42, 43.
1990b *Dabashanella hemicyclica* Huo, Shu & Fu; Shu, p. 328, pl. 3, figs 44–46.
1991 *Dabashanella retroswinga* Huo, Shu & Fu; Huo *et al.*, p. 178, pl. 38, figs 1–12.
1991 *Dabashanella hemicyclica* Huo, Shu & Fu; Huo *et al.*, p. 179, pl. 38, figs 13–16.
1991 *Dabashanella dimorpha* Zhang; Huo *et al.*, p. 179, pl. 39, figs 1–21.
1991 *Dabashanella qinghaiensis* (sp. nov.); Cui & Wang *in* Huo *et al.*, p. 179, pl. 45, fig. 8, ?figs 7, 9.
1991 *Dabashanella qilianensis* (sp. nov.); Cui & Wang *in* Huo *et al.*, p. 180, pl. 45, figs 10–12.
1991 *Phaseolella curvata* Zhang; Huo *et al.*, p. 181, pl. 37, figs 4–8.
1991 *Mononotella*(?) *lentiformis* Zhao & Xiao; Huo *et al.*, p. 185, pl. 40, figs 11, 12.

Holotype. By monotypy; a carapace, NWUX no. S82001; Huo, Shu & Fu *in* Huo *et al.* 1983b, p. 68, pl. 5, figs 18–20. Xiaoyangba section, Zhenba County, Shaanxi Province; Shuijingtuo Formation, lower Cambrian.

Material. About one hundred specimens from the Naozizhai section, Xichuan County, Henan Province.

Measurements. Based on the illustration of the holotype in Huo *et al.* (1983b, pl. 5, figs 18–20), the holotype is 0·76 mm long. The specimens we have measured for this study do not exceed 1 mm in length (for additional morphometric information, see Zhang 1987, fig. 5).

Description. As for generic diagnosis above. The genus may be monospecific (see Remarks below).

Remarks. *Dabashanella hemicyclica*, *D. retroswinga* and *Xiaoyangbaella zhenbaensis* (type species) from the type Xiaoyangba section in Zhenba County, Shaanxi Province, were each based on a single specimen and were poorly illustrated by Huo, Shu & Fu (*in* Huo *et al.* 1983b, pp. 68, 69, pl. 5, figs 14–22; see also Huo & Shu 1985, p. 175, pl. 28, figs 13–20). *D. retroswinga* was considered to differ from *D. hemicyclica* by its 'retroswing' outline, obtuse posterior cardinal spine, weak marginal ridge and different valve convexity, but the figured specimens of these species (*in* Huo *et al.* 1983b, pl. 5, figs 14–20) illustrate no characters by which to distinguish them. *Xiaoyangbaella zhenbaensis* (*op. cit.*, pl. 5, figs 21, 22) was differentiated from *Dabashanella* by its valve convexity and possession of an anterodorsal protrusion, though this kind of feature commonly occurs in our specimens of *D. hemicyclica* (see Fig. 25d). We believe that all of these species are conspecific.

A large number of *Dabashanella* specimens have subsequently been obtained from the type locality of *D. hemicyclica* in Shaanxi Province and from other localities. Thus, Tong (1987, pp. 433, 434) attempted to redefine the two original *Dabashanella* species on the basis of a valve height–length ratio of 0·6–0·7 for *D. hemicyclica* and 0·5–0·6 for *D. retroswinga*. Differences in height–length ratio were taken as evidence for sexual dimorphism within a single species by Zhang (1987; see below). Subsequently Shu (1990a, p. 67, pl. 11, figs 9–24) figured 16 specimens of *D. hemicyclica* which appear to include specimens which would be referable to both *D. hemicyclica* and *D. retroswinga* using Tong's definition. He figured only one specimen referred to *D. retroswinga* (Shu 1990a, pl. 14, fig. 10), but this has a markedly different outline from the holotype of that 'species' (for which, see Huo *et al.* 1983b, pl. 5, figs 14–17).

Specimens from Wushi County, Xinjiang Province, have been used to establish four species referred to the genus *Xinjiangella* Jiang & Xiao, 1985. *X. venustois* Jiang & Xiao (*in* Huo & Shu 1985, p. 184) and *X. dorsonodis* Zhao & Xiao (*in* Xiao & Zhao 1986, p. 80, pl. 1, fig. 7) were referred to *Dabashanella hemicyclica* by Zhao (1989b, p. 414, table 1), a reassignment with which we concur. *X. reniformia* Jiang & Xiao (*in* Huo & Shu 1985, p. 185, pl. 36, figs 7, 8) and *X. squamiformis* Xiao & Zhao (1986, p. 81, pl. 1, figs 18, 19) were more cautiously referred to *Dabashanella* by Zhao (1989b, p. 414, table 1), but are probably deformed specimens of *D. hemicyclica*. We concur with Zhao (1989b, p. 414, table 1), who referred the following taxa to *D. hemicyclica*: *Dabashanella conica* Zhao & Xiao (*in* Xiao & Zhao 1986, p. 82, pl. 1, fig. 9), *Palaeomeishucunella xibeiensis* Zhao & Xiao (*in* Xiao & Zhao 1986, p. 84, pl. 1, figs 12, 14, 15), *Indiana*? *sipa* Fleming (Xiao & Zhao 1986, p. 85, pl. 1, fig. 10), *Mononotella*? *lentiformis* Zhao & Xiao (*in* Xiao & Zhao 1986, p. 86, pl. 2, figs 1, 2) and *Phaseolella dimorpha* Zhang (1987, p. 16, fig. 12A–W). Two of Zhang's (1987, fig. 13C, E) figured specimens of *Phaseolella curvata* were referred, respectively, to *Hesslandona curvata* (Zhang) and *Dabashanella curvata* (Zhang) by Zhao (1989b, p. 414, table 1, pl. 1, figs 19, 13) but these also appear to be deformed specimens of *D. hemicyclica* (compare with Fig. 25f). The 'subspecies' *Palaeomeishucunella xibeiensis elongata* Zhao & Xiao (*in* Xiao & Zhao 1986) displays identical morphology to *D. hemicyclica* and must be considered conspecific.

Zhang's (1987, figs 3, 4) detailed examination of more than 370 specimens of *D. hemicyclica* (his '*Phaseolella dimorpha*') suggests domiciliar (carapace) dimorphism, the valves of heteromorphs (females?) being relatively higher than tecnomorphs. We have noted similar shape variation amongst our (about 100) specimens from western Henan Province, though we have been unable to distinguish discrete dimorphs.

Xiaoyangbaella nudata Zhao & Xiao (*in* Xiao & Zhao 1986), *Naviformella antiquata* Zhao & Xiao (*in* Xiao & Zhao 1986), *Paraphaseolella typica* Tong, 1987 and *Eohesslandona usualis* Shu, 1990—the former two were referred to the genus *Hesslandona* Müller by Zhao (1989b, p. 414, table 1)—were based on deformed specimens similar to those of *Phaseolella curvata*

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Zhang (compare with Zhang 1987, p. 18, fig. 13A–E). Preservational, rather than morphological, characteristics were used to distinguish these species, as already noted by Tong (1987, p. 434; see also Zhao 1989b, p. 412). All of them are deformed specimens of *D. hemicyclica*.

Specimens from Zhenba County, Shaanxi Province, were used to establish ten species assigned to six genera by Tan & Li (1988), these being: *Xaioyangbaella obesa*, *X. allocota*, *Dabashanella elongata*, *D. shanxiensis*, *Naviformella zhenbaensis*, *Paranaviformella lubrica*, *Zhenbaella acuta*, *Z. simplex*, *Z. angusta* and *Jingyangella euryacantha*. Most of these species were based on a single specimen and variously show the characteristics of deformed specimens of *D. hemicyclica* (see Tan & Li 1988, pl. 1, figs 1–15, pl. 2, figs 16–20). For example, the development of cusps at the cardinal corners, used to distinguish such forms as *Paranaviformella lubrica* Tan & Li, commonly occurs amongst many of our specimens of *D. hemicyclica* (see Fig. 25d, e). Those specimens referred by Tan & Li to *Zhenbaella* species are highly deformed, and can only be questionably referred to *Dabashanella hemicyclica*.

Dabashanella erecta Shu, 1990, *Pseudodabashanella striata* Shu, 1990 and *Paradabashanella elongata* Shu, 1990 are based on fragmentary specimens from the type section in Zhenba County, Shaanxi Province, and are probably specimens of *D. hemicyclica*. *Dabashanella qinghaiensis* and *D. qilianensis* (see Huo *et al.* 1991) are based on specimens from the middle Cambrian of Datong County, Qinghai Province. Although these lack processes at the cardinal corners, they may represent poorly preserved specimens of *D. hemicyclica*.

Occurrence Middle Subprovince. Xiaoyangba section, Zhenba County, Shaanxi Province; Shuijingtuo Formation, lower Cambrian (Huo *et al.* 1983b, 1991; Huo & Shu 1985; Cui *et al.* 1987; Tan & Li 1988; Zhao 1989a, b; Shu 1990a). Naozizhai section, Xichuan County, Henan Province; Shuigoukou Formation, lower Cambrian (Zhang 1987; Zhao 1989b; Huo *et al.* 1991; herein). Wushi County (Sugaite Phosphorite Mine), Xinjiang Province; Yurtus Formation, lower Cambrian (Jiang & Xiao *in* Huo & Shu 1985; Xiao & Zhao 1986; Zhao 1989a, b). Maojiagou section, Datong County, Qinghai Province; Maojiagou Formation, middle Cambrian (Huo *et al.* 1991).

Family uncertain

The systematic position of the following monospecific genera, each of which is based on one or two poorly preserved specimens from China, is uncertain:

1. *Wuchiapingella* Huo, 1956 (type species: *Wuchiapingella simplex* Huo, 1956, p. 442, pl. 3, fig. 18); from Liangshan section, Hanzhong City, Shaanxi Province.
2. *Jixinlingella* Lee, 1975 (type species: *Jixinlingella clithrocosta* Lee, 1975, p. 65, pl. 2, fig. 17); from Zhongbao section, Zhenping County, Shaanxi Province.
3. *Zhijinella* Yin, 1978 (type species: *Zhijinella dayuanensis* Yin, 1978, p. 384, pl. 143, fig. 7); from Dayuan section, Zhijin County, Guizhou Province.
4. *Changshabaella* Huo & Shu, 1982 (type species: *Changshabaella shaanxiensis* Huo & Shu, 1982, p. 327, pl. 1, fig. 19), from Zhongbao section, Zhenping County, Shaanxi Province.
5. *Ningqiangella* Huo & Shu, 1985 (type species: *Ningqiangella ningqiangensis* Huo & Shu 1985, p. 137, pl. 33, figs 8, 9); from Daheba, Ningqiang County, Shaanxi Province.
6. *Xingzishanella* Tan & Li, 1988 (type species: *Xingzishanella rotundata* Tan & Li, 1988, p. 21, pl. 2, fig. 10); from Zhenba County, Shaanxi Province.
7. *Shannanella* Tan & Li, 1988 (type species: *Shannanella clathrata* Tan & Li, 1988, p. 30, pl. 1, fig. 17); from Zhenba County, Shaanxi Province.
8. *Tricostatella* Tan & Li, 1988 (type species: *Tricostatella retroswinga* Tan & Li, 1988, p. 31, pl. 1, fig. 16); from Zhenba County, Shaanxi Province.
9. *Guizhouella* Shu, 1990 (type species: *Guizhouella mai* Shu, 1990a, p. 51, pl. 12, fig. 1); from Kaiyang County, Guizhou Province.
10. *Pseudodahebaella* Shu, 1990 (type species: *Pseudodahebaella striata* Shu, 1990a, p. 62, pl. 12, fig. 3); from Zhenba County, Shaanxi Province.
11. *Eotuzoia* Shu, 1990 (*Eotuzoia minima* Shu, 1990a, p. 65, pl. 2, figs 1, 2); from Zhenba County, Shaanxi Province.

7. Conclusions

The lower Cambrian bradoriid arthropods of China:

- occur in the provinces of Guizhou, Henan, Hubei, Hunan, Liaoning, Qinghai, Shaanxi, Sichuan, Xinjiang, Zhejiang and especially Yunnan;
- yield the greatest number of specimens of the group worldwide and a comparatively high diversity at all taxonomic levels;
- have much less diversity than was previously supposed: some 80 genera and nearly 300 species of bradoriids are based on Chinese material; only 16 genera and 21 species are recognised herein;
- are found from at or just below the *Abadiella* trilobite Biozone to the top of the *Palaeolenus* trilobite Biozone of the lower Cambrian, being most prolific and diverse in the Qiongzhusian Stage, where they have local biostratigraphical value;
- occur in the Middle and especially the Western subprovinces of the Cambrian of the SW China (Yangtze) Platform;
- have a high degree of endemicity, with limited palaeogeographical links with other bradoriid faunas of mostly the Redlichiid trilobite Realm, such as faunas in N China, Australia and parts of central Asia.

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9. Appendix 1: Chinese bradoriid localities mentioned in the text (Fig. 1)

Guizhou Province: Baimadong section, Kaiyang County. Dayuan section, Zhijin County. Jindingshan and Songlin sections, Zunyi (= Tsunyi) City. Meitan County. Yaoshang section, Shiqian County. Yuqing County. Weng'an County. Weiganping section, Fuquan County.
Henan Province: Naozizhai section, Xichuan County.
Hubei Province: Xihaoping section, Fangxian County. Huangshandong and Shipai sections, Yichang City. Miaohe and Yemaomian sections, Zigui County. Qingquan section in Shennongjia area.
Hunan Province: Cili County.
Liaoning Province: Beishan and Sanshilipu sections, Jinxian County.
Qinghai Province: Majiagou section, Datong County.
Shaanxi Province: Huashan, Liangshan and Yuanshan sections, Hanzhong City. Xiaoyangba section, Zhenba County. Zhongbao section, Zhenping County.
Sichuan Province: Changjianggou and Luomiaozhen sections, Guangyuan City. Fandian section, Leshan City. Gaopo section in Gaoqiao and Yuxiansi section, E'mei County. Gaoqiao section, Pengshui County. Laogongshan section, E'bian County. Zhuazhuayan section, Leipo County. Nanjiang County. Shizhu County. Zhengyuan section, Wangcang County.
Yunnan Province: Dapotou, Fengkoushao, Hongjiachong, Ma'anshan, Maotianshan and Xiaolantian sections, Chengjiang County. Kebaocun section, Yiliang County. Kuangshan and Siqitian sections, Malong County. Meishucun section, Jinning County. Qiongzhusi section, Kunming City. Qujing City. Shapushan, Shijiangjun, Shishan and Yaoying sections, Wuding County.
Xinjiang Province: Sugaite Phosphorite Mine, Wushi County.

10. Appendix 2: Key sections for the stratigraphical distribution of bradoriids (Figs 5–8)

10.1. Shapushan section, Wuding County, Yunnan Province (Fig. 5)

Shapushan (Shapu hill) is 3 km N of the town of Wuding and 1 km N of Yongji village, Wuding County. The section trends N10° E and the strata dip 7°–30° NE; it was measured (Hou X-g, 1984) along its southern slope and over its crest for some distance, beginning with the Yu'anshan Member, Qiongzhusi Formation, and ending at the base of the Longwangmiao Formation. The sequence is more or less continuously exposed, with a rich bradoriid fauna throughout. Shapushan is the best section to elucidate the succession of lower Cambrian bradoriids up to the top of the Canglangpuian Stage.

Longwangmiao Formation

14. Grey-white dolomite

Wulongjing Member, Canglangpu Formation

13. Covered by soil
12. Purple and grey-green silty shale, intercalated with thin-beds of grey-yellow siltstone, yielding abundant brachiopods
11. Grey-green argillaceous siltstone and silty shale
10. Grey-green shale, intercalated with grey-green and grey-yellow silty shale and thin-bedded grey-yellow sandstone
9. Grey-purple and grey-yellow breccia, intercalated with grey-green shale and grey-white quartzarenite

Guanshan Member, Canglangpu Formation

8. Grey-white breccia
7. Grey-white and grey-yellow quartzarenite, intercalated with purple silty shale
6. Grey-purple thick-bedded quartzarenite with cross-stratification, intercalated with purple silty shale
5. Grey-yellow, thin-bedded quartzarenite

Yu'anshan Member, Qiongzhusi Formation

4. Blue-grey mudstone, weathers grey-yellow, intercalated with 1–7 cm thick beds of grey fine sandstone and siltstone
3. Blue-grey mudstone, weathers grey-yellow, yielding the worm *Palaeoscolex sinensis* and abundant trilobites, brachiopods and bradoriids
2. Dark-grey mudstone with abundant algal fragments
1. Black carbonaceous mudstone, showing spheroidal weathering in the lower part, with 0·7 m thick black siltstone at the top and bottom respectively

Shiyantou Member, Qiongzhusi Formation

Grey siltstone

10.2. Qiongzhusi section, Kunming City, Yunnan Province (Fig. 6)

This section, first described by Lu (1941) and named after the nearby Qiongzhusi Temple, is located about 10 km W of the centre of Kunming City. It is the type section of the Qiongzhusi Formation; strata dip NE at 30°–42°. The Yu'anshan Member, Qiongzhusi Formation, was measured and collected for bradoriids in 1980 (Hou X-g).

Canglangpu Formation

13. Grey-yellow thick-bedded sandstone, intercalated with minor shales

Yu'anshan Member, Qiongzhusi Formation

12. Green-grey mudstone
11. Grey-yellow thin- to thick-bedded sandstone, intercalated with minor shales
10. Green-grey thick-bedded sandstone
9. Covered by soil
8. Green-grey mudstone with nodules, intercalated with thin-bedded grey-yellow sandstone
7. Covered by vegetation
6. Grey-green mudstone, intercalated with thin-bedded grey-yellow sandstone
5. Covered by vegetation
4. Grey-green mudstone with nodules, intercalated with thin-bedded grey-yellow sandstone
3. Grey-green silty mudstone with nodule, intercalated with grey-yellow thin-bedded sandstone
2. A concave slope covered by plants
1. Black silty mudstone

Shiyantou Member, Qiongzhusi Formation

Grey-yellow sandstone

10.3. Maotianshan section, Chengjiang County, Yunnan Province (Fig. 7)

Maotianshan (Maotian hill) became well known after the Chengjiang Lagerstätte was discovered there by Hou Xianguang in 1984. The first soft-bodied fossil to be found was what was later to become the holotype of *Naraoia longicaudata* (see Zhang & Hou 1985). The section is located on the western

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slope of Maotianshan, 5 km E of the town of Chengjiang (see, for example, Hou 1987a).

Yu'anshan Member, Qiongzhusi Formation

Top of the section truncated by a fault

5. Grey-green, grey-yellow silty mudstone, intercalated with thin- to medium-bedded unfossiliferous siltstone
4. Grey-yellow mudstone, intercalated with thin- to thick-bedded brownish unfossiliferous siltstone. The unit contains the Chengjiang Lagerstätte

3. Dark grey mudstone with many algal fragments, intercalated with thin- to medium-bedded, grey-brown, unfossiliferous siltstone. The middle and upper part of this unit yields the Chengjiang Lagerstätte
2. Dark carbonaceous mudstone
1. Dark siltstone

Shiyantou Member, Qiongzhusi Formation

Grey-yellow siltstone

10.4. Meishucun section, Jinning County, Yunnan Province (Fig. 8)

This section is near the Kunyang phosphorite mine, on the southwestern side of Dianchi Lake, about 70 km from Kunming City. It is the stratotype for the Meishucunian Stage and was the Chinese candidate section for the global Precambrian–Cambrian boundary. The section lies on the southern limb of the approximately E–W-trending Xiangtiaochong anticline, on the southwestern margin of the Yangtze Platform. Hou Xian-guang collected this section for bradoriids in 1984.

Middle Devonian Haikou Formation

7. Fine-grained, grey-green sandstone intercalated with yellow shales; contains the fish *Yangaspis jinningensis*

———Disconformity———

Yu'anshan Member, Qiongzhusi Formation

6. Yellow-green, thin-bedded shale and thin sandstones
5. Yellow-green shale intercalated with moderately thick-bedded sandstone
4. Grey shale intercalated with yellow sandstone
3. Dark-grey shale
2. Black shale intercalated with a 10 cm-thick yellow silty dolomite layer at the base
1. Black, thin-bedded siltstone intercalated silty shale

Shiyantou Member, Qiongzhusi Formation

Grey-yellow sandy-siltstone

10.5. Gaopo section in Gaoqiao, E'mei County, Sichuan Province (Fig. 9)

Located N of Zhangshan village in the Gaoqiao administrative division of E'mei County, this is a complete and well-exposed 1000 m-thick late Precambrian–Cambrian section which has been been studied by Chinese geologists since 1929. Abundant bradoriids have been collected (Hou X-g, 1980) from throughout the Yu'anshan Member (22·2 m thick) of the Qiongzhusi Formation.

Canglangpu Formation

9. Grey-purple sandstone

Yu'anshan Member, Qiongzhusi Formation

8. Grey, thin-bedded argillaceous limestone
7. Grey-green silty mudstone
6. Grey-green mudstone with carbonate nodules, yielding abundant trilobites and brachiopods
5. Grey-green mudstone, yielding abundant trilobite and brachiopod fragments
4. Grey-green silty mudstone, yielding hyolithids
3. Grey-green silty mudstone with carbonate nodules
2. Grey-green, finely laminated silty mudstone

Shiyantou Member, Qiongzhusi Formation

1. Grey-green siltstone

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