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Species of *Hollinella* (Palaeocopida: Ostracoda: Crustacea) as stratigraphical indices of the Late Permian–Early Triassic post-extinction interval

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Members of the ostracod order Palaeocopida, except three very rare genera (Puncia, Manawa and Promanawa), disappeared from the stratigraphical record close to the Permian–Triassic boundary (PTB) event. Species of the genus *Hollinella* are often present just after the end-Palaeozoic mass extinction event, in latest Permian and earliest Triassic beds. They are among the last representatives of Palaeocopida, the typical Palaeozoic straight dorsal border ostracods. The Early Triassic species have been assigned by most authors to *Hollinella tingi* (Patte, 1935), but this assignment is incorrect. This species is present in the latest Permian and the earliest Triassic, and therefore is considered a biostratigraphical index fossil of the post-mass extinction interval. A revision of *Hollinella* species from this interval is presented here. Three *Hollinella* species occur in the earliest Triassic: *H. panxiensis* Wang, 1978; *H. magninoda* Wang, 1978; and *Hollinella* (*Hollinella*) *lungcamensis* Crasquin sp. nov. The new species of the post-PTB event is present in strata exposed in the northern part of Vietnam. All three species of *Hollinella* cross the PTB and *H. (H.) lungcamensis* is characteristic of the post-extinction period (latest Changhsingian–earliest Induan).

http://zoobank.org/urn:lsid:zoobank.org:pub:C8BA4418-B7FE-4B28-ADA0-28BE317687A4

**Keywords:** Permian–Triassic extinction event; ostracods; Palaeocopida; biostratigraphical indices

Introduction

Specimens of the genus *Hollinella* Coryell, 1928 (Crustacea: Ostracoda: Palaeocopida) are present in many sections of the Permian–Triassic boundary interval. Although their preservation is always very poor, these occurrences are remarkable because this genus is one of the latest representatives of the Palaeocopida, an emblematic Palaeozoic, straight dorsal border ostracod group, which disappeared after the Permian–Triassic boundary event (PTBE). Three extremely rare genera – *Promanawa*, *Puncia* and *Manawa* – assigned to the Palaeocopida (Superfamily Puncioidea; Horne et al. 2002) are still extant in the Southern Pacific area (e.g. Hornibrook 1949, 1963). Some authors, however, consider that there are no living members of the Palaeocopida (see Martin & Davis 2001, pp. 29–30). Except for these three genera, the last well-dated Palaeocopida are known from the Early Anisian (*Triassicindivisia*, see Forel & Crasquin 2011; Crasquin & Forel 2013).

Among the residual Early Triassic Palaeocopida (Crasquin-Soleau et al. 2004), only one species, *Hollinella tingi* (Patte, 1935), is supposed to cross the PTBE, described by Patte (1935) from the Early Permian of South China. However, this species does not occur in the earliest Triassic: all putative specimens of *H. tingi* discovered in the earliest Triassic, often preserved as moulds, were assigned to this species by non-specialists, an error repeated many times. An aim of the current paper is to clarify this very confused situation. A new species, *Hollinella* (*Hollinella*) *lungcamensis* Crasquin sp. nov., is described from the post-PTBE of northern Vietnam.

Original description of *Hollinella tingi* (Patte, 1935)

It is important to note that the genus *Hollinella* frequently shows significant intraspecific variability. Sexual dimorphism is apparent from different adventral structures (e.g. a large and striated velum in females, which is absent or replaced by a small nodule row in males) and the stronger anteroventral convexity of the female carapace corresponding to the brood pouch. The carapace shape of *Hollinella* also shows strong ontogenetic variations. Such variability is also recorded from many other palaeocopid...
taxa (e.g. Sohn 1950 for Kirkbyidae and Miltonellidae; Bless & Jordan 1972 for Hollinellidae; Watabe & Kaesler 2004 for Paraparchitidae).

According to the revision of Hollinellidae by Bless & Jordan (1972), *Hollinella tingi* is very poorly known. The species was originally described as *Beyrichia tingi* by Patte (1935) from the Early Permian T‘ungstzu and Takuhesinch’ang districts of South China. No holotype was designated by Patte (1935). The preservation of this material is poor and its description was based on external moulds only. The original description in French is reproduced in the Supplemental material.

The species was redescribed by Hou (1954), the description written in Chinese and in English. The English version is not an exact translation of the Chinese one. Note that in Hou’s description and in the translation mentioned below, the orientation of the carapace is reversed, and males and females are confused. The English translation made by the third author of the present paper is given in the Supplemental material.

Hou (1954) figured the ‘holotype’ (Hou 1954, pl. 1, fig. 2a). However, it is not clear if her ‘holotype’ is the true holotype, or is a lectotype. Hou found this species in Early Permian black shale of the Chihsia Formation (Western Hubei, South China).

In 1964, Ishizaki assigned specimens discovered in the Early Pennsylvanian (Late Carboniferous) of Japan to *Hollinella tingi*. The preservation of the figured specimen (Ishizaki 1964, pl. 1, fig. 1) is so poor that it is impossible to confirm its assignment. The stratigraphical range in the Early Pennsylvanian is therefore questionable.

**‘Hollinella tingi’ and the PTBE**

In studies of Permian–Triassic ostracods, specimens of *Hollinella* are frequently reported from the latest Permian and the earliest Triassic. In most of these papers, the specimens are assigned to *H. tingi*. As explained by Crasquin-Soleau et al. (2004), all these specific assignments are incorrect. The first erroneous determination was made by Wang (1978), and subsequently repeated again and again by other authors.

Wang (1978) figured and described four *Hollinella* species from the Late Changhsingian and Early Induan of Western Guizhou and north-eastern Yunnan: *H. tingi* (Wang 1978, pl. 1, figs 5–7) and three new species, *H. magninoda* Wang, 1978 (pl. 1, fig. 11), *H. panxiensis* Wang, 1978 (pl. 1, figs 1–4) and *H. capacilacuna* Wang, 1978 (pl. 1, figs 8–10). As English translations are absent from Wang’s paper, we include new, literal translations in the Supplemental material. Wang’s descriptions and illustrations suggest to us that *Hollinella capacilacuna* and *H. magninoda* are valid species and are Late Permian in age.

We interpret specimens assigned to *H. tingi* and *H. panxiensis* as belonging to the same species, *H. panxiensis*, which has no long posterodorsal spine but just a small lateral flattening (pinch) of the posterior cardinal angle (Wang 1978, pl. 1, figs 1–4). *L_3* is elongated antero-posteriorly. When the velum is completely developed, it extends from the anterior cardinal angle to the posterior cardinal angle. Some small nodules could be present on the upper part of *L_3*. The specimen illustrated by Wang (1978, pl. 1, fig. 6) differs slightly by its higher height/length ratio, possibly due to ontogeny, and could be determined as *H. ? panxiensis*.

Wei (1981, pl. 1, figs 1–3) illustrated three specimens from the Induan–Olenekian interval of Sichuan and assigned them to *Hollinella tingi*. The first two specimens (Wei 1981, pl. 1, figs 1, 2) are very poorly preserved and this assignment appears dubious. The specimen figured by him on plate 1, figure 3 is not *Hollinella* but a species of kloedenellid.

Kozur (1985, pl. 13, fig. 3) illustrated a supposed specimen of *Hollinella tingi* from the Werfenian (Induan) of the Bük Mountains, Hungary. It is impossible to determine this corroded and abraded specimen at the species level, but it is not *H. tingi*. Furthermore, it is not reasonable to use this specific determination as a stratigraphical index for the Permian–Triassic boundary as suggested by Kozur (1985).

Shi & Chen (1987, pl. 16, figs 2–5) illustrated specimens assigned to *H. tingi* from the early and middle Changhsingian of the Meishan section but gave no description. The specimen figured by them in plate 16, figure 2, is close to *H. panxiensis*; it apparently shows cardinal pinches, but the carapace is rather longer. The other three specimens (Shi & Chen 1987, pl. 16, figs 3–5) are poorly preserved and/or broken, but the three lobes are distinct and ornamentation cannot be observed on *L_3* (Shi & Chen 1987, pl. 16, fig. 3). Shi & Chen (1987) studied all Changhsingian ostracods of the Meishan section and did not report the species from the upper part of the section. We consider that these specimens belong to *H. panxiensis*.

Hao (1992a, b, 1993, 1994, 1996) illustrated specimens of *Hollinella*, including *H. tingi*, from the Late Permian and/or the Induan of Guizhou. His 1992a paper showed 11 ostracod species from the Early Triassic, including three species of *Hollinella: Hollinella cf. H. plana* Jiang 1983 (Hao 1992a, p. 39, pl. 1, fig. 1) is not a species of *Hollinella* but a kloedenellid ostracod; and *Hollinella unispinata* (a new species characterized by long spines at cardinal angles; Hao 1992a, p. 39, pl. 1, figs 2, 3) is a synonym of *Hollinella magninoda* Wang, 1978. The specimens assigned to *H. tingi* (Hao 1992a, p. 39, pl. 1, figs 5, 6) do not belong to this species. The first one has a very different lateral outline and is very badly preserved (Hao 1992a, pl. 1, fig. 5), and the second one (Hao 1992a, pl. 1, fig. 6) shows a strong reticulation in front of *L_1* and seems to have a ventral ridge. We assign it to *H.*
Hollinella species from the Permian–Triassic boundary in Vietnam

New material has been discovered in the latest Permian–Early Triassic boundary interval of the Hong Ngai Formation at the Lung Cam section, northern Vietnam. In the Late Permian–Early Triassic this area belonged to the southern margin of the South China Craton and was a shallow marine carbonate platform (Son et al. 2007). The Lung Cam section was recently resampled and analysed in detail (Nestel et al. 2015; Wardlaw et al. 2015). More than 200 specimens of Hollinella, associated with numerous other ostracod species (work in progress), were found in residues of 12 conodont samples (VN15 to VN28) located above the extinction event and around the PTB (Fig. 1).

This rich material is quite well preserved and permits a detailed study of a new species of Hollinella characteristic of the post-extinction event. The assemblage shows a high morphological diversity, including all transitional forms between the extremes (Figs 2 and 5). Measurements were made of 201 specimens (H and L here include the adventral structure; Fig. 3). The length (L) ranges between 426 and 1130 μm and the height (H) between 282 and 807 μm. Specimens of this complete size range occur evenly in all 12 samples.

Hollinella (H.) lungcamensis sp. nov. (see description below) shows different morphotypes. A first group has free margins ornamented by several rows of spines (Figs 2, 4, 5) from the anterior cardinal angle (ACA) to the posterior cardinal angle (PCA). The second group has a well-developed velum, which is completely calcified, forming a continuous blade from the ACA to the posteroventral part of the carapace. The posterior part of the carapace is ornamented by spines. All transitional forms between these two extremes are represented. If the sizes of specimens with spines and specimens with a complete velum are plotted on an H/L diagram (Fig. 4), it becomes clear that this morphological variability is due to ontogeny.

Sexual dimorphism and ontogenetic variability in the Palaeocopida

Sexual dimorphism and ontogenetic variability in palaeocopids (Van Veen 1922; Jaanusson 1957; Henningsmoen 1965; Kesling 1969) and particularly in Hollinellidae (e.g. Fig. 6) (Jaanusson 1957; Henningsmoen 1965; Bless 1970; Bless & Jordan 1972) has been known for a long time.

The shape of the carapace changes during each moult. Some features develop gradually during ontogeny, whereas others appear suddenly at the transition to the adult stage. Five to six stages of growth, including the adult, are recorded for Hollinella. In this genus the ventral lobe is better developed than L2 and L3 during early ontogeny, whereas L2 and L3 become more prominent in the latest juvenile stages. Early instars are often completely smooth, whereas the latest ones become

panxiensis based on the presence of the pinch at the cardinal angles. The specimen of "H. tingi" illustrated by Hao (1992b, pl. 1, fig. 1) from the Changhsingian of Guizhou could be conspecific with H. panxiensis due to its complete velum extending along the entire free margins.

In a paper on the Changhsingian of Guizhou, Hao (1993, pl. 1, figs 1, 2) assigned two specimens to Hollinella tingi. The illustrations are of poor quality and there is no description. As can be seen from Hao’s figures, the cardinal pinches are indistinct but the specimens show an elongation antero-posteriorly L3 like the specimens of H. panxiensis. The three illustrated specimens are quite small (L: 0.81–0.83 mm). The description is a summary and very general, mentioning only that the ‘border’ of H. echinata possesses many short spines. Hao (1994, 1996) illustrated ostracods from the Permian–Triassic interval of Guizhou Province, but his images of Hollinella are identical to those published in Hao (1992a, b).

Forel & Crasquin (2011) illustrated four species of Hollinella from the Griesbachian (Early Triassic) of the Meishan PTB global stratotype section and point (GSSSP): H. cf. H. martensiformis, H. cf. H. panxiensis, H. sp. 1, and H. sp. 2. Hollinella cf. H. martensiformis is a species similar to the Late Permian H. martensiformis from the same section (Crasquin et al. 2010), characterized by its long and straight dorsal border with accurate cardinal angles, tubercles on the upper part of L3, and a row of tubercles along the ventral margin. It is also very close to the species from Vietnam (see below). Specimens of H. cf. H. panxiensis are quite poorly preserved and could belong to H. panxiensis. Hollinella sp. 1 and H. sp. 2 are so badly preserved that a specific assignment is impossible.

In a study on the Late Permian–Early Triassic boundary interval of the Elikah Valley section, Central Albourz, northern Iran (Forel et al. 2015), some Late Permian Hollinella were illustrated as H. sp. 1, H. sp. 2 and H. sp. 4, and two Early Triassic species as H. sp. 3 and Hollinellidae? indet. All the material is poorly preserved and does not allow a more precise determination.

Two tables are given in the Supplemental material to summarize the distributions of all the listed species and the systematic attributions considered valid in this paper.
**Figure 1.** Location map and stratigraphical column of the Lung Cam section in northern Vietnam with sample numbers (log modified after Nestell et al. 2015).

**Figure 2.** Interpretative drawing of some specimens of *Hollinella (H.) lungcamensis* Crasquin sp. nov. **A–C,** adults with well-developed velum as adventral structure; **A,** female in left lateral view; **B,** male in left lateral view; **C,** male in right lateral view. **D–F,** juveniles with spines as adventral structures; **D, F,** left lateral view; **E,** right lateral view. Scale bars = 100 μm.
granulose. In Carboniferous species of *Hollinella*, which show a tubulous layer during maturity, the last immature stage may possess a completely developed velum. Antero- and/or posterodorsal spines occur frequently in juvenile stages of *Hollinella*. They may or may not persist until maturity (Bless & Jordan 1972).

Sexual dimorphism usually appears in the adult stage, but some pre-adult dimorphism has been described from the last one or two juvenile stages (Bless et al. 1969; Bless 1970; Forel et al. 2015 and references therein). Such pre-adult dimorphism applies to the lobation and the size and shape of the adventral structures. In ‘true dimorphic’ genera, for example those of the family Hollinidae (Bless & Jordan 1971, 1972), the tecnomorph specimens retain the same morphology during ontogeny and the heteromorphs develop different adventral structures. In ‘trimorphic’ genera (Bless & Jordan 1972), juveniles are clearly morphologically different due to the partial absence of secretion of calcite prisms so that the velum is not formed. According to Bless & Jordan (1972), presumed heteromorphs differ from presumed adult tecnomorphs by the following characters: in heteromorphs $L_3$ is larger than the domicilium (part of the carapace exclusive of projecting velate structure), and velum width is smaller than the domicilium. The space between the right and left velums, the antrum, can be ornamented in heteromorphs and smooth in tecnomorphs.

Ontogenetic variability is expressed by the progressive calcification of the spines forming a continuous velum with all the transitional forms between during ontogeny. Sexual dimorphism is sometimes observable in some of the largest specimens. Males may show a greater height and some females are more elongated, with maximum height in the posterior part. However, it is difficult to assign gender for the great majority of the adult specimens.

**Material and methods**

**Material**

All specimens are deposited in the collections of Pierre et Marie Curie University, Paris, France, under the prefix P6M.
Morphological abbreviations
AB, anterior border; PB, posterior border; DB, dorsal border; VB, ventral border; ACA, anterior cardinal angle; PCA, posterior cardinal angle; S₁, S₂, S₃, sulcus from anterior to posterior; L₁, L₂, L₃, L₄, lobes from anterior to posterior; L, maximum length of carapace; H, maximum height of carapace; W, maximum width of carapace (see Fig. 7).

Systematic palaeontology

Class Ostracoda Latreille, 1806
Subclass Podocopa Sars, 1866
Order Palaeocopida Henningsmoen, 1953
Suborder Beyrichicopina Scott, 1961
Superfamily Hollinoidea Swartz, 1936
Family Hollinellidae Bless & Jordan, 1971
Genus Hollinella Coryell, 1928 emend. Kellett, 1929
Subgenus Hollinella (Hollinella) Coryell, 1928
Hollinella (Hollinella) lungcamensis Crasquin sp. nov.
(Fig. 5)

Diagnosis. A species of Hollinella (Hollinella) with clearly expressed lobation (L₁ to L₄) but without ventral lobe; spines along free margin and on lobes; ontogenetic variability of velar structures: spines at free margins are replaced by continuous velum which joins ACA and posterior part of the carapace; sexual dimorphism expressed by thickening of posterior part of the carapace.

Etymology. After Lung Cam section, Northern Vietnam (type locality).
Material. Holotype: P6M3775, right valve (Fig. 5C), sample VN20. Paratypes: P6M3776, left valve (Fig. 5A), sample VN20; P6M3777, left valve (Fig. 5E), sample VN25. Additional material: 201 complete valves and carapaces, many fragments.

Type locality. Lung Cam section, northern Vietnam (23°14′30″N, 105°13′20″E).

Type horizon. Sample VN20, Hong Ngai Formation, latest Changhsingian, latest Permian.

Occurrence. Samples VN15, VN18, VN19, VN20, VN21, VN22, VN23, VN24, VN25, VN26, VN27, VN28, Lung Cam section (Fig. 1), northern Vietnam, Hong Ngai Formation, latest Changhsingian (latest Permian–Griesbachian (parvus zone) (earliest Triassic).

Description. Species of Hollinella (Hollinella) with long, straight DB (68–80% of total L) and clear morphological variations between dimorphs occurring early in ontogeny. ACA very obtuse (130–140°); lobation well developed: L1 quite always visible, anterior part is smoothed out, top of L1 located at anterior fourth of L, not passing over hinge line, occasionally with spines; S1 quite deep, oriented backwards, base at 27–30% of H and 36–38% of L; L2 always distinct, vertical and narrow, axis at 42–45% of L; S2 narrow, vertical, base located high (26–30% of H); L1 bulbous, rounded, large (diameter 37–39% of L), highest part just at hinge line (quite not overlapping), covered with spines which can be long; spines are also distributed on the surface of the valves and on free margins of PB; ventral lobe poorly developed. Dorsal view: diamond-like carapace outline, hinge line straight.

Early ontogenetic stages. ACA very obtuse; maximum convexity of AB located above mid H; S3 and L4 invisible; the free margins are covered with several rows of isolated spines. When the specimens reach 790–800 μm, the space between velar spines is progressively calcified, calcification forming a continuous velum. Carapace outline in dorsal view biconvex with maximum width at mid L.

Late ontogenetic stages and adults (L > 750 μm and H > 550 μm). AB with large radius of curvature with maximum of curvature at 51–58% of H; S3 and L4 visible in most specimens. The velate structure is a large smooth velum, which begins a little below ACA. Some spines could be present just at the anterior end of the velum. VB is largely rounded and bordered by the velum which decreases and disappears at the junction with PB where it is replaced by spines; maximum of curvature of VB is located at 33–38% of L; velum relatively broad comprising 17–23% of H; PB with large radius of curvature with maximal convexity located at 25–29% of H, PB covered by numerous spines; PCA 105–110°; carapace outline in ventral view diamond-like with large antrum space anteriorly, right and left velums distinct at AB, posterior part of AB covered by spines; maximum width located at the posterior third of L.

Sexual dimorphism appears during ontogeny before the adult stage (and sexual maturity), as observed in material from northern Iran (Forel et al. 2015). This dimorphism is characterized by the larger PB radius of curvature and the greater posterior carapace thickness at the females.

Dimensions. L = 426–1130 μm; H = 282–807 μm; W = 419–488 μm (Fig. 3).

Remarks. Hollinella (Hollinella) lungcamensis sp. nov. is very similar to H. ulrichi (Knight, 1928) from the Late Carboniferous–Early Permian of the south-central United States, Wales, the Netherlands, Belgium and Germany (see complete synthesis on H. ulrichi (Knight, 1928) in Bless & Jordan 1972). The two species have the same ornamentation at the free margin and the same ontogenetic variability and sexual dimorphism. The main difference is the fusion of L1 and L2, and the spines which are more irregularly distributed at the ventral margin of H. ulrichi.

Figure 5. Specimens of Hollinella (H.) lungcamensis Crasquin sp. nov. from the latest Permian–earliest Triassic of the Lung Cam section, northern Vietnam. Where possible, the gender of specimens is indicated. A, paratype, left lateral external view of a left valve, ♂, P6M3776; B, left lateral external view of a left valve, ♀, P6M3778; C, holotype, right lateral external view of a right valve, ♂, P6M3775; D, right lateral external view of a right valve, ♀, P6M3779; E, paratype, left lateral external view of a left valve, ♀, P6M3780; F, left lateral external view of a left valve, ♀, P6M3781; H, right lateral external view of a complete carapace, ♀, P6M3782; I, right lateral external view of a complete carapace, ♀, P6M3784; K, right lateral external view of a right valve, P6M3785; L, right lateral external view of a complete carapace, ♀, P6M3786; M, left lateral external view of a complete carapace, ♀, P6M3787; N, right lateral external view of a right valve, ♀, P6M3788; O, left lateral external view of a complete carapace, P6M3789; P, right lateral external view of a complete carapace, P6M3790; Q, left lateral external view of a left valve, P6M3791; R, left lateral external view of a left valve, P6M3792; S, left lateral external view of a complete carapace, P6M3793; T, right lateral external view of a complete carapace, P6M3794; U, left lateral external view of a left valve, P6M3795; V, left lateral external view of a left valve, P6M3796; W, right lateral external view of a complete carapace, P6M3797; X, left lateral external view of a complete carapace, P6M3798; Y, right lateral external view of a complete carapace, P6M3799; Z, left lateral external view of a complete carapace, P6M3800; A’, left lateral external view of a complete carapace, P6M3801; B’, right lateral external view of a complete carapace, P6M3802; C’, dorsal external view of a complete carapace, P6M3803; D’, ventral external view of a juvenile complete carapace, P6M3804; E’, ventral external view of a complete carapace, ♀, P6M3805; F’, ventral external view of a complete carapace, ♀, P6M3806. For C’–F’ the anterior border is up. All specimens are at the same scale.
Hollinella spinulosa Demanet, 1949, from the Late Carboniferous of southern Limburg, the Netherlands and the Campine Basin of Belgium (see synthesis in Bless & Jordan 1972), shows fewer and more widely spaced spines on the free margins and a reticulate carapace surface. Hollinella echinata Hao, 1993, from the Changhsingian (Late Permian) of Guizhou, South China, has the same lobes and the same spines as H. lungcamensis sp. nov., but its velum runs from ACA to PCA and the H/L ratio is lower. Hollinella panxiensis Wang, 1978, from the Wuchiapin-gian–Induan of South China, has a complete velum extending from ACA to PCA, a distinct ventral lobe and flattened cardinal angles. Hollinella magninoda Wang, 1978, from the Wuchiapin-gian–Induan of South China, has long spines at ACA and PCA and a broad velum (one-third of H).

The new species is attributed to the subgenus Hollinella (Hollinella) because of the clearly identified L2, the velum ending at the lower part of BP, and the presence of a row of ventral spines in larval stages (see Fig. 6).

Hollinella from the South China Block

Hollinella tingi has also been reported, but not illustrated, from marginal marine environments of the so-called
Permian–Triassic Transition Beds and the overlying Lower Triassic Kayitou Formation of Yunnan (Mide section) and Guizhou (Tucheng section), South China (e.g. Yu et al. 2010). Recent fieldwork enabled the second author to collect abundant Hollinella specimens from the lowermost Kayitou Formation of the Mide section (preliminary analysis in Bercovici et al. 2015). These specimens are mostly preserved as moulds on the surface of cracked siltstone/fine sandstone. Abundant specimens occur with the two valves still attached dorsally in a butterfly shape, indicating very quiet hydrodynamic conditions at the time of deposition and rapid burial. Although extremely abundant, these Hollinella specimens are poorly preserved and corroded so that the original surface structure is usually not observable. Despite their poor preservation, all observed specimens could correspond to Hollinella panxiensis described above. The size range of the specimens in this assemblage suggests that several ontogenetic stages are present. The individual stages can, however, hardly be

Figure 7. Schematic representation of Hollinella (Hollinella) lungcamensis Crasquin sp. nov., with descriptive terms and abbreviations used in text. The small arrows indicate the anterior part of the carapace. A, external view of right valve; S₁, S₂, S₃, sulcus from anterior to posterior; L₁, L₂, L₃, L₄, lobes from anterior to posterior; L, maximum length of carapace; H, maximum height of carapace; small dots indicate the location of maximum of convexity of AB, PB and VB. B, external view of right valve; AB, anterior border; PB, posterior border; DB, dorsal border; VB, ventral border; ACA, anterior cardinal angle; PCA, posterior cardinal angle. C, ventral view; W, maximum width of carapace. D, dorsal view; L₁ to L₃ and S₁ to S₃, lobes and sulcus (same as A).
differentiated because specimens cannot be extracted from the matrix and are often only partially exposed. Sexual dimorphism is clearly visible in the Hollinella specimens from Mide.

No ostracods have been found so far in the underlying Late Permian Xuanwei Formation in the Mide section. The monospecific assemblage of Hollinella panxiensis from this very marginal marine succession seems to have resulted from a short proliferation event during unstable conditions.

Conclusion

Hollinella tingi (Patte, 1935) does not occur in the latest Permian–Early Triassic. Three Hollinella species are recognized in the latest Permian–earliest Triassic and are assigned to Hollinella panxiensis Wang, 1978, Hollinella magninoda Wang, 1978 and Hollinella (H.) lungcamensis Crasquin sp. nov. The first two species have quite long stratigraphical ranges extending from the Wuchiapingian to the Griesbachian. Hollinella (H.) lungcamensis, for the time being, is only present in the Hong Ngai Formation in Vietnam, which is of youngest Changhsingian and earliest Induan (H. parvus zone) age. Hollinella (H.) lungcamensis is characteristic of the post-extinction period. In the Lung Cam section, H. (H.) lungcamensis is associated with many other palaeocopid and podocopid ostracod taxa (work in progress) and with foraminifers belonging to the genera Geinitzitina, Nodosaria and Globivalvulina, the species Hyperammina deformis and Ammodiscus kalhori, and microconchids (Nestell et al. 2015). Detailed geochemical analysis of foraminiferal tests and pyrite clusters led Nestell et al. (2015) to evoke euxinic conditions on the seabed and a carbon-enriched sea-water column. The source of the carbon could have been global coal fly ash or forest fire-dispersed charcoal, or a combination of both, which accumulated in the Palaeo-Tethys Ocean. The presence of benthic ostracods in the same samples, however, indicates that the bottom water could not be anoxic or dysoxic. The analysis of the total ostracod assemblages will improve these ecological data.

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Supplemental data

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