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To cite this version:
Marie-Béatrice Forel, Sylvie Crasquin, Kinga Hips, Steve Kershaw, Pierre-Yves Collin, et al.. Biodiversity evolution through the Permian-Triassic boundary event: ostracods from the Bükk Mountains, Hungary.. Acta Palaeontologica Polonica, Polskiej Akademii Nauk, Instytut Paleobiologii, 2013, 58 (1), pp.195-219. 10.4202/app.2011.0126. hal-00833996

HAL Id: hal-00833996
https://hal.archives-ouvertes.fr/hal-00833996
Submitted on 11 Dec 2020

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Biodiversity evolution through the Permian–Triassic boundary event: Ostracods from the Bükk Mountains, Hungary

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Forel, M.-B., Crasquin, S., Hips, K., Kershaw, S., Collin, P.-Y., and Haas, J. 2013. Biodiversity evolution through the Permian–Triassic boundary event: Ostracods from the Bükk Mountains, Hungary. Acta Palaeontologica Polonica 58 (1): 195–219.

One of the most complete Permian–Triassic boundary sections located in the Bükk Mountains (Hungary) was sampled for ostracod study. Seventy-six species are recognized, belonging to twenty genera. Fifteen new species are described and figured:

- Acratia? jeannieri Forel sp. nov.,
- Acratia nagyvisnyoensis Forel sp. nov.,
- Bairdia anisongae Forel sp. nov.,
- Bairdia davehornei Forel sp. nov.,
- Callicythere? balvanyseptentrioensis Forel sp. nov.,
- Cytherellina? magyarorszagensis Forel sp. nov.,
- Eumiraculum desmaresae Forel sp. nov.,
- Hollinella fengqinglaii Crasquin sp. nov.,
- Hungarella gerennavarensis Crasquin sp. nov.,
- Langdia balbavalvensis Crasquin sp. nov.,
- Liuzhinia venninae Forel sp. nov.,
- Liuzhinia bankutensis Forel sp. nov.,
- Microcheilinella egérensis Forel sp. nov.,
- Shemonaulia? olempaskaella Forel sp. nov.

One species is renamed: Bairdia baudini Crasquin nom. nov.

Comparison of the Bálvány North section with the Meishan section (Zhejiang Province, South China), Global Boundary Stratotype Section and Point (GSSP) of the Permian–Triassic Boundary (PTB), reveals discrepancies linked to the environmental setting and particularly to bathymetry. The stratigraphical distribution of all the species is given and diversity variations are discussed. The Bálvány North section exhibits the lowest extinction rate of all PTB sections studied for ostracods analysis associated with a high level of endemism.

Key words: Ostracoda, biodiversity, Permian–Triassic boundary, Bükk Mountains, Hungary.

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Received 26 August 2011, accepted 17 September 2012, available online 16 October 2012.

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Introduction

The Permian–Triassic Boundary (PTB) was recognized in several sections of the Bükk Mountains (Northern Hungary) in continuous marine successions. The Bálvány North section (48°06’179N, 20°28’491E) is located on the northern slope of Mount Bálvány, 1 km NW of Bánkút (northern Bükk Mountains) (Fig. 1) and is one of the best known localities for the Permian–Triassic transition. This outcrop was studied in great detail by Haas et al. (2004, 2006, 2007) and Hips and Haas (2006, 2009). These authors described the facies development along the section. Numerous ostracods were observed in thin sections. We sampled this section for ostracod analysis in the framework of a large-scale study on the extinction and recovery of this group through the PTB interval. This research was conducted in South China: Meishan GSSP, Zhejiang Province (Crasquin et al. 2010a; Forel and Crasquin 2011b); Guizhou Province (Forel et al. 2009); Sichuan Province (Crasquin-Soleau and Kershaw 2005); Guangxi Province (Crasquin-Soleau et al. 2006); in Tibet (Crasquin et al. 2007; Forel and...
Crasquin 2011a; Forel et al. 2011); in Northern Italy, Bulla section (Crasquin et al. 2008); in SW Taurus, Turkey, Çürük Dağ section (Crasquin-Soleau et al. 2002, 2004a, b). In Hungary, Kozur published a systematic (1985b) and a biostratigraphic evaluation (1985a) of Upper Palaeozoic ostracods from the Bükk Mountains. Here, seventy-six species belonging to twenty genera are recognized and their potential biostratigraphic utility evaluated.

Institutional abbreviations.—UPMC P6M, Université Pierre et Marie Curie, Paris, France.

Other abbreviations.—AB, anterior border; ACA, anterior cardinal angle; ADB, anterodorsal border; AVB, anteroventral border; BSB, Boundary Shale Bed; DB, dorsal border; H, height; Hmax, maximal height; L, length; Lmax, maximal length; LV, left valve; L1-L4, lobes; PB, posterior border; PCA, posterior cardinal angle; PDB, posterodorsal border; PVB, posteroventral border; PTB, Permian–Triassic Boundary; RV, right valve; S2, median sulcus; VB, ventral border.

Geological setting

The Bükk Mountains, located in northern Hungary, to the south of the Western Carpathians, are made up of metamorphosed Palaeozoic–Mesozoic rocks. They are overlain by non-metamorphic Palaeogene–Neogene formations (Less et al. 2002). Permian–Lower Triassic deposits are known only in the northern part of the mountains. In accordance with the purpose of this paper, results of previous studies are only briefly summarized here. For detailed sedimentological description of the section and for discussion of selected topics the reader is referred to the papers by Haas et al. (2004, 2006, 2007), Hips and Haas (2006, 2009), and Sudar et al. (2008).

The studied boundary section is 3.7 m thick (Fig. 2). In the lower part of the section occur dark grey bioclastic limestone beds (wackestone–packstone) with calcareous marlstone interlayers of mid- to outer ramp facies which exhibit a deepening-upward trend (1.35 m; Nagyvisnyó Limestone Formation). In this interval the conodonts *Hindeodus praeparvus* Kozur, 1996 and *Isarcicella cf. prisca* Kozur, 1995 were identified (Haas et al. 2007; Sudar et al. 2008) which, along with marine acritarchs, bisaccate and striate pollens (Haas et al. 2004), suggest that these beds are of Permian age. This bedset unit is overlain by thin mudstone beds (0.25 m), recording the first biotic decline, and a circa 1 m thick marly siltstone bed, recording the second biotic decline (Haas et al. 2004). The lower two-thirds of this bed preserve the last...
Permian bivalve and brachiopod assemblage (Posenato et al. 2005). In addition, carbon isotope values from the bioclastic limestone display a negative shift with a prominent peak in the upper two-thirds of the BSB (Haas et al. 2006), which is considered as an isotope chemostratigraphic marker (e.g., Erwin et al. 2002). Numerous small cavate spores were encountered from the uppermost part of the BSB suggesting that this interval may be of Triassic age (Haas et al. 2004). The conodont *Hindeodus parvus* (Kozur and Pjatakova, 1976), which is recognised as the marker for the base of the Triassic (Yin et al. 1996, 2001), was found in the lower part of the overlying platy mudstone unit (0.5 m; Gerennavár Limestone Formation). Thus, the first documented occurrence of the conodont *H. parvus* is 0.55 m above the negative peak of the δ¹³C curve, and 0.2 m above the Formation boundary (Haas et al. 2007; Sudar et al. 2008). Upsection, planar stromatolites occur (0.6 m in the studied section).

**Material and methods**

Twenty-five samples have been processed for ostracod analysis (Fig. 2A). The extraction of calcareous ostracod carapaces from calcareous rocks is achieved by hot acetolysis (Lethiers and Crasquin 1988; Crasquin-Soleau et al. 2005). Nineteen samples yielded ostracods (Fig. 2B). Seventy-six species belonging to twenty genera are identified and figured (Figs. 4, 6, 10, 12, 15, 18, 21–23). Fifteen species are new described species and here described. Nearly all specimens are represented by complete carapaces; this testifies to absence or limitation of post-mortem transportation with low wave energy and/or rapid burial by high sedimentation ratio (Oertli 1971). Some of the described species are presented in open nomenclature because of poor preservation and/or too low number of specimens to differentiate between intraspecific variations and different species. However, we decided to figure all the material recovered because these new data exemplify an unexpected survival phenomenon of microbial origin in a refuge area and are important for the understanding of events following the end-Permian extinction.

**Systematic paleontology**

(M.-B. Forel and S. Crasquin)

The classification adopted here is from Moore (1961) modified after Bowman and Abele (1982) and Horne et al. (2002).

Phylum Arthropoda Latreille, 1802
Subphylum Crustacea Brunnich, 1772
Class Ostracoda Latreille, 1802
Subclass Podocopa Muller, 1894
Order Palaeocopida Henningsmoen, 1953
Suborder Beyrichicopina Scott, 1961

Superfamily Kirkbyoidea Ulrich and Bassler, 1906
Family Kirkbyidae Ulrich and Bassler, 1906

**Genus Reviya Sohn, 1961**

*Type species:* *Amphissites? obesus* Croneis and Gale, 1939; Upper Mississippian (Carboniferous), Illinois (USA).

*Reviya praecurukensis* Forel sp. nov.

Fig. 4A–H.

?2010 *Indivisia cf. pelikani* Kozur, 1985; Crasquin et al. 2010b: pl. 1: 8.

*Etymology:* In reference to *Reviya curukensis* Crasquin-Soleau, 2004, which is close in shape and occurs later, in the Lower Triassic.

*Type material:* Holotype: one complete carapace, Fig. 4A, UPMC P6M2742, sample 08BAN47. Paratype: one complete carapace, Fig. 4B, UPMC P6M2743, sample 08BAN47.

*Type locality:* Bálvány North section, Bükk Mountains, Hungary.

*Type horizon:* Level 1, Nagyvisnyó Limestone Formation, Changhsingian, Upper Permian.

*Material.*—42 complete and 6 broken carapaces, samples 08BAN47, 48, 50, 51, 56 (see Fig. 2B), levels 1, 2, 4, Nagyvisnyó Limestone Formation, Bálvány North section, Hungary, Changhsingian, Upper Permian.

*Diagnosis.*—A species of *Reviya* with a subquadangular carapace, a straight to gently convex VB, a small shoulder in the posterodorsal part and an elongated pit near mid-H.

*Dimensions* (of adults).—L 425–800 μm, H 220–440 μm (see Fig. 3).

*Description.*—Carapace subrectangular; DB straight and long; ACA and PCA clear and more or less equivalent; AB with large radius of curvature and maximum of curvature located at mid-H; VB straight and long; PB with large radius of curvature, in all the cases a little smaller than AB, with maximum of curvature located above mid-H; presence of small shoulders in postero-dorsal part of the carapace; kirkbyan pit elongated and located at mid-H and mid-L; presence of a subventral ridge parallel to free margin; surface reticulated, on best preserved specimens nodes could be observed along free margins and DB; RV overlaps LV along free margins. Sexual dimorphism expressed in the heteromorphs by enlargement of posterior part of the carapace. Internal features unknown.

![Fig. 3. Height/length diagram of *Reviya praecurukensis* Forel sp. nov.](image)
Discussion.—Reviya praecurukensis sp. nov. differs from Reviya curukensis Crasquin-Soleau, 2004 from the Griesbachian (Lower Triassic) of Western Taurus (Turkey) (Crasquin-Soleau et al. 2004a, b) and Meishan GSSP (China) (Crasquin et al. 2010a) by a more quadrangular carapace, a smaller H/L ratio and a straight VB at the RV. R. praecurukensis sp. nov. differs from the type species R. obesa (Croneis and Gale, 1939), Lower Carboniferous of USA, by the absence of ridges and from R. mimicus (Geis, 1932), Lower Carboniferous of USA, by the central position of the...
pit and the reticulation which is not parallel to free margins. One specimen discovered in the Upper Permian of the Jadar Block in NW Serbia (Crasquin et al. 2010b) was attributed to *Indivisia cf. pelikani* Kozur, 1985. This badly preserved specimen could belong to *R. praecurukensis* sp. nov.

**Stratigraphic and geographic range.**—Báylvány North section, levels 1, 2, 4, samples 08BAN47, 48, 50, 51, 56 (see Fig. 2B), Nagyvisnyó Limestone Formation, Changhsiangian, Upper Permian of Serbia.

Superfamily Hollinoidea Swartz, 1936
Family Hollinellidae Bless and Jordan, 1971

**Genus Hollinella Coryell, 1928**

*Type species:* *Hollinella dentata* Coryell, 1928; Upper Carboniferous of Oklahoma, Texas and Illinois, USA.

**Hollinella fengqinglaii** Crasquin sp. nov.

Fig. 4I–L.

**Etymology:** Dedicated to Professor Feng Qinglai (China University of Geosciences, Wuhan, Hubei Province, China).

**Type material:** Holotype: one right valve, Fig. 4I, UPMC P6M2750, sample 08BAN50. Paratype: one left valve, Fig. 4J, UPMC P6M2751, sample 08BAN60.

**Type locality:** Báylvány North section, Bükk Mountains, Hungary.

**Type horizon:** Level 1, Nagyvisnyó Limestone Formation, Changhsiangian, Upper Permian.

**Material:**—7 isolated valves and 2 broken carapaces, samples 08BAN47, 50, 51, 56, 60 (see Fig. 2B), levels 1, 2, 4, 6, Nagyvisnyó Limestone Formation, Báylvány North section, Hungary, Changhsiangian, Upper Permian.

**Diagnosis.**—A species of *Hollinella* with an elongated carapace, a small H/L ratio, a L1 vertical and thin, bulbous L2 and L3, and a well-expressed L4, which is connected ventrally with L1.

**Dimensions.**—L 240–780 μm; H 125–400 μm.

**Description.**—Carapace elongated (H/L 0.47–0.53); DB long and straight; ACA 110–120°; AB with large radius of curvature, maximum of curvature located at mid-H; VB slightly convex to nearly straight; PB with small radius of curvature, maximum of curvature located high, near to the DB; PCA quite rectangular; carapace flattened along free margins; L1 thin and quite vertical connected ventrally to L4 which is always expressed; L2 bulbous, located at mid-H, it could be subdivided vertically into two nodes connected ventrally; L3 bulbous and rounded, generally not overlapping DB; maximum of H located behind anterior third of L; ornamentation not observed. Internal features unknown.

**Discussion.**—The preservation is not very good. All the specimens are represented by isolated valves. Many authors have attributed Lower Triassic specimens of *Hollinella* from South China (Zheng 1976; Wang 1978; Wei 1981; Hao 1992, 1994) and from the Bükk Mountains (Kozur 1985b) to the species *Hollinella tingi* (Patte, 1935). Although these specimens without doubt belong to the genus *Hollinella* they are unlikely *H. tingi* (see discussion in Crasquin-Soleau et al. 2004a). In most cases, the specimens from the Lower Triassic are too corroded to allow a precise attribution. *H. fengqinglaii* sp. nov. described here differs from “*Hollinella tingi*” sensu Wang (1978) and sensu Wei (1981) from the Lower Triassic of South China in its more elongated carapace and absence of nodes on L3. *H. fengqinglaii* sp. nov. differs from *H. panxiensis* Wang, 1978 from the Upper Permian of South China in its vertical L1 and rounded L1 (elongated in *H. panxiensis*). The lateral view of *H. fengqinglaii* sp. nov. is close to *H. derini* Gerry and Honigstein, 1987 from the Upper Permian of Israel (Gerry et al. 1987). This last species has a more elongated L2 and L1 is not clearly connected to ventral lobe. The specimen of identified by Kozur (1985a: pl. 13: 3) as *Hollinella tingi* is incomplete and has a larger posterior border and a more bulbous L3.

**Stratigraphic and geographic range.**—Báylvány North section, levels 1, 2, 4, 6, samples 08BAN47, 50, 51, 56, 60 (see Fig. 2B), Nagyvisnyó Limestone Formation, Changhsiangian, Upper Permian.

Superfamily Paraparchitidae Scott, 1959 emend. Sohn, 1971

Family Paraparchitidae Scott, 1959

**Genus Shemonaella Sohn, 1971**

*Type species:* *Shemonaella dutroi* Sohn, 1971; Upper Mississippian of Alaska, USA.

**Shemonaella? olempskaella** Forel sp. nov.

Fig. 4Q–T.

**Etymology:** Dedicated to Professor Ewa Olempska (Institute of Paleobiology PAS, Warsaw, Poland).

**Type material:** Holotype: one complete carapace, Fig. 4Q, UPMC P6M2758, sample 08BAN48. Paratype: one complete carapace, Fig. 4R, UPMC P6M2759, sample 08BAN47.

**Type locality:** Báylvány North section, Bükk Mountains, Hungary.

**Type horizon:** Level 1, Nagyvisnyó Limestone Formation, Changhsiangian, Upper Permian.

**Material:**—6 complete carapaces, samples 08BAN47, 48, 55, 60 (see Fig. 2B), levels 1, 4, 6, Nagyvisnyó Limestone Formation, Báylvány North section, Changhsiangian, Upper Permian.

**Diagnosis.**—A species of *Shemonaella* with long carapace (H/L 0.57) and long straight VB.

**Dimensions.**—L 240–450 μm; H 140–250 μm.

**Description.**—Carapace long for the genus (H/L 0.57), DB straight; ACA 125–135°; AB with quite large radius of curvature, maximum at mid-H or little above; VB long and straight (looks curved); the posterior extensions of DB and VB make an angle of 10°; PB with medium radius of curvature and maximum curvature located at 2/3 of H; PCA between 135° and 145°; LV overlaps RV all along free margin; surface smooth. Internal features unknown.

**Discussion.**—The genus *Shemonaella* is a typically Carboniferous genus and is rare in the Upper Permian. At present,
only one species is reported in the literature (Shemonaella sp. 1; Crasquin et al. 2010a: fig. 4K, L). Shemonaella? olenopsiskaella sp. nov. differs from Shemonaella sp. 1 sensu Crasquin et al. 2010a from the Upper Permian of Meishan section in South China in its more elongated and preplete carapace.

The closest species in shape is Shemonaella dutroi Sohn, 1971 from Lower Carboniferous of Alaska (Sohn 1971). Here the VB is straighter and the carapace longer.

Stratigraphic and geographic range.—Bálvány North section, levels 1, 4, 6, samples 08BAN47, 48, 55, 60 (see Fig. 2B). Nagyvisnyó Limestone Formation, Changhsingian, Upper Permian.

Genus Langdaia Wang, 1978

type species: Langdaia suboblonga Wang, 1978; Lower Triassic of Guizhou and Yunnan China.

Langdaia bullabalvanyensis Crasquin sp. nov.

Figs. 5, 6A–G. 2008 Langdaia suboblonga Wang, 1978; Crasquin et al. 2008: 238, pl. 1: 3

Etymology: From the occurrence in both Bulla, Italy and Bálvány, Hungary sections.

Type material: Holotype: one complete carapace, Fig. 6A, UPMC P6M2762, sample 05BU19, Bulla section. Paratype: one complete carapace, Fig. 6B, UPMC P6M2763, sample 05BU19, Bulla section.

Type locality: Bulla section, Dolomites, Northern Italy.

Type horizon: Mazzin Member, Werfen Formation, Griesbachian, Lower Triassic.

Type locality: Bálvány North section, Bükk Mountains, Hungary.

Material.—11 complete and 1 broken carapaces, Mazzin Member, Werfen Formation, Bulla section, Northern Italy (Crasquin et al. 2008); sample 08BAN67 (see Fig. 2B), level 8, Gerennavár Limestone Formation, Bálvány North section, Griesbachian, Lower Triassic.

Diagnosis.—A species of Langdaia with large AB, long straight VB, S2 very faint.

Dimensions.—L 250–500 μm; H 150–320 μm (see Fig. 5).

[Graph of Langdaia bullabalvanyensis]

Description.—Carapace with long straight DB; ACA 140–150°; AB with large radius of curvature, maximum located at mid-H; VB long, straight in the youngest specimens, a little convex in the adults; PB with quite small radius of curvature, maximum located at or a little below mid-H; DB and VB converge towards the posterior end with an angle of 15° at the instars and 25° at the adults; PCA 150°; S2 very faint, visible on adult specimens located at mid-H and mid-L; RV overlaps LV all along free margins; surface smooth. Internal features unknown.

Discussion.—Specimens attributed to Langdaia suboblonga Wang, 1978 were found in the Lower Triassic of Northern Italy (Bulla section; Crasquin et al. 2008). This specific attribution is wrong. Langdaia suboblonga Wang, 1978 from lowermost Triassic of South China (Wang 1978; Crasquin and Kershaw 2005) has a deeper S2, a more obtuse ACA and a PB with larger radius of curvature. All the other species of the genus are more quadrangular.

Stratigraphic and geographic range.—Mazzin Member, Werfen Formation, Northern Italy, Griesbachian (Crasquin et al. 2008); Bálvány North section, level 8, sample 08BAN67 (see Fig. 2B), Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Order Podocopida Müller, 1894

Suborder Podocopina Sars, 1866

Superfamily Bairdioidea Sars, 1887

Family Bairdiidae Sars, 1887

Genus Bairdia McCoy, 1844

Type species: Bairdia curta McCoy, 1844; Carboniferous, Ireland.

Bairdia anisongae Forel sp. nov.

Figs. 6N–P, 7.

Etymology: Dedicated to Dr. Anisong Chitnarin (Suranaree University of Technology, Nakhon Ratchasima, Thailand).

Type material: Holotype: one complete carapace, Fig. 6N, UPMC P6M2774, sample 08BAN55. Paratype: one complete carapace, Fig. 6O, UPMC P6M2775, sample 08BAN62.

Type locality: Bálvány North section, Bükk Mountains, Hungary.

Type horizon: Level 4, Nagyvisnyó Limestone Formation, Changhsingian, Upper Permian.

Material.—Three complete and four broken carapaces, samples 08BAN47, 55 and 62 (see Fig. 2B), levels 1, 4, 8, Nagyvisnyó and Gerennavár Limestone Formations, Bálvány North section, Hungary, Changhsingian to Griesbachian, Upper Permian—Lower Triassic.

Diagnosis.—A species of Bairdia with straight PDB, DB, and ADB, with narrow AB and almost parallel AVB and PDB.

Dimensions.—L 210–325 μm; H 120–200 μm (see Fig. 7).

Description.—Carapace quite high (H/L 0.57–0.63), with straight DB, PDB, and ADB at both valves; DB steeply inclined backwards; AB with small radius of curvature and maximum of convexity located high (above mid-H); AVB
straight and long, almost parallel to PDB; VB long and quite straight at both valves; PB with small radius of curvature with maximum of convexity located low (lower than 1/5th of H); PDB straight and long at both valves; Hmax located a little in front of mid-L; LV overlaps RV very faintly all around the carapace with a maximum at DB, carapace biconvex and thin in dorsal view. Internal features unknown.
Discussion.—*Bairdia anisongae* sp. nov. shows the same angularity between dorsal parts (PDB/DB/ADB) as *Bairdia wushunbaoi* Crasquin, 2010 and *Bairdia paussi* Crasquin, 2010 both from Changhsingian of Meishan section (Crasquin et al. 2010a). In *B. wushunbaoi* the AB is narrower and its maximum of curvature is located higher. *B. paussi* has a more elongated carapace with a less strongly inclined DB. *Bairdia anisongae* sp. nov. differs from *B. wailiensis* Crasquin-Soleau, 2006 from the Lower Triassic of Guangxi (Crasquin-Soleau et al. 2006) (see Fig. 5J–M) in its more distinct dorsal parts, its more tapering PB and the smaller radius of curvature of AB.

Stratigraphic and geographic range.—Bálvány North section, levels 1 to 8, samples 08BAN47, 55 and 62 (see Fig. 2B), Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian to Griesbachian, Upper Permian to Lower Triassic.

*Bairdia davehornei* Forel sp. nov.

Figs. 6Q–U, 8.

Etymology: Dedicated to Professor David J. Horne (Queen Mary University, London).

Type material: Holotype: one complete carapace, Fig. 6Q, UPMC P6M2777, sample 08BAN61. Paratype: one complete carapace, Fig. 6R, UPMC P6M2778, sample 08BAN62.

Type locality: Bálvány North section, Bükk Mountains, Hungary.

Type horizon: Level 7, Gerennavár Limestone Formation, Changhsingian, Upper Permian.

Material.—32 complete and 2 broken carapaces, samples 08BAN47, 61 and 62 (see Fig. 2B), levels 1, 7, 8, Nagyvisnyó and Gerennavár Limestone Formations, Bálvány North section, Hungary, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

Diagnosis.—A species of *Bairdia* with an elongated carapace (L/H = 2) with a truncated AVB, regularly arched dorsal parts, and a rounded PB with the maximum of curvature at lower 1/3rd of H.

Dimensions.—L 290–560 μm; H 141–275 μm (see Fig. 8).

Description.—Carapace elongated (L = 2H), DB, PDB, and ADB regularly arched at LV; DB, PDB, and ADB quite straight at RV; AB with small radius of curvature, with maximum of curvature located above mid-H; AVB truncated; VB concave, particularly at RV; PB rounded with large radius of curvature, maximum of curvature located at the lower 1/3 of H; typical bairdian beak visible only on some specimens; LV overlaps RV slightly all around the carapace with maximum at DB; Hmax located near mid-L. Internal features unknown.

Discussion.—*Bairdia davehornei* sp. nov. could be compared to *Bairdia fangnianqiaoi* Crasquin, 2010 from the Griesbachian Meishan section (China; Crasquin et al. 2010a). The latter species has a more slender PB and a more elongated carapace in lateral view. *Cryptobairdia heshanensis* Chen, 2002 (Wuchiapingian of Matan and Pinding section, China; Shi and Chen 2002) is also close to *Bairdia davehornei* sp. nov. but has a more distinct flattened and a larger AB. *Bairdia davehornei* sp. nov. differs from *Bairdia ?kemerensis* from the Griesbachian of Turkey (Crasquin-Soleau et al. 2004b) in its shorter DB and smaller AB.

Stratigraphic and geographic range.—Bálvány North section, levels 1 to 8, samples 08BAN47, 61 and 62 (see Fig. 2B), Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian–Griesbachian, Upper Permian–Lower Triassic.

*Bairdia baudini* Crasquin nom. nov.

Fig. 6H, I.

Non 1978 *Bairdia subsymmetrica* Sun sp. nov.; Guan et al. 1978: 152, pl. 39: 10.

1987 *Silenites subsymmetrica* Shi, 1987; Shi and Chen 1987: 63, pl. 15: 4–11.

2004 *Bairdia subsymmetrica* (Shi, 1987); Crasquin-Soleau et al. 2004b: 285, pl. 2: 7–12.

2004 *Bairdia subsymmetrica* (Shi, 1987); Crasquin-Soleau et al. 2004a: 71, pl. 1: 13–14.

Etymology: Dedicated to Professor François Baudin (UPMC, Paris, France).

Discussion.—This species was described by Shi (Shi and Chen 1987) from the uppermost Permian (Changhsingian) of Meishan. It was attributed to the genus *Bairdia* by Crasquin-Soleau et al. (2004a, b). The species name *Bairdia subsymp-
metrical is already used for a species described by Sun (in Guan et al. 1978) from western Hubei Province, Qixia Formation, Guadalupian. Therefore, a new specific name is given.

Stratigraphic and geographic range.—Meishan section, South China, Upper Changhsingian, Upper Permian (Shi and Chen 1987); Çürük Dağ section Western Taurus, Turkey, Griesbachian, Lower Triassic (Crasquin-Soleau et al. 2004a, b); samples 08BAN48 and 62 (see Fig. 2B), levels 1, 8, Nagyvisnyó and Gerennavár Limestone Formations, Bálvány North section, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

Family Acratiidae Gründel, 1962
Genus Acratia Delo, 1930
Type species: Acratia typica Delo, 1930; Upper Carboniferous of Texas, USA.

Acratia? Jeanvannieri Forel sp. nov.

Figs. 9, 10A–J.

Etymology: Dedicated to Dr. Jean Vannier (CNRS-Lyon 1 University, Lyon, France).

Type material: Holotype: one complete carapace, Fig. 10A, UPMC P6M2803, sample 08BAN61. Paratype: one complete carapace, Fig. 10B, UPMC P6M2804, sample 08BAN63.

Type locality: Bálvány North section, Bükk Mountains, Hungary.

Type horizon: Level 7, Gerennavár Limestone Formation, Griesbachian (Lower Triassic).

Material.—139 complete and 12 broken carapaces, samples 08BAN52?, 54?, 56, 61, 62, 64, 65, 67, and 69 (see Fig. 2B), levels 3?, 4, 7, 8, Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

Diagnosis.—A species of Acratia with a compact carapace, poorly slender extremities and a poorly expressed acratian beak.

Dimensions.—L 163–708 μm; H 102–325 μm (101 measured specimens; see Fig. 9).

Description.—Compact carapace; DB long, straight at RV, straight to gently convex at LV; ADB convex in LV, straight to gently concave at RV, AB with rather large radius of curvature for the genus, with maximum of curvature located around lower 1/3rd of H; acratian beak poorly expressed in RV, absent in LV; VB straight to gently convex at LV, gently concave at RV; PVB rectangular particularly at RV; LV overlaps RV all around the carapace with maximum at ADB and PDB; AB flattened laterally at some specimens; Hmax located behind 2/3rd of L. Internal features unknown.

Discussion.—The species displays a significant intraspecific variation with regard to the carapace outline. The very small forms show a broader AB and a higher H/L ratio compared to larger specimens. The doubt on generic attribution comes from the fact that the acratian beak is poorly expressed. The internal characters should be seen to be sure.

Acratia? Jeanvannieri sp. nov. is comparable to Acratia symmetricta Hao, 1992 from the Lower Triassic of Guizhou Province (South China; Hao 1992). The DB of A.? Jeanvannieri sp. nov. is straighter, the extremities are not slender and the H/L ratio is higher (A. symmetricta: 0.44, A.? Jeanvannieri sp. nov.: 0.55).

Stratigraphic and geographic range.—Bálvány North section, levels 3? to 8, samples 08BAN52?, 54?, 56, 61, 62, 64, 65, 67, and 69 (see Fig. 2B), Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian to Griesbachian, Upper Permian to Lower Triassic.

Acratia nagyvisnyoensis Forel sp. nov.

Fig. 10K–O.

Etymology: In reference to the occurrence of the species in the Nagyvisnyó Limestone Formation.

Type material: Holotype: one complete carapace, Fig. 10K, UPMC P6M2813, sample 08BAN47. Paratype: one complete carapace, Fig. 10L, UPMC P6M2814, sample 08BAN47.

Type locality: Bálvány North section, Bükk Mountains, Hungary.

Type horizon: Level 1, Nagyvisnyó Limestone Formation, Changhsingian (Upper Permian).

Material.—7 complete and 5 broken carapaces, samples 08BAN47, 48, 50, 53, and 54 (see Fig. 2B), levels 1, 3, 4, Nagyvisnyó Limestone Formation, Bálvány North section, Hungary, Changhsingian (Upper Permian).

Diagnosis.—A species of Acratia with laterally flattened extremities, a Bairdia-type PB, and a fairly symmetrical carapace in lateral view with Hmax located at midL.

Dimensions.—L 550–610 μm; H 300–310 μm.

Description.—Lateral carapace outline subsymmetrical, Hmax located at midL; DB regularly arched at both valves; ADB and PDB quite straight to gently convex; AB with small radius of curvature, quite vertical; anterior acratian beak poorly expressed; VB convex at LV, straight to gently convex at RV; Bairdia-type PB, with maximum of curvature located at lower 1/3rd of H; LV overlaps RV all around the carapace with maximum at VB; both extremities laterally flattened. Internal features unknown.

Discussion.—Acratia nagyvisnyoensis sp. nov. is similar to Acratia subfusiformis Wang, 1978 from Wuchiapingian and Changhsingian of Southern China: Guizhou and Yunnan...
(Wang 1978), Guangxi (Shi and Chen 2002), and Meishan GSSP section, Zhejiang (Crasquin et al. 2010a). The PB are very similar in the two species. In *A. nagyvisnyoensis* sp. nov., the maximum of curvature is located lower, the Hmax is located more posteriorly and the VB is more convex. *A. nagyvisnyoensis* sp. nov. is also close to *Acratia zhongyinensis* Wang, 1978 from Wuchiapingian and Changhsingian of Southern China: Guizhou and Yunnan (Wang 1978), Guangxi (Shi and Chen 2002), and Meishan GSSP section, Zhejiang (Crasquin et al. 2010a), and from the Changhsingian of Bulla section, Italy (Crasquin et al. 2008). Both species have laterally flattened extremities. In *A. nagyvisnyoensis* sp. nov. the DB is more convex, more symmetrical in lateral view and shows a greater overlap.

**Stratigraphic and geographic range.**—Bálvány North section, levels 1, 3, 4, samples 08BAN61, 50, 53, and 54 (see Fig. 2B), Nagyvisnyó Limestone Formation, Changhsingian, Upper Permian.

**Genus *Liuzhinia* Zheng, 1976**

*Type species:* *Liuzhinia subovata* Zheng, 1976; Anisian (Middle Triassic) of Guizhou Province, China.

**Liuzhinia venninae** Forel sp. nov.

Figs. 11, 12A–K.

*Etymology:* Dedicated to Professor Emmanuelle Vennin (University of Burgundy, Dijon, France).

*Type material:* Holotype: one complete carapace, Fig. 12A, UPMC P6M2821, sample 08BAN50. Scale bars 100 μm.
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**Liuzhinia venninae Forel sp. nov.**

P6M2842, sample 08BAN63. Paratype: one complete carapace, Fig. 12D, UPMC P6M2845, sample 08BAN61.

*Type locality:* Bálvány North section, Bükk Mountains, Hungary.

*Type horizon:* Level 8, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

*Material:* 128 complete and 8 broken carapaces, samples 08BAN61, 62, 63, 67, and 69 (see Fig. 2B), levels 7, 8, Gerennavár Limestone Formation, Bálvány North section, Hungary, Griesbachian, Lower Triassic.

*Diagnosis:* A species of *Liuzhinia* with a long, almost straight DB; which is strongly biconvex in dorsal view.

*Dimensions:* L 550–610 μm; H 300–310 μm (see Fig. 11).

*Description:* Carapace small and strongly convex in dorsal view; DB long and straight; AB with quite large radius of curvature for the genus, maximum of curvature located at mid-H; VB long and straight at LV, gently concave at RV; PB with small radius of curvature (pointed in RV), dorsal part straight at RV; LV slightly overlaps RV on free margin. Internal features unknown.

*Discussion:* *Liuzhinia venninae* sp. nov. is close to *Liuzhinia antalyaensis* Crasquin-Soleau, 2004 from the Griesbachian of Western Taurus (Turkey; Crasquin-Soleau et al. 2004b) and Guangxi (South China; Crasquin-Soleau et al. 2006). Here, the DB is longer, the AB has a larger radius of curvature, the carapace is smaller and more inflated in dorsal view. *Liuzhinia venninae* sp. nov. differs from *Liuzhinia praecantalyaensis* Forel, 2010 from the Upper Changhsingian of Meishan GSSP (South China; Crasquin et al. 2010a) by the absence of a lateral compression at the extremities, a more developed valve overlap and a higher H/L ratio.

*Stratigraphic and geographic range:* Bálvány North section, levels 8, samples 08BAN61, 62, 63, 67, and 69 (see Fig. 2B), Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

**Liuzhinia bankutensis Forel sp. nov.**

Fig. 12L–R.

*Etymology:* In reference to the tourist center of Bánkút, situated near to the Bálvány North section.

*Type material:* Holotype: one complete carapace, Fig. 12L, UPMC P6M2853, sample 08BAN67. Paratype: one complete carapace, Fig. 12M, UPMC P6M2854, sample 08BAN69.

*Type locality:* Bálvány North section, Bükk Mountains, Hungary.

*Type horizon:* Level 8, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

*Material:* 14 complete and 2 broken carapaces, samples 08BAN47, 53, 63, 65, 67, and 69 (see Fig. 2B), levels 1, 3, 8, Nagyvisnyó and Gerennavár Limestone Formations, Bálvány North section, Hungary, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

*Diagnosis:* A species of *Liuzhinia* with a rounded PB and a long and straight DB and VB in both valves.

*Dimensions:* L 195–290 μm; H 105–150 μm.

*Description:* Carapace elongated in lateral view (H/L 0.53); DB long (between 50% and 65% of L) and straight; AB quite hemicircular with small radius of curvature for the genus; VB long and straight in both valves; DB and VB converge at an angle of 15–18° towards the anterior end; PB with quite large radius of curvature (particularly in small specimens); LV overlaps RV all around the carapace; surface smooth; significant intraspecific variation with regard to radius of curvature of PB in larval stages.

*Discussion:* *Liuzhinia bankutensis* sp. nov. could be compared to *Liuzhinia venninae* sp. nov. (see above), which has a shorter carapace, an AB with larger radius of curvature and a more strongly tapering PB. *Liuzhinia praecantalyaensis* Forel, 2010 from Changhsingian of South China (Yi 2004; Crasquin et al. 2010a) has a PB with smaller radius of curvature and laterally compressed extremities. *Liuzhinia antalyaensis* Crasquin-Soleau, 2004 from the Griesbachian of Taurus (Turkey, Crasquin-Soleau et al. 2004b) and South China (Guangxi, Crasquin-Soleau et al. 2006) is also close to *Liuzhinia bankutensis* sp. nov., which has a PB more rounded, a longer DB and a straight VB in RV.

*Stratigraphic and geographic range:* Bálvány North section, levels 1, 3, 8, samples 08BAN47, 53, 63, 65, 67, and 69 (see Fig. 2B), Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

Suborder Metacopina Sylvester-Bradley, 1961

Superfamily Healdioidae Harlton, 1933

Family Healdiidae Harlton, 1933

*Genus Hungarella Méhes, 1911*

*Type species:* *Hungarella problematica* Méhes, 1911; Upper Triassic of Hungary.

**Hungarella gerennavarensis** Crasquin sp. nov.

Figs. 13, 15M–P.

*Etymology:* In reference to the occurrence of the species in the Gerennavár Limestone Formation.

*Type material:* Holotype: one complete carapace, Fig. 14M, UPMC P6M2875, sample 08BAN62. Paratype: one complete carapace, Fig. 14N, UPMC P6M2876, sample 08BAN67.
Type locality: Bálvány North section, Bükk Mountains, Hungary.

Type horizon: Level 8, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Material.—5 complete and 1 broken carapaces, samples 08BAN62, 63, 64, and 67 (see Fig. 2B), level 8, Gerennavár Limestone Formation, Bálvány North section, Hungary, Griesbachian, Lower Triassic.

Diagnosis.—A species of Hungarella with a high vertical PB, Hmax located behind mid-L.

Dimensions.—L 250–560 μm; H 150–300 μm (see Fig. 13).

Description.—Carapace quite short (H/L = 0.60); PB quite vertical with angular contact with VB; VB convex to straight at RV, concave at LV; dorsal parts of LV more or
less regularly rounded, DB and PDB in continuity, ADB nearly straight; dorsal margin of RV clearly differentiated into straight PDB, DB and ADB; AB regularly arched with maximum of curvature located between lower 1/3 and 1/2 of H; Hmax located behind mid-L; LV slightly overlaps RV all around the carapace. Internal features unknown.

Discussion.—Hungarella gerrenavarensis sp. nov. differs from ”Healdia” sp. A from Griesbachian of Guangxi (Crasquin–Soloaeu et al. 2006) in its more vertical PB, from Hungarella magyarorszagensis Crasquin, 2011 from Spathian to Anisian of South Tibet (Forel and Crasquin 2011a) in the more posterior position of Hmax and the lack of a lateral compression at the AB.

Stratigraphic and geographic range.—Bálvány North section, level 8, samples 08BAN62, 63, 64, and 67 (see Fig. 2B), Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Family Bairdiocyprididae Shaver, 1961
Genus Cytherellina Jones and Holl, 1869
Type species: Beyrichia siliqua Jones, 1855; Silurian of England.

Cytherellina? magyarorszagensis Forel sp. nov.
Figs. 14, 15B–J.
2011 Bythocypris cf Bythocypris sp. B sensu Bolz, 1971; Forel and Crasquin 2011a: pl. 5: 8, table 1.
Etymology: From Hungarian Magyarország, Hungary.
Type material: Holotype: one complete carapace, Fig. 15B, UPMC P6M2864, sample 08BAN63. Paratype: one complete carapace, Fig. 15C, UPMC P6M2865, sample 08BAN61.
Type locality: Bálvány North section, Bükk Mountains, Hungary.
Type horizon: Level 8, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.
Material.—23 complete carapaces, samples 08BAN61, 62, 63, and 64? (see Fig. 2B), levels 7, 8, Gerennavár Limestone Formation, Bálvány North section, Hungary, Griesbachian, Lower Triassic; Tulong section, Tibet, Anisian, Middle Triassic (Forel and Crasquin 2011a; Forel et al. 2011).

Diagnosis.—A species of Cytherellina? with a high and vertical PB and Hmax located in front of mid-L.
Dimensions.—L 200–550 μm; H 110–320 μm (see Fig. 14).
Description.—Carapace short (H/L 0.60); PB almost vertical with angular contact with VB; VB straight to gently concave at both valves; dorsal parts of LV more or less regularly rounded, DB and PDB in continuity, ADB nearly straight; dorsal parts of RV clearly distinct, PDB, DB and ADB long and straight; AB regularly arched with maximum of curvature located at mid-H; at adult specimens AB could be laterally flattened; Hmax located in front of mid-L; LV slightly overlaps RV all around the carapace with maximum at PDB. Internal features unknown.

Discussion.—Cytherellina? magyarorszagensis sp. nov. is comparable to Pseudobythocypris guijianensis Yuan, 2009 from the Upper Chanshingian of South China (Yuan et al. 2007, 2009). The latter species is longer and the maximum of convexity of the AB is located lower. Great confusion exists in the systematics of the smooth shelled bairdiid genera of the Upper Permian–Lower Triassic. A full revision of all these forms is necessary.

Stratigraphic and geographic range.—Tulong section, Tibet, Anisian, Middle Triassic (Forel and Crasquin 2011a; Forel et al. 2011); Bálvány North section, levels 7, 8, samples 08BAN61, 62, 63, and 64? (see Fig. 2B), Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Family Pachydomellidae Berdan and Sohn, 1961
Genus Microcheilinella Geis, 1933
Type species: Microcheilus distortus Geis, 1932; Upper Mississippian of Indiana, USA.

Microcheilinella egerensis Forel sp. nov.
Figs. 15Q–X, 16.
Etymology: In reference to the city of Eger, Hungary.
Type material: Holotype: one complete carapace, Fig. 15Q, UPMC P6M2879, sample 08BAN61. Paratype: one complete carapace, Fig. 15S, UPMC P6M2881, sample 08BAN61.
Type locality: Bálvány North section, Bükk Mountains, Hungary.
Type horizon: Level 7, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Material.—35 complete and 5 broken carapaces, samples 08BAN61, 62, 63, and 67 (see Fig. 2B), levels 7, 8, Gerenna-
Family Bythocytheridae Sars, 1926
Genus Callicythere Wei, 1981
Type species: Callicythere emeiensis Wei, 1981; Lower Triassic, Sichuan Province, China

Callicythere? balvanyseptentrioensis Forel sp. nov.
Figs. 17, 18A–H.
Etymology: Latinization of Bálvány North section.
Type material: Holotype: one complete carapace, Fig. 18A, UPMC P6M2900, sample 08BAN62. Paratype: one complete carapace, Fig. 18B, UPMC P6M2901, sample 08BAN61.
Type locality: Bálvány North section, Bükk Mountains, Hungary.
Type horizon: Level 8, Gerennavár Limestone Formation, Griesbachian, Lower Triassic.

Material.—44 complete and 11 broken carapaces, samples 08BAN47, 50, 59, 61, 62, 63, 64, 67, and 69 (see Fig. 2B), levels 1, 5, 7, 8, Nagyvisnyó and Gerennavár Limestone Formations, Bálvány North section, Hungary, Changhsingian to Griesbachian, Upper Permian–Lower Triassic.

Diagnosis.—A species attributed with doubt to Callicythere with a small radius of curvature at the PB, without S2 and dorsolateral furrow.

Dimensions.—L 180–345 μm; H 110–210 μm (see Fig. 17).
Description.—Carapace quite equivalve with surface smooth without S2 nor narrow furrow; sexual dimorphism is well-expressed. Heteromorphs: DB convex; AB laterally compressed with large radius of curvature and maximum of convexity located at or below mid-H; VB slightly convex to straight; PB regularly rounded with maximum of curvature located close to mid-H; RV: DB straight and inclined backwards; anterior part of the carapace in shape of a quadrant, quite vertical in ventral part; PB equivalent to PB of LV; LV straight; PB equivalent to PB of LV.

LV overlaps RV all around the carapace; relative weak overlap with a maximum located at posterior part of DB; hinge line invaginated; larval stages show a larger AB than adults. Internal features unknown.

Discussion.—Wei (1981) included the genus Callicythere in
the Family Cytherissinellidae Kashevarova, 1958. It seems that this attribution is due to the similarity between Callicythere and Lutkevichinella Schneider, 1956 (for discussion see Wei 1981: 506). The description of the Family Cytherissinellidae is: "elongate suboblong, dorsal margin straight, anterior and posterior ends rounded, with faint to distinct narrow sulcus extending straight downward from mid-dorsal region; surface reticulated and may bear inconspicuous longitudinal ribs." (Moore 1961: Q290–Q292). In the description of Callicythere, Wei (1981) pointed out "... shallow V-shaped depression, on mid-dorsal region". Because of this "V-shaped depression", close to a true S2, and the presence of latero-ventral structures we attribute this genus to the Bythocytheridae Sars, 1926. The doubt about the generic attribution of our new species is due to the absence (or non-preservation?) of a dorso-median depression or sulcus.

Callicythere? balvanyseptentrioensis sp. nov. is close to Callicythere postiangusta Wei, 1981 from the Lower Triassic of Emei (Sichuan, South China; Wei 1981). The latter species has a PB with a larger radius of curvature and less distinct ACA.

Stratigraphic and geographic range.—Bálvány North section, levels 1, 5, 7, 8, samples 08BAN47, 50, 59, 61, 62, 63, 64, 67, and 69 (see Fig. 2B), Nagyvisnyó and Gerennavár Limestone Formations, Changhsingian to Griesbachian, Upper Permian to Lower Triassic.

Order and suborder indet.
Genus Eumiraculum Chen, 1987
Type species: Eumiraculum changxingensis Chen, 1987; Uppermost Permian, Meishan section, Zhejiang Province, China.

Eumiraculum desmaresae Forel sp. nov.
Figs. 18I–L, 19.
Etymology: Dedicated to Dr. Delphine Desmares (UPMC, Paris, France).
Remarks on biostratigraphic value of ostracods in this section

Kozur (1985a, b) proposed a zonation based on ostracods for the Upper Palaeozoic of Bükk Mountains. However, in these papers, there is no section with ostracod distribution available. He defined seven ostracod assemblage zones from the Moscovian (middle Upper Carboniferous) to Lower Triassic. Kozur (1985a) defined an “Indivisia buekkensis Assemblage Zone” as index of Upper Permian and a “Hollinella tingi Assemblage Zone” as index of index of lowermost Triassic. This last assemblage is associated with Isarcicella isarctica (Huckriede, 1958), conodont index of lowermost Triassic. The species occurring in the two last assemblage zones, VI “Indivisia buekkensis Assemblage Zone” and VII “Hollinella tingi Assemblage Zone”, which correspond to our data (Table 1). The zones are defined from borehole sediments from Bükk Mountains (see Kozur 1985a). The two species Indivisia buekkensis and “Hollinella tingi” (Hollinella tingi [Patte, 1935] is an Lower Permian species from South China; see the discussion about this last species above and in Crasquin-Soleau et al. 2004a) are not recognized in Bálvány section. Indivisia symmetrica Kozur, 1985, which is present in Kozur’s (1985a) “Indivisia buekkensis Assemblage Zone” was recognized in the upper part of Meishan GSSP section (Crasquin et al. 2010a). This species could be a good marker for the uppermost Changhsingian. Callicythere mazurensis (Styk, 1972) which is present in “Hollinella tingi Assemblage Zone” was recognized in the Upper Changhsingian of Bulla section (North Italy, Crasquin et al. 2008). Some species could be considered as Upper Changhsingian index in

Table 1. Upper Permian (VI) and Lower Triassic (VII) ostracod assemblage zones of Kozur (1985a). Asterisked is a species which actually is present before its “assemblage zone”.

| Ostracod assemblage zones | Ostracod species in assemblage zones (Kozur 1985a: table 2) | Ages |
|---------------------------|-------------------------------------------------------------|------|
| VII: “Hollinella tingi Assemblage Zone” | Callicythere mazurensis (Styk, 1972) | lowermost Triassic |
| | Cavellina sp. | |
| | Hollinella tingi (Patte, 1935) | |
| | Liuchinia sp. | |
| VI: “Indivisia buekkensis Assemblage Zone” | Indivisia buekkensis Kozur, 1985 | uppermost Changhsingian |
| | Indivisia symmetrica Kozur, 1985 | |
| | *Judahella bogschi bogschi Kozur, 1985 | |
| | Praepilatina sp. | |

Fig. 20. A. Lithostratigraphy and ostracod fauna evolution at Bálvány North section. For legend of lithology see Fig. 2. B. Variation of the number of species (continuous line) and specimens (dashed line). C. Percentage of bioclasts in thin sections of samples from the Bálvány North section, from Haas et al. (2006).
Bálvány section: *Eumiraculum desmaresae* Forel sp. nov., *Acratia nagyvisnyoei* Forel sp. nov., *Reviya praecurukensis* Forel sp. nov., *Hollinella fengqinglaiai* Crasquin sp. nov. For the Lower Griesbachian, the following species could be good biochronometers, at least locally: *Cytherellina? magyarorszagenesis* Forel sp. nov., *Langdaia bullabalvanyensis* Crasquin sp. nov.

**Ostracod biodiversity and ecological variation**

Ostracods are found from the top of the Nagyvisnyó Formation (lowest occurrence in sample 08BAN47) to the base of the Gerennavár Formation (highest occurrence in sample 08BAN69). Consequently, ostracods are present from the upper *Hindeodus praeparvus* Conodont Zone to the lower *Hindeodus parvus* Zone (Figs. 2A, 20).

Nineteen of the twenty-five samples collected from this interval yielded ostracods (Fig. 2A). The species distribution is given in Fig. 2B; abundance and species richness are presented in Fig. 20A. In productive samples, specific richness varies from 1 (08BAN66) to 28 (08BAN47) species and abundance from 4 (08BAN66) to 2135 (08BAN63) specimens. In most assemblages the variation of species richness correlates with the abundance. Only the samples 08BAN62 and 08BAN63 record a strong disparity between the abundance (increase from 1017 to 2135) and the number of species (decrease from 20 to 8). Assemblages of the Gerennavár Formation (08BAN61 to 08BAN69) show a higher abundance than the samples of the Nagyvisnyó Formation (08BAN47 to 08BAN60). Based on the iridium content, a change of sedimentation rate seems to occur at the transition between the uppermost beds of the Nagyvisnyó Formation and the lower part of the Boundary Shale Beds (Haas et al. 2007). Therefore we consider that changes in the sedimentation rate do not influence the diversity of our assemblages. However, we did not sample the BSB because of the silicilastic lithology. We observed carefully the rocks with lens on field and we haven’t seen any ostracods. The extinction rates from the Permian to the Triassic, although a decrease is recorded for the number of genera (from 17 to 14 genera) and species (from 54 to 36 species). The specific extinction rate is 74% (40 species extinct at PTB). Thus, at the Bálvány North section, the loss of ostracod diversity is confined to the genus and species levels. The species extinction rate at Bálvány North is significantly lower than the 99% recorded at Meishan section, GSSP of the PTB (Zhejiang Province, South China; Crasquin et al. 2010a; Forel et al. 2011; Crasquin and Forel in press). Fourteen species cross the PTB. On 36 Griesbachian species, 22 are new and document a specific turnover rate of about 61% in Bálvány North. This specific turnover is 67% in Meishan (but only 3 species are recognized) and 90% in Bulla (Italian Dolomites) (Crasquin and Forel in press). Two successive patterns can be distinguished here among the surviving species (Fig. 2B): the first one is documented by species which cross the PTB but disappear a few centimetres above the PTB; the second one is recorded by 7 (?9) species with a longer range within the Lower Triassic. It reflects 2 successive phases of survival for the ostracods, which are associated with the microbialites at the Bálvány North section:

- 24 ostracod species are recorded in the first 30 centimetres of the Triassic Formation, including 13 species, which are not present in Permian beds. In this portion of the Gerennavár Formation, the faunal renewal is close to 54%.
- 26 species are found in the upper part of the microbialites, including 17, which are not present in the Permian beds. This indicates a relative faunal renewal of about 47% for the upper part of the section.

The curve illustrating the variations of ostracod diversity (both species richness and abundance) can be divided into successive peaks (P) and drops (D) (Fig. 20A):

- The maximum of species diversity is recorded at the base of the section by the assemblages 08BAN47 and 08BAN48 (P1: 28 species in 08BAN47).
- Ostracods are absent from 08BAN49.1, 49.2, 49.3 (D1).
- Assemblages from 08BAN50 to 08BAN60 show a slight rediversification, reaching medium values of species richness (P2).
- Above the BSB, assemblages from the base of the Gerennavár Formation (08BAN61 to 08BAN63) are characterised by an increase of the species richness and abundance (P3). The maximal abundance is reached in 08BAN63 (2135 specimens).
- The assemblages 08BAN64 and 08BAN65 record a reduction of diversity (D3).
- A slight rediversification is recorded at the top of the sampled part of the Gerennavár Formation (P4: 08BAN66 to 08BAN69).

The samples 08BAN49.1, 49.2, 49.3, 57, 58, 68 yielded no ostracods. This absence of ostracods can be explained by (i) their initial absence at the time of deposition, implying a harsh environment, (ii) the displacement of the carapaces by current activity, (iii) the non-preservation or dissolution of carapaces. However, because most of the specimens recovered are closed carapaces, we assume the transportation to be limited (Oertli 1971). Note that instars (larval stages) are present for many species which also indicates, more strongly, that these taxa are in-situ (e.g., Boomer et al. 2003). Moreover, according to recent comparative analysis of ostracod extraction protocols, the method used in our study has limited dissolution effects on microfossils (Rodrigues et al. 2012). To conclude, the non-productive samples come from levels of homogeneous lithologies, where surrounding samples are productive. The absence of ostracods seems not to be linked to facies particularities. Therefore, we consider the assemblages observed as autochthonous and relatively representative of the biocoenosis.
A study of the Permian–Triassic interval at the Bálvány North section (Haas et al. 2006) shows a decreasing trend of abundances throughout the sampled part of the Nagyvisnyó Formation on the basis of bioclasts in thin sections (Fig. 20B). This trend and the concurrent disappearance of taxa was considered by Haas et al. (2006) to be directly related to the end-Permian events and not to local facies changes. This hypothesis can be tested by the present ostracod diversity record.

The highest species richness of ostracod assemblages is recorded at the base of the section (sample 08BAN47, P1) and is correlated with the maximum of bioclast abundance. The ostracod data following upsection show lower species richness and a very low abundance, in accordance with the

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Fig. 21. Ostracods from Bálvány North section, Bükk Mountains, Hungary. Right lateral views of complete (A–I, L–T) and broken (J, K) carapaces.

A. Bairdia cf. broutini Crasquin, 2010a. UPMC P6M2784, sample 08BAN62, Griesbachian, Lower Triassic. B–C. Bairdia cf. aurodeiformis Chen, 1987, Changhsingian, Upper Permian. B. UPMC P6M2768, sample 08BAN47. C. UPMC P6M2769, sample 08BAN47. D. Bairdia sp. A sensu Crasquin et al. (2010), UPMC P6M2787, sample 08BAN47, Changhsingian, Upper Permian. E. Bairdia sp. F, UPMC P6M2788, sample 08BAN62, Griesbachian, Lower Triassic. F. Bairdia sp. G, UPMC P6M2838, sample 08BAN54, Changhsingian, Upper Permian. G. Bairdia sp. H, UPMC P6M2789, sample 08BAN47, Changhsingian, Upper Permian. H. Bairdia sp. I, UPMC P6M2790, sample 08BAN50, Changhsingian, Upper Permian. I. Bairdia sp. J, UPMC P6M2791, sample 08BAN50, Changhsingian, Upper Permian. J. Bairdia sp. K, UPMC P6M2792, sample 08BAN59, Changhsingian, Upper Permian. K. Bairdia sp. L, UPMC P6M2793, sample 08BAN54, Changhsingian, Upper Permian. L. Bairdia sp. M, UPMC P6M2794, sample 08BAN47, Changhsingian, Upper Permian. M. Bairdia? sp. N, UPMC P6M2795, sample 08BAN52, Changhsingian, Upper Permian. N. Bairdia sp. O, UPMC P6M2796, sample 08BAN47, Changhsingian, Upper Permian. O. Bairdia sp. P, UPMC P6M2797, sample 08BAN48, Changhsingian, Upper Permian. P. Bairdia sp. Q, UPMC P6M2798, sample 08BAN59, Changhsingian, Upper Permian. Q. Bairdia sp. R, UPMC P6M2799, sample 08BAN60, Changhsingian, Upper Permian. R. Bairdia? sp. S, UPMC P6M2800, sample 08BAN62, Griesbachian, Lower Triassic. S. Bairdia? sp. T, UPMC P6M2801, sample 08BAN61, Griesbachian, Lower Triassic. T. Bairdia sp. U, UPMC P6M2802, sample 08BAN65, Griesbachian, Lower Triassic. Scale bars 100 μm.
bioclast abundance pattern. However, this trend of diversity reduction is gradual for bioclast abundance whereas it is sharp for the ostracod diversity and followed upsection by relatively stable values. We therefore conclude that the bioclast abundance pattern does not reflect the real dynamics of extinction of different organisms.

Another significant discrepancy is recorded at the base of the Gerennavár Formation where bioclasts are rare but ostracod assemblages more abundant (highest abundance in P3, sample 08BAN63) and diversified than those of the Nagyvisnyó Formation. Haas et al. (2006) indicated that packstone laminae with fine fragments of calcareous algae and other bioclasts occur in the stromatolites and interpreted them as storm deposits. In addition to the fact that ostracods are found as closed carapaces, they are found in the entire sampled part of the Gerennavár Formation (except in 08BAN68, Fig. 2A, B). We therefore deduce that their presence does not result from storm current activity but reflects more suitable environmental conditions. An analysis of the composition of assemblages documents their relative homogeneity with respect to superfamilies and families in the entire microbialite succession (Forel et al. 2013). Thus, the abundance pattern at the base of the stromatolites of the Bálvány North section is suggested to be due to special environmental conditions.

The ostracods we describe here through the Permian–Triassic interval in the Bálvány North section show 2 unusual features: (i) high abundance and diversity, in contrast with earlier studies of ostracod faunas at the very base of the Griesbachian which all document impoverished faunas (e.g., South China, Crasquin and Kershaw 2005; Crasquin-Soleau et al. 2006; Crasquin et al. 2010a; Forel and Crasquin 2011b; Tibet: Forel and Crasquin 2011a; Forel et al. 2011; Iran: Mette 2008); (ii) a lower extinction rate than the ostracods at Meishan section (Crasquin et al. 2010a; Forel et al. 2011). Lower
Triassic beds in Meishan were interpreted as deep external platform deposits (Zhang et al. 2007) of poorly oxygenated to anoxic setting (Wignall and Hallam 1993). This oxygen deficiency in a basinal environment is supported by the absence of ostracods in the Induan of the West Pingdingshan section (Chaohu, Anhui Province; Tong et al. 2005). The two first authors of this paper processed more than one hundred and fifty samples from the Griesbachian–Dienerian part of the Yinkeng Formation and no ostracods were discovered. Lower Triassic beds in Meishan were accumulated at greater water depth than the Lower Triassic beds at the the Bálvány North section (see below for details). These discrepancies between ostracod records are related to more hospitable conditions in Bálvány North provided by the microbial ecosystem from which the microbialites originate. These refuges are documented from several localities and may have prevented the oxygen depletion reaching levels lethal for ostracods (Forel et al. 2013).

Crasquin et al. (2010a) also suggested that the ostracod diversity variations in the Upper Permian of Meishan may be due to the changes in stability/instability of environments as result of sea level changes. Accordingly, increase is linked to stable conditions during high sea-level. Forel and Crasquin (2011b) refined this one-parameter model with data from the Lower Triassic of Meishan. According to Haas et al. (2004), the complete succession at the Bálvány North section was accumulated in an outer ramp setting with a deepening upward trend (Hips and Haas 2009). The important drop in ostracod diversity at the transition from interval P1 to D1 (level 1) could reflect the onset of instability, but the lithofacies do not record such environmental modifications. Stable environmental conditions due to great water depth are recorded at level 4 of the Nagyvisnyó Formation (Hips and Pelikan 2002; Haas et al. 2004, 2006). This environmental stability is indicated by the lack of distinct ostracod diversity changes, which agrees with the suggestion of Crasquin et al. (2010a). The diversity increase at the base of the Gerennavár Formation could be related in first approximation to the stability of the subtidal environment. However, because of the refuge conditions provided by Lower Triassic microbial mats, it seems unlikely to relate ostracod diversity variations within the microbialites to stability conditions. Indeed, the onset of microbial growth marks the transition between: (i) ostracod faunas mainly forced by external parameters (stability/instability related to hydrodynamism and oxygenation) in the Upper Permian Nagyvisnyó Formation; and (ii) faunas whose dynamic is entirely linked to internal parameters associated with the microbial ecosystem functioning (food and oxygen supply by microbes) in the Lower Triassic Gerennavar Formation.

The ostracods of Bükk Mountains (Hungary) present a special behaviour in the general landscape of the PTB interval. Indeed, they have here the lowest specific extinction rate (74%) of all the reference sections studied for ostracod analysis (Crasquin and Forel in press). Furthermore, the fauna exhibits an important endemism. Only 13 species are common with other areas. These palaeobiogeographical particularities of the Hungarian section will be considered in a forthcoming work.

Acknowledgments

We thank the authorities of the Bükk National Park for allowing us to sample and Attila Bartha for leading us in the National Park. We thank Martine Fordant (UPMC) for processing samples and the preparation of ostracods and Alexandre Lethiers (UPMC) for preparing the drawings and plates. We are indebted to Avi Honigstein (Israel Geological Survey, Yerusalem, Israel), Heinz Kozur (Budapest, Hungary), Alan Lord (Senckenberg Museum, Frankfurt, Germany), and Wolfgang Mette (University of Innsbruck, Austria) for their reviewing and their help to
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