Carnian (Late Triassic) ostracods
from the Sorgun Ophiolitic Mélange (Southern Turkey):
Taxonomy, palaeoenvironment, and evidence of predation

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ABSTRACT

The Mersin Ophiolitic Complex is situated in southern Turkey and contains the relics of the Palaeotethys and Neotethys Oceans and of the Huglu-Pindos basin. The succession exposed at the Tavusçayiri Block has been intensely studied but ostracods are still poorly documented. This paper illustrates and discusses the ostracods extracted from a radiolarian-rich limestone of the lower Tuvalian *Spongotortilispinus moixi* radiolarian Zone (Carnian, Late Triassic) intercalated with thick green tuffs. The moderately abundant assemblage (40 specimens) is composed of 29 species, 16 genera of seven families, including one new species: *Bairdiacypris sorgunensis* Forel sp. nov. This assemblage points to a moderately shallow subtidal environment submitted to short-lived environmental instabilities. In regards to the slightly older ostracods recently reported from the Tavusçayiri Block, the present record illustrates an upwards shallowing trend for the Carnian succession. All the taxa found are of typical Mesozoic-Cenozoic affinity, in contrast to the slightly older assemblage from the Julian of the Tavusçayiri Block (Kilek section), which also include Palaeozoic taxa. This different pattern could relate either to the disappearance of Palaeozoic taxa during the intervening interval or to their survival only in relatively deeper waters. Finally, we also report the oldest known record of a boring trace on the surface of an ostracod valve, probably of predatory origin. It represents the first evidence of predation on micro-benthos in the Triassic and is in line with several recent studies attesting the establishment of boring predation in the Late Triassic.

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INTRODUCTION

The Triassic is a key period in the history of biodiversity and ecosystems because it is bounded by two mass extinctions, the end-Permian and the end-Triassic biotic crises, and it marks the transition from the Palaeozoic to the Meso-Cenozoic evolutionary faunas. Diversity patterns through space and time during this interval are pivotal to reconstruct the rate and mechanisms of biotic recovery and transition. In this discussion, ostracods, micro-crustaceans known from the Ordovician to present-day in all types of marine waters, recently provided challenging data which demonstrate the retention of primitive characteristics up to the Julian (Early Carnian), and thus reveal the protracted transitional interval following the end-Permian crisis in deep-waters (Forel et al., 2017). This stimulating discovery was made in the Mersin Ophiolitic Complex (MOC) in southern Turkey, which appears as a key area for the study of the Triassic biotic dynamics in marine environments.

The MOC is located in the South-Taurides belt in southern Turkey. It exhibits typical oceanic sediments of the Palaeotethys and Neotethys, as well as a typical series of the Huğlu-Pindos basin in the Late Cretaceous ophiolitic series and associated infra-ophiolitic mélange. Two major independent mélange units are recognized in the MOC: the Upper Cretaceous Sorgun Ophiolitic Mélange and the Middle to Upper Triassic Hacialani Mélange (Moix et al., 2011). One of the most important and well-developed tectonic blocks of the Sorgun Ophiolitic Mélange is the Tavusçayiri Block (Masset and Moix, 2004), which yielded the best-preserved and most diverse lower Tuvalian radiolarian fauna (*Spongotortilispinus moixi* radiolarian Zone) worldwide discovered in 2004 by Masset and Moix and partly described in a series of articles by Moix et al. (2007), Kozur et al. (2007a, 2007b, 2007c, 2009) and Ozsvárt et al. (2015, 2017a, 2017b). In this paper, we illustrate and discuss the silicified ostracods from the same radiolarian-rich layer (sample G11), which include 29 species and 16 genera. The environmental affinities of these taxa reflect deposition in moderately shallow subtidal environment with possible salinity and hydrodynamic fluctuations. These new conclusions suggest a shallowing upward trend at the Tavusçayiri Block, which is reported for the first time here. The ostracod assemblage from the sample G11 also differs significantly from the older assemblage of the Tavusçayiri Block (*Tetraporobrachia haeckeli* radiolarian Zone assemblage; Forel et al., 2017) by the absence of deep-water and typical Palaeozoic taxa. This pattern might either be due to the final disappearance of deep-sea Palaeozoic taxa during this interval, marking the end of the transitional interval following the end-Permian extinction, or to the survival of such taxa only in deeper water. We also report the occurrence of a drill hole on an ostracod valve, which is probably of predatory origin. This finding represents the oldest such record for ostracods worldwide. It further confirms the Mesozoic affinity of the present assemblage and ecosystem and the establishment of drilling predation in marine environments during the Late Triassic as indicated by other fossil groups (see Klompmaker et al., 2016 for details).

GEOLOGICAL SETTING, STRATIGRAPHY AND FACIES

The studied area is located in the MOC, which belongs to the Taurides in Southern Turkey. It is situated northward from Erdemli city in Mersin area and is bounded by the villages of Gâvuruçtugu to the north and Sorgun to the south (Figure 1). The investigated section (coordinates 606066/4084886 in WGS84 system, zone 36S) belongs to the Tavusçayiri Block, which has been thoroughly described (Masset and Moix, 2004; Moix et al., 2007; Kozur et al., 2009; Ozsvárt et al., 2015). This succession occurs in the Upper Cretaceous Sorgun Ophiolitic Mélange (SOM), which is part of the MOC (Figure 1) occurring as blocks.

The base of the sequence is composed of breccia, which is unconformably overlain by polygenic conglomerates (Figure 2). The conglomerates are followed by black calciturbidites, which pass upward into a thin platform sequence, probably of early Carnian age (Moix et al., 2007; Kozur et al., 2009). The top of the platform represents a palaeo-relief locally rich in corals and filled with red pelagic limestones with abundant ammonoids indicative of the *Trachyceras austriacum* Zone of upper Julian, middle Carnian age (see Kozur et al., 2009 for details). The red pelagic limestones (Hallstatt facies) are overlain by a volcanic unit (Pietra Verde-like tuffs) with interstratifications of pelagic
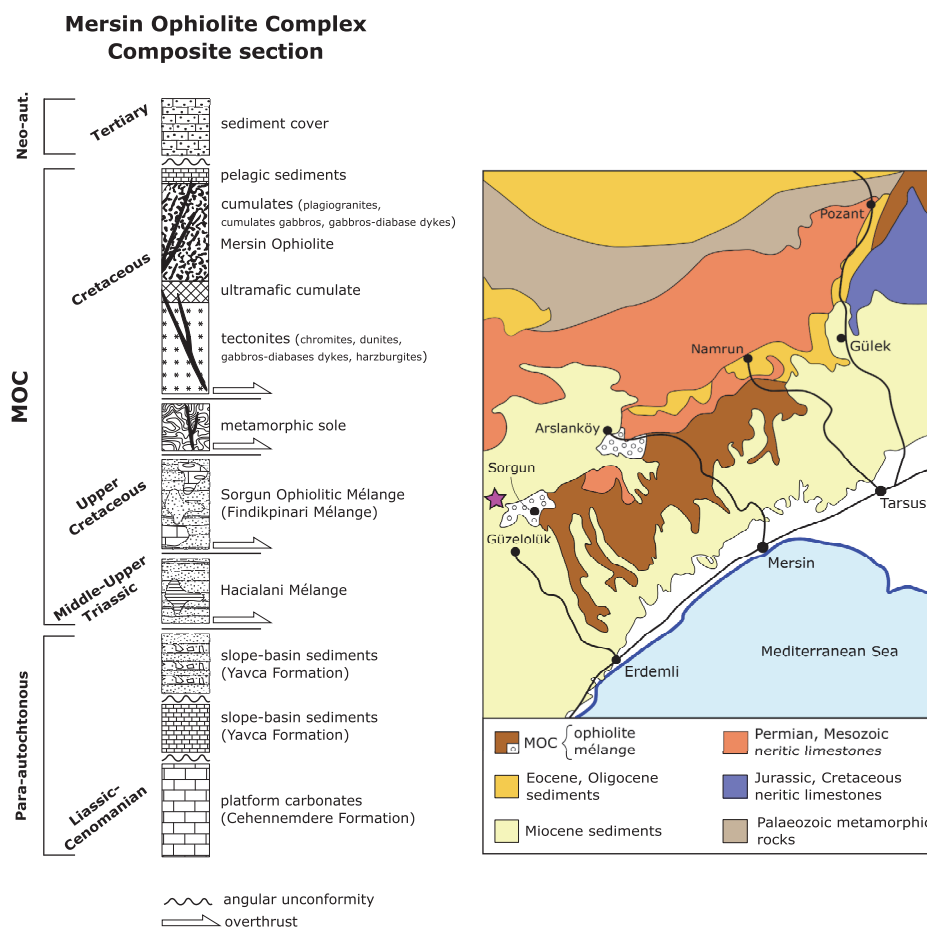
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FIGURE 1. Composite section and simplified geological map of the Mersin Ophiolitic Complex (MOC). The pink star indicates the position of the studied sample. Compiled after Parlak (1996) and Özer et al. (2004), modified from figure 1 of Moix et al. (2007).

and re-deposited limestones. They pass upward into a thick sequence of pelagic limestones intercalated with several debris-flows and calciturbidites. This sequence typically ends with a large breccia, but in a few places it is overlain by a well-developed "Ammonitico Rosso" facies (red calcareous facies rich in ammonoids) of middle Toarcian age. The uppermost part of the section is made of a breccia followed by radiolarites of late Dogger age.

This succession corresponds to the Huğlu-type sequence developed farther to the west, which was first described by Özgül (1976) in the Bozkır Units and by Monod (1977) in the Beysehir-Hoyran Nappes. The stratigraphy of the Huğlu Unit was revised by Kozur (1997) and regional correlations have been proposed by Moix et al. (2013). All the ostracods reported here come from one sample (G11, Figure 2), which has been previously analysed for radiolarians (Kozur et al., 2009). The sampled horizon is located in a limestone unit,

intercalated with thick green tuffs, and belongs to the lower Tuvalian *Spongotortilispinus moixi* radiolarian Zone (Moix et al., 2007; Figure 3). Although no microfacies information are available for this sample, other limestones intercalated within tuffites are radioalarian wackestones with abundant spicules, brachiopods, ammonoids, gastropods, ostracods, foraminifers, conodonts and pelagic crinoids.

MATERIAL AND METHODS

The sample G11 was processed using dilute acetic acid for radiolarian extraction (Masset and Moix, 2004; Moix et al., 2007; Kozur et al., 2007a, 2007b, 2007c) and yielded moderately abundant silicified ostracods characterized by their delicate lace-like preservation. This assemblage is composed of 29 species belonging to 16 genera and seven families (Table 1). Due to the relatively poor preservation and low quantity of the material, clear
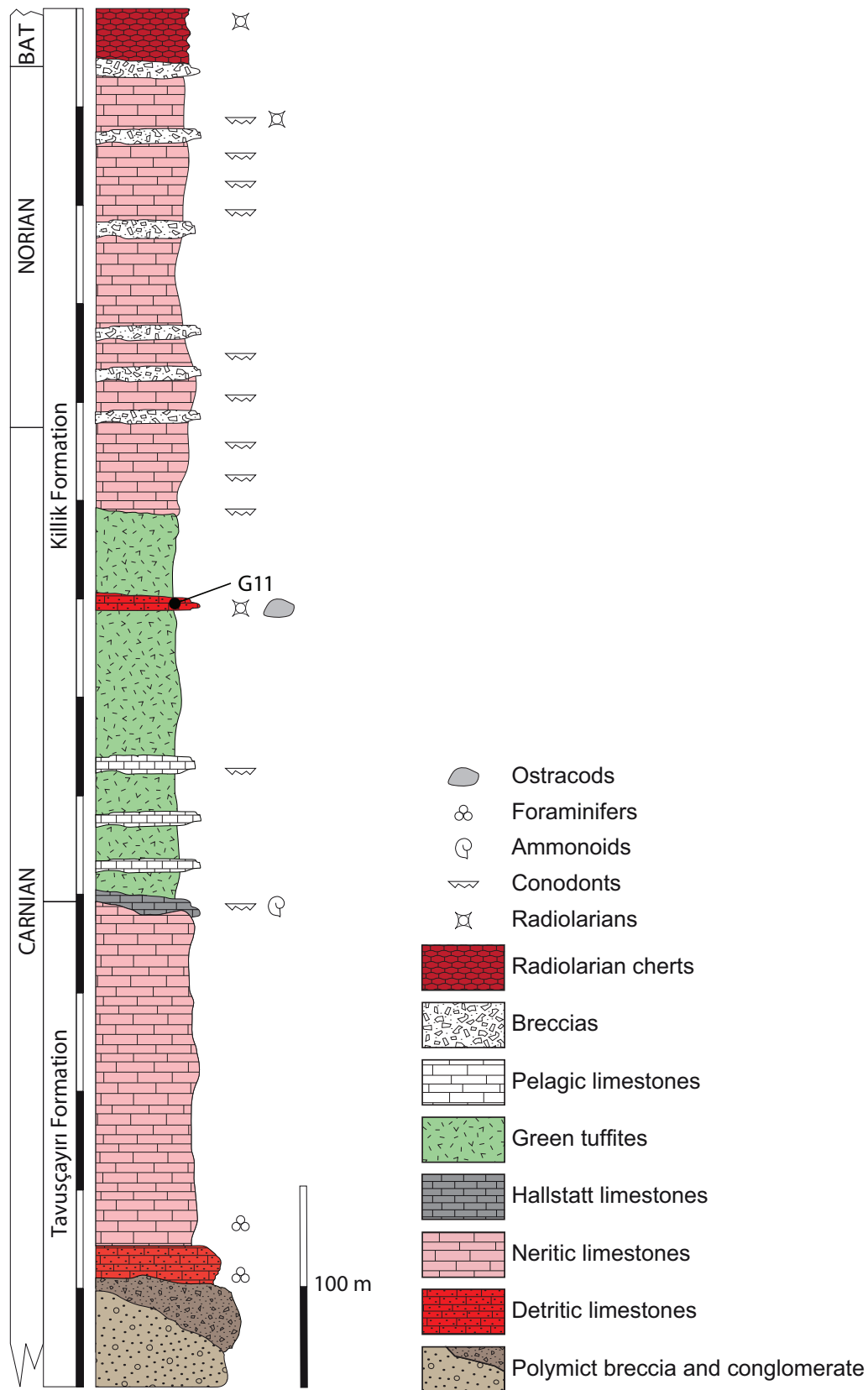
FIGURE 2. Stratigraphic log of the Tavusçayiri Block with the position of the studied sample G11 which yielded the present ostracod assemblage.

			Ammonoids		Conodonts	Radiolarians
			Zone	Subzone	Zone	Zone
CARNIAN	TUVALIAN	Upper	*Anatropites spinosus*	*Goniononites italicus*	*E. primitia*	*Nakasekoellus inkensis*
				Discotropites plinii	*E. pseudodibeli-M. communisti*	
		Middle	*Tropites subbulatus*	*Tropites subbulatus*	*Epigondolella nodosa*	
				Projuvavites crasseplicatus	*Paragondolella carpathica*	
		Lower	*Tropites dilleri*		*Paragondolella polygnathiformis*	*Spongotortilispinus moixi* ★ **Studied sample**
	JULIAN		*Austrotrachyceras austriacum*	*Neoprotrachyceras oedipus*	*Gladigondolella tethydis-Paragondolella polygnathiformis*	*Elbistanium gracile*
				Austrotrachyceras austriacum		*Tetraporobrachia haeckeli* ★ Kilek section (Forel et al., 2017)
			Trachyceras aonides	*Trachyceras aonides*		
				Trachyceras aon	*B. diebeli-P. polygnathiformis*	*Tritortis kretaensis*

FIGURE 3. Subdivisions of the Carnian stage and correlation of ammonoid, conodont and radiolarian Zones for this time interval. The stars indicate the position of the ostracod-bearing sample studied here (*Spongotortilispinus moixi* radiolarian. Zone) and ostracod fauna from the Kilek section (*Tetraporobrachia haeckeli* radiolarian Zone; Forel et al., 2017). Ammonoid zonation after Gallet et al. (1994) and Hornung et al. (2007); conodont zonation after Kozur and Mostler (1994, 1996) and Kozur (2003); radiolarian zonation after Kozur (2003), Moix et al. (2007) and Dumitrica et al. (2013).

identification of diagnostic characters was limited so most species are kept in open nomenclature, but all are illustrated for later comparisons (Figures 4-5). For the sake of brevity, the following systematic palaeontology chapter only includes the full description of the new species *Bairdiacypris sorgunensis* Forel sp. nov., as well as the synonymy and remarks on previously known species. Following Maddocks (2015), the degree of slope of the antero-dorsal and postero-dorsal margins are measured on external lateral views of the carapace or valve, with 0 being horizontal. The size convention is as follows: <400 µm very small, 400–500 µm small, 500–700 µm medium, 700–1000 µm large, >1000 µm very large.

TABLE 1. Tuvalian, *Spongotortilispinus moixi* radiolarian Zone, ostracod fauna from the sample G11 (Tavuşçayiri Block, southern Turkey) with all species identified in this work.

Class Ostracoda Latreille, 1806
Subclass Podocopa Müller, 1894
Order Podocopida Müller, 1894
Superfamily Bairdioidea Sars, 1887
Family Bairdiidae Sars, 1887

Genus *Acratia* Delo, 1930
    Acratia sp.
Genus *Bairdia* McCoy, 1844
    Bairdia sp. 1
    Bairdia sp. 2
    Bairdia? sp. 3
    Bairdia sp. 4
    Bairdia sp. 5
    Bairdia? sp. 6
    Bairdia sp. 7
    Bairdia sp. 8
    Bairdia (Urobairdia) sp. 9
Genus *Bairdiacypris* Bradfield, 1935
    Bairdiacypris sorgunensis Forel n. sp.
    Bairdiacypris sp.
Genus *Dicerobairdia* Kollmann, 1963
    Dicerobairdia sp.
Genus *Isobythocypris* Apostolescu, 1959
    Isobythocypris? cf. *postera* (Herrig, 1979a) *in* Forel et al., 2017
Genus *Medwenitschia* Kollmann, 1963
    Medwenitschia sp.
Genus *Mirabairdia* Kollmann, 1963
    Mirabairdia longispinosa Kristan-Tollmann, 1978
    Mirabairdia? sp.
Genus *Nodobairdia* Kollmann, 1963
    Nodobairdia sp. 1
    Nodobairdia? sp. 2
Genus *Petasobairdia* Chen, 1982
    Petasobairdia longispinosa (Kozur, 1971b)

Genus *Ptychobairdia* Kollmann, 1960
    Ptychobairdia kristanae Kollmann, 1960
    Ptychobairdia sp. 1
    Ptychobairdia sp. 2

Superfamily Cytheroidea Baird, 1850
Family Bythocytheridae Sars, 1866
Genus *Nemoceratina* Gründel & Kozur, 1971
    Nemoceratina (Nemoceratina) sp.

Family Cytheruridae Müller, 1894
Subfamily Cytherurinae Müller, 1894
Genus *Judahella* Sohn, 1968
    Judahella fortenodosa (Ulrichs, 1972)

Order Metacopida Sylvester-Bradley, 1961
Suborder Metacopina Sylvester-Bradley, 1961
Superfamily Healdioidea Harlton, 1933
Family Healdiidae Harlton, 1933
Genus *Ogmoconcha* Triebel, 1941
    Ogmoconcha sp.

Order Platycopida Sars, 1866
Suborder Platycopina Sars, 1866
Superfamily Cavellinoidea Egorov, 1950
Family Cavellinidae Egorov, 1950
Genus Bektasia Özdikmen, 2010
    Bektasia? sp.

Superfamily Cytherelloidea Sars, 1866
Family Cytherellidae Sars, 1866
Genus *Leviella* Sohn, 1968
    Leviella sp.

Subclass Myodocopa Sars, 1866
Order Myodocopida Sars, 1866
Superfamily Polycopoidea Sars, 1866
Family Polycopidae Sars, 1866
Genus *Polycope* Sars, 1866
    Polycope cincinnata Apostolescu, 1959

The illustrated specimens and types are deposited in the collections of the Hungarian Natural History Museum, Budapest, under the numbers INV 2018.1 to INV 2018.31.
Abbreviations. L, length; H, height; DB, dorsal border; VB, ventral border; ADB, antero-dorsal border; AVB, antero-ventral border; PDB, postero-dorsal border; PVB, postero-ventral border.

SYSTEMATIC PALAEONTOLOGY

The present taxonomy follows the classifications of Horne et al. (2002), Moore (1961) and Becker (2002). The taxonomy of Cytheroidea is based on the emendations of Whatley and Boomer (2000) and that of Bythocytheridae follows Schornikov (1990). Species left in open nomenclature, except for exceptional genera or species, are omitted.
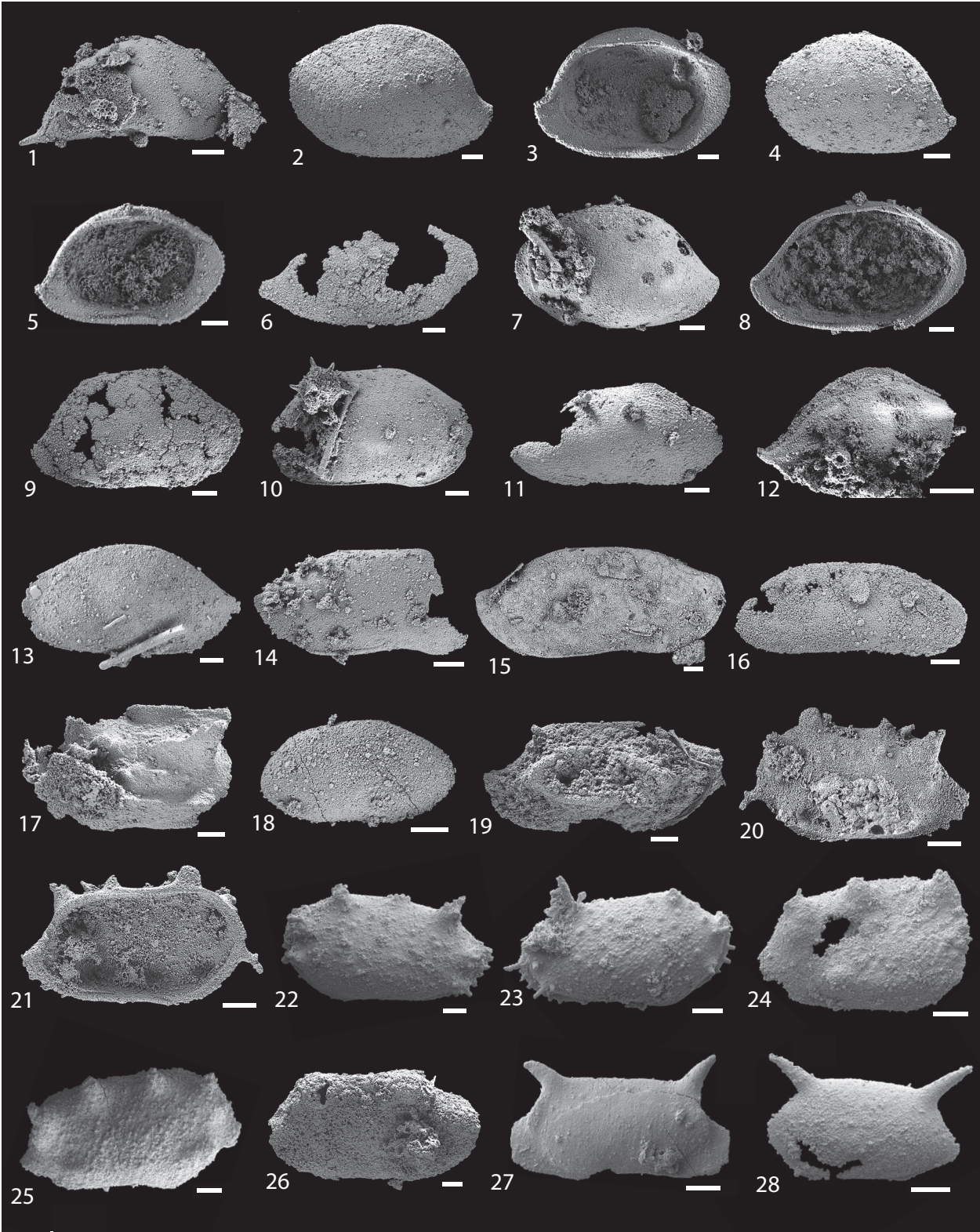
FIGURE 4 (caption next page).

Class OSTRACODA Latreille, 1806
Subclass PODOCOPA Müller, 1894
Order PODOCOPIDA Müller, 1894
Superfamily BAIRDIOIDEA Sars, 1887
Family BAIRDIIDAE Sars, 1887
Genus BAIRDIA McCoy, 1844

Type species. *Bairdia curta* McCoy, 1844, by subsequent designation of Ulrich and Bassler (1923, p. 320).

Bairdia sp. 4
Figure 4.7, 4.8

Material examined. One complete left valve (INV 2018.1).

Dimensions. L = 811 µm, H = 491 µm.

Range. *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian (this work), Late Triassic.

Occurrence. Sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. *Bairdia* sp. 4 is very close to *Bairdia* sp. 4 in Forel et al., 2017 from the *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian, Late Triassic of the Kilek section, Tavusçayiri Block, Sorgun Ophiolitic Mélange (Forel et al., 2017). Both species are only known by an isolated left valve with straight hinge line underlain by two pronounced lists, a calcified inner lamella moderately developed at AB and a raised posterior end. However, *Bairdia* sp. 4 differs from *Bairdia* sp. 4 in Forel et al., 2017 by its more elongate posterior margin, longer hinge line, poorly developed selvage along ventral margin and moderately developed calcified inner lamella at AB bordered by a thin laterally compressed area. Although kept in open nomenclature, this species is of high importance as it bears the oldest known drill hole on an ostracod valve, as discussed below.

Genus BAIRDIACYPRIS Bradfield, 1935

Type species. *Bairdiacypris deloi* Bradfield, 1935 by original designation.

Bairdiacypris sorgunensis Forel sp. nov.
Figure 4.14, 4.15

v. 2017   *Bairdiacypris aequisymmetrica* Mette, Honigstein and Crasquin; Forel, Tekin, Okuyucu, Bedi, Tuncer and Crasquin, p. 11, figs. 10R-T.

Etymology. The species name refers to the Sorgun Ophiolitic Mélange from which the material was derived.

Type material. Holotype: one right valve, adult, from the Kilek section, P6M4075 (Figure 4.15, from Forel et al., 2017); Paratype 1: one right valve, stage A-2, from the Kilek section, P6M4073 (figure 10R in Forel et al., 2017); Paratype 2: one right valve, stage A-3, from the Kilek section, P6M4074 (figure 10S in Forel et al., 2017).

Additional material examined. One broken right valve, INV 2018.2 (Figure 4.14); 4 complete valves from the Kilek section (Forel et al., 2017).

Dimensions. L = 517–1259 µm, H = 223–558 µm, H/L = 0.40–0.44 (Figure 5, all specimens from Kilek section; Forel et al., 2017).

Diagnosis. A *Bairdiacypris* species with an elongate lateral outline, sub-symmetrical anterior and posterior margins and ventral margin marked by a thin lip.

Description. Carapace very large, elongate, sub-rectangular in lateral view with Hmax around mid-L

FIGURE 4 (previous page). Ostracods from the sample G11, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huglu Tuffite, *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic. **1**, *Acratia* sp., INV 2018.9, right valve in lateral view; **2-3**, *Bairdia* sp. 1, INV 2018.10, left valve in lateral (**2**) and internal (**3**) views; **4-5**, *Bairdia* sp. 2, INV 2018.11, left valve in lateral (**4**) and internal (**5**) views; **6**, *Bairdia*? sp. 3, INV 2018.12, right valve in lateral view; **7-8**, *Bairdia* sp. 4, INV 2018.1, left valve in lateral (**7**) and internal (**8**) views; **9**, *Bairdia* sp. 5, INV 2018.13, right valve in lateral view; **10**, *Bairdia*? sp. 6, INV 2018.14, right valve in lateral view; **11**, *Bairdia* sp. 7, INV 2018.15, right valve in lateral view; **12**, *Bairdia* sp. 8, INV 2018.16, right lateral view of a complete carapace; **13**, *Bairdia* (*Urobairdia*) sp. 9, INV 2018.17, left valve in lateral view; **14-15**, *Bairdiacypris sorgunensis* Forel sp. nov., INV 2018.2, broken right valve in lateral view (**14**) and P6M4075, holotype, right valve in lateral view (**15**) from the Julian, Middle Carnian of Kilek section, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huğlu Tuffite (Forel et al., 2017); **16**, *Bairdiacypris* sp., INV 2018.18, right valve in lateral view; **17**, *Dicerobairdia* sp., INV 2018.19, broken left valve in lateral view; **18**, *Isobythocypris*? cf. *postera* (Herrig, 1979a) in Forel et al. 2017, INV 2018.3, right valve in lateral view; **19**, *Medwenitschia* sp., INV 2018.20, right valve in lateral view; **20-21**, *Mirabairdia longispinosa* Kristan-Tollmann, 1978, INV 2018.4, left valve in lateral (**20**) and internal (**21**) views; **22-23**, *Mirabairdia* sp., INV 2018.21, left valve in lateral view (**22**) and INV 2018.22, right valve in lateral view (**23**); **24-25**, *Nodobairdia* sp. 1, INV 2018.23, broken right valve in lateral view (**24**) and INV 2018.24, right valve in lateral view (**25**); **26**, *Nodobairdia*? sp. 2, INV 2018.25, right lateral view of a complete carapace; and **27-28**, *Petasobairdia longispinosa* (Kozur, 1971b), INV 2018.5.1, left valve in lateral view (**27**) and INV 2018.5.2, left valve in lateral view (**28**). Scale bars equal 100 µm.
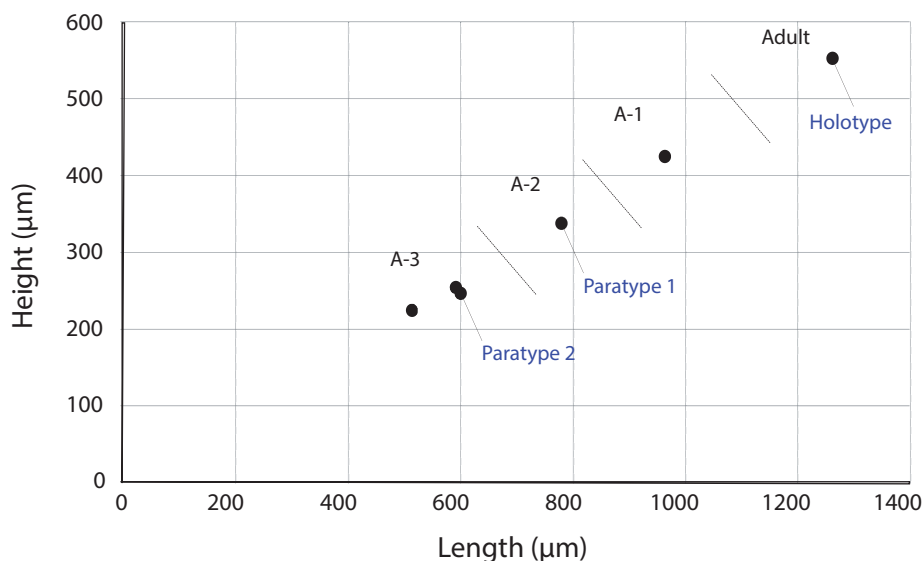
FIGURE 5. Length/height scatter plot of *Bairdiacypris sorgunensis* Forel sp. nov. All specimens are from the *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian, Late Triassic (Forel et al., 2017). In ascending order, ontogenetic stages are labelled "A-3" to "A-1" for successive juvenile stages and "Adult" for Adults.

and Lmax at/or slightly above mid-H; dorsal margin long with distinct PDB, DB and ADB separated by distinct antero-dorsal and postero-dorsal corners; DB long (about 33–40% of Lmax) and straight, ADB straight and sloping toward the anterior margin with an angle of about 25°, PDB shorter and concave upward; anterior margin with relatively large radius of convexity, maximum located above mid-H, AVB broadly rounded and strongly inclined toward AB; ventral margin long (ranging from 49 to 53% of Lmax) with concavity located in front of mid-L, marked by a thin lip running all along ventral length; posterior margin nearly symmetrical to anterior margin, but more sharply pointed upward and with a smaller radius of concavity located at the same level than anterior one; overlap not observed; surface smooth.

Range. *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian (Forel et al., 2017); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian (this work), Late Triassic.

Occurrence. Kilek section, Tavuşçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huğlu Tuffite (Forel et al., 2017); sample G11, Killik Formation, Tavuşçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. *Bairdiacypris sorgunensis* Forel sp. nov. is related to *Bairdiacypris aequisymmetrica* Mette,

Honigstein and Crasquin, 2014 from the Middle Anisian (Reifling Formation) of the Northern Calcareous Alps (Austria; Mette et al., 2014) due to its elongate morphology in lateral view and its subsymmetrical anterior and posterior margins. However, *Bairdiacypris aequisymmetrica* Mette, Honigstein and Crasquin, 2014, has less tapered and pointed anterior and posterior ends and lacks the thin lip along the ventral margin. *Bairdiacypris sorgunensis* Forel sp. nov. also differs from *Bairdia anisica* Kozur, 1970a from the Upper Anisian of Germany (Kozur, 1970a) in being more elongate with a longer and lower dorsal border, a higher anterior margin with shorter antero-ventral border and in possessing a thin lip along ventral margin. It is further different from *Bairdiacypris anisica* Kozur, 1971a, from the Upper Anisian of Hungary (Kozur, 1971a) by its more pronounced medio-ventral concavity, more rectangular outline in lateral view, more pointed anterior and posterior ends and thin lip along ventral margin. Six specimens from the Julian of the Kilek section (Forel et al., 2017) were erroneously attributed to *Bairdiacypris aequisymmetrica* Mette, Honigstein and Crasquin, 2014, as shown in the synonym list. They plot into at least four ontogenetic stages as shown in Figure 5, from A-3 to Adult. The specimen extracted from the sample G11 is 350 µm in height, which corre-

sponds to the upper size range of the A-2 stage or to the lower size range of the A-1 stage.

Genus ISOBYTHOCYPRIS Apostolescu, 1959

Type species. *Isobythocypris unispinata* Apostolescu, 1959, by original designation.

Isobythocypris? cf. *postera* (Herrig, 1979a) in Forel et al., 2017
Figure 4.18

v. 2017   *Isobythocypris?* cf. *postera* (Herrig, 1979a); Forel, Tekin, Okuyucu, Bedi, Tuncer and Crasquin, p. 17, 19, figs. 10R-T.

Material examined. One complete right valve (INV 2018.3).

Dimensions. L = 511 μm, H = 237 μm.

Range. *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian (Forel et al., 2017); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian (this work), Late Triassic.

Occurrence. Kilek section, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huğlu Tuffite (Forel et al., 2017); sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. This species is closely related to *Isobythocypris? postera* (Herrig, 1979) described from the Lower Jurassic of Germany (Herrig, 1979a), which has been documented from the Hettangian to the Pliensbachian of Germany, France and Ireland (Apostolescu, 1959; Herrig, 1979a, b; Rutherford and Ainsworth, 1989; Harloff, 1993; Harloff and Jäger, 1994; Monostori, 1996). However, we lack complete material to clearly attribute our material to *Isobythocypris? postera* (Herrig, 1979a) or to define precisely the diagnostic characters of the potential new species.

Genus MIRABAIRDIA Kollmann, 1963

Type Species. *Mirabairdia pernodosa* Kollmann, 1963 by original designation.

Mirabairdia longispinosa Kristan-Tollmann, 1978
Figures 4.20, 4.21

v. 1978   *Mirabairdia longispinosa* Kristan-Tollmann, p. 94-96, pl. 3, fig. 1-3, pl. 7, fig. 5.

Material examined. One complete left valve (INV 2018.4).

Dimensions. L = 640 μm, H = 350 μm (not considering spines).

Range. Cordovelian, Early Carnian, (Kristan-Tollmann, 1978); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian (this work), Late Triassic.

Occurrence. Cassian beds, South Tyrol, Italy (Kristan-Tollmann, 1978); sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. The present record is the youngest occurrence of *Mirabairdia longispinosa* Kristan-Tollmann, 1978, which was previously only known from the base of the Carnian (Cordovelian; Kristan-Tollmann, 1978). It is also the first record of this species outside Italy.

Genus PETASOBAIRDIA Chen in Chen and Shi, 1982

Type species. *Petasobairdia bicornuta* Chen in Chen and Shi (1982) by original designation.

Remarks. The species *Ceratobairdia crassispinosa* Monostori and Tóth, 2014, has been reported from the Ladinian, Middle Triassic of the Transdanubian Central Range, Hungary (Monostori and Tóth, 2014). However, the type material of *Ceratobairdia crassispinosa* Monostori and Tóth, 2014, does not possess the ventrolateral alate ridge and flat ventral surface, which are diagnostic characters of the genus *Ceratobairdia* Sohn, 1954. *Ceratobairdia crassispinosa* Monostori and Tóth, 2014, is also characterized by its anterior and posterior margins, which are strongly compressed laterally. For these reasons, this species is removed from *Ceratobairdia* and assigned to *Petasobairdia*, which shows laterally compressed anterior and posterior margins and ridge, nodes, denticulation or horn-like spines at the dorsal margin of the LV.

Petasobairdia longispinosa (Kozur, 1971b)
Figures 4.27, 4.28, 6.1

v. 1971b   *Ceratobairdia longispinosa* Kozur; 4; pl. 1, fig. e.

Non 1984   *Ceratobairdia longispinosa* Kozur; Salaj and Jendrejáková, pl. 1, fig. 12, pl. 3, figs. 1-4.

cf. 1996   *Ceratobairdia longispinosa* Kozur; Crasquin-Soleau and Grădinaru, pl. 5, fig. 6.

Non 2013   *Ceratobairdia longispinosa* Kozur; Sebe, Crasquin and Grădinaru, p. 520; pl. 3, fig. 11.

v. 2014   *Petasobairdia longispinosa* (Kozur); Mette, Honigstein and Crasquin, p. 81, pl. 3, figs. 7-9.

v. 2017   *Petasobairdia longispinosa* (Kozur); Forel, Tekin, Okuyucu, Bedi, Tuncer and Crasquin, figs. 12L-M.

Material examined. Five complete left valves (INV 2018.5.1–INV 2018.5.5) and one complete right valve (INV 2018.5.6).

Dimensions. L = 466–883 μm, H = 247–400 μm (this work only, not considering the spines).
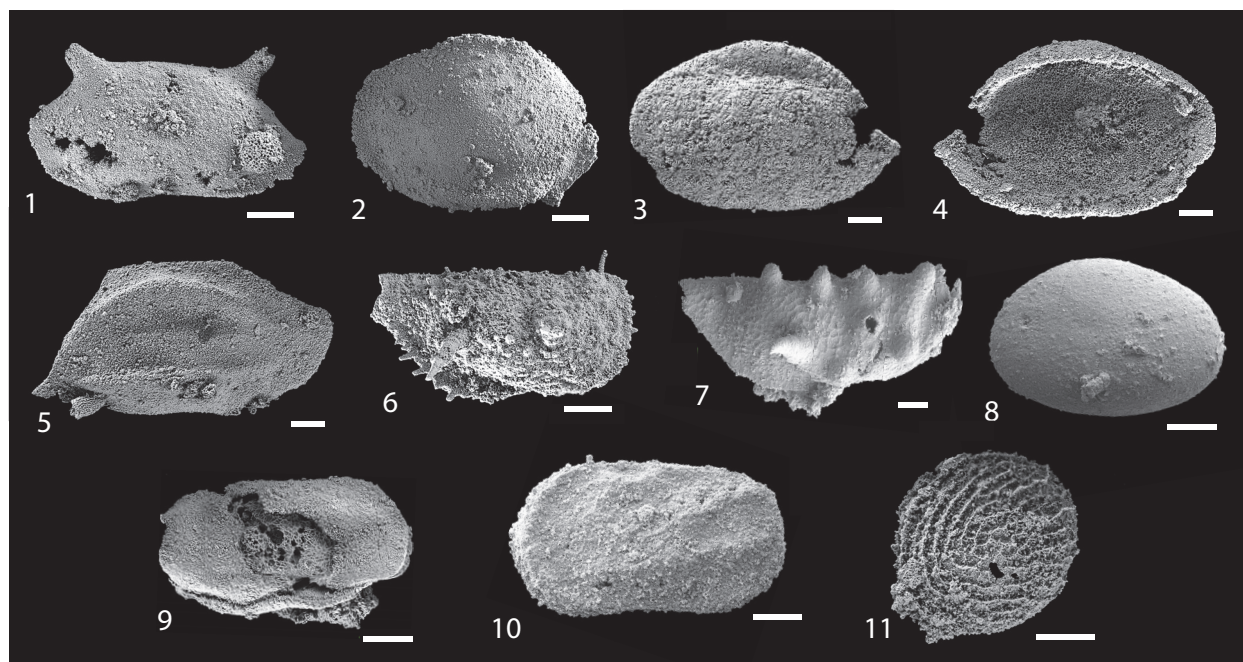
FIGURE 6. Ostracods from the sample G11, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huglu Tuffite, *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic. **1**, *Petasobairdia longispinosa* (Kozur, 1971b), INV 2018.5.3, left valve in lateral view; **2**, *Ptychobairdia kristanae* Kollmann, 1960, INV 2018.6, left valve in lateral view; **3-4**, *Ptychobairdia* sp. 1, INV 2018.26, left valve in lateral (**3**) and internal (**4**) views; **5**, *Ptychobairdia* sp. 2, INV 2018.27, right valve in lateral view; **6**, *Nemoceratina (Nemoceratina)* sp., INV 2018.28, right valve in lateral view; **7**, *Judahella fortenodosa* (Urlichs, 1972), INV 2018.7, right valve in lateral view; **8**, *Ogmoconcha* sp., INV 2018.29, right valve in lateral view; **9**, *Bektasia*? sp., INV 2018.30, right lateral view of a complete carapace; **10**, *Leviella* sp., INV 2018.31, left valve in lateral view; and **11**, *Polycope cincinnata* Apostolescu, 1959, INV 2018.8, right valve in lateral view. Scale bars equal 100 μm.

Range. Upper Anisian, Illyrian, Middle Triassic (Kozur, 1971b); Middle Anisian, Middle Triassic (Mette et al., 2014); *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian, Late Triassic (Forel et al., 2017); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic (this work).

Occurrence. Slovakia (Kozur, 1971b); Reifling Formation, Northern Calcareous Alps, Austria (Mette et al., 2014); Kilek section, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huğlu Tuffite (Forel et al., 2017); sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. Based on the illustrations in Salaj and Jendrejáková (1984), their specimens are re-attributed to the genus *Mirabairdia*. Similarly, the material from the lower Anisian of Dobrogea, Romania (Sebe et al., 2013) is rejected from *Petasobairdia longispinosa* (Kozur 1971b) because it lacks the dorsal spines or even scars of broken spines. *Petasobairdia longispinosa* (Kozur, 1971b), therefore, ranges from the Middle Anisian to the lower Tuvalian, Upper Carnian and this species is not recorded from the Middle Triassic of North Dobrogea. In the current state of knowledge, this species is restricted to the northern margins of the Meliata and Küre oceans (see for example Stampfli, 2000) during the Anisian and occurs at their southern margins in the Carnian. *Petasobairdia crassispinosa* (Monostori and Tóth, 2014) from the Ladinian of Hungary (Monostori and Tóth, 2014) differs from *Petasobairdia longispinosa* (Kozur, 1971b) only by the basal morphology of their dorsal spines, which are broader compared to the type material of *Petasobairdia longispinosa*. Several specimens of *Petasobairdia longispinosa* (Kozur, 1971b) possess this type of spine morphology so that this character is not sufficient to establish a new species. The two specimens of *Petasobairdia crassispinosa* illustrated by Monostori and Tóth (2013, 2014) are rather characterized by a relatively short and high carapace and strongly compressed anterior and posterior margins. These characters are more pronounced in the material of Monostori and Tóth (2013, 2014) compared to the type material of *Petasobairdia longispinosa* (Kozur,

1971b). But the two specimens of Monostori and Tóth (2013, 2014) are not sufficient to distinguish possible transitional forms between the two morphologies. Until more material can be studied, we keep these specimens in different species.

Genus PTYCHOBAIRDIA Kollmann, 1960

Type species. *Ptychobairdia kuepperi* Kollmann, 1960 by original designation.

Ptychobairdia kristanae Kollmann, 1960
Figure 6.2

v. 1960   *Ptychobairdia kristanae* Kollmann; p. 99, 100, pl. 25, figs. 6-9.

v. 1960   *Ptychobairdia medwenitschi* Kollmann; p. 100, pl. 26, figs. 1-11.

1963   *Ptychobairdia kristanae* Kollmann; Kollmann, p. 181.

Material examined. One complete right valve (INV 2018.6).

Dimensions. L = 670 μm, H = 490 μm.

Range. Late Triassic (Kollmann, 1960, 1963); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic (this work).

Occurrence. Austria (Kollmann, 1960, 1963); sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Superfamily CYTHEROIDEA Baird, 1850
Family CYTHERURIDAE Müller, 1894
Subfamily CYTHERURINAE Müller, 1894
Genus JUDAHELLA Sohn, 1968

Type species. *Judahella tsorfatia* Sohn, 1968, by original designation.

Judahella fortenodosa (Urlichs, 1972)
Figure 6.7

v. 1972   *Monoceratina fortenodosa* Urlichs; p. 676, pl. 1, figs. 6-8.

v. 1980   *Monoceratina fortenodosa* Urlichs; Kristan-Tollmann, Tollmann and Hamedani, p. 187, pl. 8, fig. 10.

v. 1988   *Triceratina fortenodosa* (Urlichs); Kristan-Tollmann, figs. 6, 10.

v. 1991   *Triceratina fortenodosa* (Urlichs); Kristan-Tollmann, Haas and Kovács, pl. 8, figs. 1, 2.

v. 1999   *Triceratina fortenodosa* (Urlichs); Mette and Mohtat-Aghai, pl. 6, fig. 7.

v. 2012   *Triceratina fortenodosa* (Urlichs); Mette, Elsler and Korte, p. 70.

2013   *Tuberoceratina fortenodosa* (Urlichs); Hillebrandt, Krystyn, Kürschner, Bonis, Ruhl, Richoz, Schobben, Urlichs, Kment, McRoberts, Simms, and Tomãsových, p. 70.

v. 2014   *Judahella fortenodosa* (Urlichs); Monostori and Tóth, p. 29, pl. 3, figs. 3, 4.

Material examined. One complete right valve (INV 2018.7).

Dimensions. L = 904 μm, H = 365 μm.

Range. Norian-Rhaetian, Late Triassic (Urlichs, 1972); Rhaetian, Late Triassic (Kristan-Tollmann, 1988; Kristan-Tollmann et al., 1980); Norian-Rhaetian, Late Triassic (Kristan-Tollmann, et al. 1991); Rhaetian, Late Triassic (Mette and Mohtat-Aghai, 1999); Rhaetian, Late Triassic (Mette et al., 2012); Rhaetian, Late Triassic (Hillebrandt et al., 2013); Ladinian, Middle Triassic (Monostori and Tóth, 2014); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic (this work).

Occurrence. Kössen Beds, Austria (Urlichs, 1972); Iran (Kristan-Tollmann, 1988; Kristan-Tollmann et al., 1980); Tyrol (Kristan-Tollmann, et al. 1991); Kössen Formation, Northern Calcareous Alps, Austria (Mette and Mohtat-Aghai, 1999); Kössen Formation, Eiberg Member, Northern Calcareous Alps, Austria (Mette et al., 2012); Kössen Formation, Eiberg Member, Kuhjoch section, Austria (Hillebrandt et al., 2013); Hungary (Monostori and Tóth, 2014); sample G11, Killik Formation, Tavusçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. As shown by the synonym list, this species has a complex taxonomic history in regards to its generic placement. It was originally attributed to the genus *Monoceratina* Roth, 1928, by Urlichs (1972) and later alternatively re-attributed to the genera *Triceratina* Upson, 1933, and *Tuberoceratina* Gründel and Kozur, 1972. Recently, Whatley and Boomer (2000, p. 144) reviewed the systematics of the early Cytheruridae and concluded that this species is a member of the genus *Judahella* Sohn, 1968. The present record is the oldest occurrence of *Judahella fortenodosa* (Urlichs, 1972).

Order PLATYCOPIDA Sars, 1866
Subclass MYODOCOPA Sars, 1866
Order MYODOCOPIDA Sars, 1866
Superfamily POLYCOPOIDEA Sars, 1866
Family POLYCOPIDAE Sars, 1866Genus POLYCOPE Sars, 1866

Type species. *Polycope orbicularis* Sars, 1866 by original designation.

Polycope cincinnata Apostolescu, 1959
Figure 6.11

v. 1970b   *Polycopsis hungarica* Kozur; p. 407, pl. 3, fig. 12.

v. 1971   *Polycopsis cincinnata* (Apostolescu); Bunza and Kozur, p. 15, pl. 2, figs. 10, 11.

v. 1972   *Polycope cincinnata* Apostolescu; Urlichs, p. 696, pl. 4, fig. 13.

v. 2013   *Polycope cincinnata* Apostolescu; Monostori and Tóth, p. 307, pl. 1, fig. 3.

v. 2014   *Polycope cincinnata* Apostolescu; Mette, Honigstein and Crasquin, pl. 1, fig. 2.

v. 2017   *Polycope cincinnata* Apostolescu; Forel, Tekin, Okuyucu, Bedi, Tuncer and Crasquin, p. 36, 37, fig. 24E, F.

Material examined. One complete right valve (INV 2018.8).

Dimensions. L = 460 µm, H = 470 µm.

Range. Middle Anisian, Middle Triassic (Kozur, 1970b); Anisian, Middle Triassic (Bunza and Kozur, 1971); upper Norian, Upper Triassic (Urlichs, 1972); Ladinian, Middle Triassic (Monostori and Tóth, 2013); Middle Anisian, Middle Triassic (Mette et al., 2014); *Tetraporobrachia haeckeli* radiolarian Zone, Julian, Middle Carnian, Late Triassic (Forel et al., 2017); *Spongotortilispinus moixi* radiolarian Zone, lower Tuvalian, Upper Carnian, Late Triassic (this work).

Occurrence. Felsöörs, Hungary (Kozur, 1970b); Austria (Bunza and Kozur, 1971); Kössen, Austria (Urlichs, 1972)*;* Litér quarry, Hungary (Monostori and Tóth, 2013); Riefling Formation, Austria (Mette et al., 2014); Kilek section, Tavuşçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey, Huğlu Tuffite (Forel et al., 2017); sample G11, Killik Formation, Tavuşçayiri Block, Sorgun Ophiolitic Mélange, southern Turkey (606066/4084886), Huğlu Tuffite (this work).

Remarks. The species *Polycope cincinnata* Apostolescu, 1959 is common and widespread in the Jurassic. For the sake of brevity, we follow Forel et al. (2017) and do not report all of its Jurassic occurrences but rather focus on its Triassic roots.

OSTRACOD DIVERSITY AND STRATIGRAPHIC RANGE

The sample G11 was processed for radiolarian analysis (Moix et al., 2007; Kozur et al., 2007a, 2007b, 2007c, 2009; Ozsvárt et al., 2015; 2017a, 2017b) and provided a moderately abundant assemblage of silicified ostracods belonging to 29 species, 16 genera and seven families (Table 1). Bairdiidae strongly dominate the assemblage with 23 species and 10 genera (*Acratia, Bairdia, Bairdiacypris, Dicerobairdia, Isobythocypris, Medwenitschia, Mirabairdia, Nodobairdia, Petasobairdia,*

Ptychobairdia). Each of the six remaining families is represented by one monotypic genus: Bythocytheridae (genus *Nemoceratina*), Cavellinidae (genus *Bektasia*), Cytherellidae (genus *Leviella*), Cytheruridae (genus *Judahella*), Healdiidae (genus *Ogmoconcha*) and Polycopidae (genus *Polycope*). The genus *Microcheilinella* is mentioned by Masset and Moix (2004) as part of the assemblage in G11, without illustration, and is not found here.

The present assemblage records the oldest known occurrence of the genus *Medwenitschia* that was previously documented from the Upper Norian (Kristan-Tollmann, 1971) to the Rhaetian (Kollmann, 1960, 1963). It is additionally the first Carnian record of *Nemoceratina* (*Nemoceratina*), which was reported from the Anisian-Ladinian and Norian (Kozur, 1970b; Kozur and Mostler, 1971; Bunza and Kozur, 1971). Two of the species reported here were only known from the ostracod assemblage extracted from the Kilek section of Julian age, *Tetraporobrachia haeckeli* Zone, which is also located in the Tavuşçayiri Block: *Bairdiacypris sorgunensis* Forel sp. nov. (Figure 4.11) and *Isobythocypris*? cf. *postera* (Herrig, 1979a) in Forel et al., 2017 (Figure 4.14). Five other species were previously known from the Triassic interval and outside Turkey: *Mirabairdia longispinosa, Petasobairdia longispinosa, Ptychobairdia kristanae, Judahella fortenodosa, Polycope cincinnata*. The present assemblage records the youngest occurrences of *Petasobardia longspinosa* and *Mirabairdia longispinosa*, as well as the oldest occurrence of *Ptychobairdia kristanae*. Although *Judahella fortenodosa* is known from the Ladinian through the Rhaetian, we report here the first occurrence of this species in the Carnian and in Turkey.

PALAEOENVIRONMENTAL SETTING

In order to evaluate the environmental conditions and water depth at which the present ostracod assemblage developed, we use the model established by Lethiers and Raymond (1991), based on the proportions of the following ostracod groups: (1) deep-sea taxa developed in cold-water, low-energy environments, which differ morphologically from the neritic forms by their thin tests and/or delicate or long spines, (2) *Bairdia* sensu lato that are inhabitants of euhaline thermospheric waters, (3) other neritic species that are associated with more nearshore conditions. When deep-sea species are more than 50% of the assemblage, the association is very probably reflecting deposition in the bathyal to abyssal zone and *Bairdia* are generally less than 15% of the spe-
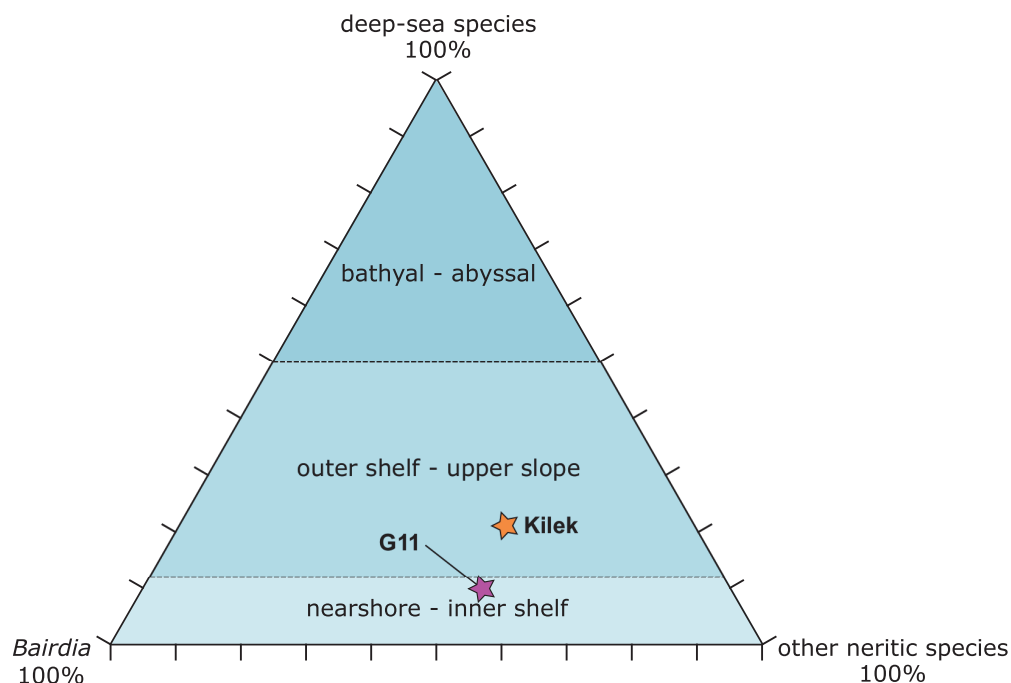
FIGURE 7. Triangular diagram of relative abundance (%) of species and genera of the ostracod assemblage in sample G11 and Kilek section (Forel et al., 2017) (based on Lethiers and Raymond, 1991).

cies. Between 50 and 12% of deep-sea species, the assemblage suggests the outer shelf-upper slope zone, where *Bairdia* are between 15 and 22% of the species. When the deep-sea taxa comprise less than 12% of the species, *Bairdia* are between 15 and 50% and suggestive of a marine, relatively warm and oxygenated platform with euhaline conditions. Where *Bairdia* are from 0 to 15% of the species, the environment is likely more euryhaline and more or less oxygenated (Lethiers and Raymond, 1991). It is worth noting that this model was established using Devonian assemblages, corresponding to different climatic conditions and different ostracod assemblages from the Triassic period. However, increasing data document the persistence of Palaeozoic taxa up to the end of the Middle Triassic (e.g., Crasquin-Soleau and Grădinaru, 1996; Forel and Crasquin, 2011; Sebe et al., 2013) and even to the Late Triassic (Forel et al., 2017). These residual taxa include Palaeocopida and typical deep-sea taxa originally described from most of the Palaeozoic and used for the establishment of the Lethiers and Raymond (1991) model. Their subsistence through the end-Permian extinction and up to the Late Triassic is a strong argument for the stability of the deep-water conditions over this interval, in spite of the drastic climatic modifications. However, the precise conditions, which allowed for such survival, are still

obscure. As a consequence, we chose to use the Lethiers and Raymond (1991) model, supplemented with information on the typical shallow-water Triassic taxa available from previous works.

In the present contribution, deep-sea species are not abundant: *Nemoceratina* (*Nemoceratina*) sp. which is the only representative of the typically deep-sea Bythoceratidae, *Acratia* sp. and *Bairdia* sp. 8 which possess characteristic spinose posterior ends. The *Bairdia sensu lato* group includes all smooth and thin-shelled Bairdiidae: *Bairdia* sp. 1–7, 9, all *Bairdiacypris* and *Isobythocypris* species, in total 11 species. The group of other neritic taxa is composed of 15 species: all thick-shelled sculptured Bairdiidae, *Judahella*, *Ogmoconcha*, *Bektasia*, *Leviella* and *Polycope*.

As a first observation, the extreme abundance of radiolarian specimens indicates blooming in the pelagic environment. The studied limestone level was originally described as a radiolarian micritic limestone intercalated within tuffites. The tuffites represent re-sedimentation, which might be consistent with the occurrence of Bouma sequences. However, until now locally, only calciturbidites (calcarenites) have been observed on the field. Regarding ostracods taxa, deep-sea taxa are 10% of the species, whereas *Bairdia* lato sensu and other neritic species are, respectively, 38% and 52% of the assemblage extracted from the sample

G11 (Figure 7). The presence of shallow-water taxa such as the genus *Bektasia,* which has been described as tolerating important salinity variations, and the species *Judahella fortenodosa*, (Kristan-Tollmann and Hamedani, 1973; Kristan Tollmann et al., 1980), indicates a rather moderately shallow subtidal environment submitted to environmental variations. The occurrence of strong-shelled sculptured Bairdiidae further indicates the influence of hydrodynamism. In modern environments, the genus *Polycope* is interpreted as an opportunistic group indicating organic-rich, fine-grained sediment and high productivity (Karanovic and Brandão, 2016). Although not abundant in the studied sample, the occurrence of this genus tends to indicate that it was deposited under the influence of the open ocean with high productivity. A previous estimate indicated a water-depth of about 150–200 m for the studied assemblage (Masset and Moix, 2004; Moix et al., 2007). Based on the observations and interpretations presented here, this estimate might be slightly high.

THE OLDEST DRILLING TRACE ON OSTRACODS

Ostracods constitute a minor component of the diet of diverse organisms, such as bivalves, gastropods, echinoids, turtles, amphibians, fishes, annelids and other crustaceans including other ostracods (e.g., Lowndes, 1930; Harding, 1962; Reyment, 1966; Robertson, 1988; Penchaszadeh et al., 2004; Costa et al., 2006; Ghioca-Robrecht and Smith, 2008; Leal, 2008; Alcalde et al., 2010; Rossi et al., 2011; Vandekerkhove et al., 2012). Identifiable evidence for the predatory pressure imposed on ostracods in the fossil record is associated with drilling gastropods of the families Naticidae and Muricidae (e.g., Maddocks, 1988; Reyment and Elewa, 2002). The oldest record of such activity on ostracods is of Early Albian, Early Cretaceous age (Maddocks, 1988). Because of the small size of ostracods, they provide an important food source for juvenile gastropods and an alternative nutritive resource when regular prey are lacking (e.g., Reyment, 1967; Maddocks, 1988). Predation on ostracods is most of the time disregarded, but these characteristics make them potential indicators of the dynamics of juvenile predators and of periods of prey impoverishment.

Among the specimens recovered from the sample G11, one complete left valve of the species *Bairdia* sp. 4 displays a drill hole located in the postero-ventral portion of the lateral surface (Figure 4.5). The drill hole is circular in outline and rep-resents the ichnogenus *Oichnus* Bromley, 1981. It was inflicted starting from the outside of the valve and is oriented approximately perpendicular to the surface. The hole is not straight-sided but is parabolic, corresponding to the ichnotaxon *Oichnus paraboloides* Bromley, 1981. The outer borehole diameter (OBD) is 51.4 µm, and the inner borehole diameter (IBD) is 18 µm. The IBD/OBD ratio is of 0.35, which indicates a rather "non-functional" hole when compared to modern drilling activity (Kitchell et al., 1986; see Grey et al., 2005 for discussion on IBD/OBD ratio variations among naticid species). In modern marine environments (e.g., Ansell and Morton, 1987) and laboratory experiments (e.g., Kowalewski, 2004; Dietl and Kelley, 2006), it has been recognized that the ichnospecies *O. paraboloides* is left by predatory gastropods.

There are several possible origins for the observed drill hole. We exclude the hypothesis of organisms seeking for domicile (domichnia) because the boreholes left by such activities should rather be cylindrical, complete with multiple drill holes (Klompmaker et al., 2016). Boring organisms in hard substrates are also not favoured, as they should leave cylindrical and complete boreholes, which may penetrate the shell at an oblique angle. *Oichnus paraboloides* Bromley, 1981, might also be of parasitic origin, but in this scenario multiple holes of small size perpendicular to the surface should be observed (Klompmaker et al., 2016). Ostracods are known as hosts of parasites in recent environments as well as in the fossil record, for other crustaceans (Recent: Vannier and Abe, 1993), ciliates (Early Triassic: Weitschat and Guhl, 1994) or Pentastomida (Silurian: Siveter et al., 2015). The parasitic nature of the ciliates found on the inner part of an ostracod carapace from the Early Triassic of Spitzberg has been discussed (see Klompmaker and Boxshall, 2015). However, the parabolic morphology of the borehole on *Bairdia* sp. 4 excludes the action of a parasite located inside the carapace. Among crustacean parasites, some are known to develop internally while others attach externally but leave minimal lesions of a few microns in diameters. The incomplete borehole on the surface of *Bairdia* sp. 4 and the absence of attachment scars further tend to reject a parasitic origin.

The OBD and IBD of the drill hole is consistent with records from ostracods of younger assemblages (Table 2). To summarize, both the morphology and size of the borehole on *Bairdia* sp. 4 in Forel et al. (2017) from the G11 sample of the Tavusçayırı Block are consistent with a predatory

TABLE 2. Summary of drill holes characteristics on fossil and recent ostracods from the literature, with OBD: outer borehole diameter, IBD: inner borehole diameter. References: [1] Reyment (1963), [2] Bhatia et al. (1989), [3] Reyment et al. (1987), [4] Reyment and Elewa (2002), [5] Hussain et al. (2004), [6] Ruiz et al. (2010) (no information was given on which species were drilled by *O. simplex* and which were drilled by *O. paraboloides*), and [7] Ruiz et al. (2011).

Species	OBD (µm)	IBD (µm)	Ichnospecies	Age	Locality	Reference
Group I	30-200	-	-	-	-	[1]
Group II	250-290	-	-	-	-	[1]
Group III	> 350	-	-	-	-	[1]
Cytherella harudiensis		-				
Alocopocythere transcendens	30-200	-	*O. paraboloides*	Lutetian	Western India	[2]
Paijenborchella trisulcata		-				
Cytherella sylvesterbradleyi	288	-	-	Paleocene	Nigeria	[3], [4]
Leguminocythereis lagaghiroboensis	120	-	-	Paleocene	Nigeria	[3], [4]
Trachyleberis teiskoterlsis	70-90	-	-	Paleocene	Nigeria	[3], [4]
Buntonia livida	282	-	-	Paleocene	Nigeria	[3], [4]
Anticythereis (?) bopaensis	400-490	-	-	Paleocene	Nigeria	[3], [4]
Ovocytheridea pulchra	90	-	-	Paleocene	Nigeria	[3], [4]
Cythereis spp.	71-240	-	-	Santonian	Nigeria	[3], [4]
Veenia fawwarensis	183-374	-	-	Santonian	Israel	[3], [4]
Anticythereis judaensis	427	-	-	Santonian	Israel	[3], [4]
Miocyprideis spinulosa	206	159	*O. paraboloides*	Lutetian	Western India	[5]
-	-	50-500	*O. paraboloides*	Neogene	Spain	[6]
-	-	25-125	*O. simplex*	Neogene	Spain	[6]
Cyprideis spp.	25-80	-	*O. simplex*	Recent	North Africa	[7]
Bairdia spp.	100-150	-	*O. simplex*	Recent	North Africa	[7]

origin. However, no potential predator has been found from this sample, which has only yielded siliceous sponges, radiolarians (Moix et al., 2007; Kozur et al., 2009) and ostracods (this work). Therefore, if a predator produced this trace, it remains unknown, but additional sampling may clarify this issue. At this time, we hypothesize that the origin of this borehole is predatory, as several elements are in line with this possibility. Two preliminary conclusions can be made: first, owing to the size of the drill hole on *Bairdia* sp. 4, it is likely that the culprit was a juvenile; second, since Bairdiidae are epibenthic organisms, the culprit might have been hunting at the sediment surface.

During the Mesozoic, drilling activity is sporadic until the end of the Cretaceous, and it subsequently increased in relation to the rise of Muricidae and Naticidae gastropods (Harper, 2006). The oldest indubitable group that includes drillers is reported from the Valanginian, Early Cretaceous (Kaim, 2004). Triassic occurrences of drill holes are rare, with only unquestionable occur-

rences in the Carnian and Norian (see summary and discussion in Klompmaker et al., 2016). The present report is a new addition to the Triassic record of drill holes and the very first known clue of Triassic drilling activity on micro-organisms.

MESOZOIC VERSUS PALAEOZOIC AFFINITY?

Following the end-Permian extinction that deeply affected marine ostracods worldwide (see Crasquin and Forel, 2014 for a review), the Triassic period is a turning point in their evolutionary history as it shows the shift from the Palaeozoic fauna to the Meso-Cenozoic or modern one. This transition extends from the oldest Meso-Cenozoic representatives in the Wuchiapingian (Late Permian) to the very last Palaeozoic taxa recently discovered from the Julian (Middle Carnian) of the Sorgun Ophiolitic Mélange (*Tetraporobrachia haeckeli* radiolarian Zone; Forel et al., 2017). Palaeocopida were major components of the Palaeozoic ostracod fauna in all types of marine environments (e.g., Becker and

Wang, 1992; Olempska and Blazsyk, 1996). They had been severely hit by the end-Permian extinction and are only residual taxa during the Triassic up to their latest record in the Julian (Middle Carnian) of the Kilek section (Forel et al., 2017). In parallel, the Triassic saw the radiation of the Cypridoidea, Platycopida, sculptured Bairdiidae and Cytheroidea, which were mainly represented by the Bythocytheridae and Editiidae (e.g., Knüpfer, 1967; Gramm and Egorov, 1986; Olempska, 1999) in the Palaeozoic, (see Crasquin and Forel, 2014 and references therein).

The ostracod assemblage obtained from the sample G11 is in line with most of the neritic assemblages of the Late Triassic, in being largely dominated by Meso-Cenozoic taxa. Meso-Cenozoic genera represent 62% of the assemblage (17 species): they include 10 sculptured and two, typically Triassic, Bairdiidae genera (*Bairdia* (*Urobairdia*), *Dicerobairdia*, *Isobythocypris*, *Medwenitschia*, *Mirabairdia*, *Nodobairdia*, *Petasobairdia*, *Ptychobairdia*) and five typical Triassic or Mesozoic monotypic genera (*Nemoceratina (Nemoceratina), Judahella, Ogmoconcha, Bektasia, Leviella*). Palaeozoic-Mesozoic (panchronic) taxa are represented by 10 species: eight *Bairdia* species and two *Bairdiacypris* species. *Acratia* is the only Palaeozoic-Mesozoic genus, which is a common component of both deep and neritic water assemblages in the Early-Middle Triassic (e.g., Kozur, 1970b; Kristan-Tollmann, 1991; Forel and Crasquin, 2011; Forel, 2012; Forel and Grădinaru, 2018) and in the Carnian as well (Forel et al., 2017; Crasquin et al., 2018). Therefore, the G11 assemblage clearly differs from the assemblage of the slightly older Kilek section (*Tetraporobrachia haeckeli* radiolarian Zone) at the Tavusçayiri Block, where Palaeozoic taxa are abundant, witnessing a deep-sea refuge for Palaeozoic taxa up to the Carnian (Forel et al., 2017). One explanation for this discrepancy is that most of the last residual Palaeozoic taxa might have gone extinct between the Julian, *Tetraporobrachia haeckeli* Zone sampled in Kilek, and the Tuvalian, *Spongotortilispinus moixi* Zone studied here (Figure 3). A second possibility

vors because of the shallower water depths compared to the Kilek assemblage. The Julian Kilek assemblage developed in the outer platform-upper slope zone (Forel et al., 2017), representing a slightly greater water depth compared to the G11 assemblage of Tuvalian age. Only high resolution and large-scale sampling will help to clarify these questions and understand if the deep-water refuge was restricted to this peculiar geographical area or a rather widespread phenomenon in the southern part of a Neotethyan sub-basin.

CONCLUSIONS

Silicified ostracods of lower Tuvalian, Late Carnian age (*Spongotortilispinus moixi* radiolarian Zone) have been extracted from the sample G11 of the Tavusçayiri Block in the Mersin Mélange located in southern Turkey. This sample previously provided the best-preserved and most diverse radiolarian fauna of that age worldwide. The ostracod assemblage is composed of 29 species, which represent 16 genera and seven families. The species *Bairdiacyris sorgunensis* Forel sp. nov. is newly described. The environmental affinities of the recovered taxa suggest a moderately shallow subtidal environment subjected to environmental variations indicative of a shallowing upward trend from the Julian to the Tuvalian at the Tavusçayiri Block. We describe and discuss the occurrence of a drill hole at the left valve of *Bairdia* sp. 4, which is likely of predatory origin. It is the oldest known record of predatory activity on marine ostracods. All ostracods from the sample G11 are typical for the Triassic period worldwide and Palaeozoic taxa are missing. This observation implies that the Palaeozoic taxa from the Tavusçayiri Block sequence were either already extinct in the late Carnian or survived only in deeper waters.

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is that the G11 assemblage lacks Palaeozoic survi-

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