BSGF - Earth Sciences Bulletin 2021, 192, 1
© O. Külköylüoğlu *et al.*, Published by EDP Sciences 2021
https://doi.org/10.1051/bsgf/2020037
urn:lsid:zoobank.org:pub:5F46972C-31B8-4500-953C-3CECC0BC5FC0

Special Issue Paleontology, M.B. Forel (Guest editor)

Available online at:
www.bsgf.fr

OPEN ACCESS

Zoogeographical and stratigraphical distribution of the genus *Zonocypris*: Supportive evidence for Anatolian Diagonal and description of a new species from Turkey

Okan Külköylüoğlu[1,*], Mehmet Yavuzatmaca[1], Ozan Yılmaz[1], Cemal Tunoğlu[2], Derya Akdemir[3], Atike Nazik[4] and Alaettin Tuncer[2]

[1] Bolu Abant İzzet Baysal University, Faculty of Arts and Science, Department of Biology, 14280 Bolu, Turkey
[2] Hacettepe University, Faculty of Engineering, Department of Geological Engineering, Ankara, Turkey
[3] University of Cologne, Faculty of Mathematics and Natural Sciences, Institute of Geology and Mineralogy, 50674 Cologne, Germany
[4] Çukurova University, Faculty of Engineering and Architecture, Department of Geology, Adana, Turkey

Received: 25 June 2019 / Accepted: 11 September 2020 / Published online: 22 December 2020

Abstract – Since its first description from Madagaskar, there are about 16 living (Recent) species of the genus *Zonocypris* reported from Afrotropical, Neotropical and Palearctic regions. Similarly, there are about 16 fossil with two (sub)species of the genus known from the Early Cretaceous (*e.g.*, India, France, Russia, China, Brazil) to Holocene (*e.g.*, Albania). Among the species, the only species known with fossil and living species is *Zonocypris costata*. In Turkey, *Zonocypris membranae* with two subspecies (*Z. m. membranae*, *Z. m. quadricella*) is the only fossil species known while living individuals of *Z. costata* were encountered the southeast Anatolia. Additionally, *Zonocypris mardinensis* n. sp. is now proposed as a new species which shows clear differences in the soft body parts (*e.g.*, aesthetasc ya in A1, knife-type G2 claw, shapes of clasping organs and hemipenis) and carapace structure (*e.g.*, LV with extension, RV with posterior denticles). Overall, living species reported herein seem to inhabit comparatively warm (15–30 °C) within the ranges of slightly acidic to alkaline (pH 6.81–8.44) and low to well oxygenated waters (3.05–18.8 mg/l) where they can tolerate salinity (electrical conductivity 103–1910 µS/cm) values within a limited elevational range (336–991 m). Our results suggest that geographic distribution of the living species of the genus is limited within southern parts of Turkey while fossil forms seem to exhibit much wider distribution in northern parts. Anatolian Diagonal as physical barrier may be considered to play a critical role on separating fossil (east-north regions) and extant (southeast region) species of the genus in Turkey. This is the first supportive evidence provided by the species of the genus *Zonocypris* that geographic barrier could have played the main role on its distribution.

Keywords: Early Cretaceous / Recent / *Zonocypris* / new species / ecology / Anatolian diagonal / global distribution

Résumé – Répartition zoogéographique et stratigraphique du genre *Zonocypris* : preuves à l'appui de la diagonale anatolienne et description d'une nouvelle espèce de Turquie. Depuis sa première description à Madagascar, il y a environ 16 espèces vivantes (récentes) du 17 genre *Zonocypris* signalées dans les régions afrotropicales, néotropicales et paléarctiques. De même, il existe environ 16 fossiles avec deux (sous) espèces du genre connu du Crétacé inférieur (*e.g.*, Inde, France, Russie, Chine, Brésil) à l'Holocène (*e.g.*, Albanie). Parmi les espèces, la seule espèce connue avec des espèces fossiles et vivantes est *Zonocypris costata*. En Turquie, *Zonocypris membranae* avec deux sous-espèces (*Z. m. membranae*, *Z. m. quadricella*) est la seule espèce fossile connue alors que des individus vivants de Z. costata ont été rencontrés dans le sud-est de l'Anatolie. De plus, *Zonocypris mardinensis* n. sp. est maintenant proposée comme une nouvelle espèce qui montre des différences nettes dans les parties molles du corps (par exemple, esthetasc ya en A1, griffe G2 de type couteau, formes des organes de serrage et de l'hémipénis) et de la structure de la carapace (par exemple, VG avec extension, RV avec postérieur denticules). Dans l'ensemble, les espèces vivantes signalées ici semblent habiter relativement chaudes (15–30 °C) dans les plages d'eaux

*Corresponding author: kulkoyluoglu_o@ibu.edu.tr

légèrement acides à alcalines (pH 6,81–8,44) et faiblement à bien oxygénées (3,05–18,8 mg/l) où elles peuvent tolérer valeurs de salinité (conductivité électrique 103–1910 mS/cm) dans une plage d'élévation limitée (336–991 m). Nos résultats suggèrent que la répartition géographique des espèces vivantes du genre est limitée dans les parties méridionales de la Turquie tandis que les formes fossiles semblent présenter une distribution beaucoup plus large dans les parties nord. La diagonale anatolienne en tant que barrière physique peut être considérée comme jouant un rôle essentiel dans la séparation des espèces fossiles (régions est-nord) et existantes (région sud-est) du genre en Turquie. Il s'agit de la première preuve à l'appui fournie par l'espèce du genre *Zonocypris* que la barrière géographique aurait pu jouer le rôle principal sur sa distribution.

Mots clés : Crétacé précoce / récent / *Zonocypris* / nouvelles espèces / écologie / diagonale anatolienne / distribution mondiale

1 Introduction

In Turkey, estimated numbers of non-marine ostracods are more than 160 species but this number is certainly an underestimation (Külköylüoğlu *et al.*, 2015). Similarly, Özuluğ *et al.* (2018) listed about 185 (sub)fossil ostracod species limited to Quaternary period but this number is too a very low estimation to show true ostracod species diversity of the country. Turkey, as a big natural bridge, plays an important role among three continents (Asia, Europe, Africa) providing possible corridors and alternative modes of distribution for many species. This is probably one of the reasons of high species diversity found in the country. In contrast, some parts of the country are known to create ecological and/or geographical barriers for some species' populations. The Anatolian Diagonal, a NE-SW-directed high mountain belt ranging from south of Gümüşhane-Bayburt in the northeastern to the Kahramanmaraş in the southwestern part of Turkey where it is bifurcated and/or divided into two branches, namely Amanos Mountains and Taurus Mountains, is an example of such eco/geographical barriers for many plant (Davis, 1971; Ekim and Güner, 1986) and animal species (Çıplak *et al.*, 1993; Rokas *et al.*, 2003; Mutun, 2010). It appears that since late Miocene, the diagonal plays critical role for the distribution of many species (Çıplak *et al.*, 1993; Mutun, 2010; Manafzadeh *et al.*, 2016, Meijers *et al.*, 2020). Most recently, Gür (2016) provided a detailed review on the geographical and geological information of the diagonal. Including historical background information supported by the contemporary studies, he found out supportive evidence that the diagonal along with a steep environmental gradient was actually playing a critical role on species distribution coped with especially in seasonal temperature changes in the area. Accordingly, Anatolian Diagonal seems to be responsible for limiting geographical distribution of many animal and plant species at different genetic levels (Çıplak, 2003; Mutun, 2010; Gür, 2016). Previous studies offered evidences about the eco/geographical (and historical as well) role of the diagonal but there is no study on aquatic invertebrates, especially on ostracod species in the region. Hence, the aims of the present study were to (1) compare the distribution of the fossil and live species of the genus *Zonocypris* worldwide, (2) discuss the first supportive evidence for the role of Anatolian Diagonal by means of using geographical distribution of the genus *Zonocypris*, and (3) describe a new species of the genus *Zonocypris*.

2 Materials and methods

A total of 14 samples (ca. 200 ml sediment) were collected from different water bodies (Tab. 1) with a standard sized hand-net (150 μm mesh size) and fixed in 70% of ethanol in 250 ml plastic bottles *in situ* (Fig. 1). In laboratory, they were washed under tap water and filtered through four different sized sieves (0.5, 1.0, 1.5 and 2.0 mm mesh size) and kept in 70% ethanol. Ostracod specimens were separated from the sediment and hand-picked under a stereomicroscope (Olympus ACH 1X) with pipets. Adult specimens were dissected in lactophenol solution for the species identification, during which both carapace and soft body parts were examined under Olympus BX-51 light microscope. Carapace and/or valves of the dissected specimens were separated from the soft body parts and kept in the micropaleontological slides. Each slide was numbered with the laboratory catalog number. We primarily used the taxonomic key of Karanovic (2012) and some other earlier sources during the identification. Scanning Electron Microscope (SEM) images acquisition of the carapaces and valves were performed with Carl Zeiss EVO-50 type SEM-EDX at the Department of Geological Engineering, Hacettepe University. We keep the samples and slides at the Limnology Laboratory of Bolu Abant İzzet Baysal University, and they can be available upon request from the first author. Six environmental variables (pH, air (Ta, °C) temperature, water temperature (Tw, °C), dissolved oxygen (DO, mg/L), electrical conductivity (EC, μS/cm), and salinity (ppt)) were measured in situ, during which a YSI-Professional Plus device was used (for details see Külköylüoğlu *et al.*, 2015).

All specimens collected from the type locality deposited separately in the vials at the Bolu Abant İzzet Baysal University, Department of Biology, Subdivision of Hydrobiology (Bolu, Turkey).

3 Results

Including the new species described herein, total of 16 live (Recent) species of the genus was reported in here (Tab. 2). Among the species, *Z. costata* is the only species known from both fossil and recent reports. The most northern fossil and Recent (live) records of the genus are so far known from Western Siberia and Turkey, respectively (Figs. 1 and 2). The fossil of the species are generally reported from Miocene to the

Table 1. Ecological variables collected from 14 different sampling sites in Turkey where living taxa of genus *Zonocypris* were reported. Type locality of new species is bold.

St.No.	St. Type	Alt.	T(a)	T(w)	pH	DO	EC	Sal	Sampling date
Adıyaman 10[*]	Spring	991	40.5	15.6	7.53	6.48	565	0.34	16.07.2012
Gaziantep 11[*]	Rheocrene spring	517	40	19.8	7.23		103	0.05	20.07.2010
Gaziantep 16[*]	Rheocrene spring	527	40	20.3	6.81		549	0.28	20.07.2010
Gaziantep 43[*]	River	336	44	30.9	8.30		414	0.20	23.07.2010
Gaziantep 68[*]	Creek	669	43	23	7.35		1910	0.07	29.07.2010
Diyarbakır 23[a]	Creek	832	29.1	18.4	7.07	7.97	476.4	0.20	18.07.2007
Diyarbakır 79[a]	Spring	754	32.6	21.6		8.5	247.1	0.10	13.08.2007
Diyarbakır 80[a]	Water body	762	32.6	28.6		5.72	414	0.20	13.08.2007
Diyarbakır 81[a]	Water body	825	32.6	29.2		6.75	600	0.30	13.08.2007
Hatay 68[*]	Creek	591	31.5	22.7	8.44	8.29	755	0.39	07.08.2012
Mardin 4[**]	Pool	932	38.9	18.1	7.55	9.17	401.8		13.08.2013
Mardin 22[*,b]	Irrigation channel	954	30.9	17.5	7.56	7.51	353.2		15.08.2013
Mardin 61[*,b]	Creek	785	36.7	21.4	7.78	8.53	699		16.08.2013
Mardin 63[*,b]	Pool	941	37.8	20.2	8.29	18.8	484.7		16.08.2013
	Min.	336	29.1	15.6	6.81	5.72	103	0.05	
	Max.	991	44	30.9	8.44	18.8	1910	0.39	
	Mean	749.83	40.8	21.32	7.63	8.01	560.73	0.20	

Abbreviations: Alt.: Altitude (m); T(a): Air temperature (°C); T(w): Water temperature (°C); DO: Dissolved oxygen in water (mg/L); EC: Electrical conductivity (µS/cm); Sal: Salinity (ppt). Note that original sampling sites (St. No.) are shown with the numbers nearby the city name. [*]: *Z. costata*; [**]: *Z. mardinensis* n. sp.; [a]: *Zonocypris* sp.; [b]: *Zonocypris*. cf. sp. Note that *Z.* cf. *costata* was reported from Malatya by Hartmann (1964) but no measurement of water variables was provided.

present while the oldest fossil record (*Zonocypris* sp 1) of the genus seem to be listed from Early Cretaceous (ca. 120 Ma) in Brazil (Do Carmo *et al.*, 2004) (Tab. 3). The youngest fossil record is known from Holocene in Tanzania, Albania, and Ethiopia (Fig. 2). In Turkey, while the fossil taxa are distributed above (northern parts) the Anatolian Diagonal, recent living taxa are apparently located below (southern parts) the diagonal (Fig. 1). *Zonocypris mardinensis* n. sp. displays several characteristics (*e.g.*, presence of extension on RV, carapace ornamentation, numbers of setae on A1 and A2, Mxl, Md-palp, shape of clasping organs, hemipenis etc.) different from the other species of the genus (see details in Figs. 3–6). Although limited with the current knowledge, values of some of those ecological variables suggest that the species of the genus tend to be found in shallow fresh to brackish water bodies where water temperature may range between 15–30 °C in alkaline waters (average pH 7.63). This suggests the fact that the species appears to prefer warm waters. If this is true, such information can be useful tool for paleontological studies to estimate past historical conditions of the habitats.

3.1 Systematics

Subphylum: Crustacea Pennant, 1777
Class: Ostracoda, Latreille, 1802
Order: Podocopida Sars, 1866
Suborder: Podocopina, Müller, 1894
Superfamily: Cypridacea Baird, 1845
Family: Cyprididae Baird, 1845
Subfamily: Cypridopsinae Kaufmann, 1900
Tribe: Zonocypridini Higuti and Martens, 2012
Genus: *Zonocypris* G.W. Müller, 1898

3.2 Diagnosis

In ventral view, carapace globular, ornamented with coarse, concentric ridges. LV overlapping RV. In dorsal view, posterior end rounded, anterior end pointed. Hinge adont. Second antenna four segmented with strong claws. Maxillular palp with cylindrical terminal segment. Uropod absent in males, flagelliform in females.

3.3 Diagnosis

Zonocypris mardinensis n. sp. (Figs. 3–6) urn:lsid:zoobank.org:act:6370E72C-FF47-42B4-9412-5134FA01AAB0

Carapace ventrally slightly concave. LV with an extension posteriorly, RV with fine denticles posteriorly. Ridges on carapace surface circular to oval and thinner. Carapace surface with a few (or without) pits. Posterior end of LV with double list. Asthetasc ya on A1 relatively long, G2 claw not knife-type in males, clasping organs asymmetric in T1 and b-d setae absent in male. Mxl-palp with a claw-like seta on the first section, Md with four smooth bunch of setal group, hemipenis short with lobe a rounded, Zenker Organ with ca. 12 whorls. Uropod flagellum like in females, ramus triangular with a subapical posterior seta (Fig. 6G). Genital organ weakly rectangular shape.

Holotype: One male with soft body parts and carapace dissected and sealed in a slide; valves kept in a micropaleontological slides for SEM photography (Collection number: OK-TR-Mardin: 01-02). Collected from type locality by M. Yavuzatmaca, O. Yılmaz, M. Tanyeri on 13 August 2013.

Allotype: One female with soft body parts and carapace dissected and sealed in a slide

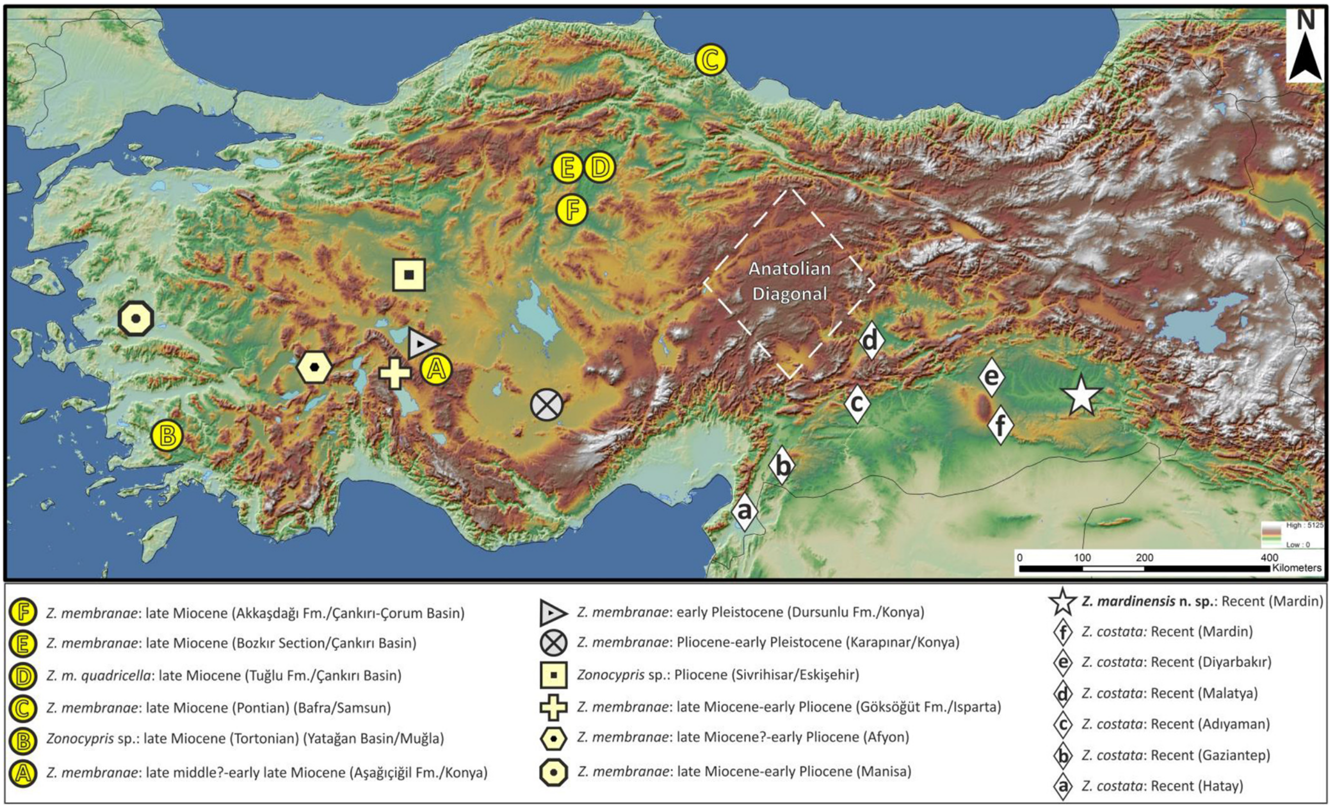

Fig. 1. Digital Elevation Model (DEM) image showing the distribution of the genus *Zonocypris* in Turkey. Anatolian Diagonal (dashed diagonal) represents high mountain ranges (*i.e.*, eco-geographical barrier) between fossil and living species of the genus.

Table 2. List of 16 recent (live) and 16 fossil species of the genus *Zonocypris* G.W. Müller, 1898 in the world.

Living species[***]	Fossil species
Zonocypris alveolata Klie, 1936	*Zonocypris costata* Vávra, 1897
Zonocypris calcarata Klie, 1936	*Z. digitalis* Babinot, 2003
Zonocypris cordata Sars, 1924	*Z. elongata* Schneider, 1963
Zonocypris corrugata Rome, 1965	*Z. expansa* Tian, 1982
Zonocypris costata (Vávra, 1897)	*Z. gujarantensis* Bhandari and Colin, 1999
Zonocypris elegans G.W. Müller, 1898	*Z. jintanensis* Chen, 1982[*]
Zonocypris glabra Klie, 1944	*Z. labyrinthicos* Nagori and Khosla, 2007
Zonocypris inconspicua Schäfer, 1952	*Z. maghrebinensis* Helmdach, 1988[**]
Zonocypris inornata Klie, 1936	*Z. mckenziei* (Raghavan *et al.*, 2007)
Zonocypris laevis Sars, 1910	*Z. membranae* Livental, 1929
Zonocypris lata Rome, 1962	*Z. oliviformis* Huang, 1979
Zonocypris peralta Rome, 1969	*Z. privis Zhao* (Mei-Yu), 1982
Zonocypris pilosa Rome, 1962	*Z. rippeae* Mostafawi, 1994
Zonocypris tuberosa G.W. Müller, 1908	*Z. spirula* Whatley and Bajpai, 2000
Zonocypris uniformis Rome, 1962	*Z. viriensis* Khosla and Nagori, 2005
Zonocypris mardinensis n. sp., this study	*Z. pseudospirula* Khosla *et al.*, 2010

(OK-TR-Mardin: 03-04); valves kept in a micropaleontological slide for SEM photography.

Paratype: Three adult males (OK-TR-Mardin: 05-07) and three females (OK-TR-Mardin: 08-10) dissected and sealed in slides. Twenty three other individuals (6 males, 11 females, 6 juveniles, 3 broken valves) collected from the type locality were kept in 70% ethanol.

Type locality: A shallow (ca. 50 cm) pool in the town Dargeçit, Mardin, Turkey.

N 37°35’621” – E041° 43’084”, ca. 932 m a.s.l.

Fig. 2. Worldwide distribution of the recent (large red star) and fossil (small yellow x) records of the genus *Zonocypris* (for details see Tabs. 2 and 3).

Description of male. A medium-sized ostracod, with oval shape (mean L = 0.62 mm, H = 0.34 mm, W = 0.37 mm; n = 6). Carapace surface with circular ridges (Figs. 3A and 3B). LV larger than RV (Fig. 3E). Greatest height near the centre of the carapace. Anterior end slightly more rounded than posterior end. Valves dorsally slightly arched. Four large and one small muscle scars around the center (Fig. 3D). Marginal ends of carapace without tubercles in external view. In dorsal view, carapace ovoid, posteriorly broadened, anteriorly slightly pointing. In internal view, LV posteriorly with an extension part (Fig. 4A), RV posteriorly with row of fine denticles on calcified inner lamella (Fig. 4B). Calcified inner lamella anteriorly wider (about ¼ of carapace length) than posterior end, double inner list prominent posteriorly. Ventral margin slightly concave. Pore canals with thin seta (Fig. 4E). Hinge-like structure with a weak posterodorsal tooth on LV (Figs. 4A and 4B). Colour of valves opaque to white.

A1 (Fig. 5A): Seven-segmented. First segment ventrally with two well developed long setae slightly plumosed, longer one extending almost the base of the penultimate (6th) segment, shorter reaching to the fifth segment. One dorso-medial seta slightly plumosed on A1 barely reaching to the next segment. Rome or Wouters organs not seen. Second segment broaden with a short dorsal seta about ¼ of the segment. Third segment with a long dorsal-apical smooth seta, reaching end of fifth segment. Fourth segment with two almost equally long smooth dorsal-apical setae and one smooth medium-sized ventral-apical seta extending about to midpoint of sixth segment. Fifth segment with three long dorsal-apical setae and one short ventral-apical smooth setae. Sixth segment with four unequally long and smooth setae. Terminal segment with two very long smooth setae and ya seta about 1/3 of long setae.

A2 (Fig. 5B): Four-segmented. Basal segment with a well-developed long smooth seta, slightly extending t-setae. Exopodial plate with long and two very short smooth setae. Second (first endopodial) segment well-developed, aesthetasc Y with three lobes and placed near middle of segment. Same segment with one long plumosed posteroproximal seta extending to tips of terminal claws. Five long and one short (slightly plumose barely reaching end of same segment) natatory setae present, long setae extending tips of the claws (Fig. 5C). Penultimate (third) segment with two t-setae in medium size, and two unequally long setae anterodorsally. G1 and G2 claws equal in size and well developed, G3 seta-like about half of the claws. Setae z1 claw-like shorter than G2 and G3, z2 and z3 setae thin (length ratio: z2 > z1 > z3). Terminal segment with a well-developed GM, Gm about half of GM and seta-like (length ratio: G1 = G2 > GM > G3 > Gm). Seta y3 twice longer than terminal segments.

Md (Fig. 5D): with a well-developed Md-coxa ending with about 8 coxal teeth and two slightly plumose short setae dorsally. Md palp four-segmented. First segment wider than length, with one long and smooth setae, and S1–S2 setae plumose about size of next two segment, alpha seta short about ¼ of S1. Vibratory plate with six (five almost equally long and one shorter) pappose setae. Second segment externally with three smooth setae (two very long reaching tips of terminal claws, one shorter seta about half of others), and four (3 + 1) medium-sized smooth setae seen internally almost reaching

Table 3. Zoogeographical and geochronological distribution of the species *Zonocypris*. Note that no records from Eocene.

Taxon	Geological age	Location	Reference
Zonocypris? sp.	Early Cretaceous (Aptian-early Albian)	Araripe Basin/Brasil	Do Carmo *et al.*, 2004
Zonocypris? *expansa*	Early Cretaceous (Aptian-Albian)	NE China	Tian and Zhao, 1982
Zonocypris? sp.	Late Cretaceous (late Cenomanian)	Cedar Canyon/Utah	Tibert *et al.*, 2009
Zonocypris sp.	Late Cretaceous	India	Whatley and Bajpai, 2000
Z. digitalis	Late Cretaceous (Campanian)	Auriol/SE France	Babinot, 2003
Z. labyrinthicos	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Nagori and Khosla, 2007
Z. gujaratensis	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Nagori and Khosla, 2007
Z. gujaratensis	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Rathore *et al.*, 2017
Z. spirula	Late Cretaceous	Gujarat/India	Khosla and Nagori, 2005
Z. spirula	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Nagori and Khosla, 2007
Z. spirula	Late Cretaceous (Maastrichtian)	Gujarat/India	Khosla *et al.*, 2009b
Z. viriensis	Late Cretaceous (Maastrichtian)	Gujarat/India	Khosla *et al.*, 2009b
Z. gujaratensis	Late Cretaceous (late Maastrichtian)	Gujarat/India	Bhandari and Colin, 1999
Z. pseudospirula	Late Cretaceous	Maharashtra/India	Khosla *et al.*, 2010
Z. gujaratensis	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Khosla *et al.*, 2011
Z. pseudospirula	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Khosla *et al.*, 2011
Z. spirula	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Khosla *et al.*, 2011
Z. gujaratensis	Late Cretaceous (Maastrichtian)	Madhya Pradesh/India	Kapur *et al.*, 2018
Z. spirula	early Paleocene	Madhya Pradesh/India	Khosla *et al.*, 2009a; Sharma and Khosla, 2009
Z. viriensis	early Paleocene	Madhya Pradesh/India	Khosla *et al.*, 2009a; Sharma and Khosla, 2009
Z. spirula	Paleocene?	Uttar Pradesh/India	Sharma *et al.*, 2008
Z. jintanensis	Oligocene	Jiangsu/China	Hou *et al.*, 1982
Z. maghrebinensis	middle Miocene (Serravalian)	Maghreb/Morocco	Helmdach, 1988
Z. membranae	late middle?-early late Miocene	Aşağıçiğil Fm./Konya, Turkey	Tuncer, 2020
Z. membranae (cf. *Paracypretta*? sp.)	late Miocene (early Tortonian)	Kythira Island/Greece	Mostafawi, 1990
Z. m. quadricella	late Miocene (Tortonian)	Southern Italy	Ligios *et al.*, 2012
Z. membranae	late Miocene (Tortonian?)	Tabriz/NW Iran	Reichenbacher *et al.*, 2011
Zonocypris sp.	late Miocene (Tortonian)	Yatağan Basin/Muğla, Turkey	Becker-Platen, 1970
Z. membranae	late Miocene (middle Pontian)	Romania	Stoica *et al.*, 2013
Z. membranae	late Miocene (middle Pontian)	Romania	Floroiu *et al.*, 2013
Z. membranae	late Miocene (Pontian)	Bafra/Samsun, Turkey	Tunoğlu *et al.*, 1997
Z. m. quadricella	late Miocene	Tuğlu Fm./Çankırı Basin, Turkey	Mazzini, 2011; Mazzini *et al.*, 2013
Z. membranae	late Miocene	Bozkır Section/Çankırı Basin, Turkey	Mazzini, 2011
Z. membranae	late Miocene	Akkaşdağı Fm./Çankırı-Çorum Basin, Turkey	Kayseri-Özer *et al.*, 2017
Z. membranae	late Miocene-early Pliocene	Manisa, Turkey	Witt, 2003
Z. membranae	late Miocene?-early Pliocene	Afyon, Turkey	Demirer *et al.*, 2017
Z. membranae	late Miocene-Pliocene	Göksöğüt Fm./Isparta, Turkey	Tuncer *et al.*, 2017; Tuncer, 2020
Z. membranae	early Pliocene (Dacian)	Serbia	Krstić, 1993, 1995[1]
Z. aff. *membranae*	early Pliocene (Dacian)	Silistra, Bulgaria (Romania Boundary)	Jiříček, 1983
Zonocypris sp.	early Pliocene	Lake Qinghai/NE Tibetian Plateau	Lu *et al.*, 2017

Table3. (continued).

Taxon	Geological age	Location	Reference
Eucypris membranae	Pliocene	Azerbaijan	Agalarova, 1956
Z. m. membranae	Pliocene (Levantian)	Bulgaria	Stancheva, 1966
Z. m. quadricella	Pliocene (Levantian)	Bulgaria	Stancheva, 1966
Zonocypris sp.	Pliocene	Sivrihisar/Eskişehir, Turkey	Tunoğlu *et al.*, 1995
Z. membranae	Pliocene	Turfan/NW China	Huanga *et al.*, 2004
Z. membranae (cf. *Virgatocypris* sp.)	Pliocene	Israel	Rosenfeld *et al.*, 1981
Z. membranae	Pliocene	Uzbekistan and Turkmenistan	Mandelstam and Schneider, 1963
Z. m. quadricella	Pliocene	Pannonian Plain (Serbia)	Krstić, 2006
Z. elongata	Pliocene	Uzbekistan	Mandelstam and Schneider, 1963
Z. membranae	late Pliocene	Caspian Basin	Krijgsman *et al.*, 2019
Zonocypris sp.	late Pliocene	Kos and Evia Islands/Greece	Mostafawi, 1988, 1994a
Z. membranae	late Pliocene (Dacian-Romanian boundary)	Romania	Olteanu, 1995[1]
Z. membranae	Pliocene-early Pleistocene	Karapınar/Konya, Turkey	Beker *et al.*, 2008
Z. membranae	Pliocene-early Pleistocene	Western Siberia	Kazmina, 1975
Z. membranae	late Pliocene-early Pleistocene (Romanian)	Romania	Van Baak *et al.*, 2015
Z. membranae	late Pliocene-early Pleistocene (Romanian)	Caspian Basin	Olteanu and Jipa, 2006
Z. m. quadricella	late Pliocene-early Pleistocene (Piacenzian-Gelasian)	Central Italy	Spadi *et al.*, 2019
Z. rippeae	late Pliocene-Late Pleistocene	N-Peloponnes, Griechenland	Mostafawi, 1994b
Z. membranae	Pliocene-Pleistocene (Dacian-Romanian)	Caspian Basin/Azerbaijan	Van Baak *et al.*, 2013
Z. membranae	late Pliocene-early Pleistocene (Akchagilian)	Grozny/Chechen Republic	Suzin, 1956[2]
Z. oliviformis	early Pleistocene	Qinghai/China	Huang, 1979
Z. mckenziei	early Pleistocene	India	Raghavan *et al.*, 2007
Z. costata	early Pleistocene	India	Raghavan *et al.*, 2007
Z. membranae	early Pleistocene	Dursunlu Fm./Konya, Turkey	Tuncer, 2020
Z. costata	Pleistocene	Kashmir Valley/NW India	Singh, 1977
Z. cf. *costata*	Pleistocene	Benot Ya'akov Fm./Israel	Kalbe *et al.*, 2015
Z. cf. *costata*	early-Middle Pleistocene transition	Lake Hula/Israel	Mischke *et al.*, 2014
Z. membranae	Late Pleistocene	Western Siberia	Konovalova, 2016
Zonocypris sp.	Late Pleistocene	Western Siberia	Konovalova, 2016

Note to cross-references for [1]Witt (2003); [2]Reichenbacher *et al.* (2011).

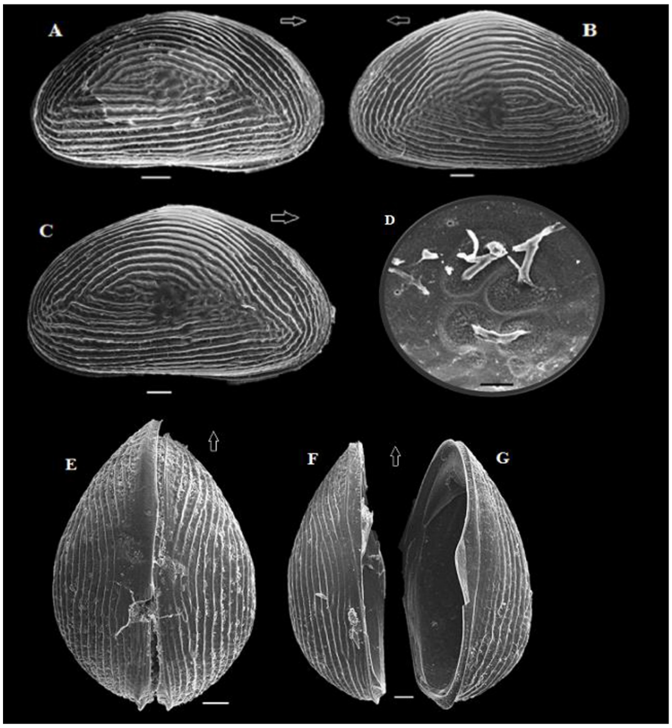

Fig. 3. *Zonocypris mardinensis* n. sp. A) external view of RV and B) LV, C) external view of RV, D) internal view of muscle scars, E) dorsal view, carapace, F) ventral view of RV, and G) LV. Male (A, B, D, E), Female (C, F, G). Scale: 50 μm for A, B, C, E, F, and 20 μm for D.

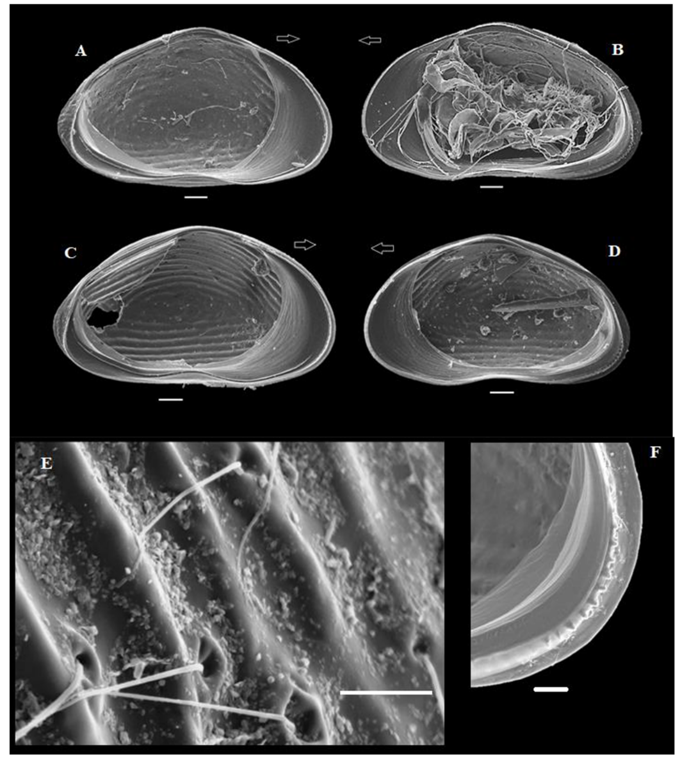

Fig. 4. *Zonocypris mardinensis* n. sp. A) male, internal view of LV and B) RV, C) female, internal view of LV and D) RV, E) pore openings with seta in male from Gaziantep, F) posterior end of RV with denticles in female from Diyarbakır. Scale bar: 55 μm for A–D, 45 μm for E, 20 μm for F.

tips of terminal claws, beta seta short and plumose. Penultimate (third) segment with four equally long and smooth extero-lateral setae barely reaching tips of terminal claws and four (3 + 1 gamma) equally long and smooth setae intero-distally, two other smooth setae (one long and one short) seen distally. Terminal segment (slightly longer than width) with one very strong and smooth claw in middle, and two almost seta-like claws, one very short seta, all smooth. Claw and setae not fused with terminal segment.

Mxl (Fig. 5E): with Mxl palp, three endites and vibratory plate with 14 plumose setae; base of first endite with two unequally long and slightly plumose setae, and with five well developed setae terminally, second endite with three setae and one almost bristle-like seta. Third endite with three claw-like plumose, and two smooth setae. Mxl palp with two segments; first segment with four equally long smooth setae, one claw-like plumose, and one long smooth setae, second (terminal) segment rectangular in shape, with four smooth claw-like setae. Distal segment of Mx1-palp elongated, ca 2× as long as basal width.

Rake-like organ (Fig. 6D): small with about 6-7 very small teeth.

T1 (Figs. 5F and 5G): Transformed into clasping organs. Left and right palps asymmetric with well-developed fingers. Right finger wide, hook-like, lower part with a long tongueshaped extension and a short a seta (Fig. 5F). Left finger, hook-like and slender, lower part of trunk ending with a long pointing process (Fig. 5G). Vibratory plate with five medium sized plumose setae. One short a seta present, others (b, c, d) setae absent (diagnostic character). Masticatory process with 8 almost equally long smooth setae.

T2 (Fig. 5H): Five-segmented with a medium-sized d2 basal seta, d1 seta absent, e-g setae plumosed (length ratio: e > f > g), g seta half of seta e. Terminal segment with one short h3 and h1 setae (both smooth) and h2 long claw-like.

T3 (Fig. 6A): Three-segmented (penultimate segment undivided). First segment with three slightly plumose (dp > d1 = d2) setae; dp seta barely reaching to the end of next segment.

Seta e about half of the segment, f seta short about half of seta e. Terminal segment with hook-like pincer organ, h2 short and curved, h3 seta slightly plumose, long about length of penultimate segment.

Zenker organ (Fig. 6B): with 12 whorls of spines, ending with 12-14 corrugated opening.

Hemipenis (Fig. 6C): Lobe a (outer lobe) short with a rounded end. Lobe b (inner lobe) broadly rounded. Medial lobe (lobe h) with nose-shaped expansion directed inwardly.

Etymology. The species is named by adding the suffix -ensis to the type locality (Mardin).

Accompanying taxa. *Ilyocypris* sp.

Description of female. Female similar in shape and size (mean L = 0.59 mm, H = 0.35 mm, W = 0.37 mm; n = 6) to male (Figs. 3C, 3F, 3G, 4C, 4D, 4E).

A2 (Fig. 6E): Four-segmented. First and second segments similar to male in size and length. This part is at least twice longer in males than females. Second segment with one long (two setae in male) well developed plumose posteroproximal

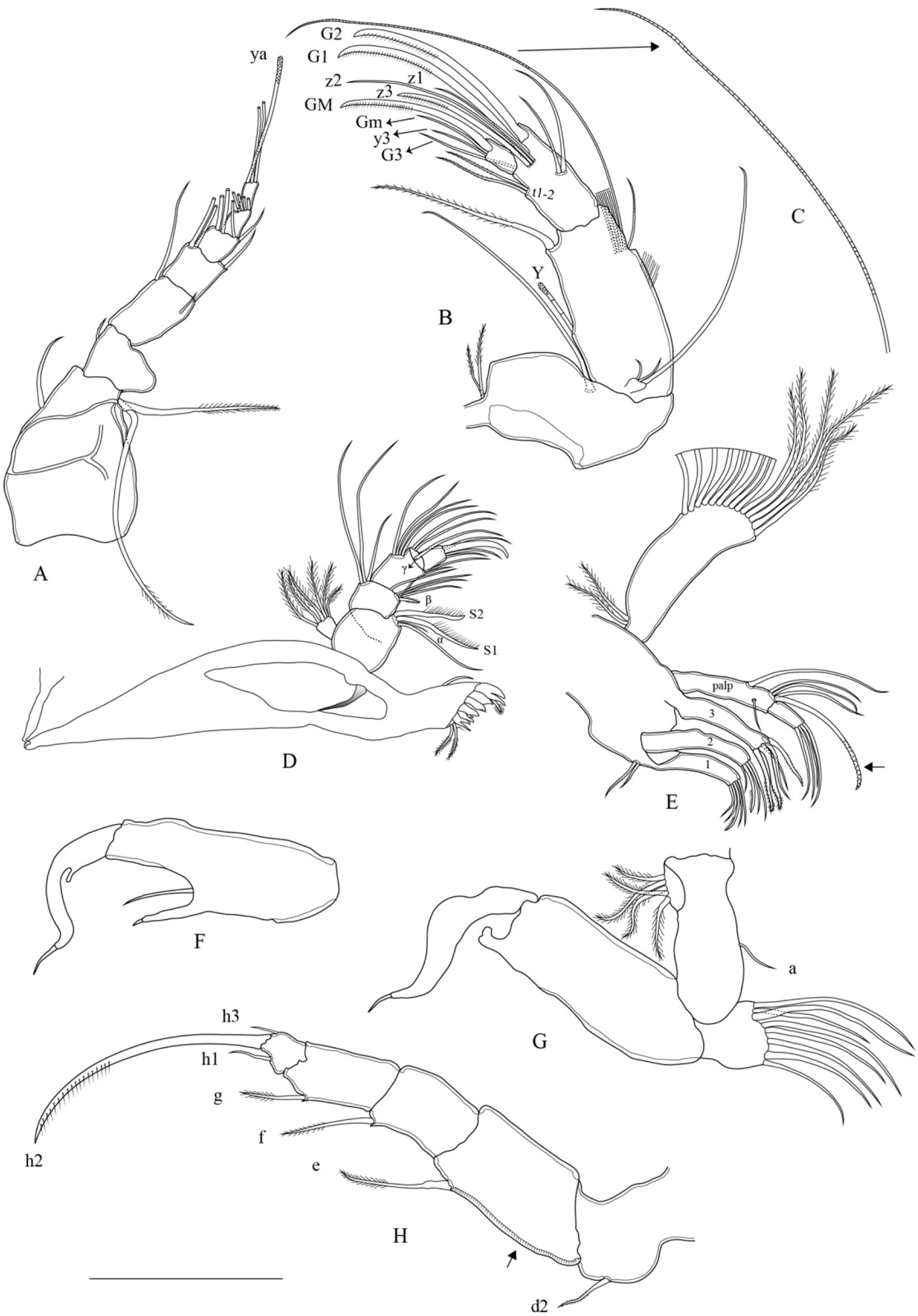

Fig. 5. *Zonocypris mardinensis* n. sp. A) Male, antennule (A1), B) antenna (A2), C) swimming setae detail, D) mandible (Md), E) maxillule (Mx1), F) left clasping organ of T1, G) T1 with right clasping organ, H) second thoracopod (T2, walking leg). Scale: 80 μm for A, B, D, E, H; 40 μm for C, F, G.

seta extending to tips of terminal claws. Penultimate (third) segment with three t-setae (two t-setae in male) in medium size, and two unequally long plumose setae anterodorsally. G1 and G2 claws well developed, G3 seta-like about ¾ of other claws. G2 very strong knife-shaped (normally shape in male). Setae z1-3 seta-like about length of G2, z3 slightly shorter than z1 and z2. Terminal segment with a smooth GM claw, Gm about z3 seta (length ratio: G1 ≈ G2 > GM ≈ G3 > Gm). T1 (Fig. 6F) normally developed with three endopodial setae (h2 > h1 > h3), h2 seta very long and plumose almost equal to length of all T1. Five short and plumose vibratory setae present in T1, seta a smooth, very short and thin, seta b not seen clearly

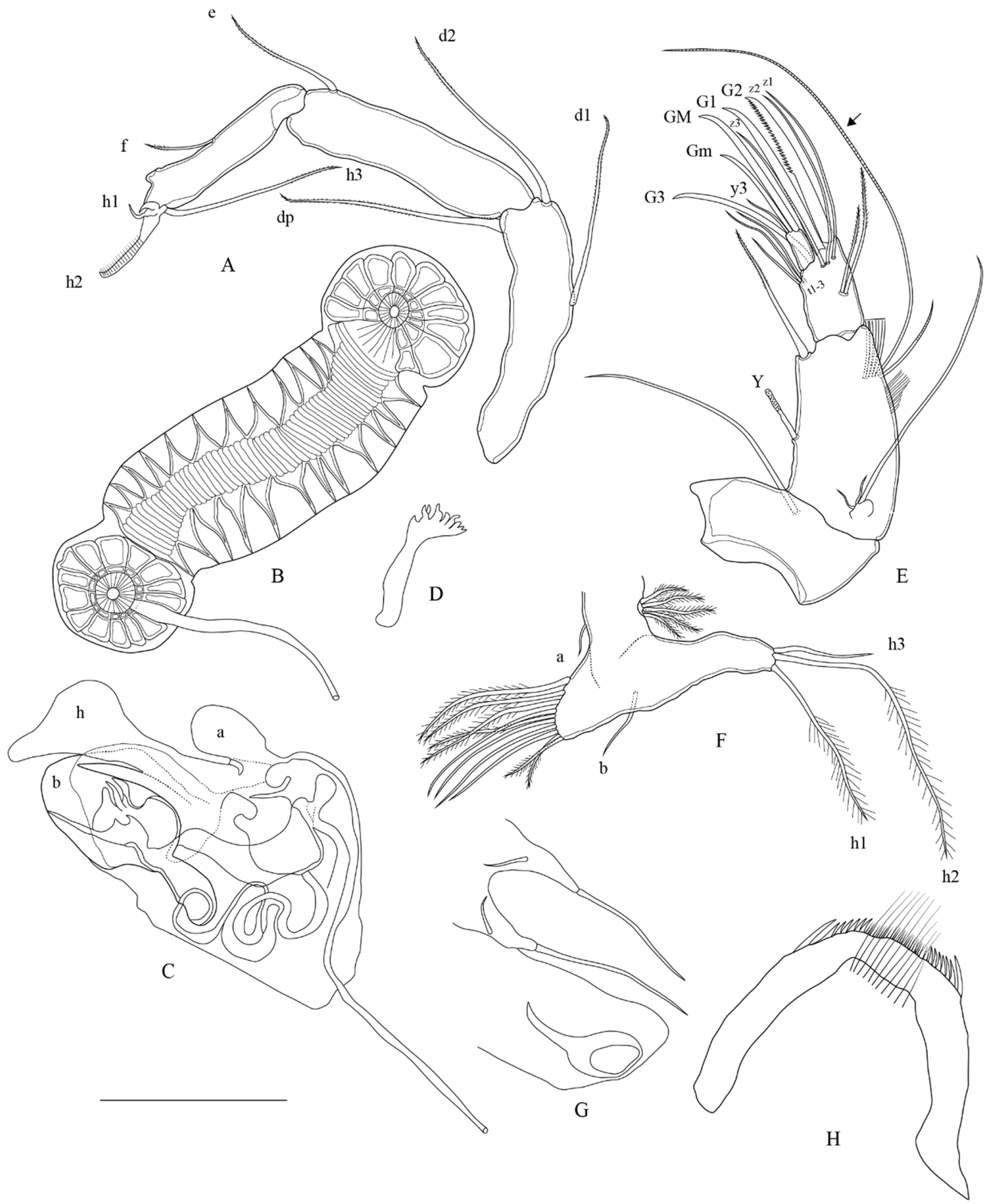

Fig. 6. *Zonocypris mardinensis* n. sp. A) third thoracopod (T3, cleaning leg), B) Zenker organ, C) hemipenis, D) rake-like organ, E) antenna (A2), F) first thoracopod (T1), G) uropod or furca with genital lobe of female, H) labium. A–D, male; E–H, female. Scale: 80 μm for A, E, F; 40 μm for B, C, H; 10 μm for D, G.

(b-c-d setae absent in males). Masticatory process short, distally with 8 + 2 plumose setae. Uropod flagellum like with a triangular ramus and a subapical posterior seta (uropod absent in males) (Fig. 6G). Genital organ smooth weakly rectangular shape (Fig. 6G). Labium (Fig. 6H) wide with short spine-like teeth and medium-sized setae.

4 Discussion and conclusion

4.1 Paleobiogeography and biogeography of *Zonocypris*

Among the fossil taxa of the genus *Zonocypris*, *Z. membranae* is the only fossil species reported from late middle?-early late Miocene to early Pleistocene in Turkey and some other countries in Europe, Africa, Asia and Caucasian region including Russia (Siberia, Crimea), Azerbaijan) and Iran (NW Iran, Tabriz Basin) (Tab. 3). Living populations of the species are not known. In contrast, extant (and fossils as well) populations of *Z. costata* are common from African countries including Tanzania, Zimbabwe, Mozambique, Kenya, Malawi, and Pliocene forms of Ethiopia, as well as Madagascar (*e.g.*, see Müller, 1898; Sars, 1910; Brehm, 1911; Delachaux, 1919; Klie, 1933; Lindroth, 1953; Fryer, 1957; Carbonel and Peypouquet, 1979) while distribution of fossil species is limited in Europe (see Cabral *et al.*, 2004). According to McKenzie (1971) *Z. costata* was also known from the Isle Aldabra. Comparing to other species (see *e.g.*, Mischke *et al.*, 2014; Kalbe *et al.*, 2015), *Z. costata* seems to be the only species with live and (sub)fossil species known from the world. For example, samples gained from about 100 cm long sediment core from Lake Oloidien (Kenya) located at 1885 m. a.s.l. included *Z. costata* whose live specimens were also known from ponds and lakes in western Uganda and central Kenya (Verschuren, pers. comm., and see details in Rumes *et al.*, 2016). Although the members of the genus, either live or fossil species, are known from many other continents, it is interesting to note that the genus has not been reported from North America, and no fossil forms known from Australia yet.

4.2 Biogeographical separation and ecology

Live individuals of *Z. costata* and *Zonocypris* spp. are known from six provinces (*e.g.*, (Adıyaman, Diyarbakır, Gaziantep, Mardin, Malatya and Hatay) in Turkey where they are all located below the Anatolian Diagonal. Hartmann (1964) was the first to report living females of the species from a river basin in Gaziantep and from ponds near a spring in Malatya (Turkey). Such finding inhere appears to be a good supportive evidence for inquiring the role of the diagonal on species distribution not only for the recent forms but also for the distribution of the fossil forms. As far as we know, this is probably the first report of a non-marine invertebrate species subjected to comparison for both fossil and recent geographical distribution of the members of the genus *Zonocypris*, meaning that below and above the diagonal. Accordingly, it can be seen that while fossil taxa are widely distributed above the diagonal, extant (living) taxa are restricted to the areas below it. From the global perspective, this actually corresponds to the northernmost occurrences of the fossil taxa of the genus when living species are much common in southern parts of the world. Up to now, including *Z. mardinensis* n. sp., there are two (or three) living species of the genus known from Turkey. Schäfer (1952) providing some line drawings of the soft body parts described *Z. inconspicua* from a pool in the central dry steppe of Turkey but since then the species has not been reported from other parts of the region. Besides, although Schäfer (1952) mentioned about the name "Ilgar-Sea" or "Ilgar Lake", it should be noted that we have failed to find any water bodies in the region called by Schäfer as "Ilgar Lake". Therefore, we were not able to find type locality of *Z. inconspicua*. We are also aware of the fact that repository of the type materials of the species is also not known (Scharf, pers. comm.). Karanovic (2012, p. 203) provided coordinates (37°09'N 38°13'E) for Ilgar Lake in Turkey. This coordinate is located in the town of Birecik, Şanlı Urfa (Turkey) that the site of Anatolian Diagonal. However, because of such uncertainties about the type locality of the lake, presence of *Z. inconspicua* is not clearly known and deserves further investigation. Considering such clear cut on the species distribution above the diagonal for fossil and below it for living species can be deduced in at least two possible explanations as ecological-geographical and/or temporal-historical ways. In ecological explanation, from the contemporary studies, we know that the species of the genus tend to be found from variety of warm and relatively shallow fresh to brackish aquatic habitats (*e.g.*, littoral zone of lakes, ponds, springs, creeks etc.) located from about sea level up to about 1000 m a.s.l. (this study). The Anatolian Diagonal consisting of high mountain ranges is shown to create a physical barrier for many species (Davis, 1971; Çıplak, 2003; Mutun, 2010; Gür, 2016; Manafzadeh *et al.*, 2016; Mutun, pers. comm.). Thus, it is possible that species of the genus have not been able to pass through high mountain ranges and reach to the west-northern parts of Anatolia. Such a barrier basically creates geographical and ecological limits for species dispersion. Synthesis of this view for individual species (*i.e.*, *Zonocypris mardinensis* n. sp.) may highlight the importance of species ecological tolerances to different aquatic conditions. For example, changes in geographical (*e.g.*, elevation) conditions can eventually be effective on changes in water conditions, simply temperature decreases with increasing elevation. Thereby, air temperature differences, for example, at high altitudes can be effective on species survival probabilities. During our study, mean values of water temperature and pH where the new species found were about 22 °C (15–31 °C) and 7.63 (6.81–8.44), respectively. These values are found in accordance with the measurements of Martens *et al.* (1996) in different shallow water bodies of Verlorenvlei (Western Cape, South Africa) where two other members of the genus (*Z. cordata* and *Z. tuberosa*) were found from wet season within the ranges of water temperature (21–27 °C), (pH 6.9–7.7), and electrical conductivity (3230–4340 μS/cm). These results imply that the species are not able to tolerate (or prefer) cold waters. If so, these species with such preference for warm waters are not supposed to survive in cold waters at high mountain ranges lined up on the Anatolian Diagonal. In another example, Külköylüoğlu *et al.* (2015) reported a new species, *Gomphocythere besni*, from a man-made pool in Adıyaman province located in the south-eastern part of Anatolia, below the diagonal. Species of the genus *Gomphocythere* are mostly known from Afrotropical region but *G. besni* is the only species known with the most northern distribution. Besides, there is only one fossil Holocene species *G. geareyi* Boomer (2010) described from Kahramanmaraş region (Boomer and Gearey, 2010), and later reported from Pleistocene materials of Adıyaman region of Turkey (Karayiğit *et al.*, 2016). Similarly, type locality of *G. geareyi* was also located below the diagonal. Up to now, no other live or fossil of the genus have been reported from western or upper parts of the diagonal. Külköylüoğlu *et al.* (2015) pointed out that ecological barrier (*e.g.*, temperature differences due to geographical constraints related to the Anatolian Diagonal) could have been played important role on species distribution since species with African origin preferred relatively warm waters and have not been able to pass through the other side of the high mountain ranges of the diagonal. Although these studies favor critical role of the diagonal, due to lack of ecological information about many ostracod species, this view needs to be confirmed with future studies.

In temporal/historical explanation: This is another way to explain limited distribution of the species below (southern parts) and above (northern parts) of the diagonal. It is just a manner of time. Hence, species of the genus *Zonocypris* have not been able to reach to the northern part of the diagonal. It means that if the conditions are suitable, species may survive above the diagonal. We argue that it is now evidenced that Anatolian Diagonal has been playing critical role on geographical distribution of several (if not many) different taxonomic groups (see above) from south to northern parts of Turkey. Although such studies are diverse, the present study provides the first evidence of the relationship between fossil and live species of the genus *Zonocypris* along with their historical distribution.

As stated above, the genus seems to be mostly related to warm and shallow fresh to brackish water bodies. Including the new species, total of 16 living (but consider about the situation for *Z. inconspicua*) and 16 fossil species of the genus is now reported in the present study. Among the species, *Z. costata* was the only species known from both fossil (from early Miocene) and recent reports. The most northern fossil and living records are known from Western Siberia and Turkey, respectively. The fossil *Zonocypris* were generally reported from Miocene to the present while the oldest fossil (*Zonocypris*, sp 1) seems to be listed from Early Cretaceous (ca. 120 Ma) in Brazil. The youngest fossil record is known from Holocene in Tanzania, Albania, and Ethiopia. Since taxonomic position of this taxon (*Zonocypris* sp 1) from Brazil has not been confirmed at species level, one may subjectively and cautiously consider excluding the presence of the fossil species from Brazil. Indeed, if this is true, fossil distribution of the species would only be limited within the countries in Africa, Asia and Europe. This approach based on supportive fossil and recent records may also explain limited geographical distribution of the genus.

4.3 Systematic position

We propose *Zonocypris mardinensis* n. sp., as a new species because of the following morphological differences from the other species of the genus. Basically, comparisons can be made with the other four sexual (*Z. corrugata*, *Z. costata*, *Z. glabra*, *Z. tuberosa*) species. As shown above in the descriptions, *Z. mardinensis* n. sp. is different from these (and other parthenogenetics) species based on differences in carapace structure (*e.g.*, presence of an extension on LV posteriorly, and fine denticles on RV posteriorly) and soft body parts (*e.g.*, A1 (relatively long aesthetasc ya), A2 (G2 claw normal in males, not knife-type), T1 (clasping organs and absence of b-d setae), Mxl (presence of a claw-like seta on the first section of the Mxl-palp, and a claw-like seta on the third endite), Md (presence of $3+1$ smooth bunch of setal group), hemipenis (short and rounded lobe a), Zenker Organ (with ca. 12 whorls). As much as these differences, some other differences can also be found between *Z. mardinensis* n. sp. and *Z. costata*; for instance, ridges are deeper, thicker, and more circular in latter species than the former species. Besides, *Z. costata* is more globular than *Z. mardinensis* n. sp. Extension part is missing on LV of *Z. costata*. Also, *Z. costata* has 17 whorls in Zenker Organ while there are 12 whorls in *Z. mardinensis* n. sp.

Zonocypris mardinensis n. sp. has also some differences with the most common fossil species *Z. membranae*: (i) *Z. membranae* has fine denticles on the inner calcified lamella of RV located anteriorly and postero-ventrally while such denticles are only located posteriorly in *Z. mardinensis* n. sp.; (ii) LV with an extension part posteriorly in *Z. mardinensis* n. sp. This part is missing in *Z. membranae* whose RV (not LV) may have a weakly developed part ventrally; (iii) Ridges on carapace surface are circular to oval and thinner in *Z. mardinensis* n. sp. while they are thicker, deeper and much circular in *Z. m. quadricella*. Note that these ridges are also very much thicker in some other fossil forms (cf. *Z. viriensis*, *Z. gujaratensis*, *Z. spirula, Z. pseudospirula*). There is no or a few pits may be seen on carapace of *Z. mardinensis* n. sp. while pits are prominent in *Z. m. quadricella* (and in *Z. cordata* whose carapace surface lacks the ridges but is only covered with pits); (iv) *Z. mardinensis* n. sp. ventrally slightly concave when ventral margin of the carapace is concave in *Z. m. quadricella*; (v) Double inner list present posterior end of LV in *Z. mardinensis* n. sp. This list is not (or if present, weakly developed) present in *Z. membranae*. Including the new species but questioning the taxonomic status of *Z. inconspicua*, there are now possibly 16 living and 15 fossil species of the genus in the world. Based on the current data available, however, the genus, *Zonocypris*, requires more detailed studies due to several issues in lack of ecological, taxonomic, and geographical knowledge. Future studies are suggested.

Acknowledgements. We thank to Drs. Burkhard Scharf, Claude Meisch, Dinçer Gülen for providing important literature information about the genus *Zonocypris*. Dr. Serap Mutun is thanked for the information about Anatolian Diagonal and her personal communications while Dr. Dirk Verschuren is thanked for the personal communication and sending papers about *Z. costata* from Lake Naivasha and Lake Oloidien in East Africa including western Uganda and central Kenya. We also thank to Caner Diker (Hacettepe University) for his help on preparing Digital Elevation Model (DEM).

References

Agalarova DA. 1956. Microfauna from Productive Beds in Azerbaijan and Red Deposids in Turkmenistan, Turkmen SSR. *Ylymlar Akademiiasy Geol Inst* 190. Ashgabat.

Babinot JF. 2003. *Zonocypris digitalis* (Ostracoda, Crustacea), nouvelle espèce du Fuvélien (Campanien continental) de Provence (sud-est France). *Rev Micropaleontol* 46: 3–9.

Beker K, Tunoğlu C, Ertekin İK. 2008. Pliocene-Lower Pleistocene Ostracoda Fauna from İnsuyu Limestone (Karapınar-Konya/ Central Turkey) and its Paleoenvironmental Implications. *Geol Bull Turk* 51: 1–31.

Becker-Platen JD. 1970. Lithostratigraphische Unterschungen im Kanozoikum Südwest Anatoliens (Türkei), Kanozoikum und Braunkohlen der Türkei. *Beiheft Geol Jahrb* 97: 244.

Bhandari J, Colin JP. 1999. Limnic Ostracodes from the Inter-Trappean Sediments (Uppermost Maastrichtian-Basal Paleocene) near Anjar (Kachchh, Gujarat State), India: Systematics, Palaeoecology and Palaeobiogeographical Affinities. *Rev Micropaleontol* 42: 3–20.

Boomer I, Gearey B. 2010. The occurence of a new species of *Gomphocythere* (Ostracoda, Limnocytheridae) in the Holocene of SE Turkey: the northernmost record for the genus. *J Micropalaeontol* 29: 115–118.

Brehm V. 1911. Einige Beitrage zur Aussereuropaische Entomostrakenfauna. *Archiv für Hydrobiologie* 6: 486–488.

Cabral MC, Colin J-P, Carbonel P. 2004. First occurrence of the genus *Zonocypris* (Ostracoda) in the Pleistocene of Western Europe (Portugal). *J Micropalaeontol* 23: 105–106.

Carbonel P, Peypouquet JP. 1979. Les ostracodes des séries du Bassin de l'Omo. *Bull Inst Géol Bassin d'Aquitaine* 25: 167–199.

Çıplak B. 2003. Distribution of Tettigoniinae (Orthoptera, Tettigoniidae) bush-crickets in Turkey: the importance of the Anatolian Taurus Mountains in biodiversity and implications for conservation. *Biodiversity and Conservation* 12: 47–64.

Çıplak B, Demirsoy A, Bozcuk N. 1993. Distribution of Orthoptera in relation to the Anatolian Diagonal in Turkey. *Articulata* 8: 1–20.

Davis PH. 1971. Distribution patterns in Anatolia with particular reference to endemism. In: Davis PH, Harper PC, Hedge IC, eds. *Plant Life of South-West Asia*. *The Botanical Society of Edinburgh* 15–27.

Delachaux T. 1919. Déscription d'un Ostracode nouveau de l'Afrique portugaise (*Stenocypris junodi* sp.nov.). *Bulletin de la Societé Portugaise pour les Sciences Naturelles* 8: 145–147.

Demirer SS, Tunoğlu C, Tuncer A, Akgün F, Kayseri-Özer MS. 2017. Paleoenvironmental and paleoclimatic interpretations on coal-bearing Dombayova Graben (Western Anatolia): An integrated study of ostracods and palynomorphs. *Abstracts of 18th Paleontology-Stratigraphy Workshop* 43–46.

Do Carmo DA, Rafael RM, Vilhena RM, Tomassi HZ. 2004. Redescrição de *Theriosynoecum silvai e Darwinula martinsi*, Membro Crato (Formação Santana), Cretáceo Inferior, bacia do Araripe, NE, Brasil. *Rev Bras Paleontolog* 7: 151–158.

Ekim T, Güner A. 1986. The Anatolian diagonal: fact or fiction? *Proc R Soc Lond B Biol Sci* 89: 69–77.

Floroiu A, Stoica M, Vasiliev I, Krijgsman W. 2013. Pontian Ostracods From Slanicul De Buzau Section (Eastern Carpathian Foredeep). *Naturalista sicil* S. IV, XXXVII, 1: 131–132.

Fryer G. 1957. Freeliving freshwater Crustacea from lake Nyasa and adjoining waters. 3. General remarks with notes on certain Malacostraca and Ostracoda. *Arch Hydrobiol* 53: 527–536.

Gür H. 2016. Anadolu Diyagonali: Bir Biyocoğrafi Sınırın Anatomisi. *Kebikeç* 43: 177–188.

Hartmann G. 1964. "Asiatische Ostracoden, Systematische und Zoogeographische Untersuchungen-Internationale", Revue der Gesamten Hydrobiologie. *Systematische Beihefte* 3: 1–155.

Helmdach FF. 1988. The ostracode fauna of the Ait Kandoula region, systematic description. In: Jacobshagen VH, ed. *The Atlas System of Morocco*. Berlin: Springer-Verlag, pp. 405–432.

Hou Y, Chen T, Yang H, Ho J, Zhou Q, Tian M. 1982. Cretaceous-Tertiary ostracode fauna from Jiangsu. *Geological Publishing House* 1–298 (in Chinese).

Huang B. 1979. .Report of Combined Investigation into Chinghai Lake Beijing Science Press, pp. 1–270 (in Chinese).

Huanga BC, Wanga YC, Liua T, Yangb TS, Lic YA, Sunc DJ, *et al.* 2004. Paleomagnetism of Miocene sediments from the Turfan Basin, Northwest China: no significant vertical-axis rotation during Neotectonic compression within the Tian Shan Range, Central Asia. *Tectonophysics* 384: 11–21.

Jiříček R. 1983. Redefinition of the Oligocene and Neogene ostracod zonation of the Paratethys. *Miscellanea micropalaeontologica. Knihovnička Zemního Plynu a Nafty* 4: 195–236.

Kalbe J, Mischke S, Dulski P, Sharon G. 2015. The Middle Palaeolithic Nahal Mahanayeem Outlet Site, Israel: reconstructing the environment of Late Pleistocene wetlands in the Eastern Mediterranean from ostracods. *J Archaeol Sci* 54: 385–395.

Kapur VV, Khosla A, Tiwari N. 2018. Paleoenvironmental and paleobiogeographical implications of the microfossil assemblage from the Late Cretaceous intertrappean beds of the Manawar area, District Dhar, Madhya Pradesh, Central India. *Hist Biol* 1–16.

Karanovic I. 2012. Recent Freshwater Ostracods of the World. Berlin, Heidelberg: Springer-Verlag, 608 p.

Karayiğit Aİ, Oskay RG, Tuncer A, Mastalerz M, Gümüş BA, Sengüler I, *et al.* 2016. A multidisciplinary study of the Gölbaşı-Harmanlı coal seam, SE Turkey. *Int J Coal Geol* 167: 31–47.

Kayseri-Özer MS, Karadenizli L, Akgün F, Oyal N, Saraç G, Sen S, *et al.* 2017. Palaeoclimatic and palaeoenvironmental interpretations of the Late Oligocene, Late Miocene–Early Pliocene in the Çankırı-Çorum Basin. *Palaeogeogr Palaeoclimatol Palaeoecol* 467: 16–36.

Kazmina TA. 1975. Stratigrafija i ostracody pliocena i rannego pleistocena yuga Zapadno-Sibirskoj ravninv. [Stratigraphy and Ostracods of the Pliocene and early Pleistocene from the South of the West-Siberian Plain]. *Trudy Instituta Gcologii i Geofiziki, Sibirskoe otdeleni Akademia Nauk SSSR* 264: 1–108 [in Russian].

Khosla SC, Nagori ML. 2005. A restudy of Ostracode fauna from the inter-trappean beds of Anjar, Kackchh District, Gujarat. *J Geol Soc India* 66(5): 573–580.

Khosla SC, Nagori ML, Jakhar SR, Rathore AS. 2009a. Mixed Marine, Brackish Water and Non-marine Microfaunal Association in the Inter-trappean Beds (Early Palaeocene) of Jhilmili, Chhindwara District, Madhya Pradesh. *J Geol Soc Ind* 73: 724–732.

Khosla SC, Nagori ML, Jakhar SR, Rathore AS, Kumari M. 2009b. A Restudy of the Ostracoda *Cypris cylindrica* Sowerby (in Malcolmson, 1840) from the Deccan Intertrappean Beds (Late Cretaceous) of Lakshmipur, Kachchh, Gujarat. *J Geol Soc Ind* 74: 579–584.

Khosla SC, Nagori ML, Jakhar SR, Rathore AS. 2010. Stratigraphical and Palaeoecological Implications of the Late Cretaceous Ostracods from the Lameta Formation of Pisdura, Chandrapur District, Maharashtra, India. *Gond Geol Magz* 25(1): 115–124.

Khosla SC, Rathore AS, Nagori ML, Jakhar SR. 2011. Non-Marine Ostracoda from the Lameta Formation (Maastrichtian) of Jabalpur (Madhya Pradesh) and Nand-Dongargaon Basin (Maharashtra), India: Their correlation, age and taxonomy. *Rev Esp Micropaleontol* 43(3): 209–260.

Klie W. 1933. Die Ostracoden der Rift Tal Seen in Kenia. *Int Rev ges Hydrob Hydrog* 29: 1–14.

Konovalova VA. 2016. Upper Neopleistocene Ostracods from the Southeastern WestSiberian Plain and Their Stratigraphic Significance. *Stratigr Geol Correl* 24: 75–91.

Krijgsman W, Tesakov A, Yanina T, Lazarev S, Danukalova G, Van Baak CGC, *et al.* 2019. Quaternary time scales for the Pontocaspian domain: Interbasinal connectivity and faunal evolution. *Earth-Sci Rev* 188: 1–40.

Krstić N. 1993. Ostracodes from three bore holes of the BGM sheet "Sombor". *Bulletin de l'Institute de Recherches Geologiques et Geophysiques Serie A-B* 45: 55–79.

Krstić N. 1995. Ostracodes of Lower and Middle Paludinian Beds of Fruska Gora s. 1. In: Marinescu F, Papaianopol I, eds. *Chronostratigraphie und Neostratotypen.: Neogene der Zentralen Paratethys IX Dacien*. Verlag Rumänische Akademie, pp. 387–425.

Krstić N. 2006. Pliocene Ostracodes of the Paludinian Beds in Pannonian Plain, Serbian Part. Belgrade: Herald of the Nature History Museum, *Special Publication*, 409 p.

Külköylüoğlu O, Yavuzatmaca M, Cabral MC, Colin J-P. 2015. *Gomphocythere besni* n.sp. (Crustacea, Ostracoda) from a man-made pool (Adıyaman, Turkey). *Zootaxa* 3937: 456–470.

Ligios S, Anadón P, Castorina F, D'Amico C, Esu D, Gliozzi E, *et al.* 2012. Ostracoda and Mollusca biodiversity and hydrochemical features in Late Miocene brackish basins of Italy. *Geobios* 45: 351–367.

Lindroth S. 1953. Taxonomic and zoogeographical studies of the ostracod fauna in the inland waters of East Africa (results of the

Swedish East African Expedition 1948). *Zoologiska Bidrag Fran Uppsala* 30: 43–156.

Lu F, An Z, Chang H, Dodson J, Qiang X, Yan H, *et al.* 2017. Climate change and tectonic activity during the early Pliocene Warm Period from the ostracod record at Lake Qinghai, northeastern Tibetan Plateau. *J Asian Earth Sci* 138: 466–476.

Manafzadeh S, Staedler YM, Conti E. 2016. Visions of the past and dreams of the future in the Orient: the Irano-Turanian region from classical botany to evolutionary studies. *Biol Rev Camb Philos Soc* 9: 1–24.

Mandelstam MI, Schneider GF. 1963. Iskopaemye ostrakody SSSR. Semeistvo Cyprididae. (The fossil Ostracoda of the U.S.S.R.: Family Cyprididae). *Trudy Vsesoyusnogo NauchnoIssledovatelskogo Geologo-Razvedochnogo Neftyanogo Instituta* (VNIGRI) 203: 1–332. [in Russian].

Martens K, Davies BR, Baxter AJ, Meadows ME. 1996. A contribution to the taxonomy and ecology of thr Ostracoda (Crustacea) from Verlorenvlei (Western Cape, South Africa). *S Afr J Zool* 31: 23–36.

Mazzini I. 2011. The genus *Zonocypris* Müller, 1898 (Crustacea, Ostracoda, Cyprididae) from continental Miocene deposits of Central Anatolia (Turkey): palaeoecological and palaeogeographical implications. *Joannea Geol Paläont* 11: 124–125.

Mazzini I, Hudačkova N, Joniak P, Kovačova M, Mikes T, Mulch A, *et al.* 2013. Palaeoenvironmental and chronological constraints on the Tuğlu Formation (Çankırı Basin, Central Anatolia, Turkey). *Turk J Earth Sci* 22: 747–777.

McKenzie KG. 1971. Species list of South African freshwater Ostracoda with an appendix listing museum collections and some further determinations. *Ann S Afr Mus* 57: 157–213.

Meijers MJM, Brocard GY, Whitney DL, Mulch A. 2020. Paleoenvironmental conditions and drainage evolution of the central Anatolian lake system (Turkey) during late Miocene to Pliocene surface uplift. *Geosphere* 16(2): 490–509.

Meisch C, Smith RJ, Martens K. 2019. A subjective global checklist of the extant non-marine Ostracoda (Crustacea). *Eur J Taxon* 492: 1–135.

Mischke S, Ashkenazi S, Almogi-Labin A, Goren-Inbar N. 2014. Ostracod evidence for the Acheulian environment of the ancient Hula Lake (Levant) during the early-mid Pleistocene transition. *Palaeogeogr Palaeoclimatol Palaeoecol* 412: 148–159.

Mostafawi N. 1988. Süßwasser-Ostracoden aus dem Plio-Pleistozän der Insel Kos (Griechenland). *Meyniana* 40: 175–193.

Mostafawi N. 1990. Neogene Ostracoden von Kythira, Griechenland. *Cour Forsch-Inst Senckenberg* 123: 161–179.

Mostafawi N. 1994a. Süßwasser-Ostracoden aus dem Ober-Pliozän von N-Euböa (Griechenland). *Neues Jahrb Geol Paläontol* 5: 309–319.

Mostafawi N. 1994b. Ostracoden aus dem Ober-Pliozän und dem Ober-Pleistozän des N-Peloponnes, Griechenland. *Neues Jahrb Geol P-A* 194(1): 95–114.

Mutun S. 2010. Intraspecific genetic variation and phylogeography of the oak gallwasp *Andricus caputmedusae* (Hymenoptera: Cynipidae): Effects of the Anatolian Diagonal. *Acta Zool Acad Sci Hung* 56: 153–172.

Müller GW. 1898. Ergebnisse einer zoologischen Forschungsreise in Madagaskar und Ost-Afrika 1889–1895 von Dr A Voeltzkow: Die Ostracoden. *Abh Senckenb Naturforsch Ges* 21: 255–296.

Nagori ML, Khosla SC. 2007. Ostracod fauna from the non-marine Inter-trappean bed of Mohgaon-Haveli, Chhindwara District, Madhya Pradesh. *Current Science* 92: 1358–1359.

Olteanu R. 1995. Dacian ostracodes. In: Marinescu F, Papaianopol I, eds. *Chronostratigraphie und Neostratotypen.: Neogene der Zentralen Paratethys IX Dacien*. Verlag Rumänische Akademie, pp. 268–385.

Olteanu R, Jipa D. 2006. Dacian Basin environmental evolution during Upper Neogene within the Paratethys domain. *Geo-Eco-Marina* 12: 91–105.

Özuluğ O, Kubanç NS, Kubanç C, Demirci Gİ. 2018. Checklist of Quaternary and Recent Ostracoda (Crustacea) species from Turkey with information on habitat preferences. *Turk J Biosci Coll* 2: 51–100.

Raghavan P, Pickford M, Patnaik R, Gayathri P. 2007. First fossil small-clawed otter, *Amblonyx*, with a note on some specimens of Lutra, from the Upper Siwaliks, India. *Estud Geol* 63(2): 135–146.

Rathore AS, Grover P, Verma V, Lourembam RS, Prasad GVR. 2017. Late Cretaceous (Maastrichtian) Non-Marine Ostracod Fauna from Khar, a New Intertrappean Locality, Khargaon District, Madhya Pradesh, India. *Paleotol J* 21(3): 215–229.

Reichenbacher B, Alimohammadian H, Sabouri J, Haghfarshi E, Faridi M, Abbasi S, *et al.* 2011. Late Miocene stratigraphy, palaeoecology and palaeogeography of the Tabriz Basin (NW Iran, eastern Paratethys). *Palaeogeogr Palaeoclimatol Palaeoecol* 311: 1–18.

Rokas A, Atkinson RJ, Webster LMI, György C, Stone GN. 2003. Out of Anatolia: longitidunal gradients in genetic diversity support an eastern origin for a circum-Mediterranean oak gallwasp *Andricus quercustozae*. *Mol Ecol* 12: 2153–2174.

Rosenfeld A, Segev A, Halbersberg E. 1981. Ostracode species and paleosalinities of the Pliocene Bira and Gesher Formations (Northwestern Jordan Valley). *Isr J Earth Sci* 30: 113–119.

Rumes B, Van der Meeren T, Martens K, Verschuren D. 2016. Distribution and community structure of Ostracoda (Crustacea) in shallow waterbodies of southern Kenya. *Afr J Aquat Sci* 41: 377–387.

Sars GO. 1910. Zoological results of the third Tanganyika Expedition, conducted by Dr WA Cunnington, 1904–1905. Report on the Ostracoda. *Proc Zool Soc Lond* 54: 732–760.

Schäfer HW. 1952. Über Süsswasser-Ostracoden aus der Türkei. *İstanbul Üniversitesi Fen Fakültesi Hidrobiyoloji Araştırma Enstitüsü Yayınları* Seri B(1): 7–32.

Sharma R, Khosla A. 2009. Early Palaeocene Ostracoda from the Cretaceous Tertiary (K-T) Deccan intertrappean sequence at Jhilmili, District Chhindwara, Central India. *J Paleontol Soc Ind* 54 (2): 197–208.

Sharma R, Bajpai S, Singh MP. 2008. Freshwater ostracoda from the (?) Paleocene-age Deccan intertrappean beds of Lalitpur (Uttar Pradesh), India. *J Paleontol Soc Ind* 53(2): 177–183.

Singh D. 1977. Comments on Some Quaternary Ostracode taxa from Nortwest India. *J Palaeontol Soc Ind* 20: 366–381.

Spadi M, Gliozzi E, Medici MC. 2019. Piacenzian-Gelasian non-marine ostracods from the Dunarobba Fossil Forest (Tiberino Basin, Umbria, Central Italy). *Pap Palaeontol* 5: 391–413.

Stancheva M. 1966. Notes on the stratigraphy and the ostracode fauna from the Pliocene and post-Pliocene in the district of the Silistra. *Bulletin of Strashimir Dimitrov Institute of Geology, Ser Paleontologie* 15: 205–207.

Stoica M, Lazăr I, Krijgsman W, Vasiliev I, Jipa D, Floroiu A. 2013. Paleoenvironmental evolution of the East Carpathian foredeep during the late Miocene-early Pliocene (Dacian Basin; Romania). *Glob Planet Change* 103: 135–148.

Suzin AV. 1956. *Ostrakody tretichnykh otlozhenii Severnogo Predkavkaz'ya* (Ostracods from the Tertiary Beds of Northern Ciscaucasia). Moscow: Gostoptekhizdat, 191 p.

Tian MQ, Zhao MY. 1982. Ostracoda from the Quicheng Formation (Lower Cretaceous) in southern Hebei. *Acta Palaeontol Sin* 21(5): 569–575.

Tibert NE, Colin JP, Leckie RM. 2009. Taxonomy, biostratigraphy and paleoecology of Cenomanian and Turonian ostracodes from the Western Interior Basin, Southwest Utah, USA. *Rev micropaléontol* 52: 85–105.

Tuncer A. 2020. Ostracoda Taxonomy and Biostratigraphy in the Yalvaç and Ilgın Continental Neogene Basins (Southwest Anatolia): Ostracoda-Based Paleoenvironmental and Paleoclimatic Approaches (Unpublished doctoral dissertation). Hacettepe University Graduate School of Science and Engineering, 526 p.

Tuncer A, Karayiğit AI, Oskay RG, Bulut Y, Tunoğlu C. 2017. Preliminary results of Coal Petrology and Micropaleontology studies of the coal-bearing sequence in the Sarkikaraağaç Coal Field, Isparta (Sw Anatolia). In: *70th Geological Congress of Turkey Abstracts*, pp. 268–269.

Tunoğlu C, Temel A, Gençoğlu H. 1995. Pliocene Ostracoda association and environmental characteristics of Sivrihisar (Eskişehir) area, Central Anatolia, Turkey. In: Ríha J, ed. *Ostracoda and biostratigraphy: Proceedings of the Twelfth International Symposium on Ostracoda, 26–30 July 1994*, Prague, Czech Republic. Balkema, Rotterdam, pp. 265–275.

Tunoğlu C, Ünal A, Bilen C. 1997. Doğu Karadeniz kıyısı boyunca Tetis-Paratetis geçişi ve etki alanlarının araştırılması. TÜBİTAK Project Report. 149 p.

Van Baak CGC, Vasiliev I, Stoica M, Kuiper KF, Forte AM, Aliyeva E, *et al.* 2013. A magnetostratigraphic time frame for Plio-Pleistocene transgressions in the South Caspian Basin, Azerbaijan. *Glob Planet Chang* 103: 119–134.

Van Baak CGC, Mandic O, Lazăr I, Stoica M, Krijgsman W. 2015. The Slănicul de Buzău section, a unit stratotype for the Romanian stage of the Dacian Basin (Plio-Pleistocene, Eastern Paratethys). *Palaeogeogr Palaeoclimatol Palaeoecol* 440: 594–613.

Whatley RC, Bajpai S. 2000. Zoogeographical relationships of the Upper Cretaceous nonmarine Ostracoda of India. *Current Science* 79(6): 694–696.

Witt W. 2003. Freshwater Ostracods from Neogene deposits of Develiköy (Manisa, Turkey), *Zitteliana A* 43: 93–108.

Cite this article as: Külköylüoğlu O, Yavuzatmaca M, Yılmaz O, Tunoğlu C, Akdemir D, Nazik A, Tuncer A. 2020. Zoogeographical and stratigraphical distribution of the genus *Zonocypris*: Supportive evidence for Anatolian Diagonal and description of a new species from Turkey, *BSGF - Earth Sciences Bulletin* 192: 1.