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Original article

New Protocytherines (Ostracods) from the Lower Cretaceous sequences of the Crimean Peninsula

Nouveaux Protocytherines (Ostracodes) du Crétacé inférieur de la péninsule de Crimée

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Abstract

One new genus of Ostracoda, *Protobrachycythere* nov. gen. (Protocytherinae, Lyubimova), and two new species, *P. taurica* nov. sp. and *P. aptica* nov. sp., are described from the Barremian and Aptian of the Crimea. Based on the ontogeny of the hinge, *Protobrachycythere* is considered as an ancestor of the *Brachycythere* Alexander, 1933 (Brachycytherinae Puri, 1954). The higher taxonomy of the Subfamily Brachycytherinae is reviewed. It is suggested to assign Brachycytherinae to the Family Brachycytheridae Puri.

Keywords: Ostracoda; Protocytherinae; Brachycytherinae; Barremian; Aptian; Crimea

Résumé

Un nouveau genre d'Ostracodes, *Protobrachycythere* nov. gen. et deux nouvelles espèces, *P. taurica* nov. sp. and *P. aptica* nov. sp., du Barrémien et de l'Aptien de la Crimée sont décrits. Suite à l'étude de l'ontogenèse de la jointure du genre *Protobrachycythere* nov. gen., ce dernier est considéré comme l'ancêtre du genre *Brachycythere* Alexander, 1933 (Brachycytherinae Puri, 1954). La taxonomie supérieure de la sous-famille Brachicytherinae est discutée. On propose d'attribuer la sous-famille des Brachicytherines à la Famille des Brachicytéridès.

Mots clés : Ostracodes ; Protocytherinae ; Brachycytherinae ; Barrémien ; Aptien ; La Crimée

1. Introduction

Although Cretaceous ostracods of the Crimean peninsula (Fig. 1) have been studied for nearly 50 years, additional attention is still required as the various Cretaceous assemblages are studied to different degrees. Berriasian ostracods are studied best (Neale, 1966; Tesakova and Rachenskaya, 1996a, b; Tesakova and Savelieva, 2005; Arkadiev et al., 2006, 2015; Savelieva, 2012, 2014; Savelieva et al., 2014). Berriasian-Valanginian ostracods were published by Rachenskaya (in Druschitz et al., 1968) and Hauterivian ostracods by Savelieva and Shurekova (2014). Papers about Barremian-Albian ostracods include Nemirovskaya (1972) and Karpuk and Tesakova (2013, 2014). There are only two papers about Maastrichtian ostracods of the Crimea (Savelieva, 2000, 2001).

The Subfamily Brachycytherinae is studied quite well, although its higher taxonomy is still uncertain. There are several publications that describe the Brachycytherines (Hartmann and Puri, 1974; Liebau, 1975) and descriptions of the genus *Brachycythere* include Grekoff (1956), Howe (1961a), Van Morkhoven (1962), Kogbe and Me'hes (1986) and Guernet and Bellier (2000). Descriptions of other Brachycytherin genera are provided by Babinot (1973), Gruendel (1977) and Morsi et al. (2011). Species of *Brachycythere* are redescribed by Hazel (1968), Damotte (1988), Rosenfeld and Honigstein (1988), Andreu (1996), Andreu and Tronchetti (1996), Okosun (1992), Morsi (2000) and Morsi et al. (2003). Many other publications

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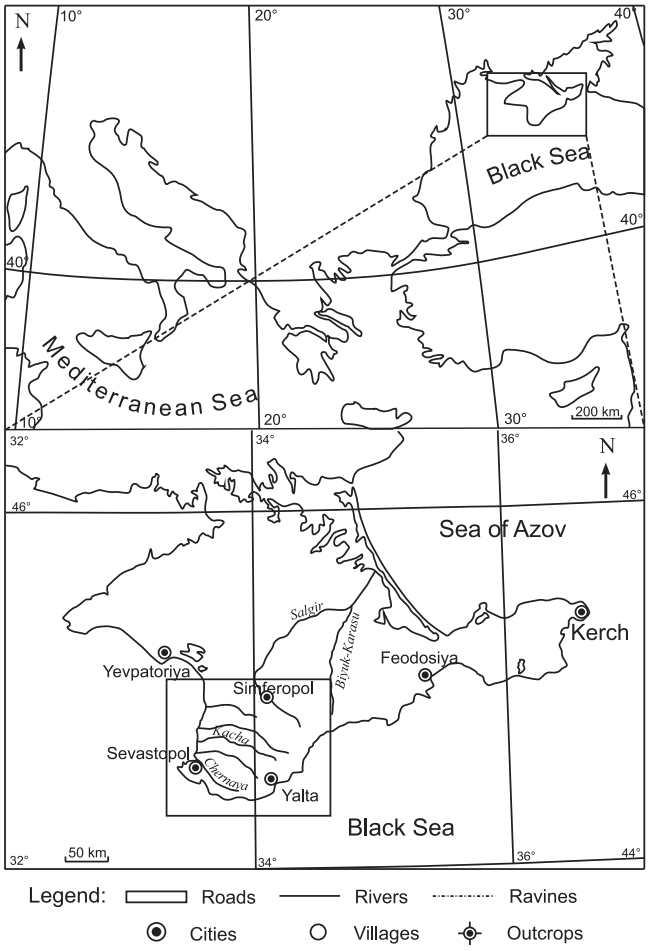

Fig. 1. Location of the studied area.

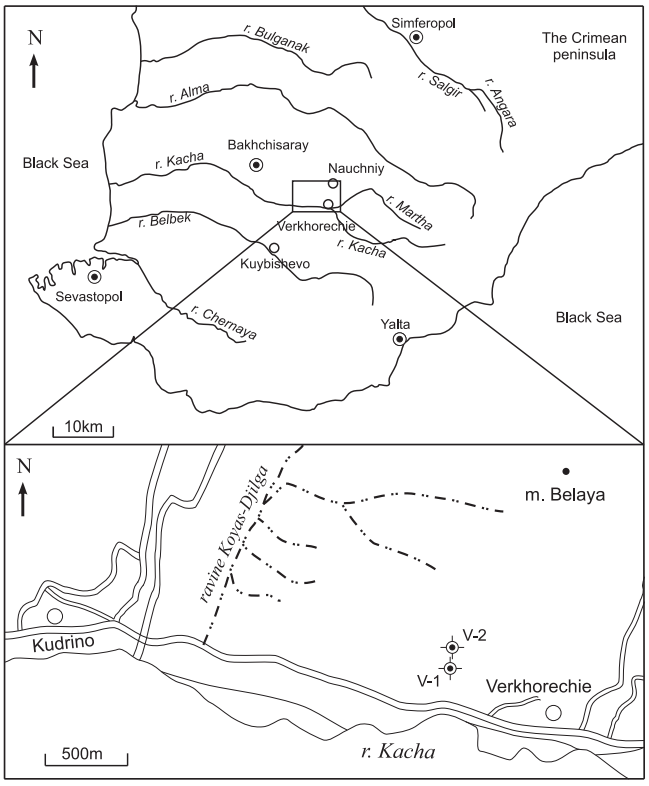

Fig. 2. Location of the studied outcrop. See legend on Fig. 1.

describe new species of *Brachycythere* (Alexander, 1933; Puri, 1953; Krommelbein, 1964; Al-Furaih, 1985; Emami, 1989; Puckett, 2002; Puckett et al., 2012; Piovesan et al., 2013). Hazel (1967) developed the taxonomic framework of brachycytherines.

Brachycytherines in the Crimea have not been found so far; however ostracods that are remarkably similar externally with *Brachycythere* Alexander, 1933 have been found in Barremian and Aptian. These Ostracods are described here under a new genus, *Protobrachycythere*.

2. Material and methods

2.1. Material

The "Verkhorechie" section was studied in this occasion (Figs. 2, 3). It consists of two distinct intervals (V-1 and V-2), which are displayed in their stratigraphic order: V-1 = N 44°41′58″ and E 33°58′36″, V-2 = N 44°42′06″ E 33°58′36″. Both of them consist of gray bioturbated clays. Based on the Calcareous Nannoplankton identified, the lower part of V-1 is assigned to the NC5D subzone (Late Barremian), the upper part of the V-1 and the base V-2 are assigned to the subzone NC5E (Late Barremian) and the upper part of V-2 is assigned to the zone NC6 (Late Barremian and Early Aptian) (Shcherbinina and Loginov, 2012).

2.2. Sample preparation

Sample preparation evolved from the technique described by Sohn (1961). Each sample of clay was dessicated and approximately 500 g were boiled with sodium bicarbonate, washed over 1 mm and 0.1 mm sieves and dried at 25 °C. Two hundred ostracod specimens from the 0.1–1 mm fraction were picked in samples with abundant ostracods, and all specimens were picked in samples with rarer ostracods. Specimens were imaged using the Scanning microscope CamScan from the Paleontological Institute of Russian Academy of Sciences. Morphometric measurements were based on the illustrations.

3. Systematic paleontology

The suprageneric taxonomy adopted in this work follows Horne (2005) and Nikolaeva et al. (1999). The morphological terminology follows Scott (1961). All figured and type material is deposited at the Geological Institute of RAS, Moscow, Russia under the curatorial numbers GIN 4802-V1, GIN 4802-V3, GIN 4802-V3-1.

Class Ostracoda Latreille, 1802
Subclass Podocopa Sars, 1866
Order Podocopida Sars, 1866
Suborder Cytherocopina Gruendel, 1967
Superfamily Cytheroidea Baird, 1850.

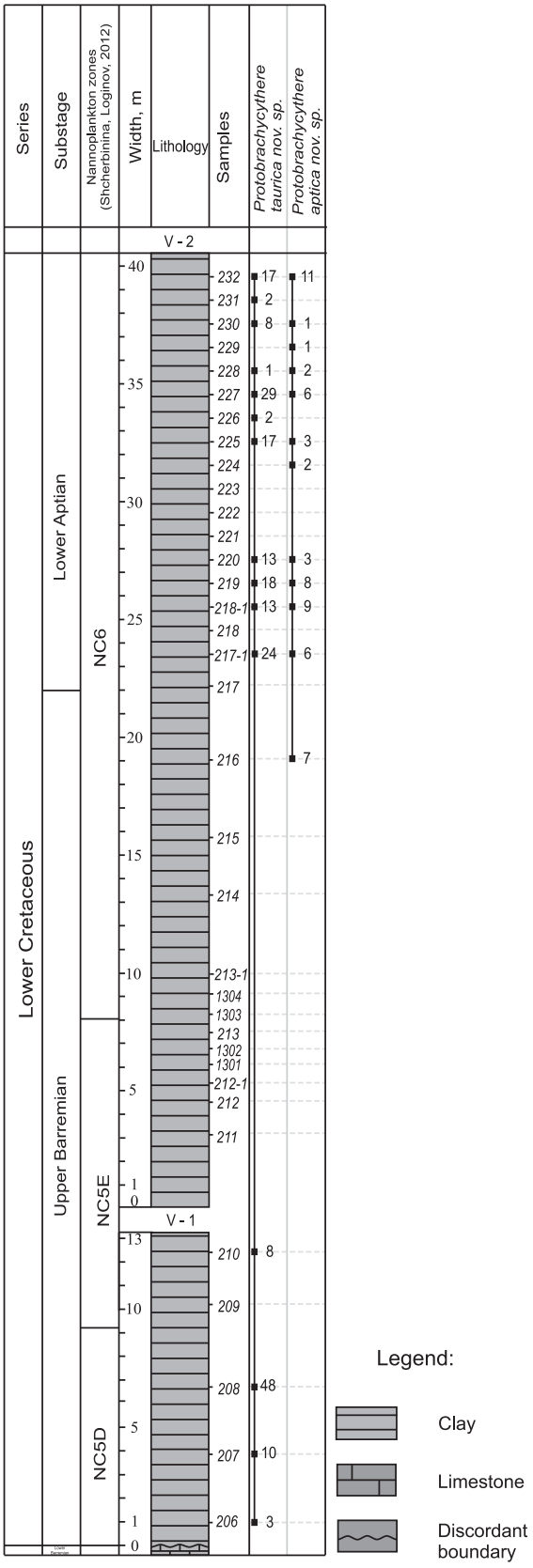

Fig. 3. Lithostratigraphic column of sections V-1 and V-2 including the occurrence of the new ostracod species.

Family Protocytheridae Lyubimova, 1956
Subfamily Protocytherinae Lyubimova, 1955

Genus ***Protobrachycythere*** nov. gen.

Type-species: *Protobrachycythere taurica* nov. sp.

Derivation of name: From Latin *Proto*–previous and a name of genus *Brachycythere.*

Diagnosis: Carapace subtriangular, with greatest inflation near venter. Anterior end is higher than posterior one. Both anterior and posterior ends are flattened. Left valve overlaps the right one. Marginal areas lack a vestibule. The hinge is antimerodont, in right valve consists of marginal slim elongate crenulated teeth, and a crenulate median element. There are three large lateral ridges, lateral surface is smooth or covered with foveolae.

Description: Carapace tumid, subtriangular, with greatest inflation near venter. Anterior end is high, broadly rounded, posterior one is angular. Both anterior and posterior ends are flattened. Left valve overlaps the right one in the anterior and posterior dorsal parts. Marginal areas lack a vestibule. Central muscle scars consist of a row of 4 oval scars and U-shaped frontal mandibular scar. The hinge is antimerodont, in right valve consists of anterior slim elongate crenulated tooth, a crenulate median element with superjacent groove, and posterior, slim elongate crenulated tooth. Lateral surface is smooth or covered with foveolae and three large lateral ridges are present. Variability is small, represented in visibility of the three ridges, which is worse in juveniles and in gradations of foveolae in the species with foveate valves.

Remarks: The new genus is inextricably connected with the genera of two subfamilies Protocytherinae and Brachycytherinae. The external view of *Protobrachycythere* nov. gen. is remarkably similar to *Brachycythere* Alexander, 1933 being tumid, subtriangle and with great posterior protuberance slightly below mid-height. The greatest height is close to the anterior hinge element. The anterior margin is high, broadly rounded, the posterior one is angular. Both anterior and posterior margins are flattened (Puckett, 2002). The new genus differs from *Brachycythere* in hinge, as *Protobrachycythere* has an antimerodont hinge during the whole ontogeny. As for *Brachycythere*, adults have hemiamphidont hinge, classic to Brachycytherinae, but juveniles have antimerodont hinge. Also there are three slightly visible ridges on the surface of the *Protobrachycythere* that are absent on the surface of *Brachycythere*. As to the difference between *Protocythere* Gruendel, 1964 and *Protobrachycythere*, in spite of the fact that both of them have antimerodont hinge, the hinge of the first ones is marked by thick anterior and posterior teeth, and the last ones teeth are slim. Both of the genera have the solid ridges on the surface of the valves, but *Protocytheres* ridges are distinct and *Protobrachycytheres* ones are subtle.

Protobrachicythere taurica nov. sp.
Plate 1, fig. 4–10

Etymology: The species is named after the Tauric Peninsula–the old name of the Crimean peninsula, where it has been found.

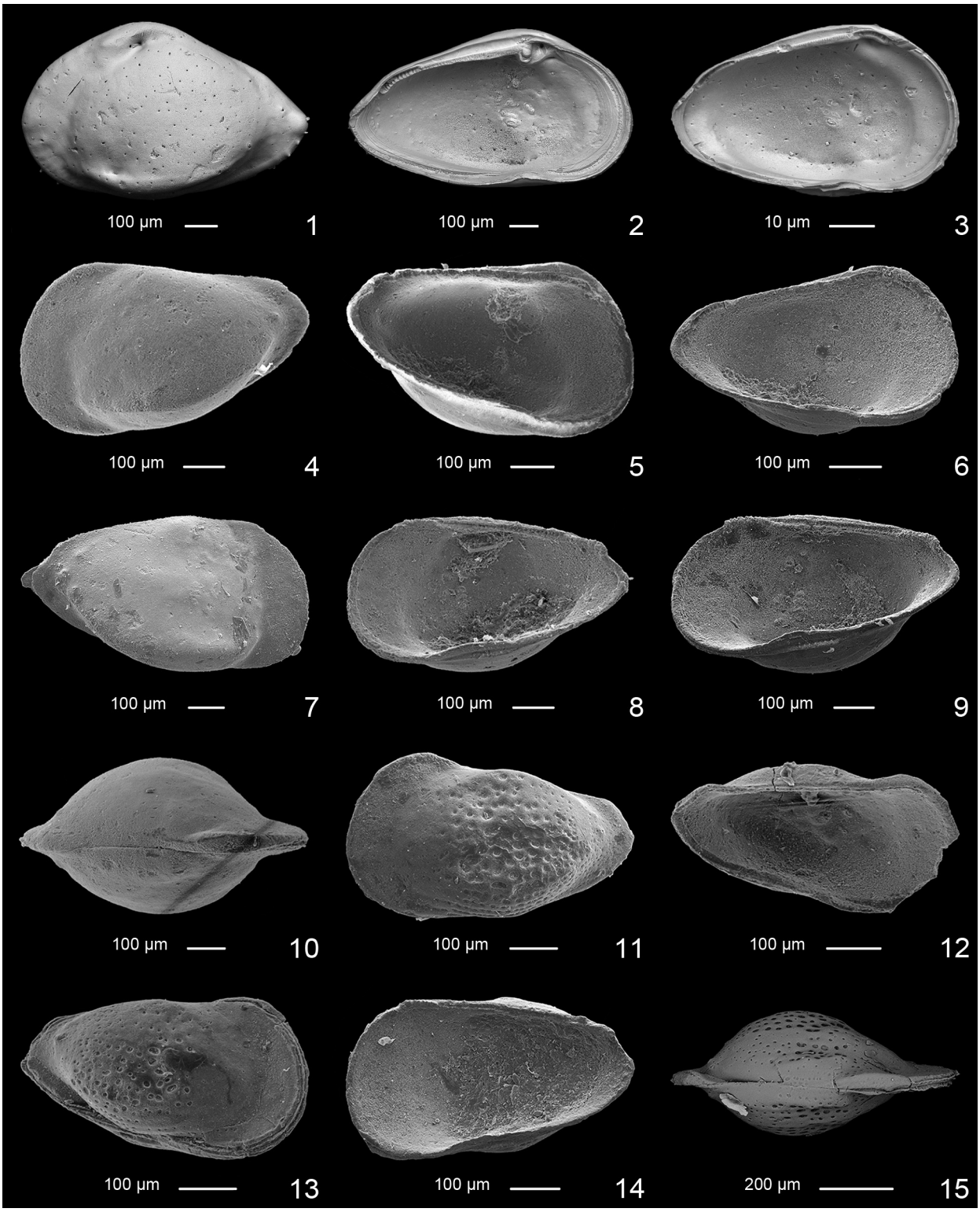

Plate 1. LV–left valve, RV–right valve. 1–3. *Brachycythere crenulata* Crane, 1965: Alabama, Santonian. 1. Exterior view of adult LV; 2. Interior view of adult LV; 3. Interior view of juvenile LV (Photos provided by Prof. T.M. Puckett). 4–10. *Protobrachycythere taurica* nov.sp., Barremian of the Crimea: 4. Holotype, exterior view of adult LV; 5, 6. Interior view of adult LV; 7. Exterior view of adult RV; 8, 9. Interior view of adult RV; 10. Carapace, dorsal view of adult. 11–15. *Protobrachycythere aptica* nov.sp., Aptian of the Crimea: 12. Holotype, exterior view of adult LV; 13. Interior view of juvenile LV; 13. Adult carapace, right external view; 14. Interior view of adult RV; 15. Carapace, dorsal view of adult.

Table 1
Protobrachycythere taurica nov. sp.

Specimen	Photo	Length (mm)	Height (mm)	Width (mm)
LV holotype (F)	Pl. 1, fig. 4	0.68	0.4	
LV (F)	Pl. 1, fig. 5	0.68	0.4	
LV (F)	Pl. 1, fig. 6	0.53	0.3	
RV (F)	Pl. 1, fig. 7	0.73	0.4	
RV (F)	Pl. 1, fig. 8	0.66	0.32	
RV (F)	Pl. 1, fig. 9	0.66	0.3	
Carapace	Pl. 1, fig. 10	0.77		0.43

LV: left valve; RV: right valve; F: female.

Holotype: Left valve, GIN 4802-V1-7; SW Crimea, outcrop V-1, sample 208, late Barremian, NC5D nannoplankton subzone (Pl. 1, fig. 4)

Paratype 1: Right valve, GIN 4802-V3-3; SW Crimea, outcrop V-1, sample 208, late Barremian, NC5D nannoplankton subzone (Pl. 1, fig. 10)

Paratype 2: Right valve, GIN 4802-V3-2; SW Crimea, outcrop V-1, sample 208, late Barremian, NC5D nannoplankton subzone (Pl. 1, fig. 9)

Diagnosis: A species characterized by smooth surface and three slightly visible lateral ridges. Hinge is antimerodont with slim anterior and posterior teeth.

Description: Carapace tumid, subtriangular, with greatest inflation near venter. The greatest width is in the central part of carapace, the greatest height is close to the anterior hinge element, the greatest length is slightly lower the mid-height. Left valve overlaps the right in anterior and posterior dorsal parts. Anterior end is high, broadly rounded, posterior is angular, with greatest posterior extent in the mid-height. Both anterior and posterior ends are compressed. Dorsal margin is in general straight, sloping posteriorly, in right valve slightly concave in posterior half, in left valve slightly convex in posterior half, with arches in anterior and posterior portion of dorsum extend above the level of the dorsal margin. Arches are small on the left valves and lacking on the right ones. Dorsal margin connects in a step with posterior end and smoothly with anterior end. Ventral margin is inclined dorsally in anterior third, connects smoothly with both anterior and posterior margins. Marginal areas lack a vestibule. Central muscle scars occur as a row of 4 oval scars and U-shaped frontal mandibular scar. The hinge is antimerodont, in right valve consists of anterior slim elongate crenulated tooth, a crenulate median element with superjacent groove, and posterior, slim elongate crenulated tooth. There are three thick broad but slightly visible lateral ridges and some thin ridges on the venter. Intercostal surface is smooth. Variability is poor, represented in visibility of the three ridges, which is worse in juveniles.

Material: 212 valves and 15 carapaces from the Late Barremian, Patruliusiceras uhligi ammonite zone of Early Aptian age, NC5D, outcrop V-1, zone NC6A, outcrop V-2 (Table 1).

Remarks: Protobrachycythere taurica differs from *P. aptica* in having smooth surface rather than a foveolate surface. Also, the three ridges are more distinct on the surface of *P. taurica*, arches in anterior and posterior portion of dorsum are lacking on the right valves of *P. taurica*, and small on *P. aptica*. The difference between *Brachycythere* and *Protocythere* are described in the remarks to the genus.

Range and occurrence: Early Cretaceous, Late Barremian-Early Aptian, Crimea.

Protobrachycythere aptica nov. sp.
Plate 1 11–15.

Etymology: The species is named after the Aptian sediments, in which it was first found.

Holotype: Left valve, GIN 4802-V3-1-99; SW Crimea, outcrop V-2, sample 216, Early Aptian, NC6A nannoplanktonic subzone (Pl. 1, fig. 11).

Paratype: Carapace, GIN 4802-V1-94; SW Crimea, outcrop V-2, sample 216, Early Aptian, NC6A nannoplanktonic subzone (Pl. 1, fig. 13).

Diagnosis: A species characterized by surface covered with foveolae and three slightly visible lateral ridges. Hinge is antimerodont with slim anterior and posterior teeth.

Description: Carapace tumid, subtriangular, with greatest inflation near venter. The greatest width is in the central part of carapace, the greatest height is close to the anterior hinge element, the greatest length is slightly below the mid-height. Left valve overlaps the right in anterior and posterior dorsal parts. Anterior end is high, broadly rounded, posterior is angular, with greatest posterior extent in the mid-height. Both anterior and posterior ends are compressed. Dorsal margin is generally straight, sloping posteriorly, in right valve slightly concave in posterior half, in left valve slightly convex in posterior half, with arches in anterior and posterior portion of dorsum extend above the level of the dorsal margin. Arches are distinct on the left valves and small on the right ones. Dorsal margin connects in a step with posterior margin and smoothly with anterior margin. Ventral margin is inclined dorsally in anterior third, connects smoothly with both anterior and posterior margins. Marginal areas lack a vestibule. Central muscle scars occuras a row of 4 oval scars and U-shaped frontal mandibular scar. The hinge is antimerodont, in right valve consists of anterior slim elongate crenulated tooth, a crenulate median element with superjacent groove, and posterior, slim elongate crenulated tooth. There are three thick slightly visible lateral ridges on the lateral side. Foveaolae occur in bottom two-thirds of carapace. Both ridges and intercostal surface are covered with foveolae. The greatest size of foveolae is in central part, and decreases towards the margins. Foveolae occur in rows that are best visible on the venter. Variability is small, represented in visibility of the three ridges, which is worse in juveniles and in gradations of foveolae.

Material: 55 valves, 4 carapaces from the Early Aptian, zone NC6A, outcrops V-2 and V-3, SW Crimea (Table 2).

Remarks: From species *P. taurica*, *P. aptica* differs in having a foveolate surface, unlike the smooth surface in *P. taurica.* Arches in anterior and posterior portion of dorsum are small on the right valves of *P. aptica* and lacking in *P. taurica*. Thin ridges on the venter, that appear in *P. taurica are* absent in *P. aptica*.

Range and occurrence: Early Cretaceous, Early Aptian, Crimea.

Table 2
Protobrachycythere aptica nov. sp.

Specimen	Figure	Length (mm)	Height (mm)	Width (mm)
LV holotype (F)	Pl. 1, fig. 11	0.56	0.35	
LV (F)	Pl. 1, fig. 12	0.46	0.25	
Carapace (F)	Pl. 1, fig. 13	0.46	0.29	
RV (M)	Pl. 1, fig. 14	0.56	0.31	
Carapace	Pl. 1, fig. 15	0.74		0.32

LV: left valve; RV: right valve; F: female, M: male.

4. Discussion

Ostracods of *Protobrachycythere* n. gen. that were found in the Barremian and Aptian sediments of the Crimea are remarkably similar externally with *Brachycythere* Alexander, 1933 (Brachycytherinae), but have an antimerodont hinge during the whole ontogeny (Pl. 1, fig. 5, 6, 8, 9, 13, 14). As for brachycytherinae, that are represented herein and in Puckett (2012), adults have hemiamphidont hinge, which in the left valve consists of round socket, knob-like tooth, crenulate median element, and posterior, slim elongate crenulate socket (Pl. 1, fig. 2), but juveniles have an antimerodont hinge, which in the left valve consists of slim elongate crenulate socket, crenulate median element, and posterior, slim elongate crenulate socket (Pl. 1, fig. 3). Both adults and juveniles of the new genus have antimerodont hinge, identical to that in juvenile *Brachycythere*. It appears that species of *Protobrachycythere* are the ancestors of the brachycytherines and based on the hinge must be placed into the Subfamily Protocytherinae Lyubimova, 1955. This fact might help to clarify the higher taxonomy of the Brachycytherinae, which was ambiguous (Table 3). Okosun (1992) placed Brachycytherinae into the Family Cytheruridae. Some authors (Alexander, 1933; Puri, 1953; Grekoff, 1956; van Morkhoven, 1962; Babinot, 1973; Damotte, 1988) assigned Brachycytherinae to the Family Cytheridae, as they

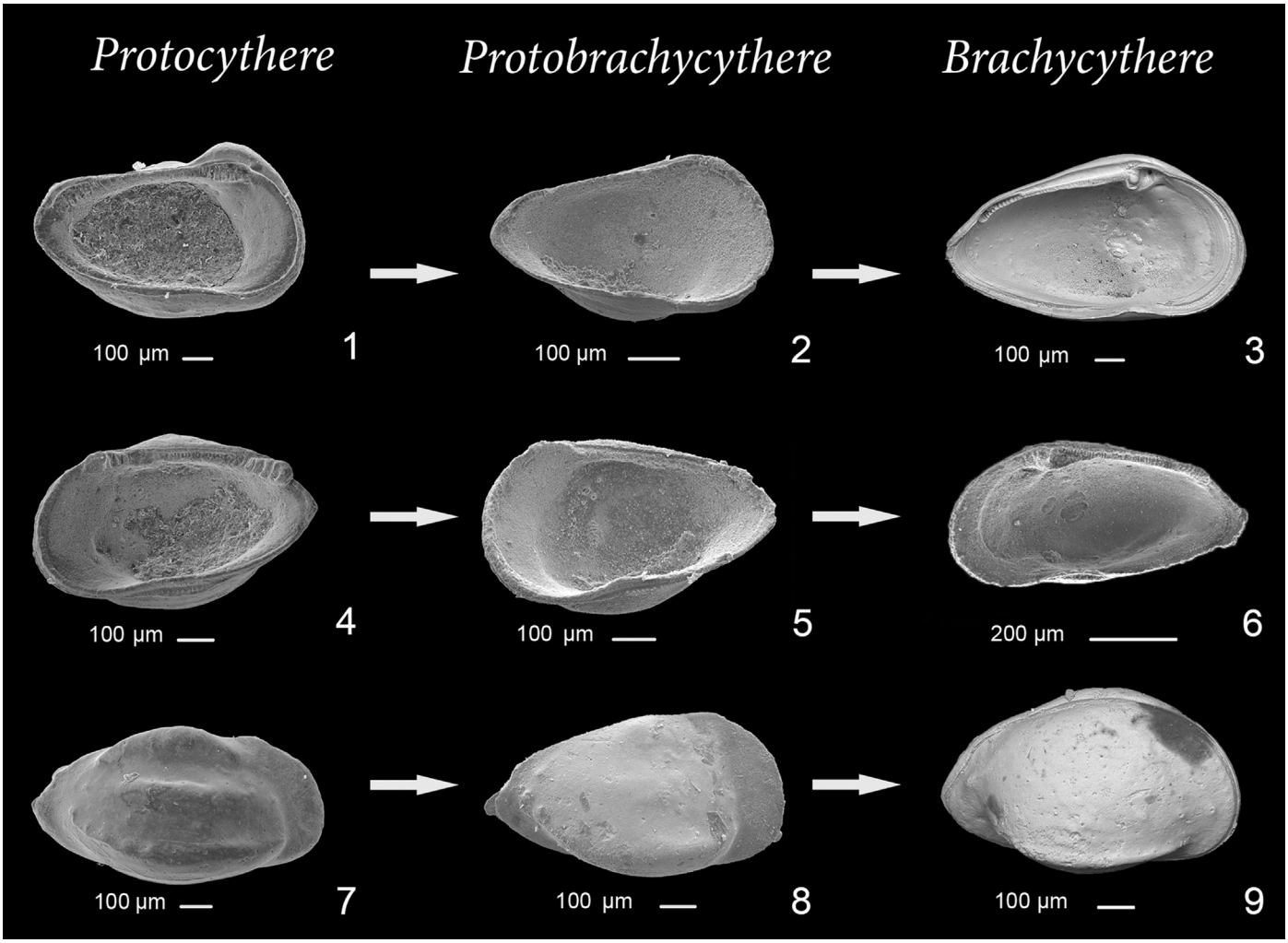

Fig. 4. Phyletic changes in line *Protocythere–Protobrachycytere–Brachycythere.* RV: right valve; LV: left valve. RV: right valve; LV: left valve. 1, 4, 7. *Protocythere triplacata* (Roemer, 1841). Late Barremian, V-1, Crimea: 1. Exterior view of adult RV; 4. Interior view of adult RV; 7. Interior view of adult LV. 2, 5, 8. *Protobrachycythere taurica* nov. sp. Late Barremian, V-1, Crimea: 2. Exterior view of adult RV; 5. Interior view of adult RV; 8. Interior view of adult LV. 3, 6 *Brachycythere jamaicaensis* Puckett & Colin, 2012, Maastrichtian, Jamaica. 3. Carapace, right external view; 6. Internal view of adult RV (photos provided by Prof. T.M. Puckett). 9. *Brachycythere crenulata* Crane 1965, Santonian part of the Blufftown Formation of eastern Alabama, interior view of adult LV (photos provided by Prof. T.M. Puckett).

Table 3
History of the classification of the brachycytherine ostracods (Puckett, 2002 with additions).

Author	Family	Subfamily
Cytheridae		
Alexander (1933)	Cytheridae	
Puri (1953)	Cytheridae	Brachycytherinae
Grekoff (1956)	Cytheridae	Cytherinae
van Morkhoven (1962)	Cytheridae	Trachyleberidinae
Babinot (1973)	Cytheridae	Brachycytherinae
Damotte (1988)	Cytheridae	Brachycytherinae
Cytheruridae		
Okosun (1992)	Cytheruridae	
Trachyleberididae		
Hazel (1967)	Trachyleberididae	Brachycytherinae
Hartmann and Puri (1974)	Trachyleberididae	Trachyleberidinae
Liebau (1975)	Trachyleberididae	Brachycytherinae
Emami (1989)	Trachyleberididae	Brachycytherinae
Guernet and Bellier (2000)	Trachyleberididae	Brachycytherinae
Morsi (2000)	Trachyleberididae	Brachycytherinae
Puckett (2002)	Trachyleberididae	Brachycytherinae
Liebau (2005)	Trachyleberididae	Brachycytherinae
Morsi and Scheibner (2009)	Trachyleberididae	Brachycytherinae
Morsi et al. (2011)	Trachyleberididae	Brachycytherinae
Puckett et al. (2012)	Trachyleberididae	Brachycytherinae
Piovesan et al. (2013)	Trachyleberididae	Brachycytherinae
Brachycytheridae		
Howe (1961a)	Brachycytheridae	
Hazel (1968)	Brachycytheridae	
Gruendel (1977)	Brachycytheridae	Brachycytherinae
Kogbe and Me'hes (1986)	Brachycytheridae	
Andreu (1996)	Brachycytheridae	
Andreu and Tronchetti (1996)	Brachycytheridae	
Nikolaeva et al. (1999)	Brachycytheridae	Brachycytherinae
Shahin (2000)	Brachycytheridae	Brachycytherinae

considered muscle scars as taxonomic indicators of Family level. Other authors (Hartmann and Puri, 1974; Liebau, 1975, 2005; Emami, 1989; Guernet and Bellier, 2000; Morsi, 2000; Puckett, 2002; Morsi and Scheibner, 2009; Morsi et al., 2011; Puckett et al., 2012; Piovesan et al., 2013) assigned Subfamily Brachycytherinae to the Family Trachyleberididae Sylvester-Bradley, 1948. Hinge in post-Jurassic adult trachyleberids is strongly amphidont, but juveniles have merodont one (Sylvester-Bradley, 1961). Another group of authors (Howe, 1961a; Hazel, 1968; Gruendel, 1977; Kogbe and Me'hes, 1986; Andreu, 1996; Andreu and Tronchetti, 1996; Nikolaeva et al., 1999; Shahin, 2000) assign Brachycytherinae to the Family Brachycytheridae Puri, 1954, whose amphidont hinge developed from the merodont hinge of ancestors–Protocytherinae (Family Protocytheridae Lyubimova, 1956) (Howe, 1961b). Considering that the brachycytherine juveniles' hinge is similar to the *Protobrachycythere* hinge interpreted that *Protobrachycythere* nov. gen. is an ancestor of the brachycytherines and that it confirms that Subfamily Brachycytherinae should be assigned to the Family Brachycytheridae.

Some phyletic changes in line *Protocythere* (Protocytherinae, Protocytheridae)–*Protobrachycytere* (Protocytherinae, Protocytheridae)–*Brachycythere* (Brachycytherinae, Brachycytheridae) can be traced. The hinge evolves from antimerodont hinge, with the thick teeth of *Protocythere* through antimerodont hinge of *Protobrachycythere* slim teeth to the adult *Brachycythere* hemiamphidont hinge. As for the external view, the shape remains mainly subtriangular, but three solid ridges change from distinct in *Protocythere* to subtle in *Protobrachycythere* to a general absence in *Brachycythere* (Fig. 4).

5. Conclusions

Protobrachycythere nov. gen. is represented by two new species *P. taurica* nov. sp. and *P. aptica* nov. sp. The antimerodont hinge of the new genus is identical to the hemiamphidont hinge of the adult Brachycytherines juveniles. This evidence indicates *Protobrachycythere* (which by the hinge has to be put to the Protocytherinae) is the ancestor of the Brachycytherine ostracods. As the amphidont hinge of Brachycytheridae is developed from the merodont hinge of ancestors (Protocytherinae), it is suggested to assign the brachycytherines to the Family Brachycytheridae.

Disclosure of interest

The author has not supplied her declaration of competing interest.

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