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New Protocytheridae and Mandocytheridae Ostracods from the Aptian of the Crimean Mountains

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Abstract—Two new Ostracoda species are described from Aptian sediments of the Crimean Mountains, *Protocythere whatleyi* Karpuk, sp. nov. (Protocytheridae Lyubimova, 1955) and *Homocythere spinasphaerica* Karpuk, sp. nov. (Mandocytheridae Gründel, 1969).

Keywords: ostracods, Protocytheridae, Mandocytheridae, Aptian, Crimea

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INTRODUCTION

The history of the study of early Cretaceous ostracods of Crimea was described in detail by Karpuk et al. (2019). Crimean ostracods are known for high levels of endemism, and therefore, new species descriptions are required. This paper continues a cycle of publications with such descriptions (Karpuk and Tesakova, 2013; Karpuk and Tesakova, 2014; Karpuk, 2016; Karpuk et al., 2019).

Two new species of late Aptian ostracods from the Crimean Mountains are described in this paper. Ostracods of these species were collected from six sections, Verkhorechie, Krasnaya Gorka, Kirpichnoe, Maryino, Kurskoe, and Zavodskaya Balka. The age of the sections was determined using ostracods, planktonic foraminifera and calcareous nannofossils (Karpuk, 2016; Brovina, 2017; Brovina et al., 2017; Karpuk et al., 2018). The new species *Protocythere whatleyi* Karpuk, sp. nov. (family Protocytheridae Lyubimova, 1955) and *Homocythere spinasphaerica* Karpuk, sp. nov. (family Mandocytheridae Gründel, 1969), are similar in having a triplicate carapace of triangular-ovate shape, and three large longitudinal ribs.

A triplicate carapace is a feature of several species, of varying systematic position depending on which feature is considered to be the most important—hinge or carapace shape. If the **hinge** is treated as the main feature (Nikolaeva, 1999), then the genera *Protocythere*, *Costacythere* Gründel, 1966, *Hehticythere* Gründel, 1974, *Reticythere* Gründel, 1978, *Pseudoprotocythere* Oertli, 1966, and *Valendocythere* Gründel, 1969 will be combined in one family, Protocytheridae Lyubimova, 1955, as all of them have an antimerodont hinge crenulated in marginal parts. They differ in carapace shape: rectangular-ovate (e.g. *Costacythere, Hehticythere, Reticythere*) or triangular-ovate (e.g. *Protocythere*), with a differing longitudinal rib joint. Species with similar carapace shape (*Protocythere*, *Posteroprotocythere* Mandelstam, 1958, *Homocythere* Kaye, 1963, *Cytherettinella* Andreev and Mandelstam, 1964, and *Veenia* Butler and Jones, 1957) are placed in different families, and the similarity may be explained as convergence in different phyletic lines.

If the **carapace shape** and the **ribs joints** are considered to be more important than the hinge, following Mandelstam (Andreev and Mandelstam, 1964), the following phyletic lineage may be considered: from *Protocythere* with a merodont type hinge in the Late Jurassic-Early Cretaceous—through *Posteroprotocythere* with a posteromerodont hinge in the Neocomian-Albian—to *Homocythere* and *Cytherettinella* with an amphidont hinge in the Aptian-Cenomanian and to *Veenia* with a holamphidont hinge in the Cenomanian. This phyletic line may be supported by the occurrence of a merodont hinge in juvenile *Homocythere*.

However, additional ontogenetic study of all genera mentioned is required to resolve this question. Therefore, this paper accepts the first, more traditional, higher taxonomy. It is noteworthy that redescription of the two genera to which the new species belong is required to specify such features as rib joints, occurrence of eye spot, hinge, and details of muscle scars.

Scanning electron microscope images were prepared in the Paleontological Institute of Russian Academy of Sciences using a CamScan. Type and figured material is deposited in the Micropaleontological Laboratory of Geological Institute of the Russian Academy of Sciences, Moscow, and prefixed with the catalogue reference GIN 4802.

SYSTEMATIC PALEONTOLOGY

The suprageneric taxonomy follows Horne (2005) and Nikolaeva et al. (1999).

Order Podocopida Sars, 1865

Family Protocytheridae Lyubimova, 1955

Genus *Protocythere* Triebel, 1938

Protocythere: Triebel, 1938, p. 180; Kashevarova et al., 1960, p. 397; Howe, 1961, p. 327; Neale, 1962, p. 442; van Morkhoven, 1963, p. 220; Nikolaeva et al., 1999, p. 68.

non *Protocythere*: Mandelstam, 1947, p. 250; Lyubimova, 1955, p. 68.

Type species. *Cytherina triplicata* Roemer, 1938 from the early Cretaceous of Europe.

Diagnosis. Large, triangular-ovate. Left valve (LV) greater than right (RV), overlapping it circle-wise. Anterior high, widely rounded; posterior narrow, angular. Lateral surface with three longitudinal isolated ribs with poorly resolved muscle spot on the middle one. Hinge antimerodont, with two large marginal teeth crenulated into six parts and a crenulated median groove in the LV. Hinge elements of RV complement those of LV. Central muscle scars comprising vertical row of four elongate adductors and V-shaped frontal scar. Calcified inner lamella wide, with long radial pore canals directed upward anteriorly.

Composition. Over 80 species.

Comparison. Differs from all genera of the family (sensu Nikolaeva, 1999) that have similar hinges, by a triangular-ovate carapace and isolated longitudinal ribs.

Remarks. Members of *Protocythere* resemble other genera that have a similar triplicate carapace (*Posteroprotocythere* Mandelstam in Mandelstam et al., 1958, *Procytherettina* Mandelstam in Mandelstam et al., 1958, *Cytherettinella* Andreev and Mandelstam, 1964 and *Veenia* Butler et Jones, 1957), but belong to different families. *Protocythere* notably differs from them in its three-element hinge, which is four-element in the other genera mentioned.

Range and occurrence. Late Jurassic–Late Cretaceous; Eurasia, North America.

Protocythere whatleyi Karpuk sp. nov.

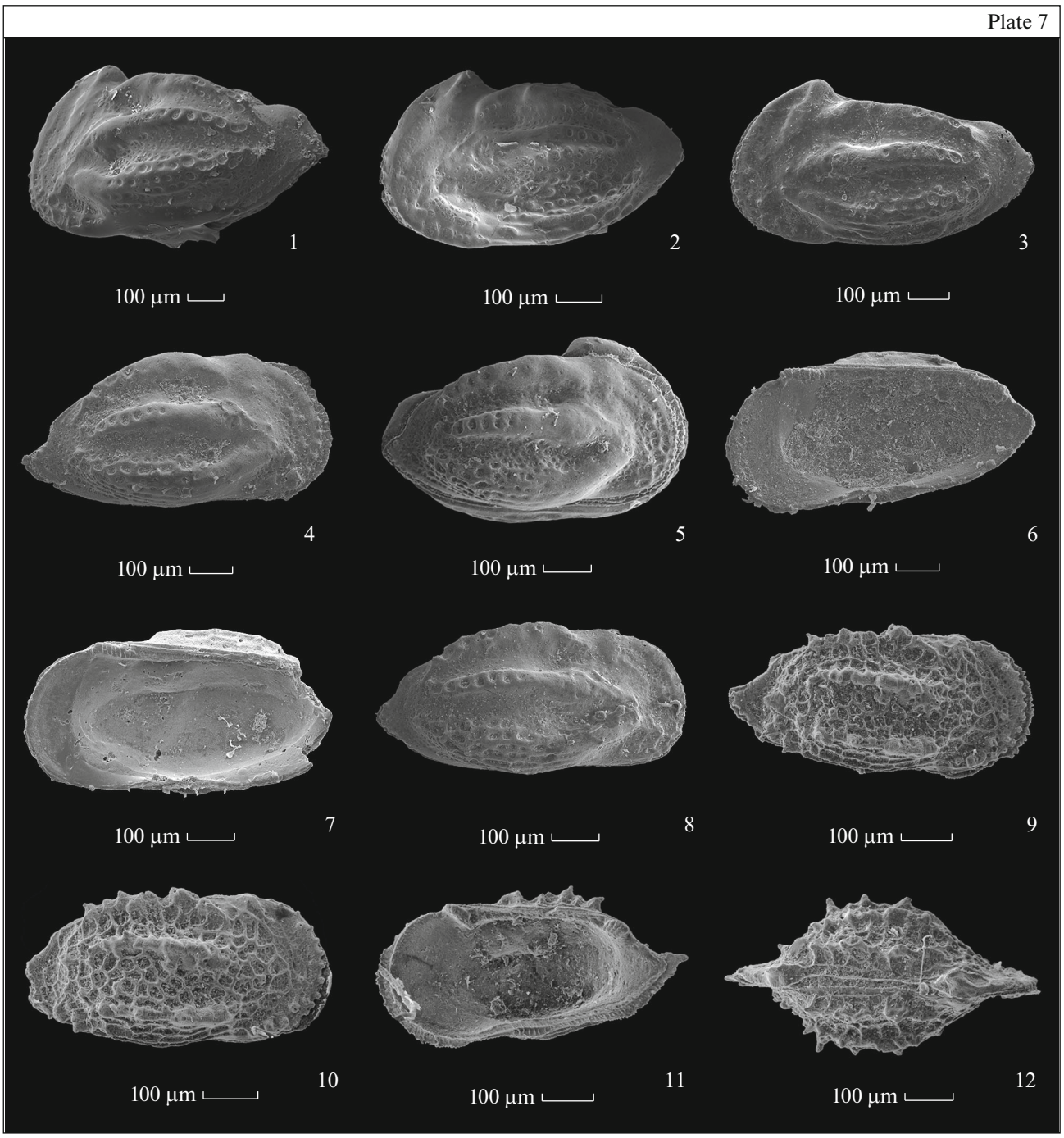
Pl. 7, figs. 1–8

Named after the paleontologist Dr. Robin Charles Whatley.

Holotype. GIN 4802-ZB-1-101, female carapace, Zavodskaya Balka section, Sample 9 (Karpuk et al., 2018); Early Cretaceous, Late Aptian, *Saxocythere omnivaga* ostracoda zone (O-zone), *Hedbergella trocoidea* planktonic foraminifera zone (PF zone), NC7C nannofossil subzone.

Description. Large, triangular-ovate. LV overlaps the RV circle-wise, especially anterodorsally and posterodorsally where the hinge ears are developed. The greatest length is at the mid-height; greatest height is at the anterior third of LV, due to the hinge ear, and on the mid-length of RV; the greatest width is at the mid-length. Males are lower and longer than females. The anterior is high, widely rounded, slightly sloping upwards. The posterior is much narrower, angular. Both anterior and posterior are flattened. The dorsal margin is straight, but seems convex in lateral view. The dorsal margin connects with the posterior margin in a step-like manner in both valves; the anterior margin in the RVs connects at an obtuse angle, in the LVs with the hinge ear. The ventral margin is not parallel to the dorsal, slightly sloping to the posterior, convex in the mid-length. The ventral margin is overhung centrally by the ventral longitudinal rib in lateral view, but in internal view shows distinct oral invagination. The ventral margin connects smoothly with both the anterior and posterior margins. The eye spot is low and wide. Three large, thick longitudinal ribs are present on the valves; dorsal and ventral are located along relevant margins and are slightly convex to corresponding sides. Another horizontal rib is in the middle between them. All three begin at the anterior end and finish at the posterior one. The middle and ventral have no joint posteriorly, but come close to each other anteriorly, showing a tendency to connection. The dorsal rib has no connection to the middle one, either anteriorly or posteriorly. The middle rib becomes thicker at the muscle spot area. The fourth longitudinal rib is poorly resolved on the LV. This rib is thinner and lower than the three main ribs; it is located under the ventral rib and is parallel to the ventral margin. The surface below the ventral rib of the RV is uniformly convex and covered with elongate fovea. A thin diagonal rib is present in the upper half of the anterior, located from the eye spot to the middle of the anterior margin.

The surface of the valves is covered with different-sized fovea, best developed on the three main ribs. Large fovea occur on the posterior halves of ribs, the anterior half of which are smooth with occasional small pores. Fovea of the dorsal and middle ribs are larger and arranged in a single row, fovea of the ventral rib are smaller and arranged in several longitudinal rows. The intercostal surface, like the anterior and posterior ends, is densely covered with small pits, which may be absent at the anterior end. Two small tubules occur at the posterior end on the continuation of the ventral and middle ribs, and there is one small tubule at the ventral half of the anterior end. Small short straight spines may occur on the anterior part, which may have a rather narrow border. The hinge, muscle scars and calcified inner lamella are typical of the genus.



Explanation of Plate 7

Figs. 1–8. *Protocythere whatleyi* sp. nov.: (1) holotype, sp. no. 4802-ZB-1- 101, female carapace, right side, Zavodskaya Balka section, Sample 9; (2)– sp. no. 4802-V-3-3-149, RV, male, external view, Maryino section, Sample 107-1; (3) sp. no. 4802-VK-064-RV male, external view, Kurskoe, Sample 1419; (4) sp. no. 4802-KK-042, LV, female, external view, Kirpichnoe, Sample 1501; Maryino: (5) sp. no. 4802-V-3-3-146, female carapace, left side, Sample 107-1; (6) sp. no. 4802-V-3-3-148, RV male, internal view, Sample 107-1; (7) sp. no. 4802-V-3-028-RV male internal view, Sample 101; (8) sp. no. 4802-V-3-3-151, LV male, external view, Sample 107-1.

Figs. 9–12. *Homocythere spinasphaerica* sp. nov.: Verkhorechie, sample 212: (9) holotype, sp. no. 4802-328-V-1-59, RV external view; (10) sp. no. 4802-328-V-1-60, RV, external view; (11) sp. no. 4802-328-V-1-61, RV internal view; (12) sp. no. 4802-328-V-1-63, carapace, dorsal view.

Dimensions, in mm

Specimen no.	Length	Height
Holotype 4802-ZB-1-101	0.63	0.37
4802-V-3-3-149	0.71	0.35
4802-VK-064	0.63	0.38
4802-KK-042	0.64	0.38
4802-V-3-3-146	0.80	0.45
4802-V-3-3-148	0.73	0.34
4802-V-3-028	0.63	0.41
4802-V-3-3-151	0.71	0.39

Variability. A different range of fovea intensity is obsereved on the surface: from strongly marked on the ribs and occurring on the intercostal surface to poorly marked on the ribs with a smooth intercostal surface. Also, the range of diagonal ribs on the anterior may change, to being totally absent.

Comparison. *Protocythere whatleyi* differs from *P. mertensi* Kaye, 1963 from the Albian of England (Kaye, 1963, p. 232, pl. 19, Figs. 1, 2) in its large fovea on the ribs and small ones between the ribs, while there are large fovea on the intercostal surface and smooth dorsal and middle ribs in the compared species. *P. mertensi* also differs in having a bigger muscle spot.

The new species differs from *P. fistulosa* Lyubimova, 1955 from the lower Volgian of Ulyanovsk Region (Lyubimova, 1955, p. 83, pl. 9, Figs. 7a, 7b), which is similar in carapace shape and occurrence of three ribs, in having the greatest width at the mid-length, distinct fovea only on the ribs, absence of an arched rib on the anterior, and absence of a joint between the middle and ventral ribs, while *P. fistulosa* has the greatest width in the posterior-ventral part, large fovea both on the ribs and between them, an arched rib on the anterior, and a distinct joint in the middle and ventral ribs.

The new species differs from *P. triplicata marginopunctata* Luppold, 2001 from the Hauterivian of Germany (Luppold, 2001, p. 144, tex-figs. 16.6, 16.7), in its shorter carapace and much larger fovea, covering all the ribs, while the compared species has tiny pits, which cover only the ventral third of the valves and the posterior third of the ribs.

Material. About 400 specimens of good and satisfactory preservation from the upper Aptian *S. omnivaga* O-zone, *G. ferreolensis, G. algerianus*, and *H. trocoidea* PF-zones and NC7 nannofossil zone of the Crimean Mountains.

Range and occurrence. *S. omnivaga* O-zone, *G. ferreolensis, G. algerianus,* and *H. trocoidea* PF-zones and NC7 nannofossil zone, Late Aptian, Crimea.

Family Mandocytheridae Gründel, 1969

Genus *Homocythere* Kaye, 1963

Homocythere: Kaye, 1963, p. 234; Malz et al., 2005, p. 162.
Neocytherettina: Lyubimova, 1965, p. 108.

Type species. *Homocythere reticulata* Kaye, 1963 from the middle Albian of Northern England.

Diagnosis. Large, subtriangular, with distinct hinge ear on LV; posterior pointed on RV and narrow rounded on LV. Three longitudinal ribs and one vertical, parallel to the anterior margin present. Intercostal surface from smooth to strongly reticulate. Hinge in adults amphidont, in LV consists of anterior reticulated pit with a knob in front, smooth tooth behind the pit, then low reticulated median element and reticulated pit. Hinge elements of RV complement those of LV with small depression opposite the knob. Duplicature rather wide anteriorly, sickle-shaped, with about 12 to 14 slightly curved marginal pore canals terminating in pore cones along the anterior marginal rim, plus about 10 to 12 false canals ending in pore cones topping the marginal rim; posteriorly six marginal and up to four false canals present (Malz et al., 2005).

Hinge merodont in juveniles, weakly crenulate. Narrow duplicature present in juveniles (about one quarter of the adult size), with some 12 to 14 straight marginal pore canals at the anterior margin, six along the posterior margin. Surface of juveniles smooth to densely pitted or fully reticulate; longitudinal ribs not present or faintly indicated by short crests (Malz et al., 2005).

Composition. 14 species.

Comparison. Similar to *Veenia* and *Homocythere* in having three longitudinal ribs and sculpture, differing in carapace shape and hinge details: presence of knob in LV.

Remarks. Ostracods of this genus are also similar to *Protocythere* and *Costacythere* Gründel, 1966, but differ from them in the hinge, which is of merodont-type in *Protocythere* and *Costacythere*.

Range and occurrence. Eastern, Central Europe, Crimea, and Kazakhstan. Early Cretaceous, Aptian, and Albian.

***Homocythere spinasphaerica* Karpuk sp. nov.**

Plate 7, figs. 9–12

Derivation of name: Latin *spina*—spike, spine, *sphaera*—sphere, as in dorsal view these ostracods resemble a spiked sphere.

Holotype. GIN no. 4802-328-V1-59; RV of male, SE Crimea, Verkhorechie Section, sample 212 (Karpuk, 2016), *Patruliusiceras uhligi* Ammonite zone, NC5E nannofossils subzone, Late Barremian.

Description. Large, LV is subtriangular due to the hinge ear, the RV is subovate, elongate. The LV overlaps the RV circle-wise, especially anterodorsally and posterodorsally where hinge ears are devel-

oped. The greatest length and width are at mid-height, the greatest height is at anterior third. The central part of the carapace is spherical; the anterior and posterior margins are flattened. Theanterior is high, widely rounded, the posterior is narrow, angular, slightly upturned, curved inward dorsally and convex ventrally. The dorsal margin is straight, with the posterior in both valves step-like; connects with the anterior in RV with oblique angle, in LV seems to connect with the hinge ear. The ventral margin is invaginated in the anterior third, connects smoothly with both anterior and posterior ends. The small eye spot is present.

Three ribs are present, longitudinal and one parallel to anterior end. The longitudinal ribs (dorsal, middle and ventral) are straight, with large conical spines. There are three similar spines on the posterior end: two are lower than the dorsal rib and one is in the middle of the posterior end. The whole surface of the anterior and posterior ends is covered with pore cones, marginal pore cones along the edge and false pore cones on the anterior and posterior ends areas. There are at least 10 marginal pore cones and about seven–eight false pore cones on the anterior, and five marginal pore cones and three false pore cones on the posterior.

The surface is covered with large fovea that combine up to ten smaller ones. Fovea of the ventral side are rectangular and polygonal, isometric on the rest of the surface. Edges of the fovea are thicker in the middle part of the valve, between the middle and ventral ribs, than on the periphery. Fovea are absent on the dorsal side, but thin longitudinal ribs are present, that are similar to fovea edges of the remaining surface of the valve. There is one such rib on the RV and two on the LV; one is as long as the space between the hinge ears, the other goes from the central on the valve up to the dorsal hinge ear. The hinge and marginal pore canal area are usual for the genus.

Dimensions in mm:

Specimen no.	Length	Height	Width
Holotype 4802-328-V1-59	0.59	0.3	
4802-328-V1-60	0.55	0.29	
4802-328-V1-61	0.6	0.29	
4802-328-V1-63	0.64		0.33

Variability. The fovea on the surface vary from large to rather small.

Comparison. Differs from *Homocythere inderensis* (Lyubimova), 1965 from the Albian of Inder (Lyubimova, 1965, p. 111, pl. 8, text-figs. 2–4) in the upturned posterior end, thinner longitudinal ribs and occurrence of the spines on the ribs.

Differs from *Homocythere similis* Malz, Lord and Whittaker, 2005 (Malz et al., 2005, p. 167, text-fig. 3), which is similar in the carapace shape, occurrence of three ribs and foveate sculpture, in having spines on the ribs and foveate sculpture on the surface of adults, whereas such sculpture is only typical for juveniles in *Homocythere similis*, while adults have pore sculpture.

Range and occurrence. SE Crimea, Verkhorechie Section, Early Cretaceous, Early Aptian.

Material. 4 valves and 1 carapace.

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