

Ordovician Ostracods from the Upper Kalar Graben of Northern Transbaikalia, Udokan Region

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Abstract—Ostracods from the Middle Ordovician Nalednyi Formation of the Udokan Region are investigated in detail. A brief history of the study of these deposits and description of the new species *Egorovellina* (?) *shuvalovae* sp. nov., *Cherskiella baikalica* sp. nov., *Gontiella mira* gen. et sp. nov., *Lepeditella nalednaya* sp. nov., *Hallatina opima* sp. nov., *Primitia kalarensis* sp. nov., *Glandites planus* sp. nov., and *Bollia sinitsae* sp. nov. are provided. The previously known ostracod species described in open nomenclature are figured.

Keywords: Ostracoda, Middle Ordovician, Nalednyi Formation, Upper Kalar Graben, northern Transbaikalia

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INTRODUCTION

In the Upper Kalar Graben, the Transbaikalian Ordovician beds are stratified into the Vorotnaya, Nalednyi, and Ust'-Nalednyi formations (*Atlas ...*, 2002; *Stratigrafiya ...*, 2007) and characterized by interbedding sandstones, siltstones, claystones, and organogenic limestones. Ordovician deposits in the Udokan Region were revealed for the first time by Yu.S. Perfil'ev in 1964 and, later, he described Lower and Middle Ordovician deposits and provided identification of a few faunal specimens (Perfil'ev, 1975). Subsequently, F.V. Nikolsky and V.I. Byalyi (Irkutsk, East Siberian Research Institute of Geology, Geophysics, and Minerals) (Nikolsky et al., 1984; Nikolsky and Byalyi, 1991), along with geologists from Chita (Chitageologiya) (Barabasheva and Pakhomov, 1990), continued the study of Ordovician deposits and, based on additional material, provided a more complete paleontological substantiation of overlying formations.

In a section on the right slope of the Nalednyi Creek in limestones of Member 24, Bed 2, outcrop 823, Nikolsky and Byalyi (1991) recorded accumulations of shells of the ostracods *Costoprimites* sp. and *Bolbinella* sp. and, in the roof of Bed 4, *Primitiella* sp. and *Eochilina* sp. (identified by G.R. Kolosnitsyna). The authors marked that Beds 2–5 belong to the Nalednyi Formation, which is analogous to the Muktei Horizon.

In the same outcrop, at the base of Member 28, a limestone interbed has yielded the ostracods *Quadrilobella* sp., *Planusella* sp., *Pribilina* sp., *Primitia* sp., and, in the roof of Member 28, there were *Macronotella* sp., *Schmidtella* sp., *Primitia* sp., and *Pribilina* sp. (also identified by G.R. Kolosnitsyna). Member 28 is

referred to the Kirensk–Kudrino Horizon. According to recent data (*Stratigrafiya ...*, 2007), the above list of ostracods, along with the assemblage of other fauna (brachiopod *Rostricelulla* sp., trilobites *Homotelus lenaensis* Z. Maximova, 1962 and *Isoletus maximus* Z. Maximova, 1962, conodonts *Stereoconus aculeiformis* Moskalenko, 1970, *S. bicostatus* Moskalenko, 1970, etc.), characterize the Ust'-Nalednyi Formation, which is dated Middle–Late Ordovician (Caradocian and Ashgillian).

It is also necessary to consider the study devoted to trilobites (Ogienko et al., 2002), which describes a complete section of the Vorotnaya Formation in the valley of the Chepa River and Nalednyi Creek. In outcrop 822 located in the Nalednyi Creek valley 0.5 km from the mouth, the authors assigned Beds 1–5 to the Nayaya Horizon of the Upper Tremadocian; the upper part of the section (Bed 6) is referred to the Ugor Horizon of the Arenigian (Floian) Stage. In addition to remains of brachiopods, trilobites, and conodonts, limestones of Bed 6 have yielded ostracods, which Kolosnitsyna assigned to *Primitiella* sp.; unfortunately, they were not accompanied by descriptions or figures of these remains. Thus, *Primitiella* sp. in question is probably the earliest known record of ostracods in Siberia, since at this level, this faunal group has not been recorded. However, it is possible that, in the characteristics of the fauna from Bed 6, there could have been mistakes in binding or identification of ostracods. In many works, it was indicated that reliable finds of ostracods on the Siberian Platform occurred since the Kimai Horizon (first appear in its upper part) (Kolosnitsyna, 1974; Ivanova, 1979; the Ordovician ..., 1982; *Stratigrafiya ...*, 2007; Kanygin et al.,

2013; Maslova et al., 2014; Stepanova, 2015, etc.). Moreover, it is known that, in this region, members of the genus *Primitiella* are characteristic of the beds of the Kirensk–Kudrino Time.

MATERIAL AND ANALYSIS OF THE OSTRACOD ASSEMBLAGE

The ostracods examined here come from the samples collected in the Udokan District by geologists of the manufacturing association *Chitageologiya* E.A. Barabasheva, A.A. Lesnyansky, N.N. Pakhomov, S.M. Sinita, and I.A. Tombasov, who investigated Ordovician deposits. We revealed ostracod remains in the beds on both slopes of the Nalednyi Creek only in the upper part of the Nalednyi Formation. Ostracods were extracted of from the host rock using standard methods not only of mechanical decomposition of limestones, but also etching in weak acetic acid (*Metodika* ..., 1973). As a result, a rather representative and diverse ostracod assemblage has been obtained, including *Primitia abundans* V. Ivanova, 1959 (Pl. 6, fig. 2), *P. cf. alta* Melnikova, 1981 (Pl. 6, fig. 3), *P. kalarensis* sp. nov., *Leperditella* sp. (Pl. 6, fig. 6), *Egorovellina* (?) *shuvalovae* sp. nov., *Cherskiella baikalica* sp. nov., *Gontiella mira* gen. et sp. nov., *Leperditella nalednaya* sp. nov., *Hallatina opima* sp. nov., *Glandites planus* sp. nov., and *Bollia sinitisae* sp. nov. In some cases, despite the fact that some taxa are identified based on singular specimens, they distinctly show characters that allow the establishment of a new taxon.

It is noteworthy that, in all studied samples, *Hallatina opima* is a background species; its large shells have distinctive characters, suggesting that, in the future, it will be possible to use this species for stratigraphical correlations directly in field conditions.

For dating host rocks, the presence of members of the family Cherskiellidae Kanygin, 1967 is particularly important. When establishing this family, Kanygin (1967) assigned to it ten heterogeneous genera varying in age. However, in a revision of the family, Ivanova (1972) has shown with certainty that the Cherskiellidae sensu Kanygin are a heterogeneous group, since the genera included in it have different types of dimorphic structures and different types of shell morphology. As a result of revision, the family retained the genera *Cherskiella* Kanygin, 1965, *Cherskiites* V. Ivanova, 1972 and tentatively Scandinavian *Nanopsis* Henningsmoen, 1954 which, in opinion of Ivanova (1972), can be considered to be ancestral to *Cherskiella*. The stratigraphic range of Cherskiellidae is limited to the Vkhorevo Horizon of the Siberian Platform, the Sakkyryr and Labystakh formations in the Sette-Daban Ridge, the Sien and Uchat formations in the Omulevka Mountains, the Tarynyuryakh Formation in the Selennyakh Range (Kanygin, 1965, 1967; Ivanova, 1973; *Ordovik* ..., 1984). These divisions are correlated with *Dd. purchisoni*–*Hs. teretius-*

culus graptolite zones of the Middle Ordovician, Llanvirnian (or Darriwilian). Thus, it is plausible that new finds of Cherskiellidae in the upper part of the Nalednyi Formation confirm the Vkhorevo–Muktei–Volgino age of this part of the section, which is not in contrast to the conclusion concerning the age made in other studies (*Atlas* ..., 2002; Kanygin et al., 2013; Maslova et al., 2014).

In the description of the fauna, the ostracod system proposed in *Prakticheskoe rukovodstvo* ... (1990) is used. The relative sizes of shells are as follows: small, medium-sized, and large shells are up to 1.0 mm, 1.1–2.0 mm, and more than 2.0 mm long, respectively. In the present study, the following abbreviations are used: (l) shell length, (h) shell height, (d) shell width, (L_1 – L_3) lobes, (S_1 – S_3) grooves with respective serial numbers.

The material is housed in the Borissiak Paleontological Institute of the Russian Academy of Sciences, Moscow (PIN), collection no. 5551.

SYSTEMATIC PALEONTOLOGY

Family Egorovellidae Schallreuter, 1966

Genus *Egorovellina* Kanygin, 1965

Egorovellina (?) *shuvalovae* Melnikova, sp. nov.

Plate 6, fig. 8

Etymology. In honor of the paleontologist Yu.V. Shuvalova.

Holotype. PIN, no. 5551/91, shell; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The carapace is small, slightly preplete in outline, elongated, equivalve. The dorsal margin is straight, slightly shorter than the shell length. The anterior and posterior ends regularly and slightly project beyond the dorsal margin. The anterior end is higher than the posterior end; the posterior end is slightly oblique in the ventral part. The ventral margin is slightly convex. The anterior half of the shell has three vertical riblike lobes, which terminate short of reaching the dorsal margin. L_1 is the shortest, curves in parallel to the anterior end; L_2 is almost straight. These lobes are fused in the dorsal part, with a very narrow slitlike groove between them. L_3 is long, higher than two anterior ones, straight in the upper half of the lateral surface and rather sharply curved to the base of the second lobe. The lobes curve anteriorly by their ventral ends and are connected with each other at the ventral margin. Groove S_2 is wide in the dorsal part and narrowed sphenoid in the ventral part. A narrow marginal brim extends along most of the free border. The carapace surface is rarely coarse-porous.

Measurements in mm. Holotype: l = 0.7; h = 0.4.

Comparison. The new species differs from *E. curvicostata* Kanygin, 1965 in the considerably smaller dimensions, the different lobe outline, and in the coarse-porous surface.

Remarks. The new species is only tentatively assigned to the genus *Egorovellina*, because one of diagnostic characters of *Egorovellina* is the second lobe always positioned closer to the ventral margin and the presence of sexual dimorphism of the marginal type. In the new species, L_2 terminates slightly below the midline, and the character of sexual dimorphism is impossible to observe.

Material. Holotype.

Family Cherskiellidae Kanygin, 1967

Genus *Cherskiella* Kanygin, 1967

Cherskiella baikalica Melnikova, sp. nov.

Plate 6, figs. 9 and 10

Etymology. From the Baikal Region.

Holotype. PIN, no. 5551/51, right valve; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The carapace is medium-sized, amplete in outline, unisulcate, moderately convex, equivalve, with a long straight dorsal margin. The anterior and posterior ends are equal in height and approximately equally project beyond the dorsal margin. The ventral margin is arched. The anterior part of the carapace has a wide lobe extending parallel to the anterior end and occupying almost the entire surface from the anterior end to the median sulcus (S_2). Its maximum height is in the dorsal part; below the middle of the shell, it is smoothly fused with the remaining surface. The lobe is split by two deep obliquely positioned furrows. The furrow nearest to the anterior margin is narrow and straight; the other groove is wider and arched towards the median sulcus. S_2 is open toward the dorsal margin, moderately long, as long as the lobe, wide, and deep. A narrow marginal brim extends along almost the entire free margin. The shell surface is smooth.

Measurements in mm:

Specimen PIN, no.	l	h
Holotype 5551/51	1.35	0.85
5551/52	1.05	0.65
5551/53	0.98	0.62

Variability. The anterior end of the shell slightly vary in height and the flattening along the free margin varies in width.

Comparison. The new species is similar in shell outline and obliquely positioned slitlike grooves to *Ch. abliterata* Kanygin, 1984 (*Ordovik ...*, 1984) described from the Middle Ordovician Vikhorevo

Horizon of the Siberian Platform and differs from it in the wide and high anterior lobe and also in the development of the median sulcus. It differs from *Ch. alexandri* V. Ivanova, 1973 in the obliquely positioned slitlike furrows, the wider anterior lobe, long S_2 , and in the absence of the posterior lobe.

Material. Ten specimens from the type locality.

Genus *Gontiella* Melnikova, gen. nov.

Etymology. In honor of the expert in ostracods T.V. Gonta.

Type species. *Gontiella mira* sp. nov.

Diagnosis. Carapace medium-sized, amplete in outline, inequivalve. S_2 wide, long, bordered by horseshoe-shaped lobe occupying most of lateral surface. Anterior lobe split by two horizontal furrows. Surface smooth.

Species composition. Type species.

Comparison. The new genus differs from *Cherskiella* and *Cherskiites* in the development of a wide median sulcus bordered by a horseshoe-shaped lobe.

Gontiella mira Melnikova, sp. nov.

Plate 6, figs. 11 and 12

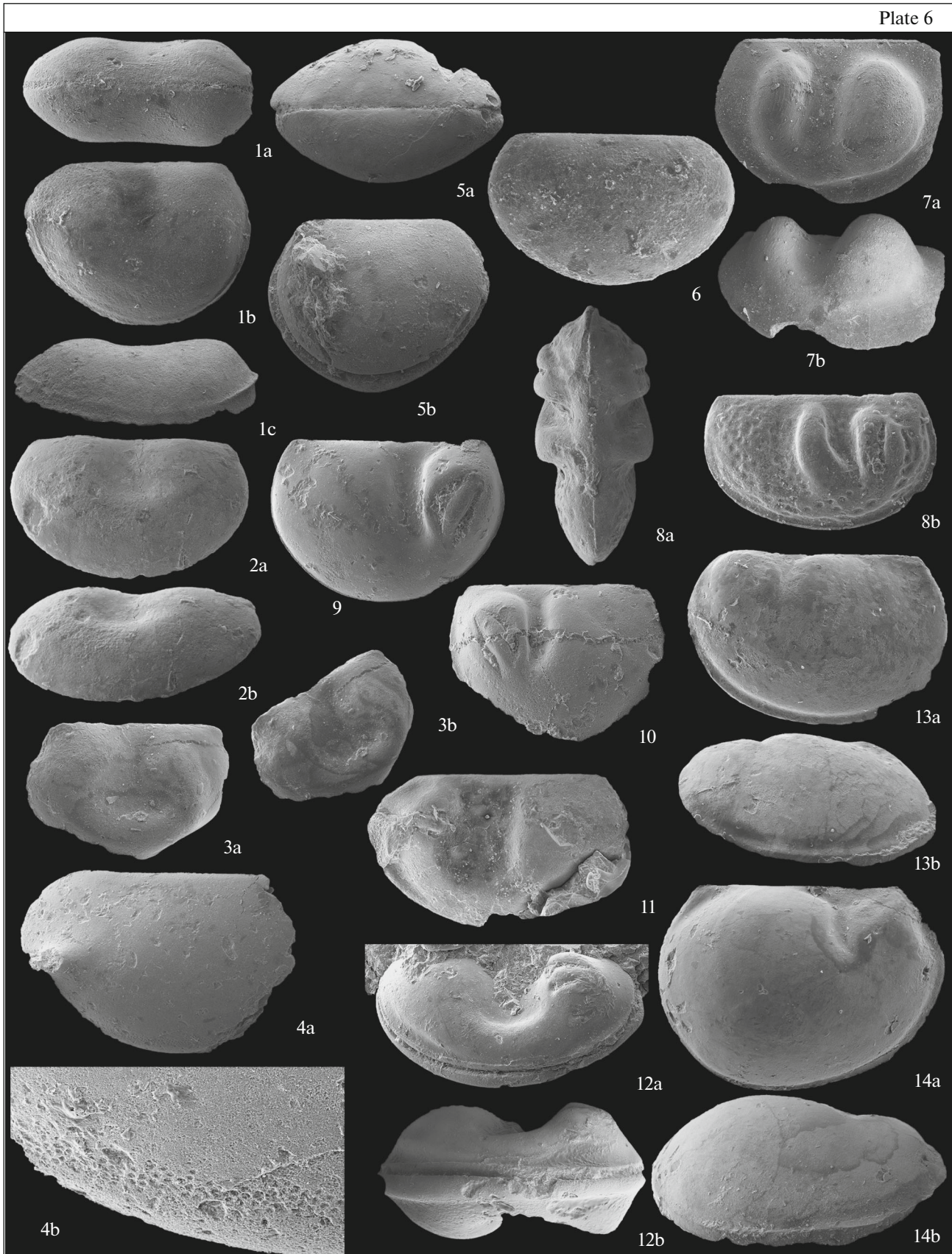
Etymology. From the Latin *mira* (surprising, magnificent).

Holotype. PIN, no. 5551/81, shell; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The shell is medium-sized, amplete in outline, unisulcate, moderately convex, with a long straight dorsal margin. The left valve slightly overlaps the right one along almost the entire free margin. The anterior and posterior ends are equally high; the anterior end projects beyond the dorsal margin to a greater extent. The ventral margin is arched. The middle part of the lateral surface has a very wide and shallow S_2 open to the dorsal margin. S_2 is bordered by a wide horseshoe-shaped lobe. The lobe is separated from the lateral surface by a distinct bend almost throughout of the free margin. The posterior branch is wider than the anterior one and smoothly fused with the lateral surface. The anterior lobe is split by two horizontal furrows. The furrows are short, sphenoid expanding towards the median sulcus. A narrow marginal brim extends along almost the entire free margin. The surface is smooth.

Measurements in mm:

Specimen PIN, no.	l	h
Holotype 5551/81	1.34	—
5551/82	1.47	0.87



← Explanation of Plate 6

All specimens come from the Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation of northern Transbaikalia (Upper Kalar Graben, Nalednyi Creek).

Fig. 1. *Primitia kalarensis* sp. nov., holotype PIN, no. 5551/131, carapace, l = 0.72 mm: (1a) dorsal margin view, (1b) lateral view of the left valve, (1c) ventral margin view.

Fig. 2. *Primitia abundans* V. Ivanova, 1959, specimen PIN, no. 5551/141, carapace, l = 0.64 mm: (2a) right valve view, (2b) ventral margin view.

Fig. 3. *Primitia* cf. *alta* Melnikova, 1981, specimen PIN, no. 5551/151, carapace, l = 0.67 mm: (3a) lateral view of the right valve, (3b) posterior end view.

Fig. 4. *Glandites planus* sp. nov., holotype of PIN, no. 5551/101, left valve, h = 1.05 mm: (4a) lateral view, (4b) magnified fragment of the valve surface in the ventral part, displaying rows of circular pores extending parallel to the ventral margin.

Fig. 5. *Leperditella nalednaya* sp. nov., holotype of PIN, no. 5551/121, carapace, h = 1.05 mm: (5a) dorsal margin view, (5b) right valve view.

Fig. 6. *Leperditella* sp. 1, specimen PIN, no. 5551/161, carapace, left valve view, l = 0.6 mm.

Fig. 7. *Bollia sinitsae* sp. nov., holotype of PIN, no. 5551/111, carapace, left valve, l = 1.0 mm: (7a) lateral and (7b) ventral margin views.

Fig. 8. *Egorovellina(?) shuvalovae* sp. nov., holotype of PIN, no. 5551/91, carapace, l = 0.7 mm: (8a) dorsal margin view, (8b) lateral view of the right valve.

Figs. 9 and 10. *Cherskiella baikalica* sp. nov.: (9) holotype of PIN, no. 5551/51, l = 1.35 mm, lateral view of the right valve, (10) specimen PIN, 5551/52, l = 1.05 mm, lateral view of the left valve.

Figs. 11 and 12. *Gontiella mira* gen. et sp. nov.: (11) specimen PIN, no. 5551/82, lateral view of the left valve; (12) holotype of PIN, no. 5551/81, carapace, l = 1.34 mm: (12a) lateral view the right valve, (12b) ventral margin view.

Figs. 13 and 14. *Hallatina opima* sp. nov.: (13) specimen PIN, no. 5551/3, left valve of male, l = 1.52 mm: (13a) lateral and (13b) ventral margin view; (14) holotype of PIN, no. 5551/1, right valve of female, l = 1.52 mm: (14a) lateral and (14b) ventral margin views.

Variability. The medial groove slightly varies in depth.

Material. Eight specimens from the type locality.

Family Leperditellidae Ulrich et Bassler, 1906

Genus *Leperditella* Ulrich, 1894

Leperditella nalednaya Melnikova, sp. nov.

Plate 6, fig. 5

Etymology. From the Nalednyi Creek.

Holotype. PIN, no. 5551/121, carapace; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The carapace is small, ample in outline, high, short, with the greatest convexity in the center of the shell, inequivalve; the left valve is deeply overlaps the right valve along the ventral margin and the middle of anterior and posterior margins. The anterior end is lower than the posterior end; the dorsal angles are blunt, with the anterior angle larger than the posterior one. The shell surface is smooth.

Measurements in mm:

Specimen PIN, no.	l	h	d
Holotype 5551/121	0.72	0.5	0.46
5551/122	0.75	0.58	—

Comparison. The new species is closest to *L. secunda* V. Ivanova, 1973 known from the Khati Formation of the northeastern Russia, differing from it in the deeper overlap, the development of the maxi-

imum convexity in the middle rather than in the posterior half of the carapace, the absence of a weak depression in the anterior thoracic part of the left valve. It differs from *L. prima* Sarv, 1956 in the smaller size, unequal height of the anterior and posterior ends, and in the deeper overlap.

Material. Ten specimens from the type locality.

Family Primitiidae Ulrich Et Bassler, 1923

Genus *Hallatina* V. Ivanova, 1964

Hallatina opima Melnikova, sp. nov.

Plate 6, figs. 13 and 14

Etymology. From the Latin *opima* (abundant, plentiful).

Holotype. PIN, no. 5551/1, shell; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The carapace is medium-sized, ample in outline, with a long dorsal margin, high, strongly convex. The anterior cardinal angle is larger than the posterior one. The posterior end is higher than the anterior end and projects beyond the dorsal margin to a lesser extent than the anterior one. S₂ is short, located closer to the dorsal margin. The median node is absent or hardly discernible. A marginal brim extends along the entire free margin and expands near the posterior cardinal angle to form a distinct area. Sexual dimorphism is manifested in the much greater convexity of the domicilium in female shells from the S₂ posteriad; the maximum convexity in females is at the midheight. Male shells are less convex compared

to females; the maximum convexity of shells is located in males closer to the S_2 . The surface is smooth.

Measurements in mm:

Specimen PIN, no.	l	h
Holotype 5551/1, ♀	1.79	1.28
5551/2, ♂	1.52	1.11
5551/3, ♀	1.9	1.36

Variability. The most widely varying characters are the length-to-height ratio of shells, the width of the marginal brim, the length of the median sulcus, and the extent of expressiveness of the area near the posterior cardinal angle.

Comparison. The new species differs from all known members of the genus *Hallatina* in the considerably greater convexity of the shell. It differs from *H. yakovlevi* (V. Ivanova, 1973) in the short, poorly delineated S_2 , while in *H. yakovlevi*, S_2 is long, deep, and narrow, with distinct median node in the anterior part.

Material. More than 300 specimens from the type locality.

Genus *Primitia* Ulrich et Bassler, 1923

Primitia kalarensis Melnikova, sp. nov.

Plate 6, fig. 1

Etymology. From the Kalar River.

Holotype. PIN, no. 5551/131, shell; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The carapace is small, high, ample in outline, moderately convex, equivalve. The anterior end is lower than the posterior end and projects beyond the dorsal margin to a slightly greater extent. The dorsal angles are rounded; the anterior cardinal angle is larger than the posterior one; the posterior cardinal angle is slightly larger than a right angle. In the middle of the valve, closer to the anterior end, there is a small short sulcus looking like depression. The greatest length is in the middle; the greatest height is shifted from the middle towards the posterior end. The lateral surface has a thin cicatrice located near the ventral margin and extending parallel to it; the ridge slightly expands along the posterior end. The surface is smooth.

Measurements in mm:

Specimen PIN, no.	l	h
Holotype 5551/131	0.72	0.63
5551/132	0.71	0.55

Variability. The shell outline slightly varies from elongated to almost round.

Comparison. The new species is most similar to *P. perpusila* V. Ivanova, 1960 in the development of a thin cicatrice near the ventral margin and differs from it in the poorly developed S_2 and the inverse relation of the heights of the anterior and posterior ends.

Material. Nine specimen from the type locality.

Family Glanditiidae V. Ivanova, 1960

Genus *Glandites* V. Ivanova, 1960

Glandites planus Melnikova, sp. nov.

Plate 6, fig. 4

Etymology. From the Latin *planus* (flat).

Holotype. PIN, no. 5551/101, left valve; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The valve is medium-sized, sharply postplete in outline, flattened; the dorsal margin is long and straight; the posterior end is much higher than the anterior end; the anterior end projects beyond the dorsal margin to a lesser extent. The ventral margin is considerably convex, oblique relative to the anterior end. The maximum length is in the middle; the maximum height is closer to the posterior end. In the middle of the anteroventral margin, there is a spine with a wide base, the length of which was impossible to estimate. The shell surface is smooth, except for the ventral part, which has four or five rows of circular pores extending parallel to the ventral margin.

Measurements in mm. Holotype: h = 1.05.

Comparison. The new species differs from other members of the genus *Glandites* in the sharply postplet outline, the absence of a median sulcus, and in the flattened lateral surface.

Material. Holotype.

Family Bolliidae Bouček, 1936

Genus *Bollia* Jones et Holl, 1866

Bollia sinitsae Melnikova, sp. nov.

Plate 6, fig. 7

Etymology. In honor of S.M. Sinitsa, an explorer of Transbaikalia.

Holotype. PIN, no. 5551/111, left valve; northern Transbaikalia, Upper Kalar Graben, Nalednyi Creek; Middle Ordovician, Llanvirnian (Darriwilian) Stage, Nalednyi Formation.

Description. The shell is small, high, slightly convex, ample in outline, unisulcate. The posterior end of the shell is higher than the anterior end. S_2 is small, long, open towards the dorsal margin. The sulcus is bordered by a horseshoe-shaped lobe consisting of two tubercles differing in height, smoothly connected in the ventral part, and do not projecting beyond the dorsal margin. The anterior branch of the lobe is oblong, narrower than the posterior branch.

The posterior branch of the lobe is wide, round, with a sharper boundary on the side of the posterior margin. The ventral structures are indiscernible. The shell surface is smooth.

Measurements in mm. Holotype: $l = 1.0$, $h = 0.7$

Comparison and remarks. The general structural pattern of the shell, with the horseshoe-shaped lobe corresponds to the expanded diagnosis of the genus *Bollia*. The new species differs from congeners in the absence of a marginal rib.

Material. Two valves from the type locality.

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