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Early-Middle Ordovician (Billingen-Volkhov stages) Orthide and Protorthide brachiopods from the East Baltic

Eva Egerquist [a] & Lars E. Holmer [a]

[a] Department of Earth Sciences, Uppsala University, Palaeobiology, Norbyvägen 22, SE 752 36, Uppsala, Sweden E-mail:

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Early–Middle Ordovician (Billingen–Volkhov stages) Orthide and Protorthide brachiopods from the East Baltic

EVA EGERQUIST[1] and LARS E. HOLMER[1]

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Abstract: Three new orthide species: *Orthidium lavensis*, *Orthidium gambolovensis* and *Ranorthis rotunda,* and one new protorthide species: *Skenidioides minutus,* are described from the Early–Middle Ordovician (Billingen–Volkhov stages) of Estonia and north-western Russia. This is the first record of *Orthidium* from Baltica, whereas *Skenidioides* was known previously only from the Keila and Oandu stages in Estonia.

Keywords: Brachiopoda, Orthida, Protorthida, new species, *Orthidium*, *Skenidioides*, *Ranorthis*, Ordovician, Russia, Estonia.

[1] *Department of Earth Sciences, Uppsala University, Palaeobiology, Norbyvägen 22, SE 752 36 Uppsala, Sweden; eva.egerquist@pal.uu.se, lars.holmer@pal.uu.se*
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Introduction

Brachiopod faunas from the Lower–Middle Ordovician in north-western Russia have been thoroughly investigated for more than one hundred and fifty years. Nevertheless detailed sampling, as well as investigation of soft sediment and mud mounds, can still reveal new taxa. In this paper, four new rhynchonelliformean brachiopods from the Arenig successions (Billingen to Volkhov stages) in Estonia and north-western Russia are described. Two of the described species belong to the widespread genus *Orthidium*, which has been recorded previously from China, Argentina, Laurentia and Scotland, but not from the Baltic region. The likewise widespread genus *Skenidioides* was known previously from Estonia, where it occurs in the Keila and Oandu stages. Thus the find of *S. minutus* considerably pushes back the first appearance of this genus in the Baltic region. Contemporaneous records are known from Wales, China and Argentina.

Geological setting and palaeogeography

Lowermost Middle Ordovician sedimentation in Baltoscandia was characterized by very slow intermittent sedimentation in a rather shallow epicontinental sea, located within the temperate climatic zone approximately 40–60 degrees south of the equator (Jaanusson 1973; Cocks & Torsvik 2005). The eastern part of the basin was characterized by predominantly siliciclastic deposition during the late Cambrian and early Tremadoc, followed by the formation of fine-grained argillites and carbonate deposits in the late Tremadoc to early Arenig. Continuous sedimentation of siliciclastic-starved carbonate sediments prevailed in the basin from the mid Arenig onwards.

The investigated localities are part of a series of quarries and exposures distributed along the so-called Baltic-Ladoga Klint, which extend from the north-western coast of Estonia to the southern shore of Lake Ladoga in Russia (Fig. 1). The Klint forms the northern edge of the Ordovician outcrop area in the East Baltic region (Popov et al. 1989; Dronov et al. 1996), and belongs to the North Estonian confacies belt, which is considered to be the shallowest part of the basin. The deposits are spatially remarkably homogenous and undisturbed and consist of horizontal, easily recognisable units of, mainly calcareous, packstones and wackestones. Most of these units can be recognised over a distance of nearly 200 kilometres along the Baltic-Ladoga Klint in Russia and north-western Estonia (Dronov et al. 2000).

The lowermost part of the Billingen Stage (Mäeküla Member) is characterized by quartzose glauconitic sand, calcareous glauconitic sandstone and clay, whereas the upper part (Vassilkovo and lower Dikari members) consists of argillaceous glauconitic limestone with thin intercalations of clay (e.g. Rubel & Popov 1994; Pushkin & Popov 1999).

Specimens of *Orthidium* were found in Billingenian strata in Estonia (*O. lavensis*) and at several localities in the St. Petersburg region whereas all specimens of *Skenidioides minutus* and *Ranorthis rotunda* were collected from the Volkhov Stage succession in Putilovo quarry and from the large mud mound in this exposure (Figs. 1 and 2).

In the Putilovo section layers of soft silt/clay sediment are intercalated with units of calcareous packstones and wackestones with varying content of glauconite. The large mud mound in Putilovo quarry is one of several similar formations in the region. It is a more or less circular, about 150 metres in diameter, probably sponge mediated (Fedorov 2003), build-up consisting of two thick clay lenses, of which the lower one sits on top of the distinct hardground surface ("Steklo") that marks the boundary between the Billingen and Volkhov regional stages. The two lenses are covered by micritic crusts and contain numerous limestone pebbles. The lower clay lens is within the *Baltoniodus triangularis* conodont Biozone, which is otherwise missing in this outcrop (Tolmacheva et al., 2003).

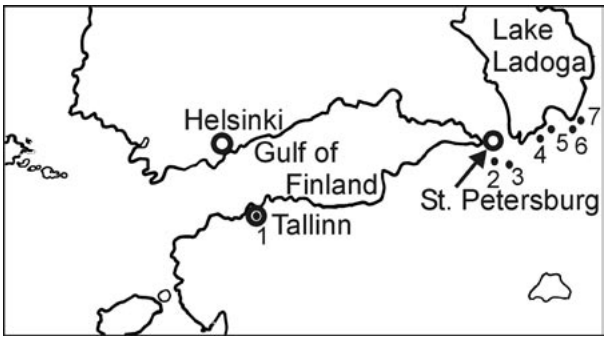

Fig. 1. Localities. 1 – Suhkrumägi. 2 – Popovka River. 3 – Tosna River with Sablino mud mound. 4 – Putilovo quarry. 5 – Lava River. 6 – Volkhov River and Babino quarry. 7 – Syas River.

All fossil material used in this investigation were washed out from soft silt/clay samples.

Systematic palaeontology

Abbreviations given in the tables are: L – maximum length, W – maximum width, D – maximum depth, LI – length of interarea, HW – hinge width, R/mm – number of ribs per mm, RAM – number of ribs at anterior margin. The studied specimens are deposited in the collections of the Museum of Evolution, Uppsala University (acronym PMU).

Order Protorthida Schuchert & Cooper, 1931

Superfamily Skenidioidea Kozłowski, 1929

Family Skenidiidae Kozłowski, 1929

Genus *Skenidioides* Schuchert & Cooper, 1931

Type species. – *Skenidioides billingsi* Schuchert & Cooper (1931, p. 243) by original designation; Caradoc, Quebec.

Skenidioides minutus sp. nov.

Fig. 3A–Z; Table 1

Etymology. – From latin *minutus* small, alluding to the fact that it is one of the smallest species of the genus.

Holotype. – PMU In 510 (Fig. 3A–D). Dorsal valve from the standard section at Putilovo quarry, Zheltiaki Member, (sample R97 P21Bcl, bed index 21B), *Paroistudus originalis* conodont Biozone.

Paratypes. – 103 specimens, including figured specimens PMU In 511–518, all from Putilovo quarry.

Diagnosis. – Small *Skenidioides* species, usually not more than 2.5 mm wide and 2 mm long. Anterior margin strongly sulcate. Radial ornament costellate with 8–12 rounded costae on the dorsal valve and 7–11 on the ventral valve. Dorsal adductor scars form a slightly raised, elongated area on each side of the median septum occupying about half the length of the shell.

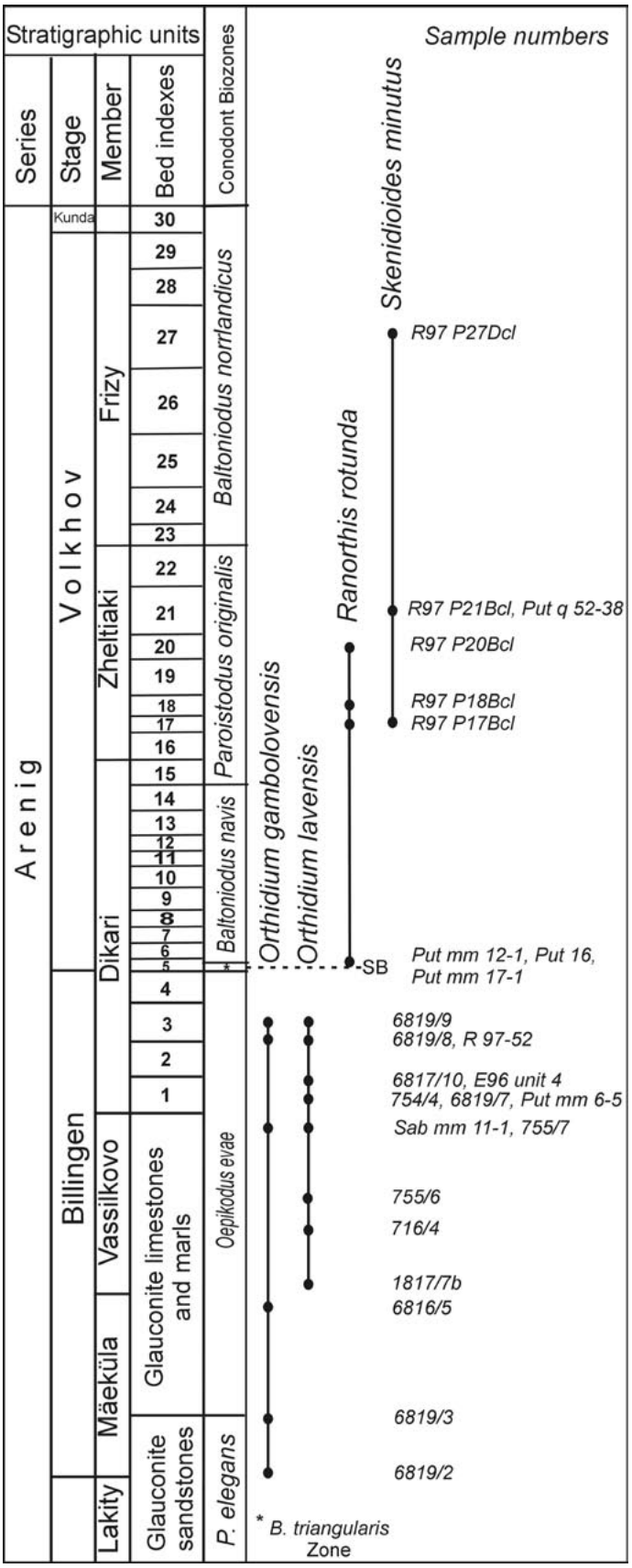

Fig. 2. Generalised stratigraphic column through the Billingen and Volkhov formations, with distribution of described species. Bed indexes are based on the system employed by Russian researchers (Dronov personal communication 1999). SB – sequence boundary.

Description. – Shell small, measured specimens are maximum 2 mm long and 2.5 mm wide; shell on average 1.25 mm long, 2.1 mm wide; 60% as long as wide. Outline semicircular with straight hinge line. Lateral profile ventribiconvex with moderately curved dorsal valve and high subpyramidal ventral valve. Anterior margin strongly sulcate. Dorsal interarea short, planar, anacline. Ventral interarea long, on average 76% of shell length, apsacline to catacline. Delthyrium open. Radial ornament costellate with 8–12 rounded costae on the dorsal valve and 7–11 on the ventral valve, depending on shell size. Costae only rarely bifurcate, but increase in number laterally as the shell grows. In ventral view the shell looks pinched at the anterior margin depending on the well-developed sulcus and fold, both of which coincide with a single costa.

Ventral interior: Teeth small, rounded, located at the angle formed by the delthyrial and hinge margins. A shallow spondylium is free anteriorly but supported at its posterior end by adventitious shell material. Muscle scars or mantle canals not seen.

Dorsal interior: Notothyrial cavity shallow; brachiophores moderately diverging; supporting plates converging and uniting with the median septum to form a septalium of about one third of shell length. Cardinal process linear, slightly crenulated, anteriorly raised and prolonged toward the front as a prominent median septum which almost reaches the anterior margin of the shell. The height of the median septum varies in different specimens so that it is sometimes highest at the anterior end of the septalium, sometimes at the anterior end of the shell. Sockets defined by a concave socket plate, in some specimens covered by the interarea in their posterior ends. Adductor scars form a slightly raised, elongated area on each side of the median septum occupying about half the length of the shell.

Discussion. – The size of the shell and the bipartite dorsal adductor field resemble *Protoskenidioides* Williams, 1974 rather than *Skenidioides*. The septalium, however, seems to be completely developed already in juvenile specimens (about 0.5 to 0.6 mm long), and the cardinal process shows no trace of being formed by coalescence of the posteromedial edges of the brachiophore plates in the way described for *Protoskenidioides* by Williams (1974, p. 84). Furthermore, the median septum is continuous with the cardinal process and not separated from it as in *Protoskenidioides* (Fig. 3 G, H, M).

Skenidioides is a widespread genus with a great number of described species. Cocks (1978) listed 10 species from Great Britain, and Cooper (1956) listed 13 from North America, all of which are considerably younger than the new Baltic species. Late Ordovician occurrences of the genus were also reported from Kazakhstan (Nikitin et al. 2003), Australia (Laurie 1991) and from different localities in China (e.g. Zhan et al. 2002). From the Baltic region the earliest report of the genus is from middle Caradoc in Estonia (Hints & Rõõmusoks 1997). Rubel (1963) reports *S. lewisi* (Davidson, 1848) from lower Llandovery (G_I–G_{II}) in Estonia and *S. acutum* (Lindström, 1861) is reported from the Silurian of Gotland. Only a few contemporaneous records of the genus are known such as an early Arenig *Skenidioides*, not yet classified to species level, which was reported from South China (Zhan & Rong 2003). Two likewise unclassified species were reported from the upper Arenig to lower Llanvirn Treiorwerth and Nantannog formations on Anglesey, Wales (Bates 1968; Neuman & Bates 1978). From South America, the genus was reported from the Upper San Juan Formation in the Precordillera basin (late Arenig to early Llanvirn), and from middle Arenig strata (*B. navis* conodont Biozone) in the Famatina basin (Benedetto 1998, 2003).

S. minutus differs from the South American species in being much smaller, and in having a very deep dorsal sulcus and high ventral fold, each of which has only one costa. The Anglesey species are larger, have strongly apsacline ventral interarea and unbranched costae.

Material and occurrence. – (Figs. 1 and 2) All material is from Zheltiaki and Frizy members (*Paroistodus originalis and Baltoniodus norrlandicus* conodont biozones) at Putilovo quarry: sample R97 17Bcl (2 ventral valves), sample R97 21Bcl (44 dorsal valves, 49 ventral valves, 3 conjoined specimens), sample R97 27Dcl (2 ventral valves, 2 conjoined specimens), sample Put.q. 52-38 (2 dorsal valves).

Order Orthidia Schuchert & Cooper, 1932

Superfamily Orthoidea Woodward, 1852

Family Orthidellidae Ulrich & Cooper, 1936

Genus *Orthidium* Hall & Clarke, 1892

Type species. – *Orthidium gemmicula* (Billings, 1862 in 1861–1865, p. 75) by original designation; Tremadoc, Quebec.

Orthidium lavensis sp. nov.

Figs. 4 and 6; Table 2

Synonymy. – *Orthidium* sp. nov. –Egerquist, 2003, p. 31

Etymology. – After Lava River, Russia, where it was first found.

Holotype. – PMU In 480 (Fig. 4A) Dorsal valve from Popovka River, Leetse Formation, Vassilkovo Member (sample 716/4). *Oepikodus evae* conodont Biozone.

Paratypes. – 163 specimens including the figured specimens PMU In 481–488.

Table 1. *Skenidioides minutus* sp. nov. Dimensions of figured specimens (in mm).

Specimen	L	W	D	LI
PMU In 510. Holotype	1.5	2.1	0.5	
PMU In 511	1.5	2.2	0.5	
PMU In 513	1.2	2.2 est.		
PMU In 514	1.3	2.3	1.1	1.1
PMU In 515	1.6	2.2	0.9	0.6
PMU In 516	1.5	2.2	0.3	
PMU In 517	1.1	2.1	0.9	0.9
PMU In 518	1.5	2.2	0.8	0.8

L – maximum length, W – maximum width, D – maximum depth, LI – length of interarea.

Table 2. *Orthidium lavensis* sp. nov. Dimensions of figured specimens (in mm).

Specimen	L	W	HW	D	R/mm
PMU In 480. Holotype	3.5	4	3.3	0.8	6
PMU In 481	1.7	2.6	2.6	0.4	
PMU In 482	2.4	3.1	3	0.7	7
PMU In 483	2.6	3.1	3.1	1.6	7
PMU In 484	2.3	2.7	2.7	1.2	6
PMU In 485	1.7	2.3	2.0	0.6	7
PMU In 486	5.0	4.9	3.9	2.7	6
PMU In 487	2.1	2.5	2.3	1.1	7
PMU In 488	2.3	2.7	2.5	1.2	7

L – maximum length, W – maximum width, D – maximum depth, LI – length of interarea.

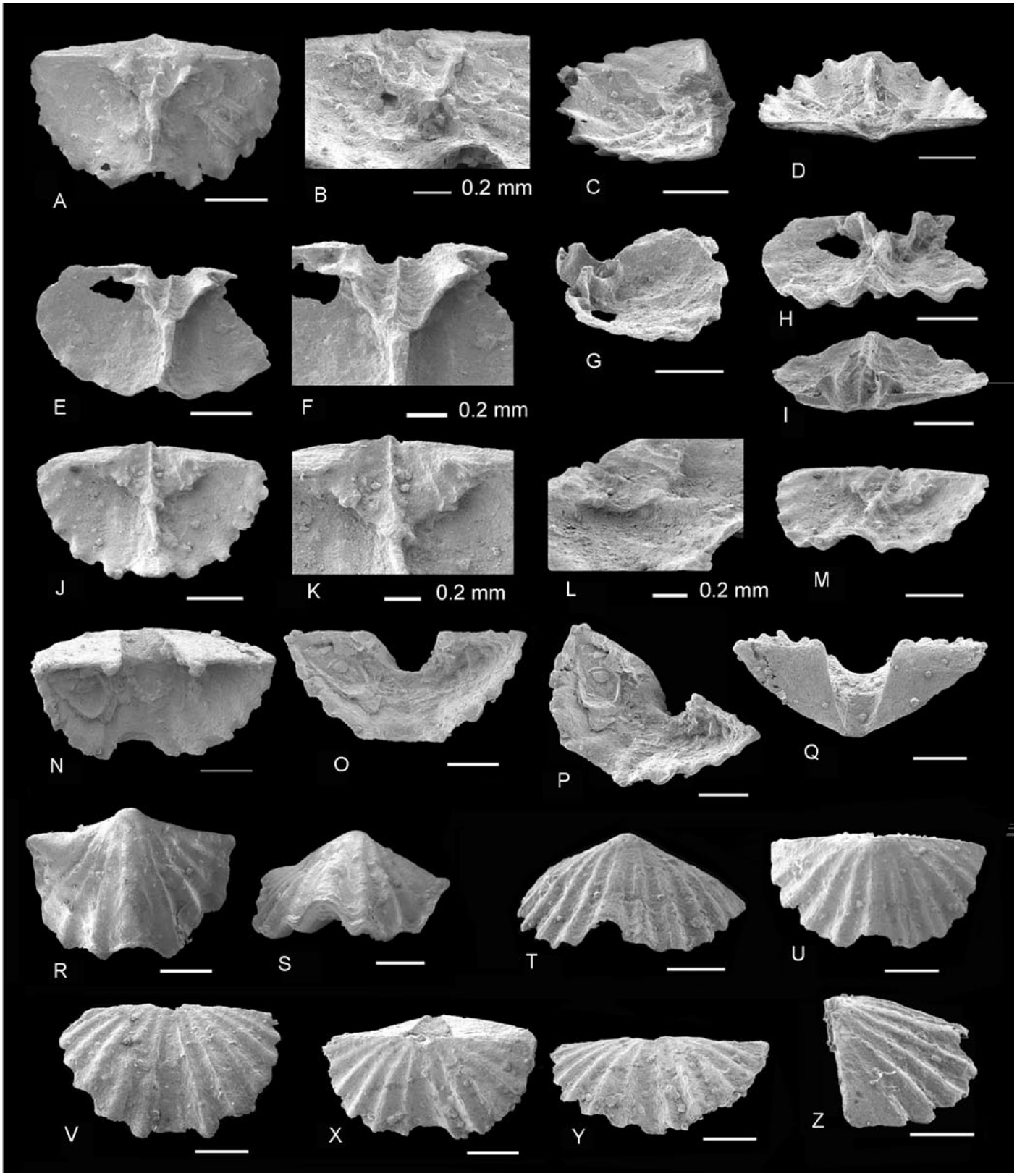

Fig. 3. *A–Z.* Skenidioides minutus *sp. nov.* Scale bars 0.5 mm if size not stated. **A–D.** PMU In 510, holotype, dorsal valve interior in different positions. **E–I.** PMU In 513, dorsal interior. **J–M.** PMU In 511, dorsal interior. **N–Q.** PMU In 514, ventral valve in different positions. **R–S.** PMU In 515, conjoined specimen in ventral and anterior view. **T, U, Z.** PMU In 517, ventral valve exterior in different positions. **V.** PMU In 516, dorsal valve exterior. **X–Y.** In 518, conjoined specimen in dorsal and anterodorsal views. All specimens are from Putilovo quarry.

Diagnosis. – Small subcircular *Orthidium* species with strongly convex ventral valve averaging 91% as long as wide and 51% as deep as long, and moderately convex dorsal valve averaging 76% as long as wide and 22% as deep as long; ornamented by 6–7 rounded ribs per mm at 2 mm anteromedially of ventral umbo. Dorsal interior with prominent, posteriorly raised median ridge.

Description. – Outline subcircular, up to 5.5 mm wide and 5.2 mm long, with straight hingeline almost as long as maximum width. Ventral valve strongly convex averaging 51% as deep as long and 91% as long as wide; dorsal valve averaging 22% as deep as long and 76% as long as wide, with sulcus. The sulcus fits into the ventral valve so that the conjoined shell looks almost planoconvex in side view, averaging 52% as deep as wide.

Radial ornament multicostellate with 6–7 rounded costellae per mm at 2 mm anteromedially of ventral umbo; concentric ornament strongly imbricate with fine wavy fila in the interspaces of the ribs. Ventral interarea triangular, slightly concave, orthocline to apsacline, delthyrium wide, open; dorsal interarea narrow, anacline.

Ventral interior with large triangular teeth supported by erect dental plates obscured by callus deposits. Diductor scars form deeply impressed narrow furrows surrounding the uplifted, wide adductor field. Anteriorly the diductor scars extend into two unbranched, subparallel vascula media.

Dorsal interior with high triangular cardinal process more or less fused to the brachiophores by callus deposits, forming a chevron shaped build-up, which normally protrudes behind the hinge line and occupies the delthyrium in conjoined valves. A high median ridge extends from the notothyrial platform about two thirds of the length of the shell. Muscle field quadripartite, anterior scars oval with the posterior ends between the smaller circular posterior scars.

Discussion. – The new species differs from the type species *O. gemmicula* (Billings, 1862) in its greater size and a more circular outline. The lateral profile differs markedly, the new species having more or less a planoconvex profile with a strongly convex ventral valve whereas in *O. gemmicula*, the dorsal valve has the greater convexity. It differs from other North American species in outline, profile and number of ribs.

Two different species are described from Argentina, of which *O. geniculatum* Herrera & Benedetto, 1989 differs from *O. lavensis* by its geniculate profile, transverse outline, sulcate ventral valve, small teeth and slender cardinalia, whereas the other species, *O. prominens* Benedetto (in Benedetto et al. 2003), differs in having a ventral sulcus and in possessing a long, slender cardinal process. Two other Argentinean brachiopods have been assigned to the genus: *Orthidium* sp.1 (Herrera & Benedetto 1989) and *Orthidium* sp. 2 (Benedetto 2001). Of these the second one differs by having a more elongate outline, deeper curved ventral valve, fewer ribs, long narrow delthyrium, and higher ventral interarea. The first one however, from the Arenig of the Precordilleran basin, is very similar to *O. lavensis*. Due to the fragmentary material this brachiopod is not yet described, but judging from the specimens that are illustrated by Herrera and Benedetto (1989), it might well be conspecific with the Baltic species. The two illustrated specimens, one dorsal and one ventral exterior, are about the same size, with a similar outline and number of ribs as those of *O. lavensis*. Furthermore, the two records are more or less contemporaneous, *O. lavensis* appears in the *O. evae* conodont Biozone whereas the Argentinian species is recorded from the *O. evae* and *B. navis* biozones.

Unclassified specimens of the genus were also reported from lower Arenig strata (Dounans Limestone) at the Highland Border in Central Scotland (Curry et al. 1982).

Material and occurrence. – (Figs. 1 and 2) *Orthidium lavensis* was found at Suhkrumägi roadcut in Tallinn, Estonia and at several localities in Russia ranging from lower Vassilkovo Member to lower Dikari Member (*Oepikodus evae* conodont Biozone).

Distribution in Estonia: Suhkrumägi roadcut: sample E 96 unit 4 (6 ventral valves).

Distribution in Russia: Popovka River: sample 716/4 (10 dorsal valves, 13 ventral valves, 3 conjoined specimens), sample 6819/7 (1 conjoined specimen), sample 6819/8 (1 ventral valve) and sample 6819/9 (12 dorsal valves, 5 conjoined specimens). Syas River: sample 754/4 (1 dorsal valve, 1 ventral valve, 4 conjoined specimens). Lava River: sample 6817/7b (1 ventral valve, 1 conjoined specimen) and sample 6817/10 (2 dorsal valve, 4 ventral valve, 10 conjoined specimens). Putilovo quarry: sample R97-52 (8 dorsal valves, 44 ventral valves, 37 conjoined specimens), the small mud mound at Putilovo quarry: sample Put mm 6-5 (2 conjoined specimens). Sablino mud mound at Tosna River: sample Sab. mm. 11-1 (3 dorsal valve, 1 ventral valve, 2 conjoined specimens). Volkhov river: sample 755/6 (1 conjoined specimen), sample 755/7 (1 conjoined specimen).

Orthidium gambolovensis sp. nov.

Figs. 5 and 6; Table 3

Etymology. – After Gambolovo village, near the locality where it was first found, in the Popovka River valley.

Table 3. *Orthidium gambolovensis* sp. nov. Dimensions of figured specimens (in mm).

Specimen	L	W	HW	D	R/mm
PMU In 489. Holotype	2.0	2.9	2.7	0.6	4
PMU In 490	1.2	2.1	1.8	0.4	4
PMU In 491	1.6	2.3	2.2	0.5	4
PMU In 492	1.3	1.6	1.4	0.5	5
PMU In 493	2.2	3.3	3.1	1.2	5
PMU In 494	1.9	2.3	2.0	1.1	4
PMU In 495	1.4	2.0	1.9	0.6	5
PMU In 496	1.2	1.9	1.9	0.6	5
PMU In 497	2.1	2.6	2.4	1.0	4
PMU In 540	1.5	1.8	1.6	0.6	5

L – maximum length, W – maximum width, D – maximum depth, HW – hinge width, R/mm – number of ribs per mm.

Table 4. *Ranorthis rotunda* sp. nov. Dimensions of figured specimens (in mm)

Specimen	L	W	HW	D	RAM
PMU In 179. Holotype	4.7	5.6	4.4		82
PMU In 180	4.9	6.0	3.8	2.0	74
PMU In 519	4.3	5.3	3.8	1.0	68
PMU In 541	3.1	3.8	3.0	0.7	63
PMU In 542	3.4	4.0	3.7	0.9	53
PMU In 543	4.3	5.6	5.3	1.7	83
PMU In 544	3.0	4.0	3.5	1.1	53
PMU In 545	3.0	3.5	3.2	1.1	44

L – maximum length, W – maximum width, D – maximum depth, HW – hinge width, RAM – number of ribs at anterior margin.

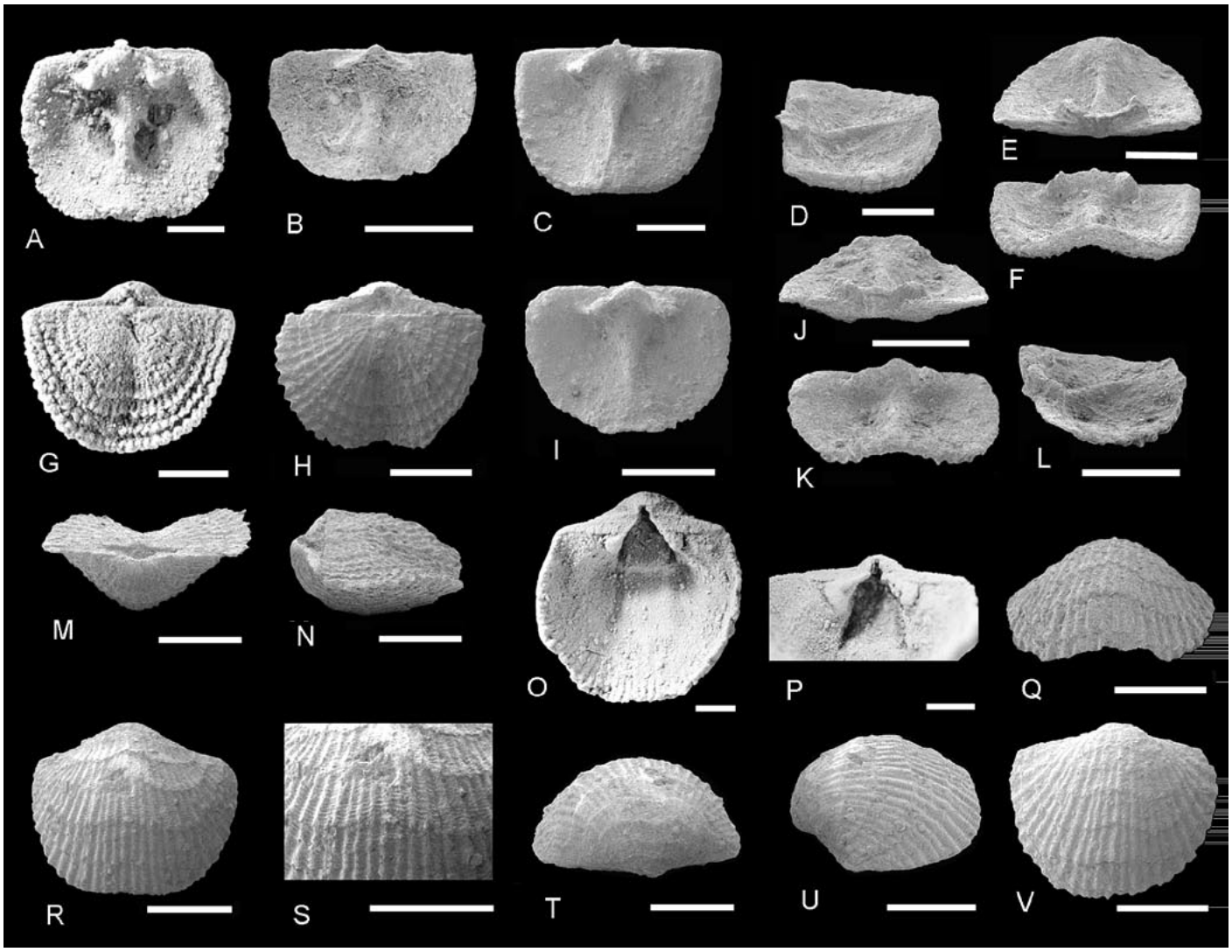

Fig. 4. A–V. *Orthidium lavensis* sp. nov. Scale bars 1 mm. **A.** PMU In 480, holotype, dorsal interior, Popovka River. **B.** PMU In 481, dorsal interior, Syas River. **C–F.** PMU In 482, dorsal valve, Sablino mud mound. **G.** PMU In 483, dorsal exterior of conjoined specimen, Syas River. **H, M, N.** PMU In 484, dorsal, posterior and lateral views of conjoined specimen, Sablino mud mound. **I–L.** PMU In 485, interior, posterior, anterior and lateral views of dorsal valve, Sablino mud mound. **O–P.** PMU In 486, ventral interior; **P.** oblique anterior view showing dental plates, Popovka River. **Q, V.** PMU In 487, ventral exterior, Sablino mud mound. **R–U.** PMU In 488, ventral exterior in different views, **S.** enlargement of shell surface showing the fine wavy concentric striation, the small mud mound at Putilovo quarry.

Holotype. – PMU In 489 (Fig. 5A–D), dorsal valve from Sablino mud mound at Tosna River, Vassilkovo Member, (sample Sabl mm 11-1), *Oepikodus evae* conodont Biozone.

Paratypes. – 90 specimens including figured specimens PMU In 490–497 & 540.

Diagnosis. – Small *Orthidium* with moderately convex ventral valve averaging 74% as long as wide and 47% as deep as long, and slightly convex dorsal valve averaging 70% as long as wide and 31% as deep as long; ornamented by 4–5 rounded ribs per mm at 2 mm from umbo, or at the anterior margin if the specimen is shorter than 2 mm. Median ridge of dorsal valve raised anteriorly.

Description. – Outline subrectangular, up to 3.3 mm wide and 2.6 mm long, with straight hingeline usually as long as maximum width. Ventral valve moderately convex averaging 47% as deep as long and 74% as long as wide, the median part usually with a low, flattened fold, which extends from the beak to the front margin; dorsal valve averaging 31% as deep as long and 70% as long as wide, with sulcus. The sulcus fits into the ventral valve so that the conjoined shell looks almost planoconvex in side view, averaging 48% as deep as wide.

Radial ornament multicostellate with 4–5 rounded costellae per mm at 2 mm from umbo, or at the anterior margin if the specimen is shorter than 2 mm; concentric ornament strongly imbricate, due to the preservation state it is not possible to distinguish any finer ornamentation. Ventral interarea rather narrow,

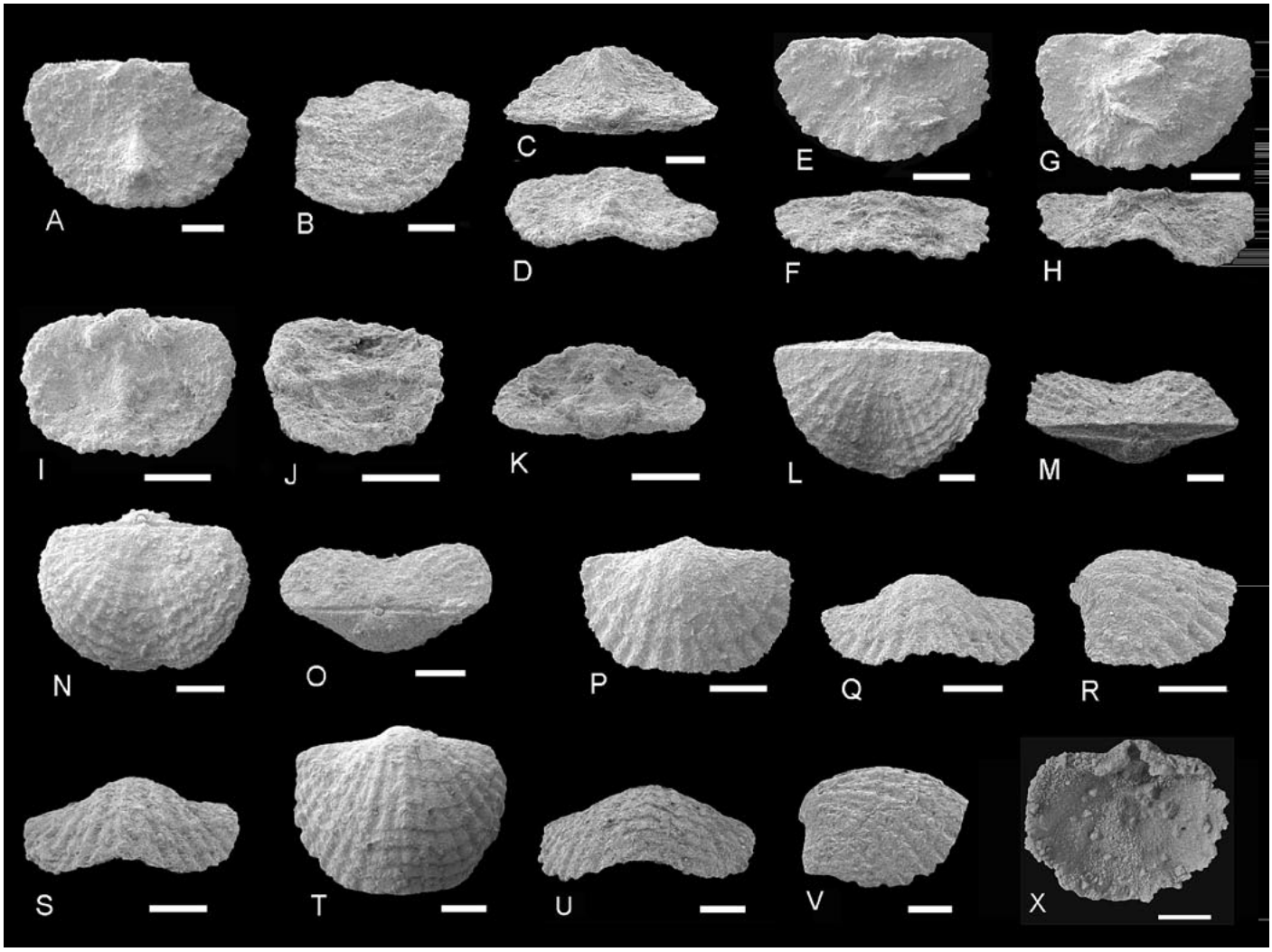

Fig. 5. A–X. *Orthidium gambolovensis* sp. nov. Scale bars 0.5 mm. **A–D.** PMU In 489, holotype, dorsal valve in interior, lateral, posterior and anterior views, Sablino mud mound. **E–F.** PMU In 490, interior and anterior of dorsal valve, Sablino mud mound. **G–H.** PMU In 491, interior and anterior of dorsal valve, Sablino mud mound. **I–K.** PMU In 492, interior, lateral and posterior views of dorsal valve, Popovka River. **L–M.** PMU In 493, dorsal exterior and posterior views of conjoined specimen, Sablino mud mound. **N–O.** PMU In 494, dorsal exterior and posterior views of conjoined specimen, Popovka River. **P–R.** PMU In 495, exterior, anterior and lateral views of ventral valve, Popovka River. **S.** PMU In 496, anterior view of ventral valve, Popovka River. **T–V.** PMU In 497, exterior, anterior and lateral views of ventral valve, Sablino mud mound. **X.** PMU In 540, interior of ventral valve, Popovka River.

orthocline to apsacline, delthyrium wide, open; dorsal interarea narrow, anacline.

Ventral interior with triangular teeth supported by erect dental plates obscured by callus deposits. Mantle canal system with two unbranched, subparallel vascula media.

Dorsal interior with high triangular cardinal process more or less fused to the brachiophores by callus deposits to form a chevron shaped build-up, which occupies the delthyrium in conjoined valves. A rounded median ridge extends from the weakly developed notothyrial platform almost to the front margin of the shell. The septum is low in its posterior part, whereas the anterior end is high, sometimes forming a raised knob. Muscle field not distinguished.

Discussion. – This species occurs slightly earlier than *O. lavensis* (lowermost Mäeküla Member, *Prioniodus elegans* conodont Biozone). However, they co-occur in some samples from the *O. evae* Biozone, and seem to have thrived together throughout the whole Biozone before disappearing close to the sequence boundary.

O. gambolovensis differs from *O. lavensis* in its smaller size, more transverse outline, flatter profile, and smaller number of ribs per mm. It has less prominent teeth and the dorsal median ridge is low posteriorly, whereas the anterior end, which extends almost to the edge of the shell, is usually raised.

It differs from the type species *O. gemmicula* in its slightly smaller size and lesser number of ribs (on average 5 ribs per mm at the anterior margin compared to 7–8). The lateral profile dif-

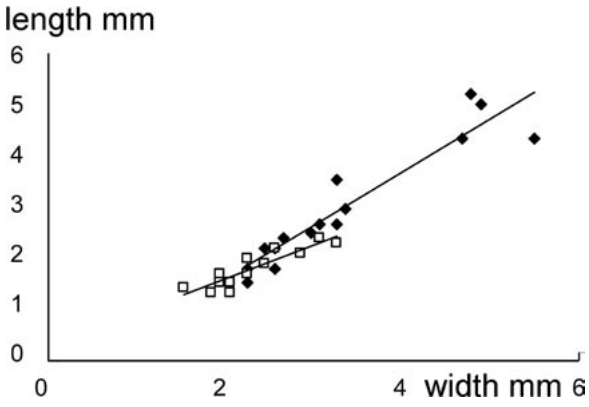

Fig. 6. Bivariate plots of length compared to width for *Orthidium lavensis* (rhombs) and *Orthidium gambolovensis* (quadrangles).

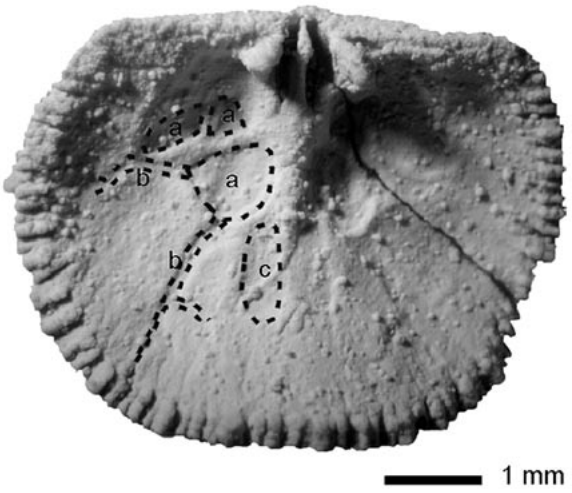

Fig. 7. Ranorthis rotunda sp. nov. Muscle scars and vascular impressions marked on the holotype; a – adductor scars, b – mantle canals, c – impression of uncertain origin.

fers markedly, the new species having more or less planoconvex profile with a moderately convex ventral valve whereas in *O. gemmicula* the dorsal valve has the greater convexity. *O. gambolovensis* differs from other North American species in size, outline and profile.

The Argentinian species *O. geniculatum* differs from *O. gambolovensis* by its geniculate profile and sulcate ventral valve, whereas other South American species differ in outline, profile, number of ribs and shape of the cardinal process.

Material and occurrence. – (Figs. 1 and 2) *Orthidium gambolovensis* was found at three localities in Russia ranging from lower Mäeküla Member to lower Dikari Member (*Prioniodus elegans* and *Oepikodus evae* conodont biozones).

Popovka river: sample 6819/2 (10 dorsal valves, 17 ventral valves, 22 conjoined specimens), sample 6819/3 (4 dorsal valves, 2 ventral valves, 20 conjoined specimens, sample 6819/8 (1 dorsal and 1 ventral valve), sample 6819/9 (3 dorsal valves, 5 conjoined specimens). Tosna river: sample 6816/5 (1 dorsal valve). Sablino mud mound at Tosna River: sample Sab mm 11-1 (2 dorsal valves, 1 ventral valve, 2 conjoined specimens).

Order Orthidia Schuchert & Cooper, 1932

Superfamily Plectorthoidea Schuchert & Le Vene, 1929

Family Ranorthidae Havlíček, 1949

Genus *Ranorthis* Öpik, 1939

Type species. – *Ranorthis norvegica* (Öpik, 1939 p. 119) by original designation; Arenig, Oslo Region.

Ranorthis rotunda sp. nov.

Figs. 7 and 8; Table 4

Etymology. – From latin *rotundus* due to the semicircular outline.

Holotype. – PMU In 179 (Figs. 7 and 8A) dorsal valve from the lower clay lens of the large mud mound at Putilovo quarry, Dikari Member, (sample Put 16), *Baltoniodus triangularis* conodont Biozone.

Paratypes. – 105 specimens including figured specimens PMU In 180, PMU In 519 and PMU In 541–545.

Diagnosis. – Semicircular *Ranorthis* species with obtuse cardinal angles, low convexity and shallow sulcus; ornament fascicostellate with five to six ribs per mm at anterior margin; cardinal process ridge-like, myophore high plate.

Description. – Shell small, largest specimen 6 mm wide; outline semicircular, hinge line straight, shorter than maximum width; cardinal angles usually obtuse, rounded; lateral profile moderately ventribiconvex, dorsal valve almost flat with shallow sulcus, ventral valve low, slightly carinate. Shell structure impunctate. Ornament fascicostellate with rounded to triangular costellae of variable dimensions, 5–6 costellae per mm at the anterior margin. Ventral interarea short (about 1/9 as long as wide), triangular, concave, apsacline; delthyrium narrowly triangular with rounded top, open. Dorsal interarea very short, flat, anacline; notothyrium open.

Interior of shell usually smooth with ribbed shell margins.

Ventral interior: Teeth of moderate size with crural fossettes; dental plates recessive, slightly curved and surrounding a small muscle field which occupies about 20% of the valve length. Adductor scar trapezoid, flanked on each side by narrow diductor scars, in front of which two moderately diverging vascula media continue.

Dorsal interior: Brachiophores high, pointed, situated at an angle of about 50 degrees to each other, laterally supported by small fulcral plates; the bases of the brachiophores converge

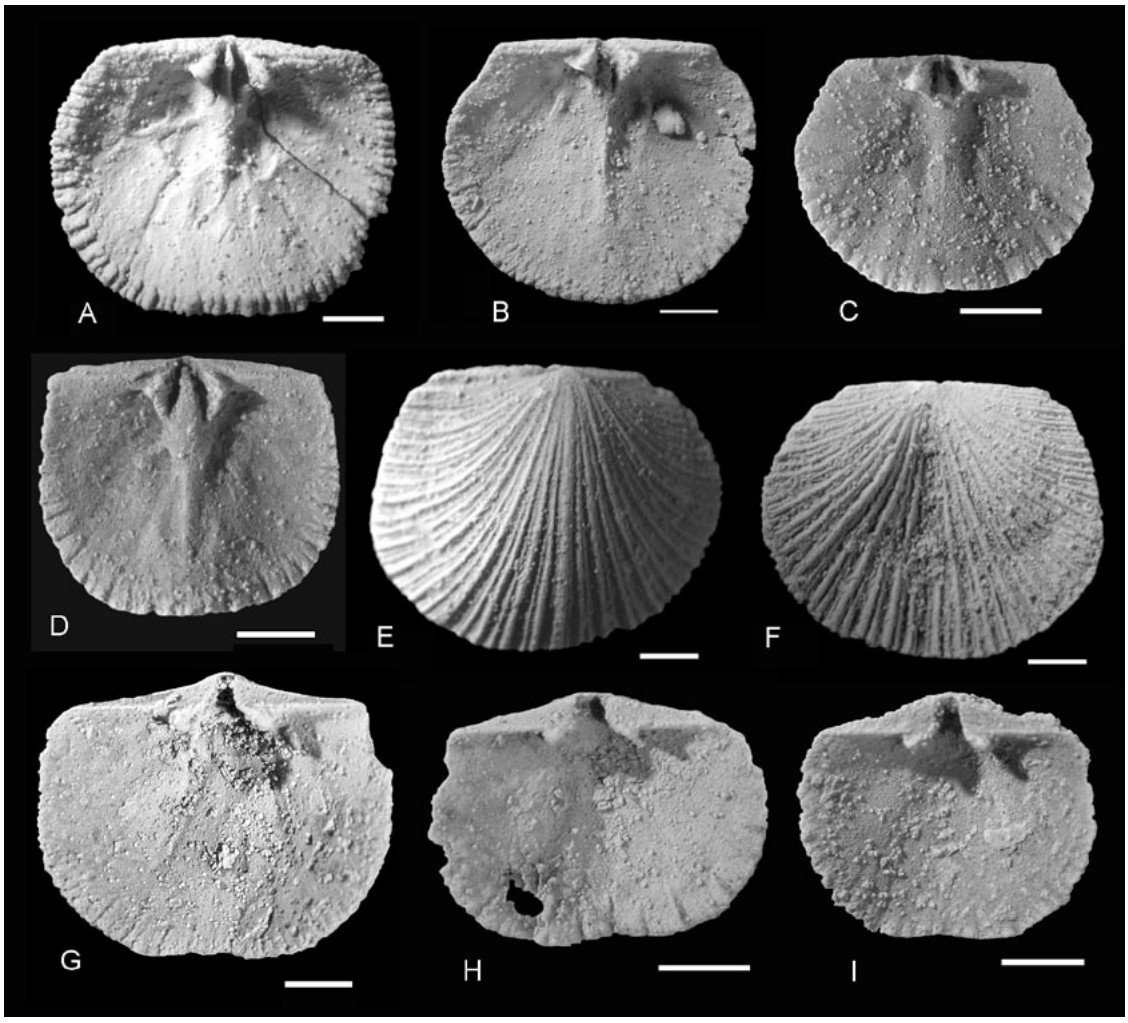

Fig. 8. A–I. *Ranorthis rotunda* sp. nov. Scale bar 1 mm. **A.** PMU In 179, holotype, interior of dorsal valve. **B.** PMU In 519, interior of dorsal valve. **C.** PMU In 541, interior of dorsal valve. **D.** PMU In 542, interior of dorsal valve. **E–F.** PMU In 180, ventral and dorsal views of conjoined specimen. **G.** PMU In 542, interior of ventral valve. **H.** PMU In 544, interior of ventral valve. **I.** PMU In 545, interior of ventral valve. All specimens are from the large mud mound at Putilovo quarry.

slightly towards the bottom of the shell, and bend forward to form a rhomboid notothyrial platform which is divided in two parts by a thin cardinal process with high blade-like myophore; the notothyrial platform continues anteriorly in a variably developed, but usually low and rounded median ridge of about half the valve length.

Adductor field 1/3 of valve length, usually reaching as long as the median ridge; posterior muscle scar rectangular, divided in two parts by a low longitudinal ridge and separated from the anterior rounded triangular scar by a low ridge which converge towards the median ridge at the posterior part of the shell. Two oval impressions, of questionable function, are positioned in front of and partly flanking the anterior end of the median ridge.

Mantle canal system feebly developed; two vascula myaria which originate at the anterior adductor scar are discernable in adult specimens (Fig. 7).

Discussion. – *Ranorthis rotunda* differs from the other Baltic species (*R? trivia* Rubel, 1961, *R. carinata* Rubel, 1961, *R. norvegica* Öpik, 1939 and *R. parvula* (Lamansky, 1905 nomen nudum) in its greater size, more rounded outline, low profile, and rather regular ribbing. It actually shows closer affinities to some of the Gondwanan species such as *Ranorthis prima* Havlíček, 1977 and *Ranorthis lipoldi* Havlíček, 1949 from the Tremadoc and Arenig of Bohemia, and to *R. sulcata* Melou, 1982 (in Babin et al. 1982) from the Arenig of Montagne Noir, France.

However, the new species differs from *R. sulcata* by its shallower sulcus, less dense ribbing, and a slender and high, instead of bulbous, myophore. It differs from *R. lipoldi* in having a more slender cardinal process, a more rounded outline and more regular ribbing, and from *R. prima* by having denser ribbing. *Ranorthis fasciata* Havlíček, 1971 from upper Tremadoc to Lower Arenig strata in Morocco, is also similar to the new species, but has a rectangular outline and more pronounced convexity.

Material and occurrence. – (Figs. 1 and 2) *Ranorthis rotunda* was found in the ordinary section and in the large mud mound at Putilovo quarry ranging from lower–middle Dikari Member to middle Zheltiaki Member (*Baltoniodus triangularis, Baltoniodus navis* and *Paroistodus originalis* conodont biozones).

Ordinary section: sample R97 17Bcl (1 dorsal valve), sample R97 18Bcl (3 dorsal valves, 1 ventral valve), sample R97 20Bcl (4 dorsal valves, 1 ventral valves, 4 conjoined specimens). The large mud mound at the Putilovo quarry: sample Put mm 12-1 (53 dorsal valves, 16 ventral valves, 11 conjoined specimens), sample Put mm 17-1 (7 dorsal valves, 3 ventral valves), sample Put 16 (1 dorsal valve, 1 ventral valve).

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