Estonian Journal of Earth Sciences, 2012, **61**, 4, 227–241 doi: 10.3176/earth.2012.4.04

New Hirnantian orthide brachiopods from the type section of the Porkuni Stage (Porkuni quarry, northeastern Estonia)

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Received 28 February 2012, accepted 25 May 2012

Abstract. Four new Hirnantian species of orthide brachiopods, *Sigmelasma peepi*, *Mendacella aerinensis*, *Drabovia*? *minuta* and *Tyronella siugensis* are described from the type section of the Porkuni Regional Stage in the Porkuni quarry, northeastern Estonia. These species occur in the reef-related shallow-water bituminous limestone (Siuge Member of the Ärina Formation). *Sigmelasma peepi* and *Tyronella siugensis* represent the families Wangyuiidae and Tyronellidae, respectively, which were hitherto unknown in the Baltic Ordovician. Additionally, a harknessellid *Reuschella* sp. is described from the stromatoporoid-coral reefs (Tõrevere Member) and skeletal grainstone (Vohilaid Member) of the same locality and formation. Together these new finds extend our knowledge of the latest Ordovician brachiopod fauna in the Baltic region, showing higher than previously expected diversity of the Porkuni Stage and distinctness of reef-related brachiopods in the shallow shelf environment. The new species are not present in the *Hirnantia* brachiopod fauna in deeper-water environments of the Central East Baltic.

Key words: reef-related orthide brachiopods, Hirnantian, northern Estonia.

INTRODUCTION

During the last decade much attention has been paid to the correlation of different facies of the Porkuni Regional Stage in the East Baltic, where the *Hirnantia* brachiopod fauna is distributed in the Livonian Tongue of the Central Baltoscandian Facies Belt (Brenchley et al. 2003; Kaljo et al. 2008; Hints et al. 2010, 2012) and the *Elsaella* and *Streptis* associations (Hints 1996; faunas in Harper & Hints 2001) occur in the shallower environments of the Estonian facies belt (Fig. 1). The first association characterizes the dolomites of the Rõa Member in the basal part of the Porkuni Stage (Rõõmusoks 1991; Hints et al. 2000) and the *Streptis* Association belongs to the reef-related skeletal grainstone (Vohilaid Member), bituminous limestone (Siuge Member) and stromatoporoid-coral reefs (Tõrevere Member).

Detailed data on the carbon isotope trend and occurrence of zonal and characteristic chitinozoans and conodonts in the uppermost Ordovician have enabled reliable correlation of sections across different facies belts (Kaljo et al. 2001, 2008). However, the knowledge of the taxonomic composition of faunas in separate parts of the Baltic Basin is uneven. The early studies of brachiopods from the Porkuni Stage in northern Estonia, beginning from Schmidt (1858), Öpik (1934), Oraspõld (1959), Hints (1975, 1986) and Rõõmusoks (1991), are complemented with only a few recent studies (e.g. Rõõmusoks 2004). Several brachiopod taxa of about 20 listed by Rõõmusoks (1967) from the Porkuni Stage are mentioned under open nomenclature ('sp.' or 'sp. nov.') and they need formal description or revision. However, the Hirnantian cosmopolitan brachiopods of the Livonian Tongue, mainly from the Kuldiga Formation (Hints et al. 2010), have been described by different authors outside the East Baltic, as for example by Cocks (1982) in Norway, and Bergström (1968) and Jin (Jin & Bergström 2010) in Sweden. The immigration of the new *Hirnantia* fauna into the Baltic Basin increased brachiopod diversity. At the same time the habitable areas and faunal diversity decreased in the Estonian facies belt due sea level fall caused by the development of the Gondwana ice cap (Hints & Harper 2003; Kaljo et al. 2011).

The taxonomy of tiny (mainly less than 5 mm in size) brachiopods in the type section of the Porkuni Stage in the Porkuni quarry, northeastern Estonia, was the aim of this study. Four new species, *Sigmelasma peepi*, *Mendacella aerinensis*, *Drabovia*? *minuta* and *Tyronella siugensis*, were identified in the samples from the Porkuni quarry. The new species, together with *Reuschella* sp., enrich the data on brachiopod diversity of the *Streptis* Association and underline the specificity of the fauna in the reef complex. *Sigmelasma peepi* and *Tyronella*

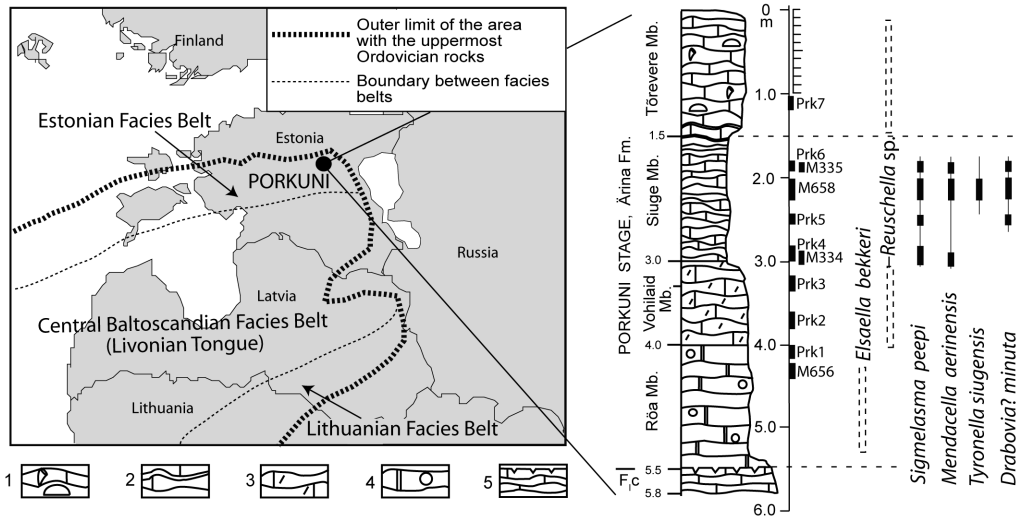


Fig. 1. Locality map with facies belts, log of the Porkuni old quarry section (modified from Hints et al. 2000) and distribution of the studied brachiopods. The levels of the studied samples processed by P. Männik for conodonts (Prk1–7 and M656, M334, M658, M335) are shown on the right side of the log. The rectangle marked by the dashed line denotes the distribution of the brachiopod on the level of the member. Legend for the log: 1, stromatoporoid-coral reef limestone; 2, bituminous limestone; 3, skeletal grainstone; 4, dolomite with crinoid ossicles; 5, argillaceous dolomite with discontinuity surface. F_1c – Pirgu Stage.

siugensis belong to the Wangyuiidae and Tyronellidae, respectively, being the first representatives of these families in the Ordovician of the Baltic region. The new species are identified only in the inter-reef facies of the Siuge Member, which is characterized by the low siliciclastic component (less than 10%), admixture of kerogen, and skeletal debris forming up to 25% of the rock (Hints et al. 2000). The harknessellid *Reuschella* sp. occurs in dolomitic skeletal limestones of the Vohilaid Member and stromatoporoid-coral limestones of the Tõrevere Member. The brachiopods described here are unknown in the Röa Member of the basal part of the Ärina Formation in northern and central Estonia and are missing also in the composition of the *Hirnantia* brachiopod fauna in southern Estonia and Latvia (Fig. 1; see also Hints et al. 2010).

MATERIAL AND METHODS

The textural and structural properties of the rocks of the reef complex complicate separation of fossils. This study is based on 11 samples (Fig. 1), which were collected by Peep Männik from the 5.5 m thick section of the Porkuni quarry and dissolved in acetic acid for extraction of conodonts.

The bulk sample size varied from 2 kg to more than 10 kg. Silicified or dolomitized shelly fauna, including the brachiopods described herein, was picked from the insoluble residues of these samples. The two lowermost samples from dolomites of the Röa Member comprised only poorly preserved stem ossicles of echinoderms. Three samples from the Vohilaid and Tõrevere members contained corals and bryozoans. The diverse shelly fauna of brachiopods, including the new species, bryozoans, tabulate and rugose corals, and skeletal fragments of echinoderms, was found in samples from the Siuge Member. The preservation of brachiopods is variable. Some structures are relatively well preserved due to silicification, whereas in other cases the shells have suffered from dissolution and silicification processes, which hampers identification of brachiopod shell structure, including the occurrence of punctae.

Most of the photos were taken with the Leica M205A motorized stereo microscope, equipped with a digital camera and Leica Multifocus z-stacking software. As the brachiopod specimens are very delicate, they were, with the exception of specimens of *Reuschella*, not white-coated before making photos because subsequent cleaning might damage them. The material studied is housed at the Institute of Geology at Tallinn University of Technology (institutional abbreviation GIT) and Museum of Geology, University of Tartu (TUG). Full data on individual collection specimens are accessible online in the Estonian geocollections database (http://geokogud.info).

SYSTEMATIC PALAEONTOLOGY

Order ORTHIDA Schuchert & Cooper, 1932
Suborder ORTHIDINA Schuchert & Cooper, 1932
Superfamily PLECTORTHOIDEA Schuchert & LeVene, 1929
Family WANGYUIIDAE Zhang, 1989
Genus *Sigmelasma* Potter, 1990b

Sigmelasma peepi sp. nov.
Figures 2, 3; Table 1

Derivation of name. After the first name of the Estonian palaeontologist Peep Männik, who collected and processed the samples, the residue of which comprised silicified brachiopods.

Holotype. Dorsal valve GIT 626-16, sample M658, 0.50–0.75 m below the upper boundary of the Siuge Member, Fig. 3C1–3. Porkuni quarry, Siuge Member, Ärina Formation, Porkuni Stage.

Paratypes. In Fig. 2: conjoined valves GIT 626-45 (A), GIT 626-47 (B); ventral valves GIT 626-26 (C), GIT 626-25 (D); in Fig. 3: dorsal valves GIT 626-22 (A), GIT 626-18 (B), GIT 626-20 (D), GIT 626-14 (E).

Diagnosis. Small biconvex shell, with high apsacline ventral interarea and narrow delthyrium with pedicle callist. Subparallel short dental plates merge with anteriorly extending septa bounding laterally short muscle field. Thin bladelike brachiophores, S-shaped in cross section, extend antero-ventrally to about mid-length of valve. Cardinal process emerges from notothyrial chamber, bilobed with crenulated myophore. Radial ornament ramicostellate.

Description. The shell is small suboval with the length–width ratio about 0.7 in smaller and up to 0.9 in larger specimens, maximum width located near mid-length. The cardinal angles are obtuse and the anterior commissure is rectimarginate to weakly sulcate. The hinge line is 80–90% of shell width. The ventral valve has the highest convexity in the middle or in the posterior part. The interarea is apsacline up to 1.2 mm high, flat, weakly concave below the umbo. The delthyrium is twice as high as wide on the hinge line. The pedicle callist on top of the delthyrium occurs in the form of arched thickening merging with thickening along the margins of the delthyrium (Fig. 2C5). The dorsal valve is less convex than the ventral valve, with the highest point in the posterior half. The sulcus is low, weakly developed. The dorsal interarea is anacline, about one-quarter height of the ventral interarea. The notothyrium is open.

The radial ornament is ramicostellate, consisting of about 15 costae appearing at the umbo; costellae appear by bifurcation. The total number of radial ribs along the shell margins is about 45, in 2 mm 7–12, most commonly 10. Rare aditicules occur on the crests of ribs.

The ventral valve has small teeth joining with callosities along the interior sides of the delthyrium; in the posterior part of the delthyrium the teeth are supported by short subparallel dental plates which merge anteriorly with septa bounding laterally the short muscle field (Fig. 2C3). The length of the muscle field is about 30% of valve length.

The dorsal valve has a bilobed cardinal process; the myophore is crenulated; the shaft cannot be differentiated. The cardinal process fills most part of the notothyrium, but does not extend above the interarea. Brachiophores are developed as thin vertical plates, S-shaped in cross section, extending to the mid-length of the valve. Brachiophores stick out from the walls of the notothyrial chamber and anteriorly are suspended over the valve floor. Dental sockets are antero-laterally supported by fulcral plates. The median ridge is not developed, muscle field is not expressed.

Comparison. *Sigmelasma peepi* sp. nov. resembles brachiopods of both genera *Sigmelasma* Potter, 1990b and *Bowanorthis* Percival, 1991 of the family Wangyuiidae. *Bowanorthis* differs from *Sigmelasma* mainly in having a prominent median ridge. The Estonian species is assigned to *Sigmelasma* due to the absence of the median ridge, its smaller size, less dense ribbing, and weakly developed sinus and sulcus.

The new species is most similar to *Sigmelasma* sp. 1, described by Potter (1990b) from the Ashgillian in northern California, USA. The Estonian species has less transverse valves, with length–width ratios of ventral and dorsal valves about 0.8, compared to 0.72 and 0.67 in *Sigmelasma* sp. 1. Details of interiors are poorly known in the American specimens, but apparent absence

Table 1. Measurements (in mm) of *Sigmelasma peepi* sp. nov.

Specimen	Length		Width	Width of the hinge line	Number of ribs	
	Ventral	Dorsal			In 2 mm	Total
Dorsal valve GIT 626-16, holotype	–	3.7	4.7	3.4	10	43
Dorsal valve GIT 626-18	–	4.5	3.5	?	10	44
Dorsal valve GIT 626-22	–	3.7	3.1	?	10	37
Ventral valve GIT 626-24	4.1	–	4.5	3.6	9	47
Dorsal valve GIT 626-56	–	2.4	3.4	3.1	11	33

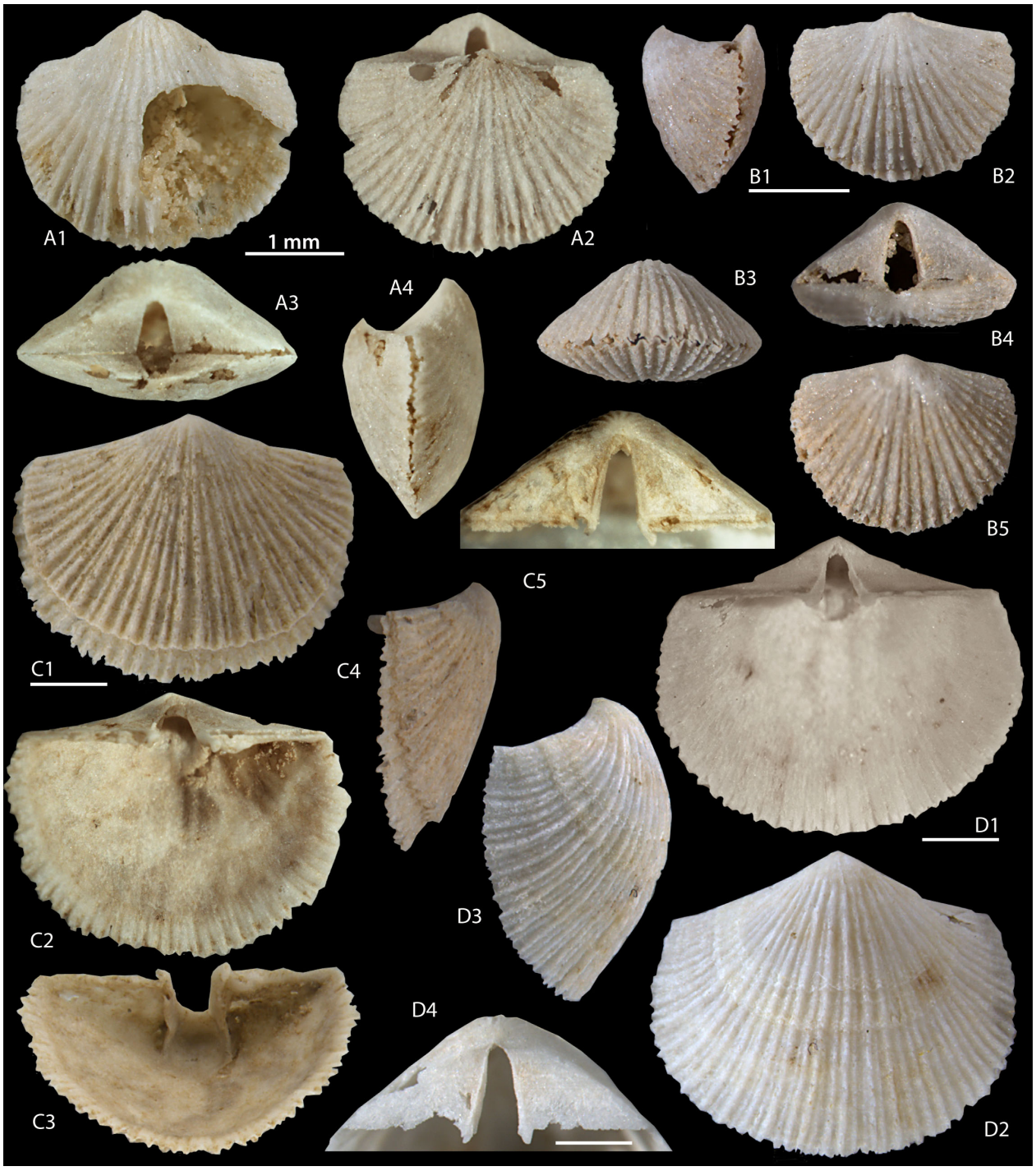
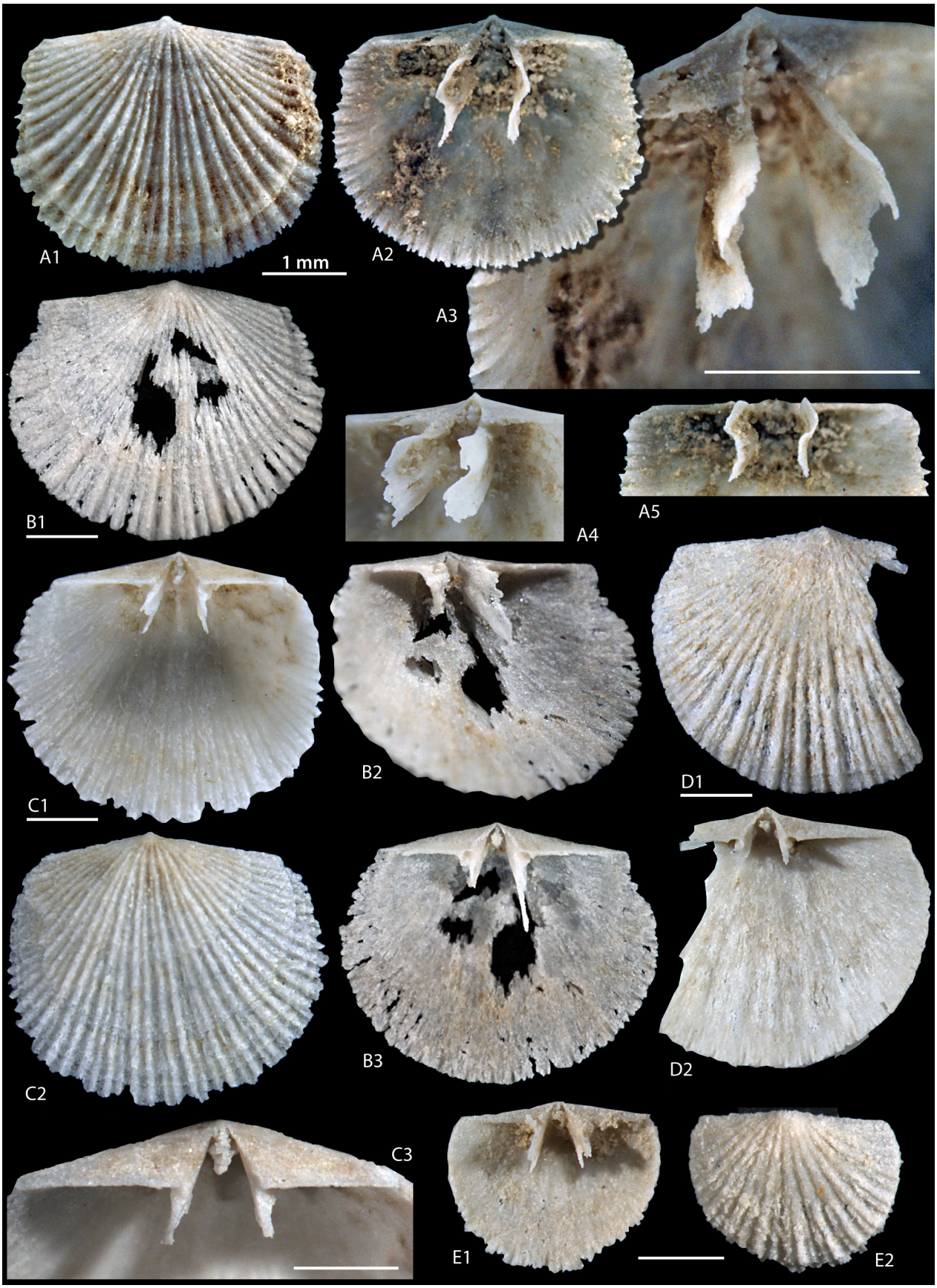


Fig. 2. A–D, *Sigmelasma peepi* sp. nov. Porkuni quarry, Porkuni Stage, Ärina Formation, Siuge Member. A1–4, conjoined valves GIT 626-45, ventral, dorsal, posterior and lateral views. B1–5, conjoined valves GIT 626-47, lateral, ventral, anterior, posterior and dorsal views. C1–5, ventral valve GIT 626-26, exterior, interior, antero-posterior and lateral views. D1–4, ventral valve GIT 626-25, interior, exterior, lateral and posterior views.

Fig. 3. A–E, *Sigmelasma peepi* sp. nov. Porkuni quarry, Porkuni Stage, Ärina Formation, Siuge Member. A1–5, dorsal valve GIT 626-22, A1 and A2 – exterior and interior views, A3–5, tilted views of cardinalia. B1–3, dorsal valve GIT 626-18, exterior and interior views. C1–3, holotype, dorsal valve GIT 626-16, interior and exterior views, posterior view of cardinalia. D1, 2, incomplete dorsal valve GIT 626-20, exterior and interior views. E1, 2, dorsal valve GIT 626-14, interior and exterior views.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of the cardinal process can be a feature which differentiates the American and Estonian specimens. The new species differs from the type species *S. pantherae* Potter, 1990b in having a less transverse outline, more numerous costae and costellae and supposedly a shorter ventral muscle field. Silurian (Llandovery to Wenlock) brachiopods of the Wangyuiidae in Estonia, such as *Wangyuia* sp. (Rubel 2011), differ from the new species in stronger ribbing and the presence of the shaft of the cardinal process.

Sigmelasma peepi from the topmost Ordovician Porkuni Stage is exteriorly rather similar to *Kinnella kielanae* (Temple 1965), a characteristic brachiopod of the *Hirnantia* brachiopod Fauna (Lesperance & Sheehan 1976; Rong 1984; Stott & Jin 2007). *Kinnella* also comprises specimens of small size, with a high ventral interarea and narrow delthyrium with pedicle callist. An essential difference is the punctate shell structure of *Kinnella* compared to the impunctate structure of *Sigmelasma*.

Material and occurrence. About 60 specimens of various preservation; Porkuni quarry; Siuge Member; Ärina Formation, Porkuni Stage (Fig. 1).

Suborder DALMANELLIDINA Moore, 1952
Superfamily DALMANELLOIDEA Schuchert, 1913
Family RHIPIDOMELLIDAE Schuchert, 1913
Subfamily RHIPIDOMELLINAE Schuchert, 1913
Genus *Mendacella* Cooper, 1930

Mendacella aerinensis sp. nov.
Figure 4; Table 2

Derivation of name. From the locality and member name Ärina in Estonia.

Holotype. Shell GIT 626-3 (Fig. 4A1–5), sample M658, 0.50–0.75 m below the upper boundary of the Siuge Member, Ärina Formation, Porkuni Stage in the Porkuni quarry.

Paratypes. In Fig. 4: dorsal valves GIT 626-37 (B), GIT 626-5 (C), GIT 626-4 (D), ventral valve GIT 626-2 (E), fragments of dorsal valves GIT 626-152 (F) and GIT 626-7 (G).

Diagnosis. Small subcircular shell, hinge line less than half shell width. Ventral beak incurved towards dorsal beak, delthyrium about twice as wide as high. Cardinal process with high middle part (trilobed) extending over dorsal interarea, brachiophores with ventro-laterally directed prolonged extensions. Ornament ramicostellate, with two median costae on ventral and one on dorsal valve.

Description. The shell is small, ventri-biconvex in profile, outline subcircular to transversely oval, with the length–width ratio from 0.8 to 1.0. Maximum width located near mid-length or slightly anterior of that. Cardinal angles are obtuse, the anterior commissure is weakly sulcate or rectimarginate. The hinge line attains 40% to 50% of shell width. The ornament is ramicostellate with two subparallel median costae on ventral and one costa on dorsal valve; 9 and 10 costae appear around the umbo on the dorsal and the ventral valve, respectively. Around the shell margins there occur up to 36 and in 2 mm up to 8 costae and costellae, which appear by bifurcation.

The ventral valve is almost twice as high as the dorsal valve, with the highest point in the posterior half. The interarea is short, apsacline, up to 1.5 mm high and concave below the umbo. The beak is incurved, lying close to the dorsal beak. The delthyrium is right-angled, about a half as high as wide on the hinge line. The teeth are stout, extending above the hinge line; crural fossettes are small. Short dental plates merge with low septa delineating laterally the weakly impressed elongate oval muscle field, whose length is 40% of valve length; the adductors occupy the middle third of the muscle field, enclosed laterally by narrow elongate diductors.

The dorsal valve is moderately convex, with faint sulcus comprising a sector with three median costae and their second- and third-order costellae. The dorsal interarea is very low, nearly orthocline. Cardinalia occupies less than one fifth of valve length. Ventrally directed brachiophores with relatively long extensions (crura) are supported laterally in proximal parts by secondary shell material. Fulcral plates are indistinguishable from the callosities bounding the dental sockets antero-laterally. On smaller specimens the sockets lie on the valve floor between the brachiophores and anterior edge of the interarea (Fig. 4F). Large specimens have the brachiophores with small plates on the lateral side, which extend ventrally higher above brachiophores and merge with thickened shell deposits around the dental sockets (Fig. 4C1, 2). These plates resemble the inner socket plates. The cardinal process occupies most of the notothyrium and extends over the interarea. It has a high

Fig. 4. A–G, *Mendacella aerinensis* sp. nov. Porkuni quarry, Porkuni Stage, Ärina Formation, Siuge Member. A1–5, holotype, conjoined valves GIT 626-3, ventral, dorsal, anterior, lateral and posterior views. B1–3, dorsal valve GIT 626-37, exterior and interior views. C1, 2, incomplete dorsal valve GIT 626-5, views of cardinalia. D1, 2, incomplete dorsal valve GIT 626-4, exterior and interior views. E1, 2, ventral valve GIT 626-2, exterior and interior views. F1, 2, fragment of dorsal valve GIT 626-152. G, view of the cardinal process in fragment of dorsal valve GIT 626-7.

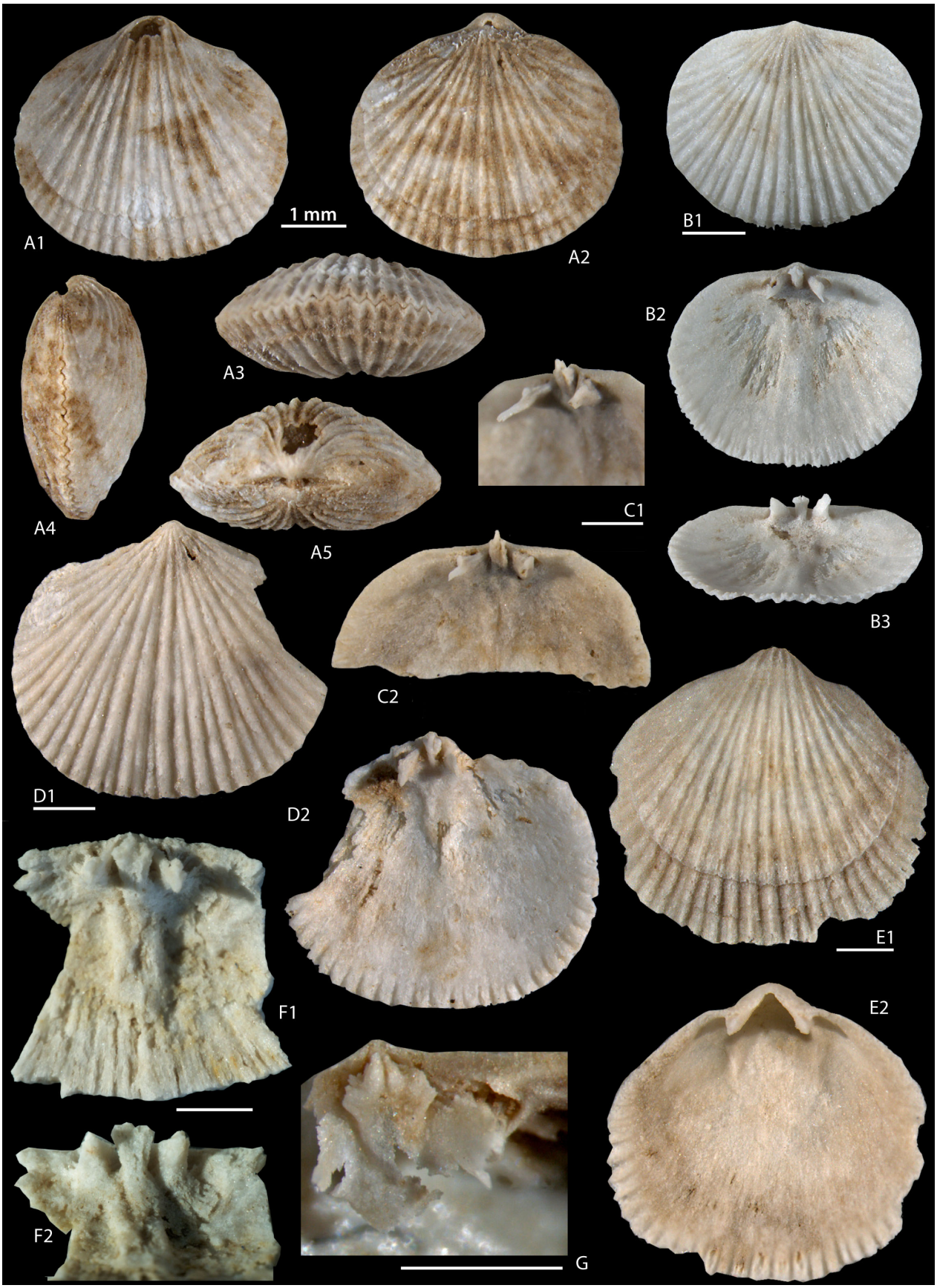
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Table 2. Measurements (in mm) of *Mendacella aerinensis* sp. nov.

Specimen	Length		Width	Width of the hinge line	Number of ribs	
	Ventral	Dorsal			In 2 mm	Total
Dorsal valve GIT 626-1	–	4.5	5.0	2.1	7	36
Ventral valve GIT 626-2	5.2	–	5.7	2.7	7	34
Shell GIT 626-3, holotype	4.3	3.7	4.7	2.2	7	36
Dorsal valve GIT 626-4	–	5.0	ca 5	2.5	7	ca 32
Dorsal valve GIT 626-37	–	3.3	4.2	2.2	8	?

median lobe (Fig. 4C2), formed by merging of inner elevated parts of the bilobed process (Fig. 4G). The median ridge is low and wide, reaching the first half of the valve. The muscle field is weakly expressed, posterior adductors are shorter than anterior adductors. External ornamentation is reflected on the inner surface by low furrows reaching up to the middle on smaller valves. The penetrating punctae are not visible because of silicification of shell substance. One row of aditicules on rib crests is observed at the anterior margin of the shell (Fig. 4A3).

Comparison. The small size and absence of fulcral plates can rise a question about the generic affiliation of the described Estonian species. It has three to four times smaller shells than the type species *Mendacella uberis* (Billings) and other species of the genus in the Upper Ordovician Ellis Bay Formation in Anticosti Island (Jin & Zhan 2008). An exception is *Mendacella* sp. from the two uppermost units of that formation (Jin & Zhan 2008), which by the small shell and ornamentation resemble the Estonian species. Most specimens of *M. aerinensis* differ from Anticosti species by less strongly impressed muscle fields and more delicate cardinalia. However, at least one dorsal valve (GIT 626-152; Fig. 4F) has the cardinalia with a raised notothyrial platform with a prominent cardinal process and strong median septum, as characteristic of species of *Mendacella*. The occurrence or absence of the fulcral plates and the diagnostic value of that feature for brachiopods of related genera *Mendacella* and *Dalejina* have been discussed by several authors (Williams & Wright 1963; Boucot et al. 1965; Harper 2000; Jin & Zhan 2008). The occurrence of those plates on specimens of *Mendacella* has been debated by Jin & Zhan (2008), according to whom these plates could have been developed very differently. On small valves of *M. aeriensis* the thickened shell deposit probably provides necessary support for teeth without fulcral plates. Both mentioned differences from the typical representatives of *Mendacella* are considered here as intraspecific. The shell form, the ornamentation with two subparallel costae on ventral valve and aditicules in one row on the crests of ribs support also the opinion that the species described above belongs into the genus *Mendacella*.

Up to now, two species, *Mendacella borrbyensis* Hints from the Vormsi and Pirgu stages (uppermost Katian) and *Mendacella circularis* Rubel from the Juuru and Raikküla stages (lower Llandovery), have been identified in the Ordovician–Silurian transition in Estonia. *Mendacella aeriensis* differs from the former species by a biconvex shell with a more convex ventral valve and transversely oval shell outline. *Mendacella borrbyensis* has a relatively larger equally convex or even dorsibiconvex shell of subtriangular outline. *Mendacella aerinensis* resembles *M. circularis* in general shell outline but the Silurian species differs in possessing fulcral plates and in the anteriorly extending shaft of the cardinal process.

Material and occurrence. 12 specimens and several incomplete valves; Porkuni old quarry; Siuge Member; Ärina Formation, Porkuni Stage (Fig. 1).

Family TYRONELLIDAE Mitchell, 1977

Tyronella Mitchell, 1977

Tyronella siugensis sp. nov.

Figure 5

Derivation of name. From the locality and member name Siuge in Estonia.

Holotype. Conjoined valves GIT 626-57 (Fig. 5A1–4), Porkuni quarry, sample M658, 0.50–0.75 m below the upper boundary of the Siuge Member, Ärina Formation, Porkuni Stage.

Paratypes. In Fig. 5: conjoined valves GIT 626-59 (B), dorsal valve GIT 626-62 (C), ventral valve GIT 626-60 (D), dorsal valve GIT 626-58 (E).

Diagnosis. Minute, transversely rounded-triangular shell with alate cardinal angles. Costae strong, with rounded crests. Delthyrium open, delthyrial cavity with low platform. Punctae rare, large on exterior surface.

Description. The minute biconvex shell has a transversely semioval outline and acute cardinal angles; the anterior commissure is rectimarginate, corrugated by ribbing. The largest specimen is 0.7 mm long and 1.6 mm wide. The ornament consists of strong round-crested costae, five on the ventral, six on the dorsal valve; growth lines are stronger in the anterior parts of the

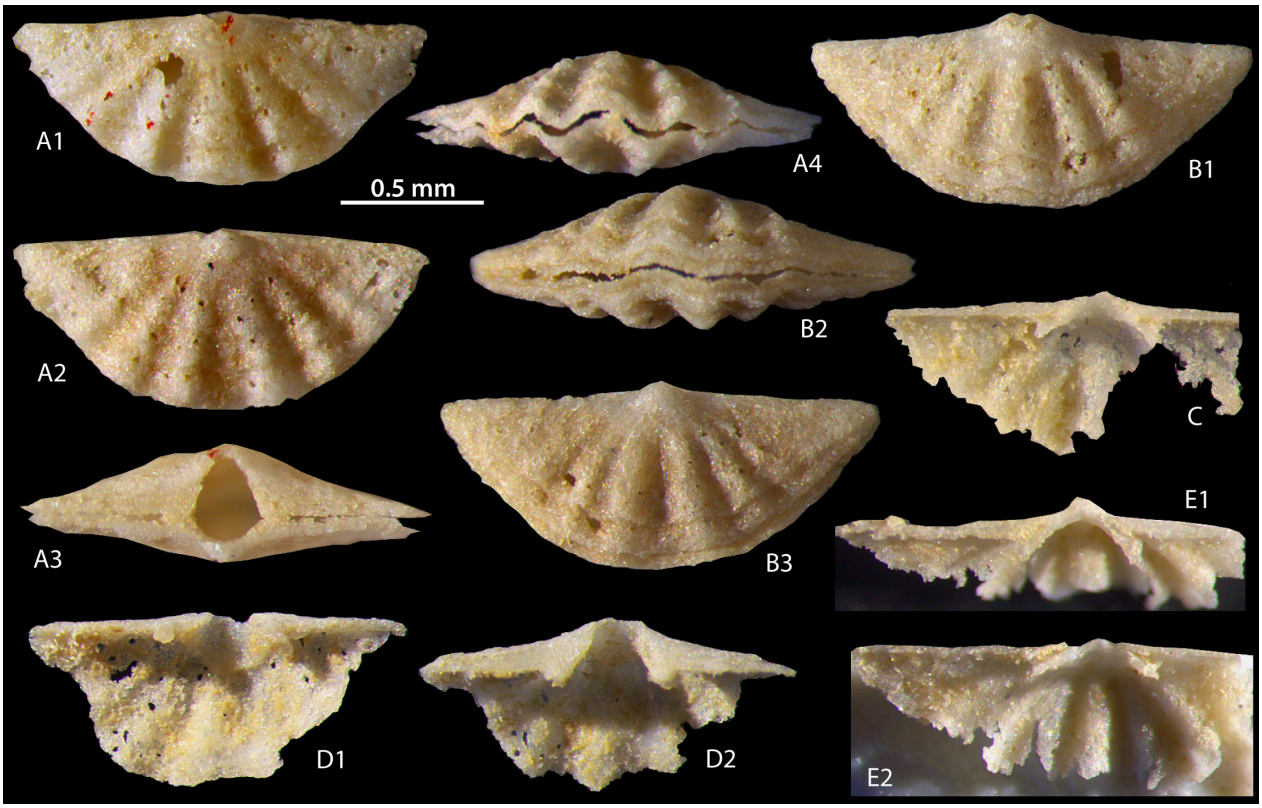

Fig. 5. A–E, *Tyronella siugensis* sp. nov. Porkuni quarry, Porkuni Stage, Ärina Formation, Siuge Member. A1–4, holotype, conjoined valves GIT 626-57, ventral, dorsal, posterior and anterior views. B1–3, conjoined valves GIT 626-59, ventral, anterior and dorsal views. C, incomplete dorsal valve GIT 626-62, interior view. D1, 2, ventral valve GIT 626-60, interior and posterior views. E1, 2, dorsal valve GIT 626-58, posterior and interior views.

valves. The shell exterior surface carries irregularly (?) spaced large pores, which supposedly penetrate the valve wall. The ventral interarea is apsacline, relatively high. The delthyrium is open, teeth are small, the delthyrial platform narrows anteriorly. The dorsal interarea has an open notothyrium; brachiophores are triangular, the floor of the notothyrium is thickened, the cardinal process is missing.

Comparison. The Estonian specimens are most similar to *Tyronella killeyensis* from the Killey Bridge Formation in Northern Ireland (Mitchell 1977) by the punctate shell substance, minute shell size and unusual for dalmanellid brachiopods transversely oval outline. They are distinguished from the Irish specimens by the absence of the cardinal process and very robust ornamentation consisting of only 5 and 6 costae, instead of 10–12 on the first specimens. The similarity of *Tyronella* to impunctate orthide brachiopods such as *Toxorthis* (Temple 1968) has been discussed by Rong (1984).

Material and occurrence. 28 specimens from the Porkuni quarry, Siuge Member of the Ärina Formation, Porkuni Stage (Fig. 1).

Superfamily ENTELETOIDEA Waagen, 1884
Family DRABOVIIDAE Havliček, 1950
Subfamily DRABOVIINAE Havliček, 1950
Drabovia Havliček, 1950

Drabovia? *minuta* sp. nov.
Figure 6; Table 3

Remarks. The generic position of the new species is not clear as it shares common features with different brachiopods among draboviniins (see below). It is tentatively assigned to *Drabovia* due to its relatively short hinge line and characteristics of the dorsal interior suggesting similarity with *Drabovia westrogothica* in Sweden (Bergström 1968) and *Drabovia* sp. in Norway (Cocks 1982). The Estonian species differs from the Swedish species in a smaller size and fascicostellate ornamentation. Moulds of *Drabovia* sp. from Norway are insufficiently known for more detailed comparison.

Derivation of name. Latin *minūtus* – tiny, small, (specimens are small for the genus).

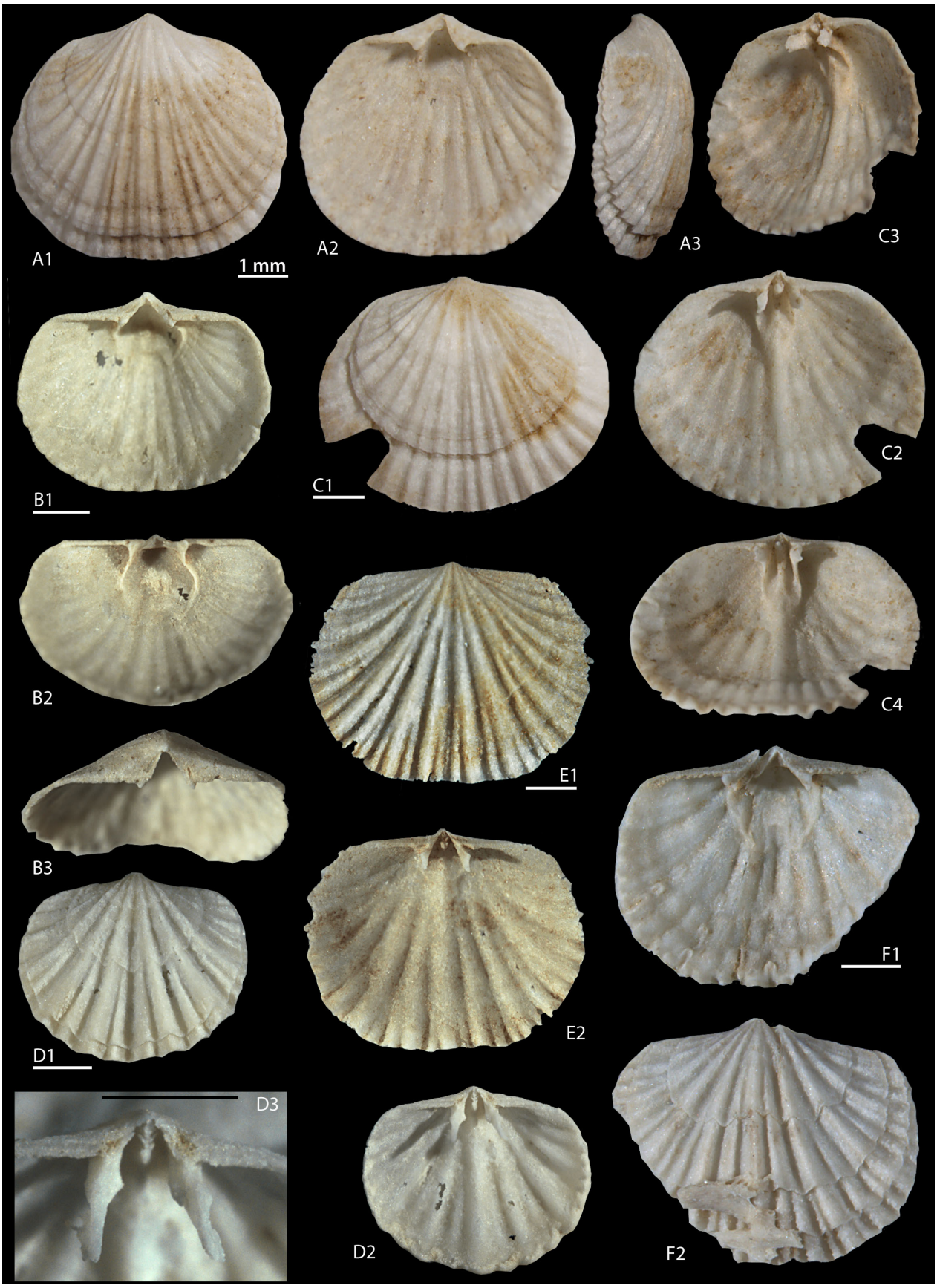
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Table 3. Measurements (in mm) of *Drabovia*? *minuta* sp. nov.

Specimen	Length		Width	Width of the hinge line	Number of ribs	
	Ventral	Dorsal			In 2 mm	Total
Ventral valve GIT 626-28	5.8	–	5.0	3.1	7	33
Ventral valve GIT 626-29	6.0	–	4.2	3.7	?	27
Dorsal valve GIT 626-32	–	4.7	5.5	3.0	5	30
Ventral valve GIT 626-38	3.6	–	4.7	3.0	6	26

Holotype. Ventral valve GIT 626-28 (Fig. 6A), Porkuni quarry, 0.50 m below the upper boundary of the Siuge Member, Ärina Formation, Porkuni Stage.

Paratypes. In Fig. 6: ventral valves GIT 626-38 (B), GIT 626-29 (F), dorsal valves GIT 626-32 (C), GIT 626-35 (D), GIT 626-33 (E).

Diagnosis. Small biconvex fascicostellate shell, fine spine-like brachiophores directed antero-ventrally, in posterior part supported by subparallel brachiophore plates. Notothyrial platform narrows anteriorly and merges with the median septum on elevated part of the valve floor; cardinal process granulated; dental plates divergent, ventral muscle field large, bilobate anteriorly.

Description. Small ventri-biconvex shell, up to 6 mm wide, suboval to circular in outline with rounded cardinal angles. The hinge line is 40–60% of shell width. The ventral interarea is apsacline, weakly concave below the umbo; the delthyrium has the pedicle callist in the apex. The dorsal interarea is orthocline, half as high as the ventral interarea, the notothyrium is open. The ornament is fascicostellate with high angular costae increasing in number by bifurcation. Around the umbo 8 and 9 costae occur on the dorsal and ventral valve, respectively; up to 33 costae and costellae are counted along the shell margin and 5–7 in 2 mm on the anterior margin. The sulcus on the dorsal valve is bounded laterally by two median costae with up to three costellae. The shell surface is stepped due to strong growth lines.

The ventral valve has small triangular teeth and thin laterally divergent dental plates, which merge with the laterally arched or weakly wavy septa bordering the oval to cordate muscle field. The adductor field seems to be shorter than the diductor fields. The dorsal valve has antero-ventrally directed long and slender brachiophores supported with subparallel plates which limit the notothyrial platform. The platform narrows anteriorly and merges with the elevated part of the valve interior corresponding to the sulcus on the exterior surface. The cardinal process has a notched myophore and an anteriorly extending shaft. Shell substance is porous.

Comparison. The cardinalia of *Drabovia*? *minuta* sp. nov. is similar to that of draboviniid species in having a crenulated cardinal process and thin brachiophore bases merging with the notothyrial platform. In its small size the new species is similar to *Diorthelasma* in the Caradocian (Sandbian to Katian) of North America (Cooper 1956) but differs from the latter in more circular outline and a short hinge line, and in a narrow anteriorly elongate notothyrial platform. The other North American draboviniins *Fascifera subcarinata* and *F. stonensis* (Cooper 1956) resemble the described Estonian specimens in their general shell outline and characteristics of the cardinalia. However, the American specimens are much larger, have a less convex dorsal valve and fine radial ornamentation.

Material and distribution. 15 specimens from the Porkuni quarry, Siuge Member of the Ärina Formation, Porkuni Stage (Fig. 1).

Family HARKNESSELLIDAE Bancroft, 1928
Genus *Reuschella* Bancroft, 1928

Reuschella sp.
Figure 7

Material. The collection consists of four ventral and two incomplete dorsal valves. Five of these specimens occur in strata that most likely correspond to the Tõrevere Member, and one specimen comes presumably from the grainstone of the Vohilaid Member. The seventh specimen from the Siuge? Member (TUG 101-78), although labelled as *Reuschella* sp., obviously does not belong to that genus due to its fibrous shell structure and absence of punctae. This specimen resembles shells of *Cliftonia*, but is too fragmentary for taxonomic identification.

Description. The shell is biconvex, transversely subrectangular, with a carinate fold and flattened lateral parts of the ventral valve. Shell length is up to 15.5 mm, maximum width 22 mm. The dorsal valve is moderately

Fig. 6. A–F, *Drabovia*? *minuta* sp. nov. Porkuni quarry, Porkuni Stage, Ärina Formation, Siuge Member. A1–3, holotype, ventral valve GIT 626-28, exterior, interior and lateral views. B1–3, ventral valve GIT 626-38, interior view and tilted views of muscle field and area. C1–4, dorsal valve GIT 626-32, exterior, interior and tilted views of interior. D1–3, dorsal valve GIT 626-35, exterior and interior views, and view of cardinalia. E1, 2, dorsal valve GIT 626-33, exterior and interior views. F1, 2, ventral valve GIT 626-29, interior and exterior views.

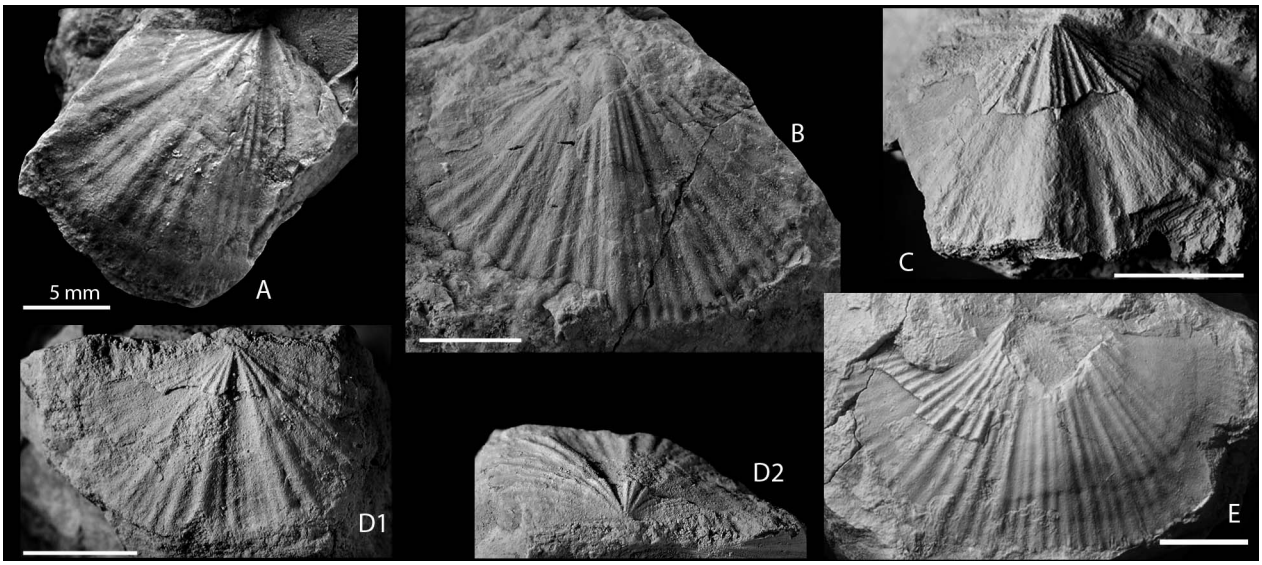

Fig. 7. A–E, *Reuschella* sp. Porkuni Stage, Ärina Formation, Tõrevere Member. A, exterior of incomplete dorsal valve TUG 101-79; Tõrevere quarry. B, exterior of ventral valve TUG 47-680; Porkuni quarry. C and D, exterior fragment and mould of ventral valve TUG 101-81A, and fragment and mould of dorsal valve TUG 101-81B with posterior view; Tõrevere quarry. E, mould of ventral valve GIT 626-186; erratic boulder of reef limestone, Ärina.

convex, with the sulcus developed between the median costae. Two sulcus-like radial furrows on lateral parts of the valve appear as a median sulcus close to the beak. The maximum width seemingly coincides with the width of the hinge line. The radial ornament is fascicostellate with up to 8 costae appearing at the beak of the dorsal valve. The costae increase in number by bifurcation; up to 32 ribs occur along the shell margin. The median sulcus comprises at least four costellae which are much thinner than the costae bounding the sulcus. Two to three ribs occur on 2 mm on the anterior margin.

Interiors are unknown. Tiny punctae are preserved on some specimens (GIT 626-155 and TUG 101-77).

Comparison. In spite of insufficient preservation, the outline, the shell shape and ornamentation of the described valves show the greatest similarity with the harknessellid brachiopods. The moderately convex valves of *Reuschella* sp. are similar to specimens of the *Reuschella horderleyensis* group (Bancroft 1945). The representatives of the *R. bilobata* group have a strongly convex dorsal valve as, for example, *R. magna* from the mid-Caradoc (Oandu Stage) of the East Baltic (Hints 1975). The described specimens differ from the Ashgillian *Reuschella* sp. (Sheehan, 1987) in Belgium and those in the Portrane Limestone (Wright 1964) in a smaller size and more robust ornamentation. The Ashgillian *Reuschella* sp. from northern Wales (Hiller 1980) is too poorly known for comparison with the Estonian material. However, in the shell size and outline the described *Reuschella* sp. is similar to *Harknessella subplicata* (Bancroft 1945), from which the Estonian specimens differ in having more robust ornamentation.

Distribution. Northern Estonia, Porkuni Stage, Tõrevere Member in the Tõrevere and Porkuni old quarries, erratic boulder in the village of Kännu; Vohilaid Member in the Röa-Jakobi old quarry.

DISCUSSION

The described new species *Sigmelasma peepi*, *Mendacella aerinensis*, *Drabovia*? *minuta* and *Tyronella siugensis* together with *Reuschella* sp. enrich the latest Ordovician brachiopod diversity in northern Estonia with specific taxa representing different families. This is the first time that the families Wangyuiidae and Tyronellidae are recognized in the Ordovician of the Baltic Basin. *Sigmelasma peepi*, of the former family, has most similar species in North America (Potter 1990b) and Australia (Percival 1991). In both regions the species of *Sigmelasma* and of its closely related *Bowanorthis* are represented by silicified specimens (Percival 1991), as are those of *S. peepi* in Estonia. It is likely that the silicification has contributed to the preservation of these small and delicate brachiopods in rocks of different ages and regions.

The new species of both newly established families in the Ordovician of the Baltic region occur in a relatively shallow-water inter-reef environment. The brachiopods of *Sigmelasma* in North America (northern California) (Potter 1990a, 1990b) and of *Tyronella* in northern Ireland (Mitchell 1977; Candela 2005) and the Percé Region of Quebec (Sheehan & Lespérance 1979) belong to relatively offshore faunas (Benthic Assemblages 4 and 5 of Boucot 1975). The appearance of these brachiopods in Estonia in the shallow-water environment (Benthic Assemblage 2) can be explained by the movement of deeper-water faunas into shallower environments during the eustatic seal level lowering at the time of the development of the Gondwana ice cap (Sheehan & Lespérance 1979).

Mendacella, *Drabovia* and *Reuschella*, or genera closely related to them (for example, *Dalejina* among Rhipidomellidae and *Horderleyella* among Harknessellidae), are common elements of the *Hirnantia* brachiopod fauna in different parts of the world. However, their role is much smaller than that of the species commonly listed as typical of that fauna. Several species of *Mendacella* occur in the Ellis Bay Formation of the Hirnantian Stage on Anticosti Island (Jin & Copper 2008; Jin & Zhan 2008;), *Dalejina* is known in Morocco (Rong & Harper 1988), harknessellids are found in Sweden and China (Bergström 1968; Rong 1984) and *Drabovia* has been recognized in Bohemia, Sweden and Norway (Bergström 1968; Cocks & Price 1975; Cocks 1982).

Acknowledgements. This study was supported by the Estonian Research Council project SF0140020s08. Dimitri Kaljo is acknowledged for critical reading of the manuscript and Gennadi Baranov for help in photographing the brachiopods. The author is grateful to the referees Jisuo Jin and Jan Percival for valuable comments and suggestions.

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Hirnantia uued ortiidsed brahhiopoodid Porkuni lademe tüüpläbilõikest (Porkuni murd Kirde-Eestis)

Linda Hints

Porkuni lademe tüüpläbilõikest Porkuni murrus on kirjeldatud neli uut brahhiopoodiliiki: *Sigmelasma peepi*, *Mendacella aerinensis*, *Drabovia*? *minuta* ja *Tyronella siugensis*. Uued liigid on kindlaks tehtud konodontide uurimiseks ettevalmistatud proovide jääkidest, kus brahhiopoodide kojad on säilinud ränistumise tõttu. Uute liikide levik on kindlaks tehtud Ärina kihistu Siuge kihistikus. Kihistu Vohilaiu ja Tõrevere kihistikust on kirjeldatud brahhiopood *Reuschella* sp. Liigid *Sigmelasma peepi* ja *Tyronella siugensis* esindavad kaht brahhiopoodide sugukonda Wangyuiidae ning Tyronellidae, mille esindajaid ei ole Eesti Ordoviitsiumis varem identifitseeritud. Kirjeldatud brahhiopoodid täiendavad seniseid andmeid Porkuni lademe liigilise mitmekesisuse kohta ja toovad esile Porkuni lademe riffidega seotud brahhiopoodifauna eripära. Uusi liike ei ole seni kindlaks tehtud sügavamaveeliste faatsieste kivimeis.