Lingulate brachiopods from Lower Ordovician (Tremadoc) chalcedonites, Holy Cross Mountains, Poland

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Lingulate brachiopods from chalcedonites of Tremadoc age are redescribed based on new material from the Holy Cross Mountains, Poland. The fauna includes 18 species, of which *Elliptoglossa polonica* and *Siphonotretella popovi* are new. The enigmatic *Orbiculoidea*? *subovalis* Biernat is redescribed as a species of the recently erected aberrant paterulids *Diencobolus* Holmer, Popov, Koneva, and Bassett. The fauna includes also *Acrotreta dissimilis* (Biernat), ?*Ditreta dividua* Biernat, *Semitreta maior* Biernat, *Eurytreta minor* Biernat, *Mamatia retracta* (Popov), *Orbithele ceratopygarum* (Brøgger), *Siphonobolus uralensis* (Lermontova), *Alichovia analogica* Biernat, *Pomeraniotreta* sp., *Akmolina* sp., *Rowellella* sp., *Acanthambonia* sp. A, *Acanthambonia*? sp. B, *Leptembolon* cf. *lingulaeformis* (Mickwitz), and the earliest known species of *Eoconulus*. Most of the recorded lingulate species are endemic, but a significant number are now known also from eastern Kazakhstan and the South Urals, as well as from the Tremadoc of Sweden and Norway.

Key words: Brachiopoda, Lingulata, Lower Ordovician, Tremadoc, Holy Cross Mountains, Poland.

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Introduction

The earliest Ordovician (Tremadoc) succession of the Holy Cross Mountains mostly comprises sandstones, conglomerates and quartzites that are poorly fossiliferous (see, e.g., Bednarczyk 1964, 1971), but at some localities (Wysoczki, Zalesie etc.), bands of chalcedonites occur (referred to the Zbilutka beds by Bednarczyk 1964, and belonging to the Wysoczki Chalcedonite Formation of Dzik and Pisera 1994). These have yielded a rich fauna and flora of Tremadoc age (*Drepanoistodus deltifer* Conodont Zone; Szaniawski 1980), notably a well-preserved fauna of mostly endemic dendroid graptolites (Kozłowski 1948). The rich lingulate brachiopod fauna (etched with HF) from these beds was first described by Biernat (1973), based on limited material of rather fragmentary nature. Subsequent collection has yielded much better preserved material that also allows a detailed SEM study. The object of this paper is to redescribe and reillustrate this unique fauna.

All studied material is from the Tremadoc chalcedonites at Wysoczki, in the eastern part of the Kielce region (see e.g., Kozłowski 1948: fig. A; Biernat 1973: fig. 1 for location).

Faunal composition and affinities

The fauna is dominated by species that are endemic to Poland, including *Semitreta maior* Biernat (37% of the counted specimens), *Elliptoglossa polonica* sp. nov. (16%), *Acrotreta dissimilis* (Biernat) (7%), *Diencobolus subovalis* (Biernat) (3%),?*Ditreta dividua* Biernat (<1%), and *Alichovia analogica* Biernat (<1%). In addition, *Mamatia retracta* (Popov) (6%) and *Siphonotretella popovi* sp. nov. (10%) have been described also from the Arenig of eastern Kazakhstan and the South Urals and *Eurytreta minor* Biernat (6%) has been recorded also from the Tremadoc of Sweden and Norway as well as from the the Batyrbay Section (*Szechuanella–Apatokephalus* and *Nileus* beds) in Kazakhstan (Popov and Holmer 1994; Holmer et al. 2001). *Siphonobolus uralensis* (Lermontova) (7%) and *Leptembolon lingulaeformis* (Mickwitz) (2%) have been described also from the late Tremadoc–early Arenig of the South Urals. The latter two belong to the so-called *Leptembolon–Thysanotos* assemblage defined by Popov and Holmer (1994). *Orbithele ceratopygarum* (Brøgger) (<1%) is the most widely distributed of the recorded species, known from coeval beds in most parts of Scandinavia as

well as in the South Urals and Kirgizia (Popov and Holmer 1994; Holmer et al. 2000).

Abbreviations.—Measurements (in millimetres if not stated otherwise) (for location of measurements see Popov and Holmer 1994: figs. 39, 40): W, L, H, width, length, height of valve; WI, LI, width, maximum length of pseudointerarea; WG, width of median groove or pedicle groove; WM1, LM1, width, length of cardinal muscle field; LS, BS, length, point of origin of dorsal median septum; N, number of measurements.

Systematic palaeontology

The illustrated and/or discussed new material is deposited in the Swedish Museum of Natural History, Stockholm (RM Br) and the material described and illustrated by Biernat (1973) is deposited (preserved in resin) in the Institute of Paleobiology, Warsaw (ZPAL Bp).

Class Lingulata Gorjansky and Popov, 1985
Order Lingulida Waagen, 1885
Superfamily Linguloidea Menke, 1828
Family Obolidae King, 1846
Subfamily Obolinae King, 1846
Genus *Leptembolon* Mickwitz, 1896

Type species: *Obolus (Leptembolon) lingulaeformis* Mickwitz, 1896; Ordovician Leetse beds (late Tremadoc–early Arenig Hunneberg Stage); northern Estonia.

Leptembolon cf. *lingulaeformis* (Mickwitz, 1896)

Fig. 1A–L.

Leptembolon lingulaeformis Mickwitz; Kozłowski 1948: 5.
Lingulella zejszneri sp. nov.; Bednarczyk 1964: 46, pl. 7: 1–14, 8: 1–4.
Lingulella cf. *zeuschneri* Bednarczyk; Biernat 1973: 56, pl. 2: 1–2.
cf. *Leptembolon lingulaeformis* (Mickwitz); Popov and Holmer 1994: 48, figs 48, 49. [full synonymy]

Material.—Total of 4 dorsal and 4 ventral valves. Figured dorsal valves: RM Br133755 (L = 1.39, W = 1.67, LI = 0.56, ML = 0.25, WI = 1.09, WG = 0.70), RM Br133758, RM Br133760; ventral valves: RM Br133756, RM Br133757 (L = 2.00, W = 1.40, LI = 0.46, ML = 0.21, WI = 0.60, WG = 0.07).

Description.—Shell evenly and subequally biconvex, slightly inequivalved, elongate, subtriangular, with maximum width at about mid-length. Ventral valve slightly longer than the dorsal, 140% as long as wide (N = 1). Ventral pseudointerarea not elevated above valve floor; occupying 65% of maximum valve width (N = 1). Pedicle groove deep, narrowly triangular. Propareas bisected by widely divergent flexure lines. Ventral internal characters poorly impressed.

Dorsal valve 140% as long as wide (N = 1). Dorsal pseudointerarea crescent-shape, occupying 43% of total valve width (N = 1). Median groove wide and poorly defined with reduced propareas. Dorsal internal characters poorly impressed.

Remarks.—Biernat (1973) found only the ventral valves of this species, and the new valves are identical to those in all aspects of morphology. Popov and Holmer (1994) questionably referred this taxon to *Leptembolon lingulaeformis*, and this view is maintained here. However, the scant available material is represented only by juveniles. As noted by Popov and Holmer (1994), it is possible that *Lingulella sanctacrucensis* (Bednarczyk 1964) is also synonymous with *L. lingulaeformis*, but its exact relationship to the type species still remains unclear. These authors also gave a more detailed comparative discussion of *Leptembolon lingulaeformis*, as well as a review of its geographic distribution.

Subfamily Elliptoglossinae Popov and Holmer, 1994
Genus *Elliptoglossa* Cooper, 1956

Type species: *Leptobolus*? *ovalis* Bassler, 1919; Ordovician Martinsburg Shale (Caradoc–Ashgill); Pennsylvania.

Elliptoglossa polonica sp. nov.

Fig. 2.

Schmidtites obtusus (Mickwitz, 1896); Biernat 1973: 54, pl. 1: 1–3, fig. 3.
Elliptoglossa sp.; Bednarczyk and Biernat 1978: 297.

Holotype: RM Br133769, ventral valve (W = 0.56, L = 0.78, WI = 0.13, LI = 0.04).

Type locality: Wysoczki. Holy Cross Mountains, Poland.

Type horizon: Tremadoc chalcedonites.

Derivation of name: After the occurrence in Poland.

Material.—Total of 35 dorsal and 16 ventral valves. Figured ventral valves: RM Br133770 (W = 0.53, L = 0.78, WI = 0.13, LI = 0.04), RM Br133771 (W = 0.63, L = 0.92, WI = 0.16, LI = 0.07), RM Br133772 (W = 0.48, L = 0.84, WI = 0.11, LI = 0.06); dorsal valves: RM Br133767 (W = 0.60, L = 0.82), RM Br133768 (W = 0.62, L = 0.94), RM Br133773.

Diagnosis.—Shell elongate oval to subcircular, about 140–180% as long as wide. Ventral pseudointerareas vestigial, with flattened triangular posterior projection. Dorsal pseudointerarea completely reduced.

Description.—Shell elongate oval, close to equi-biconvex, 140–180% as long as wide (N = 6); both valves gently and evenly convex in lateral profile. Ventral pseudointerarea forming characteristic flattened, narrow, undivided plate with posterior projection, occupying 23–25% of total valve width (N = 4) and only 5–8% of total valve length (N = 4); defined pedicle groove absent.

Dorsal valve lacking pseudointerarea, but with well defined marginal limbus, somewhat wider and higher posteriorly. Larval shell of both valves close to circular, around 0.2–0.3 mm wide and usually somewhat elongate.

Internal characters of both valves not impressed.

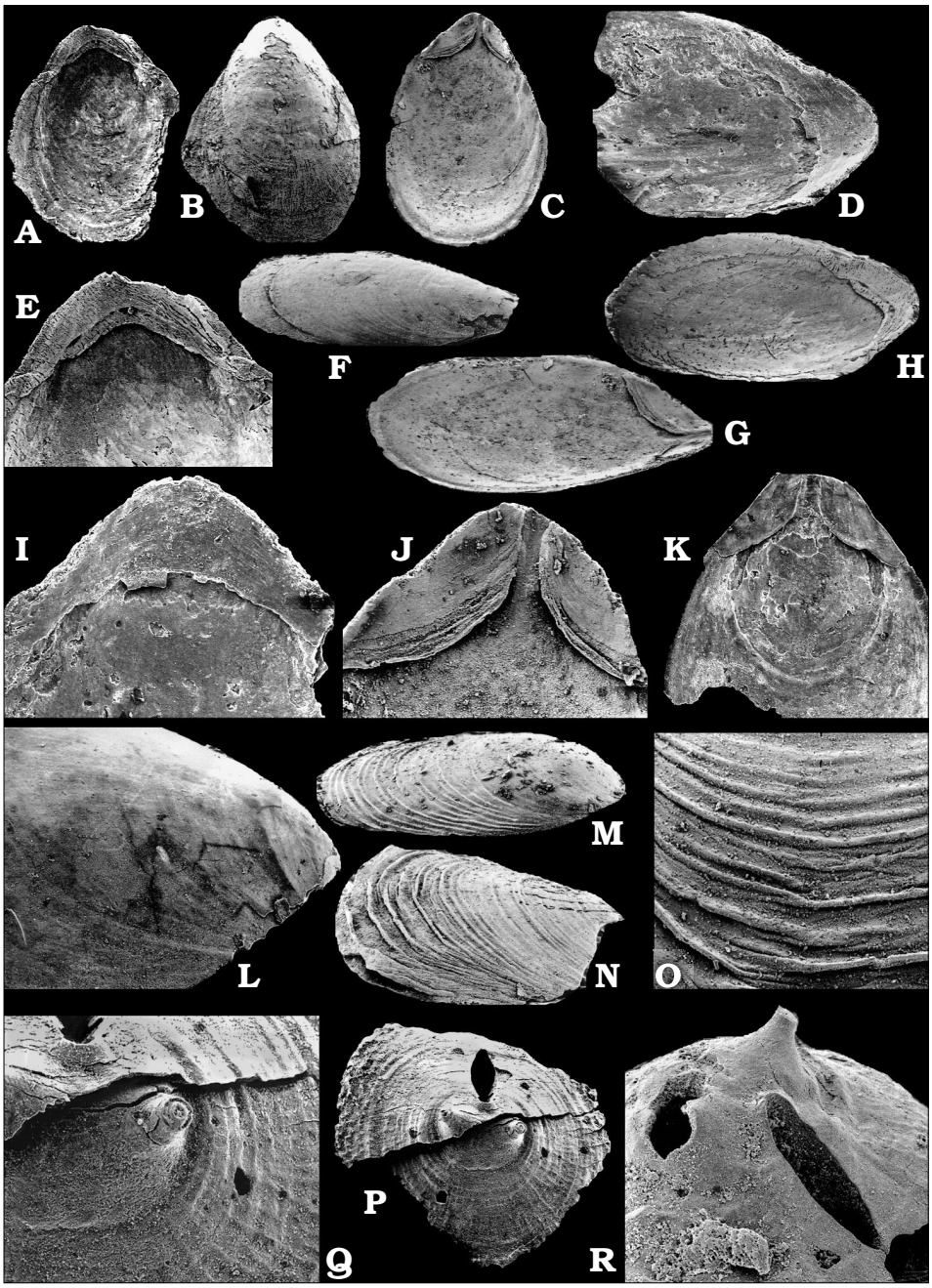

Fig. 1. **A**–**L**. *Leptembolon* cf. *lingulaeformis* (Mickwitz). **A**, **E**. Ventral valve RM Br133755, interior (A, × 18) and oblique lateral view of interior (E, × 32). **B**. Ventral valve RM Br133756, exterior; × 23. **C**, **G**, **J**. Ventral valve RM Br133757, interior (C, × 15), oblique lateral view (G, × 23) and detail of pseudointerarea (J, × 54). **D**, **I**. Dorsal valve RM Br133758, oblique lateral view of interior (D, × 30) and detail of pseudointerarea (I, × 46). **E**. Ventral valve RM Br133759, oblique lateral view of exterior; × 30. **H**. Dorsal valve RM Br133760, oblique lateral view of interior; × 26. **K**. Ventral valve RM Br133761, interior; × 37. **L**. Ventral valve RM Br133762, oblique lateral view of umbo; × 92. **M**–**O**. *Rowellella* sp. **M**. Dorsal valve RM Br133763, oblique lateral view of juvenile dorsal valve; × 41. **N**, **O**. Indeterminate valve RM Br133764, oblique lateral view (N, × 84) and detail of ornamentation (O, × 110). **P**–**R**. *Orbithele ceratopygarum* (Brøgger). **P**, **Q**. Ventral valve RM Br133765, exterior (P, × 37) and detail of larval shell (Q, × 100). **R**. Ventral valve RM Br133766, oblique lateral view of ventral valve exterior; × 80. All specimens from the Tremadoc chalcedonites, Wysoczki.

Discussion.—Biernat (1973) considered this taxon to represent juveniles of *Schmidtites obtusus*. However, following redescription of this taxon (e.g., Holmer and Popov 2000: 52, fig. 20: 4) it is clear that the Polish species is unrelated to *Schmidtites*. All characters (vestigial to completely absent pseudointerareas, lack of pedicle notch etc.) of the Polish taxon now indicate that it is a species of *Elliptoglossa,* as noted also by Bednarczyk and Biernat (1978) and Popov and Holmer (1994). *E. polonica* differs from all other species of the genus in having a vestigial ventral pseudointerarea forming a flattened, narrow, undivided plate with a posterior projection.

Family Zhanatellidae Koneva, 1986

Genus *Rowellella* Wright, 1963

Type species: *Rowellella minuta* Wright, 1963; Ordovician Portrane Limestone (Ashgill); Ireland.

Rowellella sp.

Fig. 1M–O.

Material.—Total of 1 dorsal valve and 2 indeterminate valves. Figured dorsal valve: RM Br133763 (W = 0.66, L = 1.10); indeterminate valve: RM Br133764.

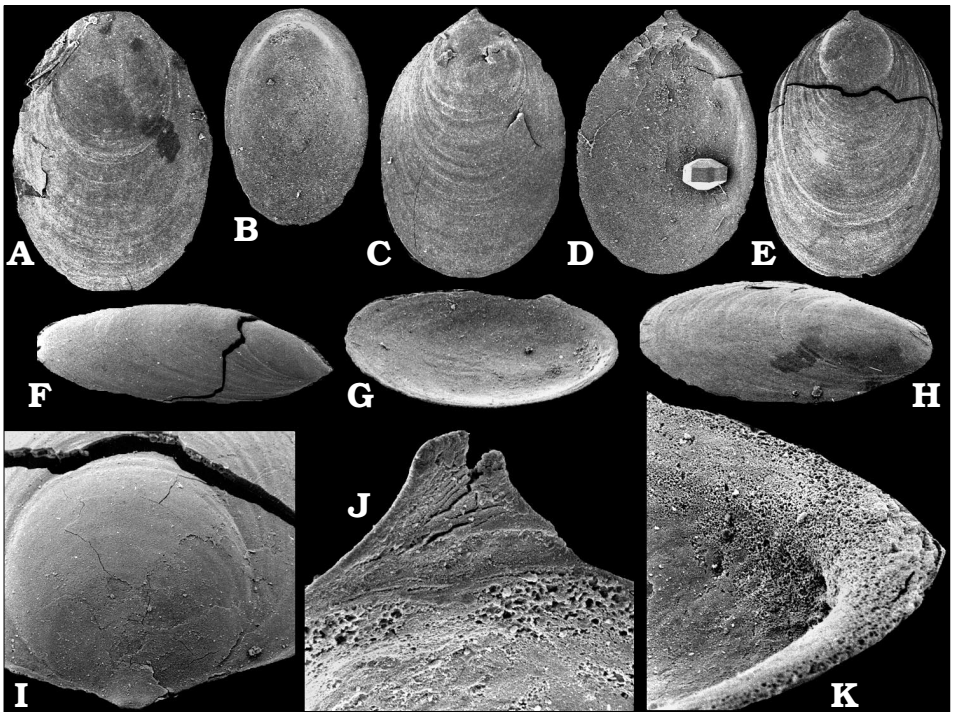

Fig. 2. **A**–**K**. *Elliptoglossa polonica* sp. nov. **A**, **H**. Dorsal valve RM Br133767, exterior (A, × 45) and oblique lateral view (H, × 45). **B**, **G**. Dorsal valve RM Br133768, interior (B, × 32) and oblique lateral view (G, × 40). **C**. Holotype, ventral valve RM Br133769, exterior, × 45. **D**. Ventral valve RM Br133770, interior, × 45. **E**, **F**, **I**. Ventral valve RM Br133771, exterior (E, × 38), oblique lateral view (F, × 40) and detail of larval shell (I, × 135). **J**. Ventral valve RM Br133772, detail of pseudointerarea, × 400. **K**. Dorsal valve RM Br133773, oblique lateral view of umbonal section of interior, × 100. All specimens from the Tremadoc chalcedonites, Wysoczki.

Remarks.—The fragmentary preservation of the scant material makes exact taxonomic discrimination difficult. Biernat (1973) distinguished two unnamed species, based on differences in shape and size, but this cannot be confirmed based on the available material. The surface ornamentation consists of ridge-like fila, superposed on growth lamellae, but the typical pitted micro-ornamentation of *Rowellella* is not present presumably due to poor preservation. Popov and Holmer (1994) described similarly poorly preserved material of *Rowellella* from the Tremadoc of Sweden, as well as from the early Arenig of Kirgizia (Holmer et al. 2000). Some similar and poorly preserved specimens of *Rowellella* were also described by Bednarczyk (1986) from early Arenigian beds in northern Poland.

Family Paterulidae Cooper, 1956

Genus *Diencobolus* Holmer, Popov, Koneva, and Bassett, 2001

Type species: *Diencobolus simplex* Holmer, Popov, Koneva, and Bassett, 2001; Upper Cambrian, *Glyptagnostus stolidotus* Biozone; Malyi Karatau, Kazakhstan.

Diagnosis (emended).—Shell biconvex, equivalved, elongate, oval to subcircular in outline; both valves with holoperipheral growth and excentric to submarginal umbo, lacking pseudointerareas and pedicle groove; larval and post-larval shell finely pitted with subcircular pits of varying sizes (2–4 μm); ventral valve with visceral area occupying the median part of the valve posterior to mid-length; dorsal interior commonly with low median ridge widening anteriorly and bearing small, elongate suboval anterior lateral muscle scars at the posterior end; central muscle scars large, suboval, situated in the mid-valve lateral to the median ridge.

Remarks.—As noted by Holmer et al. (2001), *Diencobolus* is a very enigmatic genus, only somewhat comparable with *Paterula*, but differs in having circular, not rhomboidal, post-larval pits and in lacking an emarginature in the posterior ventral margin.

Diencobolus subovalis (Biernat, 1973)

Fig. 3.

Orbiculoidea subovalis sp. n.; Biernat 1973: 103, pl. 3: 8–14, fig. 38.
Holotype: ZPAL Bp. XV/65m, dorsal (?) valve (W = 1.80, L = 2.00)
Type locality: Wysoczki. Holy Cross Mountains, Poland.
Type horizon: Tremadoc chalcedonites.

Material.—Total of 3 ventral and 4 dorsal valves in addition to 4 indeterminate valves. Figured ventral valve: RM Br133776; dorsal valves: RM Br133774, RM Br133775, RM Br133777 (W = 1.36, L = 1.59), RM Br133778.

Diagnosis.—Shell moderately biconvex, equivalved, elongately suboval in outline, holoperipheral growth in both valves; both valves externally very similar, maximum height at submarginal umbo. Ventral interior with short elevated visceral area.

Description.—Shell biconvex, equivalved, elongately suboval in outline, somewhat more than 110% as long as wide (N = 2), holoperipheral growth in both valves. Both valves externally very similar, maximum height at the submarginal, slightly swollen umbo, about 8–10% of the valve length from the posterior margin (N = 2). Concentric ornamentation lamellose. Larval and post-larval shell of both valves finely pitted, with closely packed rounded pits about equal size up to about 4 μm across. Ventral interior with short, elevated visceral area, extending to about 1/3 of valve length (N = 1), and

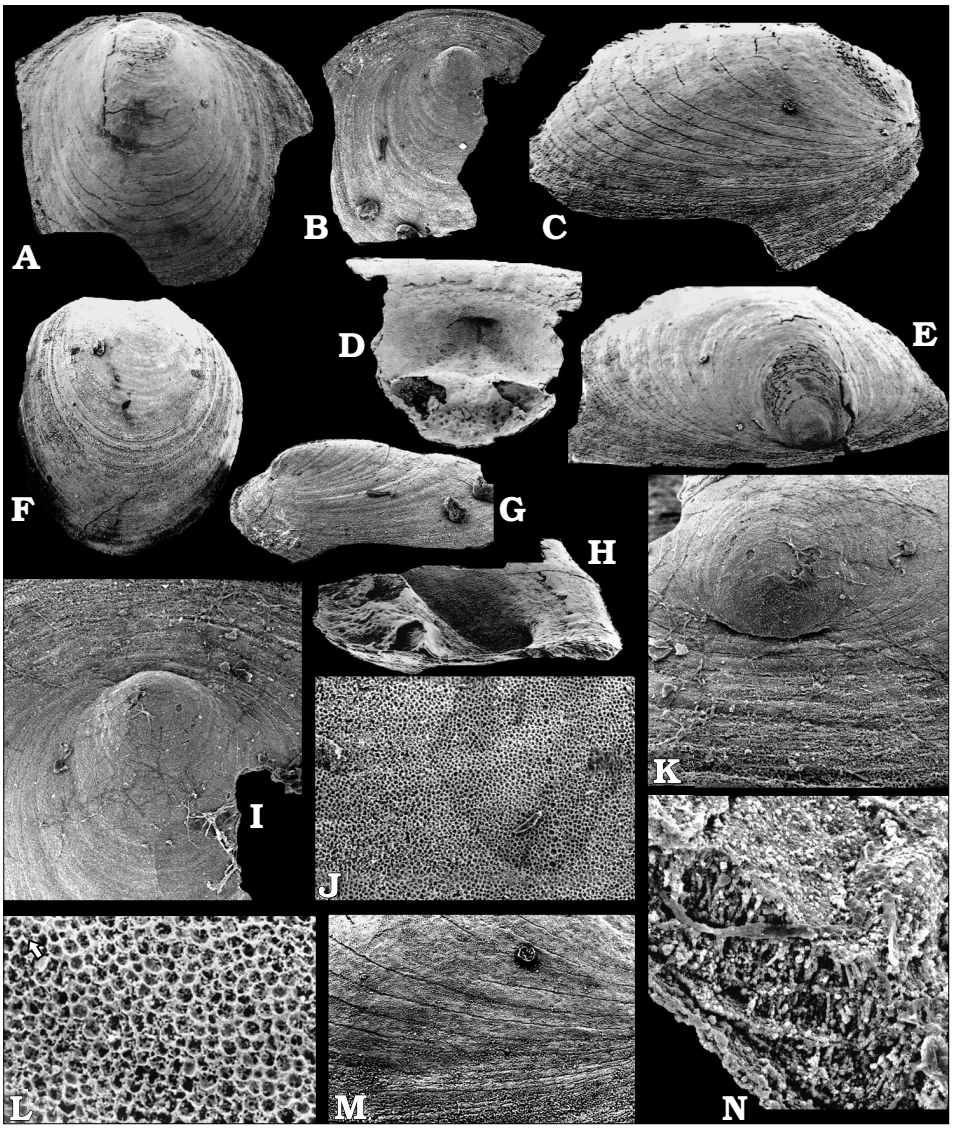

Fig. 3. **A**–**N**. *Diencobolus subovalis* (Biernat). **A**, **C**, **E**, **M**. Dorsal valve RM Br133774, exterior (A, × 37), oblique lateral view (C, × 55), oblique posterior view (E, × 51) and detail of ornamentation (M, × 100). **B**, **G**, **I**, **K**, **N**. Dorsal valve RM Br133775, exterior (B, × 18), oblique lateral view (G, × 25), detail of umbo (I, × 55), posterior view of umbo (K, × 75) and detail of shell fracture showing lamellae with baculate structure (N, × 1350). **D**, **H**. Ventral valve RM Br133776, interior (D, × 31) and oblique lateral view (H, × 42). **F**. Dorsal valve RM Br133777, exterior, × 22. **J**, **L**. Dorsal valve RM Br133778, detail of ornamentation (J, × 120) and detail of pitting (L, × 460). All specimens from the Tremadoc chalcedonites, Wysoczki.

bearing two muscle scars. Dorsal interior characters poorly defined. Well-defined marginal limbus, and strong concentric ornament

Remarks.—This species was referred questionably to the discinid genus *Orbiculoidea* by Biernat (1973), and all valves were assumed to be dorsal by comparison with similarities in shell shape and ornamentation of the dorsal valves of many Palaeozoic discinids. However, the new material includes two different valves, with virtually the same external morphology but different interior characters. One type of valve has an elevated visceral platform with two muscle scars, quite similar to the ventral visceral platform of many Palaeozoic linguliformeans. Holmer et al. (2001) described *Diencobolus simplex* from the Upper Cambrian of Kazakhstan, and this species is clearly similar to the Polish form in having dorsal and ventral valves that are almost indistinguishable, lacking both pseudointerareas and a pedicle opening, and possessing a pitted micro-ornamentation. *D. naukatensis* (Holmer et al. 2000) from the early Arenig of Kirgizia, is characterized also by this very simple morphology. *D. subovalis* differs from both these species in having a more biconvex shell with a submarginal apex in both valves, as well as an elevated ventral visceral area and lamellose ornamentation. The shell structure of *D. subovalis* is not well preserved, but appears to be baculate (Fig. 3N).

Superfamily Acrotheloidea Walcott and Schuchert, 1908 (in Walcott 1908)

Family Acrothelidae Walcott and Schuchert, 1908 (in Walcott 1908)

Subfamily Acrothelinae Walcott and Schuchert, 1908 (in Walcott 1908)

Genus *Orbithele* Sdzuy, 1955

Type species: *Discina contraria* Barrande, 1868; Ordovician Leimitz Shale (Tremadoc?); Bavaria.

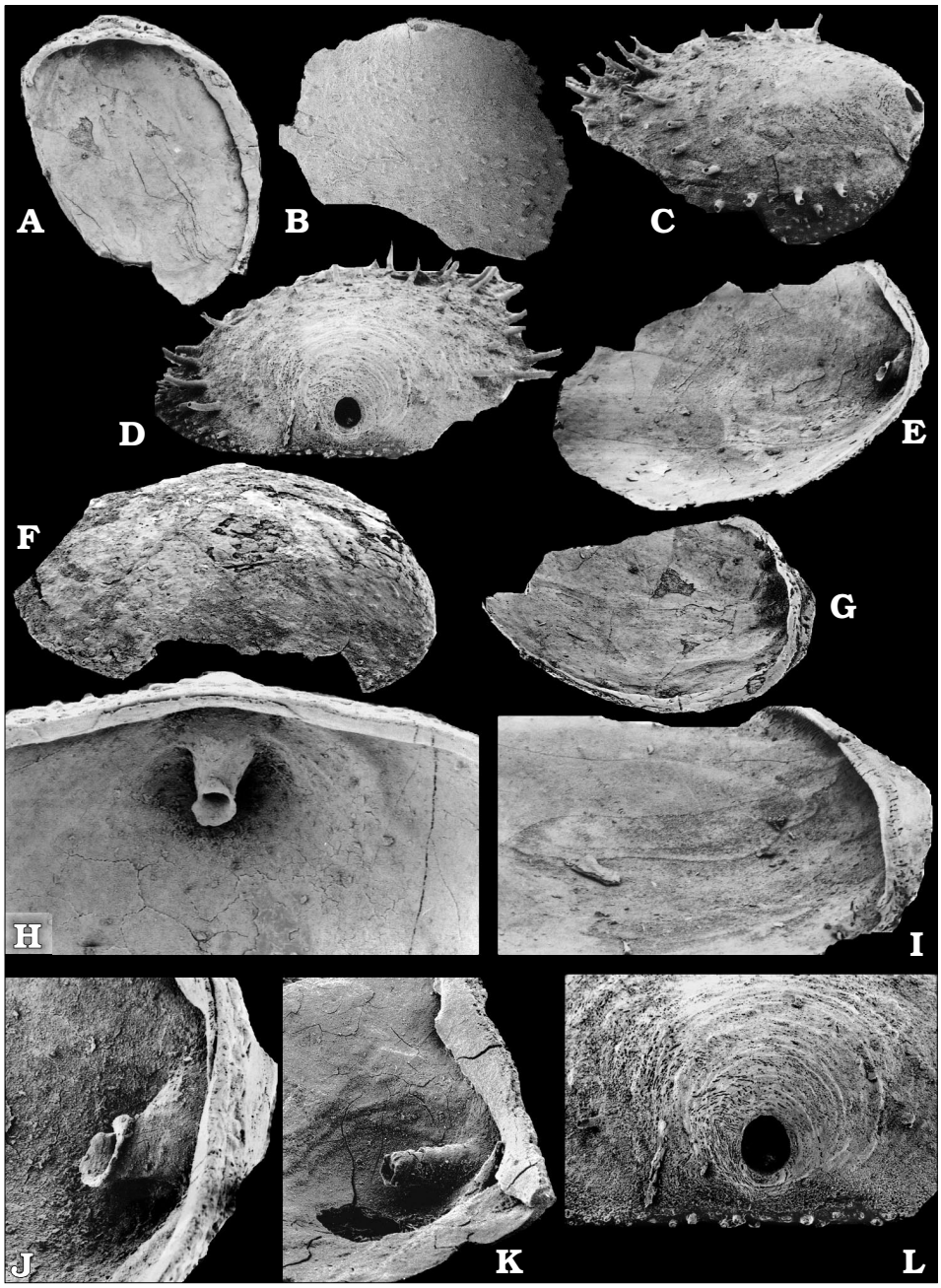

Fig. 4. **A**–**L**. *Siphonobolus uralensis* (Lermontova). **A**, **G**. Dorsal valve RM Br133779, interior (A, × 15) and oblique lateral view (G, × 23). **B**. Ventral valve RM Br133780, exterior, × 19. **C**, **D**, **L**. Ventral valve RM Br133781, oblique lateral view of exterior (C, × 33), posterior view (D, × 36) and detail of pedicle opening (L, × 80). **E**, **H**, **J**. Ventral valve RM Br133782, oblique lateral view of interior (E, × 28), detail of posterior margin (H, × 100) and detail of pedicle tube (J, × 70). **F**. Dorsal valve RM Br133783, oblique lateral view of exterior, × 26. **I**. Dorsal valve RM Br133784, oblique lateral view of interior, × 37. **K**. Ventral valve RM Br133785, detail of pedicle tube, × 55. All specimens from the Tremadoc chalcedonites, Wysoczki.

Orbithele ceratopygarum Brøgger, 1882

Fig. 1P–R.

Discina (*Acrotreta*?) *ceratopygarum* Brøgger, 1882: 47, pl. 10: 1–1b.
Orbithele bicornis sp. nov.; Biernat 1973: 101, pl. 27: 1–3, fig. 27.
Orbithele ceratopygarum (Brøgger); Popov and Holmer 1994: 146, figs 113–115. [full synonymy]
Orbithele ceratopygarum (Brøgger); Holmer, Popov, and Bassett 2000: 372, fig. 4A–G.

Material.—Total of 3 ventral valves. Figured ventral valves: RM Br133765, RM Br133766.

Diagnosis.—See Popov and Holmer (1994: 146).

Remarks.—A full comparative discussion of this widespread species was given by Popov and Holmer (1994). Recently Holmer et al. (2000) also described *O. ceratopygarum* from the Early Ordovician (early Arenig) of Kirgizia. The available specimens from the Holy Cross Mountains show no differences from the Norwegian and Swedish specimens; however, the dorsal valve of the Polish form is unknown.

Order Siphonotretida Kuhn, 1949

Superfamily Siphonotretoidea Kutorga, 1848

Family Siphonotretidae Kutorga, 1848

Genus *Siphonobolus* Havlíček, 1982

Type species: *Siphonotreta simulans* Ruzička, 1927; Ordovician Trenice Formation (Tremadoc?); Holoubkov, Bohemia.

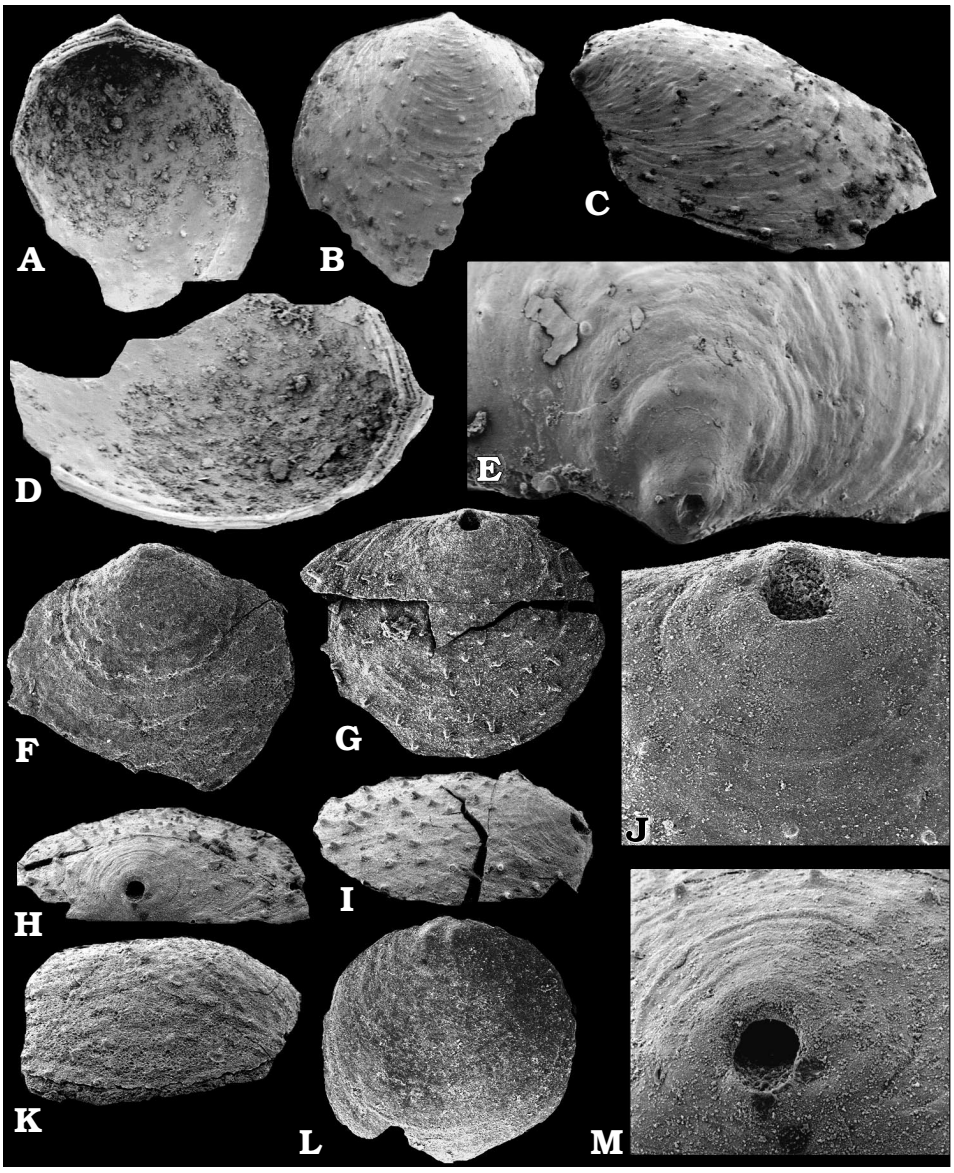

Fig. 5. **A**–**E**. *Acanthambonia* sp. A. **A**, **D**. Ventral valve RM Br133786, interior (A, × 33) and oblique lateral view (D, × 48). **B**, **C**, **E**. Ventral valve RM Br133787, exterior (B, × 28), oblique lateral view (C, × 40) and detail of larval shell and pedicle opening (E, × 170). **F**–**M**. *Acanthambonia*? sp. B. **F**, **K**. Dorsal valve RM Br133788, exterior (F, × 30) and oblique lateral view (K, × 38). **G**, **H**, **I**, **J**, **M**. Ventral valve RM Br133789, exterior (G, × 30), posterior view (H, × 32), oblique lateral view (I, × 32), detail of larval shell and pedicle opening (J, × 100) and posterior view of larval shell (M, × 110). **L**. Dorsal valve RM Br133790, exterior, × 78. All specimens from the Tremadoc chalcedonites, Wysoczki.

Siphonobolus uralensis (Lermontova, 1933)

Fig. 4.

Siphonotreta uralensis Lermontova (in Lermontova and Razumovskij), 1933: 202, pl. 1: 7–13.

Siphonotreta cf. *verrucosa* (Eichwald, 1840); Biernat 1973: 107, pl. 30: 1–5.

Siphonobolus uralensis (Lermontova, 1933); Popov and Holmer 1994: 82, fig. 73 [full synonymy]

Material.—Total of 21 ventral and 7 dorsal valves. Figured ventral valves: RM Br133780, RM Br133781, RM Br133785; dorsal valves: RM Br133779, RM Br133783, RM Br133784.

Diagnosis.—See Popov and Holmer (1994: 82).

Description.—Shell subequally biconvex and elongate subcircular, around 105–120% as long as wide (N = 2). Ventral valve moderately and evenly convex in lateral profile, less than 20% as high as long (N = 1), with maximum height anterior to the beak. Ventral pseudointerarea very low, apsacline and poorly defined laterally. The pedicle foramen is subcircular, about 0.06–0.1 mm wide. Ventral interior with long, cylindrical, internal pedicle tube.

Dorsal valve moderately convex in lateral view, less than 15% as high as long (N = 1), with maximum height placed somewhat posterior to mid-length. Dorsal pseudointerarea undivided, slightly anacline and strongly raised above valve floor. Dorsal interior with pair of large, but poorly defined, central muscle scars.

Shell surface finely pustulose (less than 10 μm across), with rows of thin and hollow spines of about equal size (about 40–70 μm across). Larval shells of both valves poorly defined.

Discussion.—The Polish material is almost identical with *Siphonobolus uralensis* (Lermontova) redescribed from the Early Ordovician of the South Urals by Popov and Holmer

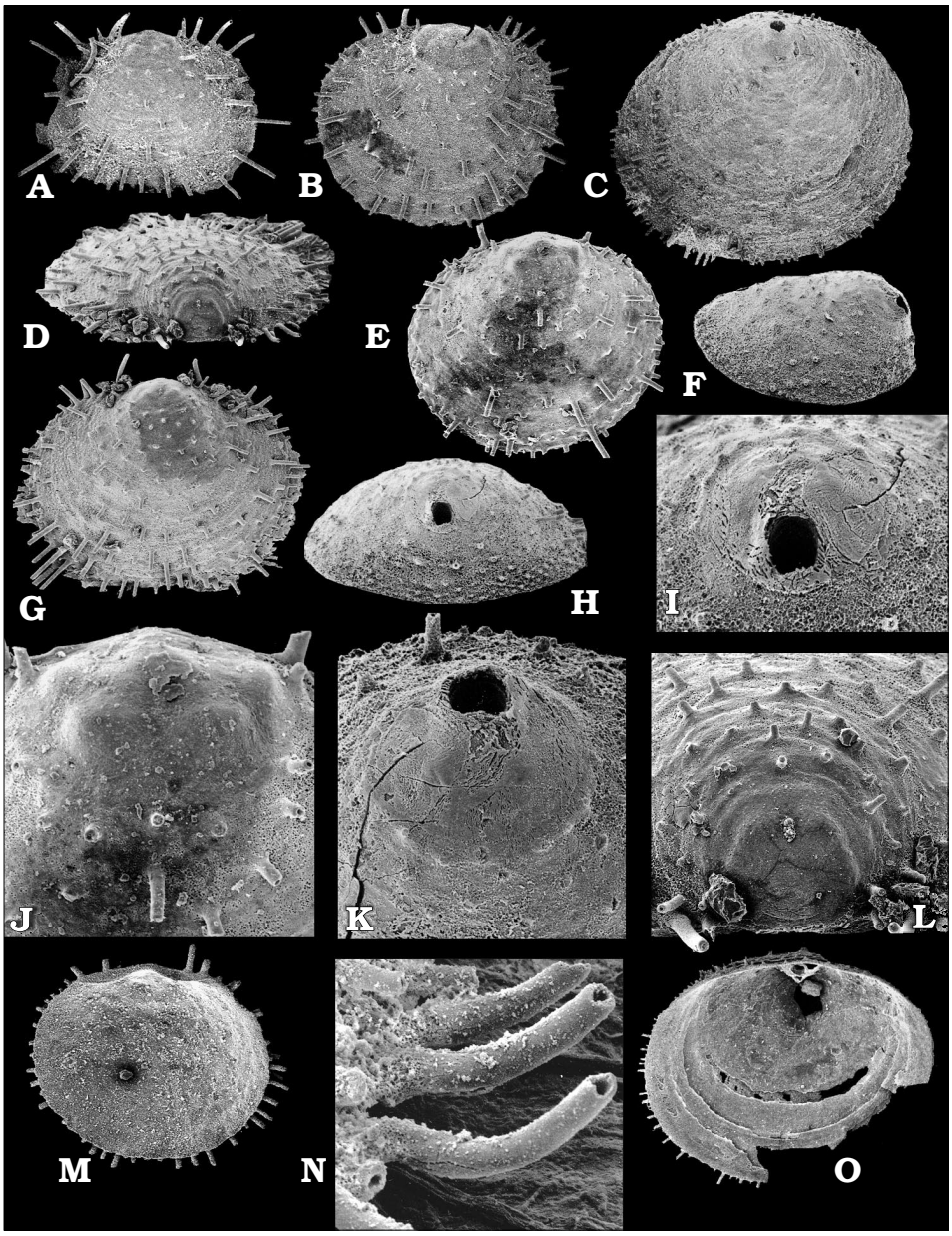

Fig. 6. **A**–**N**. *Siphonotretella popovi* sp. nov. **A**, **N**. Dorsal valve RM Br133791, exterior (A, × 26), detail of spines (N, × 100). **B**. Dorsal valve RM Br133792, exterior, × 32. **C**. Holotype, ventral valve RM Br133793, exterior, × 26. **D**, **G**, **L**. Dorsal valve RM Br133794, oblique posterior view (D, × 30), exterior (G, × 30), detail of larval shell (L, × 80). **E**, **J**. Dorsal valve RM Br133795, exterior (E, × 40) and detail of larval shell (J, × 120). **F**, **H**, **I**, **K**. Ventral valve RM Br133796, oblique lateral view (F, × 26), oblique posterior view (H, × 32), detail of larval shell and pedicle opening (I, × 80), detail of larval shell and pedicle opening (K, × 90). **M**. Dorsal valve RM Br133797, interior, × 40. **O**. Ventral valve RM Br133798, interior, × 23. All specimens from the Tremadoc chalcedonites, Wysoczki.

(1994). It differs mainly in being somewhat more subequally biconvex, rather than ventribiconvex, and in having a somewhat smaller pedicle opening, but these are commonly variable features in siphonotretid species. A comparative discussion of this species was given by Popov and Holmer (1994).

Genus *Acanthambonia* Cooper, 1956

Type species: *Acanthambonia minutissima* Cooper, 1956; Ordovician Pratt Ferry beds (Llandeilo); Alabama.

Acanthambonia sp. A

Fig. 5A–E.

Helmersenia cf. *ladogensis* (Jeremejew, 1856); Biernat 1973: 110, pl. 33: 1–7, fig. 40.

Material.—Total of 9 ventral valves. Figured ventral valves: RM Br133786, RM Br133787.

Description.—See Biernat (1973: 110).

Remarks.—Only ventral valves of this rare and poorly known species were recovered in this study, but Biernat (1973) also described and illustrated the dorsal valve. It was then tentatively considered to represent juveniles of *Helmersenia ladogensis,* but restudy of this taxon (e.g., Holmer and Popov 2000: 143, fig. 79: 3) indicates that *Helmersenia* is clearly different in the size and shape of the pedicle opening as well as in lacking an interior pedicle tube. The Polish species is most similar to species of *Acanthambonia* in having a minute apical foramen, which is continued internally as a pedicle tube along the valve floor (Biernat 1973: pl. 33: 1, fig. 40). *Acanthambonia* sp. A is the first record of the genus from Tremadoc strata, but it described under open nomenclature in view of the poor preservation of the few available specimens.

Acanthambonia? sp. B

Fig. 5F–M.

Material.—Total of 1 ventral and 2 dorsal valves. Figured ventral valve: RM Br133789; dorsal valves: RM Br133788, RM Br133790.

Remarks.—This rare and enigmatic species is similar to *Acanthambonia* sp. A in having a minute apical foramen, but appears to differ in having a more sparsely spinose ornamentation, and in being much less biconvex. The internal characters are unknown and it cannot be compared in detail with other taxa.

Genus *Siphonotretella* Popov and Holmer, 1994

Type species: *Siphonotretella jani* Popov and Holmer, 1994; Ordovician Bjørkåsholmen Limestone (Tremadoc); Ottenby, Sweden.

Siphonotretella popovi sp. nov.

Fig. 6.

Siphonotreta acrotretomorpha Gorjansky, 1969; Biernat 1973: 105, pl. 27: 4–10; 28; 29; 30: 6–8.

Siphonotretella sp.; Popov and Holmer 1994: 84, fig. 75.

Siphonotretella sp.; Holmer and Popov 2000: 145, fig. 80, 2d, e.

Holotype: RM Br133793, ventral valve (W = 1.52, L = 1.31, H = 0.50)

Type locality: Wysoczki. Holy Cross Mountains, Poland.

Type horizon: Tremadoc chalcedonites.

Derivation of name: In honour of brachiopod specialist Leonid Popov.

Material.—Total of 17 ventral and 17 dorsal valves. Figured ventral valves: RM Br 133796 (W = 1.27, L = 1.10, H = 0.50), RM Br133798 (W = 1.64, L = 1.30, H = 0.48); dorsal valves RM Br133791 (W = 1.08, L = 0.85, WI = 0.45), RM Br133792 (W = 1.00, L = 0.81, WI = 0.42), RM Br133794 (W = 1.50, L = 1.08), RM Br133795 (W = 0.88, L = 0.75), RM Br133797 (W = 0.76, L = 0.64, WI = 0.40, H = 0.14).

Diagnosis.—Ventral valve subconical, up to 50% as high as long. Ventral pseudointerarea catacline to procline, poorly defined laterally. Apical pedicle foramen not enlarged by resorbtion, continued as extremely short interior pedicle tube.

Description.—Shell ventribiconvex, transversely subcircular, around 70–90% as long as wide (N = 8). Ventral valve subconical, around 35–50% as high as long (N = 3). Ventral pseudointerarea catacline to procline, poorly defined laterally. Apical pedicle foramen small (about 0.09 mm across) and rounded, not enlarged by resorbtion, continued as extremely short interior pedicle tube. Internal characters of both valves poorly impressed.

Dorsal valve gently convex with maximum height somewhat anterior to umbo, less than 25% as high as long (N = 1). Dorsal pseudointerarea reduced to thin plate, crescent-shaped, occupying less than half of valve width and occupied mainly by median groove.

Shell surface covered by fine hollow spines of about equal size (around 20–70 μm across). Larval shell of both valves well-defined, close to circular, around 0.30–0.35 mm across.

Discussion.—This siphonotretid species was described by Biernat (1973) as *Siphonotreta acrotretomorpha* Gorjansky (1969), but as noted by Popov and Holmer (1994), restudy of the type material of this taxon from the Leetse beds in Estonia clearly shows that the Estonian species differs in having a pedicle foramen that is enlarged by resorbtion. The Polish species differs mainly from the type species *Siphonotretella jani* in having a comparatively higher (up to half as high as long) conical ventral valve with the maximum height at he beak, and a procline pseudointerarea. It is conspecific with the forms described by Popov and Holmer (1994) as *Siphonotretella* sp. from the Early Ordovician of the South Urals and Kazakhstan.

Genus *Alichovia* Gorjansky, 1969

Type species: *Alichovia ramispinosa* Gorjansky, 1969; Ordovician Idavere Stage (Caradoc); Russia.

Alichovia analogica Biernat, 1973

Alichovia analogica sp. n.; Biernat 1973: 109, pl. 31: 1–6, 32.

Diagnosis.—See Biernat (1973: 109).

Remarks.—This rare species (not illustrated here) is represented only by fragmentary branching spines in our material.

Order Acrotretida Kuhn, 1949

Superfamily Acrotretoidea Schuchert, 1893

Family Acrotretidae Schuchert, 1893

Genus *Acrotreta* Kutorga, 1848

Type species: *Acrotreta subconica* Kutorga, 1848; Ordovician Päite beds (Arenig Billingen Stage); Tosna River, Ingria.

Diagnosis.—See Holmer and Popov (1994: 436).

Acrotreta dissimilis (Biernat, 1973)

Fig. 7.

Spondylotreta dissimilis sp. n.; Biernat 1973: 78, pl. 11: 2–9, 12: 1–2.

Holotype: ZPAL Bp. XV/10d, ventral valve (W = 1.3, L = 1.1)

Type locality: Wysoczki. Holy Cross Mountains, Poland.

Type horizon: Tremadoc chalcedonites.

Material.—Total of 10 dorsal and 13 ventral valves. Figured ventral valves: RM Br133801 (W = 0.59, L = 0.52, H = 0.38), RM Br133802, RM Br133803 (W = 1.21, L = 0.89, H = 0.6); RM Br133799 (W = 1.03, L = 0.97), RM Br133800 (W = 0.63, L = 0.56, WI = 0.30, LI = 0.05, LS = 0.36, BS = 0.18), RM Br133133804, RM Br133805 (W = 1.06, L = 0.88, WI = 0.40, LI = 0.09, LS = 0.58, BS = 0.36)).

Diagnosis.—Ventral valve procline to catacline, less than 90% as high as long. Ventral pseudointerarea well defined with interridge. Ventral interior with short median septum and apical process enclosing interior pedicle tube. Muscle fields and mantle canals of both valves poorly defined. Dorsal pseudointerarea occupying less than half of valve width. Median buttress poorly defined to absent. Dorsal median septum very low and narrow.

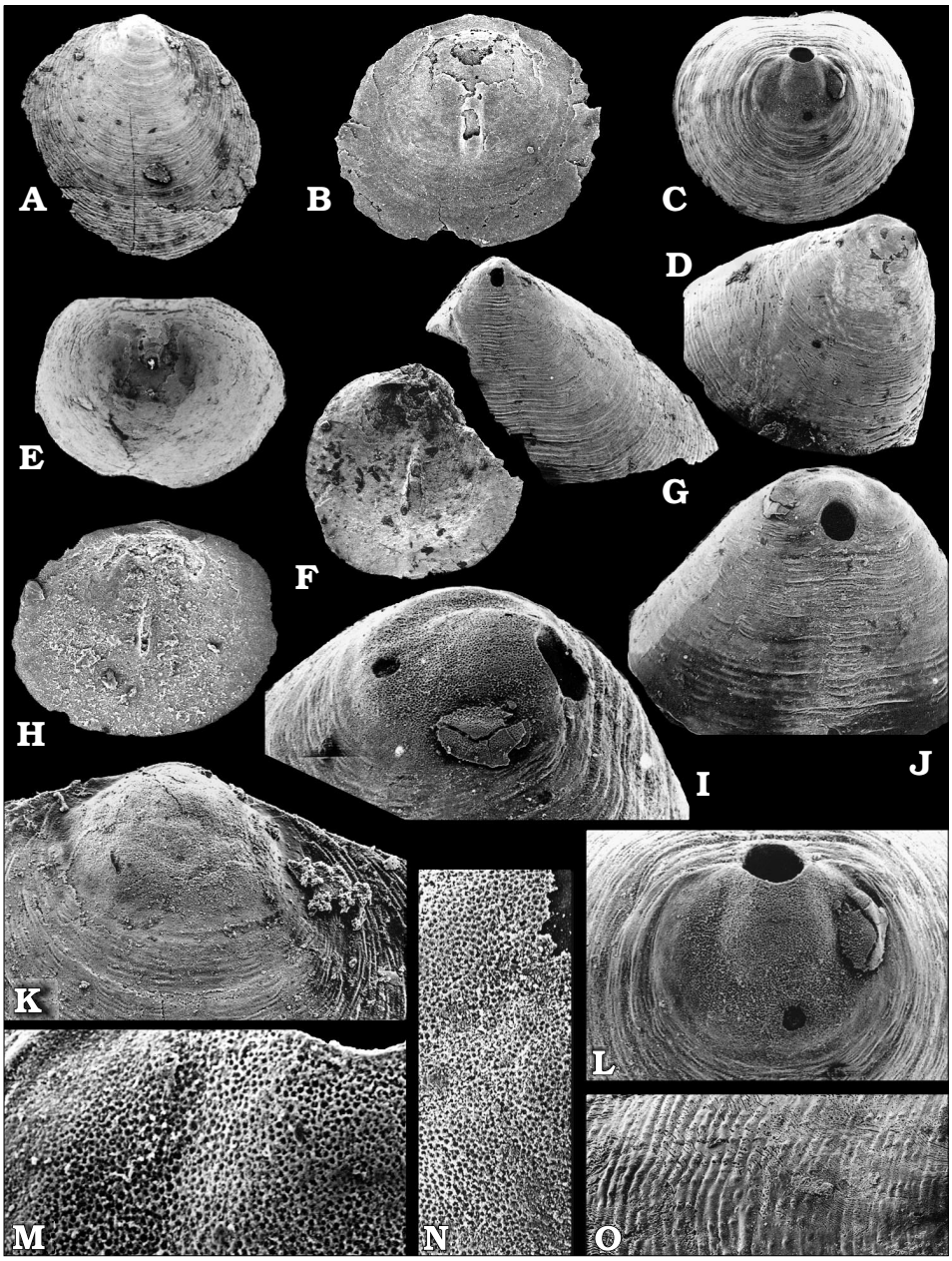

Fig. 7. **A–O**. *Acrotreta dissimilis* (Biernat). **A**, **K**. Dorsal valve RM Br133799, exterior (A, × 34), detail of larval shell (K, × 160). **B**. Dorsal valve RM Br133800, interior, × 55. **C**, **I**, **J**, **L**, **M**. Ventral valve RM Br133801, exterior (C, × 54), detail of larval shell (I, × 169), oblique posterior view (J, × 85), detail of larval shell (L, × 138), larval pitting (M, × 460). **D**, **G**, **O**. Ventral valve RM Br133802, oblique lateral view (D, × 41), oblique posterior view (G, × 19), detail of pustulose ornamentation (O, × 92). **E**. Ventral valve RM Br133803, ventral interior, × 28. **F**. Dorsal valve RM Br133804, interior, × 28. **H**. Dorsal valve RM Br133805, interior, × 33. **N**. Ventral valve RM Br133806, detail of larval pitting, × 350. All specimens from the Tremadoc chalcedonites, Wysoczki.

Description.—Shell somewhat transversely oval, around 75–95% as long as wide (N = 5). Ventral valve usually slightly procline to catacline, less than percent 80% as high as long (N = 2). Ventral pseudointerarea well defined with interridge. Pedicle foramen elongate oval, around 50 μm across, lacking exterior tube. Ventral interior with short median septum and apical process enclosing interior pedicle tube, occupying somewhat less than 50% of valve height (N = 1). Muscle fields and mantle canals of both valves poorly defined.

Dorsal valve flattened to slightly concave. Dorsal pseudointerarea occupying less than 50 percent of valve width (N = 2), with wide median groove and apsacline propareas. Median buttress poorly defined to absent. Dorsal median septum very low and narrow, extending for around 60–70% of total length (N = 2).

Larval shell of both valves close to circular, about 0.20–0.25 mm across. Ornamentation of both valves with strongly developed fila with fine pustules (less than 10 μm across), forming irregularly spaced radiating lines.

Discussion.—This species was referred to *Acrotreta* by Holmer and Popov (1994), and the new material described here supports this view. *A dissimilis* is the earliest known species of the genus, and differs from all other species in having a less conical ventral valve, with a much shorter and lower ventral median septum and apical process (see also Biernat 1973: pl. 11: 3). Moreover, the mantle canals and muscle imprints of both valves are poorly impressed by comparison with all other species of *Acrotreta*.

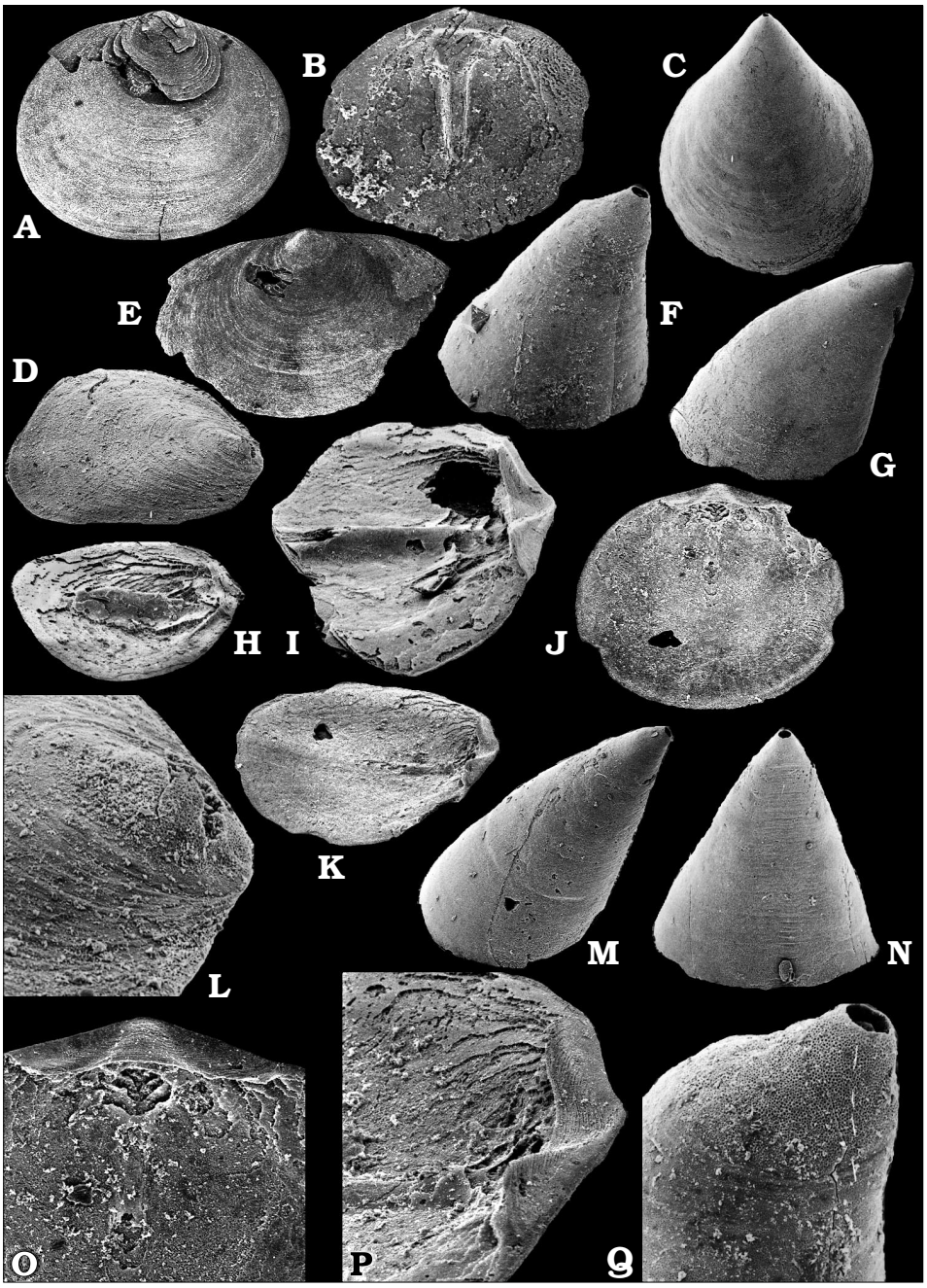

Fig. 8. **A**–**Q**. *Semitreta maior* Biernat. **A**. Dorsal valve RM Br133807, × 30. **B**. Dorsal valve RM Br133808, interior, × 40. **C**, **G**. Ventral valve RM Br133809, exterior (C, × 13) and oblique lateral view (G, × 13). **D**, **L**. Dorsal valve RM Br133812, oblique lateral view (D, × 50), detail of larval shell (L, × 195). **E**. Dorsal valve RM Br133810, exterior, × 30. **F**, **Q**. Ventral valve RM Br133811, oblique lateral view (F, × 75), detail of larval shell (Q, × 195). **H**. Dorsal valve RM Br133814, oblique lateral view, × 40. **I**. Dorsal valve RM Br133813, oblique lateral view, × 50). **J**, **K**, **P**, **O**. Dorsal valve RM Br133815, dorsal interior (J, × 25), oblique lateral view (K, × 50), detail of pseudointerarea (P, 100), detail of pseudointerarea (O, × 60). **M**, **N**. Ventral valve RM Br133816, oblique lateral view (M, 32), oblique posterior view (N, × 45). All specimens from the Tremadoc chalcedonites, Wysoczki.

Genus *Semitreta* Biernat, 1973

Type species: *Semitreta maior* Biernat, 1973; Tremadoc chalcedonites; Holy Cross Mountains, Poland.

Diagnosis.—See Popov and Holmer (1994: 122).

Semitreta maior Biernat, 1973

Fig. 8.

Semitreta maior sp. n.; Biernat 1973: 76, pl. 10: 1–11, fig. 27.
Semitreta maior Biernat; Holmer and Popov 2000: 119, fig. 61, 3a–f.
Holotype: Bp. XV/11u, ventral valve (W = 1.1, L = 1.3)
Type locality: Wysoczki. Holy Cross Mountains, Poland.
Type horizon: Tremadoc chalcedonites.

Material.—Total of 50 dorsal and 72 ventral valves. Figured ventral valves: RM Br133809 (W = 2.23, L = 2.10, H = 2.62), RM Br133811 (W = 0.39, L = 0.37, H = 0.37), RM Br133816 (W = 0.71, L = 0.60, H = 0.77); dorsal valves RM Br133807 (W = 1.27, L = 1.07), RM Br133808 (W = 0.95, L = 0.80, WI = 0.38, LI = 0.10, LS = 0.55), RM Br133810, RM Br133812, RM Br133813, RM Br133814, RM Br133815 (W = 1.52, L = 1.28, WI = 0.67, LI = 0.10).

Diagnosis.—Ventral valve high, narrowly conical, more than 100% as high as long. Ventral pseudointerarea poorly defined, apsacline. Foramen on short exterior pedicle tube. Ventral apical process elongate triangular, anterior to internal

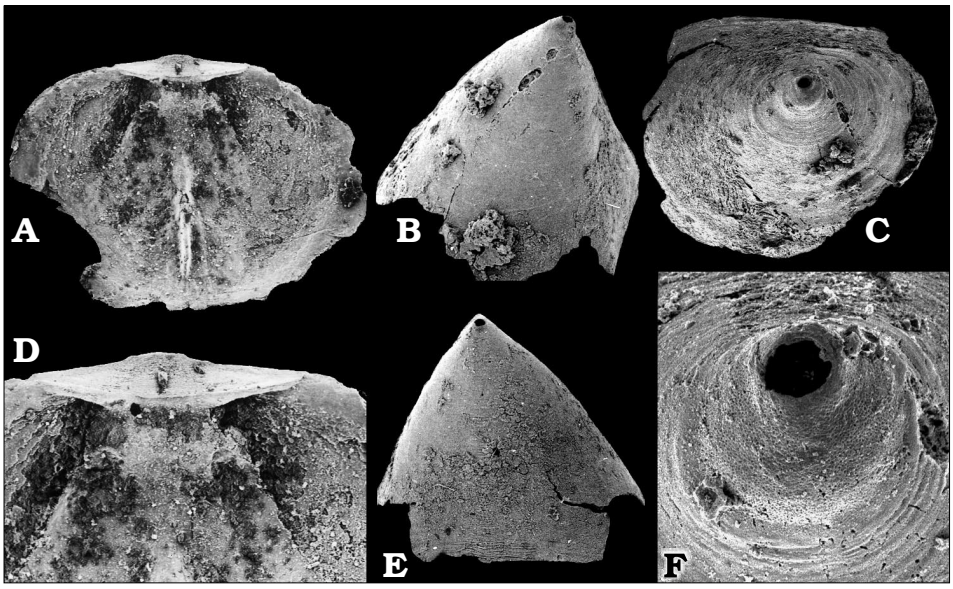

Fig. 9. **A**–**F**. ?*Ditreta dividua* Biernat. **A**, **D**. Dorsal valve RM Br133817, interior (A, × 36), detail of pseudointerarea (D, × 80). **B**, **C**, **E**, **F**. Ventral valve RM Br133818, oblique lateral view (B, × 32), exterior (C, × 30), oblique posterior view (E, × 30), detail of larval shell (F, × 165). All specimens from the Tremadoc chalcedonites, Wysoczki.

foramen. Dorsal valve flattened to geniculate, with weak median sulcus. Dorsal pseudointerarea strongly raised with triangular median groove and strongly anacline propareas. Dorsal cardinal muscle fields poorly impressed. Dorsal median buttress and median ridge variably developed.

Description.—Shell transversely suboval, around 80–95% as long as wide (N = 6). Ventral valve high, around 100–140% as high as long (N = 3). Foramen apical around 30–40 μm across, on short exterior tube, enclosed within larval shell. Ventral pseudointerarea poorly defined, apsacline. Ventral apical process elongate triangular, extending for about 30% of distance from apex to anterior margin (N = 1). Dorsal valve flattened to geniculate in lateral view, with weak median sulcus starting at umbo. Dorsal pseudointerarea strongly raised, occupying less than half of valve width, with triangular median groove and strongly anacline propareas. Dorsal cardinal muscle fields poorly impressed. Dorsal median buttress and median ridge variably developed; low and broad median septum commonly present, starting directly anterior to median buttress and extending anterior to mid-length.

Larval shell of both valves circular, about 0.15–0.20 mm across.

Discussion.—This species is the most common in the brachiopod fauna from the chalcedonites. Holmer and Popov (2000) and Popov and Holmer (1994) most recently discussed the affinities of *Semitreta*. In addition, *Semitreta kotujensis* Ushatinskaya (1994) from the Cambrian of Siberia has been described. The ventral valve of *S. kotujensis* is poorly known, but it would appear that the type species differs from all other taxa in having a narrow, high conical ventral valve with a foramen on a short exterior tube, a poorly developed apical process, in addition to a geniculate somewhat sulcate dorsal valve. The geniculation is particularly strong in gerontic specimens. By comparison with the material described by Biernat (1973), the dorsal cardinal muscle fields are more poorly impressed, and the dorsal median buttress and median ridge more variably developed.

Genus *Ditreta* Biernat, 1973

Type and only species: *Ditreta dividua* Biernat, 1973.

Diagnosis.—See Biernat (1973: 65).

?*Ditreta dividua* Biernat, 1973

Fig. 9.

?*Ditreta dividua* sp. nov.; Biernat 1973: 66, pl. 5: 1–8.
Holotype: ZPAL Bp XV/37h; ventral valve (W = 6.0, L = 1.6).
Type locality: Wysoczki. Holy Cross Mountains, Poland.
Type horizon: Tremadoc chalcedonites.

Material.—Total of 1 dorsal and 1 ventral valve. Figured ventral valve: RM Br133818 (W = 1.47, L = 1.13, H = 1.06); dorsal valve: RM Br133817 (W = 1.33, L = 1.03, WI = 0.56, LS = 0.83).

Remarks.—This species is poorly understood, and the new material includes only two specimens that appear to be similar to those described by Biernat (1973). The specimens cannot be referred with certainty to *D. dividua,* but they are similar in having a rounded shell with a straight posterior margin and a widely conical ventral valve. The ventral apical process is poorly preserved. The dorsal valve is also similar to that of *D. dividua* in having fairly well-defined cardinal muscle scars, and a low dorsal median ridge.

Genus *Eurytreta* Rowell, 1966

Type species: *Acrotreta curvata* Walcott, 1902; Early Ordovician Pogonip Limestone; Eureka district, Nevada, USA.

Diagnosis. See Popov and Holmer (1994: 95).

Eurytreta minor Biernat, 1973

Fig. 10A–K, M, O.

Eurytreta minor sp. nov.; Biernat 1973: 74, pl. 9: 1–6; fig. 26.

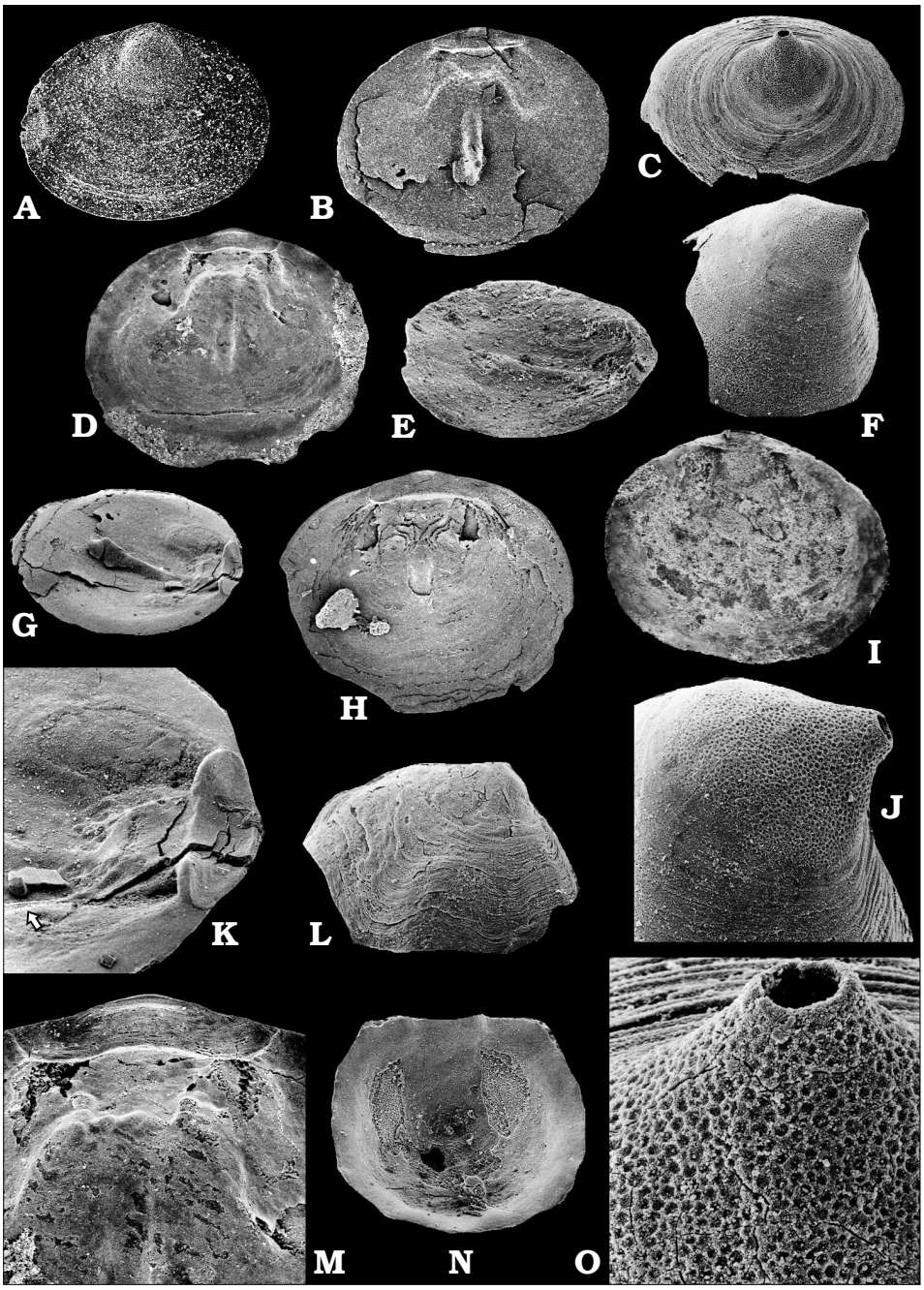

Fig. 10. **A**–**K**, **M**, **O**. *Eurytreta minor* Biernat. **A**. Dorsal valve RM Br133819, exterior, × 55. **B**, **G**, **K**. Dorsal valve RM Br133820, interior (B, × 40), oblique lateral view (G, × 40), detail of pseudointerarea (K, × 40). **C**, **F**, **J**, **O**. Ventral valve RM Br133821, exterior (C, × 75), oblique lateral view (F, × 80), detail of larval shell (J, × 60), detail of larval pitting (O, × 500). **D**, **M**. Dorsal valve RM Br133822, interior (D, × 50) and detail of pseudointerarea (M, × 135). **E**. Dorsal valve RM Br133823, oblique lateral view, × 90. **H**. Dorsal valve RM Br133824, interior, × 38. **I**. Dorsal valve RM Br133825, interior, × 53. **L**, **N**. *Eoconulus* sp. **L**. Dorsal valve RM Br133826, oblique lateral view, × 60. **N**. Dorsal valve RM Br133827, interior, × 50. All specimens from the Tremadoc chalcedonites, Wysoczki.

Eurytreta minor Biernat; Popov and Holmer 1994: 100, fig. 84 [full synonymy].

Holotype: ZPAL Bp XV/16n; ventral valve (W = 1.00, L = 0.8).

Type locality: Wysoczki. Holy Cross Mountains, Poland.

Type horizon: Tremadoc chalcedonites.

Material.—Figured ventral valve: RM Br133821; dorsal valves: RM Br133819 (W = 0.64, L = 0.51), RM Br133820 (W = 0.95, L = 0.80, WI = 0.30, LI = 0.08, WM1 = 0.63, LM1 = 0.38, LS = 0.55), RM Br133822 (W = 0.78, L = 0.68, WI = 0.26, WM1 = 0.50, LM1 = 0.30, LS = 0.40), RM Br133823, RM Br133824 (W = 1.08, L = 0.89, WI = 0.44, WM1 = 0.66, LM1 = 0.39, LS = 0.47), RM Br133825 (W = 0.74, L = 0.60, WI = 0.28). Total of 12 dorsal and 8 ventral valves.

Diagnosis.—See Popov and Holmer (1994: 100).

Description.—Shell transversely suboval, 80–87% as long as wide (N = 6). Ventral valve low conical, about 66% as high as long (N = 1). Ventral pseudointerarea procline with poorly defined intertrough. Posterior surface gently concave in lateral profile. Anterior slope of ventral valve evenly convex in lateral profile. Pedicle foramen rounded, at end of very short pedicle tube, within larval shell. Ventral apical process poorly developed, directly anterior to internal foramen.

Dorsal valve only slightly convex in lateral profile. Dorsal pseudointerarea very narrow and short, occupying 32–40% of valve width (N = 4). Median groove broadly triangular and with small propareas. Dorsal cardinal muscle field occupying

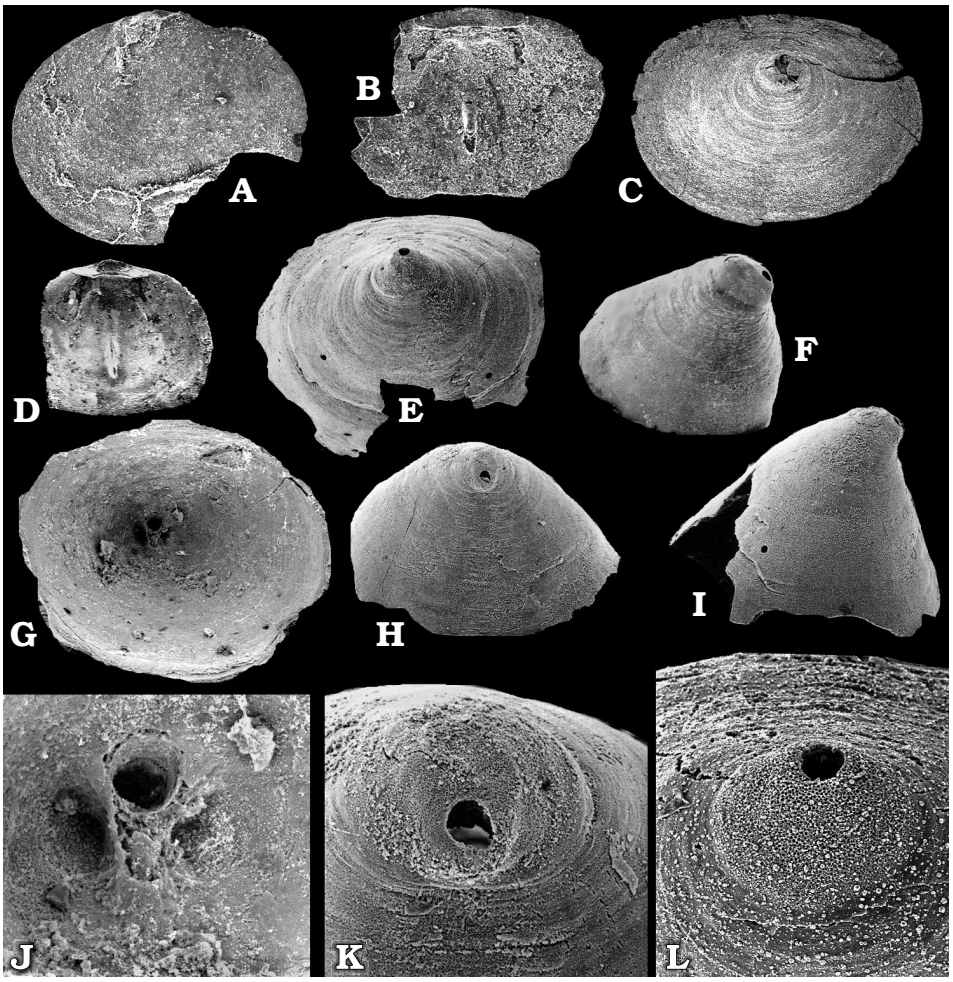

Fig. 11. **A–L**. *Mamatia retracta* (Popov). **A**. Dorsal valve RM Br133828, exterior, × 40. **B.** Dorsal valve RM Br133829, interior, × 50. **C**. Ventral valve RM Br133830, exterior, × 32. **D**. Dorsal valve RM Br133831, interior, × 27. **E**, **H**, **I**, **K**. Ventral valve RM Br133832, exterior (E, × 75), oblique posterior view (H, × 40), oblique lateral view (I, × 75), detail of larval shell (K, × 162). **F**. Ventral valve RM Br133833, oblique lateral view, 62. **G**, **J**. Ventral valve RM Br133834, interior (G, × 45) and detail of apical process (J, × 195). **L**. Ventral valve RM Br133835, detail of larval shell, × 150. All specimens from the Tremadoc chalcedonites, Wysoczki.

around 61–66% of valve width. Median buttress variably developed. Dorsal median ridge variably developed, usually very low, extending for around 52–68% of valve length. Larval shell of both valves around 0.2 mm wide.

Discussion.—A detailed comparative discussion of this and other related species of *Eurytreta* was given by Popov and Holmer (1994). The new Polish material described here is morphologically identical with the material described from the Bjørkåsholmen Limestone in Scandinavia.

Family Ephippelasmatidae Rowell, 1965

Genus *Mamatia* Popov and Holmer, 1994

Type and only species: *Paratreta retracta* Popov (in Nazarov and Popov), 1980; Ordovician Mamat Formation (Tremadoc); Chingiz Range, Kazakhstan.

Diagnosis.—See Popov and Holmer (1994: 128).

Mamatia retracta (Popov, 1980)

Fig. 11.

Myotreta sp.; Biernat 1973: 85, pl. 15: 6–8.

Paratreta retracta sp. nov.; Popov (in Nazarov and Popov) 1980: 95, pl. 25: 1–6.

Mamatia retracta (Popov); Popov and Holmer 1994: 128, fig. 102.

Mamatia retracta (Popov); Holmer and Popov 2000: 127, fig. 69, 3a–g.

Material.—Total of 57 ventral and 105 dorsal valves. Figured ventral valves: RM Br133830 (W = 1.19, L = 0.88, H = 0.66), RM Br133832, RM Br133833 (W = 0.57, L = 0.45, H = 0.32), RM Br133834, RM Br133835; dorsal valves: RM Br133828, RM Br133829 (W = 0.70, L = 0.50, WI = 0.34, LS = 0.40, BS = 0.22), RM Br133831 (W = 0.93, L = 0.78, WI = 0.48, WM1 = 0.63, LM1 = 0.37, LS = 0.56, BS = 0.26).

Diagnosis.—As for genus.

Description.—Shell transversely suboval, around 74–84% as long as wide (N = 4). Ventral valve broadly conical, around 71–75% as high as long (N = 2) with maximum height at umbo. Ventral pseudointerarea procline to almost catacline, bisected by poorly defined intertrough. Pedicle foramen at the end of very short external pedicle tube, enclosed within larval shell. Apical process slightly ridged anteriorly.

Dorsal pseudointerarea low, orthocline, occupying around 49–52% of valve width (N = 2). Dorsal median septum low, extending for around 72–80% of valve length. Dorsal median buttress and cardinal muscle scars variably developed. Larval shells of both valves well defined, transversely suboval, around 0.22 mm wide, surrounded by raised rim.

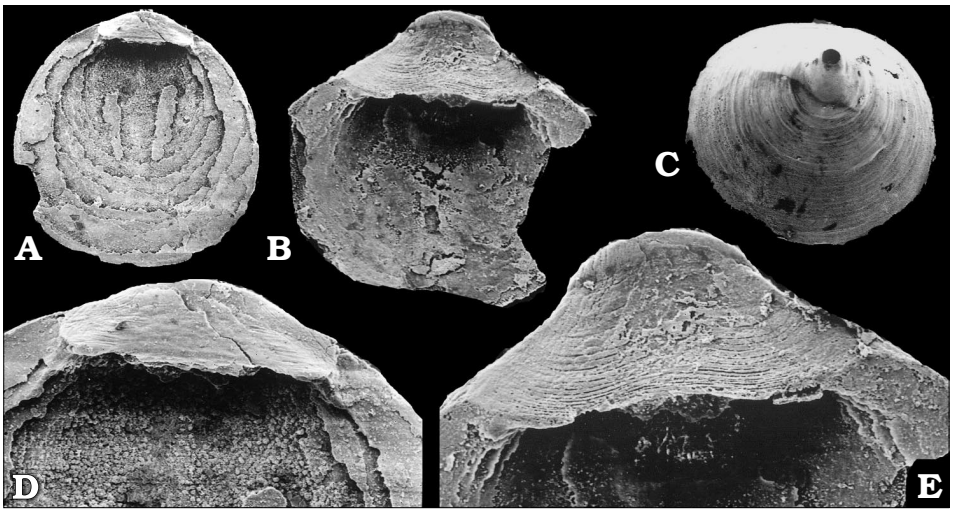

Fig. 12. **A**–**C**. *Akmolina* sp. **A**, **D**. Dorsal valve RM Br133836, interior (A, × 60), detail of pseudointerarea (D, × 180). **C**. Ventral valve RM Br133837, exterior, × 61. **B**, **E**. *Pomeraniotreta* sp. Dorsal valve RM Br133838, interior (B, × 90), detail of pseudointerarea (E, × 160). All specimens from the Tremadoc chalcedonites, Wysoczki.

Discussion.—The specimens from Poland agree closely with the types from the Chingiz Range, as well as those described by Popov and Holmer (1994) from the South Urals. The only difference is that the dorsal median septum is somewhat lower and the upper septal rod is not as well defined as in the Asian material. The median septum of the ephippelasmatids usually shows some degree of intraspecific variation.

Genus *Akmolina* Popov and Holmer, 1994

Type species: *Akmolina olentensis* Popov and Holmer, 1994; Upper Cambrian, Kujandy Formation, north-eastern central Kazakhstan.

Diagnosis.—See Holmer and Popov (1994: 126).

Akmolina sp.

Fig. 12A, C, D.

Material.—Total of 1 dorsal and 1 ventral valve. Figured ventral valve: RM Br133836 (W = 0.57, L = 0.50); dorsal valve RM Br133836 (W = 0.57, L = 0.58, WI = 0.22, LI = 0.08).

Remarks.—This unnamed species is similar to *Akmolina olentensis* in having a flattened dorsal valve with a narrow, triangular pseudointerarea and in lacking a dorsal median ridge. A single ventral valve is also similar to that of *A. olentensis*. Precise specific discrimination of these shells remains unclear in the absence of further material.

Genus *Pomeraniotreta* Bednarczyk, 1986

Type species: *Pomeraniotreta biernatae* Bednarczyk, 1986; Ordovician (*Paroistodus proteus* Biozone); northern Poland.

Diagnosis.—See Popov and Holmer (1994: 130).

Pomeraniotreta sp.

Fig. 12B, E.

Material.—One figured dorsal valve: RM Br133838.

Remarks.—This valve is similar to that of the type species in having a distinctive triangular dorsal pseudointerarea divided by a widely subtriangular median groove.

Family Eoconulidae Cooper, 1956

Genus *Eoconulus* Cooper, 1956

Type species: *Eoconulus rectangulatus* Cooper, 1956; Ordovician Pratt Ferry beds (Llandeilo); Alabama.

Eoconulus sp.

Fig. 10L, N.

Material.—Total of 3 dorsal valves. Figured specimens: RM Br133826, RM Br133827 (W = 0.70, L = 0.58).

Remarks.—Dorsal valves of this genus are commonly difficult to differentiate from each other, and without a ventral valve close comparison is impossible. It is the earliest known record of the genus and the family Eoconulidae.

Acknowledgements

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References

Barrande, J. 1868. Faune Silurienne des Environs de Hof, en Baviere. *Société Géologique de France, Bulletin* (ser. 2) 20: 489–535.

Bednarczyk, W. 1964. Stratygrafia i fauna tremadoku i arenigu (oelandianu) regionu kieleckiego Gór Świętokrzyskich. *Biuletyn Geologiczny Uniwersytetu Warszawskiego* 4: 1–216.

Bednarczyk, W. 1971. Stratigraphy and palaeogeography of the Ordovician in the Holy Cross Mts. *Acta Geologica Polonica* 21: 573–616.

Bednarczyk, W. and Biernat, G. 1978. Inarticulate brachiopods from the Lower Ordovician of the Holy Cross Mountains, Poland. *Acta Palaeontologica Polonica* 23: 293–316.

Bednarczyk, W. 1986. Inarticulate brachiopods from the Lower Ordovician in Northern Poland. *Annales Societatis Geologorum Poloniae* 56: 409–418.

Biernat, G. 1973. Ordovician inarticulate brachiopods from Poland and Estonia. *Palaeontologia Polonica* 28: 1–116.

Brøgger, W.C. 1882. *Die Silurischen Etagen 2 and 3 im Kristianiagebiet und auf Eker, ihre Gliederung, Fossilien, Schichtenstörungen und Contactmetamorphosen*. Universitets-Program 2. Semester, 1–376. A.W. Brøgger, Kristiania (Oslo).

Cooper, G.A. 1956. Chazayan and related brachiopods. *Smithsonian Miscellaneous Collection* 127: 1–1224 .

Dzik, J. and Pisera, A. 1994. Sedimentation and fossils of the Mójcza Limestone. *In*: J. Dzik, E. Olempska, and A. Pisera, Ordovician Carbonate Platform Ecosystem of the Holy Cross Mountains, Poland. *Palaeontologia Polonica* 53: 5–41.

Gorjansky, V.Yu. (Gorânskij, V.Û.) 1969. Inarticulate brachiopods of the Cambrian and Ordovician of the northwest Russian Platform [in Russian]. *Ministerstvo Geologii RSFSR, Severo-Zapadnoe Territorialnoe Geologičeskoe Upravlenie* 6: 1–173.

Gorjansky, V.Yu. (Gorânskij, V.Û.) and Popov, L.E. 1985. Morphology, systematic position and origin of the inarticulate brachiopods with calcareous shell [in Russian]. *Paleontologičeskij žurnal* 3: 3–14.

Havlícek, V. 1982. Lingulacea, Paterinacea, and Siphonotretacea (Brachiopoda) in the Lower Ordovician sequence of Bohemia. *Sborník geologických ved. Paleontologie* 25: 9–82.

Holmer, L.E. and Popov, L.E. 1994. Revision of the type species of *Acrotreta* and related lingulate brachiopods. *Journal of Paleontology* 68: 433–450.

Holmer, L.E. and Popov, L.E. 2000. Class Lingulata. *In*: A. Williams, C.H.C. Brunton, and S.J. Carlson (eds.), *Treatise on Invertebrate Paleontology, Part H*, Revised (*Brachiopoda* 2), H30–H146. Geological Society of America and University of Kansas Press, Boulder.

Holmer, L.E., Popov, L.E., and Bassett, M.G. 2000. Early Ordovician organophosphatic brachiopods with Baltoscandian affinities from the Alay Range, southern Kyrgyzstan. *GFF* 122: 367–375.

Holmer, L.E., Popov, L.E., Koneva, S., and Bassett, M.G. 2001. Cambrian–early Ordovician brachiopods from Malyi Karatau, the western Balkhash region, and Tien Shan, central Asia. *Special Papers in Palaeontology* 65: 1–180.

Jeremejew, P. 1856. Geognostische Beobachtungen An Den Ufern Des Wolchow. *Russisch-Kaiserliche Mineralogische Gesellschaft zu St. Petersbourg, Verhandlungen* 10: 63–84.

King, W. 1846. Remarks on certain genera belonging to the class Palliobranchiata. *Annals and Magazine of Natural History (London)* 18: 26–42, 83–94.

Koneva, S.P. 1986. A new family of the Cambrian inarticulate brachiopods [in Russian]. *Paleontologičeskij žurnal* 1: 49–55.

Kozłowski, R. 1948. Les graptolites et quelques nouveaux groupes d'animaux de Tremadoc de la Pologne. *Palaeontologia Polonica* 3: 1–235.

Kuhn, O. 1949. *Lehrbuch der Paläozoologie*. 326 pp. E. Schweizerbart, Stuttgart.

Kutorga, S.S 1848. Ueber die Brachiopoden-Familie der Siphonotretaeae. *Russisch-Kaiserliche Mineralogische Gesellschaft zu St. Petersbourg, Verhandlungen* 1847: 250–286.

Lermontova, E.V. and Razumovskii, N.K. (Razumovskij, N.K.) 1933. On the ancient strata of the Urals (Lower Silurian and Cambrian at the outskirts of the Kidryassovo vilage at the South Urals [in Russian]. *Zapiski Rossijskogo mineralogičeskogo obŝestva* 62: 185–217.

Menke, C.T. 1828. *Synopsis methodica Molluscorum generum omnium et specierum earum, quae in Museo Menkeano Adservantur.* 91 pp. Pyrmonti.

Mickwitz, A. 1896. Über die Brachiopodengattung Obolus Eichwald. *Memoires de l'Académie Impériale des sciences de St.Pétersbourg* 4: 1–215.

Nazarov, B.B. and Popov, L.E. 1980. Stratigraphy and fauna of Ordovician siliceous-carbonate deposits of Kazakhstan [in Russian]. *Trudy Geologičeskogo instituta Akademii Nauk SSSR* 331: 1–190.

Popov, L.E. and Holmer, L.E. 1994. Cambrian–Ordovician lingulate brachiopods from Scandinavia, Kazakhstan, and South Ural Mountains. *Fossils and Strata* 35: 1–156.

Rowell, A.J. 1966. Revision of some Cambrian and Ordovician inarticulate brachiopods. *The University of Kansas Paleontological Contributions* 7: 1–36.

Ruzička, R. 1927. Fauna vrstev Eulomovych rudniho lozizka u Holoubkova (v Ouzkem). *Rozpravy Ceske akademie ved a umeni, Trida 2 matematicko prirodnia ved* 36: 1–21.

Schuchert, C. 1893. A classification of the Brachiopoda. *American Geologist* 11: 141–167.

Sdzuy, K. 1955. Die Fauna der Leimitz-Schiefer (Tremadoc). *Senckenbergische naturforschende Gesellschaft* 492: 1–73.

Szaniawski, H. 1980. Conodonts from the Tremadoc chalcedony beds, Holy Cross Mountains (Poland). *Acta Palaeontologica Polonica* 25: 101–121.

Ushatinskaya, G.T. (Ušatinskaâ, G.T.) 1994. New Middle and Upper Cambrian acrotretids (Brachiopoda) from the northern part of the Siberian platform, and some questions of their systematics [in Russian]. *Paleontologičeskij žurnal* 4: 38–54.

Waagen, W. 1885. Salt Range Fossils. I. Productus-Limestone Fossils. *Geological Survey of india, Memoirs, Palaeontologia indica* (ser. 13, vol. 4) 5: 729–770.

Walcott, C.D. 1908. Cambrian Geology and Paleontology, pt. 3—Cambrian Brachiopoda, descriptions of new genera and species. *Smithsonian Miscellaneous Collections* 53: 53–137.

Wright, A.D. 1963. The fauna of the Portrane Limestone. 1. The inarticulate brachiopods. *British Museum (Natural History), Bulletin (Geology)* 5: 221–254.