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## ***Schmidtites celatus* (Obolida, Brachiopoda) from the "Obolus sands" (Upper Cambrian - Lower Ordovician) of Estonia**

Christian C. EMIG<sup>1</sup>

**Abstract:** Large collections of the brachiopod obolid *Schmidtites celatus* have been gathered from Upper Cambrian-Lower Ordovician strata in four northern Estonian localities. The morphological features and the taxonomic characters of the genus and of the single species representing it are re-described and illustrated. New diagnoses are proposed based on characters of the shell and morphological traits that permit *Schmidtites celatus* to be compared with and distinguished from the other obolid genera occurring in the same samples or areas, i.e. *Ungula ingraca*, *Oepikites*, and *Obolus apollinis* which now includes specimens formerly described as *Ungula convexa*. *Schmidtites celatus* differs from them mainly in the arrangement of its musculature.

**Key Words:** *Schmidtites*, Brachiopoda, Cambrian – Ordovician, Estonia, Obolid musculature

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**Résumé :** *Schmidtites celatus* (Obolida, Brachiopoda) des grès à "Obolus" (Cambrien supérieur-Ordovicien inférieur) en Estonie.- De très nombreux exemplaires du brachiopode obolide *Schmidtites celatus* ont été récoltés dans quatre localités du Nord de l'Estonie, dans des couches appartenant au Cambrien supérieur et à l'Ordovicien inférieur. L'étude des caractères morphologiques et taxinomiques du genre et de l'unique espèce a permis de redécrire et d'illustrer *Schmidtites celatus* ; de nouvelles diagnoses sont proposées pour le genre et l'espèce. Les caractères ont été comparés avec ceux des autres genres d'obolides présents dans les mêmes strates ou dans la région, i.e. *Ungula ingraca*, *Oepikites*, et *Obolus apollinis* à laquelle est rattachée *Ungula convexa*. *Schmidtites celatus* s'en distingue notamment par l'arrangement musculaire.

**Mots-Clefs :** *Schmidtites*, Brachiopoda, Cambrien – Ordovicien, Estonie, musculature, Obolides

### **Introduction**

During several field trips to northern Estonia, hundreds of well-preserved specimens were collected from strata dated Upper Cambrian to the Lowest Ordovician. They comprise the genera *Schmidtites* SCHUCHERT et LEVENE, 1929, *Ungula* PANDER, 1830, *Obolus* EICHWALD, 1829, and *Oepikites* KHAZANOVITCH et POPOV, 1984, all representatives of the family Obolidae (Lingulida: Linguloidea). Other specimens studied are in the collections of the Museum of Geology in the Institute of Geology of the University of Tartu, Estonia. Because of the controversy regarding the systematics of the lingulid taxa of the Middle Cambrian to Lower Ordovician (Tremadocian) in Estonia and Russia, the tools described by EMIG (2002) to discriminate between obolid taxa are used in the redescription of *Schmidtites*.

When comparing *Schmidtites* with the other obolid genera cited, significant differences are manifest in several characters involving the arrangement of the musculature. The statement of WILLIAMS & HURST (1977) and POPOV (1992) that the Obolidae have an almost identical pattern is not corroborated by the arrangements of the musculature. Consequently, an emended diagnosis is proposed for the genus and a new one,

including figures, is offered for the species.

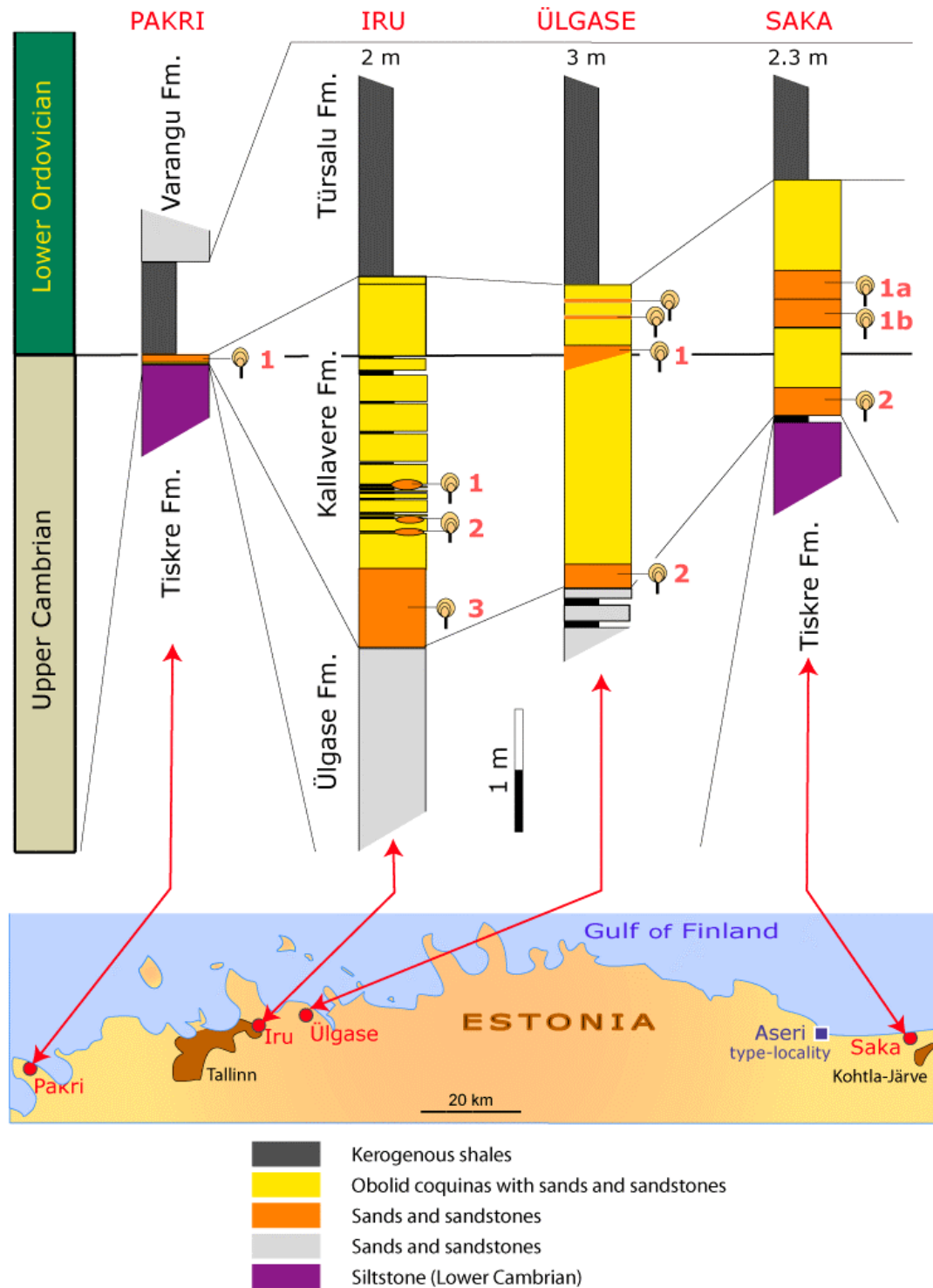
### **Geological setting and material**

Along the northwestern part of the East European Platform, the Upper Cambrian-Lower Ordovician sands and sandstones are weakly cemented and alternate with black shales and clays. They are overlain by Lower Ordovician carbonate rocks cropping out along a slope oriented N to S extending from northern Poland to Lake Ladoga in northwestern Russia: these deposits represented a shallow epicontinental basin with abundant obolid brachiopods, and are traditionally known as "Obolus sands" or "Obolus phosphorites". In Estonia, the obolid coquinas (Fig. 1; Table 1) form well-known deposits in the famous shelly phosphorite layers (see ÖPIK, 1929; KALJO *et alii*, 1986; HEINSALU *et alii*, 1987; MENS *et alii*, 1989; NEMLIHER & PUURA, 1996; PUURA, 1996; MENS *et alii*, 1996). In the Upper Cambrian and lowermost Ordovician strata of these coquinas *Schmidtites celatus* occurs with *Ungula ingraca* and *U. convexa*; this last taxon is now placed in the synonymy of *Obolus apollinis* (see EMIG, 2002). Coeval beds with obolids are known to be present in Sweden (HOLMER & POPOV, 1990; PUURA & HOLMER, 1993), Poland (BIERNAT, 1964; BEDNARCZYK, 1998), Lithuania (MENS *et alii*, 1990; LASHKOV *et alii*, 1992), and Russia (POPOV *et alii*, 1989).

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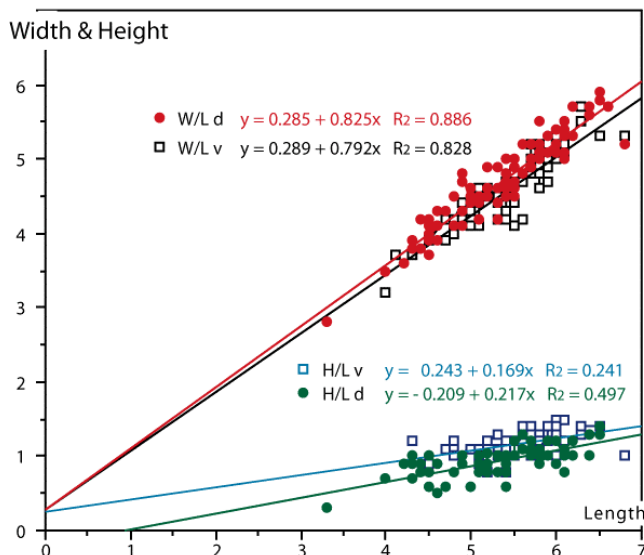
**Figure 1:** Occurrences of *Schmidtites celatus* in the columns representing the stratigraphic successions of the sampled localities and their geographical location in Estonia.

*Schmidtites celatus* has been collected in northern Estonia from 4 outcrops, the stratigraphy of which is represented graphically on Figure 1. The phosphorite brachiopod fauna consists mainly of *Schmidtites celatus* and/or *Ungula ingrca* (Table 1). Several hundred specimens have been sampled and have been deposited in the Muséum National d'Histoire Naturelle de Paris (France). Additional material collected in Ingria (Russia) was made available by the Museum of Geology, University of Tartu

(Estonia). Unfortunately, no specimens for study were available from the CNIGR museum (VSEGEI, St Petersburg, Russia) where, however, the neotype is housed.

### Systematics

The Brachiopoda are classified here in accordance with the schema of the *Treatise of Invertebrate Paleontology* (2000).



**Figure 2:** Regression curves of the Width/Length and Height/Length ratios of dorsal and ventral valves of *Schmidites celatus*.

**Phylum Brachiopoda**

**Subphylum Linguliformea WILLIAMS, CARLSON, BRUNTON, HOLMER et POPOV, 1996**

**Class Lingulata GORJANSKY et POPOV, 1985**

**Order Lingulida WAAGEN, 1885**

**Superfamily Linguloidea MENKE, 1955**

**Family Obolidae KING, 1846**

**Subfamily Obolinae KING, 1846**

***Schmidites* SCHUCHERT et LEVENE, 1929**

**Synonymy**

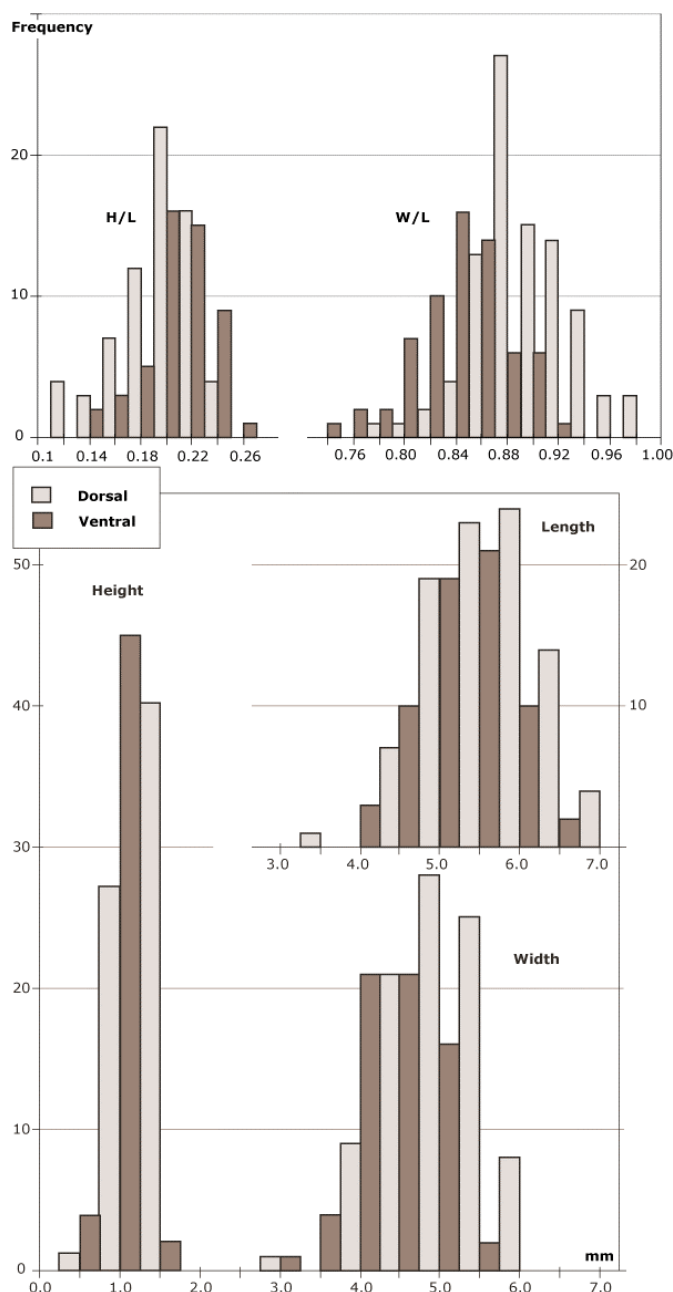
- 1869 nom. subst. pro *Schmidtia* VOLBORTH, 1869, p. 208 (non BALSAMO-CRIVELLI, 1863).
- 1877 *Schmidtia*: DALL, p. 62.
- 1892 *Schmidtia*: HALL & CLARKE, p. 83.
- 1896 *Obolus* (*Schmidtia*): MICKWITZ, p. 158
- 1908 *Obolus* (*Schmidtia*): WALCOTT, p. 142.
- 1912 *Obolus* (*Schmidtia*): WALCOTT, p. 441.
- 1929 *Schmidites*: nom. subst. - SCHUCHERT & LEVENE, p. 121.
- 1965 *Schmidites*: ROWELL, p. H266.
- 1969 *Obolus* (*Schmidites*): GORJANSKY, p. 24.
- 1989 *Schmidites*: POPOV & KHAZANOVITCH, p. 114.
- 1993 *Schmidites*: PUURA & HOLMER, p. 219.
- 1996 *Schmidites*: PUURA, p. 68.
- 1998 *Schmidites*: BEDNARCZYK, p. 50.
- 2000 *Schmidites*: HOLMER & POPOV, p. 52.

Currently, the genus is known to occur in the Upper Cambrian and Lower Ordovician (Lower Tremadocian) of Estonia, Russia (Ingria), Poland, and Sweden. The type-species is *Schmidites celatus* (VOLBORTH, 1869), originally described under the name *Schmidtia celata* VOLBORTH, 1869.

**Diagnosis**

The emended diagnosis of *Schmidites* SCHUCHERT et LEVENE, 1929 is compared to the one published previously by HOLMER & POPOV (2000). Here the International Code of Zoological Nomenclature (ICZN, 1999) is applied to the descriptions of the genus and of the species in accordance with Art. 12 and Recommendations 13 A-C a, which state that every new name must be accompanied by a description or a definition of the taxon that it denotes. Consequently, genus and species have discrete diagnoses.

Previous diagnosis from HOLMER & POPOV (2000)	Emended diagnosis
	Bi-symmetrical muscle arrangement (*).
Ventral pseudointerarea with deep narrow pedicle groove; ventral propleas elevated, slightly concave, with flexure lines; shallow heart-shaped depression in ventral valve.	<b>Ventral valve</b> Triangular umbonal region; pseudointerarea slightly concave with well-defined and slightly elevated flexure lines, and with a median narrow pedicle groove. Posterior adductor muscle unpaired.
Dorsal pseudointerareas with concave median groove and reduced, elevated propleas; dorsal visceral area with long median projection bisected by low median ridge.	<b>Dorsal valve</b> Rounded umbonal region; pseudointerarea with well-defined and elevated flexure lines. Posterior adductor muscle unpaired. <i>Vascula media</i> short, widely divergent.
<i>Vascula lateralia</i> of both valves subparallel, marginally; dorsal <i>vascula media</i> short, widely divergent.	<i>Vascula lateralia</i> (main mantle canals) of both sides subparallel to slightly curved.
Shell elongate oval or subtriangular, ventribiconvex, thick-shelled; visceral areas of both valves thickened.	Shell to subcircular to oval in outline. External surface smooth, with fine concentric growth. (* <b>Nota:</b> The Posterior Internal Oblique muscle (numbered 4": EMIG, 1982) is at present only known in <i>Lingula</i> , <i>Glottidia</i> , <i>Lingularia</i> , and <i>Dignomia</i> , all of which have an asymmetrical muscle arrangement.



**Figure 3:** Histograms of the valve dimensions (length, width, height) and ratios (height/length and width/length) of *Schmidtites celatus*.

The genus *Schmidtites*, to which only a single species is assigned, was originally named by VOLBORTH (1869) as *Schmidtia celata* with a type-locality near Aseri (Estonia; Fig. 1) in the Kallavere Formation. MICKWITZ (1896) considered it a subgenus, made up of 4 species with a number of varieties. GORJANSKY (1969) re-evaluated the infraspecific variation of *Schmidtites celatus* and placed most of MICKWITZ's species, i.e. *Obolus (Schmidtia) celatus*, *O. (S.) acuminatus*, *O. (S.) crassus*, in synonymy with it. However, *Obolus (Schmidtites) obtusus* was accepted and considered to be congeneric by GORJANSKY (1969). The first three were considered by POPOV & KHAZANOVITCH (1989) as synonyms of the type species, with *Schmidtites* thus

becoming a monospecific genus, for *Obolus (Schmidtia) obtusus* MICKWITZ, 1896, was assigned to the genus *Oepikites* KHAZANOVITCH et POPOV, 1984 by POPOV & KHAZANOVITCH (1989).

SCHUCHERT & LEVENE (1929) pointed out that *Schmidtia* is a junior synonym of a sponge genus described by BALSAMO-CRIVELLI (1863). Consequently they proposed the name *Schmidtites* be adopted for the sub-genus. ROWELL (1965) restored *Schmidtites* to generic rank.

The juvenile obolids assigned to *Schmidtites* by BIERNAT (1973) are described too poorly to allow identification. One can contend that juvenile specimens of the lingulids are generally impossible to identify because they do not express the required taxonomic features. WILLIAMS (1974) described *Schmidtites (?) simplex*, which LOCKLEY & WILLIAMS (1981) considered synonymous with *Siphonotreta micula* M'COY, 1851, and called it *Schmidtitis? micula* (M'COY). This form occurs in the Lower Ordovician of Wales, UK but was reassigned to *Apotobolus* by NAZAROV & POPOV (1980). Disregarding this assignment BOTTING & THOMAS (1999) referred a pseudoplanktonic form from the Middle Ordovician to *Schmidtitis? micula*. However, these authors pointed out that the only element implying a pelagic life for the brachiopods is their attachment to a graptolite by means of a filamentous alga. The identification of *Schmidtitis (?) sp.* by MERGL & ELICKI (2004) in Sardinia (Italy) must remain unconfirmed pending description of its soft-bodied characteristics.

### ***Schmidtites celatus* (VOLBORTH, 1869)**

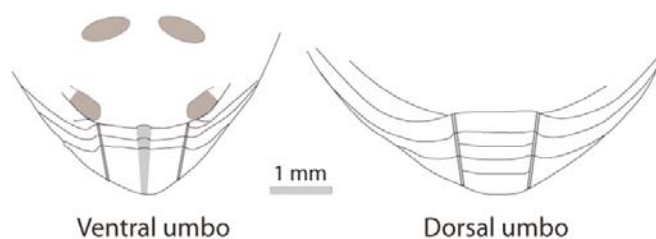
#### **Synonymy**

- 1869 *Schmidtia celata* n. sp.: VOLBORTH, p. 209-212, Pl. 27: 1-6.  
 1892 *Schmidtia celata*: HALL & CLARKE, p. 83, Figs. 37-38.  
 1896 *Obolus celatus*: MICKWITZ, p. 159, Pl. 2: 19-20.  
 1896 *Obolus celatus* var. *orbiculatus* n. var.: MICKWITZ, p. 163, Pl. 2: 21-22.  
 1896 *Obolus celatus* var. *praecisus* n. var.: MICKWITZ, p. 166, Pl. 2: 37-38.  
 1896 *Obolus acuminatus* n. sp.: MICKWITZ, p. 179, Pl. 2: 39-40.  
 1896 *Obolus acuminatus* var. *alatus* n. var.: MICKWITZ, p. 183, Pl. 2: 41-42.  
 1896 *Obolus acuminatus* var. *humeratus* n. var.: MICKWITZ, p. 194, Pl. 2: 43-44.  
 1896 *Obolus acuminatus* var. *subtriangularis* n. var.: MICKWITZ, p. 186, Pl. 2: 45-46,  
 1896 *Obolus crassus* n. sp.: MICKWITZ, p. 187, Pl. 2: 47-49, 52-55.  
 1896 *Obolus crassus* var. *angulatus* n. var.: MICKWITZ, p. 193, Pl. 2: 50-51.  
 1898 *Obolus (Lingulella) celatus*: WALCOTT, Pl. 26: 1-2.  
 1912 *Obolus (Schmidtia) celatus*: WALCOTT, p. 444, Pl. 14: 1, 1a-c.

- 1965 *Schmidtites celatus*: ROWELL, p. H266, Figs. 159: 7a-b.  
 1969 *Obolus (Schmidtites) celatus*: GORJANSKY, p. 26, Pl. 2: 4 & 8-9 (not Pl. 2: 5-7 & 10).  
 1977 *Schmidtites celatus*: ROWELL, p. 260-296, Figs. 2-3.  
 1989 *Schmidtites celatus*: POPOV & KHAZANOVITCH, p. 115, Pl. 3: 12-14; Pl. 4: 5-14; Pl. 8: 1.  
 1993 *Schmidtites celatus*: PUURA & HOLMER, p. 219, Figs. 21C & 3A-D.  
 1996 *Schmidtites celatus*: PUURA, p. 69, Figs. 56A-O.  
 2000 *Schmidtites celatus*: HOLMER & POPOV, p. 52, Figs. 20: 4a-cA-O.

Selected by POPOV & KHAZANOVITCH (*in*: POPOV *et alii*, 1989, p. 115) a neotype has been deposited under n° 97/12348 (Toolse River; Upper Cambrian, Maardu Member) at the CNIGR Museum in St-Petersburg, Russia. Our specimens collected in Pakri, Iru, Ülgase, and Saka (Estonia) are deposited in the Muséum National d'Histoire Naturelle de Paris (France) under MNHN A25534. Saka is located about 25 Km from the Aseri (Fig. 1), the original type-

locality of *Schmidtites celatus*, indicated by VOLBORTH (1869).

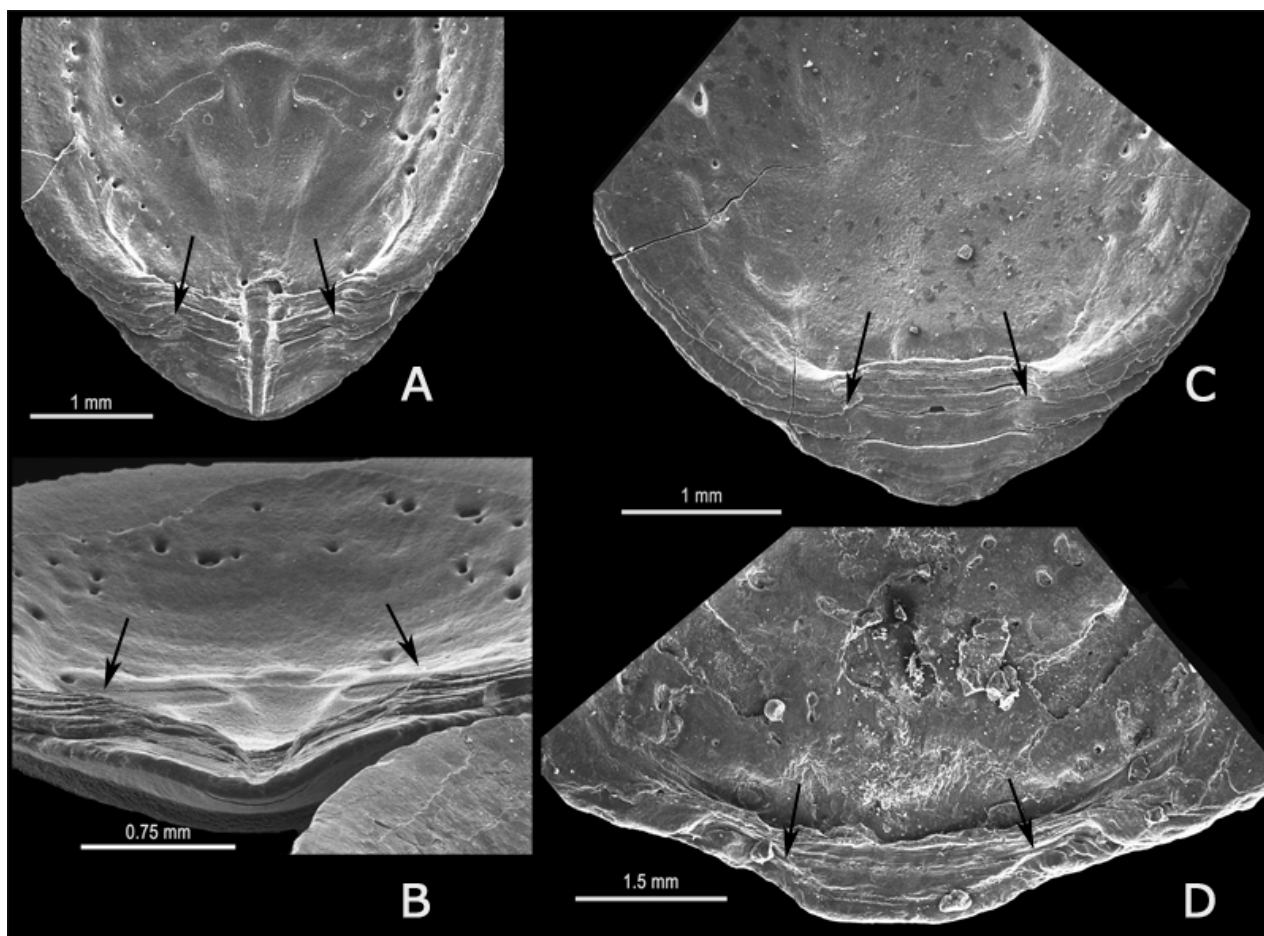


**Figure 4:** Umbonal region of *Schmidtites celatus* (internal view).

**Description**

The shell of *Schmidtites celatus* is ventri-biconvex (Fig. 2): the ventral valves (mean height = 1 mm; n = 42) are slightly higher than of the dorsal valves (mean height = 0.8 mm; n=54). The maximum height and width occur at the mid-length of the shell.

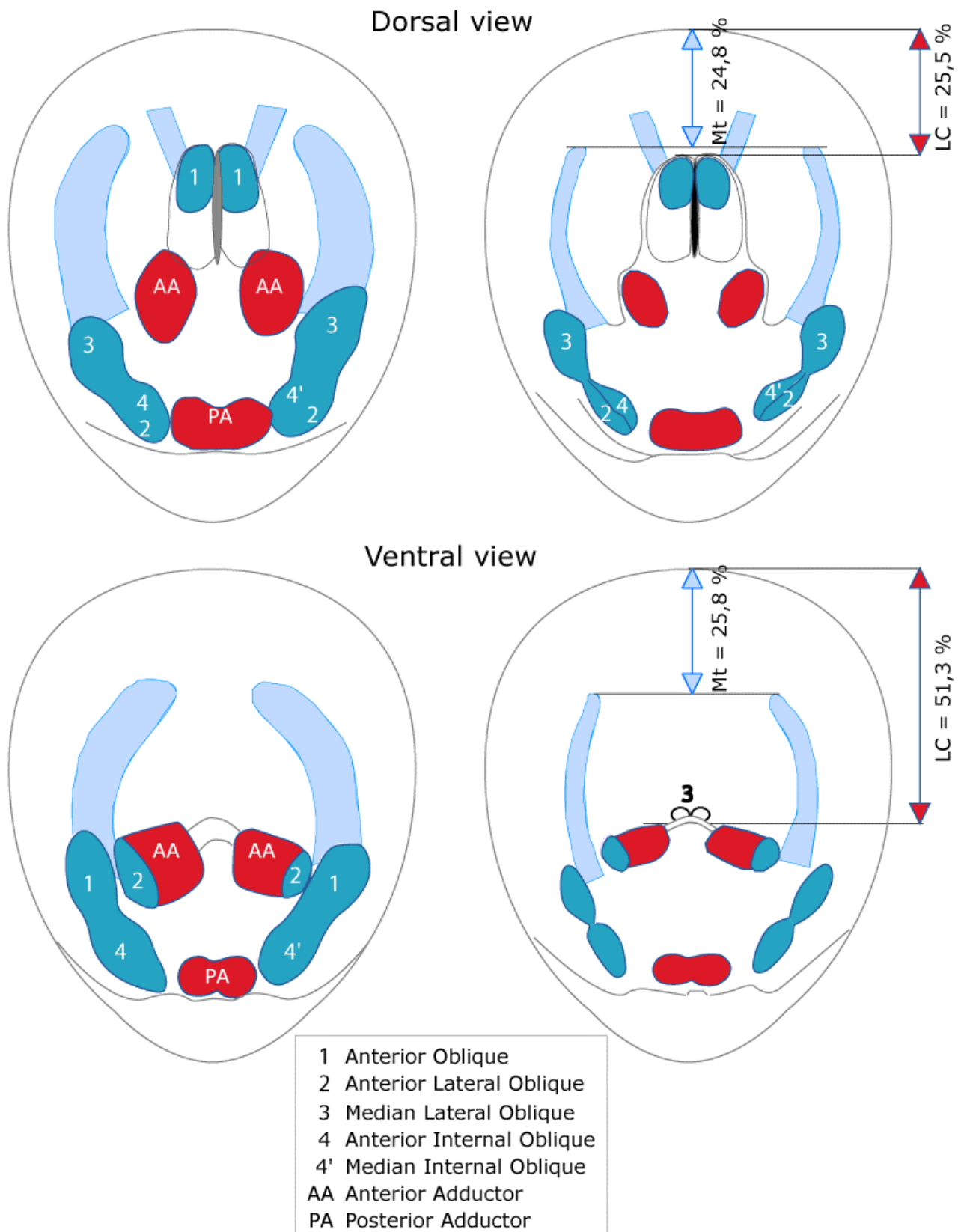
*Ventral valve and body area.* Length: 4.0 - 6.8 mm, mean = 5.3 mm, Width: 3.2-5.6 mm, mean = 4.7 mm, Width/Length ratio: 0.77 - 1.01, mean = 0.89 (n=48); Height: 0.8 - 1.4 mm, mean = 1.0 mm, Height/Length ratio: 0.14 - 0.25, mean = 0.19 (n = 42) (Figs. 2-3).



**Figure 5:** Scanning electron micrographs of *Schmidtites celatus*. A, Internal umbonal region of ventral valves with the pedicle groove and muscle scars. B, Profile view of the umbonal beak, with pedicle groove and elevated flexure lines. C and D, internal umbonal region, more or less acute, of two dorsal valves, with some muscle scars. Flexure lines indicated by arrows.

The umbonal region is rounded and continuous with the posterolateral margins (Figs. 4-5). The pseudointerarea, slightly concave on the internal side of the valve, is divided by a narrow pedicle groove and limited

laterally by well-expressed and slightly elevated flexure lines (Fig. 5). The width of the pseudointerarea occupies about half of the internal umbonal portion (Figs. 4-5).



**Figure 6:** Muscle arrangement and disposition of the main mantle canals in *Schmidites celatus*. A, their variability on the ventral body side and B, in a specimen. C, their variability in the studied specimens on the dorsal body side and D, in a specimen.

A pair of narrow, V-shaped grooves extends from the anterior adductor muscles to unite at the level of the posterior adductor muscle. These grooves are impressions of the pedicle nerves and are not visible on all specimens.

At the level of the visceral area the valve is commonly thickened. The main mantle canals (*vascula lateralia*) are subparallel to slightly curved (Figs. 6-7). The distance between the tip of the *vascula lateralia* and the anterior margin of the valve represents about 21 to 33 % (mean = 26 %; n = 9) of the length of the whole valve length, and the lophophoral cavity occupies about 42 to 57 % (mean = 52 %; n = 11) of the internal shell space (Figs. 6-7).

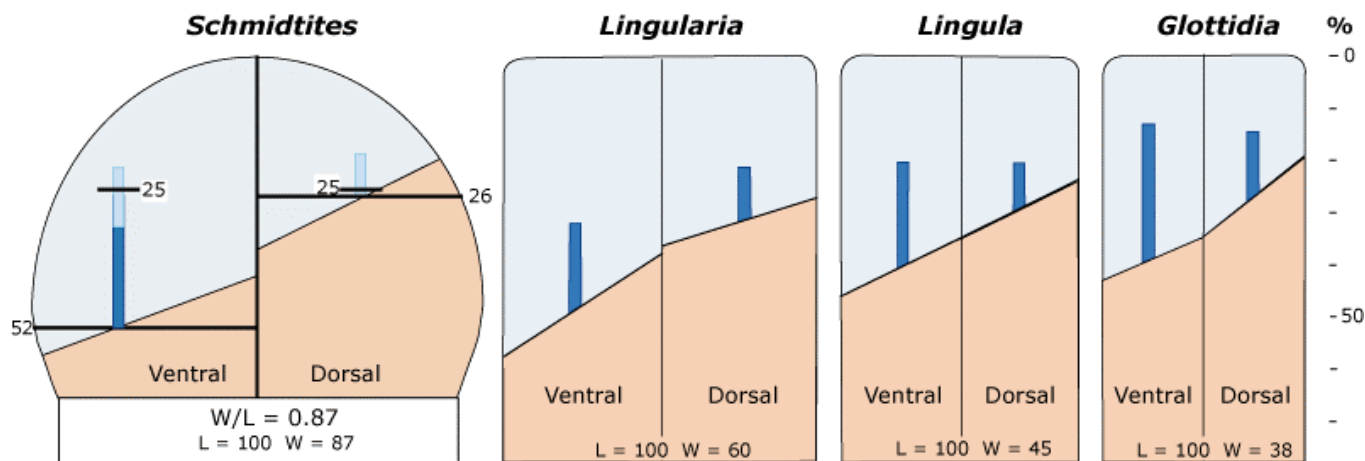
The muscle arrangement is well defined, and the posterior adductor muscle is unpaired (Figs. 6 & 8). The perimial line is not visible.

*Dorsal valve and body area.* Length: 3.3 - 6.8 mm, mean = 5.2 mm, Width: 2.8 - 5.9 mm, mean = 4.6 mm, W/L ratio: 0.76 - 1.01, mean = 0.90 (n = 62); Height: 0.3 - 1.1 mm,

mean = 0.8 mm; H/L ratio: 0.10 - 0.22, mean = 0.16 (n = 54) (Figs. 2-3).

The umbonal region is rounded and continuous with the posterolateral margins (Figs. 4-5). The pseudointerarea, slightly concave on the valve interior (Fig. 4), occupies in width about one third of the umbonal region; it is limited laterally by well-expressed and slightly elevated flexure lines (Figs. 4-5).

At the level of the visceral area the valve is thickened. It is bisected anteriorly by a weak median ridge that extends between 0.6 to 1.5 millimetres at the level of the anterior oblique muscle scars (about 14 to 30 % of the total valve length, mean = 22 %) (Fig. 6). The main mantle canals (*vascula lateralia*) are subparallel to slightly curved (Figs. 6-7). The distance between the tip of the *vascula lateralia* and the anterior margin of the valve ranges between 17 and 30 % (mean = 25 %; n = 8) of the total length of the valve, and the lophophoral cavity occupies 19 to 36 % (mean = 26 %; n = 14) of the internal shell space (Figs. 6-7).



**Figure 7:** Diagram of the extensions (minimum-maximum) of the lophophoral cavity and of the mean extension of the mantle canals based on average shell dimensions in the obolid *Schmidites celatus* from the Upper Cambrian of Estonia, compared to *Glottidia*, *Lingula* and *Lingularia* (see also BIERNAT & EMIG, 1993).

The muscle arrangement is shown on Figures 6 & 8. The anterior adductor muscles are slightly divergent anteriorly. The scar of the anterior oblique muscles cannot be defined exactly; perhaps they extended over the main length of the median ridge. The "combinierte Muskeln" that MICKWITZ (1896) described are Median Lateral Oblique muscles (3) - Anterior Lateral Oblique muscle (2), while our observations suggest that the composite muscle is 3 + 4 (Anterior Internal Oblique muscle) on the left side and 3 + 4' (Median Internal

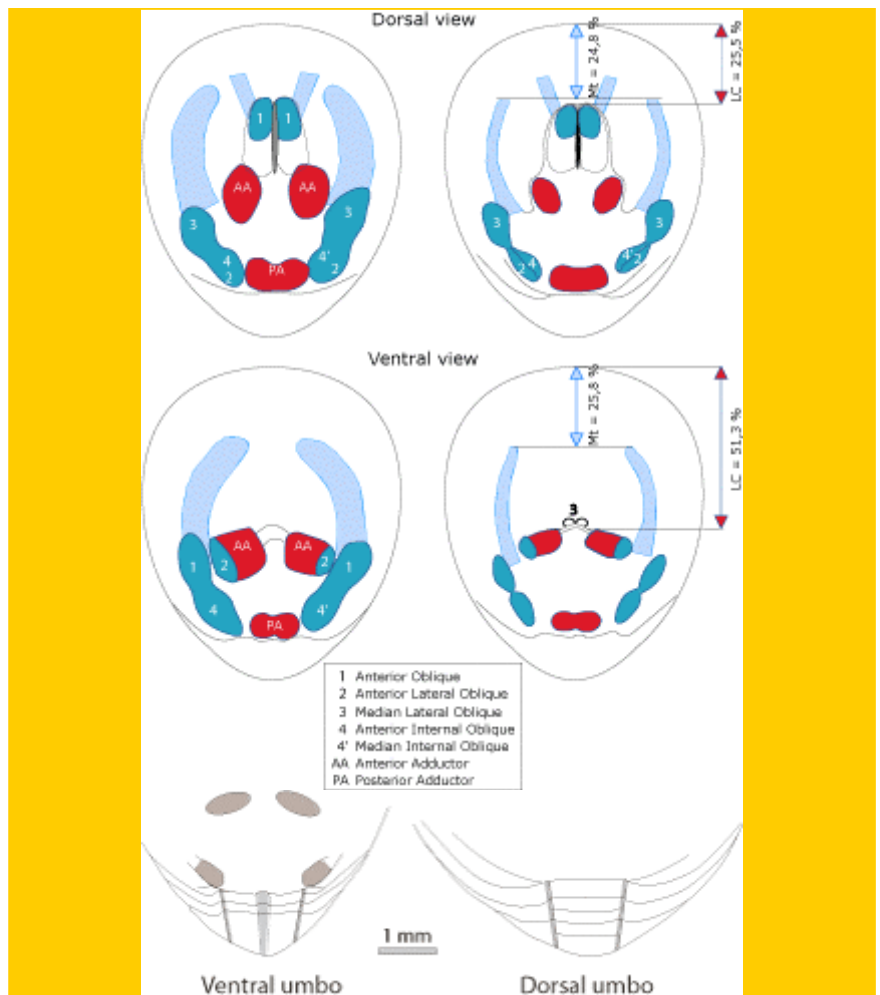
Oblique muscle) on the right side (Figs. 6 & 8). The posterior adductor muscle is unpaired. The perimial line is well marked in the anterior body part.

#### Diagnosis

The new diagnosis of *Schmidites celatus* (VOLBORTH, 1869) is compared to the previous diagnosis from POPOV *et alii* (1989). The composite figure A (Figs. 6 & 4) is an integral part of the diagnosis, and consequently should be reproduced with the diagnosis.



Previous diagnosis from PUURA (1996)	New diagnosis including the composite Fig. A
As for genus.	<p><b>Ventral valve</b>                  Umbonal region with pseudointerarea forming a rounded beak, continuous with the posterolateral margins.                  Pseudointerarea limited laterally by well-expressed and slightly elevated flexure lines and separated by a narrow subparallel pedicle groove; width about the half of the internal umbonal portion.                  Muscle arrangement as on figure A.</p>



**Figure A:** Muscle arrangement and disposition of the main mantle canals (their variability, left; in a specimen, right) and umbonal regions (internal view) in *Schmidites celatus*.

**Dorsal valve**  
 Pseudointerarea, slightly concave, width about one third of the umbonal region; limited laterally by well-expressed and slightly elevated flexure lines.  
 A median ridge extending over 0.6 to 1.5 millimetres at the level of the anterior oblique muscle scars.  
 Muscle arrangement as on figure A.  
 Anterior adductor muscles slightly divergent anteriorly; the Anterior Internal Oblique (4) (and Median Internal Oblique, 4') muscle and the Anterior Lateral Oblique muscle (2) form a composite muscle (2 + 4/4') which is aligned with the close Median Lateral Oblique muscle (3).  
*Vascula media* short, widely divergent.

Main mantle canals (*vascula lateralia*) are subparallel to slightly curved with a similar distance between the tip of the *vascula lateralia* to the anterior margin of the valve, on both ventral and dorsal sides.

Shell to subcircular to oval in outline. External surface smooth, with fine concentric growth.  
 (\*) **Nota:** The Posterior Internal Oblique muscle (numbered 4'': EMIG, 1982) is at present only known in *Lingula*, *Glottidia*, *Lingularia*, and *Dignomia*, all of which have an asymmetrical muscle arrangement.

**Occurrence**

Upper Cambrian - Lower Ordovician.

Estonia: Tsitre and Kallavere Formations (Iru, Ülgase, Maardu quarries, Jägala River, Turjekelder, Valkla River, Vihula, Toolse River, Saka, subsurface south of Maardu, subsurface of Rakvere Phosphorite Deposit, subsurface in southern Estonia, Värskä-6 core) (see PUURA, 1996).

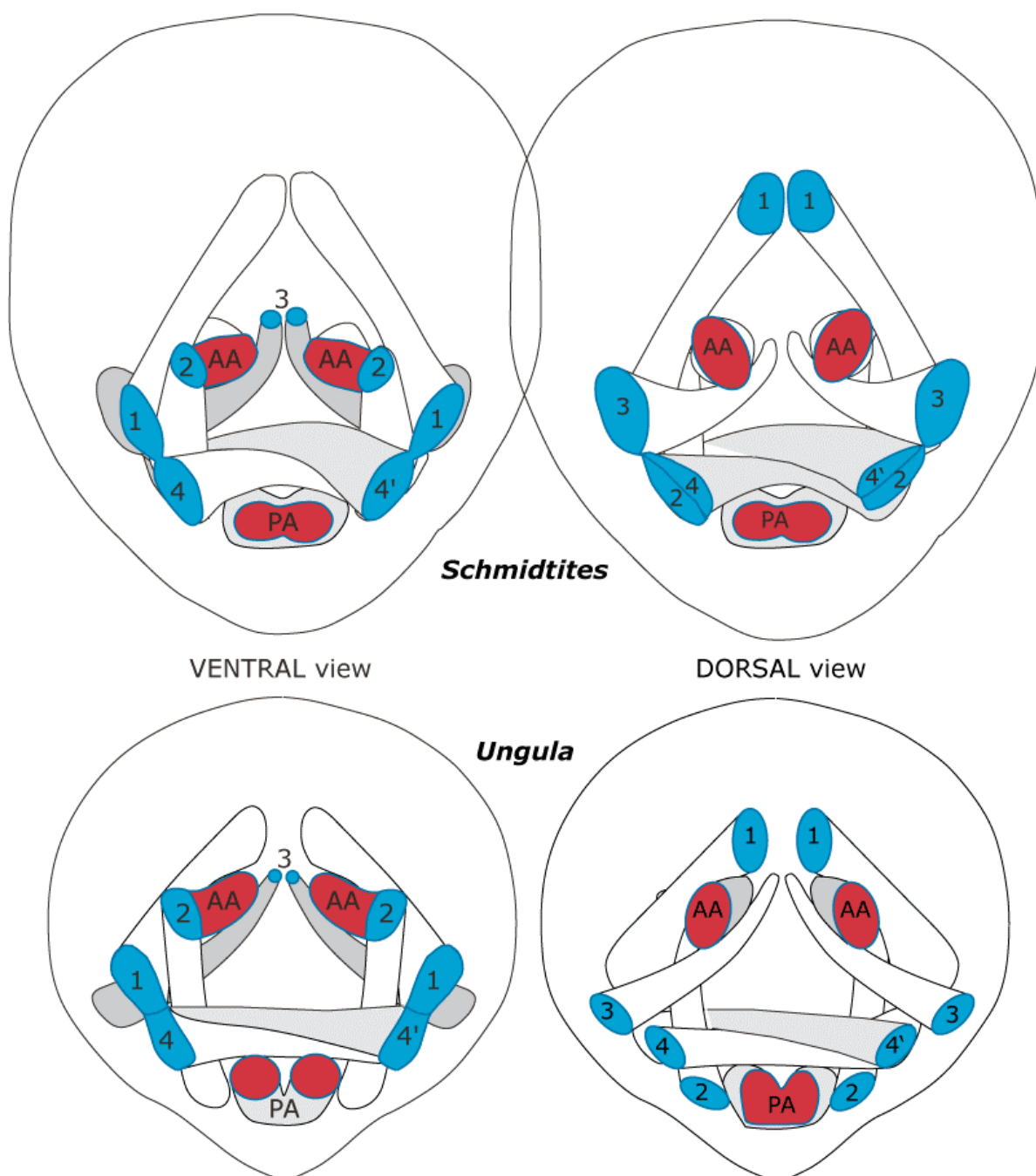
Russia: Lomashka and Tosna formations in Ingria (Luga River, subsurface of Kingisepp Phosphorite Deposit, Lomashka River, Solka River, Sarya River, Suma River, Tosna River, Putilovo Quarry, Volkhov River, Syas River) (POPOV *et alii*, 1989).

Sweden: *S. celatus* occurs in the 'Obolus' beds in the Finngrundet core as well as in erratic boulders from Uppland (PUURA & HOLMER, 1993).

Poland: Krzyze Formation in Podlasie depression (BEDNARCZYK, 1998).

**Discussion**

The statement of WILLIAMS & HURST (1977) that the Obolidae have an almost identical pattern is no longer corroborated by the arrangement of the musculature, at least in those of the obolid genera *Schmidtites*, *Obolus*, *Ungula* and *Oepikites* (see EMIG, 2002, 2003a, 2003b; and unpublished data).



**Figure 8:** Muscle arrangement in 3D on the ventral and dorsal sides in *Schmidtites celatus* and *Ungula ingraca*.

The posterior adductor muscle is unpaired on both dorsal and ventral sides in *Schmidtites celatus*; paired muscles have been established on the ventral side and unpaired on the dorsal side of *Ungula*; paired on both sides in *Obolus*, and according to HOLMER & POPOV (2000) in *Oepikites* too. Such variations in the posterior adductor (also named umbonal) musculature are contrary to the recent diagnosis by HOLMER & POPOV (2000) of the family Obolidae, in which all the genera have a "muscle system with paired umbonal muscle scars". Consequently, this diagnosis must be revised.

Not only in the Obolids but also in the Lingulides, the Anterior Oblique, Anterior Internal Oblique and Median Internal Oblique muscles on the ventral side, and the Anterior Lateral Oblique, Anterior Internal Oblique and Median Lateral Oblique muscles on the dorsal side are invariably located posterolaterally to the *vascula lateralia*, whereas the Anterior Oblique and the Anterior Adductor muscles on the ventral side and the Anterior oblique and the Anterior Adductor muscles on the dorsal side are located anterocentrally to the *vascula lateralia*.

Data in %	<i>Schmidtites celatus</i>	<i>Ungula ingraca</i>	<i>Obolus apollinis</i> (*)	<i>Keyserlingia</i>	Observations
Pakri 1	10	90			very small fragments
Iru 1	30-50	70-50	4	2	slightly re-worked
Iru 2	#	100			
Iru 3	25	69	4	2	
Ülgase 1	100				slightly re-worked
Ülgase 2	25	75		1	
Saka 1a	100	#			small fragments
Saka 1b	100				very small fragments
Saka 2	48.5	48.5		3	re-worked

**Table 1:** Distribution of the four brachiopod species in the outcrops investigated (see Fig. 1). Percentages are indicative. They were established on 200 to 300 hundred specimens at each level.

# few valves or fragments of valves

(\*) *Ungula convexa* a synonym of *Obolus apollinis* (see EMIG, 2002, 2003b)

The main difference in the muscle pattern of *Schmidtites* from those in *Obolus*, *Ungula*, and *Oepikites* is on the dorsal side and involves the disposition of the Median Lateral Oblique, Anterior or Median Internal Oblique and Anterior Lateral Oblique muscles, which are aligned in *Obolus*, *Ungula*, *Oepikites* (represented for *Ungula* on Figure 7; for *Oepikites* see HOLMER & POPOV, 2000; for *Obolus* see EMIG, 2002), but join to form a composite muscle in *Schmidtites* (Figs. 6-7). This muscle arrangement was described by MICKWITZ (1896) as "combinierte Muskeln" that is the Median Lateral Oblique muscle (3) + Anterior Lateral Oblique muscle (2). But our study shows that this composite muscle is formed on the right by the Anterior Internal Oblique muscle (4) +

Anterior Lateral Oblique muscle (2) and on the left by the Median Internal Oblique muscle (4') + Anterior Lateral Oblique muscle (2) (Figs. 6-7). The location of the scar of the Anterior Lateral Oblique muscle (2) on the ventral side (Figs. 6-7) differs from that figured by WILLIAMS & HURST (1977) and POPOV (1992).

Consequently, the musculature of the obolids is neither identical nor entirely symmetrical, and in *Schmidtites* at least is remarkably different. It may be said that the arrangement in this genus is less conservative than in other obolids, or perhaps that it should not be referred to the family Obolidae.

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