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Middle Miocene (Badenian) tusk shells (Scaphopoda) of the Višnjica area near Belgrade (Serbia)

Gordana Jovanović[1] & Jovica Jovanović[2]

Abstract. We re-examined the fossil scaphopod assemblage from the Middle Miocene (Badenian) deposits in Višnjica locality near Belgrade (Serbia) reveals high biodiversity of this neglected fossil group. The study of the nearly 300 specimens has revealed the presence of twelve species of Scaphopoda, two of which are mantiened in open nomenclature. They belong to seven genera (in both orders, Dentaliida da Costa, 1778 and Gadilida Starobogatov, 1974): *Fissidentalium badense* (Partsch in Hörnes, 1856), *Antalis* cf. *taurocostatum* (Sacco, 1897), *Antalis mutabilis* (Hörnes 1856 ex Doderlein ms), *Antalis* cf. *subprismaticum* (Baluk, 1972), *Antalis* sp., *Paradentalium sexangulum* (Gmelin, 1790), *Paradentalium michelottii* (Hörnes, 1856), *Dentalium* sp., *Omniglypta jani* (Hoernes, 1856), *Omniglypta emersoni* (Caprotti, 1979), *Gadilina taurogracilis* Sacco, 1897, *Pulsellum miocaenicum* (Boettger, 1901). Representatives of the order Dentaliida da Costa, 1778, predominate. Among the identified species, *Fissidentalium badense* is the most common in the investigated material and comprised 40% of the collected specimens. The order Gadilida is represented only by *Pulsellum miocaenicum* (Boettger, 1901).

Key words:
Scaphopoda, Badenian, Višnjica (Serbia).

Апстракт. Поново смо проучавали фосилну заједницу скафопода прикупљену из средњомиоценских (баденских) седимената Вишњице код Београда (Србија) и открили висок биодиверзитет ове занемарене фосилне групе. Од око 300 проучених примерака препознато је дванаест врста скафопода, од којих су две остављене у отвореној номенклатури: Описано је дванаест таксона из седам родова (из оба реда, Dentaliida da Costa, 1778 и Gadilida Starobogatov, 1974): *Fissidentium badense* (Partschi in Hörnes, 1856), *Antalis* cf. *taurocostatum* (Sacco, 1897), *Antalis mutabilis* (Hörnes, 1856 ex Doderlein ms), *Antalis* cf. *subprismaticum* (Baluk, 1972), *Antalis* sp., *Paradentalium sexangulum* (Gmelin, 1790), *Paradentalium michelottii* (Hörnes, 1856), *Dentalium* sp., *Omniglypta jani* (Hörnes, 1856), *Omniglypta emersoni* (Caprotti, 1979), *Gadilina taurogracilis* Sacco, 1897, *Pulsellum miocaenicum* (Boetgger, 1901). Преовлађују представници реда Dentaliida da Costa, 1778. Међу идентификованим врстама *Fissidentalium badense* је најчешћа у испитиваном материјалу и чинила је око 40% од укупног броја прикупљених примерака. Ред Gadilida Starobogatov, 1974 је заступљен само са *Pulsellum miocaenicum* (Boettger, 1901).

Кључне речи:
скафоподи, баден, Вишњица, Србија.

[1] Natural History Museum, Njegoševa 51, 11000 Belgrade, Serbia. E-mail: gordana.j@nhmbeo.rs
[2] Geological Survey of Serbia, Rovinjska 12, 11050 Belgrade, Serbia.

Introduction

Scaphopoda are exclusively marine infaunal molluscs, also known as the ''tusk shells.'' They are characterised by an external tubular calcareous shell, opened at both ends and with some degree of curvature (Reynolds, 2002). Most shells of Scaphopoda show a more or less bent shell, except a few species of Gadilida with a barrel-shaped shell. The taxonomy of scaphopods is based mainly on the shell morphology, as it is for other fossil molluscs. Important features for species identification are: shell shape, dimensions, shell surface sculpture, and apical morphology. The shells of scaphopods taper in the apical direction and in the Gadilida are sometimes also at the anterior side. Additionally, the apical features are often highly variable even within the same species, these features should be used with some caution when identifying the shell (Bastemeijer, 2006). The shape of the aperture has also aided species diagnostics. Despite the relatively large number of publications related to Miocene scaphopods from the Mediterranean area (Sacco, 1897; Fantinet, 1959; Caprotti, 1979; Pavia, 1991; Vera-Peláez et al., 1993, 2004 etc.), the scaphopods from the Middle Miocene (Badenian) sediments of the Central Paratethys have been insufficiently studied. Although the fossil scaphopods has long been known to palaeontologists, only a few papers dealt with taxonomy and descriptions of their shells (Kochansky-Devidé, 1944; Kojumdgieva & Strachimirov, 1960; Baluk, 1972; Atanacković, 1985; Harzhauser, 2002; Tita, 2007; Harzhauser et al., 2011; Jovanović, G., & Bošnjak, 2016). It should be noted that Steiner & Kabat (2001, 2004) recently published two important publications concerning the nomenclature of Scaphopoda.

The investigated scaphopods described in this paper were found in Višnjica, a locality near Belgrade. The Višnjica outcrops are currently flooded after the construction of the dam at the hydroelectric power plant "Đerdap" (Iron Gates), and the fossilferous layer is no longer visible (Fig. 1).

As to the scaphopods fossils, Višnjica is the richest among the Serbian localities. Actually, the Scaphopoda of Serbia are not very well known. The first data from Višnjica was published by Žujović (1886) and Pavlović (1903). Later, on the scaphopod shells from Serbian sites reduce to the shortlists of several identified species (Jovanović, G. & Jovanović, 1998), but they have not been illustrated nor described. The precise localities from which Pavlović's fossils were collected are not known. Labels from specimens contain only the information "Višnjica, Slatina," which denotes a source of saltwater in Višnjica. From 1897 to 1903, Pavlović collected fossils in clay layers near the village of Višnjica, the valley that runs from the church to the Danube (Pavlović, 1903). Today, Višnjička Banja with sulfur water is located in that place, not far from the mouth of the Ramadan stream. The further fossil material from P. Stevanovic's collection was gathered by Stevanović (1977) on the right bank of the Danube, at the mouth of the Ramadan stream. Both localities are known in published papers as the mouth of the Ramadan stream (Stevanović, 1977; Jovanović & Bošnjak, 2016, etc.).

The primary purpose of this paper is to provide the most accurate possible list of scaphopods of the Višnjica site and describe the identified taxa. The collection is part of the Natural History Museum Belgrade (Serbia). The collection is inventoried with the Acronym NHMB assignated to each taxon.

Geological setting

The Višnjica Clay Formation appears in Višnjica near Belgrade (Serbia), along the Danube River (Fig. 1). It is marked on the Basic geological map at scale 1:100000, sheet Pančevo (Ivković et al., 1966). Paleogeographically, the Višnjca site, during the Middle Miocene (Badenian), was a part of the southeastern margin of the Central Paratethys Sea. Geotectonically, it was a part of the Pannonian Basin System, surrounded by the Alps, Carpathians and Dinarides (Rögl, 1998). The Middle Miocene (Badenian) at the city of Belgrade and its surroundings directly overlies Upper Cretaceous or Lower Miocene sediments. The scaphopods were found in the argillaceous sediments known as the "Višnjica Clays" (Stevanović, 1977). Besides Scaphopoda, a rich fossil assemblage is mainly represented by different shallow marine organisms such as foraminifera, ostracods, echi-

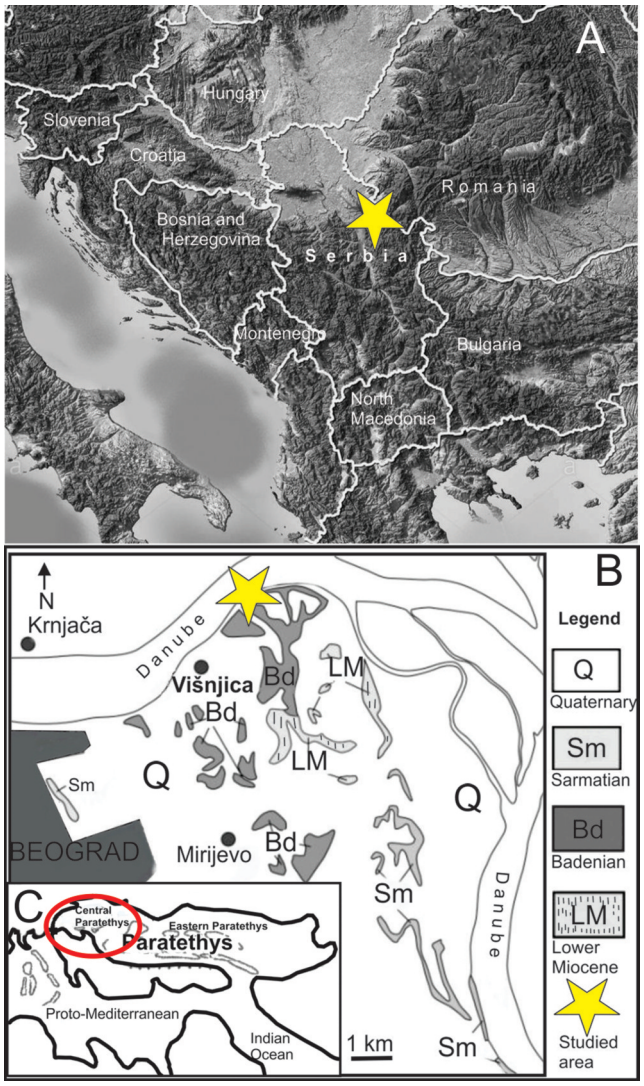

Fig. 1. A. *The geographical position of the Višnjica in Serbia and Europe.* ***B.*** *The location of the sector delivering the Scaphopoda assemblage within the geological map of the Višnjica area, the map 1:100 000 of Serbia, sheet Pančevo: (*Ivković *et al., 1966), stars display the position of the studied locality.* ***C.*** *Langhian palaeogeography after* Rögl *(1998).*

noids, bryozoans, corals, gastropods, bivalves, cephalopods such as *Aturia aturi,* along with the crabs and fish remains that are present as well. Based on calcareous nannoplankton, foraminifera and some molluscs the deposits of the Višnjica area are attributed to the Middle Miocene (Badenian, calcareous nannoplankton NN5 Zone) (Petrović, 1985; Mihajlović & Knežević, 1989; Jovanović & Bošnjak, 2016; Jovanović et al., 2019; Mandić et al., 2019).

Material and Methods

Of the nearly 300 fragmented shells, 226 specimens were identified. The fossil material comes from the Višnjica locality (wider area of Belgrade), and it is a part of the Petar Pavlović's collection, assembled in 1897 and 1903 and the Petar Stevanović's collection, assembled in 1962. Very small and eroded fragments were not identified. Stevanovic's collection contains only *Fisidentalium badense* (40 specimens). The Scaphopod shells found at this site are usually transversally broken and damaged primarily on the apex or aperture sector so that some specimens could identified only to at generic level. Tiny, especially smooth shells of some Scaphopoda pose significant difficulties for classification because the shell sculpture is one of the most important characters for genus and species identification. The identification of the material was based on the analysis of the shell morphology and the descriptions, illustrations and taxonomic criteria through published papers (e.g. Hoernes 1856; Sacco 1897; Friedberg, 1954; Kojumdgieva & Strachimirov, 1960; Emerson, 1962; Baluk, 1972; Caprotti (1966, 1979, 2009); Palmer (1974); Pavia (1991); Vera-Peláez et al. (1993, 2004), etc. Due to the fragmentary nature of the shells, only some parameters were measured. The parameters used in the determination of the order Dentaliida are (according to: Steiner, 1999 and Silva-Filho et al., 2012): measurements of length (L), width of the ventral opening (Wa), and apical width (Wp), were taken for each specimen. The parameters used in the determination of the order Gadilida are (after Shimek, 1989): the specimen was measured for length (L), width of the anterior aperture (Wa), width of the posterior aperture (Wpa). All measurements are in mm.

Systematic Palaeontology

Class: Scaphopoda Bronn, 1862
Order: Dentaliida da Costa, 1776
Family: Dentaliidae (Children, 1834)
Genus: *Fissidentalium* Fischer, 1885
Type species: *Dentalium ergasticim* Fischer, 1885 by monotypy

***Fissidentalium badense* (Partsch in Hörnes, 1856)**
Plate 1, figs. 1a, 1b, 1c

1856 *Dentalium Badense* – Hörnes, p. 652, pl. 50, fig. 30.
1897 *Entalis badensis* (Partsch) et var. – Sacco, p. 107–108, pl. 9, figs. 17–30.
1947 *Dentalium* (*Fissidentalium*) *badense* Partsch – Tauber, p. 302, pl. 7, figs. 8–10, pl. 8, fig. 3.
1960 *Dentalium* (*Entalis*) *badensis* Partsch in Hörnes – Kojumdgieva & Strachimirov, p. 225, pl. 52, figs. 19–20.
1960 *Dentalium badense* Partsch – Baldi, p. 57, pl. 1, fig. 5.
1991 *Fissidentalium badense* (Partsch in Hoernes, 1856) – Pavia, p. 146, pl. 5, fig. 4; pl. 6, fig. 6.
2009 *Fissidentalium badense* (Partsch in Hörnes, 1856) – Caprotti, p. 41.
2011 *Fissidentalium badense* (Partsch in Hoernes, 1856) – Harzhauser et al., p. 219, pl. 8. figs. 6–7.
2016 *Fissidentalium badense* (Partsch in Hörnes, 1856) – Jovanović & Bošnjak, p. 196–198, pl. 1, fig. 1.

Material: Collection P. Pavlović (12 relatively well-preserved and 78 damaged specimens; NHMB 2347, NHMB 2348, NHMB 2401, NHMB 5246) and collection P. Stevanović (8 relatively well-preserved and 32 damaged specimens, PS-1).

Dimensions (in mm): L = 37.3, Wa = 6.3, Wp = 2.8.

Description: The shell is medium to large, solid, moderately curved, narrow and elongated. The dorsal side is concave, and the ventral is convex. The shell narrows and slightly curves to the wider anterior opening. Sharp and moderately high, eight to ten radial ribs are near the apical area. Secondary ribs are between the primaries at various distances from the apex. The ribs are flattened towards the aperture and wider than the intercostal spaces. The maximum number of secondary ribs does not exceed 30 and their number and thicknes is variable. The concave intercostal spaces vary in width. Fine and dense irregular growth lines (less visible in the apical area) intersect the radial ribs in the form of a fine surface reticulation, which characterizes the shell. The apical is not preserved. The cross-section of both ends is subcircular.

Remarks: In the research of the taxonomy and ecology of the recent genus *Fissidentalium* (Fischer, 1885), Lamprell & Healy (1998) indicate the significance of the aperture and the number and rib morphology that can contribute to the research of the fossil species. *Fissidentalium badense* was originally placed in the genus *Dentalium* (Hörnes, 1856), then *Entalis* by Sacco (1897) or *Dentalium* (*Entalis*) *badensis* by Kojumdgieva & Strachimirov (1960). However, due to the shell morphology and the apical characters shared with *Fissidentalium,* the species has been recently transferred to *Fissidentalium* by Pavia (1991). The species described in Kojumdgieva & Strachimirov (1960) have more secondary ribs (35), as well as several specimens from Korytnica Basin (Poland) (Baluk, 1972).

Distribution: *Fissidentalium badense* has a wide geographic distribution and represents a species typical of the Middle Miocene of the Paratethys (e.g. Kojumdgieva & Strachimirov, 1960; Harzhauser et al., 2011; Jovanović & Bošnjak, 2016). *Fissidentalium badense* makes first appearance in the Burdigalian in northern Italy (Sacco, 1897) and Turkey (Mandic et al., 2004), where it persists up to the Late Miocene (Pavia 1991). This species has been recently found in the Early Miocene of the Paratethys (Harzhauser, 2002; Harzhauser et al., 2011).

Genus: *Antalis* H. & A. Adams, 1854
Type species: *Antalis entalis* (Linnaeus, 1758)

***Antalis* cf. *taurocostatum* (Sacco, 1897)**
Plate 1, figs. 2a, 2b

cf. -1897 *Antale* ?*taurocostatum* (+ var., pars) Sacco,0 p. 101, pl. 8, figs. 50–54, 56–58.

Material: Four specimens, NHMB 7263.

Dimensions (in mm): L = 7.50, Wa =1.40, Wp = 0.80.

Description: The small shell, solid and curved in the apical part, shows a primary longitudinal sculpture consisting of about ten primary ribs running from the posterior aperture to the anterior one. They produce a star-shaped to decagonal section. The intercostal spaces are smooth and wide. The slit is not observed.

Remarks: A certain similarity may be observed with the specimens of *Dentalium tauroscostata*

Sacco, 1897 described by Pavia (1991) lectotype (op. cit., pl. 3, fig. 4). The specimen described by Baluk (1972, pl. 3, figs 4–9) can be attributed to *Antalis taurocostata* (Pavia, 1991). The type series of *A. taurocostatus* is from the middle Miocene of Turin Hills; the Messinian specimens from Italy (Pavia, 1991) show a more curved shell and more developed secondary ribs compared with the fossil from Badenian of Višnjica.

Distribution: Middle Miocene (Lower Badenian) of Poland (Baluk, 1972), Miocene of the Mediterranean (Caprotti, 2009), Miocene and Messinian of Italy (respectively Zunino & Pavia, 2009) and Pavia (1991).

Antalis mutabilis (Hörnes, 1856 ex Doderlein ms)

Plate 1, figs. 3a, 3b

1856 *Dentalium mutabile* Hörnes, p. 654, pl. 50, fig. 32.
1897 *Antalis novemcostatum* var. – Sacco, p. 102 (pars; non pl 8, figs. 59–70 = *A. inaequicostata*).
1972 *Dentalium* (*Antalis*) *mutabile* Hörnes, 1856 – Baluk, p. 555–556, text-fig. 4; non pl. 3, figs. 4–9 (= *A. taurocostata*).
1991 *Fissidentalium mutabile* (Hoernes, 1856, Doderlein *in schedis*) – Pavia, p. 124–126, pl. 3, figs. 9, 10; pl. 4, figs. 1–5, 8, 9.
2009 *Antalis mutabile* (Hörnes, 1856 ex Doderlein ms) – Caprotti, p. 41.
2018 *Antalis* cf. *mutabilis* (Hörnes, 1856) – Harzhauser et al., p. 160, fig. 10 V.
?2019 *Fissidentalium mutabilis* – Cárdenas et al., p. 221, fig. 9, e 1 – 3.

Material: Three shell fragments, NHMB 5247.

Dimensions (in mm): L = 10.5, Wa = 2.80, Wp = 1.90.

Description: The shell is thin, medium-sized, weakly curved, with a circular cross-section. The surface of the shell is ornamented with nine strong longitudinal ribs. Secondary ribs are not developed. The surface between the ribs is flat and decorated with a fine reticulation deriving from the intersection of thin longitudinal threads and transverse grooves of equal density, which are parallel to the growth striae; the longitudinal ribs do not show any granulation. The cross-section is circular at the apex and octogonal towards the aperture. Neither slit nor pipe is observed.

Remarks: The specimen is in conformity with forms described from the Vienna Basin (Hoernes, 1856) and the specimen described by Pavia (1991). Unlike Baluk's specimens, the fossils from Višnjica have no secondary ribs. Ornamentation is similar to that of *A. mutabile* described by Pavia (1991) who gives a new diagnosis. According to Caprotti (1979, 2009), the Mediterranean *Antalis inaequicostatum* developed from the Miocene *Antalis mutabilis.* The transfer of the species from *Fissidentalium* to *Antalis* was discussed by Caproti (2009) after revision of the taxon.

Distribution: The species has been found in the Middle Miocene (Lower Badenian) of Paratethys (Baluk, 1972; Koch, 1900); the Middle Badenian (Harzhauser et al., 2018), the Langhian of Italy (Caprotti , 2009) the Upper Miocene of the Mediterranean area (Pavia, 1991; Cárdenas et al., 2010).

Antalis cf. *subprismaticum* (Baluk, 1972)

Plate 1, figs. 4a, 4b

cf.- 1972 *Dentalium* (*Dentalium*) *subprismaticum* Baluk, p. 550–551, text-fig. 2., pl. 6, figs 2–7.

Materials: Four shell fragments, NHMB 7264.

Dimensions (in mm): L = 8.10, Wa = 1.90, Wp = 1.75.

Description: The shell is small, slightly curved, decorated with seven to nine strong primary longitudinal ribs that extend the entire length of the shell. Secondary ribs appear between the primary ribs; one rib extends the whole length of the shell whereas other ribs do not appear or are very low in the apex region. The inner outline is polygonal (heptagonal) at the apex and the aperture. The convex side has four, while the concave side has three major ribs. One strong secondary rib appears on the right dorsal side, and it is the only secondary rib in this intercostal space. The intercostal space is concave, and covered by thick and delicate stripes. The aperture is damaged.

Remarks: According to Baluk (1972), the number of ribs is variable, and secondary ribs do not appear simultaneously. The specimens from Poland

have one or two, and exceptionally three or even four secondary ribs. In contrast, some secondary ribs appear at the same time in Višnjica specimens, whereas one or two supplementaries develop later in some intercostal spaces. Our specimen has a heptagonal transverse section, while *P. subprismatum* (Baluk, 1972) is octagonal in the transverse section; for this reason the identification of these fossils from Višnjica is uncertain.

Distribution: *Antalis subprismaticum* is one of the rarest scaphopods in the Miocene of Paratethys. So far, this species has been described from the Lower Badenian deposits of Korytnica Basin (Poland) only by Baluk (1972).

Antalis sp.
Plate 1, figs. 5a, 5b

Material: Ten fragmentary shells, NHMB 7265.

Dimensions (in mm): L = 6.10, Wa = 1.90, Wp = 1.70.

Description: The solid, small-sized shell bears ten low longitudinal ribs. The four ribs on the dorsal side are slighty higher. The ribs are almost at the same distance. The intercostal esent space is concave, and the inner cross-section is circular**.**

Remarks: It is assigned to the genus *Antalis* because it has a circular cross-section, as Caprotti (1979) pointed out. More material is needed to define its systematic position to a greater detail.

Genus: *Paradentalium* Cotton & Godfrey, 1933
Type species: *Dentalium intercalatum* Gould, 1859

***Paradentalium sexangulum* (Gmelin, 1790)**
Plate 1, figs. 6a, 6b, 7

1897 *Dentalium sexangulum* Schröter – Sacco, p. 92, pl. 7, figs. 48–49.
1954 *Dentalium sexangulum* Schröter – Strausz, p. 39, pl. 9, fig. 72.
1966 *Dentalium sexangulum* Schröter – Kókay p. 67.
1974 *Dentalium* (*Dentalium*) *sexangulum* Schröter – Malatesta, p. 1, pl. 1, figs. 1a, b.
1979 *Dentalium* (*Dentalium*) *sexangulum* Gmelin – Caprotti, p. 221, pl. 3, figs. 1, 2, 5.
1979 *Dentalium* (*Dentalium*) *sexangulum acutangulare* Cocconi – Caprotti, p. 222, pl. 3, fig. 6.
1984 *Dentalium sexangulum* Gmelin 1790 – Ferrero Mortara et al., p. 301.
1993 *Dentalium* (*Dentalium*) *sexangulum acutangularis* Cocconi, 1873 – Vera-Peláez, p. 124, pl. 1, figs. 3–7, 21, 22.
2004 *Dentalium sexangulum acutangularis* Cocconi, 1873 – Vera-Peláez et al. p. 60, pl. 1, figs. 7, 8 (cum syn.).
2009 *Paradentalium sexangulum* (Gmelin, 1791) – Caprotti, p. 41.

Materials: 54 fragmentary shells, NHMB 5755, 5756.

Dimensions (in mm): L = 9.00, Wa = 1.20, Wp = 0.35; L = 8.00, Wa = 1.30, Wp =0.80.

Description: Most fragmented shells have a maximum length of about ten millimeters, and a diameter maximum of 1.20 mm; all of them lack the aperture. The shell is slender, six-sided with a strong dorsal-ventral curve. The main ornamentation is given by six longitudinal ribs, not very prominent. The secondary ornamentation consists of one to two thin ribs, mostly located in the central part of the intercostal space. In some specimens, the central secondary rib is more prominent, so there are 12 of them in the adapical sector.

Remarks: The species is very variable, and Sacco (1897) described many varieties. Vera-Peláez et al. (1993, 2004) described three subspecies. Caprotti (1979) and Vera-Peláez et al. (1993) indicate that the species has been improperly attributed to Schröeter, and according to the nomenclatural rules, it must be ascribed to Gmelin. Based on the opinion of Palmer (1974) about the species with six ribs, Caprotti (2009) commented on the possibility that them are synonymous and all subspecies *Dentalium sexangulum* transferred to *Paradentalium sexangulum* (Gmelin, 1970).

Distribution: Late Miocene and Pliocene of the Mediterranean area (Fantinet, 1959; Caprotti, 1979; Malatesta, 1974), early Miocene of Austria (Harzhauser, 2002), Middle Miocene (Badenian) of Hungary (Kókay, 1966) and Serbia (Jovanović G. & Jovanović, 1998).

Paradentalium michelottii (Hörnes, 1856)

Plate 2, fig. 1

1856 *Dentalium* (*Dentalium*) *michelottii* Hörnes, pl. 1, figs. 1–3.
1897 *Dentalium michelottii* Hoernes – Sacco, p. 95, pl. 7, figs. 84–94.
1906 *Dentalium michelottii* M. Hö. typ. and var. *transiens* and var. *costulatior* – Boettger, p. 208–209.
1954 *Dentalium michelottii* – Strausz, p. 39, pl. 9, fig. 171.
1959 *Dentalium michelottii* Hoernes – Fantinet, p. 38, pl. 4, figs. 1–5.
1966 *Dentalium michelottii* Hö r n e s – Kókay, p. 67.
1974 *Dentalium* (*Dentalium*) *michelottii* Hörnes – Malatesta, p. 2, 3, pl. 1, fig. 2.
1979 *Dentalium* (*Dentalium*) *michelottii* Hörnes – Caprotti, p. 220, pl. 2, figs. 1–4.
1984 *Dentalium* (*Dentalium*) *michelottii* Hörnes – Ruggieri & Davoli, p. 76, pl. 15, figs. 7, 8.
1991 *Dentalium* (*Dentalium*) *michelottii* Hoernes, 1856 – Pavia, p. 111, pl. 1, figs. 1–3.
2004 *Dentalium michelottii* Hörnes 1856 – Vera-Peláez et al. p. 64, tab. 1, figs. 9–11, 31.
2009 *Paradentalium michelottii* (Hörnes, 1856) – Caprotti, p. 41.

Materials: Eight fragmentary shell, NHMB 7265.

Dimensions (in mm): L = 8.35, Wa = 1.90, Wp= 1.80.

Description*:* The shell is cylindrical, thin and fragile, small in size and with six longitudinal sharp ribs running on its surface. Approaching the aperture, the ribs become lower. The intercostal space is wide. At first glance, the surface of the shell between the ribs seems to be quite smooth, but sometimes between main ribs, thin, barely noticeable longitudinal ribs appear, as well as the growth streaks between primary ribs, visible only under magnification. The section is hexagonal at the apical zone; the apertural sector is not preserved.

Remarks: *D. michelloti* is currently placed in the genus *Paradentalium* (Caprotti, 2009). The specimen is similar to *Paradentalium sexangulum*, but it is smaller and has a thinner shell. Some specimens from Višnjica have strong transverse growth lines between primary ribs. The specimens described by Baluk (1972) from the early Badenian of Poland have several thin longitudinal striae. Other taxa, *Dentalium angusticostatum* (Baluk, 1972) has been attributed to *Dentalium* (*D.*) *michelottii* (Hörnes, 1856) by Pavia (1991). Like other specimens with thin shells, *P. michelottii* is poorly preserved in the fossil record of Paratethys; therefore, interpreting the taxonomy of species is quite difficult.

Distribution*: Paradentalium michelottii* is recorded in the Lower Miocene of the Northern Italian (Sacco, 1897), in the Middle and Upper Miocene of the northern Europe (Sogenfrei, 1858; Rassmussen, 1968), and the Paratethys (Hoernes, 1856; Boettger, 1906; Kókay, 1966; Baluk, 1972). In the Pliocene, the species is widespread throughout the Mediterranean Basin (Caprotti, 1979) and extends to the base of the Pleistocene (Malatesta, 1974). This Miocene species was reported from the recent fauna of the Indian Ocean by Boissevain (1906).

Genus: *Dentalium* Linnaeus, 1758

Type species: *Dentalium elephantinum* Linnaeus, 1758; by subsequent designation, Montfort, 1810: 23.

Dentalium sp.

Plate 2, figs. 2a, 2b

Material: Eight fragmentary shells, NHMB 2402.

Dimensions (in mm)*:* L = 9.60, Wa = 1.40, Wp = 1.20.

Description: The thick shell is solid, lightly curved, tubular; anterior and posterior aperture and appear more or less truncated. There are ten strong, primary, rounded longitudinal ribs, showing of unequal thickness and concave interspaces vary in width. Five broad and higher primary ribs are located on the dorsal side among which the two central ones are the highest. There is one thin secondary rib between the primary longitudinal ribs, which mainly appears in the abapical sector of the shell. The internal outline is circular in the apex section but polygonal at the aperture because of the shell thinning.

Remarks: The specimens from Višnjica described cannot be assigned to any of the hitherto known species. As pointed by Caetano et al., (2006) genus *Dentalium* has eight to 12 primary ribs, vary-

ing strength, while *Paradentalium* has six primary ribs and section hexagonal at apex, subcircular or hexagonal at mouth. *Dentalium* has section polygonal at apex, circular at mouth. One group of species of the genus *Dentalium* has prominent dorsal and two latero-dorsal ribs, while the ventral ones are less noticeable, resulting in intercostals spaces with different sizes and a circular or subcircular oral section in adult specimens. We attributed specimen from Višnjica to the genus *Dentalium* because it has ten rounded primary ribs varying strength, the intercostals spaces with different sizes, and dorsal ribs more prominent. A more extensive record of these specimens could favour their interpretation providing a better basis for species identification.

Distribution: Middle Miocene (Badenian) at Višnjica near Belgrade (Serbia, Central Paratethys).

Familly: Omniglyptidae Chistikov, 1975
Genus: *Omniglypta* Kuroda & Habe in Habe, 1953
Type species: Dentalium cerinum Pilsbry, 1905, by original designation.

Omniglypta jani (Hörnes, 1856)

Plate 2, figs. 3a, 3b

1856 *Dentalium Jani* Hörnes, p. 657, pl. 50, fig. 37.
1897 *Fustiaria Jani* (Hörn.) – Sacco, p. 112, pl. 10, fig. 25–27.
1917 *Fustiaria Jani* Hörn. – Cossmann & Peyrot, p. 17–18, pl. 1, fig. 46–49.
1954 *Fustiaria Jani* Hörn. – Friedberg, p. 561, pl. 36, fig. 28–29.
1960 *Fustiaria jani* (Hoernes) – Baldi, p. 56, pl. 1, fig. 4.
1960 *Fustiaria jani* (Hoernes, 1856) – Kojumdgieva & Strachimirov, p. 226, pl. 52, fig. 21.
1979 *Fustiaria* (*Fustiaria*) *jani* (Hoernes) – Caprotti, p. 240, pl. 1, 6–8 (cum syn.).
1985 *Fustiaria jani* (M. Hoernes, 1856) – Atanacković, p. 191–192, pl. 42, figs. 18, 19.
1991 *Gadilina jani* (Hoernes, 1856) – Pavia, p. 128–130, pl. 6, figs. 7–10.
1998 *Fustiaria jani* (M. Hoernes, 1856) – Jovanović G. & Jovanović, p. 201–202.
2009 *Omniglypta jani* (Hörnes) – Caprotti, p. 33.
2011 *Omniglypta jani* (Hoernes, 1856) – Caprotti, p. 74.
2017 *Gadilina jani* (Hörnes, 1856) – Harzhauser et al., p. 71, pl. 3, fig. 23.
2019 *Omniglypta jani* – Cárdenas et al., p. 215, fig. 9g.
2020 *Omniglypta jani* (Hörnes, 1856) – Dominici et al., p. 102.

Materials: One fragmentary shell, NHMB 5249.

Dimension: (in mm)*:* L = 6. 30, Wa = 1.10, Wp = 0.90.

Description: The shell is very slender, sub-cylindrical weakly curved. The section is ovale, thicker in the external, narrow side with subcircular internal "channel". The surface of the shell is decorated with weak, characteristic, anular transverse rings, having almost the same thickness. The space existing between each ring is always the same.

Remarks: The high variability in the density and characteristic of bands was observed in all Paratethyan and Norditalian specimens. The different distances between the bands and their shape, which is rounded in *Omniglypta jani* and completely flattened in *O. emersoni* (Caprotti, 1979), constitute the major elements of the morphological distinctions between these species (Caprotti, 1979). Furthermore, the cross-section of the shell is highly variable. For specimens of a triangular cross-section from Borelli (Carotti, 2009) could be attributed to O*mniglypta* cf. *jani.* Pavia (1991) species *Fustiaria jani* transferred into a genus *Gadilina.* Later, Caprotti (2009) *Gadilina jani* transferred into a genus *Omniglypta.*

Distribution: Early Miocene of France, Miocene and Pliocene of the Mediterranean area (Pavia 1991, Caprotti, 2009; Dominici et al., 2020); very common in the Badenian sediments of Paratethys (Harzhauser et al., 2017; Jovanović G. & Jovanović, 1998).

Omniglypta emersoni Caprotti, 2009

Plate 2, figs. 4a, 4b, 4c

1979 *Fustiaria* (*Fustiaria*) *emersoni* Caprotti, 240, pl. 11, figs. 2–5.
1993 *Fustiaria* (*Fustiaria*) *emersoni* Caprotti, 1979 – Vera-Peláez et. al., p. 136, pl. 3, figs. 9, 10–12.
?2004 *Fustiaria* cf. *emersoni* Caprotti, 1979 – Vera-Peláez et al., p. 83, pl. 4, fig. 16; pl. 5, figs. 7, 8.
2009 *Omniglypta emersoni* (Caprotti, 1979) – Caprotti, p. 34.

2011 *Omniglypta emersoni* (Caprotti, 1979) – Caprotti, p. 74.

Material: One fragmentary shell, NHMB 7266.

Dimension (in mm): L = 4.60, Wa = 0.90, Wp= 0.80.

Description: The shell is small, thin, and almost straight, with a slight increase in diameter towards the aperture and circular cross-section at it. The internal and external cross-section is circular at the apical area. The surface of the shell is decorated with wide, irregular, transverse, flattened bands of almost the same thickness that gradually become weaker when approaching the aperture. On the ventral side, bands become narrower and distorted. The space between each band is very narrow.

Remarks: Caprotti (1979) described *Fustiaria emersoni* as a new species, clearly distinguishable from *F. jani* by the irregular and flattened rings. All the numerous Miocene and Pliocene specimens examined in the past by Caprotti (1979) have a clearly circular or subcircular section. For annulated scaphopods with circular or subcircular cross-section, the author considers that the best systematic position is in the genus *Omnyglypta* Kuroda & Habe in Habe, 1953. The specimen showed similarity with *Omniglypta borreliana* (Pavia, 1991), due to the presence of the bands sculpture. However, *O. borreliana* has a subtrapezoidal section on most of the shell (it becomes subcircular only with growth whereas specimen from Višnjica have a nearly circular section with the same thickness all around it).

Distribution: This is the first finding *O. emersoni* in Paratethyan deposits. So far, this species has been described from the Miocene and Pliocene in Italy (Caprotti, 1979) and Spain (Vera-Peláez et al., 1993, 2004).

Familly: Gadilinidae Chistikov, 1975
Subfamily: Gadilininae Chistikov, 1975
Genus: *Gadilina* Foresti, 1895
Type species: *Dentalium triquetrum* Brocchi, 1814.

Gadilina taurogracilis Sacco, 1897

Plate 2, figs. 5a, 5b

1897 *Gadilina triquetra* var. *taurogracilis* – Sacco, p. 114, pl. 10, figs. 44–46.

1991 *Gadilina triquetra taurogracilis* Sacco – Pavia, p. 130, pl. 7, figs. 3a, b.

2009 *Gadilina taurogracilis* Sacco 1897 – Caprotti, p. 41.

2011 *Gadilina taurogracilis* Sacco 1897 – Harzhauser et al., p. 220, figs. 8. 1, 2.

Materials: Two specimens and 38 fragmentary shells, NHMB 5248.

Dimensions: (in mm): L = 8.40, Wa = 1.2, Wp = 0.50.

Description: The shell is cylindrical, smooth, slender, weakly curved, and subtriangular in cross-section with rounded dorsal edges. The internal cross-sections of the apex and aperture shell are rounded. The shell is compressed from the sides and tapered to the abapical aperture.

Remarks: Sacco (1897) instituted this species on the base of specimen from the Langhian of the Monte dei Cappuccini in the Turin Hills. According to this author, *G. taurogracilis* is a subspecies of the late Miocene to Pliocene scaphopod *Gadilina triquetra* (Brocchi, 1814). Pavia (1991) indicated that the less angular edges and the slender outline of the upper Miocene taxon where sufficiently definitive to distinguish this form at a specific level, and for that he designated the lectotype. Harzhauser et al. (2011) describe a similar specimen with a weakly triangular cross-section and rounded edges from the Vienna Basin (Slovakia, Central Paratethys). Caprotti (2009) believed that the species *Gadilina taurogracilis* may be regarded as the ancestor of *Gadilina triquetra*.

Distribution: Beside the Italian middle to upper Miocene, the species is known from the Chattian of Aquitaine in France (Cosmann & Peyrot, 1917), from the Eggerian of Hungary (Baldi, 1973) and early Miocene (Burdigalian of Vienna Basin) (Harzhauser et al., 2011).

Order: Gadilida Starobogatov, 1974
Suborder: Gadilimorpha Steiner, 1992
Family: Pulsellidae Scarabino in Boss, 1982
Genus: *Pulsellum* Stoliczka, 1868.
Types species: *Dentalium sowerbyi* Guilding, 1834.

Pulsellum miocaenicum (Boettger, 1901)

Plate 2, fig. 6

1901 *Pulsellum miocaenicum* sp. n. – Boettger, p. 182.

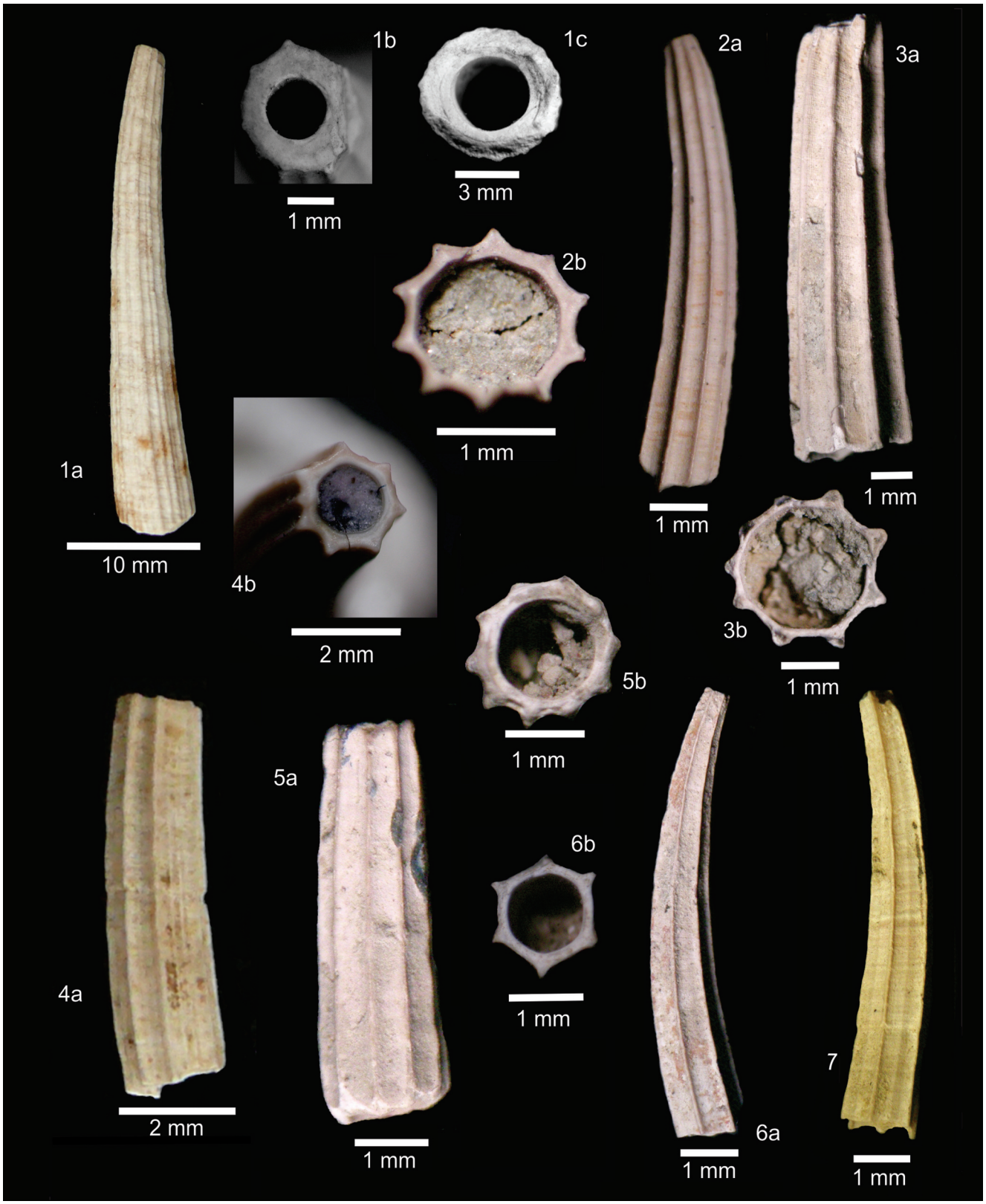

Plate 1. Figs. 1a, b. *Fissidentalium badense (Partsch in Hörnes, 1856) respectively at lateral and apical section and apertural section views.* ***Figs. 2a, b.*** *Antalis cf. taurocostatum (Sacco, 1897) at lateral, apical and apertural views.* ***Figs. 3a, b.*** *Antalis mutabilis (Hörnes, 1856 ex Doderlein ms) at lateral and apertural views.* ***Figs. 4a, b.*** *Antalis cf. subprismaticum (Baluk, 1972) at lateral and apical views.* ***Figs. 5a, b.*** *Antalis sp. at lateral and apical section views. Figs.* ***6a, b, 7.*** *Paradentalium sexangulum (Gmelin, 1791) at lateral and apertural views.*

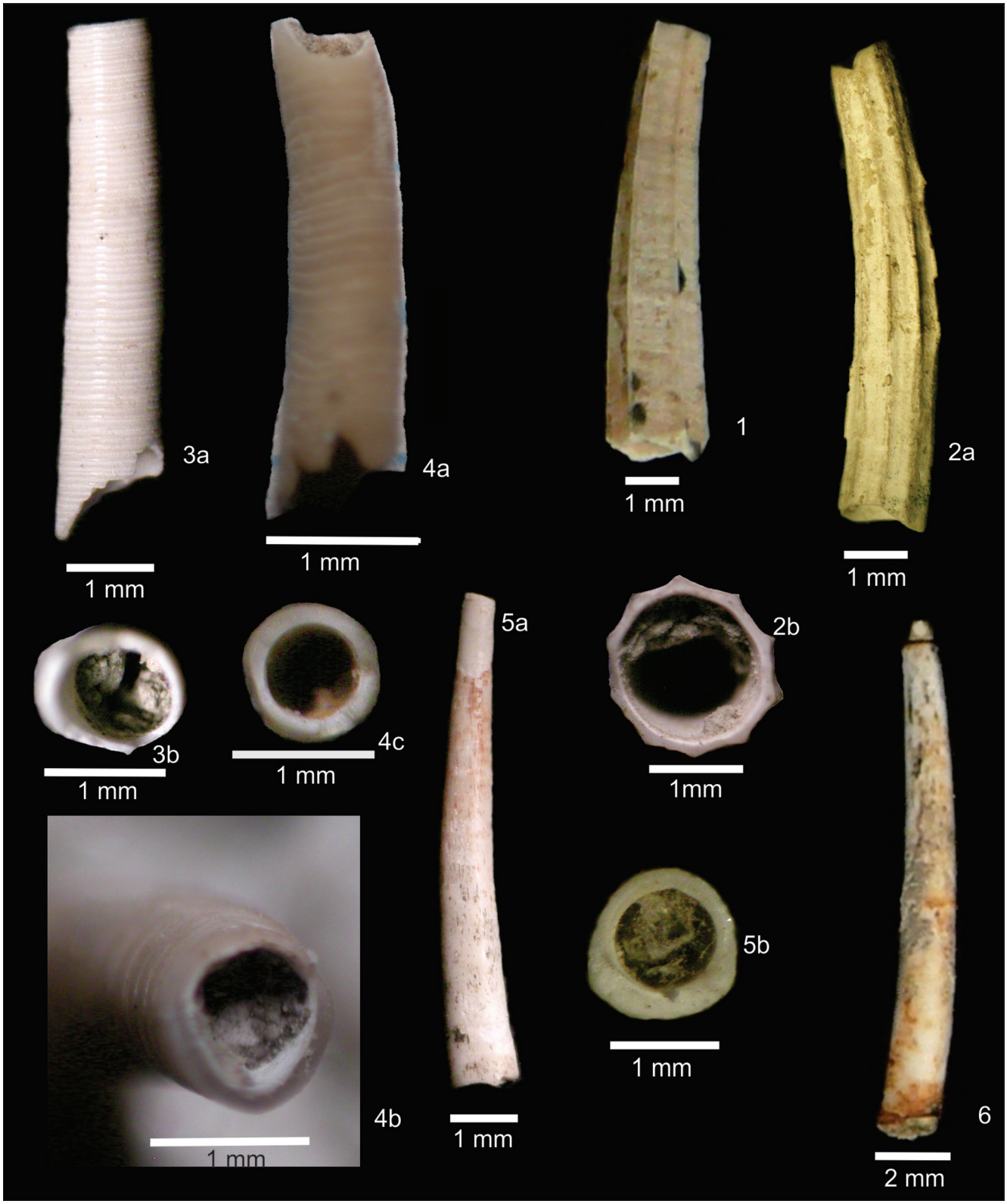

Plate 2. Fig. 1. *Paradentalium michelottii (Hörnes, 1856) at lateral view.* ***Figs. 2a, b.*** *Dentalium sp. at lateral and apertural views.* ***Figs. 3a, b.*** *Omniglypta jani (Hörnes, 1856) at lateral and apical views.* ***Figs. 4a–c****. Omniglypta emersoni (Caprotti, 1979) respectively at lateral, apical and apertural views.* ***Figs. 5a, b.*** *Gadilina taurogracilis Sacco, 1987 at lateral and apertural views.* ***Fig. 6.*** *Pulsellum miocaenicum (Boettger, 1901) at lateral view.*

1906 *Pulsellum miocaenicum* Boettger – Boettger, p. 211.
1934 *Siphonodentalium* (*Pulsellum*) *miocaenicum* (Boettger) – Zilch, p. 279, pl. 22, fig. 27.
1972 *Fustiaria* (*Episiphon*) *miocaenica* (Boettger, 1901) – Baluk, p. 560–561, pl. 4, figs. 1–12.
2016 *Fustiaria miocaenica* (Boettger, 1901) – Wysocka et al., p. 377, text-fig. 13 E.

Material: One specimen, NHMB 2493.

Dimensions: L = 11.80, Wa = 1.60, Wpa = 1.10.

Description: The small shell, very slender, slowly tapering and moderately curved - has a smooth surface without any longitudinal sculpture, but with feeble microscopic transverse growth lines. Apex and aperture are subcircular in section, the apex beras a siphonal pipe. The shell may be thin, but the section is circular or oval.

Remarks: The specimen is mostly similar to *Fustiaria* (*Episiphon*) *miocaenica* described by Baluk (1972). The lectotype was designated by Zilch (1934).

Distribution: A very rare Paratethyan species, middle Miocene (Badenian) of Poland (Korytnica Basin) (Baluk, 1972), Transylvania Basin (Romania) (Boettger, 1901).

Concluding remarks

In Serbia, the most diversified scaphopods were recognised from the Badenian Višnjica Clays, deposited during the transgression of the Parathethys Sea onto the northern slopes of Avala Mountain, near Belgrade. A small number of scaphopod taxa are recorded in other Serbian localities (Jovanović G. & Jovanović, 1998). Based on the previous records from Badenian deposits of Višnjica, Pavlović (1903) and Jovanović G. & Jovanovi, (1998) reported three and six scaphopod species, respectively. In this article, two orders were recognized: Dentaliida Da Costa, 1776 (family Dentaliidae (Children, 1834) and subfamily Omniglyptinae Chistikov, 1975) and Gadilida Starobogatov, 1974 (family Pulsellidae Scarabino in Boss, 1982).

The study of about 300 specimens has revealed the presence of ten species of Scaphopoda; other two taxons are identified generically. Eleven taxa belong to the order Dentaliida: *Fissidentalium badense* (Partsch in Hoernes, 1856), *Antalis* cf. *taurocostatum* (Sacco, 1897), *Antalis mutabilis* (Hoernes 1856 ex Doderlein ms), *Antalis* cf. *subprismaticum* (Baluk, 1972), *Antalis* sp., *Paradentalium sexangulum* (Gmelin, 1790*), Paradentalium michelottii* (Hörnes, 1856), *Dentalium* sp., *Omniglypta jani* (Hoernes,1856), *Omniglypta emersoni* Caprotti, 1979, *Gadilina taurogracilis* Sacco, 1897. One belonged to the order Gadilida: *Pulsellum miocaenicum* (Boettger, 1902). Of these 12 (*Antalis* cf. *taurocostatum* Sacco (1897), *Antalis* cf. *subprismaticum* (Baluk, 1972), *Paradentalium michelottii* (Hörnes, 1856), *Gadilina taurogracilis* Sacco (1897), *Pulsellum miocaenicum* (Boettger, 1901) were recorded for the first time from Višnjica locality. As for the taxonomic dominance, the family Dentaliidae is the richest taxon with *F. badense* about 40% of the total specimens collected.

The order for the first time species reported here not only highlight the diversity of the class Scaphopoda in the middle Miocene of the Belgrade area, but also reveal the existence of some species rare for the region Central Paratethys Sea. *Omiglypta emersoni* was first found in Paratethys deposits, whereas *Antalis subprismaticum* is one of the rarest scaphopods of the Central Paratethys. In fact, so far, this species has been described only by Baluk (1972) from Korytnica Basin (Poland). *Gadilina taurogracilis* is known from the Early Miocene of the Vienna Basin (Harzhauser et al., 2011) outside the type-area in Norhern Italy.

The geographic distribution of several taxa can be extended from the Mediterranean to the Central Paratethys, including the deposits of Serbia, such as *Fissdentalium badense, Antalis* cf. *taurocostata*, *Antalis mutabile*, *Paradentalium sexangulum*, *Omniglypta jani*, and *O. emersoni*. *Fissidentalium badense* is one of the most widely distributed dentaliid species from the Neogene/Miocene of Central Paratethys (Pavia, 1991). This species was widespread during the early Badenian from the clayey sediments of Austria (Baden-Sooss that was attributed to the Upper Lagenidae Zone by Papp & Steininger (1978) and by Rögl et al. (2009), Romania (Kostej, Lăpugiu de Sus, Bjutur): Koch, 1900; Boettger, 1901; Tita, 2007, Slovakia (Baluk, 1972), Hungary (Baldi, 1960). Some scaphopod species are widespread in both, the Pliocene deposits of Mediterranean and the Badenian deposits of the Paratethys Sea (*Fissdentalium badense*, *Antalis* cf. *taurocostata,*

Antalis mutabile, *Paradentalium sexangulum*, *Omniglypta jani, Gadilina taurogracilis, Paradentalium michelottii).* According to Sacco (1897), Fantinet (1959), Pavia (1991), Vera-Peláez et al. (1993, 2004), Caprotti (1979) *P. sexangulum* is known from the Miocene and Pliocene sediments of the Mediterranean Sea, early Miocene and Middle Miocene of the Paratethys.

In the Central Paratethys area, the Scaphopoda are not the most important fossils for the biostratigraphy of the Miocene period (Harzhauser, 2002). This is probably due to the probably due to the wide chronostratigraphic distribution of most species (Harzhauser, 2002, Harzhauser et al., 2017, 2018; Rögl et al., 2008) and small number of preserved specimens, and insufficient study of scaphopods compared to other fossils. The Miocene chronostratigraphy is primarily linked to foraminifera and nannofossil zonations and some molluscs. Based on these groups, fossil Višnjica site was compared to the Badenian stratotype Baden-Sooss in Vienna Basin (Pavlović, 1903; Luković, 1922; Mihajlović & Knežević, 1989; Jovanović & Bošnjak, 2016). The previously supposed connections with the other middle Miocene basins of the Paratethys (Vienna Basin, Korytnica, and Transylvania Basin), as inferred by some mollusc identifications, can be substantiated based on Scaphopoda. According to several autors (Stevanović, 1977; Jovanović & Bošnjak 2016; Jovanović et al., 2019), the lowermost Badenian deposits can be correlatable with the Upper Lagenidae Zone, although we do not exclude the presence of sediments correlative with the early middle Badenian *Spirorutilus carinatus* Zone (Grujičić, 2010, Mandic et al., 2019).

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Резиме

Средњомиоценске (баденске) кљова љуштуре (Scaphopoda) Вишњице код Београда (Србија)

Рад представља збирку Scaphopoda прикупљену у глиновитим седиментима средњег миоцена (бадена) Вишњице код Београда (Србија), познатијим као Вишњичке глине. Због облика љуштуре Scaphopoda подсећају на слонову кљову, па су у свету познати и под називом "Tusk shells" (кљова љуштуре). Део су збирки академика Петра Павловића и Петра Стевановића које се чувају у Природњачком музеју у Београду. У односу на друге локалитете у Србији, Вишњица је по броју врста и примерака најбогатија. Ипак, Scaphopoda из овог локалитета није била добро проучена.

Збирке Музеја су од општег интереса за проучавања ове малобројне, али занимљиве групе мекушаца чије су љуштурице прилично слабо очуване и представљене су претежно већим или мањим фрагментима. Проучавања су показала да налазишта у Вишњици садрже разноврсну фауну скафопода. У раду су по први пут су описани таксони Scaphopoda и представљене фотографије ових примерака.

Од скоро 300 љуштурица, идентификовано је 226 примерака. Врло мали и еродовани фрагменти нису идентификовани. Збирка Петра Стевановића садржи само *Fissidentalium badense* (40 примерака).

Препозната су два реда: Dentaliida da Costa, 1776 (porodica Dentaliidae (Children, 1834), и Omnigliptinae Chistikov, 1975) и ред Gadilida Starobogatov, 1974 (породица Pulsellidae Scarabino in Boss, 1982). Једанаест таксона припада реду Dentaliida (*Fissidentalium badense*, *Antalis* cf. *taurocostatum*, *Antalis mutabilis*, *Antalis* cf. *subprismaticum*, ?*Antalis* sp., *Paradentalium sexangulum*, *Paradentalium michelottii*, *Dentalium s*p., *Omniglypta jani*, *Omniglypta emersoni, Gadilina taurogracilis*) и само један реду Gadilida (*Pulsellum miocaenicum*). Збирка обухвата 12 таксона, сврстаних у седам родова. Што се тиче породица, Dentaliidae су доминирале и представља их једанаест таксона. *Fissidentalium badense* је био начешћа врста у испитиваном материјалу и чинила је око 40% од укупног броја прикупљених примерака.

Проучавања скафопода из Вишњице проширују наше знање о овој малој, али важној групи мекушаца која је била широко распрострањена у Централном Паратетису током средњег миоцена (бадена). Биостратиграфска вредност проучаваног фосилног материјала је прилично ниска, мада највећи број таксона одговара старијем делу баденског ката земаља у региону (Горња Лагенидна зона). Раније претпостављене везе са другим средњомиоценским басенима Централног Паратетиса (Бечки басен, басен Коритнице и Трансилванијски басен), како је закључено на основу идентификација других врста мекушаца, могу се поткрепити и на основу скафопода. Идентификовани таксони не само да истичу разноликост класе Scaphopoda у баденским седиментима околине Београда, већ откривају и постојање неких врста које су ретке (*Gadilina*

taurogracilis, *Antalis* cf. *subprismaticum, Pulsellum miocaenicum*) или још увек нису забележене у Централном Паратетису (*Omniglypta emersoni*). Рад доприноси бољем познавању ове класе мекушаца показујући да музејске збирке могу пружити податке значајне за палеобиогеографску анализу и палеогеографске интерпретације јужних граница Централног Паратетиса током баденског доба.

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