Geological Quarterly, 2025, 69, 22
DOI: https://doi.org/10.7306/gq.1795

New data on the lower Badenian Scaphopoda from the southwestern part of the Carpathian Foredeep (Czech Republic)

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Turek, T., Hladilová, Š., 2025. New data on the lower Badenian Scaphopoda from the southwestern part of the Carpathian Foredeep (Czech Republic). Geological Quarterly, 69, 22; https://doi.org/10.7306/gq.1795

Scaphopods from the lower Badenian (Miocene) strata of the southwestern part of the Carpathian Foredeep in Moravia and its denudation relics on the Bohemian Massif are described, by means of fieldwork and re-examination of comparative material from the depositories of the Moravian Museum and the Department of Geological Sciences, Faculty of Science, MU Brno. In total, 8 species belonging to 6 genera were found. Occurrences of *Entalina tetragona*, *Gadila ventricosa*, *Omniglypta jani*, *Fissidentalium badense, Antalis mutabilis, Antalis fossilis*, and *Paradentalium michelottii* were confirmed and *Omniglypta emersoni* was newly recorded. Both the molluscs and lithofacies prove that the species inhabited two environments: infralittoral – *Gadila ventricosa*, *Antalis fossilis*, *Omniglypta jani* and *Omniglypta emersoni*; and circalittoral – *Entalina tetragona* and *Antalis mutabilis*. *Fissidentalium badense* was present in both circalittoral and infralittoral localities, so its greater depth range can be presumed. *Paradentalium michelotii* only occurred in the Borač locality, where circalittoral and infralittoral faunas were mixed; due to their slight abrasion, these shells were probably redeposited into the circalittoral environment from shallower (infralittoral) waters.

Key words: Mollusca, Scaphopoda, Middle Miocene (Badenian), Carpathian Foredeep, Paratethys.

INTRODUCTION

Molluscs are common as fossils in the Miocene strata of the Carpathian Foredeep (CF) in Moravia (Czech Republic). While gastropods and bivalves are abundant, scaphopods are relatively rare, representing only a secondary faunal component with small numbers of individuals and species. This is likely the reason they have been rarely studied, and often ignored. They were marginally examined, for example, by Hörnes (1856), Procházka (1892), Dvořák (1952), Seitl (1981), Harzhauser et al. (2002), Pekař and Lehotský (2015) and Turek (2018).

The most important studies of Miocene and Pliocene scaphopods of the Mediterranean region are Sacco (1897), Caprotti (1979) and Pavia (1991), focusing on the Piedmont-Liguria region of northern Italy. Bałuk (1972) investigated scaphopods from the Korytnica Basin in Poland; Harzhauser (2002) studied the Korneuburg Basin; Jovanović and Jovanović (2021) researched Serbian scaphopods and Vera Peláez et al. (1993), Vera Peláez and Lozano-Francisko (2004) studied Spanish Pliocene scaphopods from the Malaga Province.

Research into new Miocene localities in the CF in Moravia from 2018 to 2022 revealed a rich assemblage of molluscs, including a significant number of scaphopod shells coming from the lower Badenian strata of the northern part of the Boskovice basin, at Boskovice, Velké Opatovice and Jevíčko, from the vicinity of Tišnov and from a brickyard in Šlapanice near Brno (Fig. 1). These localities represent predominantly isolated denudation relics of Miocene marine deposits situated outside the preserved continuous sedimentary infill of the CF; they lie directly on the crystalline basement or on pre-Miocene (Paleozoic and Mesozoic) bedrock, and are related to the penetrations of the sea along tectonically predisposed zones far into the foreland of the CF, on the Bohemian Massif. Sedimentological and palaeontological research into these deposits has been ongoing for over 150 years. Due to the uniqueness and richness of its fossil fauna, the Borač locality was designated by Brzobohatý and Cicha (1978) as a parastratotype of the lower Badenian (or the Moravian substage of the regional Badenian stage), corresponding to the lower Langhian in the standard chronostratigraphy (Hohenegger et al., 2014).

Procházka (1893a, b) was the first to examine the early Badenian molluscs, corals, foraminifers, and fish otoliths in the northern part of the Boskovice basin (i.e., the Knínice, Šebetov and Sudice localities), and also noted the finds of scaphopods in his papers. Augusta and Buday (1938) studied Miocene strata with molluscs and corals between Sudice and Boskovice, where they also described scaphopods. Vašíček (1941) studied the Miocene scaphopods from Úsobrno, and Dvořák (1952)

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Received: December 21, 2024; accepted: June 10, 2025; first published online: August 18, 2025

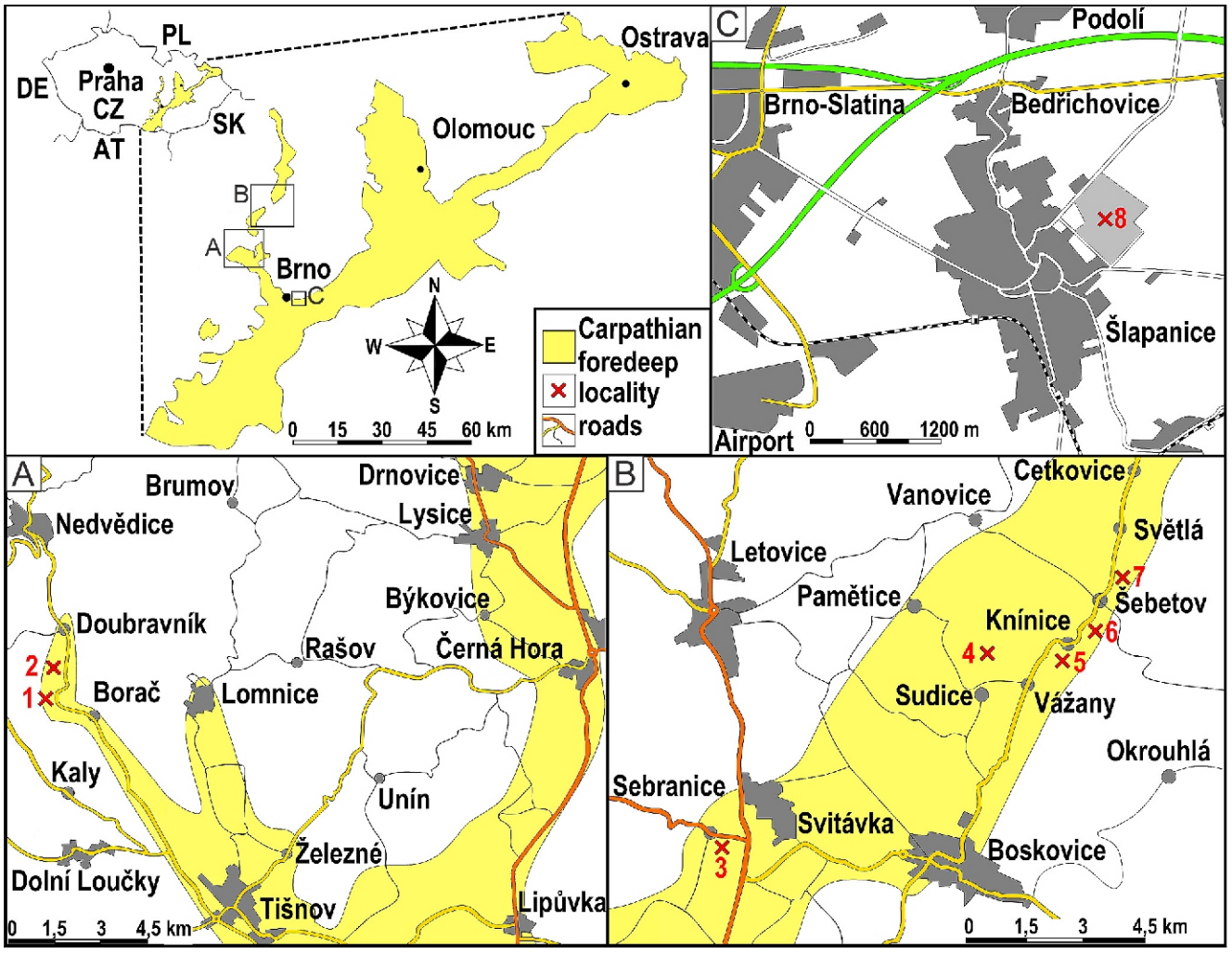

Fig. 1. Geological position of the study area together with the extent expansion of the lower Badenian strata in the Carpathian Foredeep

A – localities in the study area near Tišnov (1 – Borač; 2 – Doubravník-V propadlí); **B** – localities in the study area near Boskovice (3 – Sebranice; 4 – Knínice-Kovářovice; 5 – Knínice-South; 6 – Šebetov-Čtvrtě; 7 – Šebetov-North); **C** – Locality near Brno (8 – Šlapanice)

those from Černá Hora. Later, however, there was little attention given to the scaphopods from the northern part of the Boskovice basin, although other fossils (corals, red algae, fish otoliths, etc.) were studied in detail e.g., Augusta (1938), Vašíček (1941), Hladil (1976), Novák (1975), Zdražílková (1985), Brzobohatý (1997), Brzobohatý and Nolf (2018).

Here, we analyse scaphopods obtained in new field research and compare them with older material housed in the Moravian Museum and the Institute of Geological Sciences of the Faculty of Natural Science, Masaryk University in Brno, which have accumulated over the past 150 years. Furthermore, we summarise knowledge of scaphopod occurrences in the lower Badenian of the CF in Moravia. The stratigraphic importance of the species studied is limited. Since their first occurrences in the Early Miocene, they reached their greatest diversity in the Middle Miocene and survived generally throughout the Late Miocene and Pliocene (Fig. 2).

GEOLOGY OF THE STUDY AREA

The southwestern part of the CF in the Czech Republic represents the foreland of the tectonically active Carpathian Mountain chain. It formed as a peripheral foreland basin and developed on the passive eastern margin of the Bohemian Massif due to the subsurface loading of the Alpine-Carpathian orogenic belt. The basin continues southwards to the Alpine Foredeep/Alpine Molasse Zone, and northeastwards to the Polish part of the CF (Oszczypko et al., 2006). The outer autochthonous part of its sedimentary infill directly overlies the pre-Neogene basement, overlying the rock units of the Bohemian Massif. The paraautochthonous inner part is partly incorporated into the Outer Carpathian accretionary wedge (Carpathian Flysch Belt). In the southwestern part of the CF, sedimentation started in the Egerian - early Eggenburgian (i.e., the Aquitanian to early Burdigalian) and continued to the Badenian (Langhian – early Serravallian; Brzobohatý and Cicha, 1993; Nehyba and Šikula, 2007).

During the late Karpatian and early Badenian, the compression of the Carpathian orogenic wedge changed to a NNE and NE direction, which caused geometrical reorganisation of the CF. The areas with the maximum sedimentary thickness are situated along the axis of an almost symmetrical basin of SSW-NNE orientation. The Badenian deposits thus represent a distinct period of basin evolution (Cicha et al., 1989; Nehyba et al., 1995; Kováč, 2000, Kováč et al., 2003, 2007; Oszczypko et al., 2006; Nehyba and Šikula, 2007; Rasser et al., 2008). In the early Badenian (Langhian), the marine transgression extended

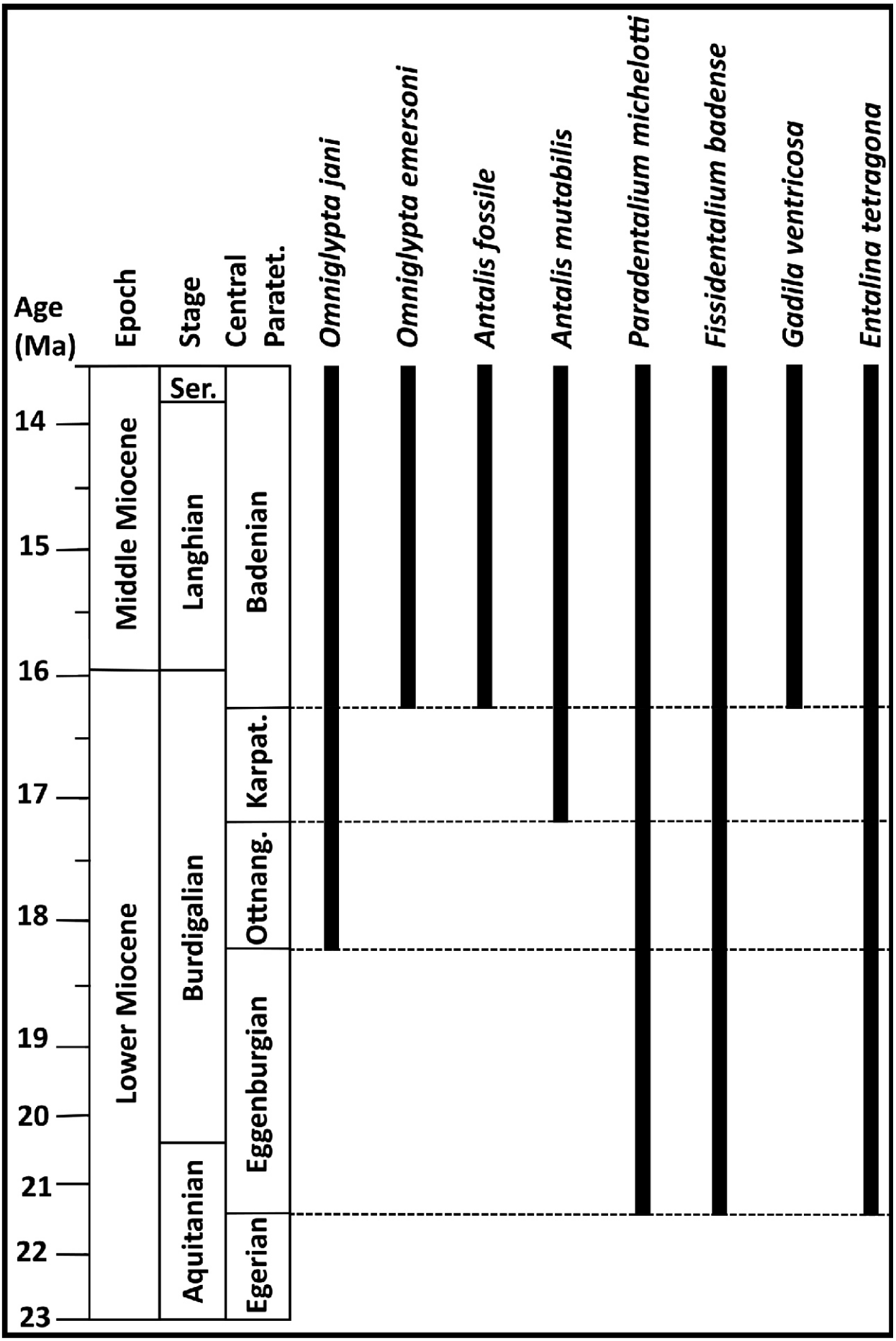

Fig. 2. Stratigraphic distribution of the Scaphopoda studied

far into the foreland (Bohemian Massif) along the tectonically predisposed zones, and isolated relics of lower Badenian deposits can thus be found far to the west on crystalline or pre-Neogene (Paleozoic and Cretaceous) bedrock (the Bohemian-Moravian Highlands, Boskovice basin etc.).

In the study area, blue-grey and brownish-grey, unstratified calcareous clays ("tegels") with a very rich micro- and macrofauna predominate, lying directly on the pre-Neogene bedrock. Depending on their relief, the clays contain subordinate layers of sand and thin biostromal or bioclastic, mainly algal, limestones with a variable amount of siliciclastic matter. The limestones are formed mainly of coralline algae and bryozoans, but other fossils are also abundant (e.g., bivalves, gastropods, corals, echinoderms, ostracods, fish teeth and scales). The final stages of the thrusting of the orogenic wedge and flexural uplift of the foreland largely led to the subsequent cessation of marine sedimentation. From the middle Badenian (middle Serravallian) onwards, the CF depocentres migrated northeastwards. Middle and upper Badenian deposits are known only in the Ostrava and Opava areas in the north, where the CF of the Czech Republic continues into Poland (Cicha et al., 1956; Cicha and Dornič, 1959; Buday et al., 1961; Čech, 1988; Kováč and Plašienka, 2003; Rasser et al., 2008).

MATERIAL AND METHODS

The materials studied come mainly from the lower Badenian deposits of the northern part of the Boskovice basin between Boskovice and Velké Opatovice. Some localities studied are completely new (e.g., Knínice-Kovářovice 1–7, Šebetov-Čtvrtě and Šebetov-North), and some are already published (e.g., Sebranice 1 and 2 and Knínice-South). Another sample group (from the published localities) originates in the vicinity of Tišnov (Borač, Doubravník-V Propadlí) and from the surroundings of Brno (Šlapanice).

At individual localities, samples were obtained from trenches dug to various depths at Knínice-Kovářovice (50 cm), Šebetov-Čtvrtě (80 cm), Borač (80 cm). There are also samples from surface collections (e.g., Knínice-Kovářovice, Šebetov – Čtvrtě, Šebetov-North, Sebranice 1 and 2, Knínice-South, and Šlapanice), and some exceptionally from profiles (e.g., the Šlapanice clay pit). Fossils occurred most often in greenish-grey clays (tegels) in the Šebetov-North, Knínice-South, Doubravník-V Propadlí, and Šlapanice localities; and grey, sandy clays were found at the Knínice-Kovářovice and Šebetov-Čtvrtě localities. Red-algal and sandy limestones with a rich macrofauna were discovered in Knínice-Kovářovice, Šebetov-North, and Sebranice 1 and 2. The Borač locality is specific for its presence of compact grey clays with a significant admixture of sands and indeterminable fragments of corals, brachiopods and molluscs. All sediments collected were floated on sieves with a mesh size of 2 mm and 0.5 mm and then studied under a binocular magnifier (*Nikon SMZ-1*). Well-preserved individual specimens were determined and, together with the most abundant gastropods and bivalves, are documented in the table (Table 1). An indeterminable portion of the fragments was not included in the total number of specimens found. For the determination, the publications of Bałuk (1972), Caprotti (1979), Pavia (1991), Vera Peláez et al. (1993) and other authors cited later in the text were consulted. The photographic documentation was performed using a microscope with *HIROX RH 2000* photo equipment. The studied material is deposited in the Moravian Museum under the accession number 5/2025. Comparative material of the Miocene scaphopods from the collections of the Institute of Geological Sciences of Masaryk University in Brno and the Moravian Museum in Brno (from the Borač, Lomnička, Hrušovany nad Jevišovkou, Černá Hora, Rudice, Židlochovice, Olomučany, Lažánky, and Drnovice localities) most often came from V.J. Procházka's original collections.

RESULTS

SYSTEMATIC PART

Abbreviations: OC – own collection, L – literature, MZM – the depository of the Moravian Museum in Brno, ÚGV – the depository of the Department of Geological Sciences, Faculty of Science, Masaryk University in Brno.

Class **Scaphopoda** Bronn, 1862
Order **Dentaliida** da Costa, 1776
Family **Omniglyptidae** Chistikov, 1975
Genus ***Omniglypta*** Kuroda, 1953
Omniglypta jani (Hörnes, 1856)
(Fig. 3, pl. 5a, b)

1856 *Dentalium Jani* – Hörnes, p. 657, pl. 50, fig. 37.
1897 *Fustiaria Jani* (Hörn.) – Sacco, p. 112-113, pl. 10, figs. 25–27.
1897 *Fustiaria Jani* var. *striatellulata* Sacc. – Sacco, p. 113, pl. 10, figs. 28–33.
1897 *Fustiaria incertula* Sacc., p. 113, pl. 10. fig. 34.
1928 *Fustiaria Jani* Hörnes – Friedberg, p. 561, pl. 36, figs. 28–29.
1947 *Dentalium* (*Laevidentalium*) *jani* Hoern. – Tauber, p. 301, pl. 7, figs. 5–7.
1960 *Fustiaria jani* (Hörn.) – Báldi, p. 55, pl. 1, fig 4.
1960 *Fustiaria jani* (Hoernes, 1856) – Kojumdgieva and Strachimirov, p. 226, pl. 52, fig. 21.
1962 *Dentalium* (*Fustiaria*) *jani* Hörn. – Caprotti, p. 95, pl. 16, figs. 8.
1972 *Fustiaria* (*Episiphon*) *jani* (Hornes, 1856) – Bałuk, p. 559–560, pl. 5, figs. 1–5.
1979 *Fustiaria* (*Fustiaria*) *jani* (Hörnes, 1856) – Caprotti, p. 240, pl. 11, figs. 1, 6-8.
1979 *Fustiaria* (*Gadilina*) *incertula* Sacco, 1897 – Caprotti, p. 242, pl. 12, figs. 6–8.
1984 *Fustiaria incertula* Sacco,1897 – Ferrero Mortara et al., p. 309, pl. 56, fig. 6.
1985 *Fustiaria jani* (Hoernes, 1856) – Atanacković, p. 191-192, pl. 42, figs. 18, 19.
1991 *Gadilina jani* (Hoernes, 1856) – Pavia, p. 128–130, pl. 6, fig. 7–10, pl. 7, figs. 1–2.
1993 *Fustiaria* (*Fustiaria*) *jani* (Hörnes, 1856) – Vera Peláez et al. p. 135-136, pl. 3, figs. 7, 8, 11.
1998 *Fustiaria jani* (M. Hoernes, 1856) – Jovanović and Jovanović, p. 201–202.
2004 *Fustiaria* cf. *jani* (Hörnes, 1856) – Vera Peláez and Lozano-Francisco, p. 82, pl. 4, fig. 15, 20; pl. 5, fig. 9.
2009 *Omniglypta jani* (Hörnes, 1856) – 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* (Höernes, 1856) – Cardenas et al., p. 215, pl. 9, fig. g.
2020 *Omniglypta jani* (Hörnes, 1856) – Dominici et al., p.102.

Table 1

Localities with scaphopod findings along with the most abundant gastropod and bivalve species

	Kníníce-Kovářovice 2	Kníníce-Kovářovice 3	Kníníce-Kovářovice 5	Kníníce-Kovářovice 6	Kníníce - South	Šebetov-North	Šebetov - Čtvrtě	Sebranice 1	Sebranice 2	Šlapanice	Doubravník-V propadlí	Borač
Scaphopoda												
Omniglypta jani **(Hörnes, 1856)**	9 / 1,4			3 / 0,2					9 / 1,6			
Omniglypta emersoni **(Caprotti, 1979)**									20 / 3,5			
Antalis fossilis **(Gmelin, 1791)**									80 / 14,2			
Antalis mutabilis **(Hörnes, 1856)**	1 / 0,2	2 / 1,2	5 / 4,9	1 / 0,1	21 / 3,4		90 / 5,8		3 / 0,5			
Paradentalium michelotti **(Hörnes, 1856)**												2 / 0,1
Fissidentalium badense **(Partsch in Hörnes, 1856)**					1 / 0,2			8 / 13	2 / 0,4	6 / 2,2		
Gadila ventricosa **(Bronn, 1827)**	14 / 2,2	6 / 3,5	2 / 2	8 / 0,7					193 / 34,2			
Entalina tetragona **(Brocchi, 1814)**	1 / 0,2	2 / 1,2	1 / 1	1 / 0,1	37 / 6	20 / 10,3	90 / 5,8	5 / 8,3	3 / 0,5	20 / 7,4	2 / 0,9	34 / 2
Bivalvia												
Varicorbula gibba **(Olivi, 1792)**				4 / 0,3	24 / 3,9	6 / 3	37 / 2,4	7 / 11,7	13 / 2,3	22 / 8,1	57 / 25,4	183 / 10,5
Limopsis anomala **(Eichwald, 1830)**							29 / 1,9					202 / 11,6
Glycymeris deshayesi **(Mayer, 1868)**	10 / 1,6	2 / 1,2	10 / 9,8	20 / 1,7								
other Bivalvia	2 / 0,3	5 / 2,9	3 / 2,9	6 / 0,5	0 / 0	4 / 2,1	7 / 0,4	1 / 1,7	10 / 1,8	5 / 1,8	0 / 0	13 / 0,7
Gastropoda												
Ancillina pusilla **(Fuchs, 1877)**					55 / 8,9	3 / 1,5	195 / 12,5		1 / 0,2			75 / 4,3
Euspira helicina **(Brocchi, 1814)**	9 / 1,4	10 / 5,8	6 / 5,9	70 / 6,1	34 / 5,5	8 / 4	49 / 3,1	2 / 3,3	58 / 10,3	62 / 22,8	8 / 3,8	369 / 21,3
Nassarius doliolum **(Eichwald, 1830)**				13 / 1,1					20 / 3,4			
Nassarius striatulus **(Eichwald, 1829)**					111 / 18	5 / 2,6	208 / 13,3	1 / 1,7		5 / 1,8	60 / 26,8	
Roxania utriculus **(Brocchi, 1814)**					4 / 0,7	1 / 0,5	38 / 2,4				1 / 0,4	14 / 0,8
Aporrhais pespelecani **(Linnaeus, 1758)**	6 / 0,9	7 / 4	1 / 1	68 / 5,9	5 / 0,8			2 / 3,3	10 / 1,8			1 / 0,1
Ptychidia vindobonensis **(Handmann, 1882)**	569 / 88,8	60 / 34,7	55 / 53,9	916 / 79					19 / 3,4			
Oligodia spirata **(Brocchi, 1814)**	2 / 0,3	6 / 3,5		9 / 0,8	261 / 42,4	114 / 58,8	685 / 43,8	31 / 51,7	4 / 0,7	139 / 51,1	67 / 29,9	307 / 17,7
other Gastropoda	18 / 2,8	73 / 42,2	19 / 18,6	38 / 3,3	63 / 10,2	33 / 17	137 / 8,8	3 / 5	119 / 21,1	13 / 4,8	29 / 12,9	535 / 30,8

Explanation: number of specimens/ percentage representation

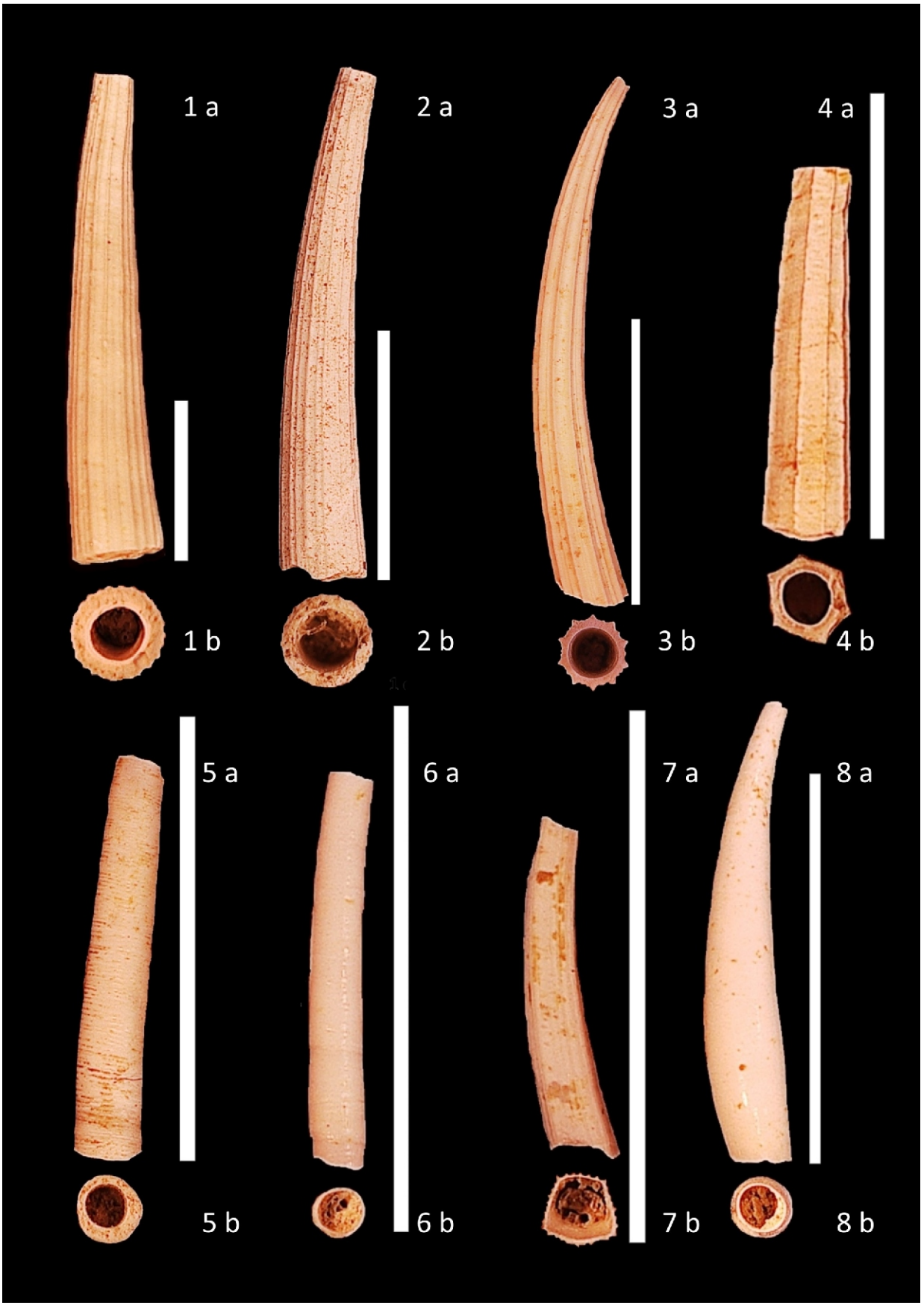

Fig. 3.1a, b – *Fissidentalium badense* (Partsch in Hörnes, 1856), Sebranice 1; 2a, b – *Antalis fossilis* (Gmelin, 1791), Sebranice 2; 3a, b – *Antalis mutabilis* (Hörnes, 1856), Šebetov – Čtvrtě; 4a, b – *Paradentalium michelotti* Hörnes, 1856, Borač; 5a, b – *Omniglypta jani* (Hörnes, 1856), Sebranice 2; 6a, b – *Omniglypta emersoni* (Caprotti, 1979), Sebranice 2; 7a, b – *Entalina tetragona* (Brocchi, 1814), Šebetov – North; 8a, b– *Gadila ventricosa* (Bronn, 1827), Sebranice 2, all scales are 1 cm

2021 *Omniglypta jani* (Hörnes, 1856) – Jovanović and Jovanović, p. 32, pl. 2, figs. 3a, 3b.

D e s c r i p t i o n. – The shell is usually small with very thin walls. The curvature is barely noticeable. The internal and external cross-sections are circular to oval. Regular rounded transverse rings are visible on the surface of the shells, creating a characteristic sculpture. The spaces between the growth lines are of similar size, distinguishing this species from *Omniglypta emersoni* (Caprotti, 1979).

D i s t r i b u t i o n. – This taxon is very abundant in the Miocene deposits of the Paratethys and Miocene and Pliocene deposits of the Mediterranean regions. It has been found in upper Burdigalian deposits in Italy (the Piedmont-Liguria region, Báldi, 1960). The Badenian finds come from the Paratethys: Austria, Czech Republic, Slovakia, Hungary, southern Poland, Bosnia, Serbia, Romania and from the Middle Miocene of the Mediterranean Sea of Italy (Piedmont-Liguria), France (Aquitaine), and Algeria (Hörnes, 1856; Procházka, 1892; Báldi, 1960; Bałuk, 1972; Caprotti, 1979; Vera Peláez et al., 1993; Jovanović and Jovanović, 2021). In the Late Miocene, this species has been documented in the Mediterranean Sea, i.e., San Marino, Italy (Piedmont-Liguria), and Algeria (Sacco, 1897; Báldi, 1960; Caprotti, 1979; Pavia, 1991; Vera Peláez and Lozano-Francisco, 2004). In the Pliocene, it occurs in the Mediterranean Sea of Italy (Piedmont-Liguria), Algeria, Morocco (Báldi, 1960), and Spain (in Estepona, Caprotti, 1979; Pavia, 1991; Vera Peláez et al., 1993).

C a r p a t h i a n F o r e d e e p i n M o r a v i a. – Knínice-Kovářovice 2 (OC), Sebranice 2 (OC), Borač (L – Procházka, 1892), Rudoltice (L – Procházka, 1895), Lažánky (L – Procházka 1899), Olomučany (MZM, L – Procházka, 1899), Židlochovice (L – Šob, 1939), Drnovice (MZM – Procházka's collection), and Sudice (ÚGV).

H a b i t a t. – Fine-grained sediments, and most often, sands of deeper seas (Caprotti, 1979; Vera Peláez et al., 1993).

Omniglypta emersoni (Caprotti, 1979)
(Fig. 3, pl. 6a, b)

1897 *Fustiaria* cf. *polita* (L.) var. *astensis* – Sacco, p. 112, pl. 10, fig. 24.
1979 *Fustiaria* (*Fustiaria*) *emersoni* – Caprotti, p. 240-241, 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 and Lozano-Francisco, p. 83, pl. 4, fig. 16, pl. 5, figs. 7, 8.
2009 *Omniglypta emersoni* (Caprotti, 1979) – Caprotti 2009, p. 32.
2011 *Omniglypta emersoni* (Caprotti, 1979) – Caprotti, p. 74.
2021 *Omniglypta emersoni* (Caprotti, 1979) – Jovanović and Jovanović, p. 32–33, pl. 2, figs. 4a–c.

D e s c r i p t i o n. – The shell is usually small to medium with thin walls and circular in internal and external cross-section. The curvature is not immediately visible. The surface of the shell is formed by irregular rings, which are mainly perpendicular to the longitudinal axis of the shell but can also be variously tilted and flattened. It differs from the species *Omniglypta jani* (Hörnes) in the shape and growth of the rings, and the larger dimensions of the shell.

D i s t r i b u t i o n. – This taxon is associated with the Badenian of the Paratethys and Miocene and Pliocene of the Mediterranean regions. In the Badenian, it occurred in the Pannonian Basin (Serbia; Jovanović and Jovanović, 2021). An earlier record of this species, noted by Caprotti (1979) from the Badenian of Poland, requires confirmation. In the Mediterranean it occurred in Italy (Piedmont-Liguria regions; Caprotti, 1979) and Spain (Málaga; Vera Peláez et al., 1993; Vera Peláez and Lozano-Francisco, 2004).

C F i n M o r a v i a. – Sebranice 2 (OC), Drnovice (MZM – Procházka's collection).

H a b i t a t. – Fine-grained sandy sediments of deeper seas (Caprotti, 1979; Vera Peláez et al., 1993).

Family **Dentaliidae** (Children, 1834)
Genus ***Antalis*** H. Adams et A. Adams, 1854
Antalis fossilis (Gmelin, 1791)
(Fig. 3, pl. 2a, b)

1897 *Antale fossile* (Schröt.) – Sacco, p. 99–100, pl. 8, figs. 24-26.
1928 *Dentalium fossile* var. *raricostata* Sacco – Friedberg, p. 558–559, pl. 36, figs. 20–21.
1938 *Dentalium fossile* Gmelin – Stchepinsky, p. 50, pl. 5, figs. 12, 13.
1958 *Dentalium* (*Antale*) *fossile* Gmelin – Erünal-Erentöz, p. 134, pl. 21, figs. 26–28.
1959 *Dentalium* (*Antale*) *fossile* Gmelin – Fantinet, p. 43, pl. 5, figs. 7–12; pl. 6, figs. 1–3.
1972 *Dentalium* (*Antalis*) *fossile* Schroeter, 1783 – Bałuk, p. 552–553, pl. 1, figs. 1–5.
1974 *Dentalium* (*Antalis*) *fossile* Gmelin – Malatesta, p. 3, pl. 1, figs. 3 a, b.
1979 *Dentalium* (*Antalis*) *fossile* Gmelin, 1790 – Caprotti, p. 230–231, pl. 6, figs. 1, 2, 4, 5.
1988 *Dentalium* (*Antalis*) *fossile* Gmelin – Gómez-Alba, p. 158, pl. 79, fig. 10.
1993 *Dentalium* (*Antalis*) *fossile* Gmelin in Linnaeus, 1789 – Vera Peláez et al., p. 129–130, pl. 2, figs. 1, 2.
2004 *Antalis fossile* (Gmelin, 1790) – Vera Peláez and Lozano-Francisco 2004, p. 69, pl. 3, figs. 1, 2.
2018 *Dentalium* (*Antalis*) *fossile* Schröter, 1784 – Büyükmeriç et al., p. 139, pl. 4, fig. R1-2.
2022 *Antalis fossile* (Gmelin, 1790) – Benyoucef et al., p. 116–117, figs. 3M–O.

D e s c r i p t i o n. – The shell is of moderate size and moderately thick, and it reaches a length of up to 3 cm. It is slightly curved with visible growth lines and 28–32 primary wide and flattened axial ribs very close to each other in adult shells creating a serrated surface. Both the internal and external cross-sections are rounded.

D i s t r i b u t i o n. – This species is described from the Badenian of the CF from Poland (Korytnica Basin), and Moravia, from the Vienna Basin (Austria; Augusta et Buday 1938; Sieber, 1959; Bałuk 1972), and from the Middle (Caprotti,1979) and Late Miocene of the Mediteranean Sea (Italian Piedmont-Liguria region (Sacco, 1897; Ferrero Mortara et al., 1984). In the Pliocene, the species inhabited the Mediterranean Sea and occurs in Turkey, Syria, Tunisia, Morocco, Algeria (Fantinet, 1959; Malatesta, 1974; Benyoucef et al., 2022), Spain (Málaga and Guadalquivir), and Italy in the Piedmont-Liguria regions (Sacco, 1897; Ferrero Mortara et al., 1984; Vera Peláez et al., 1993).

C F i n M o r a v i a. – Sebranice 2 (OC), Sudice (L – Augusta et Buday 1938).

H a b i t a t. – This species preferred clayey sandy facies with detritus (Vera Peláez et al., 1993).

Antalis mutabilis (Hörnes, 1856)
(Fig. 3, pl. 3a, b)

1856 *Dentalium mutabile* Hoernes, p. 654, pl. 50, fig. 32.
1897 *Antalis novemcostatum* var. – Sacco, p. 102–104, pl. 8, fig. 59–70.
1928 *Dentalium novemcostatum* var. *mutabilis* Dod. – Friedberg, p. 560, pl. 36, figs. 24–25.
1960 *Dentalium novemcostatum mutabile* Dod. – Báldi, p. 56-57, pl. 1, fig 3.
1972 *Dentalium* (*Antalis*) *mutabile* Hörnes – Bałuk, p. 555-556, text fig 4, pl. 3, figs. 4–9.
1979 *Dentalium* (*Antalis*) *mutabile* Doderlein in Hörnes, 1856 – Caprotti, p. 232
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. 34
2018 *Antalis* cf. *mutabilis* (Hörnes, 1856) – Harzhauser et al., p. 160, pl. 10, fig. V.
2019 *Fissidentalium mutabilis* (Höernes, 1856) – Cardenas et al., p. 215, pl. 9, fig. e1–3.
2021 *Antalis mutabilis* (Hörnes, 1856 ex Doderlein ms) – Jovanović and Jovanović, p. 29, pl. 1, figs. 3a, 3b.

D e s c r i p t i o n. – This species is very variable. The shell is medium-sized and moderately curved in the apical part. The internal cross-section is circular, while the external one is predominantly octagonal with prominent primary ribs. These create a characteristic edge formed by 7–11 serrations (usually 8–9). The two primary ribs commonly occur on the concave side, and the remaining ribs are irregularly distributed over the other parts of the shell. Between the primary ribs, secondary ribs (usually only one secondary rib between two primary ribs) commonly occur. They are higher on the concave side. On the convex side there are one to two low secondary ribs, often found though they may be absent.

D i s t r i b u t i o n. – This taxon occurs from the Early Miocene (Karpatian) to the Middle Miocene (Badenian) in the Paratethys, from the Early Miocene (Burdigalian) to the Pliocene of the Mediterranean and in the Miocene of the North Sea Basin. In the Karpatian, it occurs widely in the Vienna Basin (in southern Slovakia, Modrý Kamen). In the late Burdigalian, it occurs in Italy (the Piedmont-Liguria region), France (the Aquitaine Basin) and Turkey (Anatolia; Báldi,1960). During the Badenian, this species occurred in the Vienna Basin (Steinabrunn; Pavia, 1991; Steiner and Kabat, 2004) and in southern Poland and Romania (Transylvania). In the Middle Miocene it occurred in northern Germany (Báldi,1960) and in Middle and Late Miocene in Italy (Piedmont-Liguria; Pavia 1991). According to Caprotti (2009), *Antalis mutabilis* is the ancestral form of the present-day *Antalis inaequicostatum* known from the Mediteranean Sea.

C F i n M o r a v i a. – Knínice – Kovářovice 2 (OC), Sebranice 2 (OC), Šebetov-Čtvrtě (OC), Knínice-South (OC), Borač (L – Turek, 2018, MZM), Lomnička (L – Procházka, 1892), Židlochovice (L – Procházka, 1893, MZM), Rudoltice (L – Procházka, 1895), Lažánky (L – Procházka, 1899), Olomučany (L – Procházka, 1899, MZM – collection), Černá Hora (L – Dvořák, 1952), Sudice (L – Augusta-Buday, 1938), Drnovice (MZM – Procházka's collection), Rudice (MZM).

H a b i t a t. – According to our findings, this species preferred mainly shallow water and fine-grained substrates.

Genus ***Paradentalium*** Cotton *et* Godfrey, 1933
Paradentalium michelottii Hörnes, 1856
(Fig. 3, pl. 4a, b)

1856 *Dentalium Michelottii* – Hörnes, p. 654, pl. 50, fig. 33.
1897 *Dentalium Michelottii* var.– Sacco, p. 96-97, pl. 7, figs. 84-96.
1906 *Dentalium michelottii* Hoernes var. costulatior – Boettger, p. 208–209.
1928 *Dentalium Michelottii* Hoern. – Friedberg, p. 559, pl. 36, figs. 22–23.
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* Hörnes – Kókay, p. 67.
1972 *Dentalium* (*Dentalium*) *michelottii* – Bałuk, p. 549-550, pl. 6, fig. 1.
1974 *Dentalium* (*Dentalium*) *michelottii* Hörnes – Malatesta, p. 2, pl. 1, fig. 2.
1979 *Dentalium* (*Dentalium*) *michelottii* Hörnes, 1856 – Caprotti, p. 220, pl. 2, figs. 1–4.
1984 *Dentalium* (*Dentalium*) *michelottii* Hörne – Ruggieri and Davoli, p. 76, pl. 15, figs. 7 a–c, 8 a, b.
1991 *Dentalium* (*Dentalium*) *michelottii* Hoernes, 1856 – Pavia, p. 111–112, pl. 1, figs. 1–3.
1993 *Dentilium* (*Dentilium*) *michelottii* Hörnes, 1856 – Vera Peláez et al., p. 127–128, pl. 1, figs. 14–18.
2004 *Dentalium michelottii* Hörnes, 1856 – Vera Peláez and Lozano-Francisko, p. 64, pl. 1, figs. 9-11, 31.
2009 *Paradentalium michelottii* (Hörnes, 1856) – Caprotti, p. 41.
2021 *Paradentalium michelottii* (Hörnes, 1856) – Jovanović and Jovanović, p. 30–31, pl. 2, fig. 1.
2022 *Paradentalium michelottii* (Hörnes, 1856) – Benyoucef et al., p. 115, figs. 3A, B.

D e s c r i p t i o n. – The shell is usually medium-sized and slightly curved. The internal cross-section is circular along the entire length of the shell; the external cross-section is hexagonal and formed by 6 primary ribs on the shell surface. In some places, secondary ribs form between the primary ribs, but they weaken and disappear towards the top of the shell. The intercostal space is wide and concave. The surface of the shell between the ribs seems to be quite smooth, but barely noticeable growth lines appear.

D i s t r i b u t i o n. – The taxon occurs from the Early Miocene (Burdigalian) to the Early Pleistocene in the Mediterranean Sea and in the Middle Miocene (Badenian) of the Paratethys. It has been found in the Miocene and Pliocene sediments of the Italian Piedmont-Liguria region (Sacco, 1897; Pavia, 1991; Vera Peláez and Lozano-Francisco, 2004). In the Middle Miocene, it expanded to the Vienna Basin (Austria; Hörnes 1856; Caprotti, 1979), and to the CF as far as Poland (Hörnes, 1856; Bałuk, 1972; Pavia, 1991; Vera Peláez and Lozano-Francisco, 2004). In the Pliocene of the Mediterranean Sea, in addition to Italy, it occurred in southern France (Sacco, 1897; Malatesta, 1974; Caprotti, 1979), Spain (Estepona and Mijas), Turkey and Algeria (Chelif Basin; Fantinet, 1959; Vera Peláez et al., 1993; Vera Peláez and Lozano-Francisco, 2004; Büyükmeriç et al., 2018; Benyoucef et al. 2022). In the Early Pleistocene it occurred in the Mediterranean Sea (Malatesta, 1974; Pavia, 1991). Recently, this species may have been found in the Indian Ocean (Boissevain, 1906; Steiner and Kabat 2004), however, this finding requires confirmation.

C F i n M o r a v i a. – Borač (OC, L – Turek, 2018, MZM), Lomnička (L – Procházka, 1892), Židlochovice (L – Procházka, 1893), Rudoltice (L – Procházka, 1895), Lažánky (L – Procházka, 1899), Sudice (L – Augusta and Buday, 1938), Olomučany (MZM).

H a b i t a t. – Mainly shallow coastal sands (Vera Peláez et al., 1993, Vera Peláez and Lozano-Francisco, 2004).

Genus ***Fissidentalium*** Fischer, 1885
Fissidentalium badense (Partsch in Hörnes, 1856)
(Fig. 3, pl. 1a, b)

1856 *Dentalium Badense* – Hörnes, p. 652, pl. 50, fig. 30.
1897 *Entalis badensis* var. – Sacco, p. 107–108, pl. 9, figs. 17–26, 28–30.
1925 *Dentalium* (*Entalis*) *badense* var. *borealis* Kautsky – Kautsky, p. 53–54, pl. 5, fig. 12.
1928 *Dentalium badense* Partsch – Friedberg, p. 557–558, pl. 36, fig. 17–19.
1929 *Dentalium badense* (Partsch) – Šuklje, p. 52.
1947 *Dentalium* (*Fissidentalium*) *badense* Partsch – Tauber, p. 302, pl. 7, figs. 8–10, pl. 8, fig. 3.
1960 *Dentalium* (*Entalis*) *badensis* Partsch in Hoernes – Kojumdgieva and Strachimirov, p. 225, pl. 52, figs. 19–20.
1960 *Dentalium badense* Partsch – Báldi, p. 57, pl. 1, fig. 5.
1972 *Dentalium* (*Antalis*) *badense* Partsch in Hörnes – Bałuk, p. 551, pl. 2, figs. 1–3.
1979 *Dentalium* (*Antalis*) *badense* Partsch in Hörnes, 1856 – Caprotti, p. 228. pl. 5, figs.1–2.
1991 *Fissidentalium badense* (Partsch in Hoernes, 1856) – Pavia, p. 146–148, pl. 5, fig. 4; pl. 6, fig. 6.
1998 *Dentalium badense* Partsch – Jovanović and Jovanović, p. 201-202.
1998 *Dentalium* (*Antalis*) *badense* Partsch – Schultz, p. 76, pl. 31, fig. 12.
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 and Bošnjak, p. 195–200, pl. 1, figs. 1–6.
2021 *Fissidentalium badense* (Partsch in Hörnes, 1856) – Jovanović and Jovanović, p. 28, pl. 1, figs. 1 a–c.

D e s c r i p t i o n. – The shell is usually large, massive and slightly curved with a circular or slightly elliptical cross-section. Radial ribs and growth lines are visible on the shell. On the top of the shell, there are 8–10 sharp primary ribs, lowering and widening towards the aperture. At different distances and sections from the apex, secondary ribs appear between the primary ones, and they reach a similar size in their lower portion; it is therefore difficult to distinguish them from the primary ones in shell fragments.

D i s t r i b u t i o n. – *Fissidentalium badense* is found on many places in the Mediterranean and Paratethyan regions (Lecointre, 1952), from the Early Miocene (Burdigalian; Sacco, 1897) to the earliest Late Miocene (Cossman and Peyrot, 1917). In the Early Miocene (Burdigalian), it occurred in the Mediterranean Sea France (Saubrigues), Italy (Piedmont-Liguria), and in the Eggenburgian-Karpatian in the Paratethys (the Vienna Basin - southern Slovakia; Báldi, 1960; Caprotti, 1979). Its main distribution occurred during the Middle Miocene (Badenian; Robba, 1972), especially in the Paratethys, where it was a typical part of the fauna (Pavia, 1991): the Pannonian Basin (Hungary – Sopron, Letkés, Devecser, Várpalota), the Vienna Basin (Austria and southern Slovakia; Báldi, 1960), and the CF (southern Poland; Bałuk, 1972). In the Late Miocene it has been documented in northern Germany and in the Pliocene of Italy – Piedmont-Liguria (Báldi, 1960; Caprotti, 1979).

C F i n M o r a v i a. – Sebranice 1 (OC), Sebranice 2 (OC), Šlapanice (OC), Skalice nad Svitavou (OC), Borač (L – Turek, 2018, MZM), Lomnička (L – Procházka, 1892, MZM), Židlochovice (L – Procházka, 1893), Lažánky (L – Procházka, 1899, MZM), Jedovnice (L – Procházka, 1899, MZM), Olomučany (L – Procházka, 1899, MZM – Procházka's collection), Židlochovice (L – Šob, 1939), Černá Hora (L – Dvořák, 1952), Drnovice (MZM – Procházka collection), Židlochovice (MZM), Rudice (MZM), Lysice (MZM).

H a b i t a t. – Soft silty and muddy substrates (Jovanović and Bošnjak, 2016).

Order **Gadilida** Starobogatov, 1974
Suborder **Gadilimorpha** Steiner, 1992
Family **Gadilidae** Stoliczka, 1868
Subfamily **Gadilinae** Stoliczka, 1868
Genus ***Gadila*** Gray, 1847
Gadila ventricosa (Bronn, 1827)
(Fig. 3, pl. 8a, b)

1897 *Gadila gadus* (Montg.) – Sacco, p. 116–117, pl. 10, fig. 79.
1897 *Gadila gadus* var. *ventricosa* (Bronn) – Sacco, p. 117, pl. 10, figs. 80–85.
1898 *Cadulus olivii* (Scacchi) – Locard, p. 134, pl. 7, figs. 8–15.
1950 *Cadulus* (*Gadila*) *gadus* (Montagu) – Nicklès, p. 99, fig. 3.
1959 *Gadila gadus* (Montagu) var. *ventricosa* (Bronn) – Fantinet, p. 53, pl. 9, fig. 1.
1979 *Cadulus* (*Gadila*) *ventricosus* (Bronn, 1827) – Caprotti, p. 249, pl. 14, figs. 1–4.
1988 *Cadulus* (*Gadila*) *ventricosus* (Bronn) – Gómez-Alba, p. 160, pl. 79, figs. 16, 17.
1991 *Gadila ventricosa* (Bronn, 1827) – Pavia, p. 139–144, pl. 8, figs. 9–14.
1993 *Cadulus* (*Gadila*) *ventricosus* (Bronn, 1827) – Vera Peláez et al., p. 139–140, pl. 4, figs. 1. 2, 4, 5; pl. 5, fig. 7.
2004 *Cadulus* (*Gadila*) *ventricosus* (Bronn, 1827) – Vera Peláez and Lozano-Francisko, p. 86–87, pl. 6, figs. 1–3, 9, 10.
2011 G*adila ventricosa* (Bronn,1827) – Caprotti, p. 75.
2019 *Gadila ventricosa* (Bronn, 1827) – Cardenas et al., p. 215, pl. 9, fig. h.

D e s c r i p t i o n. – The shell is small, thin, and significantly curved. Its surface is smooth, without sculpture or growth lines, and white with a porcelaneous gloss. The cross-section is circular to elliptical (slightly flattened) along the entire length of the shell. A distinct and characteristic feature of this species is the marked compression and bulging in the anterior quarter of the shell, as a result of which the greatest diameter is not at the aperture, but ~3/4 to 4/5 along the shell length.

Distribution: This species occurs in the Badenian deposits of the Central Paratethys (Vienna Basin) and in the Middle and Late Miocene of the Mediterranean region (Italy – Piedmont-Liguria; Pavia, 1991; Vera Peláez and Lozano-Francisco, 2004). During the Pliocene, it was widespread throughout the Mediterranean region, and it has been documented in Israel, Italy, Morocco, southern France, and Spain (Málaga; Cossman and Peyrot, 1917; Pavia, 1991; Vera Peláez et al., 1993; Vera Peláez and Lozano-Francisco, 2004).

C F i n M o r a v i a. – Knínice-Kovářovice 6 (OC), Knínice-Kovářovice 2 (OC), Sebranice 2 (OC), Olomučany (L – Procházka, 1899, MZM – Procházka´s collection), Sudice (L – Augusta-Buday, 1938), Drnovice (MZM – Procházka's collection), Židlochovice (MZM), Lažánky (MZM), Rudice (MZM).

H a b i t a t. – Coastal sandy sediments (Vera Peláez et al., 1993).

Suborder **Entalimorpha** Steiner, 1992
Family **Entalinidae** Chistikov, 1979
Subfamily **Entalininae** Chistikov, 1979
Genus ***Entalina*** Monterosato, 1872
Entalina tetragona (Brocchi, 1814)
(Fig. 3, pl. 7a, b)

1856 *Dentalium tetragonum* Brocchi – Hörnes, p. 655, pl. 50, fig. 34.
1897 *Entalina tetragona* (Br.) – Sacco, p. 114, pl. 10, figs. 47–53.
1897 *Entalina tetragona* var. *paucistriata* Sacc. – Sacco, p. 114, pl. 10, figs. 54–55.
1947 *Entalina tetragona* Brocc. – Tauber, p. 301, pl. 7, fig. 1–4.
1955 *Dentalium* (*Dentalium*) *tetragonum* (Brocchi) – Rossi Ronchetti, p. 342, fig. 185.
1960 *Entalina tetragona* (Brocc.) – Báldi, p. 55, pl. 1, fig. 6.
1962 *Entalina viallii* – Caprotti, p. 97, pl. 16, figs. 1–3.
1970 *Entalina tetragona* (Brocchi) – Parenzan, p. 230, pl. 49, fig. 954.
1972 *Entalina tetragona* (Brocchi, 1814) – Bałuk, p. 561–562, text fig. 8, pl. 5, fig. 6–8.
1979 *Entalina quinquangularis* (Forbes, 1843) – Nicklès, p. 61–62, fig. 17.
1979 *Entalina tetragona* (Brocchi, 1814) – Caprotti, p. 251, pl. 13, figs. 4–8.
1991 *Entalina tetragona* (Brocchi, 1814) – Pavia, p. 132–133, pl. 8, figs. 7, 8.
1992 *Entalina tetragona* (Brocchi, 1814) – Cossignani et al., p. 40, fig. 411.
1993 *Entalina* (*Entalina*) *tetragona* (Brocchi, 1814) – Vera Peláez et al., p. 138–139, pl. 4, figs. 6–8.
1993 *Entalina tetragona* (Brocchi) – Poppe and Goto, p. 35, pl. 1, fig. 12.
1997 *Entalina tetragona* (Brocchi, 1814) – Steiner, p. 103, fig. 2, 5A.
2004 *Entalina tetragona* (Brocchi, 1814) – Vera Peláez and Lozano-Francisko, p. 92, pl. 7, figs. 2–5, 8, 9.
2011 *Entalina tetragona* (Brocchi,1814) – Caprotti, p. 75.
2019 *Entalina tetragona* (Brocchi, 1814) – Cardenas et al., p. 215, pl. 9, fig. f.

D e s c r i p t i o n. – The shell is small and thin-walled. The internal and external cross-section of the apex is quadrangular due to the primary ribs on the shell edges. The dorsal side of the shell is concave and there is one significant rib in the centre (occasionally two sharp ribs). These ribs gives a pentagonal cross-section to the shell at its aperture. The number of secondary ribs increases with the size of the shell.

D i s t r i b u t i o n. – This species occurred from the Early Miocene to the Recent. During the Early Miocene, it was widespread in the Mediterranean Sea (Italian regions of Piedmont-Liguria and the Torino Hills; Pavia 1991), and in the Paratethys – Hungary (Szokolya; Báldi, 1960). During the Badenian, it was known in the Central Paratethys – CF (Poland – Korytnica, Wieliczka etc.; Bałuk, 1972), the Vienna Basin (Hörnes, 1856; Sieber, 1959) and the Pannonian Basin (Hungary) and from the Mediterranean Sea (Italy – Piedmont-Liguria; Caprotti, 1979; Pavia, 1991; Vera Peláez and Lozano-Francisco, 2004). It has been documented in Pliocene deposits of the Mediterranean Sea in Spain (Málaga-Cuenca de Estepona; Báldi, 1960; Caprotti, 1979) and Italy (Piedmont-Liguria region; Vera Peláez et al., 1993). Today, it occurs in the Mediterranean Sea, Adriatic Sea, the East Atlantic – the Bay of Biscay, Norway (Caprotti, 1979; Pavia, 1991; Cossignani et al., 1992).

C F i n M o r a v i a. – Knínice-Kovářovice 2 (OC), Knínice-Kovářovice 5 (OC), Doubravník-V Propadlí (OC), Sebranice 2 (OC), Sebranice 1 (OC), Sebranice (MZM), Šebetov-Čtvrtě (OC), Šebetov-South (OC), Šebetov-North (OC), Borač (OC, L – Turek, 2018, MZM), Lomnička (L – Procházka, 1892), Židlochovice (L – Procházka, 1893, MZM), Lažánky (L – Procházka, 1899), Černá Hora (L – Dvořák, 1952).

H a b i t a t. – This extant species has been recorded thriving at depths spanning from 68 to 2664 m. It prefers mainly fine-grained clayey-silty substrates (Pavia 1991; Steiner and Kabat 2004).

In addition to the above-mentioned species, Augusta and Buday (1938) also noted *Dentalium bouéi* and *Dentalium entalis* at the Sudice locality; however, these specimens are neither illustrated nor described in their publication, nor have they been found in depositories or during field research. Therefore, their occurrence in the CF in Moravia cannot be unequivocally confirmed.

FOSSILS – STATES OF PRESERVATION

Based on analyses of the data obtained, the state of preservation of the fossil samples obtained from the dug trenches does not differ significantly from those obtained from surface collections. The smaller shells are mostly well-preserved and can be determined to species level. The best state of preservation was observed among the shells of *Entalina tetragona, Gadila ventricosa, Omniglypta jani,* and *Omniglypta emersoni*, which are mostly relatively small in size. By contrast, the larger shells, mainly *Fissidentalium badense*, but also *Antalis mutabilis* and *Antalis fossilis*, were often damaged or broken. The material from the depositories does not differ significantly from new samples; the depositories, however, house a higher proportion of complete shells, as they were specifically selected for museum and exhibition purposes. Particularly at sites with a large number of specimens (Šebetov-Čtvrtě, Sebranice 1, Knínice-South), we found common predation traces on shells, likely caused by naticid (the species *Euspira helicina* was found at the sites), or muricid gastropods (ichnogenus *Oichnus*), and decapods (ichnogenus *Caedichnus)*. Some predation traces had healed, which indicates the individual's survival. At the Knínice-Kovářovice site, two shells of *Antalis mutabilis* and one of *Gadila ventricosa* with probable traces of the original surface colours were discovered.

NOTES ON PALAEOECOLOGY

Scaphopods are a cosmopolitan group of marine animals; they are mostly stenohaline and live from the intertidal zone down to a depth of 6000 m. They prefer fine-grained substrates (mostly sandy or clayey) which they burrow into with their strong legs to the extent that only the apex of the shell protrudes from its surface (Knudsen, 1964; Bałuk, 1972; Lamprell and Healy, 1998). Fine-grained deposits (sandy clays, calcareous clays) were found at all the localities we studied. These localities can be divided into two groups based on the nature of the sediment.

In the first group, we observed solid grey, calcareous clay with minimal admixtures of coarser particles (Šebetov-Čtvrtě, Šebetov-North, Sebranice 2, Knínice-South, Doubravník-V Propadlí, and Šlapanice sites). These deposits mostly correspond to calmer and often deeper environments that lack significant input of clasts from the mainland (circalittoral, ~100 m); and they are inhabited by *Antalis mutabilis* and *Entalina tetragona*. Since these species prefer fine-grained substrates, the likely conclusion is that this is their original habitat. The exception is the Borač locality, which is also primarily made up of grey calcareous clay, but with abundant admixtures of sand with clasts of gneiss, and indeterminable fragments of shells of molluscs, corals, and brachiopods. This coarser-grained material was probably derived from a shallower, or more dynamic, environment.

In addition to scaphopods, other molluscs preferring fine-grained clay substrates (the gastropods *Euspira helicina* and *Oligodia spirata*, and bivalves *Varicorbula gibba* and *Limopsis anomala*) were found at these localities. *Varicorbula gibba* is an opportunistic species that appears at most localities, and larger numbers of individual specimens may indicate environmental stress or the first settlement of a new area (Dulai, 1996; Hrs-Brenko, 2006; Schneider, 2008).

At the localities belonging to the second group (Knínice-Kovářovice and Sebranice 1), the clay was yellowish and sandy, with frequent boulders of algal and sandy limestones and calcareous sandstones. This deposit corresponds to a shallow local coastal environment with higher dynamics (infralittoral, <50 m). This is determined by the presence of *Gadila ventricosa*, *Antalis fossilis*, *Omniglypta jani* and *Omniglypta emersoni,* bound to the sandy or clayey-sandy sediments (Caprotti, 1979; Vera Peláez et al., 1993).

Along with scaphopods, other molluscs also preferring predominantly fine-grained, sandy-clayey substrates were found at the Knínice-Kovářovice and Sebranice 1 localities, such as the gastropod species *Ptychidia vindobonensis* and *Euspira helicina*, and the bivalve *Glycymeris deshayesi* (Dulai, 1996; Schneider, 2008). *Fissidentalium badense* was found both in circalittoral and infralittoral localities, and it can therefore be assumed that it had a greater depth distribution (Riedi, 1986; Steiner and Kabat, 2004; Jovanović and Bošnjak, 2016).

The species composition of the scaphopods from the Moravian Museum collections mostly matches the new finds from the field research, thus corroborating the palaeoecological interpretations noted above. We cannot exclude, however, that the material from some localities could have been somehow influenced (e.g., the preferential collection of larger specimens, the selection of better-preserved individuals, or the registration of different localities from around the same village under the same name); for this reason, samples from the depositories cannot be used for more reliable palaeoecological analyses.

DISCUSSION

Most of the scaphopod species found were previously documented in the CF in Moravia, mainly thanks to the work of Procházka (1892, 1893a, b, 1899). Procházka's material is stored in the Moravian Museum depository, and during re-examination, it was found that most of Procházka's determinations correspond to current classifications. The only exception is *Omniglypta emersoni*, a species established by Caprotti (1979) and distinct from the species *Omniglypta jani*, to which Procházka assigned all the specimens he found.

By comparison with older publications, we found certain quantitative differences in the representations of some scaphopod species at individual localities. For example, Šob (1939) and Dvořák (1952) most often mention *Fissidentalium badense*, which was also found in the largest number of localities in the MZM depository; however, during our new field research, this species was only found at the Sebranice 1 and 2 and Šlapanice localities. Considering that this is the largest scaphopod occurring in Moravia, in the past, it was probably found more often than other, smaller species that were more frequently overlooked. Similarly, in the literature, mentions of *Paradentalium michelotti* are more frequent; but in the depositories, it was found only at the Olomučany and Borač localities (where we also discovered it during our field research). This species was not depicted, however, in older publications, so it cannot be excluded that it could have been confused with the similar species *Antalis mutabilis*. Conversely, *Entalina tetragona* was found in the MZM depository only at a few locations, while it is abundant in the material we found. This may be due to the smaller size of its shells, or to the fact that it was bound to deeper water environments, commonly with fewer fauna, which earlier collectors could have ignored. Only *Gadila ventricosa* and *Antalis mutabilis* are numerous in both collections and among new samples from our field research.

Antalis fossilis is the only species that was not recorded in the collections and it is listed only in the table of species from the Sudice locality (Augusta and Buday, 1938). We recently found it only at the Sebranice 2 locality, though there it was abundant. Since the Sudice and Sebranice 2 localities are close to each other, it cannot be ruled out that the occurrence of this species was limited to this area only (and to similar facies of the same age?).

Augusta and Buday (1938) also noted *Dentalium bouéi* and *Dentalium entalis* but they did not publish descriptions or images of them; furthermore, the depositories do not have samples of these species, and they were not found in our new field research; thus, their presence in the CF in Moravia cannot be confirmed. The scaphopod species recovered were widespread during the Badenian and are known from several localities in the Paratethys and Mediterranean regions (Sacco, 1897; Friedberg 1928; Bałuk, 1972; Caprotti, 1979; Ferrero Mortara et al., 1984; Vera Peláez et al., 1993). *Paradentalium michelottii* and *Omniglypta jani* are known in the Paratethys only from the Badenian, and afterwards their occurrence is limited to the Mediterranean region, where they disappeared during the Pliocene. Their disappearance in the Paratethys may have been caused by the loss of connections to the open sea at the end of the Badenian and the associated environmental changes. The most widespread species is *Entalina tetragona*, preferring greater depths with clayey-silty substrates (Pavia, 1991). It also spread to the eastern Atlantic and, together with the Mediterranean region (in contrast to the Paratethys), it has been documented at greater depths in Recent. *Gadila ventricosa* and *Antalis fossilis* are bound to mainly shallow water environments (Vera Peláez et al., 1993), which our new research also corroborates. According to Caprotti (1979) and Vera Peláez et al. (1993), *Omniglypta jani* and *Omniglypta emersoni* mainly lived in the sandy sediments of deeper seas. Considering that we found them only at localities with shallow-water molluscs and corals, it is likely that they inhabited sandy sediments of shallower depths in the CF in Moravia, unlike at the Italian and Spanish localities.

Paradentalium michelottii is an extinct species that inhabited shallow-water coastal sands (Vera Peláez et al.,1993; Vera Peláez and Lozano-Francisco, 2004). It occurs relatively rarely in the CF in Moravia, being noted in the literature from several localities with a shallow-water fauna (Lomnička, Židlochovice, Rudoltice, Lažánky, Sudice); there is also an individual specimen from Olomučany in the collections of the MZM. During our new field research, we recovered it only at Borač, where the total number of individuals was low and shells were broken or abraded. Thus, it can be presumed that they were redeposited here from their original shallow-water environments into deeper parts of this sedimentation area. This corresponds with the interpretation of a deep-water palaeoenvironment at the Borač site. The rare occurrence of this species at other localities may also be due to competition from other scaphopod species.

Comparative analysis of scaphopods from various Badenian localities of the Central Paratethys was not the subject of this work, but it could undoubtedly provide insights into their distribution. For example, just a cursory comparison of our localities with the Badenian localities of Višnjica near Belgrade (Serbia, Pannonian Basin) and Korytnica on the southern slopes of the Holy Cross Mountains (Poland, CF) indicates both certain similarities and differences. In the CF in Moravia, 8 species of scaphopods were found. Bałuk (1972) described 13 species from Korytnica (Poland), 6 of which are also known from the Moravian part of the CF. *Entalina tetragona* and *Antalis fossilis* are common species for the CF. Jovanović and Jovanović (2021) note 10 species from Višnjica (Serbia, Pannonian Basin), 5 of which are identical with those described by us. At the same time, four species, namely *Omniglypta jani*, *Antalis mutabilis*, *Paradentalium michelottii*, and *Fissidentalium badense*, occur in all three areas (Poland, Czech Republic, Serbia). This may indicate their distribution throughout the Paratethys region. The species *Omniglypta emersoni* mentioned by Jovanović and Jovanović (2021) was described only in 1979, hence Bałuk could not include it in his 1972 work, but its occurrence in the Polish part of the CF seems highly probable.

CONCLUSIONS

Our research has shown that in the lower Badenian deposits of the CF in Moravia, scaphopods are more abundant than previously assumed. In total, 6 genera with 8 species were identified. The presence of *Entalina tetragona*, *Gadila ventricosa*, *Omniglypta jani*, *Fissidentalium badense*, *Antalis mutabilis*, *Antalis fossilis* and *Paradentalium michelottii* was confirmed, and *Omniglypta emersoni* was newly documented. The material comes from the Knínice-Kovářovice 1–7, Šebetov-Čtvrtě, Šebetov-North, Sebranice 1 and 2, Knínice-South, Borač, Doubravník-V Propadlí, and Šlapanice localities, of which three (Knínice-Kovářovice 1–7, Šebetov-Čtvrtě and Šebetov-North) are described for the first time.

Small shells of *Entalina tetragona*, *Gadila ventricosa*, *Omniglypta jani,* and *Omniglypta emersoni* were among the best preserved. In turn, large shells of *Fissidentalium badense*, *Antalis mutabilis* and *Antalis fossilis* were significantly damaged and often cracked. At the Šebetov-Čtvrtě, Sebranice 1, Knínice-North localities, some traces of attacks from naticid or muricid gastropods (*Oichnus* isp.) and decapods (*Caedichnus* isp.) were observed on the shells. These predation traces had occasionally healed, indicating the survival of some individuals. At the Knínice-Kovářovice locality, there were probable traces of the original shell colours found on two individuals of *Antalis mutabilis* and one specimen of *Gadila ventricosa*.

According to the character of the substrate, the studied localities can be divided into two groups. The first includes Šebetov-Čtvrtě, Šebetov-North, Sebranice 2, Knínice-South, Doubravník-V Propadlí, and Šlapanice. Here, the presence of solid grey, calcareous clays with minimal admixtures of coarser particles is common, which corresponds to a circalittoral environment (~100 m); and is characterised by the presence of *Antalis mutabilis* and *Entalina tetragona*. At the Borač site, a significant admixture of sand with gneiss clasts and macrofauna, apparently redeposited from a shallower or more dynamic environment, appears in the grey, calcareous clays.

The localities of the second group (Knínice-Kovářovice and Sebranice 1) show yellowish, sandy clay with frequent boulders of algal and sandy limestone and calcareous sandstone, corresponding to an infralittoral environment (<50 m). This is characterised by the presence of *Gadila ventricosa*, *Antalis fossilis*, as well as *Omniglypta jani* and *Omniglypta emersoni*, which are reported at Spanish and Italian localities from the circalittoral zone (Caprotti 1979; Vera Peláez et al. 1993). *Fissidentalium badense* was found at localities of both groups and therefore its greater depth distribution can be presumed (Riedl, 1986; Steiner and Kabat, 2004; Jovanović and Bošnjak, 2016).

Paradentalium michellotii, according to Vera Peláez et al. (1993) and Vera Peláez and Lozano-Francisco (2004), is confined to a shallow-water environment and is known to occur in the Moravian part of the CF mainly from the literature. We documented its presence only at the Borač locality, interpreted as circalittoral, but only through a smaller number of individuals with broken and abraded shells. Therefore, it is likely that these were transported from shallower (infralittoral) waters.

Acknowledgements. The authors thank doc. RNDr. Nela Doláková, CSc. from the Institute of Geological Sciences, Faculty of Science, Masaryk University in Brno for valuable advice and stimulating comments on the text, Mgr. Gabriela Calábková, Ph.D., Moravian Museum Brno, for effective help in the technical processing of the manuscript, and Abigail Mokra, M.A. et M.A. for the language proofreading of the text. The authors would also like to thank the reviewers: Univ. Prof. Dr. Mathias Harzhauser; dr hab. Barbara Studencka prof. PAN and dr Gordana Jovanović for their comments and improvements to the work. This study was funded by the institutional support of long-term conceptual development of research institutions provided by the Ministry of Culture of the Czech Republic (ref. MK000094862).

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