FOLIA MALACOLOGICA
Folia Malacol. 34(1): 43–68
ISSN 1506-7629 (print) • ISSN 2300-7125 (on-line)
The Association of Polish Malacologists
Faculty of Biology, Adam Mickiewicz University
Bogucki Wydawnictwo Naukowe
Poznań, March 2026
https://doi.org/10.12657/folmal.034.005

MIDDLE MIOCENE (BADENIAN) TURRITELLIDAE (GASTROPODA: CAENOGASTROPODA) ASSEMBLAGES FROM DEVÍNSKA NOVÁ VES (VIENNA BASIN, SLOVAKIA): AN OVERVIEW, NEW KNOWLEDGE, AND PALEOECOLOGY

RADOSLAV BISKUPIČ

Independent researcher, Ludvíka Svobodu 29, 085 01, Poprad, Slovak Republic
(e-mail: biskupic.radoslav@gmail.com); https://orcid.org/0000-0003-1923-4977

ABSTRACT: A comprehensive overview of the Upper Badenian (Middle Miocene) gastropods of the family Turritellidae Lovén, 1847 from Devínska Nová Ves (Bratislava, Vienna Basin, Slovakia) is presented in this study. Rich conchological materials were obtained from six paleontological localities (Závaterná, Kasárne, Bačnegovice, Útočnice, Sandberg, Vodojem), comprising re-examined specimens from institutional collections and newly collected, specimen-rich material. The turritellids from the Brickyard locality, only known from the literature, are discussed but not evaluated. The materials from the little-known localities Záveterná, Útočnice, and Vodojem are studied for the first time. Altogether 1,007 specimens of turritellids were surveyed, of which eight species attributed to five genera were recognised. The occurrences of *Archimediella carpathica* Harzhauser et Landau, 2019 and *Viennella* sp., that have not been previously known from Devínska Nová Ves, are confirmed herein. The taxonomic status of the enigmatic species *Turritella neudorfensis* Toula, 1900, is more comprehensively discussed. Nevertheless, its generic placement remains unclear and is considered taxon inquirendum. The Turritellidae assemblages were predominantly associated with shallow-water marine, inner neritic habitats with seagrass meadows. The stratigraphic and geographic distributions of the respective species in Slovakia are summarised, and their paleoecology is discussed.

KEY WORDS: Central Paratethys; Gastropoda; Middle Miocene (Badenian); Turritellidae; Vienna Basin

INTRODUCTION

In the Middle Miocene Vienna Basin, which represented an embayment located in the north-western periphery of the Central Paratethys Sea (KOVÁČ et al. 2008, LAMBERT et al. 2008), the members of the family Turritellidae Lovén, 1847 represented significant elements in the gastropod assemblages (cf. HÖRNES 1855, HANDMANN 1882, SIEBER 1958a, 1960, ŠVAGROVSKÝ 1981a, 1982, HARZHAUSER & LANDAU 2019, BISKUPIČ 2023a, 2023c).

From several fossil-bearing localities in the Slovak part of the Vienna Basin, namely in the area of Devínska Nová Ves (formerly also known as Theben – Neudorf, Neudorf an der March, Dévény – Ujfalu), the borough of the city of Bratislava, Turritellidae gastropods were reported by numerous authors. The first mentions of the Middle Miocene turritellids from the study area were given by KORNHUBER (1865) and FUCHS (1868). They were mentioned by SCHAFFER (1898) and TOULA (1900) from a former clay pit of the locality Brickyard, with the description of a new species, *Turritella neudorfensis* Toula, 1900. Subsequently, SCHAFFER (1908) and HORUSITZKY (1917), from the famous fossiliferous site of Sandberg, and SIEBER (1958b), from an unspecified locality, briefly reported on the molluscan faunas, including the Turritellidae. Much later, ŠVAGROVSKÝ (1981a) studied in detail the molluscan assemblages across a wide area of Devínska Kobyla Hill and identified three turritellid

OPEN ACCESS
This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
CC BY 4.0
Copyright © The Association of Polish Malacologists 2026

species from Devínska Nová Ves. Three taxa belonging to this gastropod group were listed in the unpublished manuscript of ONDREJIČKOVÁ (1987). Later, the marine faunas collected from several localities of the Devínska Kobyla Hill were analysed by HYŽNÝ et al. (2012), who recognised two Turritellidae species from Sandberg. In the list of the fauna, RUMAN & HUDÁČKOVÁ (2015) mentioned six species from the Útočnice locality. Finally, the turritellids originating from Devínska Nová Ves, illustrated in ŠVAGROVSKÝ (1981a), were revised by HARZHAUSER & LANDAU (2019).

The Turritellidae material reported by SCHAFFER (1898) and TOULA (1900) from Brickyard is unavailable. No additional specimens were found there, as suggested by the research results of TOULA (1915), SENEŠ & CICHA (1973), ŠVAGROVSKÝ (1981a), TOMAŠOVÝCH (1998) and RUMAN & HUDÁČKOVÁ (2015), the author´s field works in the 90s, and the revision of the institutional collection of the Natural History Museum of the Slovak National Museum, Bratislava. Also, no shells are to be found in the Natural History Museum Vienna collections. A poorly known, almost forgotten species described from the locality, *Turritella neudorfensis* Toula, 1900, is only known from the literature. The species was not included in the comprehensive monograph on Miocene Turritellidae gastropods from the Paratethys Sea by HARZHAUSER & LANDAU (2019). Moreover, the shell description of TOULA (1900) is very brief and insufficient. Since its discovery, the taxon has not been discussed or re-examined in detail, has remained poorly understood, and its taxonomic status has remained unclear and problematic. According to MOLLUSCABASE (2025), the species is considered a taxon inquirendum. Thus, further re-examination and clarification would be needed. Since the type material seems to be lost, only the original description and illustrations provided by TOULA (1900) serve as the basis for the revision presented herein, which limits its convincing genus-level placement.

As this study shows, many specimens stored in institutional collections and some shells published in previous papers have often been incorrectly determined. Although some misidentified species mentioned by ŠVAGROVSKÝ (1981a) were clarified by HARZHAUSER & LANDAU (2019), an additional, comprehensive re-examination of turritellids from the studied area would be needed. Moreover, other paleontological localities were discovered more recently, yielding new yet unpublished conchological material.

GEOLOGICAL SETTINGS AND STRATIGRAPHY

The surveyed area is situated in the Slovak part of the Vienna Basin (Záhorská nížina Lowland), at Devínska Nová Ves (borough of the city of Bratislava) (Fig. 1). The examined material originates from the Middle Miocene marine deposits, that were stratigraphically ascribed to the Central Paratethyan Upper Badenian (Fig. 2) regional stage (ŠVAGROVSKÝ 1981a, BARÁTH et al. 1994, TOMAŠOVÝCH 1998, HOLEC 2001, HYŽNÝ et al. 2012, RUMAN & HUDÁČKOVÁ 2015), corresponding to the early Serravallian in the standard chronostratigraphy (e.g., HARZHAUSER & PILLER 2007, PILLER et al. 2007, KOVÁČ et al. 2004, 2017, 2018, PELECH et al. 2021). The sediments are dated to the *Bolivina-Bulimina* Biozone (e.g., HUDÁČKOVÁ & KOVÁČ 1993, HUDÁČKOVÁ & SPEZZAFERRI 2002, HYŽNÝ et al. 2012) and the NN6 nannoplankton Zone (e.g., LEHOTAYOVÁ 1977, HUDÁČKOVÁ & SPEZZAFERRI 2002, JAMRICH & HALÁSOVÁ 2010). The Upper Badenian sediments include the clayey Studienka Member belonging to the Hrušky Formation sensu KOVÁČ et al. (2024), and coarse-grained marginal sediments of the clastic Stupava Formation and the limestone Sandberg Formation (JAMRICH et al. 2024).

Brickyard. The site is located in the northern part of Devínska Nová Ves (48°13'42.3"N, 16°58'24.4"E),

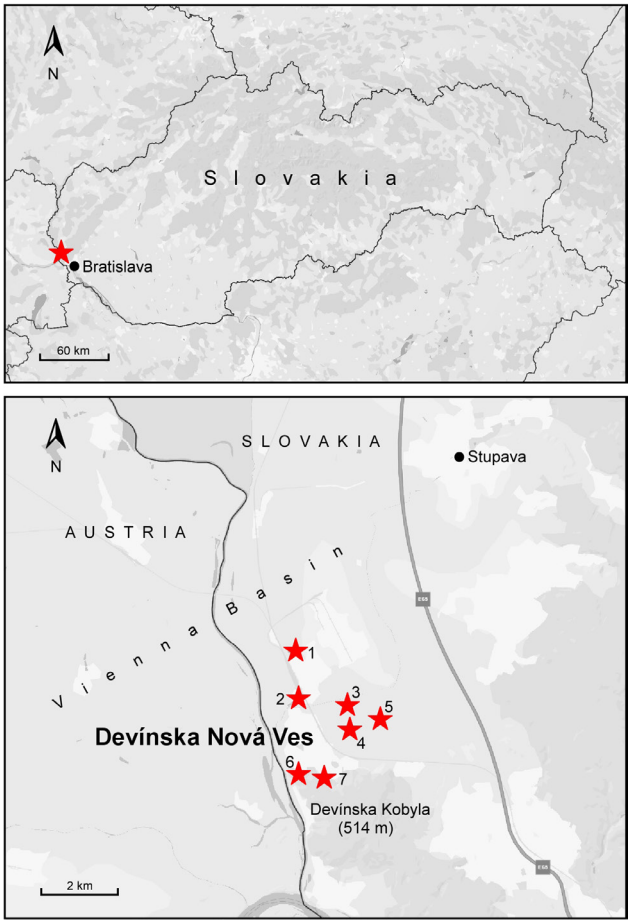


Fig. 1. Geographic position of the studied localities (red stars) at Devínska Nová Ves (Bratislava): 1 – Brickyard, 2 – Záveterná, 3 – Kasárne, 4 – Bačnegovice, 5 – Útočnice, 6 – Sandberg, 7 – Vodojem (Map source: Google Earth)

and represents two former clay pits situated on the north margin of Devínska Nová Ves, of which the second was located about 300 m N from the first initial clay pit (TOMAŠOVÝCH 1998). The first clay pit was opened in 1870 and was exploited probably until 1925, whilst the new clay pit was opened sometime after 1918 (ZLOCHOVÁ 1998). The first sub-locality no longer exists, and the second is currently abandoned, largely destroyed, and inaccessible. Marine deposits are mainly represented by massive and laminated grey calcareous clays, in places with intercalations of sands and silts (TOMAŠOVÝCH 1998). Grey calcareous clays yielded rich invertebrate (e.g., foraminifers, bryozoans, gastropods, bivalves, cephalopods, echinoids, decapods), and vertebrate (bony fishes, sharks) marine faunas studied since the 19th century (e.g., SCHAFFER 1898, TOULA 1900, 1915, ŠVAGROVSKÝ 1981a, ČINČUROVÁ 1990, HOLEC & SABOL 1996, TOMAŠOVÝCH 1998, CHALUPOVÁ 2001, HUDÁČKOVÁ & SPEZZAFERRI 2002, GREGOROVÁ 2009, RUMAN & HUDÁČKOVÁ 2015, KOŠŤÁK et al. 2016, 2018, HARZHAUSER & LANDAU 2021, HARZHAUSER et al. 2022, BISKUPIČ 2023b). Remnants of terrestrial plants were studied by BERGER (1951) and SITÁR & KOVÁČOVÁ-SLAMKOVÁ (1999).

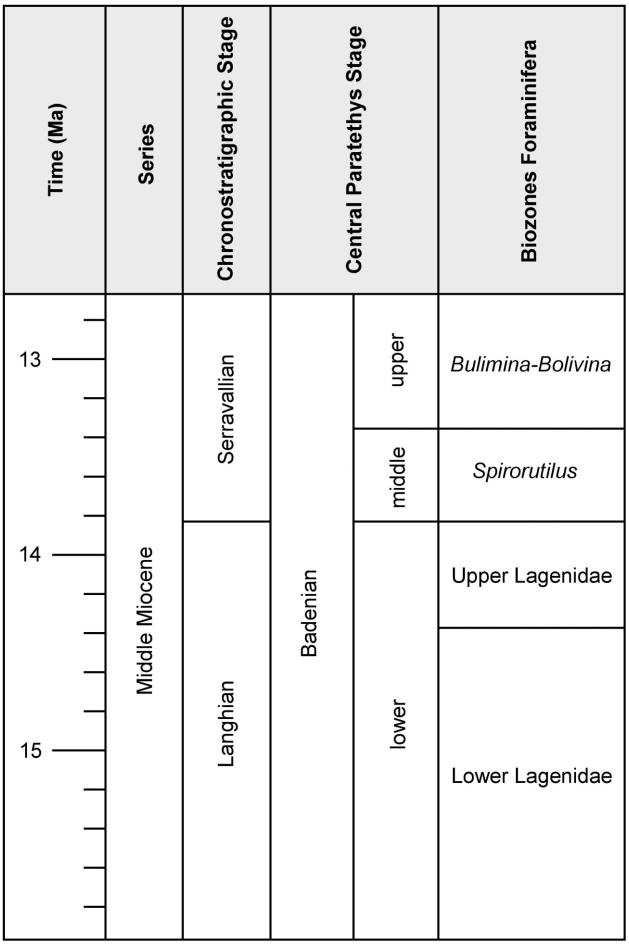


Fig. 2. Chronostratigraphic and biostratigraphic zonation of the Badenian (Middle Miocene) Vienna Basin (modified from HARZHAUSER et al. 2018)

Záveterná. The site was discovered in 2024 during excavation work in a private backyard on Záveterná Street in Devínska Nová Ves (48°13'03"N, 16°58'29"E). Fine- to coarse-grained sands with sandstone concretions were revealed there. According to the available fossil material, only two molluscan species were recorded: the bivalve *Cubitostrea digitata* (Eichwald, 1830) and the gastropod *Ptychidia vindobonensis* (Handmann, 1882). The locality has not yet been surveyed, and the marine micro- and macrofauna have not been evaluated. The age of the sediments is estimated as Badenian, based on the occurrence of the turritellid *Ptychidia vindobonensis*, which was stratigraphically distributed in the Central Paratethys during the Badenian (HARZHAUSER & LANDAU 2019), and on the correlation with the nearby Upper Badenian shallow-water sandy strata revealed at Kasárne and Bačnegovice.

Kasárne. The locality was situated on the eastern margin of Devínska Nová Ves (48°12'58"N, 16°59'27"E), approximately 200 m N from the hill of Dlhý kopec (162 m) and represented several temporal outcrops of a former construction site during the 80s. The marine sediments comprise pale- to ochreous sands and sandstone concretions, and include abundant shallow-water assemblages of bivalves and gastropods. The Badenian age of the deposits was deduced from the presence of some molluscan species (e.g. *Aequipecten elegans* (Andrzejowski, 1830), *Oopecten solarium* (Lamarck, 1819), *Pecten besseri* Andrzejowski, 1830), which typically occurred during the Badenian. The locality description, age estimation and molluscan fauna found there were reported only in the unpublished manuscript of ONDREJIČKOVÁ (1987). Currently, the area is home to the Police Force Secondary Vocational School, and the locality is inaccessible.

Bačnegovice. The locality lies in the eastern part of Devínska Nová Ves (48°12'47"N, 16°59'21"E), and is situated about 150 m SW from the Dlhý kopec hillock (162 m). The site comprises a few fields on a slightly elevated knoll in Bačnegovice, previously known in the literature as Vinohrady (cf. ŠVAGROVSKÝ 1981a, HOLEC 2001) and Útočnica (cf. MESZÁROŠ 1986, RUMAN & HUDÁČKOVÁ 2015). These deposits are mainly represented by fine-grained yellow sands, silty sands, and white and ochreous, fine- to coarse-grained sands in places intercalated with sandstone concretions; to a small extent, scattered blocks of superjacent corallinacean limestones and discontinuous intercalations of organodetritic corallinacean marls also occur. Species-rich associations of gastropods and bivalves were analysed by ŠVAGROVSKÝ (1981a), who recognised 36 molluscan taxa. Anomalies in bivalve shells were discussed by MESZÁROŠ (1986); the

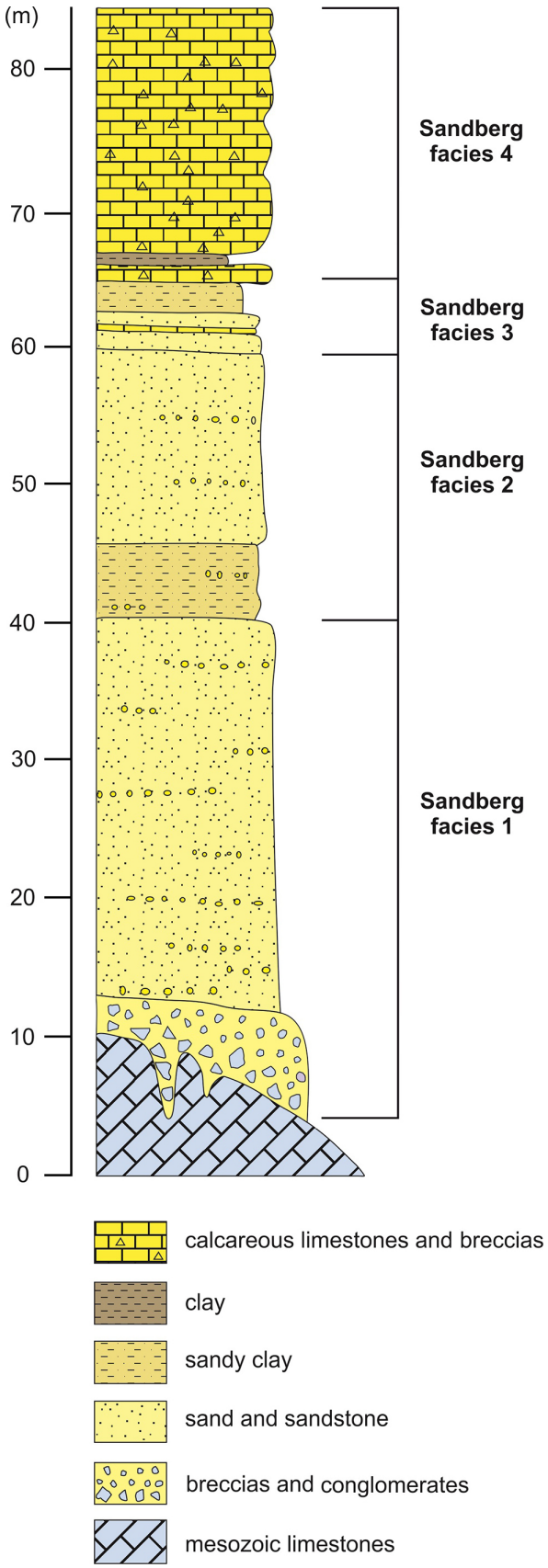


Fig. 3. Simplified lithological scheme of the Upper Badenian section of the locality Sandberg (modified from BARÁTH et al. 1994 and HYŽNÝ et al. 2012)

survey of polyplacophorans was provided by RUMAN & HUDÁČKOVÁ (2015), and the Costellariidae gastropods were recently studied by BISKUPIČ (2023d). Rare sharks and fishes were mentioned by HOLEC (2001).

Útočnice. This relatively little-known paleontological site is located on the eastern periphery of Devínska Nová Ves, approximately 700 m east of the locality Bačnegovice (48°12'51"N, 16°59'58"E), and represents a field on a slightly elevated knoll named Útočnice (152 m). The fossil-bearing marine strata are revealed at the top of the hill, comprising white, occasionally ochreous, fine- to coarse-grained sands, in places intercalated with massive sandstone concretions and intercalations of marly sands, and corallinacean limestones overlying the sandy deposits. The diverse and abundant macrofauna comprised gastropods, bivalves, scaphopods, chitons, scleractinian corals, echinoids, sharks and fishes. At present, only a few works have dealt with marine faunal assemblages, focusing on gastropods (see BISKUPIČ 2023d, 2024b).

Sandberg. This well-known fossil-bearing locality (sand quarry) is situated in the southern periphery of Devínska Nová Ves, on the north-western edge of the Devínska Kobyla Hill (Section 1: 48°12'03"N, 16°58'29"E, Section 2: 48°11'59"N, 16°58'32"E, Section 3: 48°11'51"N, 16°58'38"E). Breccias, conglomerates, sands, organodetritic algal limestones and intercalations of marls were exposed in the section reaching almost 90 m in height (Fig. 3). The faunal assemblages have been studied from the 19th century onwards. These studies have been mainly on marine and terrestrial vertebrates (e.g., BOUÉ 1830, HAUER 1837, MÜNSTER 1846, MEYER 1847, HOLEC & SCHLÖGL 2000, HOLEC 2001, SABOL & HOLEC 2002, HOLEC & EMRY 2003), but molluscs (e.g., HÖRNES 1848, 1851, 1856, KORNHUBER 1865, HORUSITZKY 1917, ŠVAGROVSKÝ 1978, 1981a) have often been the object of paleontological research. Decapods (LŐRENTHEY & BEURLEN 1929, BACHMAYER 1962, HYŽNÝ 2011), echinoids (SCHAFFER 1962, KROH 2005), bryozoans and brachiopods (BITNER et al. 2014) were studied as well. Geological settings were sketched by several authors (e.g., ŠVAGROVSKÝ 1978, 1981a, SENEŠ & ONDREJIČKOVÁ 1991, BARÁTH et al. 1994, HOLEC 2001, FORDINÁL et al. 2012). New data on the lithostratigraphy, biostratigraphy and faunal assemblages of the locality were provided by HYŽNÝ et al. (2012), BITNER et al. (2014), and JAMRICH et al. (2024).

Vodojem. The site is located on the southern margin of Devínska Nová Ves and the north slopes of Devínska Kobyla Hill (48°11'57"N, 16°58'54"E). An outcrop is situated in the forest near the reservoir and is about 4 m high and 20 m long. Pale-yellow coarse- to fine-grained sands and sandstone beds in some

places with intercalations of sandy-gravel mixture are exposed in the section and contain specimen-rich fossils of marine invertebrates. Gastropods (e.g., *Haliotis, Diloma, Archimediella, Helminthia,* Cerithiidae indet., Cypraeidae indet.), bivalves (e.g., *Glycymeris, Atrina, Flabellipecten, Ostrea, Callista, Acanthocardia, Megacardita, Callista, Panopea, Pholadomya*) and rare sand dollar echinoids (*Parascutella*) characterise the assemblage, indicating shallow-water marine conditions. The locality and its fauna have not previously been studied. Based on the associated marine fauna and lithology, the sediments can be correlated with the shallow-water sandy facies exposed at neighbouring locality Sandberg (SA 1, Sandberg facies 2 sensu Hyžný et al. 2012), indicating a late Badenian age.

MATERIAL AND METHODS

Altogether 1,007 specimens of Turritellidae from Devínska Nová Ves are re-examined. The majority of the studied shells originate from the personal collection of the author, collected over the last three decades. A minor part of the material originates from the institutional collection of the Natural History Museum of the Slovak National Museum (Bratislava), the State Geological Institute of Dionýz Štúr (Bratislava), and the Dúbravka Museum (Bratislava). Additional Turritellidae material was provided by Martin Vlačiky, Jozef Bumbera, Andrej Bernáth (all Bratislava), Jakub Borko (Kanianka), Samuel Veselý (Hrnčiarovce nad Parnou), and Róbert Hodal (Trenčín). The conchological material illustrated in this paper, initially collected by the author, is stored in the institutional collection of the Natural History Museum of the Slovak National Museum, Bratislava. The material from the Brickyard locality mentioned by Schaffer (1898) and Toula (1900) is not available, and, therefore, it is only discussed, not evaluated. The specimens of *Turritella neudorfensis* Toula, 1900 initially figured in Toula (1900: p. 15, fig. 6a, b) are re-illustrated herein, including the proposed notation of primary spiral cords; the original description in German and its translated version in English are given. Because Toula's description is relatively brief and insufficient, a revised and more precise description of the shell is provided herein in terms of the shell morphology of Allmon (1996), Landau et al. (2013), Van Dingenen et al. (2016), Landau et al. (2018) and Harzhauser & Landau (2019). The higher systematics of Gastropoda Cuvier, 1795, proposed by Bouchet et al. (2017) and the taxonomic concept of turritellids suggested by Harzhauser & Landau (2019) are followed in this study.

Morphometric abbreviations: SL – shell length, MD – maximum diameter, AA – apical angle, PA – pleural angle. Institutional abbreviations: SNM-PM – Natural History Museum of the Slovak National Museum, Bratislava; ŠGÚDŠ – State Geological Institute of Dionýz Štúr, Bratislava.

SYSTEMATICS

Class Gastropoda Cuvier, 1795

Subclass Caenogastropoda Cox, 1960

Superfamily Cerithioidea Fleming, 1822

Family Turritellidae Lovén, 1847

Subfamily Turritellinae Lovén, 1847

Genus *Archimediella* Sacco, 1895

Type species: *Turritella archimedis* Brongniart, 1823, by original designation (Sacco 1895). Rupelian (Early Oligocene), Italy

Archimediella abundans (Handmann, 1882)

(Figs 4–9)

[*Turritella (Oligodia) Archimedis* Brong.] var. *abundans* – Handmann 1882: p. 217.

Archimediella abundans (Handmann, 1882) new comb. – Harzhauser & Landau 2019: p. 26, figs 6G, 7A–B, 10C, 10D–E, 10F (cum syn.).

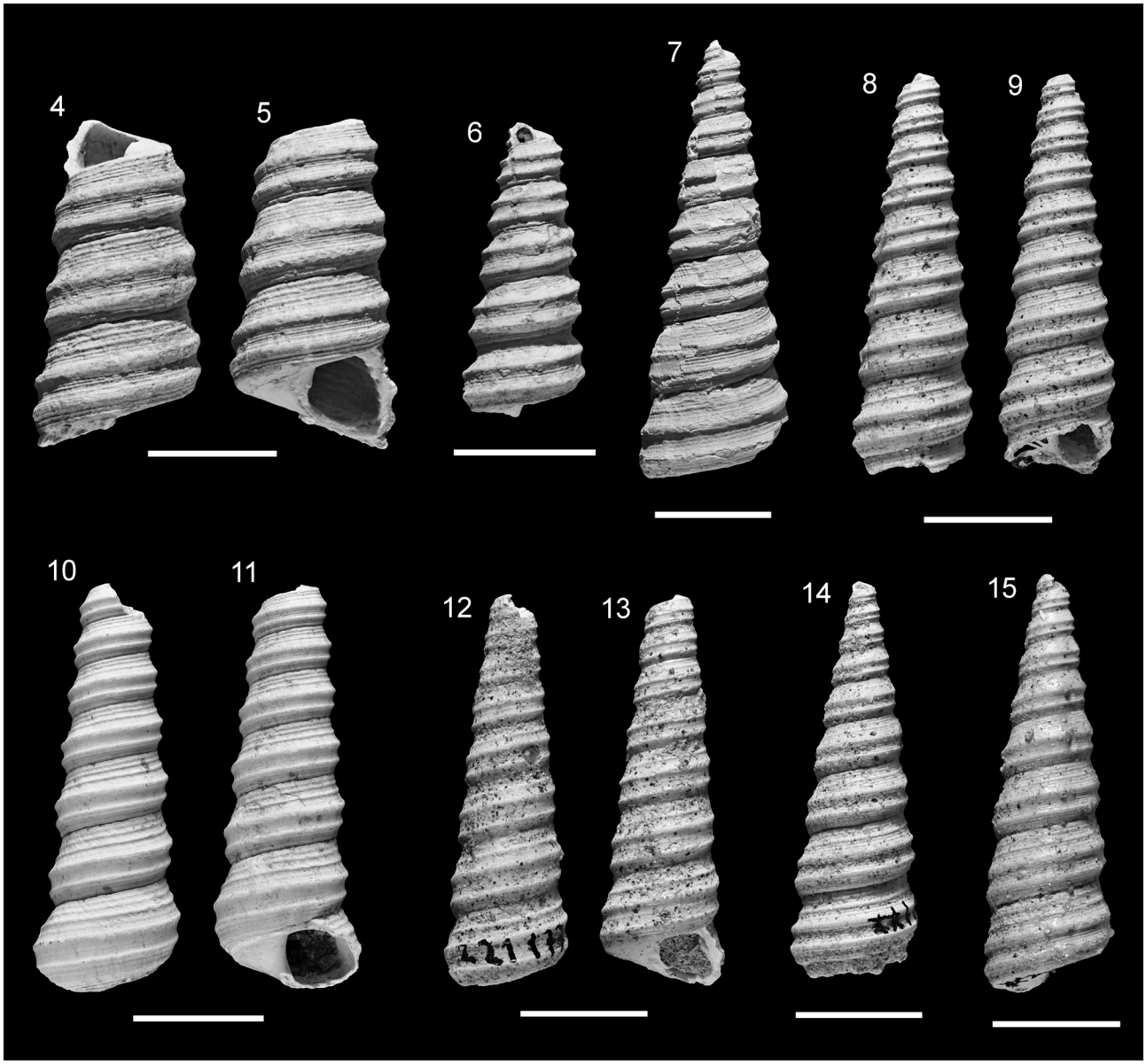
Material. Kasárne: 71 specimens, Bačnegovice: 21 specimens, Sandberg: 16 specimens, Vodojem: 1 specimen.

Illustrated material and dimensions. Figs 4–5: Z 41949, SL: 24.4 mm, MD: 12.1 mm (fragment), Bačnegovice; Fig. 6: Z 41950, SL: 19.5 mm, MD: 8.2 mm, Bačnegovice; Fig. 7: Z 41951, SL: 36.3 mm, MD: 11.4 mm, Bačnegovice; Figs 8–9: Z 21177, SL: 31.3 mm, MD: 9.1 mm, Kasárne.

Remarks. Although mostly poorly preserved specimens are available, the overall morphological features of the shells are concordant with those figured in the revised study by Harzhauser & Landau (2019). The shells studied herein represent the first evidence of *Archimediella abundans* (Handmann, 1882) from Kasárne, Útočnice, and Vodojem. Ruman & Hudáčková (2015) mentioned this species from Bačnegovice and Hyžný et al. (2012) from Sandberg as *Turritella* (*Archimediella*) *erronea* Cossmann in

Friedberg, which is a junior synonym of *A. abundans* (Handmann, 1882) (HARZHAUSER & LANDAU 2019). The species was most likely identified from Brickyard already by SCHAFFER (1898) and TOULA (1900), but under the name *Turritella archimedis* Brong. However, the species-level affiliation of these specimens cannot be verified because the material was not illustrated in their papers, and is not available in any institutional collections.

Stratigraphic and geographic distribution. In the Slovak part of the Western Carpathians, this turritellid was found in the Badenian (Middle Miocene) deposits of the eastern Vienna Basin at Kúty (drill well Kúty-45) (RUMAN & HUDÁČKOVÁ 2015), Rohožník – Konopiská (FUKSI 2015a), Pernek (own data), Devínska Nová Ves (unspecified locality) (SIEBER 1958b), Brickyard? (SCHAFFER 1898, TOULA 1900), Sandberg (HYŽNÝ et al. 2012), Devín – northeast from Devín-Terasy (ŠVAGROVSKÝ 1981a), Lomnická, Terasy, Šibeničník (HYŽNÝ et al. 2012), from the Danube Basin at Želiezovce – Lontov (drill well ŽI-2) (TEJKAL 1968, BRESTENSKÁ 1978b) and also from the Novohrad-Nógrad Basin near Kosihovce (HANO 1950), Stredné Plachtince, and Horné Strháre (ČECHOVIČ & SENEŠ 1950).



Figs 4–15. Turritellidae species, Devínska Nová Ves, Upper Badenian: 4–5 – *Archimediella abundans* (Handmann, 1882), Z 41949, Bačnegovice; 6 – *Archimediella abundans* (Handmann, 1882), Z 41950, Bačnegovice; 7 – *Archimediella abundans* (Handmann, 1882), Z 41951, Bačnegovice; 8–9 – *Archimediella abundans* (Handmann, 1882), Z 21177, Kasárne; 10–11 – *Archimediella carpathica* Harzhauser et Landau, 2019, Z 41952, Útočnice; 12–13 – *Archimediella carpathica* Harzhauser et Landau, 2019, Z 21177, Kasárne; 14 – *Archimediella carpathica* Harzhauser et Landau, 2019, Z 21177, Kasárne; 15 – *Archimediella carpathica* Harzhauser et Landau, 2019, Z 21177, Kasárne. Scale bars 10 mm

The species was distributed from the Karpatian (Early Miocene) to the Badenian (Middle Miocene) in the Central Paratethys, and from the Late Miocene (Tortonian) to the Pliocene in the Proto-Mediterranean (Harzhauser & Landau 2019).

Archimediella carpathica Harzhauser et Landau, 2019

(Figs 10–15)

Archimediella carpathica Harzhauser & Landau 2019: p. 30, figs 6H, 7C, 11A–G (cum syn.)
Archimediella carpathica Harzhauser et Landau, 2019 – Koubová et al. 2024: fig. 8H

Material. Kasárne: 7 specimens, Bačnegovice: 1 specimen, Útočnice: 9 specimens, Sandberg: 5 specimens.
Illustrated material and dimensions. Figs 10–11: Z 41952, SL: 29.1 mm, MD: 10.1 mm, Útočnice; Figs 12–13: Z 21177, SL: 28.8 mm, MD: 9.1 mm, Kasárne; Fig. 14: Z 21177, SL: 29.2 mm, 9.3 mm, Kasárne; Fig. 15: Z 21177, SL: 31.3 mm, 9.1 mm, Kasárne.
Remarks. For a full list of synonyms and a comprehensive discussion on related species, see Harzhauser & Landau (2019). The available conchological material agrees with the morphological features of the specimens illustrated by those authors. From Kasárne, Bačnegovice, Útočnice, and Sandberg, the first records of *Archimediella carpathica* Harzhauser et Landau, 2019 are confirmed herein.

From Brickyard, the taxon *Turritella pythagoraica* Hilber was reported by Schaffer (1898). This species, considered a junior synonym of *Archimediella indigena* (Eichwald, 1830), known from the Middle Miocene of the Central and Eastern Paratethys, was often confused with *A. carpathica* in the malacological literature, as stated by Harzhauser & Landau (2019). I have not seen the specimens from Brickyard, but the shell characters given in Schaffer's (1898) shell description could indicate a possible placement in *Archimediella carpathica*. Nevertheless, his description is brief, and no specimen is illustrated in his paper, which does not allow for verifying its species affiliation with certainty.
Stratigraphic and geographic distribution. In Slovakia, this taxon was identified from the Badenian (Middle Miocene) sediments of the Vienna Basin at Borský Mikuláš – Vinohrádky (Švagrovský 1982), Plavecký Mikuláš (Buday 1939), Kúty (drill well Kúty-45) (Ruman & Hudáčková 2015), and Devín – Zelené terasy (Madarás et al. 2014, Biskupič 2023a, Jamrich et al. 2024), in the Danube Basin at Modra – Kráľová (Hörnes 1855, Hladilová & Fordinál 2013), Dubová – Malý trávnik (Ruman & Hudáčková 2015, Koubová et al. 2024), Smolenice (Zlinská & Fordinál 1992), Želiezovce – Lontov (drill well ŽI-2) (Tejkal 1968, Brestenská 1978b), Salka (drill well K-5) (Brestenská 1978a), Salka – Vineyards, Bajtava, and Malá nad Hronom (Seneš 1949), in the Novohrad-Nógrad Basin at Kosihovce (Hano 1950), Pôtor, Ľuboriečka, and Horné Strháre (Čechovič & Seneš 1950) and also from the Eastern Slovakian Basin from Kuzmice (Švagrovský 1960, 1964).

This turritellid species was a common component in the molluscan assemblages of the Central Paratethys Sea during the Badenian (Middle Miocene). Its occurrence during the Tarkhanian (Middle Miocene) of the Eastern Paratethys is uncertain (Harzhauser & Landau 2019).

Genus *Helminthia* Handmann, 1882

Type species: *Turbo vermicularis* Brocchi, 1814, by subsequent designation (Landau et al. 2013). Miocene, Italy.

Helminthia tricincta (Borson, 1821)

(Figs 16–20)

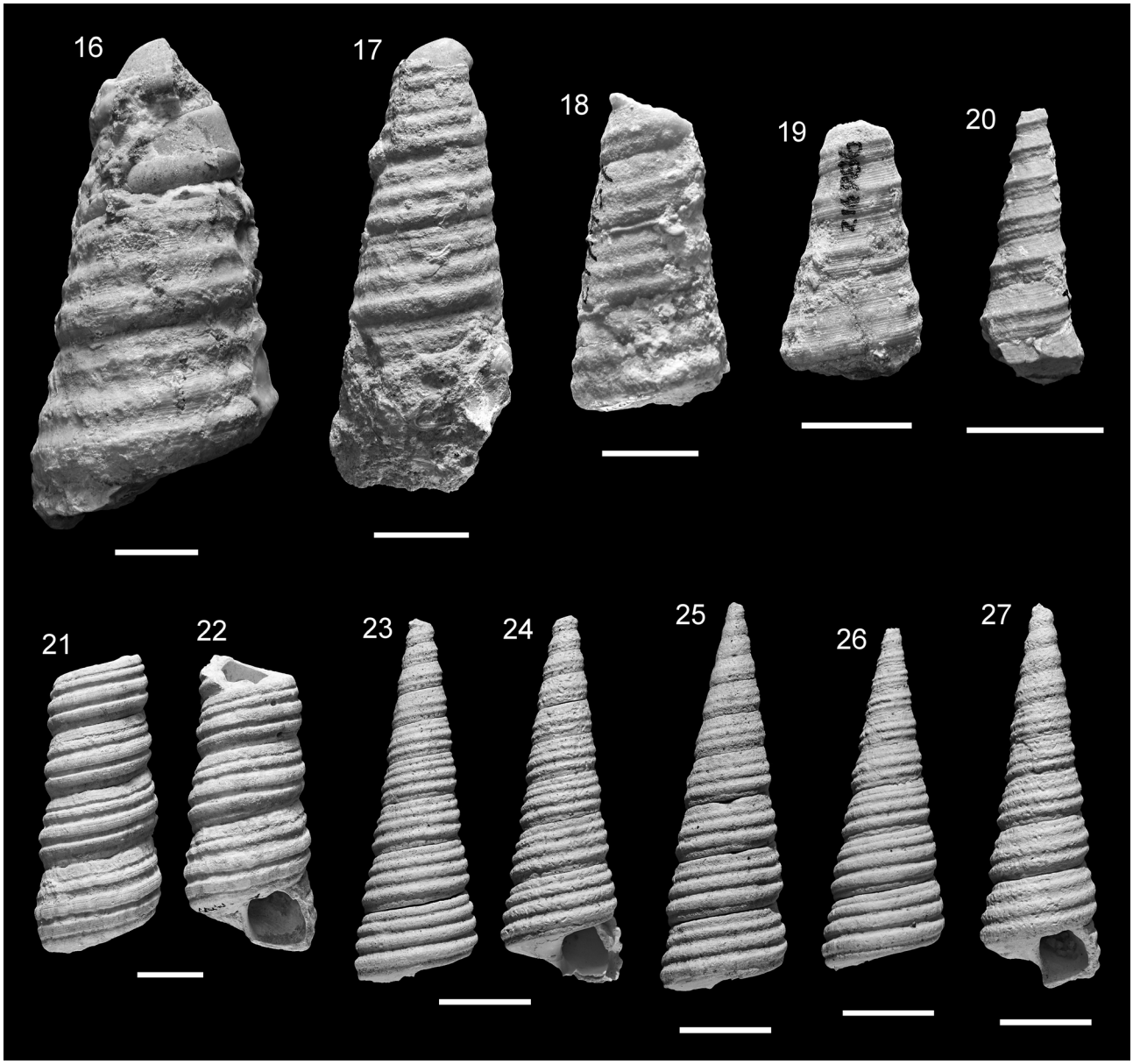
Turritella tricincta Borson 1821: p. 342, pl. 6, fig. 11.
Helminthia tricincta (Borson, 1821) – Harzhauser & Landau 2019: p. 38, figs 6I, 13A–B, 13C (cum syn.)
Helminthia tricincta (Borson, 1821) – Biskupič 2023c: p. 14., figs 4A–H, 5A–F, 6A–F, 8A–B, 9A–D

Material. Sandberg: 41 specimens.
Illustrated material and dimensions. Fig. 16: Z 17342, SL: 50.8 mm, MD: 27.4 mm (fragment), Sandberg; Fig. 17: Z 17219, SL: 43.7 mm, MD: 17.2 mm, Sandberg; Fig. 18: Z 17937, SL: 29.9 mm, MD: 14.9 mm, Sandberg; Fig. 19: Z 16986, SL: 21.8 mm, MD: 11.7 mm, Sandberg; Fig 20: Z 16986, SL: 19.4 mm, MD: 7.6 mm (juvenile specimen), Sandberg.
Remarks. The material found at Sandberg is mostly poorly preserved; the aragonite shells are often dissolved or recrystallised, sometimes preserved only as inner moulds, or as imprints of the shells with sculpture in the sandstones. Nevertheless, their shell morphology (large-sized, robust, tricostate shells) is concordant with that reported by Hörnes (1855), Sieber (1960), Harzhauser & Landau (2019), and Biskupič (2023c). Švagrovský (1981a) mentioned the species from Vineyards (=Bačnegovice) and Sandberg. However, the material from Bačnegovice belongs to *H. vermicularis* (Brocchi, 1814) and only fossils from Sandberg agree with *Helminthia tricincta* (Borson, 1821), as suggested by the revision of his material stored in the collections of SNM-PM. This species most probably also occurred at Brickyard; it was mentioned under the name *Turritella riepeli* Partsch by Schaffer (1898) and Toula (1900). From the Upper Badenian locality Rohožník – Konopiská, lo-

cated on the eastern Vienna Basin, Biskupič (2023c) distinguished two morphologically distinct morphs within the species based on conchological characters: the smooth-sculptured and the coarse-sculptured morphs. In the material from Devínska Nová Ves, only a typically coarse-sculptured morph was detected.

Stratigraphic and geographic distribution. As summarised by Biskupič (2023c), the species was found in Slovakia at only a few Middle Miocene (Badenian) sites in the eastern Vienna Basin.

Helminthia tricincta (Borson, 1821) was widespread in the Middle Miocene (Badenian) of the Central Paratethys and the Tarkhanian (Early to Middle Miocene) of the Eastern Paratethys. The species also occurred in the Tortonian (Late Miocene) and the Pliocene of the Proto-Mediterranean Sea (Harzhauser & Landau 2019).



Figs 16–27. Turritellidae species, Devínska Nová Ves, Upper Badenian: 16 – *Helminthia tricincta* (Borson, 1821), Z 17342, Sandberg; 17 – *Helminthia tricincta* (Borson, 1821), Z 17219, Sandberg; 18 – *Helminthia tricincta* (Borson, 1821), Z 17937, Sandberg; 19 – *Helminthia tricincta* (Borson, 1821) Z 16986, Sandberg; 20 – *Helminthia tricincta* (Borson, 1821) Z 16986, Sandberg; 21–22 – *Helminthia vermicularis* (Brocchi, 1814), Z 21705, Sandberg (illustrated as *Turritella* (*Haustator*) *tricincta* Borson, 1821 in Švagrovský 1981a, pl. 39, fig. 1); 23–24 – *Helminthia vermicularis* (Brocchi, 1814), Z 41953, Útočnice; 25 – *Helminthia vermicularis* (Brocchi, 1814), Z 41954, Útočnice; 26 – *Helminthia vermicularis* (Brocchi, 1814), Z 41955, Útočnice; 27 – *Helminthia vermicularis* (Brocchi, 1814), Z 41956, Útočnice. Scale bars 10 mm

Helminthia vermicularis (Brocchi, 1814)

(Figs 21–27)

Turbo vermicularis Brocchi 1814: p. 372, pl. 6, fig. 13.
Helminthia vermicularis (Brocchi, 1814) – Harzhauser & Landau 2019: p. 41, figs 6K, 7G–H, 13D–E, 13F (cum syn.)
Helminthia vermicularis (Brocchi, 1814) – Biskupič 2023c: p. 16, figs 7A–G, 8C–D, 9E–F

Material. Kasárne: 14 specimens, Bačnegovice: 66 specimens, Útočnice: 283 specimens, Sandberg: 18 specimens, Vodojem: 1 specimen.
Illustrated material and dimensions. Figs 21–22: Z 21705, SL: 42.8 mm, MD: 17.8 mm, Sandberg (illustrated as *Turritella* (*Haustator*) *tricincta* Borson, 1821 in Švagrovský 1981a, pl. 39, fig. 1); Figs 23–24: Z 41953, SL: 38 mm, MD: 12.3 mm, Útočnice; Fig. 25: Z 41954, SL: 40.1 mm, MD: 12.8 mm, Útočnice; Fig. 26: Z 41955, SL: 35.6 mm, MD: 12.3 mm, Útočnice; Fig. 27: Z 41956, SL: 39.3 mm, MD: 12.1 mm, Útočnice.
Remarks. Even though Švagrovský (1981a) determined these shells as *Turritella* (*Haustator*) *tricincta* Borson, 1821 from Vineyards (=Bačnegovice) and Sandberg, a part of the material is ascribed to *H. vermicularis* (Brocchi, 1814) in this study based on the revision of his conchological material deposited in the SNM-PM collection. The species is among the most abundant Turritellidae species at Bačnegovice and Útočnice. *H. vermicularis* (Brocchi, 1814) was listed from Brickyard in the papers of Schaffer (1898) and Toula (1900).
Stratigraphic and geographic distribution. From the Slovak part of the Western Carpathians, the species is known from several Middle Miocene (Badenian) localities of the Vienna Basin and the Novohrad-Nógrád Basin, as summarised by Biskupič (2023c). As reported by Harzhauser & Landau (2019), *Helminthia vermicularis* (Brocchi, 1814) occurred abundantly during the Middle Miocene (Badenian) through the Central Paratethys Sea and was also distributed from the Early Miocene (Burdigalian) to the Pleistocene in the Proto-Mediterranean Sea and the northeastern Atlantic.

Genus *Oligodia* Handmann, 1882

Type species: *Turritella bicarinata* Eichwald, 1830, by subsequent designation (Landau et al. 2013). Middle Miocene, Paratethys Sea.

Oligodia bicarinata (Eichwald, 1830)

(Figs 28–34)

Turritella bicarinata Eichwald 1830: p. 220.
Oligodia bicarinata (Eichwald, 1830) – Harzhauser & Landau 2019: p. 50, figs 6P, 7H, 16A–E (cum syn.)

Material. Bačnegovice: 50 specimens, Útočnice: 307 specimens, Sandberg: 80 specimens.
Illustrated material and dimensions. Figs 28–29: Z 21791, SL: 18.7 mm, MD: 6.5 mm, Sandberg; Figs 30–31: Z 41957, SL: 28.1 mm, MD: 10.6 mm, Útočnice; Fig. 32: Z 41958, SL: 23.5 mm, MD: 9.7 mm, Útočnice; Figs 33–34: Z 41959, SL: 22.9 mm, MD: 9.3 mm, Útočnice.
Remarks. Švagrovský (1981a) erroneously identified this species as *Turritella* (*Zaria*) *spirata* (Brocchi, 1814) from Vineyards (= Bačnegovice) based on a few small shell fragments. The revision of his material stored in SNM-PM clearly suggests that these specimens represent just spire fragments of *O. bicarinata* (Eichwald, 1830). The species was identified from Kasárne by Ondrejičková (1987). However, her conchological material deposited in the collections of ŠGÚDŠ comprised no specimens concordant with *O. bicarinata* (Eichwald, 1830), and thus the occurrence of the species at Kasárne is unconfirmed in this paper. These specimens were probably confused with the *Archimediella* species that occur abundantly at the locality.
Stratigraphic and geographic distribution. From Slovakia, this turritellid was mentioned from the Badenian (Middle Miocene) deposits of the Vienna Basin, and was identified from Borský Mikuláš (Švagrovský 1982), Kuchyňa (Buday 1939), Stupava – Vrchná hora (Buday 1939), Stupava – drill well HGP-3 (Fordinál et al. 2003), Devínska Nová Ves (unspecified locality) (Sieber 1958b), Devínska Nová Ves – railway sand pits (Fuchs 1868), Sandberg (Švagrovský 1981a, Hyžný et al. 2012), Bačnegovice (Švagrovský 1981a, Ruman & Hudáčková 2015), Devín – northeast from Devín-Terasy (Švagrovský 1981a), and Kúty (drill well Kúty-45) (Ruman & Hudáčková 2015), from the Danube Basin at Trstín (Fuksi 2015b), Chľaba (drill well ŠO-1) (Ondrejičková 1978), Salka – Vineyards, and Malá nad Hronom (Seneš 1949) and also from the Novohrad-Nógrad Basin near Kosihovce (Hano 1950) and Horné Strháre (Čechovič & Seneš 1950).

According to Harzhauser & Landau (2019), the Central Paratethyan records of this well-known species are known from the Karpatian (Early Miocene) and the Badenian (Middle Miocene); it was widespread in the Tschokrakian and Konkian (Middle Miocene) of the Eastern Paratethys and also from the Burdigalian (Early Miocene) to the Tortonian (Late Miocene) in the Proto-Mediterranean Sea and in the northeastern Atlantic during the Langhian to the Tortonian (Middle – Late Miocene).

Genus *Ptychidia* Handmann, 1882

Type species: *Turritella (Ptychidia) vindobonensis* Handmann, 1882, by monotypy (Handmann 1882). Middle Miocene, Paratethys Sea.

Ptychidia vindobonensis (Handmann, 1882)

(Figs 35–36)

Turritella (Ptychidia) vindobonensis Partsch forma *typica* Handmann 1882: p. 215 [new name for *Turritella turris* Bast. (Hörnes 1855: pl. 43, fig. 15)]

Ptychidia vindobonensis (Handmann, 1882) – Harzhauser & Landau 2019: p. 62, figs 6U, 7J, 18A–D, 18O (cum syn.)

Material. Záveterná: 14 specimens, Bačnegovice: 1 specimen.

Illustrated material and dimensions. Fig. 35: Z 40757, SL: 59.6 mm, MD: 13.8 mm, Záveterná; Fig. 36: Z 40757, SL: 53.3 mm, MD: 10.2 mm, Záveterná.

Remarks. Only a single shell from Bačnegovice is available, which points to the low abundance of the species at the locality. In contrast, the species seems to be the dominant turritellid at Záveterná. From Brickyard, Schaffer (1898) reported one fragmentary shell ascribed to *Turritella turris* Bast., which has often been confused with *Ptychidia vindobonensis* (Handmann, 1882) by the early authors (see discussion in Landau et al. 2013 and Harzhauser & Landau 2019). However, according to his short description, the assumed affiliation with *Ptychidia vindobonensis* is doubtful, as the specimen may also represent another similar Badenian species, *Ptychidia erynella* Harzhauser et Landau, 2019 (cf. Harzhauser & Landau 2019: figs 18E–H, J–K). Moreover, Schaffer´s specimen is not available for further re-examination, making its reliable placement in the particular species impossible. The species was also reported from Devínska Nová Ves by Sieber (1958b), but no exact locality was given in his paper. Although this taxon was documented from Kasárne by Ondrejičková (1987), the revision of her material stored in the collections of ŠGÚDŠ reveals no evidence of the species at the locality.

Tejkal (1968) was the first to clarify the taxonomic status of the species and consider *Turritella turris* var. *badensis* Sacco, 1895 as a junior synonym of *Turritella* (*Ptychidia*) *vindobonensis* Handmann, 1882. This opinion was much later confirmed by Landau et al. (2013) and Harzhauser & Landau (2019). The Handmann's (1882) proposed new subgenus name, *Ptychidia*, was accepted and elevated to full genus rank by Landau et al. (2013). For a complete list of synonyms and a discussion on the taxonomy of the species, see the monographs of those authors.

Stratigraphic and geographic distribution. From the Slovak part of the Western Carpathians, this taxon was reported from the Badenian (Middle Miocene) deposits of the eastern Vienna Basin, namely from Rohožník – Konopiská (Fuksi 2015a), Devínska Nová Ves (unspecified locality) (Sieber 1958b), and Bačnegovice (Ruman & Hudáčková 2015), from the Danube Basin at Želiezovce – Lontov (drill well ŽI-2) (Tejkal 1968, Brestenská 1978b), Chľaba (drill well ŠO-1) (Ondrejičková 1978, Holcová et al. 2019), Malá nad Hronom, and Kamenica nad Hronom (Seneš 1949), and also from the Novohrad-Nógrád Basin near Ľuboriečka, Horné Plachtince, and Modrý Kameň (Čechovič & Seneš 1950).

P. vindobonensis is known from the Badenian (Middle Miocene) of the Central Paratethys Sea (Harzhauser & Landau 2019) and was also recorded in the Serravallian (Middle Miocene) of the Proto-Mediterranean Sea and northeastern Atlantic (Landau et al. 2013).

Genus *Viennella* Harzhauser et Landau, 2019

Type species: *Turritella incisaeformis* Csepreghy-Meznerics, 1956, by original designation (Harzhauser & Landau 2019). Middle Miocene (Badenian), Hungary, Central Paratethys Sea.

Viennella sp.

(Figs 37–38)

Material. Bačnegovice: 1 specimen.

Illustrated material and dimensions. Figs 37–38: Z 41960, SL: 13.2 mm, MD: 4.4 mm, Bačnegovice.

Remarks. The shell is almost complete, but the spiral sculpture is poorly preserved, mostly abraded, and only visible in places. Early teleoconch whorls seem flat-sided, later whorls are slightly convex and bear seven spiral cords with smooth interspaces between them. This specimen resembles in shell size, shape of teleooconch whorls, and spiral sculpture the species *Viennella incisaeformis* (Csepreghy-Meznerics, 1956) (cf. Harzhauser & Landau 2019: p. 78, figs 21A–D), known from the Lower Badenian (Middle Miocene) marine sediments of the Vienna Basin (Austria) and the Pannonian Basin (Hungary). However, due to poor preservation of the shell, reliable species-level identification is not possible, and thus it remains left in open nomenclature. Although another Upper Badenian congener, *Viennella baluki* Biskupič, 2024, is known from the Slovak part of the Vienna Basin (Rohožník – Konopiská), the specimen from Devínska Nová Ves has little in common with it. *Viennella baluki* clearly differs from the studied shell in its more convex-sided teleoconch whorls, the presence of tertiary spiral cords, prominent mid-whorl angulation and strongly raised spiral sculpture (cf. Biskupič 2024a: figs 3–5). *Viennella* sp. represents the first evidence for the genus from Devínska Nová Ves.

"*Turritella*" *neudorfensis* Toula, 1900, taxon inquirendum

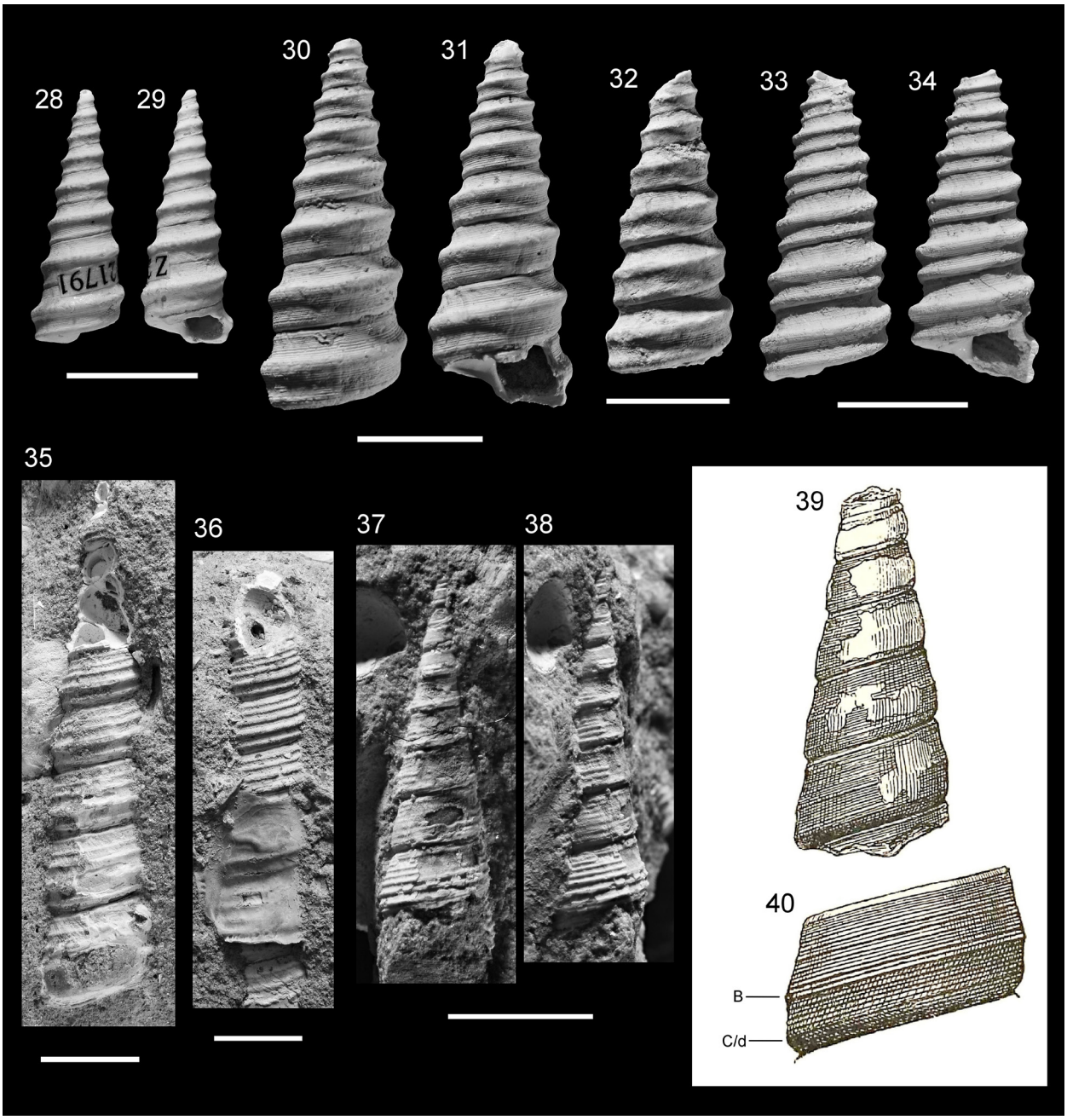
(Figs 39–40)

Turritella neudorfensis Toula 1900: p. 15.

Material. The specimens illustrated by TOULA (1900: fig. 6a, b). Repository data and the shell measurements are unknown.

Original description (TOULA 1900: p. 15). "Die Umgänge sind flach und mit etwa 30 nicht ganz gleichen Spirallinien bedeckt. Gegen die Mündung zu lassen sich zwei wenig ausgeprägte Spiralkiele erkennen." [The whorls are flat and covered by about 30 not-quite-equal spiral lines. Towards the aperture, two less pronounced spiral keels can be seen].

Emended description. Shell incomplete, robust, moderately slender, composed of five teleoconch whorls; protoconch and early teleoconch whorls are missing, order of appearance of spiral cords unknown.



Figs 28–40. Turritellidae species, Devínska Nová Ves, Upper Badenian: 28–29 – *Oligodia bicarinata* (Eichwald, 1830), Z 21791, Sandberg; 30–31 – *Oligodia bicarinata* (Eichwald, 1830) Z41957, Útočnice; 32 – *Oligodia bicarinata* (Eichwald, 1830), Z 41958, Útočnice; 33–34 – *Oligodia bicarinata* (Eichwald, 1830), Z 41959, Útočnice; 35 – *Ptychidia vindobonensis* (Handmann, 1882), Z 40757, Záveterná; 36 – *Ptychidia vindobonensis* (Handmann, 1882), Z 40757, Záveterná; 37–38 – *Viennella* sp., Z 41960, Bačnegovice; 39 – "*Turritella*" *neudorfensis* Toula, 1900, Brickyard (the reproduction of the original illustration of the syntype figured by TOULA (1900); SL, MD, and the scale bar are unknown); 40 – "*Turritella*" *neudorfensis* Toula, 1900, detail of the teleoconch whorl with the addition of the notation of primary spiral cords (B, C/d), Brickyard (the reproduction of the original illustration of the syntype figured by TOULA (1900); SL, MD, and the scale bar are unknown). Scale bars 10 mm (Figs 28–36) and 5 mm (Figs 37–38)

Shell dimensions (SL, MD) unknown. AA unknown, PA = 17°. First known teleoconch whorl abraded. Later teleoconch whorls stocky, broad, weakly convex in shape, with maximum diameter bellow mid-whorl. Whorl profile imbricate to slightly frustate, bicarinate, sutural ramp somewhat concave. Teleoconch whorls covered by two indistinct, low, suppressed primary spiral cords; medial primary B somewhat prominent, thin, forming little pronounced mid-whorl angulation, primary cord (C/d) close abapical suture slightly depressed. Primaries separated by broad, shallow, weakly concave to straight-sided interspaces. Suture linear, incised, well defined. Whorl surfaces covered by densely spaced growth lines and numerous, about 30, fine secondary and tertiary spiral threads, non-uniform in strength, separated by narrow furrows. Delicate, indistinct tubercles or nodules developed in intersections of growth lines and spiral threads. Smooth, flat, narrow spiral band running below adapical suture. Transition into base angulate based on last preserved teleoconch whorl. Last adult whorl and aperture destroyed, aperture shape and internal sculpture unknown. Lateral sinus probably in mid-whorl, inflection points not recognised, base and basal sinus unknown.

Remarks. According to the figure of Toula (1900: fig. 6a, b), the neanic teleoconch whorls and the last adult whorl are missing. Several morphological features are unavailable, such as the protoconch, the order of appearance of the spiral cords, the sculpture of early teleoconch whorls, the lateral and basal sinus, and the aperture shape; also, the presence/absence of internal sculpture cannot be confirmed. In the illustration, the growth lines are not so clearly sketched, so it is impossible to define the lateral sinus. In addition, the shell length, maximum diameter, and scale bar were not given. Another problem is that defining the primary spiral cord running close to the abapical suture is not reliably possible. It may represent spiral cord C if the species belongs to *Archimediella* or peribasal spiral cord d if it represents an *Oligodia*. On the other hand, the shape of teleoconch whorls and primary spiral cords are well-defined in the illustration and may allow its possible genus-level placement. The shell shows the imbricate, weakly bicarinate profile of teleoconch whorls and slightly concave sutural ramp, and its whorls bear two primary spiral cords. At first sight, the overall shell morphology seems concordant with the genus *Oligodia* Handmann, 1882, in the sense of Landau et al. (2013), Van Dingenen et al. (2016), and Harzhauser & Landau (2019). However, due to a lack of important diagnostic features, such as the order of appearance of the spiral cords, sculpture of early whorls, and the lateral and basal sinuses, its placement in the proposed genus is not formally possible.

Although this species was initially placed in the genus *Turritella* Lamarck, 1799 by Toula (1900), it has little in common with it. Representatives of *Turritella* featured their large-sized shells, a frustate to campanulate spire whorl profile, and well-defined primary and secondary spiral cords on early teleoconch whorls, which become faintly obsolete to attenuated in later whorls, and in having the order of appearance of primary spiral cords B-A-C (cf. Harzhauser & Landau 2019). Because the clear generic relation of the species is uncertain, it remains provisionally placed in "*Turritella*" herein for now.

It is evident that "*Turritella*" *neudorfensis* Toula, 1900 morphologically resembles the genus *Oligodia* Handmann, 1882. *Oligodia bicarinata* (Eichwald, 1830), which commonly occurred in the Paratethyan, Proto-Mediterranean, and northeastern Atlantic Miocene (cf. Landau et al. 2013, 2018, Harzhauser & Landau 2019), is a similar species that from "*T.*" *neudorfensis* differs in its typical bicarinate whorl profile and two prominent, more thickened and strongly raised primary spiral cords B and d, sometimes separated by deep, concave, and wide interspaces, making the overall sculpture appearance more coarse; also, the suture and sutural ramp are more deeply incised, and spiral threads are more delicate and uniform (cf. Harzhauser & Landau 2019: figs 16A–E). *Oligodia spirata* (Brocchi, 1814), a well-known Neogene European turritellid (cf. Landau et al. 2004, Van Dingenen et al. 2016, Harzhauser & Landau 2019), is another superficially similar species that has teleoconch whorls decorated by a very prominent carina forming strong mid-whorl angulation, the sutural ramp and abapical half of the whorls are more concave, and the tertiary spiral threads seem more delicate (cf. Harzhauser & Landau 2019: figs 16F–G), which clearly differs from the species from Devínska Nová Ves. Toula (1900) noticed some conchological similarities between *Turritella neudorfensis* and the shell from Steinebrunn (Vienna Basin, Austria) figured by Hörnes (1855: pl. 43, fig. 4) as *Turritella marginalis* Brocci var., which was later distinguished by Sacco (1895) as a new species named *Turritella* (*Haustator*) *sulcomarginalis*, and more recently transferred into *Oligodia* by Harzhauser & Landau (2019). *O. sulcomarginalis* (Sacco, 1895) from the Vienna Basin is a distinctly different species that has a much more slender shell with discernible medial primary B forming moderate mid-whorl angulation developed on nearly flat-sided teleoconch whorls (cf. Harzhauser & Landau 2019: figs 16H–J). The herein-discussed "*Turritella*" from Devínska Nová Ves is also slightly similar to *O. guillaumei* (Brébion in Lauriat-Rage et al. 1989) and *O. palumbina* Van Dingenen, Ceulemans and Landau, 2016, both known from the Lower Pliocene of the Loire Basin (France). *O. guillaumei* is a superficially similar species char-

acterised by its slightly concave latest teleoconch whorls (cf. VAN DINGENEN et al. 2016: pl. 3, figs 3–5). *O. palumbina* has similar flat-sided whorls but has a much taller and slimmer shell, slightly higher whorls and considerably faint to obsolete primaries, which are weakly developed on post-neanic teleoconch whorls (cf. VAN DINGENEN et al. 2016: pl. 3, figs 6–7). *O. chauvereauensis* Landau, Ceulemans et Van Dingenen, 2018, described from the Tortonian (Upper Miocene) of northwestern France, is a quite different turritellid, featured by its relatively broad turriculate shell, strongly carinate teleoconch whorls with prominent medial primary B placed in mid-whorl, and impressed suture (cf. LANDAU et al. 2018: pl. 17, figs 1–3).

The genus *Archimediella* Sacco, 1895 is a partly similar turritellid whose members differ from "*T.*" *neudorfensis* in their coarse spiral sculpture on teleoconch whorls, by the presence of prominent spiral cords A, B and C and numerous nonuniform secondary and tertiary spiral cords of variable strength covering the surface of teleoconch whorls (see LANDAU et al. 2018, HARZHAUSER & LANDAU 2019). For a complete description of diagnostic features that define the genus, see HARZHAUSER & LANDAU (2019).

Stratigraphic and geographic distribution. This Late Badenian (Middle Miocene) Central Paratethyan species is known only from the type locality Devínska Nová Ves – Brickyard (former clay pit), Vienna Basin, Slovakia.

TAXONOMIC COMPOSITION

Each locality is characterised by a distinct and unique diversity of turritellids (Fig. 41). Their species richness and abundance may be related to distinct ecological factors and to changes in these factors in depositional environments during the Upper Badenian. Seven Turritellidae species were recognised from these localities. The taxonomic composition of Turritellidae assemblages, except for Brickyard, is evaluated herein. Although several species of turritellids were briefly mentioned by SCHAFFER (1898) and TOULA (1900) from this site, they are not included in the statistical evaluation because the data reported by those authors are poor, they cannot be verified, and no further material is available for re-examination. It is worth noting that similar high-specimen-rich assemblages, comparable to those of Turritellidae, were observed in other gastropod families, e.g., Cerithiidae, Costellariidae, Ancillariidae, and Conidae at Útočnice, and in Turbinidae at Sandberg and Bačnegovice.

Záveterná locality is characterised by a monotypic Turritellidae association, with a single species, *Ptychidia vindobonensis* (Handmann, 1882) (14 specimens). The assemblage of **Kasárne** is characterised by the dominance of *Archimediella abundans* (Handmann, 1882) (71 specimens), accompanied by *Helminthia vermicularis* (Brocchi, 1814) (14 specimens) and rare *A. carpathica* Harzhauser et Landau, 2019 (7 specimens). At **Bačnegovice**, *Helminthia vermicularis* (Brocchi, 1814) (66 specimens) and *Oligodia bicarinata* (Eichwald, 1830) (50 specimens) represent the most common Turritellidae taxa, followed by *Archimediella abundans* (Handmann, 1882) (21 specimens), and rare *A. carpathica* Harzhauser et Landau, 2019 (1 specimen), *Ptychidia vindobonensis* (Handmann, 1882) (1 specimen), and *Viennella* sp. (1 specimen). Partly similar taxonomic composition was observed at the neighbourhood site **Útočnice**, where *O. bicarinata* (307 specimens) and *H. vermicularis* (283 specimens) prevailed in the turritellid assemblage, whereas *A. carpathica* (9 specimens) occurred rarely. The assemblages of **Sandberg** were characterised by the dominating *O. bicarinata* (80 specimens), followed by *Helminthia tricincta* (Borson, 1821) (41 specimens), *H. vermicularis* (Brocchi, 1814) (18 specimens), *Archimediella abundans* (Handmann, 1882) (16 specimens), and *A. carpathica* Harzhauser et Landau, 2019 (5 specimens). At **Vodojem**, two rare species occur: *H. vermicularis* (1 specimen) and *A. abundans* (Handmann, 1882) (1 specimen).

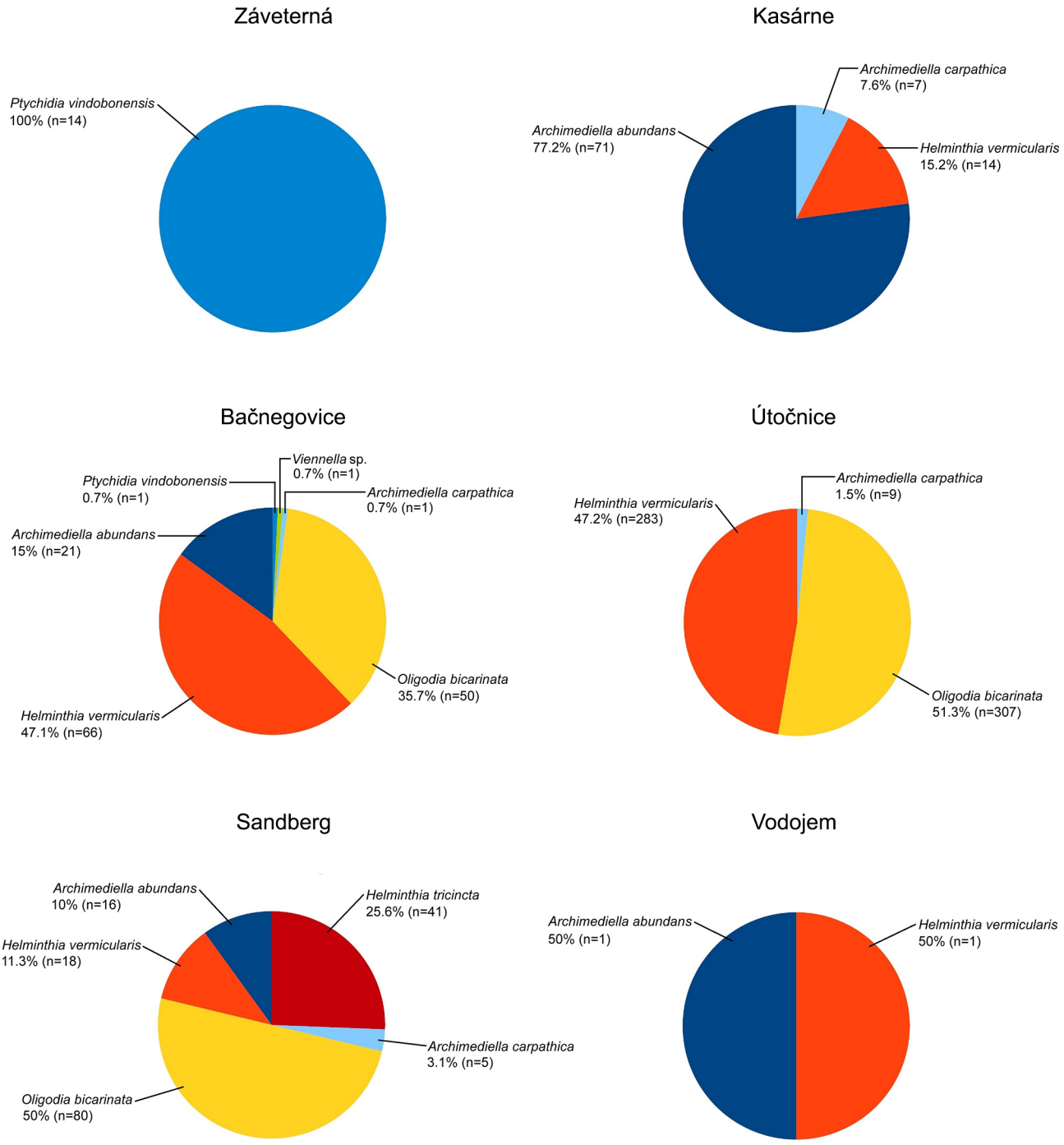


Fig. 41. Taxonomic composition and percentage representation of studied Turritellidae species at respective localities of Devínska Nová Ves

PALEOECOLOGY

The studied Turritellidae communities inhabited primarily shallow-water marine paleoenvironments with soft, sandy sea bottoms (Fig. 43). They were often associated with seagrass habitats, where they reached their highest abundance and diversity. Four paleoenvironments with Turritellidae occurrence were recognised at the respective sites, ranging from intertidal to infralittoral zones (Fig. 42). Deeper, middle neritic paleoenvironments characterised by muddy sea bottom and influenced by occasional hypoxic events were identified at the locality Brickyard. In these habitats, the herein discussed *"Turritella" neudorfensis* Toula, 1900, occurred. However, because the Turritellidae are known only from the literature and no further material is available from the locality, they are not statistically evaluated.

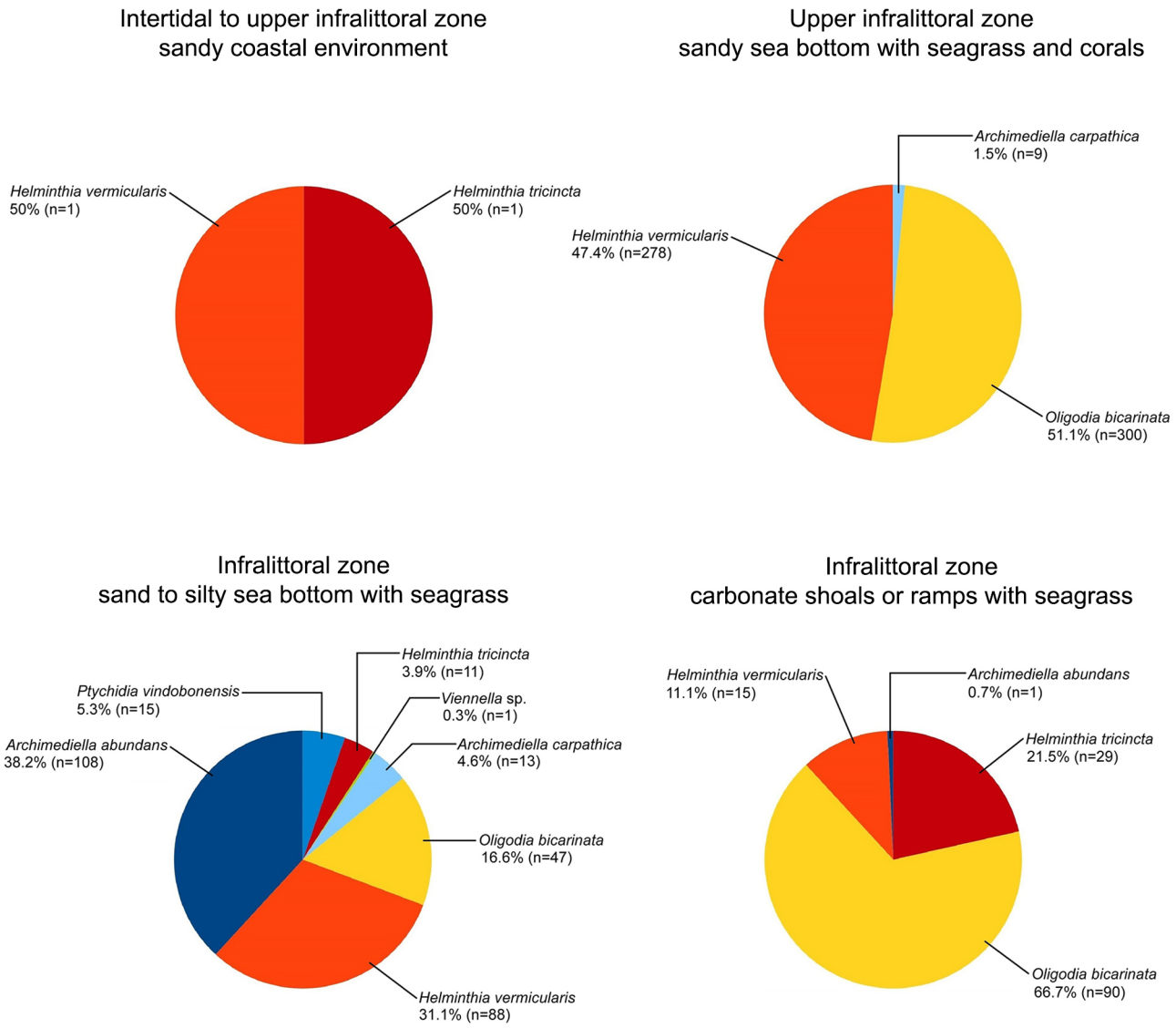


Fig. 42. Occurrence and percentage of respective Turritellidae species in the Upper Badenian marine paleoenvironments of Devínska Nová Ves

INTERTIDAL TO UPPER INFRALITTORAL ZONE – SANDY COASTAL ENVIRONMENT

Coarse-grained pale-grey sands with sandstone beds and lenses of gravel exposed at Sandberg (SA 2, Sandberg facies 2 and 3 sensu HYŽNÝ et al. 2012) indicate coastal sandy environments. Marine invertebrates (gastropods, bivalves, echinoids, decapods) and vertebrates (sharks, rays, bony fishes) are only rarely present and sparsely distributed, and the assemblage shows a strong decrease in diversity and abundance. Some layers of the Sandberg facies 3 are in places almost sterile of fossils. The presence of the echinoid *Parascutella* points to shallow-water marine and/or mobile coastal habitats characterised by sandy substrate and higher water energy (cf. KROH & NEBELSICK 2003, MIKŠA 2009). Coastal sandy habitats in the intertidal to subtidal zone can also be deduced by the occurrence of the trace fossil *Piscichnus waitemata* Gregory, 1991 (cf. ŠIMO et al. 2014, UCHMAN et al. 2018). Finds of the limpet gastropods *Patella* suggest intertidal to shallow-water environments and exposed rocky shores (e.g., POPPE & GOTO 1991, FORLI et al. 2004, 2021, ALF et al. 2020). The co-occurrence of oyster *Ostrea digitalina* (Eichwald, 1830) demonstrates a possible rocky-coastline paleoenvironment with dominant wave action in the medio/sublittoral, intertidal to shallow subtidal zone (ZÁGORŠEK et al. 2009).

In summary, the sedimentology and macrofauna suggest nearshore environments with high hydrodynamic energy and a coarse-grained, sandy to sandy-gravely substrate; sedimentation took place in intertidal/upper infralittoral zones.

Turritellidae members occupied these habitats only rarely and marginally, and reached extremely

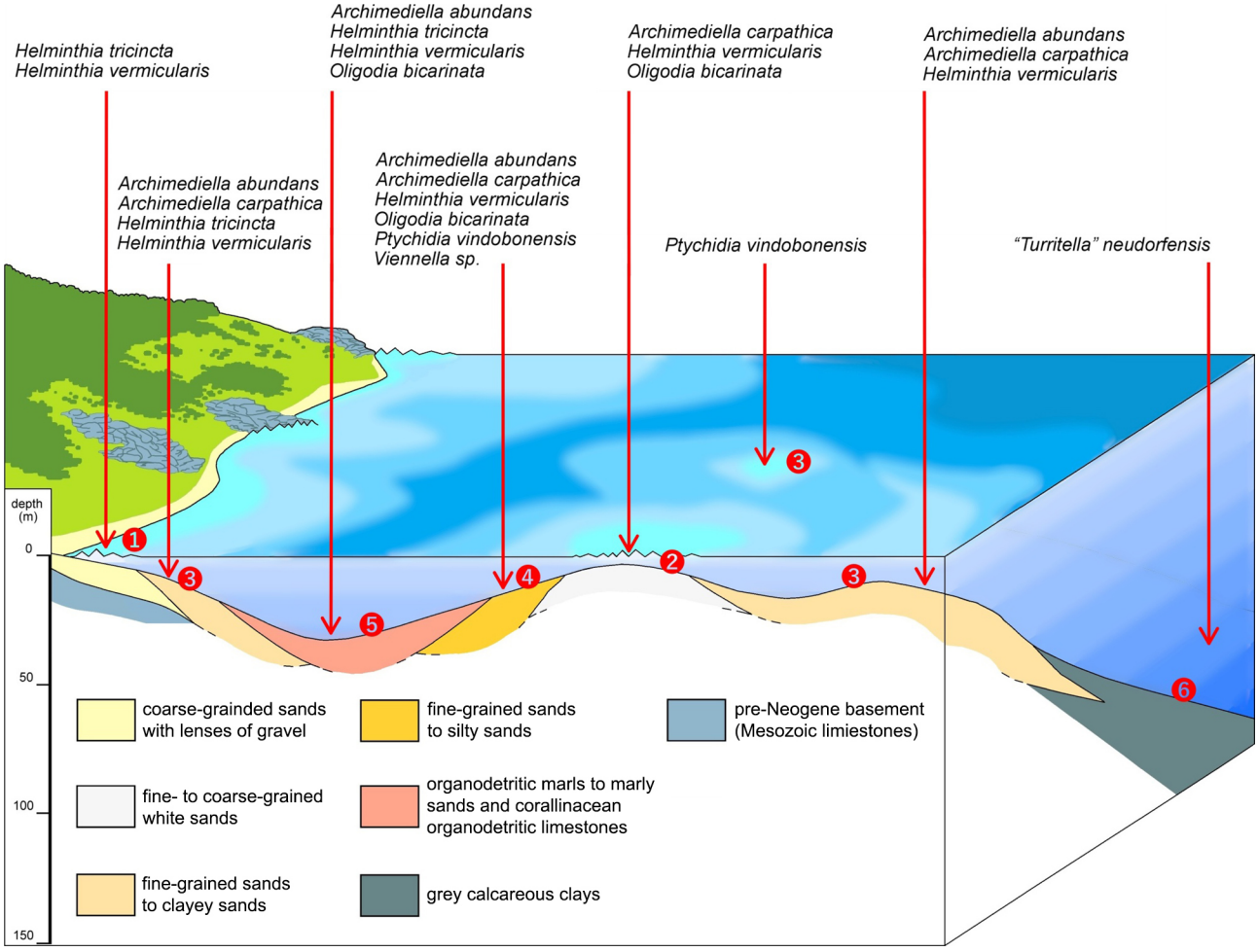


Fig. 43. Simplified, idealised reconstruction of the Upper Badenian shelf and its various paleoenvironments on the eastern margin of the Vienna Basin at Devínska Nová Ves, showing the occurrence of the respective Turritellidae species: 1 – sandy coast (intertidal to upper infralittoral zone), 2 – sandy seabottom with seagrass and corals (upper infralittoral zone), 3 – sandy seabottom with seagrass (infralittoral zone), 4 – sandy to sandy-silty seabottom with a huge seagrass meadows (infralittoral zone), 5 – sandy to clayey seabottom with corallinacean red algae and seagrass (infralittoral zone), 6 – muddy seabottom, paleoenvironment affected by sluggish water circulation and episodic hypoxic events (middle to outer neritic zone)

low diversity and abundance, as evidenced by the very sporadic finds of *Helminthia tricincta* (Borson, 1821) and *H. vermicularis* (Brocchi, 1814).

UPPER INFRALITTORAL ZONE – SANDY SEA BOTTOM WITH SEAGRASS AND CORALS

Fine- to coarse-grained white sands exposed at **Útočnice** and to a small extent also at **Bačnegovice** were most probably deposited in a shallow-water marine infralittoral habitat or subtidal mobile sandbanks, partly with seagrass meadows and small colonies of branched finger corals (*Porites*) settled on soft sandy sea bottom; well-aerated, nutrient-rich, and warm-water conditions and higher wave dynamics are assumed for this habitat (Biskupič 2023d, 2024b).

The Turritellidae fauna obtained from these strata comprises three species, of which *Oligodia bicarinata* (Eichwald, 1830) and *Helminthia vermicularis* (Brocchi, 1814) show significantly high abundance, whereas the third taxon, *Archimediella carpathica* Harzhauser et Landau, 2019, occurred only rarely.

INFRALITTORAL ZONE – SANDY TO SILTY SEA BOTTOM WITH SEAGRASS

Shallow-water marine paleoenvironments with seagrass were detected at **Kasárne, Bačnegovice**, **Sandberg**, **Vodojem**, and probably at **Záveterná**. To these habitats correspond pale-brown to pale-grey, fine-grained sands to clayey sands with sandstone beds and concretions exposed at Sandberg (SA 1, Sandberg facies 2 sensu Hyžný et al. 2012), pale- to ochreous sands and sandstone concretions occurring at Kasárne, fine-grained yellow sands to silty sands exposed at Bačnegovice and Záveterná, and fine- to coarse-grained sands and sandstones exposed at Vodojem.

Species-rich marine macrofauna (particularly molluscs) and their preservation in sandy/sandstone deposits point to shallow-water habitats with favourable conditions. Some bivalve genera, such as *Glycymeris*, *Atrina*, *Ostrea*, *Anomia*, *Codakia*, *Megaxinus*, and *Megacardita*, may indicate infralittoral settings with seagrass (cf. DULAI 1996, RUEDA et al. 2009, HARZHAUSER 2014, REICH et al. 2015, KOSKERIDOU et al. 2019, DOMINICI & FORLI 2021, PAVIA et al. 2022, SCHNEIDER et al. 2022, BISKUPIČ 2023c). The frequent occurrence of turritellids *Helminthia vermicularis* (Brocchi, 1814) and *Oligodia bicarinata* (Eichwald, 1830) and other seagrass-associated gastropods (*Gibbuliculus*, *Smaragdia*, *Bittium*) at Bačnegovice and Útočnice also suggest the seagrass habitat (cf. REICH et al. 2015, ALF et al. 2020, HARZHAUSER & LANDAU 2019, BISKUPIČ 2023c, HARZHAUSER et al. 2025). Shallow-water (infralittoral) conditions reflect the common occurrence of bivalve *Glycymeris deshayesi* (Mayer, 1868) (cf. DULAI 1996), and pectinid bivalves *Flabellipecten*, *Pecten*, and *Aequipecten* (cf. BOŠNJAK et al. 2024). According to MANDIC et al. (2004), the genus *Glycymeris* was well adapted to high-energy environments in the subtidal zone above the storm wave base; it typically occurs in intertidal to subtidal zones on sandy, muddy, and gravel substrates (ALF et al. 2020), but sometimes reaches depth down to 73 m (POPPE & GOTO 1993). A common oyster *Ostrea digitalina* (Eichwald, 1830) indicates shallow water settings down to 10 m water depth (MANDIC & HARZHAUSER 2003), and a rocky-coastline paleoenvironment with dominant wave action in the medio/sublittoral, intertidal to shallow subtidal zone (ZÁGORŠEK et al. 2009). The bivalve *Anomia ephippium* Linnaeus, 1758 indicates a hard bottom (rocks, shells) with a bathymetric range from the intertidal zone down to 150 m depths (circalittoral zone) (BERNASCONI & ROBBA 1993, POPPE & GOTO 1993, JANKE 2010) with a strong preference for intertidal to subtidal (ALF et al. 2020) or infralittoral habitats (cf. ŠVAGROVSKÝ 1981b). The abundant cockle bivalve *Acanthocardia turonica* (Hörnes, 1861) indicates shallow sublittoral conditions with a water depth of 10–15 m (HARZHAUSER et al. 2014). The common presence of articulated shells in the life position of the deep-burrowing bivalve *Panopea menardi* (Deshayes, 1829) suggests shallow subtidal habitats down to 20 m and frequent seafloor disturbances by storms (ZUSCHIN et al. 2007). Often findings of articulated shells of the suspension feeding, mainly infaunal (e.g., *Megaxinus*, *Lucina*, *Lucinoma*, *Acanthocardia*, *Megacardita*, *Venus*, *Callista*, *Thracia*, *Azorinus*, *Lutraria*, *Pholadomya*) and exceptionally also of epifaunal bivalves (*Flabellipecten*, *Pecten*), may reflect somewhat moderate water dynamics. In contrast, the presence of echinoids *Parascutella* and *Clypeaster* points to shallow-water marine and/or mobile coastal habitats with sandy substrate and higher water energy (cf. KROH & NEBELSICK 2003, MIKŠA 2009). Additionally, the high abundance of the chemosymbiotic lucinid bivalve *Microloripes* at Bačnegovice indicates eutrophic and hypoxic conditions within the substrate and seagrass roots (cf. TAYLOR & GLOVER 2000, TAYLOR et al. 2011, HOLCOVÁ et al. 2019).

Based on the macrofauna found, the paleoenvironments can be interpreted as shallow-water habitats characterised by well-aerated, nutrient-rich conditions. Sedimentation took place in the infralittoral zone above the storm wave base, on soft, fine- to coarse-grained sandy sea-bottom, partly with seagrass and influenced by higher hydrodynamics at **Kasárne**, **Sandberg**, and **Vodojem**, but in sandy-silty sea-bottom with huge seagrass meadows and moderately hydrodynamics at **Bačnegovice**, where eutrophic and hypoxic settings within the substrate and seagrass roots prevailed. A high wave energy paleoenvironment, partly with seagrass and very shallow water conditions with a depth of only a few meters, probably prevailed at **Záveterná**.

In these habitats, Turritellidae gastropods reached their highest diversity and were significant components of the gastropod assemblages. Altogether, seven species were recorded in these paleoenvironments: *Archimediella abundans* (Handmann, 1882), *A. carpathica* Harzhauser et Landau, 2019, *Helminthia tricincta* (Borson, 1821), *H. vermicularis* (Brocchi, 1814), *Oligodia bicarinata* (Eichwald, 1830), *Ptychidia vindobonensis* (Handmann, 1882), and *Viennella* sp.

INFRALITTORAL ZONE – CARBONATE SHOALS OR RAMPS WITH SEAGRASS

Organodetritic marls to marly sands and coralinacean organodetritic limestones revealed in the uppermost parts of the sections at **Bačnegovice**, **Útočnice**, and **Sandberg** (SA 2, Sandberg facies 4 sensu HYŽNÝ et al. 2012) represent corallinacean red algae-dominated nearshore habitats (carbonate platforms or shoals) with seagrass meadows in the shallow-water (infralittoral) zone (BISKUPIČ 2023d, JAMRICH et al. 2024). These habitats were characterised by well-aerated, oligotrophic and warm water conditions (JAMRICH et al. 2024).

In the Turritellidae assemblages, *Oligodia bicarinata* (Eichwald, 1830) strongly dominates, accompanied by *Helminthia tricincta* (Borson, 1821), *H. vermicularis* (Brocchi, 1814), and rare *Archimediella abundans* (Handmann, 1882).

MIDDLE NERITIC ZONE – MUDDY SEA BOTTOM INFLUENCED BY OCCASIONAL HYPOXIC EVENTS

Basinal pelitic strata exposed at the **Brickyard** locality, in which the Turritellidae fauna, including

"Turritella" neudorfensis Toula, 1900, was found, generally suggest middle to outer neritic paleoenvironments (cf. Seneš & Ondrejičková 1991, Tomašových 1998, Hudáčková et al. 2003, Chalupová 2001) affected by occasional hypoxia near muddy sea-bottom (cf. Hudáčková & Kováč 1993, Tomašových 1998, Hudáčková & Spezzaferri 2002, Kováčová et al. 2009).

In comparison with the faunal assemblages found in the new clay pit (cf. Švagrovský 1981a, Tomašových 1998), the associations of invertebrates (particularly molluscs) reported from the first clay pit (cf. Schaffer 1898, Toula 1900, 1915) are more diversified and may indicate somewhat favourable settings, such as shallower water depth (middle neritic paleoenvironments). The presence of r-strategist opportunistic bivalve *Corbula gibba* (Olivi, 1792) that typically occurred in temporarily stressed environments (Hrs-Brenko 2006), accompanied by the carnivorous naticid gastropod *Euspira*, both strongly dominating the molluscan assemblages of the first clay pit (cf. Schaffer 1898, Toula 1900), may be related to unfavourable and unstable paleoenvironmental settings, lowered water circulation or occasional hypoxic events (cf. Tomašových 1998, Hyžný et al. 2012, Biskupič 2020, 2023a, 2023c). The occurrence of thermophilic gastropod families (e.g., Xenophoridae, Costellariidae, Terebridae, Clavatulidae, Conidae) and stenohaline invertebrate faunas (e.g., brachiopods, pectinid bivalves, scaphopods, echinoids) points to warm water (subtropical) conditions and normal water salinity.

DISCUSSION

HISTORICAL DATA VERSUS NEW KNOWLEDGE

From the 19th century to the present day, the literature dealing with the Middle Miocene marine faunas from Devínska Nová Ves has reported a total of 15 Turritellidae species originating from several localities (cf. Kornhuber 1865, Fuchs 1868, Schaffer 1898, 1908, Toula 1900, Horusitzky 1917, Sieber 1958b, Švagrovský 1981a, Ondrejičková 1987, Hyžný et al. 2012, Ruman & Hudáčková 2015, Harzhauser & Landau 2019). Some of the species mentioned by those authors are invalid and considered subjective junior synonyms, as suggested by the taxonomic revision of Turritellidae from the Central Paratethys given by Harzhauser & Landau (2019). Additionally, the occurrence of some of the species previously mentioned from the study area was not confirmed, as indicated by the results of this study. Therefore, the actual number of species occurring at Devínska Nová Ves is significantly lower. One of the most relevant papers on the molluscan faunas from Devínska Nová Ves is the monograph by Švagrovský (1981a), which, in addition to remarks and detailed distributional data at the studied localities, also includes illustrations of the respective taxa. Moreover, his material is stored in the collections of SNM-PM, which allows its re-examination. Curiously, he mentioned only three species of turritellids from Devínska Nová Ves: *Turritella* (*Zaria*) *spirata* (Brocchi, 1814), *T.* (*Haustator*) *tricincta* Borson, 1821, and *T.* (*Archimediella*) *bicarinata* Eichwald, 1830. In summary, despite inconsistent and sometimes contradictory data on the taxonomic composition of this gastropod group in the study area, obtained from the available literature, the results presented in this work definitely indicate the presence of eight species of turritellids.

Another problem is the inaccessibility of material collected from unknown or destroyed localities. Sieber (1958b), from an unspecified locality situated at Devínska Nová Ves, listed three turritellid species: *Turritella badensis badensis* Sacco, *T.* (*Archimediella*) *erronea erronea* Cossm., and *T. bicarinata bicarinata* Eichw. However, the exact location of the site is unknown, and the material is not available and seems to be lost. Thus, this conchological material cannot be revised or evaluated herein. The Brickyard is another fossiliferous site that no longer exists. Seven turritellid species were identified from clays revealed there and were reported only in the papers of Schaffer (1898) and Toula (1900), namely: *Turritella turris* Bast., *T. riepeli* Partsch, *T. subangulata* Brocc.?, *T. vermicularis* Brocc., *T. archimedis* Brong., *T. pythagoraica* Hilber, and *T. neudorfensis* Toula, 1900. Nevertheless, these taxa were only briefly commented on or mentioned in the faunal list, except for the description and illustration of *"Turritella" neudorfensis* Toula, 1900. No additional turritellid material was found at the locality. Unfortunately, both clay pits are nowadays inaccessible and destroyed, which does not allow further research. For this reason, the taxonomic composition of Turritellidae from Brickyard could not be verified, and the presence of some species remains unconfirmed.

PALEOECOLOGY

In general, the turritellids are considered semi-infaunal suspension-feeding gastropods that mainly occur in nutrient-rich (Allmon 1988, 2011, Anderson et al. 2017, Nebelsick et al. 2019) and shallow-water, soft-bottom settings (Zuschin et al. 2004, Harzhauser & Landau 2019, Biskupič 2023c). In Devínska Nová Ves, the highest species richness and abundance of the family Turritellidae

were documented in sandy sediments deposited in shallow-water marine seagrass habitats.

Oligodia bicarinata (Eichwald, 1830), representing the most abundant turritellid in the studied area, preferred mainly shallow-water marine paleoenvironments (e.g., LATAL et al. 2006, TUREK & HLADILOVÁ 2019) within the corallinacean red algae habitats (HYŽNÝ et al. 2012), patch reef paleoenvironments (KOVÁCS & VICIÁN 2021), seagrass habitats, and lagoons (HARZHAUSER & LANDAU 2019). *Helminthia vermicularis* (Brocchi, 1814) was the second most abundant species in the Turritellidae associations of Devínska Nová Ves. According to HARZHAUSER & LANDAU (2019), this species commonly occurred in the shallow sublittoral seagrass habitats, also inhabited infralittoral nearshore algae-dominated habitats, but only exceptionally occurred in the basinal pelites, suggesting deeper sublittoral settings with sluggish water circulation (BISKUPIČ 2023c). In conclusion, the paleoecological settings preferred by these species are mainly consistent with those estimated for the localities discussed herein.

In contrast, the pelites exposed at Brickyard represent basinal, deeper-water marine deposits that were inhabited by enigmatic "*Turritella*" *neudorfensis* Toula, 1900. Similar molluscan assemblages, characterised by the dominance of the opportunistic, pollution-tolerant bivalve *Corbula gibba* (Olivi, 1792) and the predatory naticid gastropod *Euspira*, pointing to the sluggish water circulation and occasional hypoxic events, were described from coeval pelitic deposits of the Hrušky Formation (formerly also known as Studienka Formation) exposed in the eastern Vienna Basin, at Rohožník – Konopiská (cf. HLADILOVÁ 1991, HLADILOVÁ et al. 1998, LAMBERT et al. 2008, BISKUPIČ 2020, 2023a, 2023c) and around Devín (cf. HYŽNÝ et al. 2012, BISKUPIČ 2023a, JAMRICH et al. 2024). In the pelitic strata exposed at these localities, the representatives of the genera *Archimediella*, *Oligodia*, *Helminthia* and *Turritellinella* were found (cf. ŠVAGROVSKÝ 1981a, HYŽNÝ et al. 2012, MADARÁS et al. 2014, BISKUPIČ 2023a, 2023c). However, no shells of "*T*". *neudorfensis* were recorded there.

CONCLUSIONS

The members of the Turritellidae gastropods originating from the Upper Badenian inner neritic deposits exposed at six paleontological localities situated at Devínska Nová Ves are re-examined. Eight species attributed to five genera are confirmed: *Archimediella abundans* (Handmann, 1882), *Archimediella carpathica* Harzhauser et Landau, 2019, *Helminthia tricincta* (Borson, 1821), *Helminthia vermicularis* (Brocchi, 1814), *Oligodia bicarinata* (Eichwald, 1830), *Ptychidia vindobonensis* (Handmann, 1882), *Viennella* sp., and "*Turritella*" *neudorfensis* Toula, 1900. Two taxa, *Archimediella carpathica* and *Viennella* sp., are recorded for the first time from the study area. *Oligodia bicarinata* and *Helminthia vermicularis* are the most abundant species in the assemblages, often found in most of the localities. In contrast, *Helminthia tricincta* occurs exclusively at Sandberg, and *Viennella* sp., known by a single specimen, was found only at Bačnegovice. The assemblage at Záveterná is monotypic, composed solely of the single species, *Ptychidia vindobonensis*. Members of the genus *Archimediella*, such as *Archimediella abundans* or *Archimediella carpathica*, were distributed in all localities except Záveterná.

The highest diversity of Turritellidae was detected at Bačnegovice (six species), whereas the highest abundance was recorded at the nearby site of Útočnice (599 specimens). The assemblages of turritellids show strong preferences for shallow-water marine inner neritic habitats with seagrass meadows or mixed coralline red algae and seagrass paleoenvironments. In coastal habitats (intertidal to subtidal zones), they reached significantly lower abundance and diversity.

The Turritellidae assemblage from Brickyard is not re-examined and is not taxonomically or paleoecologically evaluated herein. The material from the locality is unavailable, which does not allow its revision. "*Turritella*" *neudorfensis* Toula, 1900, an almost forgotten, enigmatic species known only from the literature, found in the pelitic deposits of Brickyard, is more thoroughly discussed. The overall shell morphology of the species suggests a possible relationship to the genus *Oligodia* Handmann, 1882. However, as demonstrated by the figured material of TOULA, some important conchological features are not preserved or are not so clearly drawn in the illustration, and, unfortunately, do not allow its reliable genus-level placement. Therefore, its formal placement in *Oligodia* is avoided herein; the species remains provisionally assigned to "*Turritella*" and is considered taxon inquirendum for now. Only new material could clarify the uncertain taxonomic status of this turritellid. The species occupied deeper, middle neritic marine habitats and was adapted to unfavourable, unstable paleoenvironmental settings characterised by lowered water circulation or episodic hypoxic events near the soft, muddy sea floor.

ACKNOWLEDGEMENTS

I thank BARBARA ZAHRADNÍKOVÁ (Natural History Museum of the Slovak National Museum, Bratislava),

Štefan Meszároš (Dúbravka Museum, Bratislava), Klement Fordinál, and Milan Pavúk (both State Geological Institute of Dionýz Štúr, Bratislava) for providing access to the Turritellidae material for re-examination. I appreciate Mathias Harzhauser (Natural History Museum, Vienna) for help with this research. Martin Vlačiky, Jozef Bumbera, Andrej Bernáth (all Bratislava), Jakub Borko (Kanianka), Samuel Veselý (Hrnčiarovce nad Parnou), and Róbert Hodal (Trenčín) are thanked for providing further Turritellidae material for study. Finally, I acknowledge the three anonymous reviewers whose critical comments, helpful advice, and suggestions benefited the manuscript.

REFERENCES

Alf A., Brenzinger B., Haszprunar G., Schrödl M., Schwabe E. 2020. A Guide to Marine Molluscs of Europe. ConchBooks, Harxheim.

Allmon W. D. 1988. Ecology of living turritelline gastropods (Prosobranchia, Turritellidae): Current knowledge and paleontological implications. Palaios 3: 259–284.

Allmon W. D. 1996. Systematics and evolution of Cenozoic American Turritellidae (Mollusca: Gastropoda) I: Paleocene and Eocene coastal plain species related to '*Turrritella mortoni* Conrad' and '*Turritella humerosa* Conrad'. Palaeontographica Americana 59: 1–134.

Allmon W. D. 2011. Natural history of turritelline gastropods (Cerithiodea: Turritellidae): A status report. Malacologia 54: 159–202.

Anderson B. M., Hendy A., Johnson E. H., Allmon W. D. 2017. Paleoecology and paleoenvironmental implications of turritelline gastropod-dominated assemblages from the Gatun Formation (Upper Miocene) of Panama. Palaeogeography, Palaeoclimatology, Palaeoecology 470: 132–146. https://doi.org/10.1016/j.palaeo.2017.01.026

Andrzejowski A. 1830. Sur quelques coquilles fossiles de Volhynie, Podolie etc. Bulletin de la Société Impériale des Naturalistes de Moscou 2: 90–104.

Bachmayer F. 1962. Die Calappiden (Crustacea, Decapoda) aus den tortonischen Ablagerungen des Wiener Beckens. Annalen des Naturhistorischen Museums in Wien 65: 39–46.

Baráth I., Nagy A., Kováč M. 1994. Sandberg Member – Late Badenian marginal sediments on the eastern margin of the Vienna Basin. Geologické práce, Správy 99: 59–66.

Berger W. 1951. Pflanzenreste aus den tortonischen Tegel von Theben – Neudorf bei Pressburg. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, mathematish – naturwissenschaftliche Klasse 160: 273–278.

Bernasconi M. P., Robba E. 1993. Molluscan palaeoecology and sedimentological features: an integrated approach from the Miocene Meduna section, northern Italy. Palaeogeography, Palaeoclimatology, Palaeoecology 100: 267–290. https://doi.org/10.1016/0031-0182(93)90058-Q

Biskupič R. 2020. A new evidence of *Vexillum* (Gastropoda: Costellariidae) from the middle Miocene (Serravallian) of the Vienna Basin (Slovakia). Acta Geologica Slovaca 12: 75–88.

Biskupič R. 2023a. Description of a new *Turritellinella* (Caenogastropoda: Turritellidae) from the Middle Miocene of the Central Paratethys Sea. Basteria 87: 25–36.

Biskupič R. 2023b. "*Clavatula" pettkoi* n. sp. (Neogastropoda Clavatulidae) from the Badenian (Miocene) deep-water marine clays of the Studienka Formation (Vienna Basin, Central Paratethys). Biodiversity Journal 14: 315–324. https://doi.org/10.31396/Biodiv.Jour.2023.14.2.315.324

Biskupič R. 2023c. Early ontogeny, paleoecology and intraspecific variability of two *Helminthia* species (Gastropoda: Turritellidae) from the Middle Miocene (Badenian) deposits of the eastern Vienna Basin (Slovakia). Acta Geologica Slovaca 15: 11–22.

Biskupič R. 2023d. New records and paleoecology of the Middle Miocene (Badenian) Costellariidae MacDonald, 1860 (Gastropoda Neogastropoda) from Devínska Nová Ves (Vienna Basin, Slovakia). Biodiversity Journal 14: 749–764. https://doi.org/10.31396/Biodiv.Jour.2023.14.4.749.764

Biskupič R. 2024a. *Viennella baluki* sp. nov. (Gastropoda: Turritellidae) from the Serravallian (Miocene) shallow-water seagrass paleoenvironments of the Vienna Basin (Central Paratethys). Archiv für Molluskenkunde 153: 23–31. https://doi.org/10.1127/arch.moll/153/023-031

Biskupič R. 2024b. A new *Heliacus* species (Gastropoda: Architectonicidae) from the Middle Miocene marine sandy deposits of Devínska Nová Ves (Vienna Basin, Central Paratethys). Bollettino Malacologico 60: 217–225.

Bitner M. A., Zágoršek K., Halásová E., Hudáčková N., Jamrich M. 2014. Brachiopods and bryozoans from the Sandberg section (Vienna Basin, Central Paratethys) and their significance for environmental interpretation of the Early Sarmatian (= Middle Miocene) Sea. Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen 273: 207–219. https://doi.org/10.1127/0077-7749/2014/0424

Borson S. 1821. Continuazione del saggio di Orittografia Piemontese. Memorie della Reale accademia delle scienze di Torino 26: 297–364. https://www.biodiversitylibrary.org/page/7653833

Bošnjak M., Mandic O., Sremac J. 2024. Middle Miocene (Langhian and lower Serravallian/Badenian) scallops (Bivalvia: Pectinidae) from the precious collections of

the Croatian Natural History Museum. Diversity 16: 508.
https://doi.org/10.3390/d16080508

Bouchet P., Rocroi J. P., Hausdorf B., Kaim A., Kano Y., Nützel A., Parkhaev P., Schroedl M., Strong E. 2017. Revised classification, nomenclator and typification of gastropod and monoplacophoran families. Malacologia 61: 1–526.
https://doi.org/10.4002/040.061.0201

Boué A. 1830. Mémoire géologique sur le sol tertiaire et alluvial du pied septentrional des Alpes allemandes. Journal de Geologie 2: 333–385.

Brestenská E. 1978a. Faziostratotypus: Salka bei Štúrovo, Bohrung K-5. In: Papp A., Cicha I., Seneš J., Steininger F. (eds). Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys. M4 Badenien. Bratislava, Veda, pp. 175–184.

Brestenská E. 1978b. Faziostratotypus: Lontov bei Želiezovce, Bohrung ŽI-2. In: Papp A., Cicha I., Seneš J., Steininger F. (eds). Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys. M4 Badenien. Bratislava, Veda, pp. 184–188.

Brocchi G. 1814. Conchiologia fossile subapennina, con osservazioni geologiche sugli Apennini e sul suolo adiacente, 1–2. Milano (Stamperia Reale), 1–240 (1); 241–712 (2), 16 pls.
https://doi.org/10.5962/bhl.title.11569

Brongniart A. 1823. Mémoire sur les terrains de sédiment supérieurs calcaréo-trappéens du Vicentin: et sur quelques terrains d'Italie, de France, d'Allemagne, etc. qui peuvent se rapporter à la même époque. F. G. Levrault, Paris.
https://www.biodiversitylibrary.org/page/9652625

Buday T. 1939. Drei tortonische Faunenlokalitäten am Westabhang der Kleinen Karpathen. Příroda 32: 94–96.

Cox L. R. 1960. Gastropoda. General characteristics of Gastropoda. In: Moore R. C. (ed.). Treatise on invertebrate paleontology. The Geological Society of America, University of Kansas Press, Lawrence.
https://doi.org/10.17161/dt.v0i0.5584

Csepreghy-Meznerics I. 1956. Die Molluskenfauna von Szob und Letkés. Annales de l'Institut Géologique de Hongrie 45: 361–477.

Cuvier G. 1795. Second Mémoire sur l'organisation et les rapports des animaux à sang blanc, dans lequel on traite de la structure des Mollusques et de leur division en ordre, lu à la société d'Histoire Naturelle de Paris, le 11 prairial an troisième. Magazin Encyclopédique, ou Journal des Sciences, des Lettres et des Arts 2: 433–449.

Chalupová B. 2001. Miocénne ryby z okolia Devínskej Novej Vsi (Slovensko). Mineralia Slovaca, Geovestník 33: 17–18.

Čechovič V., Seneš J. 1950. Torton okolia Modrého Kameňa. Geologický Sborník 1: 130–166.

Činčurová E. 1990. Das Erste Vorkommen von *Sepia vindobonensis* Schloenbach, 1898 in Oberen Badenien (Miozän M4d) bei Bratislava. Zborník Slovenského Národného Múzea, Prírodné Vedy 36: 3–7.

Dominici S., Forli M. 2021. Lower Pliocene molluscs from southern Tuscany (Italy). Bollettino della Società Paleontologica Italiana 60: 69–98.

Dulai A. 1996. Taxonomic composition and paleoecological features of the Early Badenian (middle Miocene) bivalve fauna of Szob (Börzsöny Mts., Hungary). Annales historico-naturales Musei Nationalis Hungarici 88: 31–56.

Eichwald E. 1830. Naturhistorische Skizze von Lithauen, Volhynien und Podolien in Geognostisch-Mineralogischer, Botanischer und Zoologischer Hinsicht. Voss, Wilna.

Fleming J. 1822. The philosophy of zoology; or a general view of the structure, functions, and classification of animals. In two volumes. With engravings. Vol. 2. Constable, Edinburgh, 618 pp.
https://www.biodiversitylibrary.org/item/89676

Fordinál K., Zlinská A., Halásová E., Slamková M., Brzobohatý R. 2003. Stratigrafia bádenských sedimentov okolia Stupavy (viedenská panva, Slovensko) a rekonštrukcia paleoekologických pomerov. Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava, ročník XLIX, řada hornicko-geologická, mimořádné číslo, 4. Paleontologický seminář Ostrava, 17–18.6.2003, Ostrava: 90–92.

Fordinál K. (ed.), Maglay J., Elečko M., Nagy A., Moravcová M., Vlačiky M., Kohút M., Németh Z., Bezák V., Polák M., Plašienka D., Olšavský M., Buček S., Havrila M., Hók J., Pešková I., Kucharič Ľ., Kubeš P., Malík M., Baláž P., Liščák P., Madarás J., Šefčík P., Baráth I., Boorová D., Uher P., Zlinská A., Žecová K. 2012. Explanatory notes for the geological map of the Záhorská nížina Lowland 1:50 000. State Geological Institute of Dionýz Štúr, Bratislava.

Forli M., Dell'Angelo B., Montagna P., Taviani M. 2004. A new large *Patella* (Mollusca: Patellogastropoda) in the Pliocene of the Mediterranean Basin. Bollettino Malacologico 40: 49–78.

Forli M., Corti A., Cresti M. 2021. Further records of the Family Patellidae Rafinesque, 1815 (Mollusca: Gastropoda) in the Tuscan Pliocene. Bolletino Malacologico 57: 152–163.

Fuchs T. 1868. III. Die Tertiär-Ablagerungen in der Umgebung von Pressburg und Hainburg. In: Fuchs T., Karrer F. (eds). Geologische Studien in den Tertiärbildungen des Wiener Beckens. Jahrbuch der kaiserlichköniglichen geologischen Reichsanstalt 18: 269–286 (pp. 276–285).

Fuksi T. 2015a. Compositional changes of molluscan assemblages during the Late Badenian and Early Sarmatian in the NW Vienna basin (Malé Karpaty Mountains, Slovakia). In: Bartha I. R., Kriván Á., Magyar I., Sebe K. (eds). Neogene of the Paratethyan Region, 6th Workshop on the Neogene of Central and Southeastern Europe, 31 May–3 June, 2015, Orfü. Budapest, Abstracts, Hungarian Geological Society: 28.

Fuksi T. 2015b. Paleoekologická analýza spoločenstiev mäkkýšov vrchného bádenu a sarmatu vo vrte Trstín-1. In: Knížek M., Táborský Z., Ivanov M. (eds). Otevřený kongres České geologické společnosti a Slovenskej ge-

ologickej spoločnosti, Mikulov, 14–17 October, 2015, Mikulov, Sborník abstrakt, Masarykova univerzita a Česká geologická společnost: 33.

GREGOROVÁ R. 2009. *Diplodus* sp. (Sparidae, Perciformes): a new fossil record of an articulated skeleton from Devínska Nová Ves (Upper Badenian, Vienna Basin, Slovakia). Annalen des Naturhistorischen Museums in Wien 111 A: 313–322.

GREGORY M.G. 1991. New trace fossils from the Miocene of Northland, New Zealand: *Rorschachichnus amoeba* and *Piscichnus waitemata*. Ichnos 1: 195–205.

HANDMANN R. 1882. Zur Tertiärfauna des Wiener Beckens. Verhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt 1882: 210–222.

HANO V. 1950. Tortonská fauna od Kosihoviec na južnom Slovensku. Geologický sborník 1: 70–73.

HARZHAUSER M. 2014. A seagrass-associated Early Miocene Indo-Pacific gastropod fauna from South West India (Kerala). Palaeontographica A 302: 73–178. https://doi.org/10.1127/pala/302/2013/73

HARZHAUSER M., PECKMANN J., BIRGEL D., DRAGANITS E., MANDIC O., THEOBALT D., HUEMER J. 2014. Stromatolites in the Paratethys Sea during the Middle Miocene climate transition as witness of the Badenian salinity crisis. Facies 60: 429–444. https://doi.org/10.1007/s10347-013-0391-z

HARZHAUSER M., GRUNERT P., MANDIC O., LUKENEDER P., GALLARDO Á. G., NEUBAUER T. A., CARNEVALE G., LANDAU B. M., SAUER R., STRAUSS P. 2018. Middle and late Badenian palaeoenvironments in the northern Vienna Basin and their potential link to the Badenian Salinity Crisis. Geologica Carpathica 69: 149–168. https://doi.org/10.1515/geoca-2018-0009

HARZHAUSER M., LANDAU B. 2019. Turritellidae (Gastropoda) of the Miocene Paratethys Sea with considerations about turritellid genera. Zootaxa 4681: 1–136. https://doi.org/10.11646/zootaxa.4681.1.1

HARZHAUSER M., LANDAU B. M. 2021. An overlooked diversity – the Costellariidae (Gastropoda) of the Miocene Paratethys Sea. Zootaxa 4983: 1–70. https://doi.org/10.11646/zootaxa.4982.1.1

HARZHAUSER M., LANDAU B. M., JANSSEN R. 2022. The Clavatulidae (Gastropoda, Conoidea) of the Miocene Paratethys Sea with considerations on fossil and extant Clavatulidae genera. Zootaxa 5123: 1–172. https://doi.org/10.11646/zootaxa.5123.1.1

HARZHAUSER M., GUZHOV A., LANDAU B. 2025. A revision of the Cainozoic Cerithiidae and Plesiotrochidae (Mollusca: Caenogastropoda) of the Paratethys Sea (Europe, Asia). Zootaxa 5625: 1–180. https://doi.org/10.11646/zootaxa.5625.1.1

HARZHAUSER M., PILLER W. E. 2007. Benchmark data of a changing sea – Palaeogeography, Palaeobiogeography and events in the Central Paratethys during the Miocene. Palaeogeography, Palaeoclimatology, Palaeoecology 253: 8–31. https://doi.org/10.1016/j.palaeo.2007.03.031

HAUER F. VON 1837. Über das Vorkommen fossiler Thierreste im tertiären Becken von Wien. Neues Jahrbuch Mineralogie, Geognosie, Geologie und Petrefaktenkunde 1837: 408–431.

HLADILOVÁ Š. 1991. Results of preliminary studies of the molluscan fauna from the Rohožník locality. Scripta, Geology 21: 91–97.

HLADILOVÁ Š., FORDINÁL K. 2013. Upper Badenian Molluscs (Gastropoda, Bivalvia, Scaphopoda) from the Modra-Kráľová locality (Danube Basin, Slovakia). Mineralia Slovaca 45: 35–44.

HLADILOVÁ Š., HLADÍKOVÁ J., KOVÁČ M. 1998. Stable Isotope record in Miocene Fossils and Sediments from Rohožník (Vienna Basin, Slovakia). Slovak Geological Magazine 4: 87–94.

HOLCOVÁ K., DAŠKOVÁ J., FORDINÁL K., HRABOVSKÝ J., MILOVSKÝ R., SCHNEINER F., VACEK F. 2019. A series of ecostratigraphic events across the Langhian/Serravallian boundary in an epicontinental setting: the northern Pannonian Basin. Facies 65: 36.

HOLEC P. 2001. Chondrichthyes and Osteichthyes (Vertebrata) from Miocene of Vienna Basin near Bratislava (Slovakia). Mineralia Slovaca 33: 111–134.

HOLEC P., EMRY R. J. 2003. Another molar of the Miocene hominid *Griphopithecus suessi* from the type locality at Sandberg, Slovakia. Bulletin American Museum of Natural History 279: 625–631.

HOLEC P., SABOL M. 1996. The Tertiary Vertebrates from Devínska Kobyla. Mineralia Slovaca 28: 519–522.

HOLEC P., SCHLÖGL J. 2000. Find of *Trionyx rostratus* Arth. in the Upper Badenian deposits of the Malé Karpaty Mts, Western Carpathians. Slovak Geological Magazine 6: 106–109.

HÖRNES M. 1848. Verzeichniss der Fossil-Reste aus 135 Fundorten des Tertiär-Beckens von Wien. In: CZJZEK J. (ed.). Erläuterungen zur Geognostischen Karte der Umgebungen Wiens. Wilhelm Braumüller, Wien, p. 105.

HÖRNES M. 1851–1870. Die fossilen Mollusken des Tertiär-Beckens von Wien. Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt, 3–4: 1–42, pls. 1–5 (1851), 43–208, pls. 6–20 (1852), 209–296, pls. 21–32 (1853), 297–382, pls. 33–40 (1854), 383–460, pls. 41–45 (1855), 461–736, pls. 46–52 (1856) (3); pp. 117–214, pls 12–31 (1861); pp. 215–342, pls 32–44 (1864); pp. 343–430, pls 45–67 (1867); pp. 431–479, pls 68–85 (1870)1–479, pls. 1–85 (1870) (4). https://www.biodiversitylibrary.org/page/39181557

HORUSITZKY H. 1917. Pozsony környékének agrogeologiai viszonyai. Fritz Ármin könyvnyomdája, 69 pp.

HRS-BRENKO M. 2006. The basket shell, *Corbula gibba* Olivi, 1792 (bivalve mollusks) as a species resistant to environmental disturbances: A review. Acta Adriatica 47: 49–64.

HUDÁČKOVÁ N., BANASOVÁ M., HALÁSOVÁ E., REHÁKOVÁ D., LINTNEROVÁ O. 2003. Distribution of planktonic and benthic foraminifera in correlation with calcareous dinocysts derived from the Devínska Nová Ves clay pit and their evidence for environmental reconstruction

sequence and Biostratigraphy. In: Birth of the New World, Abstract book of the ESF–EEDEN Conference Bratislava, Univerzita Komenského, pp. 41–43.

Hudáčková N., Kováč M. 1993. The Upper Badenian – Sarmatian events in the area of the Vienna Basin eastern margin. Mineralia Slovaca 25: 202–210.

Hudáčková N., Spezzaferri S. 2002. Statistical approach to reconstruct palaeoenvironments: an example from Miocene of Devínska Nová Ves (Central Paratethys, Vienna Basin, Slovak part). In: Yanko-Hombach V., Arnold A., Hallock P., Ishman S., McGann M., Parker W. C. (eds). EMMM´2002 Environmental Micropaleontology, Microbiology and Meiobentology, Vienna, University of Vienna, Institute of Palaeontology, pp. 99–101.

Hyžný M. 2011. Synopsis of fossil decapod crustaceans from Slovakia (Western Carpathians). Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen 260: 165–171.
https://doi.org/10.1127/0077-7749/2011/0164

Hyžný M., Hudáčková N., Biskupič R., Rybár S., Fuksi T., Halásová E., Zágoršek K., Jamrich M., Ledvák P. 2012. Devínska Kobyla – a window into the Middle Miocene shallow-water marine environments of the Central Paratethys (Vienna Basin, Slovakia). Acta Geologica Slovaca 4: 95–111.

Jamrich M., Halásová E. 2010. The evolution of the Late Badenian calcareous nannofossil assemblages as a reflexion of the palaeoenvironmental changes of the Vienna Basin (Devínska Nová Ves – clay pit). Acta Geologica Slovaca 2: 123–140.

Jamrich M., Rybár S., Ruman A., Kováčová M., Hudáčková N. 2024. Biostratigraphy and paleoecology of the upper Badenian carbonate and siliciclastic nearshore facies in the Vienna Basin (Slovakia). Facies 70: 1–31.
https://doi.org/10.1007/s10347-023-00679-2

Janke K. 2010. Schnecken, Muscheln & Tintenfische an Nord- und Ostsee. Quelle & Meyer Verlag, Wiebelsheim.

Koskeridou E., Thivaiou D., Giamali Ch., Agiadi K., Mantzouka D. 2019. Seagrass-Associated Molluscan and Fish Communities from the Early Pleistocene of the Island of Rhodes (Greece). IOP Conference Series: Earth and Environmental Science 221: 012050.

Kornhuber G. A. 1865. Adalékok Pozsonymegye természettani földrajzához. Poszony, 1–82.

Košťák M., Schlögl J., Hudáčková N., Kroh A., Halásová E., Gašparič R., Hyžný M., Wanzenböck G. 2016. *Sepia* from the Miocene of the Central Paratethys: new taxa and notes on late Cenozoic cuttlefish diversity. Journal of Systematic Palaeontology 14: 1–25.
https://doi.org/10.1080/14772019.2015.1135194

Košťák M., Schlögl J., Culka A., Tomašových A., Mazuch M., Hudáčková N. 2018. The unique preservation of *Sepia* soft tissues in the Miocene deposits (Serravalian, Vienna Basin): Implications for the origin of microbodies in the fossil record. Palaeogeography, Palaeoclimatology, Palaeoecology 493: 111–118.
https://doi.org/10.1016/j.palaeo.2018.01.005

Koubová I., Jamrich M., Biskupič R., Ruman A., Zágoršek K., Hudáčková N. 2024. Paleoecological evaluation of the fossiliferous layers of Upper Badenian at the Dubová site (northwestern part of the Danube basin). Geologické výzkumy na Moravě a ve Slezsku 31: 41–54.
https://doi.org/10.5817/GVMS2024-38933

Kováč M., Baráth I., Harzhauser M., Hlavatý I., Hudáčková N. 2004. Miocene depositional systems and sequence stratigraphy of the Vienna Basin. CFS Courier Forschungsinstitut Senckenberg 246: 187–212.

Kováč M., Csibri T., Fordinál K., Hók J., Hudáčková N., Jamrich M., Joniak P., Kováčová M., Ruman A., Šarinová K., Sliva Ľ., Tomašových A., Vojtko R., Šujan M. 2024. The Miocene to Quaternary evolution of the Vienna Basin (northeastern part): Geodynamics, eustasy, stratigraphy and depositional systems. In: Tari G. C., Kitchka A., Krézsek C., Lučić D., Markič M., Radivojević D., Sachsenhofer R. F., Šujan M. (eds). The Miocene Extensional Pannonian Superbasin, Volume 1: Regional Geology. Geological Society, London, Special Publications 554.

Kováč M., Halásová E., Hudáčková N., Holcová K., Hyžný M., Jamrich M., Ruman A. 2018. Towards better correlation of the Central Paratethys regional time scale with the standard geological time scale of the Miocene Epoch. Geologica Carpathica 69: 283–300.
https://doi.org/10.1515/geoca-2018-0017

Kováč M., Hudáčková N., Halásová E., Kováčová M., Holcová K., Oszczypko-Clowes M., Báldi K., Less G., Nagymarosy A., Ruman A., Klučiar T., Jamrich M. 2017. The Central Paratethys palaeoceanography: a water circulation model based on microfossil proxies, climate, and changes of depositional environment. Acta Geologica Slovaca 9: 75–114.

Kováč M., Hudáčková N., Hlavatá J., Sopková B., Andrejeva-Grigorovič A., Halásová E., Kováčová M., Kováčová P., Sliva Ľ., Baráth I. 2008. Miocene sediments in the boreholes from the Záhorská nížina region: sedimentology, biostratigraphy and environment of deposition. Geologické práce, Správy 114: 7–49.

Kováčová P., Emmanuel L., Hudáčková N., Renard M. 2009. Central Paratethys paleoenvironment during the Badenian (Middle Miocene): evidence from foraminifera and stable isotope ($\delta^{13}C$ and $\delta^{18}O$) study in the Vienna Basin (Slovakia). International Journal of Earth Sciences 98: 1109–1127.
https://doi.org/10.1007/s00531-008-0307-2

Kovács Z., Vicián Z. 2021. New Cancellariidae (Neogastropoda) assemblages from the Middle Miocene of Hungary with description of a new species. Central European Geology 64: 59–73.
https://doi.org/10.1556/24.2020.00006

Kroh A. 2005. Catalogus Fossilium Austriae. Band 2. Echinoidea neogenica. Österreichische Akademie der Wissenschaften, Wien.

Kroh A., Nebelsick J. H. 2003. Echinoid assemblages as a tool for palaeoenvironmental reconstruction – an exam-

ple from the Early Miocene of Egypt. Palaeogeography, Palaeoclimatology, Palaeoecology 201: 157–177. https://doi.org/10.1016/S0031-0182(03)00610-2

LAMARCK J. B. M. 1799. Prodrome d'une nouvelle classification des coquilles, comprenant une rédaction appropriée des caractères génériques, et l'établissement d'un grand nombre de genres nouveaux. Mémoires de la Société d'Histoire Naturelle de Paris 1: 63–91.

LAMARCK J.-B. M. DE 1819. Histoire naturelle des animaux sans vertèbres. Tome sixième, 1re partie. Paris.

LAMBERT O., SCHLÖGL J., KOVÁČ M. 2008. Middle Miocene toothed whale with *Platanista*-like teeth from the Vienna Basin (Western Carpathians, Slovakia). Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen 250: 157–166. https://doi.org/10.1127/0077-7749/2008/0250-0157

LANDAU B. M., MARQUET R., GRIGIS M. 2004. The Early Pliocene Gastropoda (Mollusca) of Estepona, southern Spain. Part 2 Orthogastropoda, Neotaenioglossa. Palaeontos 4: 1–108.

LANDAU B. M., CEULEMANS L., VAN DINGENEN F. 2018. The upper Miocene gastropods of northwestern France, 2. Caenogastropoda. Cainozoic Research 18: 177–368.

LANDAU B. M., HARZHAUSER M., İSLAMOĞLU Y., DA SILVA C. M. 2013. Systematics and palaeobiogeography of the gastropods of the middle Miocene (Serravallian) Karaman Basin, Turkey. Cainozoic Research 11–13: 3–584.

LATAL C., PILLER W. E., HARZHAUSER M. 2006. Small-scaled environmental changes: indications from stable isotopes of gastropods (Early Miocene, Korneuburg Basin, Austria). International Journal of Earth Sciences 95: 95–106. https://doi.org/10.1007/s00531-005-0510-3

LAURIAT-RAGE A., BRÉBION P., BUGE E., CHAIX C., CHEVALIER M., MARGEREL J.-P., PAJAUD D., POUIT D., ROMAN J., VIAUD J.-M. 1989. Le gisement redonien (Pliocène) de la Marnière (La Limouzinière, Loire-Atlantique). Biostratigraphie, paléobiologie, affinités paléobiogéographiques. Géologie de la France 1–2: 117–152.

LEHOTAYOVÁ R. 1977. New data on calcareous nannoflora in pelites of the brick-kiln at Devínska Nová Ves. Západné Karpaty, séria Paleontológia 2–3: 175–188.

LINNAEUS C. 1758. Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata. Tomus I. Salvius, Holmiæ. https://biodiversitylibrary.org/page/726886

LŐRENTHEY E., BEURLEN K. 1929. Die fossilen Dekapoden der Länder der Ungarischen Krone. Geologica Hungarica, Series Palaeontologica 3: 1–421.

LOVÉN S. L. 1847. Malacozoologii. Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar 4/6: 175–199.

MADARÁS J. (ed.), BARÁTH I., BISKUPIČ R., FERENC Š. GARGULÁK M., GAŽI P., LEHOTSKÝ R., KOHÚT M., KOVÁČIK M., MAGLAY J., MALÍK P., NAGY A., PIVKO D., PLAŠIENK, D., ŠIMON L. ŠOLTÉS S., VLAČIKY M., ZLINSKÁ A. 2014. Sprievodca Sandbersko-pajštúnskym geoparkom. Bratislava, Ministerstvo životného prostredia SR. Štátny Geologický Ústav Dionýza Štúra, Bratislava.

MANDIC O., HARZHAUSER M. 2003. Molluscs from the Badenian (Middle Miocene) of the Gaindorf Formation (Alpine Molasse Basin, NE Austria) – Taxonomy, Paleoecology and Biostratigraphy. Annalen des Naturhistorischen Museums in Wien, Serie A 104: 85–127.

MANDIC O., HARZHAUSER M., ROETZEL R. 2004. Taphonomy and sequence stratigraphy of spectacular shell accumulations from the type stratum of the Central Paratethys stage Eggenburgian (Lower Miocene, NE Austria). Courier Forschungs-Institut Senckenberg 246: 69–88.

MESZÁROŠ Š. 1986. Anomalies of Upper Badenian mollusc shells from localities in vicinity of the Malé Karpaty Mts. Západné Karpaty, Séria Paleontológia 11: 57–76.

MEYER H. VON 1847. Mittheilungen an Professor Bronn gerichtet. Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde 1847: 572–581.

MAYER C. 1868. Catalogue systématique et descriptif des fossiles des terrains Tertiaires qui se trouvent au Musée Fédéral de Zurich. Troisième Cahier. Mollusques, Famille des Arcidés. Schabelitz, Zurich. https://books.google.com/books?id=kyg-AAAAcAAJ

MIKŠA G. 2009. The sand dollar *Parascutella* (Echinoidea) in the late Badenian of Croatia. Rivista Italiana di Paleontologia e Stratigrafia 115: 101–109. https://doi.org/10.13130/2039-4942/5922

MOLLUSCABASE eds. 2025. MolluscaBase. *Turritella neudorfensis* Toula, 1900 †. Accessed at: https://molluscabase.org/aphia.php?p=taxdetails&id=1629650 on 2025-08-05.

MÜNSTER G. 1846. Ueber die in der Tertiär-Formation des Wiener Beckens vorkommenden Fisch-Ueberreste, mit Beschreibung einiger neuen merkwürdigen Arten. Beiträge zur Petrefactenkunde 7: 1–31.

NEBELSICK J. H., RASSER M., HÖLTKE O., THOMPSON J. R., BIEG U. 2019. Turritelline mass accumulations from the Lower Miocene of southern Germany: implications for tidal currents and nutrient transport within the North Alpine Foreland Basin. Lethaia 53: 280–293.

OLIVI G. 1792. Zoologia Adriatica, ossia catalogo ragionato degli animali del golfo e della lagune di Venezia. Bassano [G. Remondini e fl.]. [ix] + 334 + xxxii pp., 9 pls. https://www.biodiversitylibrary.org/item/123881

ONDREJIČKOVÁ A. 1978. Faziostratotypus: Chľaba bei Štúrovo, Bohrung ŠO-1. In: PAPP A., CICHA I., SENEŠ J., STEININGER F. (eds). Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys. M4 Badenien. Bratislava, Veda, 173–175.

ONDREJIČKOVÁ A. 1987. Mollusc associations from the western part of "great" Bratislava and their biostratigraphic interpretation. Partial report, manuscript, archive ŠGÚDŠ, Bratislava, 68 pp.

PAVIA G., DULAI A., FESTA A., GENNARI R., PAVIA M., CARNEVALE G. 2022. Palaeontology of the Upper Pliocene marine deposits of Rio Vaccaruzza, Villalvernia (Piedmont, NW Italy). Rivista Italiana di Paleontologia e Stratigrafia 128: 129–210.

PELECH O., MICHALÍK J., AUBRECHT R., FORDINÁL K., HUDÁČKOVÁ N., KOHÚT M., KOVÁČOVÁ M., LEVICKÁ J., LINTNEROVÁ O., MAGLAY J., MORAVCOVÁ M., ONDREJKA M., POTFAJ M., REHÁKOVÁ D., SABOL M., SCHLÖGL J., SLIVA Ľ., SOTÁK J., ŠARINOVÁ K., ŠUJAN M., VANČOVÁ I., VOZÁROVÁ A. 2021. Slovak version of the International chronostratigraphic chart. Mineralia Slovaca 53: 103–114.

PILLER W. E., HARZHAUSER M., MANDIC O. 2007. Miocene Central Paratethys stratigraphy – current status and future directions. Stratigraphy 4: 151–168.

POPPE G. T., GOTO Y. 1991. European seashells. Volume 1 (Polyplacophora, Caudofoveata, Solenogastra, Gastropoda). Verlag Christa Hemmen, Wiesbaden.

POPPE G. T., GOTO Y. 1993. European Seashells. Volume 2 (Scaphopoda, Bivalvia, Cephalopoda). Verlag Christa Hemmen, Wiesbaden.

REICH S., DI MARTINO E., TODD J. A., WESSELINGH F. P., RENEMA W. 2015. Indirect paleo-seagrass indicators (IPSIs): A review. Earth-Science Reviews 143: 161–186.

RUEDA J. L., GOFAS S., URRA J., SALAS C. 2009. A highly diverse mollusca assemblage associated with eelgrass beds (*Zostera marina* L.) in the Alboran Sea: Microhabitat preference, feeding guilds and biogeographical distribution. Scientia Marina 73: 679–700.

RUMAN A., HUDÁČKOVÁ N. 2015. Middle Miocene chitons (Polyplacophora) from the Slovak part of the Vienna Basin and the Danube Basin (Central Paratethys). Acta Geologica Slovaca 7: 155–173.

SABOL M., HOLEC P. 2002. Temporal and spatial distribution of Miocene mammals in the Western Carpathians (Slovakia). Geologica Carpathica 53: 269–279.

SACCO F. 1895. I molluschi dei terreni terziarii del Piemonte e della Liguria. Parte 19; (Turritellidae e Mathildidae). C. Clausen, Torino, 43 pp., 3 pls.
http://www.biodiversitylibrary.org/item/47238

SCHAFFER F. 1898. Der marine Tegel von Theben – Neudorf in Ungarn. Jahrbuch der kaiserlich königlich Geologischen Reichsanstalt 47: 533–548. (1897).

SCHAFFER F. 1908. Geologischer Führer für Exkursion im Inneralpinen Wienerbecken. II. Teil. Sammlung geologischer Führer 13: Berlin (Borntraeger), 1–157.

SCHAFFER H. 1962. Die Scutelliden des Miozäns von Österreich und Ungarn. Paläontologische Zeitschrift 36: 135–170.

SCHNEIDER S., LINSE U., STAMATIADIS P., FALKENBERG J., MUTTERLOSE J., WEICH M. 2022. First record of Pliocene (Zanclean to mid Piacenzian) marine deposits on Rhodes (Greece): implications for eastern Mediterranean palaeo(bio)geography. Palaeobiodiversity and Palaeoenvironments 103: 109–128.
https://doi.org/10.1007/s12549-022-00533-3

SENEŠ J. 1949. Geologické štúdiá terciéru južného Slovenska (List Kamendín 4861/2 a Parkan 4861/4). Práce Štátneho geologického ústavu 23: 5–76.

SENEŠ J., CICHA L. 1973. Neogene of the West Carpathians. Excursions F, Xth Congress KGBA, Bratislava. 1–46.

SENEŠ J., ONDREJIČKOVÁ A. 1991. Proposal for the terminology of fossil marine benthic shelf ecosystems. Geologica Carpathica 42: 231–240.

SITÁR V., KOVÁČOVÁ-SLAMKOVÁ M. 1999. Palaeobotanical and palynological study of the Upper Badenian sediments from the NE part of the Vienna Basin (locality Devínská Nová Ves). Acta Paleobotanica, Supplement 2: 373–389.

SIEBER R. 1958a. Die Tortonfauna von Steinabrunn bei Drasenhofen (Bez. Mistelbach, N. – O.). Verhandlungen der Geologischen Bundesanstalt 1958: 142–155.

SIEBER R. 1958b. Zur makropaläontologischen Zonengliederung im österreichischen Tertiär. Erdöl-Zeitschrift 74: 108–110.

SIEBER R. 1960. Die miozänen Turritellidae und Mathildidae Oesterreichs. Mitteilungen der Geologischen Gesellschaft in Wien 51: 229–280.

ŠIMO V., STAREK D., TOMAŠOVÝCH A., FEKETE K., OLŠAVSKÝ M., ŠURKA J. 2014. (1) Sandberg – Devínska Nová Ves. In: ŠIMO V., STAREK D., TOMAŠOVÝCH A., FEKETE K., OLŠAVSKÝ M., ŠURKA J. (eds). 5th Workshop on Ichnotaxonomy – Abstracts and Guide of Excursion, 9–13 June, 2014, Smolenice, Bratislava, Slovakia. Geological Institute of Slovak Academy of Sciences, Bratislava. Guide of Excursion: 23–30.

ŠVAGROVSKÝ J. 1960. Biostratigrafia a fauna mäkkýšov vrchného tortónu východného úpätia Slanských hôr. Geologické práce 57: 3–156.

ŠVAGROVSKÝ J. 1964. Zur Torton-Sarmat Grenze im ostslowakischen Neogen. Geologický sborník 15: 79–86.

ŠVAGROVSKÝ J. 1978. Faziostratotypus: Devínska Nová Ves – Sandberg. In: PAPP A., CICHA I., SENEŠ J., STEININGER F. (eds). Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys. M4 Badenien. Bratislava, Veda, pp. 188–193.

ŠVAGROVSKÝ J. 1981a. Lithofazielle Entwicklung und Molluskenfauna des oberen Badeniens (Miozän M4d) in dem Gebiet Bratislava – Devínska Nová Ves. Západné Karpaty, séria Paleontológia 7: 5–204.

ŠVAGROVSKÝ J. 1981b. Bivalvia des oberen Badeniens (Miozän) von Borský Mikuláš (NO-Teil des Wiener Beckens) und ihr Lebensmilieu. Geologický zborník Geologica Carpathica 32: 387–426.

ŠVAGROVSKÝ J. 1982. Gastropoda, Prosobranchia. Teil I. Archaeogastropoda und Mesogastropoda des oberen Badeniens von Borský Mikuláš (NO-Teil des Wiener Beckens) und ihre stratigraphische Bedeutung. Geologický Zborník Geologica Carpathica 33: 3–50.

TAYLOR J. D., GLOVER E. 2000. Functional anatomy, chemosymbiosis and evolution of the Lucinidae. In: HARPER E. M., TAYLOR J. D., CRAME J. A. (eds). The evolutionary biology of the Bivalvia. Geological Society, London, Special Publications 177(1), pp. 207–225.

TAYLOR J. D., GLOVER E. A., SMITH L., DYAL P., WILLIAMS S. T. 2011. Molecular phylogeny and classification of the chemosymbiotic bivalve family Lucinidae (Mollusca: Bivalvia). Zoological Journal of the Linnean Society 163: 15–49.
https://doi.org/10.1111/j.1096-3642.2011.00700.x

TEJKAL J. 1968. Fauna měkkýšů a vývoj biotopu v tortonu okolí Želiezovců (Podunajská nížina). Folia facultatis scientiarum naturalium Universitatis Purkynianae Brunensis 11, Geologia 13: 1–36.

TOMAŠOVÝCH A. 1998. Mollusca from the Devínska Nová Ves – brickyard locality (Bratislava, Slovakia), Badenian. Mineralia Slovaca 30: 357–386.

TOULA F. 1900. Über den marinen Tegel von Neudorf an der March (Dévény-Ujfalu) in Ungern. Verhandlungen des Vereins für Natur- und Heilkunde zu Pressburg 11: 1–30.

TOULA F. 1915. Über den marinen Tegel von Neudorf an der March (Dévény-Ujfalu) in Ungarn und seine Mikrofauna. Geologischen Reichsanstalt Jahrbuch 64: 635–674. (1914).

TUREK T., HLADILOVÁ Š. 2019. Měkkýší fauna (Gastropoda, Bivalvia) z lokality Mušlov (vídeňská pánev). Geologické výzkumy na Moravě a ve Slezsku 26: 58–65. https://doi.org/10.5817/GVMS2019-1-2-58

UCHMAN A., TORRES P., JOHNSON M. E., BERNING B., RAMALHO R. S., REBELO A. C., MELO C. S., BAPTISTA L., MADEIRA P., CORDEIRO R., ÁVILA S. P. 2018. Feeding traces of recent ray fish and occurrences of the trace fossil *Piscichnus waitemata* from the Pliocene of Santa Maria Island, Azores (Northeast Atlantic). Palaios 33: 361–375. https://doi.org/10.2110/palo.2018.027

VAN DINGENEN F., CEULEMANS L., LANDAU B. M. 2016. The lower Pliocene gastropods of Le Pigeon Blanc (Loire-Atlantique, Northwest France), 2. Caenogastropoda. Cainozoic Research 16: 109–219.

ZÁGORŠEK K., HOLCOVÁ K., NEHYBA S., KROH A., HLADILOVÁ Š. 2009. The invertebrate fauna of the Middle Miocene (Lower Badenian) sediments of Kralice nad Oslavou (Central Paratethys, Moravian part of the Carpathian Foredeep). Bulletin of Geosciences 84: 465–496. https://doi.org/10.3140/bull.geosci.1078

ZLINSKÁ A., FORDINÁL K. 1992. Biostratigrafické a paleoekologické vyhodnotenie bádenských sedimentov okolia Smoleníc. Geologické práce 96: 69–73.

ZLOCHOVÁ K. 1998. Glavica – The Mining Area at the Border of the Housing Estate Podhorské. Životné prostredie 32: 164–165.

ZUSCHIN M., HARZHAUSER M., MANDIC O. 2004. Taphonomy and paleoecology of the Lower Badenian (Middle Miocene) molluscan assemblages at Grund (Lower Austria). Geologica Carpathica 55: 117–128.

ZUSCHIN M., HARZHAUSER M., MANDIC O. 2007. The stratigraphic framework of fine-scale gradual and disjunct faunal replacements in the Middle Miocene of the Vienna Basin (Austria). Palaios 22: 286–297. https://doi.org/10.2110/palo.2005.p05-023r

Received: November 11th, 2025
Revised: January 7th, 2026
Accepted: January 9th, 2026
Published on-line: February 11th, 2026