

New records and paleoecology of the Middle Miocene (Badenian) Costellariidae MacDonald, 1860 (Gastropoda Neogastropoda) from Devínska Nová Ves (Vienna Basin, Slovakia)

Radoslav Biskupič

Ludvíka Svobodu 29, 058 01 Poprad, Slovakia; e-mail: biskupic.radoslav@gmail.com - Orcid: <https://orcid.org/0000-0003-1923-4977>

ABSTRACT

New Middle Miocene Costellariidae gastropods recorded from the eastern marginal part of the Vienna Basin (Central Paratethys) are reported. The conchological material was retrieved from the marine sediments of the Upper Badenian (Early Serravallian) Studienka Formation exposed at three localities situated in the vicinity of Devínska Nová Ves, a borough of the city of Bratislava, Slovakia, namely from Brickyard, Bačnegovice, and Útočnice. A total of six species ascribed to the genera *Bellardithala* Harzhauser et Landau, 2021, *Ebenomitra* Monterosato, 1917, and *Pusia* Swainson, 1840 are recognised, of which *Ebenomitra pseudopyramidella* (Boettger, 1906) is recorded for the first time from Slovakia. An enigmatic *Bellardithala*, originating from the locality Brickyard, is re-examined and more comprehensively discussed but is left in open nomenclature. Paleocological evaluation of the studied Costellariidae assemblages and complex geographic and stratigraphic distribution of presented species in Slovakia are given.

KEY WORDS

Central Paratethys; Costellariidae; Gastropoda; Miocene; Vienna Basin.

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INTRODUCTION

Already at the end of the 19th century, Schaffer (1898) was the first to study Middle Miocene Costellariidae gastropods from the Slovak part of the Vienna Basin. They were later mentioned by Švagróvský (1981a, 1982), Tomašových (1998), Ruman & Hudáčková (2015), Biskupič (2020) and recently taxonomically revised by Harzhauser & Landau (2021).

In the vicinity of Devínska Nová Ves, Bratislava (historically known as Neudorf, Theben - Neudorf, Neudorf an der March, Dévény - Ujfalu), the Upper

Badenian (early Serravallian) marine gastropod assemblages, including costellariids, occur. From the deep-water marine pelitic deposits uncovered in a former clay pit of the Brickyard locality, Schaffer (1898) described *Mitra nitida* Schaffer, 1898 and *Mitra neudorfensis* Schaffer, 1898 as new. Much later, the first was transferred to *Vexillum* Röding, 1798 and the second to *Tosapusia* Habe, 1964, following Harzhauser & Landau (2021). Another shell was presented by Tomašových (1998), who recorded a single unidentified small-sized *Vexillum*, which was later placed by Harzhauser & Landau (2021) in the newly established genus *Bellardithala*

Harzhauser & Landau, 2021 but remained unassigned to any of the taxa at the species level by those authors. Furthermore, two costellariids from the locality Útočnice near Devínska Nová Ves, identified as *Vexillum (Uromitra) ebenus paraleucozona* (Boettger, 1906) and *Vexillum vindobonense* Friedberg, 1911, were mentioned in the list of the fauna by Ruman & Hudáčková (2015). Although Švagrovský (1981a) and Hyžný et al. (2012) studied species-rich Upper Badenian marine faunal assemblages, including the molluscs from Devínska Nová Ves, no costellariids were available in their material.

As suggested above, this gastropod group is relatively poorly known. In addition, some of the species, although mentioned, were only briefly reported but without shell illustrations, taxonomic remarks or their paleoecological preferences. This paper aims to comprehensively study the newly collected Costellariidae gastropods, especially in the context of their diversity and paleoecological evaluation.

MATERIAL AND METHODS

Geological setting and localities

The material study comes from marine deposits exposed at the localities of Brickyard, Bačnegovice, and Útočnice near Devínska Nová Ves (a borough of the city of Bratislava), located on the eastern margin of the Vienna Basin, Slovakia (Fig. 1), and are stratigraphically ascribed to the regional Upper Badenian stage (Fig. 2), coinciding with the early

Serravallian (Middle Miocene) stage in terms of the international chronostratigraphic scale (e.g., Harzhauser & Piller, 2007; Piller et al., 2007; Kováč et al., 2004, 2018). Marginal deposits of the Sandberg Member and basinal pelites are assigned to the Studienka Formation (e.g., Baráth et al., 1994, 2003; Tomašových, 1998; Fordinál et al., 2012) characterised by the foraminiferal *Bulimina-Bolivina* Biozone (Hudáčková & Kováč, 1993; Hudáčková & Spezzaferri, 2002) and the NN6 nannoplankton Zone (Hudáčková & Spezzaferri, 2002; Jamrich & Halásová, 2010).

BRICKYARD. The locality represents a former clay pit situated in the northern part of Devínska Nová Ves (48°13'42.3" N, 16°58'24.4" E.). The Upper Badenian deep-water marine sediments comprising massive and laminated grey calcareous clays, rarely intercalated by interlayers of sands and silts, were exposed there (Švagrovský, 1981a; Tomašových, 1998; Hudáčková & Spezzaferri, 2002; Ruman & Hudáčková, 2015). A broad spectrum of marine organisms is known from there, of which the most mentioned are the molluscs (e.g., Schaffer, 1898; Toula, 1900, 1915; Švagrovský, 1981a; Činčurová, 1990; Tomašových, 1998; Ruman & Hudáčková, 2015; Košťák et al., 2016; Harzhauser & Landau, 2021; Harzhauser et al., 2022; Biskupič, 2023). Valuable results about the stratigraphy and paleoecology of the locality were provided mainly by calcareous nannofossils (Lehotayová, 1977; Jamrich & Halásová, 2010) and foraminifers (e.g., Hudáčková & Kováč, 1993; Kováčová & Hudáčková, 2009; Kováčová et al., 2009). Assemblages of polychaetes, bryozoans, brachiopods, echinoids, ostracods, and decapods

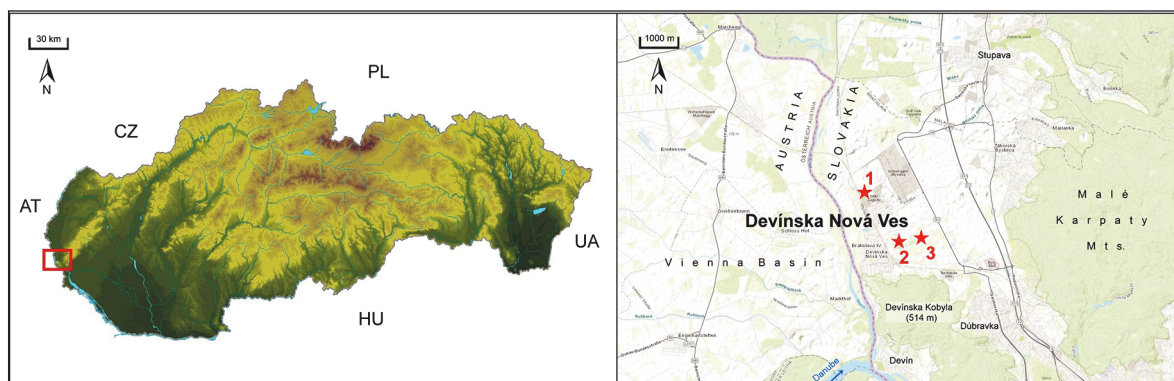


Figure 1. Geographic position of the study area (red rectangle). Red stars indicate localities in the area surrounding Devínska Nová Ves: 1 - Brickyard, 2 - Bačnegovice, 3 - Útočnice.

(e.g., Schaffer, 1898; Toula, 1900, 1915; Tomašových, 1998; Ruman & Hudáčková, 2015), accompanied by shark and fish faunas (e.g., Holec & Sabol, 1996; Chalupová, 2001; Holec, 2001; Gregorová, 2009; Schultz, 2013), were found as well.

BAČNEGOVICE. The site is located in the eastern periphery of Devínska Nová Ves (48°12'47"N, 16°59'21"E) and represents several fields on a slightly elevated hill in the area named Bačnegovice. It is situated about 150 m SW from the Dlhý kopec (162 m) and, from the literature, is also known as Vinohrady sense Švagrovský (1981a) and Holec (2001) and Útočnica sense Ruman & Hudáčková (2015). The late Badenian age of deposits was derived based on molluscan assemblages (Švagrovský, 1981a; Holec, 2001). The fossiliferous sediments are primarily represented by fine-grained yellow sands, silty sands, and white and ochreous, fine- to coarse-grained sands in places intercalated with sandstone concretions. Considerably eroded, discontinuous

scattered blocks of corallinean limestones and intercalations of organodetritic corallinean marls are exposed in the uppermost part of the group of beds. The gastropods and bivalves are the most abundant group of marine organisms found. Chitons, scaphopods, scleractinian corals, echinoids, decapods, sharks, and fishes were also identified. The molluscan assemblages were studied by Švagrovský (1981a) and Ruman & Hudáčková (2015), and rare finds of sharks and fishes were reported by Holec (2001).

ÚTOČNICE. This locality is situated on the eastern margin of Devínska Nová Ves, about 700 m east of the neighbourhood locality Bačnegovice (48°12'51"N, 16°59'58"E). The site represents a field on a slightly elevated hill named Útočnice (152 m). The shallow-water marine deposits are exposed mainly at the top of the elevation. Largely, they comprise white, occasionally ochreous, fine- to coarse-grained sands, sometimes intercalated with massive sandstone concretions. Interlayers of marly sands and corallinean limestones are

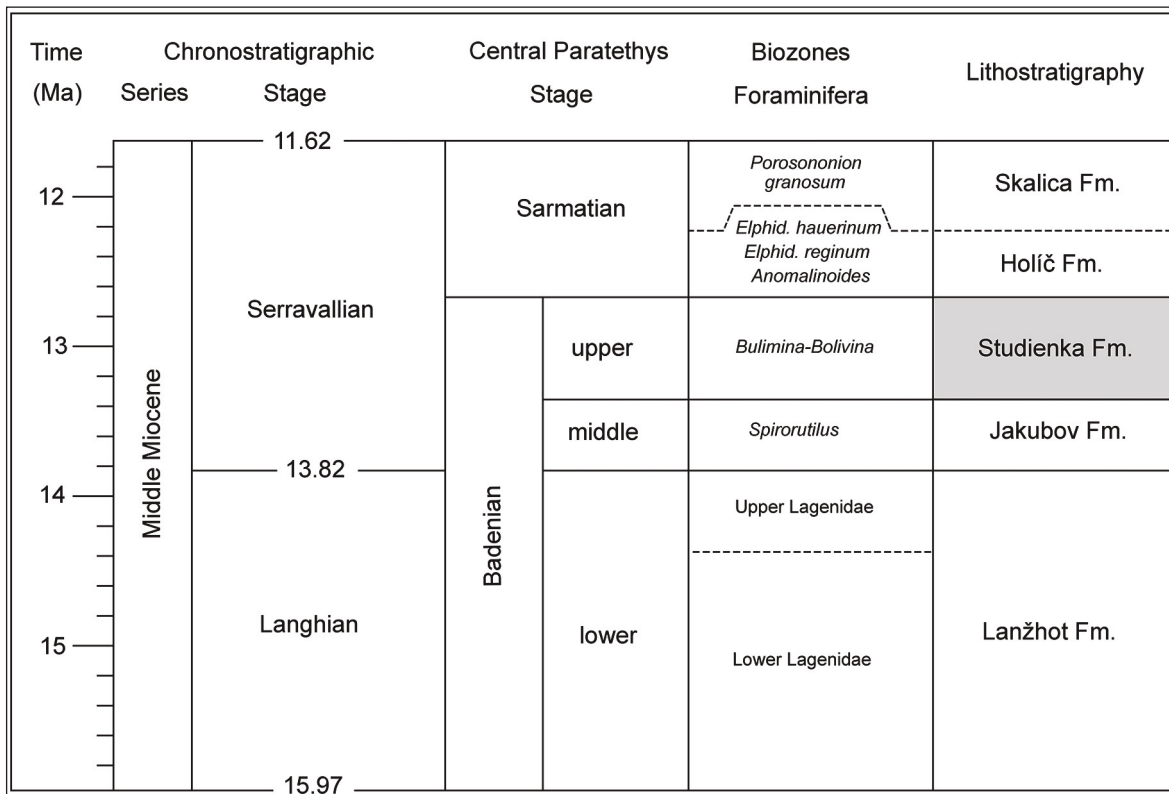


Figure 2. Chronostratigraphic and biostratigraphic zonation and lithostratigraphic units of the Middle Miocene Vienna Basin (modified from Harzhauser et al., 2018). The studied Upper Badenian Studienka Formation is marked in grey.

revealed in the uppermost part of the Badenian complex of strata. These deposits include a rich fossil fauna composed of gastropods, bivalves, scaphopods, chitons, scleractinian corals, echinoids, and rare remnants of sharks and fishes. The stratigraphical position of the sediments is derived from stratigraphically significant molluscs typical for the Badenian stage (e.g., *Cryptoplax weinlandi* Šulc, 1934, *Archimediella carpathica* Harzhauser & Landau, 2019, *Pecten aduncus* Eichwald, 1830, *Codakia leonina* (Basterot, 1825), *Cardita partschi* Goldfuss, 1840). These deposits are easily lithologically correlated to the strata exposed at the neighbouring localities Bačnegovice, also known as Vinohrady sense Švagrovský (1981a) and Holec (2001), which were attributed to the Upper Badenian by those authors.

Methods

The newly collected material of costellariids discussed herein was obtained from the localities Bačnegovice and Útočnice near Devínska Nová Ves during field works in the last two decades by the author and comprises 232 specimens. The shell of *Bellardithala* sp. was discovered in a former clay pit at Brickyard in 90' by Adam Tomašových (Bratislava). The material comprises mostly moderately preserved specimens. No shells with protoconch are available in the examined material. All measured and illustrated specimens are stored in the Natural History Museum of Slovak National Museum's institutional collection in Bratislava. In the synonymy list, only the first mention, the original description including illustrations, and the most relevant latest works regarding the Paratethyan occurrence of Costellariidae gastropods are mentioned. A complex overview of the geographic and stratigraphic distribution of studied species in Slovakia is provided. For more information about the overall geographic and stratigraphic distribution, complete synonymy lists and discussion on related species, see Harzhauser & Landau (2021). Higher systematics of gastropods follows Bouchet et al. (2017). The taxonomic concept of costellariids is adopted from Fedosov et al. (2017) and Harzhauser & Landau (2021). Morphometric abbreviations used herein: SL: shell length, MD: maximum diameter, SA: spire angle.

RESULTS

Systematics

Classis GASTROPODA Cuvier, 1795
 Subclassis CAENOGASTROPODA Cox, 1960
 Ordo NEOGASTROPODA Wenz, 1938
 Superfamilia TURBINELLOIDEA Rafinesque, 1815
 Familia COSTELLARIIDAE MacDonald, 1860
 Genus *Bellardithala* Harzhauser & Landau, 2021

TYPE SPECIES. *Voluta obsoleta* Brocchi, 1814, by subsequent designation. Pliocene, Italy.

Bellardithala partschi (Hörnes, 1852)

Mitra partschi Hörnes - Hörnes, 1852: 111, pl. 10
 figs 33a-c.

Bellardithala partschi (Hörnes, 1852) nov. comb. -
 Harzhauser & Landau, 2021: 26, figs 4D, 9D-F.

MATERIAL EXAMINED. Útočnice: 3 specimens
 (Figs 3 – 6)

REMARKS. The specimens are characterised by their moderately slender fusiform shell, with high conical to weakly scalate spire, bearing prominent axial ribs, better defined than broad, flattened spirals in their interspaces. The studied shells agree with the conchological characters of the species and are conspecific with the type material figured by Hörnes (1852), Hörnes & Auinger (1880), and Harzhauser & Landau (2021). This taxon was the most common species among the costellariids in the Central Paratethys Sea (Harzhauser & Landau, 2021), which is, however, in contrast with its rare occurrence at Devínska Nová Ves, where only three specimens were found. Even though the species was briefly mentioned from Rohožník – Konopiská in Biskupič (2020), the specimens from Slovakia are illustrated herein for the first time. The shells found represent the first evidence of the species from Devínska Nová Ves.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION.
 Central Paratethys: Middle Miocene (Badenian)
 (Harzhauser & Landau, 2021).

DISTRIBUTION IN SLOVAKIA. Middle Miocene
 (Upper Badenian): Vienna Basin: Rohožník -
 Konopiská (Biskupič, 2020), Devínska Nová Ves -
 Útočnice (this paper).

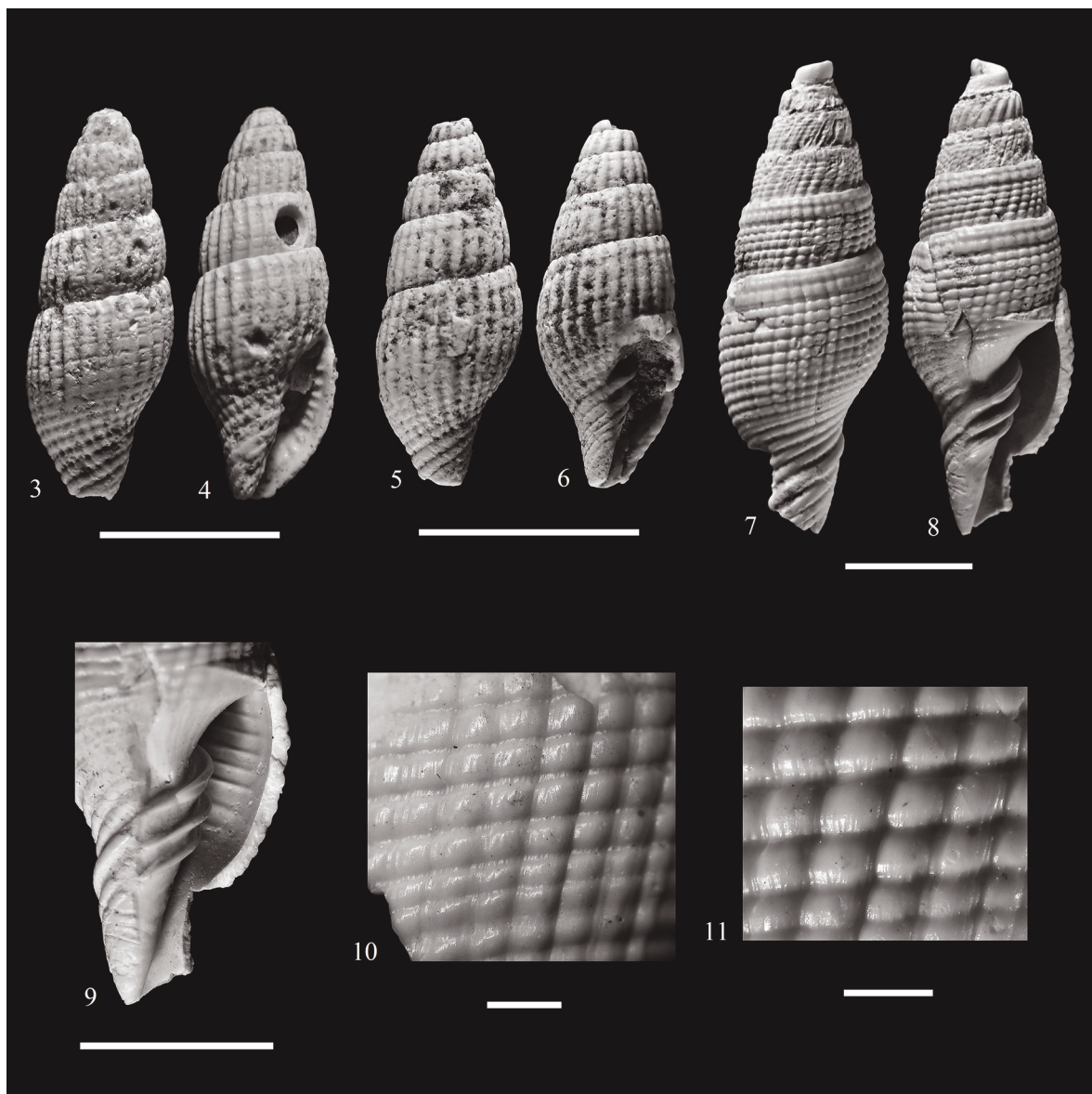
Bellardithala sp.

Vexillum (Uromitra) sp. - Tomašových, 1998: 378, pl. 10, figs. 3–4.

Bellardithala sp. - Harzhauser & Landau, 2021: 28, fig. 8G.

MATERIAL EXAMINED. Brickyard: 1 specimen. (Figs. 7–11)

DESCRIPTION. Shell medium-sized (SL: 10.14 mm, MD: 3.64 mm), fusiform, moderately slender (SA: 35°) with weakly scalate spire. Teleoconch of six slightly convex whorls, separated by narrowly incised, slightly undulating suture; last teleoconch whorl 70 % of shell height. Protoconch and first teleoconch whorls not preserved, first known early whorl abraded. Second teleoconch whorl with broad, convex, smooth, strongly opisthocline axial



Figures 3–6. *Bellardithala partschi* (Hörnes, 1852). Figs. 3, 4: Z 40740, SL: 6.68 mm, MD: 2.51 mm, Útočnice. Figs. 5, 6: Z 40741, SL: 5.14 mm, MD: 2.09 mm, Útočnice. Figs. 7–11. *Bellardithala* sp., Z 23408, SL: 10.14 mm, MD: 3.64 mm, SA: 35°, Brickyard. Figs. 7, 8: abapertural and apertural views. Figs. 9: detail of the aperture. Figs. 10, 11: details of the sculpture. Figs. 3–9: Scale bars = 3 mm. Figs. 10, 11: Scale bars = 500 μ m.

ribs, separated by interspaces of similar width, with attenuated, barely visible spiral rows and furrows. Third teleoconch whorl bearing axial sculpture of opisthoclinal, densely beaded axial ribs and broad, low spiral cords; beads with slightly elongated subrectangular shape, initially fine, poorly developed in intersections of axials and spirals, weakly distinguishable. Subsutural band placed close adapical suture, bearing one row of flattened nodules, on lower margin separated by subsutural furrow.

On fourth teleoconch whorl, well-defined subsutural band running along adapical suture, formed of two spiral rows of beads intermittent by narrow furrow; upper spiral row fine, with less pronounced low beads, lower row of beads broader, more prominent, decorated by large beads, spherical in shape. Fourth teleoconch whorl with five chain-like spiral cords, in intersections with opisthoclinal axial ribs with densely spaced prominent beads, equally in size, separated by narrowly incised interspaces in axials, interspaces between axials somewhat wider. Shape of beads pillow-like, rounded.

Penultimate whorl with six spiral rows of beads crossed by opisthoclinal axial ribs; beads conspicuous, spherical to subquadratic in shape, glossy, equal in size, densely spaced, separating by very narrow, deeply incised interspaces. Fine, barely visible microsculpture composed of delicate striae in interspaces between spiral cords. Prominent subsutural band close to adapical suture, disintegrating into two spiral rows of beads intermittent by narrow furrow; upper spiral row slightly divided in two spiral rows, bearing weakly developed beads, lower rows of beads broader, ornamented by large, rounded beads; abapically well delimited by spiral groove.

Last whorl weakly convex, bearing ten spiral rows of beads crossed by sigmoidal axial ribs of equal strength. Beads prominent, glossy, spherical to subquadratic in shape, regular in size, neatly arranged, well delimited by narrowly incised interspaces. Delicate grooves and striae decorate margins of beads in interspaces between spiral cords. Relatively wide, prominent subsutural band nearby adapical suture formed by three spiral rows of tubercles; upper spiral row slightly divided into two narrower spiral rows with small nodules, lower row of beads broader, more prominent,

ornamented by large, rounded beads; abapically separated by distinct subsutural groove. Last whorl abapically passing via distinct concavity into strongly constricted base, with well-separated, convex spiral cords bearing indistinct, subobsolete beads. Siphonal fasciole with seven smooth spiral cords; upper three cords convex, separated by distinct furrows, fourth, middle one cord more prominent, convex, well delimited; fifth to seventh cord less pronounced, somewhat flattened, broader, placed below middle one. Aperture only partly preserved, broken, probably narrow to moderately narrow, based on cross-section of last whorl. Columella with four columellar folds; three folds most prominent, weakening abapically; fourth abapical fold tiny, subobsolete, strongly suppressed. Outer lip not preserved, seven delicate lirae placed deep within aperture. Siphonal canal long, narrow.

REMARKS. The examined specimen, identified as *Vexillum (Uromitra)* sp., was first mentioned by Tomašových (1998). Later, it was redescribed and re-illustrated by Harzhauser & Landau (2021), who attributed it to the genus *Bellardithala* Harzhauser & Landau, 2021. This specimen shows specific morphological features that reliably distinguish it from all known Miocene *Bellardithala* representatives described from the Neogene of the Paratethyan, proto-Mediterranean and North-East Atlantic regions. It represents an unknown, new species, but due to the poor preservation of the material, it does not allow it to be formally described as a new taxon in this study. Unfortunately, no additional specimens are available. Thus, this enigmatic costellariid is left in open nomenclature for now. Although the specimen is characterised by some morphological features identical to the genus *Fedosovia* Harzhauser & Landau, 2021 (dense pattern of axial ribs and spiral cords forming densely spaced pillow-like, subquadrate nodes at intersections), this unknown species most likely belongs to *Bellardithala*.

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Upper Badenian): Vienna Basin: Devínska Nová Ves – Brickyard (this paper).

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: Middle Miocene (Badenian) (Harzhauser & Landau, 2021).

Genus *Ebenomitra* Monterosato, 1917

TYPE SPECIES. *Mitra ebenus* Lamarck, 1811, by subsequent designation. Present-day, Mediterranean Sea.

Ebenomitra leucozona (Andrzejowski, 1830)

Mitra leucozona Nobis - Andrzejowski, 1830: 98, pl. 4, figs. 6a-b.

Ebenomitra leucozona (Andrzejowski, 1830) nov. comb. - Harzhauser & Landau, 2021: 28, figs. 4E, 10A–C, 11A (cum syn.).

MATERIAL EXAMINED. Bačnegovice: 6 specimens; Útočnice: 174 specimens (Figs. 12–23).

REMARKS. The specimens studied herein are featured by their very broadly fusiform shell with broad orthocone, widely spaced axial ribs and are identical to those figured by several authors (e.g., Hörnes, 1852; Hoernes & Auinger, 1880; Friedberg, 1911; Bałuk, 1997; Mikuž, 2009; Harzhauser & Landau, 2021). *Ebenomitra leucozona* is characterised by its considerable intraspecific variability in shells, demonstrated by its solid, broadly biconic to moderately slender shell shape and nonuniform axial sculpture in teleoconch whorls (see references above), which is also visible in the material from Devínska Nová Ves.

Ebenomitra leucozona is considered one of the most common species in the Paratethyan Costellariidae assemblages, as noted by Harzhauser & Landau (2021). At the studied locality of Útočnice, it reaches a relatively rich occurrence, and in the Devínska Nová Ves area, it is the dominant costellariid species.

This species is characterised by its peculiar colour patterns decorating the shell surface, which is one of the features that separates it from other *Ebenomitra* members. The specimens with well-preserved residual colour patterns visible under normal light were figured by Hoernes & Auinger (1880), Mikuž (2009), and Harzhauser & Landau (2021). Even though in some studied shells of *E. leucozona*, barely recognisable residual colour patterns in normal light and also through UV light were observed, their poor preservation does not allow their high-quality illustrations.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: Middle Miocene (Badenian) (Harzhauser & Landau, 2021).

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Lower Badenian): Danube Basin: Chľaba (borehole ŠO-1) (Ondrejčíková, 1978; Švagrovský, 1982); Middle Miocene (Upper Badenian): Vienna Basin: Borský Mikuláš-Vinohrádky (Švagrovský, 1982), Rohožník-Konopiská (Ruman & Hudáčková, 2015; Biskupič, 2020), Devínska Nová Ves-Bačnegovice (Ruman & Hudáčková, 2015), Devínska Nová Ves-Útočnice (this paper); Danube Basin: Modra-Kráľová (Zahradníková & Fordinál, 2021).

Ebenomitra pseudopyramidella (Boettger, 1906)

Mitra (Uromitra) ebenus Lmk. var. *pseudopyramidella* n. nom. - Boettger, 1906: 9 [nov. nom. pro *Mitra ebenus* Hoernes & Auinger, 1880, pl. 7, fig. 13].

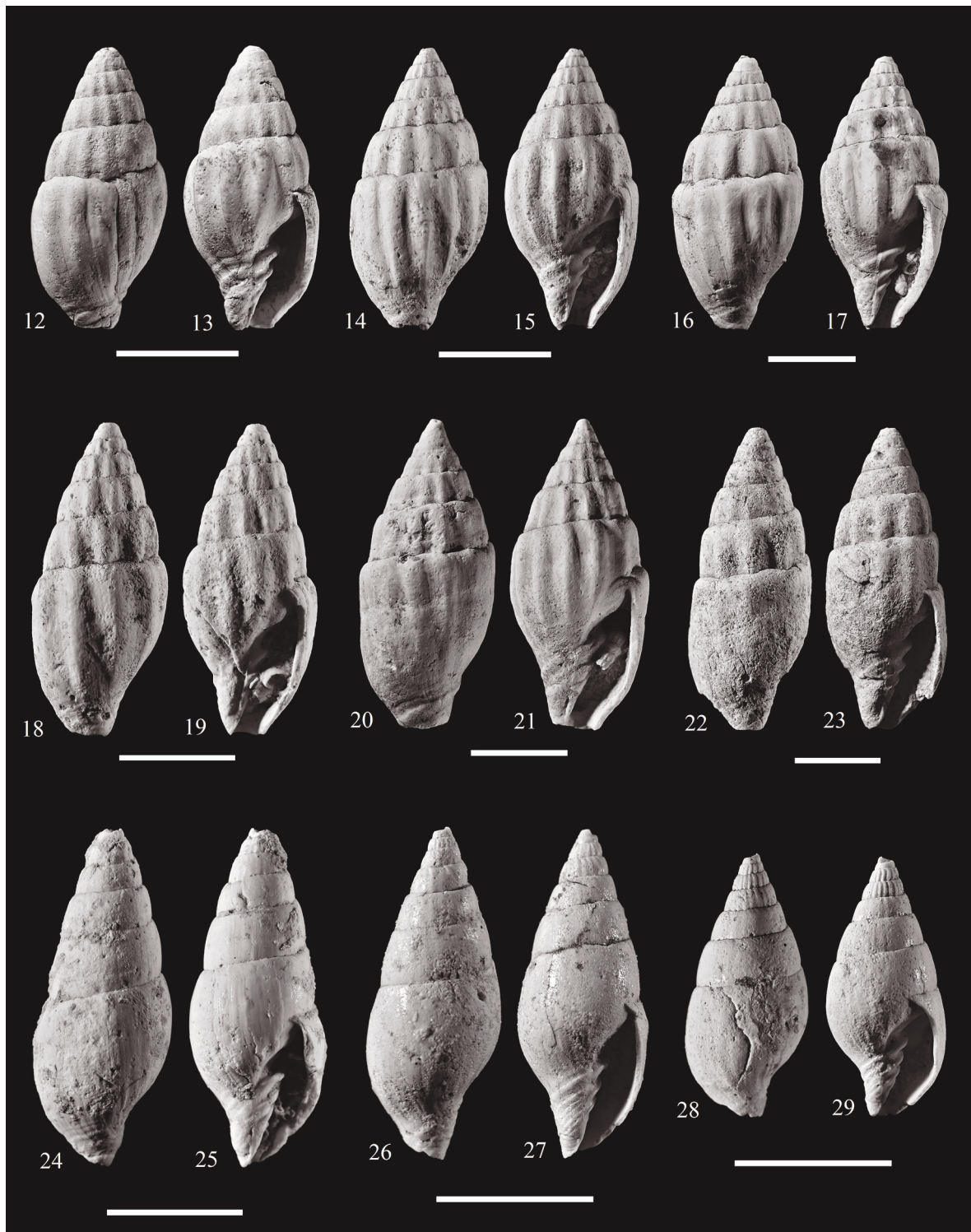
Ebenomitra pseudopyramidella (Boettger, 1906) nov. comb. - Harzhauser & Landau, 2021: 31, figs. 4F, 10D–F, 11B (cum syn.).

MATERIAL EXAMINED. Útočnice: 5 specimens (Figs. 24–29).

REMARKS. The examined shells are moderately large and solid, with relatively broad fusiform shape, and have conical to weakly cyrtocoid spire; axial ribs are well developed on early teleoconch whorls, whereas on later teleoconch whorls becoming weak to subobsolete. The presented material is conspecific with specimens illustrated in Paratethyan malacological literature (e.g., Eichwald, 1829; Hoernes & Auinger, 1880; Friedberg, 1911) and also agree with revised description and figures given by Harzhauser & Landau (2021). Only five specimens were obtained, indicating a low taxon abundance at the studied locality. The specimens from Devínska Nová Ves represent the first evidence of the species in the Slovak part of the Western Carpathians.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: Middle Miocene (Badenian) (Harzhauser & Landau, 2021).

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Upper Badenian): Vienna Basin: Devínska Nová Ves-Útočnice (this paper).



Figures 12–23. *Ebenomitra leucozona* (Andrzejowski, 1830). Figs. 12, 13: Z 40742, SL: 11.48 mm, MD: 5.37 mm, Bačnegovice. Figs. 14, 15: Z 40743, SL: 15.50 mm, MD: 7.54 mm, Útočnice. Figs. 16, 17: Z 40744, SL: 15.78 mm, MD: 7.30 mm, Útočnice. Figs. 18, 19: Z 40745, SL: 13.69 mm, MD: 5.86 mm, Útočnice. Figs. 20, 21: Z 40746, SL: 16.20 mm, MD: 7.08 mm, Útočnice. Figs. 22, 23: Z 40747, SL: 17.29 mm, MD: 7.17 mm, Útočnice. Figures 24–29. *Ebenomitra pseudopyramidella* (Boettger, 1906). Figs. 24, 25: Z 40748, SL: 12.48 mm, MD: 5.11 mm, Útočnice. Figs. 26, 27: Z 40749, SL: 10.54 mm, MD: 4.29 mm, Útočnice. Figs. 28, 29: Z 40750, SL: 8.38 mm, MD: 3.95 mm, Útočnice. Scale bars = 5 mm.

Genus *Pusia* Swainson, 1840

TYPE SPECIES. *Mitra microzonias* Lamarck, 1811, by monotypy. Present-day, Indo-Pacific.

Pusia avellanella (Boettger, 1906)

Mitra (Uromitra) avellana Bell. var. *avellanella* n. var. - Boettger, 1906: 9.

Pusia avellanella (Boettger, 1906) nov. comb. - Harzhauser & Landau, 2021: 36, figs. 4H, 13A-F (cum syn.).

MATERIAL EXAMINED. Útočnice: 5 specimens (Figs. 30–33).

REMARKS. Conchological material from Devínska Nová Ves is characterised by broadly fusiform shells covered by axial ribs weakening abapically, poorly developed on the last whorl. The specimens are conspecific with those illustrated by Hoernes & Auinger (1880), Zilch (1934), Friedberg (1911), Kojumdgieva in Kojumdgieva & Strachimirov (1960), and Bałuk (1997) and agree with the illustrations and revised description provided by Harzhauser & Landau (2021). Although the species was briefly mentioned from Rohožník – Konopiská by Biskupič (2020), the shells from Slovakia are illustrated for the first time in this work. The obtained conchological material represents the first evidence of the species from Devínska Nová Ves.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: Middle Miocene (Badenian) (Harzhauser & Landau, 2021).

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Upper Badenian): Vienna Basin: Rohožník - Konopiská (Biskupič, 2020), Devínska Nová Ves - Útočnice (this paper).

Pusia paraleucozona (Boettger, 1906)

Mitra (Uromitra) ebenus Lmk. var. *paraleucozona* n. var. - Boettger, 1906: 8.

Pusia paraleucozona (Boettger, 1906) nov. comb. - Harzhauser & Landau, 2021: 42, figs. 14A1–A2, B1–B2.

MATERIAL EXAMINED. Útočnice: 1 specimen (Figs. 34, 35).

REMARKS. Only one incomplete specimen is available in the studied material concordant with the overall shell morphology (broad fusiform shell, with broad conical to weakly cyrtocoid spire, bearing orthocone axial ribs) that characterises the species (cf. Zilch, 1934; Bałuk, 1997; Harzhauser & Landau, 2021). However, from the specimens figured in the literature, it slightly differs in its broader axial ribs and narrower interspaces between them. In the studied Costellariidae assemblages from Devínska Nová Ves, it represents a rare taxon. This species was mentioned from Slovakia in the lists of the fauna by Ruman & Hudáčková (2015) and Biskupič (2020), but the illustration of the material from Slovakia is given for the first time in this study.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: Middle Miocene (Badenian) (Harzhauser & Landau, 2021).

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Upper Badenian): Vienna Basin: Rohožník - Konopiská (Biskupič, 2020), Devínska Nová Ves - Bačnegovice (Ruman & Hudáčková, 2015), Devínska Nová Ves - Útočnice (this paper).

Pusia pseudorecticosta (Boettger, 1906)

Mitra (Costellaria) pseudorecticosta n. nom. - Boettger, 1906: 10.

Pusia pseudorecticosta (Boettger, 1906) - Harzhauser & Landau, 2021: 42, figs. 4J, 15A–D.

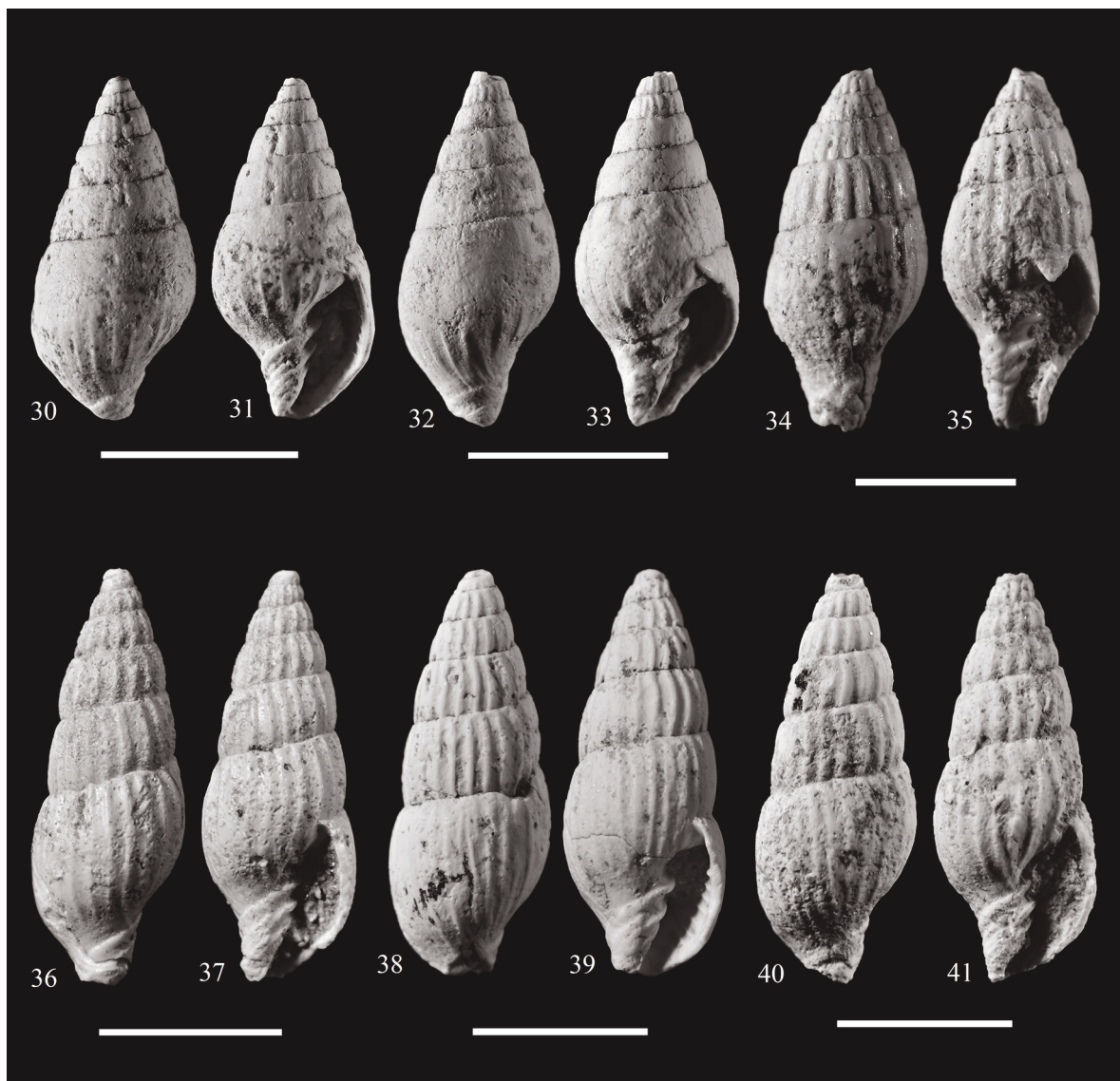
MATERIAL EXAMINED. Bačnegovice: 2 specimens; Útočnice: 35 specimens (Figs. 36–41).

REMARKS. The shells examined herein have a narrowly fusiform outline and high, slightly gradate spire, which corresponds to the specimens illustrated by Hoernes & Auinger (1880), Bałuk (1997), and Landau et al. (2013), and they also largely agree with the material presented by Harzhauser & Landau (2021). The collected specimens display some intraspecific variability in shell shape and nonuniform axial sculpture, as also seen in the material illustrated in the literature. Nevertheless, the shells from Devínska Nová Ves are mainly covered by weakly opisthocyrt axial ribs, which makes them partly different from the type material from Steinebrunn (Austria) with

orthocone axials (cf. Harzhauser & Landau, 2021). Slightly opisthocyrt axial ribs were also observed in some shells from the Miocene of the Korytnica Basin (see Bařuk, 1997: pl. 10, fig. 3) and the Karaman Basin (see Landau et al., 2013: pl. 34, fig. 10). The species belongs to one of the most abundant Paratethyan costellariid (Harzhauser & Landau, 2021), which is confirmed by its common occurrence at Útočnice. This costellariid was listed

from the Slovak part of the Western Carpathians already in Ruman & Hudáčková (2015) and Biskupič (2020); however, this contribution provides illustrated material from this region for the first time.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. Central Paratethys: ? early Miocene (Ottangian), Middle Miocene (Badenian) (Harzhauser & Landau, 2021). Eastern Paratethys: Middle



Figures 30–33. *Pusia avellanella* (Boettger, 1906). Figs. 30–31: Z 40751, SL: 8.75 mm, MD: 4.18 mm, Útočnice. Figs. 32, 33: Z 40752, SL: 8.85 mm, MD: 4.15 mm, Útočnice. Figures 34, 35. *Pusia paraleucozona* (Boettger, 1906), Z 40753, SL: 7.03 mm, MD: 3.11 mm, Útočnice. Figures 36–41. *Pusia pseudorecticosta* (Boettger, 1906). Figs. 36, 37: Z 40754, SL: 6.88 mm, MD: 2.65 mm, Útočnice. Figs. 38, 39: Z 40755, SL: 7.22 mm, MD: 2.86 mm, Útočnice. Figs. 40, 41: Z 40756, SL: 7.06 mm, MD: 2.81 mm, Útočnice. Figs. 30–33: Scale bars = 5 mm. Figs. 34–41: Scale bars = 3 mm.

Miocene (Tarkhanian) (Harzhauser & Landau, 2021). Proto-Mediterranean: Middle Miocene (Serravallian) (Landau et al., 2013).

DISTRIBUTION IN SLOVAKIA. Middle Miocene (Upper Badenian): Vienna Basin: Rohožník-Konopiská (Biskupič, 2020), Devínska Nová Ves-Bačnegovice (Ruman & Hudáčková, 2015; this paper), Devínska Nová Ves-Útočnice (this paper).

Paleoecology and taxonomic composition

All the species, except for *Bellardithala* sp., were found in fine- to coarse-grained white sands exposed at Útočnice, comprised of fauna indicating very shallow sublittoral settings. A rich occurrence of sessile epifaunal suspension-feeding oyster *Ostrea digitalina* (Eichwald, 1830) indicates a rocky coastline environment with dominant wave action in medio/sublittoral, intertidal to shallow subtidal zone (Zágoršek et al., 2009) down to 10 m water depths (Mandic & Harzhauser, 2003). A commonly occurred, sessile epifaunal suspension-feeding bivalve *Anomia ephippium* Linnaeus, 1758 points to 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, 1991; Janke, 2010). According to Švagravský (1981b), the species is abundant in shallow-water infralittoral settings. A common infaunal chemosymbiotic lucinid bivalves (*Lucina*, *Codakia*, *Megaxinus*) and some gastropods (e.g., *Smaragdia*, *Bittium*, *Theridium*, *Thetystrombus*) suggest shallow-marine seagrass paleoenvironment (cf. Reich et al., 2015). Abundant infaunal suspension-feeding bivalves *Glycymeris deshayesi* (Mayer, 1868) and *G. obtusata* (Parsch in Hörnes, 1870) indicate infralittoral settings (cf. Dulai, 1996) and well-aerated water (Švagravský, 1981b). Mandic et al. (2004) noted that the genus *Glycymeris* was well adapted to high-energy environments in the subtidal zone above the storm wave base. The co-occurrence of shallow infaunal burrowing irregular echinoids *Parascutella* and *Clypeaster* point to shallow-water marine and/or mobile coastal habitats characterised by sandy substrate and higher water energy (cf. Kroh & Nebelsick, 2003; Mikša, 2009). Moreover, the rich finds of hermatypic corals *Porites leptoclada* (Reuss, 1871) confirm the shallow marine conditions and well-aerated, clear, warm waters. In

summary, the paleoenvironment of fine- to coarse-grained white sands exposed at Útočnice can be interpreted as a shallow-water marine infralittoral habitat with soft sandy-bottom or subtidal mobile sandbanks partly with seagrass meadows. Well-aerated and nutrient-rich conditions and higher wave dynamics are assumed.

In organodetritic marls to marly sands and coralline limestones exposed at Bačnegovice and Útočnice, *Ebenomitra leucozona* (Andrzejowski, 1830) and *Pusia pseudorecticoستا* (Boettger, 1906) occurs. These deposits are characterised by the presence of typical shallow-water organisms, such as gastropods (e.g., *Bolma*, *Theridium*), bivalves (e.g., *Gigantopecten*, *Spondylus*, *Cardita*, *Chama*), and hermatypic corals (*Siderastraea*), which suggest an algae-dominated habitat with soft bottom in the infralittoral zone.

Only a single extremely rare costellariid, *Bellardithala* sp., was found in the basinal pelitic facies, which refers to its deeper marine habitat preference. As suggested by the taxonomic composition of the micro- and macrofauna and by the sedimentology at the locality, unfavourable paleoenvironmental conditions are assumed. Sedimentation took place on muddy sea-floor, in deep-water marine settings of the middle to outer neritic zone (Seneš & Ondrejčková, 1991; Tomašových, 1998; Chalupová, 2001; Hudáčková et al., 2003), influenced by occasional hypoxia near sea-floor (Hudáčková & Kováč, 1993; Tomašových, 1998; Hudáčková & Spezzaferri, 2002; Kováčová et al., 2009), and in conditions of the stratified water column (Hudáčková & Kováč, 1993; Kováčová & Hudáčková, 2009; Kováčová et al., 2009).

The Upper Badenian Costellariidae assemblages from Devínska Nová Ves include seven species (Fig. 42), of which *Ebenomitra leucozona* (Andrzejowski, 1830) represents the most abundant member (180 specimens), followed by *Pusia pseudorecticoستا* (Boettger, 1906) (37 specimens), *Ebenomitra pseudopyramidella* (Boettger, 1906) (5 specimens), *Pusia avellanella* (Boettger, 1906) (5 specimens), and *Bellardithala partschi* (Hörnes, 1852) (3 specimens). The lowest abundance reaches *Bellardithala* sp. and *Pusia paraleucozona* (Boettger, 1906); each is presented only by one specimen. At Útočnice, a higher species-richness was observed, comprising six species

(*Bellardithala partschi*, *Ebenomitra leucozona*, *E. pseudopyramidella*, *Pusia avellanella*, *P. paraleucozona*, and *P. pseudorecticosta*). Two species were recorded at Bačnegovice (*E. leucozona*, *P. pseudorecticosta*), and only one taxon (*Bellardithala* sp.) was identified from Brickyard.

DISCUSSION

Most of the taxa inhabited very shallow-water marine paleoenvironments partly with seagrasses, and algae-dominated habitats; only *Bellardithala* sp. occurred in deeper, circalittoral settings. These conclusions are consistent with the paleoecological preferences of respective Paratethyan Costellariidae species and genera (cf. Harzhauser & Landau, 2021) and largely agree with habitats of modern *Ebenomitra* and *Pusia* species (cf. Poppe & Goto, 1991; Davoli, 2000; Turner, 2008; Chirli & Linse, 2011; Fedosov et al., 2017).

Although *Bellardithala partschi* (Hörnes, 1852) is the most common taxon in the Central Paratethys realm (Harzhauser & Landau, 2021), it was known from Slovakia only from the locality Rohožník – Konopiská until now (Biskupič, 2020). *Ebenomitra leucozona* (Andrzejowski, 1830) is the most abundant Costellariidae species in the Middle

Miocene marine deposits of the Slovak part of the Vienna Basin. Its abundant occurrence concurs with the statement of Harzhauser & Landau (2021), who consider it one of the most frequent costellariid in the Central Paratethys Sea. Except for Devínska Nová Ves, *E. leucozona* is also known from Borský Mikuláš-Vinohrádky (Švagrovský, 1982; Harzhauser & Landau, 2021) and Rohožník-Konopiská (Biskupič, 2020; Ruman & Hudáčková, 2015). From the Upper Badenian clays to aleuritic sands and sandy marls uncovered at the locality “east of Devín” situated on the southern slope of the Devínska Kobyla Hill near Devín, a juvenile specimen treated as *Vexillum* (*Costellaria*) cfr. *vindobonense* (Friedberg, 1923) was figured by Švagrovský (1981a: 51, pl. 45, fig. 8). This small-sized incomplete specimen probably belongs to the genus *Pusia* Swainson, 1840; however, the species-level placement of this shell is unclear.

Only three rare Costellariidae species, including herein discussed *Bellardithala* sp., have been found at the Brickyard locality. Two of them were described as new, strictly occurring only at the type locality: *Vexillum nitidum* (Schaffer, 1898) and *Tosapusia neudorfensis* (Schaffer, 1898). The Costellariidae assemblage shows a surprisingly high endemism which has also been observed in the family Clavatulidae (cf. Schaffer, 1898, Harzhauser et al., 2022, Biskupič, 2023).

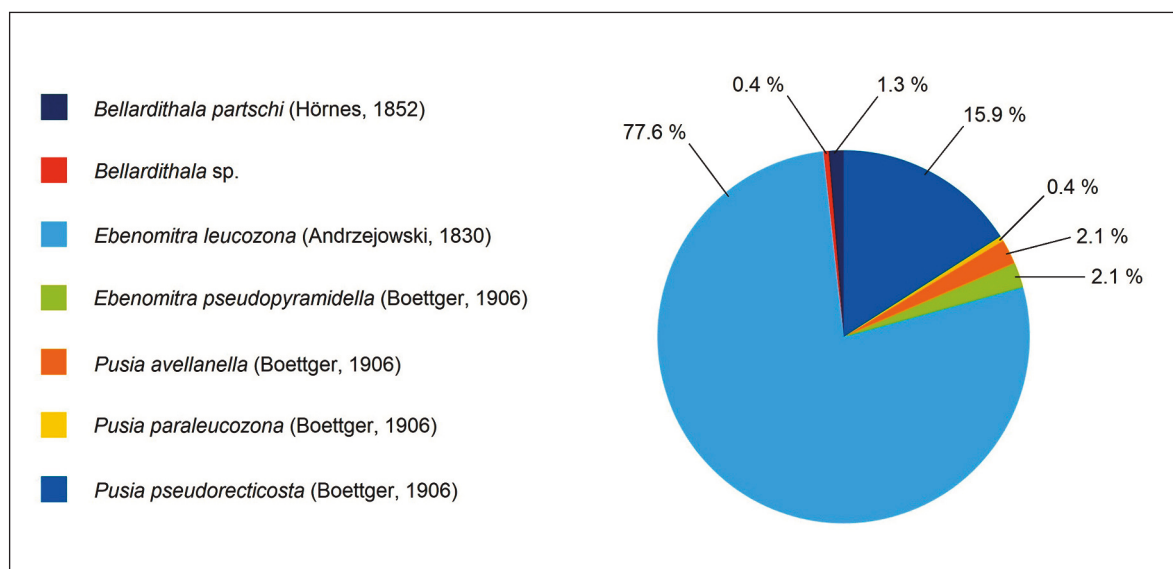


Figure 42. Percentage representation of respective Costellariidae species from the Upper Badenian marine deposits at Devínska Nová Ves.

Interestingly, no species of *Vexillum* Röding, 1798 and *Tosapusia* Habe, 1964 were recorded in the newly collected material. In the Slovak part of the Vienna Basin, the genus *Vexillum* is represented by *V. pseudoschafferi* (Biskupič, 2020), found in the Upper Badenian corallinacean marls and limestone exposed at Rohožník - Konopiská, indicating shallow-water marine algae-dominated habitat (Biskupič, 2020). Similar paleoecological conditions are estimated for corallinacean sandy marls and limestones of Bačnegovice and Útočnice; however, no shells of *Vexillum* were detected there. The genus *Tosapusia* is from Devínska Nová Ves represented by *T. neudorfensis* (Schaffer, 1898). From the Brickyard locality, it was described and illustrated by Schaffer (1898) and the syntype was re-illustrated by Harzhauser & Landau (2021). As suggested by the results of the latest works (e.g., Toulou, 1900, 1915; Švagrovský, 1981a; Tomašových, 1998; Ruman & Hudáčková, 2015), no additional specimens were found there. In the eastern Vienna Basin, another Badenian *Tosapusia* was recorded from the basinal pelitic sediments exposed in a former clay pit at Rohožník – Konopiská, *T. svagrovskyyi* (Biskupič, 2020) that is closely similar to *T. neudorfensis*.

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- Cum icone tituli et quinque aliis lithographicis, Pars prior: 1–314. Zawadzki, Vilnae.
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