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Middle Miocene (Badenian) chitons (Mollusca, Polyplacophora) from the Central Paratethys 2: Borsodbóta (Bükk Mts, Hungary)

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Abstract – Borsodbóta is a well-known Middle Miocene Mollusca site in Hungary, but no Polyplacophora remains have ever been described from there. In recent years, three chiton valves representing three species of three genera (*Stenosemus radiatus* Dell'Angelo *et al.*, *Rhyssoplax corallina* (Risso), and *Craspedochiton altavillensis* (Seguenza)) have been found in the shallow marine bioclastic gravelly sands. It is the first known occurrence of the genera *Stenosemus* von Middendorf and *Craspedochiton* Shuttleworth and the species *S. radiatus* and *C. altavillensis* in Hungary. Until now known from the Early Miocene, the stratigraphic range of *S. radiatus* is extended to the Middle Miocene. It is the first record of *Stenosemus* from the Central Paratethys. With 14 figures.

Keywords – *Craspedochiton*, lower Badenian, polyplacophorans, *Rhyssoplax, Stenosemus*

INTRODUCTION

The Middle Miocene sediments of the Central Paratethys are very rich in fossils, of which molluscs are particularly common. However, compared to gastropods and bivalves, polyplacophorans are rare and little information is available in the literature from the Hungarian localities. Csepreghy-Meznerics (1950) described the species *Chiton lepidus* Reuss very briefly and without illustration from Hidas in the Mecsek Mts. Jakubowski & Musiał (1977) and Studencka & Studencki (1988) mentioned the species *Lepidochitona (Lepidochitona) subgranosa* Bałuk and *Acanthochitona faluniensis* (Rochebrune) from Várpalota in the Bakony Mts, based on material collected by Gwidon Jakubowski (Muzeum Ziemi, Warsaw). In the early 2000s, the first publications on Hungarian Miocene chitons with detailed descriptions and illustrations appeared. Dulai (2001) has found four species from the Szokolya-2 borehole (Börzsöny Mts). Later, a more diverse assemblage of eight species was described from two sites in the Bakony Mts (Bánd, Devecser; Dulai 2005).

Smaller or larger Polyplacophora materials have been found since then from different Hungarian Middle Miocene (Badenian) sites, but have not been published so far. They are now presented in a series of short papers. Small, low-diversity assemblage has been found from Borsodbóta in the Bükk Mts (this paper). More diverse fauna has been discovered from two sites, at Várpalota (Dulai & Katona 2024), and Devecser (Dulai 2025*a*) in the Bakony Mts and from Letkés in the Börzsöny Mts (Dulai 2025*b*). In Mecsekpölöske locality (Mecsek Mts) a relatively diverse and well-preserved chiton assemblage with a high number of specimens is under description by Dulai & Szabó (in prep.).

GEOLOGICAL SETTINGS

The Paratethys was a large network of inland seas intermittently connected to the Mediterranean (Rögl 1998; Popov *et al.* 2004). Changing seaways caused the internal differentiation into the Western, Central and Eastern Paratethys. Diverse sediments of the Central Paratethys are now exposed in the area from the present-day Austria through Slovakia, Hungary, Slovenia, Croatia, Serbia, to Romania, Bulgaria, Ukraine and Poland. This area includes the Carpathian Foreland Basin and the Pannonian Basin System. The biogeographic differentiation necessitated the establishment of a regional stratigraphic scheme (Harzhauser & Piller 2007). Correlation with global chronostratigraphy is based mainly on calcareous nannoplankton and planktic and larger benthic foraminifers (Piller *et al.* 2007). The Badenian (16.303 to 12.829 Ma; Hohenegger *et al.* 2014) is a regional stage used in the Central Paratethys for part of the Middle Miocene (Langhian to middle Serravallian) (Papp *et al.* 1978).

In the coastal areas along the northern margins of the basins highly fossiliferous sands and algal-bryozoan limestones were deposited during the Badenian (Popov *et al.* 2004). The early Badenian is characterized by an exceptionally rich warm-water fauna, including molluscs, foraminifers,

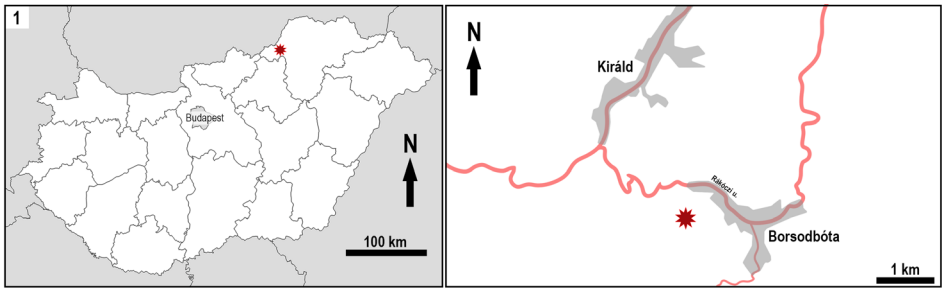
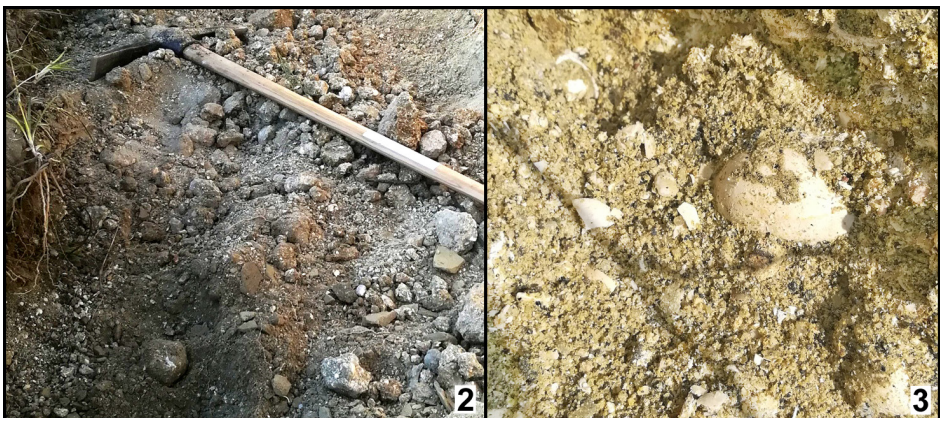


Fig. 1. Locality map showing the position of lower Badenian (Middle Miocene) fossil locality along the road between Borsodbóta and Királd (Bükk Mts, Northern Hungary)

bryozoans, corals, echinoids, decapods, and ostracods (Harzhauser & Piller 2007) referring to a stable connection with the Mediterranean (Kókay 1985; Rögl 1998).

Borsodbóta is located in Northern Hungary, at the northern margin of the Bükk Mountains (Fig. 1). The Miocene Mollusca fauna of this area has been known for a long time (roadcut between Borsodbóta and Királd, Rendek valley quarry, and row of cellars near the road; Kutassy 1928; Strausz 1966; Csepreghy-Meznerics 1969*a, b, c,* 1970). It is often referred to as the „Bóta dwarf fauna" because of the generally small size of the specimens. In reality, it may be more a matter of mechanical fragmentation of larger specimens and the sorting effect of water currents (Csepreghy-Meznerics 1970; Fehse & Grego 2012).

Borsodbóta locality (Figs 2–3) has recently come back into the focus of malacologists, mainly due to the highly diverse *Trivia* species (Fehse & Vicián 2006; Fehse 2011; Fehse & Grego 2012). According to Fehse & Grego (2012) the roadcut between Borsodbóta and Királd "is the richest early Badenian deposit for triviid and eratoid species known to date, with two dozen taxa". Fehse & Grego (2012) assume a near-shore environment, with a warmer climate than today, based on the numerous thermophilic gastropod genera. Dulai *et al.* (2010) collected some samples to investigate the Bryozoa fauna of the site, and the most diverse sample contained 61 Bryozoa species. Based on the percentage of growth forms of bryozoan colonies and the known ecological requirements of the species present also in recent seas, Moissette *et al.* (2007) suggest that the samples from Borsodbóta refer to a terrigenous platform. Some of these indicate a shallow marine part of the platform and a sandy, relatively coarse-grained facies (samples Borsodbóta 3 and 5), while others indicate a silty, sandy muddy



Figs 2–3. Mollusc species-rich lower Badenian sediments at the Borsodbóta locality (Bükk Mts, Northern Hungary). (Photos by Zoltán Vicián)

substrate at 30–60 m water depth, dominated by lunulitiform bryozoans (sample Borsodbóta 2) (Moissette *et al.* 2007; figs 5–7).

MATERIAL AND METHODS

The locality data for all herein presented material is: Borsodbóta, Pécsszabolcs Member of Lajta Limestone Formation (Selmeczi *et al.* 2024), tuffaceous sandy facies, Middle Miocene (lower Badenian).

Two of the three investigated valves were found by Dirk Fehse and given to the first author (ES). These specimens are deposited in Bavarian State Collection of Zoology, Munich (ZSM). The third valve was found by the second author (AD) in a sample collected for Bryozoan studies (Moissette *et al.* 2006, 2007; Dulai *et al.* 2010) and deposited in the Palaeontological Collection of the Hungarian National Museum Public Collection Centre – Hungarian Natural History Museum, Budapest (HNHM).

SYSTEMATIC PALAEONTOLOGY

Class Polyplacophora Gray, 1821
Subclass Neoloricata Bergenhayn, 1955
Order Chitonida Thiele, 1909
Suborder Chitonina Thiele, 1909
Superfamily Chitonoidea Rafinesque, 1815
Family Ischnochitonidae Dall, 1889
Genus *Stenosemus* von Middendorff, 1847

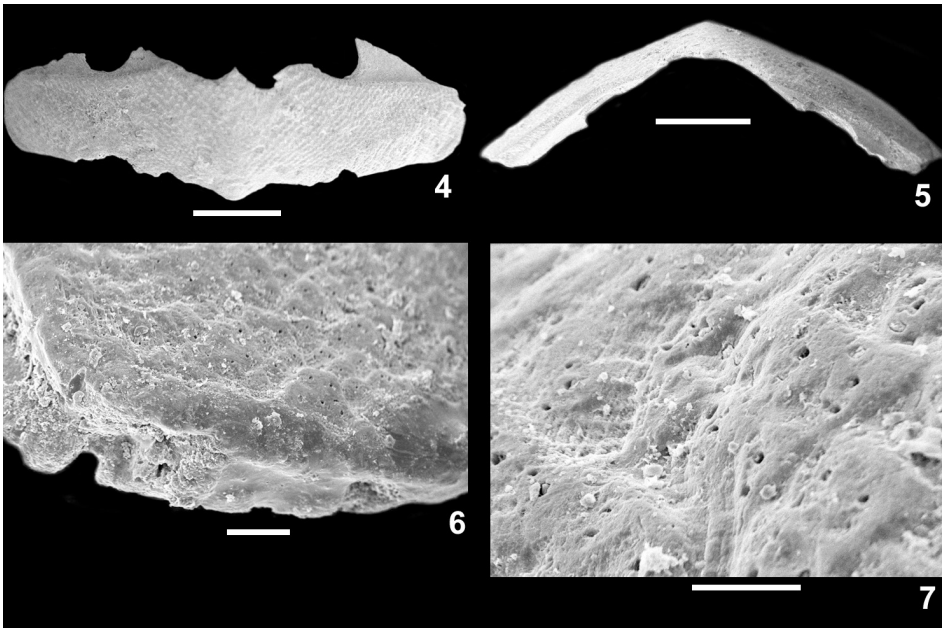
Stenosemus radiatus Dell'Angelo, Lesport, Cluzaud et Sosso, 2020 (Figs 4–7)

2020 *Stenosemus radiatus* n. sp. – Dell'Angelo, Lesport, Cluzaud & Sosso, pp. 6–8, Fig. 3. A–L.

Material – 1 intermediate valve (ZSM Mol 20191159), SEM mounted, leg. Dirk Fehse, May 2006.

Remarks – The single intermediate valve has an approximate length of 2 mm and a width of 6 mm (L/W ratio: 0.33). The dorsal elevation is 0.25. Due to the worn condition of the valve neither its exact length nor the anterior valve margin can be examined. There is evidence for a slight shallowing of this margin in the central region, while the posterior margin is almost straight with a slightly protruding apex. The valve's side slopes are straight, the valve is low elevated and

semi-carinated. Lateral areas are hardly elevated, more distinct towards the side margins. Tegmentum is sculptured with very flat, irregularly arranged granules, which tend to an antero-side direction in central area. Articulamentum is well developed, shape of apophyses is unknown, but their lateral slope is straight. Insertion plates have 4 clearly visible slit rays, of which the rearmost obviously



Figs 4–7. *Stenosemus radiatus* Dell'Angelo, Lesport, Cluzaud et Sosso, 2020, fragmentary intermediate valve. – **Fig. 4.** Dorsal view. – **Fig. 5.** Anterior view. – **Fig. 6.** Left dorso-lateral view (anterior at left) to show the multi-slitted condition of the insertion plate. – **Fig. 7.** Oblique dorsal view to show details of the tegmental granulation. Scale bars: 4–6: 1 mm, 7: 50 μm

does not end in a slit, as only 3 slits could be counted.

Apart from a lower elevation and a „missing" slit the examined valve shows strong similarities to the original description and especially to figure 3.H in Dell'Angelo *et al.* (2020). The dorsal elevation depends on which intermediate valve it is measured from and varies within a single species (e.g., Dell'Angelo *et al.* 2020: tab. 4). The current material is slightly larger than the largest intermediate valve mentioned in the original description. Despite this, slitting in the intermediate valve is only 3, while originally it was given 4–5, but the authors also clearly stated that the slit number is partly assumed from the number of slit rays. As stated above, the last slit ray in the present material does obviously not result in a distinct slit.

Distribution – **Early Miocene**: Northeastern Atlantic (Burdigalian):

Aquitaine Basin, France (Dell'Angelo *et al.* 2020); **Middle Miocene**: Central Paratethys (lower Badenian): Borsodbóta, Bükk Mts, Hungary (this paper). It is the first record of this genus and species from the Miocene of Hungary and in the Central Paratethys.

Family Chitonidae Rafinesque, 1815
Subfamily Chitoninae Rafinesque, 1815
Genus *Rhyssoplax* Thiele, 1893

Rhyssoplax corallina (Risso, 1826)
(Figs 8–10)

1999 *Chiton (Rhyssoplax) corallinus* (Risso, 1826) – Dell'Angelo & Smriglio, pp. 174–178, pls 58–59, figs 97–107. (cum syn.)
2015 *Chiton corallinus* (Risso, 1826) – Ruman & Hudáčková, pp. 160–162, figs 3.7, 4.1. (cum syn.)

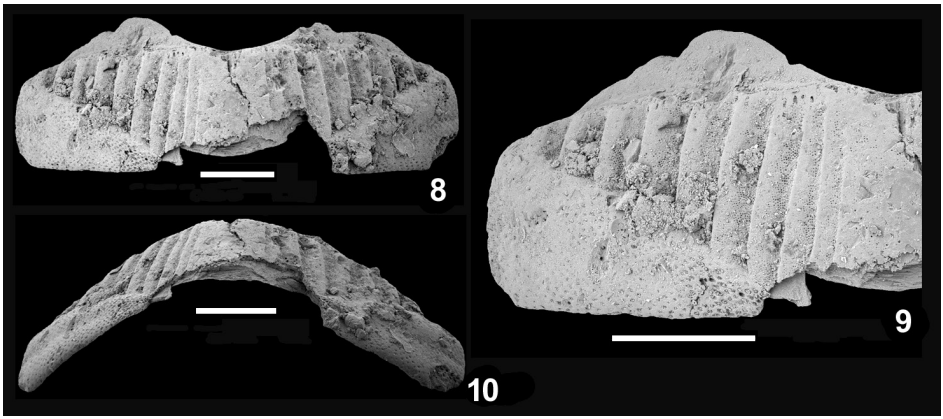
Material – 1 intermediate valve (HNHM INV 2024.560.), leg. A. Dulai, 2005.

Remarks – The single intermediate valve is fragmentary; the posterior part and the apex are missing (length: 0.8 mm; width 2.9 mm; height of tegmentum approximately 0.7 mm; L/W ratio: 0.27; dorsal elevation: 0.24). The outline of the valve is wide rectangular. The jugal area is partly broken but clearly smooth. Its anterior end has a shallow sinus, similarly to Bałuk's (1971, pl. 5, fig. 10) specimen from Korytnica, Poland, while it is straight at the Bánd material in Hungary (Dulai 2005, pl. IV, fig. 1). The lateral area is also smooth but shows numerous large pores. The pleural area is ornamented by 7 longitudinally arranged wide parallel ribs with sharp lateral margins but slightly indistinct border towards the jugal area. The interposed shallow grooves bear numerous pores. One of the apophyses is broken, the other one is subtriangular, wide, and low. In the case of the Bánd specimen, it is much more asymmetrical (Dulai 2005, pl. IV, fig. 1), so this character is again more similar to the Korytnica valve (Bałuk 1971, pl. 5, fig. 10).

This species, found in the Central Paratethys, was for a long time distinguished as *Ch. denudatus* Reuss and considered to be the Miocene ancestor of the recent *Ch. corallinus* (Reuss 1860; Rochebrune 1883; Procházka 1895; Bałuk 1971). Since the work of Laghi (1977), it has generally been accepted that they are congruent species. This identity was already partly recognized by Šulc (1934), who considered *denudatus* to be a subspecies of *Ch. corallinus*.

Distribution – *Rhyssoplax corallina* is one of the most common Polyplacophora

species of the Central Paratethys (Austria: Šulc 1934; Kroh 2002, 2003; Czech Republic: Reuss 1860; Procházka 1895; Šulc 1934; Hungary: Dulai 2005, 2025*a, b*; Dulai & Katona 2024; this paper; Dulai & Szabó in prep.; Poland: Bałuk 1971, 1984; Studencka & Studencki 1988; Macioszczyk 1988; Romania: cf. Rado 1969; Studencka & Studencki 1988; Dell'Angelo *et al.* 2007; Slovakia: Ruman & Hudáčková 2015; Ukraine: Studencka & Dulai 2010). The species is documented from the Oligocene to the present day (summarized in Dell'Angelo *et al.* 2021).



Figs 8–10. *Rhyssoplax corallina* (Risso, 1826), fragmentary intermediate valve. – **Fig. 8.** Dorsal view. – **Fig. 9.** Enlarged detail of the better-preserved side. – **Fig. 10.** Posterior view. Scale bars: 0.5 mm

Suborder Acanthochitonina Bergenhayn, 1930
Superfamily Cryptoplacoidea H. Adams et A. Adams, 1858
Family Acanthochitonidae Pilsbry, 1893
Genus *Craspedochiton* Shuttleworth, 1853

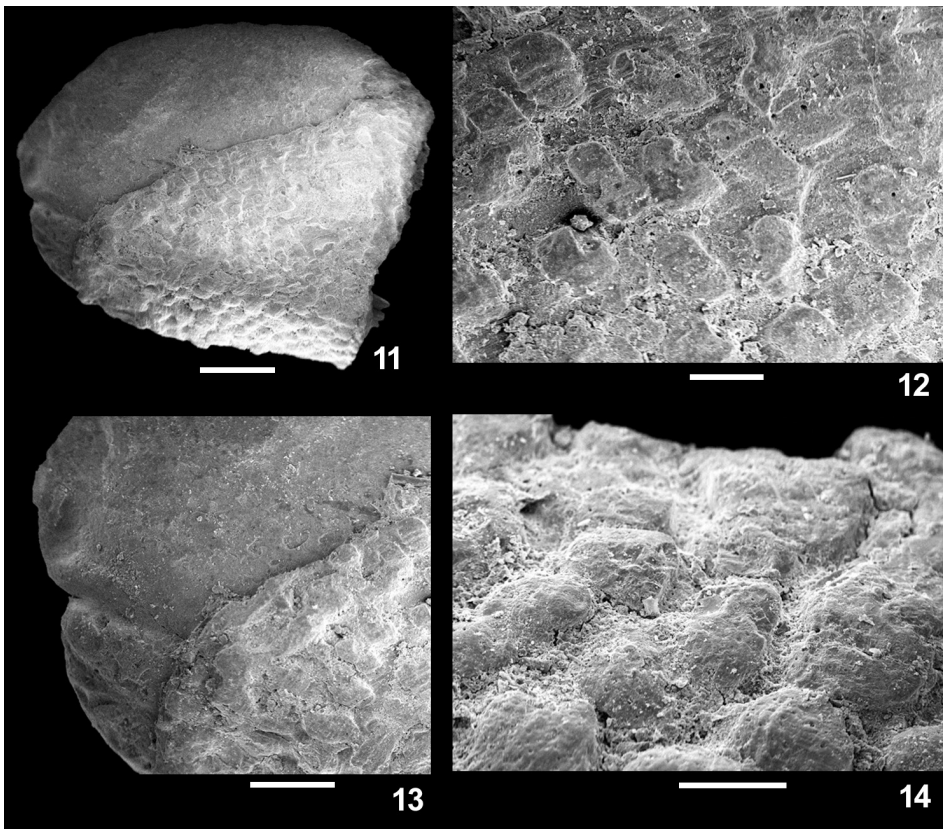
Craspedochiton altavillensis (Seguenza, 1876)
(Figs 11–14)

? 2010 *Craspedochiton profascicularis* (Boettger, 1907) – Studencka & Dulai, pp. 270–271, text-fig. 6 C–D.
2020 *Craspedochiton altavillensis* (Seguenza, 1876) – Dell'Angelo, Lesport, Cluzaud & Sosso, pp. 43–45, fig. 28.A–F. (cum syn.)
2021 *Craspedochiton altavillensis* (Seguenza, 1876) – Dell'Angelo, Sosso & Tavano, pp. 429–430, figs 166–173.

Material – 1 intermediate valve (ZSM Mol 20191158), now longitudinally broken, left part SEM mounted, leg. Dirk Fehse, May 2006.

Remarks – To estimate the valve size we measured the width from the pointed apex to the side margin of the right valve fragment and doubled it: length 5.2 mm, width 16.6 mm (L/W ratio: 0.31). Elevation was not measured. In the present specimen the jugal area is quite worn, the remaining parts show a dense arrangement of roundish-oval (in the slightly raised lateral areas) to oval-rectangular (pleural areas) granules. Articulamentum is well developed with large trapezoidal apophyses and single-slitted insertion plates.

These characters correspond well to the conservative species interpretation in Dell'Angelo *et al.* (2020). The species described as *Acanthochites profascicularis* Boettger, 1907 from the Central Paratethys is considered to be a junior synonym of *C. altavillensis* by Dell'Angelo *et al.* (1999, 2020). Studencka & Dulai (2010) argued for the difference between the two species on the basis of Laghi's



Figs 11–14. *Craspedochiton altavillensis* (Seguenza, 1876), dorsal views of a fragmentary intermediate valve, left piece. – **Fig. 11.** Complete aspect of the left piece. – **Fig. 12.** Close-up of the pleural area. – **Fig. 13.** Close-up of the left tegmental margin and underlying articulamentum. – **Fig. 14.** Enlargement of lateral area. Scale bars 11: 1 mm, 12, 14: 200 μm, 13: 0.5 mm

(1977) illustrations. The ornamentation of the single intermediate valve from Borsodbóta also differs from the highly elongated granules of the Ukrainian specimen (Studencka & Dulai 2010, text-fig. 6C–D), but the comparison is complicated by the fact that it was a much smaller juvenile specimen (width: 1.4 mm).

Distribution – In accordance with Dell'Angelo *et al.* (2021), who extensively listed the palaeobiogeographic distribution of this species, *C. altavillensis* ranges from the Early Miocene (Burdigalian) to the Pleistocene. From the Central Paratethys, the species *C. profascicularis* has been described from several sites (Romania: Boettger 1907; Zilch 1934; Poland: Bałuk 1984; and Ukraine: Studencka & Dulai 2010), whose distinctness or identity with *C. altavillensis* is disputed. It is the first record of this genus and species from the Miocene of Hungary (regardless of whether the species *C. profascicularis* is separated or synonymised with the species *C. altavillensis*).

CONCLUSIONS

The present study lists the first known chiton assemblage from the Middle Miocene (lower Badenian) sediments of the Bükk Mountains in Hungary. Despite the limited material, the sample represents the first occurrences of the genera *Stenosemus* and *Craspedochiton* for the Hungarian Polyplacophora fauna. While *Rhyssoplax corallina* is continuously represented in the Central Paratethys (for references see above), the findings of *Stenosemus radiatus* and *Craspedochiton altavillensis* require a closer palaeogeographic examination. *S. radiatus* was recently described from the Lower Miocene (Burdigalian) of the Northeastern Atlantic Aquitaine Basin (Dell'Angelo *et al.* 2020), where it co-occurs with *Rhyssoplax corallina* (Dell'Angelo *et al.* 2018). Other Hungarian Badenian chitons (Dulai 2005) that were also found in the Burdigalian of the Aquitaine Basin (Dell'Angelo *et al.* 2018) are: *Lepidopleurus cajetanus* (Poli, 1791) and *Ischnochiton rissoi* (Payraudeau, 1826), which together with *R. corallina* have a present-day coastal shallow-water distribution in the Mediterranean Sea. A further, now extinct, species, *Cryptoplax margitae* Dulai, 2001 has the same fossil occurrence, known from both the Central Paratethys (Dulai 2001) and the Aquitaine Basin (Dell'Angelo *et al.* 2020).

It is noteworthy, that the genus *Stenosemus* has a worldwide present-day distribution, but with only cold-water species found in shallow waters. The known stratigraphic range of the genus is discussed in Dell'Angelo *et al.* (2020), spanning from the Miocene of the Aquitaine Basin to the Pleistocene of the Mediterranean Sea. The present record of the genus in the Central Paratethys Sea is thus remarkable, especially as the examined locality indicates warm temperate

conditions (see also Dulai *et al.* 2010 for bryozoans; Fehse & Grego 2012 for gastropods). Whether the genus is introduced in the Paratethys Sea via the Mediterranean or a relict of the Palaeogene is speculative, but the early Badenian transgression and the associated increase in diversity are well documented in the Central Paratethys (e.g., Hladilová *et al.* 2014; Jovanović *et al.* 2019). Representatives of the genus from pre-Miocene deposits are unknown, although the re-examination of *Chiton multicavus* Bielokrys, 1999 (Bielokrys 1999) from the Late Eocene of Ukraine and *Ischnochiton marloffsteinensis* Fiedel et Keupp, 1988 (Fiedel & Keupp 1988) from the Lower Jurassic of Germany is in need to see if they are better placed in *Stenosemus* (ES pers. observations).

A further remarkable find is *Craspedochiton altavillensis*, as it – together with *Rhyssoplax corallina*, also indicates a warm water fauna. The species is well documented from the Paratethys Sea, mainly by its older names *Gymnoplax deslongchampsi* de Rochebrune, 1882 and *Acanthochites profascicularis* Boettger, 1907 (in accordance with the more conservative species interpretation by Dell'Angelo *et al.* 2020). Following the stratigraphic concept of Harzhauser *et al.* (2003), the oldest Paratethyan records of this species refer to the early Badenian Lower Lagenidae Zone of Coştei (Romania: Boettger 1907 [*Acanthochites profascicularis*]), Korytnica (Poland: Bałuk 1971, 1984) and the present record from Borsodbóta (date correlated according to Bohn-Havas *et al.* 2005). Further Paratethyan records are from Austria (Forchtenau, Gainfarn by Šulc 1934 and Kroh 2002, respectively); Romania (Delineşti, Buituri, Cîlnic by Stancu & Andreescu 1968; Rado 1969; Florei 1975, respectively), Ukraine (Varovtsi by Studencka & Studencki 1988; Studencka & Dulai 2010). The oldest species record refers to the Burdigalian of Northern Italy (Dell'Angelo *et al.* 2016) and may indicate a northward migration from the Mediterranean. No living species of this genus is currently known from the Mediterranean and most of the extant species inhabit the Indo-Pacific region (see also Schwabe & Els 2019). Care should however be taken for an interpretation of the origin of the generic Mediterranean occurrence (see also Harzhauser *et al.* 2024) as at least one living *Craspedochiton* still exists in the Atlantic, and the Burdigalian of the Aquitaine Basin yielded also representatives (Dell'Angelo *et al.* 2020).

The record of three genera of chitons at one locality in the lower Badenian of Borsodbóta, which at the present day have living representatives with almost completely different climatic requirements, is highly interesting. Single records are not sufficient to discuss any palaeoclimatic or palaeogeographic aspect of their occurrence. Maybe further chiton finds at this locality may help interpreting the faunistic composition.

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