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LATE CRETACEOUS (CAMPANIAN) RHIZOMORINE SPONGES (LITHISTID DEMOSPONGIAE) FROM THE MIECHÓW AND MOGILNO-ŁÓDŹ SYNCLINORIA (SOUTHERN AND CENTRAL POLAND)

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Abstract: Although rhizomorine lithistids are common fossils in the Late Cretaceous deposits of central Europe, their taxonomic identification has been inadequate, due to the poor preservation of their skeletons. The material studied here, comprising 916 specimens from southern and central Poland, is one of the largest Campanian fossil collections and reveals a highly diverse taxonomic assemblage of rhizomorine lithistids, containing 28 species, which belong to 17 genera. Apart from one new species, *Cryptothelion sujkowskii* sp. nov., 15 others have not been previously recorded in the Late Cretaceous of Poland. Since most of the specimens studied have a well-preserved siliceous skeleton, the presented taxonomic descriptions of rhizomorine species provide new insights into their skeletal structure and intraspecific variability. This paper also provides new data on the stratigraphic range, spatial distribution, and palaeoecology of rhizomorine lithistid species, thereby enhancing the existing knowledge of the siliceous sponge fauna, inhabiting the Late Cretaceous basins of central Europe.

Key words: Fossil sponges, rhizomorine lithistids, taxonomy, Late Cretaceous, palaeoenvironment.

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INTRODUCTION

The first evidence of the existence of rhizomorine lithistids dates back to the Cambrian (loose spicules) and Ordovician (body-preserved specimens), but they became more common only in the Late Palaeozoic (Rigby, 1991; Rigby *et al*., 1993; Carrera and Rigby, 2004). In some intervals of the Mesozoic, including the Late Cretaceous, rhizomorines flourished, and their numbers and diversity were much greater than in modern marine ecosystems (Pisera, 1999, 2002, 2006; Pisera and Lévi, 2002a–c; Van Voogd *et al*., 2024). The Late Cretaceous rhizomorine lithistids, occurring in the sediments of the epicontinental European sea, mainly from Germany, England and Czechia, were noted as early as in the 19th century (Goldfuss, 1831; Phillips, 1835; Roemer, 1840–1841, 1864; Reuss, 1846; M‘Coy, 1848; Roemer, 1870; Počta, 1884, 1892; Quenstedt, 1878; Zittel, 1878; Hinde, 1883; Griepenkerl, 1889; Wolleman, 1901, 1902). These first descriptions of fossil rhizomorines concentrated on the habitus of sponges and did not provide data on their choanosomal spicules (desmas, called rhizoclones), or their characteristics were very scanty. More detailed descriptions of the rhizoclones of sponges appeared in the works by Schrammen (1901, 1910, 1924). The rhizoclones, in comparison with the desmas of other lithistids, are usually significantly smaller, and the skeletons of Cretaceous rhizomorine specimens are often completely or partially destroyed as a result of diagenetic processes. The poor state of preservation of some of the material from Germany examined by Schrammen (1910, 1924) made it impossible to revise previously described taxa, and resulted in incomplete knowledge of their skeletons. Also, the skeletons of rhizomorine sponges from the Upper Chalk of England are usually not preserved, and only occasionally has the original opaline (opal-A) silica been replaced by a quartz polymorph (specimens mainly preserved within flints) or iron sulphide (Hinde, 1883; Wood, 2002). The lack of skeletons in many sponges described by Hinde (1883) has made some the synonyms of species from the Cretaceous of England and Germany indicated by Schrammen (1910, 1924) controversial.

The taxonomy of the Cretaceous rhizomorine sponges has been addressed in many papers, published throughout the 20th century and at the beginning of the 21st century. The rhizomorine specimens described in these studies came from Spain (Lagneau-Hérenger, 1962), France (Moret, 1921, 1926; Lagneau-Hérenger, 1967; Bert and Breton, 2017), Germany (Wagner, 1963; Ulbrich, 1974; Gruber, 1993), the Czechia (Žítt *et al.*, 2015), England (Wood, 2002), and Poland (Bieda, 1933; Hurcewicz, 1968; Świerczewska-Gładysz, 2006, 2012; Świerczewska-Gładysz *et al.*, 2019). They usually lack well-preserved skeletons and are classified primarily on the basis of habitus.

This paper presents taxonomic descriptions of rhizomorine sponges from the Campanian of Poland. Most of the specimens originated from the Miocene gravels at the Bełchatów Lignite Mine (Mogilno-Łódź Synclinorium, central Poland), which are rich in redeposited early Campanian (Late Cretaceous) siliceous sponges (Fig. 1). So far, lithistid sponges representing the Pleromidae, Isoraphiniidae, Corallistidae, Theonellidae, Phymarinidae and Phymatellidae have been studied in detail from this locality (Świerczewska-Gładysz, 2016, 2017; Świerczewska-Gładysz and Jurkowska, 2022, 2023). Additionally, museum collections of rhizomorine sponges from the Campanian of the Lelów and Miechów areas (Miechów Synclinorium, southern Poland), previously described by Hurcewicz (1968), have been revised (Fig. 1). The examined material from the Miechów Synclinorium was supplemented by specimens, collected by the authors during fieldwork in the Lelów and Jędrzejów areas (Fig. 1). The preservation of the rhizoclones is generally poorer than that of the desmas of other co-occurring lithistids. In spite of this, the observations by the present authors considerably increase the knowledge of many rhizomorine lithistids. In opposition to earlier taxonomic works that have illustrated loose rhizoclones, presented here is the choanosomal network, showing the arrangement of desmas and their variability within the choanosomal skeleton. Furthermore, the rich material allowed the evaluation of intraspecific variability in some species.

The discussion of the stratigraphical and palaeogeographical distribution, as well as the palaeoecology of the Cretaceous rhizomorine lithistids, were determinaed on the basis of a combination of literature analysis and the observations, conducted by the authors.

GEOLOGICAL SETTINGS

The studied sponges come from the lower and upper Campanian succession of the Miechów Synclinorium in southern Poland. The stratigraphy, lithology, and petrography were described by e.g., Rutkowski (1965), Hurcewicz (1968), Jurkowska (2016), Świerczewska-Gładysz (2016) and Świerczewska-Gładysz and Jurkowska (2022, 2023); for a summary see Table 1. The lower Campanian begins with a thick marly complex (up to 30 m; Rutkowski, 1965), including horizons of chert (siliceous rocks, composed of opal-CT; Jurkowska and Świerczewska-Gładysz, 2020) and nodules (Skrajniwa; Tab. 1) changing upwards into a uniform opoka (a carbonate-siliceous rock with opal-CT forming

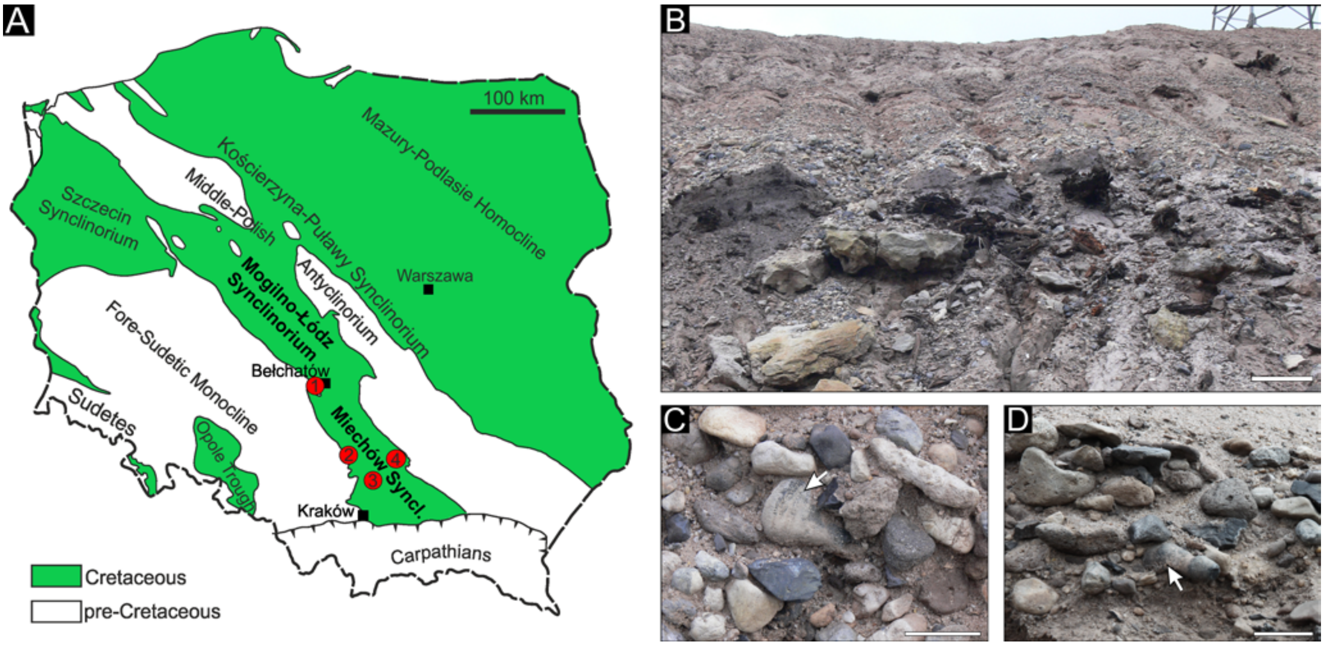

Fig. 1. Localities with the Campanian sponges studied. **A.** Tectonic sketch map of Poland (without the Cenozoic cover; after Pożaryski, 1974 and Żelaźniewicz *et al.*, 2011; simplified) with the studied localities: 1 – Bełchatów area (Bełchatów Lignite Mine); 2 – Lelów area (Pniaki, Zbyczyce, Skrajniwa, Podgaj); 3 – Miechów area (Strzeżów 1, Muniakowice); 4 – Jędrzejów area. **B.** Miocene clayey-sandy deposits with layers of alluvial gravel in the Bełchatów Lignite Mine containing redeposited early Campanian sponges (sixth exploitation level). **C, D.** The rhizomorine sponges within alluvial gravel (arrowed). Scale bars 50 cm (B) and 5 cm (C, D).

Table 1

Studied sections showing data on stratigraphy, lithology, and relevant literature.

Geologic area	Geographic region	Location	Stratigraphy	Lithology from which the studied material originate	Authors
Mogilno-Łódź Syn.	Bełchatów area	Bełchatów Lignite Mine	lower Campanian	cherts with flint cores	Pożaryski, 1960; Świerczewska-Gładysz, 2016, 2017
Miechów Synclinorium	Lelów area	Pniaki abandoned quarry	lower Campanian	opoka and chert nodules with flint cores	Hurcewicz, 1968; Jurkowska *et al.*, 2015; Jurkowska and Świerczewska-Gładysz, 2020
		Zbyczyce abandoned quarry	lower Campanian	chert nodules with flint cores	Hurcewicz 1968; Jurkowska *et al.*, 2015
		Skrajniwa natural outcrop	lower Campanian	siliceous nodules (probably cherts with flint cores) from marls	Różycki, 1938; Hurcewicz, 1968; Pożaryski, 1966
		Podgaj natural outcrop	upper Campanian	opoka	Hurcewicz, 1968;
	Miechów area	Miechów (named as Strzeżów 1) abandoned quarry	upper Campanian	gaize	Hurcewicz, 1968; Jurkowska, 2016, 2022
		Muniakowice natural outcrop	upper Campanian	opoka	Rutkowski, 1965; Hurcewicz, 1968; Jurkowska, 2016
	Jędrzejów	Jędrzejów road cutting	upper Campanian	opoka and gaize	Świerczewska-Gładysz and Jurkowska, 2013; Jurkowska, 2016

a siliceous framework; Jurkowska, 2022), with marly intercalation and horizons of chert nodules (with flint cores in the lower part of the complex; Jurkowska and Świerczewska-Gładysz, 2020; Zbyczyce, Pniaki, Podgaj; Tab. 1). The upper Campanian is characterized by opoka with a significant amount of detrital quartz (Jurkowska, 2022; Muniakowice, Podgaj, Jędrzejów: lower part of the section), which changes into gaize (a carbonate-siliceous rock with opal-CT and detrital quartz; Jurkowska, 2022; Strzeżów 1 and Jędrzejów: upper part of the section; Tab. 1).

The Campanian sponges were also collected in the Bełchatów Lignite Mine (Kleszczów Graben, Mogilno-Łódź Synclinorium), where the geological conditions of the occurrence of early Campanian lithistid sponges were described in detail in previous works (Świerczewska-Gładysz, 2016, 2017). Campanian deposits in the Bełchatów area, known mainly from boreholes, are represented by opoka with marly intercalations and horizons of chert nodules. The horizons of cherts with black flint cores, similar to the Miechów Synclinorium section, occur in the lower part of the lower Campanian (Pożaryski, 1960). The secondary silicified lithistid sponges, as well as cherts and clasts of Campanian opoka, are found in gravels, occurring in the lower part of Neogene fluvial sands (the Upper Gravels in the lithostratigraphic subdivision, after Krzyszkowski and Winter, 1996).

The Campanian succession of the Miechów and Mogilno-Łódź Synclinorium was deposited in the epicontinental European Basin, but it differs lithologically from most parts of the basin, where chalk (a carbonate rock, composed of coccoliths) with flint horizons (siliceous rocks of nano-α-quartz) predominates. This lithological variation of carbonate siliceous (opoka) and siliceous (cherts) *vs.* chalk was controlled by the dSi (dissolved silicon) seawater concentration and the dynamic balance of dSi concentration between seawater and porewater (Jurkowska and Świerczewska-Gładysz, 2024). The opoka facies occurs in regions, where the dSi seawater concentration was high enough to enable the precipitation of silica polymorphs during diagenesis, which facilitated the development of siliceous sponges (Jurkowska and Świerczewska-Gładysz, 2022).

MATERIAL, STAGE OF PRESERVATION AND METHODS

The material described here comprises a total of 916 specimens. The collection from the Bełchatów Lignite Mine, consisting of 724 specimens, is housed in the Geological Museum of the Faculty of Geographical Sciences, University of Łódź, Poland (Collection UL no. XXV). The material from southern Poland, collected by H. Hurcewicz and the authors, includes 74 specimens from Zbyczyce, 37 specimens from Pniaki, 65 specimens from Skrajniwa, 3 specimens from Jędrzejów, 8 specimens from Miechów, 7 specimens from Podgaj and 1 specimen from Muniakowice, which are also housed in this institution (Collections UL, nos. III and IIa). Material described by Bieda (1933) and some specimens from an unpublished collection of A. Schramanen, housed in the Palaeontological Collection of the University of Tübingen, were examined for comparison.

All of the sponges from Poland studied here are preserved as siliceous material, but the primary biogenic opal-A is not preserved. After burial, complex and multistage diagenetic processes led to the complete dissolution of the primary opal-A, and in the final stage, the voids left by the spicules were infilled by a secondary mixture of opal-CT and nano-α-quartz (Jurkowska *et al.*, 2024). The skeletons of limonitized specimens were dissolved, and only rare siliceous (mixed nano-α-quartz and opal-CT) desmas are preserved.

The skeletons were cleaned in an ultrasonic cleaner to remove clay minerals and quartz grains. The skeletal material of specimens coming from the marls, opoka, and gaize were etched with 10% hydrochloric acid. The fragments of skeletons were examined under an SEM microscope at the Faculty of Geology, Geophysics, and Environmental Protection, AGH University of Science and Technology. Due to the silicification of the sponges, it was not possible to isolate individual rhizoclones, which made their measurement difficult. Therefore, their size has been given with some approximation, based on 10 measurements. The thickness of the desmas was measured at the thickest point of the axial part.

TERMINOLOGY

The sponge terminology was adopted from Boury-Esnault and Rützler (1997), Hooper *et al.* (2002), Finks *et al.* (2003), and Łukowiak *et al.* (2022). Small, often papillary pores on the outer surface of the choanosomal skeleton of some rhizomorine species are described in palaeontological literature as "ostia" (= inhalant canal openings, understood as the inlet to the skeletal inhalant canals), while papillary, usually large pores on the upper side, are termed "postica" (= exhalant canal openings, understood as the outlet of the skeletal exhalant canals) or oscula, which often does not reflect the structure of the skeletal canal system. The observations by the present authors indicate that skeletal exhalant canals in Cretaceous rhizomorines open directly at the surface of the choanosomal skeleton or at the bottom of the furrows or canals, running under the external layer of the choanosomal skeleton (subcortical canals after Reid, 2004). Pores on upper side of a sponge play the role of oscula only in this last case. The pores on the outer surface also often lead to shallow grooves or furrows, situated under the external layer of choanosomal skeleton, with inlets of inhalant canals, the number and arrangement of which do not correspond to those of the pores on the outer surface.

REMARKS ON SYSTEMATICS

Rhizomorine sponges are a polyphyletic group, and modern lithistids with rhizoclone desmas are classified into three families, based on the absence/presence and type of microscleres: Scleritodermatidae Sollas, 1888, Siphonidiidae Lendenfeld, 1903 and Azoricidae Sollas, 1888 (Pisera and Lévi, 2002a–c; Van Voogd *et al.*, 2024). Recently, the classification of living sponges has been supported by molecular phylogenetic studies (Morrow and Cárdenas, 2015; Schuster *et al.*, 2015). In palaeontological literature, sponges with rhizoclones are classified into the Suborder Rhizomorina Zittel, 1878, within which numerous ancient families have been distinguished (e.g., Schrammen, 1924; Laubenfels, 1955). Reid (2004) attempted to assign fossil families and genera to the Scleritodermatidae, Siphonidiidae, and Azoricidae, which he raised to the rank of superfamiles. The lack of preserved microscleres in fossil taxa makes this classification, based on the macroscopic features of species and the characteristics of their megascleras, questionable.

The taxonomy of Cretaceous rhizomorines is also debatable for some genera, especially *Verruculina* Zittel, 1878 and *Amphitelion* Zittel, 1878. Acording to Zittel (1878), *Verruculina* is characterized by papillary oscula only on the upper side, while *Amphitelion* has papillary pores on both surfaces. The presence or absence of papillae often does not correlate with other characteristics of species; therefore, Hinde (1883) and Schrammen (1910) recognized *Amphitelion* as a synonym of *Verruculina*. However, Schrammen (1924) distinguished the genera *Amphitelion* and *Verruculina* once again. Moreover, this author described six other new genera, containing species previously included in *Verruculina*. The diagnoses of these genera given by Schrammen (1924) are based on a combination of the size and shape of the desmas with various macroscopic features. Unfortunately, the characteristic features proposed by Schrammen (1924) are often impossible to recognize, due to the poor preservation of sponges. Therefore, in subsequent publications, all or some of these genera were not accepted and were treated as synonyms of *Verruculina* (e.g., Hurcewicz, 1968; Ulbrich, 1974; Brimaud and Vachard, 1986; Pisera, 2002; Świerczewska-Gładysz, 2006). Another attempt to organize the systematics of this group of sponges was by Reid (2004), who included Schrammen's genera *Heterothelion*, *Cryptothelion*, *Amphistomium* and *Sporadothelion* as subgenera of *Amphitelion*, while *Chondriophylum* and *Amphichondrium* were included in *Verruculina*. According to Reid's (2004) modified diagnosis, *Amphitelion* is distinguished from *Verruculina* mainly by the form of the desmas and the absence of special cortical desmas. However, this second feature cannot be considered diagnostic for *Amphitelion sensu* Reid (2004) because special superficial desmas also were recorded by Schrammen (1924) and by the present authors in *Cryptothelion* and *Sporadotelion*. The species described here are very diverse in terms of skeletal structure (not just the shape and size of the desmas themselves) and canal distribution, which is often not reflected in the classification proposed by Reid (2004). Accordingly, the authors of the present study have actepted only a few of his diagnoses of genera. In most cases, the present authors have adopted

Schrammen's (1924) taxonomy, although they acknowledge that further research, based on better-preserved material, may reveal that some of these genera are synonyms.

SYSTEMATIC PALAEONTOLOGY

Class Demospongiae Sollas, 1885
Subclass Heteroscleromorpha Cárdenas *et al*., 2012
Order Tetractinellida Marshall, 1876
Suborder Spirophorina Bergquist and Hogg, 1969
"Rhizomorine Lithistids"
Genus *Aulosoma* Schrammen, 1924

Type species: *Spongia radiciformis* Phillips, 1835, p. 90, pl. 1, fig. 9, designated by Schrammen, 1924, pp. 106–167.
Diagnosis: See Schrammen (1924).
Remarks: Schrammen (1924) distinguished a new genus *Aulosoma* with the type species *Spongia radiciformis* Phillips, 1835, which was previously included in the genus *Scytalia* Zittel, 1878. The differences in the shape and size of rhizoclones and the skeletal canalization of *Aulosoma* and *Scytalia* pointed out by Schrammen (1924) are unambiguous and the separation of these taxa was followed also by Reid (2004). According to Schrammen (1924), the lateral outgrowths in *Aulosoma* are not developed or finger-like, while after Reid (2004), *Aulosoma* is characterized only by a body with alternating swellings and constrictions. The differences in these diagnoses are related to the taxonomic position of *Siphonocoelia tuberculosa* Roemer, 1864 with finger-like outgrowths, classified as *Aulosoma* (Schrammen, 1924) or *Stachyspongia* (Zittel, 1878; Schrammen, 1910; Hurcewicz, 1968; Ulbrich, 1974, Gruber, 1993). Analysis of the rich material from Poland has shown that the structures of the skeletons and the canalization of both species are very similar, which indicates their close relationship and thus confirms the validity of Schrammen's (1924) diagnosis. In the opinion of Reid (2004), the presence of skeletal fibres on the spongocoel surface, observed in the topotype of *A. radiciformis*, is considered a diagnostic feature of *Aulosoma*. In the studied material, these fibres occur not only in both species of *Aulosoma* but also in *Pseudoscytalia terebrata* (Phillips, 1835); therefore, this feature cannot be considered unique for *Aulosoma*.

Aulosoma radiciformis (Phillips, 1835)
Figs 2A–G, 3A–D

1835 *Spongia radiciformis* – Phillips, p. 90, pl. 1, fig. 9.
partim 1968 *Scytalia radiciformis* (Phillips) – Hurcewicz, pp. 53–55, pl. 12, figs 1–3, text-fig. 12.
1968 *Scytalia terebrata* (Roemer) – Hurcewicz, pp. 55–57.
1993 *Scytalia radiciformis* (Phillips) – Gruber, p. 59, pl. 25, fig. 3, pl. 26, fig. 1 [cum syn.].

Material: 115 specimens from Bełchatów (ULXXV/1R/1–112), 5 specimens from Pniaki (ULIIa/50–54), 7 specimens from Podgaj (ULIII/562, 563, 759, 760, 764–766), 8 specimens from Pniaki (ULIII/531–534, 676, 731, 1064, 1592), 34 specimens from Zbyczyce (ULIII/513, 518, 759, 767, 768, 960, 954, 955, 964, 965, 967, 969, 977, 1151, 1158, 1183, 1299, 1300, 1302, 1303, 1304, 1305, 1332–1335, 1338, 1344, 1349, 1350, 1352, 1359, 1365, 1509), 106 specimens from Skrajniwa (ULIIa/39–44; ULIII/219, 301–303, 305–308, 310–313, 316, 317, 319–321, 323, 324, 326–328, 330, 331, 335, 337–340, 349–352, 375, 412, 425, 460, 464–467, 469, 471, 473–483, 485–490, 498, 501, 507, 509, 512–515, 520–535, 538–542, 1104, 1157, 1161, 1165, 1167, 1172–1177, 1181, 1190).
Description: Narrow cylindrical sponges (Fig. 2A–F) up to 110 mm in height, and with a deep and narrow (4–12 mm wide) tubular spongocoel (Fig. 2E). Usually solitary, but sometimes consists of two and four fused individuals (Fig. 2D, E). Rounded apex is nearly flat or slightly concave, covered by fine radiate furrows, with a centrally situated osculum. Horizontal, ring-like bulges on the outer surface are more or less prominent. In large specimens, 3–7 bulges are usually distributed on the entire sponge surface, rarely being concentrated in the upper part of the sponge. In young individuals (Fig. 2F) and some adult-sized, slender specimens, the ring-like bulges are very poorly developed. Occasionally, in some specimens, additional single, rounded bulges occur. Basal part is usually destroyed, rarely with a preserved fragment of the bent stalk (up to 30 mm long and 10 mm wide). Root-like outgrowths (or their remains) are noted occasionally, mainly in the lowermost part, rarely higher upwards, on one side of the sponge. Very delicate, anastomosing grooves, 0.1–0.2 mm wide, are visible on the outer surface of some well-preserved specimens. Inhalant canal openings, 0.25–0.45 mm in diameter (rarely up to 0.5 mm), are densely spaced (ca. 60/cm^2) and on some specimens locally arranged in vertical rows. Inhalant canals run obliquely and penetrate at least half of the wall thickness. Exhalant canal openings (observed mainly in the uppermost part of the spongocoel) round or oval exhalant, 0.5–0.6 mm x 0.5–1.2 mm in size, are distributed in indistinct vertical and horizontal rows (Fig. 2G). Locally, the openings are fissure-like and up to 2 mm long. The terminal parts of long exhalant canals are strongly oblique to the surface of the spongocoel. Exhalant canals branch dichotomously about halfway of the wall thickness or near the outer surface. A few exhalant canals are observed in the preserved fragments of stalks.

Irregularly branched rhizoclones, with arched, rarely straight axis, 250–300 µm in size and 25–30 µm thick, form a compact network (Fig. 3D). The network is especially dense on the outer surface (Fig. 3A, B), where locally (mainly in the lower part of the sponge) they mask inhalant canal openings. The largest (up to 400 µm in size), poorly branched rhizoclones occur near the canals. On the surface of the spongocoel, rhizoclones form skeletal fibres, ca. 150–200 µm wide, which show a vertical orientation (Fig. 3C). Rhizoclones, extending between the fibres and covering the exhalant canal openings, are locally preserved. Ornamentation of desmas is variable, they can be moderately (on the outer surface) or poorly spiny (on the inner surface). Spines are usually conical, sometimes long, while spines with multifurcating tips are very rare (Fig. 3B). Inside the wall, the spine tips are usually dissolved.

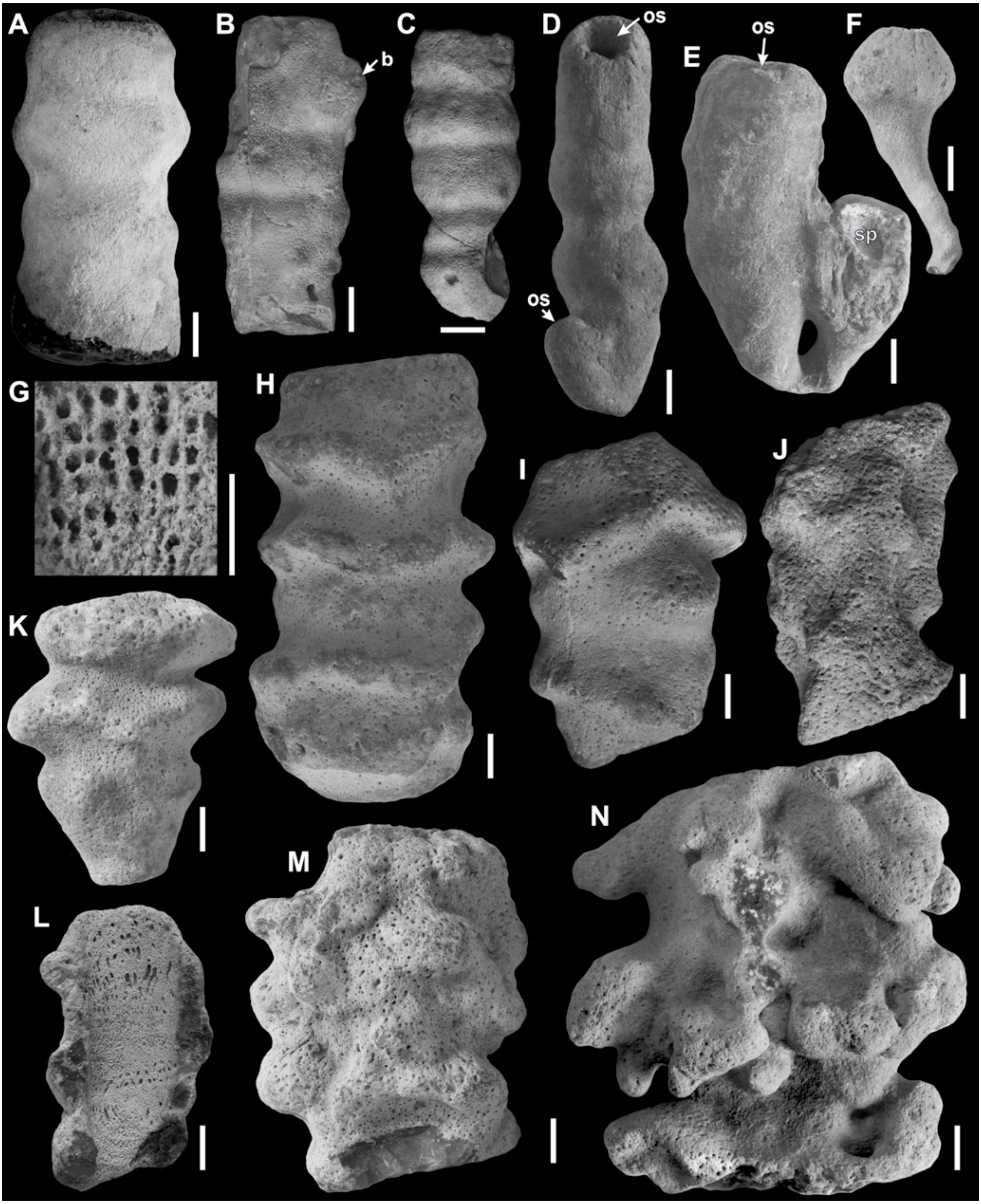

Fig. 2. Rhizomorine sponges. **A–G.** *Aulosoma radiciformis* (Phillips, 1835); A–C – lateral view of a specimen with ring-like transversal bulbous and a single bulge (b); A – ULXXV/1R/1, Bełchatów; B – ULXXV/1R/2, Bełchatów, C – ULXXV/1R/7; E, D – specimens consisting of two joined individuals; narrow spongocoel (sp) and osculum (os) pointed; D – ULXXV/1R/4, Bełchatów; E – ULXXV/1R/5, Bełchatów; F – young individual with preserved stalk; ULXXV/1R/8, Bełchatów; G – exhalant canal opening on the spongocoel surface; ULXXV/1R/9, Bełchatów. **H–N.** *Aulosoma tuberculosa* (Roemer, 1864); H–K – lateral view of specimens with irregular ribs and thickenings or short outgrowths; H – ULXXV/2R/1, Bełchatów; I – ULXXV/2R/2, Bełchatów; J – ULXXV/2R/3, Bełchatów; K – ULXXV/2R/4, Bełchatów; L – longitudinal section of specimens with visible tubular spongocoel; exhalant canal openings locally covered by an additional skeletal network; ULXXV/2R/8, Bełchatów; M, N – lateral view of specimens with well-developed folds and outgrows; ULXXV/2R/6, Bełchatów; J – ULXXV/2R/7, Bełchatów. Scale bars 10 mm.

Remarks: Some of the specimens, poorly preserved and without developed transversal thickenings, described by Hurcewicz (1968) as *A. radiciformis*, probably represent corallistid species *Schrammeniella scytaliforme* (Schrammen, 1910), co-occurring in the studied assemblage (Świerczewska-Gładysz, 2017). Moreover, Hurcewicz (1968) noted single protriaenes in one specimen from the opoka from Zbyczyce. However, these spicules, unknown in recent rhizomorine lithistids (compare Pisera and Lévi 2002a, b), are not preserved *in situ*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian), Germany (Lower Saxony: Campanian); southern England (Upper Chalk, probably lower Campanian); France (Paris Basin: Turonian; Provence: Coniacian); Spain (Catalonia: Aptian).

Aulosoma tuberculosa (Roemer, 1864)
Figs 2H–N, 3E–G

1864 *Siphonocoelia tuberculosa* – Roemer, p. 29, pl. 11, fig. 4.
partim 1924 *Aulosoma radiciformis* (Phillips, 1835) – Schrammen, pp. 106–107.
1924 *Aulosoma bulbosa* – Schrammen, p. 142, pl. 15, fig. 6.
1968 *Stachyspongia tuberculosa* (Roemer) – Hurcewicz, p. 58, pl. 12, fig. 5, pl. 13, fig. 3.
1974 *Stachyspongia tuberculosa* (Roemer) – Ulbrich, pp. 42–43, pl. 7, fig. 2 [cum syn.].
1993 *Stachyspongia tuberculosa* (Roemer) – Gruber, pp. 59–60, pl. 17, fig. 3–4.

Material: 48 specimens from Bełchatów (ULXXV/2R/1–46), 2 specimens from Miechów (ULIII/104, 105), 1 specimen from Pniaki (ULIIa/56), 1 specimen from Jędrzejów (ULIIa/45, 46), 2 specimens from Skrajniwa (ULIII/329, 1169).

Description: Wide cylindrical sponges, up to 120 mm high and 85 mm wide (Fig. 2H–K, M, N), with a deep tubular spongocoel (Fig. 2L). Outer surface with irregular, variably oriented rounded ribs and thickenings or short outgrowths (Fig. 2H–K). Outgrowths are conical with a rounded apex or finger-like. In large specimens, outgrowths are usually longer and occasionally fused, often located on prominent folds and oriented transversely or obliquely to the sponge axis (2M, N). Apex and basal parts are usually destroyed, and a fragment of a thin stalk is rarely preserved. The longer stalk is half the length of the sponge body and 95 mm long. Canal openings on both surfaces are clearly visible on specimens with a slightly destroyed surface. Outer surface with round canal openings, 0.3–0.7 mm in diameter, evenly distributed, ca. 0.40–50/cm^2. Inhalant canals run more or less obliquely to the surface of the sponges. Exhalant canals start just below the outer surface, where they are 1 mm in diameter. They run obliquely in the wall and terminate on the surface of the spongocoel as round, elliptical or fissure-like openings, 1–1.5 mm x 1–4 mm in size, distributed in indistinct vertical and horizontal or oblique rows (Fig. 2L).

Very dense skeletal layer on the outer surface consists of spiny, irregularly branched rhizoclones, 300–450 µm in size and 30 µm thick (Fig. 3F, G). Long clones and axes of desmas are covered by prominent, conical or multiple spines (Fig. 3G). Less branched rhizoclones, covered mainly by wide conical spines, occur inside the wall. Near the canals the desmas are elongated or arched, up to 500 µm in size (Fig. 3E). On the surface of the spongocoel, densely packed rhizoclones form vertical fibres, which mask the canal openings in well-preserved specimens.

Remarks: Zittel (1878) attributed the discussed species as *Stachyspongia* Zittel, 1878 due to the presence of prominent outgrows on the outer surface of the sponges. This view was accepted later (Griepenkerl, 1889; Schrammen, 1910; Moret, 1926; Hurcewicz, 1968; Ulbrich, 1974). Schrammen (1924) recognized this species as a morphotype of *Aulosoma radiciformis* (Phillips, 1835). The observations of the present authors support the attribution of this sponges to *Aulosoma*, but they believe that it is a separate species. Some, especially small specimens of *A. tuberculosa* without prominent outgrowths, resemble *A. radiciformis*, but the thickenings in the first species are irregular and variously oriented with respect to the sponge axis, unlike the alternately arranged transverse thickenings and narrowings in the second species. Moreover, specimens of *A. tuberculosa* differ from *A. radiciformis* also in a wider spongocoel, and large and less densely distributed inhalant canal openings on the outer surface. Dense structures of the skeleton and the distribution of the skeletal canals of both species are very similar, but the rhizoclones of *A. tuberculosa* are large and spinier on the outer surface.

A. tuberculosa is a rare Late Cretaceous sponge and its intraspecific variability is poorly known. Analysis of rich material from Bełchatów has revealed a great variability in the morphology of the outer sponge surface. Some studied specimens have very well-developed simple outgrowths or folds with secondary outgrowths, sometimes growing together as in the unique specimen of *Aulosoma bulbosa* Schrammen, 1924 from the lower Campanian of Glentorf (Lower Saxony), considered here as a junior synonym of *A. tuberculosa*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Campanian; Saxony-Anhalt: Santonian, lower Campanian); France (Paris Basin: Turonian; Provence: Coniacian).

Genus *Pseudoscytalia* Schrammen, 1924

Type species: *Spongia terebrata* Phillips, 1835, p. 90, pl. 1, fig. 10, designated by Schrammen, 1924, p. 110.

Diagnosis: See Schrammen (1924).

Remarks: Reid (2004) synonymized the genus *Pseudoscytalia* Schrammen, 1924 with *Scytalia* Zittel, 1878, but the present authors have accepted the view of Schrammen (1910) that representatives of *Pseudoscytalia* differ from individuals of *Scytalia* by smaller, more branched rhizoclones and the presence of a dense, exterior layer of the choanosomal skeleton (= Deckschicht after Schrammen, 1924; = cortical layer after Reid, 2004).

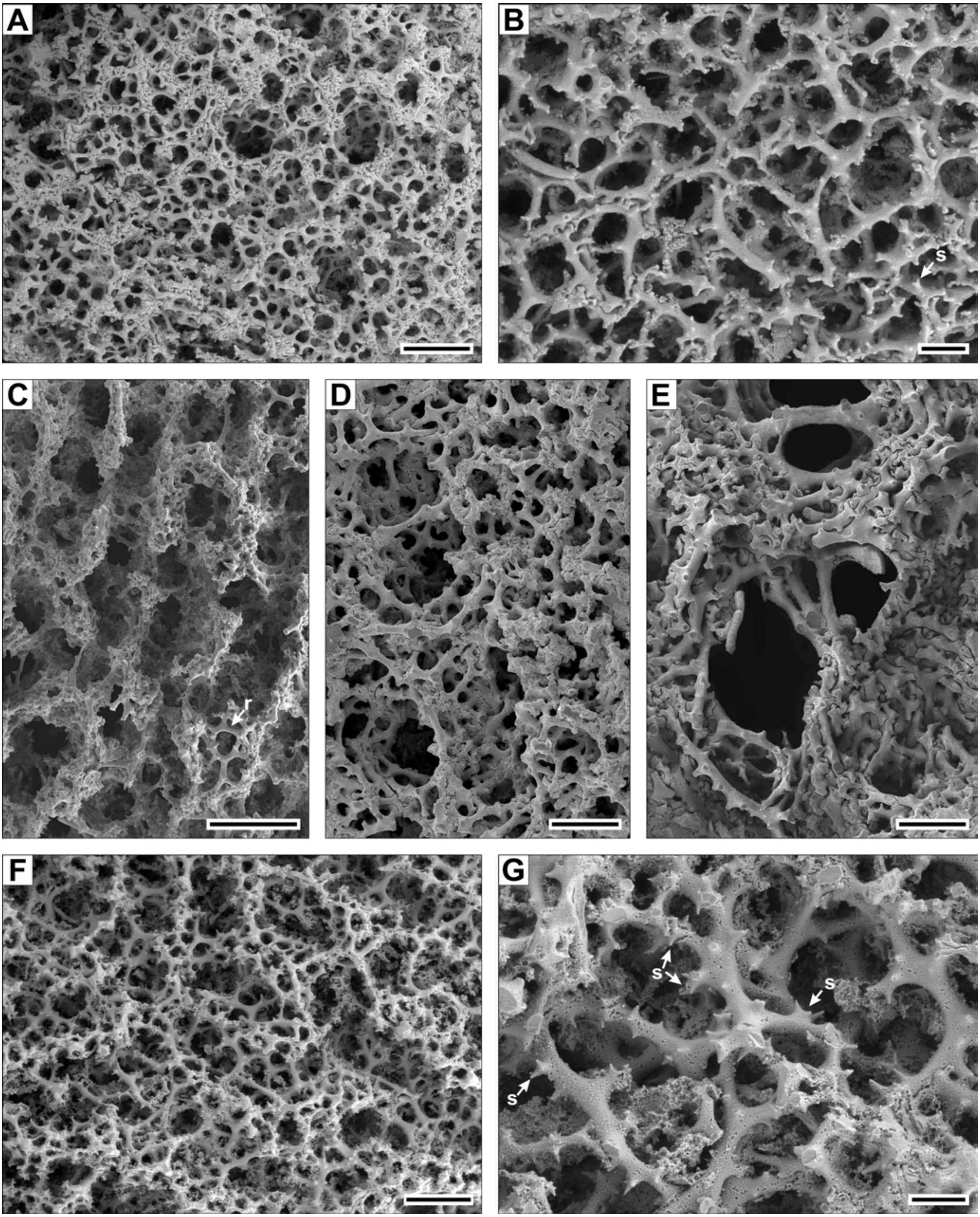

Fig. 3. Skeletons of rhizomorine sponges. **A–D.** *Aulosoma radiciformis* (Phillips, 1835); A, B – dense skeleton on the outer surface; A – network with inhalant canal opening; B – detail with visible rhizoclones covered by conical, rarely multiple spines (s); ULXXV/1R/3, Bełchatów; C – skeleton on the surface of spongocoel with rhizoclones (r) extending between the skeletal fibres; ULXXV/1R/6, Bełchatów; D – skeleton inside the wall pierced by canals; ULXXV/1R/7, Bełchatów. **E–G.** *Aulosoma tuberculosa* (Roemer, 1864); ULXXV/2R/5, Bełchatów; E – skeleton inside the wall pierced by canals; F, G – skeleton on the outer surface with conical and multiple spines (s). Scale bars 100 μm (B, G), 200 μm (D, E) and 500 μm (A, C, F).

Pseudoscytalia terebrata (Phillips, 1835)
Figs 4A–I, 5A–E

1835 *Spongia terebrata* – Phillips, p. 90, pl. 1, fig. 10.
1883 *Scytalia fastigiata* – Hinde, p. 44, pl. 6, fig. 3.
1878 *Scytalia terebrata* (Phillips) – Zittel, p. 65.
1883 *Scytalia terebrata* (Phillips) – Hinde, p. 45.
partim 1910 *Scytalia terebrata* (Phillips) – Schrammen, p. 150.
1910 *Scytalia terebrata* Phillips sp. var. *elongata* – Schrammen, p. 151.
1924 *Pseudoscytalia terebrata* (Phillips) – Schrammen, pp. 110–111, pl. 3, fig. 11.
1924 *Pseudoscytalia fastigiata* (Lee) – Schrammen, p. 111, pl. 15, fig. 4.
1926 *Scytalia terebrata* (Phillips) – Moret, pp. 13–14, pl. 18, fig. 7, pl. 20, fig. 5, text-fig. 30.
1968 *Scytalia turbinata* (Roemer) – Hurcewicz, pp. 51–53, pl. 11, figs 3, 4.
non 1968 *Scytalia terebrata* (Roemer) – Hurcewicz, pp. 55–57, pl. 12, fig. 4, text-fig. 13 [= *Aulosoma radiciformis* (Phillips)].

Material: 48 specimens from Bełchatów (ULXXV/3R/1–48), 29 specimens from Skrajniwa (ULIIa/19; ULIII/ 296, 300, 342, 346, 541, 543, 544, 546, 547, 549–551, 553, 554, 681, 724, 1143–1145, 1147, 1148, 1151, 1152, 1185, 1186, 1508, 1537, 1640), 2 specimens from Jędrzejów (ULIIa/47, 48).

Description: Wide or narrow conical to nearly cylindrical sponges, up to 150 mm high (Fig. 4C–F), sometimes with gentle transverse wrinkles (Fig. 4D). Some specimens are bilaterally flattened, rarely with one or three flattened sides (Fig. 4G, I); the latter specimens are semicircular or triangular in transverse section. Other specimens have a shallow depression situated on the lateral surface of the sponges, separated from the apex by a transverse sharp edge (Fig. 4A) or an elongated depression, which are bounded on one side by a prominent, pointed ridge (Fig. 4B). This long ridge runs obliquely or nearly parallel to the sponge axis. The sponge apex is widelyconical or slightly convex, usually covered by deep radially branching furrows, surrounding a round or oval osculum (Fig. 4I). Tubular spongocoel, deep, narrow to moderately wide (Fig. 4C). Specimens with a destroyed outer surface show round or oval inhalant canal openings, 0.6–0.8 mm x 1–1.2 mm in size, arranged in indistinct horizontal rows. These openings, situated on the bottom of thin, short (2–3 mm long), variably oriented grooves, lead to slightly oblique, short inhalant canals. Rarely visible, densely spaced, round or oval canal openings on the surface of the spongocoel, 0.5–1.2 x 0.5–1.5 mm in size, are regularly distributed in vertical rows, separated by a skeletal strand, which is 0.3–0.5 wide (Fig. 4H). Winding and strongly branched exhalant canals begin directly below the outer sponge surface. They run slightly oblique to the surface of the spongocoel.

Dense skeleton inside the wall consists of small rhizoclones (220–380 µm in size and 30–40 µm thick). Rhizoclones are branched, often with four long branches, resembling tetraclones (Fig. 5A). Branches of rhizoclones have numerous spines (only occasionally preserved), which are conical or with forked tips. Rhizoclones around exhalant canals, up to 400–420 µm in size, are poorly branched with short branches arising from one side of the slightly arched to nearly straight axis (Fig. 5B, C). In places, where the exhalant canals are very ramified and run closely to each other, the skeletal network has a fibrous structure (Fig. 5B). Outer surface of well-preserved specimens is covered by a fine porous layer with branched rhizoclones, usually not exceeding ca. 200 µm in size (Fig. 5D). Network on the surface of the spongocoel, masking the canal openings, has the form of longitudinal fibres, ca. 400–500 µm wide, separated by thinner furrows (Fig. 5E). Neighbouring fibres are connected by thin (50–150 µm wide) transverse skeletal bands, approximately 200–300 µm apart.

Remarks: Schrammen (1910) synonymized *Scytalia turbinata* (Roemer, 1864) and *Spongia terebrata* Phillips, 1835, but later indicated significant differences in the skeletal structure of both species and assigned the latter species to the new genus *Pseudoscytalia* (Schrammen, 1924). Specimens from Bełchatów show a choanosomal skeleton, typical for *P. terebrata*, i.e., a well-developed dense, finely porous external skeletal layer (absent in *S. turbinata*) and a compact network inside the wall, consisting of small branched rhizoclones (see Schrammen, 1924, pl. 3, fig. 11; Moret, 1926, text-fig. 30), unlike the poorly branched and large desmas of *S. turbinata* (up to 700 µm in size, after Ulbrich, 1974).

Moret (1926) suggested that the rhizoclones in *S. terebrata* form fibres. The present authors have also noted a fibrous structure of the skeleton on the surface of the spongocoel and near the exhalant canals in the studied specimens, but deeper the skeleton is compact, with variably oriented rhizoclones, which is in agreement with the observations of Schrammen (1924).

The specimens from the Miechów Synclinorium, recognized by Hurcewicz (1968) as *S. turbinata*, are strongly secondarily silicified, with poorly preserved desmas, but fragments of the thick external layer of the skeleton, characteristic for *P. terebrata*, are clearly visible. In turn, this skeletal layer is absent in specimens described by Hurcewicz (1968) as *Scytalia terebrata* (Phillips), which show features characteristic for *Aulosoma radiciformis* (Phillips), described above.

Analysis of the material from Poland shows a large variability in the shape. Transverse wrinkles occur on both cylindrical and conical specimens. Therefore, in the opinion of the present authors, the distinction by Schrammen (1924) of cylindrical specimens with transverse folds, first described by Schrammen (1910) as *S. terebrata* Phill. sp., var. *elongata* as a separate species *Pseudoscytalia fastigiata* (Lee, 1839), is unjustified. Furthermore, two specimens of *Spongia fastigiata* described by Lee (1839, p. 10, fig. 8) are not cylindrical: they have a funnel-shaped lower part and a prominent conical top. The spiculation of Lee's specimens is unknown; therefore, their taxonomic position remains unclear.

The sponges, included by Hinde (1883) in *Scytalia fastigiata* (Lee, 1839), have no transverse wrinkles, and only one transverse, collar-like ridge on one side of the sponge, which separates the apical part from the slightly concave

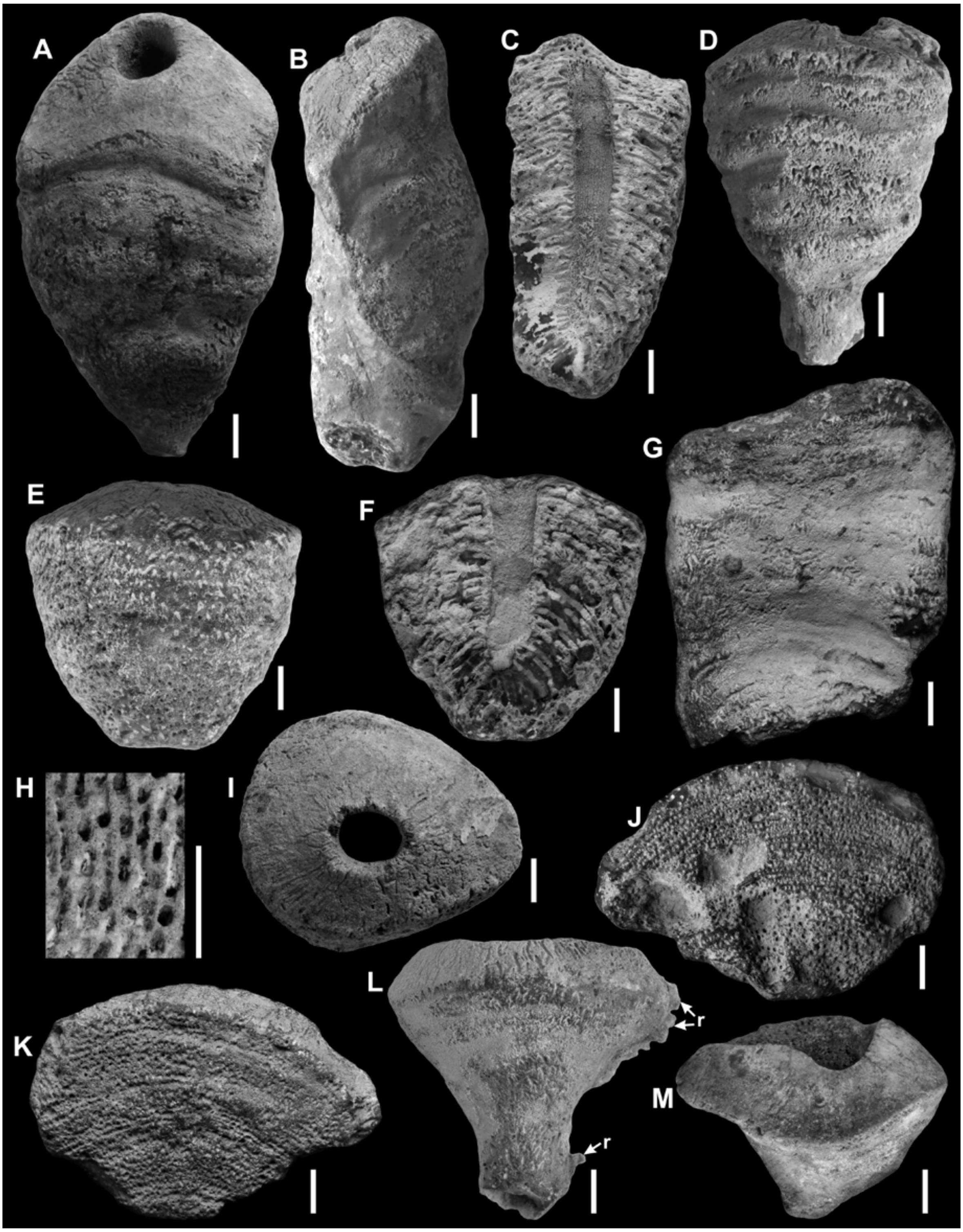

Fig. 4. Rhizomorine sponges. **A–I.** *Pseudoscytalia terebrata* (Phillips, 1835); A – specimen with a collar-like ridge; ULIII/546, Skrajniwa; B – specimen with a longitudinal ridge; ULXXV/3R/7, Bełchatów; C – longitudinal section of a cylindrical specimen with visible canals and tubular spongocoel covered by fibres of an additional network; ULXXV/3R/1, Bełchatów; D – specimen with transverse wrinkles (previously assigned to *Scytalia turbinata* (Roemer)); ULIII/543, Skrajniwa; E – wide-conical specimen with destroyed outer layer of the skeleton; visible inhalant canal openings; ULXXV/3R/2, Bełchatów; F – longitudinal section of the same specimen; spongocoel infilled by chert; G – bilaterally flattened specimen; ULXXV/3R/5, Bełchatów; L – fragment of the spongocoel surface without a secondary network; visible exhalant canal openings; ULXXV/3R/6, Bełchatów; I – apex of a specimen covered by furrows radiating from the osculum; ULXXV/3R/4, Bełchatów. **J–M.** *Leiochonia cryptoporosa* Schrammen, 1901; J – lower surface of a fragment of disc-like sponges with destroyed superficial network; visible concentrically arranged canal openings; ULXXV/4R/1, Bełchatów; K – upper surface of the same specimens with destroyed superficial network; L – funnel-like specimen with fragmentarily preserved superficial skeletal layer and remains of root-like outgrows (r); upper margin covered by furrows; ULXXV/4R/2, Bełchatów; M – asymmetric specimen with a wide spongocoel; ULXXV/4R/3, Bełchatów. Scale bars 10 mm (A–G, I–M) and 5 mm (H).

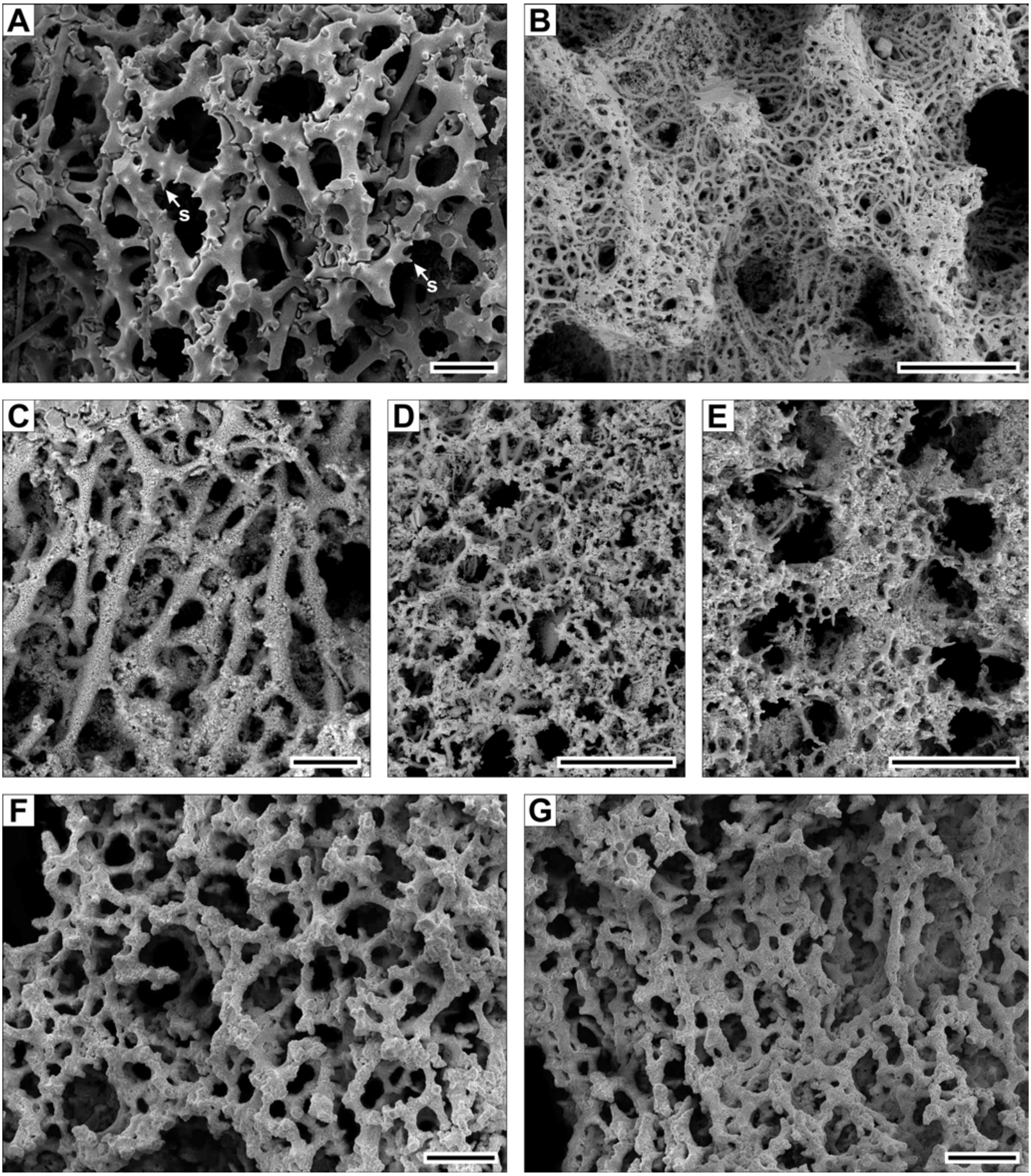

Fig. 5. Skeletons of rhizomorine sponges. **A–E.** *Pseudoscytalia terebrata* (Phillips, 1835); **A** – skeleton inside the wall; rhizoclones with well-preserved conical or forked spines (s); ULXXV/3R/3, Bełchatów; **B** – fragment of the skeleton pierced by exhalant canals; ULXXV/3R/4, Bełchatów; **C** – elongated rhizoclones on the wall of the exhalant canal; ULXXV/3R/4, Bełchatów; **D** – skeleton on the outer surface of the sponge; ULXXV/3R/4, Bełchatów; E – skeleton on the surface of the spongocoel, ULXXV/3R/4, Bełchatów. **F, G.** *Leiochonia cryptoporosa* Schrammen, 1901; F – strongly diagenetically modified skeleton inside the wall, pierced by canals; ULXXV/5R/x, Bełchatów; G – detail of the skeletal network near canal of the same specimen. Scale bars 100 µm (A, C), 200 µm (F, G) and 500 µm (B, D, E).

lateral surface below. Specimens of this shape are rare in the studied collection (Fig. 4A), where specimens with long, asymmetrical ridges are more frequent (Fig. 4B). The irregularly flattened sponges, observed in the material from Poland (Fig. 4G), are intermediate forms between the morphotype with ridges and the regular conical form.

Specimens with ridges are similar to some species of *Cytoracea* Schrammen, 1924 and *Pseudocytoracea* Lagneau-Hérenger, 1962. They differ from *Cytoracea* by evenly distributed canal openings, while from *Pseudocytoracea* by a compact, fibre-free structure of the skeleton inside the wall.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Campanian); Southern England (Upper Chalk, probably lower Campanian); France (Paris Basin: Turonian; Provence: Santonian).

Genus *Leiochonia* Schrammen, 1901

Type species: *Leiochonia cryptoporosa* Schrammen, 1901, p. 16, pl. 5, fig. 3, by monotypy.

Diagnosis: See Reid (2004).

Leiochonia cryptoporosa Schrammen, 1901
Figs 4J–M, 5F, G

1901 *Leiochonia cryptoporosa* – Schrammen, p. 16, pl. 5, fig. 6.

1910 *Leiochonia cryptoporosa* Schrammen – Schrammen, p. 160, pl. 21, figs 4–5.

1910 *Leiochonia robusta* – Schrammen, p. 160.

1967 *Leiochonia cryptoporosa* Schrammen – Lagneau-Hérenger, p. 80, pl. 1, fig. 1.

?1968 *Leiochonia cryptoporosa* Schrammen – Hurcewicz, pp. 49–50, pl. 11, fig. 2.

1974 *Leiochonia cryptoporosa* Schrammen – Ulbrich, p. 45, pl. 8, fig. 1, pl. 18, fig. 3 [cum syn.].

1993 *Leiochonia robusta* Schrammen – Jahnke and Gasse, pl. 1, fig. 2a, b.

Material: 25 specimens from Bełchatów (ULXXV/4R/1–25), 2 specimens from Pniaki (ULIIa/55; ULXXV/1191), 1 specimen from Miechów (ULIII/109), 1 specimen from Skrajniwa (ULIIa/55).

Description: The material studied consists of funnel-like and disc-like specimens, up to 65 mm high and 95 mm wide (Fig. 4L, M). One of them has numerous thin outgrowths on one side of the sponge (Fig. 4L). Other specimens are fragments of the wall, 0.9–23 mm thick and up to 100 mm in size. Angular upper margin nearly perpendicular or slightly oblique to the outer surface of the sponge, covered by deep branched grooves. Growth wrinkles and a concentric arrangement of the canal openings on both sponge surfaces are visible on specimens with destroyed outer layers of the skeleton (Fig. 4J, K). Inhalant canal openings are rounded, elliptical, comma-like or in the form of fissures, 1 mm wide and 2 mm long. Exhalant canal openings are round or elliptical, 0.7–1 mm in size. Inhalant and exhalant canals are branched in one plane, perpendicular to both surfaces of the sponge.

Inside the wall, small (ca. 220–300 µm in size and 25–45 µm thick) rhizoclones are irregularly branched (Fig. 5F). Near the canals, they are larger (up to 380 µm in size), with arched axes and branches arising from the convex side (Fig. 5G). Ornamentation of rhizoclones is not observed, due to the strong secondary silicification of the specimens. Both surfaces are covered by the dense skeletal layer (if preserved), which masks the canal openings. Individual rhizoclones in this layer are very poorly visible.

Remarks: Schrammen (1910) distinguished a new species *Leiochonia robusta*, which differ from the previously described *Leiochonia cryptoporosa* Schrammen, 1901 only by a fourfold thicker wall. The studied specimens are characterized by a variable wall thickness, and some of them are more massive than the specimens of *L. cryptoporosa* described so far, the wall of which is maximum 10–15 mm thick (Schrammen, 1910; Lagneau-Hérenger, 1967; Ulbrich, 1974). The shape and thickness of the wall of these specimens correspond very well to the specimens of *Leiochonia robusta* from the Schrammen collection (Jahnke and Gasse, 1993), which suggested that this species is the thick-walled morphotype of *L. cryptoporosa*.

L. cryptoporosa was previously recorded from the Campanian of the Miechów area by Hurcewicz (1968). Unforunately, her only one specimen has no preserved desmas and its morphological features were destroyed by cutting and acid treatment, therefore this determination cannot be verified.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian; ?Miechów area: upper Campanian); Germany (Lower Saxony: Campanian; Saxony-Anhalt: lower Campanian); France (Paris Basin: Coniacian; Auvergne-Rhône-Alpes region: Turonian; Provence: Santonian).

Genus *Cytoracia* Pomel, 1872 (= *Cytoracea*, Schrammen, 1910; = *Coelocorypha* Zittel, 1878 after Reid, 2004)

Type species: *Stellispongia grandis* Roemer, 1864, p. 49, pl. 17, fig. 2, designated by Schrammen, 1910, p. 153.

Diagnosis: See Schrammen (1924).

Cytoracia turbinata Schrammen, 1910
Fig. 6A–D

1910 *Cytoracia turbinata* – Schrammen, pp. 156–157, pl. 23, figs 4, 5.

1968 *Coelocorypha bulbosa* – Hurcewicz, pp. 41–42, pl. 2, figs 4, 5.

1968 *Jereica* sp. – Hurcewicz, pp. 37–38, pl. 10, fig. 5.

1974 *Cytoracea turbinata* Schrammen – Ulbrich, p. 42, text-fig. 14 [cum syn.].

Material: 1 specimen from Bełchatów (ULXXV/19R/1), 2 specimens from Pniaki (ULIII/1197, 1658) and 1 specimen from Zbyczyce (ULIII/1513).

Description: Bulbous, more or less bilaterally flattened sponges with two concavities on the lateral sides. Sponges up to w60 mm high (Fig. 6A–D). Small, flattened base with

Fig. 6. Rhizomorine sponges. **A–D.** *Cytoracia turbinata* Schrammen, 1910; A – apex of the specimen with central osculum surrounded by furrows (specimen previously assigned to *Coelocorypha bulbosa*, Hurcewicz 1968); ULIII/1197, Pniaki; B – lateral view of the same specimen; C – lateral view of the specimen previously assigned to *Jereica* sp.; ULIII/1513, Zbyczyce; D – small specimen with the basal part attached to another sponge (as); ULXXV/19R/1, Bełchatów. **E–J.** *Stichophyma multiformis* Bronn, 1837; E – longitudinal section of the specimen with visible exhalant canals; ULXXV/6R/1, Bełchatów; F – cylindrical specimen with ring-like thickening and well-preserved porous surface; ULXXV/6R/2, Bełchatów; G – wide conical specimen with ring-like thickening and well-preserved porous surface; ULXXV/6R/4, Bełchatów; H – cylindrical specimen with fragmentarily preserved porous layer; inhalant canal openings visible in damaged places; ULXXV/6R/5, Bełchatów; I – juvenile specimen with ring-like thickening; ULIIa/38, Skrajniwa; J – apex of the specimens with exhalant canal openings; ULXXV/6R/4, Bełchatów. **K–M.** *Jereica polystoma* (Roemer, 1864); K – club-like specimen; inhalant canal openings visible in the upper part, where the porous external layer is destroyed; ULXXV/17R/1, Bełchatów; L – longitudinal section of specimen; visible exhalant canals (ec) and initial sections of inhalant canals (ic); ULXXV/17R/3, Bełchatów; M – specimen with polygonal exhalant canal openings on the apex; sponge's surface with remnant of opoka (op); ULXXV/17R/4, Bełchatów. **N–P.** *Jereica micropora* Moret, 1926; N – apex of the specimen with exhalant canal openings; ULXXV/18R/2, Bełchatów; O – lateral view of the same egg-like specimen; P – club-like specimen with well-preserved porous layer; locally visible round inhalant canal openings; ULXXV/18R/1, Bełchatów. Scale bars represent 10 mm.

a jagged edge is attached to a fragment of another sponge. Slightly convex area of the sponge extends from the base to the top and then turns into a large, tapering and curving downwards bulge or passes into a flattened ridge, running almost along the entire narrow side. The upper side, jointly with the ridge and bulge, is covered by deep, branching furrows, up to 1 mm wide, visible in places, where the external layer of the skeleton that masks them has been destroyed. Furrows surround a very small, elliptical osculum (4.5 mm in size in the largest specimen), located slightly asymmetrically with respect to the apex of the sponge. Exhalant canal openings, 0.8–1 mm in size, are irregularly distributed on the surface of the deep spongocoel. The single inhalant canal openings, 0.6 mm in diameter, located in concavities are rarely visible, covered by the thick external layer of the skeleton. Inhalant canals penetrate obliquely into the skeleton.

Small, branched rhizoclones are well preserved only near the base of the sponge, where they form a very dense network.

Remarks: *C. turbinata* is a rare species, distinguished from other representatives of *Cytoracia* by a small bulbous body with a few, variously located concavities with fields of inhalant canal openings. (Schrammen, 1910, 1924; Moret, 1926; Ulbrich, 1974).

The specimens, distinguished by Hurcewicz (1968) as the new species *Coelocorypha bulbosa*, have only two concavities, like the sponge, illustrated by Schrammen (1910, pl. 23, figs 4, 5) and the specimen from the Schrammen's collection, housed in the Palaeontological Collection of the University of Tübingen (no. 1854/53). The strongly bilaterally flattened specimen, described by Hurcewicz (1968) as *Jereica* sp., has a partially destroyed apex with deep furrows and the asymmetrically located osculum (not present in the genus *Jereica*), which Hurcewicz (1968) did not notice.

Occurrence: Poland (Bełchatów: early Campanian sponge redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Campanian; Subhercynian area: lower Campanian); France (Provence: Santonian).

Genus *Stichophyma* Pomel, 1872

Type species: *Manon turbinatum* Roemer, 1840–1841, p. 3, pl. 1, fig. 5 designated by de Laubenfels, 1955, p. 48.
Diagnosis: See Reid (2004).

Stichophyma multiformis (Bronn, 1837)
Figs 6E–J, 7A–D

1837 *Siphonia multiformis* – Bronn, pl. 27, fig. 20.

1864 *Jerea multiformis* Bronn – Roemer, p. 33.

1883 *Stichophyma tumidum* – Hinde, p. 41, pl. 5, figs 3, 4.

1901 *Jereica multiformis* Bronn – Schrammen, p. 21.

1910 *Stichophyma multiformis* Bronn – Schrammen, pp. 145–146.

1933 *Jereica polystoma* (Roemer) – Bieda, p. 10.

1964 *Stichophyma multiformis* Bronn – Giers, p. 219.

1968 *Stichophyma turbinatum* (Roemer) – Hurcewicz, pp. 38–39, pl. 9, figs 2, 3, text-fig. 10.

1968 *Verruculina abnormis* – Hurcewicz, pp. 27–28, pl. 8, fig. 2, text-fig. 6.

1968 *Jereica polystoma* (Roemer) – Hurcewicz, pp. 36–37, pl. 9, fig. 1a-c.

Material: 40 specimens from Bełchatów (ULXXV/6R/1–40), 3 specimens from Pniaki (ULIII/1637, 1538, 1551), 4 specimens from Zbyczyce (ULIII/912, 1011, 1514, 1194) and 6 specimens from Skrajniwa (ULIII/361, 362, 689, 1150, 1198; ULIIa/38).

Description: Cylindrical, club-like, rarely conical sponges, reaching a height of at least 140 mm (Fig. 6E–J). Outer surface usally with a few horizontal ring-like thickenings (Fig. 6F), rarely with irregular thickenings or nearly smooth (mainly in small specimens). One destroyed specimen has a fragment of stalk preserved, which is 88 mm long and 30 mm wide. Outer surface of sponge covered by thick (up to 1–1.5 mm) layer of skeleton with numerous rounded, flat or slightly papillary pores, 0.4–0.5 in diameter, distributed randomly or grouped in short rows. Density of pores ca. 80–90/cm^2. On the stalk, pores are very sparsely distributed. Inhalant canal openings, ca. 1 mm in diameter, are visible in places, where the external layer is destroyed (Fig. 6H). Inhalant canals are perpendicular or slightly oblique to the outer surface. Long, exhalant canals run vertically (Fig. 6E) and are terminated by round or oval openings, located on the flattened apex (Fig. 6I). In large specimens, there are several dozen exhalant openings, usually 4–5 mm in diameter, spaced at 1.5–2.5 mm. In small specimens, a few or a dozen exhalant openings are smaller (1.5–3 mm in diameter) and sparsely distributed.

Outer skeletal layer is extremely dense, and contains small and robust rhizoclones, 280–300 µm in size and 50 µm thick (Fig. 7A). These rhizoclones have straight or arched axes and short branches. Numerous minute spines are discretely single or multiple, usually with a blunt top. Loose internal network with large skeletal pores is preserved between the inhalant canals and consists of large, moderately thorny rhizoclones (Fig. 7B, C). Spines are short, usually with a rounded top. Most of these tetraclones, with a few long branches, arising from both sides of the arched axis, are 400–450 µm in size and 25–55 µm thick. In axial part of sponge, there are large rhizoclones, up to 600–620 µm in size, usually with two clones at the ends of the straight axis. On the wall of the canals, they are very densely packed vertically and form a fibrous structure (Fig. 7D).

Remarks: The specimens described from England and Germany are cylindrical or club-like, while wide conical specimens occur, although rarely, in the material from Bełchatów.

Stichophyma multiformis has not been noted so far in the Cretaceous of the Miechów Synclinorium, but some sponges, described by Bieda (1933) and Hurcewicz (1968) as: *Jereica polystoma* (Roemer, 1864), *Verruculina abnormis* Hurcewicz, 1968 (Fig. 6I) and *Stichophyma turbinatum* (Roemer, 1840–1841), clearly belong to this species. Four specimens, classified as *S. turbinatum*, represent the small forms of *S. multiformis*. Like some large representatives of

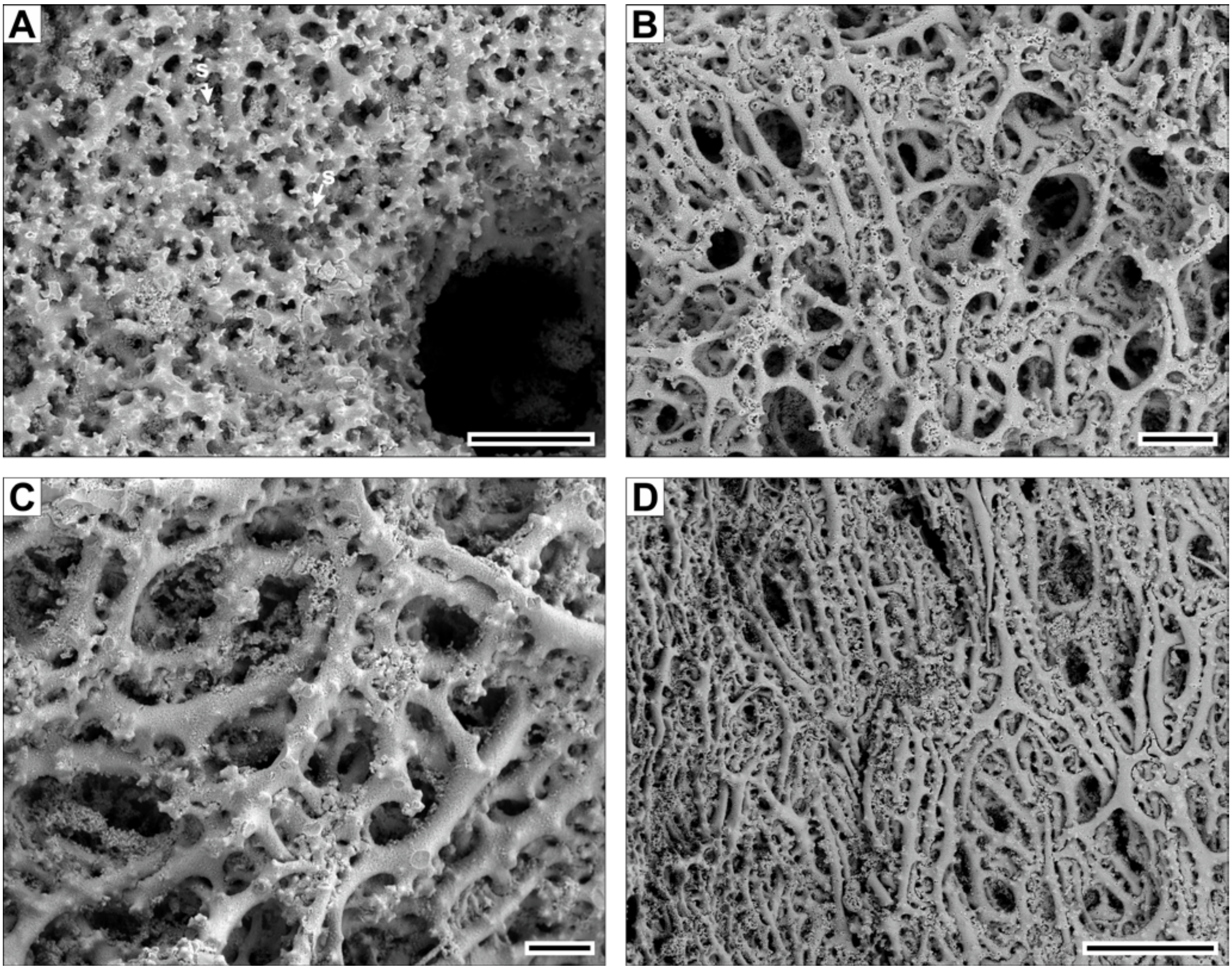

Fig. 7. Skeleton of *Stichophyma multiformis* Bronn, 1837; ULXXV/6R/3, Bełchatów. **A.** External skeletal layer consisting of small rhizoclones with minute single or multiple spines (s); visible single pore. **B, C.** Loose network located between inhalant canals. **D.** Densely packed rhizoclones on the wall of the exhalant canal. Scale bars 100 μm (C) and 200 μm (A, B, D).

S. multiformis, small forms are narrow conical specimens, often with transversal thickenings (Fig. 6I), unlike the small egg-like representatives of *Stichophyma turbinata* (Roemer, 1840–1841; Schrammen, 1910). In the latter species, exhalant canal openings are very numerous and densely packed on the sponge top, while in the discussed specimens, there are only 6–12 canal openings (see Hurcewicz, 1968, pl. 9, fig. 3). Differences in the structure of the skeleton between *S. turbinata* and *S. multiformis* remain unknown. Specimens of *S. multiformis* and *J. polystoma* are very similar, but the inhalant canal openings in *S. multiformis* are larger and less densely distributed (Schrammen, 1910, 1924), which is clearly visible in the material from Bełchatów, encompassing both species. In museum specimens from the Campanian of southern Poland, described as *J. polystoma*, the density of inhalant openings is 80–120 (Bieda, 1933; Hurcewicz, 1968), which is typical for *S. multiformis*. In addition, the external layer of these specimens is more compact, with a larger number of massive rhizoclones than in *J. polystoma* (compare Figs 7A, 8A). Internal rhizoclones of *S. multiformis* are generally smaller and more branched than the desmas of *J. polystoma* (see Schrammen, 1924), but rhizoclones surrounding the exhalant canals are long, poorly branched and resemble rhizoclones of *J. polystoma*. This non-diagnostic type of desmas (usually the best preserved in the examined material) was presented by Hurcewicz (1968, pl. 9, fig. 1b).

Two specimens distinguished as *Verruculina abnormis* are strongly secondarily silicified, but longitudinal fibres with elongated desmas (see Hurcewicz, 1968, text-fig. 6) can be recognized on the walls of the exhalant canals. A similar fibrous structure occurs on the walls of exhalant canals of *Stichophyma* and *Jereica*, while it has not been observed in the studied herein representatives of *Verruculina* and other related genera. The arrangement of canals, and the size and distribution of the canal openings observed in both specimens allows them to be assigned to *S. multiformis*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów and Kraków areas: lower Campanian); Germany (Lower Saxony: Campanian; Saxony-Anhalt: lower Campanian; Westphalia: upper Campanian), southern England (Upper Chalk, probably lower Campanian).

Genus *Jereica* Zittel, 1878

Type species: *Jerea polystoma* Roemer, 1864, p. 34, pl. 12, fig. 5, designated by Moret, 1926, p. 87.
Diagnosis: See Reid (2004).

Jereica polystoma (Roemer, 1864)
Figs 6K–M, 8A–C

?1839 *Siphonia clava* – Lee, p. 12, figs 2–4.

1864 *Jerea polystoma* – Roemer, p. 34, pl. 12, fig. 5.

non 1933 *Jereica polystoma* (Roemer) – Bieda, pp. 10–11 [= *Stichophyma multiformis* Bronn, 1837].

non 1968 *Jereica polystoma* (Roemer) – Hurcewicz, pp. 36–37, pl. 8, fig. 2, text-fig. 6 [= *Stichophyma multiformis* Bronn, 1837].

1974 *Jereica polystoma* (Roemer) – Ulbrich, pp. 38–39, pl. 6, figs 2–4; pl. 17, fig. 5 [cum syn.].

1993 *Jereica polystoma* (Roemer) – Gruber, pp. 57–58, pl. 16, figs 1–4, pl. 25, fig. 1.

Material: 9 specimens from Bełchatów (ULXXV/17R/1–9), 1 specimen from Jędrzejów (ULIIa/49).

Description: Club-like to nearly cylindrical sponges, rarely fig-shaped, up to 130 mm in height and 115 mm in width (Fig. 6K–M). Some specimens are only fragments of long stalks. Apex flattened or slightly rounded, with ca. 20 (in large specimens) densely packed exhalant canals, which are rounded, elliptical or polygonal, 3–4.5 mm in size (Fig. 6M). Outer surface covered by thick external layer with very densely packed (ca. 350–400/cm^2), round pores, 0.2–0.3 mm in size. Inhalant openings, hidden under porous layer (Fig. 6K), lead to very narrow canals, running obliquely downwards and ending near the axial part with longitudinal exhalant canals. Parallely arranged exhalant canals, separated by c. 1 mm wide skeletal bands (Fig. 6L), run along the entire sponge body; 2–3 canals reach the lowest part of the sponge.

Skeletal layer on outer surface with small (250–300 µm in size and 25–35 µm thick), moderately spiny rhizoclones, with strongly arched to nearly straight axis and short clones forming weak zygoses (Fig. 8A). Very long spines are single or forked. Desmas inside the wall are less ornamented and the spines seem to be short, but this may be the result of diagenetic dissolution of the spine tips. Under the outer layer of the skeleton, the occasionally preserved rhizoclones are straight or slightly arched, usually up to 450–500 µm in size and 40 µm thick (Fig. 8C). On the wall of inhalant canals, the rhizoclones are loosely arranged transversely relative to the canal axis. They form elongated zygoses, which causes the network in the area of the inhalantion canals to have a fibrous structure. On the wall of exhalant canals, rhizoclones with straight axis branch into 2–3 very short dominating clones. These rhizoclones are 600–700 µm in size and very densely packed, mostly parallel to the canal axis (Fig. 8B). Oval skeletal pores, 200–250 µm in size, occur locally between them. Network between exhalant canals with loose and less regularly arranged rhizoclones, with a similar size to those on the canal walls, but sometimes with slightly longer clones and an arched axis, or with a curved termination.

Remarks: *Jereica polystoma* is characterized by a large variability in the size of the exhalant canal openings, between 1–5 mm (Schrammen, 1910, 1924; Moret, 1921, 1926; Ulbrich, 1974; Gruber, 1993). All specimens studied herein show very large openings; Moret (1921) distinguished such specimens as *Jereica polystoma* forme *clava* (Lee, 1839). However, the spiculation of specimens from the Upper Chalk of England, described by Lee (1839, p. 12, figs 2–4) as *Siphonia clava*, is unknown and it is not certain whether they really represent the same species of *Jereica*.

The tested specimens differ significantly in habitus. Ulbrich (1974) correlated the shapes of the representatives of the *J. polystoma* with their occurrence in various facies, recognizing cylindrical specimens as typical for the littoral environment and the wide, more irregular ones as typical for neritic settings.

Specimens from the Lelów and Kraków areas, described by Bieda (1933) and Hurcewicz (1968) as *J. polystoma*, were recognized here as *Stichophyma multiformis*, due to the characteristic compact skeleton on the outer surface and the large, relatively sparsely arranged inhalant canal openings that do not exceed 60–80/cm^2.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Jędrzejów area: upper Campanian); Germany (Lower Saxony: Campanian; Saxony-Anhalt: lower Campanian), France (Paris Basin: Coniacian).

Jereica micropora Moret, 1926
Figs 6N–P, 8D–F

1926 *Jereica punctata* forme *micropora* nov. form. – Moret, pp. 88–89, pl. 11, fig. 8, pl. 19, fig. 4, 4’, text-figs 25, 26.

Material: 4 specimens from Bełchatów (ULXXV/18R/1–4) and 1 specimen from Pniaki (ULIII/1634).

Description: Club- or egg-like sponges, up to 90 mm high and c. 65 wide, with or without remains of stalk (Fig. 6N–O). Outer surface with densely packed pores, ca. 400–480/cm^2. In the lower part, pores are round, ca. 0.1–0.2 mm in size, separated by a relatively wide skeletal band, while in the upper part, they are round, oval or polygonal and 0.1–0.4 mm in size. Round inhalant canal openings, 0.6–0.8 mm in diameter, are only locally observed in places with destroyed external layer or in upper part of sponge, where external skeletal layers are poorly developed (Fig. 6P). Short inhalant canals are oblique to the surface of the sponge. Exhalant canal openings, 1.2–2 mm in size, densely arranged on a flattened or slightly concave apex (Fig. 6N). Axial bundle with ca. 50–60 exhalant canals runs vertically, and a few canals are visible in the uppermost part of the stalk.

Dense skeletal network on the outer surface consists of irregularly branched small rhizoclones, 300–350 µm in size and 20–30 µm thick (Fig. 8D). Strongly arched rhizoclones near the pores with branches, up to 80 µm long, arise from the convex side. Short single or forked spines are

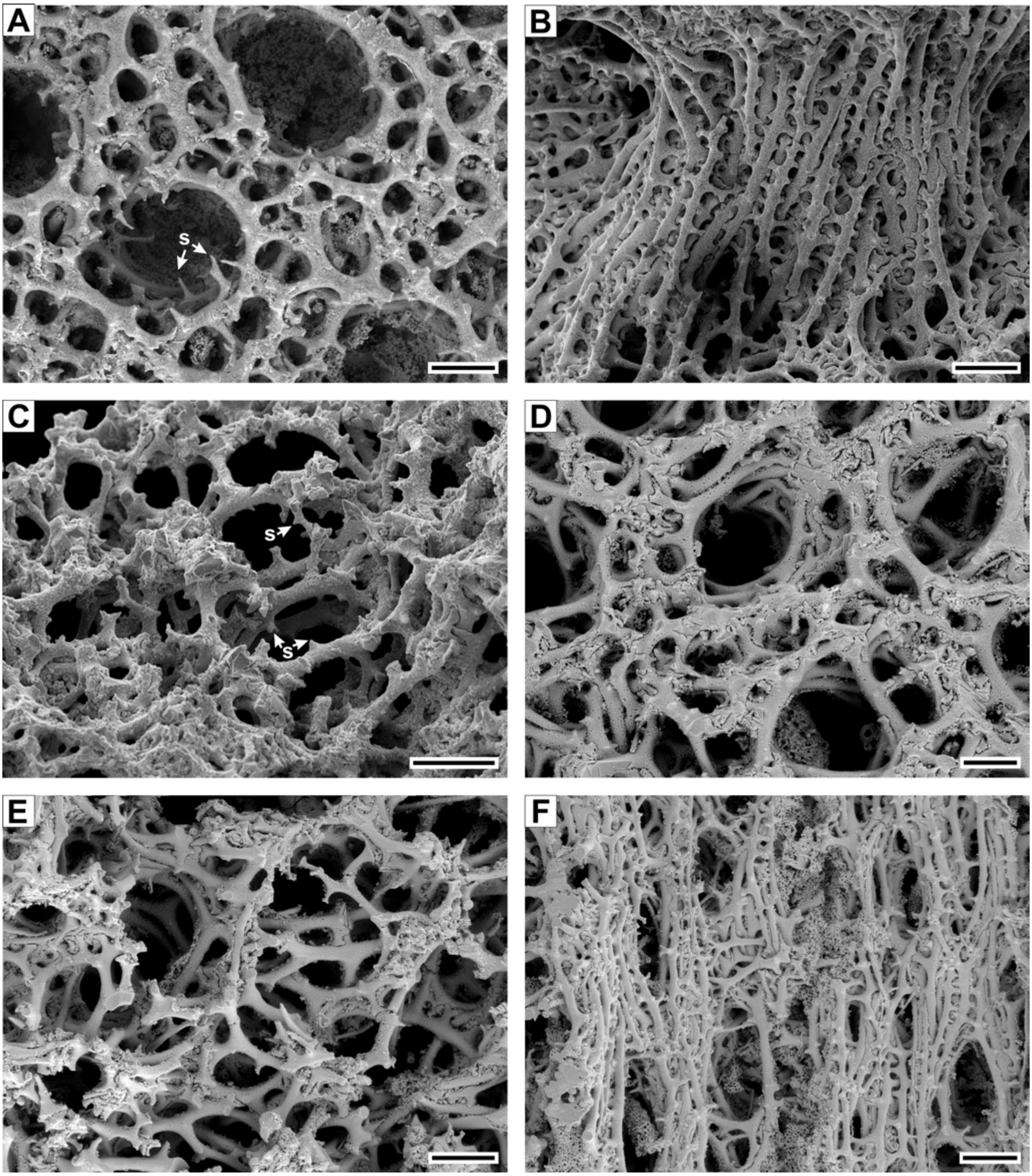

Fig. 8. Skeletons of rhizomorine sponges. **A–C.** *Jereica polystoma* (Roemer, 1864); ULXXV/17R/2, Bełchatów; A – superficial network on the sponge's outer surface; rhizoclones with long spines (s); B – skeleton inside the wall; rhizoclones with dissolved tops of spines (s); C – rhizoclones on the wall of exhalant canal. **D–F.** *Jereica micropora* Moret, 1926; ULXXV/18R/1, Bełchatów; D – superficial network on the sponge's outer surface; E – network from the lateral part of sponge's wal;. D – rhizoclones on the wall of the exhalant canal. Scale bars 100 μm (A, D) and 200 μm (B, C, E, F).

not numerous. Desmas inside the lateral part of the sponge's wall (preserved only in the lowermost part of specimens) are poorly spiny (Fig. 8E). These rhizoclones, ca. 400–600 μm in size, have an arched or straight axis, and sometimes relatively long clones. Irregularly branched, smaller rhizoclones (ca. 400 μm in size) distributed transversely in the inhalant canals, form very elongated zygoses, arranged parallel to the canals. Compact network in axial part of sponges and on the wall of exhalant canals with large elliptical pores (up to 400 μm in size), surrounded by elongated rhizoclones, usually 600–650 μm in size, arranged parallel to the axis of the canals (Fig. 8F).

Remarks: The habitus of the specimens from the Campanian of Poland, the size of pores and their inhalant and exhalant canal openings, and also the shape and ornamentation of the rhizoclones correspond very well to *J. punctata* forme *micropora* described from Santonian of France by Moret (1926) from the Santonian of France. In the opinion of the present authors, this taxon should be considered as a separate species. *J. micropora* differs from *J. punctata* (Goldfuss, 1831) in smaller exhalant canal openings and a more elongated body shape, which makes the examined specimens similar to one of the morphotypes of *J. polystoma* (Roemer, 1864), characterized by relatively small openings of the exhalant canals (Ulbrich, 1974). Contrary to the thorny, poorly branched rhizoclones of the latter species and also the other representatives of *Jereica* (compare Schrammen, 1924; Moret, 1921; Ulbrich, 1974; Jahnke and Gass, 1993), the rhizoclones of *J. micropora* are weakly spiny and more branched. A characteristic feature of *J. micropora* is also a network on the outer surface, consisting of slender rhizoclones, interlocked by long zygoses.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); France (Provence: Santonian).

Genus *Seliscothon* Zittel, 1878

Type species: *Spongia plana* Phillips, 1835, p. 177, pl. 1, fig. 1, designated by de Laubenfels, 1955, p. 45.

Diagnosis: See Reid (2004).

Seliscothon planum (Phillips, 1835)
Figs 9A–C, 10A–D

1835 *Spongia plana* – Phillips, p. 177, pl. 1, fig. 1.

1910 *Seliscothon planum* (Phillips) aberratio *pustulosa* nov. aber. – Schrammen, p. 166.

1924 *Seliscothon planum* (Phillips) var. *pustulosa* – Schrammen, p. 92.

1926 *Seliscothon planum* (Phillips) – Moret, p. 73, pl. 20, fig. 1, pl. 17, fig. 13 [cum syn.].

1968 *Seliscothon planum* (Phillips) – Hurcewicz, p. 32, pl. 7, figs 1–4, text-fig. 8.

1968 *Seliscothon verrucosum* Schrammen – Hurcewicz, p. 334, pl. 4, fig. 3, pl. 5 fig. 3, pl. 8, fig. 1a, b, pl. 13, fig. 4, text-fig. 9.

1974 *Seliscothon planum* (Phillips) – Ulbrich, pp. 36–37, pl. 5, fig. 2, pl. 17, figs 1, 2.

1993 *Seliscothon planum pustulosa* Schrammen – Jahnke and Gasse, pl. 1, fig. 3a–c.

Material: 15 specimens from Bełchatów (ULXXV/14R/1–15), 3 specimens from Miechów (ULIII/995, 910, 993), 2 specimens from Pniaki (ULIII/934, 1193), 1 specimen from Skrajniwa (ULIII/708), 5 specimens from Zbyczyce (ULIII/770, 992, 1067, 1516, 1529).

Description: Funnel-like sponges, up to 120 mm in diameter (Fig. 9A, B). Upper part flattened with the centre slightly concave, rarely wide conical, with obliquely angular margin. Wall, 5–12 mm thick, occasionally with ring-like, concentric thickenings on both sides. Narrow conical lower (part well preserved only in one small specimen) is 30 mm long. Upper surface covered with small, punctiform openings, ca. 0.4–1 mm in diameter, and sometimes with protruding margins or in the shape of flattened papillae (Fig. 9C). These openings are usually most densely packed in the central part of the upper surface of the specimens. Their average density is usually 60–80/cm^2, but in some specimens reaches 100–120/cm^2. Lower surface without openings. Skeletal canals not developed.

Skeletal network on the upper side with densely arranged, small (up to 400 μm in size and 50 μm thick) thorny rhizoclones with straight or arched axis and short, sometimes bifurcated clones (Fig. 10A, B). Large thorns are solitary, while smaller spines are usually forked at the base (Fig. 10B). Thin oxeas, ca. 500 long, protruding from this network are rarely observed. A similar network, but less dense, is locally preserved on the lower side of some specimens. Skeleton inside the wall has lamellar structures, consisting of very densely packed rhizoclones with spines varying in length, often with forked tips (Fig. 10C). Edges of radially arranged lamellae, visible in places with destroyed outer layers on both sponge surfaces, are straight and usually 250–500 μm wide. They are spaced at 100–500 μm apart. The lamellae are connected at irregular intervals (300–1,500 μm long) by transversal skeletal strands, similarly wide or narrower than the lamellae (Fig. 10D). Single elongated rhizoclones occur between them. Spinose rhizoclones, forming lamellae and strands, are straight or slightly arched and poorly branching, 500–600 μm in size. Smaller, irregular branched rhizoclones are rare and occur mainly in the transverse strands. Fragments of the dense network on the outer surface are very poorly preserved and individual desmas are invisible.

Remarks: Schrammen (1910, 1924) distinguished *S. planum* var. *pustulosa*, characterized by small, papillary openings on the upper surface. This morphotype, which is rare in the Cretaceous of Germany, is numerous in the collection from Bełchatów and southern Poland (it accounts for almost 50% of all specimens of *S. planum*), where it was previously described as *S. verrucosum* Schrammen, 1924 (Hurcewicz, 1968). The present studies, based on a larger number of specimens, and comparison with *S. verrucosum* from Bełchatów proved the similarity in character of the skeleton with that of *S. planum*. This morphotype shows a large variation in the size of the openings on the upper surface, as in the typical specimens of *S. planum* (see Schrammen, 1910; Ulbrich 1974; Jahnke and Gasse, 1993). In contrast to *S. verrucosum*, the discussed sponges show lamellar structures of the skeleton, characteristic for *S. planum* and exhalant pores on the upper surface, piercing only the superficial network.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian; ?Miechów area: upper Campanian); Germany (Lower Saxony: Turonian, Campanian; Saxony-Anhalt: lower Campanian); southern England (Upper Chalk, probably lower Campanian), France (Saumur, Maine-et-Loire department: Turonian, Paris Basin: Coniacian; Provence: Santonian).

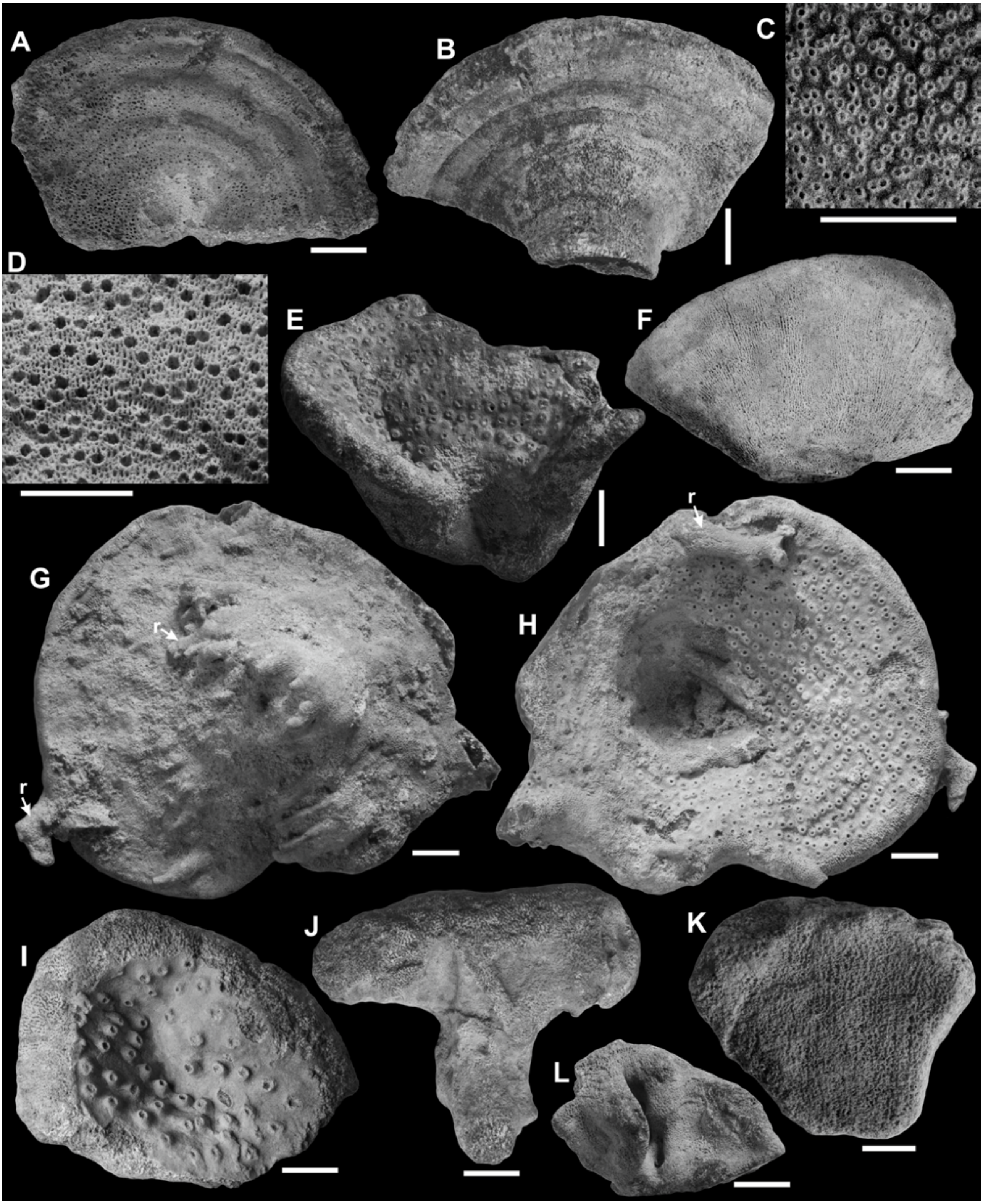

Fig. 9. Rhizomorine sponges. **A–C.** *Seliscothon planum* (Phillips, 1835); A – upper surface of funnel-like specimen with punctiform pores and concentric thickenings; ULXXV/14R/2, Bełchatów; B – lower surface of the same specimen; C – fragment of the upper surface with slightly papillary pores; ULIII/770, Zbyczyce. **D–H.** *Seliscothon verrucosum* Schrammen, 1924; D – fragment of the upper surface without the external skeletal layer; visible exhalant pits piercing the outermost part of the fibrous network; ULXXV/15R/5; E – leaf-shaped specimen; ULXXV/15R/3, Bełchatów; F – lower surface of a fragmentarily preserved specimen; visible fibrous structure of skeleton; ULXXV/15R/4, Bełchatów; G – lower surface of a funnel-like specimen with numerous root-like outgrows (r); ULXXV/15R/2, Bełchatów; H – upper surface of the same specimen with papillary openings. **I–L.** *Seliscothon* sp.; I – upper surface of a mushroom-shaped specimen with prominent papillary openings; XXV/5R/1, Bełchatów; J – lateral view of the same specimen; K – lower surface of a fragmentarily preserved specimen; visible skeletal fibres and wide transversal strands; XXV/5R/2, Bełchatów; L – lower surface of a fragmentarily preserved specimen with a superficial network and irregular thickenings; XXV/5R/3, Bełchatów. Scale bars 10 mm.

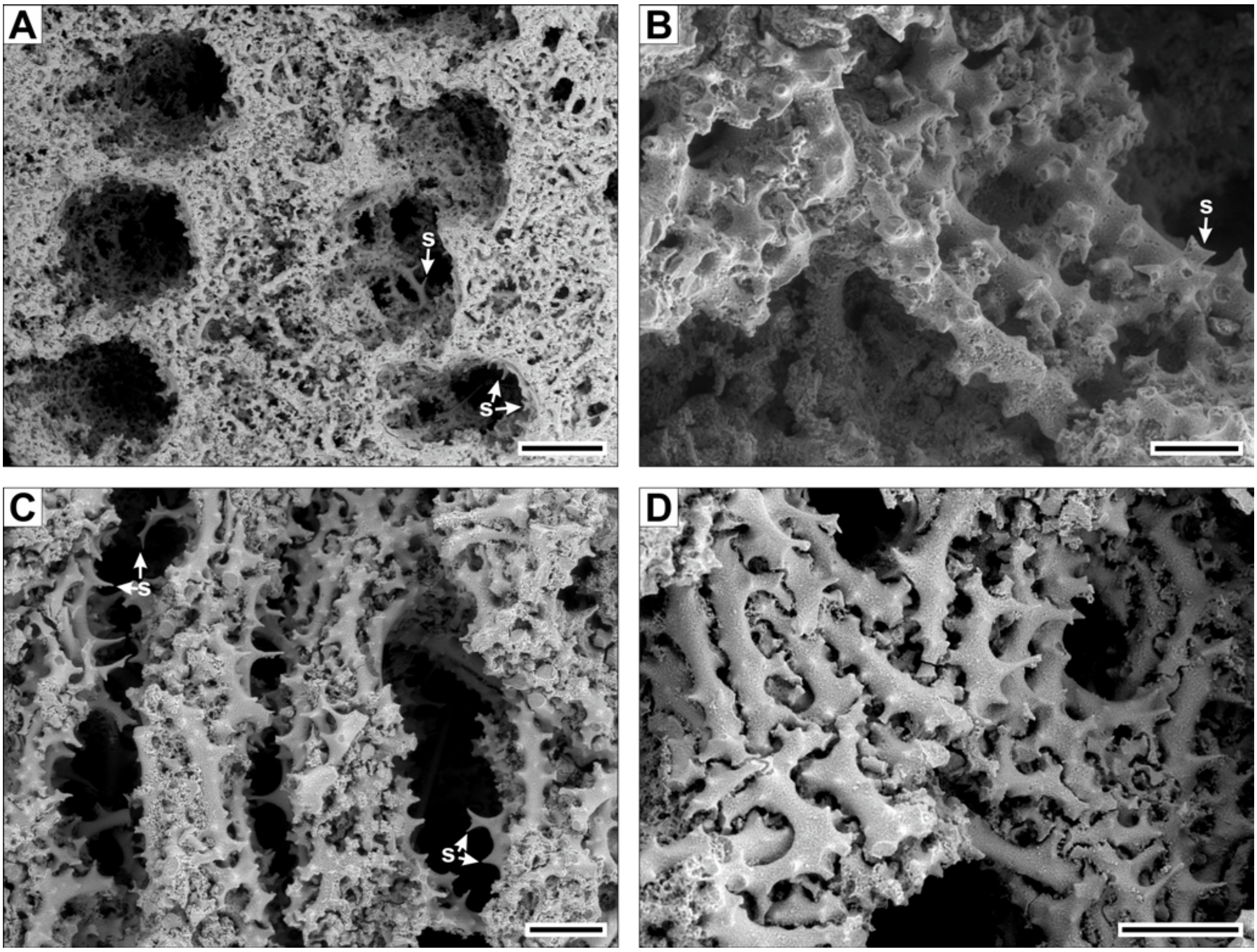

Fig. 10. Skeleton of *Seliscothon planum* (Phillips, 1835); ULXXV/14R/2, Bełchatów. **A, B.** Skeletal network on the upper side of the sponge with exhalant openings; rhizoclones with simple and forked spines (s). **C.** Lamellar structure of the network consists of elongated, spiny (s) rhizoclones. **D.** Detail with transversal skeletal strands. Scale bars 100 µm (B), 200 µm (C, D) and 500 µm (A).

Seliscothon verrucosum Schrammen, 1924
Figs 9D–H, 11A–D

1924 *Seliscothon verrucosum* – Schrammen, p. 92, pl. 1, figs 4, 5, pl. 15, fig. 7.

1974 *Seliscothon verrucosum* Schrammen – Ulbrich, pp. 37–38, pl. 5, fig. 4.

Material: 16 specimens from Bełchatów (ULXXV/15R/1–16), 1 specimen from Skrajniwa (ULIIa/57).

Description: Ear-, leaf-shaped sponges, sometimes with an outwardly curved margin, rarely funnel-like, up to 11 cm wide (Fig. 9D–H). Wall is 0.7–16 mm thick near the rounded margin. Very short stalk with a few outgrowths that sometimes appear also on the upper part of the body. Exhalant openings on the upper surface, ca. 0.5 mm in diameter, are situated on the top of the rounded papillae, 1.5 mm in diameter, which have a density of about 9–16/cm^2 (Fig. 9E, H). Exhalant openings lead to small pits, which pierce the surfaces of the skeletal layer and the outermost part of the fibrous internal network (Fig. 9D). Inhalant openings and skeletal canals not present.

Rhizoclones, occurring in the superficial network on the inner surface, reach 450 µm in size and a thickness of 50 µm and are densely covered by massive spines, often with dissolved tips (Fig. 11A, B). These rhizoclones have a strongly bent, arched or almost straight axis and branches variable in length , occasionally forked. They form a compact network with evenly distributed, numerous round pores, ca. 150–200 µm in diameter. The lower surface of the specimens is covered by a similar skeletal network but with rare and less regularly arranged pores (Figs 9F, 11C). Radially arranged skeletal fibres, 100–300 µm wide, occur under the superficial skeletal layers. Centrally located fibres run parallel to the surface of the sponge, while the outer fibres slightly bend out towards both wall surfaces. In the network below the inner surface, there are transverse beams, of a similar width to twice as narrow as the fibres, and also single rhizoclones connect the fibres at intervals of 200–300 µm, forming a reticular structure. The fibres near the outer surface are slightly wavy and structures of the skeleton are less regular (Fig. 11C, D). Fibres and transversal beams consisting of spiny rhizoclones, are mainly elongated or arched, 600–700 µm in size, with short branches on the curved side. Smaller (up to 500 µm) and more irregularly branched rhizoclones are less numerous.

Remarks: The macroscopic and choanosomal skeletal features fully correspond to the characteristics of *S. verrucosum*

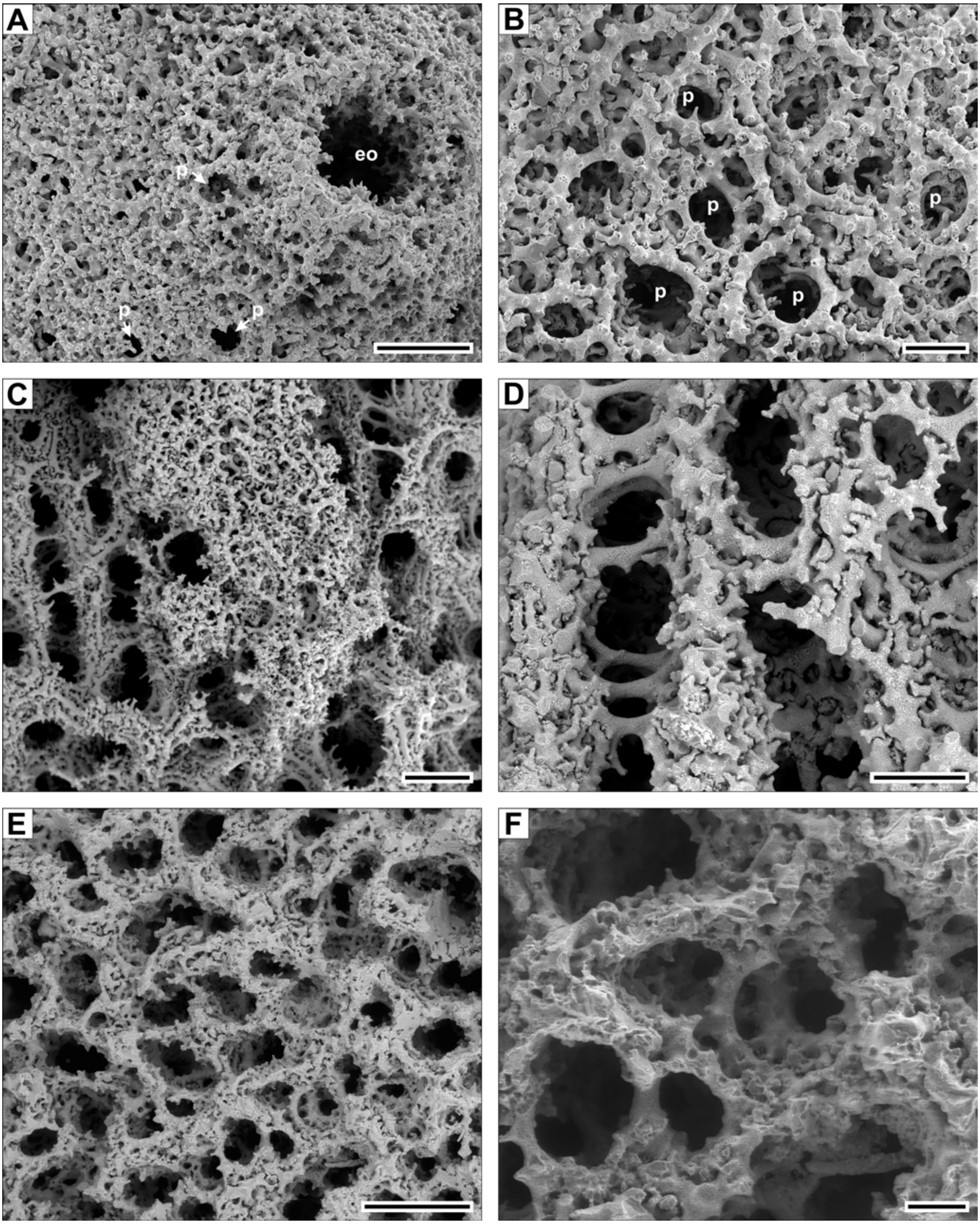

Fig. 11. Skeletons of rhizomorine sponges. **A–D.** *Seliscothon verrucosum* Schrammen, 1924; ULXXV/15R/1; A – skeletal network on the upper side of the sponge with papillary exhalant opening (eo) and small pores (p); B – detail of superficial network with numerous round pores (p); C – fibrous skeleton, partially covered by a superficial dense network (in the centre) occurring on the sponge's lower surface; D – detail of fibrous skeleton. **E, F.** *Pachyselis azoricoides* (Moret, 1926); superficial network on the outer surface with numerous pores; ULXXV/13R/3, Bełchatów. Scale bars 100 µm (F), 200 µm (B, D) and 500 µm (A, C, E).

from the Campanian of Germany, presented by Schrammen (1924) and Ulbrich (1974). The fact that the pit-like exhalant canals penetrate not only the surface layer of the skeleton, but also the outermost part of the fibrous network, has not been reported previously.

S. verrucosum was noted in the Campanian of the Miechów Synclinorium (Hurcewicz, 1968), but all attributes of the museum specimens conform with one of the morphotypes of *S. planum* described here, which was distinguished by Schrammen (1910, 1924) as *S. planum* var. *pustulosa*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Santonian, Campanian; Saxony-Anhalt: lower Campanian).

Seliscothon sp.

Fig. 9I–L

Material: 6 specimens from Bełchatów (XXV/5R/1–6).

Description: An almost complete specimen, ca. 60 mm wide and 43 mm high, is a mushroom-shaped sponge with a slightly concave upper side and a slightly rounded margin (Fig. 9I, J). The lower side of the upper part is smooth (Fig. 9K) or with prominent irregular folds and thickenings, which continue on the stem (Fig. 9J). These irregular thickenings are observed also on three other, fragmentarily preserved specimens (Fig. 9L). Thickness of the wall (measured in places without thickenings) is 7–12 mm. Openings, 1 mm in diameter, on the upper side of the sponge are located on the top of the very prominent conical papillae, 3 mm in diameter. Density of the papillae is usually 4/cm^2; in the centre 5/cm^2. Skeletal canals and openings on the outer surface are absent.

Fine-porous skeletal layer containing small, irregularly branched rhizoclones, covers both surfaces of the choanosomal skeleton, but is better developed on the upper side (Fig. 9I). The skeleton is fibrous, but single desmas are hardly recognizable. Fibres, 250–300 µm wide, are connected by a transverse strand of similar width or slightly narrower at 500–1,500 µm intervals. Radial fibres diverge at small angles towards both surfaces. Their regular arrangement is disturbed within the thickenings occurring on the lower surface of the sponge.

Remarks: Due to the presence of papillary openings on the upper surface, the present specimens resemble *S. verrucosum*, but the papillae are more prominent, conical and less densely arranged than in the last species, and the pits inside the papillae penetrate only the surface layer. The thickness of transversal strands connecting the fibres suggests that they consist of more than one rhizoclone, as is the case in *S. verrucosum*. This type of skeletal structure was noted in *S. phlyctioides* Moret, 1926, but that species is characterized by an upper surface with very small pores (Moret, 1926, pp. 77–78, pl. 5, figs 1–3, text-figs 20, 21). Moreover, all studied specimens show irregular thickenings on the lower surface, not noted in *S. verrucosum*. Similar thickenings and large openings on the upper side occur in *Trachynotus auriculus* Schrammen (1910), but in this species star-like exhalant canals are developed. Despite the indicated differences with other representatives of *Seliscothon*, a new species was not proposed, due to the poorly preserved desmas.

Occurrence: Poland (Bełchatów: early Campanian sponge redeposited into the Neogene).

Genus *Pachyselis* Schrammen, 1924

Type species: *Achilleum auriforme* Roemer, 1840–1841, p. 2, pl. 1, fig. 3, designated by Schrammen, 1924, p. 94.

Diagnosis: See Schrammen (1924).

Pachyselis azoricoides (Moret, 1926)

Figs 11E, F, 12A–D

1926 *Seliscothon azoricoides* – Moret, pp. 78–79, pl. 19, figs 11, 11', pl. 21, fig. 5, text-fig. 23.1.

?1926 *Seliscothon azoricoides* forme *crassum* nov. form. – Moret, pp. 79–80, pl. 20, fig. 7.

1962 *Seliscothon azoricoides* Moret – Lagneau-Hérenger, p. 180, pl. 15, fig. 6, text-pl. 29, fig. 2.

Material: 11 specimens from Bełchatów (ULXXV/13R/1–11).

Description: Cup- or funnel-like sponges with a short stalk (Fig. 12A–D). Base of stalk (preserved in one specimen) rounded with a few small bulbous thickenings. Upper margin rounded. The largest, almost complete specimen is 38 mm high and 65 mm wide (Fig. 12A, B); the largest fragment is 75 mm in size. Wall thickness very variable, from 7 mm to 17 mm. Both surfaces covered by densely arranged, small pores. Rounded pores on the upper surface, 0.1–0.2 mm in diameter, are separated by a skeletal band of similar width or slightly wider. Density of the pores is 9–10/mm^2. Broken bundles of oxeas, located in these pores, were observed in three samples. Outer surface with more densely packed, variously shaped pores, 0.1–0.3 mm in size (Fig. 11E). Skeletal canals not developed.

Elongated, poorly branched rhizoclones (500–600 µm long, occasionally up to 800 µm long) forming straight to slightly undulating skeletal fibres (they are visible in places with destroyed outermost part of skeleton; Fig. 12C). Inside the wall, the fibres are parallel to the surfaces of the sponge. The outer fibres bend towards both surfaces, where they are covered by a dense superficial network, especially well-developed in the lower part of the sponges (Fig. 11E, F). The superficial network consists of small rhizoclones (usually 300–400 µm), irregularly branched or arched with clones on one side. Ornamentation of rhizoclones poorly preserved and tips of spines usually dissolved.

Remarks: After Moret (1926), *Seliscothon azoricoides* may be distinguished from other species of *Seliscothon* by a well-developed finely-porous superficial network on both surfaces. This feature, in combination with the fibrous skeleton of this species, corresponds to the diagnosis of *Pachyselis* Schrammen, 1924, therefore, the present authors propose to change the generic assignment of this species. *P. azoricoides* differs from the leaf- or ear-like specimens of *P. auriformis* (Schrammen, 1910) (the only one representative of the genus described so far) by a more regular shape of the body and the type of rhizoclones in the superficial network. In *P. azoricoides* they are small and branched (sea also Lagneau-Hérenger, 1962), while in *P. auriformis* they are flattened (Schrammen, 1910). Due to secondary silification of the specimens, the present authors have recognized

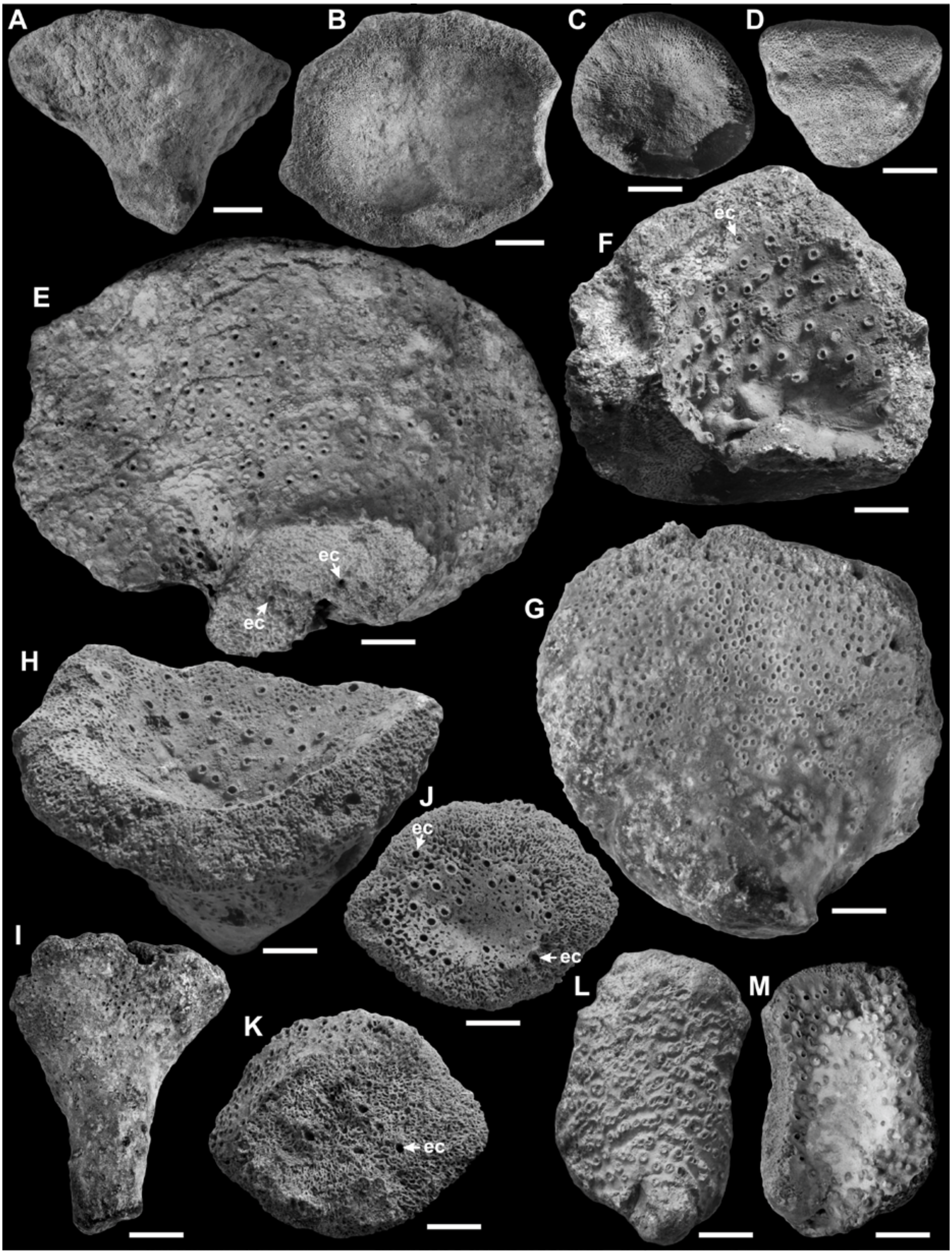

Fig. 12. Rhizomorine sponges. **A–D.** *Pachyselis azoricoides* (Moret, 1926); A – thin-walled, funnel-like specimen; ULXXV/13R/1, Bełchatów; B – upper view of the same specimen; C – thick-walled specimen; ULXXV/13R/2, Bełchatów; D – upper view of the same specimen; skeletal fibres visible in places where the superficial network is destroyed. Scale bars represent 10 mm. **E–K.** *Amphithelion reussi* (M'Coy, 1848); E – outer surface of specimen (previously assigned to *Amphithelion macrommata* (Roemer, 1964); in the basal part several exhalant canals (ec) visible; ULIII/1047, Pniaki; F – inner surface of fragmentarily preserved specimen with prominent papillary exhalant openings and several exhalant pit-like canals (ec); ULXXV/9R/1, Bełchatów; G – outer surface of specimen with densely arranged inhalant pores; ULXXV/9R/2, Bełchatów; H – lateral view of cup-like specimen; ULXXV/9R/7, Bełchatów; I – fragment of stalk; ULXXV/9R/5, Bełchatów; J – central part of fragmentarily preserved specimen; visible low papillary exhalant openings and exhalant canals (ec); ULXXV/9R/6, Bełchatów; K – cross-section of the lower part of the same specimen with exhalant canals (ec). **L, M.** *Amphithelion crassum* (Roemer, 1864); ULXXV/12R/1, Bełchatów; L – outer surface of specimen; M – inner surface of the same specimen. Scale bars 10 mm.

large rhizoclones, similar to desmas of *P. azoricoides* illustrated by Moret (1926), only locally inside the wall. The oxeas, noted in *P. auriformis* (Schrammen, 1910, 1924), have not been described earlier in the discussed species.

The described specimens are characterized by a high variability in shape and wall thickness. The massive specimens resemble sponges, distinguished by Moret (1926) as *S. azoricoides* forme *crassum*. The material from the Aptian of Catalonia also includes the thick-walled morphotype (Lagneau-Hérenger, 1962).

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene); Spain (Catalonia: Aptian); France (Provence: Santonian); Belgium (Eocene).

Genus *Amphithelion* Zittel, 1878

Type species: *Verrucospongia macrommata* Roemer, 1864, p. 45, designated by Schrammen, 1924, p. 117.

Emended diagnosis: Thick-walled, funnel- or leaf-like sponges with papillary pores on both surfaces. Inhalant canals lacking. Long exhalant canals are oblique while in the central part of the body they run to the sponge base/stalk. Large, poorly branched rhizoclones interlocking into anastomosed fibres inside the wall, while they are densely packed and form a superficial layer of the choanosomal network on both surfaces.

Remarks: After Schrammen (1924) the genus *Amphitelion* is characterized by the lack of inhalant and exhalant canals. Contrary to this diagnosis, Schrammen (1910, 1924) included in *Amphithelion macrommata* (Roemer, 1864), for instance, *Verruculina papillata* Hinde, 1883, which has developed exhalant canals. Reid (2004) classified this latter species in the subgenus *Amphithelion* (*Cryptothelion*), but unlike *Cryptothelion sensu* Schrammen, 1924, the discussed species is characterized by a fibrous structure of the skeleton (Hinde, 1883). This feature is diagnostic for *Amphithelion sensu* Schrammen (1924), while it has been omitted in the taxonomy of Reid (2004). Gruber (1993) and also the present study confirm the occurrence of exhalant canals in *A. macrommata* and synonymy with *V. papillata* Hinde, and thus necessitates the change in the diagnosis of *Amphithelion*, taking into account the presence of exhalant canals.

Amphithelion reussi (M'Coy, 1848)
Figs 12E–K, 13A–D

1848 *Manon reussi* – M'Coy, pp. 398–399.

1864 *Verrucospongia macrommata* – Roemer, p. 45, pl. 16, fig. 4.

1878 *Amphithelion macrommata* Roemer – Zittel, p. 60, pl. 3, fig. 15.

1883 *Verruculina reussi* (M'Coy) – Hinde, p. 40, pl. 5, fig. 1.

1883 *Verruculina macrommata* Zittel – Hinde, p. 40.

1883 *Verruculina papillata* – Hinde, p. 41, pl. 5, figs 2, 2a.

1901 *Amphithelion macrommata* Roemer – Schrammen, p. 21.

1910 *Verruculina macrommata* Roemer – Schrammen, p. 140, text-pl. 8, fig. 6.

1933 *Verruculina reussi* (M'Coy) – Bieda, p. 10.

1968 *Verruculina reussi* (M'Coy) – Hurcewicz, pp. 20–22, pl. 2, fig. 3a, b, pl. 3, figs 1, 2a, b. 1968 *Amphithelion marommata* (Roemer) – Hurcewicz, pp. 29–30, pl. 6, fig. 3, text-fig. 7.

1993 *Amphithelion marommata* (Roemer) – Gruber, pp. 61–62, pl. 18, figs 1–2, 3?, pl. 26, fig. 3

Material: 79 specimens from Bełchatów (ULXXV/9R/1–79), 8 specimens from Pniaki (ULIII/1047, 1450, 1487, 1500, 1517, 1521, 1627, 1638), 9 specimens from Skrajniwa (ULIII/633, 635, 685, 1128, 1133, 1134, 1137, 1196, 1355), 7 specimens from Zbyczyce (ULIII/63, 354, 387, 1487, 1488, 1489, 1532), 1 specimen from Miechów (ULIII/106).

Description: Dish-, cup- or funnel-like sponges with rounded upper margin and often with the remains of a thick stalk (Fig. 12E–K). Occasionally, the wall of asymmetrical specimens is sub-divided into two wide lobes, or their upper margin forms rounded outgrowths or is wrapped inside. The largest specimen is up to 130 cm wide and 140 mm high. Fragments of isolated stalks are up to 55 mm long and 15 mm in diameter (Fig. 12I). The thickness of the wall near the upper margin is usually 10–15 mm thick, rarely only 7 mm. In the lower part of the sponges, the wall is thicker, usually 15–20 mm, but in some large specimens it can be up to 25–31 mm thick. Upper surface with conical or tubular papillae (observed in well-preserved specimens), up to 2.5–3 mm high and 2–3 mm in diameter, irregularly spaced at 3–5/cm^2 (Fig. 12F, H, J). Openings on the top of the papillae are ca. 1–2 mm in diameter. Close to the margins of specimens, exhalant canals are pit-like (Fig. 12F). A few long exhalant canals, occurring in the central part of the sponge, are strongly oblique to perpendicular to the upper surface of the sponge, and near the base and in the stalk (if present), run vertically (Fig. 12E, K). Pores on the lower surface are flat or with a prominent ring-like margin, 0.5–1.5 mm in diameter (Fig. 12E, G). They are unevenly scattered, arranged in irregular groups or in short, winding rows, which run in different directions. Their density is usually 15–20/cm^2. On the stalk, their density is only 5–6/cm^2 (Fig. 12I). Inhalant canals are not developed in the skeleton.

Both surfaces of the choanosomal skeleton with densely packed, elongated, poorly branched rhizoclones, 350–450 µm in size (Fig. 13A, B). Rhizoclones have straight or arched epirhabd, 35–55 µm thick, but some of them are very massive, up to 80 µm thick. Inside the wall, rhizoclones (Fig. 13C, D) of similar size form anastomosing skeletal fibres, 300–500 µm thick, which surround irregular spaces, 200–900 µm in size (spaces are the largest in cross-section, parallel to the upper surface of the specimens). Desmas located near skeletal spaces usually have short clones (50–100 µm long), arising on one side of the axis. Rhizoclones are sparsely covered with tubercles, rarely with spines (often with dissolved tips, resembling tubercles). Young desmas are almost smooth (Fig. 13C).

Remarks: Schrammen (1910, 1924) included the material from England, described by Hinde (1883) as *Verruculina reussi* M'Coy (1848), into *Amphithelion macrommata* (Zittel, 1887), known from the Cretaceous of Germany, while the

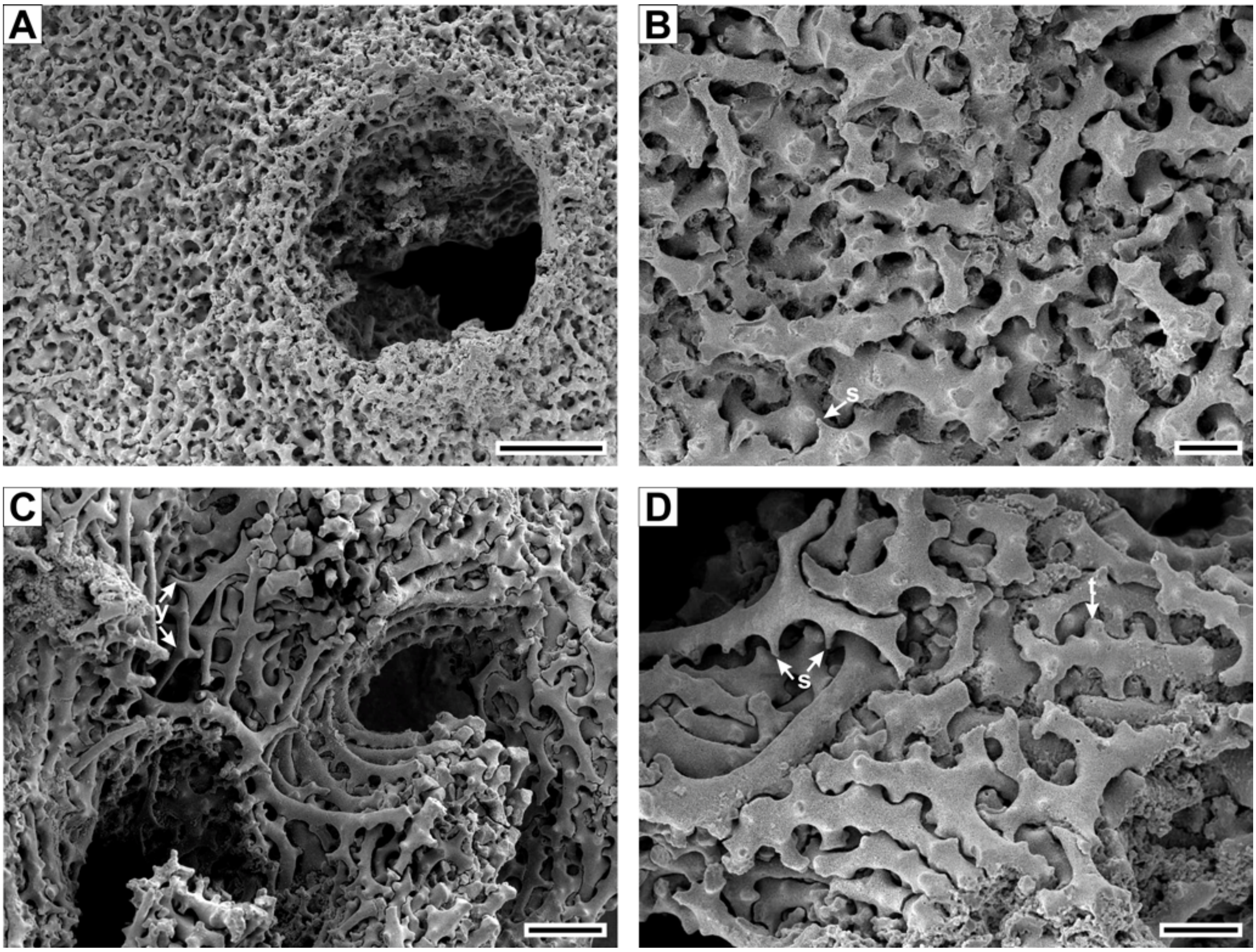

Fig. 13. Skeleton of *Amphithelion reussi* (M'Coy, 1848). **A.** Superficial network on the outer surface of the sponge with pore; ULXXV/9R/4, Bełchatów. **B.** Detail of the superficial network; massive rhizoclones with dissolution ornamentation. **C.** Anastomosed skeletal fibres with several young, weakly ornamented desmas (y); ULXXV/9R/3, Bełchatów. **D.** Detail of fibre; rhizoclones with spines (s) and tubercules (t). Scale bars 100 μm (B, D), 200 μm (C) and 500 μm (A).

specimens described by M'Coy (1848) were retained by him as the separate species *V. reussi* due to the lack of data on their desmas. This view is incomprehensible, because Hinde (1883) did not describe desmas as well, therefore Schrammen (1910, 1924) synonymised the two species of Hinde (1883) solely on the basis of macroscopic features. In the opinion of the present authors, the specimens described by M'Coy (1848) also show very distinct macroscopic features, identical to those of *A. macrommata* (Zittel, 1887), and in this case the latter species should be considered a junior synonym of *A. reussi* (M'Coy, 1848).

The similarity of the specimens, described by Hinde (1883) as *V. reussi* to *A. macrommata*, was questioned by Bieda (1933) and later by Hurcewicz (1968), who distinguished both species in the material from the Miechów and Kraków areas. The difference in the size of the openings on the upper and lower sides of the sponges (1.0 mm and 2 mm in *A. macrommata*, and 0.75 mm and 1–1.5 mm in *A. reussi*, respectively) pointed out by these researchers does not correspond to the descriptions of these species, given by Hinde (1883) and Schrammen (1910). This is also contradicted by the present research, based on the collections of F. Bieda and H. Hurcewicz and the very rich material from Bełchatów, which shows a large variability in the size of canal openings within *A. reussi*. Moreover, according to Hurcewicz (1968), the skeleton of *A. reussi* is composed of thinner and spinier rhizoclones than *A. macrommata*. The strongly secondary silicified specimens of *A. reussi* from the collection of Hurcewicz have significantly more poorly preserved skeletons than specimens, described by Hurcewicz (1968) as *A. macrommata*, and the differences in their spiculation are the effect of partially dissolved desmas. The rhizoclones observed in some less secondarily silicified specimens from Bełchatów, described here as *A. reussi*, are massive and identical with rhizoclones of *A. macrommata*, presented by Zittel (1878) and Hurcewicz (1968, p. 30, text-fig. 7).

The second species from the Cretaceous of England, identified by Schrammen (1910) as the synonym of *A. macrommata*, is *Verruculina papillata* Hinde, 1883, which according to Hinde (1883) differs from *V. reussi* by the presence of longitudinal exhalant canals. These canals were very well documented by Hinde (1883), but Schrammen (1910), however, did not comment on this difference in his description of *A. macrommata* and did not provide information about the canalization of this species. Later, Schrammen (1924) considered the lack of exhalant canals as characteristic for *Amphithelion*. Observations by the present authors, based on a very large number of specimens, have indicated that in the cross-section of the wall of many specimens, the exhalant canals are indeed invisible, because long canals are developed only in the lower (central) part of the specimens.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Miechów area: upper Campanian; Kraków area: Santonian or Campanian sponges redeposited into the Miocene); Germany (Lower Saxony: Campanian); southern England (Upper Chalk, probably lower Campanian).

Amphithelion crassum (Roemer, 1864)
Figs 12L, M, 14A–D

1864 *Chenendopora crassa* – Roemer, p. 43, pl. 16, fig 1.

1878 *Manon circusporosum* – Quenstedt, p. 372, pl. 132, fig. 55.

1910 *Verruculina crassa* (Roemer) – Schrammen, p. 140.

1924 *Amphistomium* (?) *crassum* (Roemer) – Schrammen, p. 116.

Material: 3 specimens from Bełchatów (ULXXV/12R/1–3).
Description: Cup- or asymmetrical funnel-like sponges with 0.9–1.1 mm thick wall. The largest, slightly damaged specimen is 52 mm in height (Fig. 12L, M). Upper surface covered by conical papillae, 1.8 mm high and 1.5 mm in diameter near the base, with small openings on the top (on undamaged papillae they measure ca. 0.5 mm in diameter). The bases of adjacent papillae may sometimes be fused. Papillae are densely packed, ca. 16–24/cm^2. Tops of papillary pores on the outer surface were usually destroyed and only a ring-like margin has remained after them. Their arrangement and size (1.2–1.5 mm in diameter) are similar to the papillae on the upper surface. Opening on the top of these papillae is 0.5 mm in diameter.

Poorly branched, elongated rhizoclones are extremely densely packed within the superficial skeletal layer of the outer surface, where they reach up to 400 µm in size and are 25–40 µm thick (Fig. 14A, B). Due to the secondary silification of the sponges, the ornamentation of these rhizoclones is nearly completely destroyed. On the inner surface the desmas are not preserved. Inside the wall, anastomosing fibres, 500 µm thick, consist of slenderer rhizoclones (350–450 µm in size and 25–30 µm thick) with short clones, but some of them reach 200 µm length (Fig. 14C, D). Rhizoclones are sparsely covered by fine conical spines of varying length, long spines single or bifurcating.

Remarks: Zittel (1878) included *Chenendopora crassa* Roemer, 1864 and *Manon circusporosum* Quenstedt, 1878 in the genus *Amphithelion* as two separate taxa. Following the revision of Roemer's and Quenstedt's material, Schrammen (1910) considered both species to be synonyms, emphasizing that Roemer's illustration was too schematic, and the features of the species are more faithfully reflected in the illustration of Quenstedt (1878). Due to the similar arrangement of the prominent papillary pores on both surfaces of the sponge, Schrammen (1924) considered the discussed species as representatives of the genus *Amphistomium*. According to Schrammen (1924), this species differs from the representatives of *Amphithelion* in the presence of a superficial skeletal layer on both sponge surfaces, but in the specimens described so far from Germany, no spicules have been preserved within these layers or inside the wall. The present authors placed the discussed species in *Amphithelion* because the analysis of the material from Poland has shown that the shape and size of the desmas, both within surface network and inside the wall, are very similar to the desmas of *Amphithelion reussi*. They differ in the ornamentation of the rhizoclones (spines in *A. crassum* and tubercules and rare spines in *A. reussi*), but in both of these species the desmas form characteristic fibres, not occurring in *Amphistomium*. The present authors share the view of Schrammen (1910) that the size and arrangement of the pores on the outer side of both species are very similar, while the pores on the upper side of *A. crassum* are smaller and much less densely arranged than in *A. reussi*.
Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene); Germany (Lower Saxony: Turonian).

Genus *Verruculina* Zittel, 1878

Type species: *Chenendopora aurita* Roemer, 1864, p. 43, pl. 16, fig. 2, designated by Zittel, 1878, p. 122.
Diagnosis: See Schrammen (1924).

Verruculina aurita (Roemer, 1864)
Figs 15A–E, 16A–D

1864 *Chenendopora aurita* – Roemer, p. 43, pl. 16, fig. 2.

1876–80 *Verruculina auriformis* Roemer – Zittel, p. 153, fig. 68.

1889 *Verruculina aurita* (Roemer) – Griepenkerl, p. 16.

1901 *Verruculina aurita* (Roemer) – Wolleman, p. 5.

1910 *Verruculina seriatopora* (Roemer) – Schrammen, pp. 141–142, pl. 21, fig. 1, text-pl. 8, fig. 5.

1924 *Verruculina aurita* (Roemer) – Schrammen, pp. 124–125, pl. 3, fig. 6.

1924 *Verruculina aurita* (Roemer) var. *rudista* – Schrammen, pp. 125–126, pl.

1993 *Verruculina aurita* (Roemer) – Gruber, pp. 60–61, pl. 17, figs 7, 8, pl. 26, fig. 2.

Material: 19 specimens from Bełchatów (XXV/22R/1–19), 1 specimen from Pniaki (ULIII/1636b), 2 specimens from Skrajniwa (ULIII/638, ULIII/1138).
Description: Ear-, funnel- or bowl-like sponges (Fig. 15A–C), often with a massive stalk (Fig. 15D) and a rounded margin (if preserved), covered by numerous branched furrows. The specimen up to 96 mm wide; thickness of wall is 12–18 mm, sometimes up to 20 mm. On the upper surface, there are exhalant canal openings with a diameter of 1–2 mm, located on the top of small papillae (often destroyed). They are irregularly distributed, and their density is 6–16/cm^2. Branched exhalant canals are very long, with short unbranched terminal section more or less perpendicular to

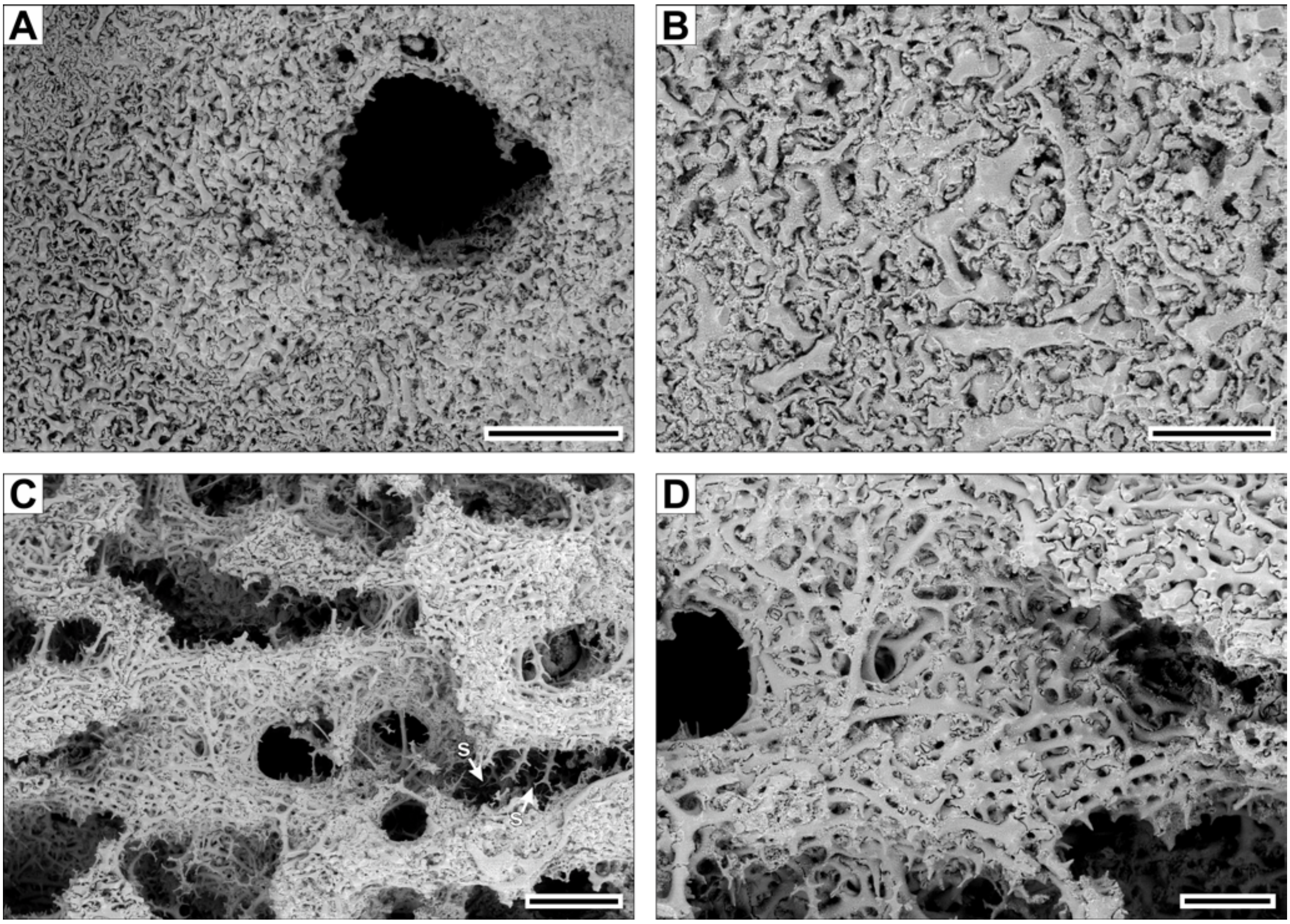

Fig. 14. Skeleton of *Amphithelion crassum* (Roemer, 1864); ULXXV/12R/2A, Bełchatów. **A.** Diagenetically modified superficial network on the outer surface of the sponge with pore. **B.** Detail of the superficial network. **C.** Anastomosed skeletal fibres; rhizoclones with long spines, often with forked tips (s). **D.** Detail of fibres. Scale bars 200 µm (B, D) and 500 µm (A, C).

the inner surface of the sponge. Lower surface covered by small (0.3–0.5 mm in diameter), densely packed pores, 300–350/cm^2. In places where the outer layer of skeleton is destroyed, small inhalant canal openings, up to 0.8 mm, are visible (Fig. 18E). They often occur at the bottom of shallow, anastomosed grooves. Directly below the outer surface, the inhalant canals penetrate the wall perpendicularly or obliquely; in deeper parts of the wall, they are difficult to distinguish.

Most specimens are strongly secondarily silicified an rhizoclones are rarely well preserved (Fig. 16A–D). Branched, medium spiny rhizoclones create a dense, irregular network that is only slightly more compact on the wall surface. Rhizoclones usually 250–300 µm in size, but large desmas (up to 400 µm in size) also occur locally. Spines with blunt tips, usually very short, exceptionally prominent and up to 30–40 µm high. Occasionally, young desmas without ornamentation appear.

Remarks: Schrammen (1910) recognized *Chenendopora aurita* Roemer, 1864 as the junior synonym of *Manon seriatopora* Roemer, 1840–1841, which he included in the genus *Verruculina* Zittel, 1878. Later, however, he accepted *Verruculina aurita* as a separate species (Schrammen, 1924). According to Schrammen (1924), the inclusion of *M. seriatopora* in *Verruculina* is doubtful, because of the lack of data on the skeleton of this species and the impossibility of its verification, due to the loss of the specimens, described by Roemer (1840–1841). Nevertheless, in subsequent publications on Cretaceous sponges, *V. aurita* was still synonymised with *V. seriatopora* (Moret, 1926; Lagneau-Hérenger, 1962; Hurcewicz, 1968; Gruber, 1993). The lack of an unambiguous diagnosis of *V. seriatopora* has led to the inclusion of several taxa in this species that differ significantly from *V. aurita*, e.g., the rhizoclones of specimens, described by Moret (1926), are very large, up to 900 µm in size. In turn, the specimens described by Hurcewicz (1968) as *V. seriatopora* were identified as *V. tenuis* (Świerczewska-Gładysz, 2006). The specimens examined here show all the characteristics of *V. aurita* given by Schrammen (1924) and differ macroscopically from the specimen of *Manon seriatopora* presented by Roemer (1840–1841) in more scattered, irregularly arranged exhalant canal openings on the upper surface (see also Roemer, 1864; Zittel, 1876–1880).

The shape of most of the specimens studied here is similar to that of the sponges from the Campanian of Misburg, described by Schrammen (1924) as *Verruculina aurita* var. *rudista*. This morphotype is represented by thick funnel-like sponges, resembling *Heterothelion cupula* Schrammen. In addition to the differences in the skeletal structure between the two species, as noted by Schrammen (1924), the exhalant canals are also an important diagnostic feature. These

Fig. 15. Rhizomorine sponges. **A–E**. *Verruculina aurita* (Roemer, 1864); A – upper view of the bowl-like specimen with papillary openings; XXV/22R/2, Bełchatów; B – cross-section of the wall of the same specimen with visible branching canals; C – lower surface of the same specimen with fine-pores; D – fragment of funnel-like specimens with destroyed superficial fine-porous layer; visible inhalant canal openings; XXV/22R/3, Bełchatów; E – outer surface with a fine-porous layer (left side of specimen) and without this layer, with visible inhalant canal openings (right side of specimen); XXV/22R/4, Bełchatów. **F–J.** *Cryptothelion sujkowskii* sp. nov.; F – inner surface of the specimen with exhalant openings, sometimes with a preserved ring-like margin; on the cross-section of the wall, visible end sections of the oblique exhalant canals (ec); holotype, ULXXV/23R/6, Bełchatów; G – outer surface with a fine-porous superficial layer of the same specimen; in the cross-section of the basal part of specimen, visible longitudinal exhalant canals (ec); H – inner surface of a platy-like fragment of specimen; visible papillary exhalant openings; paratype, ULXXV/23R/4, Bełchatów; I – outer surface of the same specimen; J – outer surface of the narrow funnel-like specimen; paratype, ULXXV/23R/1, Bełchatów. Scale bars 10 mm.

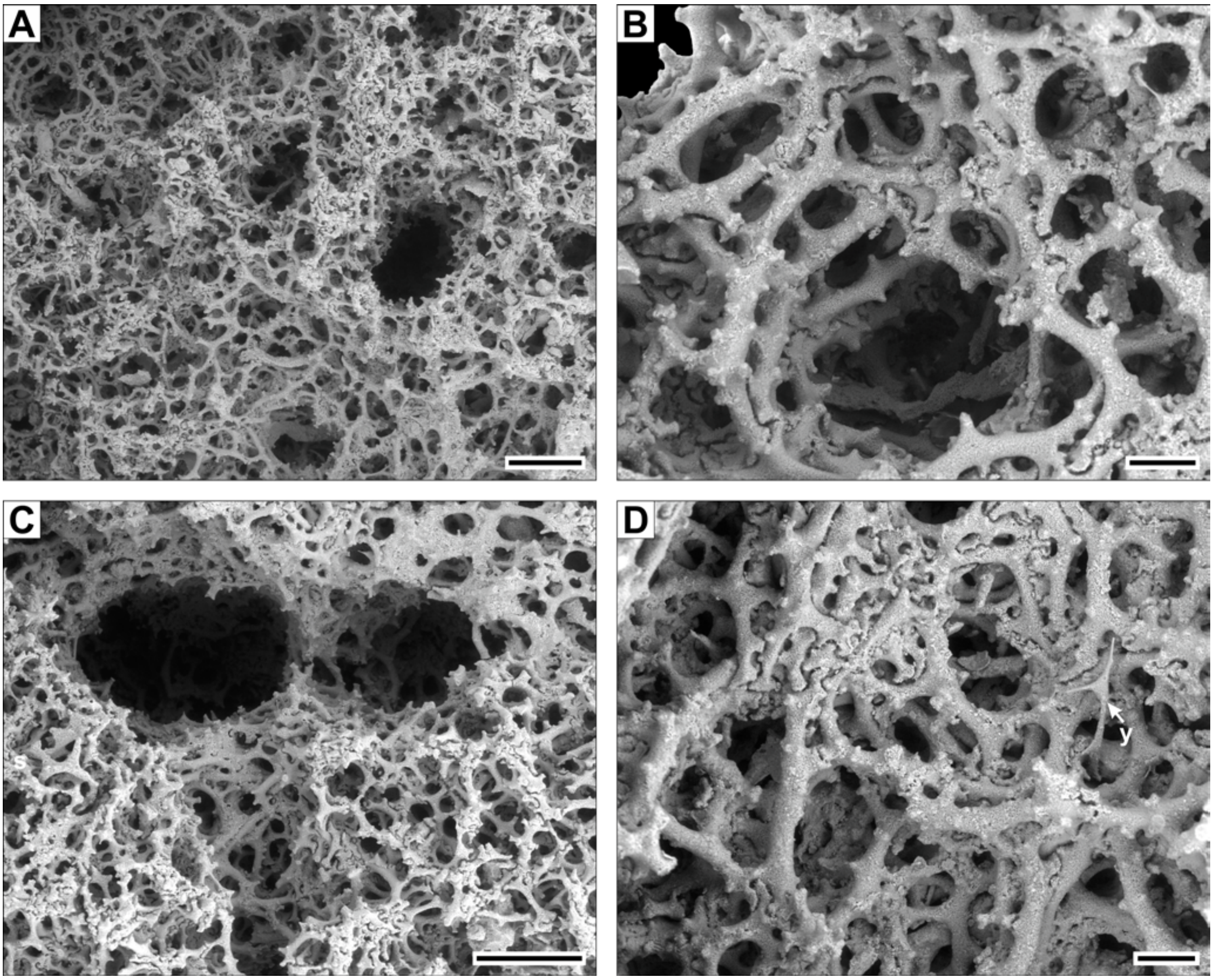

Fig. 16. Skeleton of *Verruculina aurita* (Roemer, 1864); XXV/22R/1, Bełchatów. **A, B.** Portion of the skeleton pierced by inhalant canals. **C.** Portion of the skeleton pierced by exhalant canals. **D.** Detail of the skeleton with small to medium spiny rhizoclones and smooth, young desma (y). Scale bars 100 μm (B, D) and 500 μm (A, C).

canals are straight and vertical in *H. cupula*, whereas they are strongly branched in *V. aurita*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Campanian; Saxony-Anhalt: Santonian).

Genus *Cryptothelion* Schrammen, 1924

Type species: *Cryptothelion geminum* Schrammen, 1924, p. 122, pl. 3, fig. 5.

Diagnosis: See Schrammen (1924).

Cryptothelion sujkowskii sp. nov.
Figs 15F–J, 17A–F

Diagnosis: Funnel-like sponges with papillary oscula on the inner surface and densely arranged small pores on the outer surface, corresponding to modified skeletal meshes. Long exhalant canals strongly oblique to the inner surface of sponges in the upper part and nearly perpendicular in the lower part. Weakly branched, massive rhizoclones, elongated or slightly arched with spines and tubercles, which are single or with multifurcate tips.

Derivation of name: In honour of Professor Zbigniew Sujkowski, an outstanding researcher of the Cretaceous System in Poland.

Holotype: ULXXV/23R/6 (Figs 15F, G, 17D–F).

Paratypes: ULXXV/23R/4 (Figs 15H–I, 17A–C); ULXXV/23R/1 (Fig. 15J).

Material: 15 specimens from Bełchatów (XXV/23R/1–15).

Type locality and stratigraphic horizon: The holotype was found in the north-western part of the Bełchatów lignite mine (N 51º14′; E19º14′); Miocene (?Pannonian) lag gravel, distinguished in the local lithostratigraphic scheme as the Upper Gravels, occurring in the basal part of the Clayey-Sandy Unit. It is reworked from a lower Campanian deposit.

Description: In the studied collection, this species is represented by fragmentarily preserved funnel-like specimens (Fig. 15E–G, J) with a rounded, occasionally outwards turned margin and some platy-like fragments (Fig. 15H, I). The largest fragment is 75 mm high and 95 wide. Wall, averagely 7–13.5 mm thick, thins out towards the upper margin. Exhalant canal openings, usually 0.5 mm in diameter, are

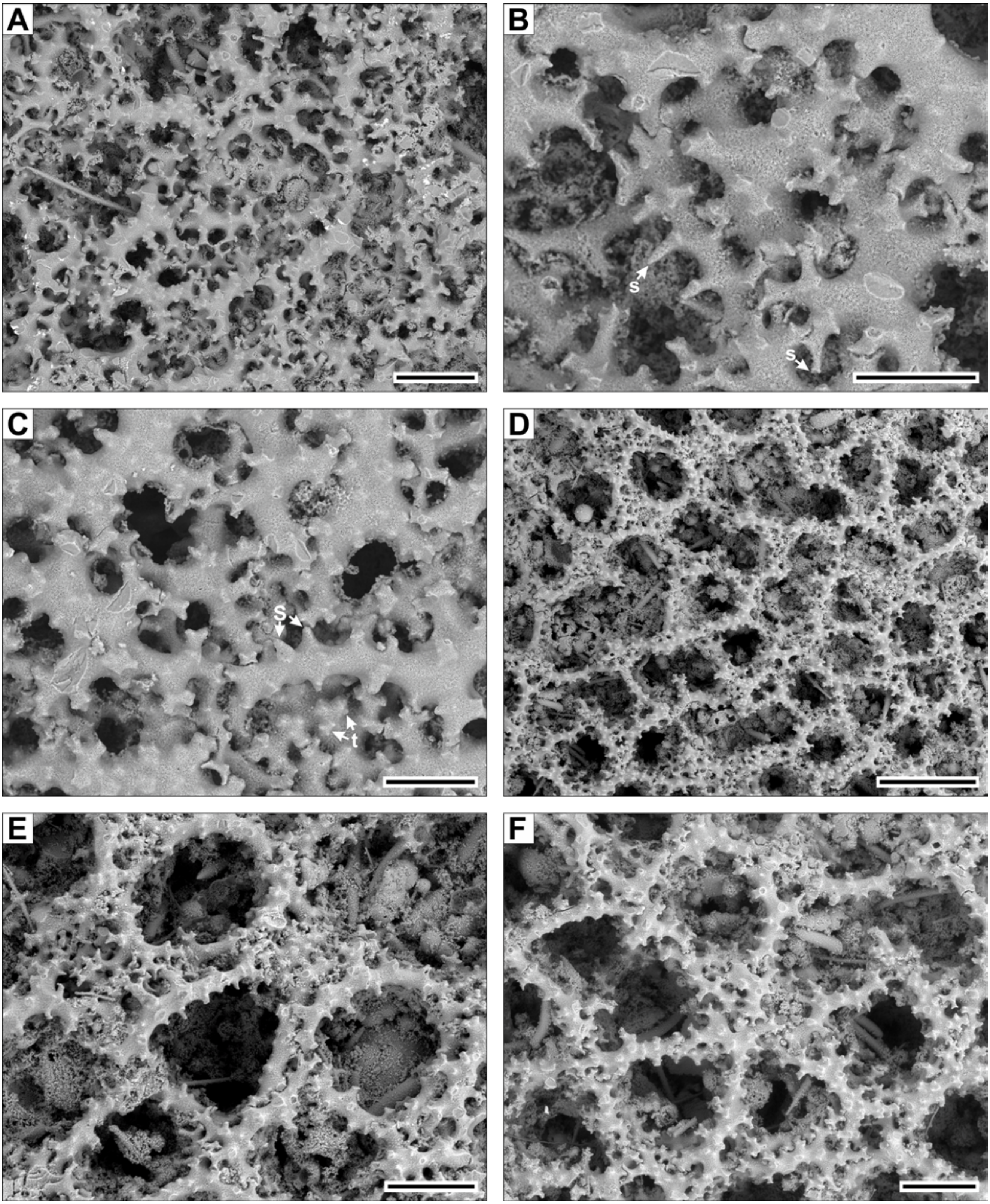

Fig. 17. Skeleton of *Cryptothelion sujkowskii* sp. nov. **A–C.** Skeleton on the inner surface of the choanosomal skeleton; rhizoclones covered by spines (s) and tubercles with single tips or with short spines or small lumps (t); paratype, ULXXV/23R/4, Bełchatów. **D–F.** Superficial network on the outer surface of choanosomal skeleton with fine pores, separated by thin bridges, consisting of 2–3 or only one rhizoclone; holotype, ULXXV/23R/6, Bełchatów. Scale bars 100 μm (B, C), 200 μm (A, E, F) and 500 μm (D).

situated on the top of rounded papillae, 0.75–1.5 mm in diameter (in specimens with a destroyed surface, the remains of papillae are thick, prominent rings). The papillae are irregularly distributed, 10–30/cm^2. In the central part of the sponges, long exhalant canals run more or less longitudinally from the base to the inner surface. In the upper part of the sponges, exhalant canals are oblique to the inner surface. Superficial skeletal layer on outer surface with fine pores, which are polygonal or rounded, 0.1–0.2 mm, occasionally 0.3 mm in size (Fig. 17D–F). Inhalant canals not visible.

Massive rhizoclones on the inner surface are 350–380 µm in size and 50–60 µm thick (Fig. 17A–C). They are irregularly branched, with straight or slightly arched axis and thick clones of various length. In the lower part of the sponges, single additional rhizoclones form a loose network covering the openings. Rhizoclones, forming a loose network inside the wall, are very poorly preserved. Skeletal bridges separating pores on the outer surface usually consist of 2–3 desmas (Fig. 17E), but sometimes only a single rhizoclone, 400–420 µm long and 40–50 µm thick, with a straight epirhabd and very short clones, occurs mainly at the end of the desma (Fig. 17F). In this superficial network, smaller (250–380 µm in size) and more branched desmas also occur, with short clones on one side of the slightly arched axis. Desmas are ornamented with rounded tubercles and conical spines (sometimes very long). Some tubercles bifurcate at the extreme tip, forming short spines or small lumps.

Remarks: The proposed new species is included in *Cryptothelion*, due to the very small, punctiform pores on the outer surface, which are slightly modified meshes within the outer layer of the skeletal network. Its other features also correspond to this genus. *C. sujkowskii* differs from *C. geminum* (the only other representative of *Cryptothelion*) in the shape and ornamentation of the rhizoclones, which in the latter species are strongly arched and tuberculate, while the rhizoclones of *C. sujkowskii* are elongated and covered by spines and tubercles, often with forked tips. In *C. sujkowskii* the density of exhalant openings is up to 30/cm^2, while in *G. geminum* it is only 6–10/cm^2.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene).

Genus *Heterothelion* Schrammen, 1924

Type species: *Verruculina cupula* Schrammen, 1910, p. 142, designated by Schrammen, 1924, p 118, pl. 3, fig. 2.

Diagnosis: See Schrammen (1924).

Heterothelion cupula (Schrammen, 1910)

Figs 18A–F, 19A, B

1910 *Verruculina cupula* – Schrammen, p. 142.

1924 *Heterothelion cupula* Schrammen – Schrammen, p. 118, pl. 3, fig. 2.

non 1926 *Verruculina cupula* Schrammen – Moret, p. 86, pl. 20, fig. 10, pl. 21, fig. 2, text-fig. 24.3.

1968 *Verruculina cupula* Schrammen – Hurcewicz, pp. 27–28, pl. 5, fig. 1a–c.

1974 *Heterothelion cupula* Schrammen – Ulbrich, p. 46, pl. 8, fig. 4, pl. 18, fig. 4 [cum syn.].

1993 *Verruculina cupula* Schrammen – Jahnke and Gasse, pl. 4, fig. 5a, b.

Material: 20 specimens from Bełchatów (ULXXV/10R/1–20), 7 specimens from Skrajniwa (ULIII/49, 637, 640, 1130, 1131, 1139, 1141, 1151).

Description: The largest specimens measure ca. 75–95 mm in width and ca. 80–95 mm in height. Most of them are regular, wide-conical (Fig. 18B), less often narrow-conical (Fig. 18D). Others are laterally flattened or occasionally with rounded ribs in their upper part, occasionally with a preserved fragment of thin stalk (Fig. 18C). The upper surface is usually flat or slightly concave, but occasionally heavily concave and relatively deep, reaching half of the sponge height (Fig. 18A, D, E). In the latter sponges, the thickness of the wall near the rounded upper margin is 5–6 mm. The exhalant canal openings, situated on the upper surface, are usually 1.5–2 mm in diameter, papillary or with a prominent rim (in well-preserved specimens; Fig. 18D, E). Their density is 5–8/cm^2, but more densely packed canal openings (up 10–11/cm^2) are also observed, especially in the central part of the specimens. Long, cylindrical exhalant canals, 1 mm wide, run vertically downwards (Fig. 18A). Pores on the outer surface, 0.4–0.5 mm in diameter, with small ring-like margins (observed only in well preserved specimens; Fig. 18F). They are irregularly distributed, usually 100–150/cm^2, rarely up to 200–250/cm^2. On specimens with a destroyed outermost porously skeletal layer, inlets of inhalant canals, 0.5–0.8 mm in size (Fig. 18B), are distributed at ca. 35–40/cm^2. Short inhalant canals are perpendicular or slightly oblique to the outer surface of the wall.

The choanosomal skeleton is observed only locally on the outer surface of some specimens (Fig. 19A, B), where the thick external network consists of massive (50–70 µm thick), branched rhizoclones, usually ca. 300–450 µm in size, covered by tubercles and massive spines, usually with a dissolved top. Most of the rhizoclones are arched, but straight, poorly branched rhizoclones also occur.

Remarks: *Heterothelion cupula* is a polymorphic species. In the material from the Campanian of Poland, apart from regular conical specimens, similar to those described from the Santonian–Campanian of Lower Saxony (Schrammen, 1910, 1924; Ulbrich, 1974; Jahnke and Gasse, 1993), a morphotype with rounded ribs in the upper part of the body has also been noted (see also Hurcewicz, 1968).

Specimens from the Santonian of southern France, described by Moret (1926) as *H. cupula*, in contrast to representatives of this species, show a deep spongocoel, reaching to their base. The rhizoclones of *H. cupula* are mainly covered by thick tubercles (compare Schrammen, 1924; Ulbrich, 1974), whereas the rhizoclones of these specimens are strongly spiny (Moret, 1926, text-fig. 24.3). The pointed differences indicate that the specimens from France represent an another rhizomorine species.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: Santonian, Campanian).

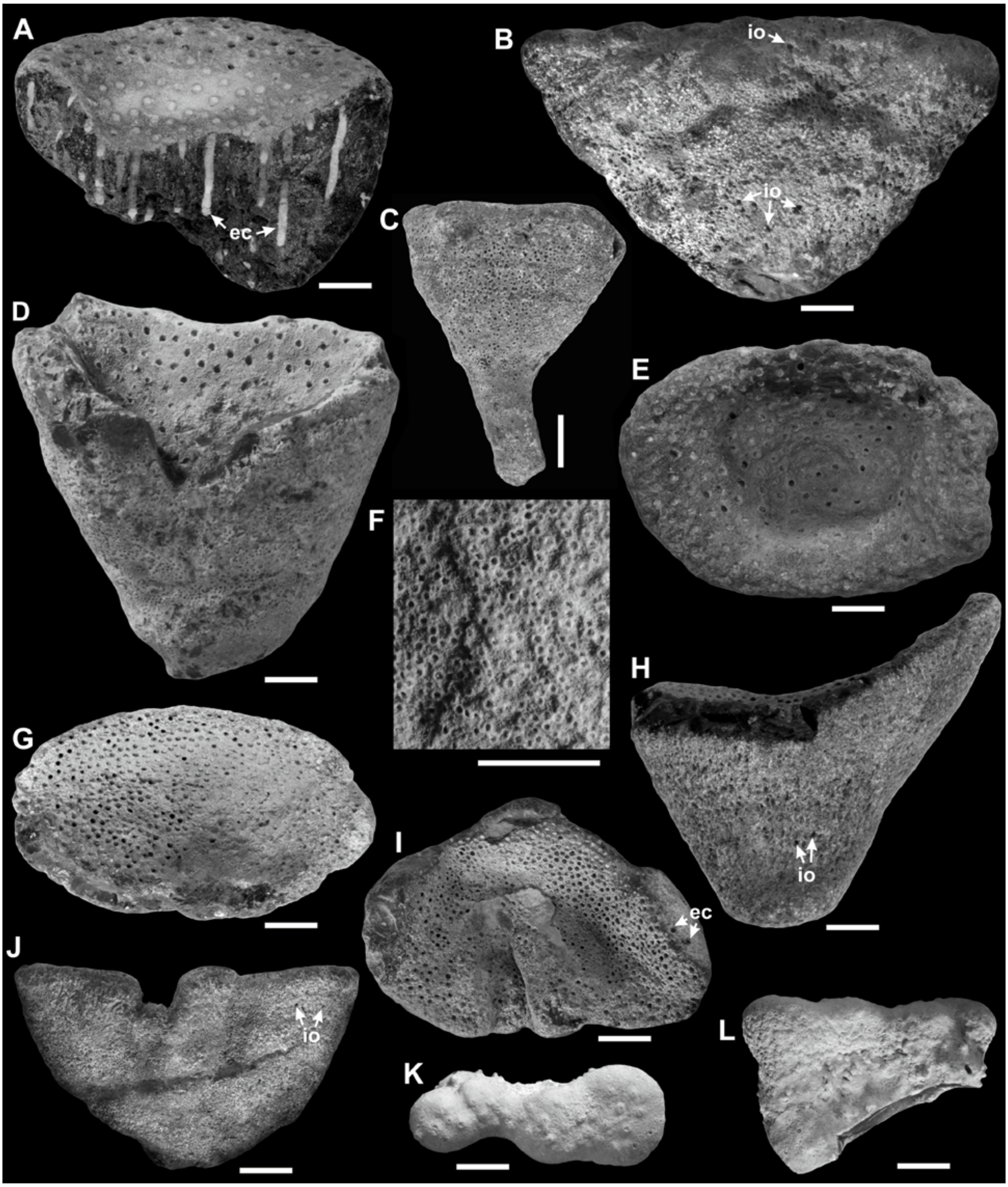

Fig. 18. Rhizomorine sponges. **A–F.** *Heterothelion cupula* (Schrammen, 1910); A – fragment of the specimen with a flat upper surface with exhalant canal openings; with vertical exhalant canals visible in the cross-section of the wall; ULXXV/10R/7, Bełchatów; B – lateral view of a wide-conical specimen; inhalant canal openings (io) visible in places where the superficial, porous layer is destroyed; ULXXV/10R/1, Bełchatów; C – specimens with preserved fragment of the stalk; ULXXV/10R/4, Bełchatów; D – lateral view of a narrow conical specimen with deep, bowl-like upper surface; some exhalant canal openings papillary or with a prominent rim; ULXXV/10R/3, Bełchatów; E – deep, funnel-like upper surface with exhalant canal openings; ULXXV/10R/5, Bełchatów; F – detail of the superficial layer with minute, papillary pores; ULXXV/10R/6, Bełchatów. **G–J.** *Heterothelion* cf. *cupula* Schrammen, 1910; G – heavily concave upper surface with exhalant canal openings; ULXXV/8R/1, Bełchatów; H – lateral view of the same specimens with destroyed superficial porous layer; visible inhalant canals opennigs (io); I – upper surface with exhalant canal openings; cross-section of exhalant canals (ec) visible in places where the wall is demaged. ULXXV/8R/2, Bełchatów; J – lateral view of the same specimen with longitudinal ribs on the outer surface; inhalant canals openings (io) visible only in places where the superficial porous layer is destroyed. **K, L.** *Heterothelion lobata* Schrammen, 1924; ULXXV/21R/, Bełchatów; K – upper view of the fragmentarily preserved specimen with papillary exhalant canal openings; L – lateral view of the same specimen with papillary pores. Scale bars 10 mm (A–E, G–L) and 1 mm (F).

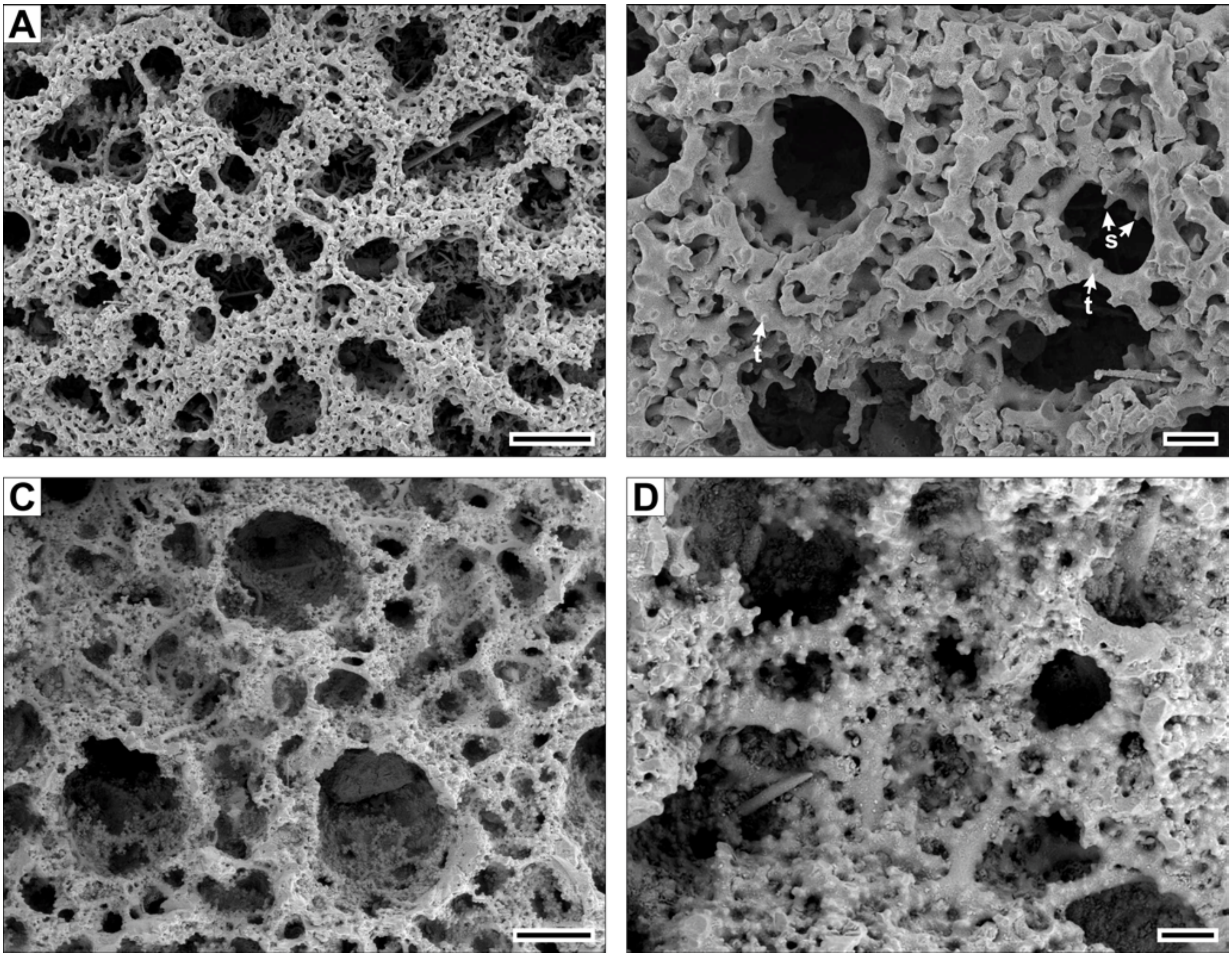

Fig. 19. Skeletons of rhizomorine sponges. **A, B.** *Heterothelion cupula* (Schrammen, 1910); diagenetically modified superficial skeletal network on the outer surface with small inhalant pores; visible poorly ornamented rhizoclones with spines (s) and tubercles (t); ULXXV/10R/2, Bełchatów. **C, D.** *Heterothelion* cf. *cupula* Schrammen, 1910; superficial skeletal network on the inner surface with exhalant canal openings; visible rhizoclones with prominent, simple or multifurcate tubercles; ULXXV/8R/3, Bełchatów. Scale bars 100 μm (B, D) and 500 μm (A, C).

Heterothelion cf. *cupula* Schrammen, 1910
Figs 18 G–J, 19C, D

cf. 1910 *Verruculina cupula* – Schrammen, p. 141.

cf. 1974 *Heterothelion cupula* Schrammen – Ulbrich, p. 46, pl. 8, fig. 4, pl. 18, fig. 4 [cum syn.].

Material: 8 specimens from Bełchatów (XXV/8R/1–8), 1 specimen from Skrajniwa (ULIII/1132).

Description: Conical sponges, sometimes laterally flattened and/or with irregular folds (Fig. 18H, J). One specimen consists of two fused individuals. Specimens up to ca. 65 mm high and 74 mm in diameter. Upper surface slightly to heavily concave (Fig. 18G, I). Thickness of the wall thinning towards the upper edge, which in one specimen has short, rounded outgrowths. Canal openings on the upper surface are papillary or with a protruding edge, 0.7–1 mm in diameter. They are densely packed, usually 25–40/cm^2. Long exhalant canals running parallel to the sponge axis. Poorly visible pores on the outer surface small, usually 0.3–0.4 mm in diameter. Their density is up to ca. 280–320/cm^2. Inhalant canal openings, situated below this fine porous layer, are less densely arranged, usually 35–40/cm^2 (Fig. 18H). Short inhalant canals (only occasionally visible) are straight and run obliquely or perpendicularly to the outer surface.

Fragments of choanosomal skeleton are preserved only on the upper surface (Fig. 19C, D), where a network with large meshes (up to 500 μm in size) occurs. Rhizoclones, 400–550 μm long and 50–80 μm thick, are covered by prominent simple or multifurcate tubercles, up to 20 μm in diameter. Poorly or moderately branched rhizoclones with a straight axis are most common. Arched rhizoclones occur near the openings.

Remarks: The shape of the body and the pattern of canals in the specimens, described here as *Heterothelion* cf. *cupula*, are similar to those of *H. cupula* (Schrammen, 1910), but the exhalant canal openings are smaller and more densely arranged. Their density in *H. cupula* from Poland and Germany does not exceed 15/cm^2 (Ulbrich, 1974), while in the discussed specimens it reaches up to 40/cm^2. The rhizoclones of the latter species are less tuberculate than in *H.* cf.

cupula, but this may be related to their poor state of preservation. Comparison of the skeletons of both taxa is also hampered by the fact that the preserved fragments of their skeletal network come from different parts of the sponges.
Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene).

Heterothelion lobata Schrammen, 1924
Fig. 18K, L

1924 *Heterothelion angulatum* Schrammen var. *lobata* – Schrammen, p. 119, pl. 14, fig. 6.

Material: 2 specimens from Bełchatów (ULXXV/21R/1, 2).
Description: Both specimens are fragments of irregular folds with a slightly expanded uppermost part (Fig. 18K, L). The length and width of the specimens is 45 mm x 8–17 mm and 34 mm x 22 mm, respectively. Upper side flat with rounded margin. Lateral side with small pores located on the top of the papillae, up to 1 mm in diameter, arranged in short rows, usually ca. 70–80/cm^2. Papillary openings on the upper surface are large, up to 1.5 mm, irregularly distributed, 6–8/cm^2. Terminal sections of exhalant canals run perpendicularly to the upper surface of the fold. Initial sections of these canals and inhalant canals not visible.

Tuberculate rhizoclones, poorly visible only on the upper surface of the sponges, are irregularly branched and up to ca. 400–500 µm in size. Rhizoclones inside the wall are not visible.
Remarks: Schrammen (1924) described *Heterothelion angulatum* var. *lobata*, which is represented only by a single specimen from the Sudmerberg area (Goslar, Germany). The specimens studied here differ from it in more prominent papillary openings on the outer side, but such variability is frequently noted in many Cretaceous rhizomorine species and usually is related to the state of preservation of the specimens. Due to the very characteristic shape of the specimens, which is completely different from the top- or table-shaped representatives of *Heterothelion angulatum* (Schrammen, 1910), the authors consider these specimens to represent a separate species.
Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene); Germany (Lower Saxony: Coniacian or Santonian).

Genus *Sporadothelion* Schrammen, 1924

Type species: *Sporadothelion dissipatum* Schrammen, 1924, pp. 120–121, pl. 3, fig. 4, by original designation.
Diagnosis: See Schrammen (1924).

Sporodothelion dissipatum Schrammen, 1924
Figs 20A–F, 21A–D

1883 *Verruculina miliaris* (Reuss) – Hinde, p. 39, pl. 3, fig. 3, 3a.

1924 *Sporodothelion dissipatum* – Schrammen, pp. 120–121, pl. 3, fig. 4.

partim 2006 *Verruculina miliaris* (Reuss) – Świerczewska-Gładysz, pp. 280–281, text-fig. 38j.

Material: 56 specimens from Bełchatów (ULXXV/24R/1–56).
Description: Ear- or fan-like sponges, often with a rounded margin, bent towards the sponge interior (Fig. 20C), up to 55 mm wide and 75 mm high. Usually, wall folded or strongly curved outwards, resulting in a convex exhalant surface. Rarely wall with wide lobes (Fig. 20A, B) or long, flat outgrowths (Fig. 20D, E), occasionally forked. Thickness of wall is 4–6 mm. Exhalant surface with oscula located on the top of narrow conical or tubular fistules, 3–6 mm high and 1.5 mm in diameter near their base. They are very irregularly arranged, usually 4–10/cm^2 and occasionally the lower parts of adjacent fistules may be fused. Deep furrows, running under outermost skeletal layer on upper surface, usually have a star-like arrangement. This regular pattern is often disturbed, especially near the margin. Canal openings in the furrows are 0.4–0.5 mm in diameter. Their density is up to 28–30/cm^2. Long exhalant canals straight or winding. Inhalant surface covered by small, 0.3–0.4 mm in size, papillary pores. They are usually arranged in sinuous or anastomosed rows and their density is 120–320/cm^2. Inhalant canal openings, located in shallow grooves under the outer, porous layer are round or oval, ca. 0.1 mm in size; their density is 35–40/cm^2. Inhalant canals straight, penetrating at least 1/3 of the wall thickness (due to the state of preservation, their total length is impossible to determine).

Upper surface covered by a dense network, which is usually strongly secondarily silicified, but single desmas, up to 200–250 µm in size, are recognizable (Fig. 21A). These desmas are very variable in shape – branched, with long clones or poorly branched, with an arched to nearly straight axis. Their ornamentation is almost completely dissolved, individual small tubercles are preserved extremely rarely. Rhizoclones forming the main skeleton (only occasionally preserved) are also of different shape, but significantly larger, up to 300–400 µm in size and 45 µm thick (Fig. 21B–D). Arched rhizoclones occur mainly across the furrows. Desmas strongly ornamented by prominent, mushroom-like tubercles, up to 15–20 µm in diameter and massive, conical spines, usually with dissolved tips (Fig. 21D). In the central part of wall, the desmas are less ornamented, but this may be the result of diagenesis. On exhalant surface of some strongly secondary silicified specimens, imprints of densely arranged, very thin oxeas, up to 350 µm in length are noted.

Remarks: *S. dissipatum* is distinguished from other representatives of *Sporadothelion* in the morphology of the exhalant surface: the openings are situated on very tall, tubular or narrow conical fistules (Hinde, 1883; Schrammen, 1924). Moreover, *S. dissipatum* has very well-developed furrows under both superficial networks, wherein on the exhalant side these furrows have a star-like arrangement (Schrammen, 1924), similarly as in *Chondriophyllum astraea* (Hinde, 1883). Due to silification of the wall, no branching of canals was observed. All other characteristic features are very clearly visible in the studied material, but the specimens from Poland differ from the material from Germany and England in more densely arranged pores on the outer surface (40–60/cm^2 after Schrammen, 1924). For this reason, the studied specimens with broken fistules on the exhalant surface resemble *Sporadothelion damaecornis*,

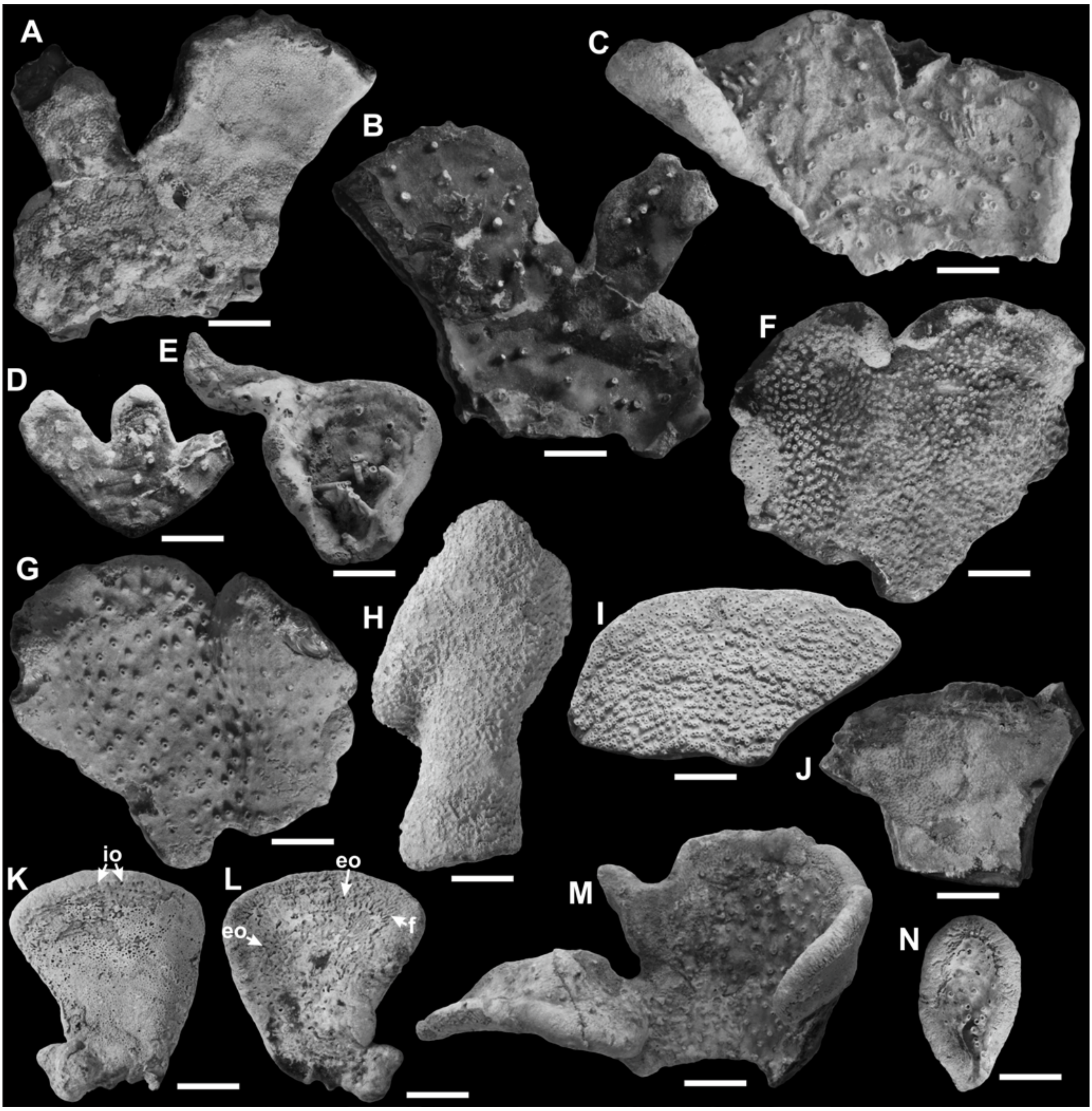

Fig. 20. Rhizomorine sponges. **A–E.** *Sporodothelion dissipatum* Schrammen, 1924; A – outer surface of the fragmentarily preserved specimen with long lobes; papillary pores locally well-preserved; ULXXV/24R/1, Bełchatów; B – inner surface of the same specimen; conical and tubular fistules with destroyed tops; C – specimen with a margin bent towards the sponge interior; long, tubular fistules with oscula on their top very well-preserved locally; ULXXV/24R/3, Bełchatów; D – inner surface of the fragmentarily preserved specimen with three short outgrows; ULXXV/24R/4, Bełchatów; E – inner surface of fan-like specimen with very long outgrows and oscula on top of the long tubular fistules; ULXXV/24R/5, Bełchatów. **F–I.** *Sporadothelion miliare* (Reuss, 1846); F – outer surface of fan-like specimen with undulating wall and turned-up margin; visible papillary pores; ULXXV/11R/1, Bełchatów; G – inner surface of the same specimen with papillary exhalant openings; H – lower view of the specimen with stem-like lower part; ULXXV/11R/2, Bełchatów; I – outer surface of flat, fan-like specimen with papillary pores; ULXXV/11R/3, Bełchatów. **J–N.** *Sporadothelion damaecornis* (Roemer, 1864); J – outer surface of the specimen with well-preserved papillary pores; ULXXV/26R/1, Bełchatów; K – outer surface of the specimen with damaged papillary pores; inhalant canal openings (io) visible where the entire porous layer has been destroyed; ULXXV/26R/4, Bełchatów; L – inner surface of the same specimen; deep, anastomosing furrows (f), and exhalant canal openings (eo) visible under the damaged external layer in the upper part of the specimen; M – inner surface of the specimen with long lobes; visible oscula on the top of conical papillae; ULXXV/26R/5, Bełchatów; N – inner surface of small specimen; visible oscula and furrows covering rounded margin; ULXXV/26R/6, Bełchatów. Scale bars 10 mm.

but the rhizoclones of the latter species, in contrast to the tuberculate desmas of *S. dissipatum*, are sparsely spiked.

Tuberculate desmas typical for *S. dissipatum* were recognized in one poorly preserved specimen with destroyed papillae from the upper Campanian of the middle Vistula River valley. This specimen was previously classified as *Verruculina miliaris* (Reuss, 1846) (Świerczewska-Gładysz, 2006), but in the light of new data about the ornamentation of desmas of the latter species (thorny rhizoclones), it is currently classified as *S. dissipatum*.

Morphology of specimens from Coniacian of Czechia described by Zahalka (1887, pp. 6–11, pl. 10, figs 1–8) as *Verruculina miliaris* (Reuss) are very similar to *S. dissipatum*, but its preservation does not allow species attribution.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene, middle Vistula River valley: upper Campanian); Germany (Lower Saxony: lower Campanian); England (Flamborough: Upper Chalk, probably lower Campanian).

Sporadothelion miliare (Reuss, 1846)
Figs 20F–I, 22A–E

partim 1846 *Manon miliaris* – Reuss, p. 78, pl. 19, figs 10–12, non fig. 13.

partim 1968 *Verruculina miliaris* (Reuss) – Hurcewicz, pp. 22–23, pl. 4, fig. 2, non pl. 4, fig. 1, non pl. 7, fig. 5 [= *Sporadothelion damaecornis*].

partim 1968 *Verruculina* cf. *damaecornis* (Roemer) – Hurcewicz, p. 23, pl. 3, figs 3.

partim 2006 *Verruculina miliaris* (Reuss) – Świerczewska-Gładysz, pp. 280–281, text-figs 38k, 41f; non text-fig. 38j [= *Sporadothelion dissipatum*] [cum syn.].

Material: 31 specimens from Bełchatów (XXV/11R/1–31), 9 specimens from Zbyczyce (ULIII/905–910, 1048, 1502, 1504), 1 specimen from Pniaki (ULIII/1636a).

Description: The material examined includes one strongly crushed, flattened, funnel-like specimen, ca. 180 mm wide, with irregularly folded wall and remains of thick, root-like outgrows. Other specimens are fragments of fan- or leaf-like sponges, up to 57 mm in size, with a thin (usually 3 mm, occasionally 5–6 mm thick), often irregularly undulating wall or divided into smaller lobes, and a turned-up margin (Fig. 20F, G, I). In the lower part of some specimens, the margins of the wall grow together to form a stem-like structure (Fig. 20H). Exhalant surface with quite evenly distributed, wide conical papillae, 1.5–2 mm in diameter near their base and ca. 1 mm high, with an osculum on the rounded top, ca. 1 mm in diameter. Density of oscula is 8–12 /cm^2. Straight, arched or winding exhalant canals are oblique to the surface of the sponge. Their openings, 0.15–0.2 mm in diameter, are densely packed on the bottom of the furrows, 0.2–0.3 mm wide, running under the external layer of the skeleton. The inhalant surface is densely covered (ca. 60–70/cm^2, occasionally 120/cm^2) by small pores (ca. 0.5–0.6 mm in diameter), located on the rounded papillae. The papillae are arranged in undulating series, separated from each other at ca. 0.3–0.9 mm. On the cross-section of the wall system, thin horizontal canals, running under the superficial network, are visible. Their arrangement is impossible to determine. Inhalant canals that branch from horizontal canals are long and bifurcated.

The superficial network on both surfaces of the sponge wall is very dense and thick (Fig. 22A–D), and sometimes covers the oscula and pores. This network consists of small (250–350 µm in size), strongly branched rhizoclones, ca. 25–30 µm thick. The rhizoclones are densely covered with fine, simple or multifurcating spines. In the superficial network on the inner surface, additionally elongated rhizoclones (200–280 µm in size) occur (Fig. 22C, D). Some of them show flattened axial part, ca. 60 µm wide (Fig. 22C). Locally occurring, young desmas are very poorly ornamented. Larger (up to 400 µm in size) and poorly branched rhizoclones with a straight or slightly arched axis occur around canals and furrows (Fig. 22E). Rhizoclones inside the wall are not visible. Imprints of densely packed, thin oxeas, oriented in one direction often occur on the upper side of strongly secondarily silicified specimens.

Remarks: *Sporadothelion miliare* is a common Late Cretaceous sponge (Schrammen, 1910, 1924; Bieda, 1933; Moret, 1926; Hurce-wicz, 1968; Świerczewska-Gładysz, 2006), but details of its desmas were poorly known, due to the poor state of preservation of the skeleton in previously described specimens. According to the description given by Schrammen (1924), the skeleton of *S. miliare* consists of strong, arched, slightly branched rhizoclones that are more or less covered with tubercles. The observations of the present authors, consistent with the illustration of Moret (1926, text-fig. 24.4), indicated that the rhizoclones are spiny. Except for large rhizoclones occurring inside the wall, there are small, highly spiky desmas, forming a superficial network.

Sporadothelion miliaris were noted in Cenomanian and Coniacian of Czechia [stratigraphy after Čech *et al.*, 1980 as *Manon miliare*: Frič (1869), *Amphitelion miliare*: Počta (1884) and *Verruculina miliaris*: Záhalka, 1887]. The morphology of some of these described specimens differs from that of *S. miliaris* (see also Schrammen, 1910, p. 139) and, moreover, the data on their desmas are too scarce to consider them as representatives of this species.

Analysis of a large number of specimens has revealed a high variability of shape, previously not known from *S. miliare*. Specimens from Zbyczyce, with the wall divided into two lobes, were classified by Hurcewicz (1968) as *S.* cf. *damaecornis*.

Occurrence: Poland (Bełchatów area: early Campanian sponges redeposited in the Miocene; Lelów area: lower Campanian; Kraków area; lower Campanian or Santonian specimens redeposited into the Miocene; middle Vistula River valley: upper Campanian and upper Maastrichtian); Germany (Lower Saxony: Turonian); England (Flamborough: Upper Chalk, probably lower Campanian); France (Provence: Santonian).

Sporadothelion damaecornis (Roemer, 1864)
Figs 20J–N, 23A–D

1864 *Verrucospongia damaecornis* – Roemer, p. 45, pl. 16, fig. 5.

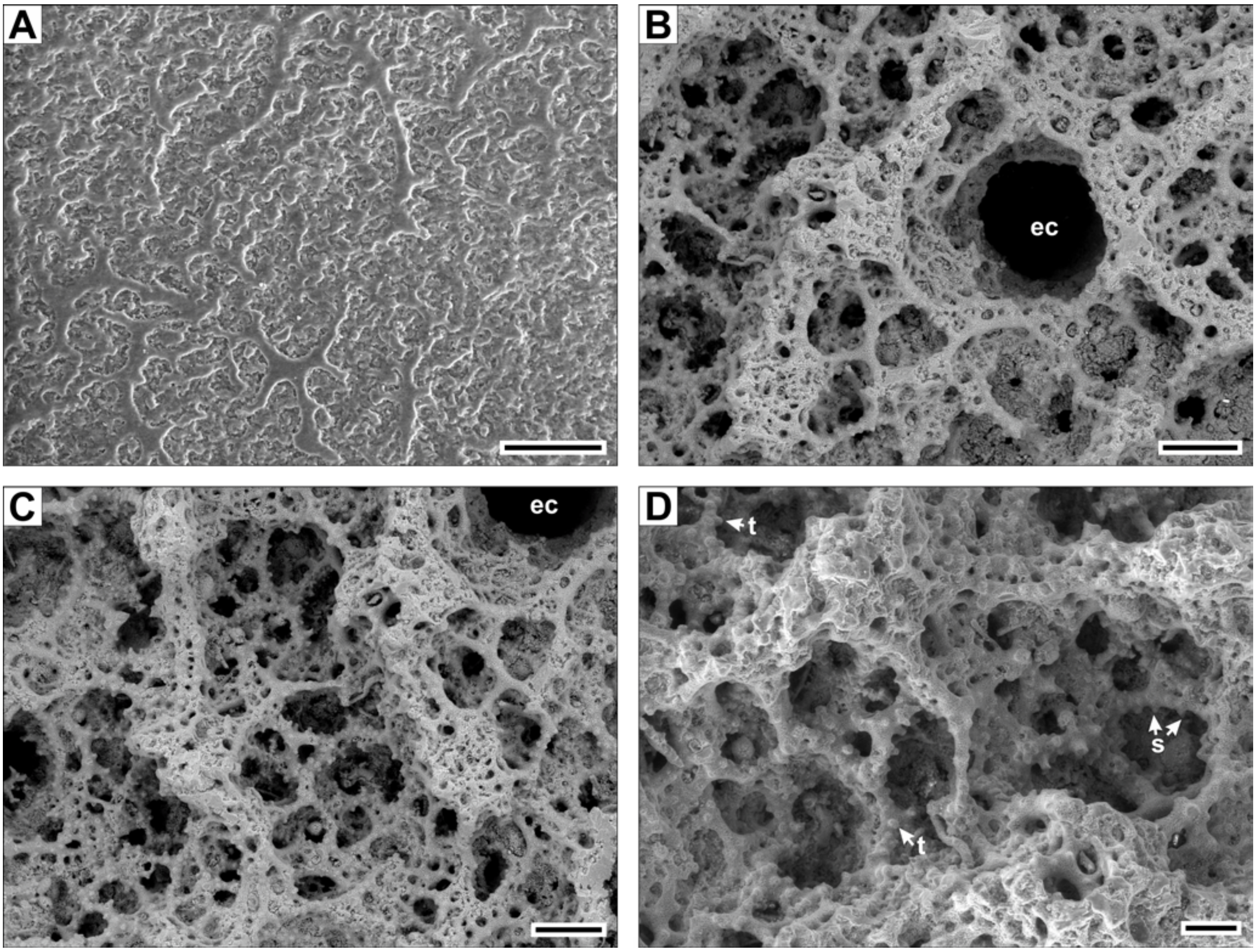

Fig. 21. Skeleton of *Sporodothelion dissipatum* Schrammen, 1924; ULXXV/24R/2, Bełchatów. **A.** Silicified superficial layer on the inner surface with poorly preserved rhizoclones. **B–D.** Part of the skeleton located under the superficial layer on the exhalant surface with horizontal furrows and exhalant canal (ec); rhizoclones with tubercles (t), and short spines (s). Scale bars 100 µm (A, D) and 200 µm (B, C).

1878 *Amphithelion damaecorne* (Roemer) – Zittel, p. 60.

1910 *Verruculina damaecornis* (Roemer) – Schrammen, p. 137.

1924 *Sporadothelion damaecornis* (Roemer) – Schrammen, pp. 121–122.

1939 *Verruculina damaecornis* (Roemer) – Bieda, pp. 9–10.

partim 1968 *Verruculina* cf. *damaecornis* (Roemer) – Hurcewicz, p. 23.

partim 1968 *Verruculina miliaris* (Reuss) – Hurcewicz, pp. 22–23, pl. 4, fig. 1, pl. 7, fig. 5.

Material: 66 specimens from Bełchatów (XXV/26R/1–26); 6 specimens from Zbyczyce (ULIII/112, 908, 915, 1127, 1167, 1628), 2 specimens from Pniaki (ULIII/912, 913).

Description: The studied material consists of mainly wall fragments, usually 5–6 mm, rarely only 4 mm thick. The more nearly complete specimens, up to 45 mm high, are fan- and ear-shaped, occasionally with slightly concave inhalant surface, or are funnel-like with thin stalk (Fig. 20J–N). Margin rounded, covered by deep furrows (visible only in well preserved specimens) (Fig. 20N), sometimes divided into short, rarely elongated lobes (Fig. 20M, N). Some specimens have remnants of root-like outgrowths, which grow both at the base and from the higher parts of the sponge. Exhalant surface with oscula, placed on the top of short (up to 2 mm high), narrow conical papillae, 0.8–1.2 mm in diameter, which are irregularly arranged, 10–15/cm^2. Papillae occasionally grow together at the base or at the apex (in specimens with a strongly concave exhalant surface). Exhalant canal openings, situated at the bottom of deep, anastomosing furrows, 0.2–0.4 mm wide. These furrows are oriented parallel to the direction of sponge growth, but in the lower part of the sponge their arrangement is often disturbed. Long exhalant canals arched or sinusoidal, probably with lateral branches. Papillary pores on inhalant surface are small, up to 0.4 mm and distributed at 180–320/cm^2. They are usually arranged in short, wavy rows, spaced at 0.2–0.3 mm, rarely in irregular groups. Furrows on inhalant surface run more or less parallel to the direction of sponge growth. Round or oval inhalant canal openings, lying in furrows, are 0.2–0.4 mm in diameter and their density is 50–80/cm^2. They are distributed in indistinct rows, parallel to the sponge margin. Forked inhalant canals straight or sinusoidal, running deep into the wall at very different angles.

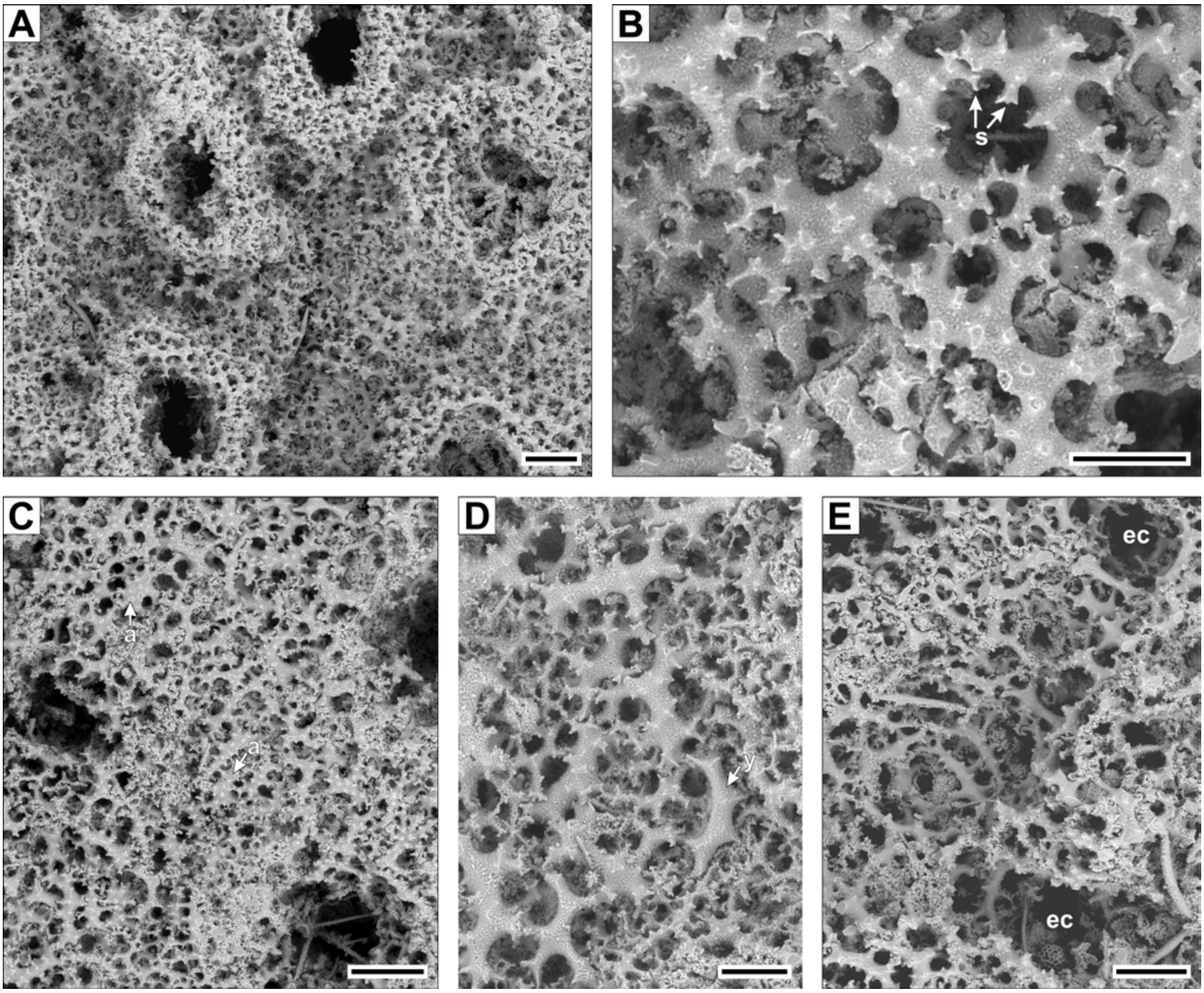

Fig. 22. Skeleton of *Sporadothelion miliare* (Reuss, 1846); ULXXV/11R/4, Bełchatów. **A, B.** Superficial network on the inhalant surface with inhalant pores; visible branched rhizoclones with fine, simple or multifurcating spines (s). **C, D.** Superficial network on the exhalant surface with oscula; among the small, densely packed rhizoclones, several with a wide axial part (a) and young, poorly ornamented ones (y) are visible. **E.** Part of the skeleton located under the superficial network on the inner surface with horizontal furrows and an exhalant canal (ec). Scale bars 100 µm (B, D) and 200 µm (A, C, E).

Compact skeletal network on both surfaces contains branched rhizoclones, up to 220 µm in size and 20-30 µm thick, with arched, rarely straight axis (Fig. 23A). Most of them have clones arising from both sides. They are ornamented by very small, blunt spines and lumps (due to diagenesis, their shape cannot be precisely determined). Deeper in the wall, a loose network is formed by slender, variously shaped rhizoclones, up to 380–400 µm in size and 30 µm thick (Fig. 23B–D). Some are branched and sometimes resemble tetraclones, others have a curved, sinusoidal or straight axis and clone usually only on one side, forming long, lateral zygoses. Elongated rhizoclones occur mainly on the wall of canals and furrows (Fig. 23C). Rhizoclones are poorly ornamented by blunt, short spines and minute lumps (?tubercles or dissolved fine spines; Fig. 23D).

Remarks: All previously described specimens of *S. damaecornis* from Germany (Roemer, 1864; Zittel, 1878; Schrammen, 1910, 1924) and Poland (Bieda, 1933; Hurcewicz, 1968) lacked preserved desmas, and until now this species has been distinguished solely on the basis of shape body and morphology of both surfaces. Schrammen (1924) also placed this species in the genus *Sporadothelion* only on the basis of the arrangement of the papillae in rows on the outer surface. The studied material allows the present authors to point out other characteristic features of this species, which are consistent with the diagnosis of *Sporadothelion*, e.g., the well-developed furrows under the outer layers of the skeleton, the branching canals and the elongated, weakly spiny rhizoclones.

The specimen illustrated by Roemer (1864) has a body with a few long lobes, therefore only specimens with the body divided into lobes were classified by Hurcewicz (1968) as *Verruculina* cf. *damaecornis*, while other ones, differing exclusively by their fan- or ear-like habitus, were included in *V. miliaris*. Analysis of rich material from Bełchatów led to the conclusion that both species, similar to *S. dissipatum*, are characterized by large variability in habitus, therefore a body with lobes cannot be considered diagnostic. In shape

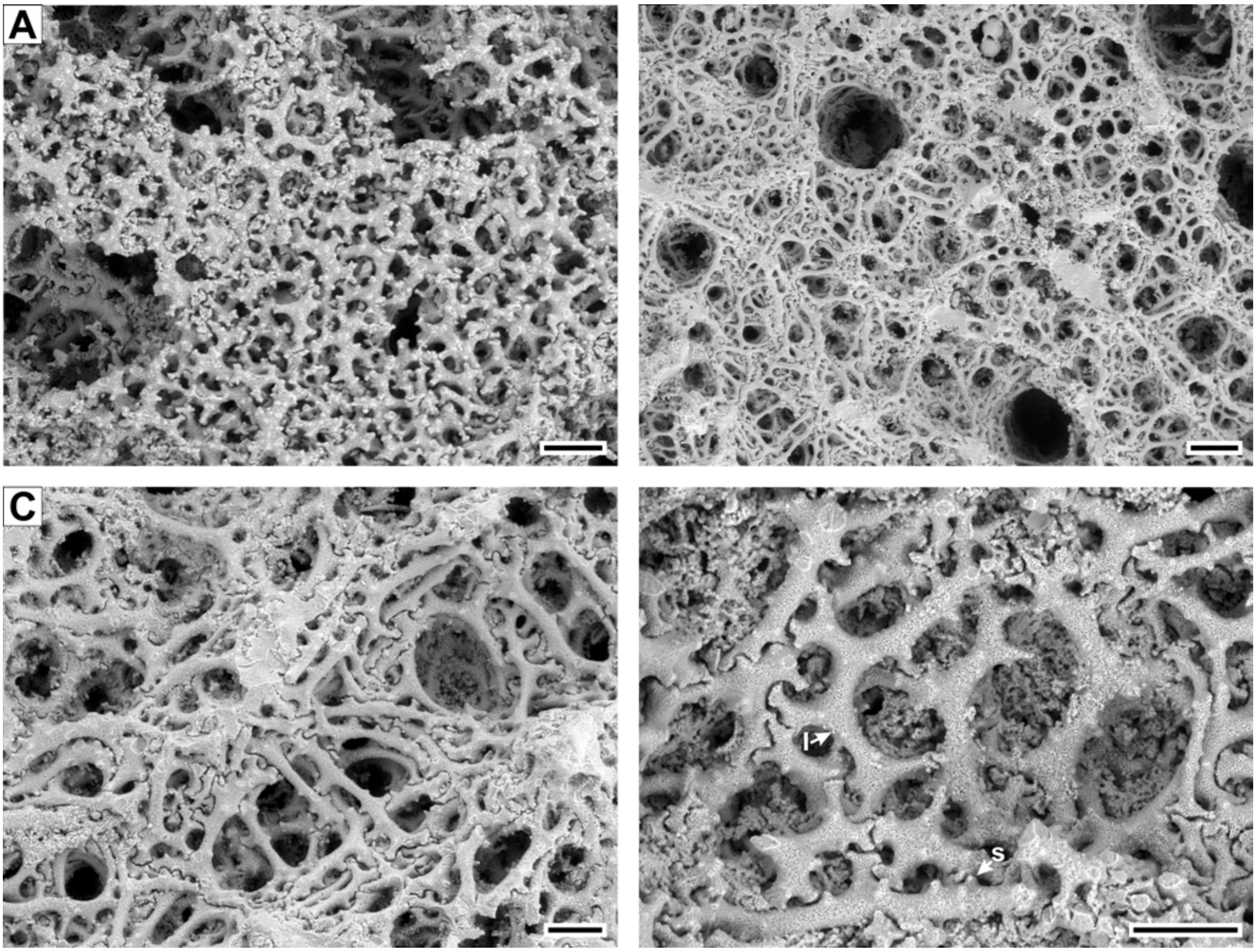

Fig. 23. Skeleton of *Sporadothelion damaecornis* (Roemer, 1864). **A.** Superficial network on the exhalant surface; locally visible horizontal furrows running beneath this network; ULXXV/26R/3, Bełchatów. **B, C.** Skeleton within the wall pierced by canals; ULXXV/26R/2, Bełchatów. **C.** Detail of the skeletal network with rhizoclones sparsely covered by spines (s) and minute lumps (l); ULXXV/26R/3, Bełchatów. Scale bars 100 μm (A, C, D) and 200 μm (B).

and size, the rhizoclones of *S. damaecornis* are similar to the desmas of *S. miliare* but differ in ornamentation; in *S. miliare* the spines are abundant, with simple or multifurcating tips, while in *S. damaecornis* the spines are less numerous and have blunt tips. In addition to the difference in the skeleton, *S. damaecornis* is characterized by narrower, more irregularly distributed papillae on the upper surface and smaller papillae on the outer surface. These differences contradict the suggestion of Bieda (1933) that *S. damaecornis* may be a morphotype of *S. miliare*.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Miocene; Lelów area: lower Campanian; Kraków area: Santonian or Campanian sponges redeposited into the Miocene); Germany (Lower Saxony: Turonian).

Chondriophyllum Schrammen, 1924

Type species: *Manon tenue* Roemer, 1840–1841, p. 3, pl. 1, fig. 7, designated by Schrammen, 1924, p. 126, pl. 2, fig. 13.
Diagnosis: See Schrammen (1924).

Chondriophyllum tenue (Roemer, 1840–1841)
Figs 24A–G, 25A–D

1840–1841 *Manon tenue* – Roemer, p. 3, pl. 1, fig. 7.

2006 *Verruculina tenuis* (Roemer) – Świerczewska-Gładysz, p. 280, text-fig. 38 h, i [cum syn.].

Material: 29 specimens from Bełchatów (XXV/7R/1–29), 1 specimen from Muniakowice (ULIII/110), 2 specimens from Zbyczyce (ULIII/746,1629), and 5 specimens from Pniaki (ULIII/1042, 1044, 1587, 1628).

Description: Thin-walled (3–4 mm thick; occasionally thicker, up to 5–6 mm), funnel-, cup-, ear- or fan-like sponges with a rounded margin (Fig. 24A–G), that is straight or with rounded lobes (Fig. 24A). The largest fragment measures 80 mm x 62 mm. Exhalant surface with oscula placed on the top of short (0.5–1 mm high), conical papillae, up to 0.3–0.8 mm in diameter at the base. Papillae distributed irregularly15–30/cm^2; rarely in some places in indistinct transverse rows (Fig. 24E). Sometimes two neighbouring papillae may fuse. Canal openings, 2–3 mm in diameter, are arranged at the bottom of thin grooves covered by a superficial network at intervals of 0.5–1.4 mm. Grooves single or anastomosing. Straight exhalant canals are perpendicular or slightly oblique to the inner surface. Papillary pores on inhalant surface are small (up to 0.3 mm in diameter) and very densely arranged, 400–500/cm^2 (in many specimens the papillae are worn off and only their central hole is visible). Sometimes, 2–3 papillae grow together at the base. Very shallow grooves on the inhalant surface are short, running more or less parallel to the direction of sponge growth. Inhalant canal openings, usually 1–2 mm in size and spaced at 0.4–0.8 mm, lead to straight inhalant canals. On available wall sections, the inhalant and exhalant canals penetrate approximately half of the wall thickness.

Compact network on both surfaces consists of small, irregularly branched rhizoclones (120–200 µm in size), which are densely covered by tiny, occasionally bifurcate spines and small lumps (Fig. 25A, C). In addition, the rhizoclones on the inhalant side of the sponges are often flattened with epirhabds up to 40 µm thick. Inside the wall, the skeleton is dense with branched rhizoclones, 180–250 µm large and 30–40 µm thick (Fig. 25D). Elongated rhizoclones, with a straight or slightly arched axis, 250–320 µm in size, occur near the canals (Fig. 25B). Spines (often partly dissolved) short, widely conical, rarely long.

Remarks: *Ch. tenue* is one of the most common Cretaceous rhizomorine species (Roemer, 1840–1841, 1864; Roemer, 1870; Schrammen, 1910, 1924; Moret, 1926; Bieda, 1933; Lagneau-Hérenger, 1962; Giers, 1964; Hurcewicz, 1968; Ulbrich, 1974; Świerczewska-Gładysz, 2006). However, some details of the skeletal structure and skeletal canalization have often been omitted in the descriptions of this species or the descriptions are contradictory. The observations of the present authors are most consistent with the characteristics of this species, given by Ulbrich (1974). This researcher was the only one to note the presence of canal openings in grooves below the superficial skeletal layers on both sponge surfaces. The size of rhizoclones recorded by Ulbrich (1974), i.e., 0.25–0.41 mm, is more variable than was assumed by Schrammen (1924), but Ulbrich (1974) did not connect it with the arrangement of desmas in the skeleton. The present study indicates that the smallest rhizoclones (usually considered typical of this species) are found on the surface of the skeleton, while the larger ones occur near the canals.

The studied sponges are characterized by high individual variability in density of oscula and pores, habitus and wall thickness. A similar intraspecific diversity was observed among specimens of *Ch. tenue* from the Campanian of Germany (Schrammen, 1910, 1924; Ulbrich, 1974; specimens from Schrammen's collection housed in the Palaeontological Collection of the University of Tübingen) and the Turonian of the Opole Basin (unpublished material of EŚG). In the collection from the Opole Basin, thick-walled specimens (ca. 6 mm) predominate, while in the studied material most of the sponges are thin-walled, like the material from the Campanian of Lower Saxony.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited in the Miocene; Lelów and Kraków areas: lower Campanian; middle Vistula River valley: upper Campanian and upper Maastrichtian; Opole area: upper Turonian–lower Coniacian); Germany (Lower Saxony: Turonian, Santonian, Campanian; Saxony-Anhalt: lower Campanian; Westfalen: upper Campanian); ?Czechia (Cenomanian); Spain (Catalonia: Aptian); France (Provence: Santonian).

Chondriophyllum astraea (Hinde, 1883)
Figs 24H–L, 26A–D

1883 *Verruculina astraea* – Hinde, p. 37, pl. 3, fig. 5, 5a.
1910 *Verruculina astraea* Hinde – Schrammen, p. 142.
1924 *Chondriophyllum astraea* (Hinde) – Schrammen, p. 127.
1926 *Verruculina astraea* Hinde – Moret, p. 86, pl. 21, fig. 1, text-fig. 24.1.
1962 *Verruculina astraea* Hinde – Lagneau-Hérenger, p. 178.
1968 *Coscinostoma fragilis* Schrammen – Hurcewicz, p. 46, pl. 13, figs 1, 2.

Material: 19 specimens from Bełchatów (ULXXV/16R /1–19), 5 specimens from Skrajniwa (ULIII/405–409), 1 specimen from Zbyczyce (ULIII/1190).

Description: The material studied consists of two complete and four destroyed funnel-like specimens, up to 66 mm high and 70 mm wide (Fig. 24H–L), and numerous wall fragments, usually 4–5 mm thick (occasionally 8 mm). Exhalant surface with small oscula (0.7–0.8 mm in diameter), which are papillary or have only a slightly protruding edge (Fig. 24 I, J). They are quite regularly spaced at 2–3 mm intervals and their density is 9–12/cm^2. In places, where the upper surface is destroyed, bifurcated exhalant canals running beneath the external layer of the choanosomal network are in the form of grooves. They are arranged radially around groups of 3–4 openings, leading to exhalant canals that penetrate deep into the wall (Fig. 24L). Apart from them, at the bottom of the grooves, there are sparsely placed small openings, which are the outlets of short lateral branches of the canals. The inhalant surface has densely distributed (about 5–6/mm^2), very small pores, 0.2–0.3 mm in diameter (Fig. 24H). These pores are usually arranged in short (2–3 mm long) wavy series at different orientations. Below the outer layer occur fine, undulating or anastomosed grooves, 0.4–0.5 mm wide (Fig. 24K). Grooves are separated by ridges of similar width. They are visible in specimens with a destroyed outer porous layer or near the upper margin of specimens, where they have a more or less longitudinal arrangement. Sparsely arranged openings on the bottom of the grooves, ca. 0.35–0.5 mm in diameter, lead to straight inhalant canals, running perpendicular or obliquely to the sponge surface.

Both sponge surfaces are covered with a dense layer of choanosomal skeleton (Fig. 26A–C), containing rhizoclones 200–300 µm in size and 30 µm thick, poorly ornamented by conical spines (their tips are often dissolved). Irregularly branched rhizoclones predominate, while arched ones are rare. On the inner side, the network sometimes covers the oscula. Occasionally preserved, poorly ornamented rhizoclones from network lying directly beneath superficial skeletal layer are 300–400 µm in size (Fig. 6A, D). They are nearly straight, arched or irregularly branched.

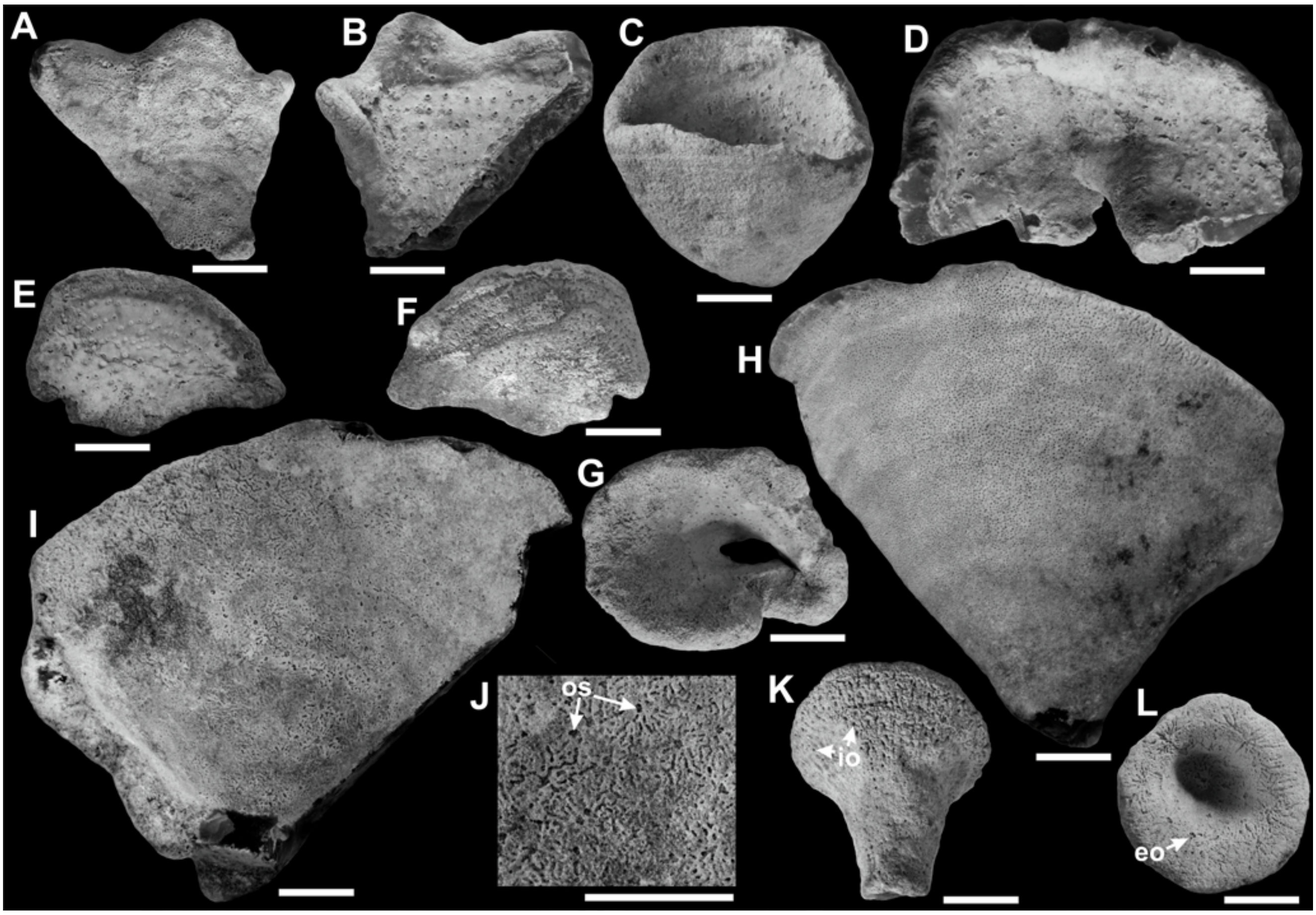

Fig. 24 Rhizomorine sponges. **A–F.** *Chondriophyllum tenue* (Roemer, 1841); A – inhalant surface with pores of fan-like specimen with the margin divided into rounded lobes; ULXXV/7R/1, Bełchatów; B – exhalant surface with small oscula of the same specimen; C – lateral view of cup-like specimen with destroyed inhalant surface; ULXXV/7R/2, Bełchatów; D – exhalant surface of ear-like specimen; ULXXV/7R/3, Bełchatów; E – exhalant surface of the specimen with oscula arranged in indistinct transverse rows; ULXXV/7R/4, Bełchatów; F – inhalant surface of the same specimen with destroyed superficial layer; visible inhalant canal openings; G – exhalant surface of the specimen with partly destroyed superficial layer; visible shallow grooves. **H–L.** *Chondriophyllum astraea* (Hinde, 1883); H – outer surface with inhalant pores of large funnel-like specimen; ULXXV/16R/1, Bełchatów; I, J – inner surface of the same specimen; visible oscula and radially arranged grooves; K – lateral view of a small specimen; outer surface with destroyed superficial porous layer and visible anastomosed grooves and inhalant canal openings (io); ULXXV/16R/3, Bełchatów; L – inner surface of the same specimen with damaged surface layer; visible groups of exhalant canal openings (eo) surrounded by radial grooves. Scale bars 10 mm.

Remarks: Two very similar rhizomorine species, characterized by a star-shaped arrangement of the exhalant canals, have been described from the Upper Cretaceous. In *Coscinostoma fragilis* the groups of “postiken” (= exhalant canal openings) are located in pits or on small elevations, while the papillary oscula are lacking, which distinguishes this species from *Verruculina astraea* Hinde, 1883 (Schrammen, 1910, 1924). All examined specimens from Poland, including the material described by Hurcewicz (1968) as *C. fragilis*, are classified here as *V. astraea*. The observed differences in the morphology of the upper surface of these sponges are related to their state of preservation. Well-preserved specimens (mainly from Bełchatów and three specimens from Hurcewicz’s collection) show a thick layer of a superficial skeleton with oscula, while specimens with a partially or completely destroyed external network and exposed groups of underlying canal openings, resemble *C. fragilis*. Some rhizoclones from the inner part of the wall of the studied specimens have shapes and sizes identical to the only desmas of *V. astraea* described so far (Moret, 1924), while others resemble the weakly branched rhizoclones of *C. fragilis* presented by Schrammen (1924) and Ulbrich (1974). In the opinion of Schrammen (1924), rhizoclones of *C. fragilis* are medium-sized, but this feature has not been confirmed by other researchers, who also observed small rhizoclones in specimens, classified as *C. fragilis* (Moret, 1926; Lagneau-Hérenger, 1962; Ulbrich, 1974), which are very similar to the branched desmas, forming a superficial network in the specimens of *V. astraea* from Poland. Therefore, the differences in the skeletons of the two species are not clear, which may be due to the fact that the descriptions were based on rhizoclones, derived from incorrectly classified specimens or that both species are in fact synonyms. The latter hypothesis may be supported by the fact that both species were often recorded in the same Cretaceous sections (Schrammen, 1910, 1924; Moret, 1926; Lagneau-Hérenger, 1962). Resolving this issue requires further research, based on specimens with better preserved skeletons.

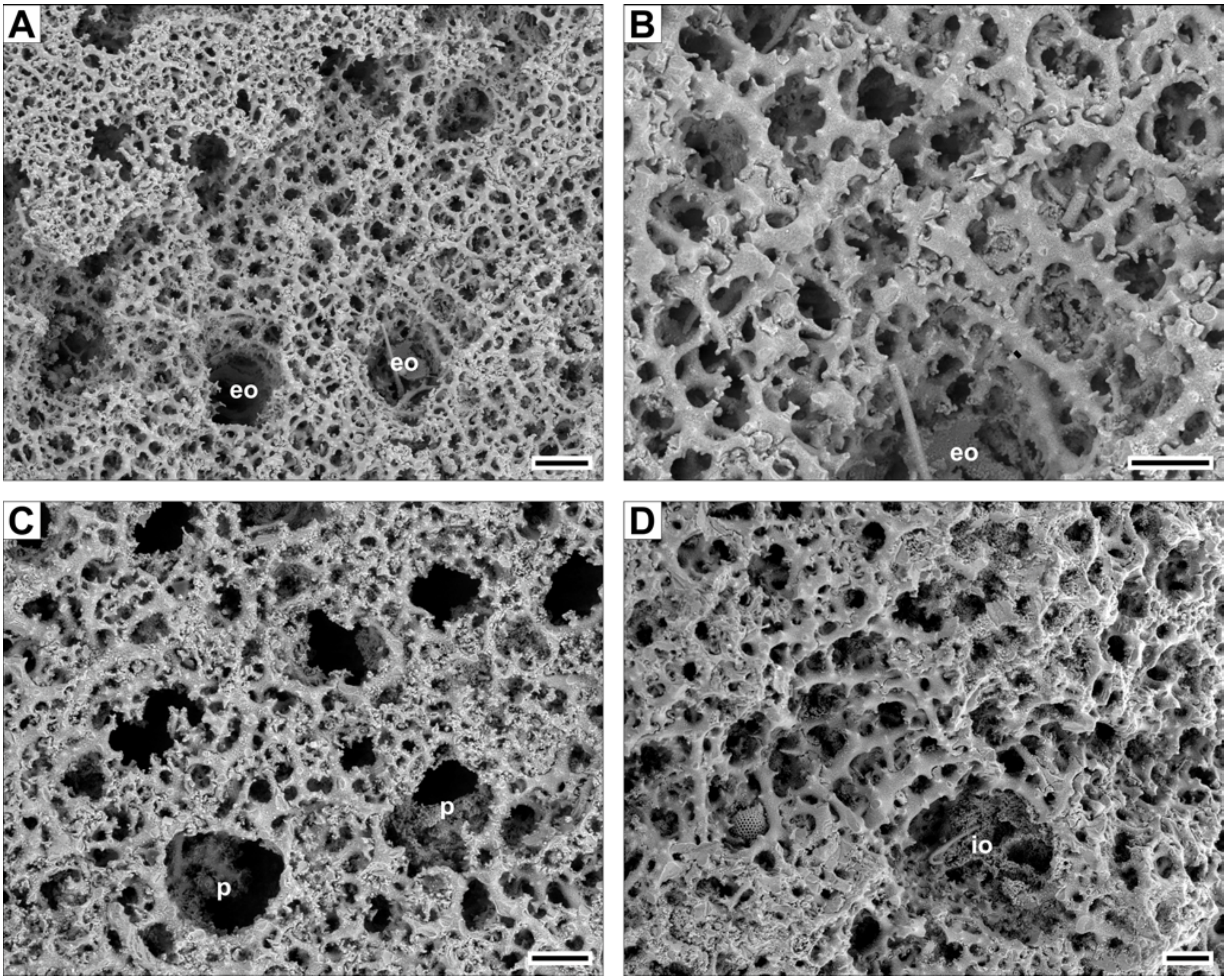

Fig. 25. Skeleton of *Chondriophyllum tenue* (Roemer, 1841). **A.** Skeleton with fine groves and exhalant canal openings (eo), partially covered (top-left) by a dense superficial network; ULXXV/7R/6, Bełchatów. **B.** Detail of the skeleton with exhalant canal openings (eo); rhizoclones spiny and branched; elongated rhizoclones near the canal. **C.** Superficial network on the inhalant surface with pores; ULXXV/7R/4, Bełchatów. **D.** Detail of the skeleton beneath the superficial network; visible spiny rhizoclones and an inhalant canal opening (io). Scale bars 100 μm (B–D) and 200 μm (D).

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian); Germany (Lower Saxony: upper Campanian); England (Flamborough: Upper Chalk, probably lower Campanian); France (Provence: Santonian); Spain (Catalonia: Aptian).

Genus *Amphistomium* Schrammen, 1924

Type species: *Amphistomium aequabile* Schrammen, 1924, p. 115, pl. 2, fig. 10, pl. 15, fig. 10, by original designation.
Diagnosis: See Schrammen (1924).

Amphistomium spinatum Schrammen, 1924
Fig. 27A–F

1924 *Amphistomium spinatum* – Schrammen, p. 116.

Material: 17 specimens from Bełchatów (ULXXV/25R/1–17).

Description: Leaf-, ear- or fan-like sponges, with wall 4–5 mm thick, sometimes composed of lobes joined together, up to 50 mm in size. Occasionally sponges body is divided into long, flattened twigs. On both surfaces, canal openings are located on the top of high (up to 3–4 mm), narrow conical or tubular fistules. On the exhalant side, the fistules are 1.5 mm in diameter. Their density is 6–12/cm^2. On the inhalant surface, the fistules, ca. 1 mm in diameter, are more densely arranged, at 16–20/cm^2. Deep furrows, 0.2–0.3 mm wide, running under the superficial networks of both sides of the wall are observed only in the cross-sections of a few specimens (the arrangement of these furrows is not visible in the plane parallel to the sponge surface). Short segments of canals, visible in the cross-section of the wall, are variably oriented and probably are lateral branches of exhalant canals.

Both surfaces are covered by a secondary siliceous layer, consisting of weakly spiny, small (ca. 200–250 μm in size),

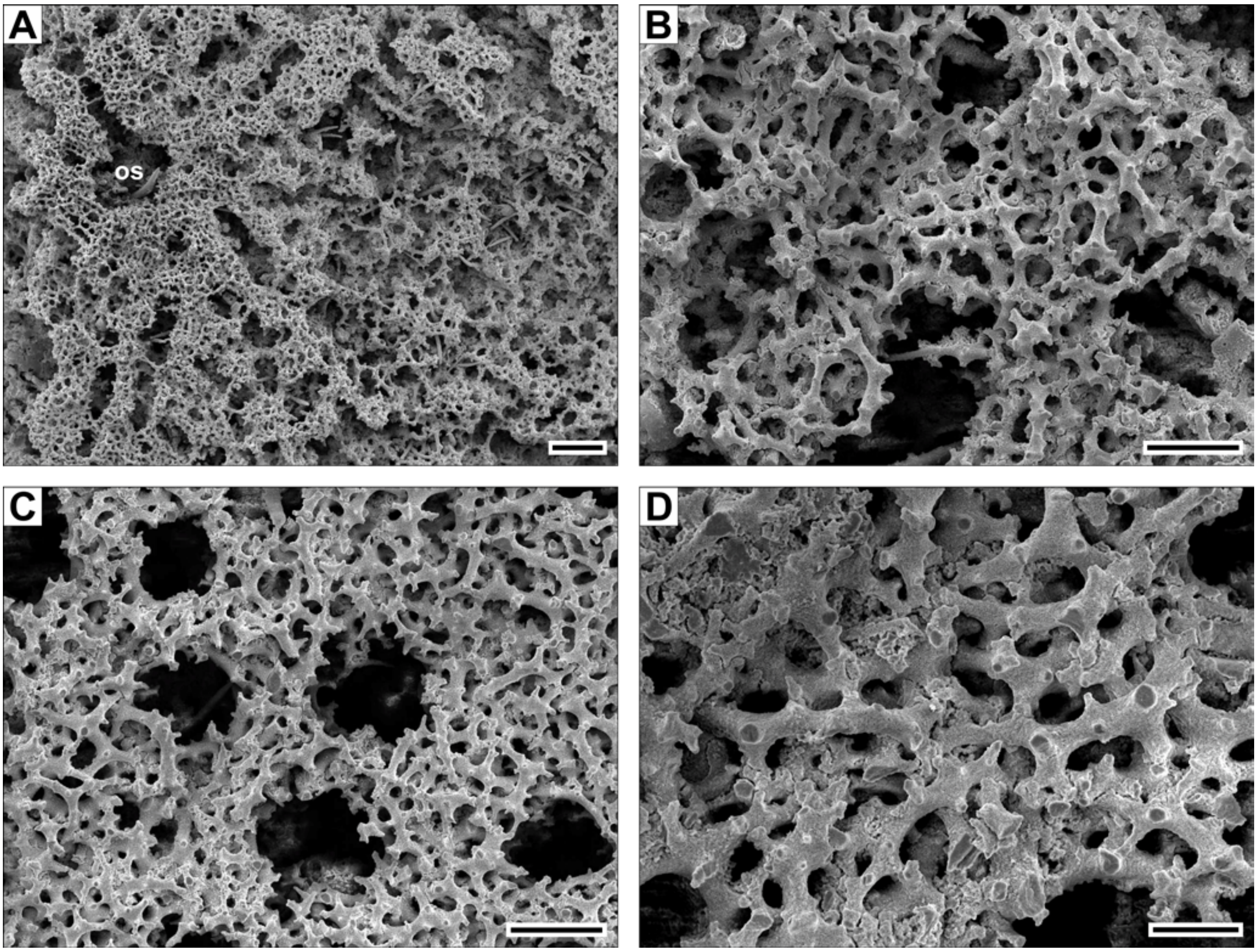

Fig. 26. Skeleton of *Chondriophyllum astraea* (Hinde, 1883). ULXXV/16R/2, Bełchatów. **A.** Partly destroyed superficial network on the inner surface with osculum (os) and furrows (left) and skeleton under the superficial layer (right). **B.** Detail of the superficial network. **C.** Superficial network on the outer surface with pores. **D.** Detail of the skeleton under the superficial network on the outer surface; visible poorly ornamented rhizoclones. Scale bars 100 µm (D), 200 µm (B, C) and 500 µm (A).

branched rhizoclones (desmas very rarely recognizable, mainly near the edge of the sponge). Spines are massive, wide-conical. Single desmas recognizable in the strongly secondarily silicified network (occasionally visible in the cross-section of the wall) are elongated rhizoclones, up to 300–380 µm in size, with very short clones. Imprints of thin oxeas, densely packed and oriented in one direction, approximately 2–3 mm long, are often visible on the upper surface.

Remarks: The specimens described here were included in *A. spinatum*, due to their very characteristic morphology.

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited in the Miocene); Germany (Lower Saxony: Campanian).

Genus *Amphichondrium* Schrammen, 1924

Type species: *Verruculina convoluta* Quenstedt, 1878, p. 368, pl. 132, figs 49–51, designated by Schrammen, 1924, p. 128.

Diagnosis: See Schrammen (1924).

Amphichondrium convolutum (Quenstedt, 1878)
Figs 27G–J, 28A–D

1870 *Chenendopora tenuis* – Roemer, pl. 31, fig. 1.

1878 *Verruculina convoluta* – Quenstedt, p. 368, pl. 132, figs 49–51.

1910 *Verruculina convoluta* Quenstedt – Schrammen, p. 138 [cum syn.].

1924 *Amphichondrium convolutum* Quenstedt – Schrammen, p. 128, pl. 3, fig. 12.

Material: 14 specimens from Bełchatów (ULXXV/20R/1–19), 1 specimen from Skrajniwa (ULIII/1125), 3 specimens from Zbyczyce (ULIII/ 931, 938, 1515).

Description: Ear- or fan-like sponges, up to c. 70 mm high and 120 mm wide (Fig. 27I, J). Wall, usually 5–8 mm thick, rarely 3–4 mm, is often folded. The folds sometimes grow together to form tubes with the exhalant surface outwards (Fig. 27G, H). The margin of the less destroyed specimens is slightly thickened, rounded, and often bent towards the exhalant surface. The small, irregular base of sponges is often attached to a fragment of another sponge. Remains

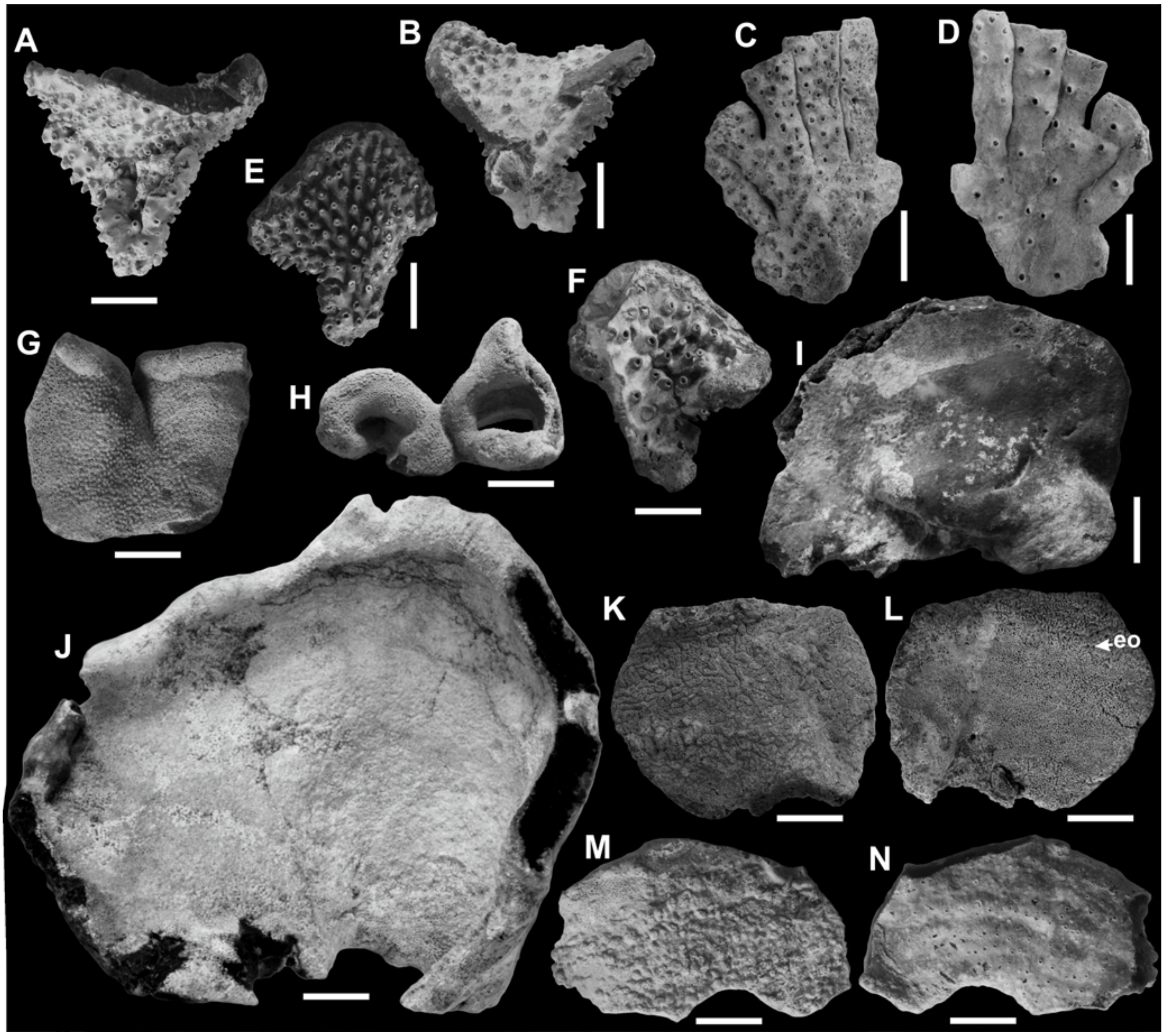

Fig. 27. Rhizomorine sponges. **A–F.** *Amphistomium spinatum* Schrammen, 1924; A – inhalant surface of the specimen with preserved basal part; canal openings located on tubular fistules; ULXXV/25R/1, Bełchatów; B – exhalant surface of the same specimen; tubular fistules with destroyed tops; C – inhalant surface of the fragmentarily preserved specimen with twig-like outgrows; tubular fistules destroyed; ULXXV/25R/3, Bełchatów; D – exhalant surface of the same specimen with destroyed tubular fistules; ULXXV/25R/2, Bełchatów; E – inhalant surface of the specimen; ULXXV/25R/3, Bełchatów; F – exhalant surface of the same specimen. **G–J.** *Amphichondrium convolutum* (Quenstedt, 1878); G – lateral view of the specimen with folds growing together and exhalant surface visible on the outside; ULXXV/20R/2, Bełchatów; H – upper view of the same specimen; I – inhalant surface of the specimen with locally well-preserved papillary pores; ULXXV/20R/3, Bełchatów; J – exhalant surface of the largest specimen with papillary pores; ULXXV/20R/4, Bełchatów. **K, L.** *Plinthodermatium exile* Schrammen, 1910; ULXXV/27R/1, Bełchatów; K – inhalant surface of fragmentarily preserved specimen, covered by anastomosed, narrow furrows and small pores; L – exhalant surface of the same specimens with densely arranged pores; exhalant canal openings visible near the margin, where superficial layer is destroyed. **M, N.** *Plinthodermatium* sp.; ULXXV/28R/1, Bełchatów; M – inhalant surface of the fragmentarily preserved specimen with prominent protuberances and densely arranged pores; N – exhalant surface of the same specimen with sparsely arranged pores. Scale bars 10 mm.

of numerous, thin outgrowths directed outwards from the inhalant sponge surface are preserved in some specimens. Outgrowths, running on the exhalant surface, occur occasionally as well. Both surfaces are covered by densely packed, small papillae (they are well preserved especially in the concave parts of the sponge wall) with pores situated on their top. On the exhalant surface, the papillae are 0.2–0.3 mm in size, and their density is 120–200/cm^2. Inhalant surface with slightly smaller (0.1–0.2 mm in diameter) and more densely arranged pores (density up to 250/cm^2). Canals inside the wall not visible due to secondary silification of the sponge.

The compact skeletal network on both surfaces consists of branched rhizoclones with a straight or slightly arched

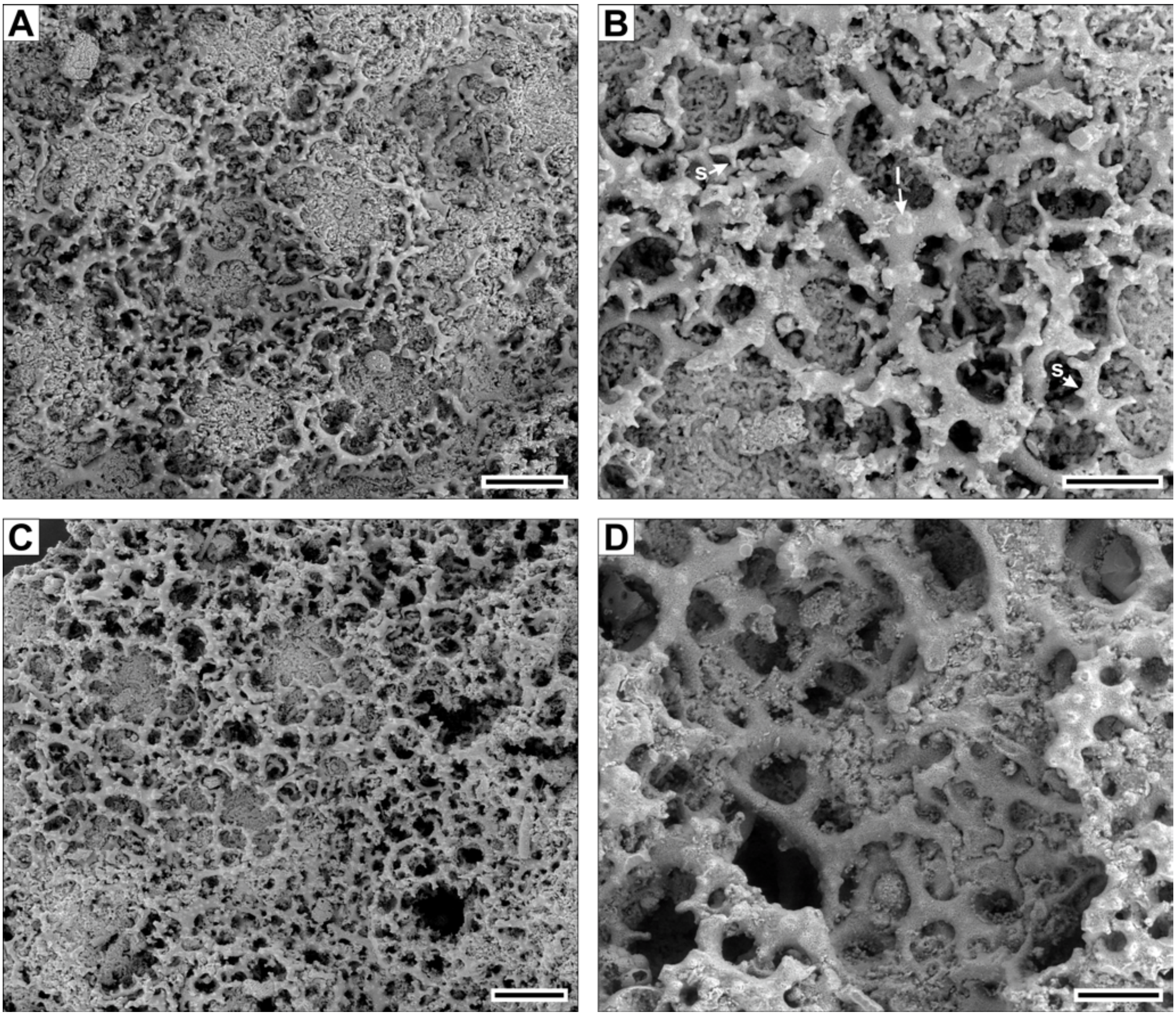

Fig. 28. Skeleton of *Amphichondrium convolutum* (Quenstedt, 1878); ULXXV/20R/1, Bełchatów. **A, B.** Skeleton on the exhalant surface of the specimen; visible rhizoclones covered by short spines (s) and tubercles with tops divided into small lumps (l). **C.** Skeleton on the inhalant surface. **D.** Rhizoclones under the superficial layer (central), probably located on the wall of the canal. Scale bars 100 μm (B, D) and 200 μm (A, C).

axis, 180–250 μm in size and 20–40 μm thick (Fig. 28A–C). The largest, poorly branched rhizoclones are up to 350 μm (Fig. 28C). Clones usually simple, but sometime forked. Rhizoclones are covered by short, conical spines, with rounded tips (the effect of dissolution?), and less numerous tubercles with the top often divided into 2–3 small lumps (or fine spines destroyed as a result of diagenesis). Small fragments of choanosomal network occasionally visible just below the superficial layer covering the upper surface, are less dense and consist of irregularly branched, poorly ornamented rhizoclones, up to 300 μm in size. Locally within this network (probably on the wall of furrows or canals), rhizoclones are tightly packed (Fig. 28D).

Remarks: The macroscopic features of the specimens examined do not differ from those of the specimens of *Amphichondrium convolutum*, described from the Upper Cretaceous of England and Germany (Hinde, 1883; Roemer, 1870; Quenstedt, 1878; Schrammen, 1910, 1924), and also from Schrammen's specimen, housed in the Palaeontological Collection of the University of Tübingen (no. 1854/38). The shape and size of desmas of the specimens from Bełchatów are also typical for this species (Schrammen, 1924). Specimens with a destroyed surface resemble *Chonella tenuis*, but the latter species is characterized by larger, poorly branched rhizoclones (Schrammen, 1924, pp. 128–129, pl. 3, fig. 9).

Occurrence: Poland (Bełchatów: early Campanian sponges redeposited into the Neogene; Lelów area: lower Campanian; Opole area: Turonian); Germany (Lower Saxony: Turonian, Campanian); England (Flamborough: Upper Chalk, probably lower Campanian).

Genus *Plinthodermatium* Schrammen, 1910

Type species: *Plinthodermatium exile* Schrammen, 1910, p. 158, pl. 23, fig. 1, by monotypy.

Diagnosis: See Schrammen (1924).

Plinthodermatium exile Schrammen, 1910
Fig. 27K, L

1910 *Plinthodermatium exile* – Schrammen, p. 158, pl. 23, fig. 1.

1924 *Plinthodermatium exile* – Schrammen, p. 127, pl. 3, fig. 7, pl. 14, fig. 7.

Material: 3 specimens from Bełchatów (ULXXV/27R/1–3).
Description: The examined specimens consist of only lamellar fragments 3 mm thick. The largest fragment is 40 mm in size (Fig. 27K, L). Inhalant surface with anastomosed furrows, 3 mm wide, which separate flat protuberances, 1–3 mm in size. Very small pores, 0.1 mm in diameter, are located on protuberances and in furrows, where they are arranged in 1–2 rows. Their density is ca. 25/mm^2. Pores on exhalant, smooth surface are slightly larger, ca. 0.2 mm in diameter, and less densely arranged (16/mm^2). Near the margin of one specimen, where superficial layer is destroyed, there are sparsely arranged exhalant canal openings, ca.0.3 mm in diameter, at the bottom of thin anastomosing furrows.

Poorly preserved dense network on both surfaces contains small (usually 200–250 µm in size), branched spiky rhizoclones. Rhizoclones arranged across the furrows are elongated and slightly larger, up to 300 µm in size.
Remarks: *P. exile* is a very rare species, known so far only from a few specimens from the Campanian of Germany. Despite secondary silicification, all features typical of this species, described by Schrammen (1910, 1924) and observed in the undescribed specimen from the Schrammen's collection housed in the Palaeontological Collection of the University of Tübingen (no. 1854/28), are very readily recognizable in the material from Poland.
Occurrence: Poland (Bełchatów: early Campanian sponge redeposited in the Neogene); Germany (Lower Saxony: upper Campanian).

Plinthodermatium sp.
Fig. 27M, N

Material: 1 specimen from Bełchatów (ULXXV/28R/1).
Description: Fragments of lamellar sponge, measuring 45 mm, with partly preserved rounded, probably upper margin (Fig. 27M, N). Thickness of wall is 3 mm. Inhalant surface with prominent protuberances, 1–2 mm in size. Protuberances hemispherical or irregular, often composed of 2–3 connected nodules. They are unevenly arranged, separated by thin furrows (0.2–0.3 mm wide) or a wide depression, up to 2.5 mm in size. Near the sponge margin, the protuberances are less numerous and flattened. Pores covering all elements of the sculpture on the inhalant surface are 0.15–0.2 mm in diameter. Their density is ca. 12–16/mm^2. Pores with slightly protruding edge, 0.5 mm in diameter, are sparsely arranged on the exhalant side and their density is only 45/cm^2.

The specimen is strongly secondarily silicified, thus single, branched rhizoclones, ca. 250 µm in size and with massive spines are observed only in some places near the inner surface.
Remarks: The specimens described here differ from *P. exile* mainly in the significantly less densely arranged pores on the exhalant surface and also in the shape of protuberances on the inhalant surface. However, a new species is not proposed, due to scarcity of the material and the poorly preserved skeleton.
Occurrence: Poland (Bełchatów: early Campanian sponge, redeposited in the Neogene).

TAXONOMIC COMPOSITION OF CAMPANIAN RHIZOMORINE LITHISTIDS FROM THE MIECHÓW AND MOGILNO-ŁÓDŹ SYNCLINORIA

Rhizomorine sponges are the most numerous and taxonomically diverse group of Campanian lithistids from the Miechów and Mogilno-Łódź synclinoria. In the material studied, 28 species were distinguished, including one new species *Cryptothelion sujkowskii* sp. nov., and 15 species, which were reported from the Cretaceous of Poland for the first time (Tab. 2).

Of the 24 previously described species (Bieda, 1933; Hurcewicz, 1968) from the opoka and marls of the Miechów Synclinorium, only 12 taxa were accepted after revision, while the genus affiliation of several species was changed. The new species proposed by Hurcewicz (1968), *Verruculina abnormis* and *Coelocorypha bulbosa*, are recognized here as junior synonyms of *Stichophyma multiformis* (Bronn, 1837) and *Cytoracia turbinata* Schrammen, 1910, respectively. Specimens shaped like thin twigs, distinguished by Hurcewicz (1968) as the new species *Bolidium arbustum*, are probably only root-like outgrowths, often occurring on the specimens of several rhizomorine species studied here. The taxonomic position of unique specimens, described by Hurcewicz (1968) as the new species *Stichophyma pumiliformis*, *Scytalia* sp. and *Trachynotus auriculus* (Schrammen, 1910), also remains undetermined due to the poor state of preservation of their skeleton and, in the case of the latter, due to the destruction of the specimen during preparation with hydrochloric acid applied by Hurcewicz. Specimens of five species, described by Hurcewicz (1968), were included in other rhizomorine taxa, which were recognized in the material from Bełchatów (see systematic part).

The taxonomic composition of the Campanian assemblages from the Miechów and Mogilno-Łódź synclinoria is similar, with nine species recorded only in the gravels at the Bełchatów Lignite Mine. Of these, seven are rare species, represented by single or only a few specimens. Therefore, the present authors interpret that these differences in composition may be due to the fact that the material from Belchatow is much more numerous.

Most of the species described here are also known from the Turonian–Campanian sponge fauna of Europe. Only a few are recorded in older (Aptian of Spain, Cenomanian of the Czechia) or younger (late Maastrichtian of Poland) assemblages (Tab. 2). Nevertheless, representatives of some Cretaceous genera were still living in the Paleogene and Neogene (Moret, 1924, 1926; Matteucci and Russo, 2012; Frisone *et al*., 2016), but only one species, *Pachyselis*

Table 2

Stratigraphic and palaeogeographic distribution of rhizomorine sponges studied here.

Rhizomorinid species	Aptian	Albian	Cenom.	Turon.	Coniac.	Santon.	Campan.	Maastr.
Amphichondrium convolutum (Quenstedt, 1878)*				■ G, O	— —	— —	▩ ■ ?E G	
Amphistomium spinatum Schrammen, 1924*							▥ ■ G	
Amphithelion crassum (Roemer, 1864)*				■ G	— —	— —	▥	
Amphithelion reussi (M'Coy, 1848)						■ ?K	▩ ▤ ■ ?E G	
Aulosoma radiciformis (Phillips, 1835)	■ S	— —	— —	■ F	■ F	— —	▩ ■ ?E G	
Aulosoma tuberculosa (Roemer, 1864)				■ F	■ F	■ G	▩ ■ G	
Chondriophyllum astraea (Hinde, 1883)*	■ S	— —	— —	— —	— —	■ F	▩ ■ ?E G	
Chondriophyllum tenue (Roemer, 1841)	■ S	— —	■ ?C	■ G,O	■ O —	■ F,G	▩ ■ ?E G V	— — ■ V
Cryptothelion sujkowskii sp. nov.*							▥	
Cytoracia turbinata Schrammen, 1910*						■ F	▩ ■ G	
Heterothelion cupula (Schrammen, 1910)						■ G	▩ ■ G	
Heterothelion cf. *cupula* (Schrammen, 1910)*							▩	
Heterothelion lobata Schrammen, 1924*					■ ?G	■ ?G	▥	
Jereica micropora Moret, 1926*						■ F	▩	
Jereica polystoma (Roemer, 1864)					■ F	— —	▥ ▤ ■ G	
Leiochonia cryptoporosa Schrammen, 1901				■ F	■ F	■ F	▩ ▤ ■ G	
Pachyselis azoricoides (Moret,1926)*	■ S	— —	— —	— —	— —	■ F	▥ —	— — —
Plinthodermatium exile Schrammen, 1910*							▥ ■ G	
Plinthodermatium sp.*							▥	
Pseudoscytalia terebrata (Phillips, 1835)				■ F	— —	■ F	▩ ■ ?E G	
Seliscothon planum (Phillips, 1835)				■ F,G	■ F	■ F	▩ ▤ ■ ?E G	
Seliscothon verrucosum Schrammen, 1924						■ G	▩ ■ G	
Seliscothon sp.*							▥	
Sporadothelion damaecornis (Roemer, 1864)				■ G	— —	■ ?K	▩	
Sporodothelion dissipatum Schrammen, 1924*							▥ ■ ?E,G V	
Sporadothelion miliare (Reuss, 1846)				■ G	— —	■ ?K,F	▩ ■ ?E V	— — ■ V
Stichophyma multiformis (Bronn, 1837)*							▩ ■ ?E G	
Verruculina aurita (Roemer, 1864)*						■ G	▩ ■ G	

■ occurrence in the European Basin ▩ occurrence in the Mogilno-Łódź and Miechów synclinoria

▤ occurrence only in the Miechów Synclinorium ▥ occurrence only in the Mogilno-Łódź Synclinorium

C – Czechia (after Počta, 1884); *E* – England (after Hinde, 1883); *F* – France (after Moret, 1926; Lagneau-Hérenger, 1967); *G* – Germany (after Roemer, 1840–1841, 1864; Roemer, 1870; Griepenkerl, 1889; Schrammen, 1910, 1924; Gierst, 1964; Ulbrich, 1974); *K* – Poland, Kraków area (after Bieda, 1933); *O* – Poland, Opole area (after F. Roemer, 1870); *S* – Spain (after Lagneau-Hérenger, 1962); *V* – Poland, middle Vistula River valley (after Świerczewska-Gładysz, 2006, 2012); distribution of species in the Campanian of Miechów Synclinorium (after Bieda, 1933; Hurcewicz, 1968), complemented by data from the present study; species recorded in Poland for the first time are marked with an asterisk.

azoricodes (Moret, 1926), was found in post-Cretaceous deposits, i.e., the Eocene of Belgium (Moret, 1926). The discontinuous stratigraphic record of some species is probably due to poor recognition of the Cretaceous lithistid sponge fauna.

The species composition of the rhizomorine fauna studied, like the previously described assemblages of other lithistids from the Campanian of southern and central Poland (Świerczewska-Gładysz, 2016, 2017; Świerczewska-Gładysz and Jurkowska, 2022, 2023), shows the greatest similarity to the fauna from the Campanian of Germany. Eighteen species are in common with the Campanian assemblages of Lower Saxony and Saxony-Anhalt (Schrammen, 1901, 1910, 1924; Ulbrich, 1974; Tab. 2). The stratigraphic range of four of these is restricted to the Campanian, and they have been known until now only from Germany. This indicates that within the Campanian European epicontinental sea there was a broad connection between the Lower Saxony and Subhercynian basins and the basins of central and southern Poland, enabling the migration of sponges.

Ten species found in the studied collection were noted in the Upper Chalk of England (Phillips, 1835; Hind, 1883; Tab. 2). The age of these fossils is problematic, but description given by Hinde (1883) and the observations of others (Witham, 1993; Wood, 2002) suggest that they probably came from the Flamborough Sponge Beds of early Campanian age.

REMARKS ON THE ECOLOGY OF CRETACEOUS RHIZOMORINE SPONGES

Recent rhizomorine sponges, included in the families Azoricidae, Scleritodermidae, and Siphonidiidae, prefer warm seas and many of them have a worldwide distribution (Van Voogd *at el*., 2024). Most representatives of these three families are deep-water sponges (Pisera and Lévi, 2002a–c; Longo *et al*., 2005), often found at depths of > 500 m (Schlacher-Hoenlinger *et al*., 2005; Maldonado *et al*., 2015; Carvalho *et al*., 2020) or even > 1,000 m (Kelly, 2007; Xavier, 2021). Only a few species are noted in shelf seas at depths of < 50 m, and some of these are associated with submarine caves (Gomes, 1988; Muricy and Minervino, 2000; Perez *et al*., 2004; Manconi *et al*., 2006; Gómez *et al*., 1998; Santín *et al*., 2024).

Currently, the only evidence for the existence of deep-sea rhizomorines in the Cretaceous is the poorly preserved loose rhizoclones, recorded in the El Rayo Formation in Puerto Rico, deposited in the environment of the slope of an island arc (Pisera *et al*., 2006). Loose rhizoclones have been found among spicules, occurring in the Cenomanian deep-water facies of the Skole Nappe (Carpathian basin), but these spicules were transported over a long distance and may have originated in a much shallower environment (Bąk *et al*., 2014). Additionally, loose rhizoclones have been recorded in the Aptian of the Pieniny Klippen Belt (Slovakian Western Carpathians), which at the time was located at the edge of the Palaeoeuropean shelf, rimming the northermost margin of the Mediterranean Tethys (Michalík *et al*., 2008). These deposits are interpreted as the facies of outer shelves. Most other reports of the occurrence of Cretaceous rhizomorine sponges come from the deposits of the European epicontinental sea.

Defretin-Lefranc (1960) concluded, on the basis of the available data on the occurrence of rhizomorines in the Cretaceous deposits of France, that these fossil sponges are characteristic for nearshore, detrital facies. Rhizomorines occurring in detrital facies are known also from Czechia. They are noted in the late Cenomanian nearshore sandstones of the southern part of the Bohemian Basin (Počta, 1884, 1892; stratigraphy after Čech *et al*., 1980; Valečka, 2020) and lower Turonian clayey and silty deposits, exposed in a few localities in the Chrtníki and Plaňany areas, Bohemian Basin (Žítt *et al*., 2006, 2015). The sponge assemblage with rhizomorines from the latter area is recognized as intermediate between shallow (nearshore) and deep-water (outer shelf) assemblages. In the Cenomanian–lower Turonian siliceous clays and silts of the Danubian Basin (southern Germany), where hexactinellids and other lithistids are abundant, rhizomorines are very rare and represented by only two species (Wagner, 1963; Schneider *et al*., 2013). Also, only one species was described from the Turonian glauconitic sandstones of the Münsterland Basin (western Germany; Rauff, 1933). More taxonomically diverse rhizomorines occur in the nearshore Santonian and lower Campanian sandy, clayey, and silty deposits of Subhercynian Basin (Saxony-Anhalt, Germany; Griepenkerl, 1889; Schrammen, 1910; Ulbrich, 1974). However, among the 16 rizomorine species, distinguished in these facies by Ulbrich (1974), only one species (*Seliscothon mantelli* Goldfuss, 1831) is common and in terms of abundance, rhizomorines are less numerous than the co-occurrence of other lithistid sponges.

Cretaceous rhizomorine sponges are not limited to detrital deposits. They often occur in marls /marly-limestones, but their frequency and diversity vary . In lower Campanian marls of the Subhercynian Basin, interpreted as offshore facies, a rhizomorine fauna is represented by nine species, of which the most numerous are *Chondriophyllum tenue* (Roemer, 1840–1841) and *Jereica polystoma* (Roemer, 1864; Ulbrich, 1974). The percentage of rhizomorines in this sponge assemblage is slightly higher than that of the shallow-water facies in this area. The most numerous and taxonomically diverse Cretaceous rhizomorines, represented by approximately 40 species, were described from the lower and upper Campanian marls/marly limestones of Lower Saxony (Schrammen, 1901, 1910, 1924), deposited in a quiet environment, below the storm wave base (Wiese *et al*., 2013). Taxonomically diverse rhizomorines were also distinguished in the sponge assemblage, occurring in the Aptian marls and limestones of Catalonia (Spain; 20 species: Lagneau-Hérenger, 1962; lithology after Moreno, 2005), the Santonian marly-limestone facies of Saint-Cyr and/or Nice areas (ca. 15 species after Moret, 1926) and the Coniacian of the Paris Basin (ca. 10 species after Moret, 1926). However, except for a few species, rhizomorine sponges in these assemblages show a low frequency. A few rhizomorine species are noted in the marly limestones and marls of the Turonian of the Synclinal d'Eygaliers (Drôme Department, southern France; Lagneau-Hérenger, 1967; lithology after Letourneur and Porthault, 1966), the lower Santonian of Chalvet (Saint-André-des-Alpes, Alpes-de-Haute-Provence; Bert and Breton, 2017) and the Campanian of Münsterlandes (Gasse *et al.*, 1988). Three rhizomorine species were also reported from the upper Turonian and lower Coniacian marly limestones and marls of the Opole Basin (southern Poland; Roemer, 1870; Leonhard, 1897; Schrammen, 1910; Świerczewska-Gładysz *et al.*, 2019), but in the currently available sections, rich in hexactinellids, only very rare *Chondriophyllum tenue* is noted (unpublished data of EŚG). The marly-calcareous facies of the Opole Basin were deposited in oligotrophic conditions (Jurkowska *et al.*, 2018; Płachno *et al.*, 2018), which are tolerated well by hexactinellid sponges (Leys *et al.*, 2004).

A large part of the collection from Miechów Synclinorium studied here comes from the lower Campanian marls of Skrajniwa (Lelów area; Tab. 1), where rhizomorines are represented mainly by massive sponges (*Heterothelion cupula*, *Aulosoma radiciformis*, *Pseudoscytalia terebrata*). This is probably a taphonomic effect, as these secondarily silicified fossils were collected from soil covering the weathered marl.

The abundant secondary silicified rhizomorines from the Miechów Synclinorium were also noted in chert horizons within the lower Campanian opoka with marly intercalations. They are most numerous and taxonomically diverse in the horizons of cherts with flint cores, occurring in the lower Campanian (*Sphenoceramus patootensiformis* Zone). The lithistid sponges from the Miocene fluvial gravels of Bełchatów, coming also from the lower Campanian cherts and opoka, are dominated by thick-walled rhizomorines (especially *Amphithelion reussi*), resistant to damage during river transport.

In the upper Campanian opoka and gaize of the Miechów Synclinorium, limonitized specimens of rhizomorine sponges have poorly preserved skeletons and morphological features. Thus, the taxonomic diversity of rhizomorines from these layers is very poorly recognized. Their numbers in the upper Campanian rocks, similar to those of other lithistids, are significantly lower than those of hexactinellids, while in the gaize, rhizomorines are more numerous and hexactinellids are very rare (Świerczewska-Gładysz and Jurkowska, 2013). The change in the composition of sponge assemblages was associated with the progressive shallowing of the sea (Świerczewska-Gładysz and Jurkowska, 2013).

Rhizomorine sponges are found also in the upper Campanian and lower Maastrichtian opoka of the Middle Vistula River succession, which is rich in hexactinellids (Świerczewska-Gładysz, 2006, 2012). Due to the poor state of preservation of this first group of fossils (heavily limonitised), they are poorly known. Additionally, two rhizomorine species are known from an uppermost Maastrichtian assemblage of phosphatized sponges (Świerczewska-Gładysz, 2006), which were redeposited from opoka in glauconitic sandstone (Świerczewska-Gładysz and Olszewska-Nejbert, 2006). The sedimentation of late Maastrichtian opoka of the Middle Vistula River succession took place during shallowing, related to regression of the epicontinental sea (Machalski *et al.*, 2022).

Part of the material described by Schrammen (1910) comes from the late Campanian deposits of Ahlten (Lower Saxony), which are classified as opoka (Wiese *et al.*, 2013). Out of the 10 species described from these deposits, as many as 9 were found in the Polish Campanian opoka.

In the white chalk, where hexactinellids predominate, rhizomorines are rare or absent (Reid, 1962; Nestler, 1961; Olszewska-Nejbert and Świerczewska-Gładysz, 2011). They are mainly known from the Northern Chalk Province (East Yorkshire, England). These sponges, with more common representatives of *Seliscothon*, *Amphitelion* and "*Verruculina*" [see Hinde, 1883; Deville de Periere *et al.*, 2019, pl. 3e: a specimen recognized here as *Seliscothon* sp. and pl. 3f: probably *Amphitelion reussi* (M'Coy, 1848), occur in some layers of chalk with marl intercalations or marl beds within the chalk (Witham, 1993; Deville de Periere *et al.*, 2019)].

The assumption that the occurrences of Cretaceous rhizomorines in detrital facies and gaize were deep-water hexactinellid sponges and are extremely rare or absent, indicates that some rhizomorine species tolerated nearshore conditions and/or high sedimentation rates. However, these sponges cannot be considered indicators of nearshore environments, because the Cretaceous rhizomorine sponges were also found in different facies of the outer shelf and they are generally most abundant and taxonomically diverse in the marls and opoka with marly intercalations of the outer shelf. The development of rhizomorine sponges was influenced by the availability of nutrients, among which dSi could play an important role on the basis of the abundant occurrence of these sponges in cherts, horizons of which record events of high dSi concentration (Jurkowska and Świerczewska-Gładysz, 2020). The low dSi content of modern shelf waters has resulted in living rhizomorines, similar to most lithistid sponges, colonizing deep ocean basins (Maldonado *et al.*, 1999). The lower frequency of rhizomorines in some sections of limestones and white chalk might have been associated with low dSi concentration (Jurkowska and Świerczewska-Gładysz, 2020), as well as oligotrophy. The availability and concentration of picoplanktonic food particles greatly affect demosponge development (Perea-Blázquez *et al.*, 2013) and could also be a factor, controlling rhizomorine sponge distribution in the Cretaceous epicontinental sea.

Modern rhizomorine sponges usually live attached by their base to hard substrates (Manconi *et al.*, 2006; Carvalho *et al.*, 2020) or they are one of the components of reef-like sponge clusters (Maldonado *et al.*, 2015), and only some of them occur on soft bottoms (e.g., sandy calcarenite: Van Soest, 2017). However, the muddy bottom, typical for the Cretaceous epicontinental sea, was not a limiting factor in their distribution. Cretaceous rhizomorines, similar to other lithistid sponges, were well adapted to living on a soft bottom. Many sponges have the remains of root-like outgrowths, which stabilized sponges on a soft substratum. Moreover, the sometimes-preserved basal plates, which were attached to the skeletons of other sponges, indicate that rhizomorines used bioclasts for settlement.

CONCLUSIONS

Rhizomorine sponges are the most numerous and taxonomically diverse group among Campanian lithistids from the Miechów and Mogilno-Łódź synclinoria, comprising a total of 28 species. In the Campanian of the Miechów Synclinorium, 18 species were identified, among them six are new for this area. All of these species, along with 10 others, including one new species, *Cryptothelion sujkowskii* sp. nov., occur in the early Campanian assemblage of redeposited sponges from the Miocene fluvial gravel of the Bełchatów Lignite Mine in Poland.

The taxonomic composition of the rhizomorine assemblage studied is most similar to that from the Campanian of Germany. The 18 species described here are known from the Lower Saxony and Subhercynian basins.

Cretaceous rhizomorines occur in various facies of the European epicontinental sea, which indicates that they inhabited both nearshore and offshore environments. The increase in their numbers in sections, accompanied by a simultaneous decrease in the numbers of deep-water hexactinellids, suggests that some rhizomorine species tolerated conditions of high rate of sedimentation and shallow water.

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