Middle Jurassic cyclostome bryozoans from the Polish Jura

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New collections of bryozoans from the Middle Jurassic (Late Bajocian and Bathonian) of Poland add significantly to our knowledge of the diversity and biogeography of the Cyclostomata at a time when they were the dominant bryozoan order in the fossil record. A total of 16 species and one form-genus ("*Berenicea*") are present. Most are encrusters, predominantly on hiatus concretions. A single erect species was found in deposits interpreted as regurgitates of a marine vertebrate. The following new species are described: *Microeciella annae* sp. nov., *M. kuklinskii* sp. nov., *M. maleckii* sp. nov., *M. mokrskoensis* sp. nov., *M. magnopora* sp. nov., *Reptomultisparsa harae* sp. nov., and *Hyporosopora bugajensis* sp. nov. The taxonomic importance of the morphology of both the gonozooids and pseudopores is underlined, especially for encrusting species of the "*Berenicea*" type that are otherwise difficult to distinguish from one another. The described bryozoan assemblage encrusting hiatus concretions from the Polish Middle Jurassic is the richest that has been documented globally from this kind of substrate.

Key words: Bryozoa, Cyclostomata, Middle Jurassic, Bajocian, Bathonian, Poland.

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Introduction

Cyclostomes are the only extant order of the bryozoan class Stenolaemata. The Jurassic period was a crucial time in cyclostome evolution, witnessing their radiation and brief domination prior to the appearance of the order Cheilostomata which prevail in Late Cretaceous–Recent bryozoan faunas. The first significant evolutionary radiation of cyclostomes occurred in the Middle Jurassic (Taylor and Larwood 1990; Jablonski et al. 1997), the order peaking at an estimated 77 species and 29 genera in the Bathonian (Taylor and Ernst 2008). Our knowledge of the Middle Jurassic radiation of cyclostomes is geographically constrained, as the data available is based essentially on studies of French, German, English and to a lesser extent Russian (Viskova 2006, 2007, 2008) and North American (Cuffey and Ehleiter 1984; Taylor and Wilson 1999) material. Maximum species richness documented for the Middle Jurassic occurs in the Bathonian Caillasse de la Basse Ecarde at St Aubin-sur-Mer, Normandy from where 33 species have been recorded within sponge reef and hardground settings (Walter 1970; Palmer and Fürsich 1981; Taylor and Ernst 2008). The rich Normandy, bryozoan fauna may serve as a reference point for evaluating other Jurassic localities.

Jurassic bryozoans have been neglected compared to older and younger representatives of the phylum (Taylor and Ernst 2008). The causes are twofold. Firstly, Jurassic bryozoans mainly consist of cyclostomes, the taxonomy of which relies on a few skeletal features only. Currently, critical characters, at least for genus-level taxonomy, are larval brooding polymorphs called gonozooids. However, gonozooids are lacking in many colonies, probably due to some unknown environmental factors (McKinney and Taylor 1997). Secondly, cyclostome distribution in the Jurassic is very patchy geographically, and most species consist of small-sized, encrusting colonies that may be easily overlooked (Taylor and Ernst 2008).

Studies of Jurassic bryozoans from Poland are very limited. Middle Jurassic bryozoans were first described by Reuss (1867) from the uppermost Bathonian–lowermost Callovian condensed deposits of the classic locality at Balin in southern Poland. This collection has been recently revised by Taylor (2009) who established the presence of 23 species. Rehbinder (1914), during stratigraphical work on the Bajocian–Bathonian deposits of the Polish Jura area, listed some cyclostomes which he assigned to such genera as *Berenicea*, *Diastopora* and *Stomatopora*. However, as his work is not illustrated, it is impossible to confirm his identifications. Cyclostomes referred to as *Berenicea parvitubulata* Gregory, 1896 and *Stomatopora dichotoma* (Lamouroux, 1821) were described by Pugaczewska (1970) from the Kimmeridgian of Wierzbica and Sobków, and the Tithonian of Brzostówka in central Poland. More recently, Upper Jurassic bryozoans have been investigated by Hara and Taylor (1996) from the Oxfordian of

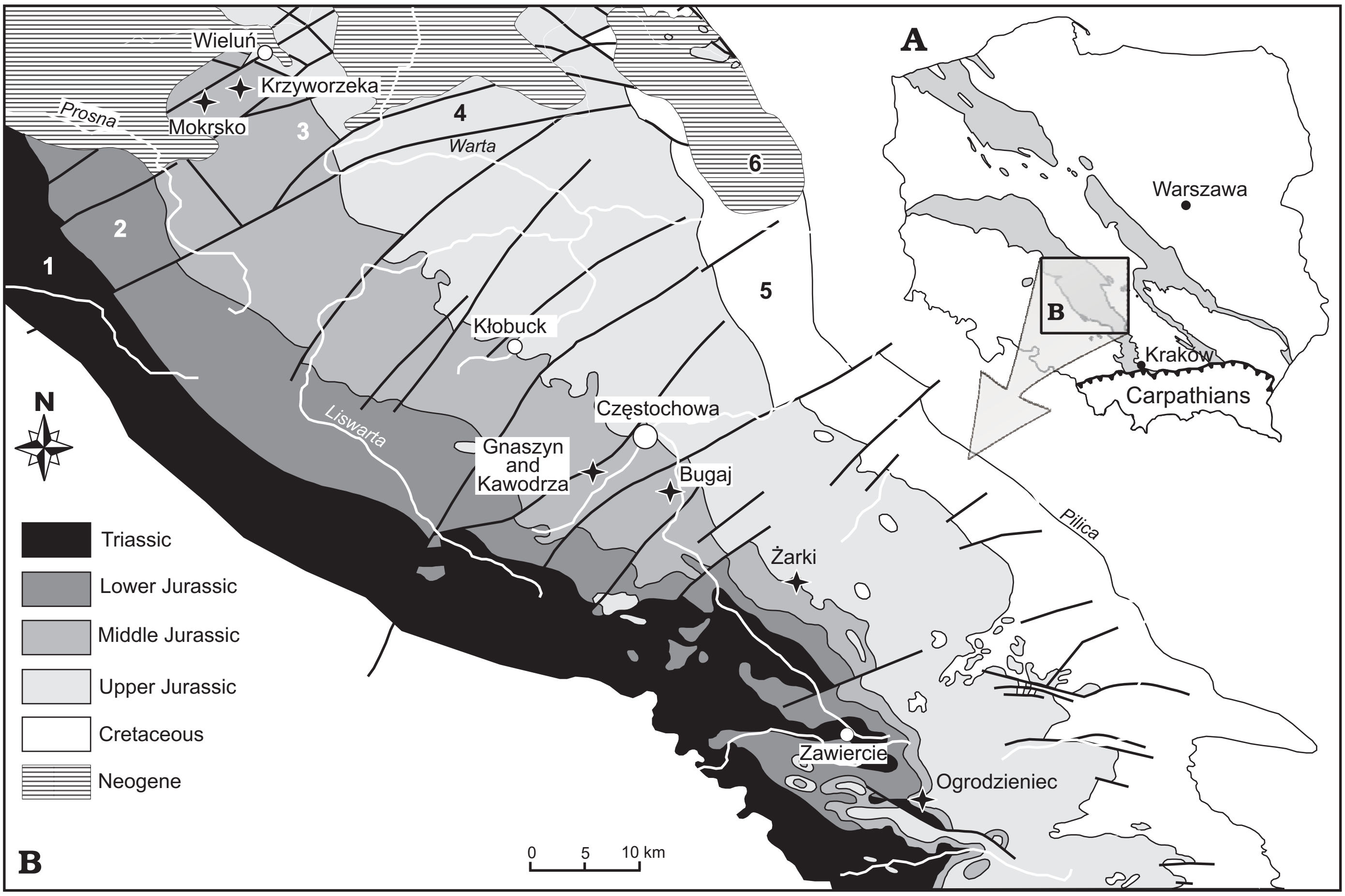


Fig. 1. **A**. Map of Poland with Jurassic deposits indicated (shaded areas) after removal of the Cenozoic cover. **B**. Geological map of the Polish Jura area with sampled localities indicated (asterisks). Adapted from Zatoń et al. 2006.

Bałtów, and by Hara and Taylor (in press) from the Kimmeridgian of Małogoszcz and Wierzbica, central Poland. In addition, Zatoń et al. (2006) and Hara (2007) summarized the generic diversity of the Polish Bajocian–Bathonian and Callovian–Oxfordian bryozoans, respectively.

Here we describe some newly-collected Middle Jurassic cyclostome bryozoans from the Polish Jura (south-central Poland). These Bajocian–Bathonian bryozoans include several new species, adding significantly to our knowledge of bryozoan diversity during the Jurassic in the eastern part of the Mid-European epicontinental Basin. Pseudopore morphology, as visible using SEM, is shown to be valuable in discriminating between species of otherwise very similar morphology.

Institutional abbreviation.—GIUS, Department of Palaeontology, Faculty of Earth Sciences, University of Silesia, Poland; NHM, Natural History Museum, London, UK.

Other abbreviations.—AD, aperture diameter (in cerioporines); FWL, frontal wall length (of autozooids); FWW, autozooid frontal wall width; GDL, gonozooid dilated length (i.e., length of the brood chamber); GTL, gonozooid total length; GW, gonozooid width; IWT, interzooidal wall thickness; LAM, longitudinal apertural measurement (of autozooids); LPM, longitudinal peristome measurement; OL, ooeciopore length; OW, ooeciopore width; PL, pseudopore length; PW, pseudopore width; TAM, transverse apertural measurement; TPM , transverse peristome measurement.

Geological setting

The Polish Jura is a monoclinal structure oriented from south-east to north-west in southern and south-central Poland, from the Kraków area in the south to Wieluń in the north (Fig. 1). The Middle Jurassic sediments of the Polish Jura were deposited in the Polish Basin that was an eastern extension of the Mid-European epicontinental sea. The Polish Basin was bordered by the Fennoscandian Shield to the north, the Belorussian High and Ukrainian Shield to the east, the Bohemian Massif to the west and the pre-Carpathian landmass to the south (see Dadlez 1989; Ziegler 1990; Feldman-Olszewska 1997). During Bathonian times, the Polish Basin broadened incrementally, attaining its peak in the Late Bathonian when almost the entire area of the Polish Lowlands was submerged by the sea (Matyja and Wierzbowski

1998). Sedimentation was dominated by clastic deposits (Feldman-Olszewska 1997) which, as suggested by Dadlez (1997) and Marynowski et al. (2007), were primarily derived from the Fennoscandian and Bohemian landmasses.

The Upper Bajocian and Bathonian epicratonic sediments of the Polish Jura comprise a monotonous sequence of dark-grey, unconsolidated claystones and mudstones, intercalated with numerous isolated or horizon-forming carbonate (calcite and siderite) concretions. The sediments are referred to as the Ore-bearing Częstochowa Clay Formation (e.g., Dayczak-Calikowska et al. 1997; Majewski 2000; Matyja and Wierzbowski 2000; Kopik 2006; Marynowski et al. 2007), and are thought to have been deposited in a quiet marine environment, generally below storm wave-base (see Matyja et al. 2006a, b, c) on an oxygenated sea-floor (Szczepanik et al. 2007; Zatoń et al. 2009). However, occasional horizons of hiatus concretions (sensu Voigt 1968) occur in the Polish Jura (Zatoń et al. 2006), marking distinct pauses in sedimentation and/or erosion of the sea-floor. The common abrasion of the concretions, best manifested in the form of truncated *Gastrochaenolites* borings, attests to the episodic presence of shallower and more hydrodynamically agitated environments.

The ore-bearing clays are currently exposed in numerous clay-pits, the majority of which are still active. They are known for their rich and diverse fossils (e.g., Różycki 1953; see also Zatoń et al. 2007 for summary), including abundant ammonites enabling biostratigraphical subdivision. The exposed clays range from the *Parkinsonia parkinsoni* Zone of the Upper Bajocian to the *Oxycerites orbis* Zone of the Upper Bathonian (Kopik 1998, 2006; Matyja and Wierzbowski 2000; Matyja et al. 2006a, b, c; Zatoń 2007). The highest zone of the Upper Bathonian, the *Clydoniceras discus* Zone, has been identified using dinoflagellate cysts in the northern and southern parts of the Polish Jura by Poulsen (1998) and Barski et al. (2004) respectively.

According to Różycki (1953), the localities here investigated are situated either within the southern (Ogrodzieniec) and northern sedimentary region (Żarki, Bugaj, Mokrsko, and Krzyworzeka) of the Polish Jura (Fig. 1B). Bryozoan-encrusted hiatus concretions have been detected at all of these localities (partly described by Zatoń et al. 2006). In the majority, they occur at single horizons. However, in Krzyworzeka they form two, separated horizons within the host clays. Stratigraphically, the hiatus concretions belong to the uppermost Bajocian *Parkinsonia parkinsoni* Zone (Mokrsko), Middle Bathonian, *Tulites subcontractus* or *Morrisiceras morrisi* Zone (Bugaj) and Upper Bathonian *Procerites hodsoni* Zone (Ogrodzieniec, Żarki) and/or *Oxycerites orbis* Zone (Krzyworzeka).

Material and methods

Most (>100 colonies) of the bryozoans here investigated come from hiatus concretions. However, a few branch fragments were also found in faunal aggregates interpreted as regurgitates (Zatoń and Salamon 2008) at Gnaszyn Dolny (Middle Bathonian, *Morrisiceras morrisi* Zone), and one well-preserved colony occurs on an oyster shell from Kawodrza Górna (Lower Bathonian, *Zigzagiceras zigzag* Zone). It must be stressed that the bryozoans encrusting shells are uncommon and when present are generally not well-preserved in the ore-bearing clays of the Polish Jura due to their common encrustation by siderite and pyrite. Therefore, the hiatus concretions provide the best material for study.

Colonies and groups of colonies were sawn off the hiatus concretions, cleaned ultrasonically and examined in an uncoated state using a LEO 1455VP low vacuum scanning electron microscope housed at the NHM. Images were generated using backscattered electrons (BSE detector).

Measurements of bryozoan morphological characters are mostly based on Pitt and Taylor (1990).

Systematic palaeontology

Phylum Bryozoa Ehrenberg, 1831

Class Stenolaemata Borg, 1926

Order Cyclostomata Busk, 1852

Suborder Tubuliporina Milne-Edwards, 1838

Family Stomatoporidae Pergens and Meunier, 1886

Genus *Stomatopora* Bronn, 1825

Type species: *Alecto dichotoma* Lamouroux, 1821, Bathonian, Calvados, France.

Stomatopora bajocensis (d'Orbigny, 1850)

Fig. 2A.

1850 *Alecto bajocensis* sp. nov.; d'Orbigny 1850: 288.
1867 *Stomatopora bouchardi* Haime, 1854; Reuss 1867: 2 (partim).
1963 *Stomatopora bajocensis* (d'Orbigny, 1850); Illies 1963: 74, pl. 7: 1–2.
1970 *Stomatopora bajocensis* (d'Orbigny, 1850); Walter 1970: 36, pl. 1: 7.
2009 *Stomatopora bajocensis* (d'Orbigny, 1850); Taylor 2009: 22.

Material.—Two fragmentary colonies GIUS 8-3509-1–2.

Measurements.—FWL, 825–1575 μm; FWW, proximal: 120–140 μm, distal: 220–300 μm; LAM, 80 μm; LPM, 120 μm; TAM, 80 μm; TPM, 110 μm; PW, 6.3 μm.

Description and remarks.—This encrusting, uniserial species has been found on only two hiatus concretions. In both cases, the ancestrula is lacking and branches bifurcate at an angle of about 110°, suggesting an early astogenetic stage. Autozooids are straggly, long and slender, proximally narrow but gradually widening towards the distal end. Peristomes and apertures are circular in outline, about 110 and 80 μm in diameter, respectively. Apertures may possess deep diaphragms. Pseudopores are widely-spaced and almost circular in outline.

Although the ancestrula is missing and the astogenetic stages of the colonies cannot therefore be determined exactly, the size of the autozooids is characteristic of *Stomato-*

pora bajocensis (d'Orbigny, 1850) among Jurassic species of this genus.

Stratigraphic and geographic ranges.—Middle Bathonian of Bugaj and Upper Bathonian of Ogrodzieniec, Polish Jura. This species is also known from the uppermost Bathonian–lowermost Callovian of Balin, southern Poland (see Taylor 2009), Upper Aalenian–Upper Bathonian of France and England (Walter 1970) and Bajocian of Germany (Illies 1963).

Stomatopora recurva Waagen, 1867

Fig. 2B.

1867 *Stomatopora recurva* sp. nov.; Waagen 1867: 647, pl. 32: 9a, b.
1867 *Stomatopora dichotoma* Lamouroux, 1821; Reuss 1867: 2 (partim), pl. 1: 3.
1867 *Stomatopora bouchardi* Haime, 1854; Reuss 1867: 2 (partim).
1867 *Stomatopora dichotomoides* d'Orbigny, 1850; Reuss 1867: 3 (partim).
1970 *Stomatopora recurva* Waagen, 1867; Walter 1970: 42, pl. 1: 5, 6.
2009 *Stomatopora recurva* Waagen, 1867; Taylor 2009: 26, figs. 2C, 3E, F.

Material.—Five fragmentary colonies GIUS 8-3509-2–6.

Measurements.—FWL, 1000–1100 µm; FWW, 600–800 µm; LPM, 200–300 µm; TPM, 250–450 µm; PW, 15–17.5 µm.

Description and remarks.—Only five fragmentary colonies, with worn and partly infilled zooids, of this uniserial species were found, all encrusting hiatus concretions. The ancestrula seems to be lacking. The branches, 600–800 µm wide, are straight or curved (Fig. $2B_1$), with bifurcation angles as high as 125° decreasing to about 87°. Delayed separation of daughter branches may occur after bifurcation, briefly producing biserial branches (Fig. $2B_1$). The apertures of autozooids are spaced 1000–1100 µm apart, similar to the specimens of *Stomatopora recurva* from Balin (Taylor 2009). Peristomes are preserved to a height of about 125 µm. Pseudopores are teardrop-shaped, large, 15–17.5 µm wide, bevelled and closely spaced.

The robustness of this species distinguishes it from the other Jurassic species of *Stomatopora*, such as *S. bajocensis* (d'Orbigny, 1850), *S. dichotomoides* (d'Orbigny, 1850), and *S. corallina* (d'Orbigny, 1850) (see Taylor 2009).

Stratigraphic and geographic range.—Uppermost Bajocian of Mokrsko and Middle Bathonian of Bugaj, Polish Jura. *Stomatopora recurva* is also known from the Upper Aalenian–Lower Bajocian of Germany, France and England (Walter 1970), and uppermost Bathonian–lowermost Callovian of Balin, southern Poland (Taylor 2009).

Genus *Proboscinopora* Pitt and Taylor, 1990

Type species: *Proboscina divisi* Vine, 1893, Middle Jurassic, Cornbrash (probably basal Callovian), Thrapston, Northamptonshire, England.

Proboscinopora? sp.

Fig. 2C.

Material.—One poorly preserved colony GIUS 8-3509-7.

Measurements.—FWL, 500–800 µm; FWW, 200–300 µm; LAM, 120–200 µm; TAM, 83–120 µm; LPM, 183–266 µm; TPM, 133–200 µm; PL, 15–20 µm; PW, 2.5–3.8 µm.

Description.—Colony encrusting with narrow oligoserial, ribbon-like branches. Generally up to 2–3 autozooids across the width of the branches which are slightly convex, low, and bifurcate irregularly at variable angles (Fig. $2C_1$). Autozooids are elongate, have circular or longitudinally elliptical apertures, variably spaced and short preserved peristomes. Frontal walls are ornamented by very narrow, slit-like pseudopores elongated parallel to growth direction (Fig. $2C_2$).

Remarks.—Colony-form agrees with the genus *Proboscinopora*, introduced by Pitt and Taylor (1990) for *Proboscina*-like colonies lacking basal gonozooids (it is possible that peristomial gonozooids were developed but were lost when the peristomes broke off). However, the fragmentary nature of the single colony described here precludes its unequivocal identification as *Proboscinopora* as it may alternatively be an infertile colony of *Oncousoecia* (see Taylor and Zatoń 2008) which has a very similar colony-from. The distinctive slit-like pseudopores while typical of many stomatoporids can also be found in species of *Microeciella* (family Oncousoeciidae) and *Multisparsa* (family Multisparsidae) (see below and Taylor 2009).

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

Family Oncousoeciidae Canu, 1918

Genus *Microeciella* Taylor and Sequeiros, 1982

Type species: *Microeciella beliensis* Taylor and Sequeiros, 1982, Toarcian, Jurassic, Belchite, Spain.

Remarks.—*Microeciella* was introduced by Taylor and Sequeiros (1982) for bereniciform cyclostomes with simple ovoidal gonozooids that had previously been incorrectly assigned to *Microecia* (a subjective junior synonym of *Plagioecia*). The status of the genus was recently clarified by Taylor and Zatoń (2008) who argued that Recent species placed in *Eurystrotos* Hayward and Ryland, 1985 actually belonged in *Microeciella*. Five new species of *Microeciella* are recognized among the material studied here. They can be distinguished using the following key:

1. autozooidal frontal wall width < 200 µm — 2
   autozooidal frontal wall width > 200 µm — 4
2. ooeciopore located distally of brood chamber — *M. annae*
   ooeciopore subterminal — 3
3. brood chamber elongate, about 1.5 × longer than wide — *M. mokrskoensis*
   brood chamber equidimensional — *M. maleckii*
4. ooeciopore significantly smaller than autozooidal aperture — *M. kuklinskii*
   ooeciopore about same size as an autozooidal aperture — *M. magnopora*

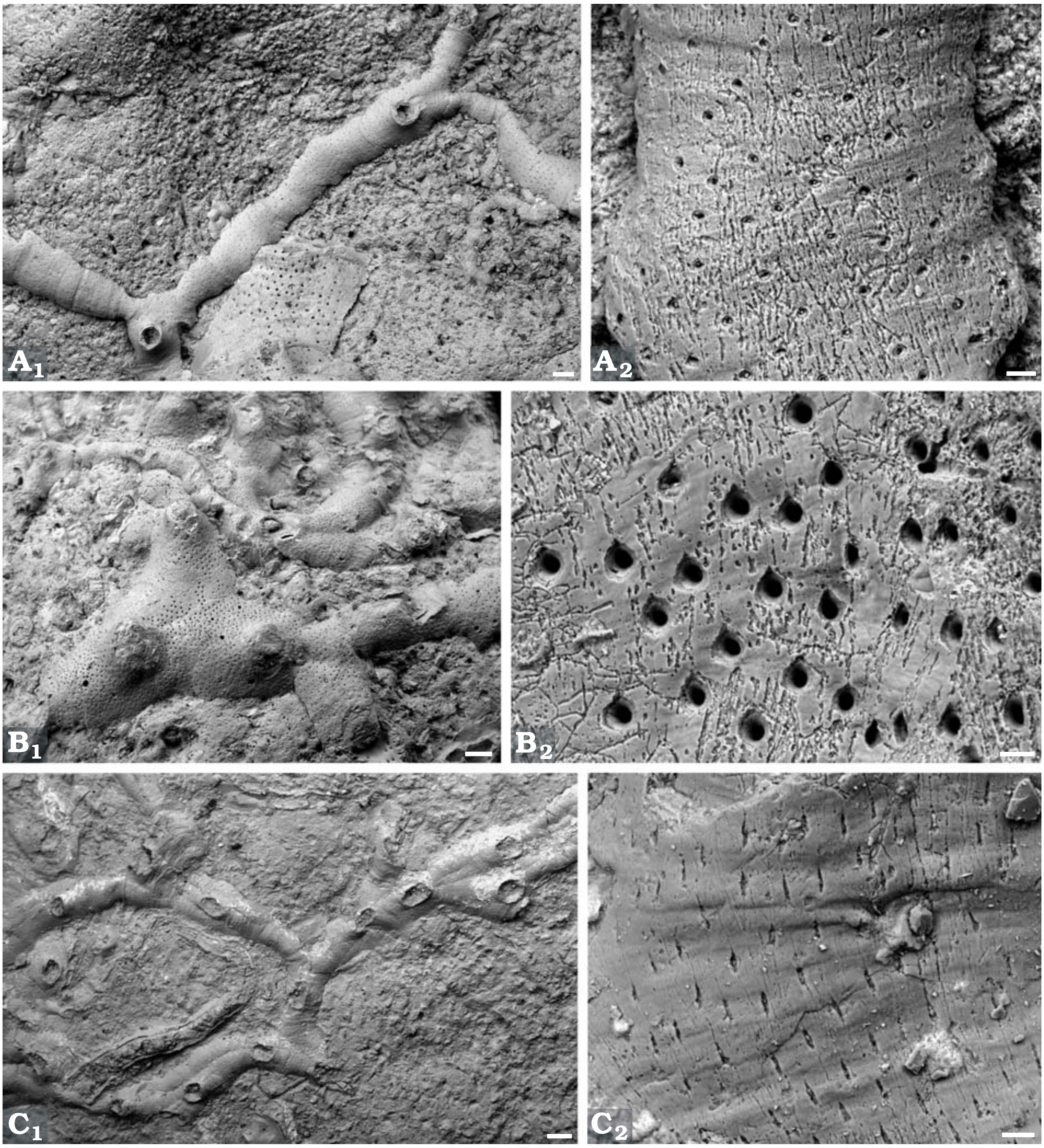


Fig. 2. Stomatoporid cyclostome bryozoans from the Middle Jurassic ore-bearing clays of the Polish Jura. **A**. *Stomatopora bajocensis* (d'Orbigny, 1850), Upper Bathonian, Ogrodzieniec, GIUS 8-3509-1. A_1, autozooids showing high-angled bifurcations; A_2, pseudopores. **B**. *Stomatopora recurva* Waagen, 1867, Middle Bathonian, Bugaj, GIUS 8-3509-2. B_1, colony fragment showing early and later bifurcations; B_2, pseudopores. **C**. *Proboscinopora*? sp., Middle Bathonian, Bugaj, GIUS 8-3509-7. C_1, branching oligoserial colony, partly pyritised (white spots); C_2, pseudopores. Scale bars: 300 μm (A_1), 200 μm (B_1, C_1), 20 μm (A_2, B_2, C_2). BSE SEM images of uncoated specimens.

Microeciella annae sp. nov.

Fig. 3.

Etymology: In honour of the late Anna Zatoń (1958–2002), the first author's mother.

Type material: Holotype: GIUS 8-3509-8, colony encrusting an oyster shell; paratype: GIUS 8-3509-9, colony encrusting a hiatus concretion.

Type locality: Kawodrza Górna ("Gliński" clay-pit), Polish Jura, Poland.

Type horizon: Ore-bearing Częstochowa Clay Formation, Lower Bathonian (*Zigzagiceras zigzag* Zone), Jurassic.

Material.—Two colonies, the holotype and paratype listed above.

Measurements.—FWL, 466–800 μm; FWW, 116–150 μm; LAM, 66–83 μm; TAM, 58–75 μm; LPM, 100–116 μm; TPM, 83–108 μm; GTL, 1180 μm; GDL, 685 μm; GW, 500 μm; OL, 91 μm; OW, 100 μm; PL, 7.5–12.5 μm; PW, 5 μm.

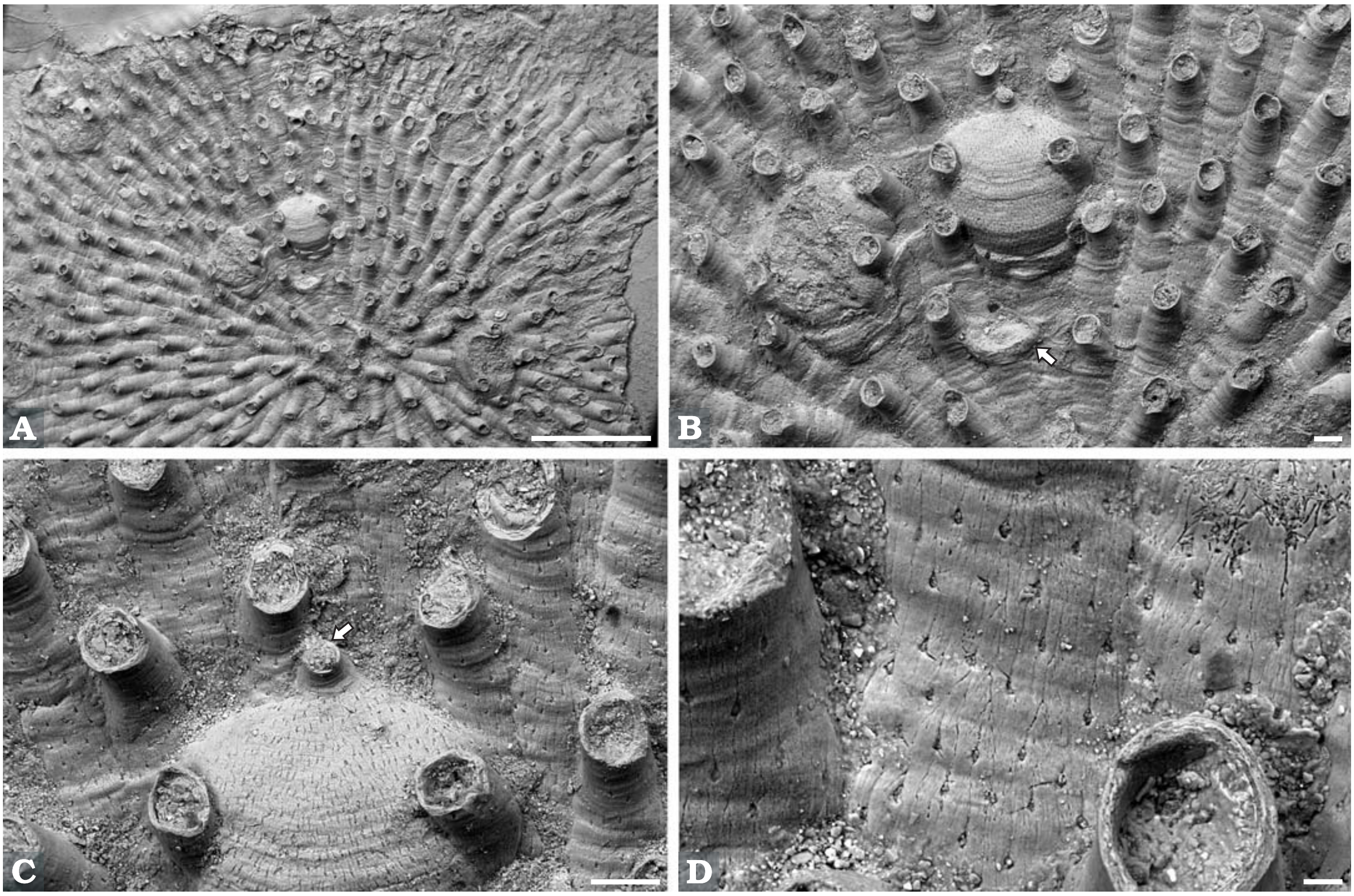


Fig. 3. Oncousoeciid cyclostome bryozoan *Microeciella annae* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura. Holotype, GIUS 8-3509-8, Kawodrza Górna, Lower Bathonian. **A**. General colony view. **B**. Three gonozooids, one of which is aborted (arrow). **C**. Close-up of ooeciopore (arrow) and autozooids. **D**. Pseudopores. Scale bars 1000 μm (A), 100 μm (B), 100 μm (C), 20 μm (D). BSE SEM images of uncoated specimens.

Diagnosis.—*Microeciella* with ovoidal brood chambers and a terminal, subcircular ooeciopore located on a short, straight ooeciostome; autozooids small, frontal walls less than 150 μm wide; pseudopores longitudinally elongate, spindle-shaped.

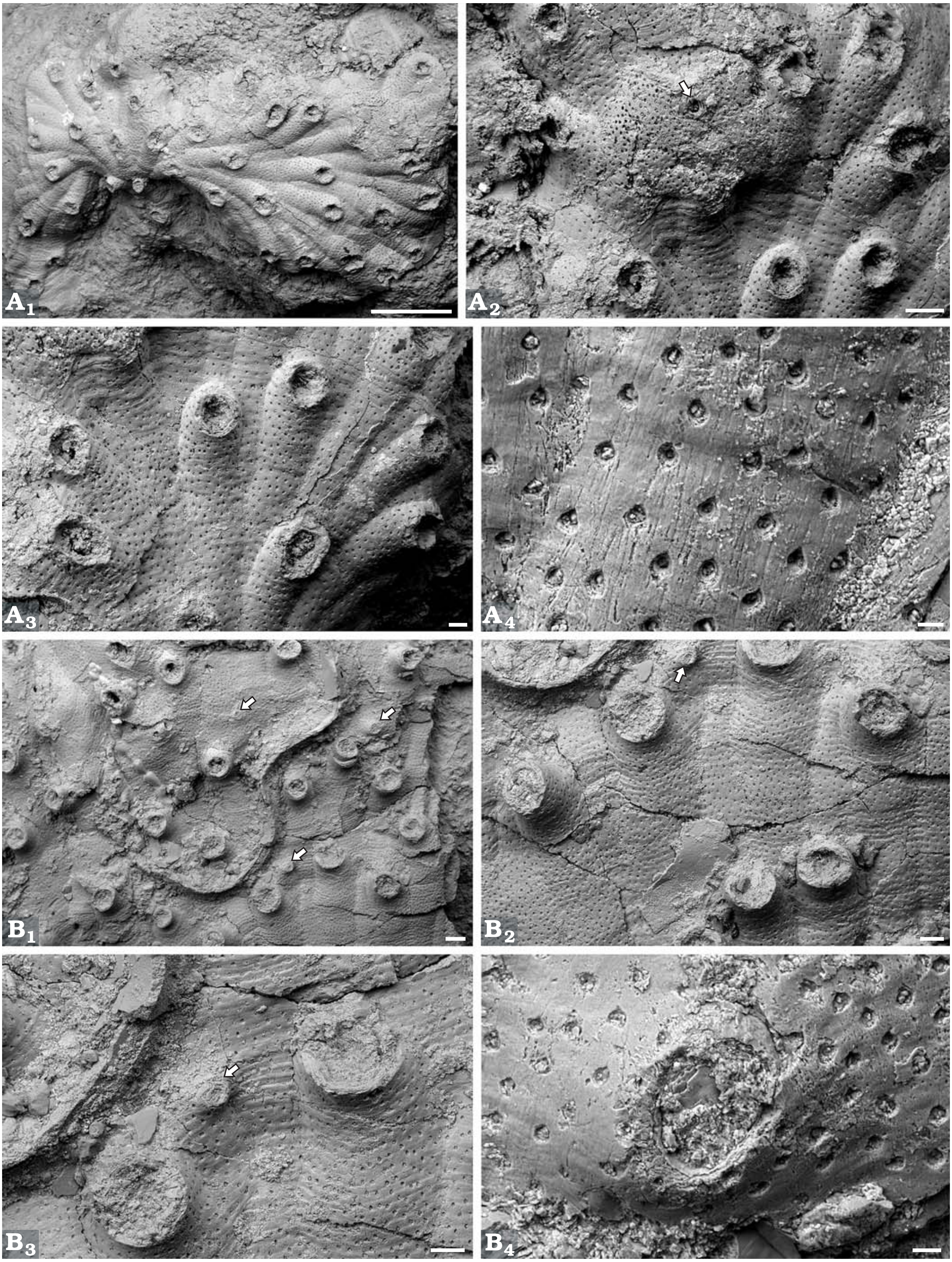
Description.—Colony encrusting, small (holotype 8 mm in diameter), multiserial, unilamellar, discoidal, bereniciform (Fig. 3A). Growing edge low.

Autozooids small, elongate, flat proximally and slightly convex distally; zooidal boundaries grooved. Peristomes salient, tapering distally. Apertures subcircular to longitudinally elongate. Pseudopores narrow, teardrop to spindle-like in shape, pointed distally, sparse (Fig. 3D).

Gonozooids common, occurring in three generations in the holotype (Fig. 3A); however, all but two are crushed, and one of the remaining two is incompletely formed. Proximal frontal wall flat, indistinguishable from an autozooid. Brood chamber ovoidal, only slightly longer than wide, convex, lateral edges indented by apertures of neighbouring autozooids, roof densely pseudoporous. Ooeciopore terminal, located beyond distal edge of brood chamber, subcircular, smaller than autozooidal aperture; ooeciostome short, upright, tapering distally.

Remarks.—This new species of *Microeciella* differs from the type species *M. beliensis* Taylor and Sequeiros, 1982, as well as from other Jurassic *Microeciella* species including *M. duofluvina* (Cuffey and Ehleiter, 1984), *M. pollostos* Taylor and Wilson, 1999, in its terminal ooeciopore and more rounded brood chamber. The terminal ooeciopore of *M. annae* sp. nov. is reminiscent of the Recent species *M. suborbicularis* (Hincks, 1880) (see Taylor and Zatoń 2008), previously placed in *Eurystrotos* (Hayward and Ryland 1985). *Microeciella* sp. from the Upper Bathonian–Lower

Fig. 4. Oncousoeciid cyclostome bryozoan *Microeciella kuklinskii* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura. **A**. Holotype, GIUS 8-3509-10, Bugaj, Middle Bathonian. A_1, general colony view; A_2, close-up of a gonozooid with ooeciopore (arrowed); A_3, autozooids; A_4, pseudopores. **B**. Paratype, GIUS 8-3509-12, Bugaj, Middle Bathonian. B_1, colony surface with nanozooids visible (arrowed) encrusted by foraminifers and serpulid; B_2, autozooids and one nanozooid (arrowed); B_3, two autozooids and one nanozooid; B_4, close-up of nanozooid and pseudopores. Scale bars: 1000 μm (A_1), 200 μm (A_2, B_1), 100 μm (A_3, B_2, B_3), 20 μm (A_4, B_4). BSE SEM images of uncoated specimens. →


A1
A2
A3
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B4

Callovian of Balin, southern Poland, has a similar ovoidal brood chamber but a subterminal ooeciopore (see Taylor 2009).

One infertile colony from the Middle Bathonian of Bugaj (GIUS 8-3509-9), which possesses a similar discoidal colony-form, autozooids and pseudopores, is provisionally assigned to *Microeciella annae*.

Stratigraphic and geographic range.—Lower Bathonian of Kawodrza Górna and Middle Bathonian of Bugaj, Polish Jura.

Microeciella kuklinskii sp. nov.

Fig. 4.

Etymology: In honour of Dr. Piotr Kukliński, a bryozoan ecologist from the Institute of Oceanology, Polish Academy of Sciences, Sopot.

Type material: Holotype: GIUS 8-3509-10; paratypes: GIUS 8-3509-11–12.

Type locality: Bugaj, Polish Jura, Poland.

Type horizon: Ore-bearing Częstochowa Clay Formation, Middle Bathonian (*Tulites subcontractus* or *Morrisiceras morrisi* Zone), Jurassic.

Material.—The holotype and two paratypes listed above.

Measurements.—FWL, 1000–1371 µm; FWW, 250–333 µm; LAM, 125–200 µm; TAM, 125–150 µm; LPM, 166–266 µm; TPM, 183–233 µm; GTL, 2040 µm; GDL, 735 µm; GW, 815 µm; OL, 65 µm; OW, 65 µm; PL, 20–23 µm; PW, 15–18 µm.

Diagnosis.—*Microeciella* with ovoidal or heart-shaped brood chamber, strongly subterminal ooeciopore; autozooids large, frontal walls more than 250 µm wide; pseudopores large; teardrop-shaped pseudopores; nanozooids occasionally present.

Description.—Colony encrusting, multiserial, unilamellar, bereniciform.

Autozooids large, elongate, with flat proximal and convex distal frontal wall; zooidal boundaries distinct. Preserved peristomes short, tapering distally. Apertures subcircular to longitudinally elongate. Pseudopores moderately spaced, large, teardrop-shaped, pointed distally (Fig. 4A_4).

Nanozooids occur sporadically over the colony surface only in one paratype (GIUS 8-3509-12), often in close proximity to autozooidal apertures (Fig. 4B); peristomes short, upright; apertures circular to subcircular in outline, c. 70 µm long by 63 µm wide.

Gonozooids uncommon, with flat to slightly convex frontal walls, proximally indistinguishable from autozooids. Brood chamber ovoidal or heart-shaped, only slightly wider than long, accentuated by two small lobes distally (Fig. 3B), roof densely pseudoporous, similar in convexity to autozooidal frontal walls. Ooeciopore subterminal, located well below distal edge of brood chamber, circular in outline, much smaller than an autozooid aperture.

Remarks.—Although only one colony preserves a gonozooid, the overall morphology of this species of *Microeciella* is sufficiently distinct to justify the creation of a new species. Two paratype colonies (GIUS 8-3509-11–12) without gonozooids are included in this species on the basis of their similar autozooid and pseudopore characteristics. It is worth noting that nanozooids, polymorphs occurring rarely in Jurassic bryozoans, have never been detected previously in the genus *Microeciella*. Their scattered occurrence on the colony surface is reminiscent of the extant cyclostome *Plagioecia sarniensis*. Silén and Harmelin (1974) interpreted such patterns of "occasional nanozooid" development as due to irregularities of the substratum disturbing the normal growth of the colony and resulting in narrowing of the space available such that a normal autozooid could not be budded.

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

Microeciella maleckii sp. nov.

Fig. 5.

Etymology: In honour of the late Professor Jerzy Małecki, author of numerous papers on Polish fossil bryozoans.

Holotype: GIUS 8-3509-13.

Type locality: Ogrodzieniec, Polish Jura, Poland.

Type horizon: Ore-bearing Częstochowa Clay Formation, Upper Bathonian (*Procerites hodsoni* Zone), Jurassic.

Material.—One colony, the holotype.

Measurements.—FWL, 563–913 µm; FWW, 100–163 µm; LAM, 75–113 µm; TAM, 50–88 µm; LPM, 113–150 µm; TPM, 75–125 µm; GTL, 838 µm; GDL, 525–725 µm; GW, 513–700 µm; OL, 38 µm; OW, 50 µm; PL, 6.3–12.5 µm; PW, 5–6.3 µm.

Diagnosis.—*Microeciella* with ovoidal, bulbous brood chambers indented by autozooidal peristomes and subterminal, subcircular to slightly transverse ooeciopores; autozooids small, frontal walls less than 165 µm wide; pseudopores teardrop-shaped, pointed distally.

Description.—Colony encrusting, multiserial, unilamellar, bereniciform.

Autozooids small, elongate with slightly convex frontal walls; zooidal boundaries distinct, grooved. Peristomes tapering distally. Apertures subcircular to longitudinally elongated, some closed by terminal diaphragms. Pseudopores moderately spaced, teardrop-shaped, longer than wide, pointed distally (Fig. 5D).

Gonozooids partly or entirely crushed (Fig. 5B, C). Proximal frontal wall indistinguishable from an autozooid. Brood chamber ovoidal, only slightly longer than wide, with bulbous, convex frontal wall, outline indented by apertures of neighbouring autozooids, roof densely pseudoporous. Ooeciopore subterminal, smaller than an autozooidal aperture, subcircular or slightly transverse.

Remarks.—Cyclostomes having similar ovoidal, bulbous brood chambers with subterminal ooeciopore have been recently described by Viskova (2008) from the Middle Oxfordian of Russia under the name *Hyporosopora mittai* Viskova, 2008. However, as the genus *Hyporosopora* is used for cyclostomes with subtriangular, boomerang-like or heart-shaped brood chambers, the species described by Viskova (2008) is better placed in *Microeciella*. The new species *M. maleckii* differs from *M. mittai* in having wider gonozooids, 713–700 µm compared to 370–400 µm in *M. mittai*. Differ-

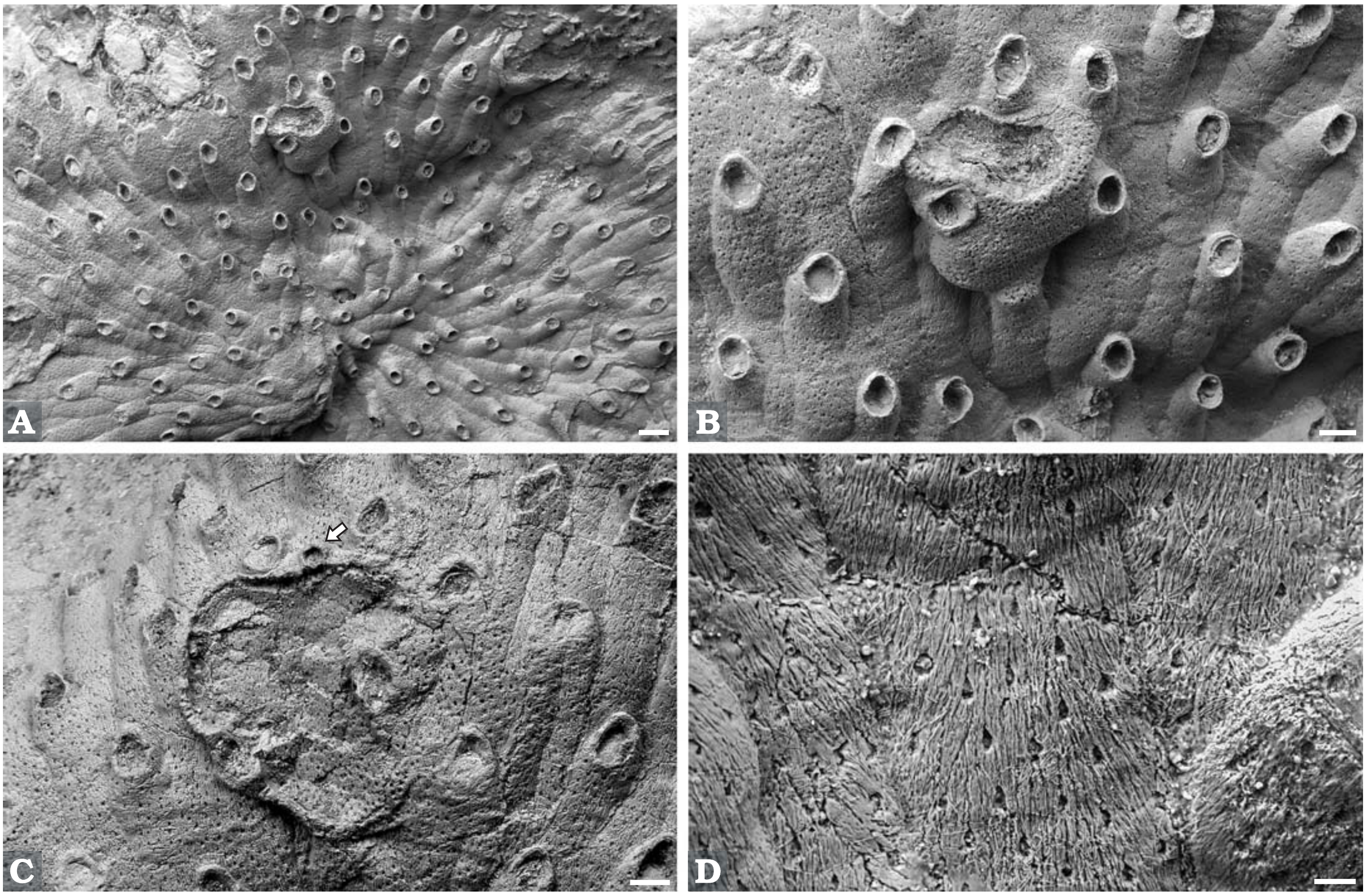

Fig. 5. Oncousoeciid cyclostome bryozoan *Microeciella maleckii* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura. Holotype, GIUS 8-3509-13, Ogrodzieniec, Upper Bathonian. **A**. General colony view. **B**. Close-up of a gonozooid and autozooids.**C**. Close-up of a crushed gonozooid wit an ooeciopore preserved (arrowed). **D**. Pseudopores. Scale bars 200 µm (A), 100 µm (B, C), 20 µm (D). BSE SEM images of uncoated specimens.

ences between *M. maleckii* and other species of *Microeciella* described in the present study are evident from the species identification key (above).

Stratigraphic and geographic range.—Upper Bathonian of Ogrodzieniec, Polish Jura.

Microeciella mokrskoensis sp. nov.

Fig. 6.

Etymology: From the type locality Mokrsko.

Holotype: GIUS 8-3509-14.

Type locality: Mokrsko, Polish Jura, Poland.

Type horizon: Upper Bajocian (*Parkinsonia parkinsoni* Zone).

Material.—One colony, the holotype.

Measurements.—FWL, 807–923 µm; FWW, 115–161 µm; LAM, 92–115 µm; TAM, 69–92 µm; LPM, 138–161 µm; TPM, 104–161 µm; GTL, 1086 µm; GDL, 657 µm; GW, 428 µm; PL, 12.5–17 µm; PW, 5 µm.

Diagnosis.—*Microeciella* with longitudinally elongate gonozooids, the brood chamber about 1.5 times longer than wide; autozooids small, frontal wall width less than 165 µm; pseudopores elongate, pyriform, pointed distally.

Description.—Colony encrusting, multiserial, unilamellar, bereniciform, with distinct rejuvenative growth (Fig. 6A).

Autozooids small, elongate with frontal wall flat proximally but slightly convex distally; zooidal boundaries shallowly grooved or indistinct. Peristomes short, upright, tapering distally. Apertures circular to longitudinally elongated, some closed by deep terminal diaphragms. Pseudopores closely spaced, longitudinally elongated, pyriform, pointed distally (Fig. 6D).

Gonozooids represented by one aborted and one roofless example. Proximal frontal wall indistinguishable from an autozooid. Brood chamber longitudinally elongate, about 1.5 × longer than wide (Fig. 6C). Ooeciopore not observed, inferred to have been subterminal.

Remarks.—All of the gonozooids observed in the studied colony are either aborted or have lost the roofs of their brood chambers. Nevertheless, their overall morphology is sufficiently different from that seen in the other species of *Microeciella* described in this paper to justify the recognition of *M. mokrskoensis* as a separate species. The long gonozooid is somewhat reminiscent of *M. beliensis* Taylor and Sequeiros, 1982, from the Lower Jurassic of Spain (see Taylor and Sequeiros 1982), and *M. duofluvina* (Cuffey and Ehleiter,

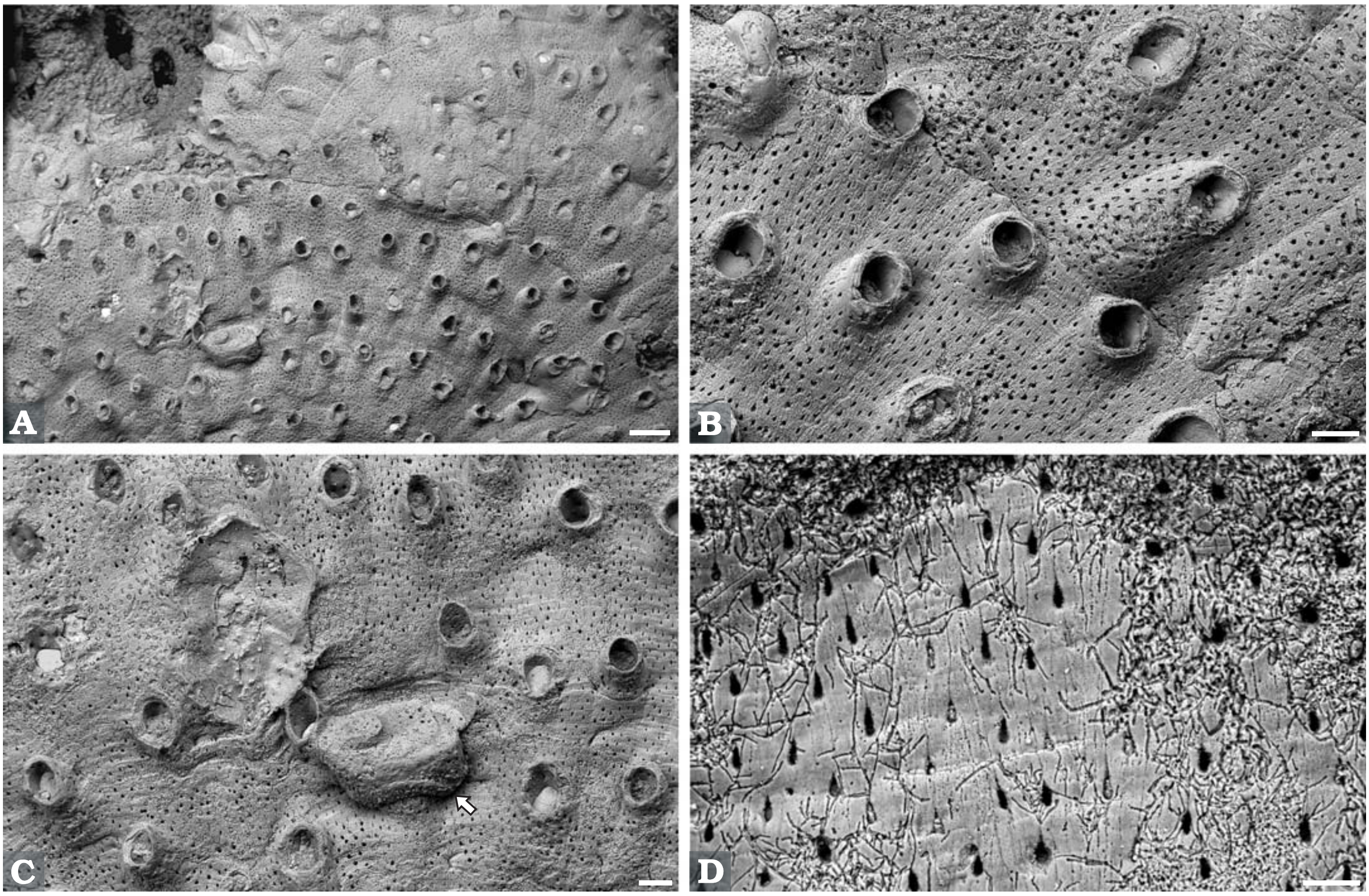

Fig. 6. Oncousoeciid cyclostome bryozoan *Microeciella mokrskoensis* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura. Holotype, GIUS 8-3509-14, Mokrsko, Upper Bajocian. **A**. General colony view. **B**. Autozooids. **C**. Close-up of the gonozooids, the one of which is roofless and the second one is aborted (arrowed). **D**. Pseudopores. Scale bars: 300 μm (A), 100 μm (B, C), 30 μm (D). All images from SEM BSE, specimens uncoated.

1984) from the Middle Jurassic Carmel Formation of Utah (see Taylor and Wilson 1999). However, *M. mokrskoensis* differs from *M. beliensis* in having wider and much longer gonozooids, whereas the brood chamber of *M. duofluvina* is more than 2 × longer than wide compared with 1.5 × in *M. mokrskoensis*.

Stratigraphic and geographic range.—Upper Bajocian of Mokrsko, Polish Jura.

Microeciella magnopora sp. nov.

Fig. 7.

Etymology: In reference to the unusually large size of the ooeciopore.

Type material: Holotype: GIUS 8-3509-15; paratype: GIUS 8-3509-2.

Type locality: Bugaj, Polish Jura, Poland.

Type horizon: Middle Bathonian (*Tulites subcontractus* or *Morrisiceras morrisi* Zone), Jurassic.

Material.—Holotype and paratype listed above.

Measurements.—FWL, 850–1150 μm; FWW, 250–275 μm; LAM, 100–125 μm; TAM, 100–125 μm; LPM, 125–200 μm; TPM, 150–175 μm; GTL, 1250–1625 μm; GDL, 550–725 μm; GW, 512–625 μm; OL, 150 μm; OW, 162 μm; PL, 15–16.5 μm; PW, 1.6–3.3 μm.

Diagnosis.—*Microeciella* with gonozooids having equidimensional, ovoidal or heart-shaped brood chambers with a large ooeciopore about the same size as an autozooidal aperture; autozooids large, frontal walls more than 250 μm wide; pseudopores narrow, slit-like.

Description.—Colony encrusting, sheet-like, multiserial, bereniciform. Early astogenetic stages preserved but ancestrula not visible.

Autozooids large, elongate, widening distally towards apertures, with rather flat frontal wall but with distinct boundaries. Peristomes short, upright, tapering distally. Apertures circular to subcircular, some closed by terminal diaphragms. Pseudopores closely-spaced, narrow, slit-like, longitudinally elongate (Fig. $7A_4$).

Gonozooids uncommon. Proximal frontal wall indistinguishable from that of an autozooid. Brood chamber ovoidal or heart-shaped, V-shaped at its proximal end, slightly longer than wide, bulbous, roof densely pseudoporous (Fig. $7A_3$). Ooeciopore, preserved in only one gonozooid, subterminal, circular in outline, large, similar in size to an autozooidal aperture (Fig. $7A_3$).

Remarks.—Although the gonozooids in the paratype specimen are roofless, without the distinctive large ooeciopore be-

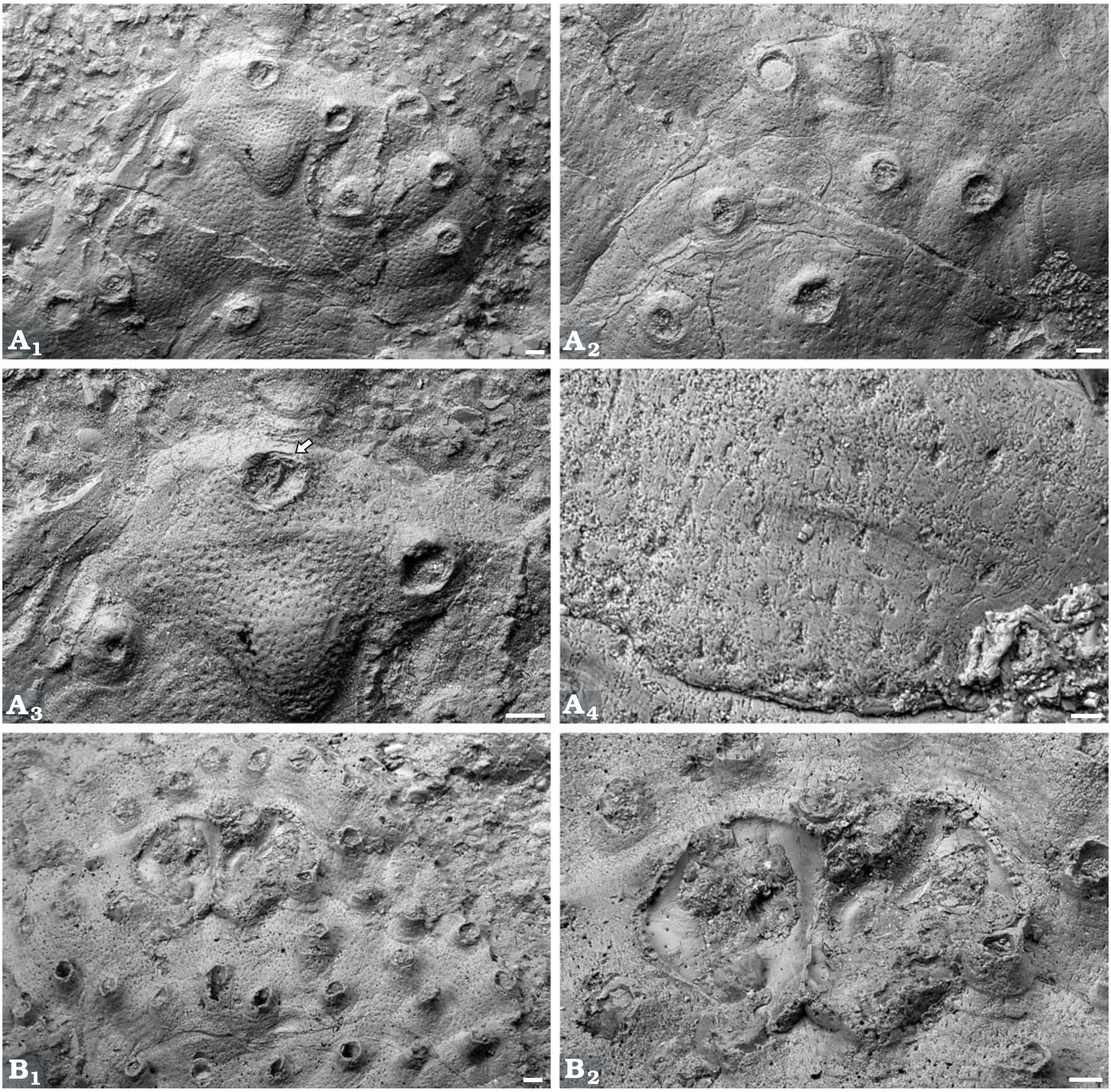

Fig. 7. Oncousoeciid cyclostome bryozoan *Microeciella magnopora* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura. **A**. Holotype, GIUS 8-3509-15, Bugaj, Middle Bathonian. A_1, general view of the preserved colony; A_2, autozooids; A_3, close-up of the gonozooid with the ooeciopore (arrowed); A_4, pseudopores. **B**. Paratype, GIUS 8-3509-2, Bugaj, Middle Bathonian. B_1, autozooids and two roofless gonozooids; B_2, close-up of the gonozooids. Scale bars 100 µm (A_1, A_2, A_3, B_1, B_2), 20 µm (A_4). BSE SEM images of uncoated specimens.

ing visible, the general shape of the brood chambers is similar to the holotype, as are the autozooids and pseudopores. Therefore, we place the two specimens in the same new species, *M. magnopora*.

No other species of *Microeciella* have such a large ooeciopore as that of *M. magnopora*, in which it is approximately the same size as the autozooidal apertures. Neglecting ooeciopore size, the closest resemblance among the Polish species of *Microeciella* described in this study is with *M. kuklinskii* which has autozooids of about the same size and a similarly-shaped brood chamber. However, the pseudopores of the two species are quite different, those of *M. kuklinskii* being broad and teardrop shaped, contrasting with the narrow, slit-like pseudopores of *M. magnopora*.

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

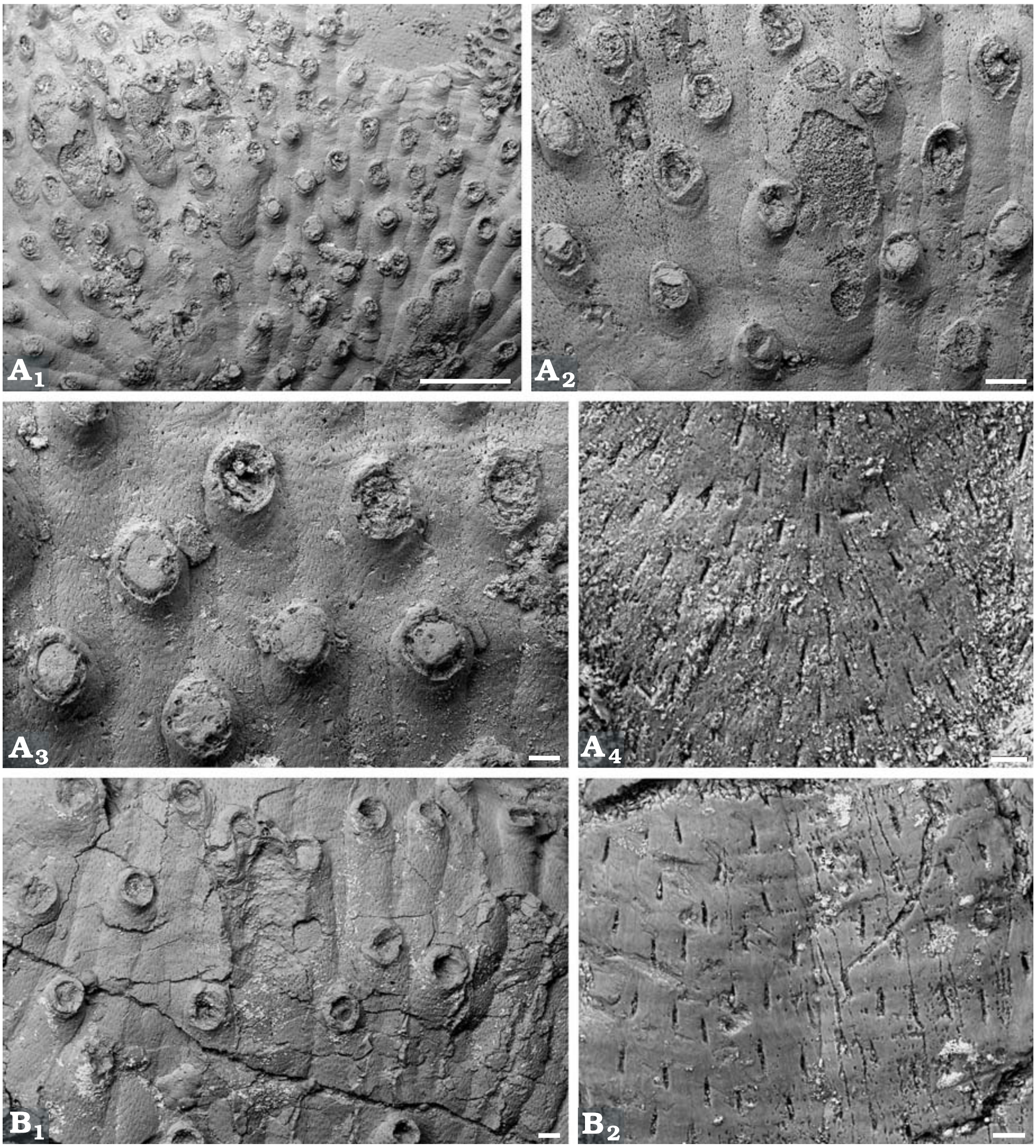

Fig. 8. Multisparsid cyclostome bryozoan *Reptomultisparsa harae* sp. nov. from the Middle Jurassic Inferior Oolite of England and ore-bearing clays of the Polish Jura. **A**. Holotype NHM D52832, Upper Bajocian, Shipton Gorge, Dorset, UK. A_1, colony with gonozooids; A_2, close-up of a gonozooid; A_3, autozooids, some of which have terminal diaphragms; A_4, pseudopores. **B**. Paratype, GIUS 8-3509-16, Middle Bathonian, Bugaj, Polish Jura. B_1, autozooids and worn gonozooid; B_2, pseudopores. Scale bars 1 mm (A_1), 200 µm (A_2), 100 µm (A_3, B_1), 20 µm (A_4, B_2). BSE SEM images of uncoated specimens.

Family Multisparsidae Bassler, 1935

Genus Reptomultisparsa d'Orbigny, 1853

Type species: *Diastopora incrustans* d'Orbigny, 1850; Bathonian, Normandy, France.

Reptomultisparsa harae sp. nov.

Fig. 8.

Etymology: In honour of Dr Urszula Hara, bryozoologist at the Polish Geological Institute, Warsaw.

Type material: Holotype: NHM D52832; paratype: GIUS 8-3509-16.

Type locality: Shipton Gorge, Dorset.

Type horizon: Inferior Oolite, Microzoa Beds (Upper Bajocian, *Parkinsonia parkinsoni* Zone), Jurassic.

Material.—Holotype and one paratype listed above, the latter from the Middle Bathonian of Bugaj, Polish Jura.

Measurements.—FWL, 900–1260 µm; FWW, 240–260 µm; LAM, 160–200 µm; TAM, 120–160 µm; LPM, 220–260 µm; TPM, 180–220 µm; GTL, 2100–2400 µm; GDL, 1570–1620 µm; GW, 660–760 µm; OL, 190–215 µm; OW, 165–215 µm; PL, 12.5–17.5 µm; PW, 1.25–2.5 µm.

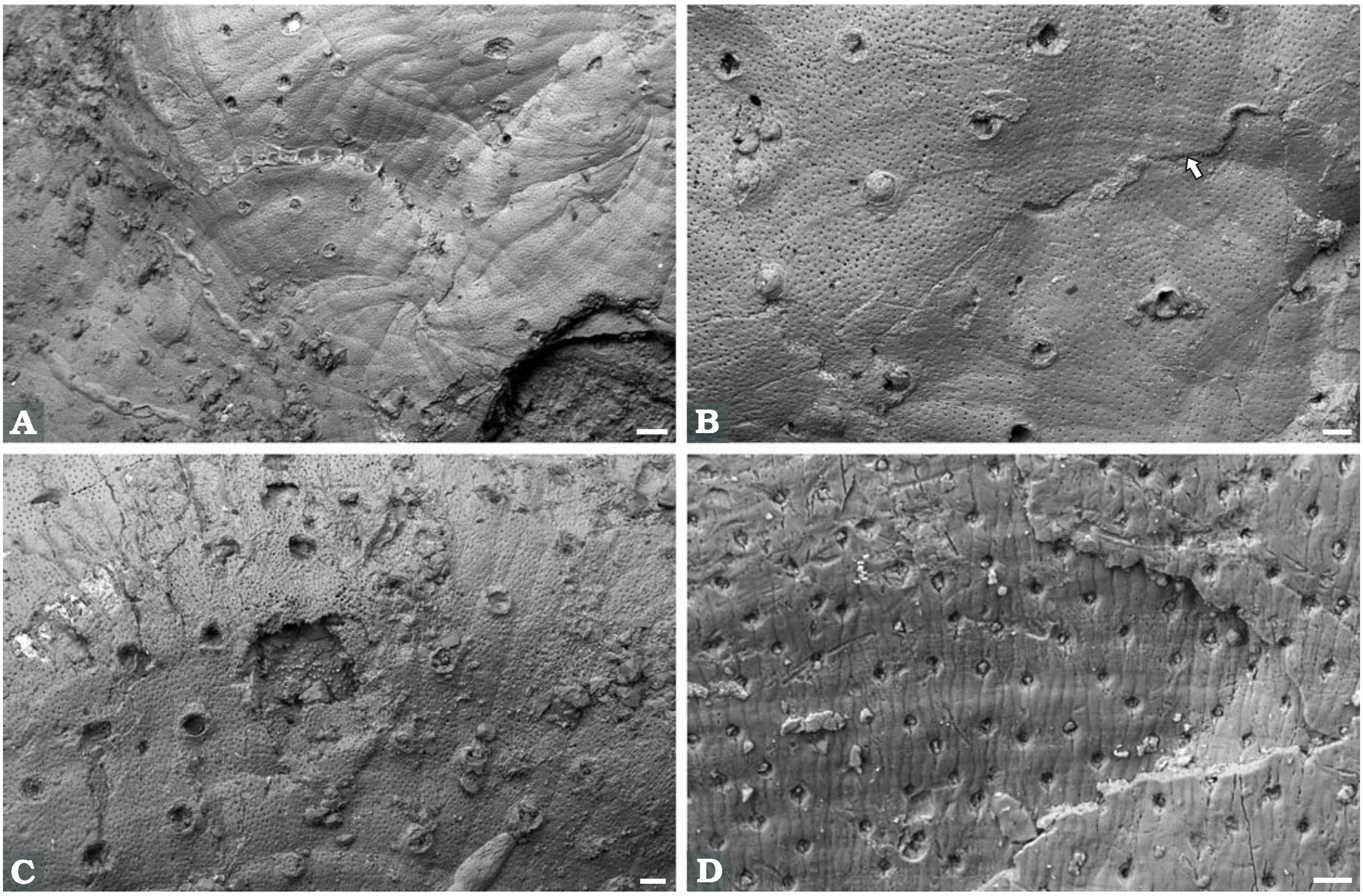

Fig. 9. Multisparsid cyclostome bryozoan *Reptomultisparsa* aff. *cobra* (Pitt and Thomas, 1969) from the Middle Jurassic ore-bearing clays of the Polish Jura, GIUS 8-3509-17. **A**. Colony with spiral overgrowth. **B**. Proximal regrowth from broken edge (arrowed). **C**. Crushed and partly worn gonozooid. **D**. Pseudopores. Scale bars 200 µm (A), 100 µm (B, C), 20 µm (D). BSE SEM images of uncoated specimens.

Diagnosis.—*Reptomultisparsa* with elongate ovoidal brood chamber, 2–3 × longer than wide, ooeciopore subcircular and about same diameter as an autozooidal aperture; autozooids large, about 250 µm wide; pseudopores slit-like.

Description.—Colony encrusting, sheet-like, multiserial, unilamellar, bereniciform. Early growth stages unknown.

Autozooids large, elongate with slightly convex frontal walls; zooidal boundaries well-marked, shallowly grooved. Preserved peristomes short, tapering distally. Apertures circular or longitudinally elliptical. Pseudopores slit-like, much longer than wide, densely spaced (Fig. 8A_4, B_2).

Gonozooids common, well-preserved in the holotype (Fig. 8A_1, A_2) and crushed or aborted in the paratype (Fig. 8B_1). Proximal frontal wall long, flat. Brood chamber convex, longitudinally elongated, ovoidal in shape, 2–3 × longer than wide, edges indented by apertures of neighbouring autozooids. Roof densely pseudoporous. Ooeciopore subterminal, circular or somewhat transversely elliptical, as large as an autozooidal aperture.

Remarks.—There are no significant differences between the holotype of this new species from the British Upper Bajocian and the paratype from the Polish Middle Bathonian. The two colonies have autozooids of similar size, the shape and size of the gonozooids is identical, and both have distinctive slit-like pseudopores. The type species of *Reptomultisparsa*, *R. incrustans*, has much larger gonozooids than *R. harae* and forms multilamellar colonies on gastropod shells inferred to have been occupied by hermit crabs (see Taylor 1994 and references therein). Many other Jurassic species assigned to this genus (e.g., *R. walfordiana* [Canu and Bassler, 1922], *R. cobra* [Pitt and Thomas, 1969], *R. incrustans* [d'Orbigny, 1850], and *R. microstoma* [Michelin, 1845]) have flatter colony surfaces, with more convex autozooidal frontal walls and brood chambers, as well as autozooidal apertures spaced widely apart relative to their diameters. The Polish Oxfordian species *R. norberti* Hara and Taylor, 1996, differs from *R. harae* in having a gonozooid of low profile with a very wide ooeciopore.

Stratigraphic and geographic range.—Upper Bajocian of Shipton Gorge, Dorset, England, and Middle Bathonian of Bugaj, Polish Jura.

Reptomultisparsa aff. *cobra* (Pitt and Thomas, 1969)

Fig. 9.

Material.—Three colonies on two samples: GIUS 8-3509-17–18, two of which possess gonozooids.

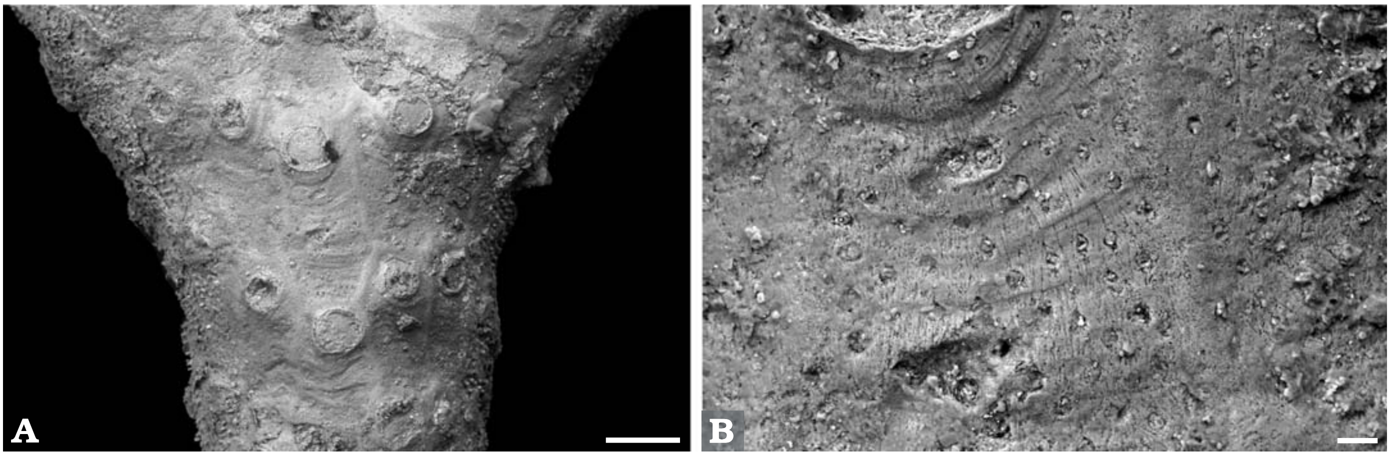

Fig. 10. Multisparsid cyclostome bryozoan *Idmonea* sp. from the Middle Jurassic ore-bearing clays of the Polish Jura, GIUS 8-3509-19. **A**. Autozooids. **B**. Pseudopores. Middle Bathonian (*Morrisiceras morrisi* Zone), Gnaszyn Dolny. Scale bars: 200 μm (A) , 20 μm (B). BSE SEM images of uncoated specimens.

Measurements.—FWL, 472–980 μm; FWW, 120–180 μm; LAM, 66–100 μm; TAM, 57–85 μm; LPM, 100–133 μm; TPM, 100–116 μm; GTL, 1760 μm; GDL, 1120–1216 μm; GW, 600–733 μm; OL, 121 μm; OW, 114 μm; PL, 7.5–10 μm; PW, 6.3–7.5 μm.

Description.—Colony encrusting, multiserial, sheet-like, bereniciform, multilamellar; surface planar. Spiral overgrowths are common (Fig. 9A). Growing edge low, only one generation of zooids visible at the budding zone (Fig. 9A). Early growth stages unknown.

Autozooids slender, variable in length but mostly long, with flat or very gently convex frontal walls, zooidal boundaries indistinct. Apertures widely spaced, circular or slightly elongated, some closed by terminal diaphragms. Peristomes short, upright. Pseudopores teardrop-shaped, densely spaced, longer than wide, usually pointed distally, located at boundaries between narrow longitudinal strips of calcification (Fig. 9D).

Gonozooids preserved in two colonies, uncommon, crushed and/or filled with pyrite. Proximal frontal wall flat, indistinguishable from an autozooid. Brood chamber evidently more convex than an autozooid, longitudinally elongated, spindle-like in shape with maximum width at mid-length (Fig. 9C). Ooeciopore subterminal, circular in outline, larger than an autozooidal aperture.

Remarks.—The Polish material described here differs from the holotype of *R. cobra* (Pitt and Thomas, 1969), originally described from the Lower Bathonian of southern Britain (Oxfordshire), which has a more elongate, less spindle-shaped brood chamber . However, the differences are slight, the British and Polish material having autozooids and pseudopores of similar sizes and shapes. A related species from Balin with larger autozooids was recently described under the name *R.* aff. *cobra* (Pitt and Thomas, 1969) by Taylor (2009).

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

Genus Idmonea Lamouroux, 1821

Type species: *Idmonea triquetra* Lamouroux, 1821, Bathonian, Normandy, France.

Idmonea sp.

Fig. 10.

Material.—GIUS 8-3509-19, Gnaszyn Dolny, Middle Bathonian, comprising six branch fragments, partially coated by siderite, retrieved from a sample interpreted as a regurgitate by Zatoń and Salamon (2008).

Measurements.—FWL, 400–507 μm; FWW, 147–187μm; LAM, 80–107 μm; TAM, 67–107 μm; LPM, 120–133 μm; TPM, 93–133 μm; PW, 8 μm.

Description.—Colony erect comprising bifurcating branches about 820 μm in diameter, ovoidal in cross-section.

Autozooid frontal walls flat to slightly convex, a distinct convex boundary wall present. Apertures transversely elliptical or circular, some closed by terminal diaphragms, variable in size with those located at the midline of the branches being largest (Fig. 10A). Peristomes short, upright. Pseudopores small and dense, teardrop-shaped, about as long as wide, pointed distally (Fig. 10B).

Gonozooids not observed.

Remarks.—Historically, the tubuliporine genus *Idmonea* has been interpreted in different ways, either as an encruster with branches of a subtriangular shape in cross-section, or as an erect genus with branches of similar cross-sectional shape. As was noted by Pitt and Taylor (1990), the Jurassic type species, *I. triquetra* Lamouroux, 1821, has encrusting branches. However, from the encrusting base, erect branches may arise with ovoidal cross-sections and autozooids opening around the entire circumference (Walter 1970). These contrast with branches of erect species historically assigned to *Idmonea*, signifying a taxonomic difference. The erect branches described here from the Polish Jurassic do, however, possess an ovoidal cross-section, although the morphology of the encrusting base is unknown. The branches were found in the sample interpreted as regurgitate by Zatoń and Salamon (2008). Therefore,

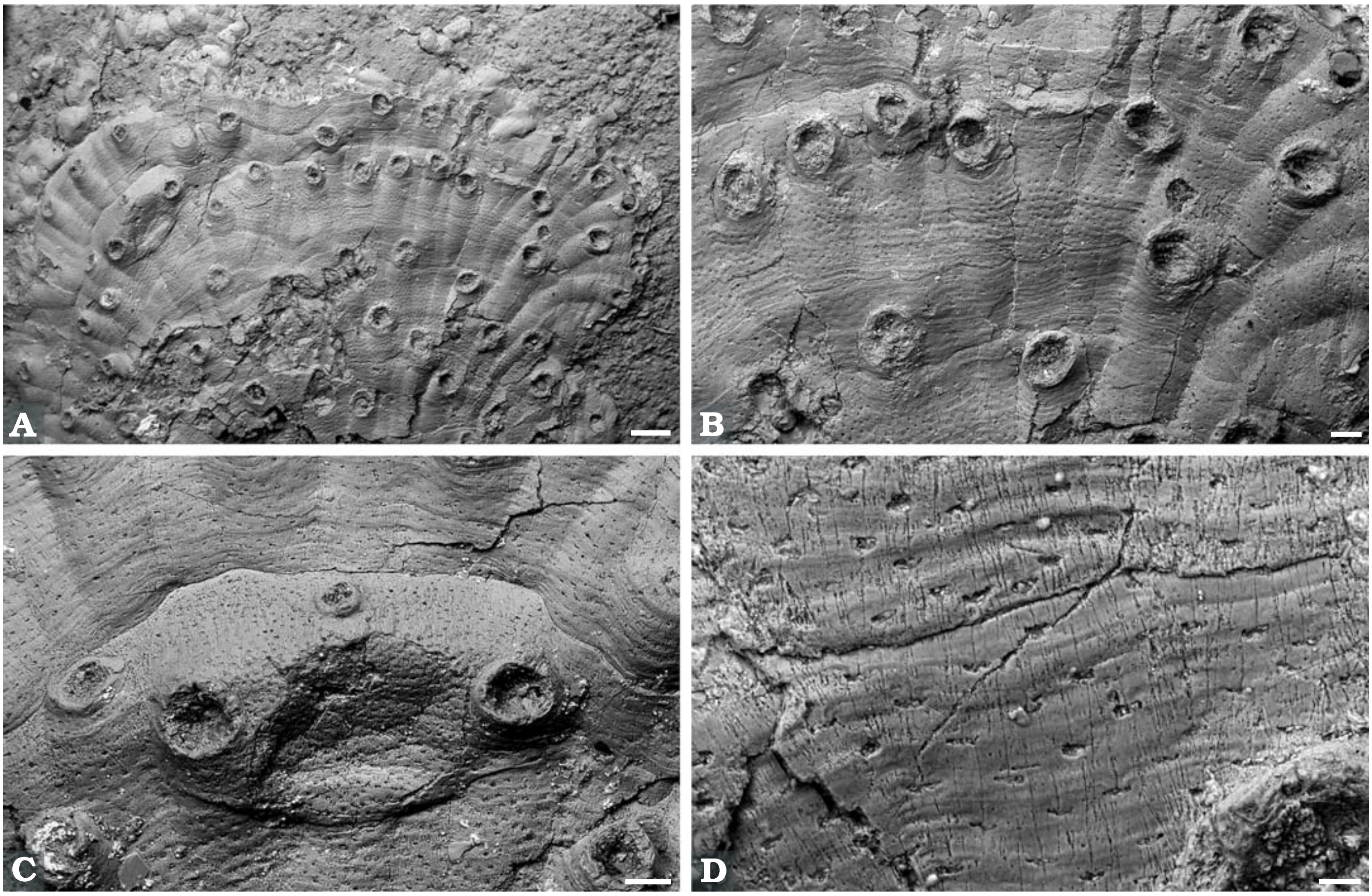

Fig. 11. Plagioeciid cyclostome bryozoan *Hyporosopora bugajensis* sp. nov. from the Middle Jurassic ore-bearing clays of the Polish Jura, holotype, GIUS 8-3509-20. **A**. Colony view. **B**. Autozooids. **C**. Partly crushed gonozooid. **D**. Pseudopores. Scale bars: 300 µm (A), 100 µm (B, C), 20 µm (D). BSE SEM images of uncoated specimens.

they may have been swallowed by a durophagous marine vertebrate, either incidentally or as part of its normal diet.

Stratigraphic and geographic range.—Middle Bathonian of Gnaszyn Dolny, Polish Jura.

Family Plagioeciidae Canu, 1918

Genus *Hyporosopora* Canu and Bassler, 1929

Type species: *Hyporosopora typica* Canu and Bassler, 1929, Bathonian of Normandy, France.

Hyporosopora bugajensis sp. nov.

Fig. 11.

Etymology: From the type locality Bugaj in the Polish Jura.

Type material: Holotype: GIUS 8-3509-20; paratype: GIUS 8-3509-21.

Type locality: Bugaj, Polish Jura.

Type horizon: Ore-bearing clays (Middle Bathonian, *Tulites subcontractus* or *Morrisiceras morrisi* Zone), Jurassic.

Material.—Holotype and paratype listed above.

Measurements.—FWL, 750–1388 µm; FWW, 183–250 µm; LAM, 100–166 µm; TAM, 100–150 µm; LPM, 166–200 µm; TPM, 116–233 µm; GTL, 1183 µm; GDL, 510 µm; GW, 920 µm; OL, 40 µm; 70 µm; PL, 2.5–5 µm; PW, 15–17.5 µm.

Diagnosis.—*Hyporosopora* with large autozooids, usually more than 1 mm long; gonozooids with small transversely elliptical brood chambers; pseudopores transverse, gull wing-shaped.

Description.—Colony encrusting, sheet-like, multiserial, bereniciform, unilamellar, surface covered by transverse growth checks (Fig. 11A).

Autozooids long, with flat to slightly convex frontal walls; zooidal boundaries distinct, shallowly grooved. Preserved peristomes short, tapering distally. Apertures circular to elliptical, some closed by diaphragms, irregularly arranged often forming ill-defined transverse rows. Pseudopores transversely elongate, narrow, gull wing-shaped, spaced a moderate distance apart (Fig. 11D).

Gonozooid preserved in the holotype only. Proximal part indistinguishable from an autozooid. Brood chamber small, inflated, broad, width nearly twice length, elliptical (Fig. 11C), lateral margins slightly indented by autozooidal apertures. Roof densely pseudoporous. Ooeciopore terminal, transversely elliptical, much smaller than an autozooidal aperture. Ooeciostome short, upright.

Remarks.—This new species of *Hyporosopora* species has the longest autozooids, averaging 1113 µm, of all the bereniciform cyclostomes described in the present paper. The

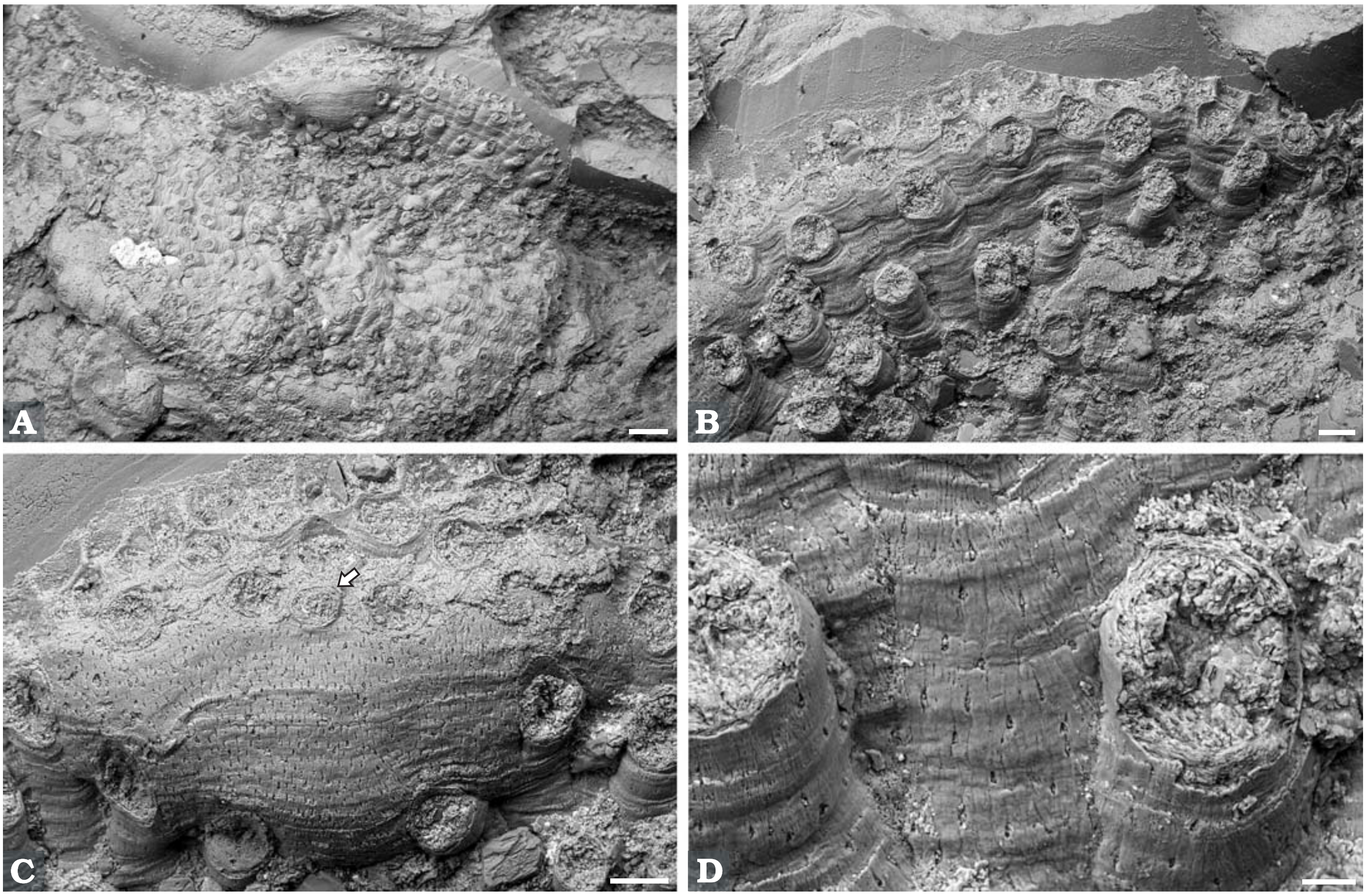

Fig. 12. Plagioeciid cyclostome bryozoan *Hyporosopora tenera* (Reuss, 1867) from the Middle Jurassic ore-bearing clays of the Polish Jura, GIUS 8-3509-12. **A**. Colony view. **B**. Marginal autozooids. **C**. Gonozooid with ooeciopore (arrowed). **D**. Pseudopores. Scale bars: 300 µm (A), 100 µm (B, C), 30 µm (D). BSE SEM images of uncoated specimens.

gonozooid is small for *Hyporosopora* and more transversely elliptical than the type species *H. typica* or *H. tenera* (Reuss, 1867) in which it more clearly resembles an equilateral triangle. Transversely elongate pseudopores, as seen in the new species, are rare in cyclostomes and have not been recorded previously from any species of *Hyporosopora*. The gull wing-shaped pseudopores of *H. bugajensis* most closely resemble those seen in the unifoliate erect species *Diastopora lamourouxi* Milne Edwards, 1838. These pseudopores are sufficiently unusual that we have no hesitation in assigning an infertile colony to *H. bugajensis* as a paratype.

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

Hyporosopora tenera (Reuss, 1867)

Fig. 12.

1867 *Berenicea tenera* sp. nov.; Reuss 1867: 8 (partim), pl. 1: 9.
2009 *Hyporosopora tenera* (Reuss, 1867); Taylor 2009: 37, figs. 7C, 9A–F.

Material.—GIUS 8-3509-12.

Measurements.—FWL, 300–440 µm; FWW, 112–137 µm; LAM, 75–112 µm; TAM, 75–100 µm; LPM, 100–125 µm; TPM, 100–125 µm; GDL, 500 µm; GW, 1000 µm; OL, 66 µm; OW, 91 µm; PL, 15–17.5 µm; PW, 2.5 µm.

Description.—Colony encrusting, sheet-like, multiserial, bereniciform, unilamellar, discoidal in shape (Fig. 12A).

Autozooids small, elongate, with slightly convex frontal walls exhibiting fine growth lines; zooidal boundaries distinct, shallowly grooved. Preserved peristomes short, upright. Apertures small-sized, generally circular but sometimes longitudinally elongate, occasionally closed by terminal diaphragms. Pseudopores longitudinally elongate, narrow, slit-like, rather sparse (Fig. 12D).

Gonozooids represented by one example close to colony margin. Brood chamber inflated, much wider than longer, rounded subtriangular in shape, distal edge almost straight, roof densely pseudoporous (Fig. 12C). Proximolateral margins indented by apertures of neighbouring autozooids. Ooeciopore terminal, wider than longer but almost circular, smaller than an autozooidal aperture.

Remarks.—The morphology of the gonozooid and the size and other characteristics of the autozooids in this specimen match those of the holotype of *Hyporosopora tenera* (Reuss, 1867) from the Upper Bathonian–Early Callovian of Balin, as recently redescribed by Taylor (2009). The only differ-

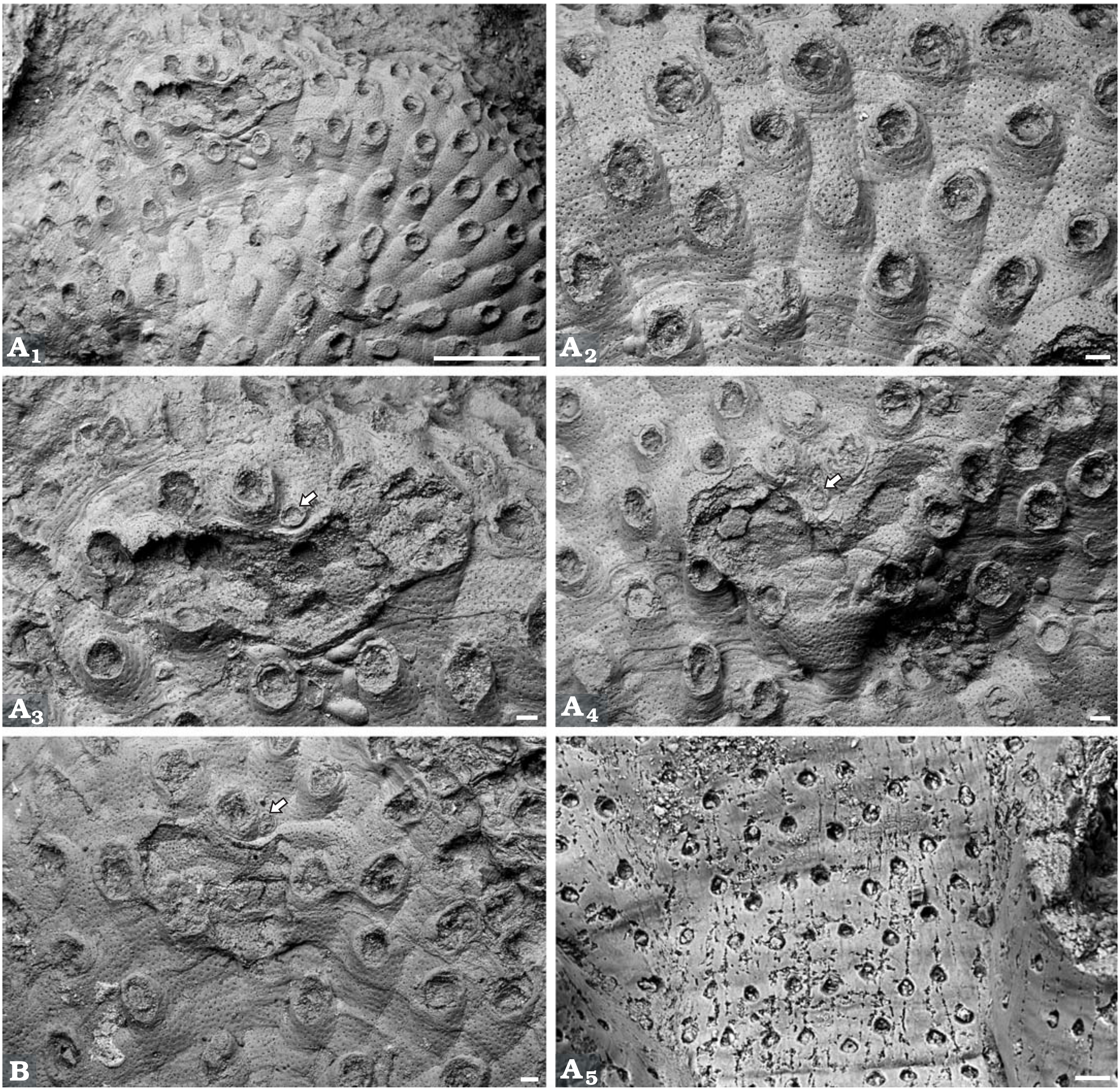

Fig. 13. Plagioeciid cyclostome bryozoan *Hyporosopora* aff. *sauvagei* (Gregory, 1896) from the Middle Jurassic ore-bearing clays of the Polish Jura. **A**. Middle Bathonian, Bugaj, GIUS 8-3509-22. A_1, colony view; A_2, autozooids; A_3, boomerang-like gonozooid, ooeciopore arrowed; A_4, heart-shaped gonozooid, ooeciopore arrowed; A_5, pseudopores. **B**. Middle Bathonian, Bugaj, NHM BZ 5612(2), subtriangular gonozooid, ooeciopore arrowed. Scale bars: 1 mm (A_1), 100 µm (A_2–A_4, B), 20 µm (A_5). BSE SEM images of uncoated specimens.

ence is the somewhat smaller brood chamber. However, as the colony described has only one gonozooid preserved, we cannot compare the full size-range of gonozooids between the holotype and the new specimen.

Hyporosopora tenera (Reuss, 1867) differs from the most similar species *Hyporosopora typica* by having much smaller autozooids, the width of which is well below 200 µm.

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura and Upper Bathonian to Lower Callovian of Balin, southern Poland.

Hyporosopora aff. *sauvagei* (Gregory, 1896)

Fig. 13.

Material.—Two colonies: GIUS 8-3509-22 and NHM BZ 5612(2).

Measurements.—FWL, 716–816 µm; FWW, 266–283 µm;

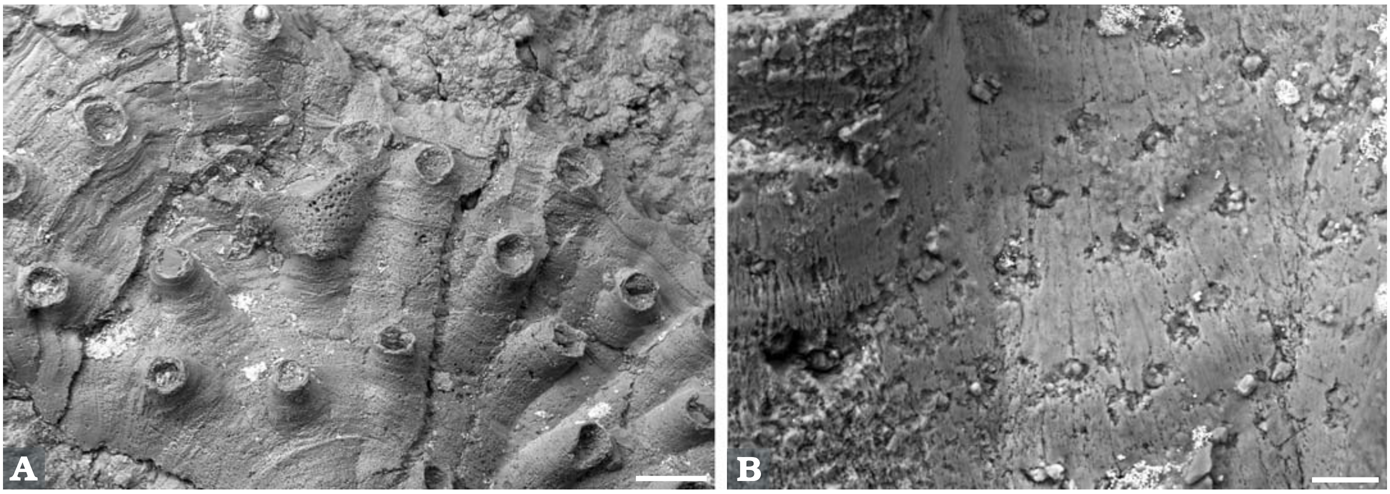

Fig. 14. Plagioeciid cyclostome bryozoan *Hyporosopora* sp. from the Middle Jurassic ore-bearing clays of the Polish Jura, GIUS 8-3509-23. **A**. Autozooids and partly crushed gonozooid. **B**. Pseudopores, Upper Bathonian, Żarki (Żar1). Scale bars: 200 µm (A), 20 µm (B). BSE SEM images of uncoated specimens.

LAM, 133–200 µm; TAM, 133–150 µm; LPM, 200–283 µm; TPM, 166–233 µm; GDL, 760–783 µm; GW, 1300–1450 µm; OL, 100–130 µm; OW, 100–116 µm; PL, 12.5–15 µm; PW, 10 µm.

Description.—Colony encrusting, sheet-like, multiserial, bereniciform, unilamellar, surface covered by transverse growth checks (Fig. $13A_1$).

Autozooids large, elongate, gently convex, zooidal boundaries distinct. Preserved peristomes short, tapering distally. Apertures circular to longitudinally elliptical, some closed by terminal diaphragms. Pseudopores densely spaced, teardrop-shaped, wide, pointed distally (Fig. $13A_5$).

Gonozooids present but crushed, one preserved in specimen NHM BZ 5612(2) and two in specimen GIUS 8-3509-22. Proximal part flat. Brood chamber shape variable within same colony (GIUS 8-3509-22): much broader than long, boomerang-like (Fig. $13A_3$) or nearly equidimensional and heart-shaped with prominent distal lobes (Fig. $13A_4$). Roofs densely pseudoporous. Margins indented by neighbouring autozooidal apertures. Ooeciopore terminal, subcircular, much smaller than autozooidal aperture. Ooeciostome short, upright.

Remarks.—The material described here resembles the holotype (NHM B194) of *Hyporosopora sauvagei* from the Upper Bathonian Bradford Clay of Bradford on Avon, Wiltshire, England. However, the Polish material has teardrop-shaped pseudopores in contrast to those of the holotype which are transversely elongate and broadly U-shaped. Colonies of putative *H. sauvagei* from Balin also possess teardrop-shaped pseudopores (Taylor 2009). However, in view of the importance for taxonomy of pseudopores shown by the current study, it is best to assign both the Balin and Bugaj material to *H.* aff. *sauvagei*.

Stratigraphic and geographic range.—Middle Bathonian of Bugaj, Polish Jura.

Hyporosopora sp.

Fig. 14.

Material.—One colony GIUS 8-3509-23.

Measurements.—FWL, 566–700 µm; FWW, 150–166 µm; LAM, 58–116 µm; TAM, 66–116 µm; LPM, 100–133 µm; TPM, 100–133 µm; GTL, 816 µm; GDL, 183 µm; GW, 500 µm; PL, 8.8–10 µm; PW, 8.8–10 µm.

Description.—Colony encrusting, sheet-like, multiserial, bereniciform, unilamellar.

Autozooids elongate, frontal walls flat to convex, zooidal boundaries indistinct in some places. Apertures subcircular, some closed by terminal diaphragms. Preserved peristomes short, tapering distally. Pseudopores poorly preserved due to worn frontal walls, large, as wide as long, drop-shaped, pointed distally (Fig. 14B).

One broken gonozooid preserved. Brood chamber small, broader than long, bulbous, sharply delineated from proximal frontal wall, subtriangular in outline with distally extending two lateral lobes; roof densely pseudoporous (Fig. 14A). Ooeciopore not visible.

Remarks.—This species is characterized by a small brood chamber differing in shape and size from the other species of *Hyporosopora* described here. While it may represent a new species, more material is required to justify such distinction.

Stratigraphic and geographic range.—Upper Bathonian of Żarki, Polish Jura.

Family Incertae sedis

"*Berenicea*" spp.

Material.—51 colonies: GIUS 8-3509-2, GIUS 8-3509-23–73.

Remarks.—Several spot- or sheet-like tubuliporine colonies that are badly preserved (26 colonies are abraded) or devoid of gonozooids (the rest of the colonies) cannot be generically

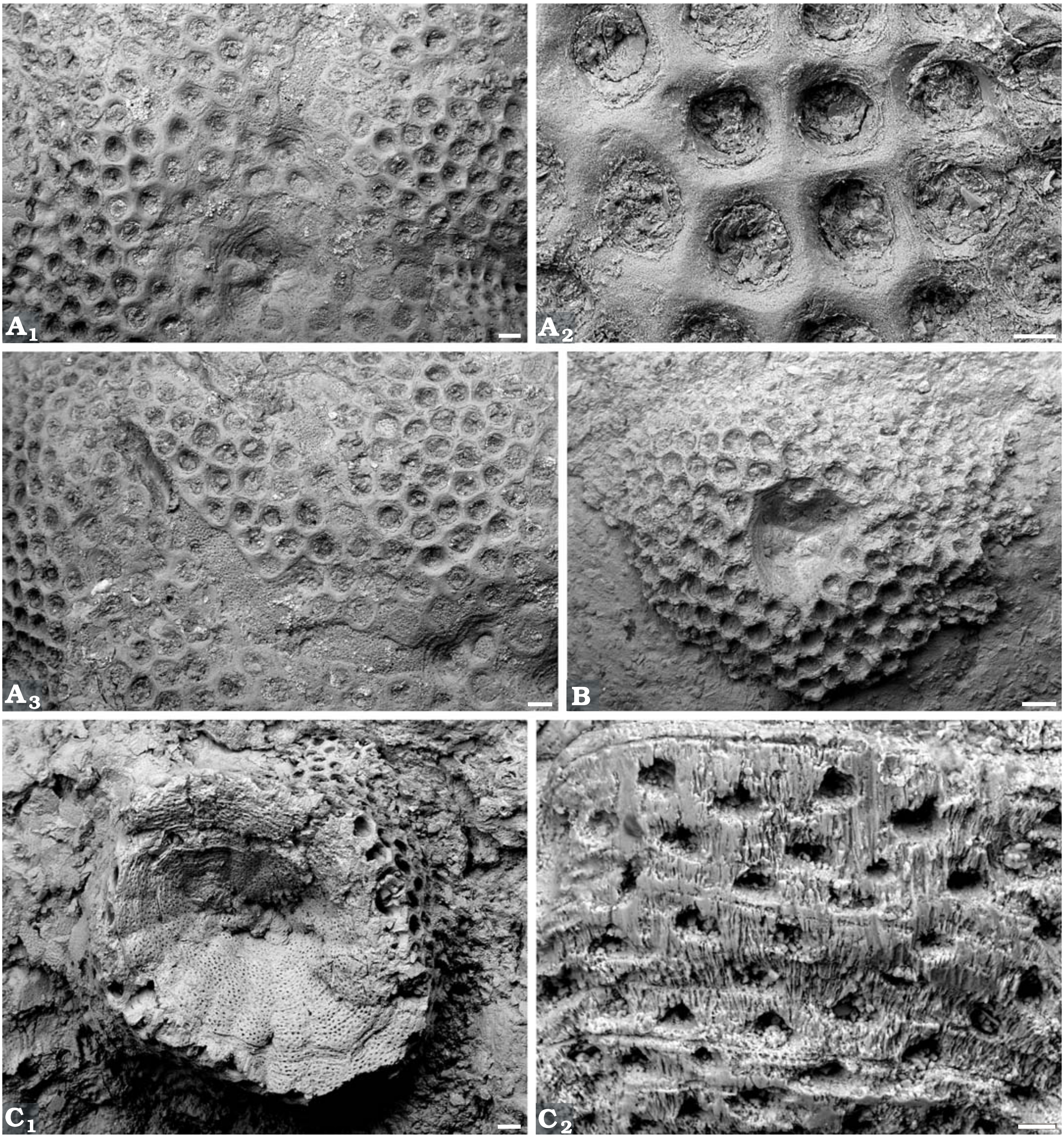

Fig. 15. Cerioporine cyclostome bryozoan *Ceriocava* sp. from the Middle Bathonian of Bugaj, Polish Jura. **A**. NHM Bz 5612(1). A_1, centre of cone-like subcolonies; A_2, autozooidal apertures; A_3, elongated and curved gonozooid. **B**. NHM BZ 5613, centre of cone-like subcolonies. **C**. NHM BZ 5614. C_1, centre of flabellotrypiform colony; C_2, pseudopores. Scale bars 300 μm (B), 200 μm (A_1, A_3, C_1), 100 μm (A_2), 20 μm (C_2). BSE SEM images of uncoated specimens.

assigned and are therefore placed in the form-genus "*Berenicea*" (see Taylor and Sequeiros 1982).

Stratigraphic and geographic range.—Uppermost Bajocian to Bathonian of Ogrodzieniec, Żarki, Bugaj, Mokrsko, and Krzyworzeka, Polish Jura.

Suborder Cerioporina Hagenow, 1851

Family Cavidae d'Orbigny, 1854

Genus *Ceriocava* d'Orbigny, 1854

Type species: *Millepora corymbosa* Lamouroux, 1821, Bathonian, Normandy, France.

Ceriocava sp.

Fig.15.

Measurements.—AD, 133–200 μm; IWT, 50–133 μm; GTL, 3500 μm; GW, 333 μm; PL, 15–20 μm; PW, 20–28 μm.

Material.—31 colonies: GIUS 8-3509-2, GIUS 8-3509-74–77, NHM BZ 5612–34.

Description.—Colonies varying from dome- and cone-like with autozooids opening over entire upper surface (Fig. 15A, B), or flabellate (flabellotrypiform) with autozooids opening only at subvertical growing edge and frontal surface of colony comprising exterior wall, depressed centrally (Fig. $15C_1$).

Autozooidal apertures rounded polygonal, surrounded by thick interzooidal walls (mean thickness 64–81 μm) with ridges at zooidal boundaries giving a honeycomb-like pattern (Fig. $15A_2$); terminal or subterminal diaphragms visible in thin-sections. Pseudopores, best visible on frontal surfaces of flabellitrypiform colonies, densely spaced, teardrop-shaped with broad base (mean width 22 μm), pointed distally (Fig. $15C_2$).

Gonozooids narrow and elongate, often curved; roof pseudoporous; ooeciopore not identified (Fig. $15A_3$).

Remarks.—As interpreted by Walter (1970), *Ceriocava corymbosa* (Lamouroux, 1821) encompasses a wide range of colony morphotypes, including the ramose erect forms normally associated with the genus as well as flabellotrypiform and dome-shaped encrusters. Material of this "species" from the Upper Bathonian–Lower Callovian of Balin exhibits a further morphotype: dendroid colonies composed of stacks of cap-like overgrowths (Taylor 2009). It is beyond the scope of the current paper to resolve the difficult taxonomy of Jurassic *Ceriocava* which would demand both thin section and SEM study of a large amount of comparative material. However, topotypical *Ceriocava corymbosa* (Lamouroux, 1821) from Normandy differs from the Polish material described here by its larger autozooidal apertures (mean diameter 268 μm), much smaller (mean width 10 μm) and denser pseudopores, and shorter but much wider gonozooids.

Stratigraphic and geographic range.—Upper Bajocian to Upper Bathonian of Mokrsko, Bugaj, Ogrodzieniec, and Krzyworzeka, Polish Jura.

Discussion

The majority of bryozoans recorded from the Jurassic globally have small, encrusting colonies and in ecological terms were "weeds" (Taylor and Ernst 2008). Most were assigned by 19th century researchers to the genera *Stomatopora*, *Proboscina,* and especially, *Berenicea*. Their taxonomy caused difficulties at that time and continues to do so today. Species of "*Berenicea*", now treated as a form-genus (Taylor and Sequieros 1982), differ very subtly from one another. Some of the differences are manifested in zooidal size but others only become apparent when gonozooids are present or after scanning electron microscopy of the tiny pseudopores. With respect to gonozooids, these brooding polymorphs have been used for genus- and family-level taxonomy since the work of Canu and Bassler (Canu 1918; Canu and Bassler 1929). However, gonozooids are typically present in only a small minority of colonies (McKinney and Taylor 1997); those colonies lacking gonozooids can be difficult or impossible to identify and are best assigned simply to the form-genus "*Berenicea*".

Much less use has been made of pseudopores in cyclostome taxonomy because these micron-scale features were too small to study prior to the advent of SEM. It is becoming clear that striking differences exist in the morphologies of pseudopores between species of cyclostomes. In some species they are more or less circular when viewed on the surfaces of frontal exterior walls (e.g., *Stomatopora bajocensis*, Fig. $2A_2$), whereas in others their shape is non-equidimensional. For example, many of the species described in this paper have teardrop-shaped pseudopores (e.g., *Stomatopora recurva*, Fig. $2B_2$; *Microeciella kuklinskii*, Fig. $4A_4$; *Hyporosopora* aff. *sauvagei*, Fig. $13A_5$), whereas others are longitudinally elongated teardrop-shaped (e.g., *M. annae*, Fig. 3D, *M. maleckii*, Fig. 5D), longitudinally slit-shaped (e.g., *Proboscinopora*? sp., Fig. $2C_2$; *Reptomultisparsa harae*, Fig. $8A_4$, B_2), or transversely elongate and gullwing-shaped (e.g., *H. bugajensis*, Fig. 11D). Similar variations in pseudopore shape have been noted in previous studies of Jurassic (Taylor 2009; Hara and Taylor in press) and Recent (Taylor and Zatoń 2008) cyclostomes of the *Berenicea*-type. While pseudopore shape has undoubted value in distinguishing between species that may be extremely similar in other respects, its significance at higher taxonomic levels has yet to be evaluated. At least some pseudopore morphologies cross-cut traditional taxonomy based largely on gonozooids.

The combination of gonozooid and pseudopore morphology has allowed us to distinguish a far greater number of species encrusting mostly hiatus concretions from the Late Bajocian to Bathonian of the Polish Jura than would otherwise have been possible. At least 11 different species of the *Berenicea*-type have been distinguished, representing a significant increase in the previously known diversity of cyclostomes in the Middle Jurassic of Poland. The preservation of the material studied here is good, allowing pseudopore morphology to be resolved in detail. Unfortunately, this is not the case for many other Jurassic bryozoan faunas, especially those from well-cemented carbonates in which it may not be possible to achieve such taxonomic precision.

Jurassic bryozoans encrusting hiatus concretions are known mainly from Germany and England. However, little attention has been paid to them and thus the diversity of organisms colonizing these substrates is poorly known. Hitherto, the richest bryozoan assemblage was known only from the Pliensbachian (Lower Jurassic) hiatus concretions of Osterfeld, Germany (Voigt 1968; Illies 1971, 1973), where seven species represented mainly by *Stomatopora* and "*Berenicea*" were encountered. Upper Sinemurian (Lower Jurassic) bryozoans encrusting hiatus concretions from Dorset, England (Hesselbo and Palmer 1992) are encrusted by "*Berenicea*"- and *Stomatopora*-like colonies, but these have not been described in detail. Beside the form-genus "*Berenicea*", fifteen species are described from the hiatus concretions of the Polish Jura, making the assemblage the richest ever reported on this kind of substrate.

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