Cyclostome bryozoans from the Kimmeridgian (Upper Jurassic) of Poland

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ABSTRACT
Few bryozoans have been described from Kimmeridgian deposits worldwide. A fauna of cyclostome bryozoans is described here for the first time from two localities in the Lower Kimmeridgian of the Holy Cross Mountains of Poland. Containing eight species, all encrusting, it represents the most diverse Kimmeridgian bryozoan fauna yet discovered. Two of the species are new, *Reptoclausa radwanskii* n. sp. and *Hyporosopora radomensis* n. sp. The record of *Reptoclausa* helps to bridge the gap between Aalenian and Hauterivian occurrences of this genus.

KEY WORDS
Bryozoa,
Upper Jurassic,
Kimmeridgian,
Poland.

RÉSUMÉ
Bryozoaires cyclostomes du Kimméridgien (Jurassique supérieur) de Pologne.
Peu de de bryozoaires ont été décrits à partir de dépôts kimméridgiens. Pour la première fois, une faune de cyclostome bryozoaires est décrite ici à partir de deux localités du Kimméridgien inférieur des Montagnes Sainte-Croix de Pologne. Contenant huit espèces, toutes encroûtantes, elle représente la faune bryozoaire kimméridgienne la plus diversifiée jamais découverte. Deux de ces espèces sont nouvelles, *Reptoclausa radwanskii* n. sp. et *Hyporosopora radomensis* n. sp. L'occurence de *Reptoclausa* contribue à combler le fossé entre Aalénien et Hauterivien pour ce genre.

MOTS CLÉS
Bryozoa,
Jurassique supérieur,
Kimméridgien
Pologne.

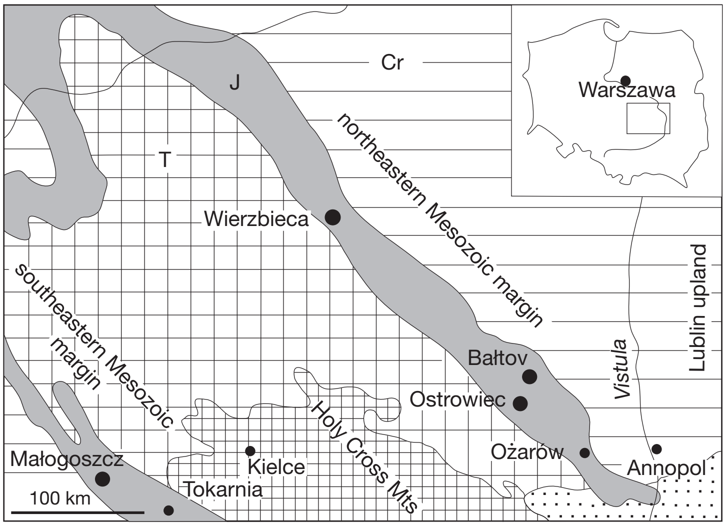

FIG. 1. — Location of Oxfordian-Kimmeridgian bryozoan-bearing exposures along the Mesozoic margins of the Holy Cross Mountains, Poland (adapted from Radwańska 1999). Abbreviations: **Cr**, Cretaceous; **J**, Jurassic; **T**, Triassic.

INTRODUCTION

The Jurassic was an important time in bryozoan evolution (Taylor & Ernst 2008), the only geological period in which bryozoan faunas were dominated by species belonging to the stenolaemate order Cyclostomata. The Jurassic also saw the first appearance of the gymnolaemate order Cheilostomata, which are the most abundant and diverse bryozoans in today's oceans. Nevertheless, Jurassic bryozoans have been inadequately studied. This in part reflects the fact that most species form small, weedy colonies encrusting shells and sedimentary hardgrounds. Furthermore, Jurassic bryozoan assemblages seldom comprise more than ten species, and both the geographical and stratigraphical distributions of Jurassic bryozoans are very patchy. Relatively few Jurassic bryozoans have been described from countries outside France, England and Germany. The great majority of species come from the Middle Jurassic; Lower and Upper Jurassic bryozoan faunas are uncommon.

Bryozoans are particularly depauperate in the Kimmeridgian stage of the Upper Jurassic. D'Orbigny (1850) described a single Kimmeridgian bryozoan (*Diastopora tenuis*) from the Pas-de-Calais, as well as two species (*Alecto corallina* and *A. rupellensis*) from the "Corallien" of Pointe-du-Ché near La Rochelle in deposits now regarded as Early Kimmeridgian. He subsequently introduced a third Kimmeridgian species, *Berenicea rugosa* d'Orbigny, 1853, from Angoulins in the same region. Subreefal Early Kimmeridgian caves on the Chay Peninsula near Angoulins have cyclostome bryozoans encrusting thrombolitic pseudostalactites hanging from the cave roofs (Taylor & Palmer 1994). Encrusting bryozoans have occasionally been recorded in the Kimmeridgian Clay of southern England (e.g., Wignall 1990), and ctenostome bryozoan borings are not uncommon in Kimmeridgian bivalve shells from northern Europe (see e.g., Pohowsky 1978). Moreover, the intensive boring activity of the ctenostome bryozoan *Ropalonaria arachne* (Fischer, 1866) has been described from the Lower Kimmeridgian *Lopha* shellbeds of the SW margin of the Holy Cross Mountains in Poland (see Radwańska & Radwański 2003). The first record of the occurrence of a Lower Kimmeridgian bryozoan from Poland was *Stomatopora dichotoma* (Lamouroux, 1821), reported by Pugaczewska (1970) during her studies on the Jurassic ostreiform bivalves from the same region. Radwańska & Radwański (2003) first mentioned epizoic bryozoans encrusting large terebratulid brachiopods from Malogoszcz, also in the Holy Cross Mountains.

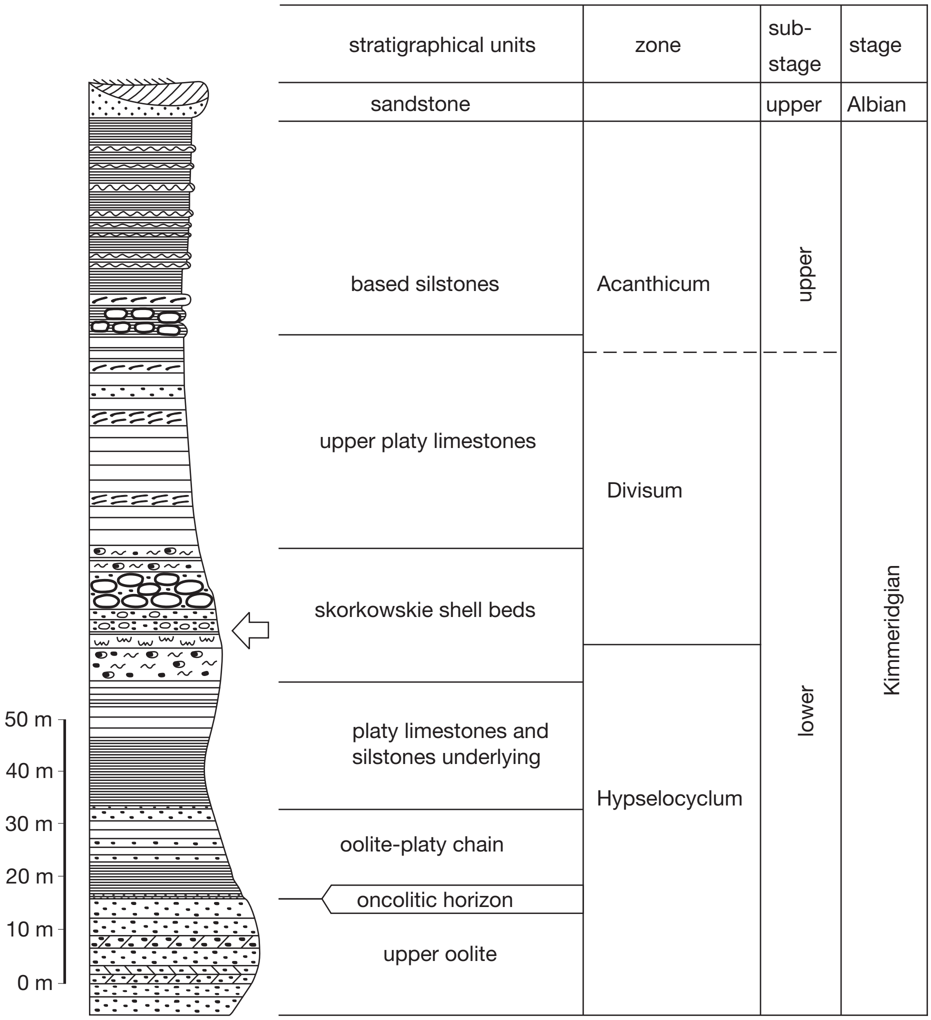

FIG. 2. — Profile of the Lower Kimmeridgian marly-limestone sequence at Małogoszcz Quarry, near Kielce (adapted from Radwański 2003), showing the main bryozoan-bearing horizon (arrowed).

However, apart from the earliest known cheilostome (*Pyriporopsis pohowskyi* Taylor, 1994) from questionably Kimmeridgian deposits in the Yemen, no other Kimmeridgian bryozoans have been described. The purpose of the current paper is to supplement our knowledge of Kimmeridgian bryozoans by describing some recently collected material from two localities on the margins of the Holy Cross Mountains in Poland. The presence of bryozoans at these localities has been mentioned in palaeoecological studies but they have never been formally described. In doing so we hope to increase awareness of these easily neglected and poorly understood fossils.

GEOLOGICAL SETTING

Late Jurassic (Upper Oxfordian-Early Kimmeridgian) sediments in central Poland, including the Holy

Cross Mountains, were deposited on a wide carbonate ramp, with an inner shallow-marine platform dominated by oolites, oncolites, bioclastic grainstones and biogenic limestones, and an outer part comprising open shelf sponge megafacies. Benthic assemblages in these shallow-marine sequences contain mainly echinoids, brachiopods, bivalves and corals (see Dzik 1979, 1982; Machalski 1989, 1998; Radwańska 1999; Radwańska & Radwański 2003; Radwański & Roniewicz 2005). The Lower Kimmeridgian is very well developed along the southwestern and northeastern margins of the Holy Cross Mountains, as at Małogoszcz and Wierzbica quarries respectively (Fig. 1), the two localities yielding the bryozoans described in this paper.

The huge Małogoszcz Quarry is located about 1 km north of Małogoszcz town (Fig. 1). The section here (Fig. 2) begins with lower and upper oolitic limestones separated by micritic banded limestones. The ammonite fauna, with *Pachypictonia albinea* (Oppel, 1862) which is characteristic of the entire section, encompasses the *platynota* and *hypselocyclum* zones. The top of the upper oolite is marked by a hardground overlain by an oncolitic limestone followed in turn by 17 m of oolitic-platy limestones. The latter represent, especially in their upper part, deposition in a shallow-water, high-energy environment. They are overlain by 12 m of dark marls followed by about 10 m of thin-bedded, platy sublithographic limestone. The upper boundary of the platy limestone is a marked discontinuity surface containing numerous burrows and borings and encrusted by oysters and serpulids. Overlying this surface is the 6 m thick Skorków lumachelle, forming the lowermost part of a succession of micritic limestones rich in bivalves (mostly *Actinostreon* Bayle, 1878) and other benthic fossils. Shells from the Skorków lumachelle are often bored by the ctenostome bryozoan *Ropalanaria arachne* (Fischer, 1866) and may be encrusted by serpulids and the cyclostome bryozoans described in this paper.

Marly shell beds of the Skorków type containing coquinas of *Actinostreon* (= *Lopha* Röding, 1798) occur in the Lower Kimmeridgian from the southwestern to the northeastern margins of the Holy Cross Mountains and form a correlative horizon. The ammonite fauna in the Skorków lumachelle includes *Rasenia* Enay, 1959, *Prorasenia* Schindewolf, 1925, *Ataxioceras* Fontannes, 1879, *Crussoliceras* Enay, 1959, and *Garnierisphinctes* Enay, 1959, as well as *Aspidoceras uhlandi* (Oppel, 1863) which is very common in the upper part. The age of the bryozoan-bearing part of the sequence can be precisely dated by these ammonites as belonging to the Lower Kimmeridgian zones of Ataxioceras hypselocyclum and Katroliceras divisum (Fig. 2) (see Matyja *et al.* 2006). Above the Skorków lumachelle at Małogoszcz Quarry are about 15 m of upper platy limestones containing *Exogyra* (*Nanogyra*) Say, 1820 and belonging to the uppermost part of the *divisum* Zone.

Upper Jurassic deposits on the northeastern margin of the Holy Cross Mountains form part of a monocline dipping gently at 6-8°. The Lower Kimmeridgian is well exposed in the large abandoned quarry at Wierzbica, situated about 20 km south of Radom (Fig. 1). The lower part of the Wierzbica succession represents a shallowing upward sequence ranging from open shelf deposits at the bottom to oolitic barrier, hypersaline lagoon, tidal flat deposits. A capping 1.5 m thick hardground containing numerous borings marks a period of erosion or non-deposition and forms a regional discontinuity (see Gutowski 2004, 2006; Pieńkowski & Niedźwiecki 2005). Two oolitic and platy limestones, about 60 m in total thickness, and an oyster lumachelle are present. The oyster lumachelle, composed mainly of *Nanogyra* Beurlen, 1958, consists of alternating marls or micritic limestones and bioclastic packstones. In the lower part of this unit very characteristic "*Lopha* beds" are present. These biostromes are rich in *Actinostreon gregarea* (Sowerby, 1815) and can be correlated over both the northeastern and southwestern margins of the Holy Cross Mountains. The total thickness of the "*Lopha* beds" is 31-33 m in Wierzbica quarry. The ammonites *Ataxioceras hypselocyclum* and *Crussoliceras* sp. has been found respectively 4 and 1.5 m above the top of the "*Lopha* bed" at Wierzbica Quarry. These taxa co-occur in the Submediterranean province in the uppermost part of the *hypselocyclum* Zone (Gutowski 1998, 2006). Above the oyster lumachelle there is a complex of grey and ash-grey clays with thin (*c.* 10 cm thick) shellbeds containing *Nanogyra virgula* (Defrance, 1820). An accumulation of large flat shells of the oyster *Deltoideum* occurs in the uppermost part of the sequence at Wierzbica Quarry (Gutowski 1998; Machalski 1998). These *Deltoideum* shells, which are often encrusted, are the source of many of the cyclostome bryozoans described below.

The lithofacies yielding the bryozoans at Wierzbica are similar to those occurring at Małogoszcz, ranging from biocalcarenites through oolites and shellbeds to marlstones, although the sediments at Wierzbica are muddier than those at Małogoszcz. Other benthic fossils from Wierzbica, such as terebratulid brachiopods and ostreid bivalves, have been described by Pugaczewska (1970), Dzik (1979, 1982) and Machalski (1989, 1998).

MATERIAL AND METHODS

Material is deposited in the following institutions: NHM, Natural History Museum, London; PGI, Polish Geological Institute, Warsaw; UW, University of Warsaw. NHM numbers with brackets are used to distinguish different species encrusting the same substrate.

Specimens were cleaned ultrasonically before SEM study. Two SEMs were used, a LEO VP1455 at the NHM and a LEO 1430 at the Polish Geological Institute. The LEO VP1455 allowed back-scattered electron imaging of uncoated specimens. Measurements were made from calibrated SEM images as well as using the eyepiece micrometer affixed to the WILD M10 microscope.

SYSTEMATICS

The descriptions given below of existing species are based on Polish Kimmeridgian material rather than type or topotype specimens of the species concerned. Given that very few established species of Jurassic bryozoans have been adequately revised using SEM to restudy the types, species concepts are often broad and in need of refinement. Fuller synonymies can be found in Walter (1970).

Order CYCLOSTOMATA Busk, 1852
Suborder TUBULIPORINA
Milne-Edwards, 1838
Family STOMATOPORIDAE
Pergens & Meunier, 1886

Genus *Stomatopora* Bronn, 1825

TYPE SPECIES. — *Alecto dichotoma* Lamouroux, 1821, Bathonian.

Stomatopora dichotomoides (d'Orbigny, 1850) (Fig. 3)

Alecto dichotomoides d'Orbigny, 1850: 288.

Stomatopora dichotomoides – Haime 1854: 163, 164, pl. 6, fig. 2a-c. — Gregory 1896b: 50, pl. 1, fig. 3. — Illies 1963: 73, pl. 8, figs 1, 2, pl. 9, figs 1-3. — Walter 1970: 39, pl. 1, fig. 9.

MATERIAL EXAMINED. — Wierzbica Quarry: MUZ PIG 1719.II.1; NHM BZ 5511, BZ 5512(1). — Skorków Lumachelle, Małogoszcz Quarry: NHM BZ 5518(1), BZ 5519(2), BZ 5520(2).

OCCURRENCE. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland. Recorded by Walter (1970) from the Upper Aalenian to Upper Bathonian of France, England and Germany (see also Illies 1963), and by Taylor (2008) from the Upper Bathonian/Lower Callovian of Poland.

MEASUREMENTS. — Transverse apertural diameter = 0.08-0.10 mm; transverse peristomial diameter = 0.16-0.20 mm; frontal wall length = 0.62-0.80 mm; frontal wall width (proximal) = 0.20 mm; frontal wall width (distal) = 029-0.32 mm.

DESCRIPTION

Colony encrusting with uniserial branches bifurcating dichotomously; internodes comprising one to four zooids. Ancestrula short (0.4 mm), aperture 0.05 mm in diameter, protoecium of low profile, 0.24 mm wide with scattered pseudopores. Single budded zooid before first branch bifurcation at *c.* 140°, subsequent bifurcations at lower angles, those in late astogeny as little as 60°, the daughter zooids remaining conjoined for half of more of their lengths before separating.

Zooids monomorphic, elongate, subcylindrical. Apertures subcircular, set atop short preserved

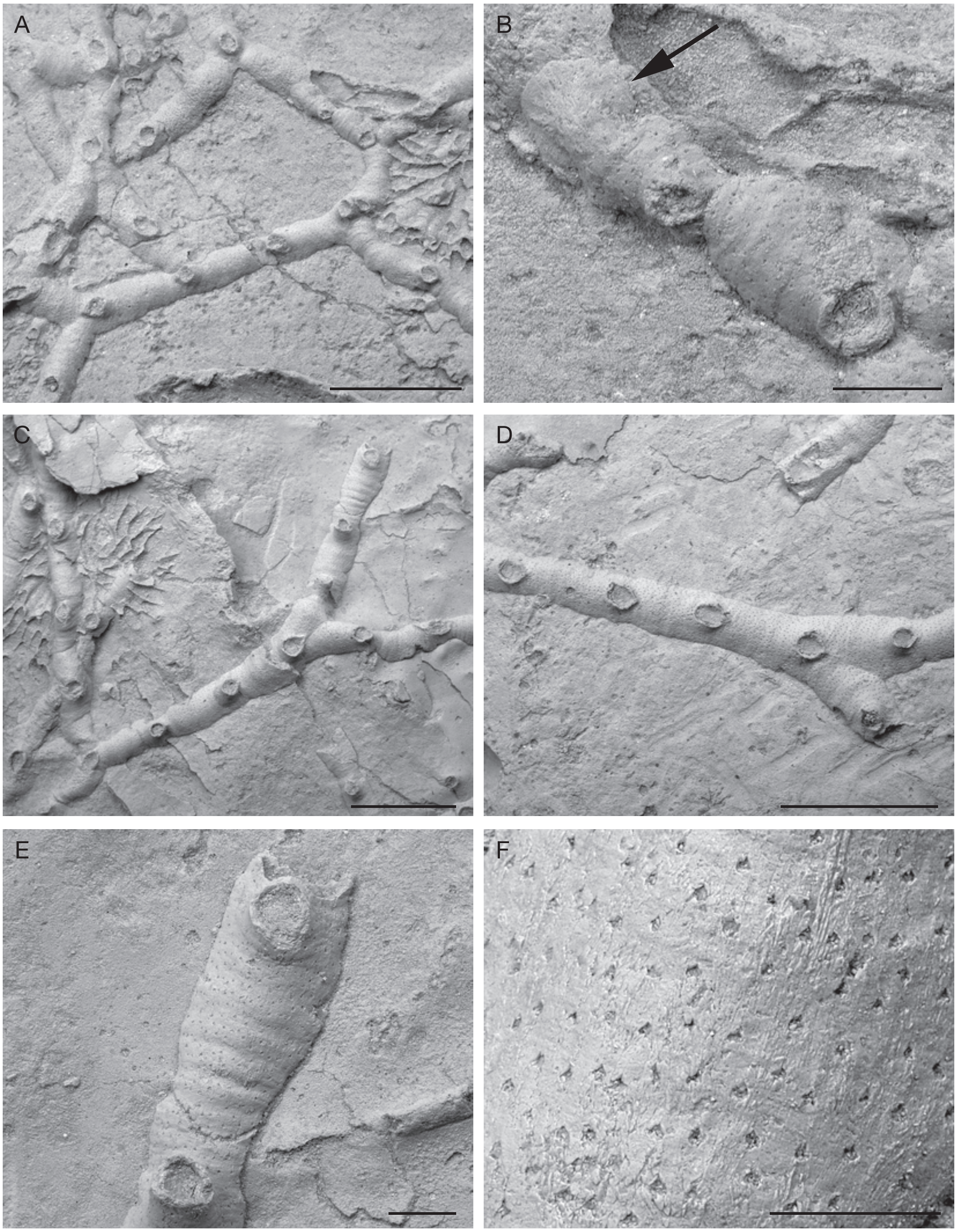

FIG. 3. — *Stomatopora dichotomoides* (d'Orbigny, 1850), Lower Kimmeridgian, Wierzbica Quarry, NE margin of the Holy Cross Mts, Poland: **A**, **B**, NHM BZ 5511; **A**, intergrown colonies; **B**, ancestrula (protoecium arrowed) and first budded zooid; **C-F**, NHM BZ 5511(1); **C**, low angled bifurcations from late astogeny; **D**, long internode; **E**, single zooid; **F**, pseudopores in the same zooid. Scale bars: A, C, D, 1 mm; B, E, 200 µm; F, 100 µm.

peristomes. Pseudopores drop-shaped, pointed distally, about 10 μm wide.

REMARKS
The genus *Stomatopora* remains problematical because of the loss of the type material of the type species, *S. dichotoma*, and the failure of Walter's (1970) neotype to match the generally applied concept of the genus as a strictly uniserial encruster (see Pitt & Taylor 1990; Taylor & Wilson 1999). Unfortunately, *Stomatopora* lacks the basal gonozooids that are so useful in the taxonomy of other Mesozoic cyclostomes.

Species-level taxonomy of Jurassic *Stomatopora* was advanced greatly by the detailed studies of zooidal budding undertaken by Illies (1963). Nevertheless, it is becoming evident from SEM study of pristine specimens that some apparent "species" may in fact comprise more than one species differing in the detailed morphology of their pseudopores. The Polish Kimmeridgian specimens assigned here to *S. dichotomoides* have drop-shaped pseudopores (Fig. 3F), whereas otherwise identical specimens from the British Bathonian (e.g., NHM D13428) often possess long, slit-shaped pseudopores. Unfortunately, pseudopore morphology is unknown in the French Bajocian type material of *S. dichotomoides*.

As here interpreted, *S. dichotomoides* is a species common in the Middle Jurassic that develops more or less regular colonies of roughly circular outline. The radially spreading form is achieved by a pattern of astogenetic decrease in branch bifurcation angle (Gardiner & Taylor 1982). One or two zooids are typically present in each internode in most colonies of Middle Jurassic *S. dichotomoides* but some of the Polish Kimmeridgian colonies can have up to four zooids in some internodes (Fig. 3D).

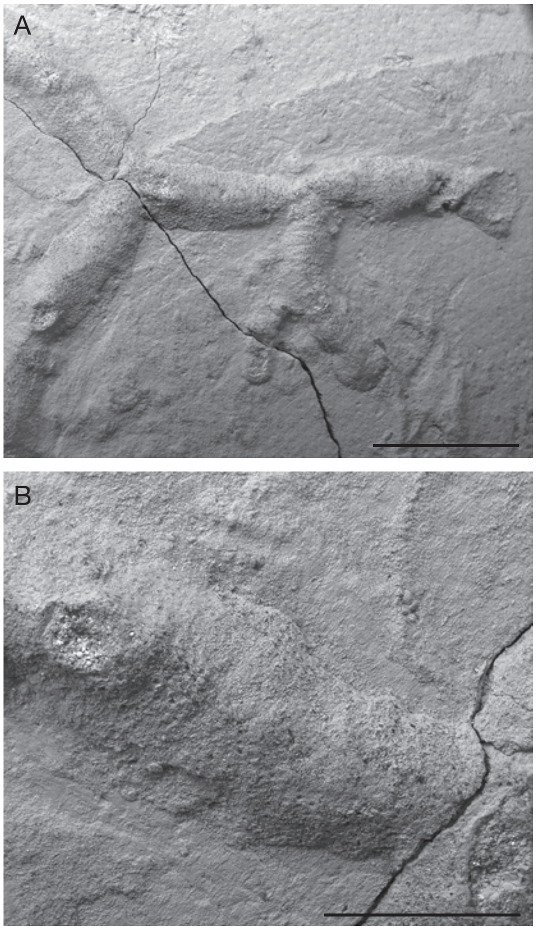

FIG. 4. — *Stomatopora* sp., NHM BZ 5518(2), Lower Kimmeridgian, Skorków Lumachelle, Małogoszcz Quarry, Holy Cross Mts, Poland: **A**, early astogeny with ancestrula at bottom right; **B**, autozooid. Scale bars: A, 1 mm; B, 500 μm.

Stomatopora sp.
(Fig. 4)

MATERIAL EXAMINED. — Skorków Lumachelle, Małogoszcz Quarry: NHM BZ 5518(2).

MEASUREMENTS. — Transverse apertural diameter = 0.15-0.18 mm; longitudinal apertural diameter = 0.24-0.27 mm; frontal wall length = 0.96-1.0 mm; frontal wall width = 0.36-0.45 mm.

OCCURRENCE. — Lower Kimmeridgian, Małogoszcz Quarry, Holy Cross Mts, Poland.

DESCRIPTION
Colony encrusting with uniserial, often curved branches bifurcating dichotomously, initially at about 180°, subsequently at lower angles; first internode contains ancestrula plus one budded zooid, later internodes 1-4 zooids. Ancestrula large, 0.78 mm long by 0.30 mm wide, protoecium

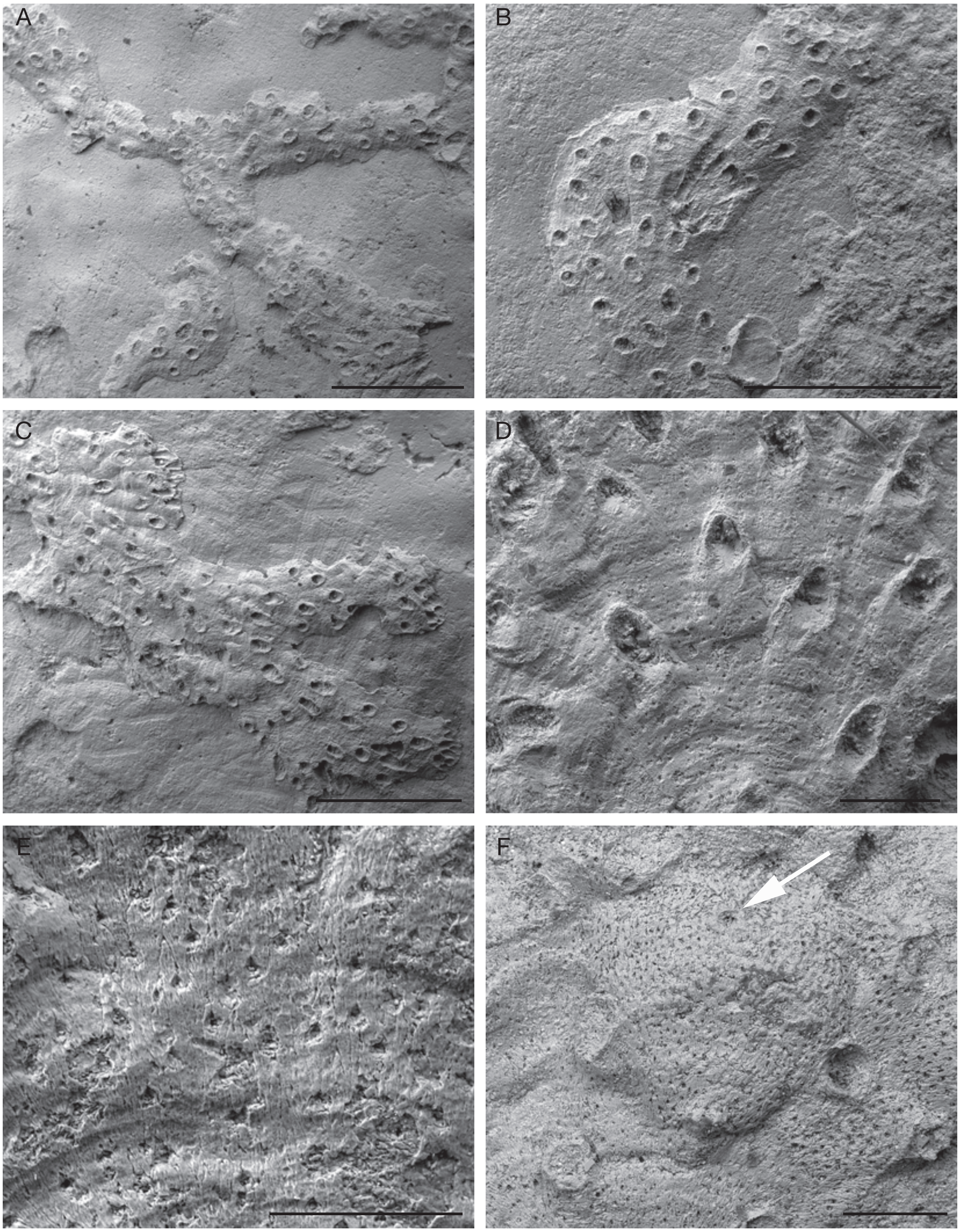

FIG. 5. — *Oncousoecia* sp., Lower Kimmeridgian, Holy Cross Mts, Poland: **A**-**E**, NHM BZ 5519(1), Małogoszcz Quarry; **A**, lobate branches; **B**, oligoserial branch; **C**, branches growing over shell substrate grazed by echinoids; **D**, autozooids; **E**, autozooidal pseudopores; **F**, NHM BZ 5513, Wierzbica Quarry, gonozooid with ooeciopore arrowed. Scale bars: A-C, 1 mm; D, F, 200 μm; E, 100 μm.

0.36 mm wide; details of pseudopores and aperture not visible.

Zooids monomorphic, large, elongate, subcylindrical. Apertures longitudinally elongate (Fig. 4G, H). Pseudopores apparently subcircular.

REMARKS

Two colonies of this species encrust the dorsal valve of a brachiopod. Both colonies are small in size, the largest containing only 11 zooids, and neither are well preserved. Nevertheless, their zooids are clearly significantly larger than those of *S. dichotomoides* described above. That this difference in zooid size is not entirely ecophenotypic is shown by the presence of a colony of *S. dichotomoides* with smaller zooids on the same substrate as the two colonies of *Stomatopora* sp.

The available material of *Stomatopora* sp. is too sparse and poorly preserved to give a precise determination. Among named Jurassic species of *Stomatopora*, the species with the largest zooids is *S. recurva* Waagen, 1867, recorded by Walter (1970) from the Upper Aalenian and Lower Bajocian of Germany, France and England. However, probable specimens of *S. recurva* from the Upper Bathonian or Lower Callovian of Poland (Taylor 2008) have smaller zooids than the Lower Kimmeridgian species described here. For example, the protoecium in Balin material of putative *S. recurva* measures 0.25 mm wide (vs. 0.36 mm), and the ancestrula is 0.50 mm long (vs. 0.78 mm).

Family ONCOUSOECIIDAE Canu, 1918

Genus *Oncousoecia* Canu, 1918

TYPE SPECIES. — *Alecto dilatans* Johnston, 1847, Recent (see Taylor & Zatoń 2008).

***Oncousoecia* sp.**
(Fig. 5)

MATERIAL EXAMINED. — Małogoszcz Quarry: NHM BZ 5519(1). — Wierzbica Quarry: NHM BZ 5513, BZ 5514.

MEASUREMENTS. —Width of branches = 0.4-1.2 mm; longitudinal apertural diameter = 0.05-0.07 mm; transverse apertural diameter = 0.04-0.06 mm; longitudinal peristome diameter = 0.08-0.11 mm; transverse peristome diameter = 0.06-0.08 mm; frontal wall length = 0.22-0.35 mm; frontal wall width = 0.09-0.12 mm; gonozooid length = 0.40 mm; gonozooid width = 0.40 mm; ooeciopore length = 0.04 mm; ooeciopore width = 0.08 mm.

OCCURRENCE. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland.

DESCRIPTION

Colony encrusting, with ribbon-like, oligoserial branches, usually between three and eight zooids wide, forming lobate expansions, relatively flat, seldom bifurcating (Fig. 5B), occasionally anastomosing, uniserial in early astogeny.

Autozooids very small, rather short, visible throughout their lengths, with transversely wrinkled frontal walls. Apertures nearly subcircular or slightly transversely elliptical, bordered by a narrow peristome tapering distally. Pseudopores drop-shaped, about 10 µm wide.

Gonozooids low in profile, as wide as long, more or less inverted pear-shaped, bulbous in the distal part. Ooeciopore subterminal, transversely elongate.

REMARKS

Specimens of *Oncousoecia* described from the Lower Kimmeridgian of Poland occur as small and delicate encrusting colonies with ribbon-like oligoserial branches (Fig. 5A-C). Transverse and longitudinal apertural measurements and frontal wall length and width, as well as the morphology of the frontal wall, are almost the same as in *Oncousoecia parvula* (Canu & Bassler, 1926), as redescribed by Pitt & Taylor (1990) from the Aptian Faringdon Sponge Gravel. The main difference lies in the morphology of the gonozooid which in the Polish Lower Kimmeridgian material is triangular or inverted pear-shaped, as well as the ooeciopore which is subterminal (Fig. 5F) rather than terminal.

Oncousoecia elengatula (d'Orbigny, 1850), ranging from Upper Aalenian to Upper Bajocian according to Walter (1970: 25), has a similar frontal wall width to the Polish Kimmeridgian specimens, and this feature is one of the more useful morphometric characters for distinguishing Jurassic cyclostome species. The sole species of *Oncousoecia* sp. from the Middle Upper Oxfordian of Baltow (Holy Cross Mts, Poland) (see Hara & Taylor 1996) is somewhat similar to the Lower Kimmeridgian species. However, the width of the frontal wall in the Lower Kimmeridgian material is smaller and the gonozooid has a different shape, being inverted pear-shaped rather than pyriform as in the Baltow specimen. In view of the sparse and indifferently preserved material available from the Polish Lower Kimmeridgian, species determination is deferred.

Genus *Microeciella* Taylor & Sequeiros, 1982

TYPE SPECIES. — *Microeciella beliensis* Taylor & Sequeiros, 1982, Toarcian.

Microeciella **sp.**
(Fig. 6)

MATERIAL EXAMINED. — Skorków Lumachelle, Małogoszcz Quarry: NHM BZ 5520(3), BZ 5521. — *Deltoideum* Beds, Wierzbica Quarry NHM BZ 5515(1).

MEASUREMENTS. — Longitudinal apertural diameter = 0.08-0.10 mm; transverse apertural diameter = 0.06-0.08 mm; longitudinal peristome diameter = 0.11-0.12 mm; transverse peristome diameter = 0.08-0.10 mm; frontal wall length = 0.40-0.70 mm; frontal wall width = 0.13-0.18 mm; gonozooid length = 0.45-0.47 mm; gonozooid width = 0.32-0.45 mm; ooeciopore length = 0.035 mm; ooeciopore width = 0.04 mm.

OCCURRENCE. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland.

DESCRIPTION
Colony encrusting, small, multiserial, growing as irregular fan-shaped lobes. Ancestrula not observed, early astogenetic zooids small, oligoserial.

Autozooids slender, varying in length, boundaries well-defined, tapering somewhat distally; frontal wall with a fine transverse ornament. Apertures slightly longitudinally elongate, relatively small, some closed by terminal diaphragms. Peristomes narrow, longitudinally elongate, slightly acute. Pseudopores circular when corroded, about 10 μm in diameter.

Gonozooids numerous, generally located close to growing edge, slightly longer than wide or subcircular, proximal undilated frontal wall about as long as distal dilated frontal wall which is densely pseudoporous. Ooeciopore subterminal, smaller than autozooidal apertures, slightly transversely elongate or approximately circular; ooeciostome worn.

REMARKS
Microeciella was introduced by Taylor & Sequeiros (1982) for multiserial, discoidal to fan-shaped bereniciform tubuliporines possessing longitudinally ovoidal gonozooids (see also Taylor & McKinney 2006). It was intended to accommodate species previously assigned in error to *Microecia* Canu, 1918, whose type species (*Berenicea sarniensis* Norman, 1864) is nowadays placed in *Plagioecia* Canu, 1918. Soon after, Hayward & Ryland (1985) introduced *Eurystrotos*, based on the Recent type species *Alecto compacta* Norman, 1866, for much the same reason. Taylor & Zaton (2008) have recently shown that *Eurystrotos* is a subjective junior synonym of *Oncousoecia* and differs from *Microeciella* in having branching, ribbon-like colonies.

The Polish Kimmeridgian species of *Microeciella* resembles the Toarcian type species *M. beliensis* from Spain, but the autozooids of the latter are longer and wider and the gonozooids are also longer. The same dimensions in the Polish species match reasonably well with those of two Middle Jurassic species from the Carmel Formation of Utah (see Taylor & Wilson 1999). Taking into account these quantitative characters, the greatest resemblance is with *M. pollostos* Taylor & Wilson, 1999 but a more detailed comparison between various species of *Microeciella* for the Polish material to be identified to species level.

Family MULTISPARSIDAE Bassler, 1935

Genus *Reptoclausa* d'Orbigny, 1853

TYPE SPECIES. — *Reptoclausa neocomiensis* d'Orbigny, 1853, Valanginian.

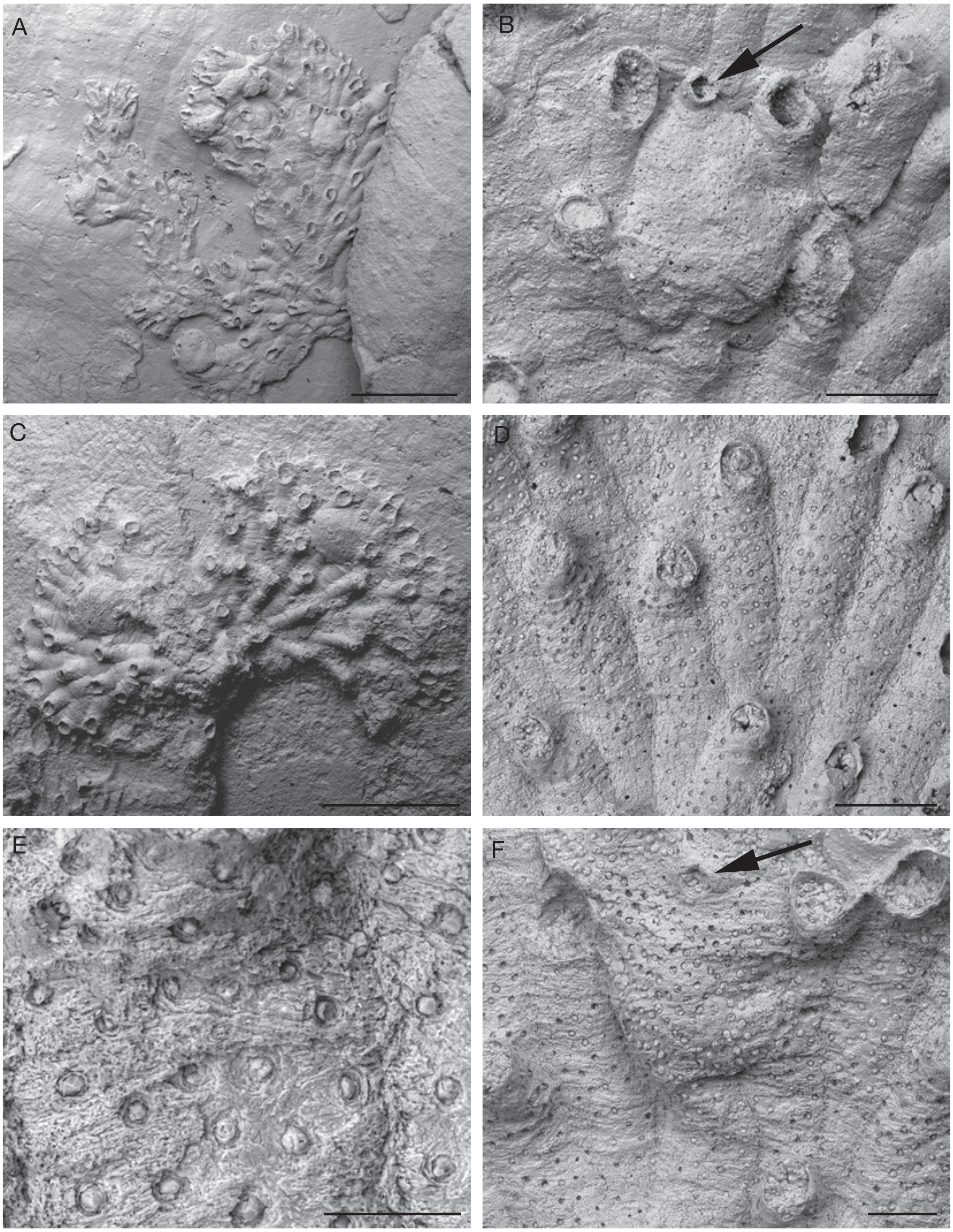

FIG. 6. — *Microeciella* sp., Lower Kimmeridgian, Holy Cross Mts, Poland: **A**, **B**, NHM BZ 5521, Skorków Lumachelle, Małogoszcz Quarry; **A**, lobate branches; **B**, gonozooid with ooeciopore arrowed; **C**, NHM BZ 5520(3), Skorków Lumachelle, Małogoszcz Quarry, small fertile colony with two fan-like lobes; **D**-**F**, NHM BZ 5541(1), *Deltoideum* beds, Wierzbica Quarry; **D**, corroded autozooids; **E**, worn pseudopores; **F**, gonozooid with ooeciopore arrowed. Scale bars: A, C, 1 mm; B, D, 200 µm; E, 50 µm; F, 100 µm.

Reptoclausa radwanskii n. sp.
(Fig. 7)

Bryozoan colony – Radwańska & Radwański 2003: 87, pl. 1, fig. 3a, b.

Diagnosis. — *Reptoclausa* with unilamellar, to multilamellar colonies, stellate to discoidal or irregular in outline shape, surface with fine transverse wrinkling; autozooidal ridges narrow, long, arranged radially interspersed with kenozooidal areas forming wedge-shaped to elongate longitudinal furrows, shorter than the autozooecial ridges; gonozooids subpyriform in shape.

Holotype. — UW ARMaBy 007, colony figured here as Figure 7A-C, A. Radwański collection, encrusting shell of brachiopod *Sellithyris*.

Paratypes. — UW ARMaBy 008-009, other colonies on same *Sellithyris* shell as holotype, including that shown in Figure 7D, A. Radwański collection. NHM BZ 5522, Skorków Lumachelle, Małogoszcz Quarry (Fig. 7E, F).

Type horizon. — Lower Kimmeridgian.

Type locality. — Małogoszcz Quarry, SW margin of the Holy Cross Mts, Poland.

Etymology. — Named for Professor Andrzej Radwański, University of Warsaw, in recognition of his contributions to the palaeontology of the Holy Cross Mts, in particular that of Małogoszcz quarry, and who also collected some of the studied specimens of this new species.

Measurements. — Longitudinal apertural diameter = 0.20-0.24 mm; transverse apertural diameter (top of ridge) = 0.12-0.15 mm; transverse apertural measurement (side of ridge) = 0.07-0.09 mm; transverse peristome measurement (top of ridge) = 0.18-0.21 mm; transverse peristome measurement (side of ridge) = 0.15-0.18 mm; autozooidal frontal wall length = 0.48-0.62 mm; autozooidal frontal wall width = 0.18-0.24 mm; total gonozooidal frontal wall length = 0.72 mm; gonozooidal width = 0.45-0.66 mm.

Occurrence. — Lower Kimmeridgian, Małogoszcz Quarry, Holy Cross Mts, Poland.

Description

Colonies encrusting, sheet-like, up to 30 mm in diameter, stellate to discoidal or irregular in outline shape, commonly unilamellar but rarely multilamellar, surface with fine transverse wrinkles. Autozooids arranged in narrow radiating ridges 5-12 mm long and 1.2-2.4 mm wide, forming lobes at growing edge, ridges about 2 mm apart, separated by slightly depressed areas occupied by kenozooids. Zooidal boundaries poorly defined on colony surface. Growing edge 0.18-0.3 mm wide. Early astogeny unknown.

Autozooids very slightly salient, two to four rows of larger zooids occupying ridge crest, zooidal size gradually decreasing down ridge flanks. Apertures subcircular to somewhat longitudinally elongate, with thin peristomes, often occluded by terminal diaphragms.

Gonozooid abraded in only known example (Fig. 7C), more or less pyriform in shape, slightly longer than wide, ooeciopore destroyed.

Kenozooids featureless, clearly seen only at growing edge, where they form buds narrower than those of the autozooids, and in worn specimens where they appear as longitudinal striations.

Remarks

Only a few species exist of *Reptoclausa*, an Aalenian-Aptian genus characterised by having ridges containing autozooids separated by furrows with kenozooids. The new species described here from the Lower Kimmeridgian fills the Upper Jurassic gap in the range of the genus. *Reptoclausa porcata* Taylor, 1980, from the Aalenian (Lower Inferior Oolite) of the Cotswolds, England, shows some similarities with *R. radwanskii* n. sp. but differs in having wider apertures and much longer gonozooids. Another species, *R. hagenowi* (Sharpe, 1854), from the Aptian Sponge Gravel of Oxfordshire, England, differs from *R. radwanskii* n. sp. in having more sinuous and discontinuous autozooidal ridges. New ridges in *R. hagenowi* arise by bifurcation of established ridges (see Pitt & Taylor 1990: 82) and their pattern is not as regular as in *R. radwanskii* n. sp. Autozooidal apertures in *R. radwanskii* n. sp. are larger and not transverse as in *R. hagenowi*. *Reptoclausa neocomiensis* described from the Upper Hauterivian (see Hillmer 1971), differs from *R. radwanskii* n. sp. in having longer and wider autozooids which are hexagonal in shape in comparison with the longitudinally elongate autozooids of *R. radwanskii* n. sp. Autozooidal ridges are shorter in *R. neocomiensis* and the gonozooid is much longer and narrower.

Like *Reptoclausa porcata* (see Taylor 1980), the new Polish species *R. radwanskii* n. sp. may have

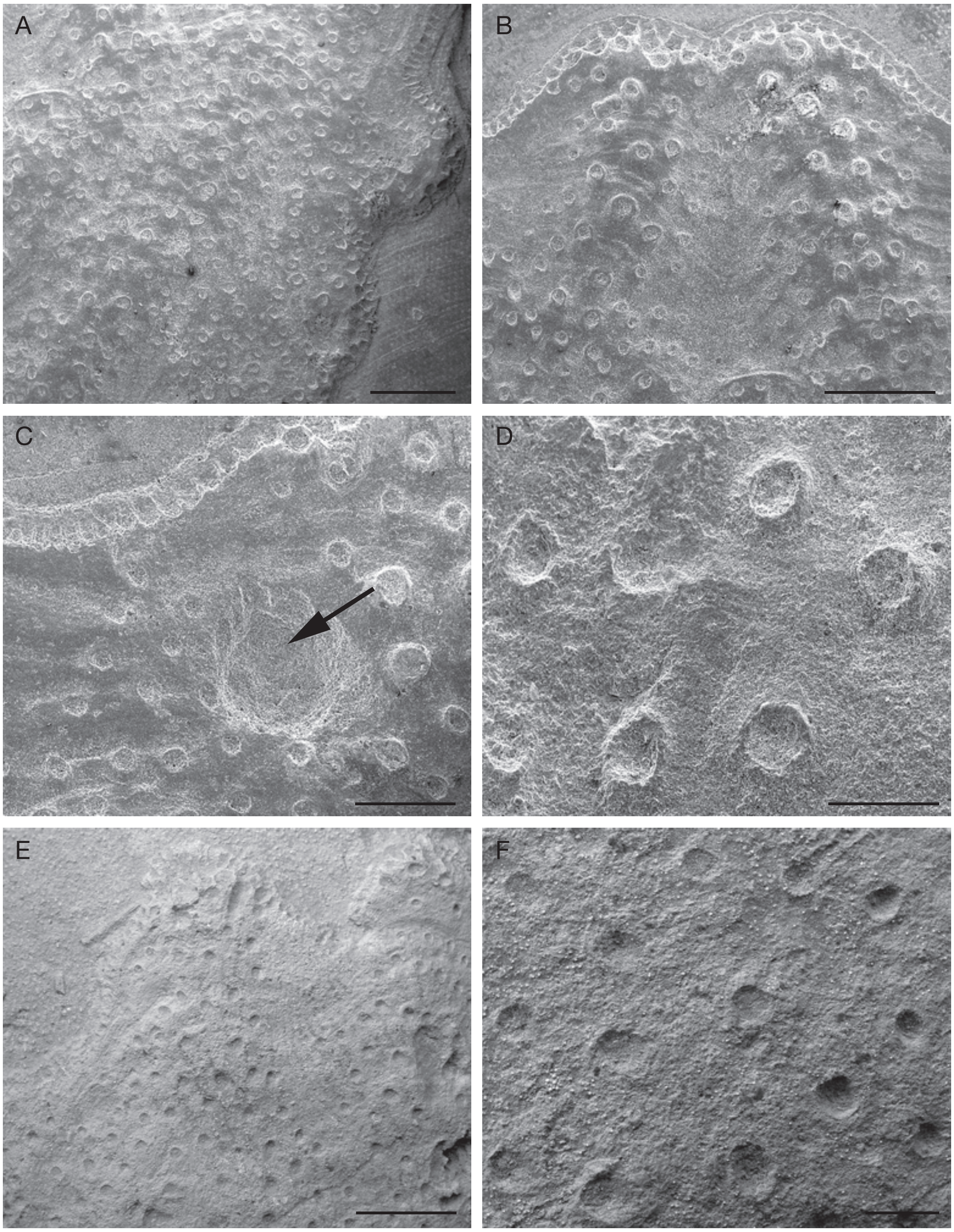

FIG. 7. — *Reptoclausa radwanskii* n. sp., Lower Kimmeridgian, Małogoszcz Quarry, Holy Cross Mts, Poland: **A**-**C**, holotype, UW ARMaBy 007; **A**, edge of colony overgrowing brachiopod shell (visible bottom right); **B**, two autozooidal ridges forming convex lobes at colony growing edge and separated by kenozooidal troughs of lower profile; **C**, cavity left by destroyed gonozooid (arrowed); **D**, paratype, UW ARMaBy 008, autozooids; **E**, **F**, NHM BZ 5522; **E**, part of colony showing autozooidal ridges and striate kenozooidal areas between; **F**, autozooids showing large variation in aperture size according to position on ridge. Scale bars: A, B, E, 1 mm; C, 500 µm; D, F, 200 µm.

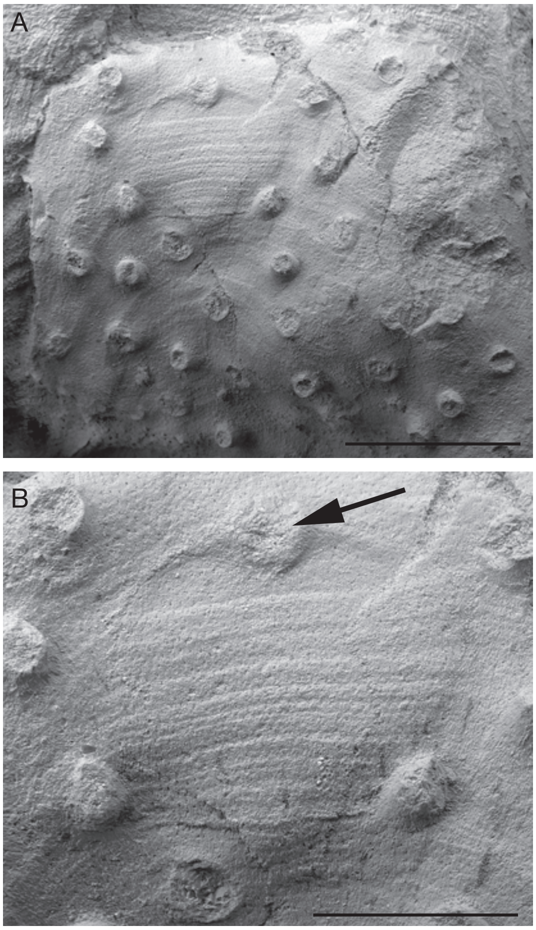

FIG. 8. — *Reptomultisparsa* sp., NHM BZ 5523, Lower Kimmeridgian, Skorków Lumachelle, Małogoszcz Quarry, Holy Cross Mts, Poland: **A**, part of colony showing autozooids and a gonozooid; **B**, detail of gonozooid with ooeciopore arrowed. Scale bars: A, 1 mm; B, 500 µm.

been associated with living host brachiopods because bryozoan growth can be found to terminate at growth lines on the brachiopod shell, suggesting that growth of both the bryozoan and brachiopod were checked simultaneously (see also Radwański & Radwańska 2003: 85-88).

Genus *Reptomultisparsa* d'Orbigny, 1853

TYPE SPECIES. — *Diastopora incrustans* d'Orbigny, 1850, Bathonian.

Reptomultisparsa **sp.**
(Fig. 8)

MATERIAL EXAMINED. — Skorków Lumachelle, Małogoszcz Quarry: NHM BZ 5523. — Wierzbica Quarry: MUZ PIG 1719.II.2.

MEASUREMENTS. — Longitudinal apertural diameter = 0.12-0.16 mm; transverse apertural diameter = 0.10-0.12 mm; longitudinal peristome diameter = 0.22-0.28 mm; transverse peristome diameter = 0.18-0.24 mm; frontal wall length = 0.60-1.0 mm; frontal wall width = 0.18-0.22 mm; gonozooid length = 0.86 mm; gonozooid width = 0.92 mm; transverse ooeciopore width = 0.18 mm.

OCCURRENCE. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland.

DESCRIPTION

Colony encrusting, sheet-like, discoidal, unilamellar, growing edge bordered by a narrow basal lamina. Ancestrula and early astogeny not observed.

Autozooids long, frontal walls almost flat. Apertures subcircular, a little longer than wide, widely spaced, Peristomes indistinct, narrow, slightly tapering distally. Pseudopores longitudinally elongate, worn.

Gonozooids represented by a single example, slightly longitudinally elongate, rounded triangular in outline shape, surface flat (not inflated), crossed by transverse growth bands. Ooeciopore transversely elongate, larger than autozooidal apertures, subterminal.

REMARKS

The genus *Reptomultisparsa* comprises bereniciform tubuliporines with large, longitudinally elongate gonozooids, and commonly multilamellar colonies. In some species, including the type species *R. incrustans*, the gonozooids are several times longer than wide. However, that in the Lower Kimmeridgian species described here is almost equidimensional (Fig. 8B), recalling the proportions more characteristic of *Microeciella* and highlighting a problem commonly encountered when trying to assign Jurassic cyclostomes to genera based on gonozooid shape.

The Polish Lower Kimmeridgian species resembles *R. norberti* Hara & Taylor, 1996, from the Oxfordian of Poland. Gonozooids in both species have relatively flat frontal walls but those of *R. norberti* are ovoidal or fusiform in outline shape, unlike the rounded triangular gonozooids of the Lower Kimmeridgian species. Another species, *R. tumida* Taylor, 1980, described from the Bathonian of England, also has a more elongate gonozooid, as well as smaller autozooids. Specific determination of the Polish Lower Kimmeridgian species is deferred in view of the scarcity of the material available.

Family Plagioeciidae Canu, 1918

Genus *Plagioecia* Canu, 1918

Type species. — *Tubulipora patina* Lamarck, 1816, Recent.

?***Plagioecia rugosa*** (d'Orbigny, 1853) (Fig. 9)

Berenicea rugosa d'Orbigny, 1853: 861.

Plagioecia rugosa – Hara & Taylor 1996: 97, figs 21, 22.

Material. — *Deltoideum* Beds, Wierzbica Quarry: NHM BZ 5512(2). — Małogoszcz Quarry: NHM BZ 5524, BZ 5525.

Measurements. — Longitudinal apertural diameter = 0.09-0.12 mm; transverse apertural diameter = 0.08-0.11 mm; frontal wall length = 0.51-0.66 mm; frontal wall width = 0.15-0.18 mm.

Occurrence. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland. Originally described from the Kimmeridgian of Angoulins, France (d'Orbigny, 1853).

Description

Colony multiserial, unilamellar or multilamellar, moderately thick, circular to subcircular in outline, occasionally developing marginal or frontal subcolonies that overgrow the parent colony. Growing edge exposing several generations of zooidal buds with stout mural tubercles covering surfaces of interior walls. Colony surface crossed by prominent transverse ridges, semi-regularly spaced (0.06-0.08 mm apart), low in profile and occasionally indistinct, curved in direction of colony growth.

Autozooids immersed proximally, slightly convex distally, moderately large. Apertures relatively small, closely-spaced, arranged in quincunx, slightly longitudinally elongate; preserved peristomes low, thick. Terminal diaphragms present, frequent. Pseudopores roughly circular in shape.

Gonozooids not observed in the Polish Lower Kimmeridgian material.

Remarks

Three bereniciform colonies among the material studied are notable for having surfaces ornamented by transverse ridges. This feature characterises several species from the Jurassic (see Hara & Taylor 1996), including two that invite particular comparison with the Polish Lower Kimmeridgian material: *Hyporosopora baltovensis* Hara & Taylor, 1996 from the Middle Upper Oxfordian of Baltow in Poland, and *Plagioecia rugosa* from the Lower Kimmeridgian of Charente-Maritime in France. Whereas the gonozooid in *H. baltovensis* is rounded subtriangular and lacks penetrating autozooids (Hara & Taylor 1996: fig. 11), that of *P. rugosa* is broader and has a few autozooids piercing the roof (Hara & Taylor 1996: fig. 22). Autozooid size is very similar in the two species but the transverse ridges appear to be more prominent in *P. rugosa* than in *H. baltovensis*. Unfortunately, available material from the Polish Lower Kimmeridgian (Wierzbica and Małogoszcz quarries) is infertile, making its identification difficult. Nevertheless, we favour tentative assignment to *P. rugosa* because of the well-developed transverse ridges, especially in a colony from Małogoszcz Quarry (Fig. 9E), and also the presence of marginal subcolonies (Fig. 9A). The latter have been observed in material of *P. rugosa* (e.g., NHM BZ3105) from the type region near La Rochelle but have not been seen in *H. baltovensis*.

Genus *Hyporosopora* Canu & Bassler, 1929

Type species. — *Hyporosopora typica* Canu & Bassler, 1929, Bathonian.

Hyporosopora radomensis n. sp. (Figs 10; 11)

?*Hyporosopora* sp. – Taylor 1981: 868, text-fig. 3.

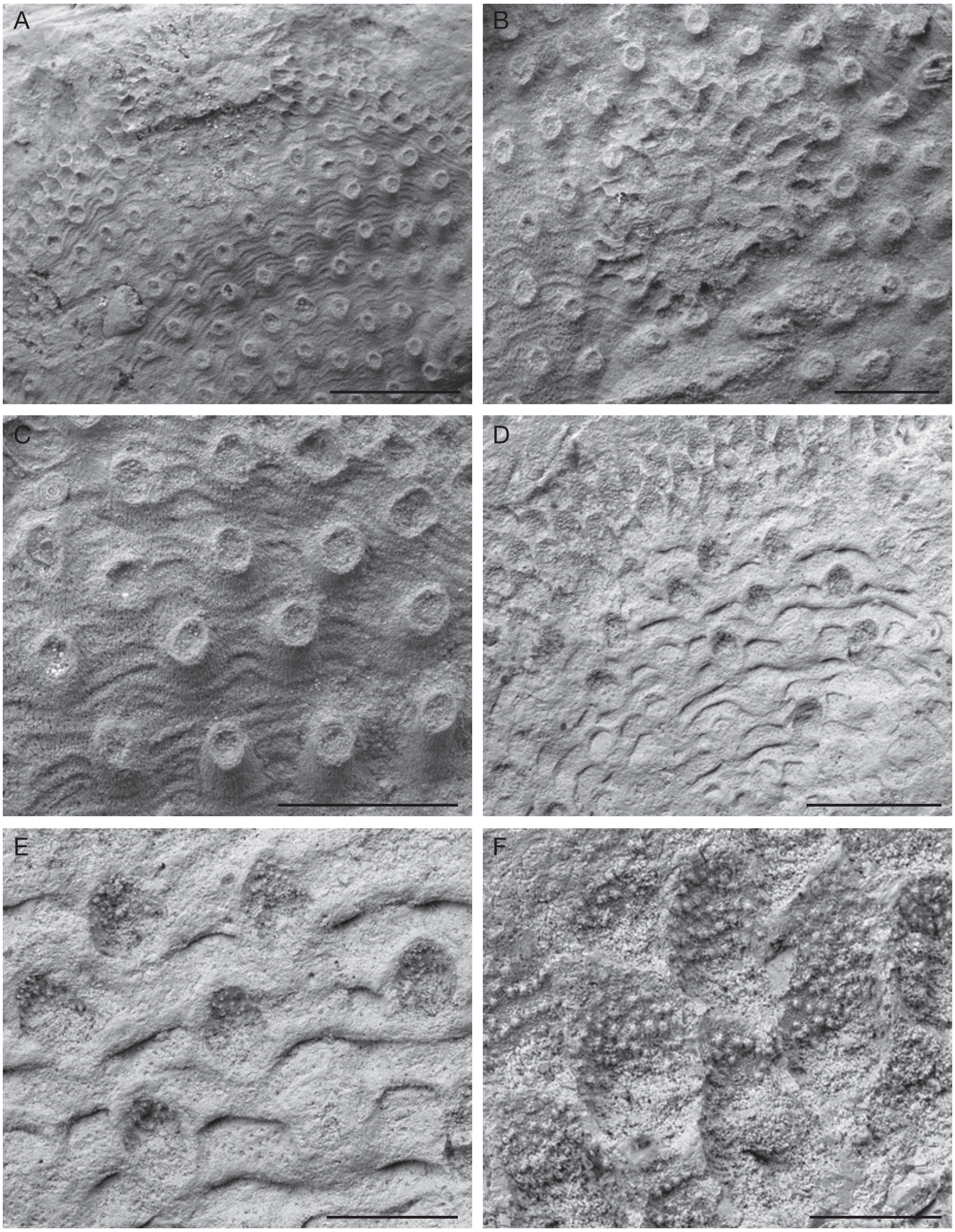

FIG. 9. – ?*Plagioecia rugosa* (d'Orbigny, 1853), Lower Kimmeridgian, Holy Cross Mts, Poland: **A**-**C**, NHM BZ5512(2), *Deltoideum* beds, Wierzbica Quarry; **A**, edge of colony with damaged marginal subcolony (top); **B**, frontal subcolony; **C**, autozooids and transverse ridges; **D**-**F**, NHM BZ 5524, Małogoszcz Quarry; **D**, worn colony edge; **E**, detail of autozooidal apertures and broad, flat-topped transverse ridges; **F**, new buds at abraded growing edge showing prominent mural tubercles. Scale bars: A, 1 mm; B-D, 500 µm; E, 200 µm; F, 100 µm.

Diagnosis. — *Hyporosopora* with colonies unilamellar or multilamellar due to overgrowth of parent colony by marginal subcolonies; autozooids 0.52-0.84 mm long 0.15-0.18 mm wide, pseudopores drop-shaped; gonozooids numerous, inflated part wider than long, heart-shaped when small, boomerang-shaped when large with lobes extending well distally of ooeciopore, 0.90-1.80 mm long by 0.75-1.40 mm wide; ooeciopore terminal, very small, 0.03 mm long by 0.04-0.05 mm wide.

Holotype. — MUZ PIG 1719.II.6, figured here as Figures 10A, B, 11A.

Paratypes. — Same locality as holotype: MUZ PIG 1719.II.3; NHM D59464, D59466, BZ 5512(3), BZ 5515(2), BZ 5516, BZ5517. — Malogoszcz Quarry: NHM BZ 5520(1), BZ 5526, BZ 5527.

Type horizon. — Lower Kimmeridgian, Divisum Zone, *Deltoideum* beds.

Type locality. — Wierzbica Quarry, SW margin of the Holy Cross Mts, Poland.

Etymology. — After Radom, a city close to the type locality.

Measurements. — Longitudinal apertural diameter = 0.12-0.14 mm; transverse apertural diameter = 0.09-0.12 mm; longitudinal peristome diameter = 0.15-0.20 mm; transverse peristome diameter = 0.15-0.18 mm; frontal wall length = 0.52-0.84 mm; frontal wall width = 0.15-0.18 mm; gonozooid length = 0.90-1.80 mm, gonozooid width = 0.75-1.40 mm; ooeciopore length = 0.03 mm; ooeciopore width = 0.04-0.05 mm.

Occurrence. — Lower Kimmeridgian, Wierzbica and Małogoszcz quarries, Holy Cross Mts, Poland. Possibly also Tithonian (Portland Limestone Formation), Dorset, England.

Description

Colonies encrusting, subcircular or fan-shaped, unilamellar, occasionally multilamellar, thin. Subcolonies often developed around margins of parental colonies, sometimes coalescing and/or overgrowing parent colony. Distal fringe of basal lamina extending more than 0.25 mm beyond budding zone. Ancestrula normally overgrown by later budded zooids, about 0.34 mm long, aperture 0.06 × 0.05 mm, protoecium 0.13 mm in diameter.

Autozooids with convex frontal walls usually well marked at colony surface, crossed by faint growth lines in many colonies. Apertures arranged in quincunx, small, longitudinally elongate, some closed by terminal diaphragms; preserved peristomes short. Pseudopores drop-shaped.

Gonozooids numerous, present even in small colonies, distributed unevenly, inflated part wider than long, variable in outline shape, the smaller examples being heart shaped and larger boomerang-shaped with lobes extending well distally of ooeciopore, outlines sometimes indented by autozooidal peristomes. Ooeciopore small, terminal, transversely elongate or less often subcircular.

Remarks

This is the most common species found in our material from the Lower Kimmeridgian of Wierzbica and Małogoszcz quarries. Colonies are fan-shaped when small but become subcircular with age and may develop numerous subcolonies along the growing edge (Fig. 10F). The boomerang shape of the most fully developed gonozooids (Fig. 11B) recalls two other Jurassic species of *Hyporosopora*: *H. sauvagei* (Gregory, 1896), from the Bathonian of England, and the *Hyporosopora* sp. of Taylor (1981), from the Tithonian Portland Stone of Dorset. However, *H. radomensis* n. sp. differs from *H. sauvagei* in having smaller autozooids (e.g., frontal wall width 0.15-0.18 mm in *H. radomensis* n. sp. vs. 0.23 mm in *H. sauvagei*) and drop shaped pseudopores, contrasting with the crescent-shaped pseudopores evident in the type of *H. sauvagei* (NHM B194). The un-named Portlandian *Hyporosopora* sp. is tentatively identified as *H. radomensis* n. sp. pending restudy using SEM.

DISCUSSION

The cyclostome bryozoan fauna described here from two Lower Kimmeridgian localities in the Holy Cross Mountains of Poland comprises eight species and is the most diverse bryofauna yet recorded globally of Kimmeridgian age. All eight species have been found at Małogoszcz Quarry, but only six at Wierzbica Quarry where *Stomatopora* sp. and *Reptoclausa radwanskii* n. sp. have not been recorded.

All of the cyclostomes are encrusters; no erect species were found. It should be noted, however, that our sampling strategy at Wierzbica and Małogoszcz

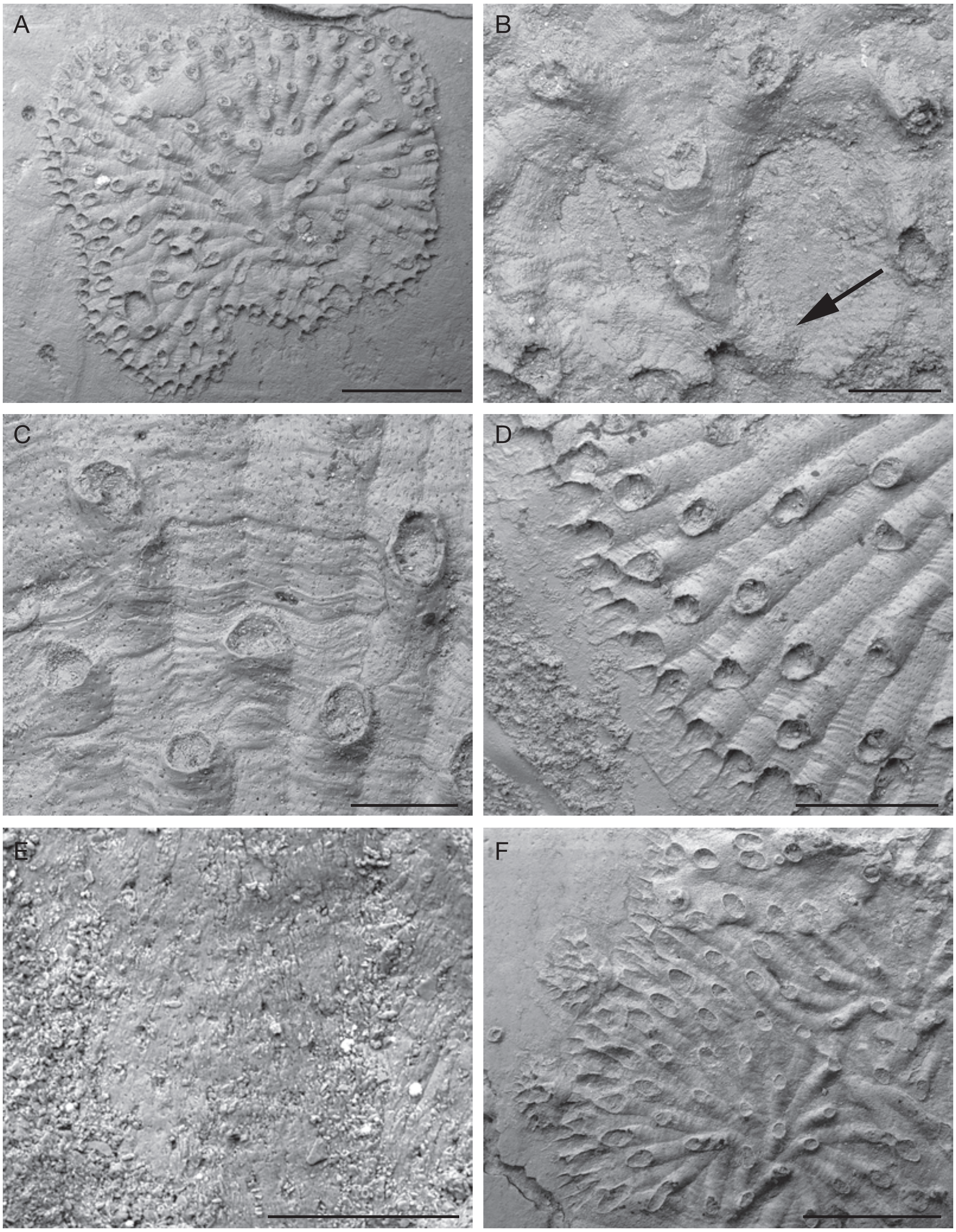

FIG. 10. — *Hyporosopora radomensis* n. sp., Lower Kimmeridgian, Holy Cross Mts, Poland: **A**, **B**, holotype, MUZ PIG1719.II.6, Wierzbica Quarry; **A**, fertile colony; **B**, early astogeny with protoecium arrowed; **C**, **D**, NHM D59466, Wierzbica Quarry; **C**, autozooids; **D**, growing edge showing fringe of exposed basal lamina extending distally beyond budding zone; **E**, NHM D59464, Wierzbica Quarry, autozooidal pseudopores; **F**, NHM BZ 5527, Małogoszcz Quarry, juxtaposed colonies, the lower colony developing a pair of marginal subcolonies (left). Scale bars: A, F, 1 mm; B, C, 200 μm; D, 500 μm; E, 100 μm.

quarries focused on shell substrates and not the collection of bulk sediment samples in which delicate erect species are more likely to have been found. Nonetheless, thick-branched and foliose erect cyclostomes do seem to be absent as these would have been noticed during surface picking. The low diversity and dominance of encrusting species is typical for the Jurassic as a whole. Relatively few Jurassic bryozoan faunas contain more than 10 species, and many comprise entirely encrusting cyclostomes (Taylor & Ernst 2008). Therefore, the Lower Kimmeridgian of Poland matches the general pattern for Jurassic bryozoan assemblages, being dominated by small, "weed-like" encrusting species.

The Polish Lower Kimmeridgian bryozoans mostly belong to genera that are ubiquitous in the Jurassic and Cretaceous. The only exception is *Reptoclausa*. Previously recorded from the Middle Jurassic (Aalenian) and Lower Cretaceous, the finding of the new species *R. radwanskii* n. sp. belonging to this genus in the Lower Kimmeridgian provides an intermediate record between these older and younger occurrences. Several cyclostome genera that are present in the Middle Jurassic disappear from the fossil record in the Upper Jurassic only to reappear in the Lower Cretaceous (Taylor & Larwood 1990; Taylor & Ernst 2008). This Lazarus Effect points to the survival of cyclostomes during the Late Jurassic in regional or habitat refuges where they either did not enter the fossil record or have yet to be sampled by palaeontologists.

An unfulfilled hope of this study was to find cheilostome bryozoans. Only two species of cheilostomes have been recorded from the Jurassic: *Pyriporopsis pohowskyi* Taylor, 1994 from the Oxfordian or Kimmeridgian of the Yemen, and *P. portlandensis* Pohowsky, 1973 from the Tithonian of southern England. It may be significant that both occurrences are from facies more dominated by pure limestones than the Polish Lower Kimmeridgian sediments which contain more muddy sediment, possibly also reflecting Tethyan vs. Boreal influence.

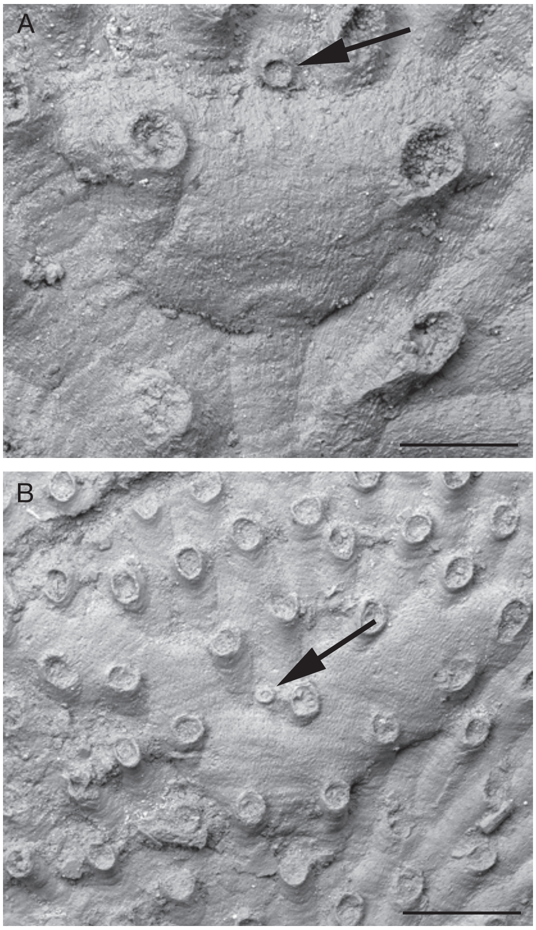

Fig. 11. — *Hyporosopora radomensis* n. sp. showing shape and size variations in gonozooids (ooeciopores arrowed), Lower Kimmeridgian, Wierzbica Quarry, Holy Cross Mts, Poland: **A**, holotype, MUZ PIG 1719.II.6, small gonozooid with heart-shaped dilation; **B**, NHM D59464, large gonozooid with boomerang-shaped dilation. Scale bars: A, 200 μm; B, 500 μm.

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REFERENCES

CANU F. & BASSLER R. S. 1929. — Études sur les ovicelles des bryozoaires jurassiques. *Bulletin de la Société linnéenne de Normandie* 2 (8): 113-131.

DZIK J. 1979. — Some terebratulid populations from the Lower Kimmeridgian of Poland and their relation to the biotic environment. *Acta Palaeontologica Polonica* 24: 473-492.

DZIK J. 1982. — Succession of oyster lumachelles on soft bottom. *Przegląd Geologiczny* 6: 280-285.

GARDINER A. R. & TAYLOR P. D. 1982. — Computer modelling of branching growth in the bryozoan *Stomatopora*. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* 163: 389-419.

GREGORY J. W. 1896b. — *Catalogue of the Fossil Bryozoa in the Department of Geology British Museum (Natural History). The Jurassic Bryozoa*. British Museum (Natural History), London, 239 p.

GUTOWSKI J. 1998. — Oxfordian and Kimmeridgian of the northeastern margin of the Holy Cross Mountains, Central Poland. *Geological Quarterly* 42: 59-72.

GUTOWSKI J. 2006. — Stop B.26 – Wierzbica, large abandoned quarry of former cement works – the oolitic sedimentary cycle (Lower Kimmeridgian). Jurassic of Poland and adjacent Slovakian Carpathians. *Field Guidebook of 7th International Congress on the Jurassic System, Poland, Kraków 2006*: 181-188.

GUTOWSKI J. 2004. — Early Kimmeridgian oolitic sedimentary cycle in the Wierzbica quarry, NE margin of the Holy Cross Mts., Poland. *Tomy Jurajskie* 2: 37-48.

HAIME J. 1854. — Description des Bryozoaires fossiles de la formation Jurassique. *Mémoires Société géologique de France* 5 (2): 156-218.

HARA U. & TAYLOR P. D. 1996. — Jurassic bryozoans from Baltów, Holy Cross Mountains, Poland. *Bulletin of the Natural History Museum, London*, Geology Series, 52: 91-102.

HAYWARD P. J. & RYLAND J. S. 1985. — Cyclostome bryozoans. *Synopses of the British Fauna*, new series, 34: 1-147.

HILLMER G. 1971. — Bryozoen (Cyclostomata) aus dem Unter-Hauterive von Nordwestdeutschland. *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg* 40: 5-106.

ILLIES G. 1963. — Über *Stomatopora dichotoma* (LAMX.) und *St. dichotomoides* (d'ORB.) [Bryoz. Cycl.] aus dem Dogger des Oberrheingebietes. *Oberrheinische Geologische Abhandlungen* 12: 45-80.

LAMOUROUX J. V. 1821. — *Exposition méthodique des genres de l'ordre des polypiers*. Agasse, Paris, 115 p.

MACHALSKI M. 1989. — Life position of the oyster *Deltoideum delta* (Smith) from the Kimmeridgian of Poland, and its environmental significance. *Neues Jarbuch Geologische Paleontologische Mh.* 10: 603-614.

MACHALSKI M. 1998. — Oyster life positions and shell beds from the Upper Jurassic of Poland. *Acta Palaeontologica Polonica* 43: 609-634.

MATYJA A., WIERZBOWSKI A., RADWAŃSKA U. & RADWAŃSKI A. 2006. — Stop B2.8 – Małogoszcz large quarry of cement works (Lower and lowermost Upper Kimmeridgian). *Field Guidebook of 7th International Congress on the Jurassic System, Poland, Kraków* 2006: 190-198.

ORBIGNY A. D' 1850. — *Prodrome de Paléontologie stratigraphique universelle*. Tome 2. Masson, Paris, 428 p.

ORBIGNY A. D' 1853. — *Paléontologie française, Terrains Crétacés.* Tome 5, *Bryozoaires*. Masson, Paris, 1192 p.

PIEŃKOWSKI G. & NIEDWIEŹCKI G. 2005. — Pterosaur tracks from the Early Kimmeridgian interval deposits of Wierzbica, Poland. *Geological Quarterly* 49: 339-346.

PITT L. J. & TAYLOR P. D. 1990. — Cretaceous Bryozoa from the Faringdon Sponge Gravel (Aptian) of Oxfordshire. *Bulletin of the British Museum (Natural History)*, Geology Series, 46: 61-152.

POHOWSKY R. A. 1978. — The boring ctenostomate Bryozoa: taxonomy and paleobiology based on cavities in calcareous substrata. *Bulletins of American Paleontology* 73 (No. 301): 1-192.

PUGACZEWSKA H. 1970. — Traces of the activity of bottom organisms on the shells of the Jurassic ostreiform pelecypods of Poland. *Acta Palaeontologica Polonica* 15: 425-439.

RADWAŃSKA U. 1999. — Lower Kimmeridgian echinoids of Poland. *Acta Geologica Polonica* 49: 287-364.

RADWAŃSKA U. & RADWANSKI A. 2003. — Siedlisko życia, miejsce pogrzebania oraz epibionty ramienionogów *Sellithyris subsella* (Leymerie, 1846) z muszlowców dolnego kimerydu Małogoszcza. *Tomy Jurajskie* 1: 85-92.

RADWAŃSKI A. 2003. — Rezydualne brykiety kolapsyjne w pakietach margli górnego kimerydu Małogoszcza. *Tomy Jurajskie* 1: 77-84.

RADWAŃSKI A. & RONIEWICZ E. 2005. — Coral lumps in Early Kimmeridgian oyster shellbeds and oolites of Małogoszcz. *Tomy Jurajskie* 3: 97-107.

TAYLOR P. D. 1980. — Two new Jurassic Bryozoa from southern England. *Palaeontology* 23: 699-706.

TAYLOR P. D. 1981. — Bryozoa from the Jurassic Portland Beds of England. *Palaeontology* 24: 863-875.

TAYLOR P. D. 2008. — Bryozoans from the Middle Jurassic of Balin, Poland: a revision of material described by A.E. Reuss (1867). *Annalen des Naturhistorischen*

Museums in Wien, Serie A, 82 (3): 262-268.
TAYLOR P. D. & ERNST A. 2008. — Bryozoans in transition: the depauperate and patchy Jurassic biota. *Palaeogeography, Palaeoclimatology, Palaeoecology* 263: 9-23.
TAYLOR P. D. & LARWOOD G. P. 1990. — Major evolutionary radiations in the Bryozoa, *in* TAYLOR P. D. & LARWOOD G. P. (eds), Major evolutionary radiations. *Systematics Association Special Volume* 42: 209-233.
TAYLOR P. D. & MCKINNEY F. K. 2006. — Cretaceous Bryozoa from the Campanian and Maastrichtian of the Atlantic and Gulf Coastal Plains, United States. *Geologica Scripta* 132: 1-346.
TAYLOR P. D. & PALMER T. J. 1994. — Submarine caves in a Jurassic reef (La Rochelle, France) and the evolution of cave biotas. *Naturwissenschaften* 81: 357-360.
TAYLOR P. D. & SEQUEIROS L. 1982. — Toarcian bryozoans from Belchite in north-east Spain. *Bulletin of the British Museum (Natural History)*, Geology Series, 37: 117-129.
TAYLOR P. D. & WILSON M. A. 1999. — Middle Jurassic bryozoans from the Carmel Formation of southwestern Utah. *Journal of Paleontology* 73: 816-830.
TAYLOR P. D. & ZATOŃ M. 2008. — Taxonomy of the bryozoan genera *Oncousoecia*, *Microeciella* and *Eurystrotos* (Cyclostomata: Oncousoeciidae). *Journal of Natural History* 42 (39-40): 2557-2574.
WALTER B. 1970. — Les Bryozoaires jurassiques en France. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon* 35: 1-328 (dated 1969; published 1970).
WIGNALL P. B. 1990. — Benthic palaeoecology of the Late Jurassic Kimmeridge Clay of England. *Special Papers in Palaeontology* 43: 1-74.

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