BRYOZOA OF THE MÓJCZA LIMESTONE

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Fragments of bryozoan colonies with phosphatic coats occur abundantly throughout the section of the Mójcza Limestone. They provide a record of faunal evolution in the area from the end of the Arenig to the beginning of the Ashgill. Single-walled palaeotubuliporine Cyclostomata and ramose gracile rhabdomesines dominate the assemblages, and typical Trepostomata and Cryptostomata, prevailing in coeval faunas in other regions, are virtually absent in Mójcza. The Mójcza fossil assemblages are also unusual in the abundance of early astogenetic stages of bryozoan colonies, probably due to high juvenile mortality on the soft bottom with few detrital particles suitable for settlement of larvae exposed. This enables recognition of single-walled stages in colony development of several species of the rhabdomesines and related bryozoans.

Key words: Bryozoa, Ordovician, astogeny, paleoecology.

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INTRODUCTION

Among fragmented calcareous fossils with calcium phosphate coatings, of which the Mójcza Limestone is mainly composed, pieces of bryozoan zoaria are very common. They occur throughout the whole section and represent an assemblage which is rather unusual in its composition if compared with published reports on Ordovician bryozoan faunas. That is to say, the most abundant taxa in bryozoan-dominated communities of the Early Palaeozoic – represented by massive and ramose trepostome colonies – are virtually missing in Mójcza. Even the leaf-like ptilodictyids, very common in other Early Paleozoic localities of the world, do not occur in Mójcza. The assemblage is dominated, instead, by delicate, ramose colonies of primitive single-walled cyclostomes and non-articulated possible ancestors of arthrostylid cryptostomes. Only some fragments of branches may possibly represent early fenestellid cryptostomes. All these groups of early bryozoans are still rather superficially known, especially regarding their early astogeny, and the Mójcza materials provide interesting insights into their early evolution.

Another peculiar feature of the Mójcza bryozoan assemblages is the abundance of bases of young colonies. It seems that also most of the fragmentary specimens represent juvenile colonies, as suggested by invariably thin secondary calcareous coatings produced by the common soft tissue of the colony in double-walled bryozoans. Neither dissepiments nor merging branches have been identified in presumed phylloporinid and fenestellid cryptostomes of the Mójcza Limestone. In each of the more common species several specimens representing early stages of astogeny have been identified. In fact, the Mójcza material provides the first unquestionable evidence of the earliest, single-walled, stages of astogeny in arthrostylid bryozoans.

This makes the Mójcza bryozoan faunas very interesting from an evolutionary point of view but, at the same time, very difficult to treat taxonomically. Evidently most of the taxa are new but, being represented by fragmentary specimens, cannot be properly defined. Therefore, in the following descriptions open nomenclature is generally used and in only a few cases are species identifications proposed. The main purpose of the present paper, which is little more than a preliminary report on the fauna, is to present new evidence on the early astogeny of Ordovician bryozoans and their morphologic diversity rather than strict taxonomic and nomenclatorial conclusions.

Acknowledgements. — I am very thankful to Paul D. TAYLOR [British Museum (Natural History)] for his thorough review and several helpful comments.

FAUNAL DYNAMICS

Although phosphatic bryozoan remnants occur in virtually all samples of the Mójcza Limestone they are not uniformly distributed in the section. In some horizons they are quite rare, presumably because of preservational factors rather than real differences in productivity. This hampers quantitative description of the faunal dynamics (in terms of per cent contribution of species) but some patterns can still be detected by an analysis of the abundance of particular species in samples (Figs 1–2).

There are at least six levels in the Mójcza section where bryozoans are very abundant. The lowermost one, below the discontinuity surface, is of the lowest taxonomic diversity. The assemblage is dominated by a species of *Wolinella* indistinguishable from, and thus probably conspecific with, *W. baltica* DZIK, 1981. Unlike the Baltic area, in Mójcza this species is not replaced in higher horizons by other species of the genus and occurrs continuously up to the early Caradoc. Other bryozoans occur only subordinately in these oldest horizons, represented mainly by other early cyclostomes (*Corynotrypa* and *Voigtia*) and rare thinly ramose zoaria of the rhabdomesines. The basalmost part of the Mójcza Limestone is slightly enriched, if compared with the rest of the section in fragmentary juvenile zoaria of massive trepostomes, dominated by species representing presumably the genera *Hemiphragma* and *Esthoniopora*. Such trepostomes occur throughout the section invariably in very low quantities.

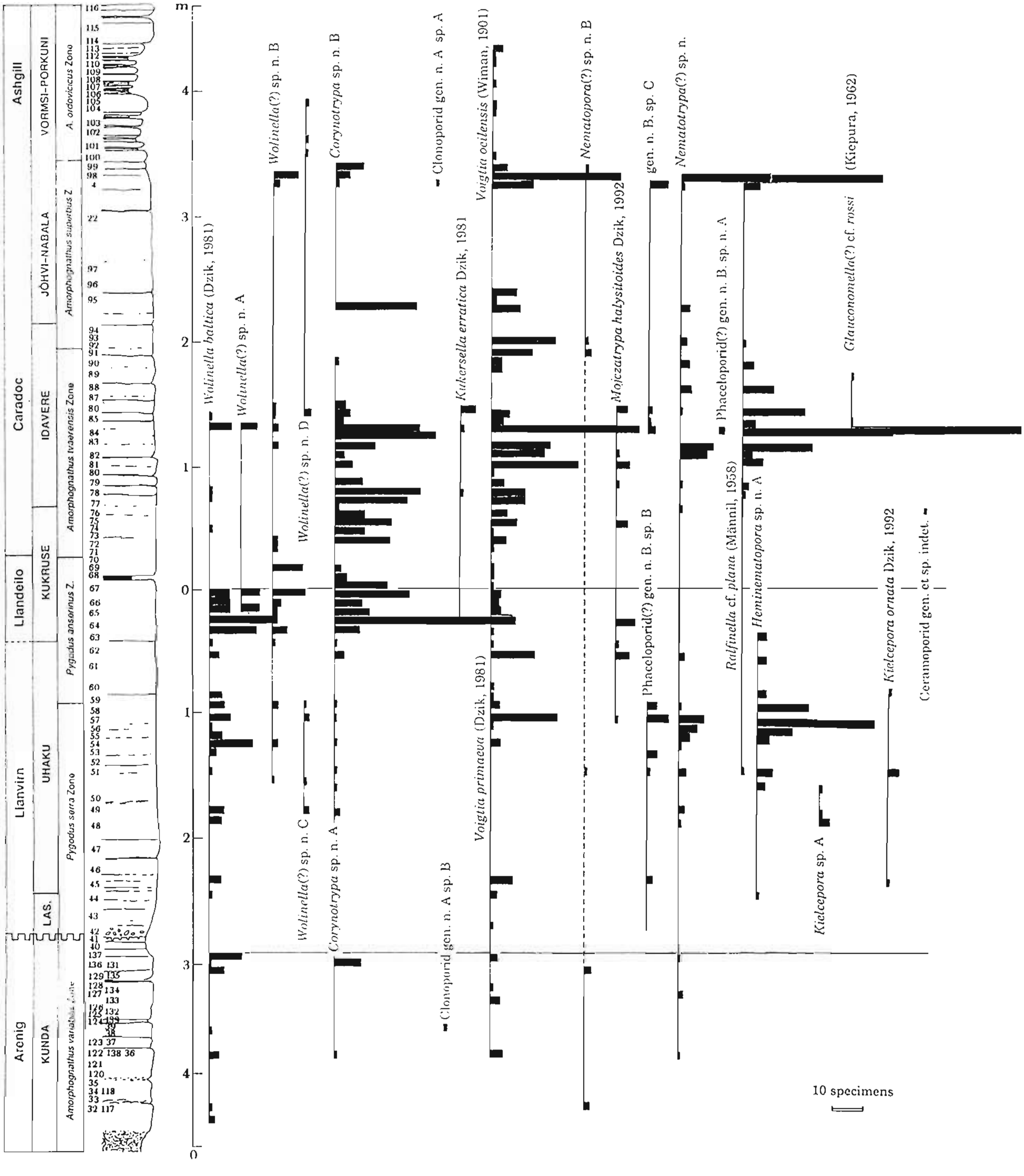

Fig. 1.
Distribution of palaeotubuliporine and kielceporid bryozoans in the Mójcza section.

The next bryozoan-rich horizon corresponds approximately to the *Pygodus serra – P. anserinus* zonal boundary. Although all the genera present lower in the section are represented here too, the dominant bryozoan is a species of *Heminematopora* with two rows of zooecia.

The third horizon, immediately below the bentonite, is very similar in its taxonomic composition to that below the discontinuity surface, except for a much higher contribution of *Corynotrypa*.

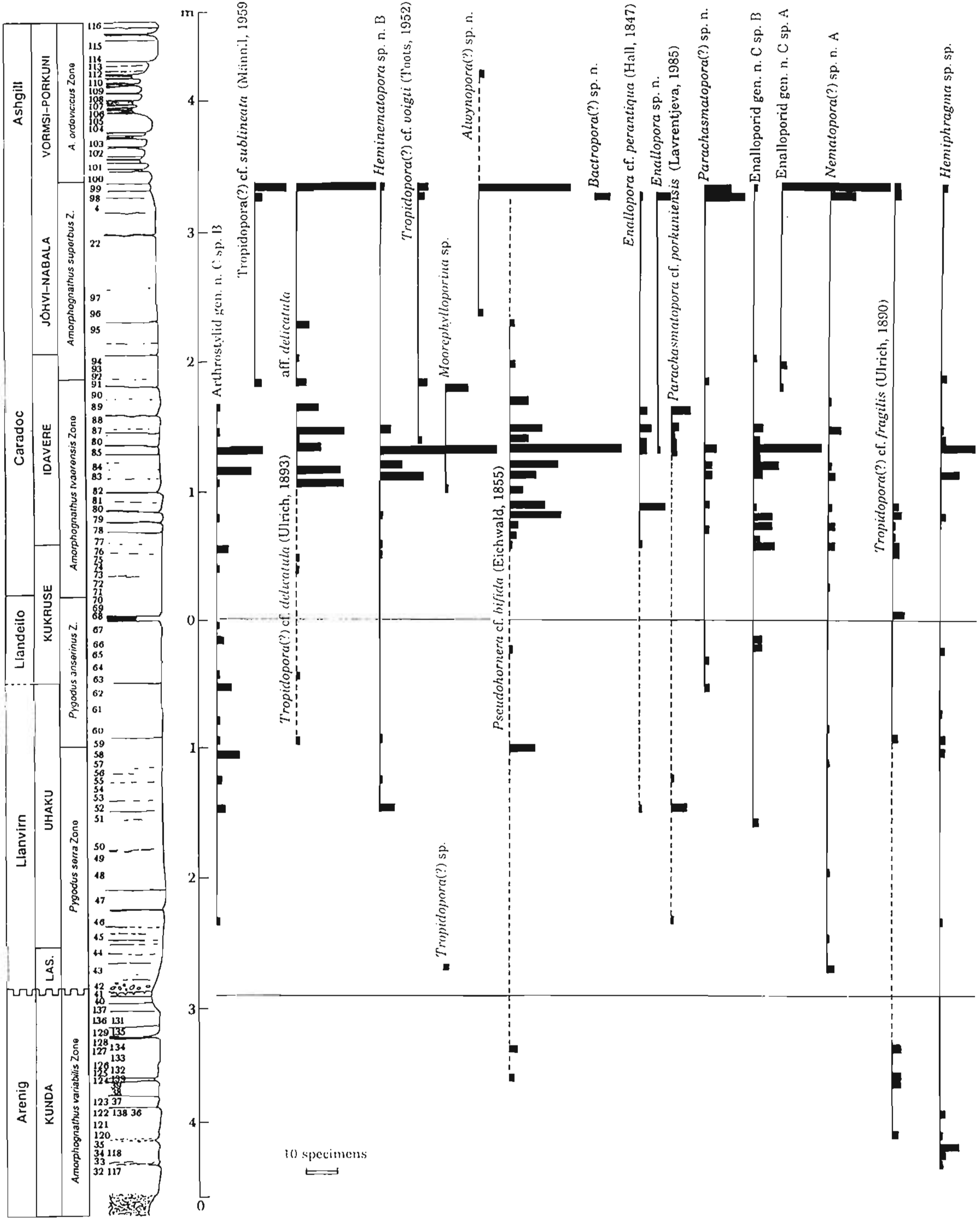

Fig. 2.
Distribution of enalloporid and other bryozoans in the Mójcza section.

Corynotrypa and *Enallopora* increase even more in their contribution above the bentonite layer, in the fourth level, about 1.5 meters higher, being supplemented by several species of *Heminematopora*, *Nematopora*, and other, mostly unnamed, rhabdomesines. This is the bryozoan assemblage of the highest taxonomic diversity in the Mójcza Limestone.

Above this level *Wolinella baltica* and *Corynotrypa* disappear but several other cyclostomes and rhabdomesines join the assemblage. This fauna may be distinguished as the fifth one. In the topmost bed of the Mójcza Limestone, above a zone of poor record, the last, very diverse assemblage has been identified. The marly strata of the Zalesie Formation above do not contain well preserved fossils but, judging from occasional specimens, they may be of the same kind as those at the top of the limestone series.

PALEOECOLOGY

All the bryozoan assemblages identified in the Mójcza Limestone are composed almost exclusively of extremely gracile kinds of zoaria, with ramifying branches bearing generally not more than three rows of zooecia, usually one or two. This suggests extremely quiet conditions, unknown in any of the better described localities outside the Holy Cross Mountains.

As mentioned already above, an even more striking feature of the Mójcza bryozoan assemblages is the abundance of early developmental stages of colonies and lack of more advanced stages, which could be easily identified even in fragmented material on the basis of more extensive secondary growth of extrazooecial tissue in double-walled forms. This suggests an unusually high juvenile mortality of the Mójcza bryozoans.

Numerous colony attachments may help to recognize factors that produced such unusual population dynamics. Some initial, single-walled parts of the rhabdomesines show attachments to very narrow, spine-like objects (Text-fig. 6l), others were evidently attached to small particles of skeletal detritus. It seems thus that a lack of available hard substrates was the limiting factor in developing bryozoan faunas on the sea bottom during the extremely slow deposition of the Mójcza Limestone. This indicates that the sediment was not winnowed during deposition that took place in very quiet conditions. The bottom was therefore constantly covered by a very fine calcareous mud with few skeletal particles being exposed (see DZIK and PISERA 1994).

DESCRIPTIONS

Note. — Because of variable state of preservation, with phosphatic coatings missing in some specimens and thick enough to obliterate details in others, it is usually difficult to make accurate measurements. However, dimensions of particular specimens can be easily inferred from the camera lucida drawings with given scale, which illustrate the following descriptions.

Order **Cyclostomata** BUSK, 1852

Family **Corynotrypidae** DZIK, 1981

Genus *Wolinella* DZIK, 1981

Type species: *W. polonica* DZIK, 1981.

Wolinella baltica DZIK, 1981
(Pl. 57: 9, 11–12; Text-fig. 3a–e, k)

1981. *Wolinella baltica* sp. n.; DZIK, p. 855, Pl. 117: 4, Text-fig. 3a.

Type horizon and locality: Baltic erratic boulder E-089, *Eoplacognathus pseudoplanus* Zone, Late Kundan, early Llanvirn.

Remarks. — The distinguishing characters of the species is the basal communication between zooecia by two pores and erect uniserial zoaria with peristomes arranged spirally along the axis. In some specimens, presumably representing juvenile branches with weakly developed secondary laminar tissue, zooecia communicate more widely, without any distal basal walls. Most of specimens of

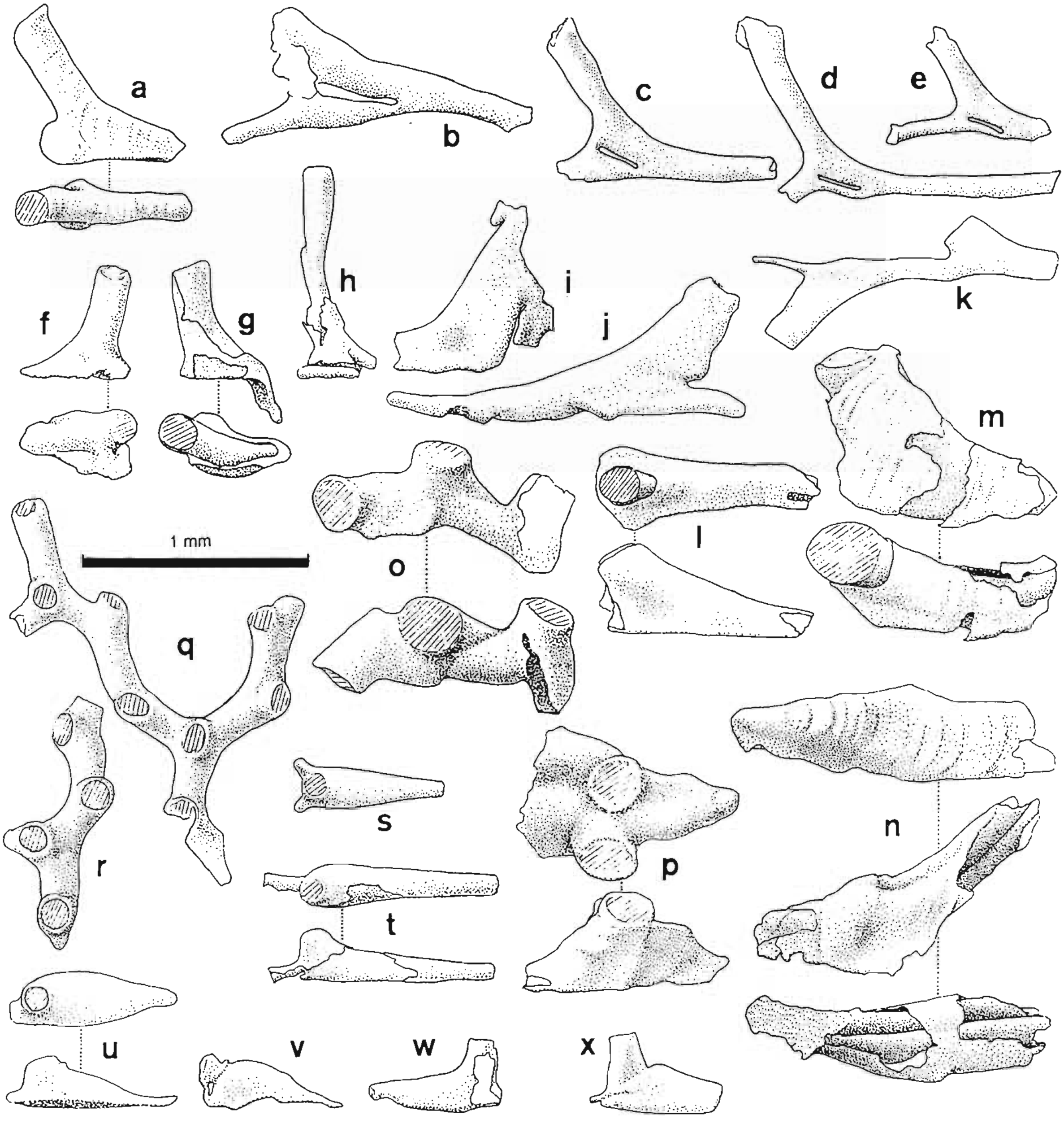

Fig. 3.

Uniserial single-walled bryozoans from the Mójcza Limestone. **a–e**, **k**. *Wolinella baltica* DZIK, 1981; a–b, sample MA-85; c–e, sample MA-14; k, sample MA-59. **f–h**. *Wolinella*? sp. n. A, sample MA-85. **i–j**, **l–n**. *Wolinella*? sp. n. B; i, n, sample MA-99; j, sample MA-7; m, sample MA-85; l, sample MA-87. **o–p**. *Wolinella*? sp. n. C; sample MA-51. **q–r**. *Wolinella*? sp. n. D; q, sample MA-23; r, sample MA-20. **s–t**, **x**. *Corynotrypa* sp. n. A., sample MA-85. **u–w**. *Corynotrypa* sp. n. B, sample MA-99.

Wolinella in the Mójcza Limestone represent erect, gracile branches of colonies, although specimens with more than two zooecia intact, necessary to prove it, are very rare (Text-fig. 3k). It remains unclear what the base of the colony looked like. Some ancestrulae with *Wolinella*-like morphology have been found that may represent initial stages of astogeny (Pl. 57: 8; DZIK 1981: Text-fig. 4). Such ancestrulae produced two daughter zooecia basally, which suggest that at least the first zooidal generations of their colonies were encrusting. Encrusting zooecia otherwise morphologically undistinguishable from the species also occur in the section (Pl. 57: 7–8, Text-fig. 3a–b). Some other encrusting specimens with simple tubular peristomes found in the topmost samples of the Mójcza Limestone show internal channel systems more complicated than in typical *W. baltica* and may represent another corynotrypid.

Distribution. — Well preserved phosphatic nuclei occur commonly in the basal, Kundan part of the section being undistinguishable from coeval Baltic specimens. The species occurred in the Holy Cross Mountains much longer than in the Baltic area, ranging into the Early Caradoc.

Wolinella? sp. n. A
(Pl. 57: 10; Text-fig. 3f–h)

Remarks. — This is a species of encrusting *Wolinella*-like bryozoan with a canal system resembling *W. polonica* (cf. Pl. 57: 13) but with unusually long peristomes.

Distribution. — From immediately below to 1.3 m above the bentonite; top of *P. anserinus* and *A. tvaerensis* Zones, Llandeilo – Early Caradoc.

Wolinella? sp. n. B
(Pl. 57: 7–8; Text-fig. 3i–j, l–n)

Remarks. — Several large isolated zooecia of a single-walled encrusting bryozoan have been found in the upper part of the Mójcza Limestone. These resemble species of *Wolinella* in the shape of the peristome but differ in the much larger size and lateral compression of the peristome. Some specimens transitional in size and shape to the encrusting form, here tentatively attributed to *W. baltica* are difficult to classify. Transitions to multiseriality are also known that may suggest occurrence of a whole plexus of such large-sized single-walled species leading to *Flabellotrypa* morphologies.

Distribution. — From 1.5 m below the bentonite to the topmost bed of the Mójcza Limestone: *E. lindstroemi* Subzone, Uhakuan, Llanvirn to *Amorphognathus superbus* Zone, Nabalan?, Ashgill?

Wolinella? sp. n. C
(Text-fig. 3o–p)

Remarks. — A few specimens from the *E. lindstroemi* Subzone of the Llanvirn represent a species of an encrusting bryozoan with large zooecia which are unflattened laterally and branching zoaria. Wenlockian *Corynotrypa hennigi* BROOD, 1975 is somewhat similar to the species under discussion.

Distribution. — From 1.8 to 1.0 m below the bentonite, *E. lindstroemi* Subzone, Uhakuan, late Llanvirn.

Wolinella? sp. n. D
(Text-fig. 3q–r)

Remarks. — Close to the top of the Mójcza Limestone *Stomatopora*-like fragmentary zoaria occur that range into the Zalesie Formation. All peristomes are oriented in one direction but the zoarial branches remain round in cross section. It is thus not clear whether the colonies were encrusting or erect. No evidence of wall pseudoporosity has been found and presumably this is a corynotrypid.

Distribution. — From about 1.5 m above the bentonite to the marls of the Zalesie Formation: *Amorphognathus tvaerensis* Zone of the Caradoc to Ashgill.

Genus *Corynotrypa* BASSLER, 1911

Type species: *Hippothoa delicatula* JAMES, 1878; Lower Cincinnatian at Cincinnati, Ohio.

Corynotrypa sp. n. A
(Pl. 57: 1–4; Text-fig. 3s–t, x)

1981. *Corynotrypa* sp. (aff. *C. schucherti* BASSLER); DZIK, Pl. 118: 1, 5.

Remarks. — This is the oldest known species of *Corynotrypa* with elongated tubular zooecia that frequently develop a circular hemiseptum at the base of the peristome and another small, shelf-like hemiseptum behind the connection with the proximal zooecium. It occurs abundantly in the Early

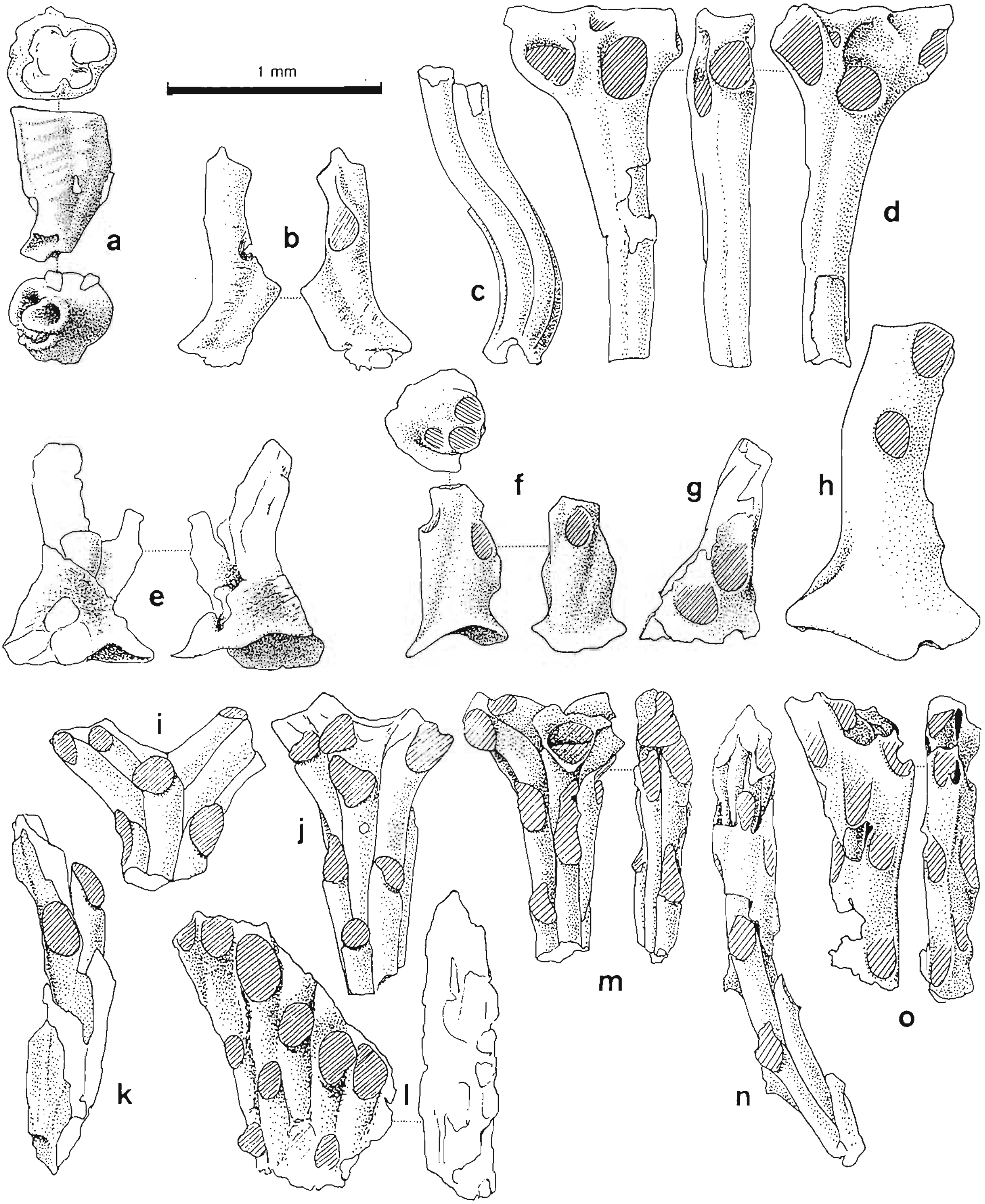

Fig. 4.
Bifoliose possible diploclemids from the Mójcza Limestone. **a–b**. Phaceloporid? gen. n. B sp. n. A.; a, sample MA-85; b, sample MA-85. **c–d**. Phaceloporid? gen. n. B sp. B; sample MA-54. **e–h**. Phaceloporid? gen. n. B or nematoporid; e, sample MA-93; f, sample MA-46; g. sample MA 58; h, sample MA-58. **k–o**. Phaceloporid? gen. n. B sp. n. C; i–k, sample MA-98; l, sample MA-87; m–o, sample MA-99.

Ordovician of both the Baltic area and Holy Cross Mountains but, being known only from isolated zooecia, cannot be properly defined as a new species.

Distribution. — Occurs from the base of the Mójcza Limestone to about 1.8 m above the bentonite; latest Arenig to Late Caradoc.

Corynotrypa sp. n. B
(Text-fig. 3u–w)

Remarks. — More typical for the genus, inflated and basally flattened zooecia occur sporadically together with the species discussed above and replace it in the topmost strata of the Mójcza Limestone and Zalesie Formation.

Distribution. — Isolated occurrence at 0.8 m above the bentonite and then (possibly another species with similar zooecia) from 2.2 m above the bentonite to the Zalesie Formation marls; *A. tvaerensis* Zone, Caradoc, and *A. superbus* to *A. ordovicicus* Zone, late Caradoc and Ashgill.

Family **Clonoporidae** Brood, 1975
Gen. n. A

Remarks. — Two species of single-walled non-pseudoporous bryozoans with multiserial erect colonies occurring in the Mójcza·Limestone cannot be attributed to any known genera. In apparent lack of pseudopores and multiserial colony branches they are transitional between the families Corynotrypidae and Crownoporidae. Brood (1975) proposed a new family Clonoporidae to classify multiserial non-pseudoporous cyclostomes but he did not redescribe the type species of *Clonopora, C. semireducta* Hall, 1883, and based his concept of the genus on species of *Cystoporella* Bassler, 1953, synonimized by him with *Clonopora. Cystoporella*, with its short peristomes, semilunar apertures, and bottle-shaped zooecia bears much resemblance to *Diploclema* and should rather be classified together with this peculiar genus. Another group of species, characterized by long tubular peristomes, were identified with *Clonopora* in the Ordovician (Dzik 1981). They possessed rare, large pseudopores and therefore are interpreted as ancestral to the family Crownoporidae. Revision of the type material of *C. semireducta* is thus necessary to solve these nomenclatorial questions. The Mójcza species under discussion differ from all the species attributed previously to *Clonopora* and related genera in their much narrower zooecia and, presumably, their early astogeny.

Gen. n. A sp. n. A
(Text-fig. 5a)

Remarks. — A single well preserved initial encrusting part of presumably erect multiserial (at least six rows of peristomes) colony is built of very narrow zooecia. Distinct growth lines clearly indicate that this is a single-walled bryozoan which, being evidently devoid of pseudoporosity seems to belong not to the Crownoporidae.

Distribution. — Only sample MA-98 immediately below the top of the Mójcza Limestone.

Gen. n. A sp. n. B.
(Text-fig. 5b)

Remarks. — The only known specimen represents a segment of erect, radially symmetrical colony branch with four rows of very minute zooecia (similar in size to those of the preceding species).

Distribution. — Sample MA-125, *Microzarkodina ozarkodella* Subzone, Kundan, earliest Llanvirn.

Family **Phaceloporidae** Miller, 1889

Remarks. — Bryozoans described below share with *Phacelopora* neither colony articulation nor show any wall perforation. The reason why they are provisionally classified here in the family is their possible affinities to *Schallreuterella*, proposed here to have a colony organization similar to *Phacelopora*, even if not articulated.

Gen. n. B

Remarks. — There is a group of non-porous single-walled bryozoans with multiserial erect branches in the Mójcza Limestone. They can be characterized by elongated tubular zooecia with short peristomes and early astogenetic stages with all the zooecia vertically oriented, almost without any creeping stage. It is possible that these fossil bryozoans are related to *Diploclema* ULRICH, 1889, which is suggested also by a tendency to develop bifoliate narrow zoarial branches.

Schallreuterella HILLMER, 1987 is an enigmatic Ashgill cheilostome-like bryozoan with normal zooecia arranged in pairs along zoarial branches composed of a pair of thin tubular, presumably permanently immature stolozooecia. Very clear sutures separating all the zooecia (HILLMER 1987, 1991) indicate that there was no continuous external cover of a skeleton secreting tissue, thus these were single-walled bryozoans. It seems thus possible that Gen. n. B, with its extreme basal elongation of the zooecia is ancestral to *Schallreuterella*. Another early bryozoan that shows zooecia in the axial parts of colony branches similarly elongated and separated by sutures is *Phacelopora*. *P. lineapunctata* SCHALLREUTER *et* HILLMER, 1987 from the Ojl Myr flint clearly shows such features but, unlike *Schallreuterella*, both the axial narrow heterozooecia, which develop non-mineralized articulations, and paired autozooecia had medial rows of pseudopores (SCHALLREUTER and HILLMER 1987: Pl. 4). This makes its possible derivation from Gen. n. B and relationship to *Schallreuterella* suggested by the presence of narrow central stolozooecia and lateral pairs of autozooecia with gaping apertures, a little more difficult. There is another species of ramose bryozoan with medial stolozooecium? penetrated with pores, namely *"Protocrisina" ulrichi* BASSLER, 1911 (see GORJUNOVA 1987: Pl. 21: 3b). Early Caradoc (Kukrusean) in age *"P." ulrichi* bears numerous densely distributed zooecia but *"P." carnica* VINASSA DE REGNY, 1915, from the Late Caradoc of the Carnic Alps, had sparsely distributed zooecia in pairs (VINASSA DE REGNY 1915: Pl 1: 1).

Gen. n. B. sp. n. A.
(Text-fig. 4a–b, e?)

Remarks. — Several basal parts of colonies are attributed to this species. At least some of them show distinct growth lines that indicate that these were single-walled bryozoans that developed a common bud at the top of erect colony branches. Although growth lines continue around the branch, particular zooecia are distinct which indicates that their differentiation was rather early. The ancestrula can be identified with some confidence in three specimens. It varies very much in length, so these zoaria may actually represent different bryozoan species. In some cases the phosphatic coating is so thick that it is not even clear whether they all were single-walled.

Distribution. — Zoarial bases of this kind occur from about 1.0 m below to 1.8 m above the bentonite; end of *P. serra* Zone of the latest Llanvirn to the beginning of the *A. superbus* Zone, late Caradoc.

Gen. n. B. sp. n. B
(Pl. 58: 17; Text-fig. 4c–d)

Remarks. — These are zoaria with unusually long zooecia in bunches of at least four that tend to develop a bilaterally symmetrical arrangement at the level of their peristomes. Although growth lines are not visible, and most of available specimens are internal moulds, very clear separation of the zooecia by sutures, visible on fragmentary external phosphatic coatings, suggests they were single-walled. They seem to be closely related to the species described above and this is why their congenerity is suggested.

Distribution. — Rare from immediately above the discontinuity to 1.3 m below the bentonite; *E. reclinatus* to *E. lindstroemi* Subzones of the Llanvirn.

Gen. n. B. sp. n. C
(Text-fig. 4k–o, f–h?)

Remarks. — These are generally narrow bifoliose zoaria that branch dichotomously. Peristomes are very short and apertures ovally elongated or slightly semilunar. The proximal margin of the aperture was slightly thickened internally. Only in a few specimens is the external morphology partially preserved and, as far as it can be inferred from fragments of external phosphatic coating, some apertures had a proximal shelf-like structure (Text-fig. 4k, m) that resembles a little the frontal calcified areas in *Schallreuterella*. External ornamentation with longitudinal ribs, especially well developed along margins of flattened zoarial branches (Text-fig. 4o), does not allow exclusion of the possibility that these are actually double-walled Bryozoa. The same problem concerns basal colony parts (Text-fig. 4f–h) that possibly belong to the species, although a thick phosphatic cover hardly allows recognition of the details of their morphology. With the peristome of the ancestrula opening somewhat above the base, they show some resemblance to advanced rhabdomesines.

Distribution. — From less than 1.5 m above the bentonite to the top of the Mójcza Limestone, *A. tvaerensis – A. superbus* Zones, Caradoc.

Family **Crownoporidae** ROSS, 1967

Genus *Voigtia* HILLMER *et* SCHALLREUTER, 1985

Type species: *Voigtia octoginta* HILLMER *et* SCHALLREUTER, 1985; Baltic erratic boulder probably of Jöhvian age, Caradoc.

Voigtia primaeva (DZIK, 1981)

(Pl. 57: 15–16, 18; Text-fig. 5c–d, f, j)

1981. *Clonopora primaeva* sp. n.; DZIK, p. 857, Pl. 119: 1, 4–5.

Type horizon and locality: Baltic erratic boulder E-112, *Baltoniodus variabilis* Zone, Kukrusean, early Caradoc.

Remarks. — *V. primaeva* differs from the succeeding species in its well-developed communication canals between zooecia and the variably distributed but generally numerous (several per zooecium) pseudopores. The first character is easily identifiable in the oldest samples from the Mójcza Limestone but their preservation rarely enables identification of pseudopores. It is thus not quite clear whether this similarity expresses species identity of the Baltic and Holy Cross Mountains populations or is due only to the same early stage in their evolutionary advancement.

Voigtia octoginta from Late Caradoc age flint is definitely a related form that differs in more numerous pseudopores and radially arranged peristomes around gracile erect colony branches (HILLMER and SCHALLREUTER 1985). It seems thus reasonable to classify this and the following Mójcza species within the same genus *Voigtia* instead of *Clonopora*, the Devonian type species of which still awaits redescription.

Distribution. — The lineage is represented for sure already in the *M. ozarkodella* Subzone and continues upward at least to the Caradoc when passes into succeeding *E. oeilensis*. No clear-cut boundary between these species has been identified.

Voigtia oeilensis (WIMAN, 1901)

(Pl. 57: 17; Text-fig. 5e, g–h, k)

1962. *Enallopora exigua* (ULRICH); KIEPURA, p. 394, Pl. 6: 1–2.

1984. *Enallopora oeilensis* (WIMAN); SPJELDNAES, p.13, Pl. 1: 1–3, Text-fig. 3A–D.

1982. non *Enallopora oeilensis* (WIMAN); BROOD, p. 175, Fig. 7A, F (captions, illustrations Fig. 8)

1987. non *Enallopora* cf. *oeilensis* (WIMAN); SCHALLREUTER and HILLMER, Pl. 5: 4a, b.

Type horizon and locality: Erratic boulder from Ojl Myr, Gotland, Porkunian, Ashgill.

Remarks. — This species is very common in the upper part of the Mójcza section being represented by both internal moulds and specimens with external coatings. Unlike its above described predecessor it had communication canals only at early stages in the development of zooecia and later they were cut off, although some tubular blind extensions of the proximal zooecial base are commonly preserved. Large pseudopores occur both at the frontal zooecial wall and, not so commonly, at the basal side of branches. These features, together with long, tubular peristomes and apparent lack of any secondary basal thickening of the zoarial branches (which would indicate the presence of a hypostegal pseudocoel) suggest that the type population of *Crisinella oeilensis* WIMAN, 1901 from

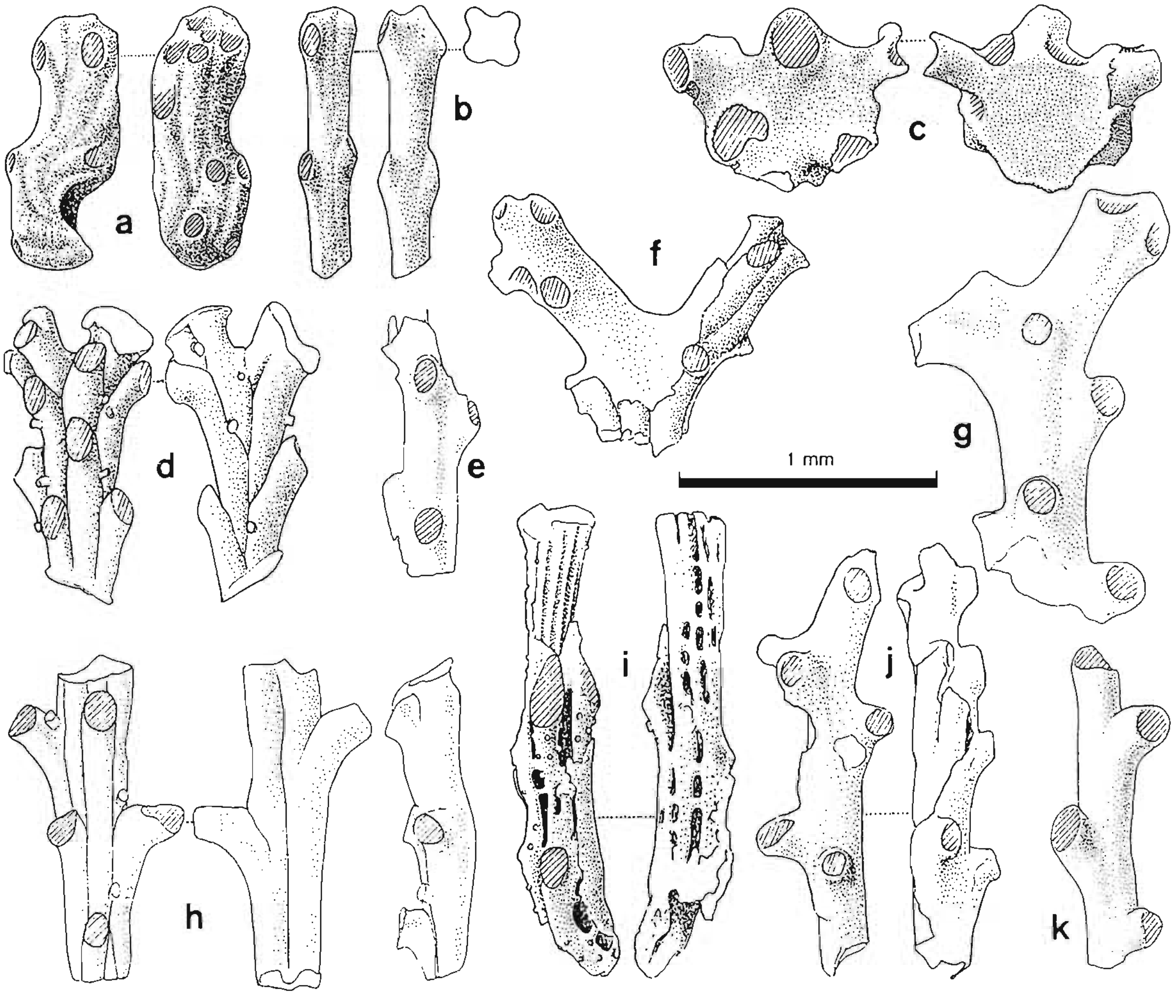

Fig. 5.
Multiserial erect cyclostomes from the Mójcza Limestone. **a**. Clonoporid gen. n. A sp. n. A; sample MA-98. **b**. Clonoporid gen. n. A sp. n. B; sample MA-125. **c–d**, **f**, **j**. *Voigtia primaeva* DZIK, 1981; sample MA-85. **e**, **g–h**, **k**. *Voigtia oeilensis* (WIMAN, 1901); sample MA-99. **i**. *Kukersella erratica* DZIK, 1981; sample MA-85.

boulders of Ojl Myr is conspecific or at least closely related to slightly older Mójcza populations. SPJELDNAES (1984: p. 13) interpreted pores that occur usually at frontal walls below the peristome in his silicified material as heterozooecia but their similarity to pores in older Baltic and Mójcza specimens is too apparent to be without meaning. The pores opens to the interior of the zooecia, any septa or even constrictions are missing which makes their heterozooecial nature quite unlikely. Rather, as already proposed in the case of *C. primaeva*, these were pseudopores similar to those in *Voigtia* and *Kukersella*, which differ only in being smaller and more numerous.

Specimens attributed to this species by BROOD (1982) and SCHALLREUTER and HILLMER (1987) represent non-porous double(free)-walled bryozoan species.

Distribution. — In the upper part of the Mójcza Limestone and probably also in the Zalesie Formation; Caradoc and Ashgill.

Genus *Kukersella* TOOTS, 1952

Type species: *Kukersella boreale* TOOTS, 1952, Kuckers shale, Kukrusean, Caradoc, Estonia.

Kukersella erratica DZIK, 1981
(Text-fig. 5i)

1981. *Kukersella erratica* sp. n.; DZIK, p. 857, Pl. 119: 2–3.

Type horizon and locality: Baltic erratic boulder E-112, *Baltoniodus variabilis* Zone, Kukrusean.

Remarks. — A few specimens of *Kukersella* from the Mójcza Limestone show a very thin central zone of narrow zooecia (endozone) without diaphragms. In this respect they are similar to Baltic specimens of *K. erratica* but differ from the other species of the genus (BROOD 1975; GORJUNOVA 1987; BUTTLER 1989). BUTTLER (1989: p. 220) interpreted the endozone as being produced by permanently immature kenozooids and suggested that *K. erratica* was distinct generically. Another possibility, in agreement with BUTTLER's concept, is that *K. erratica* was the most primitive species of the genus that had not yet developed the mode of budding typical for more advanced forms. There seems to be a gradual increase in the extend of the endozone from the Uhakuan (Llandeilo) species of GORJUNOVA (1987: Pl. 6: 3), through Kukrusean type populations of *K. boreale* (BROOD, 1975) up to Ashgill populations attributed to the same species by BUTTLER (1989).

Distribution. — Rare in the narrow zone from 1.3 to 1.5 m above the bentonite; *A. tvaerensis* Zone, Idaverean, Caradoc. Possibly also about 0.4 m below the bentonite, Kukrusean.

Family **Ceramoporidae** ULRICH, 1882
Gen. et sp. indet.
(Pl. 57: 19)

Distribution. — Only a single colony fragment from sample MA-6, 0.5 m above the bentonite; *A. tvaerensis* Zone, Caradoc.

Order **Trepostomata** ULRICH, 1882
Suborder **Rhabdomesina** ASTROVA *et* MOROZOVA, 1956
Family **Flabellotrypidae** DZIK, 1992

Remarks. — This family has been proposed for early Paleozoic bryozoans with fan-like encrusting colonies that are transitional between the palaeotubuliporine Cyclostomata, primitive Trepostomata, and rhabdomesine Cryptostomata. Its placement in the suborder Rhabdomesina is arbitrarily chosen.

Genus *Mojczatrypa* DZIK, 1992

Type species: *Mojczatrypa halysitoides* DZIK, 1992.

Mojczatrypa halysitoides DZIK, 1992
(Pl. 57: 14; Text-fig. 6a–b)

1992. *Mojczatrypa halysitoides* gen. et sp. n.; DZIK, p. 48, Figs 2A–C, 3A.

Type horizon and locality: Llandeilo of the Mójcza Limestone at Mójcza (sample MA-62).

Remarks. — Unlike superficially similar species of *Flabellotrypa* (KIEPURA 1962; BROOD 1975) that developed fan-like colonies attached to the substrate with their flat side, the Mójcza species produced colony fans cemented to the substrate with their narrow margin, oriented thus vertically. Some expanding distally ancestrula-like specimens may suggest that adult colonies were possibly cateniform (like in tabulate coral *Halysites*).

Distribution. — Fragmentary zoaria of this kind occur from 1.0 m below to 1.5 m above the bentonite; *P. anserinus* to *A. tvaerensis* Zones, Llandeilo and Early Caradoc.

Family **Kielceporidae** DZIK, 1992

Remarks. — These Paleozoic bryozoans are usually classified (together with members of the family Arthrostylidae) within the cryptostomes because of slender, commonly bilaterally symmetrical ramose zoaria and short zooecia with oval apertures. The most characteristic feature of the group, however, is its early astogeny, which is completely unlike that of the Cryptostomata (DZIK 1992). The

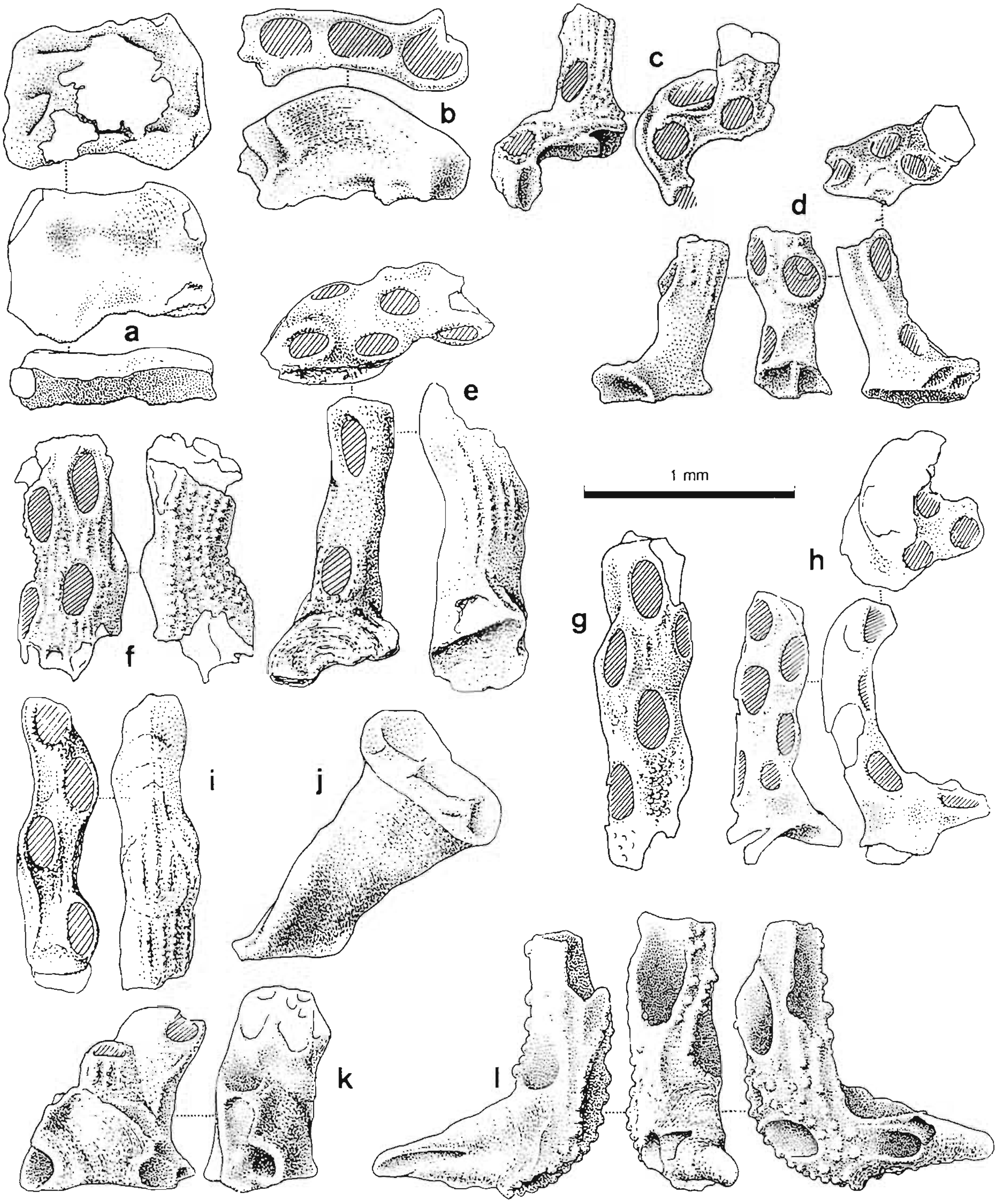

Fig. 6.
Primitive rhabdomesines with well-developed single-walled stage from the Mójcza Limestone. **a–b**. *Mojczatrypa halysitoides* Dzik, 1992; a, sample MA-85; b, sample MA-7. **c–i**. *Kielcepora* sp. A; c–d, f–h, sample MA-85; e, sample MA-83; i, sample MA-91. **j–l**. *Kielcepora ornata* Dzik, 1992; j, sample MA-46; k, sample MA-52; l, sample MA-58.

earliest conical part of the colony is single(fixed)-walled and the following double(free)-walled zoarium emerges from its frontal area of the common bud. This is the case both in late Paleozoic typical rhabdomesines (Tavener-Smith 1974) and the oldest known ancestors of the arthrostylids.

The same kind of early astogeny characterized massive colonies of primitive trepostomes (PODELL and ANSTEY 1979) while zoaria of the cryptostomes originated in a more sophisticated way (MCKINNEY 1978; MCKINNEY and KING 1984) even in the oldest undoubted cryptostome with a known early astogeny, *Prophyllodictya* (DZIK 1992). *Ojlepora orosa* (WIMAN, 1901) is the best known species of this group (SPJELDNAES 1984; DZIK 1992).

Genus *Kielcepora* DZIK, 1992

Type species: *Kielcepora ornata* DZIK, 1992.

Remarks. — These are *Nematopora*-like bryozoans but usually with zooecia opening only on one side of colony branches. The colony establishes from ancestrula as a widely gaping frontally single-walled conical structure.

Kielcepora ornata DZIK, 1992
(Pl. 58: 1, 18–19; Text-fig. 6j–l)

1992. *Kielcepora ornata* gen. et sp. n.; DZIK, p. 51, Figs 3B, 4A–C.

Type horizon and locality: Uhakuan (Llanvirn) of Mójcza Limestone at Mójcza (sample MA-57)

Remarks. — The species can be characterized by relatively large zooecia with robust granulation of areas between zooecial apertures. The basal single-walled cone of the colony is very well developed with distinct growth lines. Attachment surfaces preserved in several specimens indicate that larvae settled on small detrital particles. In some cases only a needle like objects served as the substrate, similar to the Carboniferous rhabdomesines described by TAVENER-SMITH (1974).

Distribution. — From 2.2 m to 1.0 m below the bentonite; *E. robustus* to *E. lindstroemi* Subzones, Llanvirn.

Kielcepora sp. A
(Pl. 58: 2–4; Text-fig. 6c–i)

1992. *Kielcepora* sp. A; DZIK, Fig. 3C.

Remarks. — This species differs from the preceding one, which may be its ancestor, mostly in the smaller size of its zooecia and in the much narrower single-walled part of the basal cone. In this respect it resembles *Ojlepora orosa* (see SPJELDNAES 1974: Pl. 5: 5; DZIK 1992) which had thicker branches with more densely distributed zooids in at least three rows.

Distribution. — From 1.3 m below to 1.5 m above the bentonite; *E.lindstroemi* to *A. tvaerensis* Zone, Llanvirn to Early Caradoc.

Kielcepora sp. B
(Text-fig. 8a–b)

Remarks. — A few well preserved very slender branches show some similarity to the preceding species and differ mostly in their very delicate granulation and the presence of a distinct medial ridge at the reverse side of the branches.

Distribution. — Occurs in the narrow zone about 1.8 m below the bentonite, boundary between the *P. serra* and *P. anserinus* Zones, Llandeilo.

Genus *Glauconomella* BASSLER, 1952

Type species: *Glaconome disticha* GOLDFUSS, 1831; Wenlockian of England.

Glauconomella? cf. *rossi* (KIEPURA, 1962)
(Pl. 58: 9?; Text-fig. 7a–c, d?)

1962. *Heminematopora rossi* sp. n.; KIEPURA, p. 399, Pl. 11: 1.

Type horizon and locality: Baltic erratic boulder O.204 of the Ostseekalk from Mochty, Poland; Late Caradoc.

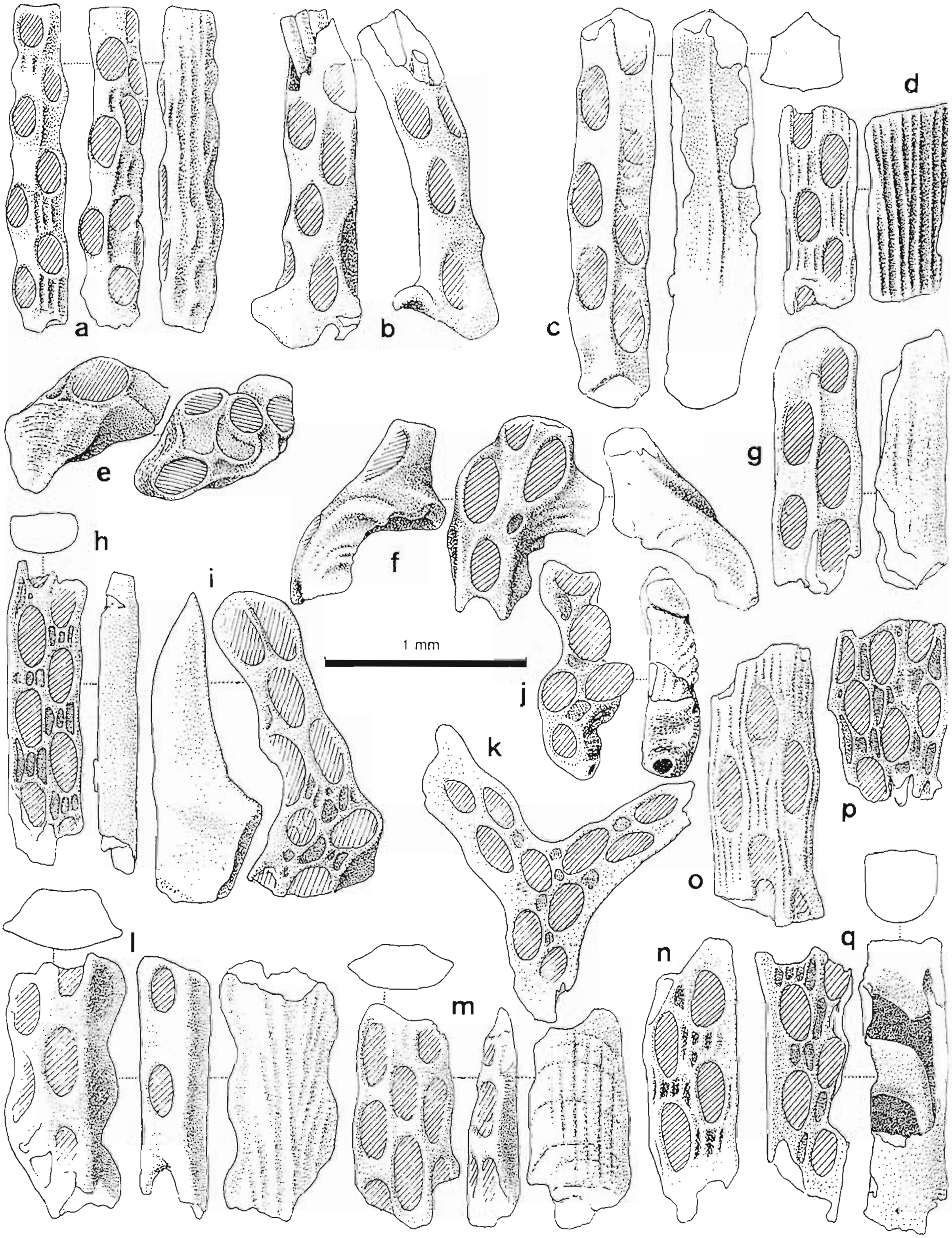

Fig. 7.
Multiserial rhabdomesines with zooecia opening on one side of the colony branches from the Mójcza Limestone. **a–c**, **d**? *Glauconomella*? cf. *rossi* (KIEPURA, 1962); a–c, sample MA-85. **e–q**. *Ralfinella* cf. *plana* MÄNNIL, 1958; e, sample MA-58; f, l, m, o, sample MA-85; h–i, k, p–q, sample MA-99; j, sample MA-91.

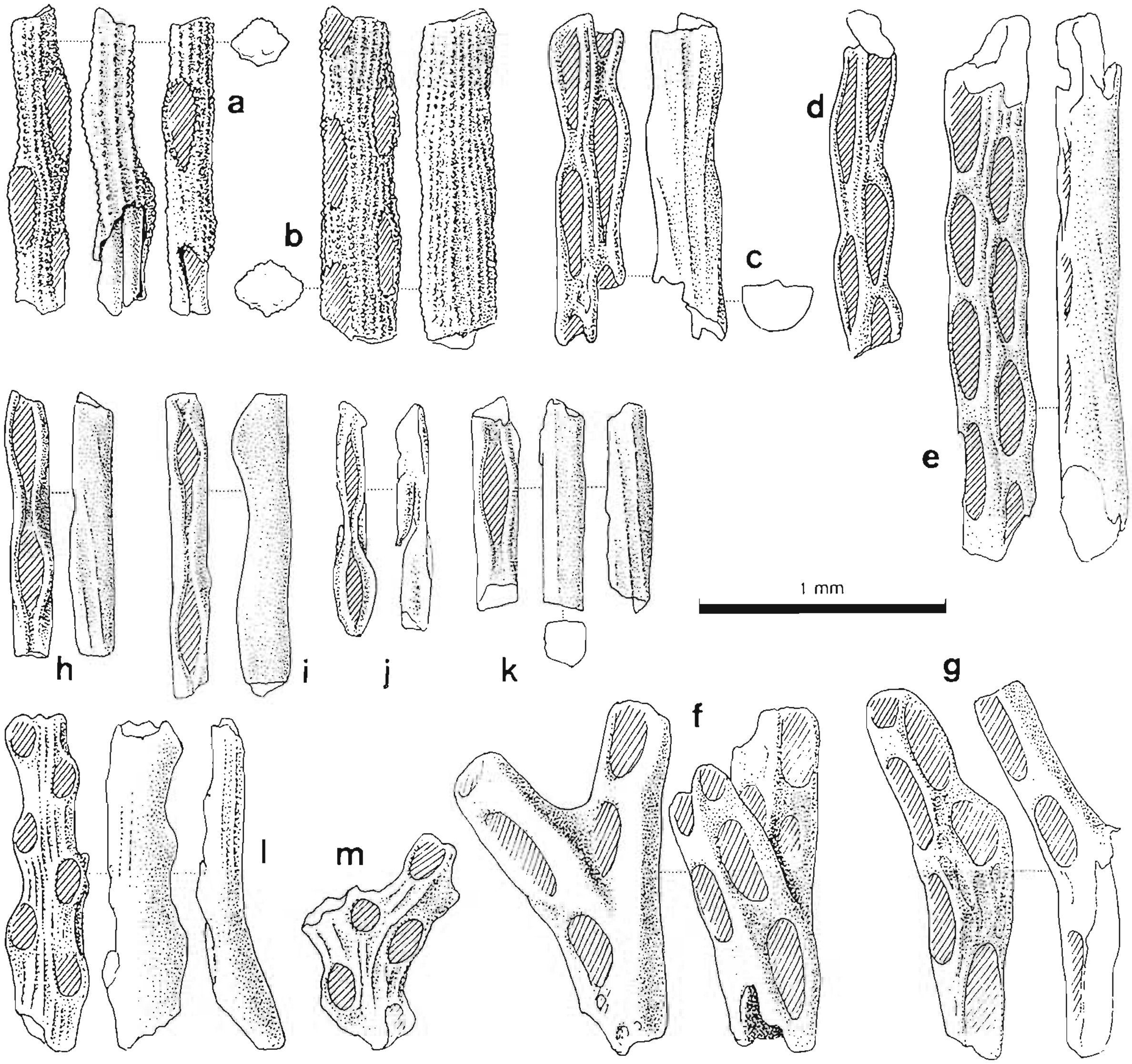

Fig. 8.
Bi- and monoserial rhabdomesines with peristomes on one side of the colony branches from the Mójcza Limestone. **a–b**. *Kielcepora* sp. B; a, sample MA-50; b, sample MA-27. **c–e, f–g**. *Heminematopora* sp. n. A; c–e, sample MA-58; f–g, sample MA-62. **h–k**. *Heminematopora* sp. n. B, sample MA-85. **l–m**. *Alwynopora*? sp. n., sample MA-99.

Remarks. — The Mójcza specimens represent exclusively unbranched parts of presumably juvenile colonies. In their general shape and distribution of zooecia they are closely similar to Baltic specimens of *"H." rossi*. The pattern of branching of KIEPURA's species is basically different from that of *Heminematopora* which develops new branches on the obverse side, not laterally. This is the case also with *Glauconomella plumula* (WIMAN, 1901) from the Ojl Myr erratics which, like the type species of the genus, had monopodially branched colonies (SPJELDNAES 1984). Actually, colonies morphologically identical with *G. plumula* have been described by KIEPURA (1962) from the same boulder in which the holotype of *"H." rossi* was found.

One specimen in the Mójcza material has preserved some of the basal part of the colony. Although the ancestrula is not preserved, the general appearance of the base is very similar to that in *Kielcepora*.

Distribution. — From 1.3 m above to 1.8 m above the bentonite; *A. tvaerensis* Zone, Caradoc.

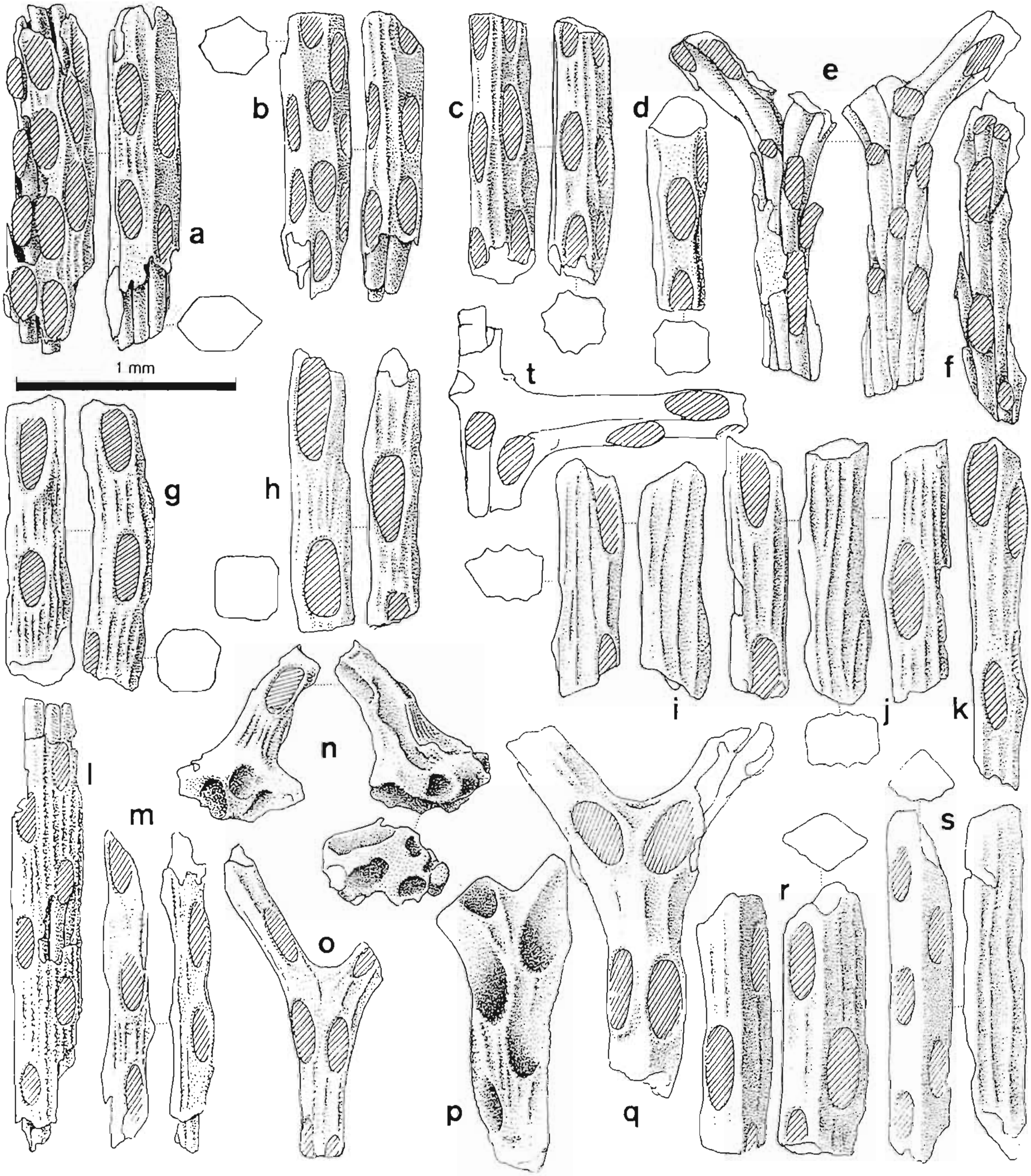

Fig. 9.
Arthrostylids with radially arranged zooecial apertures from the Mójcza Limestone. **a–c.** *Tropidopora*? cf. *voigti* (TOOTS, 1952); sample MA-99. **e, l**? *Tropidopora*? cf. *fragilis* (ULRICH, 1890); l, sample MA-80. **d, f–h, k, t.** *Tropidopora*? cf. *delicatula* (ULRICH, 1893); d, sample MA-99; f, k, sample MA-87; g, sample MA-99; h, sample MA-85; t, sample MA-83. **m–o.** *Tropidopora*? aff. *delicatula* (ULRICH, 1893); sample MA-99. **i–j.** *Tropidopora*? sp.; sample MA-43. **p–s.** *Tropidopora*? cf. *sublineata* MÄNNIL, 1959; sample MA-99.

Genus *Tropidopora* HALL, 1886

Type species: *Tropidopora nana* HALL, 1886; Onondaga Limestone, Onondaga Valley, New York.

Remarks. — Bryozoans that are here tentatively attributed to *Tropidopora* are usually classified within *Nematopora* ULRICH 1888. In the case of the Mójcza species assignment to *Nematopora* is unacceptable unless the colony base attributed to *Nematopora* by BLAKE (1983: Fig. 221: 4) does not belong to this genus. Such an early astogeny characterizes another, probably unrelated, group of the Mójcza bryozoans with much more robust granulation of the branch surface (in this respect they also fit BLAKE's specimen). Although early astogeny is unknown in *Tropidopora nana*, its general appearance seems to be a little closer to the group under discussion than the type species of *Nematopora*. Some arthrostylids, namely *Arthrotrypa* (see LOBDELL 1992), have zoarial branches closely similar to some of the Mójcza species but the latter do not show any articulation surfaces. Instead, dichotomous (Text-fig. 9e, o–q) and perhaps lateral (Text-fig. 9t) branching is their common feature. This makes any arthrostylid affinities of the discussed Mójcza species unlikely.

Tropidopora? cf. *voigti* (TOOTS, 1952)
(Text-fig. 9a–c)

1952. *Nematopora voigti* n. sp.; TOOTS, p. 123, Pl. 10: 4.
1987. GPIMH G 3/14; SCHALLREUTER and HILLMER, Pl. 2: 7.

Type horizon and locality: Kava, Estonia, Kuckers shale, Kukrusean, early Caradoc.

Remarks. — The Estonian species is at least related to this one and judging from the illustration of TOOTS (1952) has a similar ornamentation of the interzooecial areas with irregular longitudinal ridges, pairs of which (with a furrow inbetween) separate zooecial rows. Cross sections of fragmentary colony branches from Mójcza are variable and usually irregular. Zooecial rows vary in number from four (rarely) to six. Unfortunately, the material in both cases is too fragmentary and poorly preserved to enable reliable comparison. The species seems to occur also in the Baltic Ojl Myr flint (SCHALLREUTER and HILLMER 1987: Pl. 2: 7).

N. lineata (BILLINGS, 1866) is another closely similar, if not conspecific, form but, according to BASSLER's (1911: p. 158) description, singular ridges separate zooecial rows in this species, similarly to related species from Ojl Myr flint (see SCHALLREUTER and HILLMER 1987). *N. ovalis* ULRICH, 1890 was similarly ornamented (BASSLER 1911) but had fewer zooecial rows.

Distribution. — The species occurs in the upper part of the Mójcza Limestone, from 0.8 m above the bentonite to the top; *A. tvaerensis* to *A. superbus* Zones, Caradoc.

Tropidopora? cf. *fragilis* (ULRICH, 1890)
(Text-fig. 9e, l?)

1911. *Nematopora fragilis* ULRICH; BASSLER, p. 157, Text-fig. 78.

Type horizon and locality: Girardeau Limestone, Richmondian, Alexander County, Illinois.

Remarks. — This one differs from the preceding species in its more gracile appearance and smaller apertures. Surface ornamentation is not preserved well enough in any of the available specimens.

Distribution. — Internal moulds of zoaria of this morphology occur throughout the whole Mójcza Limestone section but their species identity can rarely be safely determined.

Tropidopora? cf. *delicatula* (ULRICH, 1893)
(Text-fig. 9d, f–h, k, t)

1911. *Nematopora delicatula* ULRICH; BASSLER, p. 155, Fig. 76a–b.

Type horizon and locality: Girardeau Limestone, Richmondian, Alexander County, Illinois.

Remarks. — Of the two branching fragments of zoaria the one from sample MA-83 (Text-fig. 9t) produces an additional branch laterally, which is suggestive of monopodial organization.

Distribution. — Rectangular in cross section zoaria of this kind occur from 0.5 m below the bentonite to the top of the Mójcza Limestone; Llandeilo to late Caradoc.

Tropidopora? aff. *delicatula* (ULRICH, 1893)
(Text-fig. 9m–o)

Remarks. — Unlike the preceding form colony branches of this one from sample MA-99 bifurcate. A single basal part has been found that is unfortunately partially worn but the ancestrula can be identified and the generally rhabdomesine pattern of early astogeny is apparent.

Distribution. — Topmost bed of the Mójcza Limestone, possibly also below this horizon; *A. superbus* Zone, Late Caradoc.

Tropidopora? sp.
(Text-fig. 9i–j)

Remarks. — The only two fragments found of colony branches show two rows of zooecia distributed along their opposite sides.

Distribution. — 0.2 m above the discontinuity surface; *E. reclinatus* Subzone, Llanvirn.

Tropidopora? cf. *sublineata* MÄNNIL, 1959
(Text-fig. 9p–s)

1962. *Nematopora sublineata* MÄNNIL, 1959; KIEPURA, p. 400, Pl. 9: 6.
1987. GPIMH G 3/8-12; SCHALLREUTER and HILLMER, Pl. 2: 1–5.

Remarks. — This seems to be an extremely variable species regarding both distribution of zooecia along colony branches and their ornamentation. Some fragments show crenulation of ridges and weak development of peristome in distal parts of zooecia (Text-fig. 9p), which make them similar to *N. sublineata* as described by KIEPURA (1962). There seems to be a gradation in the sample towards less typical morphologies. Some fragments triangular in cross section have only two rows of zooecia on their reverse sides and are devoid of any peristomes, being ornamented only with longitudinal riblets (Text-fig. 9s).

Distribution. — Top of the Mójcza Limestone; *A. superbus* Zone, late Caradoc.

Family **Bactroporidae** SIMPSON, 1897
Genus *Bactropora* HALL *et* SIMPSON, 1887

Type species: ?*Trematopora granistriata* HALL, 1881; ?Ludlowville Shale, Darien Center, New York.

Remarks. — A single, poorly known species from Mójcza, superficially similar to *Nematopora*, shows a very strange early astogeny, which makes its attribution difficult even at the ordinal level. In the presence of a tapering basal part with granular longitudinal ribs it is similar to both the bactroporids and *Nematoporella* of the arthrostylids but it is not quite clear if these structures are homologous.

Bactropora? sp. (cf. *Nematoporella falcata* LOBDELL, 1992)
(Text-fig. 10a)

Discussion. — In tubular branches of this species zooecia are spirally arranged in approximately six vertical rows. The surface between peristomes is ornamented with crenulated longitudinal ribs. These ribs continue almost to the apex of the base. The colony branch is thus closely similar to, if not identical with, *Nematoporella falcata* LOBDELL, 1992 from the Late Ordovician Stony Mountain Formation of North Dakota classified by LOBDELL (1992) in the Arthrostylidae. The phosphatic coating at the protoecium is exfoliated in the best specimen partially exhibiting tips of phosphatic nuclei of the interiors of a few zooecia. The zooecia are arranged parallel to the ornamented apex of the zoarium and this makes rather unlikely that this was an articulation joint. If this is, instead, the initial part of the colony the ancestrula may be represented among these zooecia, perhaps being double-walled from the beginning.

The way in which the early astogeny proceeded in *Bactropora*? sp. (accepting that its conical apex represents the initial part of the colony) is difficult to visualize. One may ask how the colony was attached to the substrate? It could be anchored in the mud with soft tissue appendages or perhaps a kind of articulation with a basal attachment organ similar to that of the phyllodictyids was present.

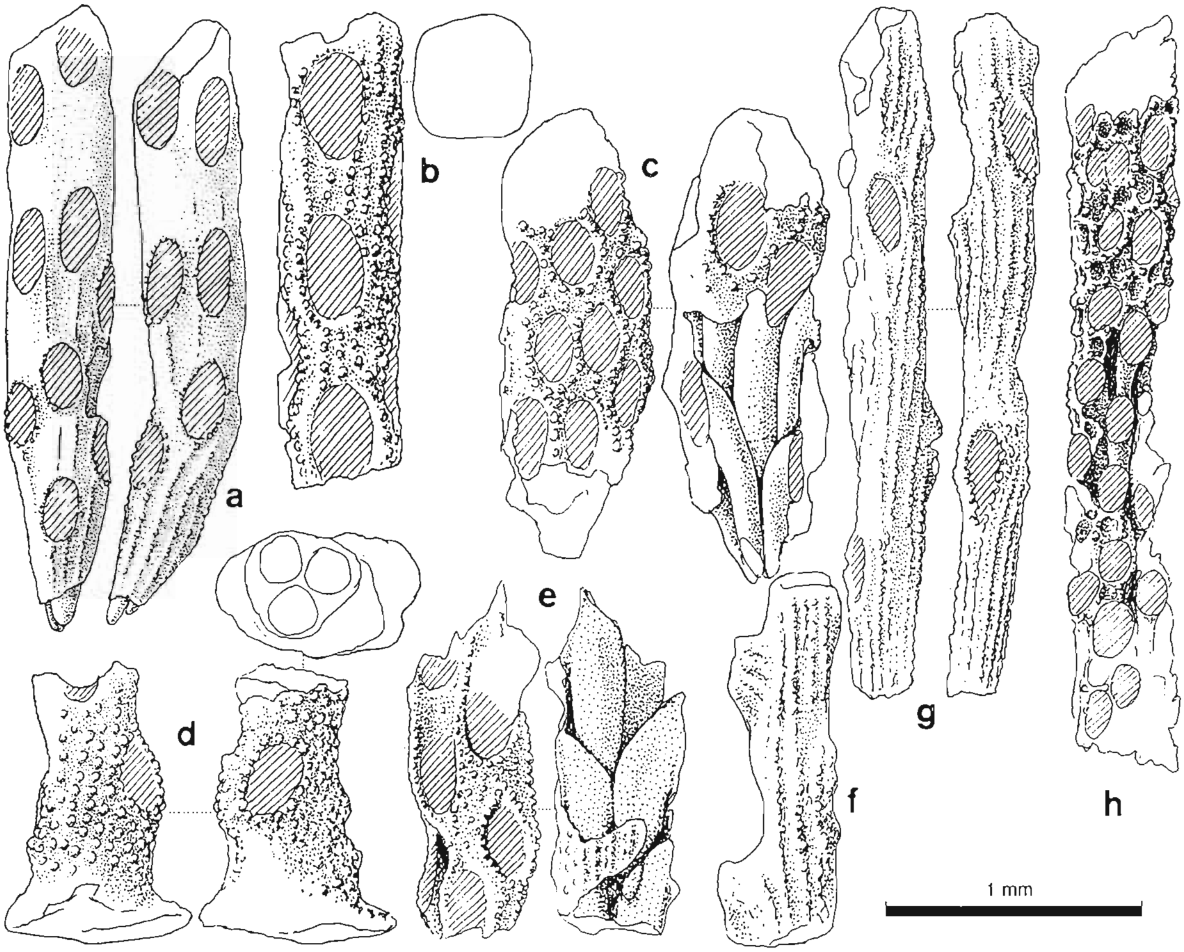

Fig. 10.
Radial colony branches ornamented with stylets from the Mójcza Limestone. **a**. *Bactropora*? sp.; sample MA-98. **b–e**. *Nematopora*? sp. n. A; b–c, d, sample MA-85; e, sample MA-30. **f–g**. *Kielanopora robusta* DZIK, 1992; sample MA-99. **h**. *Nematopora*? sp. n. B; sample MA-99.

Bactropora solida SPJELDNAES, 1984 from the Ojl Myr erratics had the colony branches with more numerous zooecia and peristomes smaller in diameter.

Distribution. — Nuclei of similar morphology can be found in several samples of the Mójcza Limestone but well preserved specimens are known only from about 0.2 m below the top of the formation; *A. superbus* Zone, latest Caradoc.

Family **Ralfinidae** LAVRENTJEVA, 1985

Remarks. — These are bryozoans with zooecial morphology similar to the phyllodictyid cryptostomes but with apertures opening only on one side of the colony branches. The Mójcza material shows a morphocline ranging from typical ralfinids to *Heminematopora*, classified usually among the arthrostylids. Fragments of the colony bases showing a single-walled stage in the astogeny provide evidence that at least the Mójcza forms are relatives of the Arthrostylidae rather than true cryptostomes.

Genus *Ralfinella* LAVRENTJEVA, 1985

Type species: *Pseudohornera*? *plana* MÄNNIL, 1958; Jöhvian (Caradoc) of Alliku, Estonia.

Ralfinella cf. *plana* MÄNNIL, 1958
(Pl. 58: 20–23; Text-fig. 7e–q.)

1985. *Ralfinella plana* MÄNNIL, 1958; LAVRENTJEVA, p. 30, Pl. 24: 2–3.

Type horizon and locality: Jöhvian of Alliku, Estonia.

Remarks. — In the sample MA-85, which provided the most numerous collection of this species in the Early Caradoc, coeval with the Estonian type population, along with specimens closely similar to the holotype, there are also several other variants. They grade from forms with relatively flat reverse side and steep lateral rows of peristomes (Pl. 58: 20; Text-fig. 7l) to narrow branches with only two rows of zooecia with a flat obverse side (Text-fig. 7g). Such high narrow branches with a prominent rib network between peristomes characterize populations from the top of the Mójcza Limestone but specimens with three rows occur there too. Whether this is just a change in population variability, or several related species are present in the collection cannot be decided with the available data.

The colony attachment is known only from a few specimens, which are identified as conspecific on the basis of shallow depressions separating peristomes. The more reliably identified specimen from sample MA-85 has only a single row of at least two zooecia (possibly including the ancestrula) at the beginning of the astogeny. Growth lines are visible on flanks indicating the extent of the initial single-walled stage (Text-fig. 7f).

Distribution. — Two- and three-serial zoarial branches of this kind occur in the Mójcza Limestone from 0.3 m above the bentonite (possible even lower) to the top of the section; *A. tvaerensis* to *A. superbus* Zone, Caradoc.

Genus *Heminematopora* BASSLER, 1952

Type species: *Heminematopora virginiana* BASSLER, 1952; Edinburg Formation at Strasburg Junction, Virginia.

Heminematopora sp. n. A
(Pl. 58: 16; Text-fig. 8c–e, f–g)

Remarks. — Zoarial branches with two rows of zooecia are included in this species. They are closely similar to wider branches classified here as *Ralfinella* but they clearly precede stratigraphically three-serial zoaria in the Mójcza section without any overlap in their ranges. The only known branched specimen developed the branching in the same way as the type species, that is frontally (see BLAKE 1983: Fig. 275: 1a).

Distribution. — From 1.5 m to 0.3 m below the bentonite; *E. lindstroemi* Subzone and *P. anserinus* Zone; late Llanvirn to Llandeilo.

Heminematopora sp. n. B
(Pl. 58: 7–8; Text-fig. 8h–k)

Remarks. — These are very characteristic uniserial zoaria with a striated reverse side and flanks. Their proximity to the preceding species seems apparent although the only known bifurcating specimen (Pl. 58: 7) branches laterally.

Distribution. — From 1.5 below the bentonite to the top of the Mójcza Limestone; *E. lindstroemi* Subzone to *A. superbus* Zone; late Llanvirn to the end of the Caradoc.

Family **Nematotrypidae** SPJELDNAES, 1984 *sensu* DZIK, 1992
Genus *Nematotrypa* BASSLER, 1911

Type species: *Nematotrypa gracilis* BASSLER, 1911; Kuckers shale, Kukrusean, early Caradoc.

Nematotrypa? sp. n. A
(Pl. 58: 14–15; Text-fig. 11a–i)

1982. *Pseudohornera orosa* (WIMAN); BROOD, p. 175, Fig. 6G–H (actual pictures Fig. 8).

1992. *Nematotrypa*(?) sp.; DZIK, Fig. 5.

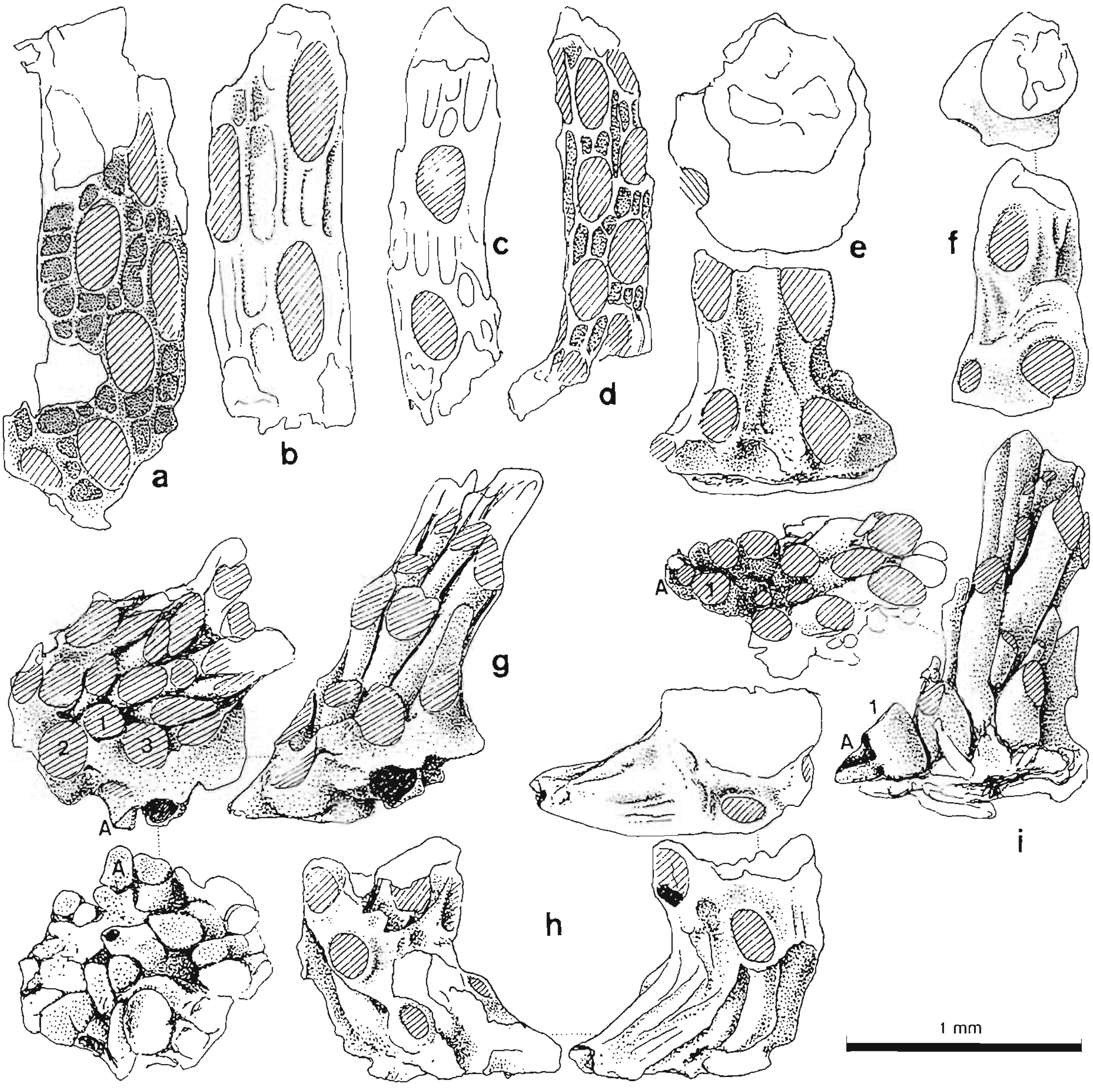

Fig. 11.
Metapore-bearing ramose bryozoans of the Mójcza Limestone. **a–i**. *Nematotrypa*? sp. n. A; a–b, e, sample MA-99; c, g, sample MA-84; f, sample MA-60; h, sample MA-87; i, sample MA-98.

Remarks. — Thinly ramose zoaria included in this species are very variable and it is difficult to identify particular species in poorly and unusually preserved material from Mójcza. Unlike smaller branches of associated arthrostylids the depressions separating peristomes are relatively deep and at least in some cases, when their nuclei are well preserved it is clear that they can be identified as true metapores, deep but without any diaphragms.

There are many basal parts of zoaria preserved. Although any direct evidence of a single-walled stage is missing, the early astogeny is arthrostylid in character. Unlike typical trepostomes or cryptostomes, the ancestrula was not surrounded by zooids of later generations but they were arranged more or less linearly in several rows. In some specimens in which an external phosphatic coating is preserved, the colony base is ornamented by longitudinal ridges and deeper, mesopore-like, structures seem to develop later in astogeny. One specimen shows questionable growth lines, obliterated by a thick phosphatic coating (Text-fig. 11f), that may indicate an extension of the single-walled stage of early astogeny. Another specimen (Text-fig. 11i) seems to show a communication canal between the ancestrula and the zooecium of the first asexuallly budded zooid, which also suggests a single-walled stage recapitulating features of possible palaeotubuliporine ancestors.

Distribution. — Hard to determine. Such fragmentary colony branches occur throughout the whole section but the only specimens preserved well enough to be safely determined specifically have been found in its upper part.

Family **Enalloporidae** MILLER, 1889

Genus *Nematopora* ULRICH, 1888

Type species: *Trematopora minuta* HALL, 1876; Waldron Shale of Indiana, Wenlock.

Remarks. — This highly tentative relocation of *Nematopora*, which is in conflict with a long tradition of its interpretation as an arthrostylid, is based on the above mentioned identification of basal parts of a *Nematopora* colony by BLAKE (1983).

Nematopora? sp. n. A

(Text-fig. 10b–e)

Remarks. — The species is characterized by relatively robust coarsely granulated branches with usually four rows of large zooecia. Some specimens that may belong also to the species have more numerous rows of smaller zooecia sometimes opening on one side of the zoarial branch (Text-fig. 10c, e).The whole surface between peristomes is covered with tubercles. Basal parts of the colony (Text-fig. 10d) show that there was no single-walled stage and the ancestrula grew almost vertically.

Distribution. — From just above the discontinuity surface to just below the top of the Mójcza Limestone; *E. reclinatus* Subzone to *A. superbus* Zone; Llanvirn to late Caradoc.

Nematopora? sp. n. B

(Text-fig. 10h)

Remarks. — This species differs from co-occurring *N.*? sp. n. A in the much smaller size of the zooecia, more prominent but less numerous tubercles (stylets) surrounding peristomes and the development of depressions separating peristomes in the form of shallow metapores.

Distribution. — Although it is quite unlikely that in all cases the same species is represented, zoaria nuclei of this morphology occur throughout the whole section of the Mójcza Limestone.

Genus *Kielanopora* DZIK, 1992

Type species: *Kielanopora robusta* DZIK, 1992.

Remarks. — The two species described below, although probably related to *Nematopora*, differ very much from the type species of the genus and should be classified separately (DZIK 1992). Their most remarkable feature is the very narrow colony base with a double-walled almost vertical ancestrula and longitudinal ornamentation of the colony surface.

Kielanopora robusta DZIK, 1992

(Pl. 58: 5–6; Text-fig. 10f–g)

1992. *Kielanopora robusta* gen. et sp. n.; DZIK, p. 53, Fig. 3D.

Type horizon and locality: Kukrusean (Early Caradoc) of Mójcza Limestone at Mójcza (sample MA-85).

Remarks. — In this species zooecia are sparsely distributed along the zoarial branch, usually in two rows, and their peristomes are elevated. The surface of the zoarium is ornamented with longitudinal rows of coarse tubercles.

Distribution. — The topmost metre of the Mójcza Limestone; late Caradoc.

Kielanopora sp. A
(Pl. 58: 11–13; Text-fig. 12e–h)

Remarks. — This is one of the most characteristic species of the Mójcza bryozoan fauna. Zooecia arranged laterally along narrow axis and opening to one side of it are ornamented, like the axis itself with strong longitudinal riblets. An affinity to the preceding species is suggested by early astogeny, if the only specimen proposed to be the colony base (Pl. 58: 12) with vertically oriented, double-walled ancestrula really represents it.

Distribution. — From 1.6 m below the bentonite to the top of the Mójcza Limestone; *E. lindstroemi* Subzone to *A. superbus* Zone; late Llanvirn to latest Caradoc.

Genus *Enallopora* D'ORBIGNY, 1849

Type species: *Gorgonia perantiqua* HALL, 1847, Trenton at Middleville, New York.

Enallopora cf. *perantiqua* (HALL, 1847)
(Text-fig. 12b–d)

1982. *Enallopora oeilensis* (WIMAN); BROOD, p. 175, Fig. 7A, F (actual pictures Fig. 8).

Type horizon and locality: Trenton at Middleville, New York.

Remarks. — The Mójcza specimens show general features of the holotype although the mode of preservation is basically different.

The beginning of the colony is known from a single specimen from sample MA-98 (Text-fig. 12c). The possible ancestrula is very small, with its peristome close to the protoecium. At least two next generation zooecia grew almost horizontally, with their peristomes located close to the base. Zooecia of following generation were much more elongated and vertically oriented, with peristomes opening near the first colony bifurcation.

Distribution. — From 1.5 m below to 1.7 m above the bentonite; *E. lindstroemi* Subzone to *A. tvaerensis* Zone, Llanvirn to early Caradoc.

Enallopora sp. n.
(Pl. 58: 10; Text-fig. 12a, j, m)

Remarks. — This species differs from *E.* cf. *perantiqua* in its smaller zooecia. A juvenile colony from sample MA-98 (Text-fig. 12m) shows its early astogeny. The ancestrula, like in preceding species, is very small. The next four zooecia creep horizontally. The reverse side of the colony base is ornamented with longitudinal ribs and the earliest single-walled stage, if present, was restricted at the most to the ancestrula (its ornamentation is not visible).

Distribution. — From 1.3 m above the bentonite to 0.2 m below the top of the Mójcza Limestone, Caradoc.

Genus *Parachasmatopora* MOROZOVA *et* LAVRENTJEVA, 1981

Type species: *Parachasmatopora maennili* MOROZOVA *et* LAVRENTJEVA, 1981; Idaverean of Aluvere, Estonia, Caradoc.

Parachasmatopora cf. *porkuniensis* LAVRENTJEVA, 1985
(Text-fig. 12n–s)

1985. *Parachasmatopora porkuniensis* sp. nov.; LAVRENTJEVA, p. 48, Pl. 15: 2, 3, Fig. 12.
1987. *Parachasmatopora* cf. *porkuniensis* LAVRENTJEVA; SCHALLREUTER and HILLMER , Pl. 1: 7.
1992. *Parachasmatopora*(?) sp.; DZIK, Fig. 8.

Type horizon and locality: Porkunian at the type locality, Estonia, Ashgill.

Remarks. — Basal parts of the colony have been found in sample MA-20 (Text-fig. 12s). Unlike *Enallopora*, the ancestrula was much elongated and grew vertically opening just below the first branching of the colony. The basal disc of the ancestrula is located marginally, with a few (not more than three) zooecia of the first generation located distally of it.

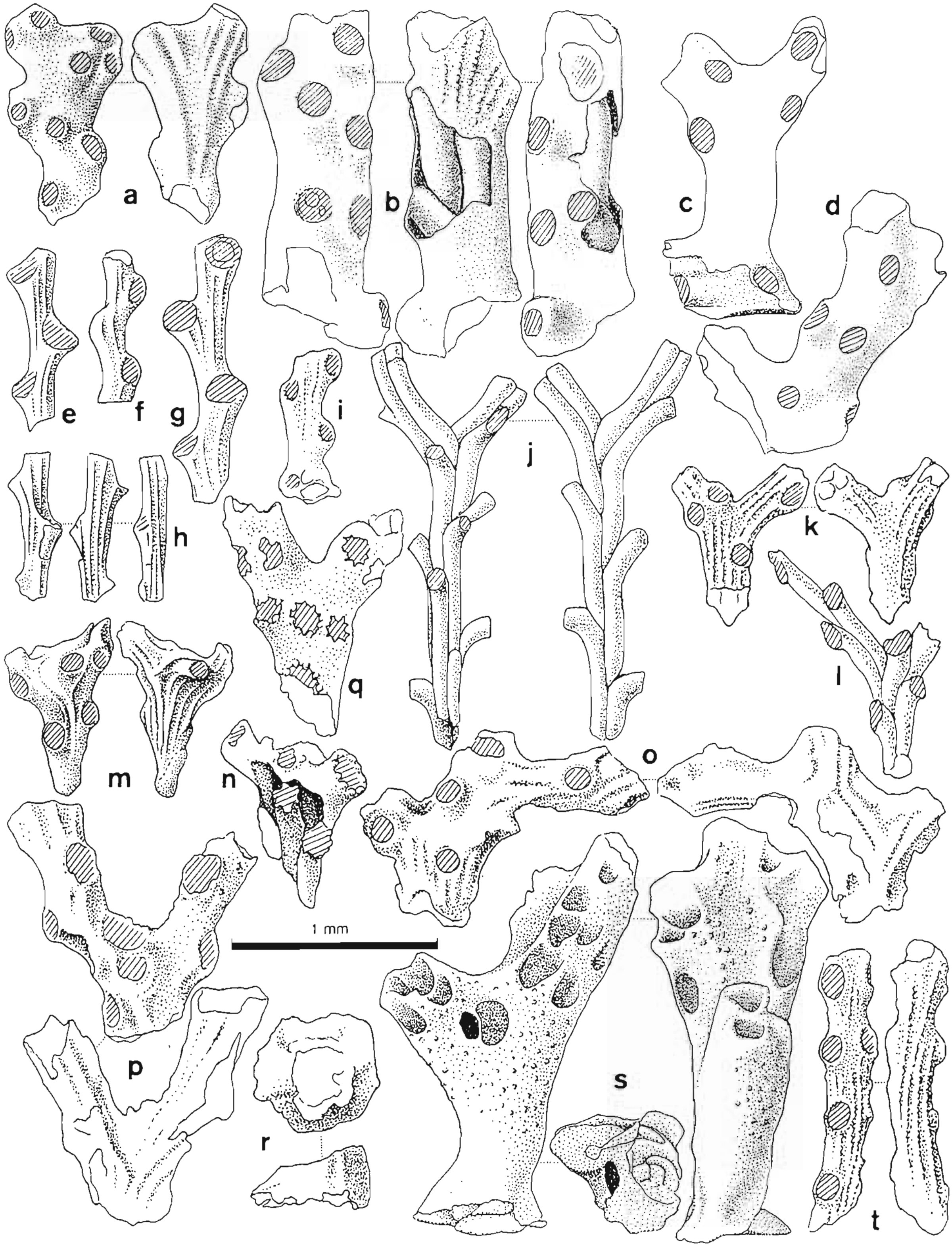

Fig. 12.

Ramose double-walled bryozoans with elongated peristomes from the Mójcza Limestone. **a**, **j**, **m**. *Enallopora* sp. n.; a, sample MA-85; j, sample MA-22; m, sample MA-98. **b–d**. *Enallopora* cf. *perantiqua* (HALL, 1847); b, sample MA-85; c, sample MA-98; d, sample MA-20. **e–h**. *Kielanopora* sp. A; e, h, sample MA-85; g, sample MA-20; f, sample MA-99. **i**, **k–l**, **t**. *Alwynopora*? sp. n., sample MA-99. **n–s**. *Parachasmatopora* cf. *porkuniensis* LAVRENTJEVA, 1985; n, q, sample MA-83; o–r, sample MA-85; s, sample MA-20.

The same arrangement of first zooids has been identified by McKinney and King (1984) in *Parachasmatopora*? sp. from the Kukrusean of Estonia. Although definitely derived in respect to *Enallopora*, this pattern of early astogeny is not closely similar to that of the phyllodictyid or fenestellid cryptostomes, where spirally budding zooids of the first generations surrounded the ancestrula. It seems more reasonable to accept the independent origin of phylloporinid colony shapes within the Enalloporidae (as well as Ralfinidae) rather than modifications of the early astogeny within a monophyletic group.

Distribution. — From 2.3 m below to 1.5 m above the bentonite; *E. robustus* Subzone to *A. tvaerensis* Zone, Llanvirn to early Caradoc.

Genus *Alwynopora* Taylor *et* Curry, 1985

Type species: *Alwynopora orodamnus* Taylor *et* Curry, 1985; Arenig of Ireland.

Alwynopora? sp. n.

(Text-figs 12i, k-l, t; ?8l–m)

Remarks. — This species is known only from small fragments of colony branches. Some of them resemble species of *Ralfinella* described above but usually peristomes are much smaller and somewhat elevated. With so little evidence available one cannot be sure that these are not remnants of a fenestellid cryptostome.

Alwynopora orodamnus from the Arenig of Ireland (Taylor and Curry 1985) is similar in general morphology to the species under discussion and may be congeneric with it, although the Irish species does not show any surface ornamentation.

Distribution. — Relatively common in the topmost bed of the Mójcza Limestone, possibly also in older strata, even below the bentonite.

Incertae familiae

Genus *Pseudohornera* Roemer, 1876

Type species: *P. diffusa* (Hall, 1852), Clintonian of New York.

Remarks. — The type species of the genus has been suggested by Tavener-Smith (1975: Text-fig. 3) to be a modified phyllodictyid. If the specimens from the Mójcza Limestone really represent *Pseudohornera* this could hardly be the case.

Pseudohornera cf. *bifida* (Eichwald, 1855)

(Text-fig. 13a–e)

1985. *Pseudohornera bifida* (Eichwald.); Lavrentjeva, p. 34, Pls 4: 2–3, 5: 2, 4, 6: 1, Figs 9, 13–14, 21.

Type horizon and locality: *Orthoceras* limestone, Llanvirn? of Erras, Estonia.

Remarks. — The available specimens are poorly preserved and the identification is based solely on the presence of numerous elongated zooecia that open along one side of bifurcating colony branches. The colony base bears some blind heterozooecia of presumably mechanical function on the reverse side.

Distribution. — Colony fragments of this shape occur throughout the Mójcza Limestone section.

Suborder **Halloporina** Astrova, 1965

Family **Dittoporidae** Vinassa de Regny, 1920

Genus *Hemiphragma* Ulrich, 1893

Type species: *Batostoma irrasum* Ulrich, 1886; Blackriveran of Minnesota.

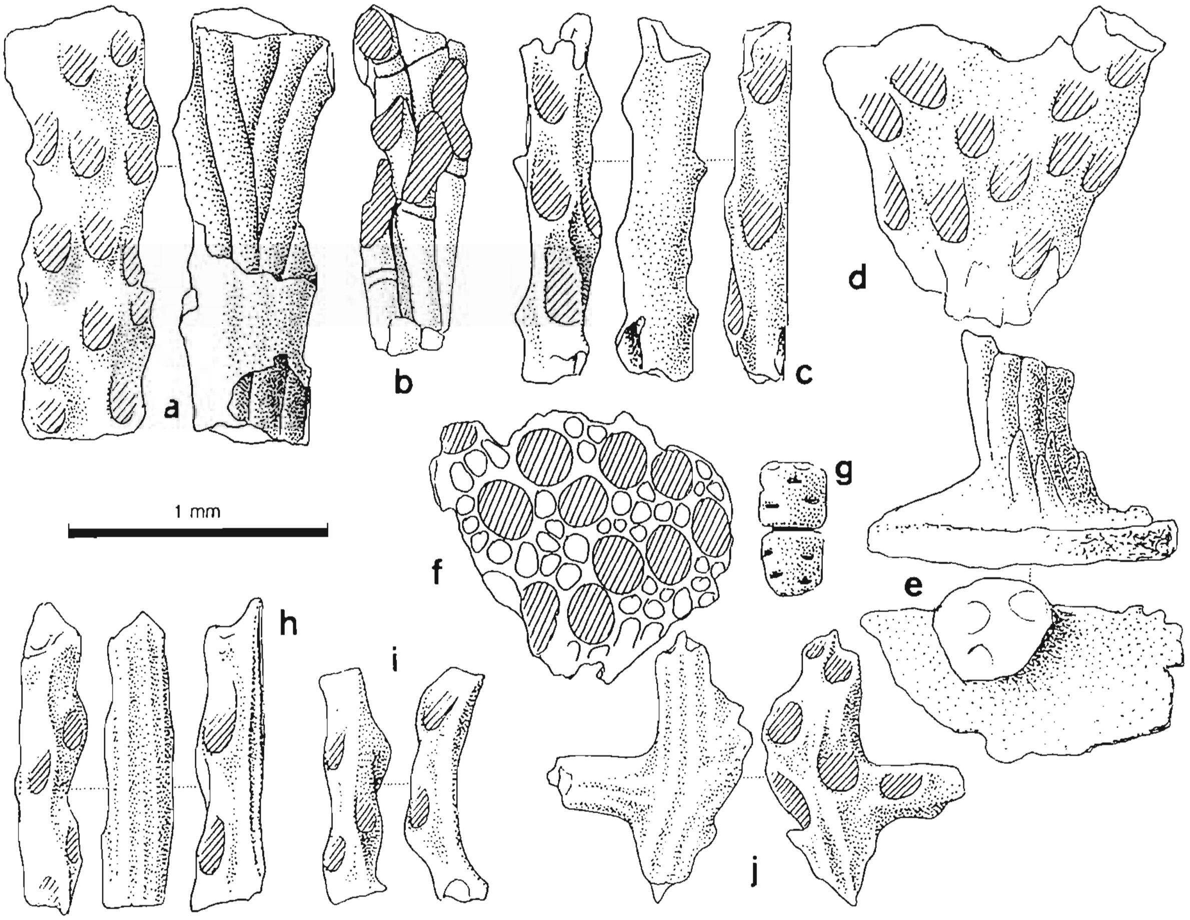

Fig. 13.
Massive trepostomes and cryptostomes from the Mójcza Limestone. **a–e.** *Pseudohornera* cf. *bifida* (EICHWALD, 1855); a, d–e, sample MA-85; b, sample MA-80; c, sample MA-87. **f.** *Hemiphragma* spp.; sample MA-52. **g.** Dittoporid gen. et sp. indet.; sample MA-98. **h–j.** *Moorephylloporina* sp.; sample MA-91.

Hemiphragma spp.
(Pl. 57: 5–6; Text-fig. 13f)

Distribution. — Internal moulds of zooecia (see CONTI and SERPAGLI 1988) and small fragments of juvenile zoaria probably representing several species of this and related genera (Text-fig. 13g) occur throughout the whole section of the Mójcza Limestone.

Order **Cryptostomata** VINE, 1883

Family **Phylloporinidae** ULRICH, 1890

Genus *Moorephylloporina* BASSLER, 1952

Type species: *Moorephylloporina typica* BASSLER, 1952; Edinburg formation, Blackriveran of Virginia.

Moorephylloporina sp.
(Text-fig. 13h–j)

1982. *Fenestella* cf. *striolata* EICHWALD; BROOD, p. 175, Fig. 6B–E (actual pictures Fig. 8).

Remarks. — A high ridge separating zooecial rows and longitudinal riblets ornamenting the reverse side of colony branches characterize the species.

Distribution. — Only single level 1.8 m above the bentonite; beginning of the *A. superbus* Zone, late Caradoc.

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PLATE 57

Corynotrypa sp. n. A 260

Fig. 1. Phosphate-coated zooecium ZPAL BrV/1033 in lateral view, sample MA-84, *A. tvaerensis* Zone, Early Caradoc, × 75.

Fig. 2. Phosphatic nucleus of zooecium ZPAL BrV/868 in lateral view, sample MA-5, *A. tvaerensis* Zone, Early Caradoc, × 75.

Fig. 3. Phosphate-coated zooecium ZPAL BrV/869 in lateral view, same sample, × 75.

Fig. 4. Branching phosphate-coated zooecium ZPAL BrV/870 in lateral view, same sample, × 7 5.

Hemiphragma sp. 281

Figs 5, 6. Phosphatic nuclei of zooecia with hemiphragms ZPAL BrV/1013,1014, sample MA-65, *P. anserinus* Zone, Llandeilo, × 40.

Wolinella? sp. n. B 260

Fig. 7. Phosphate-coated encrusting zooecium ZPAL BrV/1011 in lateral view, sample MA-10, *E. robustus* Subzone, Llanvirn, × 45.

Fig. 8. Phosphate-coated encrusting zooecium ZPAL BrV/ in lateral view, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 45.

Wolinella baltica Dzik, 1981 258

Fig. 9. Phosphate-coated ancestrula ZPAL BrV/1012 in lateral view, sample MA-10, *E. robustus* Zone, Llanvirn, × 75.

Fig. 11. Phosphate-coated erect zooecium ZPAL BrV/1027 in lateral view, sample MA-87, *A. tvaerensis* Zone, Early Caradoc, × 40.

Fig. 12. Phosphatic nucleus of erect zooecium ZPAL BrV/947 in lateral view, sample MA-14, *M. ozarkodella* Subzone, earliest Llanvirn, × 60.

Fig. 13. Phosphatic nucleus of fragmentary zoarium with partially fosphatized wall of *Wolinella polonica* Dzik, 1981 (type species of the genus) from erratic boulder E-137 illustrated for comparison, × 75.

Wolinella? sp. n. A 260

Fig. 10. Phosphate-coated encrusting zooecium ZPAL BrV/1021 in lateral view, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 45.

Mojczatrypa halysitoides Dzik, 1992 266

Fig. 14. Phosphate-coated proximal part of zoarium ZPAL BrV/1018 in lateral view, sample MA-62, *P. anserinus* Zone, Llandeilo, × 45.

Voigtia primaeva (Dzik, 1981) 264

Fig. 15. Phosphate-coated zoarial branch ZPAL BrV/1039, obverse side, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 45.

Fig. 16. Phosphate-coated zoarial branch ZPAL BrV/1038, obverse side, same sample, × 45.

Fig. 18. Ppartial phosphatic nucleus of zoarial branch ZPAL BrV/1037, obverse side, same sample, × 45.

Voigtia oeilensis (Wiman, 1901) 264

Fig. 17. Partial phosphatic nucleus of zoarial branch ZPAL BrV/848, obverse side, sample MA-4, *A. superbus* Zone, Late Caradoc, × 55.

Ceramoporid gen. et sp. indet. 266

Fig. 19. Phosphatic nucleus of encrusting colony ZPAL BrV/902, sample MA-6, *A. tvaerensis* Zone, Early Caradoc, × 55.

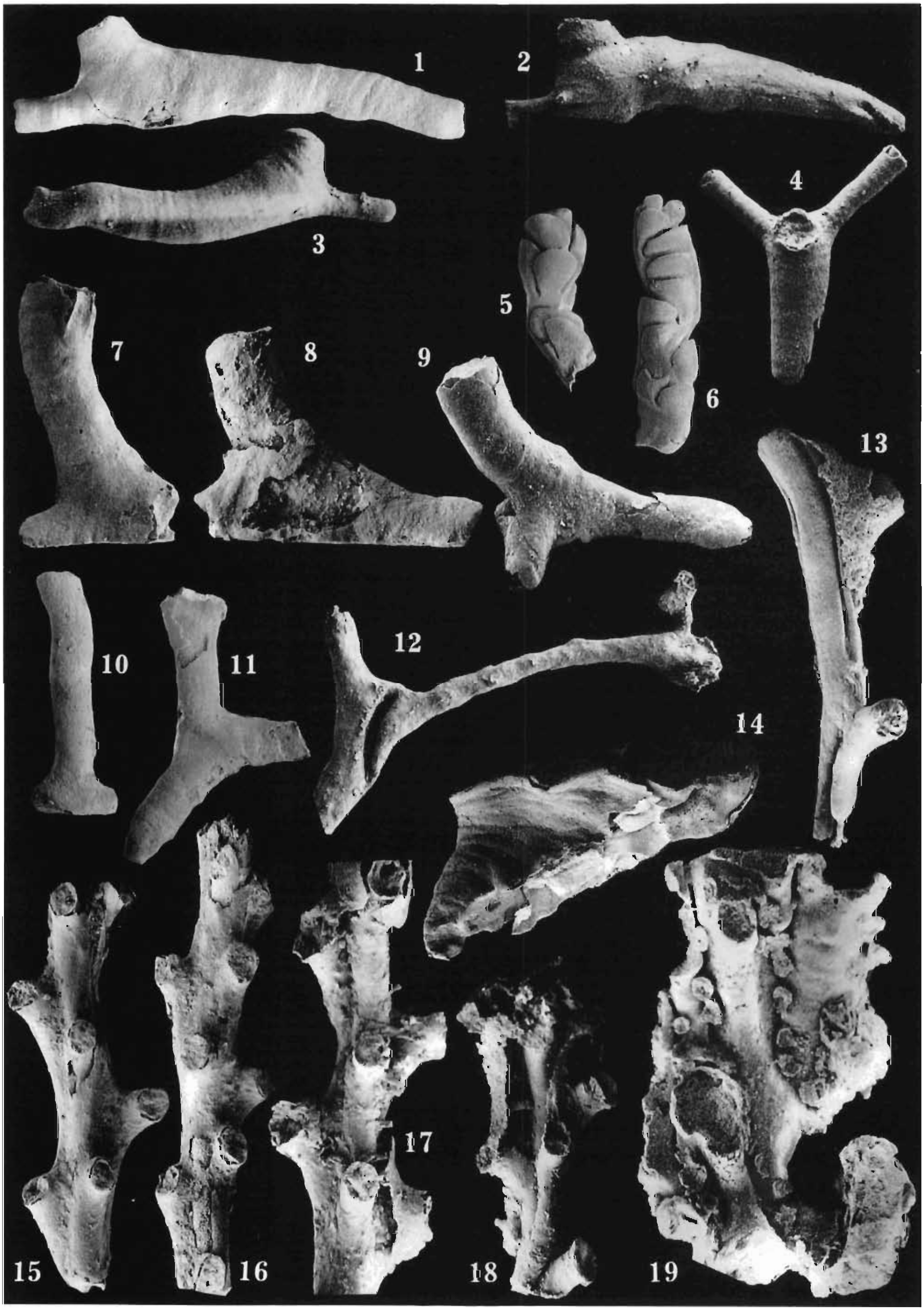
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PLATE 58

Kielcepora ornata Dzik, 1992 268

Fig. 1. Phosphate-coated proximal part of zoarium ZPAL BrV/1020, obverse side, sample MA-57, *E. lindstroemi* Zone, Late Llanvirn, × 40.

Fig. 18. Phosphate-coated piece of zoarium ZPAL BrV/1040, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 45.

Fig. 19. Phosphate-coated piece of zoarium ZPAL BrV/1019, sample MA-57, *E. lindstroemi* Zone, Late Llanvirn, × 40.

Kielcepora sp. A 268

Fig. 2. Phosphate-coated zoarial branch ZPAL BrV/1028, obverse side, sample MA-87, *A. tvaerensis* Zone, Early Caradoc, × 40.

Fig. 3. Phosphate-coated zoarial branch ZPAL BrV/1024, obverse side, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 40.

Fig. 4. Phosphate-coated zoarial branch ZPAL BrV/1026, obverse side, sample MA-87, *A. tvaerensis* Zone, Early Caradoc, × 40.

Kielanopora robusta Dzik, 1992 277

Fig. 5. Phosphate-coated basal part of zoarium ZPAL BrV/1025, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 40.

Fig. 6. Phosphate-coated zoarial branch ZPAL BrV/1031, sample MA-84, *A. tvaerensis* Zone, Early Caradoc, × 35.

Heminematopora sp. n. B 275

Fig. 7. Phosphate-coated bifurcating zoarial branch ZPAL BrV/1022, obverse side, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 40.

Fig. 8. Phosphate-coated bifurcating zoarial branch ZPAL BrV/1023 in lateral view, same sample, × 40.

Glauconomella? cf. *rossi* (Kiepura, 1962) 268

Fig. 9. Phosphate-coated zoarial branch ZPALBrV/1011, reverse side, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 40.

Enallopora sp. n. 278

Fig. 10. Phosphatic nucleus of colony branch ZPAL BrV/975, sample MA-22, *A. superbus* Zone, Late Caradoc, × 60.

Kielanopora sp. A 278

Fig. 11. Phosphate-coated zoarial branch ZPAL BrV/, sample MA-5, *A. tvaerensis* Zone, Early Caradoc, × 75.

Fig. 12. Phosphate-coated base of zoarium ZPAL BrV/1012, sample MA-65, *P. anserinus* Zone, Llandeilo, × 35.

Fig. 13. Phosphate-coated zoarial branch ZPAL BrV/1015, sample MA-58, *E. lindstroemi* Zone, Llanvirn, × 35.

Nematotrypa? sp. n. A 277

Fig. 14. Phosphate-coated zoarial branch ZPAL BrV/1029, sample MA-87, *A. tvaerensis* Zone, Early Caradoc, × 35.

Fig. 15. Phosphate-coated zoarial branch ZPAL BrV/1017, sample MA-58, *E. lindstroemi* Zone, Late Llanvirn, × 40.

Heminematopora sp. n. A 275

Fig. 16. Phosphate-coated zoarial branch ZPAL BrV/1016, obverse side, sample MA-58, *E. lindstroemi* Zone, Late Llanvirn, × 40.

Phaceloporid? gen. n. B sp. n. B 263

Fig. 17. Phosphatic nucleus of zoarial branch ZPAL BrV/1040, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 40.

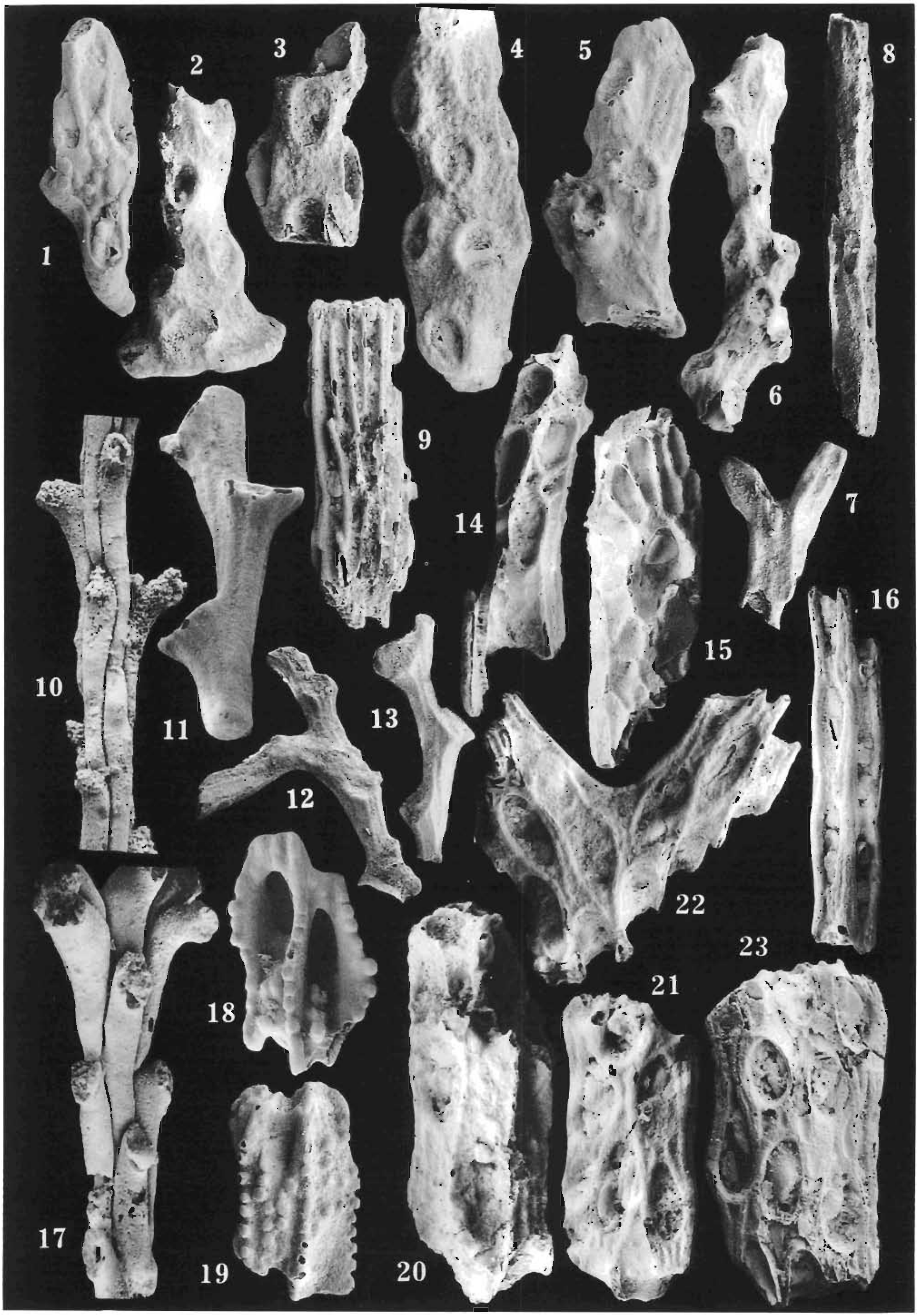
Ralfinella cf. *plana* Männil, 1958 275

Fig. 20. Phosphate-coated zoarial branch ZPAL BrV/1032, obverse side, sample MA-84, *A. tvaerensis* Zone, Early Caradoc, × 30.

Fig. 21. Phosphate-coated zoarial branch ZPAL BrV/1030, obverse side, sample MA-87, *A. tvaerensis* Zone, Early Caradoc, × 35.

Fig. 22. Phosphate-coated bifurcating zoarial branch ZPAL BrV/1034, obverse side, sample MA-84, *A. tvaerensis* Zone, Early Caradoc, × 35.

Fig. 23. Phosphate-coated zoarial branch ZPAL BrV/1041, obverse side, sample MA-85, *A. tvaerensis* Zone, Early Caradoc, × 45.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