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Upper Ordovician Bryozoa from the Montagne de Noire, southern France

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SYNOPSIS This study focuses on bryozoans from the Upper Ordovician rocks of the Montagne de Noire, southern France and additional material from contemporary rocks of the Carnic Alps. Based on museum collections, 68 bryozoan species were identified with 18 species being new: *Ceramoporella grandis* sp. nov., *Crassalina fungiforme* sp. nov., *Lichenalia nodata* sp. nov., *Atactoporella magnopora* sp. nov., *Dekayia buttleri* sp. nov., *Stigmatella carnica* sp. nov., *Trematopora gracile* sp. nov., *Bythopora tenuis* sp. nov., *Nicholsonella divulgata* sp. nov., *N. recta* sp. nov., *Matsutrypa elegantula* sp. nov., *M. rogeri* sp. nov., *Nematotrypa punctata* sp. nov., *Stellatodictya valentinae* sp. nov., *Ptilodictya feisti* sp. nov., *Pseudohornera dmitrii* sp. nov., *Ralfinella elegantula* sp. nov. and *Moorephylloporina contii* sp. nov. Trepostomes are the most abundant and diverse group with 40 of the total 68 species, but cyclostomes, cystoporates and cryptostomes are also present. The age of the fauna is Caradoc to Ashgill, according to the distribution of species and genera. The fauna has palaeogeographical connections to the Upper Ordovician of Wales, Estonia and North America.

KEY WORDS Bryozoa, taxonomy, Ordovician, Montagne de Noire, Carnic Alps, palaeobiogeography

Contents

Introduction **362**
Aims of the study 362
Stratigraphy and localities 362
Materials and methods 362
Bryozoan fauna 363
Palaeobiogeographical implications 363
Systematic palaeontology **363**
Phylum Bryozoa Ehrenberg, 1831 363
Class Stenolaemata Borg, 1926 363
Order Cyclostomata Busk, 1852 363
Suborder Paleotubuliporina Brood, 1973 363
Family Corynotrypidae Dzik, 1981 363
Genus *Corynotrypa* Bassler, 1911*b* *363*
Corynotrypa sp. 363
Family Crownoporidae Ross, 1967 365
Genus *Kukersella* Toots, 1952 [= *Crownopora* Ross, 1967] 365
Kukersella borealis (Bassler, 1911*a*) 365
Order Cystoporida Astrova, 1964 365
Suborder Ceramoporina Bassler, 1913 365
Family Ceramoporidae Ulrich, 1882 365
Genus *Ceramopora* Hall *in* Silliman *et al.*, 1851 365
Ceramopora italica (Vinassa de Regny, 1942) 366
Genus *Ceramoporella* Ulrich, 1882 366

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Ceramoporella discoidalis Conti, 1990 366
Ceramoporella grandis sp. nov. 366
Genus *Crepipora* Ulrich, 1882 367
Crepipora vesiculosa Boulange, 1963 367
Suborder Fistuliporina Astrova, 1964 367
Family Anolotichiidae Utgaard, 1968 367
Genus *Crassalina* Utgaard, 1968 367
Crassalina fungiforme sp. nov. 367
Family Rhinoporidae Miller, 1889 369
Genus *Lichenalia* Hall *in* Silliman *et al.,* 1851 369
Lichenalia nodata sp. nov. 369
Order Trepostomida Ulrich, 1882 371
Suborder Halloporina Astrova, 1965 371
Family Monticuliporidae Nicholson, 1881 371
Genus *Prasopora* Nicholson & Etheridge, 1877 371
Prasopora fistuloporoides (Vinassa de Regny, 1910) 371
Prasopora grayae Nicholson & Etheridge, 1877 372
Genus *Homotrypa* Ulrich, 1882 [= *Homotrypella* Ulrich, 1882] 372
Homotrypa miqueli (Prantl, 1940) 372
Genus *Atactoporella* Ulrich, 1883 372
Atactoporella magnopora sp. nov. 373
Atactoporella irregularis Boulange, 1963 373
Atactoporella sp. 373
Family Heterotrypidae Ulrich, 1890 375
Genus *Dekayia* Milne-Edwards & Haime, 1851 375
Dekayia minima Conti, 1990 375
Dekayia buttleri sp. nov. 375
Dekayia sp. 377
Genus *Heterotrypa* Nicholson, 1879 377
Heterotrypa magnopora Boulange, 1963 377
Genus *Hemiphragma* Ulrich, 1893 377
Hemiphragma subtile Conti, 1990 378
Genus *Stigmatella* Ulrich & Bassler, 1904 378
Stigmatella sinuosa Conti, 1990 378
Stigmatella carnica sp. nov. 378
Stigmatella massalis Bassler, 1911*a* 381
Family Halloporidae Bassler, 1911*a* *381*
Genus *Hallopora* Bassler, 1911*a* *381*
Hallopora elegantula (Hall, 1852) 382
Hallopora cystoidales Conti, 1990 382
Hallopora enodis Bassler, 1927 382
Hallopora gracilens Bassler, 1927 385
Genus *Diplotrypa* Nicholson, 1879 385
Diplotrypa languedociana Dreyfuss, 1948 385
Genus *Parvohallopora* Singh, 1979 386
Parvohallopora onealli (James, 1875) 386
Genus *Calloporella* Ulrich, 1882 386
? Calloporella ornata Dreyfuss, 1948 387
Family Trematoporidae Miller, 1889 387
Genus *Trematopora* Hall, 1852 387
Trematopora tuberculosa Hall, 1852 387
Trematopora sardoa (Vinassa de Regny, 1942) 387
Trematopora gracile sp. nov. 388
Trematopora sp. 1 388
Trematopora sp. 2 388
Genus *Eridotrypa* Ulrich, 1893 391
Eridotrypa spicata Dreyfuss, 1948 391

Eridotrypa constans Conti, 1990 391
Genus *Batostoma* Ulrich, 1882 392
? *Batostoma* sp. 392
Family Batostomellidae Miller, 1889 392
Genus *Bythopora* Miller & Dyer, 1878 [= *Batostomella* Ulrich, 1882] 392
Bythopora dendrina (James, 1878*a*) 392
Bythopora tenuis sp. nov. 393
Bythopora subgracilis (Ulrich, 1893) 393
Family Mesotrypidae Astrova, 1965 395
Genus *Mesotrypa* Ulrich, 1893 395
? *Mesotrypa rotundipora* (Dreyfuss, 1948) 395
Family Ralfimartitidae Gorjunova, 2005 395
Genus *Dybowskites* Pushkin, 1987 395
Dybowskites orbicularis (Modzalevskaya, 1953) 395
Halloporina sp. indet. 397
Suborder Amplexoporina Astrova, 1965 397
Family Amplexoporidae Miller, 1889 397
Genus *Monotrypa* Nicholson, 1879 397
Monotrypa testudiformis Dreyfuss, 1948 397
Genus *Amplexopora* Ulrich, 1882 398
Amplexopora dalpiazzi (Vinassa de Regny, 1910) 398
Amplexopora sp. 398
Amplexopora cf. *robusta* Ulrich, 1883 399
Incertae sedis 399
Genus *Nicholsonella* Ulrich, 1890 399
Nicholsonella divulgata sp. nov. 399
Nicholsonella recta sp. nov. 399
Order Cryptostomida Vine, 1884 401
Suborder Rhabdomesina Astrova & Morozova, 1956 401
Family Arthrostylidae Ulrich, 1882 401
Genus *Ulrichostylus* Bassler, 1952 401
Ulrichostylus radiatus Conti, 1990 401
Genus *Nematopora* Ulrich, 1888 401
Nematopora hispida Conti, 1990 401
Family Hyphasmoporidae Vine, 1886 403
Genus *Matsutrypa* Gorjunova, 1985 403
Matsutrypa elegantula sp. nov. 403
Matsutrypa rogeri sp. nov. 403
Family Nematotrypidae Spjeldnaes, 1984 405
Genus *Nematotrypa* Bassler, 1911*a* *405*
Nematotrypa punctata sp. nov. 405
Suborder Ptilodictyina Astrova & Morozova, 1956 405
Family Ptilodictyidae Zittel, 1880 405
Genus *Stellatodictya* Gorjunova *in* Gorjunova & Lavrentjeva, 1993 405
Stellatodictya valentinae sp. nov. 405
Genus *Ptilodictya* Lonsdale, 1839 407
Ptilodictya feisti sp. nov. 407
Genus *Graptodictya* Ulrich, 1882 [= *Arthropora* Ulrich, 1882] 408
Graptodictya meneghinii (Vinassa de Regny, 1942) 408
Graptodictya sp. 408
Suborder Stictoporellina Gorjunova *in* Gorjunova & Lavrentjeva, 1993 408
Family Stictoporellidae Nickles & Bassler, 1900 408
Genus *Stictoporellina* Nekhoroshev, 1956 408
Stictoporellina eremita (Prantl, 1940) 410
Genus *Stictoporella* Ulrich, 1882 410
? *Stictoporella* sp. 410

Genus *Astrovidictya* Gorjunova & Lavrentjeva, 1993 410
Astrovidictya sparsa Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 410
Incertae sedis 413
Ptilodictyina sp. indet. 1 413
Ptilodictyina sp. indet. 2 413
Ptilodictyina sp. indet. 3 413
Suborder Phylloporinina Lavrentjeva, 1979 413
Family Phyllopoprinidae Ulrich *in* Foerste, 1887 413
Genus *Pseudohornera* Roemer, 1876 413
Pseudohornera dmitrii sp. nov. 414
Family Chasmatoporidae Schulga-Nesterenko, 1955 414
Genus *Chasmatopora* Eichwald, 1855 414
Chasmatopora hypnoides (Sharpe, 1853) 414
Family Ralfinidae Lavrentjeva, 1985 417
Genus *Ralfina* Lavrentjeva, 1985 417
Ralfina lusitanica (Sharpe, 1853) 417
Genus *Ralfinella* Lavrentjeva, 1985 417
Ralfinella elegantula sp. nov. 417
Suborder Fenestellina Astrova & Morozova, 1956 417
Family Fenestellidae King, 1849 417
Genus *Moorephylloporina* Bassler, 1952 417
Moorephylloporina contii sp. nov. 418
Acknowledgments **419**
References **419**
Appendix: Descriptive statistics **422**

Introduction

Aims of the study

This study is a systematic description of the bryozoan fauna mainly from the Upper Ordovician of Montagne de Noire, southern France and, in addition, from the contemporary rocks of the Carnic Alps (Uggwa Formation, Siltstone Member). Strata of the same age and similar facies also outcrop in Sardinia and Portugal. Bryozoans from these areas have been known for at least 150 years. Publications dealing with Ordovician bryozoans of the Mediterranean area include Vinassa de Regny (1910, 1914, 1915, 1942), Nekhoroshev (1936), Prantl (1940), Dreyfuss (1948), Termier & Termier (1950), Boulange (1963), Conti (1983, 1990) and Conti & Serpagli (1984, 1987, 1988). Despite these, many species remain poorly known and need to be re-described. Furthermore, thin sections from rock specimens have revealed a number of previously undescribed small-sized bryozoans. These species are often neglected. However, they make up a considerable part of the diversity of these faunas. Results of this study will also be used for stratigraphic and palaeobiogeographic correlation.

Stratigraphy and localities

The Upper Ordovician fauna occurs in the Montagne de Noire in southern France in two different strata: a clastic formation of graywackes (= 'formation gréseuse' of Dreyfuss 1948) and an overlying calcareous formation (= 'calcaires et marnes schisteuses' of Dreyfuss 1948). The uppermost part of the graywackes is very fossiliferous and was dated as Caradoc by Dreyfuss (1948), while he estimated the calcareous formation as Ashgill. However, Havliček (1981) assumed the age for both formations as middle to upper Caradoc (upper Berounian) based on brachiopods. The faunas of both formations include bryozoans, brachiopods, crinoids and rare corals.

The Ordovician fossiliferous rocks of Sardinia have similar lithostratigraphic divisions. As discussed in Conti (1990), bryozoans occur in two lithostratigraphic units informally named '*c*' and '*e*' (Cocozza & Leone 1977). The *c* unit consists of weakly calcareous greenish to dark grey siltstones and fossiliferous argillites. This level is estimated as Caradoc in age. The *e* unit contains more calcareous rocks and is also highly fossiliferous. Its age is probably middle Ashgill (Conti 1990).

The second source of material is the siltstone/sandstone member of the Uqua (= Uggwa) Formation, exposed in Valbertad in the Italian Carnic Alps. It is regarded as Caradoc to earliest Ashgill in age (Bagnoli *et al.* 1998; Feretti & Schönlaub 2001).

Materials and methods

The material from the Montagne de Noire, southern France (Upper Ordovician), is deposited in the Laboratoire de Paléobotanique et Paléontologie (Cc) 062, Université de Montpellier II, under numbers UM2-AE 1–UM2-AE 90. It comes from two localities: Grange du Pin farm near the

village of Gabian and the mountain Petite Glauzy between Roujan and Vailhan, southern France (Raimund Feist, Montpellier, pers. comm.). In total, 266 orientated thin sections were prepared from this collection. Another collection from the same localities was provided from the University of Rennes, France, numbers IGR 3600–36060, including 100 orientated thin sections. In addition, 6 orientated thin sections were made from this collection. Material from the Carnic Alps is deposited at the Senckenberg Museum, Frankfurt am Main, Germany, numbers SMF 2116–2153. From these samples 28 thin sections were made. The type material of Sharpe (1853) is deposited at the Natural History Museum, London, numbers NHM PD 2209-PD 2215.

Bryozoans were investigated mostly through transmitted light microscopy using thin sections, with some scanning electron microscope (SEM) images and acetate peels. Morphological character terminology is adapted from Anstey & Perry (1970) for trepostomes and from Snyder (1991*a*, *b*) and Hageman (1991*a*, *b*) for cryptostomes. Measurements of cylindrical objects such as branches (Branch Width), autozooecial apertures (Aperture Width), or acanthostyles (Acanthostyle Diameter) were measured as a minimum diameter to avoid errors because of potential oblique orientations of thin sections. For hollow objects such as apertures, autozooecial chambers or tunnel structures, the inner diameter was measured. In cryptostome taxa, spacing of objects at the colony surface was measured from centre to centre (e.g. Aperture Spacing Along (Across) Branch). Established metrics were used when possible: complete number of autozooecial apertures per 2 mm (per 5 mm in fenestrate taxa) in a longitudinal direction, number of complete autozooecial, mesozooecial, exilazooecia apertures per 1 mm^2 at the colony surface or in tangential thin sections. Additional quantitative characters were the number of complete mesozooecia, exilazooecia and acanthostyles surrounding each autozooecial aperture. Spacing of horizontal structures such as diaphragms or cystiphragms were quantified either by measuring the number in 1 mm of the length of the host autozooecium or mesozooecium or by measuring the distance between two successive diaphragms or cystiphragms.

Statistics were summarised with arithmetic mean, sample standard deviation, coefficient of variation, minimum and maximum value.

Bryozoan fauna

Bryozoans from the Upper Ordovician of the Montagne de Noire are represented by all orders known in the Lower Palaeozoic except Ctenostomata. The overwhelming majority are trepostome bryozoans, 40 out of 68 species (58.9 %). These are mostly ramose species, with a few massive and encrusting forms. The second most abundant group are the ptilodictyines, with 10 species (14.7 %). Cystoporates are represented by 6 species (8.9 %), all of them encrusting or sub-massive, except for *Crassalina fungiformis* sp. nov., which has a cone-shaped colony. Rhabdomesines and fenestellines are both represented by 5 species each (7.3 % respectively). Two cyclostomes occur (2.9 % of the total species). Some thin encrusting bryozoans, belonging mostly to cystoporates, were also recognised. However, the available material was not sufficient for description and they are not here included. The bryozoan fauna from the Montagne de Noire therefore has a higher diversity than reported here.

Palaeobiogeographical implications

The majority of the bryozoans from the Montagne de Noire are restricted to southern Europe. Connections to faunas of Wales and Estonia are evident by the presence of *Prasopora grayae* Nicholson & Etheridge, 1877, *Dybowskites orbicularis* (Modzalevskaya, 1953), *Stigmatella massalis* Bassler, 1911*a* and *Astrovidictya sparsa* Lavrentjeva, 1993. The species *Kukersella borealis* (Bassler, 1911*a*), *Hallopora elegantula* (Hall, 1852) and *Parvohallopora onealli* (James, 1875) had a worldwide distribution in the Upper Ordovician. However, some species also show distinct connections to the Upper Ordovician of North America: *Hallopora enodis* Bassler, 1927, *H. gracilens* Bassler, 1927, *Bythopora dendrina* (James, 1878*a*), *B. subgracilis* (Ulrich, 1893) and *Amplexopora* cf. *robusta* Ulrich, 1883. The species *Trematopora tuberculosa* Hall, 1852 is known from the Lower Silurian of North America.

Material has been deposited at the following institutions: Laboratoire de Paléobotanique et Paléontologie (Cc) 062, Université de Montpellier II, France (**UM2-AE**), University of Rennes, France (**IGR**); Natural History Museum, London (**NHM**); Senckenberg Museum, Frankfurt am Main, Germany (**SMF**).

Systematic palaeontology

Phylum **BRYOZOA** Ehrenberg, 1831
Class **STENOLAEMATA** Borg, 1926
Order **CYCLOSTOMATA** Busk, 1852
Suborder **PALEOTUBULIPORINA** Brood, 1973
Family **CORYNOTRYPIDAE** Dzik, 1981
Genus ***CORYNOTRYPA*** Bassler, 1911*b*

Type species. *Hippothoa delicatula* James, 1878*a*, Middle Ordovician of North America and Estonia, Upper Ordovician of North America.

Diagnosis. Encrusting uniserial colony with simple conical autozooecia. Autozooecia narrow at their proximal end and widen at their distal end. Circular apertures with low peristomes at the distal end of the autozooecia. Calcified interior walls with interzooidal pores absent (Taylor 1985).

Occurrence. Middle Ordovician – Upper Permian, worldwide.

Corynotrypa sp. (Pl. 1, figs 1–2)

Material. Single colony UM2-AE 74. Upper Ordovician (?Ashgill) of Montagne de Noire, southern France.

Description. Encrusting uniserial, runner-like colony with simple conical autozooecia. Autozooecia monomorphic, moderately long and slender, with relatively short and narrow proximal portion, 2–3 spaced in 2 mm distance, bifurcating at angles of 70–85°. Zooecial length 0.46–0.90 mm, zooecial width 0.20–0.24 mm. Chambers of contiguous zooids linked by a communication canal. Apertures rounded, 0.06–0.10 mm in diameter. Ancestrula not observed.

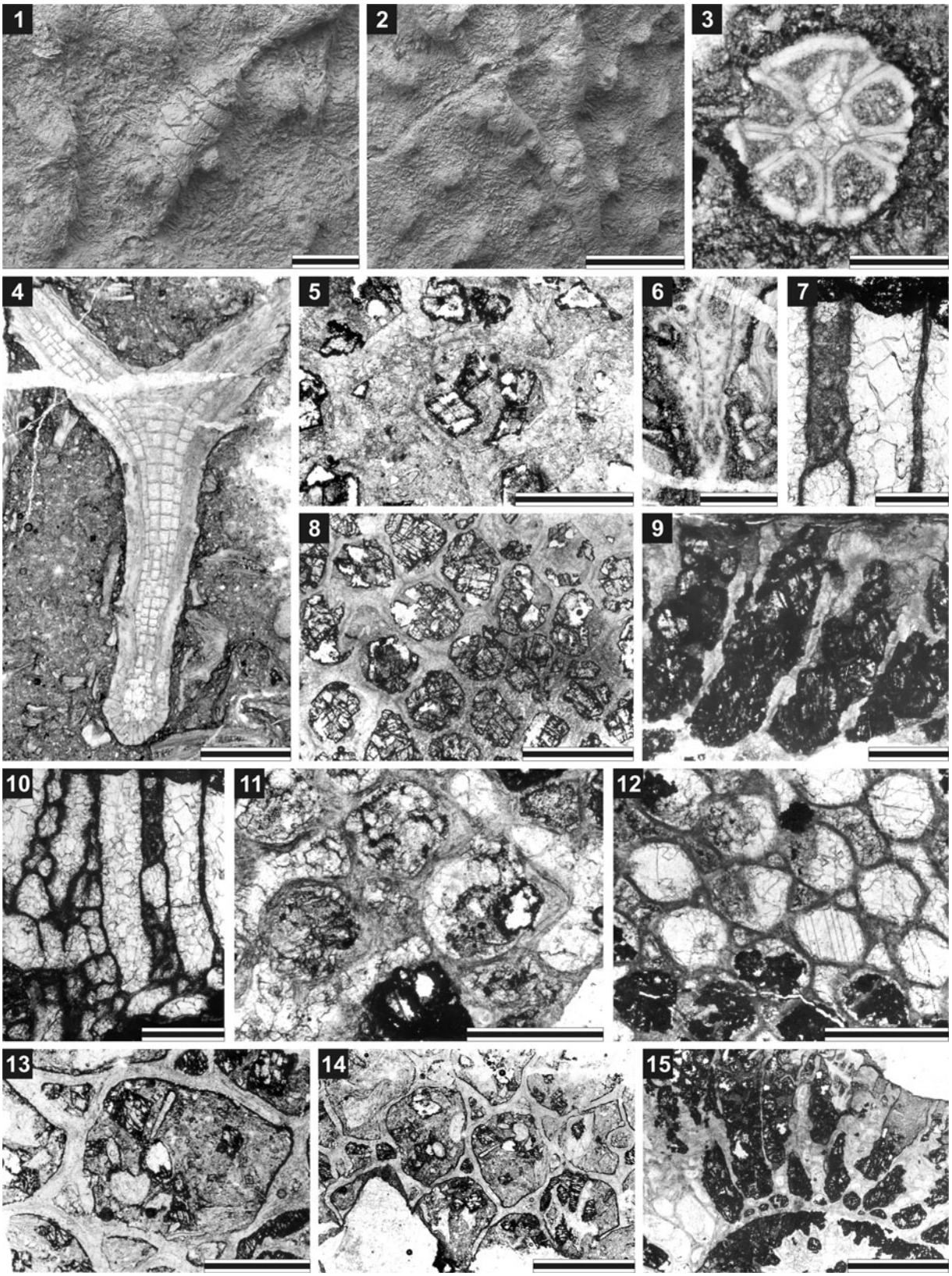

Plate 1 **1–2,** *Corynotrypa* sp. UM2-AE 74: **1**, scale bar = 0.2 mm; **2**, scale bar = 0.5 mm. **3–4, 6**, *Kukersella borealis* (Bassler, 1911*a*): **3**, UM2-AE 37, cross-section of the branch, scale bar = 0.25 mm; **4**, UM2-AE 12, longitudinal section, scale bar = 1 mm; **6**, UM2-AE 36, tangential section, scale bar = 0.5 mm. **5, 8, 9,** *Ceramopora italica* (Vinassa de Regny, 1942), IGR 36040: **5**, tangential section, scale bar = 0.5 mm; **8**, tangential section, scale bar = 1 mm; **9**, longitudinal section, scale bar = 0.5 mm. **7, 10–12,** *Ceramoporella discoidalis* Conti, 1990, IGR 36042: **7**, longitudinal section, scale bar = 0.5 mm; **10**, longitudinal section, scale bar = 1 mm; **11**, tangential section; scale bar = 0.5 mm; **12**, tangential section; scale bar = 1 mm. **13–15**, *Ceramoporella grandis* sp. nov, IGR 36043: **13**, tangential section, scale bar = 0.5 mm; **14**, tangential section, scale bar = 1 mm; **15**, longitudinal section, scale bar = 2 mm.

Remarks. Unfortunately, the preservation of the specimen does not allow exact assignment. It is generally similar to the species *Corynotrypa inflata* Bassler, 1911*b* (described by Taylor & Wilson 1994). It is also similar to the species *Corynotrypa gibbosa* Kiepura, 1962 from the Upper Ordovician of Poland, but differs from the latter by having wider distal parts of zooecia (0.20–0.24 mm vs. 0.10–0.21 mm, respectively). *Corynotrypa delicatula* (James, 1878*a*) from Upper Ordovician (Richmond) of North America differs from the present material by having longer zooecia (0.46–0.90 mm vs. 0.32–1.52 mm, respectively).

Family **CROWNOPORIDAE** Ross, 1967
Genus ***KUKERSELLA*** Toots, 1952
[= ***CROWNOPORA*** Ross, 1967]

Type species. *Kukersella bassleri* Toots, 1952 [= *Mitoclema boreale* Bassler, 1911*a*], Kukruse Stage (Middle Ordovician), Estonia.

Diagnosis. Colony erect, branching, with narrow cylindrical branches arising from an encrusting base. Thick-walled exozone with pseudoporous frontal wall. Exozonal zooecia connected by interzooecial pores. Endozonal zooecia polygonal in cross-section, building a discrete axial bundle, thin-walled with abundant diaphragms (after Buttler 1989).

Remarks. *Kukersella* Toots, 1952 differs from *Cuffeyella* Taylor & Wilson, 1996 by the colony form: ramose with the axial bundle vs. encrusting uniserial to multiserial, respectively.

Occurrence. Lower to Upper Ordovician, Europe, North America.

Kukersella borealis (Bassler, 1911*a*) (Pl. 1, figs 3–4, 6; Appendix)

1911*a* *Mitoclema boreale* Bassler: 69, pl. 6, fig. 8, text-fig. 15.
1952 *Kukersella bassleri* Toots: 117, pl. 7, figs 1, 9.
1967 *Crownopora singularis* Ross: 645, pl. 72, figs 1–4, pl. 73, figs 1–4, pl. 74, figs 1–4.
1973 *Crownopora singularis* Ross 1967; Boardman & Cheetham: 145, fig. 34.
1973 *Kukersella boreale* (Bassler, 1911*a*); Brood: 254, fig. 2.
1974 *Kukersella boreale* (Bassler, 1911*a*); Brood: 425, fig. 2A.
1975 *Kukersella bassleri* Toots, 1952; Brood: 113, pl. 8, figs 6–7, pl. 12, fig. 3.
1975 *Kukersella boreale* (Bassler, 1911*a*); Brood: 114, pl. 8, figs 1, 5, pl. 12, figs 1–2.
1987 *Kukersella* cf. *boreale* (Bassler, 1911*a*); Hillmer & Schallreuter: fig. 2N.
1987 *Kukersella* sp. nov. Gorjunova: pl. 4, figs 3a, b, c.
1989 *Kukersella borealis* (Bassler, 1911*a*); Buttler: 223–225, figs 4A-E, 5A-E, 6A-E.
1990 *Kukersella boreale* (Bassler, 1911*a*); Conti: 117, pl. 22, figs 1–7.
1991*a* *Kukersella borealis* (Bassler, 1911*a*); Buttler: 104–105, pl. 7, figs 7–8.

Lectotype. USNM 57184-1 (Bassler, 1911*a*; text-fig.15, pl. 8, top right fragment), Kunda Stage (Lower Ordovician), Estonia.

Material. 25 colonies were measured.

Occurrence. *Kukersella borealis* (Bassler, 1911*a*) has nearly a worldwide distribution in Middle to Upper Ordovician rocks. The investigated material comes from the Upper Caradoc to Lower Ashgill of Montagne de Noire and from the siltstone/sandstone member, Uggwa Formation, from the Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy.

Description. Ramose colonies with an axial bundle consisting of 1–15 axial zooecia, bifurcating occasionally, branch diameter 0.39–1.75 mm. Axial zooecia thin-walled, polygonal in cross-section, containing abundant, closely spaced diaphragms, numbering 6.0–11.5 per 1 mm of zooecial length. Autozooecia long, thick-walled, budding in the exozone, possessing well-developed peristomes, connected distally by communication pores. Autozooecial apertures rounded to oval, spaced widely in alternating rows. Frontal walls quite thick, consisting of laminated skeleton, carrying pseudopores. Pseudopores densely spaced, rounded in cross-section, funnel-shaped in longitudinal section.

Remarks. Investigated material matches generally to the earlier descriptions of the species *Kukersella borealis* (Bassler, 1911*a*). Buttler's (1989) material from the Ashgill of southern Wales reveals thicker colonies (average 1.08 mm vs. 0.63 mm in present material) and larger number of axial zooecia (average 17.6 vs. 6.3 in present material).

Remarks. The specimen depicted in cross-section as *Monticulipora* (*Monotrypa*) *paronai* Vinassa de Regny, 1910 (pl. 1, fig. 19) is herein assigned to *Kukersella borealis* (Bassler, 1911*a*).

Order **CYSTOPORIDA** Astrova, 1964
Suborder **CERAMOPORINA** Bassler, 1913
Family **CERAMOPORIDAE** Ulrich, 1882
Genus ***CERAMOPORA*** Hall *in* Silliman *et al.*, 1851

Type species. *Ceramopora imbricata* Hall, 1852; Middle Silurian (Niagara Group), Lockport, New-York, USA.

Diagnosis. Colonies thin discoid expansions; encrusting, free, or in a combination. Autozooecia large, commonly rhombically arranged, living chambers ovate or rhomboidal in cross-section, budding from the epitheca. Communication pores abundant, most commonly just distal to ends of the lunaria. Lunaria small in the inner exozone, large on the colony surface. Diaphragms absent. Exilazooecia few to abundant in intermonticular areas, generally small and subcircular in cross-section, lacking diaphragms. Monticules with depressed centre, exilazooecia of central cluster more angular then intermonticular exilazooecia.

Remarks. *Ceramopora* differs from *Ceramoporella* by the absence of diaphragms and more common communication pores, and from *Acanthoceramoporella* Utgaard, 1968 by lacking acanthostyles and diaphragms.

Occurrence. Upper Ordovician to Middle Silurian, North America, Europe, Siberia.

Ceramopora italica (Vinassa de Regny, 1942) (Pl. 1, figs 5, 8, 9; Appendix)

1942 *Coeloclema italicum* Vinassa de Regny: 1028, pl. 2, fig. 2, text-fig. B.
1942 *Ceramopora* sp. Vinassa de Regny: 1027, pl. 1, fig. 15.
1990 *Ceramopora italica* (Vinassa de Regny, 1942); Conti: 108, pl. 16, figs 5–9.

HOLOTYPE. Pictured in Conti 1990, pl. 16, figs 5–8.

MATERIAL. IGR 36039–36041.

OCCURRENCE. Upper Ordovician (probably Ashgill), Montagne de Noire (southern France). Upper Ordovician, Upper Caradoc (unit *c*), Sardinia, Italy.

DESCRIPTION. Encrusting colonies, 2.38–2.70 mm thick. Autozooecia large, budding from a thick epitheca radially from the centre of the colony. Autozooecial apertures polygonal with rounded corners, becoming rhombic in deeper tangential sections, 2.5–3.5 apertures in 2 mm and 2–3 in 1 mm^2 of colony surface. Lunaria distinct on colony surface, becoming indistinct in deeper tangential section. Autozooecial diaphragms absent. Exilazooecia small, rare, short, rounded-polygonal to subcircular in cross-section. Autozooecial walls slightly beaded, indistinctly laminated, up to 0.03–0.06 mm thick in basal parts of autozooecia, increasing up to 0.10 mm thick in distal parts.

REMARKS. *Ceramopora italica* (Vinassa de Regny, 1942) has larger autozooecial apertures than the most similar species *C. discoidalis* (Vinassa de Regny, 1942) from the Upper Ordovician of Sardinia (0.47–0.70 mm vs. 0.20 mm in *C. discoidalis*).

Genus ***CERAMOPORELLA*** Ulrich, 1882

TYPE SPECIES. *Ceramoporella distincta* Ulrich, 1882. McMicken Member, Eden Formation; Cincinnati, Ohio, USA.

DIAGNOSIS. Colonies encrusting or frondose. Maculae flush with colonial surface or slightly elevated as monticules, having circular or elongated central cluster of extrazooecial vesicular skeleton. Autozooecia moderately small in exozone, ovate to subcircular in cross-section. Communication pores rare. Lunaria large, prominent. Autozooecial diaphragms planar or convex, usually one, rarely more, per autozooecium, appearing at same level in neighbouring autozooecia. Exilazooecia partially to completely isolating autozooecia; large and subangular in cross-section in inner exozone, smaller and more circular distally. Exilazooecial diaphragms rare.

REMARKS. *Ceramoporella* Ulrich, 1882 differs from *Acanthoceramoporella* Utgaard, 1968 by lacking acanthostyles and having fewer communication pores. It also differs from *Ceramopora* Hall *in* Silliman *et al*., 1851 by having fewer communication pores and in the presence of diaphragms.

OCCURRENCE. Middle to Upper Ordovician, North America, Europe.

Ceramoporella discoidalis Conti, 1990 (Pl. 1, figs 7, 10–12; Appendix)

1990 *Ceramoporella discoidalis* Conti: 109–110, pl. 17, figs 6–10.

HOLOTYPE. IPUM 21807 (Museum of the Institute of Palaeontology, Modena University, Italy). SW Sardinia; unit *e* (Ashgill).

MATERIAL. Single colony (tangential and longitudinal sections) IGR 36042.

OCCURRENCE. Upper Ordovician (? Ashgill); Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Lower Ashgill (unit *e*), Sardinia, Italy.

DESCRIPTION. Encrusting colony, 2.6–3.0 mm thick. Secondary overgrowths common. Autozooecia large, budding from the basal epitheca, recumbent in proximal parts, then bending sharply and intersecting branch surface at right angles. Autozooecial diaphragms planar to curved proximally, usually one per autozooecium. Autozooecial apertures rounded to polygonal. Lunaria well-developed, prominent. Exilazooecia small, common, 1–5 surrounding each autozooecial aperture, rounded–polygonal in cross-section. Zooecial walls in the endozone straight, 0.02–0.03 mm thick; in exozone regularly thickened, indistinctly laminated, 0.04–0.07 mm thick. Communication pores common.

REMARKS. Investigated material is very similar to the species *Ceramoporella discoidalis* Conti, 1990 from the Upper Ordovician of Sardinia. The present colony has smaller apertures, which, however, fall within the range of variation of the Sardinian material. *Ceramporella distincta* Ulrich, 1882 from the Middle to Upper Ordovician of North America has thinner colonies and smaller autozooecial apertural diameters (0.225 mm vs. 0.436 mm in present specimen; measurements of type material for *C. distincta* from Karklins (1984)).

Ceramoporella grandis sp. nov. (Pl. 1, figs 13–15)

HOLOTYPE. IGR 36043.

TYPE LOCALITY. Grange du Pin, Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician (? Caradoc to Ashgill).

ETYMOLOGY. The specific name indicates the large autozooecial apertures of the new species (from Latin 'grandis' = large).

DIAGNOSIS. Moderately thick encrusting colony, autozooecia having large apertures and rare diaphragms; exilazooecia abundant. Cyst-like structures in lower part of exozone.

DESCRIPTION. Encrusting colony, 2.50–3.12 mm thick. Secondary overgrowths common. Autozooecia large, growing from the basal epitheca, recumbent in proximal parts for short distance, then bending sharply and intersecting branch surface at right angles. Autozooecial diaphragms planar, rare. Autozooecial apertures polygonal, 0.68–0.90 mm in diameter. Lunaria large, with weakly developed core; 0.36–0.54 mm wide, 0.29–0.30 mm long and 0.07–0.11 mm thick. Exilazooecia common, 1–6 surrounding each autozooecial aperture, indenting the autozooecia, rounded–polygonal in

cross-section, 0.12–0.24 mm in diameter. Zooecial walls in the endozone straight, 0.036–0.042 mm thick; in exozone regularly thickened, indistinctly laminated, 0.090–0.120 mm thick. Epitheca consists of lamellar material that is underlain by blocky calcite. Communication pores rare. Cyst-like structures (vesicles) in the lower part of exozone present.

Remarks. *Ceramoporella grandis* sp. nov. differs from *C. discoidalis* Conti, 1990 by having larger autozooecial apertures (0.68–0.90 mm vs. 0.34–0.60 in C. discoidalis) and fewer autozooecial diaphragms and communication pores.

Genus ***CREPIPORA*** Ulrich, 1882

Type species. *Chaetetes venusta* Ulrich, 1878, Upper Ordovician, Economy Member, Eden Formation, North America.

Diagnosis. Colonies encrusting, hollow ramose, or solid ramose with monticules. Autozooecial apertures subangular to subcircular in cross-section, commonly rhombically packed. Wall laminae short, irregular, not concentric around living chamber. Communication pores abundant, subcircular in cross-section. Lunaria well-developed, with one or more cores. Diaphragms thin to thick, irregularly spaced. Exilazooecia rare to absent, abundant in monticules, having sparse diaphragms. Acanthostyles rare, small. Monticules having cores of small to large exilazooecia, acanthostyles and ring of larger autozooecia.

Remarks. *Crepipora* Ulrich, 1882 differs from *Ceramoporella* Ulrich, 1882 in having acanthostyles and fewer exilazooecia, and from *Acanthoceramoporella* Utgaard, 1968 in having fewer and smaller acanthostyles and fewer exilazooecia.

Occurrence. Middle to Upper Ordovician, North America, Europe.

Crepipora vesiculosa Boulange, 1963 (Pl. 2, figs 1–4; Appendix)

?1915 *Prasopora carnica* Vinassa de Regny: 101, pl. 12, figs 7–9.
1963 *Crepipora vesiculosa* Boulange: 35–36, text-fig. 1, pl. 1, fig. 1.

Holotype. N 6. Upper Ordovician (Ashgill). Glauzy (Herault). Collection of the l'Institut de gèologie de Lyon.

Occurrence. Upper Ordovician (probably Ashgill); Grange du Pin, Montagne de Noire, southern France.

Material. UM2-AE 65; IGR 36019, IGR 36044–36048, IGR 36051.

Description. Encrusting colonies, 1.3–4.0 mm thick. Secondary overgrowths common. Autozooecia large, budding from the basal epitheca, recumbent in proximal parts, then bending sharply and intersecting colony surface at right angles. Autozooecial diaphragms absent. Autozooecial apertures rounded to oval, rhombic in deep tangential section, spaced 3 in 2 mm. Lunaria well-developed, prominent. One to three indistinct rod-like structures present in each lunarium. Exilazooecia rare, usually not isolating autozooecia, rounded in cross-section, usually covered by skeletal material. Cyst-like vesicles in interzooecial spaces common, having circular cross-sections, regularly shaped, 0.18–0.22 mm in diameter. Zooecial walls in the endozone undulating, 0.024–0.036 mm thick; in exozone regularly thickened, occasionally beaded, coarsely laminated, 0.09–0.10 mm thick. Communication pores rare, positioned in laminated walls of the exozone, 0.10–0.12 mm in diameter.

Remarks. The species *Crepipora vesiculosa* Boulange, 1963 differs from other species of the genus in having large autozooecial apertures; from *C. venusta* Ulrich, 1878 by the presence of abundant cyst-like vesicles, absence of diaphragms and rare acanthostyles; and from *Crepipora uxnormensis* (Bassler, 1911*a*) from the Upper Ordovician of Estonia in having more exilazooecia.

Suborder **FISTULIPORINA** Astrova, 1964

Family **ANOLOTICHIIDAE** Utgaard, 1968

Genus ***CRASSALINA*** Utgaard, 1968

Type species. *Crepipora epidermata* Ulrich, 1890, Fernvale Formation, Upper Ordovician, USA.

Diagnosis (after Utgaard 1968). Encrusting colony, flat to convolute. Monticules small to large, slightly elevated to slightly depressed. Recumbent portion of autozooecia short to long. Axes generally parallel in adjacent autozooecia. Autozooecia angular to subangular in cross-section at zooecial bend, subangular to subrounded in outer exozone. Lateral and distal sides commonly composed of overlapping vertical portions of vesicular skeleton. Autozooecial walls moderately thick, granular to granular–prismatic. Zones of thicker wall lacking distinct boundary and with crystal aggregates fanning outward, producing minutely spotted amalgamated appearance. Lunaria becoming larger and thicker in outer exozone; proximal side with uneven nodes and ridges; most lunaria with one minute longitudinal core-like structure near centre. Walls of adjacent autozooecia and vesicular skeleton unconformably abutting proximal side of lunaria. Vesicles variable but generally small, subangular to subrounded in cross-section. Monticular centres with irregular tube-like and oblique vesicles surrounded by larger zooecia. Lunaria locally and, in part, radially arranged around apertures.

Remarks. *Crassalina* Utgaard, 1968 is distinct with its cyst-like interzooecial spaces and well developed lunaria. The most similar genus, *Bythotrypa* Ulrich, 1893, has larger interzooidal spaces and less developed lunaria. Another similar genus, *Anolotichia* Ulrich, 1890, has large, light coloured longitudinal calcite rods in its lunaria.

Occurrence. Two species are known: *Crassalina epidermata* (Ulrich, 1890) from the Upper Ordovician of North America and *C. cystata* Conti, 1990 from the Upper Ordovician of Sardinia and Montagne de Noire.

Crassalina fungiforme sp. nov. (Pl. 2, figs 12–16; Appendix)

Holotype. UM2-AE 1 (three thin sections).

Paratype. Unprepared colony UM2-AE 89.

Type locality. Le Glauze, Montagne de Noire, southern France.

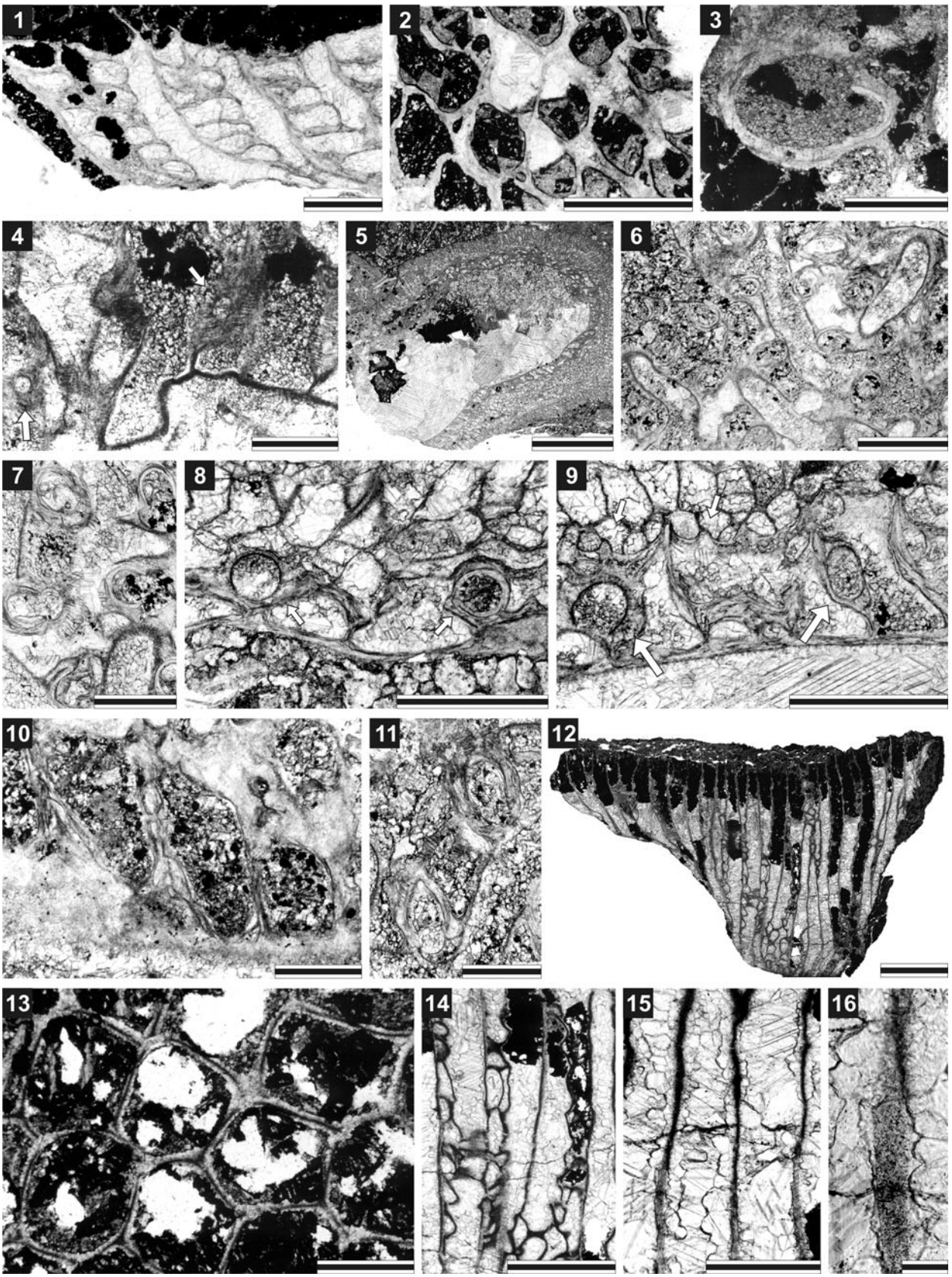

Plate 2 **1–4**, *Crepipora vesiculosa* Boulange, 1963. **1**, **2**, IGR 36051: **1**, longitudinal section, scale bar = 1 mm; **2**, tangential section, scale bar = 1 mm; **3**, IGR 36047, tangential section, scale bar = 0.5 mm; **4**, IGR 36044, longitudinal section, scale bar = 0.5 mm. **5–11**, *Lichenalia nodata* sp. nov. **5**, **9**, holotype UM2-AE-2-3: **5**, cross-section through the tubular colony, scale bar = 5 mm; **9**, longitudinal section displaying autozooecia, nodes (short arrows) and tunnel structures (long arrow), scale bar = 1 mm; **6**, **7**, **11**, paratype UM2-AE-80-4: **6**, tangential section

TYPE STRATUM. Upper Ordovician, Caradoc.

ETYMOLOGY. The specific name refers to the cup-shaped colony of the new species.

DIAGNOSIS. Massive cup-shaped colonies. Autozooecia having indistinct lunaria. Mesozooecia rare.

DESCRIPTION. Massive colonies, cup-shaped, growing from the crenulated epitheca, 21–24 mm in diameter, 12 mm in height. Autozooecia straight, in basal region often beaded, budding directly from the epitheca. Autozooecial apertures polygonal in tangential section, spaced 3 in 2 mm and averaging 3 in 1 mm^2 of the colony surface. Lunaria poorly developed. Autozooecial diaphragms absent. Mesozooecia rare, polygonal in tangential section, budding in exozone, lacking diaphragms. Styles absent. Walls straight to crenulated, differentiated in zones of fibrous and hyaline structure. Fibrous walls 0.024–0.030 mm thick, dark; hyaline walls 0.042–0.090 mm thick, light coloured.

REMARKS. This species possesses typical anolotichiid walls with differentiated structure, partly fibrous and partly hyaline (see generic diagnosis) and a vesicular skeleton. However, lunaria are indistinct, contrary to the type species which has strongly developed lunaria. Therefore, this species is placed tentatively in the genus *Crassalina* Utgaard, 1968. The colony shape of this bryozoan is similar to *Dianulites fastigiatus* Eichwald, 1829 described in detail by Taylor & Wilson (1999).

Family **RHINOPORIDAE** Miller, 1889

Genus ***LICHENALIA*** Hall *in* Silliman *et al.*, 1851

TYPE SPECIES. *Lichenalia concentrica* Hall, 1852. Middle Silurian, USA.

DIAGNOSIS. Encrusting, hollow ramose or free-lying colonies. Autozooecia with long recumbent portions on laminated basal layer. Diaphragms few. Lunaria highly elevated, hyaline, variable in size and shape. Tunnels covered by rounded roofs on vesicular skeleton, appearing as elevated, anastomosing ridges on colony surface. Large blister- or box-like vesicles in outer exozone, partly isolating autozooecia, having thick laminated roofs with indistinct tubules. Walls thin, laminated.

REMARKS. Another rhinoporid genus, *Rhinopora* Hall, 1851, differs from *Lichenalia* in its bifoliate frondose colony shape and shorter autozooecia. Buttler (1991*c*) discusses the morphology and possible function of tunnels in rhinoporid bryozoans. Two alternative hypotheses for the tunnels exist. According to one hypothesis, they are brooding chambers like in cyclostome bryozoans (Buttler 1991*c*). Another hypothesis regards the tunnels as the site of a soft-bodied epibiont that was overgrown by the bryozoan colony ('bioclaustration' after Palmer & Wilson 1988).

OCCURRENCE. The species *Lichenalia concentrica* Hall, 1852 is common in the Middle Silurian of North America. Apparently the same species has been reported from the Upper Ordovician (Porkuni Stage, Ashgill) of Estonia (Bassler 1911*b*) and from the Ordovician and Silurian of Wales (Spjeldnaes 1957; Buttler 1991*a*, *c*; Snell 2004). The new species *Lichenalia nodata* sp. nov. is known from the Upper Ordovician of southern Europe.

Lichenalia nodata sp. nov. (Pl. 2, figs 5–11; Appendix)

?1990 *Ceramophylla* sp. Conti: 109, pl. 17, figs 1–5, pl. 22, fig. 12.

HOLOTYPE. UM2-AE-2-3 (Pl. 2, figs 5, 9).

PARATYPES. UM2-AE-80-4 (Pl. 2, figs 6, 7, 11), UM2-AE-80-9.

TYPE LOCALITY. Grange du Pin, Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician (Caradoc).

ETYMOLOGY. The specific name refers to the large nodes of the new species.

MATERIAL. UM2-AE-2-(1, 2, 5, 9, 15, 16, 17, 18, 20, 23, 35, 39, 46), -80-(3, 4, 6, 9, 10, 12); SMF 2116–2123.

OCCURRENCE. Upper Ordovician, Caradoc, Grange du Pin, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

DIAGNOSIS. Encrusting *Lichenalia* with laminar, hollow ramose or free-lying colonies; tunnels abundant, large in diameter; prominent nodes present.

DESCRIPTION. Encrusting, laminar or hollow tube-like colonies. Hollow colony flattened, up to 9 × 17 mm in cross-section. Encrusting layers 0.63–1.10 mm thick. Autozooecia budding from thick basal layer, recumbent for a short distance, then bending to the colony surface, hemispherical to trapezoidal in cross-section at the base, rhombic in deep tangential section, becoming circular in the outer exozone. Autozooecial apertures rounded to oval, 0.18–0.24 mm wide (0.20 mm average), arranged in regular quincunx order, spaced 2–3 in 2 mm and 4 in 1 mm^2 of colony surface. Lunaria prominent, 0.18–0.30 mm wide and 0.16–0.22 mm long. Lunarial deposits 0.06–0.09 mm thick. Locally a single

displaying apertures and tubular structures, scale bar = 1 mm; **7**, tangential section displaying apertures and tubular structure, scale bar = 0.5 mm; **11**, tangential section displaying apertures, scale bar = 0.5 mm; **8**, UM2-AE-2-18, cross-section displaying autozooecia and tunnel structures (arrows), scale bar = 1 mm; **10**, UM2-AE-80-3, longitudinal section displaying communication pores, scale bar = 0.5 mm. **12–16**, *Crassalina fungiforme* sp. nov. holotype UM2-AE 1: **12**, longitudinal section, scale bar = 3 mm; **13**, tangential section, scale bar = 0.5 mm; **14**, longitudinal section, scale bar = 2 mm; **15**, longitudinal section, scale bar = 1 mm; **16**, longitudinal section displaying wall structure, scale bar = 0.1 mm.

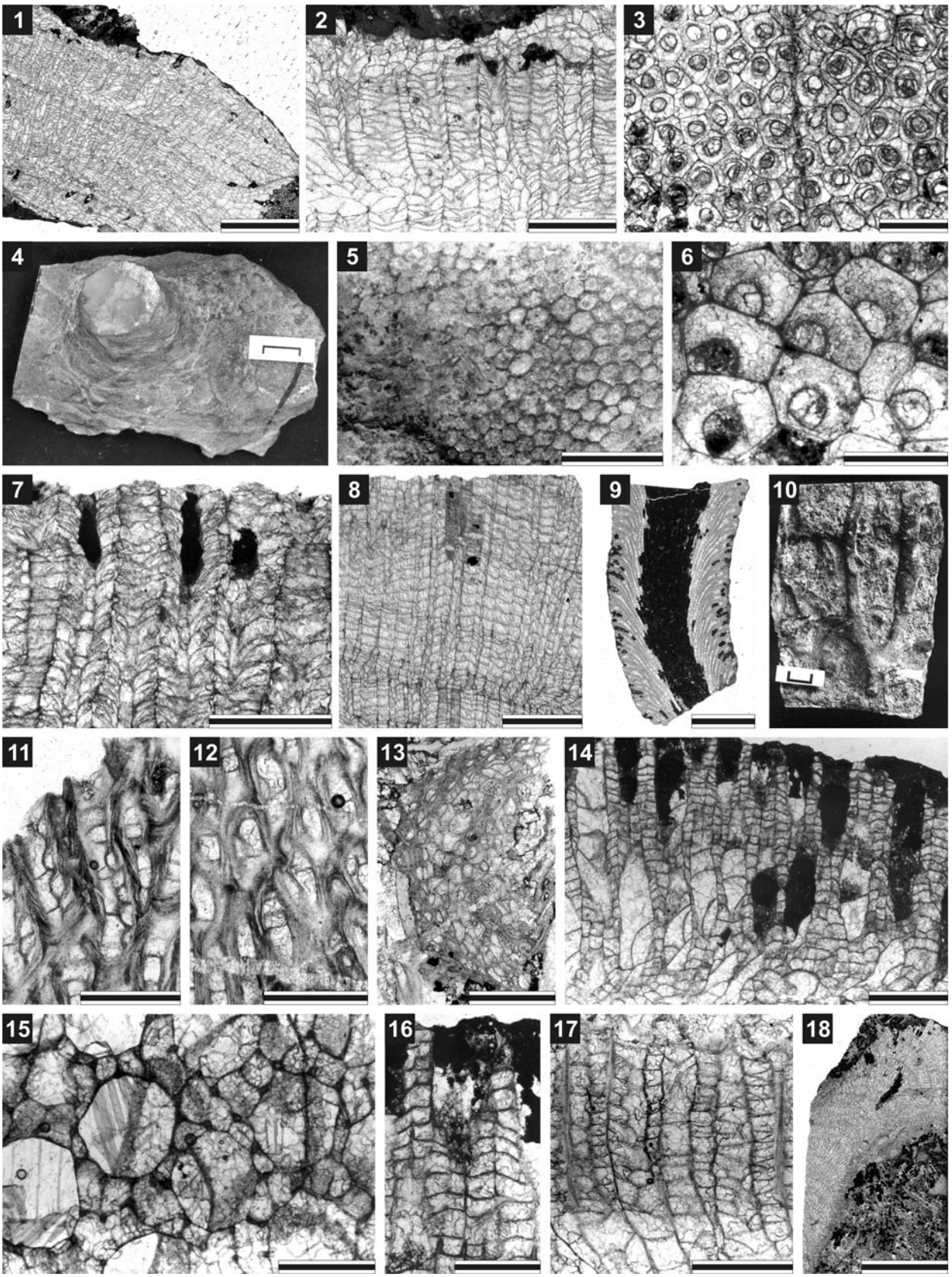

Plate 3 **1–3**, *Prasopora fistuloporoides* (Vinassa de Regny, 1910), IGR 36001: **1**, longitudinal section, scale bar = 3 mm; **2**, longitudinal section, scale bar = 1 mm; **3**, tangential section, scale bar = 1 mm. **4–8**, *Prasopora grayae* Nicholson & Etheridge, 1877. **4–5**, **7**, UM2-AE 11: **4**, incrusting colony with the base of a ramose branch, scale bar = 10 mm; **5**, macula, scale bar = 3 mm; **7**, longitudinal section, scale bar = 2 mm; **6**, UM2-AE-7, tangential section, scale bar = 0.5 mm; **8**, IGR 36003, longitudinal section, scale bar = 2 mm. **9–13**, *Homotrypa migueli* (Prantl, 1940).

diaphragm developed per autozooecium. Exilazooecia usually positioned at junctions between autozooecia, rounded in cross-section, 0.066–0.150 mm in diameter. Zooecial skeleton thickly laminated. Layer of granular deposits on the colony surface developed. Styles locally abundant, 0.072–0.150 mm in diameter, consisting of granular material, originating in outer granular skeleton of the colony, forming prominent nodes on colony surface. Tunnels common, having granular–prismatic roofs, bifurcating frequently, circular in cross-section, 0.24–0.41 mm in diameter, with 0.020–0.035 mm thick walls consisting of radially fibrous calcite.

Remarks. *Lichenalia nodata* sp. nov. differs from *Lichenalia concentrica* Hall, 1852 in the presence of nodes, the slightly larger apertures (0.18–0.24 mm in *L. nodata* vs. 0.16–0.22 mm in *L. concentrica*, data from Buttler 1991*a*), as well as the larger diameter of the tunnel structures (0.29 mm average vs. 0.21 mm in *L. concentrica*).

Order **TREPOSTOMIDA** Ulrich, 1882
Suborder **HALLOPORINA** Astrova, 1965
Family **MONTICULIPORIDAE** Nicholson, 1881
Genus ***PRASOPORA*** Nicholson & Etheridge, 1877

Type species. *Prasopora grayae* Nicholson & Etheridge, 1877. Upper Ordovician, Scotland.

Diagnosis. Lamellar, encrusting, discoidal or massive, hemispherical colonies, having an epitheca. Zooecia with rounded-polygonal or rounded apertures, with thin amalgamated walls displaying indistinct longitudinal microstructure. Cystiphragms abundant, developing throughout entire autozooecial length or separated. Autozooecial diaphragms rare. Mesozooecia abundant, with frequent diaphragms, clustered with megazooecia, forming maculae. Acanthostyles small, rare and indistinct, sometimes absent.

Remarks. *Prasopora* differs from *Monticulipora* d'Orbigny, 1850 by having more abundant mesozooecia, rounded autozooecial apertures, wall structure and, usually, more abundant cystiphragms.

Occurrence. Middle Ordovician to Lower Silurian, worldwide.

Prasopora fistuloporoides (Vinassa de Regny, 1910) (Pl. 3, figs 1–3; Appendix)

1910 *Monticulipora* (*Prasopora*) *fistuloporoides* Vinassa de Regny: 13–14, figs 8–11.
1915 *Prasopora fistuloporoides* (Vinassa de Regny, 1910); Vinassa de Regny: 100–101, pl. 13, figs 1–3.
v1940 *Prasopora thorali* Prantl: 89–91, pl. 1, fig. 10, text-figs 2–3.
1942 *Prasopora fistuloporoides* (Vinassa de Regny, 1910); Vinassa de Regny: 1039, pl. 3, figs 4–5.
1948 *Prasopora thorali* Prantl, 1940; Dreyfuss: 24–25, pl. 1, figs 1–9.
1948 *Prasopora thorali* var. *elliptica* Prantl, 1940; Dreyfuss: 25.
1988 Monticuliporidae genus et species indet.; Conti & Serpagli: 143, pl. 10, text-fig. 5E.
1990 *Prasopora fistuloporoides* (Vinassa de Regny, 1910); Conti: 92, pl. 1, figs 5–8, pl. 2, figs 1–2.
1991*b* *Prasopora thorali* Prantl, 1940; Buttler: 163–164, figs 16–17.

Holotype. Specimen pictured by Vinassa de Regny (1910: pl. 3, figs 4–5). Original not located. Upper Ordovician (Caradoc), Carnic Alps (Italy).

Material. Tangential and longitudinal section of a single colony IGR 36001. Grange du Pin, Montagne de Noire, southern France; Upper Ordovician (? Ashgill).

Occurrence. Upper Ordovician (? Ashgill); Valbertad, Carnic Alps, Italy. Upper Ordovician (? Ashgill); Montagne de Noire, southern France. Upper Ordovician (Caradoc); Llanbedrog, North Wales. Upper Ordovician, Lower Ashgill (unit *e*); Sardinia, Italy.

Description. Discoidal colony, 2.5 mm in diameter, 8.0 mm thick in the middle, barely differentiated into exo- and endozone. Secondary overgrowths common, single sheets 2.5–3.0 mm thick. Autozooecia prismatic, bearing abundant cystiphragms and diaphragms. Maculae comprising of larger autozooecial apertures indistinctly outlined. Autozooecial apertures polygonal in tangential section, spaced 4.5–5.0 in 2 mm, 4.5 in 1 mm^2 of the colony surface in intermacular area; 3–4 in 2 mm in maculae. Cystiphragms numerous, densely spaced, constricting middle part of zooecia, about a half of their diameter. Mesozooecia rare, spaced usually 3 in 1 mm^2, polygonal in tangential section, bearing closely spaced diaphragms. Zooecial walls amalgamated, 0.006–0.012 mm thick. Small styles in zooecial walls and in junctions between zooecia.

Remarks. *Prasopora fistuloporoides* (Vinassa de Regny, 1910) differs from the species *P. grayae* Nicholson & Etheridge, 1877 in having larger apertures (0.39 mm vs. 0.28 mm in average) and less abundant mesozooecia. *Prasopora thorali* Prantl, 1940, distinguished only on presence of styles, is surely a synonym of *P. fistuloporoides* (see Conti 1990). Small styles, positioned very shallow in the skeleton of these bryozoans, occur in most *Prasopora* species and their appearance can apparently be very occasional. The two species have clear similarities, so the presence or absence of styles is not effective for discrimination.

9, IGR 36005, longitudinal section, scale bar = 3 mm; **10**, UM2-AE 4, scale bar = 5 mm; **11**, **12**, IGR 36006: **11**, longitudinal section of the exozone displaying cystiphragms and diaphragms; **12**, deep tangential section, displaying acanthostyles, scale bar = 0.5 mm; **13**, UM2-AE 4-7, cross-section, scale bar = 1 mm. **14–16**, *Atactoporella magnopora* sp. nov. Holotype IGR 36004: **14**, longitudinal section, scale bar = 1 mm; **15**, tangential section, scale bar = 0.5 mm; **16**, longitudinal section, scale bar = 0.5 mm. **17–18**, *Atactoporella irregularis* Boulange, 1963. **17**, longitudinal section of the exozone, scale bar = 1 mm; **18**, longitudinal section of the branch, scale bar = 10 mm.

Prasopora grayae Nicholson & Etheridge, 1877 (Pl. 3, figs 4–8; Appendix)

1877 *Prasopora grayae* Nicholson & Etheridge: 392.
1881 *Monticulipora* (*Prasopora*) *grayae* Nicholson & Etheridge, 1877; Nicholson: 203, figs 42–43.
1987 *Prasopora grayae* Nicholson & Etheridge, 1877; Ropot & Pushkin: 190, pl. 22, figs 4.
1991*b* *Prasopora grayae* Nicholson & Etheridge, 1877; Buttler: 163, figs 13–15.

Lectotype. MNH D 32195, MNH D 32196. Craighead Beds (Upper Ordovician). Craighead Quarry, Ayrshire, Scotland.

Material. UM2-AE 7-11; IGR 36003.

Occurrence. Middle Ordovician, Kukruse and Keila Stages, Belorussia. Upper Ordovician, ? Caradoc to Ashgill, Petite Glauzy, Montagne de Noire, southern France. Upper Ordovician, Caradoc, Llanbedrog, North Wales. Upper Ordovician, Scotland.

Description. Massive, sometimes hemispheric, multilayered colonies, up to 35 mm thick. Single layers 1.74–2.80 mm thick, weakly differentiated into exo- and endozone. Autozooecia prismatic, bearing abundant cystiphragms and diaphragms. Maculae of clusters of mesozooecia and megazooecia indistinctly outlined, up to 2.6–2.8 mm in diameter. Autozooecial apertures rounded to polygonal, spaced 5–7 in 2 mm, 8–13 in 1 mm^2 of colony surface in intermacular area; 4–6 in 2 mm in maculae. Cystiphragms large, rounded, numerous, spaced widely, usually restricted to one side of a zooecium, occupying 1/4 to 1/2 of its diameter. Mesozooecia quite common, spaced 2–5 in 1 mm^2, surrounding some zooecia, polygonal in tangential section, originating from the basal part of the colony, bearing closely spaced diaphragms. Zooecial walls amalgamated, 0.006–0.012 mm thick.

Remarks. *Prasopora grayae* Nicholson & Etheridge, 1877 differs from *Prasopora fistuloporoides* (Vinassa de Regny, 1910) by having smaller autozooecial apertures and more abundant mesozooecia.

Genus ***HOMOTRYPA*** Ulrich, 1882 [= ***HOMOTRYPELLA*** Ulrich, 1882]

Type species. *Homotrypa curvata* Ulrich, 1882. Upper Ordovician (Cincinnatian); North America.

Diagnosis. Ramose and frondose colonies, often flattened, sometimes encrusting and irregularly massive in initial stages. Autozooecia with polygonal, rounded or oval apertures. Walls slightly thickened in exozone, integrated, diagonally and longitudinally laminated. Cystiphragms only in exozone, diaphragms commonly in exozone. Mesozooecia from rare to abundant, sometimes clustering maculae. Acanthostyles abundant, commonly small.

Remarks. The genus *Homotrypa* Ulrich, 1882 differs from the genus *Monticulipora* d'Orbigny, 1850 by the occurrence of cystiphragms in the exozone.

Occurrence. Middle Ordovician to Lower Silurian. North America, Europe, Australia, Siberia.

Homotrypa miqueli (Prantl, 1940) (Pl. 3, figs 9–13; Appendix)

1940 *Homotrypella miqueli* Prantl: 93–94, pl. 1, fig. 6, pl. 2, figs 8–9.

Holotype. Figured by Prantl (1940: pl. 1, fig. 6). Figures of the thin sections (cross and tangential sections) were erroneously cited by Prantl as pl. 2, figs 1–2. They are actually pl. 2, figs 8–9. Originals untraceable at the National Museum in Prague (Kamil Zágoršek, pers. comm., 2005).

Material. UM2-AE 4-7, 12-1, 13-2, 15-2, 25, 36; IGR 36005–36010; SMF 2124.

Occurrence. Upper Ordovician, Caradoc to Ashgill, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill, Uggwa Formation, siltstone/sandstone member, Valbertad, Carnic Alps, Italy.

Description. Ramose colonies, branch diameter 2.75–6.75 mm. Endozone 1.58–2.70 mm wide, exozone 0.68–1.75 mm wide, distinct. Secondary overgrowths as well as single-layered encrusting stages occurring. Autozooecia long in the endozone, bending gently and intersecting branch surface at angles of 50–55°, originating sometimes in outer endozone interzooidally. Autozooecial apertures oval, in larger colonies rounded–polygonal, spaced 4–6 (mean = 5) in 2 mm of colony surface. Autozooecial diaphragms rare to absent in the endozone, concentrated mostly in transitional region between endo- and exozone, widely spaced in outer exozone. Cystiphragms occurring in exozone, positioned in the distal part of autozooecia. Mesozooecia rare to common, rounded to polygonal in cross-section, very short, restricted to the outermost part of exozone, containing no diaphragms. Autozooecial walls crenulated, displaying granular microstructure, 0.006–0.010 mm thick in endozone; distinct reverse V-shaped lamination and dark serrated medial line, 0.054–0.100 mm thick in exozone. Acanthostyles variable in size and origin: small, dark coloured styles, restricted to exozone, common; large, prominent styles, having distinct hyaline cores and laminated sheaths, occurring irregularly in inner exozone of more heavily calcified areas, seemingly absent in some colonies; if present, usually 2–4 surrounding each autozooecial aperture.

Remarks. *Homotrypa migueli* (Prantl, 1940) is very similar to *H. similis* Foord, 1883 in the low budding angle of the autozooecia and rare mesozooecia. The latter species has smaller autozooecial aperture diameters (0.12 mm vs. 0.16 mm in *H. migueli* at average; data from Karklins 1984).

Genus ***ATACTOPORELLA*** Ulrich, 1883

Type species. *Atactoporella typicalis* Ulrich, 1883, Upper Ordovician (Cincinnatian); North America.

Diagnosis. Flattened encrusting and massive, rarely dendroid colonies. Autozooecial apertures petaloid. Diaphragms and cystiphragms common, especially in distal parts of autozooecia. Mesozooecia common, containing frequent horizontal diaphragms. Acanthostyles common, large, inflecting autozooecia.

Remarks. *Atactoporella* Ulrich, 1883 differs from *Monticulipora* d'Orbigny, 1850 by having larger acanthostyles and more abundant mesozooecia and from *Prasopora*

Nicholson & Etheridge, 1877 by having larger acanthostyles. *Peronopora* Nicholson, 1881 is morphologically very similar to *Atactoporella*, but differs from it by the bifoliate colony form.

Occurrence. Middle to Upper Ordovician of North America, and Upper Ordovician to Lower Silurian of Europe.

Atactoporella magnopora sp. nov. (Pl. 3, figs 14–16; Appendix)

Holotype. IGR 36004 (longitudinal and tangential sections of a single specimen).

Type locality. Petite Glauzy, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, probably Ashgill.

Etymology. The species name '*magnopora*' refers to the large autozooecial apertures of the new species.

Description. Massive hemispheric colony, consisting of encrusting layers, 17 mm high and 25 mm in diameter. Layers 1.6–5.0 mm thick. Secondary overgrowths common, usually marked by repeated appearance of prominent acanthostyles. Autozooecia straight, budding slightly recumbent from the substrate and intersecting branch surface at right angles. Autozooecial apertures rounded to slightly angular to petaloid, spaced 3–4 in 2 mm of the colony surface and 4–5 in 1 mm^2. Autozooecial diaphragms thin, widely spaced, variously shaped: horizontal, curved and cystoidal. Cystiphragms small, flattened, spaced 33–44 in 1 mm of autozooecial length, positioned usually on one side of the autozooecial chamber. Mesozooecia abundant, angular in cross-section, isolating autozooecial apertures, 8–11 surrounding each aperture, bearing abundant horizontal diaphragms. Acanthostyles large and prominent, having distinct hyaline cores and dark sheaths, occurring in autozooecial, but more common in mesozooecial walls, usually positioned at junctions between autozooecia and/or mesozooecia, up to 6 surrounding each autozooecial aperture, originating in proximal parts of colony or growth layers, arising often from such horizontal elements as cystiphragms and mesozooecial diaphragms. Indistinct maculae comprised of megazooecia present.

Remarks. *Atactoporella magnopora* sp. nov. differs from the similar species *A. mundula* Ulrich, 1879 and *A. ortoni* (Nicholson, 1874) by having larger apertures (0.24–0.38 mm in *A. magnopora* vs. 0.11–0.18 mm in *A. mundula* and 0.18–0.27 mm in *A. ortoni*; measurements are from Ulrich (1883)). The new species differs from *A. typicalis* Ulrich, 1883 by colony shape as well as larger and more widely spaced autozooecial apertures (0.24–0.38 mm in *A. magnopora* vs. 0.17 mm in *A. typicalis* Ulrich, 1883).

Atactoporella irregularis Boulange, 1963 (Pl. 3, figs 17–18, Plate 4, figs 1–3; Appendix)

1963 *Atactoporella irregularis* Boulange: 35–37, pl. 1, figs 2a, b; text-fig. 2.

?1990 *Prasopora carnica* Vinassa de Regny, 1914; Conti: 91, pl. 1, figs 1–4.

Holotype. N 82, Upper Ordovician (Ashgill). Glauzy (Herault). Collection of the l'Institut de gèologie de Lyon.

Material. UM2-AE 2-2, 2-3, 2-31, 4-1, 5, 32; IGR 36002.

Occurrence. Upper Ordovician, Caradoc to Ashgill, Grange du Pin, Petite Glauzy, Montagne de Noire, southern France.

Description. Flattened ramose colonies, branch diameter up to 9–11 mm, having distinct exozone, displaying growth zonation, usually growing from an extensive encrusting base which may be multilamellar. Single layers 1–4 mm thick, weakly differentiated into exo- and endozone; endozones 1.40–1.75 mm wide. Autozooecia tubular–prismatic, bending at low angles from the endozone, in the outermost exozone perpendicular to the colony surface. Distinct zonation in autozooecial budding occurs every 1.3–4.8 cm (3.0 cm average). Maculae of megazooecia and mesozooecia indistinctly outlined, up to 2.5–2.6 mm in diameter. Autozooecial apertures rounded–polygonal, spaced 3.5–6.0 in 2 mm, 7–11 in 1 mm^2 of colony surface in intermacular area; 2.5–4.5 in 2 mm, 5.0–8.5 in 1 mm^2 in maculae. Cystiphragms abundant throughout autozooecia, becoming closely spaced in the outermost exozone, restricting middle or side zooecial chambers, occupying 1/3 to 1/2 of its diameter. Diaphragms abundant in the endozone, sparse in exozone. Mesozooecia abundant, spaced 22–33 in 1 mm^2, separating autozooecia, 6–10 surrounding each autozooecium, polygonal in tangential section, bearing closely spaced, straight diaphragms, originating at the base of the exozone. Zooecial walls amalgamated, 0.006–0.012 mm thick. Acanthostyles common, 0.018–0.030 mm in diameter, occurring at junctions between autozooecia as well as in autozooecial and mesozooecial walls, having indistinct hyaline cores, restricted to distal parts of exozone.

Remarks. *Atactoporella irregularis* Boulange, 1963 is similar to *A. typicalis* Ulrich, 1883 in its growth form and autozooecial budding pattern, but the latter species has smaller autozooecial aperture widths (0.17 mm vs. 0.21 mm).

Remark. The species *Prasopora carnica* Vinassa de Regny, 1915 described in Conti (1990) may belong to the species *Atactoporella irregularis* Boulange, 1963. The latter species developed extensive encrusting sheets that are also characteristic for *P. carnica*. Acanthostyles appeared sporadically throughout the colony and may be lacking in scarce material. Furthermore, the figures of *Prasopora carnica* in Vinassa de Regny (1915: pl. 12, figs 7–9) strongly resemble *Crepipora vesiculosa* Boulange, 1963. Therefore, *Prasopora carnica* Vinassa de Regny, 1915 may be a synonym. Unfortunately, the type material for papers by Vinassa de Regny (1914, 1915) cannot be found.

Atactoporella sp. (Pl. 4, figs 4–11; Appendix)

Material. UM2-AE 2-9, UM2-AE 2-35, UM2-AE 2-47.

Occurrence. Upper Ordovician, Caradoc, Grange du Pin, Montagne de Noire, southern France.

Description. Sub-ramose to massive colony, up to 3.6 mm in diameter, with indistinct exozone. Autozooecia long, with polygonal cross-sections in endozone, bending quite sharply in exozone. Autozooecial apertures rounded to angular and

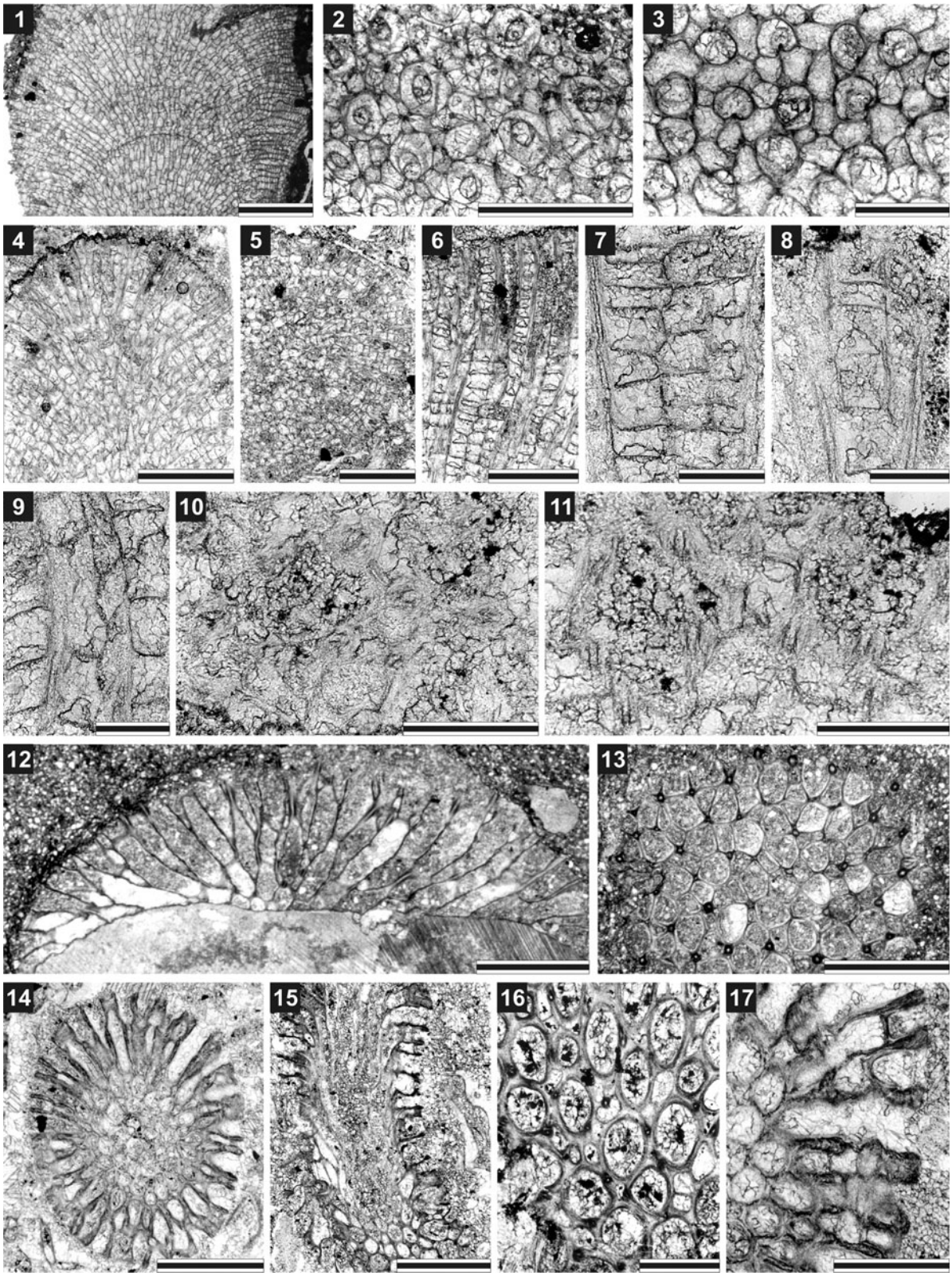

Plate 4 **1–3,** *Atactoporella irregularis* Boulange, 1963. **1**, UM2-AE 2-2, longitudinal section of the exozone, scale bar = 2 mm; **2**, IGR 36002, tangential section, scale bar = 1 mm; **3**, UM2-AE 2-31, tangential section, scale bar = 0.5 mm. **4–11,** *Atactoporella* sp. **4**, UM2-AE 2-35, longitudinal section, scale bar = 1 mm; **5**, UM2-AE-2-47, cross-section, scale bar = 1 mm; **6–9**, UM2-AE 2-9: **6**, longitudinal section, scale bar = 0.5 mm; **7**, longitudinal section, scale bar = 0.2 mm; **8**, longitudinal section, scale bar = 0.2 mm; **9**, longitudinal section, scale bar = 0.2 mm; **10**, **11**, UM2-AE 2-47: **10**, tangential section, scale bar = 0.2 mm; **11**, tangential section, scale bar = mm. **12–13**, *Dekayia minima* Conti, 1990. **12**, SMF 2138, longitudinal section, scale bar = 1 mm; **13**, SMF 2135, tangential section, scale bar = 1 mm. **14–17**, *Dekayia buttleri* sp. nov. **14**, UM2-AE 2-15, cross-section, scale bar = 1 mm; **15**, holotype UM2-AE 80-6, longitudinal section, scale bar = 1 mm; **16**, UM2-AE 80-20, tangential section, scale bar = 0.5 mm; **17**, UM2-AE 2–6, cross-section of the exozone, scale bar = 0.5 mm.

petaloid, spaced 7–8 per 2 mm. Autozooecial diaphragms common to rare, straight, thin. Flat cystiphragms occurring occasionally, positioned on one side of the autozooecial chamber. Mesozooecia abundant, large, 4–6 surrounding each autozooecial aperture, angular in cross-section, bearing abundant straight and curved diaphragms, originating in endozone. Acanthostyles long, originating in endozone, 4–6 surrounding each autozooecial aperture, having distinct 0.015–0.020 mm wide hyaline cores and wide laminated sheaths. Autozooecial walls granular–prismatic, 0.005–0.010 mm thick in endozone; laminated, slightly thickened in exozone, moderately thickened in places where acanthostyles are developed.

Remarks. The present specimen shows some similarities to *Atactoporella typicalis* Ulrich, 1883 described originally from the Cincinnatian of Ohio, USA. The latter species has a predominantly encrusting colony form with development of subramose fronds. Its dimensions are very similar to the present specimen. Unfortunately, the present material is too scarce to make more detailed remarks.

Family **HETEROTRYPIDAE** Ulrich, 1890

Genus ***DEKAYIA*** Milne-Edwards & Haime, 1851

Type species. *Dekayia aspera* Milne-Edwards & Haime, 1851. Upper Ordovician (Cincinnatian), North America.

Diagnosis. Ramose, encrusting or massive colonies. Maculae generally low or flush with the colonial surface and can have megazooecia, slightly larger acanthostyles, and a central cluster of mesozooecia, which is subsolid in some species. Autozooecia are generally angular or subangular in cross-section. Autozooecial walls are characteristically undulatory to crenulated. In exozones individual zooecial walls irregular and thick. Diaphragms commonly absent in inner endozone and either distantly and irregularly spaced or lacking in the outer endozone and the exozone. Mesozooecia rare in intermonticular areas and commonly absent. They consist of a series of beaded chambers, visible in some longitudinal and transverse sections. Tubular diaphragms do occur in mesozooecia but are extremely rare. Acanthostyles occur in all species, can originate throughout endozone and inner exozone and some terminate below colony surface.

Remarks. *Dekayia* Milne-Edwards & Haime, 1851 differs from *Heterotrypa* Nicholson 1879 by having fewer mesozooecia and usually larger acanthostyles.

Occurrence. Lower to Upper Ordovician, North America and Europe.

Dekayia minima Conti, 1990 (Pl. 4, figs 12–13, Appendix)

1990 *Dekayia minima* Conti: 104, pl. 12, figs 4–6, pl. 13, fig. 8.

Holotype. IPUM 21903e. (Museum of Institute of Palaeontology, Modena University, Italy). Upper Ordovician, Upper Caradoc (unit *c*), Sardinia (Italy).

Material. UM2-AE 21, 36, 38; SMF 2125–2128, SMF 2135–2140.

Occurrence. Upper Ordovician, Upper Caradoc (unit *c*), Sardinia, Italy. Upper Ordovician Ashgill, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy.

Description. Ramose branched and massive colonies, branch diameter 2.20–2.88 mm. Exozone 0.58–0.75 mm wide, endozones 1.04–1.38 mm wide. Bifurcations not observed. Autozooecia bending gently from endozone, intersecting colony surface at right angles. Autozooecial apertures rounded to polygonal, often petaloid, spaced 5–6 in 2 mm and 7–9 in 1 mm^2 of colony surface. Diaphragms in autozooecia usually absent, rarely 3–4 in proximal parts of autozooecia. Maculae of megazooecia indistinctly outlined. Mesozooecia abundant, spaced 9 in 1 mm^2, polygonal in cross-section, bearing thin, common diaphragms, beaded, budding deeply in endozone. Clusters of 3–4 mesozooecia common. Acanthostyles abundant, thick, prominent, possessing wide hyaline core, 3–7 surrounding each autozooecial aperture, spaced 9–12 in 1 mm^2 of colony surface. Autozooecial walls granular–prismatic, 0.012 mm thick in endozone; irregularly thickened, finely laminated, displaying reverse V-structure in longitudinal section, 0.018–0.030 mm thick in exozone.

Remarks. *Dekayia minima* Conti, 1990 differs from other species of the genus by having fewer diaphragms. It is very similar to *Dekayia aspera* Milne-Edwards & Haime, 1851, which has clearly differentiated endozonal and exozonal acanthostyles. *Dekayia pengawsensis* Buttler, 1991*a*, from the Ashgill of Wales, possesses hemispheric colonies, larger autozooecial apertures (0.29 mm average vs. 0.25 average in *D. minima*) and abundant diaphragms. *Dekayia crenulata* Prantl, 1940 has rare mesozooecia, abundant diaphragms and smaller autozooecial apertures (aperture width 0.17–0.21 vs. 0.15–0.33 mm in *D. minima*).

Dekayia buttleri sp. nov. (Pl. 4, figs 14–17; Pl. 5, fig. 1; Appendix)

Holotype. UM2-AE 80-6.

Paratypes. UM2-AE 80-20, UM2-AE 2-15.

Type locality. Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Lower Ashgill.

Etymology. This species is named for Caroline Buttler, who has contributed greatly to research on Palaeozoic bryozoans.

Material. UM2-AE 2-(6, 30, 46), 13-3, 36, 71, 81-6; IGR 36010.

Occurrence. Upper Ordovician, Caradoc to Ashgill, Petite Glauzy, Grange du Pin, Montagne de Noire, southern France.

Description. Ramose colonies, branch diameter 1.63–2.30 mm, with 0.45–0.65 mm wide exozones and 0.73–1.00 mm wide endozones. Autozooecia long, having polygonal cross-section in endozone, bending in exozone at angles of 50–70° to the colony surface. Autozooecial apertures rounded to angular and petaloid, spaced 5–7 per 2 mm. Autozooecial diaphragms rare to absent, straight and thin. Mesozooecia common, 4–6 surrounding each autozooecial

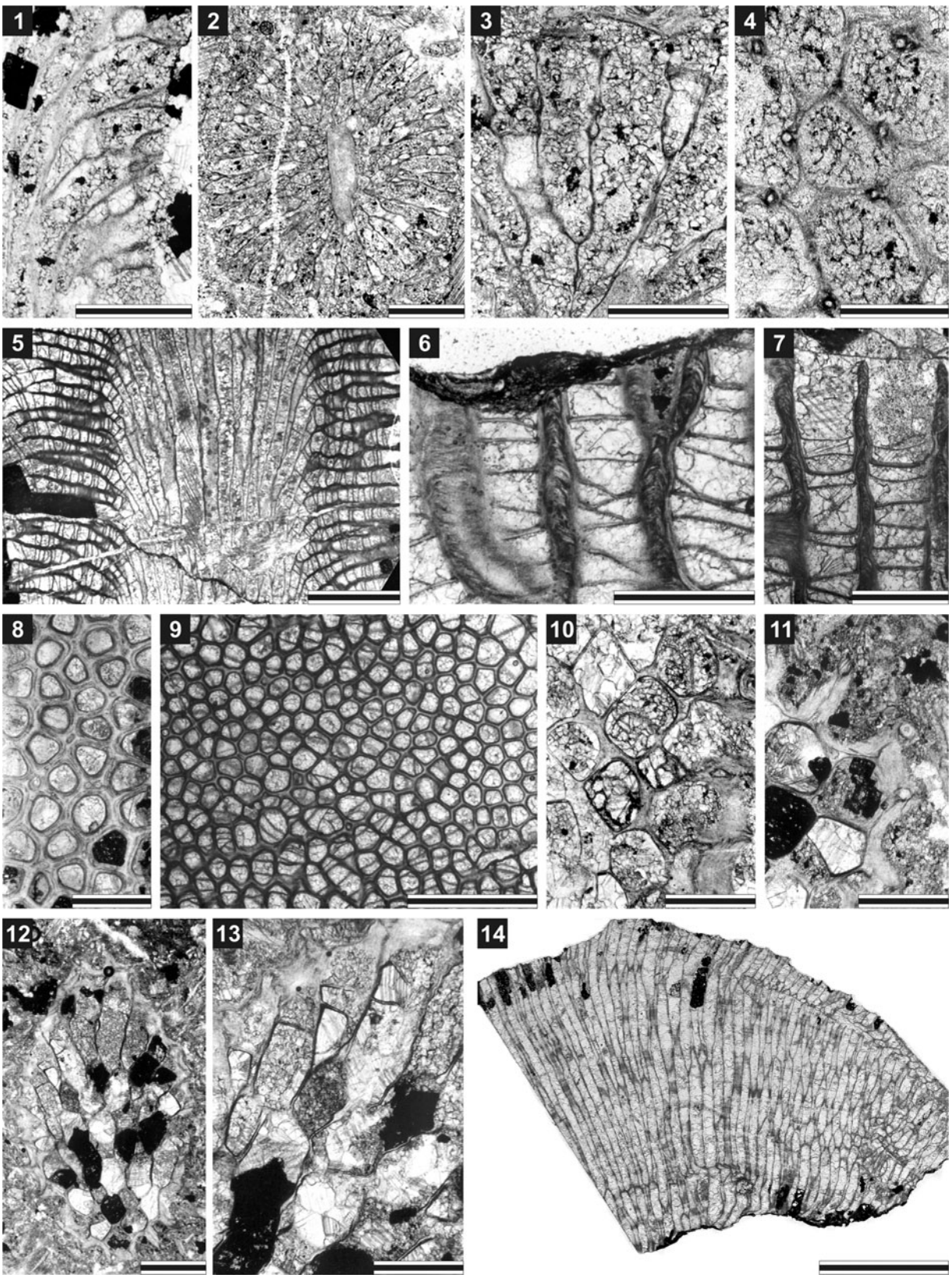

Plate 5 **1**, *Dekayia buttleri* sp. nov. UM2-AE 2-30, longitudinal section, scale bar = 0.5 mm. **2–4**, *Dekayia* sp. **2**, **3**, UM2-AE 80-5: **2**, longitudinal section, scale bar = 1 mm; **3**, longitudinal section, scale bar = 0.5 mm; **4**, UM2-AE 80-9, tangential section, scale bar = 0.2 mm. **5–9**, *Heterotrypa magnopora* Boulange, 1963. **5**, IGR 36036, longitudinal section of the branch, scale bar = 2 mm; **6**, IGR 36037, longitudinal section of the exozone, scale bar = 0.5 mm; **7**, IGR 36036, longitudinal section of the exozone, scale bar = 0.5 mm; **8**, UM2-AE 61, tangential section, scale bar = 1 mm; **9**, IGR 36036, tangential section, scale bar = 2 mm. **10–13**, *Hemiphragma subtile* Conti, 1990. **10–12**, UM2-AE 74-2: **10**, tangential section, scale bar = 0.5 mm; **11**, tangential section, scale bar = 0.5 mm; **12**, cross-section, scale bar = 1 mm; **13**, UM2-AE 80-9, longitudinal section, scale bar = 1 mm, **14**, *Stigmatella sinuosa* Conti, 1990, IGR 36029, longitudinal section, scale bar = 5 mm.

aperture, angular to rounded in cross-section, bearing abundant straight and curved diaphragms, originating at the base of exozone, slightly beaded in places where diaphragms occurring. Acanthostyles small, 3–4 surrounding each aperture, originating at base of exozone, having distinct hyaline cores and dark laminated sheaths. Autozooecial walls granular–prismatic, 0.005 mm thick in endozone; laminated, regularly thickened in exozone, up to 0.025–0.040 mm thick.

Remarks. *Dekayia buttleri* sp. nov. differs from *D. minima* Conti, 1990 in having more abundant mesozooecia and smaller acanthostyles.

Dekayia sp. (Pl. 5, figs 2–4; Appendix)

Material. UM2-AE 80-(5, 9, 19, 20), 81-2.

Occurrence. Upper Ordovician (Ashgill); Grange du Pin, Montagne de Noire, southern France.

Description. Encrusting colony, 1.05–1.50 mm thick. Autozooecia prismatic, having polygonal cross-section in endozone, bending sharply in exozone and intersecting colony surface at right angles. Autozooecial apertures rounded–polygonal, spaced 6–9 per 2 mm. Autozooecial diaphragms rare to absent, straight, thin. Mesozooecia locally abundant, angular in cross-sections, bearing straight diaphragms, short, originating in exozone, locally sealed by skeleton near the surface, beaded around diaphragms. Acanthostyles 0.020–0.035 mm in diameter, occurring throughout exozone, 2–3 surrounding each autozooecial aperture, having distinct hyaline cores and dark laminated sheaths. Autozooecial walls granular–prismatic, 0.005–0.010 mm thick in endozone; laminated, displaying distinct rare monilae in exozone, up to 0.03 mm thick.

Remarks. The present material is similar to *Dekayia gregaria* Ulrich, 1882 from the Upper Ordovician of Cincinnati, USA. The latter species has thin encrusting colonies and rare mesozooecia.

Genus ***HETEROTRYPA*** Nicholson, 1879

Type species. *Monticulipora frondosa* d'Orbigny, 1850. Upper Ordovician (Cincinnatian); North America.

Diagnosis. Frondose, ramose or less commonly encrusting colonies. Autozooecial walls variably thick. Zooecial boundaries form a conspicuous dark line in inner exozones and in a broad zone of abutting laminae or are completely obscured in outer exozones. Walls generally amalgamate. Diaphragms are generally few in endozones, but are moderately abundant in some species. In exozones, autozooecial diaphragms are closely and regularly spaced, thin, planar and perpendicular to the zooecial walls. Intermonticular mesozooecia range from abundant and regularly arranged to scattered or absent. Mesozooecia commonly develop moniliform chambers at proximal ends and tend to become smaller or are terminated distally within exozones. Diaphragms in mesozooecia noticeably thicker and more closely spaced than autozooecial diaphragms. Two kinds of acanthostyles within the genus; regular acanthostyles limited to exozone and endacanthostyles originating in both endozone and exozone. Endacanthostyles occur in all species. Monticules generally have a central cluster of a few mesozooecia.

Remarks. *Heterotrypa* differs from the most similar genus *Dekayia* Milne-Edwards & Haime, 1851 by having fewer and smaller acanthostyles as well as more abundant mesozooecia.

Occurrence. Middle Ordovician to Devonian.

Heterotrypa magnopora Boulange, 1963 (Pl. 5, figs 5–9; Appendix)

1963 *Heterotrypa magnopora* Boulange: 37, pl. I, fig. 4 a, b; text-fig. 3.

Holotype. N 333, Institut Catholique de Toulouse. Upper Ordovician (Ashgill), Grange de Pin (Montagne de Noire, southern France).

Material. UM2-AE 60-61; IGR 36036–36037.

Occurrence. Upper Ordovician, ? Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France.

Description. Ramose colonies, branch diameter 4–12 mm, often oval in cross-section. Endozone 1.75–4.90 mm; exozone distinct, 1.13–3.55 mm wide. Secondary overgrowths common. Autozooecia polygonal in cross-section in endozone, growing for a long distance in endozone, then bending sharply in exozone and intersecting colony surface at right angles. Autozooecial apertures polygonal with rounded corners in exozone, spaced 4.0–6.5 in 2 mm of intermacular area, 3.5–4.5 in 2 mm of macular area 7–10 in 1 mm^2 of macular area and 4–6 in 1 mm^2 of macular area, respectively. Endozonal diaphragms thin, absent to rare, widely spaced. Exozonal diaphragms in autozooecia abundant, thick, originating from cortex of exozonal walls, spaced closely, often oblique. Mesozooecia rare, small, restricted to exozone. Acanthostyles usually small, rare to common, spaced 1–5 around autozooecial apertures, having distinct hyaline cores, often indenting into the autozooecia. Autozooecial walls 0.006 mm thick, slightly wavy in endozone; 0.054–0.162 mm thick, displaying reverse U-shaped lamination and thick cortex, from which exozonal diaphragms originate. Maculae consisting of larger autozooecia, 1.86–2.60 mm in diameter, spaced 3.60–4.34 mm from centre to centre.

Remarks. *Heterotrypa magnopora* Boulange, 1963 is distinguished by its large autozooecial apertures, small acanthostyles, which are restricted to the exozone and rare diaphragms in endozone. *Heterotrypa sladei* Buttler, 1991*a* from the Slade and Redhill Beds (upper Rawtheyan, Ashgill) of Wales is very similar to *H. magnopora*, but differs in having more abundant mesozooecia, more abundant diaphragms in endozone, as well as smaller autozooecial apertures (0.23 mm vs. 0.27 mm average in *H. sladei*). *Heterotrypa frondosa* (d'Orbigny, 1850) differs in having more mesozooecia. Marintsch (1998) described the junior homonym *Heterotrypa magnopora* without apparent knowledge that the species name was previously used by Boulange (1963). This species must therefore be re-named because of the priority rule of the International Commission of Zoological Nomenclature.

Genus ***HEMIPHRAGMA*** Ulrich, 1893

Type species. *Batostoma irrasum* Ulrich, 1886. Middle Ordovician (Trenton), North America.

Diagnosis. Colonies massive and ramose. Autozooecia with polygonal and polygonal–rounded apertures. Complete and perforated diaphragms abundant in exozone. Autozooecial walls in exozone strongly thickened, partly integrated, displaying sloped and longitudinally lamellar microstructure. Mesozooecia usually rare, but sometimes abundant. Acanthostyles usually small and rare, but sometimes abundant.

Remarks. *Hemiphragma* Ulrich, 1893 is most similar to *Phragmopora* Vinassa de Regny, 1921, differing in the presence of acanthostyles and smaller mesozooecia.

Occurrence. Lower to Middle Ordovician, North America, Europe, Siberia.

Hemiphragma subtile Conti, 1990 (Pl. 5, figs 10–13)

1990 *Hemiphragma subtile* Conti: 97, pl. 7, figs 1–6.

Holotype. IPUM 21849 (Museum of Institute of Palaeontology, Modena University, Italy). SE Sardinia; unit *c* (Upper Caradoc).

Material. UM2-AE 12-2, 74-2, 80-(9, 10).

Occurrence. Upper Ordovician, Ashgill, Le Glauzy, Grange du Pin, Montagne de Noire, southern France. Sicily, Upper Ordovician, Upper Caradoc (unit *c*).

Description. Ramose colonies, branch diameter 1.15–2.75 mm. Endozone 0.63–1.18 mm wide; exozone 0.26–0.79 mm wide. Autozooecia polygonal in cross-section in endozone, becoming rounded–polygonal in exozone, bending at high angles in exozone, bearing moderately thick hemiphragms. Autozooecial apertures 0.18–0.23 mm wide. Hemiphragms most abundant in outermost parts of autozooecia, long and curved to proximal end on their inner edge. Mesozooecia rare, 0.09–0.10 mm in diameter, restricted to exozone. Acanthostyles abundant, 0.06–0.09 mm in diameter, prominent, having distinct and wide hyaline cores. Walls straight, displaying hyaline microstructure, 0.024–0.030 mm thick in endozone; laminated, integrated, with distinct median lining, thickened up to 0.16 mm in exozone.

Remarks. The present species is most similar to *Hemiphragma subtile* Conti, 1990, from the Upper Ordovician of Sicily. It differs only in having smaller colonies. *Hemiphragma subtile* Conti, 1990 differs from *H. pulchra* Loeblich, 1942, from the Bromide Formation (Middle Ordovician), Oklahoma, USA, by its smaller colony size and smaller autozooecial apertures (0.18–0.23 mm vs. 0.28–0.40 mm in *H. pulchra*).

Genus ***STIGMATELLA*** Ulrich & Bassler, 1904

Type species. *Stigmatella crenulata* Ulrich & Bassler, 1904. Upper Ordovician (Richmondian); North America.

Diagnosis. Encrusting, massive or ramose colonies. Autozooecia with angular, rounded–angular and petaloid apertures. Walls thin, amalgamate, longitudinal or diagonally laminated microstructure, with regular thickenings because of development of acanthostyles. Diaphragms thin, abundant or rare, sometimes absent. Mesozooecia rare, with abundant diaphragms, often beaded, restricted to exozone, budding from zooecial walls. Acanthostyles usually abundant, short, originating in zooecial walls repeatedly through and restricted to the exozone.

Remarks. *Stigmatella* Ulrich & Bassler, 1904 differs from the most similar genus *Heterotrypa* by the longitudinally and obliquely laminated wall structure and by repeated development of acanthostyles through the exozone.

Occurrence. Lower Ordovician to Lower Silurian, worldwide.

Stigmatella sinuosa Conti, 1990 (Pl. 5, fig. 14, Plate 6, figs 1–4; Appendix)

1990 *Stigmatella sinuosa* Conti: 104–105, pl. 9, fig. 8, pl. 12, figs 7–8, pl. 13, figs 1–2.

Holotype. IPUM 21874 (Museum of the Institute of Palaeontology, Modena University, Italy). Upper Ordovician (Caradoc to Ashgill), Sardinia (Italy).

Material. IGR 36028ab, 36029, 36031–36032, 36034, 36050.

Occurrence. Upper Ordovician, ? Ashgill, Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

Description. Encrusting colonies, sometimes hemispherical, 1–16 mm thick. Secondary overgrowths common, single layers up to 1–4 mm thick. Repeated exozones common. Autozooecia budding for a short distance in endozone parallel to substrate, then bending sharply and intersecting colony surface at right angles. Autozooecial apertures rounded–polygonal, spaced 4–8 in 2 mm in intermacular areas, 2–5 in 2 mm in macular areas, 6–13 in 1 mm^2 of intermacular area and 4.0–7.5 in 1 mm^2 in macular area, respectively. Diaphragms rare to absent, thin and straight to slightly curved. Mesozooecia rare to common, more abundant in maculae, polygonal in cross-section, 3–8 in 1 mm^2 of colony surface, restricted to exozone, beaded, containing abundant diaphragms. Acanthostyles common, small with indistinct cores, spaced in corners of autozooecial apertures, 1–8 surrounding autozooecial apertures, originating repeatedly in exozone. Autozooecial walls 0.006–0.010 mm thick, often crenulated, finely laminated and displaying indistinct median lining, regularly beaded because of development of acanthostyles. Maculae consisting of megazooecia and exilazooecia, 2.6–3.0 mm in diameter, spaced about 3.0–3.5 mm from centre to centre.

Remarks. *Stigmatella sinuosa* Conti, 1990 is similar to *S. massalis* Bassler, 1911*a*, from the Keila Stage of Estonia, in having rare and beaded mesozooecia and small acanthostyles, but differs from it in smaller autozooecia in macular area (see below).

Stigmatella carnica sp. nov. (Pl. 6, figs 5–8; Appendix)

Holotype. SMF 2129, single specimen, four thin sections.

Type locality. Valbertad, Carnic Alps, Italy.

Type stratum. Upper Ordovician, Upper Caradoc to Lower Ashgill, Uggwa Formation, siltstone/sandstone member.

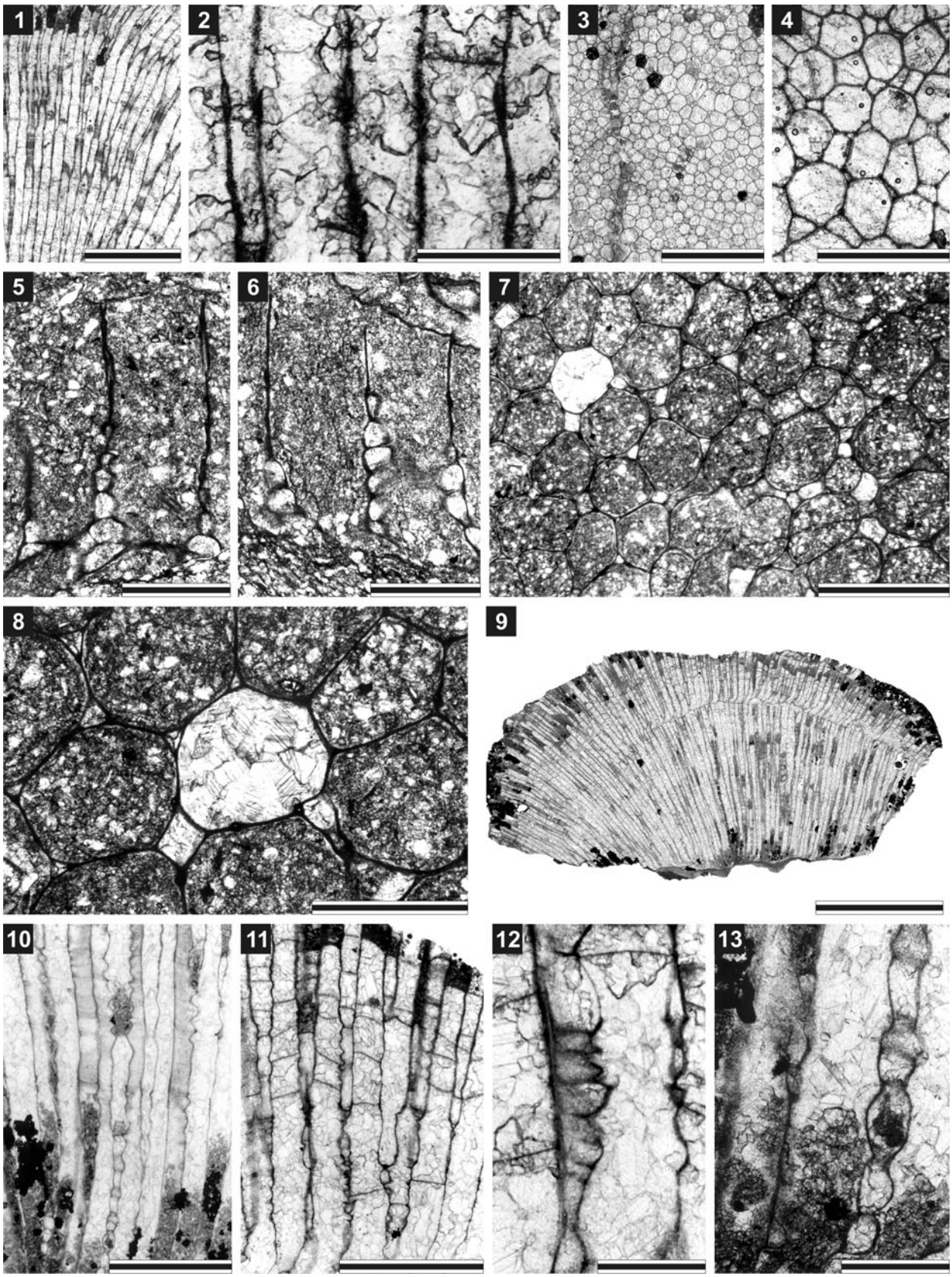

Plate 6 **1–4**, *Stigmatella sinuosa* Conti, 1990, IGR 36029: **1**, longitudinal section, scale bar = 2 mm; **2**, longitudinal section, scale bar = 0.5 mm; **3**, tangential section, scale bar = 3 mm; **4**, tangential section, scale bar = 1 mm. **5–8**, *Stigmatella carnica* sp. nov, SMF 2129: **5**, longitudinal section, scale bar = 0.5 mm; **6**, longitudinal section, scale bar = 0.5 mm; **7**, tangential section, scale bar = 1 mm; **8**, tangential section, scale bar = 0.5 mm. **9–13**, *Stigmatella massalis* Bassler, 1911*a*. UM2-AE 76: **9**, longitudinal section, scale bar = 10 mm; **10**, longitudinal section, scale bar = 2 mm; **11**, longitudinal section, scale bar = 2 mm; **12**, longitudinal section, scale bar = 0.5 mm; **13**, longitudinal section, scale bar = 0.5 mm.

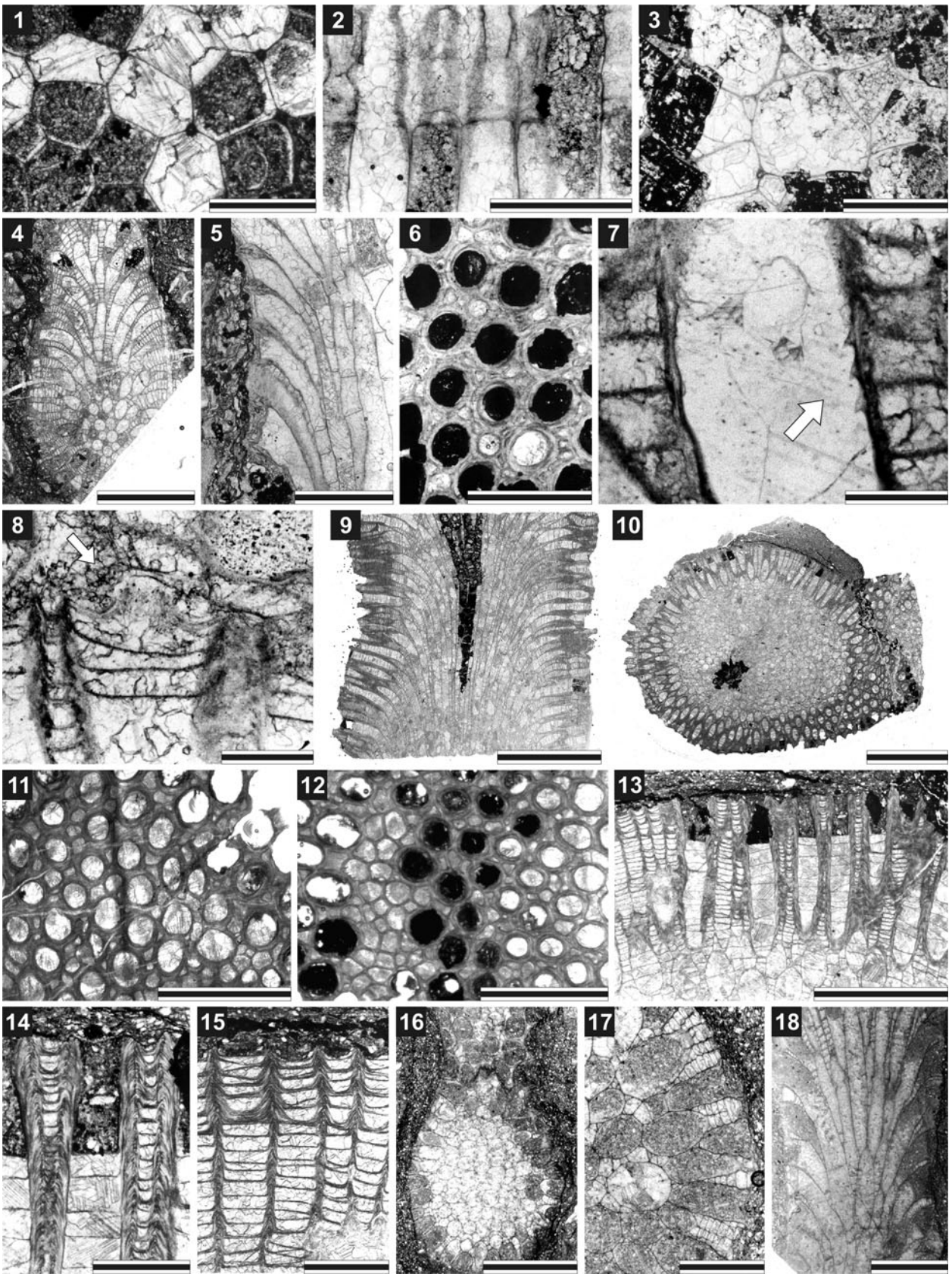

Plate 7 **1–3**, *Stigmatella massalis* Bassler, 1911*a*. UM2-AE 76: **1**, tangential section, scale bar = 0.5 mm; **2**, longitudinal section, scale bar = 1 mm; **3**, tangential section, scale bar = 0.5 mm. **4–8**, *Hallopora elegantula* (Hall, 1852). **4**, UM2-AE 28, oblique section of the branch, scale bar = 2 mm; **5**, UM2-AE 59-14, longitudinal section, scale bar = 1 mm; **6**, IGR 36021, tangential section, scale bar = 1 mm; **7**, **8**, IGR 36054: longitudinal section, arrow = mural spines, scale bar = 0.2 mm; **8**, longitudinal section, arrow = cup-like apparatus; scale bar = 0.25 mm.

ETYMOLOGY. The specific name refers to the type locality of this species in the Carnic Alps.

DIAGNOSIS. Encrusting colony; autozooecia prismatic, with rounded–polygonal apertures; autozooecial diaphragms rare; mesozooecia common, beaded, bearing abundant diaphragms; acanthostyles common; maculae consisting of megazooecia.

DESCRIPTION. Encrusting colony (apparently discoidal), 3.2 mm thick in central part. Secondary overgrowths common. Autozooecia bending gently to the colony surface, sometimes originating from mesozooecia. Autozooecial apertures rounded–polygonal, spaced 7–9 in 2 mm in intermacular area, 6 in 2 mm in macular area and 4 in 1 mm^2 in all areas. Diaphragms rare, thin and straight to slightly curved. Mesozooecia common, more abundant in maculae, polygonal in cross-section, spaced 3–8 in 1 mm^2 of colony surface, beaded, containing abundant diaphragms. Mesozooecial diaphragms spaced 7.0–12.5 per 1 mm of axial length of mesozooecia. Acanthostyles common, distributed irregularly, small, having distinct cores, positioned in autozooecial walls, indenting autozooecial apertures, 1–3 surrounding each autozooecial aperture. Autozooecial walls 0.01–0.04 mm thick, straight, indistinctly laminated, beaded regularly in places of development of acanthostyles. Maculae consisting of megazooecia and exilazooecia.

REMARKS. *Stigmatella carnica* sp. nov. is most similar to *S. halysa* Armstrong, 1945, from the Upper Ordovician of Canada, in having beaded mesozooecia and small acanthostyles, but differs from it by having larger and more widely spaced autozooecia (7–9 vs. 8–12 apertures per 2 mm in intermacular areas, respectively). The present material is also very similar to *S. ottawaensis* Fritz, 1957 (Ottawa Formation, Middle Ordovician, North America), from which only the holotype was described as having a hemispheric colony 50 mm in diameter and 20 mm thick. Fritz (1957) reported 7–8 autozooecial apertures per 2 mm in intermacular areas and 5 in the same distance in maculae.

Stigmatella massalis Bassler, 1911*a* (Pl. 6, figs 9–13, Plate 7, figs 1–3; Appendix)

1911*a* *Stigmatella massalis* Bassler: 211–212, text-figs 115a–d.

MATERIAL. Two colonies UM2-AE 76 and IGR 36030, 36035.

OCCURRENCE. Upper Ordovician, Caradoc, Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Hemispherical massive colonies, 35 mm in diameter and 17–19 mm thick. Secondary overgrowths present. Repetitious exozones common. Autozooecia budding for a short distance in endozone parallel to substrate, then bending sharply and intersecting colony surface at right angles. Autozooecial apertures polygonal, spaced 5.5–7.0 in 2 mm of intermacular area and 3.5–4.0 in 2 mm of macular area. Diaphragms thin and straight to slightly curved, rare to absent in endozone, becoming abundant in exozone. Mesozooecia rare to common in intermacular areas, abundant in maculae, polygonal in cross-section, restricted to the exozone, beaded, containing abundant diaphragms. Acanthostyles common, small with distinct cores, spaced in corners of autozooecial apertures, 1–3 surrounding each autozooecial aperture, originating repeatedly in exozone. Autozooecial walls 0.005–0.015 mm thick, often strongly crenulated, finely laminated, beaded on regular distances because of development of acanthostyles. Maculae consisting of larger autozooecia and exilazooecia, 2.8–3.2 mm in diameter, spaced about 6–7 mm apart.

REMARKS. The present material matches well in morphological peculiarities and dimensions with *Stigmatella massalis* Bassler, 1911*a*, originally described from the Keila Stage (Caradoc) of Estonia. Its differs from *S. sinuosa* Conti, 1990 in having more abundant mesozooecia, larger autozooecial apertures in macular area (0.49 mm in present material vs. 0.40 mm in *S. sinuosa*), as well as more abundant diaphragms. *Stigmatella catenulata* Parks & Dyer, 1922 from the Upper Ordovician of Canada is also similar in having beaded mesozooecia and sparse acanthostyles, but differs in having smaller and more closely spaced autozooecial apertures. Furthermore, autozooecial walls in *S. catenulata* are less crenulated than in *S. massalis*.

Family **HALLOPORIDAE** Bassler, 1911*a*

Genus ***HALLOPORA*** Bassler, 1911*a*

TYPE SPECIES. *Callopora elegantula* Hall, 1852, Lower Silurian (Niagaran), USA.

DIAGNOSIS. Ramose cylindrical colonies with distinct exozones. Apertures polygonal or rounded–polygonal, with perforated covers in some species. Walls in exozone weakly, sometimes significantly, thickened, displaying diagonally laminated microstructure. Diaphragms thin, planar and sloping, especially abundant in distal part of exozone. Mesozooecia variable in number, with frequent diaphragms. Styles absent.

REMARKS. The genus *Hallopora* Bassler, 1911*a* differs from *Diplotrypa* Nicholson, 1879 by its ramose colony form, arrangement of diaphragms and wall microstructure. *Parvohallopora* Singh, 1979 differs from *Hallopora* by the angular to subcircular shape of autozooecia in cross-section, usually smaller autozooecia and mesozooecia, as well as rare cystoidal diaphragms.

OCCURRENCE. Lower Ordovician to Upper Silurian, North America, Europe, Siberia, Australia.

9–15, *Hallopora cystoidalis* Conti, 1990. UM2-AE 16: **9**, longitudinal section of the branch, scale bar = 5 mm; **10**, cross-section of the branch, scale bar = 5 mm; **11**, tangential section, scale bar = 2 mm; **12**, tangential section, scale bar = 2 mm; **13**, cross-section of the exozone, scale bar = 2 mm; **14**, cross-section of the exozone, scale bar = 0.5 mm; **15**, cross-section of the exozone, scale bar = 0.5 mm. **16–18**, *Hallopora enodis* Bassler, 1927. **16**, SMF 2132, cross-section of the branch, scale bar = 3 mm; **17**, **18**, SMF 2131: **17**, cross-section of the exozone, scale bar = 1 mm; **18**, longitudinal section of the branch, scale bar = 1 mm.

Hallopora elegantula (Hall, 1852) (Pl. 7, figs 4–8; Appendix)

Material. UM2-AE 15-(1–5), 28, 59-14, 82; IGR 36021–36023, IGR 36053–36059; SMF 2130.

Occurrence. *Hallopora elegantula* (Hall, 1852) is widely distributed in the Upper Ordovician of Europe and Scandinavia and Lower to Middle Silurian of North America. Investigated material comes from the Montagne de Noire, southern France (Upper Ordovician, Upper Caradoc to Lower Ashgill), and from the Carnic Alps, Italy (Upper Ordovician, Upper Caradoc to Lower Ashgill, Uggwa Formation, siltstone/sandstone member.)

Description. Ramose colonies, branch diameter 2.5–11.0 mm. Endozone 1.1–4.0 mm wide; exozone distinct, 0.7–3.5 mm wide. Autozooecia long, growing parallel to branch axis for a long distance in endozone, in exozone bending sharply and intersecting colony surface at high angles, having rounded–polygonal shape in cross-section in endozone, rounded in exozone. Origination of autozooecia from mesozooecia common. Autozooecial apertures distinctly rounded to oval, spaced 3–6 in 2 mm distance and 3–5 in 1 mm^2. Autozooecial diaphragms thin, rare to absent in endozone, planar, cystoidal and inclined, developed as extension of wall cortex, spaced 6–8 in 1 mm of autozooecial axial length in exozone. Cystoidal diaphragms rare, restricting parts of autozooecia. Distinctive cap-like apparatus *sensu* Conti & Serpagli (1987) present. Mural spines common. Mesozooecia long, budding in endozone, or from autozooecia in inner exozone, polygonal in tangential sections, often separating autozooecia completely from each other, 9–19 surrounding each autozooecium in exozone. Mesozooecial diaphragms abundant, planar and inclined, spaced 12–21 in 1 mm of axial length of a mesozooecium. Autozooecial walls indistinctly laminated, 0.01–0.02 mm thick in endozone; displaying distinct reverse V-shaped structure with dark autozooecial border, having well developed cortex continued in diaphragms, 0.03–0.11 mm thick in exozone. Monticulae consisting of larger autozooecia and gatherings of mesozooecia, slightly elevated.

Remarks. *Hallopora elegantula* (Hall, 1852) differs from *H. cystoidales* Conti, 1990 by having smaller autozooecial apertural diameters (average of 0.31 mm vs. 0.39 mm in *H. cystoidales*). The species *H. peculiaris* Pushkin, 1987 *in* Ropot & Pushkin, 1987, has larger apertures (average of 0.37 mm vs. 0.31 mm in *H. elegantula*), smaller mesozooecia and fewer diaphragms in autozooecia. Conti (1990) has summarised a comprehensive synonymy list for *H. elegantula* with Ordovician and Silurian records of this species. McKinney (pers. comm., 2005) suggested that these records may include two different species, restricted to the Ordovician and Silurian, respectively. Indeed, there are two 'variations' of *H. elegantula*, thick-walled and thin-walled ones. Our material is certainly conspecific with Conti's material from Sardinia and also very similar to the lectotype AMNH 1746/1 (The American Museum of Natural History) described by Ross (1969), and to the material from the Niagaran of Indiana, USA, described by Perry & Hattin (1960). However, a redescription of *H. elegantula* is beyond the scope of present paper.

Hallopora cystoidales Conti, 1990 (Pl. 7, figs 9–15; Appendix)

1990 *Hallopora cystoidales* Conti: 99, pl. 8, figs 3–7.

Holotype. IPUM 19997a (Museum of the Institute of Palaeontology, Modena University, Italy). Upper Ordovician, Upper Caradoc (unit *c*), Sardinia (Italy).

Material. UM2-AE 16–17; IGR 36011.

Occurrence. Upper Ordovician, Upper Caradoc (unit *c*), Sardinia (Italy). Upper Ordovician, Caradoc, Le Glauzy, Montagne de Noire, southern France.

Description. Ramose colonies, branch diameter 4–13 mm. Endozone 3.0–6.5 mm wide; exozone distinct, 0.50–3.25 mm wide. Autozooecia long, growing parallel to branch axis for a long distance in endozone, in exozone bending sharply and intersecting branch surface at angles of 70–90°, having rounded–polygonal shape in cross-section in endozone. Autozooecial apertures rounded to oval, spaced 3.0–3.5 in 2 mm distance and 2–3 in 1 mm^2 in intermacular areas. Origination of autozooecia from mesozooecia common. Autozooecial diaphragms thin, rare to absent in endozone, planar, cystoidal and inclined, developed as extension of wall cortex, spaced 5–7 in 1 mm of autozooecial axial length in exozone. Cystoidal diaphragms usually positioned on distal side of autozooecia. Mesozooecia long, originating in endozone or inner exozone, polygonal in tangential sections, only rarely completely surrounding autozooecia. Mesozooecial diaphragms abundant, planar and inclined, spaced 8–21 in 1 mm of axial length of a mesozooecium. Zooecial walls indistinctly laminated, 0.01–0.025 mm thick in endozone; displaying distinct reverse V-shaped structure with dark autozooecial border, having well developed cortex continued in diaphragms, 0.06–0.13 mm thick in exozone. Maculae consisting of larger autozooecia and gatherings of mesozooecia, slightly elevated, 3.0–3.5 mm in diameter.

Remarks. *Hallopora cystoidales* Conti, 1990 can be distinguished by its large apertures, abundant diaphragms and presence of cystoidal diaphragms in exozone and by rare diaphragms in endozone. *Hallopora peculiaris* Pushkin, 1987 *in* Ropot & Pushkin 1987, has similar autozooecial apertural diameters, but differs in having smaller mesozooecia and in the absence of cystoidal diaphragms in autozooecia. *Hallopora elegantula* (Hall, 1852) has smaller autozooecial apertures (average of 0.31 mm vs. 0.39 mm in *H. cystoidales*) and more abundant mesozooecia.

Hallopora enodis Bassler, 1927 (Pl. 7, figs 16–18, Pl. 8, figs 1–3; Appendix)

1927 *Hallopora enodis* Bassler: 154, pl. 7, fig. 9, pl. 10, figs 3–5.

Material. SMF 2131–2134.

Occurrence. Upper Ordovician (Richmondian); Anticosti Island. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy.

Description. Ramose colonies, branch diameter 5.0–5.5 mm. Exozone distinct, 1.06–1.50 mm wide, endozone 2.5–2.88 mm wide. Autozooecia long, growing parallel to

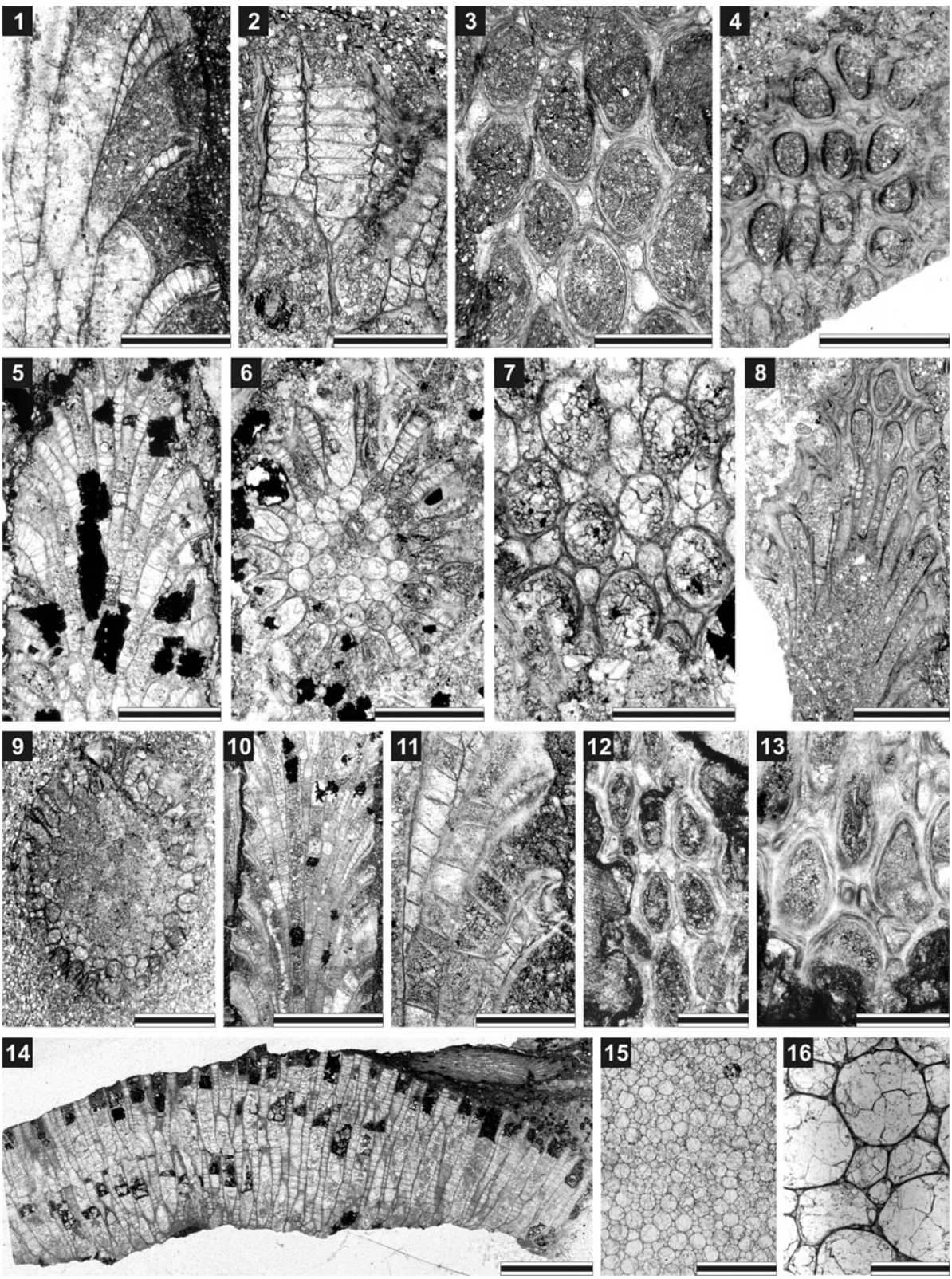

Plate 8 **1–3**, *Hallopora enodis* Bassler, 1927. **1**, SMF 2132, longitudinal section of the branch, scale bar = 1 mm; **2**, SMF 2134, cross-section of the branch, scale bar = 0.5 mm; **3**, SMF 2131, tangential section, scale bar = 1 mm. **4, 8–13**, *Parvohallopora onealli* (James, 1875). **4**, SMF 2142, tangential section, scale bar = 1 mm; **8**, SMF 2143, longitudinal section, scale bar = 1 mm; **9**, SMF 2152, longitudinal section, scale bar = 1 mm; **10**, **11**, UM2-AE 29: **10**, longitudinal section, scale bar = 2 mm; **11**, longitudinal section, scale bar = 0.5 mm; **12**, UM2-AE 21, longitudinal section, scale bar = 0.5 mm; **13**, UM2-AE 38, longitudinal section, scale bar = 0.5 mm. **5–7**, *Hallopora gracilens* Bassler, 1927. **5**, UM2-AE 2–11, longitudinal section, scale bar = 1 mm; **6**, UM2-AE 2-16, cross-section, scale bar = 1 mm; **7**, UM2-AE 2-43, tangential section, scale bar = 0.5 mm. **14–16**, *Diplotrypa languedociana* Dreyfuss, 1948. **14**, IGR 36012, longitudinal section, scale bar = 3 mm; **15**, **16**, IGR 36013: **15**, longitudinal section, scale bar = 2 mm; **16**, longitudinal section, scale bar = 0.5 mm.

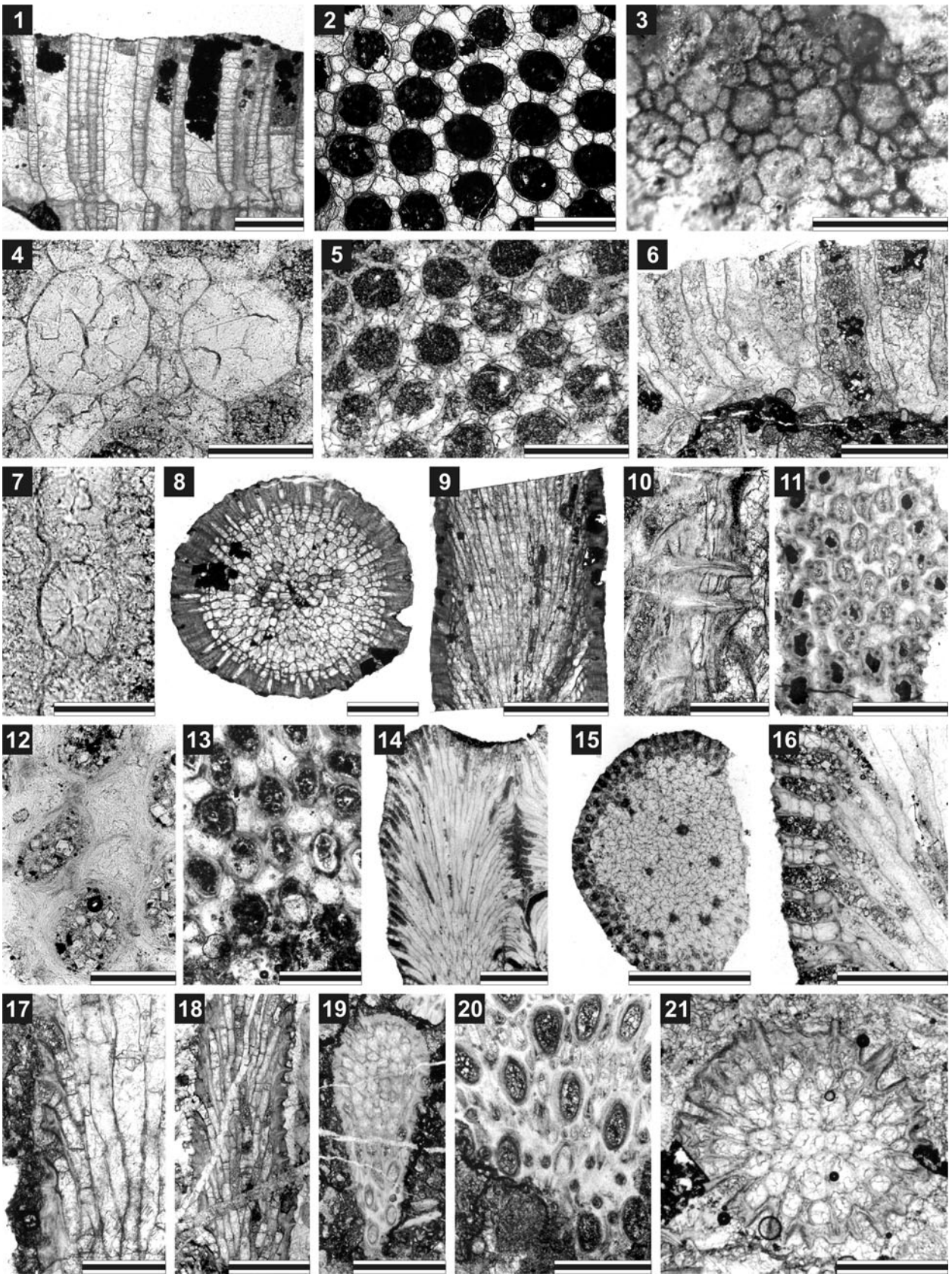

Plate 9 **1–2**, *Diplotrypa languedociana* Dreyfuss, 1948. **1**, IGR 36016, longitudinal section, scale bar = 1 mm; **2**, UM2-AE 6, tangential section, scale bar = 1 mm. **3–7**, ?*Callopora ornata* Dreyfuss, 1948. **3**, **6**, **7**, UM2-AE 78: **3**, colony surface, scale bar = 0.5 mm; **6**, longitudinal section, scale bar = 0.5 mm; **7**, longitudinal section, scale bar = 0.1 mm. **4**, **5**, UM2-AE 77: **4**, tangential section, scale bar = 0.2 mm; **5**, tangential section, scale bar = 0.5 mm; **8–11**, *Trematopora sardoa* (Vinassa de Regny, 1942). **8**, **9**, UM2-AE 54: **8**, cross-section, scale bar = 1 mm; **9**, longitudinal section,

branch axis for a long distance in endozone, in exozone bending sharply and intersecting branch surface at angles of 40–45°, having rounded–polygonal shape in cross-section in endozone, rounded in exozone. Autozooecial apertures rounded to oval, spaced 1.5–3.0 in 2 mm distance and 1.5–3.5 in 1 mm^2 in intermacular area. Autozooecial diaphragms thin, rare to absent in endozone, planar, inclined, developed as extension of wall cortex. Cystoidal diaphragms, mural spines and cap-like apparati absent. Mesozooecia long, usually restricted to exozone, polygonal in cross-section, 4–15 surrounding each aperture and often separating autozooecia completely from each other, slightly beaded in places where diaphragms occur. Mesozooecial diaphragms abundant, planar and inclined, spaced 8–21 in 1 mm of axial length of a mesozooecium. Autozooecial walls indistinctly laminated, 0.01–0.02 mm thick in endozone; displaying distinct reverse V-shaped structure with dark autozooecial border, having well developed cortex continued in diaphragms, 0.03–0.11 mm thick in exozone. Maculae consisting of megazooecia and numerous mesozooecia are indistinct in present material.

Remarks. *Hallopora enodis* Bassler, 1927 differs from *H. elegantula* (Hall, 1852) and *H. cystoidalis* Conti, 1990 in having larger apertures and more abundant mesozooecia (apertural diameters average 0.49 mm vs. 0.31 mm in *H. elegantula* and 0.39 mm in *H. cystoidales*).

Hallopora gracilens Bassler, 1927 (Pl. 8, figs 5–7; Appendix)

1927 *Hallopora gracilens* Bassler, 154–155, pl. 8, figs 10–11, pl. 10, figs 6–8.

Material. UM2-AE 2-(11, 16, 18, 21, 43, 45).

Occurrence. Upper Ordovician, Upper Caradoc; Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Ashgill, Anticosti Island, Canada.

Description. Ramose colonies, branch diameter 2.0–2.4 mm. Exozone distinct, 0.45–0.60 mm wide, endozone 1.1–1.2 mm wide. Autozooecia long, growing parallel to branch axis for a long distance in endozone, in exozone bending sharply and intersecting branch surface at angles of 80–90°, having rounded–polygonal shape in cross-section in endozone. Autozooecial apertures rounded to oval, spaced 4 in 2 mm distance. Autozooecial diaphragms thin, rare to absent in endozone, planar; becoming common in exozone, planar, rarely cystoidal and inclined, developed as extension of wall cortex, spaced 6–8 in 1 mm of autozooecial axial length. Cystoidal diaphragms rare, usually positioned on distal side of autozooecia. Cap-like apparati and mural spines absent. Mesozooecia arising in endozone, polygonal in cross-section, often separating autozooecia completely from each other. Mesozooecial diaphragms abundant, planar and inclined, spaced 11–17 in 1 mm of axial length of a mesozooecium. Autozooecial walls indistinctly laminated, 0.02 mm thick in endozone; displaying distinct reverse V-shaped structure with dark autozooecial border, having well developed wall cortex continued in diaphragms, 0.06–0.10 mm thick in exozone.

Remarks. *Hallopora gracilens* Bassler, 1927 differs from the species *H. elegantula* (Hall, 1852) in having smaller apertures (average of 0.22 mm vs. 0.31 mm in *H. elegentula*), more slender colonies and lacking mural spines and cup-like apparati.

Genus ***DIPLOTRYPA*** Nicholson, 1879

Type species. *Monticulipora* (*Diplotrypa*) *petropolitana* Nicholson, 1879 (*non Favosites petropolitanus* Pander, 1830). Sweden; Middle Ordovician.

Diagnosis. Massive, variably shaped colonies, exozone poorly developed. Budding pattern interzooecial. Zooecial arrangement disordered; zooecia gradually expand distally through early ontogeny and curve outward toward colony surface; zooecia characterised by ontogenetic progression of mesozooecia expanding into autozooecia. Mesozooecial stage of early zooecial ontogeny extended; after mesozooecial stage, diaphragms widely spaced in proximal ends and closely spaced in distal ends of mesozooecia; mesozooecia occasionally fuse to form autozooecia; mesozooecia commonly isolate autozooecia. Autozooecial apertures polygonal to rounded. Autozooecial walls commonly thin throughout colony and composed of finely crystalline microlaminae. Diaphragms thin, planar, concave, convex or cystoidal, variably spaced. Acanthostyles rare. Maculae usually consisting of megazooecia.

Remarks. *Diplotrypa* Nicholson, 1879 differs from other genera of the family Halloporidae by its massive colony form and thin zooecial walls.

Occurrence. Lower Ordovician to Upper Silurian, North America, Asia and Europe.

Diplotrypa languedociana Dreyfuss, 1948 (Pl. 8, figs 14–16, Pl. 9, figs 1–2; Appendix)

1948 *Diplotrypa languedociana* Dreyfuss: 31, pl. 3, figs 1–3.

1990 *Diplotrypa sardoa* Conti: 98, pl. 7, figs 7–8, pl. 8, figs 1–2, pl. 9, fig. 7.

Holotype. Figured in Dreyfuss (1948: pl. 3, figs 1–3). Montagne de Noire; Upper Ordovician, Ashgill.

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scale bar = 2 mm; **10**, UM2-AE 32, longitudinal section displaying acanthostyles, scale bar = 0.5 mm; **11**, UM2-AE 53, tangential section, scale bar = 1 mm. **12–16**, *Trematopora tuberculosa* Hall, 1852, IGR 36052: **12**, tangential section, scale bar = 0.2 mm; **13**, tangential section, scale bar = 0.5 mm; **14**, longitudinal section, scale bar = 2 mm; **15**, cross-section, scale bar = 2 mm; **16**, longitudinal section of the exozone, scale bar = 1 mm. **17–21**, *Trematopora gracile* sp. nov. **17**, holotype UM2-AE 21, longitudinal section of the exozone, scale bar = 0.5 mm; **18**, UM2-AE 4–23, longitudinal section, scale bar = 1 mm; **19**, UM2-AE 36, longitudinal section, scale bar = 0.5 mm; **20**, paratype UM2-AE 28, tangential section, scale bar = 0.5 mm; **21**, UM2-AE 71, cross-section, scale bar = 0.5 mm.

Material. UM2-AE 6, UM2-AE 18; IGR 36012–36014, 36016; SMF 2141.

Occurrence. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member. Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy. Upper Ordovician, Lower Ashgill (unit *e*), Sardinia, Italy.

Description. Discoid colonies, 25–32 mm in diameter, 4–9 mm thick, with indistinct endozone. Secondary overgrowths common; single layers up to 2–3 mm thick. Autozooecia bending gently from epitheca, arising from colony centre to periphery. Autozooecia in outer exozone often developing from mesozooecia or merging of 2–3 mesozooecia to autozooecium. Autozooecial apertures rounded, spaced 2–4 in 2 mm and 2–4 in 1 mm^2 of the colony surface. Autozooecial diaphragms usually common, rare to absent in shorter autozooecia, planar, curved proximally or cystoidal, irregularly spaced in autozooecia. Mesozooecia abundant, 4–12 surrounding each autozooecial aperture, sometimes as large as autozooecia, bearing abundant straight diaphragms. Autozooecial walls fine fibrous microstructure, 0.012–0.030 mm thick. Acanthostyles common or completely absent, 0.03–0.06 mm in diameter, having distinct 0.024–0.030 mm wide cores.

Remarks. *Diplotrypa languedociana* Dreyfuss, 1948 is distinguished by having abundant mesozooecia, large apertures and secondary overgrowths. It differs from *D. pseudopetropolitana* (Astrova, 1965) by having larger autozooecial aperture diameters (0.40–0.66 mm vs. 0.32–0.45 mm in *D. pseudopetropolitana*) and more abundant mesozooecia, and from *D. petropolitana* (Nicholson, 1879) by its more abundant mesozooecia. *Diplotrypa nontabulata* Buttler, 1991b has fewer autozooecial diaphragms and smaller autozooecial apertures (average of 0.38 mm vs. 0.51 mm in *D. languedociana*).

Genus ***PARVOHALLOPORA*** Singh, 1979

Type species. *Monticulipora ramosa* d'Orbigny, 1850. Upper Ordovician, North America.

Diagnosis. Ramose colonies. Colonial surface smooth or with regularly spaced monticules. Exozone well developed. Autozooecia intersecting colonial surface at sharp angles, polygonal in cross-section in endozone, becoming polygonal or circular to subcircular in exozone. Autozooecial diaphragms planar to curved, rarely cystoidal, usually present in endozone, sometimes absent in exozone. Mesozooecia abundant between most autozooecia, rounded to subrounded or rarely polygonal in cross-section, having diameters less than a half of autozooecia. Mesozooecial diaphragms planar to curved.

Remarks. *Parvohallopora* Singh, 1979 differs from *Hallopora* Bassler, 1911*a* by its absence of mural spines, smaller and more abundant mesozooecia, polygonal shape of autozooecial cross-section in endozones, rare cystoidal diaphragms and wall microstructure with U to V shaped laminae.

Occurrence. Middle to Upper Ordovician, North America and Europe.

Parvohallopora onealli (James, 1875) (Pl. 8, figs 4, 8–13; Appendix)

Lectotype. *Callopora onealli* James, 1875; UC 230-C, Field Museum of Natural History, James Collection. Upper Ordovician, 'Eden shale of Cincinnati' (Karklins, 1984).

Paralectotypes. *Callopora onealli* James, 1875; UC 230-1, 230-2, 230-3, 230-A, 230-B, 230-E, 230-G, Field Museum of Natural History, James Collection. Upper Ordovician, 'Eden shale of Cincinnati' (Karklins, 1984).

Material. UM2-AE 20–23, 28–29, 37–38, 40 (Collection Thoral. Montagne de Noire, southern France), SMF 2142–2143, SMF 2152–2153.

Occurrence. This species is common in the Middle to Upper Ordovician of North America and Europe. Investigated material comes from the following localities: Upper Ordovician, Ashgill, Le Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill, Uggwa Formation, siltstone/sandstone member; Valbertad, Carnic Alps, Italy.

Description. Ramose colonies, branch diameter 2.25–2.80 mm. Exozone 0.56–0.88 mm wide, endozone 1.04–1.13 mm wide. Secondary overgrowths present. Autozooecia long, polygonal in cross-section in endozone, growing for a long distance in endozone, then bending gently and intersecting colonial surface at angles of 25–35°. Autozooecial apertures oval to polygonal, spaced 4.0–4.5 in 2 mm distance and 4 in 1 mm^2 on the colony surface in intermacular area. Diaphragms usually developed in proximal ends of autozooecia, 5.0–6.5 spaced in 1 mm, straight, thin, occasionally appearing in exozone, rarely cystoidal (only in exozone). Mural spines absent. Mesozooecia abundant, 5–8 surrounding each autozooecial aperture, polygonal to rounded, restricted to exozone, usually closed by skeleton, possessing numerous diaphragms. Mesozooecial diaphragms straight, thin, 10–19 spaced in 1 mm of axial length of a mesozooecium. Styles absent. Autozooecial walls straight, 0.01 mm thick in endozone; 0.08–0.12 mm thick, with distinct reversed U to V shaped structure in exozone.

Remarks. *Parvohallopora onealli* (James, 1875) differs from *P. nodulosa* (Nicholson, 1874) by having smaller colony diameters and smaller autozooecial apertural diameters (average of 0.20 mm vs. 0.23 mm in *P. nodulosa*). It is also very similar to *P. laevigata* Singh, 1979, differing in the smaller colony diameter and more abundant autozooecial diaphragms.

Genus ***CALLOPORELLA*** Ulrich, 1882

Type species. *Calloporella harrisi* Ulrich, 1882. Upper Ordovician (Cincinnatian); North America.

Diagnosis. Sheet-like, sometimes multilayered encrusting colonies. Autozooecial apertures rounded to oval. Autozooecial walls thickened in surface areas, showing oblong or oblique laminated structure. Diaphragms complete, horizontal, sometimes thickened, varying in number. Mesozooecia abundant, often isolating autozooecia.

Remarks. *Calloporella* Ulrich, 1882 differs from the similar genera *Diplotrypa* Nicholson, 1879 and *Hallopora*

Bassler, 1911*a* by having thin lamellar colonies and thickened autozooecial walls.

Occurrence. Middle to Upper Ordovician, Europe and North America.

?Calloporella ornata Dreyfuss, 1948 (Pl. 9, figs 3–7; Appendix)

1948 *Calloporella ornata* Dreyfuss: 32, pl. 4, figs 1–2.

Material. Two colonies UM2-AE 77 (? Ashgill) and UM2-AE 78.

Occurrence. Upper Ordovician, Lower Ashgill, Grange du Pin, Le Glauzy, Montagne de Noire, southern France.

Description. Thin encrusting discoidal colonies, 7.2 mm in diameter, 0.60–1.13 mm thick. Autozooecia bud from thin epitheca, recumbent near the base for short distance. Apertures rounded to polygonal, spaced 5–7 in 2 mm at colony surface, 10 in 1 mm^2 at colony surface. Rare thin diaphragms in autozooecia. Mesozooecia abundant, separating autozooecia in 1–2 rows, 7–13 surrounding each autozooecium, polygonal in cross section, budding near the base of colony, frequently beaded, containing rare thin diaphragms. Autozooecial walls 0.006 mm thick, crenulated, displaying granular structure in endozone, finely laminated in exozone. Acanthostyles absent. Maculae consisting of megazooecia.

Remarks. Present material is similar to *Calloporella ornata* Dreyfuss, 1948. However, Dreyfuss (1948) did not describe the wall structure in detail. Original material described by Dreyfuss (1948: 32, pl. 4, figs 1–2) was not found. The wall structure of the available material is completely different from that in *Calloporella* spp. (cf. Boardman 2001: fig. 4.2, longitudinal thin section of the type species *C. harrisi* Ulrich 1882). Walls in *Calloporella* are typically thickened, well-laminated, with a dark medial layer. ?*Calloporella ornata* Dreyfuss, 1948 is similar to *C. harrisi* Ulrich, 1882, from which it differs in having larger and more widely spaced autozooecial apertures (aperture diameters in intermacular areas 0.20–0.24 mm vs. 0.16 mm in *C. harrisi*; aperture spacing 5–7 vs. 8–9 apertures in 2 mm distance in intermacular area in *C. harrisi*).

Family **TREMATOPORIDAE** Miller, 1889

Genus ***TREMATOPORA*** Hall, 1852

Type species. *Trematopora tuberculosa* Hall, 1852; Lower Silurian (Niagarian); North America.

Diagnosis. Ramose colonies, often beginning from encrusting basis. Autozooecial apertures oval to rounded with peristomes. Diaphragms usually rare, often absent in endozone. Abundant mesozooecia with abundant diaphragms, thin-walled and beaded in initial parts of exozone, near colony surface becoming thick-walled. Mesozooecial apertures completely covered by laminated skeleton. Acanthostyles abundant, often arranged near outer peristome range or in mesozooecial walls. Walls thin in endozone, thickened in peripheral parts of exozone displaying obliquely laminated microstructure.

Remarks. *Trematopora* Hall, 1852 differs from *Batostoma* Ulrich, 1882 by having oval to rounded autozooecial apertures and abundant mesozooecia covered with skeletal material, and from *Eridotrypa* Ulrich, 1893 by having autozooecia that bend sharply in exozone, possess rounded apertures and are arranged irregularly on the colony surface, as well as by abundant acanthostyles.

Occurrence. Ordovician to Silurian, worldwide.

Trematopora tuberculosa Hall, 1852 (Pl. 9, figs 12–16; Appendix)

1852 *Trematopora tuberculosa* Hall: 149, pl. 40A, fig. 1a–g.
1883 *Trematopora tuberculosa* Hall, 1852; Ulrich: 259, pl. 13, figs 2, 2a, 2b.
1906 *Trematopora tuberculosa* Hall, 1852; Bassler: 43, pl. 13, figs 15–16, pl. 25, fig. 8.
1959 *Trematopora tuberculosa* Hall, 1852; Boardman: 7–12, pl. 1, figs 1–4, pl. 2, figs 1–3.

Material. Single specimen IGR 36052.

Occurrence. Upper Ordovician, ? Upper Caradoc to Lower Ashgill, Petite Glauzy, Montagne de Noire, southern France. Lower Silurian, Niagarian; North America.

Description. Ramose flattened colonies, 4.3 mm in diameter. Endozone 3.4–3.58 mm in diameter; exozone distinct, 0.36–0.45 mm wide. Autozooecia long, growing at first parallel to the branch axis in endozone, in exozone bending to the colony surface. Autozooecial apertures rounded, spaced 6–9 in 2 mm and 10–15 in 1 mm^2 of colony surface. Autozooecial diaphragms absent. Mesozooecia abundant, rounded to polygonal in cross-section, 4–7 surrounding each autozooecial aperture, restricted to the outer exozone, bearing abundant diaphragms, covered on colony surface by calcitic skeleton. Autozooecial walls in endozone 0.01 mm thick, indistinctly laminated; weakly thickened in exozone, displaying longitudinal lamination, 0.020–0.025 mm thick. Acanthostyles abundant, large, having distinct cores, originating at base of exozone, 3–5 surrounding each autozooecial aperture. Colony surface covered with abundant and prominent monticules.

Remarks. *Trematopora tuberculosa* Hall, 1852 differs from *T. sardoa* (Vinassa de Regny, 1942) by having slightly larger autozooecial apertures (average diameters 0.12 mm vs. 0.09 mm in *T. sardoa*) and more abundant and larger sizes of monticules. *Trematopora primigensis* Ulrich, 1886 is also similar to *T. tuberculosa*, differing in having smaller colonies and lacking monticules.

Trematopora sardoa (Vinassa de Regny, 1942) (Pl. 9, figs 8–11; Appendix)

1942 *Leptotrypella* ? *sardoa* Vinassa de Regny: 1039–1040, pl. 3, figs 9–12.
1963 *Trematopora hirsuta* Boulange: 38–39, pl. 1, fig. 5a–b, text-fig. 4A–B.
1990 *Trematopora sardoa* (Vinassa de Regny 1942); Conti: 95–96, pl. 4, figs 7–8, pl. 5, figs 1–4.

Holotype. Figured by Vinassa de Regny (1942: pl. 3, figs 9–12).

Material. UM2-AE 2-4, 13,15-2, 20-22, 24, 28, 32, 39, 41, 51, 52, 53, 54, 56, 57, 63a-1, 67-3; IGR 36018, 36020.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

Description. Ramose colonies, branch diameter 1.53–3.43 mm. Distinct exozones 0.3–0.5 mm wide. Autozooecia budding in endozone for long distance parallel to branch axis, bending gently towards exozone, in exozone bending sharply and intersecting colony surface at right angles, having larger cross-sectional diameter in endozone than in exozone, lacking diaphragms. Autozooecial apertures rounded to oval, often indented by acanthostyles, having petaloid shape, possessing distinct peristome, spaced 4–7 in 2 mm and 10–14 in 1 mm^2 of colony surface. Mesozooecia abundant, separating autozooecia, 5–8 surrounding each aperture, originating in outer part of endozone, rounded–polygonal in cross-section, appearing beaded in longitudinal view, covered by skeleton near colony surface, bearing abundant diaphragms. Mesozooecial diaphragms thick, planar or slightly curved distally, spaced 12–19 in 1 mm of the mesozooecial length. Acanthostyles thick, abundant, 2–6 surrounding each autozooecial aperture, spaced 27–36 in 1 mm^2 of the colony surface, restricted to exozone, having distinct cores and wide sheaths. Autozooecial walls granular–prismatic, 0.006 mm thick in endozone; laminated, 0.03–0.24 mm thick in exozone. Small maculae consisting of mesozooecia and/or acanthostyles common, irregularly shaped.

Remarks. *Trematopora sardoa* (Vinassa de Regny, 1942) can be distinguished by its exozone, abundant mesozooecia and acanthostyles, absence of autozooecial diaphragms and maculae consisting of mesozooecia and acanthostyles. It is similar to *Trematopora cumingsi* Troedsson, 1928 from the Middle Ordovician of Greenland, which, however, has larger apertural diameters (0.25–0.55 mm vs. 0.07–0.16 mm in present species). *Trematopora pauca* (Brown, 1965) from the Middle Ordovician of Kentucky has fewer mesozooecia and maculae consisting of larger apertures.

Trematopora gracile sp. nov. (Pl. 9, figs 17–21; Appendix)

Holotype. UM2-AE 21 (longitudinal, cross and tangential sections).

Paratype. UM2-AE 28 (tangential section).

Type locality. Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Etymology. The specific name '*gracile*' refers to the slender colonies (derived from Latin 'gracilis' = slender).

Material. UM2-AE 4-1, 4-2, 4-23, 13-3, 15-1, 20, 22, 24, 26, 30, 36, 38, 59-14, 67, 63, 71; SMF 2144-2145.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy.

Diagnosis. Slender colonies with distinct narrow exozones; mesozooecia abundant, short, covered at surface; acanthostyles abundant, large.

Description. Ramose colonies, branch diameter 0.44–1.68 mm. Endozones 0.38–1.10 mm wide; exozones distinctly separated, 0.13–0.33 mm wide. Autozooecia long, budding at first parallel in endozone, in exozone bending to colony surface. Autozooecial apertures oval, spaced 4 in 2 mm and 10 in 1 mm^2 of colony surface. Autozooecial diaphragms thin, planar, most abundant at endo/exozone transition, in outer exozone rare to absent, in endozone irregularly spaced. Mesozooecia abundant, rounded to polygonal in cross-section, 6–7 surrounding each autozooecial aperture, very short, restricted to outer part of the exozone, lacking diaphragms, covered on colony surface by calcitic skeleton. Clusters of 4–5 mesozooecia between autozooecia common. Zooecial walls in endozone 0.01–0.02 mm thick, indistinctly laminated; thickened in exozone, displaying clear longitudinal lamination, 0.072–0.126 mm thick. Acanthostyles abundant, large, having distinct cores 0.01–0.03 mm in diameter, originating in the outermost endozone, protruding from colony surface and protruding up to 0.24–0.28 mm, 4–8 surrounding each autozooecial aperture.

Remarks. *Trematopora gracile* sp. nov. differs from other species of the genus by its thinner colony branches, smaller autozooecial apertures and shorter mesozooecia. *Trematopora borenshultensis* Brood, 1978, from the uppermost Ordovician of Sweden, is the most similar species, but has thicker colony branches (1.50–2.50 mm vs. 0.44–1.68 mm in diameter) and larger autozooecial apertures (0.11 mm vs. 0.09 mm on average).

Trematopora sp. 1 (Pl. 10, figs 1–5; Appendix)

Material. UM2-AE 80-(1, 6, 11, 19, 20, 21), UM2-AE 81–2.

Occurrence. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France.

Description. Ramose colony, 3.12 mm in diameter (incomplete), with 0.96–1.00 mm wide exozone. Autozooecia long, having polygonal cross-section in endozone, bending in exozone. Autozooecial apertures rounded–polygonal, spaced 5.5–7.0 per 2 mm. Autozooecial diaphragms rare to absent in endozone, common in exozone, straight, thin. Mesozooecia abundant, 3–6 surrounding each aperture, angular in cross section, bearing straight diaphragms, very short, originating near middle of exozone, sealed by calcitic skeleton near branch surface, slightly beaded in places where diaphragms occur. Acanthostyles relatively large and short, 2–4 surrounding each autozooecial aperture, originating at base of exozone, having distinct hyaline cores and laminated sheaths. Autozooecial walls granular–prismatic, 0.005 mm thick in endozone; laminated, regularly thickened in exozone, up to 0.06–0.10 mm thick.

Remarks. The present material differs from *Trematopora primigensis* Ulrich, 1886 from the Middle Ordovician of USA and Estonia in having more abundant diaphragms and less closely spaced apertures (5.5–7.0 vs. 7–10 per 2 mm in *T. primigensis*).

Trematopora sp. 2 (Pl. 10, figs 6–8; Appendix)

Material. UM2-AE 80-(8, 11, 13, 18, 20, 21).

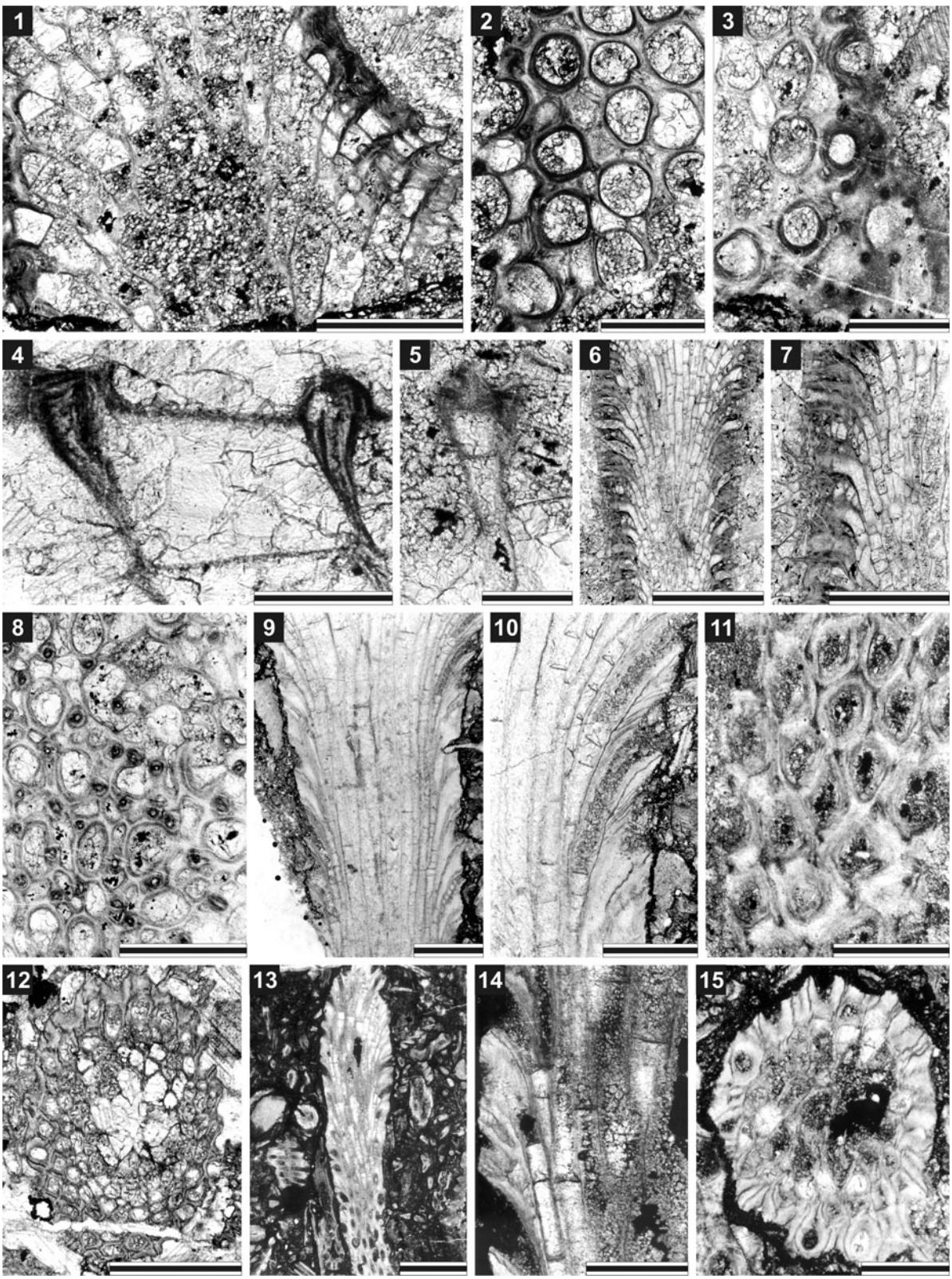

Plate 10 **1–5**, *Trematopora* sp. 1. **1**, UM2-AE 80-11, longitudinal section, scale bar = 1 mm; **2**, UM2-AE 81-2, tangential section, scale bar = 0.5 mm; **3**, UM2-AE 80-1, tangential section, scale bar = 0.5 mm; **4**, **5**, UM2-AE 80-20: **4**, longitudinal section of the exozone, scale bar = 0.2 mm; **5**, longitudinal section, scale bar = 0.2 mm. **6–8**, *Trematopora* sp. 2. **6**, UM2-AE 80-13, longitudinal section, scale bar = 2 mm; **7**, UM2-AE 80-20, longitudinal section of the exozone, scale bar = 1 mm; **8**, UM2-AE 80-13, tangential section, scale bar = 0.5 mm. **9–12**, *Eridotrypa spicata* Dreyfuss, 1948. **9**, **10**, UM2-AE 22: **9**, longitudinal section, scale bar = 1 mm; **10**, longitudinal section, scale bar = 0.5 mm; **11**, IGR 36010, tangential section, scale bar = 0.5 mm; **12**, UM2-AE 4–1, cross section of the branch, scale bar = 1 mm. **13–15**, *Eridotrypa constans* Conti, 1990. **13**, **14**, UM2-AE 20: **13**, longitudinal section, scale bar = 2 mm; **14**, longitudinal section of the exozone, scale bar = 0.5 mm; **15**, UM2-AE 37, cross-section, scale bar = 0.5 mm.

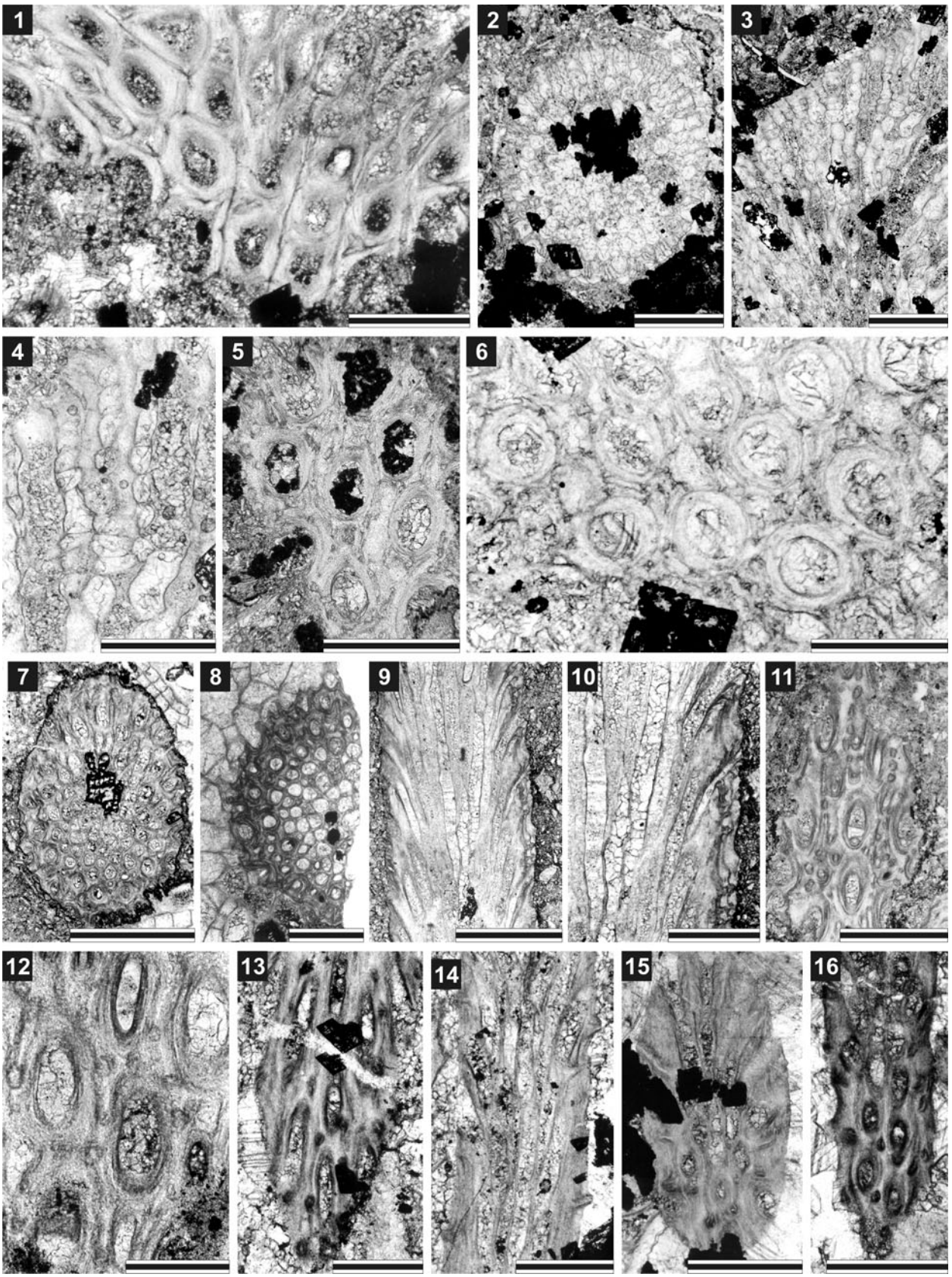

Plate 11 **1**, *Eridotrypa constans* Conti, 1990. **1**, UM2-AE 2-32, tangential section, scale bar = 0.5 mm. **2–6**, ? *Batostoma* sp. **2**, UM2-AE 71, cross-section of the branch, scale bar = mm; **3**, **4**, UM2-AE 67-6: **3**, longitudinal section of the branch, scale bar = 1 mm; **4**, longitudinal section of the exozone, scale bar = 0.5 mm; **5**, UM2-AE 59-2, tangential section, scale bar = 0.5 mm; **6**, UM2-AE 71, tangential section, scale bar = 0.4 mm. **7–12**, *Bythopora dendrina* (James, 1878*a*). **7**, UM2-AE 22, cross-section of the branch, scale bar = 1 mm; **8**, UM2-AE 25,

Occurrence. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France.

Description. Ramose colony, 2.34 mm in diameter. Exozone 0.45 mm wide, endozone 1.44 mm wide. Secondary overgrowths common. Autozooecia long, having polygonal cross-section in endozone, bending sharply in exozone. Autozooecial apertures rounded to angular and petaloid, spaced 5–6 per 2 mm. Autozooecial diaphragms common in endozone, becoming most abundant at transition from endo- to exozone, rare to absent in exozone, straight, thin. Mesozooecia abundant, often separating autozooecia in 2 rows, 7–9 surrounding each aperture, angular in cross-section, bearing abundant straight and curved diaphragms, originating at base of exozone, slightly beaded in places where diaphragms occurring. Acanthostyles long, prominent, 3–4 surrounding each aperture, originating at base of exozone, having distinct hyaline cores and wide dark laminated sheaths. Autozooecial walls granular–prismatic, 0.005 mm thick in endozone; laminated, 0.03–0.75 mm thick in exozone.

Remarks. The present material differs from *Trematopora sardoa* (Vinassa de Regny, 1942) in having larger apertures (0.11 mm vs. 0.09 mm on average) and smaller mesozooecia.

Genus ***ERIDOTRYPA*** Ulrich, 1893

Type species. *Cladopora aedilis* Eichwald, 1855 [= *Eridotrypa mutabilis* Ulrich, 1893]. Middle Ordovician, Estonia.

Diagnosis. Ramose colonies, with narrow exozone. Autozooecia weakly bending towards branch surface, with oval and oval-rounded apertures, arranged in diagonal rows. Autozooecial walls in exozone thickened, having obliquely laminated microstructure. Diaphragms common throughout colony. Mesozooecia rare, short, differently closed at colony surface. Acanthostyles rare, small and short, sometimes absent. Small, needle-like structures in zooecial walls may occur.

Remarks. *Eridotrypa* differs from the most similar genus *Batostoma* by its constant ramose colony form, weak bending of autozooecia to colony surface, short mesozooecia and small, rare acanthostyles and from *Bythopora* by the constant presence of diaphragms in autozooecia and mesozooecia and in its wall microstructure.

Occurrence. Lower Ordovician to Middle Devonian; Europe, North America, Siberia.

Eridotrypa spicata Dreyfuss, 1948 (Pl. 10, figs 9–12; Appendix)

1948 *Eridotrypa spicata* Dreyfuss: 26–27, pl. 1, figs 12–19.

Material. UM2-AE 2-3, 4-1, 13-2, 20-23, 74-2, (about 10 fragments); IGR 36010.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France.

Description. Ramose colonies, branch diameter 1.58–2.25 mm, with 0.38–0.63 mm wide exozone. Autozooecia long, orientated for long distance parallel to branch axis, bending slightly in exozone, polygonal and having larger diameter in endozone, oval to rounded–polygonal in exozone. Autozooecial diaphragms spaced widely in endozone, more densely in inner exozone, and usually absent in outermost parts of zooecia. Mesozooecia rare, small, short, polygonal in cross-section, spaced usually at junctions between autozooecia, bearing closely spaced diaphragms. Acanthostyles common, 5–6 surrounding each aperture, small, having distinct calcitic core, restricted to exozone. Autozooecial walls in endozone having indistinct lamination, 0.006–0.020 mm thick, becoming continually thicker in the inner exozone and up to 0.078–0.138 mm in the outer exozone. Autozooecial walls in exozone displaying serrated dark border between autozooecia and distinct reverse V-shaped lamination.

Remarks. The investigated material matches with *Eridotrypa spicata* Dreyfuss, 1948, especially in the typical arrangement of autozooecial diaphragms. However. Dreyfuss (1948) did not mention any acanthostyles and he quoted a larger average autozooecial diameter: 0.30 mm vs. 0.12 in our material. These differences may be an artefact of measuring weathered material. The present material is also similar to *E. obliqua* Conti, 1990, which has rarer autozooecial diaphragms.

Eridotrypa constans Conti, 1990 (Pl. 10, figs 13–15, Pl. 11, fig, 1; Appendix)

1990 *Eridotrypa constans* Conti: 106, pl. 13, figs 9–10, pl. 14, figs 1–2.

Holotype. IPUM 21997f (Museum of the Institute of Palaeontology, Modena University, Italy). Upper Ordovician, Lower Ashgill (unit *e*), Sardinia (Italy).

Material. Two colonies UM2-AE 2-32, 20, 36, 37, 38.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France. Upper Ordovician, Lower Ashgill (unit *e*), Sardinia (Italy).

Description. Ramose colonies, branch diameter 1.05–1.30 mm. Endozone 0.21–0.45 mm wide; exozone 0.30–0.42 mm wide. Autozooecia long, growing for long distance parallel to branch axis, bending gently in exozone, rounded–polygonal and having larger diameter in endozone. Autozooecial apertures oval, 0.09–0.10 mm in diameter. Autozooecial diaphragms spaced 0.07–0.15 mm in exozone, a

cross-section of the branch, scale bar = 0.5 mm; **9**, **11**, UM2-AE 22: **9**, longitudinal section of the branch, scale bar = 1 mm; **10**, longitudinal section of the exozone, scale bar = 0.5 mm; **11**, tangential section, scale bar = 0.5 mm; **12**, UM2-AE 48, tangential section, scale bar = 0.1 mm. **13–16**, *Bythopora tenuis* sp. nov. **13**, **14**, holotype UM2-AE 80-14: **13**, tangential section, scale bar = 0.5 mm; **14**, longitudinal section of the branch, scale bar = 0.5 mm; **15**, paratype UM2-AE 4-12, cross-section of the branch, scale bar = 0.5 mm; **16**, paratype UM2-AE 4–8, tangential section, scale bar = 0.5 mm.

little more distant in endozone and absent in outermost parts of autozooecia. Mesozooecia rare, up to 0.3 mm in diameter, short, oval in cross-section, usually located at junctions between autozooecia. Acanthostyles rare, up to 0.020–0.025 mm in diameter, having distinct calcitic core, restricted to exozone. Autozooecial walls in endozone having indistinct lamination, 0.01 mm thick, becoming continually thicker in the inner exozone and up to 0.09 mm in the outer exozone. Autozooecial walls in exozone displaying serrated dark border between autozooecia and distinct reverse V-shaped lamination.

Remarks. *Eridotrypa obliqua* Conti, 1990 differs from *E. constans* Conti, 1990 in having fewer autozooecial diaphragms. *Eridotrypa spicata* Dreyfuss, 1948 has more widely spaced diaphragms in both endo- and exozones as well as a narrower exozone.

Genus ***BATOSTOMA*** Ulrich, 1882

Type species. *Monticulipora* (*Heterotrypa*) *implicatum* Nicholson, 1881. Upper Ordovician (Cincinnatian); North America.

Diagnosis. Ramose or encrusting colonies, monticules generally low. Zooecial walls in endozone thin, dark, granular and connected directly with well defined, dark, granular, slightly serrated zooecial–mesozooecial boundaries. Zooecia generally oval in cross-section and containing thin, laminated, irregularly spaced diaphragms. Laminae of adjacent zooecial walls lie nearly parallel to zooecial boundaries to form a V-shaped pattern. Mesozooecia polygonal in cross-section, filling spaces between autozooecia. Laminated walls of mesozooecia usually thinner than autozooecial walls and lacking entirely in earlier growth stages of some species. Mesozooecia containing closely spaced diaphragms that generally are curved convexly outward. Larger mesozooecia have more than one longitudinal row of curved diaphragms. Mesozooecial diaphragms generally thicker than those of autozooecia and consisting of a thin dark granular layer on proximal sides and a thicker laminated layer on distal sides. Acanthostyles variable in size and abundance.

Remarks. *Batostoma* Ulrich, 1882 differs from the most similar genus *Trematopora* Hall, 1852 by having fewer mesozooecia, which are usually closed by a calcitic skeleton in the latter genus and by its more abundant autozooecial diaphragms. It differs from *Eridotrypa* by having mesozooecia that originate more deeply in the endozone.

Occurrence. Lower Ordovician to Lower Silurian, worldwide.

? ***Batostoma*** sp. (Pl. 11, figs 2–6; Appendix)

Material. UM2-AE 59-2, 67-1, 67-6, 71.

Occurrence. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France.

Description. Ramose colonies, branch diameter 2.5–3.0 mm. Exozone distinct, 0.3–0.4 mm wide, endozone 1.9–2.2 mm wide. Autozooecia long, polygonal in cross-section in endozone, bending sharply in exozone. Autozooecial apertures rounded to slightly angular, spaced 4.5–6.0 per 2 mm. Autozooecial diaphragms absent. Mesozooecia abundant, originating at base of exozone, beaded in places of development of diaphragms, 6–7 surrounding each aperture. Diaphragms in mesozooecia straight, 5–6 spaced per 1 mm of mesozooecial length. Acanthostyles having distinct hyaline cores, 5–7 surrounding each aperture, 0.04–0.06 mm in diameter. Autozooecial walls in endozone 0.01 mm thick, granular-prismatic; sharply increasing in thickness to 0.08–0.10 mm in exozone, having laminated structure. Mesozooecial walls 0.02 mm thick, laminated.

Remarks. The present material shows similarities to *Batostoma* Ulrich, 1882, but differs from the type species *Batostoma implicatum* (Nicholson, 1881) in lacking autozooecial diaphragms, having smaller colonies and smaller autozooecial apertures (autozooecial aperture width 0.12–0.16 mm vs. 0.23–0.30 mm in *B. implicatum*; data from Boardman 1960).

Family **BATOSTOMELLIDAE** Miller, 1889

Genus ***BYTHOPORA*** Miller & Dyer, 1878

[= ***BATOSTOMELLA*** Ulrich, 1882]

Type species. *Helopora dendrina* James, 1878*a* [= *Bythopora fruticosa* Miller & Dyer, 1878], Upper Ordovician, Cincinnatian; North America.

Diagnosis. Thin ramose colonies with narrow exozones. Autozooecia bud almost vertically, bending weakly at colony surface. Autozooecial apertures narrow and oval, arranged in oblong rows. Zooecial walls thickened in exozone, indistinctly fibrous, laminated. Diaphragms rare or absent. Acanthostyles common, small. Mesozooecia (pits or pustulae of some authors) short, usually rare to absent, but may be abundant.

Remarks. *Bythopora* Miller & Dyer, 1878 resembles *Eridotrypa* Ulrich, 1893, but differs by having rare to absent diaphragms and less curved autozooecia as well as by less difference in autozooecial diameters from endozone to exozone.

Occurrence. Middle Ordovician to Lower Silurian, North America, Europe.

Bythopora dendrina (James, 1878*a*) (Pl. 11, figs 7–12; Appendix)

1878*a* *Helopora dendrina* James: 3.
1878*b* *Helopora dendrina* James: 14–15.
1878 *Bythopora fruticosa* Miller & Dyer: 6, pl. 4, figs 6, 6a.
1890 *Bythopora fruticosa* Miller & Dyer; Ulrich: 376.
1900 *Bythopora dendrina* James, 1878; Nickles & Bassler: 185.
1906 *Bythopora dendrina* James, 1878; Bassler: 20.
1967 *Bythopora dendrina* James, 1878; Ross: 642–644, pl. 67, figs 1–8, 10–13, pl. 69, fig. 4, pl. 72, fig. 3.
1979 *Bythopora dendrina* James, 1878; Singh: 203–206, pl. 22, figs 3–5, pl. 23, figs 1a–1c, 2.
1998 *Bythopora dendrina* James, 1878; Marintsch: 57–61, pl. 10, figs 4–6.
1990 *Bythopora crenulata* Conti: 105, pl. 13, figs 3–7.

Material. UM2-AE 2-(2, 9, 23, 47), 15, 21-23, 25, 28.30, 37–39, 48.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France. Middle to Upper Ordovician of North America.

Description. Ramose colonies, branch diameter 0.95–2.00 mm, with poorly differentiated endo- and exozones. Endozone 0.6–1.0 mm wide, exozone 0.25–0.50 mm wide. Autozooecia long, orientated for a long distance parallel to branch axis in endozone, bending very gently in exozone and intersecting colony surface at angles of 37–55°, having polygonal cross-section shape in endozone, becoming circular in exozone. Autozooecial apertures small, oval, arranged in quite regular diagonal rows, spaced 7–8 in 2 mm of the colony surface. Autozooecial diaphragms rare to absent, planar, thin, restricted usually to the exozone. Mesozooecia (? immature, initial autozooecia; see discussions in Singh (1979), Marintsch (1998) and Key (1990, 1991)) common, 2–5 surrounding each autozooecial aperture, small, rounded in cross-section, restricted to exozone, lacking diaphragms. Walls in endozone straight, sometimes slightly wavy, having granular microstructure, 0.060–0.012 mm thick, becoming continuously thickened in exozone, finely laminated, with indistinct dark border, 0.054–0.114 mm thick in the outermost exozone. Acanthostyles abundant, small, regularly spaced between apertures in one row, developed in a successive order through outermost exozone, 0.024–0.054 mm in diameter, having distinct hyaline cores and dark laminated sheaths.

Remarks. It is difficult to perform a reliable comparison of *B. dendrina* (James, 1878*a*) because of inadequate descriptions of material assigned to this species. *Bythopora crenulata* Conti, 1990 does not sufficiently differ from existing descriptions of *B. dendrina* (Ross 1967; Singh 1979; Marintsch 1998). Conti (1990) notes that *B. crenulata* differs by smaller apertures and crenulated walls. However, the value given by him is even larger than in previous studies (the minimal aperture diameter is taken for Remarks as the most reliable value for the tube diameter):

Conti (1990): 0.054–0.164 mm (mean 0.099 mm);
Ross (1967): 0.08–0.16 mm (holotype);
Singh (1979): 0.06–0.10 (mean 0.08);
Marintsch (1998): 0.04–0.12 (mean 0.08 mm);
Present paper: 0.06–0.114 (mean 0.079 mm).

Crenulated walls occur occasionally in thicker branches among trepostome bryozoans so that this feature appears to be of minor significance.

Bythopora tenuis sp. nov. (Pl. 11, figs 13–16; Appendix)

Holotype. UM2-AE 80-14.

Paratype. UM2-AE 4-(12, 8).

Type locality. Grange du Pin, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Etymology. The specific name '*tenuis*' refers to the thin colonies of the new species (derived from Latin 'tenuis' = thin).

Material. UM2-AE 4-(5, 7, 9, 13, 19, 20). Montagne de Noire, southern France, Upper Ordovician, Ashgill.

Description. Ramose colonies, branch diameter 0.53–1.02 mm, 0.19–0.25 mm wide exozones. Autozooecia long, having polygonal cross-section in endozone, bending gently in exozone, intersecting colony surface at angles of 24–26°. Autozooecial apertures oval, spaced 7–8 per 2 mm longitudinally. Autozooecial diaphragms rare to absent, straight, thin. Mesozooecia absent. Acanthostyles large, 3–5 surrounding each aperture, originating at base of exozone, having distinct hyaline cores and dark laminated sheaths. Autozooecial walls granular–prismatic, 0.005 mm thick in endozone; laminated, regularly thickened in exozone.

Remarks. *Bythopora tenuis* sp. nov. differs from the most similar species, *B. dendrina* (James, 1878*a*) in having smaller autozooecial apertures (0.064 mm vs. 0.079 mm in *B. dendrina*) as well as in the absence of mesozooecia. It differs from the similar species *B. parvula* (James, 1878*a*) in having larger acanthostyles and more closely spaced autozooecial apertures (7–8 vs. 5 per 2 mm in *B. parvula*).

Bythopora subgracilis (Ulrich, 1893) (Pl. 12, figs 1–4; Appendix)

1893 *Homotrypella* (?) *subgracilis* Ulrich: 230–231, pl. 26, figs 10–16.
1911*a* *Bythopora subgracilis* (Ulrich, 1893); Bassler: 241–242, text-figs 135a–d, 136a, b.
1998 *Batostomella subgracilis* (Ulrich, 1893); Marintsch: 61–63, pl. 11, figs 1–4.
1998 *Batostomella subgracilis* (Ulrich, 1893) var. *robusta*; Marintsch: 63–64, pl. 11, fig. 5, pl. 12, figs 1–2.

Material. UM2-AE 80-(15, 20, 21), 81-(1, 5, 6).

Occurrence. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, North America.

Description. Ramose colonies, branch diameter 7 mm, with poorly differentiated endo- and exozone regions. Autozooecia long, growing for a long distance in endozone parallel to branch axis then bending gently in exozone and intersecting branch surface at angles of 30–34°, having polygonal cross-sectional shape in endozone, becoming circular in exozone. Autozooecial apertures small, oval, arranged in regular diagonal rows, spaced 4–7 in 2 mm distance. Autozooecial diaphragms rare to absent, planar, thin, restricted usually to the exozone. Mesozooecia rare to common, 2–5 surrounding each autozooecial aperture, small, rounded in cross section shape, restricted to exozone, lacking diaphragms. Walls in endozone straight, sometimes slightly wavy, having granular microstructure, 0.100–0.015 mm thick, becoming continuously thickened in exozone, finely laminated, with indistinct dark border, 0.12–0.16 mm thick in exozone. Spine-like acanthostyles abundant, small, short, regularly spaced between apertures in one row, 0.024–0.054 mm in diameter, having distinct hyaline cores.

Remarks. The present material is most similar to *Batostomella subgracilis* (Ulrich, 1893) var. *robusta* Marintsch, 1998 from the Hermitage Formation (Middle Ordovician) of east-central Tennessee, USA. It differs from *B. dendrina* in

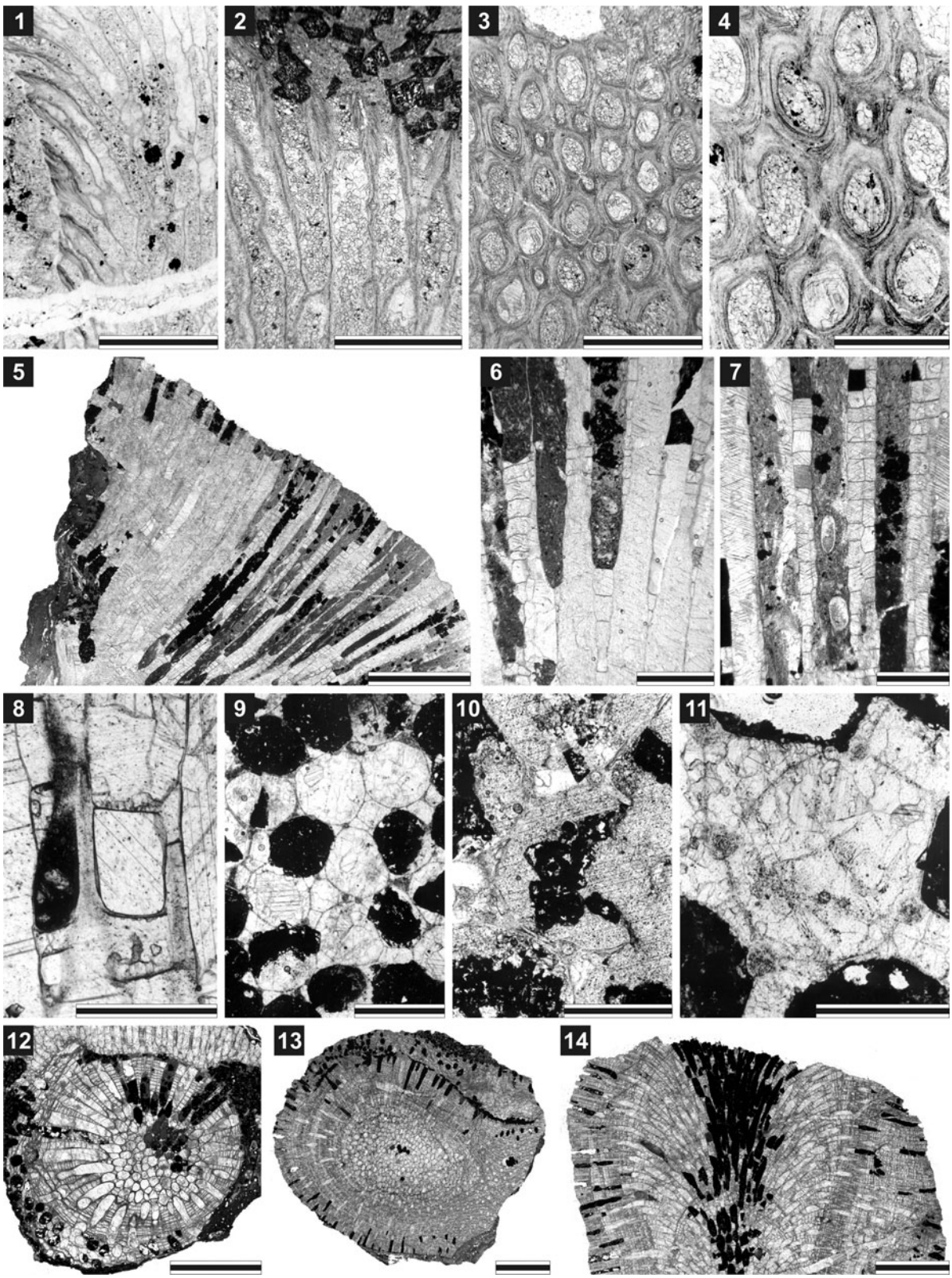

Plate 12 **1–4**, *Bythopora subgracilis* (Ulrich, 1893). **1**, **2**, UM2-AE 81-5: **1**, longitudinal section of the branch, scale bar = 2 mm; **2**, longitudinal section of the exozone, scale bar = 1 mm; **3**, **4**, UM2-AE 81-3: **3**, tangential section, scale bar = 1 mm; **4**, tangential section displaying acanthostyles and mesozooecia, scale bar = 0.5 mm. **5–11**, ? *Mesotrypa rotundipora* (Dreyfuss, 1948). **5–8**, IGR 36015: **5**, longitudinal section of the hemispheric colony, scale bar = 5 mm; **6**, longitudinal section, scale bar = 1 mm; **7**, longitudinal section, scale bar = 1 mm; **8**, longitudinal section displaying acanthostyles in autozooecial walls, scale bar = 0.5 mm; **9–11**, UM2-AE 83: **9**, tangential section, scale bar = 1 mm; **10**, tangential section displaying acanthostyles, scale bar = 0.5 mm; **11**, tangential section displaying acanthostyles, scale bar = 0.5 mm. **12–14**, *Dybowskites orbicularis* (Modzalevskaya, 1953). **12**, IGR 36028a, cross-section of the branch, scale bar = 5 mm; **13**, **14**, UM2-AE 58: **13**, cross-section of the branch, scale bar = 5 mm; **14**, longitudinal section of the branch, scale bar = 5 mm.

having larger colonies and larger autozooecial apertures, but smaller acanthostyles.

Family **MESOTRYPIDAE** Astrova, 1965

Genus ***MESOTRYPA*** Ulrich, 1893

TYPE SPECIES. *Diplotrypa infida* Ulrich, 1886. Middle Ordovician, North America.

DIAGNOSIS. Massive, hemispheric, conical or discoidal colonies. Autozooecial apertures polygonal or rounded. Walls thin, longitudinally laminated, indistinctly separated. Diaphragms planar, sloped, curved and funnel-shaped. Mesozooecia abundant, budding from base of colony. Acanthostyles may be large, growing from the base of colony, or small, visible at colony surface.

REMARKS. *Mesotrypa* Ulrich, 1893 differs from the most similar genus *Diazzipora* Vinassa de Regny, 1921 by having acanthostyles and larger mesozooecia.

OCCURRENCE. Middle Ordovician to Lower Silurian, worldwide.

? ***Mesotrypa rotundipora*** (Dreyfuss, 1948) (Pl. 12, figs 5–11; Appendix)

1948 *Diplotrypa rotundipora* Dreyfuss: 30–31, pl. 3, figs 4–5.

HOLOTYPE. Figured by Dreyfuss (1948: pl. 3, figs 1–3).

MATERIAL. UM2-AE 72, 83; IGR 36027, 36015, 36060.

OCCURRENCE. Upper Ordovician, Ashgill, Montagne de Noire, southern France.

DESCRIPTION. Discoidal colonies with short endozones, up to 40–70 mm in diameter, 11–35 mm thick. Secondary overgrowths not observed. Autozooecia bending gently from epitheca, radiating from colony centre to periphery, others developing above epitheca from mesozooecia or merging of 2–3 mesozooecia into an autozooecium. Autozooecial apertures rounded, spaced 2.0–3.5 in 2 mm and 2–4 in 1 mm^2 of colony surface. Autozooecial diaphragms rare to absent, planar or slightly curved, spaced irregularly in autozooecia. Mesozooecia common, 2–7 surrounding each autozooecial aperture, polygonal in cross-section, beaded, bearing straight diaphragms spaced 3.0–5.5 per 1 mm of the mesozooecial length. Mesozooecial apertures angular, taking shape of spaces between autozooecia. Autozooecial walls hyaline or fibrous, 0.012 mm thick. Acanthostyles large, developed repeatedly at different stages of colony growth, having indistinct cores, 0.04–0.08 mm in diameter.

REMARKS. ? *Mesotrypa rotundipora* (Dreyfuss, 1948) can be distinguished by its large apertures and thick colonies without endozones, rare autozooecial diaphragms and beaded mesozooecia. It differs from the similar species *M. pyriformis* (Eichwald, 1829) from the Middle Ordovician of Estonia in having larger autozooecia, and from *M. bystrowi* Modzalevskaya, 1953 in having larger apertures and fewer diaphragms. Species described by Conti (1990) as *Panderpora gemmata* and *P. moniliformis* are very similar morphologically to *Mesotrypa rotundipora* (Dreyfuss, 1948). Conti (1990: 102–103) mentioned diaphragms and cup-like apparati in *P. gemmata*. However, his picture of an oblique section of *P. gemmata* (pl. 10, fig. 10) shows distinct acanthostyles of the type that are observed and described here in the species *M. rotundipora*. *Panderpora gemmata* has smaller autozooecial apertural diameters than the material described here, but morphologically they are similar.

Family **RALFIMARTITIDAE** Gorjunova, 2005

Genus **DYBOWSKITES** Pushkin, 1987

TYPE SPECIES. *Lioclemella clavata* Bassler, 1911*a*. Upper Ordovician, Caradoc, Estonia.

DIAGNOSIS. (after Gorjunova (2005), modified). Ramose, frondescent, sometimes segmented colonies. Autozooecia long, tubular, growing from branch axis, bending abruptly in exozone. Zooecial walls usually strongly laminated in exozone. Diaphragms straight, usually abundant in endozone and rare to absent in exozone. Hemiphragms rare to absent. Mesozooecia large and abundant. Acanthostyles usually abundant and of two types: larger with distinct cores and smaller ones without distinct cores.

REMARKS. *Dybowskites* Pushkin, 1987 differs from the most similar genera *Ralfimartites* Gorjunova, 2005 and *Bodywskites* Gorjunova, 2005 in its absence of axial zooecia. Gorjunova (2005: 57) regarded the large acanthostyles as special heterozooecia, named 'aulozooecia'. In this publication, the conventional term 'acanthostyle' is preferred for these structures.

OCCURRENCE. Upper Ordovician, Europe.

Dybowskites orbicularis (Modzalevskaya, 1953) (Pl. 12, figs 12–14, Pl. 13, figs 1–4; Appendix)

1921 *Leioclema spineum ramosum* Bekker: 41, pl. 6, figs 14–18.
1948 *Batostoma gabiani* Prantl, 1940; Dreyfuss: 27, pl. 2, figs 1–3.
1953 *Lioclema spineum* Ulrich var. *orbicularis* Modzalevskaya: 147, pl. 9, figs 4–6, text-fig. 23
1991*a* *Leioclema orbicularis* Modzalevskaya, 1953; Buttler: 83–84, pl. 2, figs 5–8, pl. 3, figs 1–2.

HOLOTYPE. No. 477, St. Petersburg University. Middle Ordovician (*Echinospherites* limestone, C_1); St. Petersburg district, Russia.

MATERIAL. UM2-AE 58–59; IGR 36024–36027, 36028a.

OCCURRENCE. Middle Ordovician, Uhaku to Idavere Stage; north-western Russia, Estonia. Upper Ordovician (Ashgill), Wales. Upper Ordovician, Ashgill, Montagne de Noire, southern France.

DESCRIPTION. Ramose colonies. Branch diameters 8–20 mm, displaying distinct, 4–5 mm wide exozones, with occasional secondary overgrowths. Autozooecia long, having polygonal to slightly rounded cross-sections in inner endozone, growing at first parallel to branch axis in endozone and then bending gently towards exozone, increasing in diameter; bending sharply in basal exozone and decreasing in diameter; from base of exozone growing nearly perpendicular to colony surface. Autozooecial apertures oval to slightly polygonal, rounded to petaloid, bordered by thick peristome, 2.5–3.5

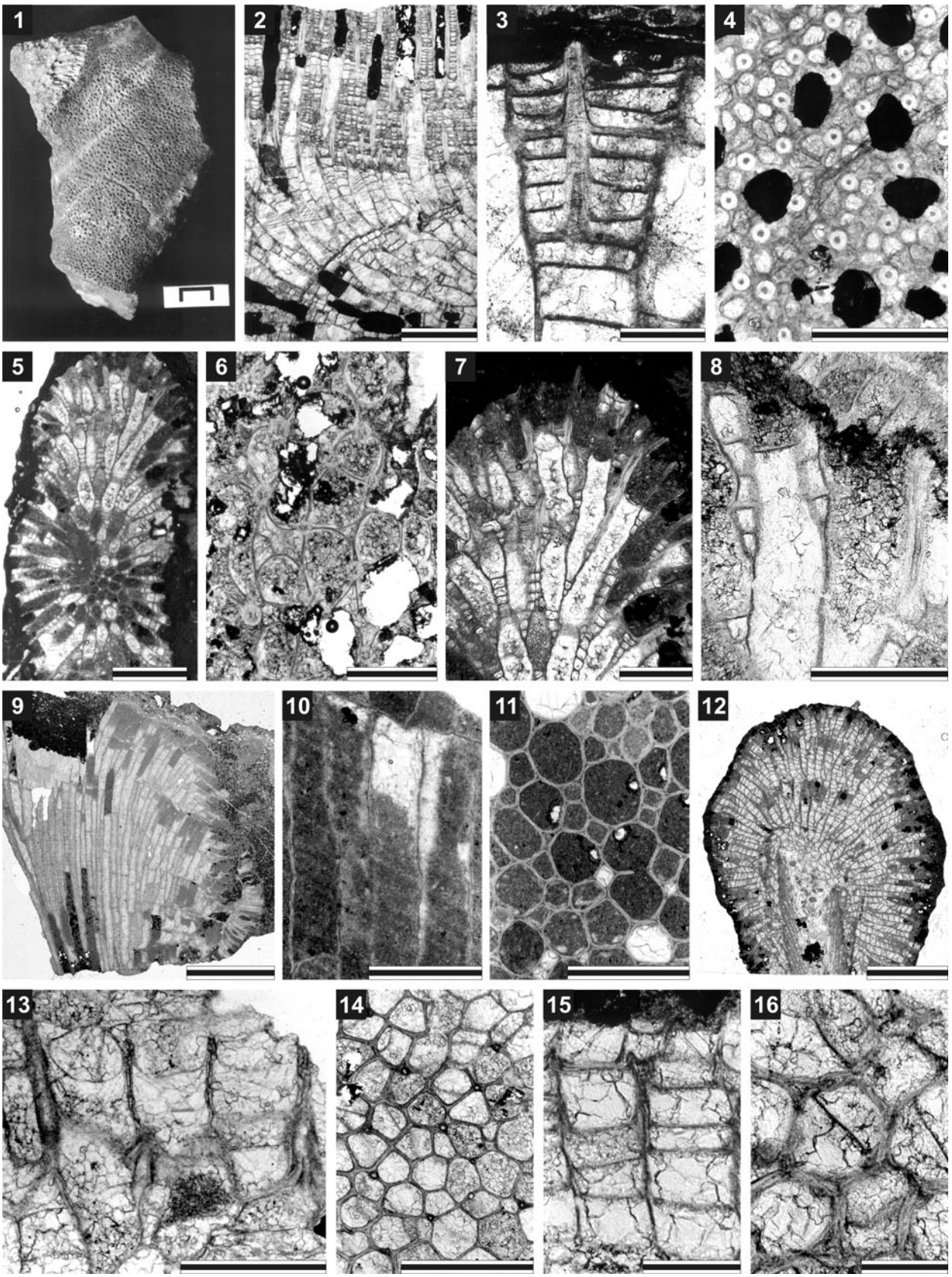

Plate 13 **1–4**, *Dybowskites orbicularis* (Modzalevskaya, 1953). **1**, **2**, **4**; UM2-AE 58: **1**, scale bar = 10 mm; **2**, longitudinal section of the exozone, scale bar = 2 mm; **4**, tangential section, scale bar = 1 mm. **3**, IGR 36028a, cross-section of the exozone displaying acanthostyle and mesozooecia, scale bar = 0.5 mm; **5–8**, *Halloporina* sp. indet. **5**, UM2-AE 23, cross and longitudinal section of colony, scale bar = 2 mm; **6**, UM2-AE 2-2, tangential section colony, scale bar = 0.5 mm; **7**, UM2-AE 23, longitudinal section of colony, scale bar = 1 mm; **8**, UM2-AE 28,

spaced in 2 mm and 1.5–2.5 in 1 mm^2. Thin, straight basal diaphragms in autozooecia rare to absent; if present, usually appear at transition between endo- and exozone. Mesozooecia abundant, polygonal in cross-section, originating deep in endozone, bearing abundant diaphragms, 5–8 surrounding each autozooecial aperture, covered on colony surface by laminated calcitic skeleton. In outer endozone, sometimes nearly as large as autozooecia, often beaded at places of diaphragm attachment, less abundant than in outer exozone, often enclosed. In exozone, having smaller diameters than in outer endozone, completely separating autozooecia. Mesozooecial diaphragms abundant, spaced 9–18 in 1 mm of zooecial length in exozone, separated from each other by 0.03–0.15 mm. Acanthostyles large, prominent, projecting up 0.24–0.30 mm above branch surface, abundant, possessing wide dark cores and thin laminated sheaths, consisting of indistinct granular material, originating in endozone, inflecting an autozooecial living chamber, 3–5 surrounding each aperture, spaced 5–8 in 1 mm^2 of branch surface. Autozooecial walls granular–prismatic, 0.006–0.018 mm thick in endozone; finely laminated, displaying distinct reverse U-shaped structure, 0.024–0.072 mm thick in exozone.

Remarks. *Dybowskites orbicularis* (Modzalevskaya, 1953) differs from *D. clavus* (Bassler, 1911*a*) in having larger colonies and more widely spaced autozooecial apertures (2.5–3.5 vs. 4–5 per 2 mm in *D. clavus*).

Halloporina sp. indet. (Pl. 13, figs 5–8; Appendix)

Material. UM2-AE 2-2, 2-18, 2-20, 21, 23, 28, 30, 38-39, 68.

Occurrence. Upper Ordovician, Ashgill, Montagne de Noire, southern France.

Description. Ramose colonies. Branches 1.90–3.50 mm in diameter, with 1.14–2.24 mm wide endozones and 0.38–0.63 mm wide exozones. Autozooecia long, having polygonal to slightly rounded cross-sections in inner endozone, growing at first parallel to branch axis in endozone and then bending gently towards exozone, increasing in diameter; intersecting colony surface at low angles. Autozooecial apertures oval to slightly polygonal, spaced 3.5–5.0 in 2 mm. Thin, straight basal diaphragms in autozooecia rare to absent; if present, usually appear at transition between endo- and exozone. Mesozooecia common, polygonal in cross-section, originating deep in endozone, bearing abundant diaphragms, 3–5 surrounding each autozooecial aperture, covered on colony surface by laminated calcitic skeleton, often beaded at places of diaphragm attachment. Mesozooecial diaphragms abundant, spaced 7–10 in 1 mm of zooecial length in exozone, separated from each other by 0.06–0.10 mm. Acanthostyles large, prominent, abundant, possessing wide dark cores and thin laminated sheaths, consisting of indistinct granular material, originating in endozone, inflecting an autozooecial living chamber, 1–3 surrounding each aperture. Autozooecial walls granular–prismatic, 0.006–0.012 mm thick in endozone; finely laminated, displaying distinct reverse U-shaped structure, 0.024–0.072 mm thick in exozone.

Remarks. This bryozoan shows similarities to *Lioclema* Ulrich, 1882 in having large and abundant acanthostyles and beaded mesozooecia. However, *Lioclema* has autozooecia bending sharply in exozones, as well as more abundant mesozooecia which are usually restricted to exozones.

Suborder **AMPLEXOPORINA** Astrova, 1965
Family **AMPLEXOPORIDAE** Miller, 1889
Genus ***MONOTRYPA*** Nicholson, 1879

Type species. *Chaetetes undulatus* Nicholson, 1879. Middle Ordovician (Trentonian); Canada.

Diagnosis (after Astrova 1978). Massive irregular, discoidal or hemispherical colonies; exozone and endozone not clearly distinct. Autozooecia with polygonal apertures, thin undulating walls without thickenings. Diaphragms complete, thin, rare, sometimes absent. Exilazooecia rare or absent. Acanthostyles absent.

Remarks. *Monotrypa* Nicholson, 1879 differs from other genera of the family Amplexoporidae by having thinner walls, fewer exilazooecia and no acanthostyles.

Occurrence. Middle Ordovician to Upper Devonian; worldwide.

Monotrypa testudiformis Dreyfuss, 1948 (Pl. 13, figs 9–11; Appendix)

1948 *Monotrypa testudiformis* Dreyfuss: 29–30, pl. 2, figs 4, 5.

Material. UM2-AE 73, 77, (Dreyfuss-Collection); IGR 36033.

Occurrence. Upper Ordovician, Lower Ashgill, Petit Glausy, Montagne de Noire, southern France.

Description. Massive hemispherical colonies, consisting of overgrowing layers, 19 mm in diameter, 10 mm high; exozone and endozone not distinct. Autozooecia straight, large, budding slightly inclined from thin basal epitheca. Autozooecial apertures polygonal, spaced 4.0–4.5 in 2 mm in intermacular areas of colony surface; 3.0–3.5 in 2 mm in the macular areas. Autozooecial diaphragms rare, thin and planar. Exilazooecia rare in intermacular areas, abundant in maculae, sometimes isolating autozooecia, beaded in longitudinal view, originating both in endo- and exozones, polygonal in cross-section. Autozooecial walls usually straight, sometimes slightly wavy, thin, varying in thickness from

longitudinal section of the exozone of colony, scale bar = 0.5 mm. **9–11**, *Monotrypa testudiformis* Dreyfuss, 1948. **9**, IGR 36033, longitudinal section of the hemispheric colony, scale bar = 5 mm; **10**, **11**, UM2-AE 77: **10**, longitudinal section of the exozone, scale bar = 1 mm; **11**, tangential section, scale bar = 1 mm. **12–14**, *Amplexopora dalpiazzi* (Vinassa de Regny, 1910). **12**, UM2-AE 62, colony encrusting on *Eridotrypa spicata* Dreyfuss, 1948, scale bar = 3 mm; **13**, UM2-AE 2-3, longitudinal section, scale bar = 0.5 mm; **14**, UM2-AE 2-27, tangential section, scale bar = 1 mm. **15–16**, *Amplexopora* sp. UM2-AE 4–2: **15**, longitudinal section, scale bar = 0.2 mm; **16**, tangential section, scale bar = 0.2 mm.

0.012–0.024 mm, finely laminated. Maculae distinct, consisting of megazooecia and abundant exilazooecia. Obscure acanthostyles at junctions of autozooecia and exilazooecia, generally less than 0.02 mm in diameter.

Remarks. *Monotrypa testudiformis* Dreyfuss, 1948 differs from *M. squamata* Dreyfuss, 1948 and *M. cantarelloidea* Dreyfuss, 1948 by having smaller autozooecial apertures and more abundant exilazooecia. Dreyfuss (1948) reported the following autozooecial aperture diameters: *M. testudiformis*: 0.5 mm; *M. squamata*: 0.7 mm; *M. cantarelloidea*: 1 mm.

Genus ***AMPLEXOPORA*** Ulrich, 1882

Type species. *Atactopora septosa* Ulrich, 1879. Uppser Ordovician (Cincinnatian); North America.

Diagnosis. (after Boardman, 1960). Ramose, frondescent, encrusting or massive colonies. Monticules generally well developed. Wall structure fibrous in exozone. Laminae from adjacent zooecia intersect along sharply defined zooecial boundary at angles of less than 90° to form a V-shaped pattern pointing distally. Distinct zooecial linings present in some species. Diaphragms extremely variable in thickness, curvature, parallelism and spacing, with compound and cystoidal diaphragms and cystiphragms common in many species. Mesozooecia lacking or few; early chambers are beaded and later diaphragms regularly and closely spaced. Acanthostyles usually abundant and of two types: those that are generally concentrated in zooecial walls and extend throughout exozone, occurring in all species and other acanthostyles that are concentrated in zooecial corners and extend through a part of exozone occurring in some species. These latter acanthostyles inflect autozooecial walls.

Remarks. *Amplexopora* Ulrich, 1882 differs from the similar genera *Anaphragma* Ulrich & Bassler, 1904 and *Monotrypa* d'Orbigny, 1850 by having more abundant diaphragms and a different wall microstructure.

Occurrence. Lower Ordovician to Lower Silurian, North America, Australia, Siberia, Europe.

Amplexopora dalpiazzi (Vinassa de Regny, 1910) (Pl. 13, figs 12–14; Appendix)

1910 *Monticulipora* (*Heterotrypa*) *Dal Piazzi* Vinassa de Regny: 10–11, pl. 1, figs 23–25.
1910 *Monticulipora* (*Montorypella*) *Consuello* Vinassa de Regny: 9–10, pl. 1, figs 12–13, 16–17.
1914 *Monotrypella Consuello* (Vinassa de Regny); Vinassa de Regny: 203.
1915 *Monotrypella Consuello* (Vinassa de Regny); Vinassa de Regny: 102.
1942 *Monotrypella Consuello* (Vinassa de Regny); Vinassa de Regny: 1036.
1990 *Amplexopora dalpiazzi* (Vinassa de Regny, 1910); Conti: 103–104, pl. 11, figs, 7–9, pl. 12, figs 1–3.

Holotype. Figured by Vinassa de Regny (1910: pl. 1, figs 23–35).

Material. UM2-AE 2-1, 2-3, 2-4, 2-26, 26, 46, 62, 67.

Occurrence. Upper Ordovician, Ashgill, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc (unit *c*), Sardinia, Italy.

Description. Encrusting and ramose colonies. Encrusting colonies 1.0–3.0 mm thick, single branch 3.4 mm in diameter. Narrow, distinct exozone. Secondary overgrowths common. Autozooecia growing for a short distance in endozone parallel to substrate, then bending sharply and intersecting colony surface at angles of 70–90°. Autozooecial apertures polygonal, spaced 7 in 2 mm of intermacular area and 5–6 in 2 mm of macular areas, and 12.5 in 1 mm^2 of intermacular areas and 10 in 1 mm^2 of macular areas. Diaphragms in endozone rare, planar, thin; in exozone abundant, spaced 6–9 in 1 mm of the longitudinal section, straight, curved, or cystiphragmoid. Mesozooecia rare, polygonal in cross-section, spaced 1.5–2.5 in 1 mm^2 of colony surface, restricted to exozone, often beaded, containing abundant diaphragms. Acanthostyles common, small to large and prominent, spaced 1–3 around autozooecial apertures, having distinct hyaline cores and wide, dark sheaths, often inflecting autozooecia, originating from base of exozone. Autozooecial walls in endozone 0.01 mm thick, granular; in exozone 0.03–0.06 mm thick, displaying reverse V-shaped lamination with dark, serrated median lining. Maculae 2.0–2.5 mm in diameter, consisting of megazooecia.

Remarks. *Amplexopora dalpiazzi* (Vinassa de Regny, 1910) is distinguished by its usually encrusting colony form and prominent acanthostyles. *Amplexopora multitabulata* Troedsson, 1928, from the Middle Ordovician of Greenland, is similar in the development of abundant diaphragms and large acanthostyles, but differs in having larger and more closely spaced autozooecial apertures (4–5 vs. 7 per 2 mm in *A. dalpiazzi*).

Amplexopora sp. (Pl. 13, figs 15–16)

Material. UM2-AE 4-2.

Occurrence. Upper Ordovician, Caradoc, Grange du Pin, Montagne de Noire, southern France.

Description. Encrusting colonies 1.00–1.13 mm thick. Secondary overgrowths common. Autozooecia growing for a short distance in endozone parallel to substrate, then bending sharply and intersecting colony surface at angle of 90°. Autozooecial apertures polygonal, 0.15–0.20 mm in diameter (mean = 0.17 mm; 5 measurements), 4–5 spaced per 2 mm. Diaphragms abundant, thin, spaced more closely in distal parts of autozooecia (11–22 per 1 mm) than in proximal parts (9–10 per 1 mm) in longitudinal section, usually straight, occasionally curved to cystoidal. Mesozooecia rare, polygonal in cross-section, short, 0.060–0.084 mm in diameter. Acanthostyles abundant, 4–5 surround each autozooecial aperture, having distinct hyaline cores and wide, dark sheaths, often inflecting autozooecia, restricted to distal parts of autozooecia. Autozooecial walls 0.01–0.20 mm thick, displaying reverse V-shaped lamination and dark, serrated median lining. Maculae not observed.

Remarks. The present material differs from *Amplexopora dalpiazzi* (Vinassa de Regny, 1910) by having smaller autozooecial apertures (autozooecial aperture width in intermacular area 0.17 mm vs. 0.23 mm, on average, in *A. dalpiazzi*), as well as smaller and more abundant acanthostyles. Unfortunately, the scarce material does not justify establishing a new species.

Amplexopora cf. *robusta* Ulrich, 1883 (Pl. 14, figs 1–6; Appendix)

MATERIAL. Single colony UM2-AE 79.

OCCURRENCE. Upper Ordovician (? Caradoc), Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Ramose colony with oval cross-section, 6–9 mm in diameter. Exozone 0.9–1.4 mm wide, endozone 4.2–6.2 mm wide. Secondary overgrowths common. Autozooecia growing for a long distance in endozone, then bending sharply and intersecting colony surface at angles of 80–90°. Autozooecial apertures polygonal, 5–6 per 2 mm in intermacular areas and 4–4.5 in macular areas. Diaphragms in endozone thin, straight, spaced 2–3 per 1 mm length; in exozone thin to thick, straight and inclined, 5–10 spaced per 1 mm autozooecial length. Mesozooecia rare, polygonal to rounded in cross-section, short, small. Acanthostyles rare, more common in maculae, having distinct hyaline cores and wide, dark sheaths, often inflecting autozooecia, originating in outer part of endozone. Autozooecial walls 0.005 mm thick, granular in endozone; displaying reverse V-shaped lamination with a dark median lining, 0.05–0.10 mm thick in exozone. Maculae consisting of megazooecia, 1.7–2.1 mm in diameter.

REMARKS. The present material is similar to *Amplexopora robusta* Ulrich, 1883 from the Upper Ordovician of North America. It differs from *A. ampla* Ulrich & Bassler, 1904 in having more closely spaced apertures (7 vs. 5–6 per 2 mm in present material).

INCERTAE SEDIS

Genus *NICHOLSONELLA* Ulrich, 1890

TYPE SPECIES. *Nicholsenella ponderosa* Ulrich, 1890, Middle Ordovician (Trenton), North America.

DIAGNOSIS. Encrusting, frondose, ramose, less commonly massive colonies. Apertures rounded and irregularly petaloid. Walls structureless, very thin, irregularly thickened in different part of colonies. Diaphragms usually abundant throughout colony, more rarely only in exozone. Mesozooecia abundant, containing frequent diaphragms, sometimes beaded, irregularly closed by calcitic material at colony surface. Acanthostyles small, abundant, short, restricted to outermost exozone.

REMARKS. *Nicholsonella* Ulrich, 1890 and some other genera (e.g. *Dianulites*) are unique among trepostome bryozoans by their re-crystallised walls which suggest a diagenetically unstable aragonitic (McKinney 1971) or high magnesium calcite composition (Taylor & Wilson 1999).

OCCURRENCE. ? Lower to Upper Ordovician, North America and Siberia.

Nicholsonella divulgata sp. nov. (Pl. 14, figs 7–9; Appendix)

HOLOTYPE. UM2-AE 28–29.

PARATYPES. UM2-AE 15-2, 15-3.

TYPE LOCALITY. Grange du Pin, Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician, Ashgill.

ETYMOLOGY. The specific name derives from Latin 'divulgatus' (= usual) and refers to the characteristic appearance of this species.

MATERIAL. UM2-AE 25; IGR 36049.

MEASURED MATERIAL. Holotype UM2-AE 28, paratypes UM2-AE 15-2 and UM2-AE 15-3.

DIAGNOSIS. Ramose colonies with narrow endozones; autozooecial apertures polygonal; large and abundant mesozooecia and acanthostyles.

DESCRIPTION. Ramose colonies, branch diameter 2.38–4.00 mm, with 0.50–0.56 mm wide exozones and 1.38–2.88 mm wide endozones. Autozooecia growing parallel to branch axis in endozone, then bending at angles of 70–80° to colony surface. Autozooecial apertures rounded to petaloid due to inflecting acanthostyles, spaced 4–6 in 2 mm distance and 10–11 in 1 mm^2 of colony surface. Autozooecial diaphragms absent or extremely rare; if present, thin, slightly curved proximally. Mesozooecia abundant, sometimes as large as autozooecia, often separating autozooecia, originating in endozone, bearing abundant planar diaphragms, sometimes appearing beaded in longitudinal view, rounded to polygonal in cross-section, sealed by skeletal material at colony surface, 5–9 surrounding each autozooecial aperture. Mesozooecial diaphragms thick, planar, 8–11 occurring in 1 mm of the longitudinal section. Walls in endozone 0.012–0.030 mm thick, structureless; in exozone irregularly thickened, displaying indistinct longitudinal laminations. Acanthostyles large, prominent, originating in endozone, having distinct to obscure hyaline cores with narrow sheaths, occurring both in autozooecial and mesozooecial walls, often inflecting deeply into them, 5–8 surrounding each aperture.

REMARKS. *Nicholsonella divulgata* sp. nov. is similar in its autozooecial morphology and colony growth form to *N. irregularis* Loeblich, 1942, which has larger acanthostyles and more closely spaced autozooecial apertures, to *N. parafrondifera* McKinney, 1971, which has larger and more closely spaced autozooecial apertures, and to *N. faveolata* Pushkin, 1987 which has larger acanthostyles.

Nicholsonella recta sp. nov. (Pl. 14, figs 10–13; Appendix)

HOLOTYPE. IGR 36010.

PARATYPE. UM2-AE 21.

TYPE LOCALITY. Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician, Ashgill.

ETYMOLOGY. The specific name derives from the Latin 'rectum' (= slender) and refers to slender colony branches.

MATERIAL. UM2-AE 2-20, 68-2.

OCCURRENCE. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France.

DIAGNOSIS. Ramose colonies with narrow exozones; autozooecia in endozones having smaller diameters; abundant mesozooecia and acanthostyles.

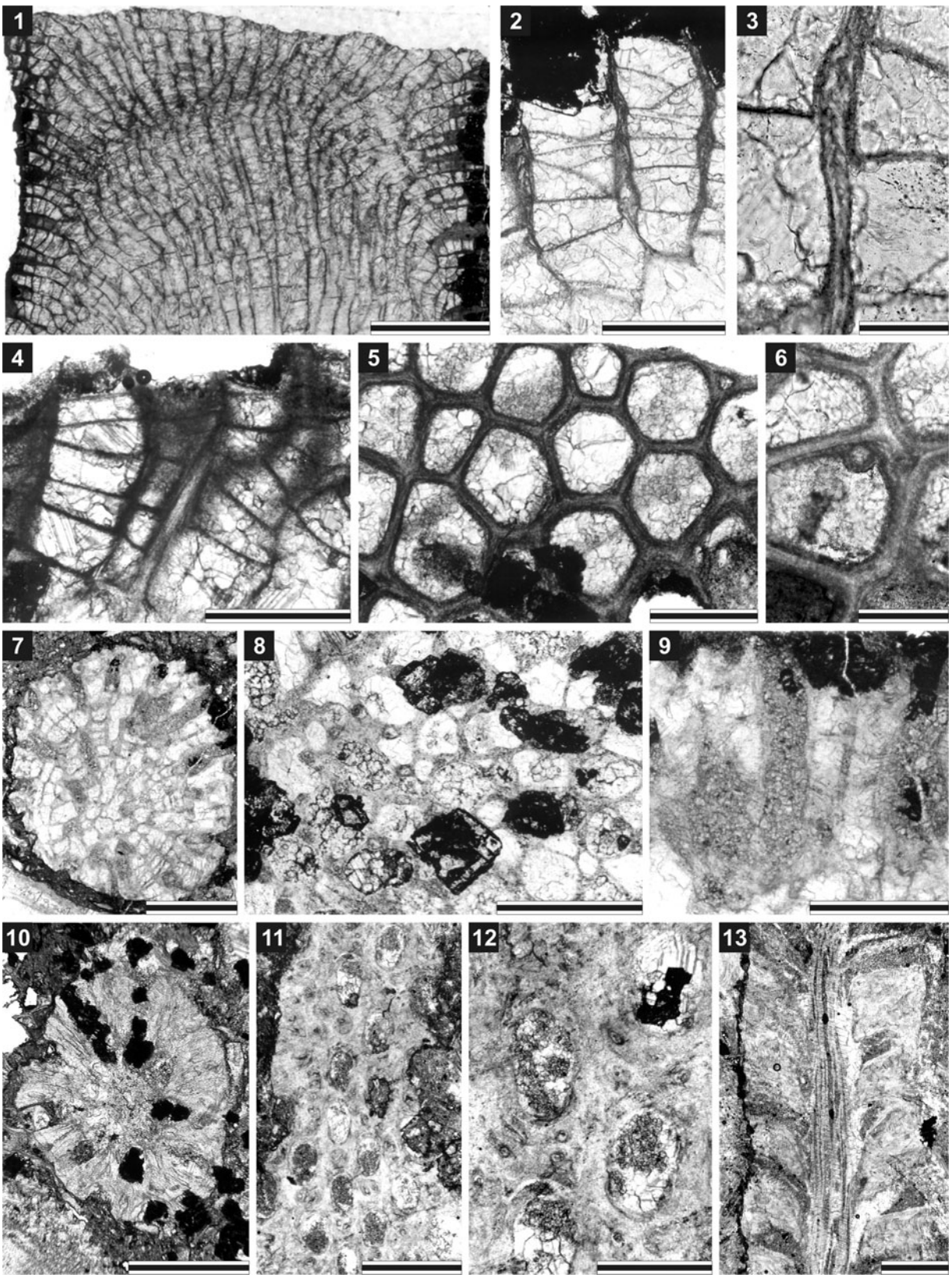

Plate 14 **1–6**, *Amplexopora* cf. *robusta* Ulrich, 1883. UM2-AE 79: **1**, longitudinal section of the branch, scale bar = 2 mm; **2**, longitudinal section of the exozone, scale bar = 0.5 mm; **3**, longitudinal section of the exozone displaying wall structure, scale bar = 0.1 mm; **4**, longitudinal section of the exozone displaying acanthostyle, scale bar = 0.5 mm; **5**, tangential section, scale bar = 0.5 mm; **6**, tangential section displaying acanthostyle, scale bar = 0.2 mm. **7–9**, *Nicholsonella divulgata* sp. nov. **7**, holotype UM2-AE 29, cross-section of the branched colony, scale bar = 1 mm; **8**, paratype UM2-AE 15-2, tangential section, scale bar = 0.5 mm; **9**, holotype UM2-AE 29, longitudinal section of the exozone, scale bar = 0.5 mm. **10–13**, *Nicholsonella recta* sp. nov. **10**, UM2-AE 2-20, cross-section of the branch, scale bar = 1 mm; **11–13**, holotype IGR 36010: **11**, tangential section, scale bar = 1 mm; **12**, tangential section, scale bar = 0.5 mm; **13**, longitudinal section, scale bar = 1 mm.

Description. Ramose colonies, branch diameter 2.4–2.8 mm, with sharply distinct, 0.63–1.00 mm wide endozones and 0.65–1.13 mm wide exozones. Autozooecia in endozone long, having smaller diameters than in exozone, building a bundle, growing parallel to branch axis for a long distance; in exozone bending sharply, increasing in diameter and intersecting colony surface at angles of 67–86°. Autozooecial apertures oval and petaloid due to inflecting acanthostyles, having 0.03 mm thick peristomes, arranged in regular diagonal rows, spaced 2.5 in 2 mm parallel branch axis and 3.5 in the same distance longitudinally, and 3 in 1 mm^2 of branch surface. Autozooecial diaphragms absent. Mesozooecia abundant, separating autozooecia in 1–2 rows, near colony surface almost completely covered by calcitic material, wall structure not seen because of strong recrystallisation. Acanthostyles abundant, originating from base of the exozone, 0.10–0.21 mm in diameter, having distinct hyaline cores, up to 0.03–0.06 mm in diameter and dark coloured sheaths. Walls in endozone straight, granular, 0.02 mm thick; in exozone laminated, 0.05–0.09 mm thick.

Remarks. *Nicholsonella recta* sp. nov. differs from other species of the genus in its autozooecial budding pattern with a distinct bundle of autozooecia in the endozone and a sharply distinct exozone, and by having larger autozooecial apertures, more abundant and larger acanthostyles and smaller mesozooecia.

Order **CRYPTOSTOMIDA** Vine, 1884

Suborder **RHABDOMESINA** Astrova & Morozova, 1956

Family **ARTHROSTYLIDAE** Ulrich, 1882

Genus ***ULRICHOSTYLUS*** Bassler, 1952

Type species. *Helopora divaricatus* Ulrich, 1886. ? Decorah Shale (= Trentonian), Middle Ordovician, Minnesota, USA.

Diagnosis. Colonies dendroid to unbranched. Autozooecial apertures arranged in 6–8 longitudinal rows. Prominent longitudinal ridges separating apertural rows. Axial region formed by well defined linear axis. Autozooecia attenuated to weakly inflated at their bases, budding from branch axis at angles of 20–40°, having triangular cross-section in endozone, becoming elliptical in exozone, orientated at angles of 60–70° to colony surface. Diaphragms rare to absent. Exozonal wall material well developed. Metazooecia absent. Paurostyles scattered, weakly developed, concentrated in walls between longitudinally successive zooecial boundaries.

Remarks. *Ulrichostylus* Bassler, 1952 is similar to *Helopora* Hall in Silliman *et al*., 1851, but differs from it in lacking metazooecia with diaphragms and acanthostyles.

Occurrence. Middle to Upper Ordovician, North America, Scandinavia, Southern Europe.

Ulrichostylus radiatus Conti, 1990 (Pl. 15, figs 1–4; Appendix)

1990 *Ulricostylus radiatus* Conti: 116, pl. 21, figs 7–12.

Holotype. IPUM 2190e (Museum of the Institute of Palaeontology, Modena University, Italy), pictured in Conti (1990: pl. 21, figs 7–12).

Material. UM2-AE 2-(2, 3, 25, 42), 4-(1, 2), 20–21, 30–31, 80-(1, 2, 11, 19).

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

Description. Ramose colonies with well defined median axis, branch diameter 0.36–1.30 mm, with 0.10–0.24 mm wide exozones. Autozooecia long, budding from the median axis at angles of 21–36°, bending gently to branch surface, triangular in cross-section in endozone, becoming oval in exozone, lacking diaphragms. Autozooecial apertures narrow, oval, arranged regularly in diagonal rows on branch surface, spaced 4–5 in 2 mm longitudinally. Walls in exozone hyaline, continuous from median axis as a median layer in exozonal walls, sheathed by outer laminated skeleton in exozone, having well defined zooecial boundaries; endozonal walls 0.006–0.015 mm thick, exozonal walls 0.024–0.360 mm thick. Styles and heterozooecia absent.

Remarks. *Ulrichostylus radiatus* Conti, 1990 is similar to *U. spiniformis* (Ulrich, 1893) from the Middle Ordovician of USA (figured by Blake 1983: fig. 281g–h). Unfortunately, no comprehensive description of the latter species is available to make an exact comparison.

Genus ***NEMATOPORA*** Ulrich, 1888

Type species. *Trematopora minuta* Hall, 1876. Lower Silurian, Clintonian, North America.

Diagnosis. Thin ramose colonies, sometimes articulated at base. Axial region consisting of well defined median axis; planar median wall developed locally in some species. Autozooecia shortened-tubular, triangular in cross-section in endozone, inflated at bases, diverging from median axis, bending abruptly, having length of 4–6 autozooecial diameter. Diaphragms rare. Autozooecial apertures oval or rounded, arranged regularly in 4–10 longitudinal rows, commonly having peristomes. Zooecial boundaries well defined, narrow. Extrazooecial skeleton well developed. Paurostyles common on ridges in many species. Nodes rarely occur. Heterozooecia absent.

Remarks. *Nematopora* Ulrich, 1888 is similar to *Glauconomella* Bassler, 1952 in zooecial shape and wall structure, but differs from it by budding and branching patterns.

Occurrence. Middle to Upper Ordovician, worldwide.

Nematopora hispida Conti, 1990 (Pl. 15, figs 5–9; Appendix)

1990 *Nematopora hispida* Conti: 115–116, pl. 22, figs 1–5.

Holotype. IPUM 21856, (Museum of the Institute of Palaeontology, Modena University, Italy). Upper Ordovician (Upper Caradoc to Lower Ashgill), Sardinia (Italy), pictured by Conti 1990: pl. 22, figs 2–3.

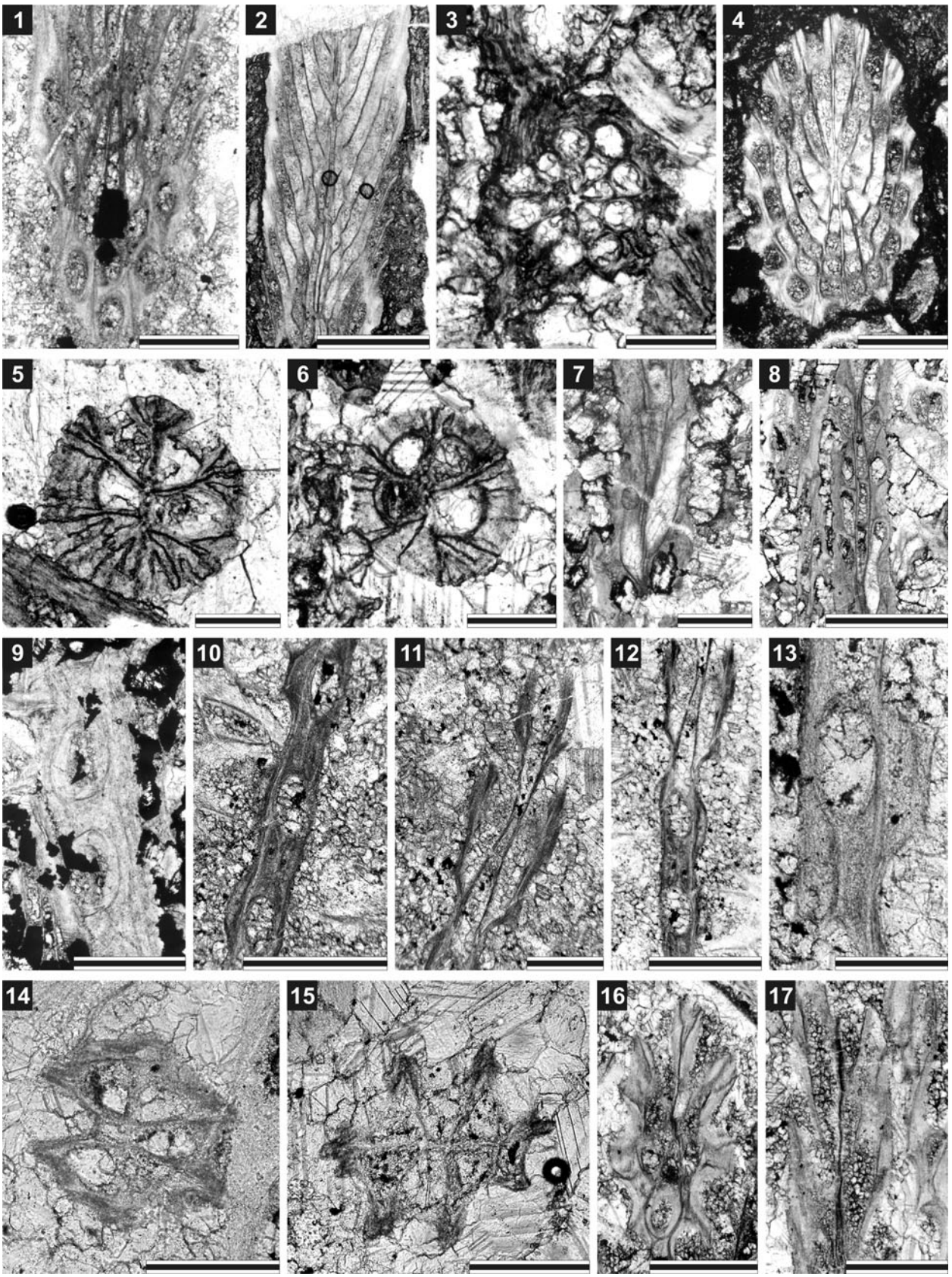

Plate 15 **1–4**, *Ulrichostylus radiatus* Conti, 1990. **1**, UM-2 AE 2-25, oblique section of the branch, scale bar = 0.5 mm; **2**, UM2-AE 22, longitudinal section of the branch, scale bar = 1 mm; **3**, UM2-AE 4-1, cross-section of the branch, scale bar = 0.25 mm; **4**, UM2-AE 22, oblique section of the branch, scale bar = 0.5 mm. **5–9**, *Nematopora hispida* Conti, 1990. **5**, UM2-AE 4-8, cross-section of the branch, scale bar = 0.2 mm; **6**, UM2-AE 4-1, cross-section of the branch, scale bar = 0.2 mm; **7**, UM2-AE 4-14, longitudinal section, scale bar = 0.25 mm; **8**, UM2-AE 4-10,

Material. UM2-AE 2-4, 4-1, 4-3, 4-8, 4-10, 4-13, 15-4, 13-1, 13-2, 67; SMF 2147.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

Description. Ramose colonies, consisting of flattened branches with a median wall. Autozooecia budding from median wall, long, recumbent in endozone and bending sharply in exozone. Terminal diaphragms rare. Autozooecial apertures oval, 0.084–0.150 mm wide, arranged in 4 longitudinal rows. Medial wall 0.03–0.06 mm thick, containing 7–8 rods. Endozonal walls granular, straight, 0.01–0.03 mm thick. Internal granular skeleton thin, well-developed, dark, continuous with peristomes and extensions from the axial region to branch surface, building ridges on the colony surface. Outer lamellar skeleton well developed.

Remarks. The present material matches the description of *Nematopora hispida* Conti, 1990 from the Upper Ordovician of Sardinia. *Nematopora lineata* (Billings, 1862) is similar to *N. hispida*, but differs in the budding pattern, which results in apertures opening radially around the stem. Autozooecia in *N. hispida* bud predominantly from the median wall and open only on the obverse side of the stem.

Family **HYPHASMOPORIDAE** Vine, 1886

Genus **MATSUTRYPA** Gorjunova, 1985

Type species. *Matsutrypa mera* Gorjunova, 1985. Lower Silurian, Llandovery; Estonia.

Diagnosis. Thin ramose colonies. Axial region consisting of well defined median axis. Autozooecia shortened-tubular, triangular in cross-section in endozone, inflated at their bases, diverging from median axis, bending abruptly. Diaphragms rare. Autozooecial apertures oval or rounded, arranged regularly in diagonal rows, commonly having peristomes. Zooecial boundaries well-defined, narrow. Extrazooecial skeleton well developed. Styles absent. Paired metazooecia present between successive autozooecial apertures.

Remarks. *Matsutripa* Gorjunova, 1985 is similar to *Streblotrypa* Vine, 1885, but differs in having only two metazooecia between autozooecia.

Occurrence. Upper Ordovician to Lower Silurian, Estonia, Sweden, France.

Matsutrypa elegantula sp. nov. (Pl. 15, figs 10–15; Appendix)

Holotype. UM2-AE 80-6 (Pl. 15, figs 10–12).

Paratypes. UM2-AE 80–8 (Pl. 15, fig. 13), UM2-AE 80–15.

Type locality. Grange du Pin, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Etymology. The species name refers to the narrow branches and regular arrangement of apertures on the branch.

Material. UM2-AE 13-4, 68-5, 80-(13, 10, 18), 81-1.

Diagnosis. Slender ramose colonies, autozooecia growing in 6–7 rows from median axis or lamina; longitudinal ridges well-developed; diaphragms rare to absent, outer laminated skeleton weakly developed, styles absent.

Description. Colonies ramose, with well-defined axial rod, branches 0.26–0.49 mm in diameter. Bifurcation rare. Autozooecia moderately long, growing in regular spiral order, building 6 rows around median axis or short lamina, autozooecial bases inflated. Autozooecial apertures oval, bordered by well-developed peristomes, 5–6 spaced in a distance of 2 mm longitudinally. Superior hemisepta present, short, blunt; inferior hemisepta absent. Diaphragms in autozooecia absent. Well-developed straight ridges between apertural rows, two paired shallow metazooecia between each aperture. Outer laminated skeleton weakly developed. Rods in median lamina absent.

Remarks. *Matsutrypa elegantula* sp. nov. is similar to *M. rogeri* sp. nov. However, it differs in having thinner branches, smaller and more closely spaced autozooecial apertures (5–6 vs. 2.5–4.0 apertures per 2 mm longitudinally in *M. rogeri*).

Matsutrypa rogeri sp. nov. (Pl. 15, figs 16–17, Pl. 16, figs 1–3; Appendix)

Holotype. UM2-AE 80-13 (Pl. 15, fig. 17).

Paratypes. UM2-AE 80-12 (Pl. 15, fig. 16), UM2-AE 80–3 (Pl. 16, figs 2–3).

Type locality. Grange du Pin, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Etymology. This new species is named for the American bryozoologist Roger Cuffey, who has contributed immensely to bryozoan research.

Material. UM2-AE 80-(2, 16, 18, 21) Ashgill, Montagne de Noire, southern France.

Diagnosis. Slender ramose colonies, autozooecia growing in 6–7 rows from the median axis or lamina; longitudinal ridges well-developed; diaphragms may be common, outer laminated skeleton well-developed, styles absent.

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longitudinal and part of tangential section, scale bar = 1 mm; **9**, UM2-AE 4-19, tangential section, scale bar = 0.5 mm. **10–15**, *Matsutrypa elegantula* sp. nov. **10–12**, holotype UM2-AE 80-6: **10**, tangential section, scale bar = 0.5 mm; **11**, oblique section of the branch, scale bar = 0.25 mm; **12**, tangential section, scale bar = 0.5 mm; **13**, paratype UM2-AE 80-8, tangential section, scale bar = 0.5 mm; **14**, UM2-AE 80-10, cross-section, scale bar = 0.2 mm; **15**, UM2-AE 80-18, cross-section, scale bar = 0.5 mm. **16–17**, *Matsutrypa rogeri* sp. nov. **16**, paratype UM2-AE 80–12, oblique section of the branch, scale bar = 0.5 mm; **17**, holotype UM2-AE 80–13, longitudinal section of the branch, scale bar = 0.5 mm.

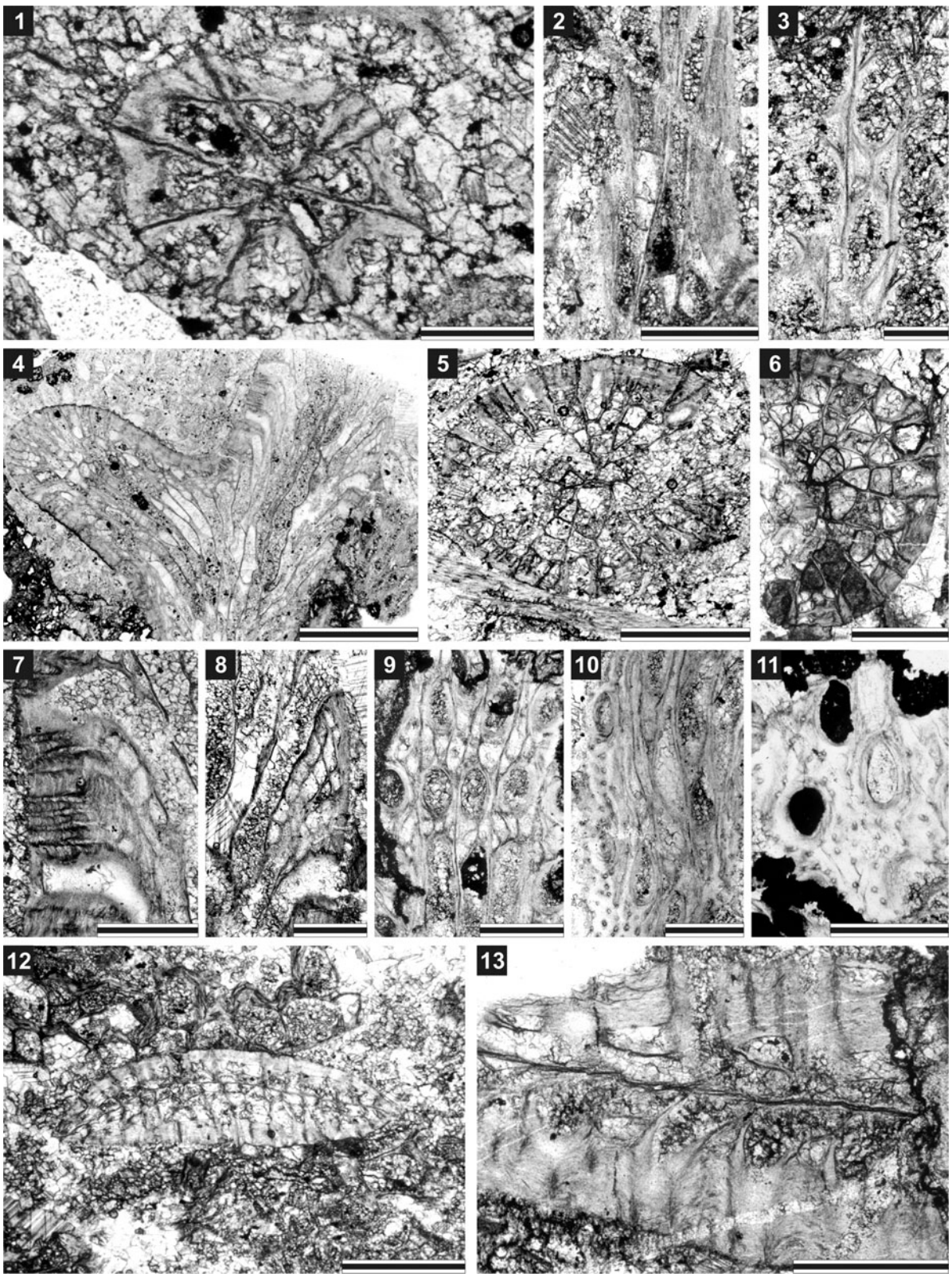

Plate 16 **1–3**, *Matsutrypa rogeri* sp. nov. **1**, UM2-AE 80-18, cross-section, scale bar = 0.2 mm; **2–3**, paratype UM2-AE 80-3: **2**, longitudinal section displaying diaphragms, scale bar = 0.5 mm; **3**, tangential section, scale bar = 0.2 mm. **4–11**, *Nematotrypa punctata* sp. nov. **4**, paratype UM2-AE 80-2, longitudinal section of the branch, scale bar = 2 mm; **5**, UM2-AE 80-20, cross-section of the branch, scale bar = 1 mm; **6**, UM2-AE 4-1, cross-section of the branch, scale bar = 0.5 mm; **7–8**, paratype UM2-AE 80-2: **7**, longitudinal section of the exozone displaying acanthostyles, scale bar = 0.5 mm; **8**, longitudinal section of the exozone displaying heterozooecia, scale bar = 0.5 mm; **9**, holotype UM2-AE 30, deep tangential section, scale bar = 0.5 mm; **10**, paratype UM2-AE 2-46, deep tangential section, scale bar = 0.5 mm; **11**, UM2-AE 4-1, shallow tangential section with acanthostyles, scale bar = 0.5 mm. **12–13**, *Stellatodictya valentinae* sp. nov. UM2-AE 80-7: **12**, cross-section, scale bar = 1 mm; **13**, longitudinal section, scale bar = 0.5 mm.

DESCRIPTION. Colonies ramose, with well-defined axial rod, branches 0.44–0.75 mm in diameter. Articulation or bifurcation not observed. Autozooecia moderately long, growing in regular spiral order, building 6–7 rows around median axis or short lamina, autozooecial bases inflated. Autozooecial apertures oval, bordered by well-developed peristomes, 2.5–4.0 (mean (X) = 3) spaced per 2 mm distance longitudinally. Hemisepta absent. Diaphragms in autozooecia occasional, densely spaced. Well-developed straight ridges between rows of autozooecial apertures, single fine median ridge between autozooecial apertures. Two elongated metazooecia between each autozooecial aperture. Outer laminated skeleton well developed.

REMARKS. *Matsutrypa rogeri* sp. nov. is similar to *M. modica* Gorjunova, 1985 from the Upper Ordovician of Estonia. However, it differs in having more widely spaced apertures (2.5–4.0 vs. 8 per 2 mm longitudinally in *M. modica*).

Family **NEMATOTRYPIDAE** Spjeldnaes, 1984

Genus ***NEMATOTRYPA*** Bassler, 1911*a*

TYPE SPECIES. *Nematotrypa gracilis* Bassler, 1911*a*. Middle Ordovician (Kukruse Stage), Estonia.

DIAGNOSIS. (after Gorjunova 1985) Ramose colonies. Long, tubular autozooecia, bearing well-developed hemiphragms and oval apertures. Abundant heterozooecia (tektitozooecia of Kopajevich, 1975) between autozooecia. Nodes on colony surface sometimes developed.

REMARKS. *Nematotrypa* Bassler, 1911*a* differs from the most similar genus *Pseudonematopora* Balakin, 1974 in the presence of hemiphragms and nodes on branch surfaces.

OCCURRENCE. Middle to Upper Ordovician, Europe and Siberia.

Nematotrypa punctata sp. nov. (Pl. 16, figs 4–11; Appendix)

HOLOTYPE. UM2-AE 30 (Pl. 16, fig. 9).

PARATYPES. UM2-AE 2-46 (Pl. 16, fig. 10), UM2-AE 80-2 (Pl. 16, figs 4, 7, 8).

TYPE LOCALITY. Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician, Ashgill.

ETYMOLOGY. The species name refers to the abundant styles giving a punctuate appearance.

MATERIAL. UM2-AE 2-15, 4-1, 4-19, 12-14, 59-8, 63a -1, 59-21, 80-14, 80-20.

OCCURRENCE. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France.

DIAGNOSIS. Ramose cylindrical colonies, with poorly developed median axis or lamina, having sparse and large heterozooecia as well as abundant styles.

DESCRIPTION. Ramose cylindrical colonies, branches 1.5–2.5 mm in diameter, with distinct 0.30–0.75 mm wide exozone. Branching common. Medial axis poorly developed or absent, sometimes transformed to median lamina. Autozooecia extremely long in endozone, bending abruptly towards branch surface. Autozooecial diaphragms rare, hemiphragms absent. Autozooecial apertures oval, arranged in distinct diagonal rows, having well-developed peristomes, spaced 3–4 per 2 mm longitudinally and 7–9 in the same distance diagonally. Peristome wall 0.03 mm thick. Heterozooecia form conical tubes, often beaded in appearance, bearing numerous proximally curved diaphragms, arising from base of exozone, covered by calcitic skeleton at branch surface, having polygonal shape in cross-section, arranged in 2–3 rows between autozooecial apertures, spaced 4–6 between neighbouring autozooecia, 0.04–0.12 mm in diameter near the colony surface. Autozooecial walls hyaline, 0.010–0.025 mm thick in endozone; reverse V-shaped, laminated, with dark median lining, 0.035–0.450 mm thick in exozone. Styles abundant, arising from base of exozone, having distinct hyaline cores, arranged in regular rows between apertures, 0.025–0.040 mm in diameter.

REMARKS. *Nematotrypa punctata* sp. nov. shows some similarities to *N. indigena* Gorjunova, 1985 from the Middle Ordovician of Estonia. The new species differs in having fewer heterozooecia and more abundant styles.

Suborder **PTILODICTYINA** Astrova & Morozova, 1956

Family **PTILODICTYIDAE** Zittel, 1880

Genus ***STELLATODICTYA*** Gorjunova *in* Gorjunova & Lavrentjeva, 1993

TYPE SPECIES. *Stellatodictya plana* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993. Upper Ordovician, Caradoc, north-western Russia.

DIAGNOSIS. Colonies consisting of wide bifoliate, flattened branches, ellipsoidal in cross-section. Mesotheca straight, with median rods. Autozooecia with knee-like bend, shortened, lacking diaphragms and hemisepta. Autozooecial apertures rounded, having prominent peristomes, arranged in diagonal rows. Interspaces between autozooecia consisting of vesicular skeleton and covered by outer laminated skeleton. Vesicles large, having shape of polygonal boxes with different height of vertical walls and slightly curved roofs. Stellatopores developed in outer laminated skeleton, adjoining autozooecia and surrounding them in a single row. Maculae absent.

REMARKS. *Stellatodictya* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 differs from *Oanduellina* Pushkin, 1977 by flattened branched colony form, rounded autozooecia apertures, vesicles of peculiar shape and stellatopores.

OCCURRENCE. Two species are known: *S. plana* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 from the Upper Ordovician (Caradoc to Ashgill) of north-western Russia and India (Süttner & Ernst 2007), and *S. valentinae* sp. nov. from the Upper Ordovician (Ashgill) of Montagne de Noire, southern France.

Stellatodictya valentinae sp. nov. (Pl. 16, figs 12–13, Pl. 17, figs 1–6; Appendix)

HOLOTYPE. UM2-AE 20 (Pl. 17, fig. 3).

PARATYPES. UM2-AE 24, UM2-AE 80-18 (Pl. 17, fig. 1).

TYPE LOCALITY. Montagne de Noire, southern France.

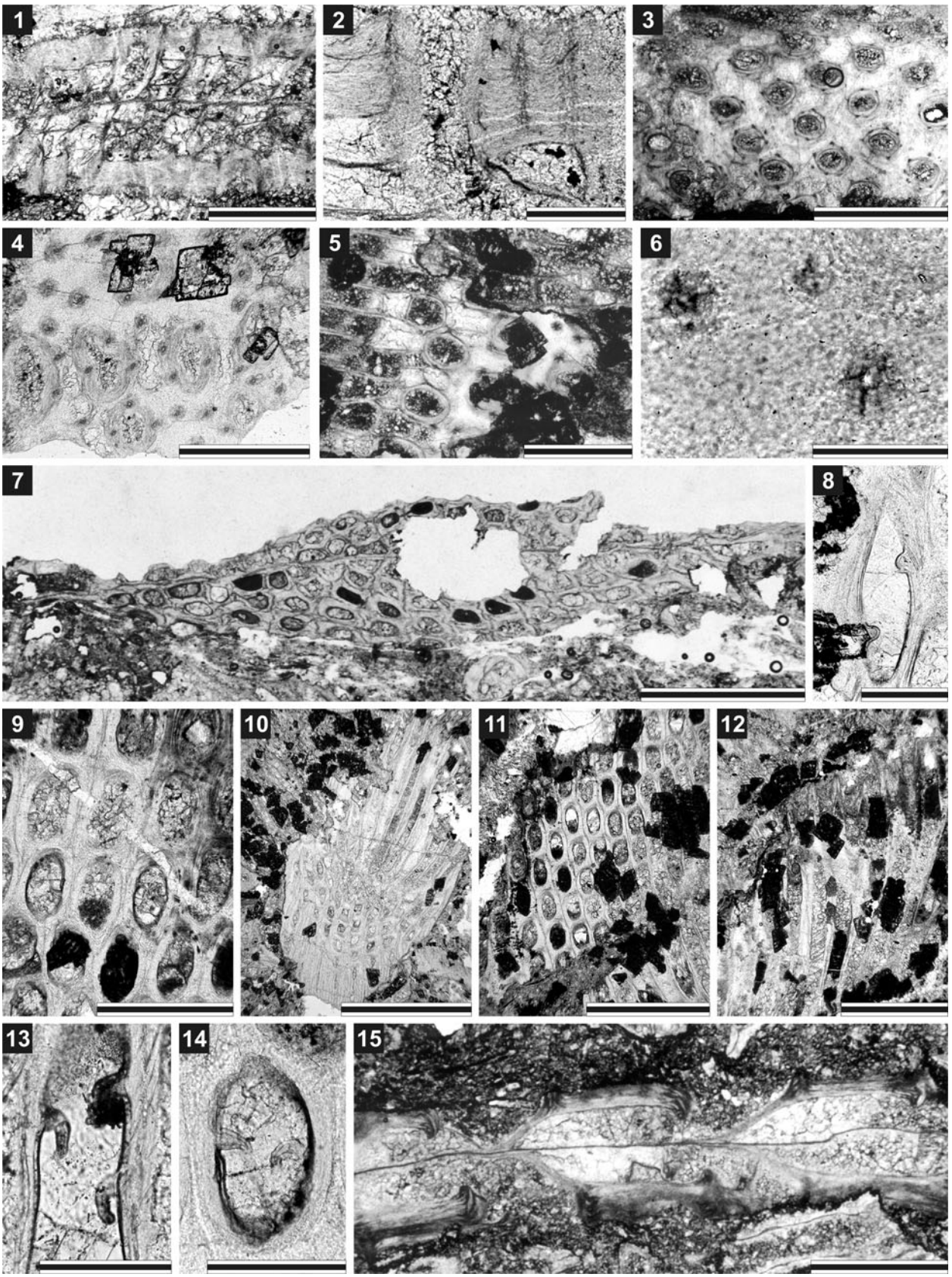

Plate 17 **1–6**, *Stellatodictya valentinae* sp. nov. **1**, paratype UM2-AE 80-18, cross-section, scale bar = 0.5 mm; **2**, UM2-AE 80-7, longitudinal section, scale bar = 0.2 mm; **3**, holotype UM2-AE 20, tangential section, scale bar = 1 mm; **4**, UM2-AE 13-4, tangential section, scale bar = 0.5 mm; **5**, UM2-AE 15-2, tangential section, scale bar = 0.5 mm; **6**, UM2-AE 80-13, tangential section displaying stellatopores, scale bar = 0.1 mm. **7–14**, *Ptilodictya feisti* sp. nov. **7**, paratype UM2-AE 2-15, cross-section of the branch, scale bar = 1 mm; **8**, UM2-AE 2-25, deep

TYPE STRATUM. Upper Ordovician, Upper Caradoc to Lower Ashgill.

ETYMOLOGY. This species is named for the Russian bryozoologist Valentina D. Lavrentjeva, who has contributed greatly to research on Palaeozoic bryozoans.

MATERIAL. UM2-AE 13-4, 15-2, 15-3, 20, 24, 30, 36, 69-1, 69-3, 80-(7, 12, 13, 15); Grange du Pin, Montagne de Noire, southern France; Upper Ordovician, Ashgill.

DIAGNOSIS. Bifoliate colonies; autozooecia arranged in 16–17 rows; apertures rounded, small; stellatopores abundant, small.

DESCRIPTION. Bifoliate branching colony, branches 2.50–3.75 mm wide and 0.57–0.80 mm thick. Autozooecia short, at first recumbent on mesotheca, then bending sharply and intersecting branch surface at angles of 80–90°, sub-rectangular in cross-section at base. Hemisepta absent. Autozooecial apertures rounded to oval, arranged in 16–17 quite regular diagonal rows, spaced 6–10 in 5 mm of longitudinal direction and 15–19 in 5 mm diagonally. Mesotheca straight, 0.18–0.24 mm thick, having abundant median rods. Median rods consisting of hyaline material, rounded to ellipsoidal in cross-section, 0.012–0.018 mm in diameter. Vesicles at base of exozone, having shape of polygonal boxes with slightly curved roofs, usually separating autozooecia in 1–3 rows and occurring 1–3 in vertical view, covered by outer laminated skeleton, 0.036–0.090 mm wide in deep tangential section, 0.042–0.180 mm high in longitudinal section. Outer laminated skeleton variably thickened, well-developed in exozone, bearing abundant stellatopores. Inner granular skeleton 0.006–0.012 mm thick in endozone, continuous in peristomes of apertures and 0.024–0.030 mm thick there. Stellatopores having distinct light hyaline cores with radially arranged rays, surrounded by dark sheaths, appearing stellate in cross-section, 5–9 surrounding each autozooecial aperture. Maculae absent.

REMARKS. *Stellatodictya valentinae* sp. nov. is similar to the type species *S. plana* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993, but differs by having smaller autozooecial apertures (0.09–0.15 vs. 0.16–0.17 mm) and smaller stellatopores (0.012–0.030 mm vs. 0.030–0.050 mm). *Ptylodictya* sp., described by Prantl (1940: 85–86, pl. 1, fig. 3), may be similar because of its '... rectangular network', which might be vesicular skeleton. Furthermore, species described by Nekhoroshev (1936: 10–11, pl. 2, figs 7–8) as *Ptilodictya* sp. ex. gr. *lanceolata* Goldfuss from the Upper Ordovician of Carnic Alps, could also belong to this species.

Genus ***PTILODICTYA*** Lonsdale, 1839

TYPE SPECIES. *Flustra lanceolata* Goldfuss, 1829. Lower Silurian, (Wenlockian), Great Britain.

DIAGNOSIS. Colonies lancet or belt form, rarely dichotomous ramose. Mesotheca straight, locally zigzag, sometimes thickened in exozone. Autozooecia straight, tubular, long; sub-rectangular to sub-hexagonal in endozone; commonly sub-rectangular in exozone, rarely oval. Apertures arranged in longitudinal rows, separated by straight ridges. Diaphragms absent. Hemisepta present: superior and sometimes inferior. Monticules irregularly distributed, flat to slightly raised.

REMARKS. *Ptilodictya* Lonsdale, 1839 differs from *Cladodictya* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 in having longer autozooecia and presence of ridges.

OCCURRENCE. Middle Ordovician to Lower Devonian, North America, Europe and Siberia.

REMARK. Goryunova & Lavrentjeva (1993: 65) mentioned the species *Ptilodictya dichotoma* Portlock, 1847 as being described from the Upper Ordovician of France. However, such a publication does not exist. The original citation of *Ptilodictya dichotoma* is from Portlock (1843) and is from the Silurian of the British Isles (Tyrone, Ireland).

Ptilodictya feisti sp. nov. (Pl. 17, figs 7–14)

HOLOTYPE. UM2-AE 2-34 (Pl. 17, figs 9, 12, 14).

PARATYPES. UM2-AE 2-10, 2-15 (Pl. 17, fig. 7).

TYPE LOCALITY. Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician, Caradoc.

ETYMOLOGY. This species is named for Raimund Feist, who provided a bryozoan collection from Montagne de Noire.

MATERIAL. UM2-AE 2-25, 80-10.

OCCURRENCE. Upper Ordovician (Caradoc to Ashgill); Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Ramose flattened bifoliate colony with sharp edges, 2.54–5.00 mm wide and 0.6 mm thick. Autozooecia long, straight, budding at sharp angles from the straight mesotheca, rectangular at their bases, becoming rhomboidal in middle tangential section and rounded at branch surface. Autozooecial apertures arranged in 13–23 rows, spaced 6 in 2 mm longitudinally and 8–9 in 2 mm across branch, 0.12–0.14 mm in diameter. Mural spines inside autozooecia abundant, long, curved proximally. Styles absent. Zooecial boundaries distinct. Zooecial walls displaying sharp reverse V-shaped lamination. Mesotheca straight, three-layered, 0.04 mm thick.

REMARKS. *Ptilodictya feisti* sp. nov. is most similar to *Ptilodictya gladiola* Billings, 1866 from the Upper Ordovician to Lower Silurian of Canada. However, the latter species

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tangential section displaying mural spine, scale bar = 0.2 mm; **9**, holotype UM2-AE 2-34, tangential section, scale bar = 0.5 mm; **10**, UM2-AE 2-10, oblique section of the branch, scale bar = 2 mm; **11**, UM2-AE 2-25, tangential section, scale bar = 1 mm; **12**, holotype UM2-AE 2-34, longitudinal section, scale bar = 1 mm; **13**, UM2-AE 2-25, longitudinal section displaying mural spines, scale bar = 0.2 mm; **14**, holotype UM2-AE 2-34, deep tangential section displaying mural spines, scale bar = 0.2 mm, **15**, *Graptodictya meneghinii* (Vinassa de Regny, 1942). UM2-AE 22, longitudinal section, scale bar = 0.5 mm.

has more closely spaced apertures (9 vs. 6 in 2 mm longitudinally).

Genus ***GRAPTODICTYA*** Ulrich, 1882 [= ***ARTHROPORA*** Ulrich, 1882]

TYPE SPECIES. *Ptilodictya perelegans* Urlich, 1878. Waynesville Shale (Upper Ordovician); Ohio, USA.

DIAGNOSIS. Branching colonies, irregularly anastomosing in some species. Mesotheca slightly sinuous in longitudinal section, may zigzag in cross-section. Autozooecia budding in exozone at angles 80–90° to mesotheca. Pustules abundant along autozooecial boundaries and throughout exozonal walls and extrazooecial skeleton. Living chambers elliptical to oval in cross-section. Superior hemisepta common, generally short and blunt, rarely thin and long, curving proximally. Exilazooecia absent to rare, generally subelliptical in cross-section, commonly closed by thickened walls. Monticules absent to rare. Extrazooecial stereom laminae commonly crinkled, forming abundant and longitudinal striae between autozooecia and along colonial margins and proximal parts of colonies.

REMARKS. *Graptodictya* Ulrich, 1882 differs from *Proavella* Männil, 1958 in having branched rather than reticular colonies.

OCCURRENCE. Middle Ordovician to lower Silurian of Estonia, Sweden, North America.

Graptodictya meneghinii (Vinassa de Regny, 1942) (Pl. 17, fig. 15, Pl. 18, figs 1–3; Appendix)

1942 *Pachydictya Meneghinii* Vinassa de Regny: 1030–1031, pl. 1, figs 6–8.
1942 *Graptodictya* sp Vinassa de Regny: 1030, pl. 1, figs 4–5.
1942 *Pachydictia* (?) *sardoa* Vinassa de Regny: 1031, pl. 1, fig. 11.
1988 *Graptodictya* sp. Conti & Serpagli: 143, pl. 11, fig. 5, pl. 12, figs 2–3.
1990 *Graptodictya meneghinii* (Vinassa de Regny); Conti: 113–114, pl. 20.

HOLOTYPE. Figured by Vinassa de Regny (1942: pl. 1, figs 6–8), Upper Ordovician, Sardinia, Italy.

MATERIAL. UM2-AE 2-34, 12-5, 12-9, 12-15, 22, 30, 37, 80-(2, 10).

OCCURRENCE. Grange du Pin, Montagne de Noire, southern France, Upper Ordovician, Ashgill. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

DESCRIPTION. Branching colonies, 2.05–2.50 mm wide, 0.50–0.60 mm thick. Autozooecia quite long, budding in endozone at angles of 33–42° to the mesotheca, bending in exozone and intersecting branch surface at angles of 80–90°, oval to sub-polygonal in cross-section. Superior hemisepta common, short and blunt, curving proximally. Autozooecial apertures oval, arranged in 7–9 regular alternating rows, spaced 8.0–8.5 in 5 mm longitudinally and 14–16 in 5 mm diagonally. Heterozooecia absent. Mesotheca slightly sinuous in longitudinal section and generally straight in cross-section. Extrazooecial skeletal laminae commonly crinkled, forming abundant longitudinal striae between autozooecia and along branch margins and proximal parts of colonies.

REMARKS. *Graptodictya meneghinii* (Vinassa de Regny, 1942) is similar to *G. boreniensis* Brood, 1978 from the *Dalmanitina* beds (Hirnantian) of Sweden. However, it differs in having wider branches and larger apertures (0.110 mm vs. 0.084 mm in *G. boreniensis*). *Graptodictya meneghinii* (Vinassa de Regny, 1942) differs from *G. bonnemai* Bassler, 1911*a* in having wider branches and more widely spaced autozooecial apertures (8.0–8.5 vs. 12–15 per 5 mm longitudinally).

Graptodictya sp. (Pl. 18, figs 4–6; Appendix)

MATERIAL. UM2-AE 4-(4, 11, 14, 19, 20, 22).

OCCURRENCE. Upper Ordovician Caradoc; Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Branching colonies, 1.72 mm wide, 0.48–0.56 mm thick. Autozooecia long, budding in endozone at angles of 35–45° to the mesotheca, bending in exozone and intersecting branch surface at angles of 65–75°, oval to sub-polygonal in cross-section. Superior hemisepta short and blunt, curving proximally; inferior hemisepta absent. Autozooecial apertures oval, arranged in at least 7–9 regular alternating rows, spaced 10 in 5 mm longitudinally and 13.5 in 5 mm diagonally. Heterozooecia absent. Mesotheca slightly sinuous in longitudinal section and generally straight in cross-section, 0.04 mm thick, three-layered. Extrazooecial skeleton finely laminated, longitudinal striae between autozooecia not developed.

REMARKS. *Graptodictya* sp. differs from *G. meneghinii* (Vinassa de Regny, 1942) in having narrower branches, slightly smaller and more closely spaced autozooecial apertures as well as in the absence of longitudinal striations.

Suborder **STICTOPORELLINA** Gorjunova *in* Gorjunova & Lavrentjeva, 1993

Family **STICTOPORELLIDAE** Nickles & Bassler, 1900

Genus ***STICTOPORELLINA*** Nekhoroshev, 1956

TYPE SPECIES. *Stictoporella cribrosa* Ulrich, 1886, Upper Ordovician, Caradoc, Blackriver, Minnesota, USA.

DIAGNOSIS. Bifoliate, reticulate colonies. Mesotheca straight or weakly bending, without rod-like structures. Recumbent portion long, then bending sharply into exozone. Diaphragms rare or absent. Hemisepta absent. Autozooecial apertures rounded or oval, lacking nodes, irregularly arranged. Angular to rounded–oval metazooecia without diaphragms distributed irregularly between autozooecial apertures. Nodes absent.

REMARKS. *Stictoporellina* Nekhoroshev, 1956 differs from *Stictoporella* Ulrich, 1882 in its reticulate colony form and from *Oanduellina* Pushkin, 1977 by its irregular spacing of autozooecial apertures as well as absence of hemisepta.

OCCURRENCE. Four species are known: *S. cribrosa* (Ulrich, 1886), Upper Ordovician, Caradoc, Blackriver,

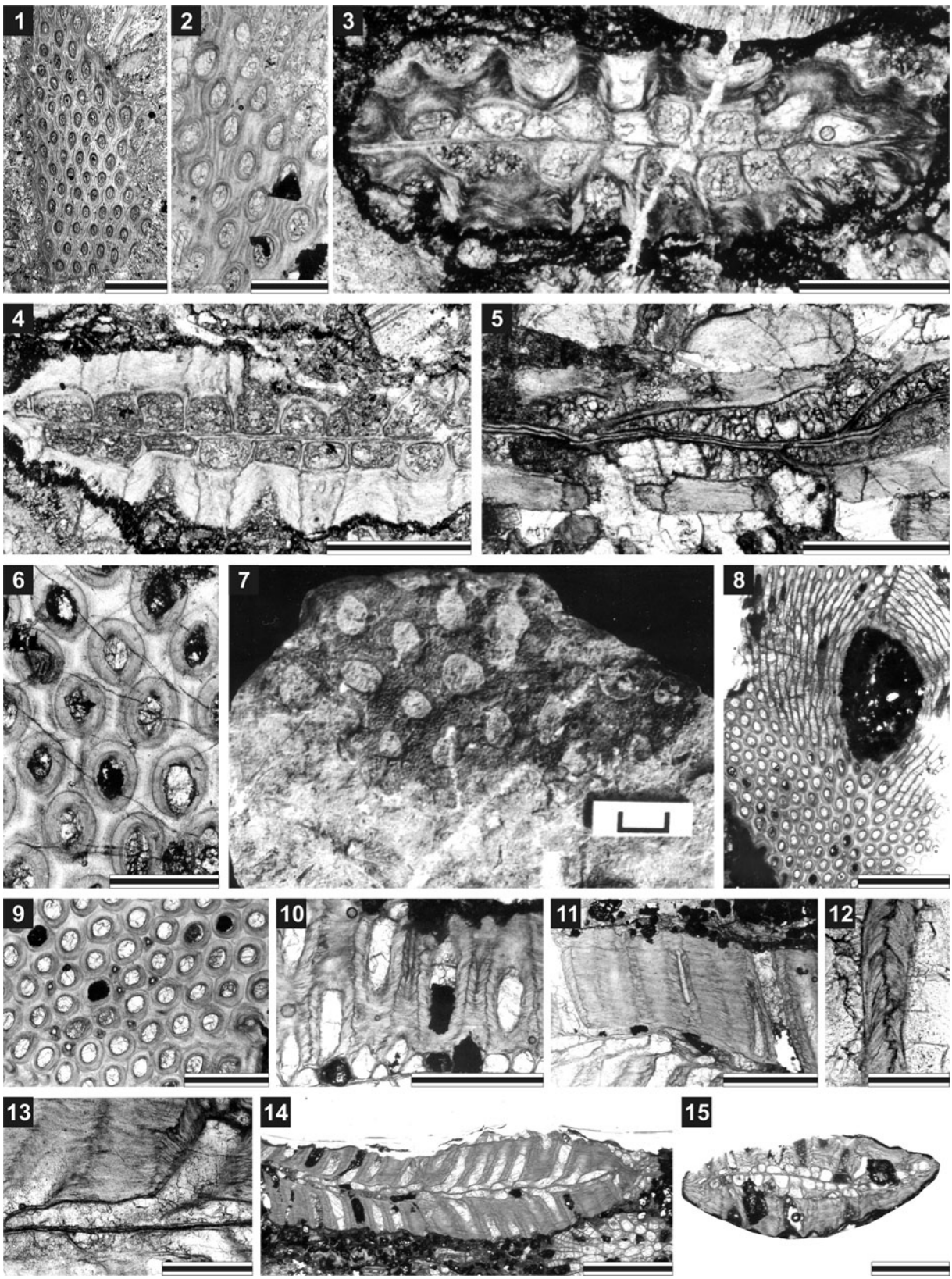

Plate 18 **1–3**, *Graptodictya meneghinii* (Vinassa de Regny, 1942). **1**, UM2-AE 80-2, tangential section, scale bar = 1 mm; **2**, UM2-AE 2-34, tangential section, scale bar = 0.5 mm; **3**, UM2-AE 30 cross-section, scale bar = 0.5 mm. **4–6**, *Graptodictya* sp. **4**, UM2-AE 4-22, cross-section, scale bar = 0.5 mm; **5**, UM2-AE 4-11, longitudinal section, scale bar = 0.5 mm; **6**, UM2-AE 4–14, tangential section, scale bar = 0.5 mm. **7–15**, *Stictoporellina eremita* (Prantl, 1940). **7**, UM2-AE 80, scale bar = 5 mm; **8–14**, UM2-AE63a: **8**, tangential section, scale bar = 2 mm; **9**, tangential section, scale bar = 1 mm; **10**, cross-section, scale bar = 1 mm; **11**, longitudinal section, scale bar = 1 mm; **12**, cross-section of the exozone displaying wall structure, scale bar = 0.3 mm; **13**, longitudinal section, scale bar = 0.5 mm; **14**, longitudinal section, scale bar = 2 mm; **15**, UM2-AE 64, cross-section of the branch, scale bar = 1 mm.

Minnesota, USA; *S. cribrilina* (Coryell, 1921), Upper Ordovician, Caradoc, Blackriver, Tennessee, USA; *S. clausa* Nekhoroshev, 1961, Upper Ordovician, Ashgill, Dolbor-Horizon, Krasnoyarski Region, Siberia; and *S. eremita* (Prantl, 1940), Ashgill, Montagne de Noir, southern France.

Stictoporellina eremita (Prantl, 1940) (Pl. 18, figs 7–15; Appendix)

1940 *Graptodictia eremita* Prantl: 84–85, pl. 1, fig. 1.
1993 *Proavella* (?) *eremita* (Prantl, 1940); Gorjunova & Lavrentjeva: 71.

Holotype. Specimen figured by Prantl (1940: pl. 1, fig. 1). National Museum, Prague. Upper Ordovician, Montagne de Noire, southern France.

Material. UM2-AE 63a, 64, 80.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France.

Description. Robust bifoliate, net-like colonies. Branches flattened, joined by anastomoses. Branches 2.20–3.20 mm wide, 1.96–3.10 mm thick, lens-shaped in cross-section. Fenestrules elliptical or rounded, 2.4–4.0 mm wide, 2.8–4.8 mm long. Anastomoses 2.94–3.52 mm wide. Autozooecia arranged irregularly in 10–12 rows, recumbent portion long, bending sharply in exozone and intersecting branch surface at almost right angles. Diaphragms in autozooecia rare. Hemisepta absent. Autozooecial apertures rounded to oval, spaced 8–9 in 5 mm of colony surface. Apertures located in the middle of depressed areas, the borders of which form a hexagonal pattern. Rounded–oval metazooecia usually scarce, locally common, lacking diaphragms, budding throughout exozone. Walls in endozone 0.012–0.015 mm thick, granular–prismatic; in exozone laminated, 0.14–0.17 mm thick, with zigzag-formed dark line indicating autozooecial borderings, in monticules moniliform. Mesotheca 0.025–0.040 mm thick, three-layered with an inner dark layer between two lighter outer layers. Monticules rare, high and consisting of autozooecia.

Remarks. *Stictoporellina eremita* (Prantl, 1940) is similar to *S. cribrosa* (Ulrich, 1886), but differs by having larger autozooecial apertures, fewer apertures per 5 mm (8–12 vs. 15–17) and fewer metazooecia. *Stictoporellina clausa* Nekhoroshev, 1961 has smaller branches, fewer autozooecial rows (6–9) and more autozooecial apertures per 5 mm (18).

Genus ***STICTOPORELLA*** Ulrich, 1882

Type species. *Stictoporella interstincta* Ulrich, 1882. Upper Ordovician, Cincinnatian, Kentucky, USA.

Diagnosis. Ramose bifoliate colonies, branching or lamellar, leaf-shaped, with narrow edges lacking apertures. Mesotheca straight, or slightly undulating. Autozooecia bending in exozone, intersecting branch surface at almost right angles. Diaphragms rare or absent. Upper hemisepta occasionally developed. Apertures rounded, irregularly arranged. Metazooecia rare to absent, occasionally clustered.

Remarks. *Stictoporella* Ulrich, 1882 differs from *Stictoporellina* Nekhoroshev, 1956 in having branching and lamellar colonies rather than reticulate colonies.

Occurrence. Middle Ordovician to Middle Silurian, North America, Siberia.

? ***Stictoporella*** sp. (Pl. 19, figs 1–4; Appendix)

Material. UM2-AE 74 (three cross-sections and one tangential section of a single colony).

Occurrence. Upper Ordovician, ? Ashgill, Montagne de Noire, southern France.

Description. Ramose bifoliate branch, having edges containing autozooecia, 4.2 mm wide and 2.4–2.9 mm thick. Autozooecia long, budding with slight bending towards the colony surface, hemispherical to slightly rectangular at their bases in cross-section, becoming circular, arranged in at least 3–4 horizontal stages in cross-section. Hemisepta and diaphragms not observed. Autozooecial apertures oval, arranged in regular longitudinal rows, spaced 10 in 5 mm longitudinally and 22–23 in 5 mm across the branch. Mesotheca straight, without median rods, three-layered with median hyaline layer and two outer granular layers, 0.018 mm thick. Metazooecia small, oval in cross-section, 1–2 occurring between autozooecial apertures, occasionally absent, originating in inner exozone. Outer laminated skeleton well-developed, variably thickened. Laminae deposited obliquely to distinct, dark coloured and serrated autozooecial boundaries, which appear as longitudinal ribs on colony surface. Inner granular skeleton well-developed, 0.030–0.048 mm thick.

Remarks. This colony shows similarities to *Stictoporella* Ulrich, 1882, especially in wall structure and presence and arrangement of metazooecia. Unfortunately, no longitudinal thin section could be prepared. Arrangement of autozooecia in 3–4 horizontal stages is quite unusual for this genus.

Genus ***ASTROVIDICTYA*** Gorjunova & Lavrentjeva, 1993

Type species. *A. sparsa* Lavrentjeva, 1993. Upper Ordovician, Caradoc, north-western Russia, Estonia, and Lithuania.

Diagnosis. Branching bifoliate colonies, branches oval or lens-shaped in cross section. Mesotheca straight or crenulated, containing hyaline rods. Autozooecial diaphragms rare. Both superior and inferior hemisepta present, straight or hook-shaped, long. Apertures oval or elliptical. Single or doubled metazooecia between autozooecial apertures, becoming abundant at branch edges. Flat maculae lacking autozooecia rare.

Remarks. *Astrovidictya* Gorjunova & Lavrentjeva, 1993 differs from *Oanduella* Männil, 1958 in having branched instead of reticulated anastomosing colonies as well as regular arrangement of metazooecia.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, north-western Russia, Estonia, Lithuania. Upper Ordovician (Upper Caradoc to Lower Ashgill), Grange du Pin, Montagne de Noire, southern France.

Astrovidictya sparsa Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 (Pl. 19, figs 5–12, Pl. 20, figs 1–3, 7; Appendix)

1993 *Astrovidictya sparsa* Lavrentjeva: 86–87, pl. 16, fig. 4, pl. 17, fig. 1.

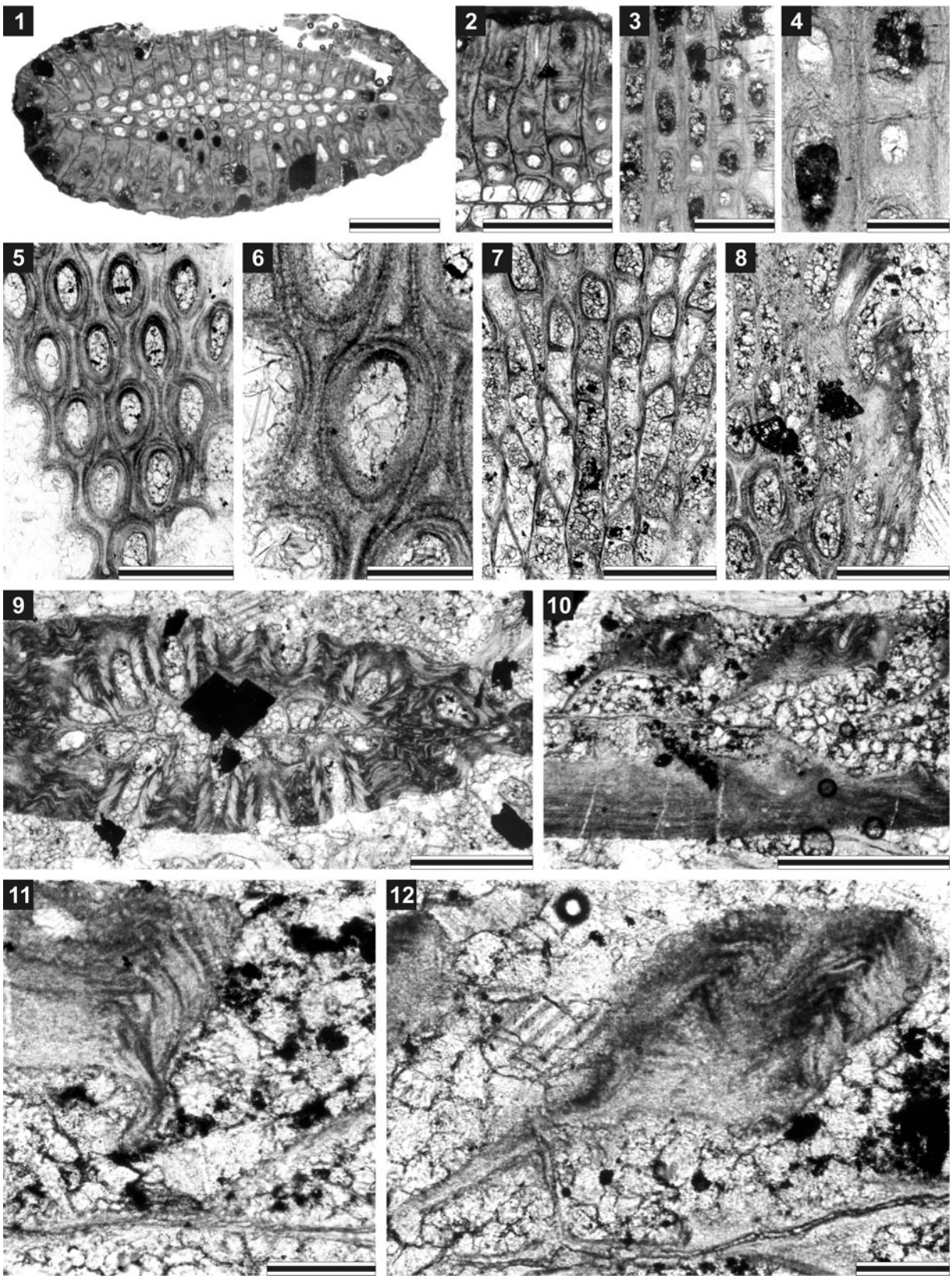

Plate 19 **1–4**, ? *Stictoporella* sp. UM2-AE 74: **1**, cross-section of the branch, scale bar = 1 mm; **2**, cross-section of the exozone, scale bar = 1 mm; **3**, tangential section, scale bar = 0.5 mm; **4**, tangential section displaying apertures and metazooecia, scale bar = 0.2 mm. **5–12**, *Astrovidictya sparsa* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993. **5**, UM2-AE 80-13, tangential section, scale bar = 0.5 mm; **6**, **7**, UM2-AE 80-13: **6**, tangential section displaying metazooecia, scale bar = 0.2 mm; **7**, deep tangential section displaying hemisepta, scale bar = 0.5 mm; **8**, UM2-AE 80-14, randomly orientated section, displaying edge of the branch with abundant metazooecia, scale bar = 0.5 mm; **9**, UM2-AE 2-15, cross-section of the branch, scale bar = 0.5 mm; **10–12**, UM2-AE 80-18: **10**, longitudinal section, scale bar = 0.5 mm; **11**, longitudinal section displaying superior hemisepta, scale bar = 0.1 mm; **12**, longitudinal section displaying inferior hemisepta, scale bar = 0.1 mm.

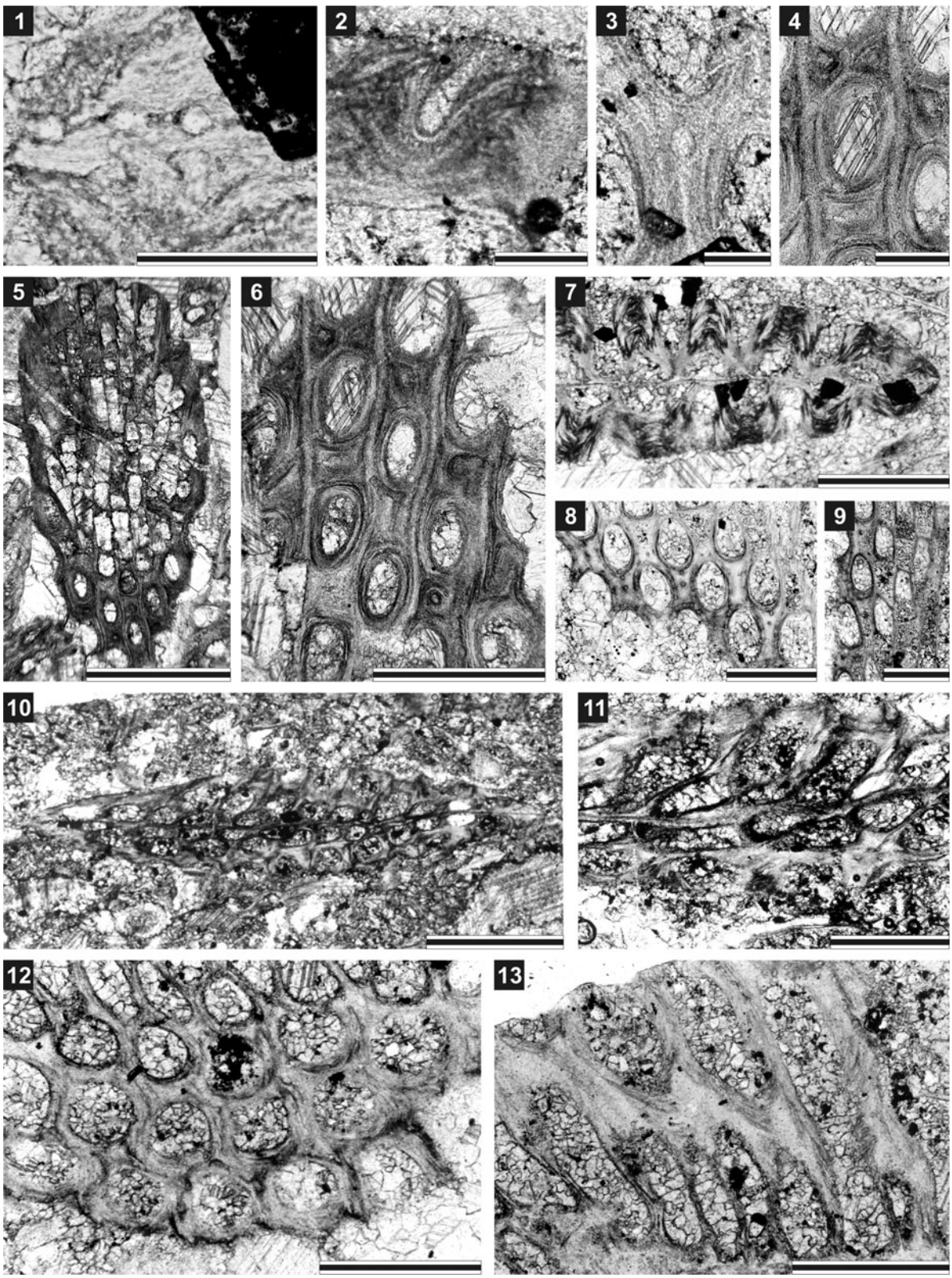

Plate 20 **1–3, 7**, *Astrovidictya sparsa* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993. **1**, UM2-AE 2-46, cross-section, displaying rods in mesotheca, scale bar = 0.1 mm; **2**, UM2-AE 80-18, longitudinal section displaying bottle-shaped metazooecium, scale bar = 0.1 mm; **3**, UM2-AE 80-14, tangential section, displaying an aperture of a metazooecium, scale bar = 0.1 mm; **7**, UM2-AE 2-46, cross-section of the branch, scale bar = 0.5 mm. **4–6**, Ptilodictyina sp. indet. 2. UM2-AE 11; **4**, tangential section, scale bar = 0.2 mm; **5**, oblique section, scale bar = 1 mm; **6**, tangential section, scale bar = 0.5 mm. **8–9**, Ptilodictyina sp. indet. 1. UM-2-AE 80-8: **8**, tangential section, scale bar = 0.5 mm; **9**, deep tangential section, scale bar = 0.5 mm. **10–13**, Ptilodictyina sp. indet. 3. **10**, **11**, UM2-AE 80-18: **10**, cross-section of the branch, scale bar = 1 mm; **11**, cross-section, scale bar = 0.5 mm; **12**, **13**, UM2-AE 80–4: **12**, tangential section, scale bar = 0.5 mm; **13**, deep tangential section displaying inferior hemisepta, scale bar = 0.5 mm.

HOLOTYPE. 3535/1080, Paleontological Institute, Moscow. Keila Stage, Caradoc, Upper Ordovician, Lithuania.

MATERIAL. UM2-AE 2-(15, 46), 4-1, 80-(1, 5, 7, 12, 13, 14, 18).

OCCURRENCE. Upper Ordovician, Caradoc, north-western Russia, Estonia, Lithuania. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Bifoliate branching colonies. Branches 1.90–3.90 mm wide, 0.66–0.70 mm thick. Autozooecia short, bending sharply toward colony surface, rectangular at base, becoming oval at colony surface. Autozooecia arranged in 8–17 regular rows, spaced 3–4 in 2 mm longitudinally and 7.0–7.5 in 2 mm diagonally at colony surface. Superior hemisepta long, curved proximally; inferior hemisepta long, straight. Metazooecia bottle-shaped, usually one, rarely two between autozooecia longitudinally, numerous along branch edges. Metazooecial apertures circular to oval, often sealed by skeletal material at colony surface, 0.054–0.066 mm in diameter. Zooecial walls granular, thin in endozone; thickened, coarsely laminated in exozone. Small granules occurring at colony surface, few or none in deeper sections. Mesotheca straight, 0.03–0.60 mm thick, containing abundant rods. Rods rounded in cross-section, consisting of hyaline calcite, spaced densely. Low longitudinal ridges developed.

REMARKS. *Astrovidictya sparsa* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 differs from *A. hamatilis* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1993 in having smaller and more widely spaced apertures (3–4 apertures in 2 mm in *A. sparsa* Lavrentjeva *in* Gorjunova & Lavrentjeva, 1963, 1993 vs. 5.5–6 in 2 mm in *A. hamatilis*), as well as absence of diaphragms.

INCERTAE SEDIS

Ptilodictyina sp. indet. 1 (Pl. 20, figs 8–9; Appendix)

MATERIAL. UM2-AE 80-(8, 6).

OCCURRENCE. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Bifoliate branching colony. Branches 1.90–2.34 mm wide. Autozooecia short, bending sharply to branch surface, rectangular at their bases, becoming oval at branch surface. Autozooecia arranged in 9–10 regular rows, spaced 3 in 2 mm longitudinally and 6.5 in 2 mm diagonally at branch surface. Superior hemisepta present, curved proximally; inferior hemisepta absent. Zooecial walls granular, thin in endozone; finely laminated in exozone. Small microacanthostyles abundant, scattered between autozooecial apertures. Mesotheca straight, no median rods observed.

REMARKS. The present material is most similar to the genus *Cladodictya* Lavrentjeva & Gorjunova, 1993. This genus is characterised by shortened, box-like autozooecia with long superior hemisepta, freely branched colonies and abundant styles between apertures. However, the available material is not sufficient for a definite assignment.

Ptilodictyina sp. indet. 2 (Pl. 20, figs 4–6; Appendix)

MATERIAL. UM2-AE 4-(11, 8, 20).

OCCURRENCE. Upper Ordovician, Caradoc, Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Bifoliate branching colonies. Branches 1.2–1.3 mm wide, 0.6 mm thick. Autozooecia short, bending sharply to branch surface, rectangular at their bases, becoming oval at branch surface. Autozooecial apertures arranged in 6–7 rows, spaced 5.0–5.5 in 2 mm longitudinally and 7.5 in 2 mm diagonally at branch surface, 0.080–0.100 mm in diameter (mean = 0.085 mm). Short superior hemisepta present, inferior hemisepta absent. Mural spines absent. Single or paired shallow metazooecia positioned between autozooecia longitudinally, 0.04–0.06 mm in diameter. Low longitudinal ridges developed. Zooecial walls granular, thin in endozone; thickened, laminated in exozone. Mesotheca straight, without rods.

REMARKS. The present material is most similar to the genus *Phaenopora* Hall, 1851. However, no longitudinal section is available, which makes it difficult to compare it with known species of this genus.

Ptilodictyina sp. indet. 3 (Pl. 20, figs 10–13)

MATERIAL. UM2-AE 80-(4, 18).

OCCURRENCE. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France.

DESCRIPTION. Bifoliate branching colonies. Branches 2.5–3.9 mm wide and 0.78 mm thick, flattened, lens-shaped with sharp edges in cross-section. Autozooecia long, bending sharply to colony surface, rectangular to hexagonal at bases, becoming oval at branch surface, arranged in 12–17 rows. Autozooecial apertures round to oval, 0.15–0.19 mm in diameter (X = 0.164 mm). Both superior and inferior hemisepta present, blunt. 10–12 spine-like styles surrounding each autozooecial aperture, 0.010–0.015 mm in diameter. Zooecial walls granular, thin in endozone; thickened, laminated in exozone. Mesotheca straight, lacking rods.

REMARKS. The present specimen is similar to *Ptilodictya* Lonsdale, 1839. However, the scarce material does not allow a definite assignment.

Suborder **PHYLLOPORININA** Lavrentjeva, 1979

Family **PHYLLOPOPRINIDAE** Ulrich in Foerste, 1887

Genus ***PSEUDOHORNERA*** Roemer, 1876

TYPE SPECIES. *Retepora diffusa* Hall, 1852. Lower Silurian, USA.

DIAGNOSIS. Branching colonies. Autozooecia long with or without diaphragms, arranged in 2–8 rows. Hemisepta may occur.

REMARKS. *Pseudohornera* Roemer, 1876 differs from *Phylloporina* Ulrich in Foerste, 1887 in having branched instead of reticulate colonies and by the absence of heterozooecia.

Occurrence. Middle Ordovician to Lower Silurian, Estonia, North America.

Pseudohornera dmitrii sp. nov. (Pl. 21, figs 1–8; Appendix)

Holotype. UM2-AE 80-15.

Paratypes. UM2-AE 80-21, 41.

Type locality. Grange du Pin, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France.

Etymology. This species is named for the Russian bryozoologist Dmitri V. Lisitsyn, who has contributed greatly to research on Palaeozoic bryozoans.

Material. UM2-AE 4-21, 37, 21, 30, 46, 48, 80-(4, 5, 6, 13, 18, 19).

Diagnosis. Branched colonies; diaphragms present, hemisepta absent, styles present.

Description. Branches dichotomous, not anastomising, 0.51–0.90 mm wide and 0.72–1.08 mm thick, rounded in cross-section. Autozooecia long, tubular, rounded to rectangular in cross-section in endozone, budding in four rows, producing 3–4 vertical stages in cross-section. Autozooecial apertures rounded to oval, arranged in 4 alternating rows, spaced 4 in 2 mm longitudinally. Diaphragms rare; hemisepta absent. Styles occurring on both reverse and obverse surfaces, arranged in regular longitudinal rows, 0.035–0.055 mm in diameter. Low ridges between autozooecial rows. Heterozooecia absent.

Remarks. *Pseudohornera dmitrii* sp. nov. differs from *P. surculosa* Lavrentjeva, 1985 from the Upper Ordovician (Caradoc) of Estonia in having more widely spaced apertures (4 in 2 mm vs. 6–8 in 2 mm in *P. surculosa*).

Family **CHASMATOPORIDAE** Schulga-Nesterenko, 1955

Genus ***CHASMATOPORA*** Eichwald, 1855

Type species. *Retepora tenella* Eichwald, 1855. Upper Ordovician, Ashgill, Vormsi, Estonia.

Diagnosis. Reticulate colonies, irregularly anastomosing; fenestrules vary in shape and dimensions; autozooecia growing along indistinct median axis, opening in four rows on obverse side of branches; diaphragms and hemisepta rare; apertures oval, rarely rounded; keel nodes occasionally present; capillaries (?) in autozooecial walls; reverse surface striated or papillose.

Remarks. *Chasmatopora* Eichwald, 1855 differs from *Parachasmatopora* Morozova & Lavrentjeva, 1981 by having four autozooecial rows on branches. It differs from *Esthonioporina* Lavrentjeva, 1975 by its anastomosing colony form.

Occurrence. Middle Ordovician to Lower Silurian, USA, Estonia, Russia, Siberia, France, Italy, Australia.

Chasmatopora hypnoides (Sharpe, 1853) (Pl. 21, figs 9–15, Pl. 22, figs 1–3; Appendix)

v1853 *Synocladia hypnoides* Sharpe: 147, pl. 7, fig. 10.
1880 *Dictionema* ? *corniculata* Meneghini: 216, pl. 1, fig. 6.
1910 *Fenestella* (*Reteporina*) *carnica* Vinassa de Regny: 17, pl. 2, figs 12–14.
1936 *Chasmatoporella metzi* Nekhoroshev: 7, pl. 1, fig. 1.
1940 *Chasmatoporella metzi* Nekhoroshev, 1936; Prantl: 87, pl. 1, figs 2–3.
1942 *Fenestella* (*Reteporina*) *corniculata* (Meneghini, 1880); Vinassa de Regny: 1033–1034, pl. 2, figs 5–6.
1942 *Protocrisina sardoa* Vinassa de Regny: 1027, pl. 1, fig. 10, text-fig. A.
? 1948 *Phylloporina hypnoides* (Sharpe, 1853); Dreyfuss: 33, pl. 4, figs 11, 11a, 12, pl. 9, fig. 11.
1968 *Chasmatoporella* sp.; Annoscia: 221, pl. 7, fig. 1.
1985 *Chasmatopora metzi* (Nekhoroshev, 1936); Lavrentjeva: 45, pl. 17, fig. 2.
1988 *Graptodictya* sp. Conti & Serpagli: pl. 11, figs 4–6.
1990 *Chasmatopora corniculata* (Meneghini, 1880); Conti: 112–113, pl. 19, figs 3–12, pl. 22, fig. 6.
2001 *Moorephylloporina hypnoides* (Sharpe, 1853); Morozova: 41.

Holotype. NHM PD 2215, Upper Ordovician, Portugal.

Material. NHM PD 2209, NHM PD 2210, NHM PD 2211, NHM PD 2212, NHM PD 2213; UM2-AE 2–6, 2–42, 36–38, 66–67, 70, 74–2; SMF 2148–2149.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France. Uggwa Formation, siltstone/sandstone member, Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia (Italy). Upper Ordovician, Portugal.

Description. Reticulate colony consisting of anastomosing branches with irregular fenestrules. Branches rounded to square in cross-section, 0.42–0.88 mm wide. Tubular autozooecia budding from median lamina, arranged in two stages in cross-section, 8–9 times longer than their diameter, flattened on proximal end, possessing long vestibules. Hemisepta and diaphragms absent. Autozooecial apertures oval, having distinct peristome, arranged in four slightly alternating rows on one side of colony; two inner rows belonging to autozooecia of upper stage and two outer rows belonging to lower stage. Apertures of inner autozooecial rows smaller, often slit-shaped and arranged more closely than apertures of outer rows: 7.5–11.0 autozooecial apertures spaced in 5 mm distance in inner rows and 6–8 in 5 mm distance in outer rows. One or two small tubular structures (heterozooecia?) occurring between apertures, 0.010–0.025 mm in diameter. Low keel between inner autozooecial apertures present.

Remarks. *Chasmatopora hypnoides* (Sharpe, 1853) is distinct because of its large and widely spaced apertures, absence of diaphragms and presence of tubular heterozooecia on the obverse colony surface. *Chasmatopora livonica* (Nekhoroshev, 1960) from the Upper Ordovician of Latvia is similar to *C. hypnoides*, but differs in having thinner branches, absence of heterozooecia and presence of diaphragms.

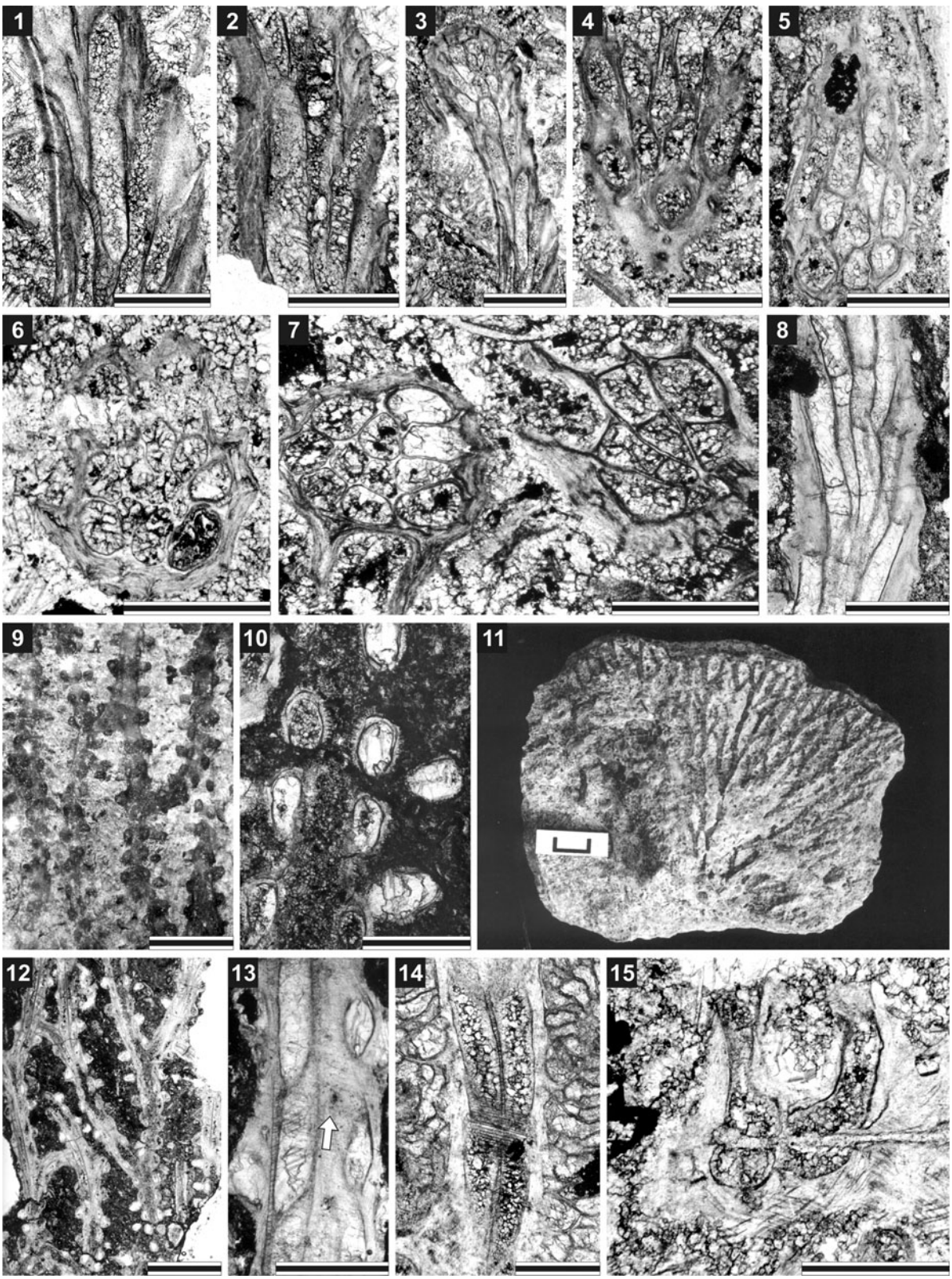

Plate 21 **1–8**, *Pseudohornera dmitrii* sp. nov. **1**, holotype UM2-AE 80-15, deep tangential section, scale bar = 0.5 mm; **2**, UM2-AE 80-13, longitudinal section, scale bar = 0.5 mm; **3**, holotype UM2-AE 80-15, scale bar = 1 mm; **4**, paratype UM2-AE 80-21, tangential section, scale bar = 0.5 mm; **5**, UM2-AE 46, tangential section, scale bar = 0.5 mm; **6**, UM2-AE 80-6, cross-section, scale bar = 0.5 mm; **7**, holotype UM2-AE 80-15, cross-section, scale bar = 0.5 mm; **8**, paratype UM2-AE 21, longitudinal section, displaying diaphragms in autozooecia, scale bar = 0.5 mm. **9–15**, *Chasmatopora hypnoides* (Sharpe, 1853). **9**, **10**, **12**, UM2-AE 70: **9**, colony surface displaying apertures, scale bar = 2 mm; **10**, tangential section displaying apertures, scale bar = 0.5 mm; **12**, tangential section, scale bar = 2 mm; **11**, UM2-AE 70, scale bar = 5 mm; **13**, UM2-AE 66, tangential section displaying apertures and heterozooecia (arrow), scale bar = 0.5 mm; **14**, UM2-AE 37, deep tangential section, scale bar = 0.5 mm; **15**, UM2-E2 42, cross-section of the branch, scale bar = 0.5 mm.

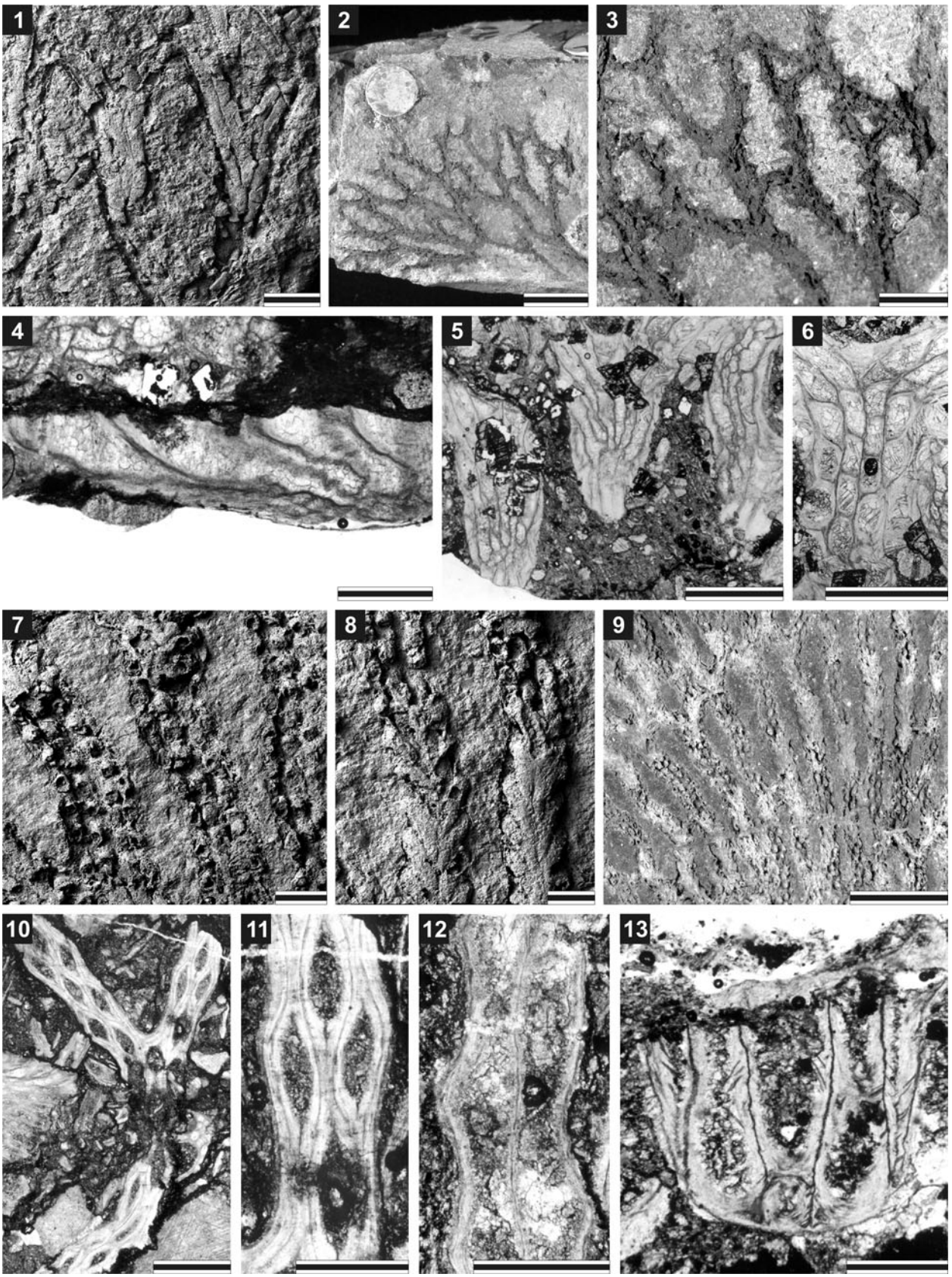

Plate 22 **1–3**, *Chasmatopora hypnoides* (Sharpe, 1853). **1**, NHM PD 2209, scanning electron micrograph (SEM), scale bar = 1 mm; **2–3**, holotype NHM PD 2215: **2**, scale bar = 5 mm; **3**, scale bar = 2 mm. **4–9**, *Ralfina lusitanica* (Sharpe, 1853). **4**, UM-2 AE-69-1 longitudinal section, scale bar = 0.5 mm; **5**, **6**, UM-2 AE-69-2: **5**, oblique section, scale bar = 1 mm; **6**, tangential section, scale bar = 1 mm; **7–9**, holotype NHM PD 2214 (*Synocladia lusitanica* Sharpe, 1853): **7–8**, SEM, scale bar = 1 mm; **9**; scale bar = 5 mm. **10–13**, *Ralfinella elegantula* sp. nov. **10–11**, holotype UM2-AE 29: **10**, tangential section, scale bar = 1 mm; **11**, tangential section, scale bar = 0.5 mm; **12**, UM2-AE 37, deep tangential section, scale bar = 0.5 mm; **13**, paratype UM2-AE 26, cross-section, scale bar = 0.25 mm.

Family **RALFINIDAE** Lavrentjeva, 1985

Genus ***RALFINA*** Lavrentjeva, 1985

TYPE SPECIES. *Phylloporina aluverensis* Männil, 1958. Upper Ordovician (Caradoc), Idavere horizon, Estonia.

DIAGNOSIS. Reticulate colonies consisting of regularly anastomosing branches. Autozooecia tubular, long, growing parallel to thin reverse wall, bending sharply to frontal side of colony; oval apertures arranged in 3–7 rows. Diaphragms rare to absent, thin, planar. Walls thickened, separated by thin laminae, protruding on colony surface as longitudinal ridges. Reverse side of colony concave, smooth. Heterozooecia absent.

REMARKS. *Ralfina* Lavrentjeva, 1985 differs from *Ralfinella* Lavrentjeva, 1985 by its reticulate colony form.

OCCURRENCE. Upper Ordovician to Lower Silurian, Europe.

Ralfina lusitanica (Sharpe, 1853) (Pl. 22, figs 4–9; Appendix)

v1853 *Synocladia lusitanica* Sharpe: 147, pl. 7, fig. 9.
1948 non *Phylloporina hypnoides* (Sharpe, 1853); Dreyfuss: 33, pl. 4, figs 11, 11a, 12, pl. 9, fig. 11.

HOLOTYPE. NHM PD 2214. Upper Ordovician, Portugal.

MATERIAL. UM-2 AE-69-(1-3).

OCCURRENCE. Upper Ordovician, Ashgill, Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Portugal.

DESCRIPTION. Reticulate colonies consisting of anastomosing branches or branches with V-shaped dissepiments carrying autozooecia. Branches flattened, sub-rectangular in cross-section, 0.75–0.95 mm wide, 6–7 per 10 mm of colony width. Fenestrules elliptical, spaced 2–3 per 10 mm of colony length. Autozooecia long, arranged in 3–4 slightly alternating rows rectangular in deep tangential section, becoming oval at colony surface. Diaphragms and hemisepta lacking. Vestibule weakly developed. Ridges on autozooecial borders forming regular pattern on branch surface, having regular hexagonal to rhombic appearance. Autozooecial walls in endozone 0.012–0.042 mm thick; in exozone 0.090–0.120 mm thick. Extrazooecial skeleton weakly developed.

REMARKS. *Ralfina lusitanica* (Sharpe, 1853) differs from *R. aluverensis* (Männil, 1958) by the arrangement of autozooecia in 3–4 rows instead of 5–6 in *R. aluverensis* and by more closely spaced branches (6–7 vs. 4–6 branches per 10 mm, respectively).

Genus ***RALFINELLA*** Lavrentjeva, 1985

TYPE SPECIES. *Pseudohornera* (?) *plana* Männil, 1958. Upper Ordovician, Caradoc, Estonia.

DIAGNOSIS. Dichotomously branching colonies. Autozooecia tubular, long, budding parallel to thin reverse wall, bending sharply to frontal side of colony; oval apertures arranged in 2–3 rows, in places of bifurcation in 4–5 rows. Diaphragms rare to absent, thin, planar. Walls thickened, separated by thin laminae protruding on colony surface as longitudinal ridges. Reverse side concave, smooth. Heterozooecia absent.

REMARKS. *Ralfinella* Lavrentjeva, 1985 differs from *Ralfina* Lavrentjeva, 1985 by its dichotomously branching colony form.

OCCURRENCE. Upper Ordovician, Caradoc, Estonia. Upper Ordovician, Upper Caradoc to Lower Ashgill, Montagne de Noire, southern France.

Ralfinella elegantula sp. nov. (Pl. 22, figs 10–13; Appendix)

HOLOTYPE. UM2-AE 29.

PARATYPE. UM2-AE 21, 26.

TYPE LOCALITY. Montagne de Noire, southern France.

TYPE STRATUM. Upper Ordovician, Ashgill.

ETYMOLOGY. The specific name derives from the Latin 'elegantis' (elegant) and refers to its delicate colony form.

MATERIAL. UM2-AE 25, 27, 37, 59-3; SMF 2150.

OCCURRENCE. Upper Ordovician, Ashgill, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy.

DIAGNOSIS. Dichotomously branching colonies; autozooecia budding in 2–3 rows.

DESCRIPTION. Dichotomously branching colonies. Branches sub-rectangular in cross-section, 0.48–0.83 mm wide. Reverse side of branches convex. Autozooecia tubular, long, circular in cross-section, arranged in 2–3 weakly alternating rows. Thin planar diaphragms occasionally present. Hemisepta absent. Vestibule weakly developed. Ridges on autozooecial borders forming regular rhombic pattern at branch surface. Autozooecial walls displaying dark serrated borders and reversed V-shaped laminae, 0.042–0.100 mm thick; exozonal walls usually slightly thicker than in endozone. Wall laminae deposited at angles of 50–60° to median line.

REMARKS. *Ralfinella elegantula* sp. nov. differs from *R. plana* (Männil, 1958) by the arrangement of autozooecial apertures in 2–3 rows instead of 3 rows as well as less closely spaced autozooecial apertures.

Suborder **FENESTELLINA** Astrova & Morozova, 1956

Family **FENESTELLIDAE** King, 1849

Genus ***MOOREPHYLLOPORINA*** Bassler, 1952

TYPE SPECIES. *Moorephylloporina typica* Bassler, 1952. Middle Ordovician, Black River, USA.

DIAGNOSIS. Colonies consisting of anastomosing branches. Short oblique dissepiments sometimes present. Autozooecia long, having oblong–rectangular shape in deep tangential section, weakly developed vestibules, arranged in two slightly alternating rows on branches. Autozooecial rows separated by low keel on obverse colony surface; one row of nodes on keel. Branches rounded in cross-section; their reverse walls thin, carrying thin longitudinal ribs and microacanthostyles.

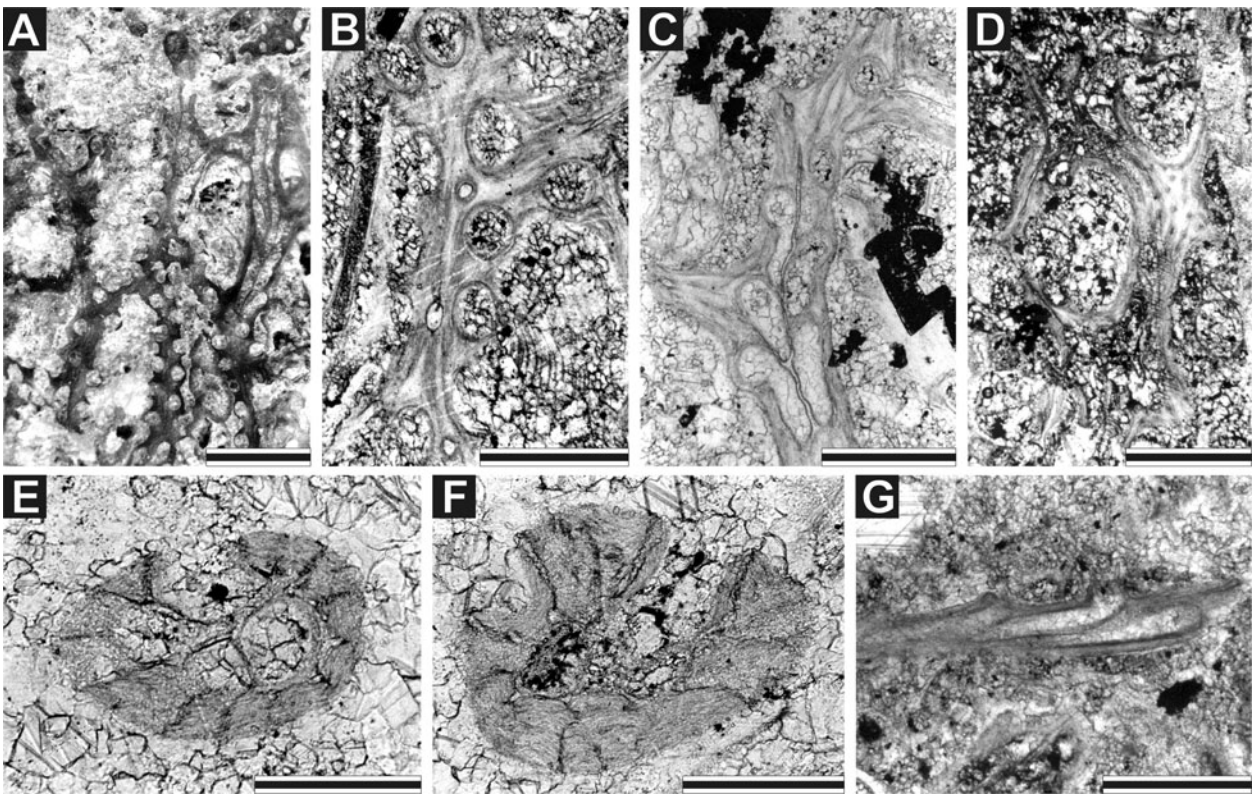

Figure 1 *Moorephylloporina contii* sp. nov. **A**, paratype UM2-AE 90, scale bar = 1 mm; **B**, holotype UM2-AE 80-21, tangential section, scale bar =0.5 mm; **C**, paratype UM2-AE 2-33, deep tangential section, scale bar = 0.5 mm; **D**, holotype UM2-AE 80-21, deep tangential section, scale bar = 0.5 mm; **E**, **F**, UM2-AE 81-4: **E**, cross-section, scale bar = 0.2 mm; **F**, cross-section, scale bar = 0.5 mm; **G**, UM2-AE 2-37, longitudinal section, scale bar = 0.5 mm.

Remarks. *Moorephylloporina* Bassler, 1952 differs from *Fenestella* Lonsdale, 1839 by having anastomosing colonies, weakly developed vestibules and by autozooecia with oblong–rectangular shapes in deep tangential section.

Occurrence. Middle Ordovician to Lower Silurian, USA, Estonia, South Europe, Burma, Siberia.

Moorephylloporina contii sp. nov. (Fig. 1A–G; Appendix)

1990 *Moorephylloporina* sp. Conti: 113, pl. 20, figs 1–3.

Holotype. UM2-AE 80-21 (Figs 1B, D).

Paratypes. UM2-AE 90 (Fig. 1A), UM2-AE 2-33 (Fig. 1C).

Type locality. Grange du Pin, Montagne de Noire, southern France.

Type stratum. Upper Ordovician, Ashgill.

Etymology. This species is named for the Italian palaeontologist Stefano Conti, who has contributed greatly to the investigation of the Ordovician bryozoans of Sardinia.

Material. UM2-AE 2-37, 20, 21, 23, 24, 28, 30, 36, 74-2, 71, 80-(2, 6, 12), 81-4; SMF 2151.

Occurrence. Upper Ordovician, Upper Caradoc to Lower Ashgill, Grange du Pin, Montagne de Noire, southern France. Upper Ordovician, Upper Caradoc to Lower Ashgill, Valbertad, Carnic Alps, Italy. Upper Ordovician, Upper Caradoc to Lower Ashgill (units *c* and *e*), Sardinia, Italy.

Diagnosis. Delicate reticulate colonies; branches with median keels and nodes; small autozooecial apertures; heterozooecia present.

Description. Reticulate colonies consisting of regularly anastomosing branches. Branches rounded in cross-section, 0.25–0.36 mm wide. Fenestrules elliptical. Autozooecial apertures rounded to oval, arranged in two alternating rows on branches, 5–6 in each fenestrule length. Low keel between autozooecial aperture rows, 0.018–0.024 mm wide, carrying elliptical nodes, 0.03 mm wide, 0.09 mm long, spaced 0.33–0.48 mm from centre to centre along branch. Ovicells (?) in form of rounded chambers, 0.192 mm in diameter, occasionally occurring at bases of fenestrules. Heterozooecia with rounded apertures, 0.042–0.084 mm in diameter, occasionally occurring between autozooecia. Inner granular skeleton variably thick, usually well-developed. Outer lamellar skeleton usually well-developed on both obverse and reverse sides of colony. Microstylets occurring both on reverse and obverse sides of colony, 0.012 mm in diameter.

Interior description. Autozooecia rectangular in deep tangential section, 0.30–0.39 mm long, 0.072–0.078 mm deep, 0.096–0.138 mm wide (measured in the middle part of the deep tangential section). Vestibule weakly developed, 0.06 mm long. Hemisepta absent.

REMARKS. *Moorephylloporina contii* sp. nov. is similar to the species *M. katerinae* Morozova & Lavrentjeva, 1981 from the Middle Ordovician of Estonia. The new species differs in having smaller autozooecial apertures (autozooecial aperture width 0.07–0.11 mm vs. 0.12 mm in *M. katerinae*).

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Appendix: Descriptive statistics

Abbreviations: N = number of measurements, X = mean, SD = sample standard deviation, CV = coefficient of variation, MIN = minimal value, MAX = maximal value.

Kukersella borealis (Bassler, 1911*a*) (25 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	25	0.62	0.266	42.75	0.39	1.75
Autozooecial aperture width, mm	8	0.12	0.021	17.70	0.10	0.15
Endozone width, mm	17	0.23	0.123	53.41	0.10	0.63
Pseudopore diameter, mm	15	0.02	0.005	21.40	0.02	0.03
Axial zooecia width, mm	20	0.08	0.023	27.77	0.04	0.13
Axial zooecia number	17	6	4.089	64.97	1	15
Frontal wall thickness, mm	10	0.04	0.014	38.66	0.02	0.06
Chamber depth, mm	7	0.11	0.017	15.29	0.08	0.13
Chamber width, mm	10	0.13	0.023	17.41	0.10	0.16
Chamber length, mm	7	1.00	0.125	12.50	0.80	1.15
Diaphragm spacing, mm	20	0.11	0.037	33.11	0.03	0.17
Diaphragms per 1 mm	11	9	1.610	18.74	6	11

Ceramopora italica (Vinassa de Regny, 1942) (3 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.57	0.065	11.49	0.47	0.70
Exilazooecia width, mm	7	0.16	0.055	34.01	0.09	0.23
Lunaria length, mm	8	0.15	0.035	23.62	0.12	0.21
Lunaria width, mm	8	0.29	0.051	17.43	0.21	0.37

Ceramoporella discoidalis Conti, 1990 (single colony IGR 36042).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	15	0.47	0.078	16.77	0.34	0.60
Exilazooecia width, mm	10	0.17	0.062	36.97	0.09	0.31
Lunaria length, mm	7	0.19	0.041	21.81	0.13	0.24
Lunaria width, mm	7	0.28	0.044	15.74	0.22	0.33
Lunarial deposit thickness, mm	7	0.10	0.021	20.67	0.07	0.13

Crepipora vesiculosa Boulange, 1963 (8 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	15	0.50	0.073	14.74	0.40	0.63
Exilazooecia width, mm	11	0.18	0.065	35.81	0.08	0.28
Colony thickness, mm	9	2.28	0.835	36.69	1.30	4.00
Lunaria length, mm	15	0.21	0.064	30.52	0.12	0.31
Lunaria width, mm	15	0.28	0.059	21.24	0.19	0.37
Lunarial deposit thickness, mm	15	0.09	0.035	39.53	0.04	0.15

Crassalina fungiforme sp. nov. (single colony, UM2-AE 1).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.61	0.08	13.59	0.50	0.80
Mesozooecia width, mm	5	0.19	0.03	17.43	0.16	0.24

Lichenalia nodata sp. nov. (2 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	15	0.20	0.018	9.05	0.18	0.24
Lunaria width, mm	14	0.25	0.045	17.56	0.18	0.32
Lunaria length, mm	15	0.20	0.026	12.58	0.16	0.24
Lunarial deposit thickness, mm	10	0.04	0.006	15.06	0.03	0.05
Exilazooecia width, mm	10	0.05	0.021	39.91	0.04	0.11
Tunnel diameter, mm	20	0.29	0.036	12.35	0.24	0.41

Prasopora fistuloporoides (Vinassa de Regny, 1910) (single colony, IGR 36001).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	20	0.39	0.032	8.29	0.33	0.43
Autozooecial aperture width, mm (macular area)	10	0.52	0.046	8.85	0.43	0.61
Mesozooecia width, mm	6	0.15	0.034	22.13	0.13	0.22
Diaphragm spacing, mm	7	0.15	0.038	25.85	0.09	0.22
Cystiphragm spacing, mm	10	0.12	0.042	35.60	0.07	0.20

Prasopora grayae Nicholson & Etheridge, 1877 (5 colonies).

	N	X	SD	CV	MIN	MAX
Colony thickness, mm	6	16.00	9.940	62.12	8.00	35.00
Layer thickness, mm	6	2.10	0.383	18.31	1.74	2.80
Autozooecial aperture width, mm (intermacular area)	99	0.28	0.032	11.72	0.22	0.39
Autozooecial aperture width, mm (macular area)	46	0.38	0.048	12.75	0.26	0.50
Mesozooecia width, mm	50	0.10	0.032	31.35	0.07	0.20
Diaphragm spacing, mm	40	0.19	0.077	39.89	0.08	0.43
Cystiphragm spacing, mm	40	0.17	0.043	25.68	0.07	0.24
Cystiphragms per 1 mm	9	6.13	1.159	18.90	5.00	8.00
Mesozooecia in 1 mm²	8	3.58	0.989	27.52	2.00	5.00

Homotrypa miqueli (Prantl, 1940) (6 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	30	0.16	0.037	22.83	0.11	0.25
Acanthostyle diameter, mm	10	0.12	0.034	29.42	0.07	0.18
Mesozooecia width, mm	10	0.07	0.021	29.57	0.04	0.10
Diaphragm spacing, mm	20	0.10	0.051	49.29	0.03	0.25
Cystiphragm spacing, mm	20	0.09	0.030	31.42	0.06	0.18

Atactoporella magnopora sp. nov. (single colony IGR 36004).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	24	0.31	0.032	10.38	0.24	0.38
Mesozooecia width, mm	24	0.12	0.036	30.69	0.06	0.21
Acanthostyle diameter, mm	24	0.03	0.005	18.88	0.02	0.05
Mesozooecia per aperture	24	9.50	0.834	8.78	8	11

Atactoporella irregularis Boulange, 1963 (2 colonies, IGR 36002 and UM2-AE 3).

	N	X	SD	CV	MIN	MAX
Aperture width, mm (intermacular area)	30	0.21	0.022	10.60	0.17	0.26
Aperture width, mm (macular area)	20	0.30	0.023	7.77	0.26	0.35
Mesozooecia width, mm	20	0.11	0.028	25.12	0.07	0.18
Diaphragm spacing, mm	10	0.13	0.029	22.22	0.09	0.20
Cystiphragm spacing, mm	10	0.11	0.024	21.58	0.07	0.15
Cystiphragms per 1 mm	7	9	3.842	45.03	4	15
Mesozooecia per aperture	30	8	1.098	13.78	6	10
Acanthostyle diameter, mm	15	0.02	0.005	22.47	0.02	0.03

Atactoporella sp. (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	10	0.15	0.028	19.74	0.12	0.19
Mesozooecia width, mm	10	0.07	0.015	19.83	0.048	0.10
Acanthostyle diameter, mm	10	0.07	0.011	16.58	0.050	0.09

Dekaya minima Conti, 1990 (4 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	43	0.25	0.033	13.33	0.16	0.33
Acanthostyle diameter, mm	33	0.07	0.008	11.57	0.05	0.08
Mesozooecia width, mm	41	0.10	0.034	33.07	0.05	0.19
Acanthostyles per aperture	37	3.50	1.016	29.38	2	7

Dekayia buttleri sp. nov. (6 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	6	1.97	0.233	11.83	1.63	2.30
Autozooecial aperture width, mm	25	0.17	0.029	15.75	0.12	0.22
Acanthostyle diameter, mm	10	0.05	0.012	25.16	0.04	0.07
Mesozooecia width, mm	15	0.07	0.020	25.68	0.04	0.10
Acanthostyles per aperture	10	3	0.738	25.44	2	4
Mesozooecia per aperture	10	5	0.738	15.06	4	6

Dekayia sp. (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	11	0.22	0.049	22.22	0.16	0.31
Mesozooecia width, mm	6	0.06	0.014	24.19	0.05	0.08

Heterotrypa magnopora Boulange, 1963 (4 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	7	6.94	2.818	40.58	4.00	12.00
Exilazooecia width, mm	10	1.97	0.743	37.77	1.13	3.55
Autozooecial aperture width, mm (intermacular area)	55	0.27	0.052	19.26	0.16	0.39
Autozooecial aperture width, mm (macular area)	24	0.38	0.048	12.67	0.30	0.47
Mesozooecia width, mm	12	0.10	0.028	27.69	0.05	0.15
Acanthostyle diameter, mm	12	0.05	0.015	29.48	0.03	0.08
Maculae diameter, mm	4	2.25	0.307	13.65	1.86	2.60
Maculae spacing, mm	3	3.86	0.414	10.71	3.60	4.34
Autozooecial diaphragm spacing in exozone, mm	30	0.10	0.041	42.11	0.04	0.22
Autozooecial diaphragms per 1 mm in exozone	8	12	2.448	19.69	9	17
Autozooecial diaphragm spacing in endozone, mm	15	0.32	0.218	69.29	0.12	0.90
Autozooecial diaphragms per 1 mm in exozone	4	4	2.287	52.27	1	6
Wall thickness in exozone, mm	20	0.10	0.033	33.32	0.05	0.16

Stigmatella sinuosa Conti, 1990 (5 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	102	0.31	0.041	13.37	0.22	0.47
Autozooecial aperture width, mm (macular area)	82	0.40	0.072	17.93	0.26	0.59
Exilazooecia width, mm	83	0.11	0.030	26.62	0.05	0.17

Stigmatella carnica sp. nov. (single colony, SMF 2129).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	10	0.45	0.034	7.65	0.40	0.50
Autozooecial aperture width, mm (macular area)	5	0.53	0.044	8.30	0.46	0.58
Exilazooecia width, mm	20	0.10	0.027	26.18	0.08	0.18
Mesozooecia per autozooecial aperture	10	5	1.101	22.46	3	6

Stigmatella massalis Bassler, 1911*a* (single colony, UM2-AE 76).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	20	0.32	0.027	8.45	0.28	0.40
Autozooecial aperture width, mm (macular area)	15	0.49	0.045	9.19	0.42	0.58
Mesozooecia width, mm	15	0.11	0.021	18.82	0.07	0.15
Acanthostyle diameter, mm	20	0.04	0.007	17.85	0.03	0.05

Hallopora elegantula (Hall 1852) (10 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	123	0.31	0.051	16.35	0.17	0.44
Mesozooecia width, mm	97	0.12	0.047	38.35	0.03	0.24
Mesozooecia per aperture	71	8.00	2.526	31.86	1.00	13.00
Mesozooecial diaphragms per 1 mm	9	17.22	2.906	16.87	12.00	21.00

Hallopora cystoidalis Conti, 1990 (3 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	42	0.39	0.047	12.31	0.28	0.48
Mesozooecia width, mm	40	0.13	0.045	34.39	0.08	0.27
Mesozooecia per aperture	25	8	2.814	33.50	5	14
Autozooecial diaphragms spacing, mm	20	0.18	0.076	43.06	0.06	0.33
Autozooecial diaphragms per 1 mm	10	6	0.537	8.85	5	7
Mesozooecial diaphragms spacing, mm	20	0.08	0.021	26.13	0.05	0.13
Mesozooecial diaphragms per 1 mm	6	14	4.877	35.61	8	21
Exilazooecia width, mm	10	0.09	0.026	30.57	0.06	0.13

Hallopora enodis Bassler, 1927 (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	38	0.49	0.065	13.21	0.37	0.70
Mesozooecia width, mm	34	0.13	0.045	35.21	0.06	0.23
Mesozooecia per aperture	13	9	3.338	37.73	4	15
Mesozooecial diaphragms per 1 mm	10	15	1.372	8.98	14	18

Hallopora gracilens Bassler, 1927 (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	11	0.22	0.012	5.57	0.20	0.24
Mesozooecia width, mm	21	0.09	0.026	29.49	0.04	0.14
Mesozooecia per aperture	5	8	0.894	10.65	7	9
Mesozooecial diaphragms per 1 mm	7	14	2.429	17.07	11	17

Diplotrypa languedociana Dreyfuss, 1948 (7 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	145	0.51	0.063	12.22	0.40	0.66
Mesozooecia width, mm	141	0.18	0.053	29.64	0.07	0.37
Mesozooecia per aperture	133	8	2.019	24.19	4	12

Parvohallopora onealli (James, 1875) (2 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	59	0.20	0.039	19.72	0.12	0.30
Mesozooecia width, mm	40	0.10	0.040	41.82	0.05	0.22
Mesozooecia per aperture	13	6	1.528	25.46	4	8
Autozooecial diaphragms per 1 mm	6	6	0.548	9.44	5	6.5

? *Calloporella ornata* Dreyfuss, 1948 (2 colonies, UM2-AE 77 and UM2-AE 78).

	N	X	SD	CV	MIN	
Autozooecial aperture width, mm (intermacular area)	29	0.22	0.012	5.54	0.20	0.24
Autozooecial aperture width, mm (macular area)	8	0.29	0.023	8.15	0.24	0.30
Mesozooecia width, mm	30	0.09	0.029	33.44	0.04	0.16
Mesozooecia per aperture	23	10	1.273	13.31	7	13

Trematopora tuberculosa Hall, 1852 (single colony IGR 36052).

	N	X	SD	CV	MAX	MIN
Autozooecial aperture width, mm	20	0.12	0.018	14.45	0.09	0.16
Mesozooecia width, mm	20	0.08	0.018	21.89	0.04	0.11
Acanthostyle diameter, mm	20	0.04	0.007	16.16	0.03	0.06
Acanthostyles per aperture	10	4	0.675	18.24	3	5
Mesozooecia per aperture	10	5	1.135	21.83	4	7

Trematopora sardoa (Vinassa de Regny, 1942) (9 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	7	2.54	0.791	31.18	1.38	3.43
Exilazooecia width, mm	8	0.42	0.082	19.80	0.30	0.50
Autozooecial aperture width, mm	65	0.09	0.022	23.98	0.07	0.16
Mesozooecia width, mm	65	0.08	0.018	22.79	0.04	0.12
Acanthostyle diameter, mm	65	0.08	0.013	17.00	0.05	0.10
Acanthostyles per aperture	60	4	0.833	22.63	2	6
Acanthostyles per 1 mm^2	7	31	3.324	10.63	27	36

Trematopora gracile sp. nov. (20 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	20	1.09	0.308	28.16	0.44	1.68
Endozone width, mm	13	0.68	0.217	32.03	0.38	1.10
Exilazooecia width, mm	13	0.264	0.054	20.64	0.13	0.33
Autozooecial aperture width, mm	33	0.09	0.015	16.52	0.07	0.12
Acanthostyle diameter, mm	33	0.06	0.014	23.56	0.04	0.10
Acanthostyles per aperture	14	5.5	1.223	21.94	4	8
Mesozooecia width, mm	22	0.05	0.010	20.46	0.03	0.07

Trematopora sp. 1 (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.20	0.029	14.06	0.14	0.25
Mesozooecia width, mm	20	0.10	0.022	21.70	0.06	0.13
Acanthostyle diameter, mm	10	0.05	0.011	21.58	0.04	0.07
Mesozooecia per aperture	10	4	1.080	24.00	3	6

Trematopora sp. 2 (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.11	0.019	16.74	0.09	0.16
Mesozooecia width, mm	20	0.06	0.011	19.12	0.03	0.07
Acanthostyle diameter, mm	20	0.05	0.012	22.85	0.03	0.08
Mesozooecia per aperture	10	8	0.823	10.69	7	9
Acanthostyles per aperture	10	3.5	0.527	15.06	3	4

Eridotrypa spicata Dreyfuss, 1948 (4 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	4	1.80	0.307	17.02	1.58	2.25
Exozone width, mm	6	0.49	0.101	20.46	0.38	0.63
Autozooecial aperture width, mm	21	0.12	0.021	17.09	0.10	0.17
Mesozooecia width, mm	6	0.06	0.020	32.57	0.04	0.09
Autozooecial diaphragms spacing (endozone), mm	20	0.61	0.210	34.24	0.20	1.00
Autozooecial diaphragms spacing (exozone), mm	20	0.19	0.066	34.73	0.10	0.38
Mesozooecia width, mm	15	0.09	0.033	34.77	0.07	0.20
Acanthostyle diameter, mm	4	0.05	0.008	15.19	0.04	0.06
Exozonal wall thickness, mm	10	0.11	0.022	21.25	0.07	0.14

Eridotrypa constans Conti, 1990 (4 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	4	1.19	0.144	12.14	1.05	1.35
Autozooecial aperture width, mm	15	0.11	0.010	9.81	0.10	0.12

? *Batostoma* sp. (single colony).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	19	0.14	0.014	10.25	0.12	0.16
Mesozooecia width, mm	10	0.06	0.010	15.06	0.05	0.08
Acanthostyle diameter, mm	10	0.04	0.008	18.01	0.04	0.06

Bythopora dendrina (James, 1878*a*) (16 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	16	1.46	0.297	20.28	0.95	2.00
Endozone width, mm	11	0.76	0.169	22.22	0.60	1.00
Exilazooecia width, mm	11	0.34	0.095	28.11	0.25	0.50
Autozooecial aperture width, mm	41	0.08	0.012	13.37	0.06	0.11
Acanthostyle diameter, mm	18	0.04	0.008	22.96	0.02	0.05
Mesozooecia width, mm	28	0.04	0.008	20.30	0.03	0.05

Bythopora tenuis sp. nov. (5 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	8	0.78	0.151	19.40	0.53	1.02
Autozooecial aperture width, mm	20	0.06	0.008	12.29	0.05	0.07
Acanthostyle diameter, mm	20	0.05	0.008	15.23	0.05	0.07
Acanthostyles per aperture	7	4	0.787	22.03	3	5

Bythopora subgracilis (Ulrich, 1893) (2 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	60	0.17	0.035	21.04	0.10	0.23
Mesozooecia width, mm	40	0.06	0.018	30.83	0.02	0.11
Acanthostyle diameter, mm	10	0.03	0.005	17.87	0.02	0.04

? *Mesotrypa rotundipora* (Dreyfuss, 1948) (7 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	35	0.61	0.097	16.00	0.40	0.80
Mesozooecia width, mm	30	0.23	0.063	28.05	0.10	0.41
Mesozooecia per aperture	20	5	1.432	28.93	2	7
Mesozooecial diaphragms per 1 mm	20	4	0.757	18.80	3	5.5

Dybowskites orbicularis (Modzalevskaya, 1953) (2 colonies, UM2-AE 58 and UM2-AE 59).

	N	X	SD	CV	MIN	MAX
Branch width, mm	5	11.80	4.817	40.82	8	20
Autozooecial aperture width, mm	19	0.33	0.045	13.78	0.25	0.43
Mesozooecia width, mm	15	0.12	0.021	16.86	0.09	0.16
Acanthostyle diameter, mm	25	0.14	0.021	14.69	0.11	0.20
Acanthostyles per aperture	24	4	0.770	21.23	3	5
Mesozooecia per aperture	11	6	1.286	20.21	5	8
Autozooecial diaphragms per 1 mm	10	11	2.744	24.39	9	18
Autozooecial diaphragms spacing, mm	20	0.07	0.030	40.50	0.03	0.15

Halloporina sp. indet. (3 colonies).

	N	X	SD	CV	MIN	MAX
Branch diameter, mm	7	2.44	0.54	22.10	1.90	3.50
Autozooecial aperture width, mm	32	0.36	0.070	19.42	0.22	0.49
Mesozooecia width, mm	28	0.12	0.036	30.27	0.06	0.18
Acanthostyle diameter, mm	31	0.09	0.022	23.68	0.05	0.13
Acanthostyles per aperture	15	3	0.926	30.86	2.00	5.00

Monotrypa testudiformis Dreyfuss, 1948 (2 colonies, UM2-AE 73 and UM2-AE 77).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	33	0.39	0.026	6.76	0.32	0.44
Autozooecial aperture width, mm (macular area)	25	0.48	0.029	5.92	0.42	0.54
Exilazooecia width, mm	30	0.13	0.056	43.60	0.06	0.22
Acanthostyles per aperture	10	8	1.619	20.76	6	11

Amplexopora dalpiazzii (Vinassa de Regny, 1910) (2 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	30	0.23	0.027	11.42	0.18	0.28
Autozooecial aperture width, mm (macular area)	14	0.31	0.025	8.17	0.28	0.37
Mesozooecia width, mm	7	0.11	0.033	30.24	0.07	0.15
Acanthostyle diameter, mm	15	0.07	0.019	25.21	0.05	0.12
Autozooecial diaphragms spacing, mm	20	0.17	0.053	31.77	0.11	0.27
Diaphragms per 1 mm	8	7	1.004	14.47	6	9

Amplexopora cf. *robusta* Ulrich, 1883 (single colony, UM2-AE 79).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (intermacular area)	20	0.28	0.045	16.28	0.18	0.32
Autozooecial aperture width, mm (macular area)	10	0.36	0.019	5.28	0.34	0.38
Mesozooecia width, mm	10	0.07	0.024	35.14	0.02	0.10
Acanthostyle diameter, mm	7	0.07	0.005	7.59	0.06	0.08

Nicholsonella divulgata sp. nov. (4 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	13	0.18	0.031	17.33	0.14	0.24
Mesozooecia width, mm	15	0.12	0.049	41.39	0.01	0.21
Acanthostyle diameter, mm	17	0.06	0.009	15.00	0.04	0.07
Acanthostyles per aperture	8	6	1.165	20.26	5	8
Mesozooecia per aperture	7	7	1.254	17.21	5	9

Nicholsonella recta sp. nov. (3 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	14	0.23	0.024	10.26	0.19	0.28
Aperture spacing along branch, mm	10	0.73	0.052	7.11	0.62	0.82
Aperture spacing across branch, mm	10	0.50	0.054	10.87	0.43	0.60
Acanthostyle diameter, mm	7	0.15	0.038	24.57	0.10	0.21

Ulrichostylus radiatus Conti, 1990 (14 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	14	0.84	0.302	35.91	0.36	1.30
Endozone width, mm	14	0.52	0.242	46.26	0.16	0.93
Exilazooecia width, mm	14	0.16	0.043	26.70	0.10	0.24
Autozooecial aperture width, mm	10	0.09	0.014	16.67	0.06	0.10

Nematopora hispida Conti, 1990 (14 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	14	0.71	0.280	39.622	0.39	1.43
Branch thickness, mm	9	0.52	0.187	36.218	0.28	0.90

Matsutrypa elegantula sp. nov. (12 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	12	0.34	0.063	18.67	0.26	0.49
Autozooecial aperture width, mm	15	0.08	0.010	11.45	0.07	0.10
Aperture spacing along branch, mm	8	0.40	0.027	6.87	0.36	0.43

Matsutrypa rogeri sp. nov. (25 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	25	0.60	0.077	12.92	0.44	0.75
Autozooecial aperture width, mm	24	0.09	0.011	12.08	0.07	0.11
Aperture spacing along branch, mm	4	0.77	0.038	4.98	0.72	0.81

Nematotrypa punctata sp. nov. (6 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	8	1.863	0.350	18.806	1.50	2.50
Autozooecial aperture width, mm	10	0.102	0.014	13.202	0.08	0.12

Stellatodyctia valentinae sp. nov. (8 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.12	0.015	12.42	0.09	0.15
Aperture spacing along branch, mm	20	0.37	0.034	9.22	0.31	0.43
Stellatopores per aperture	20	7	1.046	14.14	5	9
Stellatopore diameter, mm	20	0.02	0.005	21.00	0.01	0.03

Graptodictya meneghinii (Vinassa de Regny, 1942) (4 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	18	0.11	0.022	19.66	0.08	0.16
Aperture spacing along branch, mm	8	0.56	0.032	5.70	0.51	0.61
Aperture spacing across branch, mm	8	0.27	0.012	4.652	0.25	0.28
Zooecial chamber depth, mm	5	0.14	0.005	3.61	0.13	0.14
Branch thickness, mm	5	0.56	0.050	8.83	0.50	0.60

Graptodictya sp. (5 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	25	0.10	0.015	15.34	0.06	0.12
Aperture spacing along branch, mm	10	0.66	0.041	6.20	0.60	0.72
Aperture spacing across branch, mm	10	0.38	0.035	9.11	0.31	0.42

Stictoporellina eremita (Prantl, 1940) (2 colonies, UM2-AE 63a and UM2-AE 64).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	40	0.18	0.017	9.78	0.15	0.22
Mesozooecia width, mm	15	0.06	0.022	37.32	0.03	0.10
Aperture spacing along branch, mm	38	0.19	0.032	17.23	0.14	0.30
Branch width, mm	7	2.60	0.311	11.96	2.20	3.20
Fenestrule width, mm	10	3.02	0.464	15.34	2.40	4.00
Fenestrule length, mm	10	4.08	0.598	14.57	2.80	4.80
Branch thickness, mm	6	2.57	0.448	17.43	1.96	3.10

? *Stictoporella* sp. (single colony, UM2-AE 74).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	10	0.12	0.012	10.32	0.10	0.14
Mesozooecia width, mm	6	0.06	0.020	33.68	0.03	0.08
Aperture spacing along branch, mm	6	0.51	0.047	9.16	0.45	0.55
Aperture spacing across branch, mm	10	0.28	0.058	20.63	0.22	0.39

Astrovidictya sparsa Lavrentjeva, 1993 (3 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	30	0.11	0.016	13.86	0.08	0.15
Mesozooecia diameter, mm	15	0.04	0.008	19.50	0.03	0.05
Aperture spacing along branch, mm	10	0.56	0.051	9.13	0.48	0.62
Aperture spacing across branch, mm	10	0.33	0.021	6.30	0.30	0.36

Ptilodictyina sp. indet. 1 (two fragments of a single colony, UM2-AE 80-8 and UM2-AE 80-6).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	20	0.14	0.013	8.98	0.12	0.17
Microacanthostyle diameter, mm	20	0.02	0.005	19.12	0.02	0.03
Aperture spacing along branch, mm	5	0.46	0.046	10.02	0.40	0.50
Aperture spacing across branch, mm	9	0.31	0.026	8.41	0.28	0.35

Ptilodictyina sp. indet. 2 (3 fragments, UM2-AE 4-11, -8, -20)

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	10	0.12	0.012	10.32	0.10	0.14
Mesozooecia width, mm	6	0.06	0.020	33.68	0.03	0.08
Aperture spacing along branch, mm	6	0.51	0.047	9.16	0.45	0.55
Aperture spacing across branch, mm	10	0.28	0.058	20.63	0.22	0.39

Pseudohornera dmitrii sp. nov. (7 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm	10	0.14	0.028	19.96	0.12	0.20
Node diameter, mm	10	0.04	0.006	13.97	0.04	0.06
Branch width, mm	7	0.74	0.137	18.63	0.51	0.90

Chasmotopora hypnoides (Sharpe, 1853) (7 colonies).

	N	X	SD	CV	MIN	MAX
Autozooecial aperture width, mm (inner row)	51	0.13	0.013	9.98	0.10	0.16
Autozooecial aperture width, mm (outer row)	28	0.16	0.010	6.99	0.13	0.17
Aperture spacing along branch (inner row)	31	0.51	0.045	8.85	0.43	0.60
Aperture spacing along branch (outer row)	30	0.75	0.096	12.71	0.63	0.98
Branch width, mm	33	0.59	0.121	20.38	0.42	0.88

'*Synocladia*' *hypnoides* Sharpe, 1853 (Holotype, NHM PD 2215).

	N	X	SD	CV	MIN	MAX
Branch width, mm	8	0.47	0.082	17.52	0.38	0.60
Autozooecial aperture width, mm	5	0.15	0.021	14.43	0.13	0.18
Fenestrule width, mm	5	1.80	0.180	10.00	1.62	1.98
Fenestrule length, mm	4	6.17	0.783	12.70	5.40	7.20

Ralfina lusitanica (Sharpe, 1853) (single colony, UM-2 AE-69).

	N	X	SD	CV	MIN	MAX
Branch width, mm	5	0.83	0.091	10.94	0.75	0.95
Zooecial chamber width, mm	5	0.14	0.014	10.20	0.13	0.16
Branch thickness, mm	3	0.63	0.050	8.00	0.58	0.68

'Synocladia' lusitanica Sharpe, 1853 (Holotype, NHM PD 2214).

	N	X	SD	CV	MIN	MAX
Branch width, mm	10	0.82	0.086	10.54	0.70	1.00
Autozooecial aperture width, mm	10	0.15	0.022	14.35	0.13	0.18
Fenestrule width, mm	10	0.60	0.135	22.43	0.50	0.93
Fenestrule length, mm	3	1.16	0.293	25.29	0.83	1.38
Aperture spacing along branch, mm	6	0.41	0.035	8.35	0.38	0.45

Ralfinella elegantula sp. nov. (7 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	16	0.62	0.103	16.78	0.48	0.83
Branch thickness, mm	11	0.51	0.100	19.59	0.38	0.68
Wall thickness, mm	15	0.07	0.017	25.15	0.04	0.10
Autozooecial aperture width, mm	16	0.13	0.018	14.56	0.09	0.16
Aperture spacing along branch, mm	5	0.87	0.123	14.25	0.678	1.00
Aperture spacing across branch, mm	4	0.42	0.101	24.05	0.36	0.57

Moorephylloporina contii sp. nov. (10 colonies).

	N	X	SD	CV	MIN	MAX
Branch width, mm	15	0.31	0.027	8.59	0.25	0.36
Autozooecial aperture width, mm	30	0.09	0.013	14.70	0.07	0.11
Aperture spacing along branch, mm	10	0.29	0.029	9.76	0.25	0.34
Aperture spacing across branch, mm	3	0.19	0.051	27.14	0.15	0.25
Fenestrule width, mm	10	0.49	0.108	22.29	0.30	0.65
Fenestrule length, mm	7	0.79	0.146	18.53	0.60	0.96
Distance between branch centres, mm	4	0.79	0.055	6.98	0.73	0.85
Zooecial chamber width, mm	5	0.12	0.018	15.14	0.10	0.14