LOWER DEVONIAN CORALS AND BRYOZOA FROM THE LICK HOLE FORMATION OF NEW SOUTH WALES

by A. E. H. PEDDER

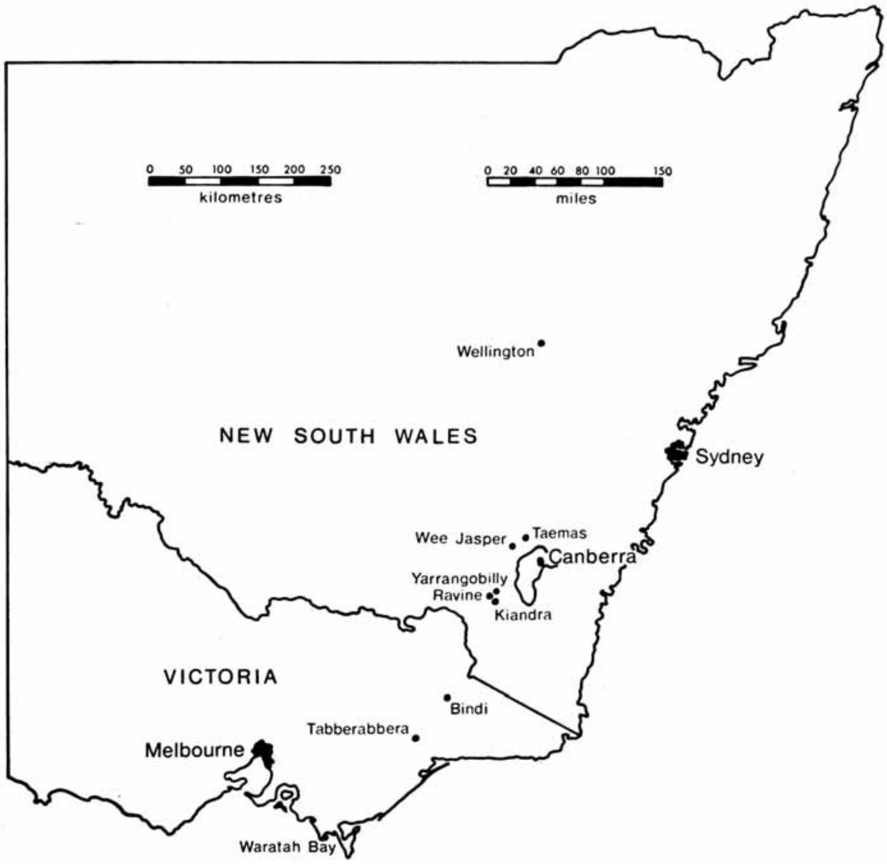
ABSTRACT. Corals and a bryozoan are described from the middle part of the Lick Hole Formation. Reasons are given for supposing that the fauna is intermediate in age between the *Zelolasma gemmiforme* and *Chalcidophyllum recessum* faunas of the Wee Jasper and Taemas areas of New South Wales. The new assemblage, which is referred to as the *Tropidophyllum hillae* fauna, is of Praguian age and may correlate approximately with the Bell Point fauna at Waratah Bay, Victoria. *Tropidophyllum hillae* gen. et sp. nov., *Chalcidophyllum discorde giandarrense* subsp. nov. and *Heterotrypa rapinae* sp. nov. are erected.

THIS article describes corals and bryozoa from the Lick Hole Formation of the Devonian inlier at Ravine, near Kiandra in the Snowy Mountains of southern New South Wales. Although limited in species the fauna evokes interest in that it appears to correlate with some part of the poorly fossiliferous interval represented by the Majurgong Formation in the standard Lower Devonian section of southern New South Wales at Wee Jasper. It is also important in that, in conjunction with previous work, it sheds further light on the possible range of *Polygnathus linguiformis dehiscens* in Australia, as well as on the problem of the precise age of the Bell Point Limestone of Victoria.

Previous work. The first account of the Lick Hole Formation was given by Andrews (1901) in his work on the geology of the Kiandra Goldfield. Andrews referred to it informally as the Lobb's Hole Limestone and surmised, incorrectly as is now clear, that the Lick Hole and nearby Yarrangobilly Limestones are lenticles of similar age in a questionably Upper Silurian sequence. Harper briefly described the formation in 1913 and a few years later Carne and Jones (1919, p. 380) published an assay of a limestone sample from it. The formational name Lick Hole and the first regional maps covering the outcrop area stem from geological surveys, begun in 1949, for the Snowy River Hydro-Electric Scheme (Adamson 1957; Adamson *et al.* 1966; Moye, Sharp, and Stapledon 1969*a*, *b*). The most detailed mapping and biostratigraphic studies of the Lick Hole Formation available at the present are those of Flood and the writer (Flood 1969).

W. S. Dun provided faunal lists for Andrews (1901, p. 16; Dun 1902, p. 175) and Harper (1913, p. 179); the first were said to purport an Upper Silurian age, the other an undoubted Devonian age. R. Etheridge also identified forms for Andrews (1901, p. 16). Fossils identified by H. O. Fletcher for Adamson (1957, p. 15) were said to indicate a lower Middle Devonian age. The widely accepted correlation (David and Browne 1950, p. 233; Browne 1959, p. 126) between the Lick Hole Formation and Murrumbidgee Group was first put forward in print by Benson (1922, p. 94). The most significant palaeontological works to date have been the description of cricoconarids by Sherrard (1967), in which the true Lower Devonian age of the Lick Hole Formation was

[Palaeontology, Vol. 14, Part 3, 1971, pp. 371–86, pls. 67–68.]



TEXT-FIG. 1. Map of New South Wales and Victoria showing localities mentioned in the text.

first indicated, and figures of conodonts, principally in Flood (1969), but also in Pedder, Jackson, and Philip (1970, pl. 40, figs. 15, 16, 19, 21, 23), which refine the correlation between the Ravine and Wee Jasper/Taemas sequences.

STRATIGRAPHY

The thickness of the Lick Hole Formation was given as 1830 ft (558 m) by Adamson (1957, p. 8) and as 1400 ft (420 m) by Moye, Sharp, and Stapledon (1969*b*, p. 145). The 1600 ft (488 m) figure given below was obtained by P. G. Flood and the writer using compass and tape before the earlier measurements were available to us.

The section begins on the Kiandra/Ravine road at Grid Reference point 29421760 and continues along the road for the lower 1300 ft; the upper 300 ft were measured up the slope from the road to Round Top Trig. Station at Grid Reference point 29461753 (see also Flood 1969, fig. 1).

Unit no.		*Thickness in feet and metres* *Unit*	*Total from base*
5	Mudstone, olive-grey, poorly bedded, poorly exposed; no fossils seen. Contact with overlying Round Top Formation distinct and probably conformable	300 (91·5)	1300–1600 (396·3–487·8)
4	Mudstone, olive-grey, with dark micro-crystalline calcareous nodules; rare brachiopods	120 (36·6)	1180–1300 (359·7–396·3)
3	Mudstone, calcareous and partly slightly silty, bluish-grey, with numerous biogenic nodular layers; upper few feet ledge-forming; *Tropidophyllum hillae*, *Chalcidophyllum discorde giandarrense*, *Heterotrypa rapinae*, brachiopods (currently under study by P. G. Flood), *Tentaculites chapmani*, bivalves, ostracods, etc.	360 (109·8)	820–1180 (249·9–359·7)
2	Mudstone, olive-grey, some thin biogenic nodular limestone interbeds; brachiopods and some bivalves present	522 (159·1)	298–820 (90·8–249·9)
1	Mudstone, bluish-grey and siltstone, calcareous, dark grey; few brachiopods present. Contact with underlying Milk Shanty Formation distinct and apparently conformable	298 (90·8)	0–298 (0–90·8)
	Total thickness of Lick Hole Formation 1600 ft (487·8 m)		

CORRELATION AND SIGNIFICANCE OF THE LICK HOLE FAUNA

The best Lower Devonian reference sections in south-east Australia are those around Wee Jasper and Taemas on the flanks of the Narrangullen Anticline, some 50 miles (80 km) north-north-east of the Ravine Inlier. The oldest fauna known in these sections is the *Zelolasma gemmiforme* assemblage of the Cavan Limestone, which is separated from higher faunas by the generally poorly fossiliferous Majurgong Formation at Wee Jasper (Pedder, Jackson, and Philip 1970), and by the Majurgong and lower beds of the Taemas Limestone at Taemas (Browne 1959).

The stratigraphically important conodont element *Polygnathus linguiformis dehiscens* is common to both the *Zelolasma gemmiforme* and Lick Hole faunas (Flood 1969). The corals of the two assemblages, however, are entirely different. This may be due to changes of facies, or to faunal provincialism. But the facies are not disparate, nor are the faunas separated by any great geographical distance. This leads one to suspect that the Lick Hole fauna may be either slightly younger or slightly older than the *Z. gemmiforme* fauna. The corals suggest that it is younger, because the widely distributed genus *Chalcidophyllum* is unknown elsewhere in beds as old as the *Z. gemmiforme* fauna and a species closely related to *Tropidophyllum hillae* occurs in the post *Z. gemmiforme* Bindi Limestone of Victoria (Philip and Pedder 1968).

As the fauna of unit 3 of the Lick Hole Formation appears to be intermediate in age between the *gemmiforme* and *recessum* assemblages of Philip and Pedder (1967, 1968) it is now formally designated as the *Tropidophyllum hillae* assemblage. In view of the Praguian age of the *Z. gemmiforme* and *Chalcidophyllum recessum* faunas (Pedder, Jackson, and Philip 1970, p. 212), the *Tropidophyllum hillae* assemblage should also be referred to the Praguian Stage.

Two significant points emerge from the composition and assumed correlation of the new fauna. First, an approximate correlation is implied, by the identification of the Lick Hole *Chalcidophyllum* as a subspecies of *C. discorde*, between the Lick Hole and Bell Point Limestone of Waratah Bay, Victoria. Secondly, the known range of *Polygnathus linguiformis dehiscens* in Australia is extended upwards into beds equivalent to some part of the Majurgong Formation at Wee Jasper. If correct this would reduce considerably the gap between the previously known upper limit of *P. linguiformis dehiscens* and the lower limit of *P. linguiformis foveolatus* in Australia (Philip and Jackson 1967, text-fig. 1). Such a gap is not known in the Carnic Alps where both subspecies have now been recognized (Skala 1969).

SYSTEMATIC PALAEONTOLOGY

Unless otherwise stated all specimens were collected by the writer in January 1967 from the Kiandra/Ravine road section described above.

Depositories of fossils are abbreviated as follows: AM: Australian Museum, Sydney, New South Wales. GSNSW: Geological Survey of New South Wales, Sydney. UNE: Department of Geology, University of New England, Armidale, New South Wales.

Phylum COELENTERATA
Order RUGOSA Milne-Edwards and Haime 1850
Family CYATHOPHYLLIDAE Dana 1846
Genus TROPIDOPHYLLUM nov.

Type species. Tropidophyllum hillae sp. nov.

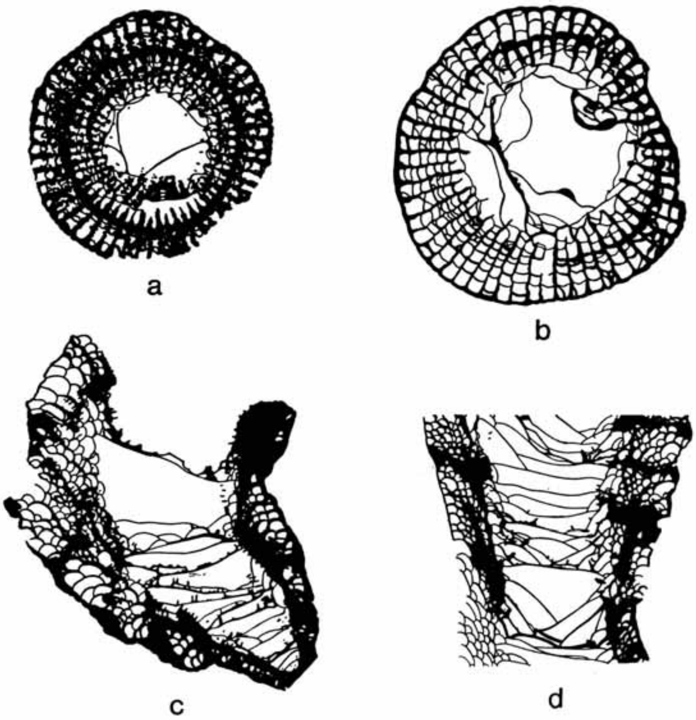
Diagnosis. Tetracoral, solitary except for rare buds that are not known to have developed beyond an early stage, or to have produced a genuinely fasciculate colony. Calicular platform absent, or if present narrow and flat to weakly excert. Outer wall with broad subdued interseptal ridges; either invaginated and continuous with septal bases, or embedding them. Septa radially arranged, faintly to highly carinate; adaxially dilated and spinose; apart from scattered axial lobes they are markedly withdrawn from the axis. Exceptionally strongly carinate septa may be slightly retiform. Septal trabeculae monacanthine with widely divergent fibres, inwardly projecting and subparallel to, less commonly divergent within the plane of the septum. Septa contiguous or united by sclerenchyme in the adaxially dilated region, usually forming an inner wall. Dissepiments in a few or several rows, generally inwardly sloping, although locally the outermost are flat-lying and may be rhomboid. Tabulae mostly broad to complete, and commonly, together with peripheral tabellae, form flat to concave tabularial surfaces which are characteristically periodically invested with sclerenchyme.

Derivation of name. Greek, *tropos* = keel (carina) and *phyllon* = leaf.

Remarks. The genus is also represented by an undescribed species in the Bindi Limestone (Praguian) of Victoria and possibly by calicular moulds figured by Talent as Rugosa indet. E (1963, pl. 12, figs. 1–7) from the Kilgower Member at Tabberabbera, Victoria.

The trabeculae, variation in the relationship of the septal ends to the wall, and the adaxially expanded septal ends relate the new genus to *Zelolasma* (see Pedder, Jackson, and Philip 1970, p. 232). The two genera are distinguished by growth habit, which is colonial in *Zelolasma* and solitary in *Tropidophyllum*.

The solitary species *Ceratophyllum shandiense* Zheltonogova (in Khalfin 1961, p. 403) and *Cyathophyllum pannosum* Hill and Jell (1969, p. 6) from beds said to be of Eifelian age in the Salair and Queensland respectively, also appear to be related to the new genus. However, the dilation of their septa does not seem to be associated with sclerenchymal investment of the dissepiments and the relationship of wall to septa has not yet been



TEXT-FIG. 2. *Tropidophyllum hillae* gen. et sp. nov., all figures enlarged $\times 3$: *a*, transverse section of paratype 11, UNE F11675, a specimen with strongly dilated and carinate septa; *b*, transverse section of paratype 14, AM AM6456c, a large specimen with weakly dilated and weakly carinate septa; *c*, longitudinal section of paratype 2, UNE F11666, a trochoid specimen; *d*, longitudinal section of paratype 4, UNE F11668, a ceratoid specimen.

described in these species. *Ceratophyllum*, interpreted on the group of species close to *C. typus* Gürich (Fedorowski 1967), differs from *Tropidophyllum* in being prominently bilaterally symmetrical in early stages and in having a more consistently fan-shaped trabecular arrangement. *Cyathophyllum*, based on *C. dianthus* Goldfuss (Birenheide 1963, p. 376), is a colonial genus with fine septa and no thickening of the dissepimentarial or tabularial surfaces.

Gurievskiella Zheltonogova (see also Hill and Jell 1969, p. 11) is distinguished from the new genus by its everted dissepimentarium, weakly divergent fibres within the trabeculae and domed tabularium composed mostly of numerous vesicular tabellae.

Tropidophyllum hillae sp. nov.

Plate 67, figs. 1–14; text-figs. 2*a–d*

1901 *Amplexus* (?); Dun, W. S., in Andrews, p. 16.
1902 *Amplexus* (?); Dun, p. 175.
?1913 *Cyathophyllum*; Dun, W. S. ('the Palaeontologist') in Harper, p. 179.
1922 *Amplexus*, spp. ind.; Benson (in part), p. 143 (Lobb's Hole specimen only).
?1922 *Cyathophyllum*, sp. indet.; Benson (in part), p. 146 (Lobb's Hole specimen only).
1969 Solitary rugosan; Flood (in part), p. 7.

Derivation of name. Patronym in honour of Professor Dorothy Hill.

Type series. Holotype and paratypes 1–4, UNE F11664 to F11668 respectively, 943–970 ft above the base and 630–657 ft below the top of the Lick Hole Formation. Paratypes 5, 6, UNE F11669, F11670, 823–849 ft above the base and 751–777 ft below the top of the Lick Hole Formation. Paratype 7, UNE F11671, 889 ft above the base and 711 ft below the top of the Lick Hole Formation. Paratype 8, UNE F11672, 890–897 ft above the base and 703–710 ft below the top of the Lick Hole Formation. Paratype 9, UNE F11673, 970–990 ft above the base and 610–630 ft below the top of the Lick Hole Formation. Paratypes 10, 11, UNE F11674, F11675, 990–1000 ft above the base and 600–610 ft below the top of the Lick Hole Formation. Paratypes 12–16, AM AM6456a–e (all on one large thin section) and F43438 (remaining hand specimen), unrecorded horizon within the Lick Hole Formation. Paratypes 12–16 were collected by the Geological Survey of New South Wales in 1949; although the museum label reads 'Middle Devonian, Yarrangobilly, N.S.W. (Lobb's Hole)' there is no doubt that they come from the Lick Hole Formation. Paratype 17, GSNSW F14710, unrecorded horizon within the Lick Hole Formation. This specimen was collected by E. C. Andrews at about the turn of the century on 'O'Hare's Creek, Lobb's Hole, Kiandra' and should have come from approximately 1 mile south-west of the type locality; it is the specimen identified in print as *Amplexus* (?) sp.

Twenty-eight thin sections have been cut from the type material.

Diagnosis. Corallum trochoid to ceratoid; maximum length approximately 3 cm, diameter 2 cm. Exterior walls confluent with, or embracing the septal bases. Septa smooth to highly carinate, radially arranged, 26×2 to 32×2 in number at maturity.

EXPLANATION OF PLATE 67

Figs. 1–14. *Tropidophyllum hillae* gen. et sp. nov., Lick Hole Formation, Kiandra/Ravine road section, southern New South Wales. 1, holotype, UNE F11664, part of longitudinal section showing non-divergent monacanthine trabeculae, $\times 10$. 2, paratype 8, UNE F11672, exterior view before sectioning, $\times 2$. 3, paratype 2, UNE F11666, part of longitudinal section showing divergent monacanthine trabeculae, $\times 10$. 4, paratype 10, UNE F11674, part of transverse section of a markedly carinate specimen, $\times 10$. 5, holotype, UNE F11664, part of transverse section showing sclerenchyme and septal bases that are not confluent with the wall, $\times 10$. 6, paratype 1, UNE F11665, part of transverse section of a specimen having thick septa with bases confluent with the wall, $\times 10$. 7, paratype 3, UNE F11667, transverse section showing well-developed inner wall, $\times 3$. 8, holotype, UNE F11664, transverse section near the base of the calice, $\times 3$. 9. holotype, UNE F11664, typical longitudinal section, $\times 3$. 10, paratype 8, UNE F11672, transverse section of a specimen with thin septa, $\times 3$. 11, paratype 9, UNE F11673, longitudinal section showing outwardly inclined dissepiments and abundant axial lobes, $\times 3$. 12, paratype 1, UNE F11665, transverse section across the calice of a specimen with profuse sclerenchyme, $\times 3$. 13, paratype 9, UNE F11673, transverse section, note budding and the locally retiform septa, $\times 3$. 14, paratype 11, UNE F11675, transverse section of a specimen having thick, strongly carinate septa, $\times 3$.

Major septa only slightly longer than the minor septa. Sclerenchyme and/or septal dilation form an interior wall in the inner region of the dissepimentarium. Trabeculae monacanthine, parallel, inclined at 45° peripherally, variably flattened adaxially. Dissepiments variable, in up to 10 rows. Tabulae broad, mostly forming flat or concave tabularial surfaces. Sclerenchyme periodically developed on dissepimentarial and tabularial surfaces.

Description. Corallites are trochoid or ceratoid. When complete the largest were probably a little over 3 cm long and at least 2·1 cm in diameter; more typically they are 2·0–2·5 cm in length measured along the convex side and 1·2–1·5 cm across the top of the calice. Minor rejuvenations are common. Some topotypes were evidently eroded prior to fossilization; where exteriors are well preserved there are abundant fine growth ridges and usually pronounced septal grooves and broad, rather flat interseptal ridges. Offsets are known in only one specimen (Pl. 67, fig. 13) and these did not develop beyond an early stage. At first sight they appear to have originated by axial gemmation, but closer inspection reveals that the formation of two of them preceded that of the third and that all are probably better regarded as peripheral offsets.

The calice, which is about as deep as it is wide, generally has a rather flat, broad base and an extremely narrow peripheral platform. Thickness of the exterior wall ranges from 0·05 to 0·4 mm but is usually from 0·1 to 0·2 mm. In some cases the axial plate and wall are strongly invaginated at the septal bases and pass imperceptibly into them, in others the septal base is distinct and embraced by the wall. Septal arrangement is radial. Despite considerable variation in thickness the septa are invariably relatively dilated in a peritabularial zone and commonly in collaboration with sclerenchyme, but in some cases by contiguity alone, form a distinct inner wall close to the inner margin of the dissepimentarium. Carinae may be totally suppressed, although more commonly zigzag and yardarm carinae are present, and locally are so highly developed that the septa are retiform. The major septa, which are only a little longer than the minor septa, extend between one and two thirds of the distance to the axis. Short axial lobes are commonly present in the periaxial region of the tabularium. Trabeculae are monacanthine with widely divergent fibres, parallel and distally form strongly denticulate septal edges. Peripherally they are directed upwards and inwards at about 45°, adaxially they usually flatten, in places so much that they become nearly, or quite flat. In the following table measurements are in millimetres, *Dt* is the diameter of the tabularium and *Dc* of the calice or corallite.

Dissepiments are confined to one or two rows in early stages; later there are up to 10, usually 6 or 7 rows, except following a rejuvenation when there are typically 4 or so rows. The dissepiments vary greatly in shape and size. Most are well inflated and moderately inclined inwards, but some in the outermost 1 or 2 rows are highly arched and even outwardly inclined, while others in the inner rows are elongated and almost vertical. Some dissepiments, especially in the more carinate specimens fail to cross the interseptal loculi. A few tabellae may be present. Tabulae are mostly gently sinuous, broad and commonly complete. Where they are closely spaced, 3, or exceptionally 4 may be counted over a vertical distance of 1 mm; the most widely spaced tabulae are 3–4 mm apart. Sclerenchymal thickening of the dissepimentarial and tabularial surfaces is developed periodically.

Specimen	*Mean or measurable Dt*	*Mean or measurable Dc*	*Dt/Dc*	*No. of septa*	*Orientation of thin section*
Paratype 2	1·8	3·9	0·46	—	longitudinal
Paratype 15	2·5	4·0	0·62	16×2	transverse
Paratype 5	3·6	6·0	0·60	16×2	transverse
Holotype	5·0	6·5	0·77	—	longitudinal
Paratype 3	5·0	8·7	0·57	24×2	transverse
Paratype 11	5·5	13·0	0·43	27×2	transverse
Paratype 1	6·0	11·5	0·52	27×2	transverse
Holotype	6·4	11·5	0·56	26×2	transverse
Paratype 16	—	13·8	—	25×2	transverse (calice)
Paratype 2	6·8	14·0	0·49	—	longitudinal
Paratype 8	7·0	12·6	0·55	27×2	transverse
Paratype 4	7·5	14·2	0·53	27×2	transverse
Paratype 6	—	14·5	—	29×2	transverse (calice)
Paratype 8	7·7	14·2	0·55	28×2	transverse
Paratype 9	8·5	13·0	0·65	—	longitudinal
Paratype 10	8·8	16·0	0·55	27×2	transverse
Paratype 14	9·0	15·4	0·58	28×2	transverse
Paratype 9	—	19·0	—	32×2	transverse (calice)
Paratype 9	—	21·0	—	32×2	transverse (calice)

Genus CHALCIDOPHYLLUM Pedder 1965

1965 *Chalcidophyllum* Pedder, p. 204.

Type species. Chalcidophyllum campanense Pedder 1965, p. 204. Bell Point Limestone (Praguian), Waratah Bay, Victoria.

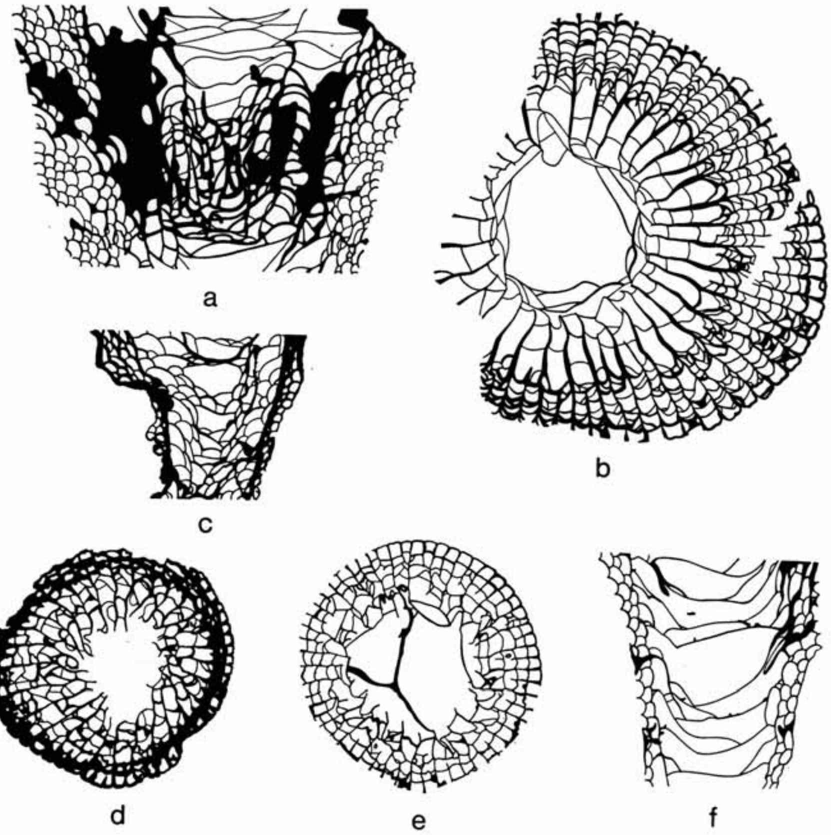
Diagnosis. Corallum solitary and possibly weakly compound; corallites trochoid to cylindrical. Wall invariably invaginated at the septal bases and continuous with them; septal grooves prominent. Peripheral stereozone developed in some species. Septa normally smooth, usually radially arranged, apparently without trabeculae and typically highly differentiated into two orders. Minor septa may be almost entirely suppressed. Dissepiments numerous in large species, relatively less numerous in others, inosculating and forming a herringbone dissepimentarium in some species; at the periphery they are small, but adaxially become larger and more elongate. Tabulae broad and commonly depressed axially.

Remarks. The following taxa now comprise the genus: *Chalcidophyllum campanense* Pedder 1965, *C. campanense* var. *nanum* Pedder 1965, *C. angulare* (Hill 1950), *C. discorde* Pedder 1965, *C. discorde giandarrense* subsp. nov., *C. gigas* Pedder 1970, *C. recessum* (Hill 1940), and *C. vesper* Pedder 1970. The genus is currently known with certainty only from the Emsian and possibly the late Siegenian of eastern Australia.

Chalcidophyllum discorde Pedder 1965

?1940 Gen. et sp. indet.; Hill, pl. 9, fig. 9.
1954 *Mictophyllum cresswelli* (Chapman) var. *cylindricum* Hill, p. 109, pl. 7, figs. 9*a*, *b*.
1954 *Mictophyllum* sp. or *Disphyllum* sp.; Hill (in part ?), p. 110, pl. 7, fig. 11.
1965 *Chalcidophyllum discorde* Pedder, pp. 206, 7, pl. 30, figs. 14, 15; pl. 34, fig. 1.

Remarks. The holotype and paratype are from the Bell Point Limestone at Bell Point, Waratah Bay, Victoria. Other material tentatively included in the above synonymy is



TEXT-FIG. 3. *Chalcidophyllum discorde giandarrense* subsp. nov., all figures enlarged ×3: *a*, longitudinal section of paratype 4, UNE F11680, a large specimen with wide dissepimentarium; *b*, transverse section of paratype 4, UNE F11680, a large specimen with little septal dilation; *c*, longitudinal section of paratype 1, UNE F11677, a specimen with peripherally dilated septa invested with sclerenchyme; *d*, transverse section of paratype 1, UNE F11677, a specimen showing pinnate septal arrangement and peripherally dilated septa invested with sclerenchyme; *e*, transverse section of paratype 2, UNE F11678, a specimen with undilated septa; *f*, longitudinal section of paratype 2, UNE F11678, a specimen with a narrow dissepimentarium.

apparently from the Bird Rock Member of the Waratah Limestone at Walkerville, Waratah Bay and the Taemas Limestone at Cavan, near Taemas, New South Wales.

Chalcidophyllum discorde giandarrense subsp. nov.

Plate 68, figs. 1–11; text-figs. 3a–f

1969 Solitary rugosan; Flood (in part), p. 7.

Derivation of name. Giandarra, name now corrupted to Kiandra.

Type series. Holotype and paratype 1, UNE F11676, F11677 respectively, 1168–1180 ft above the base and 420–432 ft below the top of the Lick Hole Formation. Paratype 2, UNE F11678, 970–990 ft above the base and 610–630 ft below the top of the Lick Hole Formation. Paratype 3, UNE F11679, 990–1000 ft above the base and 600–610 ft below the top of the Lick Hole Formation. Paratype 4, UNE F11680, 1000–1002 ft above the base and 598–600 ft below the top of the Lick Hole Formation. Paratype 5, UNE F11681, unit 3 of the Lick Hole Limestone. This specimen was collected by the author in 1964 from the Kiandra/Ravine road section before the section had been measured.

Sixteen thin sections have been prepared from the type material.

Diagnosis. Corallum solitary, typically ceratoid, up to 5·5 cm in length and 2·8 cm in diameter. Wall invaginated at septal bases. Septa typically 29×2 to 31×2 in number, maximum 38×2. Septal dilation and sclerenchymal investment variable, where pronounced major septa leave an axial space of about 4 mm diameter, where subdued or absent, the axial space is normally 6–8 mm in diameter. Dissepiments steeply inclined, typically in 2–5 rows, exceptionally 7 or 8 rows. Tabulae broad where septa are short.

Description. The solitary corallum is usually ceratoid, rarely subcylindrical, and may grow to a length of at least 5·5 cm and a diameter at the distal end of 2·8 cm; most specimens, however, are a little less than 2 cm across the calice. The calice, which is not freely exposed in the type material, would be deep with steep sides and have a broad flattish base. Well-defined septal grooves and growth ridges mark the exterior of the coral.

The wall, which is 0·05–0·22 mm thick, is invariably invaginated at the septal bases and may also be flexed midway between the septa to form a faint interior ridge and

---

EXPLANATION OF PLATE 68

Figs. 1–11. *Chalcidophyllum discorde giandarrense* subsp. nov., Lick Hole Formation, Kiandra/Ravine road section, southern New South Wales. 1, holotype, UNE F11676, part of longitudinal section showing fine structure of a septum, $\times10$. 2, paratype 4, UNE F11680, exterior view before sectioning, note the prominent septal grooves, $\times2$. 3, paratype 4, UNE F11680, part of transverse section showing invagination of the wall at the septal bases and fibronormal septal structure, $\times10$. 4, paratype 1, UNE F11677, longitudinal section showing sclerenchymal investment of the dissepimentarium, $\times3$. 5, holotype, UNE F11676, longitudinal section showing sclerenchymal investment of the tabularium, $\times3$. 6, holotype, UNE F11676, transverse section showing unequally dilated septa, $\times3$. 7, paratype 5, UNE F11681, longitudinal section showing narrow dissepimentarium in early stages, $\times3$. 8, paratype 2, UNE F11678, longitudinal section of a specimen with uniformly thin septa, $\times3$. 9, paratype 4, UNE F11680, transverse section of a specimen with uniformly thin septa, $\times3$. 10, paratype 1, UNE F11677, transverse section through the lower part of the calice, note the weakly pinnate arrangement of the septa, carinae and septal dilation, $\times3$. 11, paratype 2, UNE F11678, transverse section of an early stage of a specimen with short undilated septa, $\times3$.

Figs. 12–16. *Heterotrypa rapinae* sp. nov., Lick Hole Formation, Kiandra/Ravine road section, southern New South Wales. 12, holotype, UNE F11682, longitudinal section of the exozone and the outermost part of the endozone, note acanthopores and moniliform mesopores, approx. $\times25$. 13, paratype 3, UNE F11685, randomly orientated section showing rejuvenation on the right, passing laterally into an overgrowth on the left, $\times15$. 14, paratype 2, UNE F11684, tangential section in the exozone showing an area of thickened zoecial walls and atypically high concentration of acanthopores, approx. $\times25$. 15, holotype, UNE F11682, tangential section in the outer part of the endozone showing large acanthopores, approx. $\times25$. 16, holotype, UNE F11682, tangential section within the exozone, note 'amalgamate' structure, approx. $\times25$.

corresponding exterior groove. Septa merge with the wall at the periphery. They are in two orders and are usually radially arranged. The length and dilation of the septa and the thickness and persistence of sclerenchyme on dissepimentarial and tabularial surfaces vary appreciably from specimen to specimen and also periodically within a single specimen. Where the septa are short there is little or no dilation, or sclerenchyme investment, and the axial space is typically 6–8 mm in diameter. Where the septa are longer and dilated the dissepimentarial surfaces are coated with sclerenchyme, which may or may not be continuous with the dilated parts of the septa, and the axial space is generally about 4 mm in diameter. Long septa may be irregularly sinuous at the axis and the axis may be somewhat excentric. Septa are typically smooth, although coarse carinae may occur in the peripheral parts of strongly dilated septa. The fine structure is fibronormal, even, as far as can be discerned, in the carinate parts of the septa. In the following table measurements are in millimetres, *Dt* is the diameter of the tabularium and *Dc* is the diameter of either the calice or the corallite.

Specimen	*Mean or measurable Dt*	*Mean or measurable Dc*	*Dt/Dc*	*No. of septa*	*Orientation o, thin section*
Paratype 1	2·0?	2·0	—	21 undiff.	transverse
Paratype 1	3·3	5·0	0·66	21 major	transverse
Paratype 2	5·0	5·9	0·85	21×2	transverse
Paratype 5	5·0	7·5	0·67	—	longitudinal
Holotype	6·0	13·0	0·46	—	longitudinal
Paratype 3	7·0	13·0?	—	31×2	transverse
Paratype 2	8·0	10·0	0·80	—	longitudinal
Paratype 5	8·0	11·0	0·73	25×2	transverse (calice)
Paratype 1	8·0	11·5	0·70	—	longitudinal
Holotype	9·0	16·5	0·55	29×2	transverse
Paratype 2	9·5	12·5	0·76	29×2	transverse
Paratype 4	9·5	16·0	0·59	29×2	transverse
Paratype 1	10·5	13·2	0·79	29×2	transverse
Paratype 4	14·5	23·5	0·62	35×2	transverse
Paratype 4	—	28·0	—	38×2?	transverse (calice)

In stages during which the coral enlarges to a diameter of 3 mm dissepiments are absent or rare and confined to one row. Subsequently there are typically 2–5 and exceptionally as many as 7 or 8 rows of dissepiments. The dissepiments are steeply inclined and mostly of moderate size, although some are larger and markedly more elongated. The tabularium consists of marginal tabellae, in places inosculating, and tabulae. Where the major septa are short the tabulae are commonly broad and in some cases complete.

Remarks. The new subspecies differs from the nominate species in having a generally narrower dissepimentarium and shorter, more dilated and less regular major septa. Specimens of the new subspecies that have undilated septa may resemble *Chalcidophyllum recessum*, but examples of that species normally have fewer septa at given diameters (e.g. 23×2 to 27×2 at 16·0 mm in *C. recessum*; 29×2 to 31×2 at 16·0 mm in *C. discorde giandarrense*). In *C. vesper* the major septa are consistently long and attenuate in the tabularium and there is a uniformly well-developed peripheral stereozone.

Phylum BRYOZOA
Order TREPOSTOMATA Ulrich 1882
Family HETEROTRYPIDAE Ulrich 1890
Genus HETEROTRYPA Nicholson 1879

1879 *Monticulipora (Heterotrypa)* Nicholson, pp. 291, 93, 94.
1882 *Dekayella* Ulrich, p. 155.
1966 *Heterotrypa* Nicholson; Boardman and Utgaard, pp. 1105–1107, pls. 140–142.

Remarks. Boardman and Utgaard (1966, p. 1090) recognize two kinds of acanthopores in Ordovician species of *Heterotrypa*, based primarily on their spatial relationships to the zoaria. A histogram (text-fig. 4) of the frequencies of acanthopore diameters suggests that the acanthopores of the Lick Hole species fall into two groups. These, however, do not seem to correspond to the endacanthopores and exacanthopores of the Ordovician species, as the larger ones occur both at and between the zoecial corners and both groups may originate in either the outer endozone or exozone. The same authors (1966, p. 1091) stress that the presence or absence of two kinds of acanthopores is not absolutely diagnostic of the genus. Nevertheless until intermediate Silurian forms are better known concern will remain regarding the generic assignment of the Devonian species.

Some Devonian species presently ascribed to *Leioclema* (Ulrich 1882, pp. 141, 54) resemble the new species, but Owen (1969, p. 631), who has examined the type material of *Leioclema*, notes that it appears to be related to such genera as *Rhombopora* and other rhabdomesids which are normally placed in the order Cryptostomata. In view of this Owen erected *Asperopora*, based on *Callopora aspera* Hall, for several Silurian and Helderbergian bryozoa that had previously been accommodated in *Leioclema*. The Lick Hole species resembles *Asperopora* apart from its fine structure, which is essentially leioclemid (see Boardman 1960, p. 30) and therefore very different from the fine structure of *Asperopora aspera* depicted by Tavener-Smith (1969, fig. 1). *Paralioclema* (Morozova 1960, p. 93) is likely related to the new species, but is probably better restricted to forms with especially large acanthopores. Such forms are presently only known from the Givetian and Frasnian of the Minusinsk and Kuznetsk Basins of Siberia. The relationship of the new species to *Thallostigma* (Hall 1883, p. 154; abstract 1881, p. 12), which has usually been regarded as a synonym of *Leioclema*, cannot be assessed until *T. intercellata* Hall (1883, p. 154; abstract 1881, p. 13; 1886, pl. 32, figs. 15–20), the type species, has been more fully described.

Heterotrypa rapinae sp. nov.

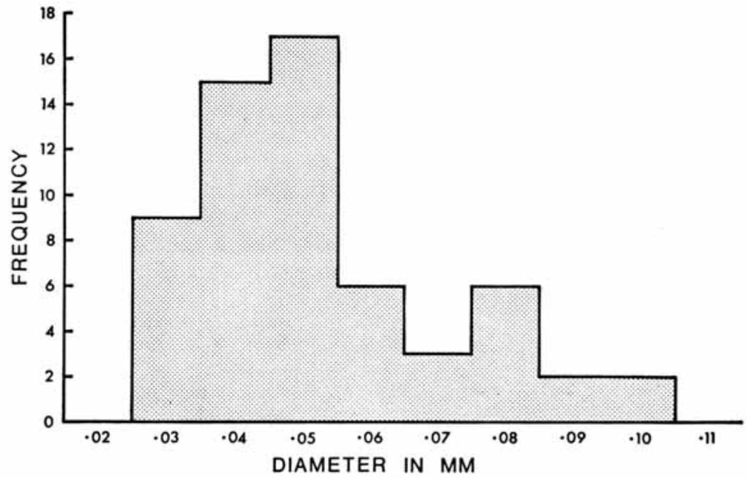
Plate 68, figs. 12–16; text-fig. 4

1957 *Favosites* sp. (A species with very fine corallites); Fletcher, H. O., in Adamson, p. 15.
1969 bryozoan; Flood, p. 7.
1969*b* *Favosites* sp.; Moye, Sharp, and Stapledon, p. 145.

Derivation of name. The Old French word *ravine*, which is derived from the Latin *rapina* meaning robbery. Hence *rapinae* (genitive) indicating that the types are from the locality known as Ravine.

Type series. Holotype, UNE F11682, 889 ft above the base and 711 ft below the top of the Lick Hole Formation. Paratype 1, UNE F11683, 890–897 ft above the base and 703–710 ft below the top of the Lick Hole Formation. Paratypes 2–4, UNE F11684–F11686, 943–970 ft above the base and 630–657 ft below the top of the Lick Hole Formation. Paratypes 5–7, AM F43419–F43421, unrecorded horizon within the Lick Hole Formation. Paratypes 5–7 were collected by the Geological Survey of New South Wales in 1949 and are the specimens identified by Fletcher in Adamson (1957) as *Favosites* with very fine corallites. The museum label cites their occurrence as 'Middle Devonian, Yarrangobilly, N.S.W. (Lobb's Hole)' but the matrix, associated fauna, and Adamson's work indicate that they are from the Lick Hole Formation.

The type series includes 13 thin sections.



TEXT-FIG. 4. Histogram of the frequency of diameters of 60 randomly chosen acanthopores from the holotypes and paratypes 1–5 of *Heterotrypa rapinae* sp. nov. Ten measurements were taken from each specimen. Note that the majority of acanthopores are either 0·3–0·6 mm in diameter, or 0·8 mm in diameter.

Description. Zoarium ramose or less commonly subramose. Rejuvenation may occur within the exozone and overgrowths, usually with a well-developed basal plate, may also be present. One slide of UNE F11685 shows a rejuvenation passing laterally into an overgrowth. Matrix obscures zoarial surfaces in the type series, but groups of thick-walled zoecia suggest the presence of monticles.

In early stages the zoecia closely parallel the zoarial axis; later they curve outwards gently, except in the outermost region of the endozone where there is a marked increase in curvature. Normally the entire exozone is directed perpendicularly to the zoarial surface. Diameter of the endozone is usually between 8 and 18 mm and that of the zoarium between 14 and 22 mm. In overgrowths the endozone is abbreviated and for the most part corresponds only to the outer endozone of unrejuvenated zoaria.

Inside the boundary between the endozone and exozone the thickness of the walls is approximately 0·007 mm. At the boundary the walls thicken in the normal trepostomatous manner and in certain exozonal areas, which seem to represent monticles, are as much as 1·3 mm thick. Wall laminae are highly arched over the centre of the walls and commonly continue on to the diaphragms of the mesospores. Zoecia and mesospores, which are polygonal in cross section within the endozone, lose so much of their angularity in the endozone that their interior may be almost rounded. Zoecial diaphragms are usually 1–2 mm apart in the endozone and 0·15–0·75 mm apart in the exozone.

Although some mesopores originate deep in the endozone, in some cases at a previous growing tip, most first become evident in the outer endozone. Contractions at the diaphragms impart a characteristic moniliform appearance to the mesopores, especially in the endozone. Diaphragms within the mesopores are 0·1–0·2 mm apart.

As the histogram represented in text-fig. 4 shows, acanthopores tend to be of two sizes—0·03–0·06 mm diameter and 0·08 mm diameter. They originate either in the outer endozone or exozone and usually continue to the surface. Those that originate in the endozone do so invariably at zoecial corners. Those that originate in the exozone commonly do so between the zoecial corners. There is no correlation between the size of the acanthopores and their place of origin. Most of the acanthopores remain fixed relative to other structures, but a few can be seen to migrate within the walls (Pl. 68, fig. 12). Zoecial walls may or may not be inflected by the acanthopores.

In the following table of quantitative data measurements are from inter-monticular exozonal areas. In each case the number of measurements per zoarium is 10.

Character	*Range*	*Mode*	*Mean*	*Standard deviation*	*No. of measurements*	*Zoria measured*
No. of whole zoecia per 1 mm²	6–15	9	9	1·75	60	6
No. of whole mesopores per 1 mm²	1–13	4	5	2·76	60	6
No. of whole acanthopores per 1 mm²	7–22	14	14	3·95	60	6
Thickness of wall in mm	0·03–0·10	0·07	0·07	0·021	60	6
Maximum diameter of zoecial void in mm	0·18–0·30	0·23	0·23	0·034	60	6

Remarks. Heterotrypa pontensis Ross (1961, p. 40) from the Lower Devonian Garra Formation near Wellington is a similar species. It is distinguished from *H. rapinae* by its finer zoecia (orifices 0·15–0·20 mm in diameter), narrower walls (average inter-monticular width 0·03 mm) and acanthopores, which apart from rare large ones of 0·06 mm diameter, have an average diameter of 0·03 mm. *H. australis* Etheridge (1899, p. 34) from the Lower Devonian Tabberabbera Formation of Victoria is unidentifiable (Talent 1963, p. 53), but in any case is certainly a much coarser species with zoecial diameters of 1 mm. '*Heterotrypa rushworthensis*' Chapman (1920, p. 174) from the Lower Devonian of Rushworth, Victoria, was founded on an inorganic object (Ross 1961, p. 106). *H. yakovlevi* Sheynmann (1926, p. 921) and variety *palmipedalis* (1926, p. 922) from the Givetian of the Minusinsk Basin are distinguished from the new species by their narrower walls and smaller zoecia (0·17–0·20 mm diameter in *H. yakovlevi* and even less in var. *palmipedalis*). Later Russian authors have referred *H. yakovlevi* to the genus *Lioclema* (Nekhoroshev 1948, p. 62; Morozova 1960, p. 87).

None of the Silurian species of *Heterotrypa* described to date (Astrova 1959, p. 40; Perry and Hattin 1960, p. 702; Ross 1961, p. 39) is similar to *H. rapinae*.

Acknowledgements. Mr. P. G. Flood, formerly of the University of New England, accompanied the writer in the field in January 1967 and later made available prior to publication the results of his studies of the Lick Hole conodonts and brachiopods. Dr. J. W. Pickett of the Geological Survey of New South Wales located and loaned specimens collected and referred to in publication by Andrews. Mr. H. O. Fletcher and Dr. A. Ritchie of the Australian Museum arranged for the loan of specimens identified by Fletcher in Adamson 1957.

The work was undertaken at the University of New England, Armidale, as part of a larger project on the Devonian biostratigraphy of eastern Australia and was supported financially by the Australian Research Grants Committee.

REFERENCES

ADAMSON, C. L. 1957. Reconnaissance geology of the Snowy Mountains area. Progress report no. 10. Tumbarumba. *Tech. Rep. Min. Dep. N.S.W.* **2** (for 1954), 7–15, map.

—— *et al.* 1966. *Australia 1:250,000 Geological Series Sheet SI 55–15, Wagga Wagga.* N.S.W. Dep. Mines, Sydney.

ANDREWS, E. C. 1901. Report on the Kiandra Lead. *Miner. Resour. N.S.W.* **10.**

ASTROVA, G. G. 1959. Siluriyskie mshanki tsentral'noy i zapadnoy Tuvy. *Trudy paleont. Inst.* **79.**

BENSON, W. N. 1922. Materials for the study of the Devonian palaeontology of Australia. *Rec. geol. Surv. N.S.W.* **10,** 83–204, pls. 13–14*a* (separates paginated 1–122).

BIRENHEIDE, R. 1963. *Cyathophyllum-* und *Dohmophyllum*-Arten (Rugosa) aus dem Mitteldevon der Eifel. *Senckenbergiana Lethaea,* **44,** 363–458.

BOARDMAN, R. S. 1960. Trepostomatous Bryozoa of the Hamilton Group of New York State. *Prof. Pap. U.S. geol. Surv.* **340.**

—— and UTGAARD, J. 1966. A revision of the Ordovician bryozoan genera *Monticulipora, Peronopora, Heterotrypa,* and *Dekayia. J. Paleont.* **40,** 1082–1108, pls. 133–142.

BROWNE, I. A. 1959. Stratigraphy and structure of the Devonian rocks of the Taemas and Cavan areas. Murrumbidgee River, south of Yass, N.S.W. *J. Proc. roy. Soc. N.S.W.* **92,** 115–128, pls. 4–7.

CARNE, J. E., and JONES, L. J. 1919. The limestone deposits of New South Wales. *Miner. Resour. N.S.W.* **25.**

CHAPMAN, F. 1920. Silurian silicified corals and a polyzoan from Rushworth. *Rec. geol. Surv. Vict.* **4,** 171–175, pls. 13–15.

DAVID, T. W. E. 'edited and much supplemented by' BROWNE, W. R. 1950. *The Geology of the Commonwealth of Australia,* vol. 1. Edward Arnold & Co., London.

DUN, W. S. 1902. Miscellaneous determination. *Rep. Dep. Min. N.S.W.* **1901,** 175.

ETHERIDGE, R. (*fil.*) 1899. Descriptions of new or little-known Victorian Palaeozoic and Mesozoic fossils, no. 1. *Progr. Rep. geol. Surv. Vict.* **11,** 30–36, pls. A, B.

FEDEROWSKI, J. 1967. A revision of the genus *Ceratophyllum* Gürich, 1896 (Tetracoralla). *Acta palaeont. pol.* **12,** 213–222, pls. 1–3.

FLOOD, P. G. 1969. Lower Devonian conodonts from the Lick Hole Limestone, southern New South Wales. *J. Proc. roy. Soc. N.S.W.* **102,** 5–9, pls. 1, 2.

HALL, J. 1883. Bryozoans of the Upper Helderberg and Hamilton Groups. *Trans. Albany Inst.* **10,** 145–197 (extracts separately paged and distributed in 1881).

—— 1886. Bryozoa of the Upper Helderberg Group [plates and explanations only]. *Ann. Rep. N.Y. State Geol.* **5** (for 1885), pls. 25, 27, 29–32, 40, 41, 44, 45, 48, 50, 51, 53.

HARPER, L. F. 1913. Notes on certain areas geologically examined during the year:— County Buccleuch (southern half). *Rep. Dep. Min. N.S.W.* **1912,** 179.

HILL, D. 1940. The lower Middle Devonian rugose corals of the Murrumbidgee and Goodradigbee Rivers, N.S.W. *J. Proc. roy. soc. N.S.W.* **74,** 247–276, pls. 9–11.

—— 1954. Devonian corals from Waratah Bay, Victoria. *Proc. roy. Soc. Vict.* **66,** 105–118, pls. 6–9.

—— and JELL, J. S. 1969. Devonian corals from Ukalunda. *Publ. Qd. geol. Surv.* **340** *palaeont. Pap.* **16** (authorship overprinted Jell and Hill on some copies).

KHALFIN, L. L. (ed.) 1961 (1960 on title-page). Biostratigrafiya paleozoya Sayano-Altayskoy Gornoy oblasti, Tom II, Sredniy Paleozoy. *Trudy sib. nauchno-issled. Inst. Geol. Geofiz. miner. Syr'.* **20.**

MOROZOVA, I. P. 1960. Devonskie mshanki Minusinskikh i Kuznetskoy kotlovin. *Trudy paleont. Inst.* **86.**

MOYE, D. G., SHARP, K. R., and STAPLEDON, D. H. 1969*a*. Snowy Mountains region (Silurian System, Southern and Central Highlands Fold Belt). *J. geol. Soc. Aust.* **16**, 114–119.

—— —— —— 1969*b*. Snowy Mountains area (Devonian System, Southern and Central Highlands Fold Belt). Ibid. **16**, 143–146.

NEKHOROSHEV, V. P. 1948. *Devonskie mshanki Altaya. Paleontologiya SSSR, tom* 3, *chast'* 2, *vyp.* 1. Akad. Nauk SSSR, Moscow and Leningrad.

NICHOLSON, H. A. 1879. *On the Structure and Affinities of the 'Tabulate Corals' of the Palaeozoic Period with Critical Descriptions of Illustrative Species.* William Blackwood & Sons, Edinburgh and London.

OWEN, D. E. 1969. Wenlockian Bryozoa from Dudley, Niagara, and Gotland and their palaeogeographic implications. *Palaeontology*, **12**, 621–636, pls. 114–116.

PEDDER, A. E. H. 1965. A revision of the Australian Devonian corals previously referred to *Mictophyllum*. *Proc. roy. Soc. Vict.* **78**, 201–220, pls. 30–34.

—— JACKSON, J. H., and PHILIP, G. M. 1970. Lower Devonian biostratigraphy in the Wee Jasper region of New South Wales. *J. Paleont.* **44**, 206–251, pls. 37–50.

PERRY, T. G., and HATTIN, D. E. 1960. Osgood (Niagaran) bryozoans from the type area. Ibid. **34**, 695–710, pls. 85–90.

PHILIP, G. M., and JACKSON, J. H. 1967. Lower Devonian subspecies of the conodont *Polygnathus linguiformis* Hinde from southeastern Australia. Ibid. **41**, 1262–1266.

—— and PEDDER, A. E. H. 1967. A correlation of some Devonian limestones of New South Wales and Victoria. *Geol. Mag.* **104**, 232–239, pl. 12.

—— —— 1968. Stratigraphical correlation of the principal Devonian limestone sequences of eastern Australia. *Internat. Symp. Dev. System, Calgary, 1967*, **2**, 1025–1041. Alberta Soc. Petrol. Geol., Calgary.

ROSS, J. P. 1961. Ordovician, Silurian, and Devonian Bryozoa of Australia. *Bull. Bur. min. Resour. Aust.* **50.**

SHERRARD, K. M. 1967. Tentaculitids from New South Wales, Australia. *Proc. roy. Soc. Vict.* **80**, 229–245, pls. 37, 38.

SHEYNMANN, YU. M. 1926. Trepostomata iz srednego devona Minusinskogo uezda Eniseyskoy gub. *Izv. geol. Kom.* **44**, 917–936, pls. 25, 26.

SKALA, W. 1969. Ein Beitrag zur Geologie und Stratigraphie der Gipfelregion des Poludnig (Karnische Alpen, Österreich). *Jb. geol. Bundesanst. Wien*, **112**, 235–264, pls. 1–3.

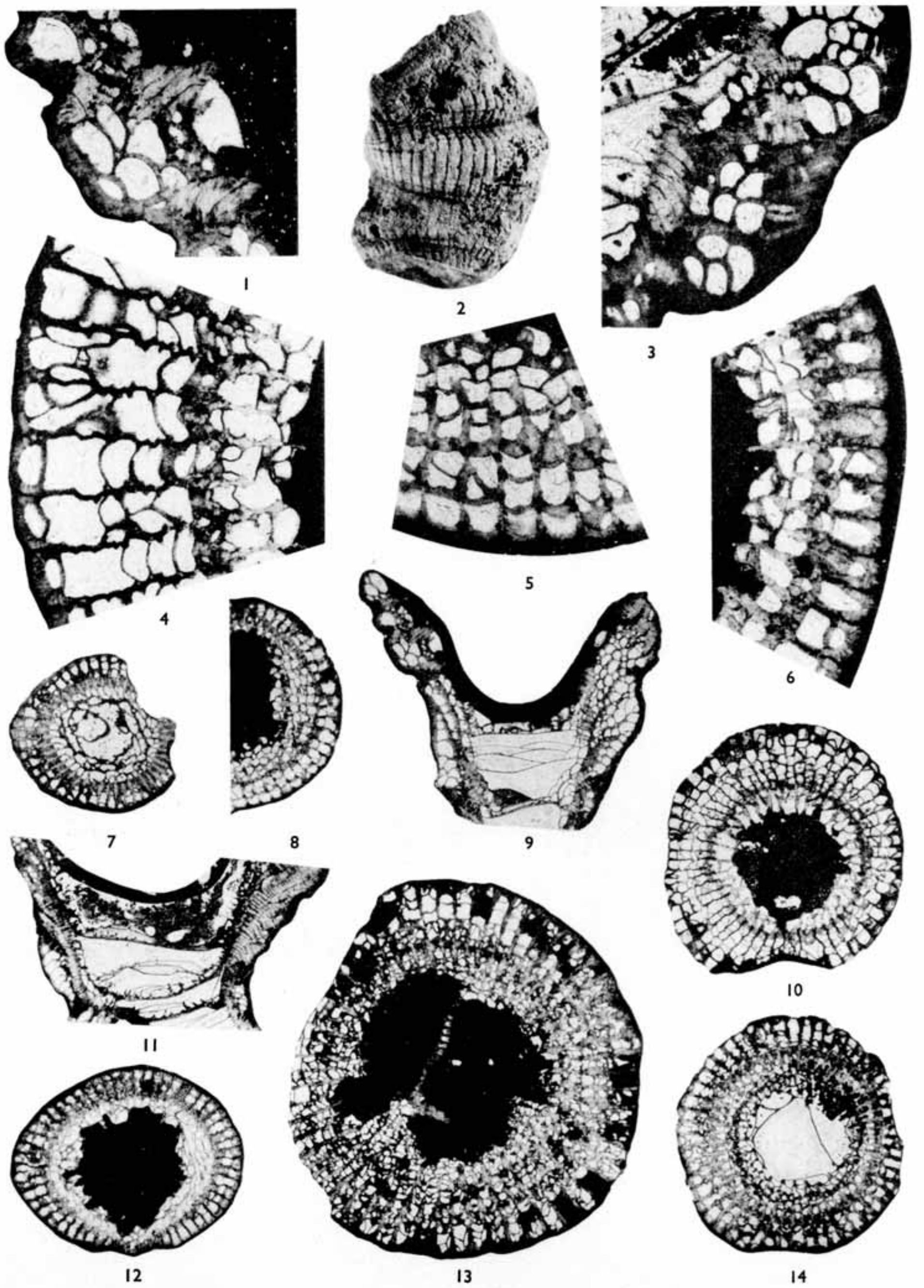
TALENT, J. A. 1963. The Devonian of the Mitchell and Wentworth Rivers. *Mem. geol. Surv. Vict.* **24.**

TAVENER-SMITH, R. 1969. Wall structure and acanthopores on the bryozoan *Leioclema asperum*. *Lethaia*, **2**, 89–97.

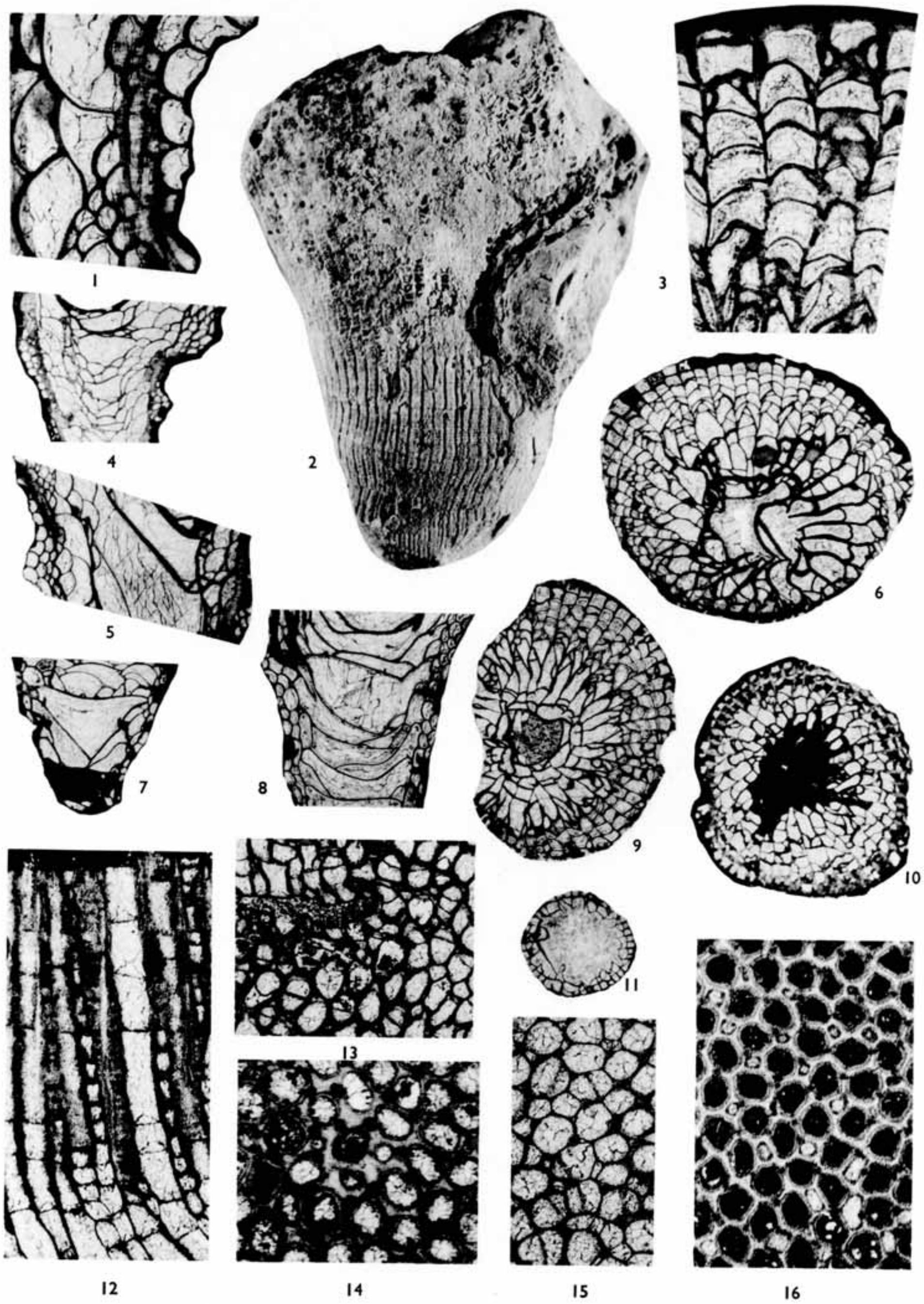
ULRICH, E. O. 1882. American Palaeozoic Bryozoa. *J. Cincinn. Soc. nat. Hist.* **5**, 121–175, pls. 6–8.

A. E. H. PEDDER
Institute of Sedimentary and Petroleum Geology
3303 33rd Street N.W.
Calgary 44, Alberta
Canada

Manuscript received 8 September 1970



PEDDER, Lower Devonian corals



PEDDER, Lower Devonian corals and bryozoa