

SBM 1020

ISSN 0305-0462

THE  
NATURAL HISTORY MUSEUM  
17 JUN 1999  
PRESENTED  
GENERAL LIBRARY

# Bulletin of The Natural History Museum

## Geology Series



VOLUME 55 NUMBER 1 24 JUNE 1999

---

**The Bulletin of The Natural History Museum** (formerly: *Bulletin of the British Museum (Natural History)*), instituted in 1949, is issued in four scientific series, Botany, Entomology, Geology (incorporating Mineralogy) and Zoology.

The Geology Series is edited in the Museum's Department of Palaeontology  
Keeper of Palaeontology: Prof S.K. Donovan  
Editor of Bulletin: Dr M.K. Howarth  
Assistant Editor: Mr C. Jones

---

Papers in the *Bulletin* are primarily the results of research carried out on the unique and ever-growing collections of the Museum, both by the scientific staff and by specialists from elsewhere who make use of the Museum's resources. Many of the papers are works of reference that will remain indispensable for years to come. All papers submitted for publication are subjected to external peer review for acceptance.

A volume contains about 160 pages, made up by two numbers, published in the Spring and Autumn. Subscriptions may be placed for one or more of the series on an annual basis. Individual numbers and back numbers can be purchased and a Bulletin catalogue, by series, is available. Orders and enquiries should be sent to:

Intercept Ltd.  
P.O. Box 716  
Andover  
Hampshire SP10 1YG  
Telephone: (01264) 334748  
Fax: (01264) 334058  
Email: intercept@andover.co.uk  
Internet: <http://www.intercept.co.uk>

Claims for non-receipt of issues of the Bulletin will be met free of charge if received by the Publisher within 6 months for the UK, and 9 months for the rest of the world.

*World List* abbreviation: *Bull. nat. Hist. Mus. Lond. (Geol.)*

© The Natural History Museum, 1999

ISSN 0968-0462

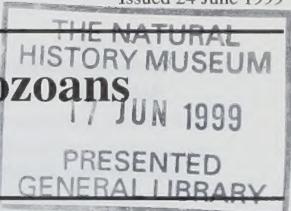
Geology Series  
Vol. 55, No. 1, pp. 1-45

The Natural History Museum  
Cromwell Road  
London SW7 5BD

Issued 24 June 1999

Typeset by Ann Buchan (Typesetters), Middlesex  
Printed in Great Britain by Henry Ling Ltd, at the Dorset Press, Dorchester, Dorset

# Latest Paleocene to earliest Eocene bryozoans from Chatham Island, New Zealand



DENNIS P. GORDON

National Institute of Water & Atmospheric Research, P.O. Box 14–901 Kilbirnie, Wellington, New Zealand

PAUL D. TAYLOR

Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, England, UK

## CONTENTS

Introduction .....	2
Geological setting .....	2
Colony morphology and palaeoecology .....	3
Systematic Palaeontology .....	4
Order Cyclostomata .....	5
<i>Stomatoporina</i> sp. ....	5
? <i>Oncousoecia</i> sp. ....	5
? <i>Idmidronea</i> sp. ....	6
<i>Cinctipora solomoni</i> sp. nov. ....	6
? <i>Attinopora</i> sp. ....	8
‘Entalophorid’ sp. ....	8
‘ <i>Berenicea</i> ’ sp. ....	9
Erect tubuliporine base sp. 1 .....	10
Erect tubuliporine base sp. 2 .....	11
<i>Ceriopora rekohuensis</i> sp. nov. ....	11
? <i>Tetrocycloecia</i> sp. ....	11
<i>Disporella</i> sp. ....	11
Order Ctenostomata .....	13
<i>Immergentia</i> sp. ....	13
Order Cheilostomata .....	14
<i>Fustrellaria australis</i> sp. nov. ....	15
<i>Akatopora chathamica</i> sp. nov. ....	16
<i>Caleschara</i> sp. ....	16
<i>Micropora quadriporosa</i> sp. nov. ....	17
? <i>Hoplitaechmella</i> sp. ....	17
Microporid sp. ....	19
<i>Inversaria gondwanae</i> sp. nov. ....	21
<i>Chondriovulum fossilis</i> sp. nov. ....	21
<i>Ogiva incompta</i> sp. nov. ....	23
<i>Onychocella?</i> <i>lamellosa</i> sp. nov. ....	23
? <i>Onychocella</i> sp. ....	25
Onychocellid sp. ....	25
<i>Aspidostoma litotes</i> sp. nov. ....	27
<i>Aspidostoma cinnabarinum</i> sp. nov. ....	27
<i>Cellaria minus</i> sp. nov. ....	27
<i>Cellaria perexigua</i> sp. nov. ....	27
<i>Cellaria elementaria</i> sp. nov. ....	28
<i>Cellaria aff. depressa</i> Maplestone, 1900 ....	28
<i>Smitticellaria morioriana</i> gen. et sp. nov. ....	30
? <i>Escharicellaria</i> sp. ....	31
<i>Melychocella cynura</i> gen. et sp. nov. ....	32
<i>Arachnopusia gracilis</i> sp. nov. ....	35
? <i>Pavobeisselina</i> sp. ....	35
<i>Hippopleurifera australis</i> sp. nov. ....	38
<i>Exochella?</i> <i>gracilis</i> sp. nov. ....	38
<i>Escharoides?</i> <i>crassa</i> sp. nov. ....	38
<i>Lepraliellid</i> sp. 1 ....	41
<i>Lepraliellid</i> sp. 2 ....	41
<i>Chataimulosia primaeva</i> gen. et sp. nov. ....	41

Discussion .....	42
Acknowledgements .....	42
References .....	42

**SYNOPSIS.** Named bryozoans have not previously been recorded from the New Zealand Paleocene or earliest Eocene. We here describe 42 species, 21 new, from the Red Bluff Tuff of Waipawan age (latest Thanetian to earliest Ypresian) collected from Pukekio, Chatham Island, New Zealand. Twelve of the species are cyclostomes, one is a stenostome boring, and 29 are cheiostomes. Three genera are new – *Melychocella*, *Smitticellaria* (Cellariidae) and *Chataimulosia* (Buffonellidae), the latter comprising the earliest occurrence of the Buffonellidae, the only family in the collection representative of a ‘cryptocystid’ frontal shield. The following species are new: *Cinctipora solomoni*, *Ceriopora rekohuensis*, *Flustrellaria australis*, *Akatopora chathamica*, *Micropora quadriporosa*, *Inversaria gondwanae*, *Chondriovulum fossilis*, *Ogiva incompta*, *Onychocella? lamellosa*, *Aspidostoma liotes*, *A. cinnabarina*, *Cellaria minus*, *C. peregrina*, *C. elementaria*, *Smitticellaria morioriana*, *Melychocella cynura*, *Arachnopusia gracilis*, *Hippopleurifera australis*, *Exochella? gracilis*, *Escharoides? crassa* and *Chataimulosia primaeva*. Forward range extensions include *Flustrellaria*, *Inversaria*, and possibly *Escharicellaria* and *Pavobeisselina*. Backward range extensions include unequivocal *Cinctipora* and *Cinctiporidae*, and *Akatopora*. Newly recorded for the southern hemisphere are *Flustrellaria*, *Inversaria*, *Hippopleurifera*, and possibly *Hoplitaechmella*, *Escharicellaria*, and *Pavobeisselina*. The overall taxonomic character of the bryofauna is mixed, both geographically and temporally, with genera reminiscent of northern hemisphere Maastrichtian and Danian bryofaunas co-occurring with families like Arachnopusiidae and Romancheinidae that are common in Neogene and Recent southern hemisphere bryofaunas.

## INTRODUCTION

This is the first of a projected series of publications intended formally to describe the Cenozoic Bryozoa of New Zealand. The last, and only, major monograph of New Zealand Cenozoic bryozoans was that of Brown (1952): *The Tertiary cheiostomatous Polyzoa of New Zealand*, a seminal work for the study of New Zealand bryozoans, including living faunas. The title notwithstanding, Brown’s material also included Pleistocene specimens then regarded as Pliocene in age. Further, no material older than Oligocene was studied, so the rich Eocene bryofaunas of the Oamaru District and Chatham Islands have remained neglected until very recently, when two species of Catenicellidae were described (Gordon & Braga 1994), and virtually nothing has been reported from the Paleocene.

The Paleocene in New Zealand is represented by the local Teurian Stage, deposits of which are widespread but thin. With the exception of two well-known early Teurian (= Danian) localities at Wangaloa and Boulder Hill, eastern Otago, Teurian rocks are almost devoid of microfossils. Bryozoa (undescribed) have been recorded from only one mainland Paleocene locality, the Kauru Formation near Oamaru (Stilwell *et al.*, 1994), where they are reportedly abundant, and latest Paleocene bryozoans are richly represented in parts of the Red Bluff Tuff on the Chatham Islands (Campbell *et al.*, 1993).

New Zealand Paleocene bryozoans potentially have considerable evolutionary interest. Whereas Maastrichtian bryofaunas are known from several parts of the world, Paleocene faunas are much rarer (MacLeod *et al.*, 1997), and limited knowledge of bryozoan systematics and stratigraphy across the K-T boundary hampers interpretations of extinction and survival which have relied almost entirely on evidence from northern European localities (e.g., McKinney *et al.*, 1998). Studies of European and North American Cretaceous and Paleocene Bryozoa have shown that, although numerous Maastrichtian taxa disappeared at the K-T boundary, a number of genera and species persisted into the Danian (Voigt 1985a; Viskova & Weiss 1998). In fact, the Danian is notable for the relative paucity of taxonomic novelty among Bryozoa, and this is true also of the Thanetian. By contrast, there is a spectacular Ypresian diversification of Bryozoa, including higher taxonomic levels (families and genera) (Voigt 1985a; Taylor 1993; Gordon & Voigt 1996). Indeed, Voigt (1985a) regarded the Danian as

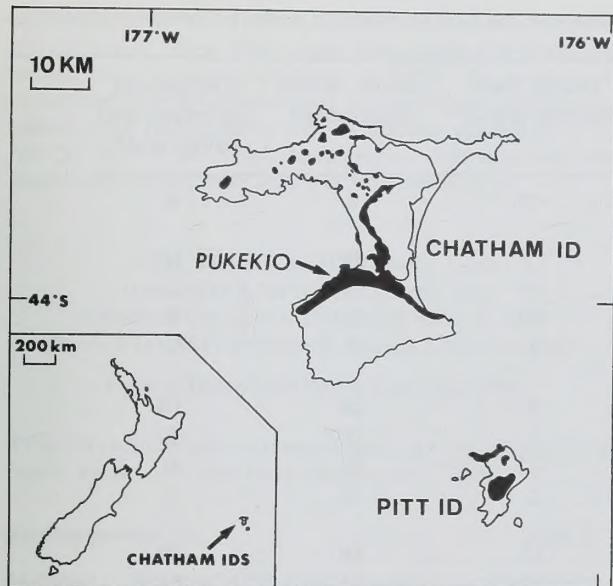
taxonomically the last stage of the Cretaceous for Bryozoa. The reasons for taxonomic conservatism among Paleocene bryozoans are unclear, especially since frontal-shield evolution in Late Cretaceous cheiostomes appears to have resulted in innovative morphological characters (most notably the ascophorine ascus and hypostegal coelom) that predominate in Eocene taxa (Gordon & Voigt 1996). A macroevolutionary lag in recovery following the K-T extinction event is one possibility, but the relative paucity of Paleocene bryofaunas compared to later Eocene ones may accentuate the contrast.

Here, we describe a bryozoan fauna of 42 species from the latest Paleocene to earliest Eocene Red Bluff Tuff on Chatham Island, New Zealand. Apart from a study of Argentinian bryozoans of the Roca Formation early this century (Canu 1911) and that of Brood (1976) on a Madagascan fauna, no other Paleocene bryozoans have been reported from the Southern Hemisphere. Consequently, the fauna reported here helps to fill a major gap in our knowledge of the taxonomy, stratigraphy, and palaeobiogeography of early Palaeogene Bryozoa.

## GEOLOGICAL SETTING

The Chatham Islands form a small archipelago located some 850 km east of the South Island of New Zealand, at the eastern end of the Chatham Rise, a submarine extension of the New Zealand subcontinent (Fig. 1). The two largest islands – Chatham Island and Pitt Island – are populated. The geology of the Chathams has been comprehensively described by Campbell *et al.* (1993). A pre-mid-Cretaceous basement of metamorphic rocks (Chatham Schist) is overlain by a sequence of Cretaceous and Cenozoic sedimentary, volcanic and volcanioclastic rocks. Many of the sedimentary units are richly fossiliferous, and include several cool-water limestones dominated by bryozoans, foraminifera and molluscs.

The Red Bluff Tuff is described by Campbell *et al.* (1993: 74) as ‘... a predominantly calcareous palagonite tuff of basaltic composition, with beds of lapillistone and tuff-breccia’. Widely distributed on both Chatham and Pitt Islands, at most localities it is a brick-red to yellow-brown colour, except for the lower parts which are dark green and grey-brown, and is generally well bedded with cross-bedding, graded bedding, and other evidence of water sorting



**Fig. 1** Simplified map of the Chatham Islands with the distribution of the Kekerione Group (Paleocene-Miocene), which includes the Red Bluff Tuff, marked in black (redrawn from Campbell *et al.*, 1993: fig. 4.35) and the bryozoan locality Pukekio indicated. Inset map shows the position of the Chatham Islands relative to the mainland of New Zealand.

(Campbell *et al.*, 1993). At several localities (Waihere Bay on Pitt Island, Red Bluff and the coast south of Point Weeding to Pukekio Hill on Chatham island) the formation is reasonably accessible and can exceed 50 m in thickness. In high land south of Lake Huro it is around 100 m thick.

The Red Bluff Tuff is a fossiliferous and largely marine unit belonging to the Kekerione Group. Fossil content includes spores, pollen, foraminifera, calcareous nannofossils, sponges, corals, bryozoans, brachiopods, bivalves, gastropods, nautiloids, barnacles, echinoderms, vertebrates (teeth), and trace fossils, with epifaunal assemblages dominating (Campbell *et al.*, 1993). Though reported as being present, the Bryozoa of the Red Bluff Tuff have never been described. The collection described here was made during a recent (February 1997) palaeontological expedition to the Chatham Islands (see Acknowledgments) and comes from Pukekio (Fig. 1), southwest of the radio station near Waitangi on the main Chatham Island (NZMS 260 Chatham Islands 1: 50 000 topographical map, 1981, grid reference 432540). The locality is New Zealand Fossil Record CH/f477. Determinations of foraminifera from Pukekio show the lower part of the formation to be late Teurian (= mid-Thanetian). The middle part of the formation ranges from early to late Waipawan (= latest Thanetian to earliest Ypresian). Whereas stratigraphy, cross-bedding, and textural characters suggest shallow-marine depositional conditions, fossil evidence is said to indicate mid-shelf to upper bathyal environments (Campbell *et al.*, 1993).

## COLONIAL MORPHOLOGY AND PALAEOECOLOGY

Listed below are the 42 bryozoan species found in the Red Bluff Tuff with their colonial morphologies.

### Cyclostomata

<i>Stomatoporina</i> sp.	encrusting, runner
? <i>Oncousoecia</i> sp.	encrusting, runner
' <i>Berenicea</i> ' sp.	encrusting, patch/sheet
? <i>Idmidronea</i> sp.	fixed-erect, planar tree
' <i>Entalophorid</i> ' sp.	fixed-erect, tree-like
? <i>Attinopora</i> sp.	fixed-erect, tree-like
<i>Cinctipora solomoni</i> sp. nov.	fixed-erect, tree-like
Erect tubuliporine base sp. 1	fixed-erect, ?tree-like
Erect tubuliporine base sp. 2	fixed-erect, ?tree-like
<i>Ceriopora rekohuensis</i> sp. nov.	encrusting, mound
? <i>Tetrocyclaecia</i> sp.	fixed-erect, tree-like
<i>Disporella</i> sp.	encrusting, patch

### Ctenostomata

<i>Immergentia</i> sp.	shell-boring, runner
------------------------	----------------------

### Cheilostomata

<i>Flustrellaria australis</i> sp. nov.	encrusting, patch/sheet
<i>Akatopora chathamica</i> sp. nov.	encrusting, patch/sheet
<i>Caleschara</i> sp.	encrusting, patch/sheet multi-lamellar

<i>Micropora quadriporosa</i> sp. nov.	encrusting, patch
? <i>Hoplitaechmella</i> sp.	encrusting, patch
<i>Microporid</i> sp.	?fixed-erect, ?rod/?planar tree
<i>Inversaria gondwanae</i> sp. nov.	fixed-erect, tree-like
<i>Chondriovulum fossils</i> sp. nov.	?fixed-erect, tree-like
<i>Ogiva incompta</i> sp. nov.	?fixed-erect, planar tree
<i>Onychocella?</i> <i>lamellosa</i> sp. nov.	encrusting, patch/sheet/mound/ multilamellar

? <i>Onychocella</i> sp.	encrusting, patch/sheet
<i>Onychocellid</i> sp.	?encrusting, ?patch/sheet
<i>Aspidostoma litotes</i> sp. nov.	fixed-erect, ?tree-like
<i>Aspidostoma cinnabarinum</i> sp. nov.	encrusting, patch/sheet
<i>Cellaria minus</i> sp. nov.	flexible-erect, tree-like
<i>Cellaria perexigua</i> sp. nov.	flexible-erect, tree-like
<i>Cellaria elementaria</i> sp. nov.	flexible-erect, tree-like
<i>Cellaria aff. depressa</i> Maplestone	flexible-erect, tree-like
<i>Smiticellaria morioriana</i> sp. nov.	?flexible-erect, planar tree
? <i>Escharicellaria</i> sp.	?flexible-erect, planar tree
<i>Melychocella cynura</i> sp. nov.	?flexible-erect, ?rod/?planar tree

<i>Arachnopusia gracilis</i> sp. nov.	fixed-erect, ?rod/?planar tree
? <i>Pavobeisselina</i> sp.	rooted, lobate
<i>Hippoleufera australis</i> sp. nov.	encrusting, patch/sheet
<i>Exochella?</i> <i>gracilis</i> sp. nov.	fixed-erect, ?rod/planar tree
<i>Escharoides?</i> <i>crassa</i> sp. nov.	encrusting, patch/sheet
<i>Lepraliellid</i> sp. 1	encrusting, patch/sheet
? <i>Lepraliellid</i> sp. 2	self-encrusting, free, multi-lamellar

<i>Chataimulosia primaeva</i> sp. nov.	encrusting, patch/sheet
--	-------------------------

There is some margin of error in interpreting colonial morphologies owing to the incompleteness of colony fragments. Almost 50% of the 42 species are surface encrusters, predominantly those forming more-or-less circular patches or sheets. Only ca. 7% (excluding the shell-boring species) of the fauna consists of ramifying, runner-like colonies. Some 46% of the fauna are erect species, of which slightly less than half were probably basally rooted, allowing for bending of whole colonies in a current. The proportional representation of colonial morphologies in the Red Bluff Tuff fauna can be compared with bryofaunas from other settings (Table 1).

Although encrusters dominate taxonomically the bryofauna in the

**Table 1** Percentage occurrences of different bryozoan colony morphologies in different settings based on numbers of species, not numbers of colonies or colony fragments (\* from Gordon (1987); † from Lee *et al.* (1997)).

MORPHOLOGY	Red Bluff Tuff	Recent, shell gravel*	Recent, shell/ volcanic gravel*	Eocene, mobile rockground†	Terrigenous, carbonate mud (deep sea)*
<b>Shell-boring</b>	<b>2</b>	<b>0</b>	<1	<b>0</b>	<b>0</b>
<b>Total encrusting</b>	<b>50</b>	<b>72</b>	<b>77</b>	<b>59</b>	<b>10</b>
runner	7	6	15	7	0
patch	38	61	59	50	8
mound	5	5	3	2	2
<b>Total fixed-erect</b>	<b>29</b>	<b>12</b>	<b>8</b>	<b>26</b>	<b>10</b>
tree	22	8	6	26	8
rod	7	0	<1	0	0
lamellar	0	4	2	0	2
<b>Total flexible-erect</b>	<b>17</b>	<b>15</b>	<b>13</b>	<b>14</b>	<b>39</b>
tree	17	15	13	13	31
rod	0	0	0	1	2
lamellar	0	0	0	0	6
<b>Total dwarf-rooted</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>41</b>
conical	0	0	2	0	33
lobate	2	0	0	0	4
pedunculate	0	0	0	0	4
<b>Free-living</b>	<b>0</b>	<1	<b>0</b>	<b>1</b>	<b>0</b>

Red Bluff Tuff at Pukekio (ca. 50% of all species), this proportion does not conform to the generalised pattern of modern bryozoan colonial morphologies on hard substrata around New Zealand. Gordon (1987) has shown that from a range of modern habitats, excluding the deep-sea and regardless of bryozoan diversity, the proportion of bryozoan species as planar or mounded encrusters of hard substrata is fairly consistent, ranging from 67–76% of the total bryofauna. This is a taxonomic measure, independent of actual numbers of colonies in each category, which are very difficult to obtain. The lower proportion of encrusting species in the Red Bluff Tuff samples could be correlated with the relative paucity of hard substrata (e.g., basaltic pebbles and cobbles, shell and other biogenic carbonate like stylasterid colonies). Alternatively, it may be a function of poor sampling. For Cenozoic cheilostome faunas in tropical America, Cheetham & Jackson (1998) have shown that encrusting species are far more numerous than erect or free-living species but have fewer occurrences per species and much less abundance per species. They are consequently the least well-sampled, and this may also be the case for the Red Bluff Tuff. The relative numbers of encrusting species at the Pukekio site is even less than that (59%) at Alma, Oamaru, where there is a notable mobile rockground dominated by bryozoans (Lee *et al.*, 1997). At the Alma site (and also at nearby Fortification Road, Kakanui) it is possible to count actual numbers of colonies because of the large numbers of lithoclasts, available for attachment in life, and the preservation of the bases of fixed-erect colonies. (Numbers of colonies of species that are articulated in life are impossible to determine owing to fragmentation.) The numbers of fixed-erect colony bases (mostly

indeterminable to species but representing only 8 out of 301 bryozoan colonies counted) was significantly less than the numbers of fixed-erect species (20) represented in the Alma fauna and Fortification Road bryofauna from broken fragments found in the sieved sediment matrix between the clasts. Smith (1995) has summarised the range of taphonomic and other problems that confound palaeoecological reconstruction of bryozoan faunas, and these apply to the Red Bluff Tuff and Oamaru sites. One feature of the Red Bluff Tuff fauna may be noted, however – the unusually high number of cellariid species, including four species of *Cellaria*. Even accounting for taphonomic filters, this preponderance of *Cellaria* species at a single locality is truly noteworthy compared with later Cenozoic and Recent bryofaunas in New Zealand. Generally, the basally rooted, often articulated, erect colonies of cellariids are adapted to live in significant current speeds, as well as being able to tolerate moderate amounts of fine sedimentation (Lagaaaj & Gautier 1965).

## SYSTEMATIC PALAEONTOLOGY

Specimen repositories and abbreviations: NHM, The Natural History Museum, London; IGNS, Institute of Geological & Nuclear Sciences (formerly New Zealand Geological Survey), Hutt City, New Zealand.

The species described were studied by scanning electron microscopy (SEM), using type and other specimens. Sorted material was soaked in hypochlorite solution overnight then washed in water

while being subjected to light sonication. Cheilostomes and shelly specimens with boring ctenostomes were mostly gold-coated and imaged using secondary electrons at IGNS. The majority of cyclostomes were left uncoated and examined in an environmental chamber with back-scattered electron detector attached to an ISI ABT-55 SEM at the NHM. Morphometric determinations were made using eyepiece micrometres or from micrographs.

Class STENOLAEMATA Borg, 1926

Order CYCLOSTOMATA Busk, 1852

Suborder TUBULIPORINA Milne Edwards, 1838

Family STOMATOPORIDAE Pergens & Meunier, 1886

Genus **STOMATOPORINA** Balavoine, 1958

TYPE SPECIES. *Alecto incurvata* Hincks, 1859, by original designation; Recent, U.K. (see Hayward & Ryland 1985).

**Stomatoporina** sp.

Figs 2, 3

MATERIAL. NHM BZ 4766, colony encrusting a pectinid bivalve shell.

DESCRIPTION. Colony encrusting, a narrow branch, about 5 mm long and 0.25–0.48 mm wide, initially uniserial and gently bowed, subsequently biserial and straight, lacking bifurcations but with beginnings of a single lateral ramification proximally; early astogenetic stages not preserved. Autozooids curved to left in uniserial part of branch, alternating in position of direction of curvature in biserial part; extent of frontal walls obscure, ridged distally, without preserved peristomes; apertures small, longitudinally elliptical, 0.06 × 0.04 mm, opening in a plane oblique to colony surface. Gonozooids absent. Kenozooids present at branch margins.

REMARKS. The sole specimen of this species is provisionally

assigned to *Stomatoporina* on account of the curved proximal, uniserial branch with autozooids opening to one side and straight distal, biserial branch with autozooids opening alternately left and right. There is a particularly close resemblance in colony shape to a specimen of *S. spirata* (Walford) from the Jurassic of Dorset figured by Illies (1975, fig. 2a, pl. 1, fig. 6). Only three species of this Middle Jurassic (Bajocian) – Recent genus have been described (see Illies 1975; Hayward & Ryland 1985; Pitt & Taylor 1990), all from northern Europe. Therefore, the recognition of a probable *Stomatoporina* species in New Zealand greatly extends the known geographical range of the genus. More material is required before formally describing the species as new.

Family **ONCOUSOECHIDAE** Canu, 1918

Genus **ONCOUSOE CIA** Canu, 1918

TYPE SPECIES. *Tubulipora lobulata* Hincks, 1880 (=*Alecto dilatans* Johnston, 1847; see Hastings 1963), by original designation; Recent, U.K.

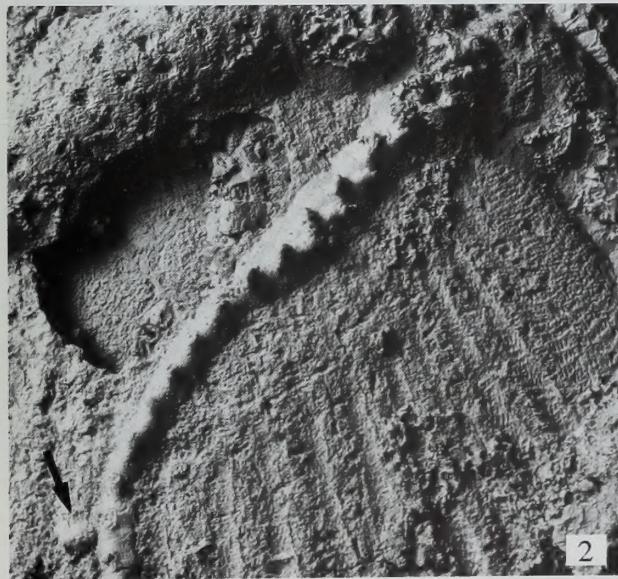
?**Oncousoechia** sp.

[not figured]

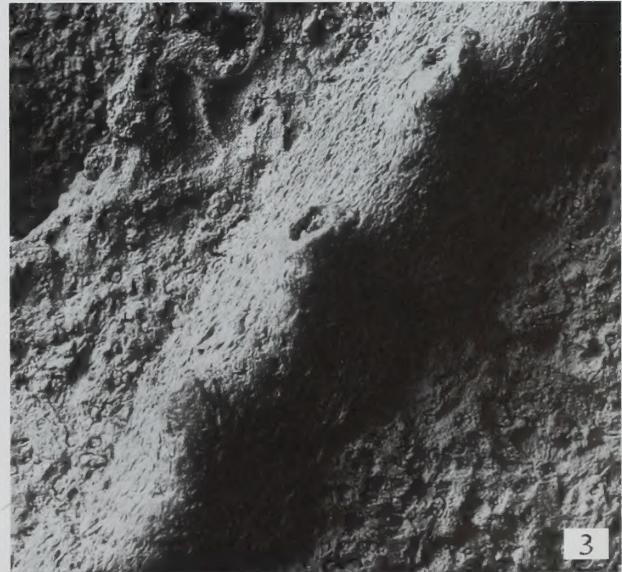
MATERIAL. NHM BZ 4767.

DESCRIPTION. Colony small, fewer than 10 zooids being preserved, encrusting, initially uniserial, becoming bi- or triserial; ancestrula lacking or not identifiable. Autozooids with transversely elongate apertures about 0.10 mm long by 0.12 mm wide.

REMARKS. This small, immature colony lacks gonozooids and is therefore of highly uncertain affinity. However, the oligoserial zooids are reminiscent of some species of *Oncousoechia* to which the colony is very provisionally assigned. Alternatively, the specimen may be an immature *Tubulipora* or the encrusting base of an erect genus.



Figs 2–3 *Stomatoporina* sp., NHM BZ 4766. 2, entire colony with short lateral ramification arrowed, × 18. 3, uniserial proximal branch, × 115.



## Family TUBULIPORIDAE Milne Edwards, 1838

Genus *IDMIDRONEA* Canu, 1920

TYPE SPECIES. *Idmonea maxillaris* Lonsdale, 1845, by original designation (see Ostrovsky & Taylor 1996); Jacksonian (= Priabonian), Wilmington, North Carolina.

*?Idmidronea* sp.

Fig. 4

MATERIAL. NHM BZ 4768.

DESCRIPTION. Colony erect, branching, only proximal branches preserved, considerably thickened by kenozooidal overgrowths, basal branch up to 1.5 mm in diameter, attached to a cheilostome. Autozooids opening on laterofrontal sides of branches, with two or more apertures per series, most completely covered by kenozooidal overgrowths; visible apertures about 0.08–0.10 mm in diameter. Kenozooids extremely worn, narrow, apparently variable in growth direction.

REMARKS. This basal fragment of an erect colony is impossible to assign with certainty to a particular genus although the likelihood is that it belongs to the common and diverse genus *Idmidronea*. Hinds (1975) showed how homeomorphic genera of 'idmidroneid growth form' cyclostomes could be recognized on the grounds of the presence, orientation and skeletal organization of the kenozooids. Branches beyond the immediate vicinity of the colony base and in a good state of preservation are required before generic attribution can be undertaken using Hinds growth mode criteria. In the case of the Red Bluff Tuff specimen, it is impossible even to determine whether the overgrowing kenozooids are fixed-walled (i.e. having calcified

exterior frontal walls) or are free-walled (i.e. lacking calcified exterior frontal walls).

## Family CINCTIPORIDAE Boardman, McKinney &amp; Taylor, 1992

Genus *CINCTIPORA* Hutton, 1873

TYPE SPECIES. *Cinctipora elegans* Hutton, 1873, by monotypy; Pliocene to Recent, New Zealand.

*Cinctipora solomoni* sp. nov.

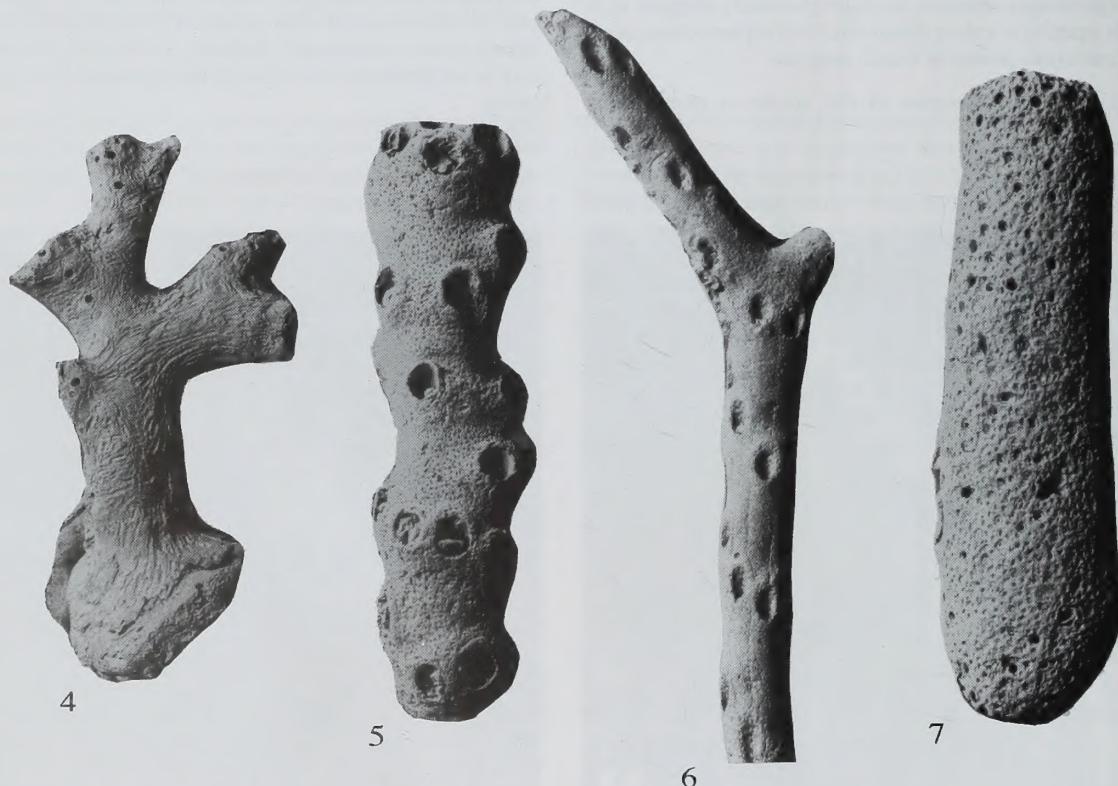
Figs 8–11

HOLOTYPE. IGNS BZ 203–1, from Pukekio, Chatham Island.

PARATYPES. IGNS BZ 203–2. NHM BZ 4769–4770.

NAME. To commemorate Tommy Solomon (Tame Horomona Rehe) who died in 1933 as the last full-blooded Moriori, the first people to inhabit the Chatham Islands.

DESCRIPTION. Colony erect, with narrow, cylindrical, bifurcating branches, 1.2–2.1 mm in diameter (typically less than 1.6 mm), widest immediately prior to bifurcation and narrowest immediately after bifurcation. Autozooids large, disposed in annular rings, 9–11 zooids around branch circumference. Skeletal organization free-walled, each autozooid intersecting colony surface at a low angle, with an elongate, subhexagonal skeletal shield averaging 1.18 mm in length ( $n = 23$  zooids from 4 colonies; range = 0.98–1.37 mm) and 0.39 mm in minimum width ( $n = 23$  zooids from 4 colonies; range = 0.30–0.54 mm). Skeletal shield having large interzooidal pores, diminishing in number distally, and occasional broad pustules.



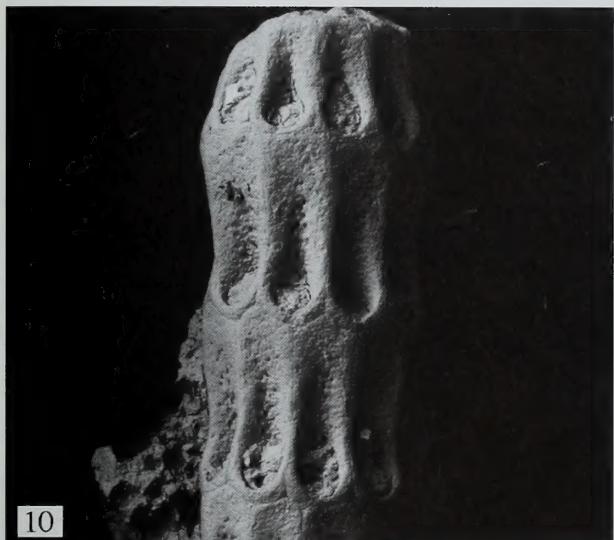
Figs 4–7 Erect branching cyclostomes. 4, *?Idmidronea* sp., NHM BZ 4768, proximal branches and colony base,  $\times 11$ . 5, *?Attinopora* sp., NHM BZ 4771,  $\times 29$ . 6, 'Entalophorid' sp., NHM BZ 4773, bifurcating branch,  $\times 12$ . 7, *?Tetrocycloecia* sp., NHM BZ 4778, worn branch,  $\times 15$ .



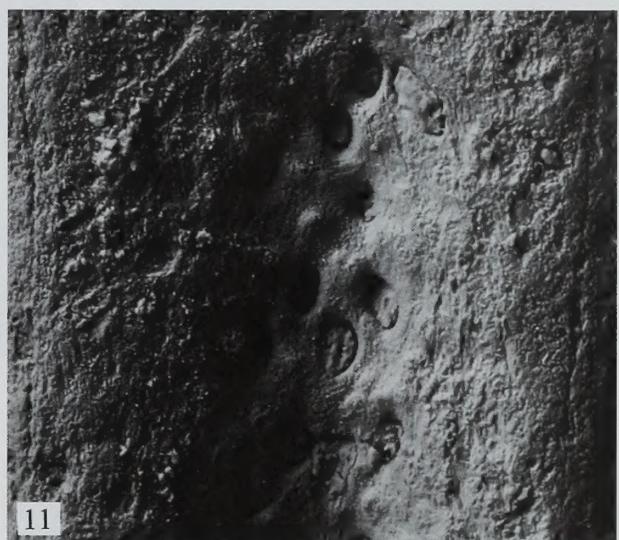
8



9



10



11

**Figs 8–11** *Cinctipora solomoni* sp. nov. **8–9**, IGNS BZ 203–1, holotype; **8**, bifurcating branch,  $\times 13$ ; **9**, skeletal shields, including one example (lower right) divided by a transverse wall,  $\times 40$ . **10–11**, IGNS BZ 203–2, paratype; **10**,  $\times 28$ ; **11**, interzooidal pores on skeletal shield,  $\times 265$ .

Aperture width averages 0.23 mm ( $n = 23$  zooids from 4 colonies; range = 0.18–0.30 mm).

**REMARKS.** This species is very similar to *C. elongata* Boardman *et al.* (1992) which is also recorded from the Chatham Islands, though from the considerably younger Whenuataru Tuff (Pliocene). However, colony branches in *C. solomoni* are typically narrower, with generally fewer zooids around the branch circumference (9–11 cf. 10–16), and the zooids are smaller and less elongate: length:minimum width ratio is about 3:1 in *C. solomoni* compared with 4:1 in *C. elongata*. Unlike other species of *Cinctipora*, none of the specimens of *C. solomoni* have terminal diaphragms but it is unclear whether this is due to preservational factors or ontogenetic stage of the available zooids, or is a species difference. Two autozooids from separate branches have a transverse wall subdividing their skeletal shields into proximal and distal halves (Fig. 9). In another branch the

apertures of several proximal autozooids are plugged by clusters of small zooids which are best interpreted as kenozooids, although it is possible that they are the zooids of a fouling species which settled within the dead autozooids of an old branch of *C. solomoni*.

At the present day *Cinctipora* is endemic to the seas around New Zealand, and knowledge of the fossil record suggests that it has been so throughout the Neogene. Hitherto, the only pre-Neogene record of putative *Cinctipora* is from the Upper Cretaceous of South Africa (Boardman *et al.*, 1992), but there is some doubt about the correct attribution of this Upper Campanian or Maastrichtian species, especially in view of the small size of the zooids compared with all other cinctiporids which are characterized by zooidal gigantism. Therefore, the recognition of an unquestionable species of *Cinctipora* in the Red Bluff Tuff is important in providing a clear range extension of the genus in its modern biogeographical province back into the Late Paleocene or

Early Eocene. Unfortunately, the discovery of *C. solomoni* does not favour one or other of the two models for the origin of cinctiporids which were proposed by Boardman *et al.* (1992; note that a slight modification of model 1 has subsequently been presented as the preferred hypothesis by Boardman 1998).

**Genus ATTINOPORA** Boardman, McKinney & Taylor, 1992

TYPE SPECIES. *Pustulopora zealandica* Mantell, 1850, by original designation; Recent, New Zealand.

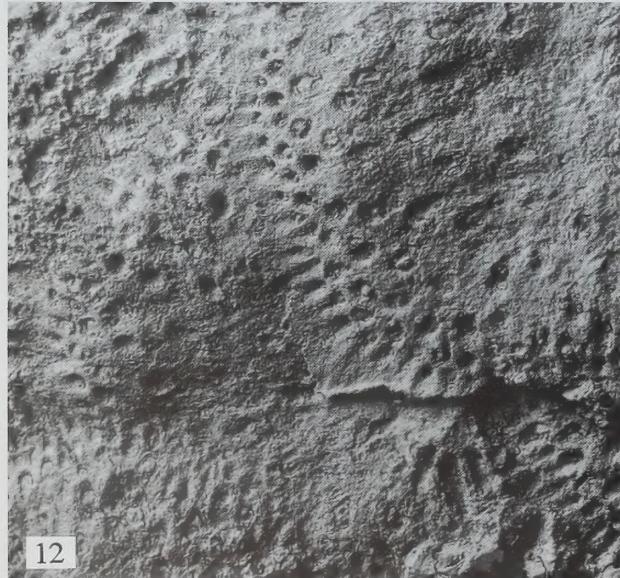
**?Attinopora** sp.

Fig. 5

MATERIAL. NHM BZ 4771–4772.

DESCRIPTION. Colony erect, with narrow, cylindrical branches, 0.7–0.9 mm in diameter, strongly curved in one specimen; bifurcations assumed to exist but not observed. Autozooids large, fixed-walled, frontal walls flat and minutely pseudoporous, about 0.9 mm long; zooidal boundaries not prominent; autozooids disposed in annular to irregularly spiral patterns with about 7 zooids around the branch circumference; apertures subcircular or slightly elongate longitudinally, 0.16–0.20 mm in diameter.

REMARKS. With only two small specimens available, it is impossible to be certain of the generic identity of this species. There are several genera of vinculariiform tubuliporines to which it may potentially belong, e.g., *Diaperoecia*, *Mecynoecia*, *Entalophoroecia*. However, the large size of the zooids and their arrangement on the colony surface, together with the biogeographical provenance, prompt a tentative identification as the cinctiporid genus *Attinopora*. Like other cinctiporids, gonozooids have never been observed in *Attinopora*, but a much larger suite of specimens would be needed for their absence to be reasonably established in the Red Bluff Tuff species.



Figs 12–13 'Berenicea' sp., NHM BZ 4774. 12, ill-preserved, multilayered colony,  $\times 37$ . 13, lobate outgrowth,  $\times 70$ .

**Family ENTALOPHORIDAE Auctt.**

**'Entalophorid'** sp.

Fig. 6

MATERIAL. NHM BZ 4773.

DESCRIPTION. Colony erect, with bifurcating cylindrical branches, slender, about 0.8 mm in diameter. Autozooids large, fixed-walled, 7–8 around the branch circumference; frontal walls slightly convex, slender, approximately 1.6–1.8 mm long by 0.4 mm wide, a narrow groove marking the zooidal boundary; apertures longitudinally elongate, 0.3 mm long by 0.2 mm wide. Gonozooids not observed.

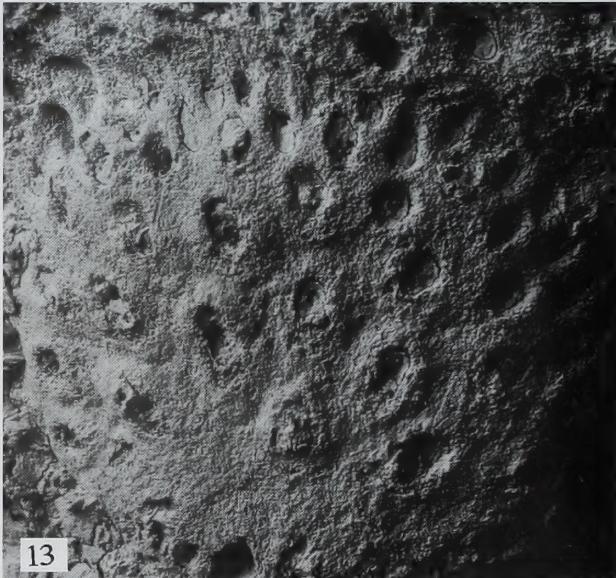
REMARKS. The absence of a gonozooid in the solitary specimen belonging to this species precludes generic identification. In the older literature such vinculariiform tubuliporines are generally assigned to *Entalophora* Lamouroux, 1821 (type species *E. cellariooides* Lamouroux, 1821 from the Middle Jurassic). However, this genus is nowadays applied in a more restricted sense for species with simple, subtriangular gonozooids and, moreover, branches having a narrow axial canal (see Walter 1970). An axial canal is not present in the Red Bluff Tuff material.

**Family INCERTAE SEDIS**

**Genus 'BERENICEA'** Lamouroux, 1821

TYPE SPECIES. *Berenicea diluviana* Lamouroux, 1821, by subsequent designation; Jurassic (Bathonian), Calvados, France.

REMARKS. Following Taylor and Sequeiros (1982), the generic designation '*Berenicea*' is used informally for species of bereniciform tubuliporines in which the gonozoocium is unknown (*Berenicea* Lamouroux, 1821 is a *nomen dubium*).



**'Berenicea'** sp.

Figs 12, 13

MATERIAL. NHM BZ 4774.

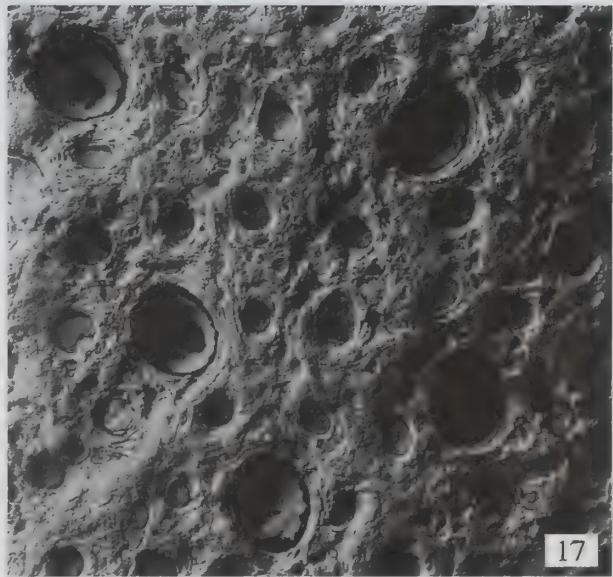
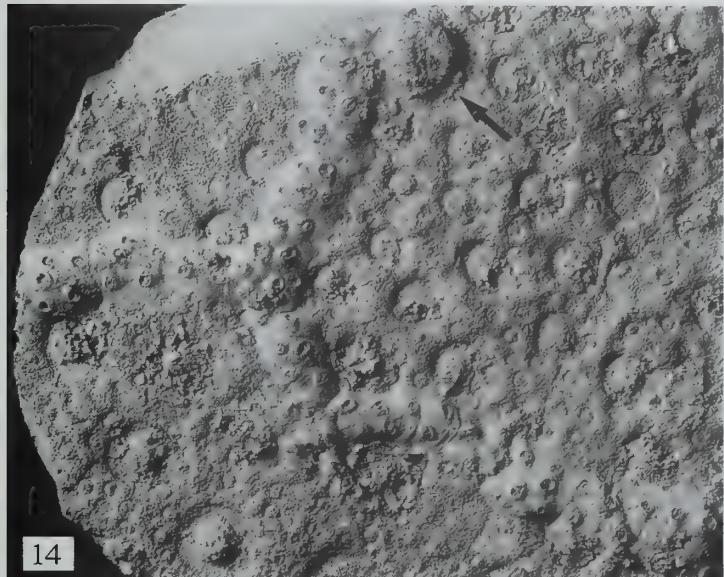
DESCRIPTION. Colony encrusting, multiserial, sheet-like, multi-layered with superimposed discoidal subcolonies; maximum colony diameter 9 mm. Distal fringe of basal lamina broad, extending well beyond budding zone. Autozooids with gently convex frontal walls; apertures longitudinally elongate, about 0.15 mm long by 0.09 mm wide. Gonozooids not observed.

REMARKS. The only specimen is poorly-preserved, with a heavily corroded colony surface. In the absence of gonozooids the correct

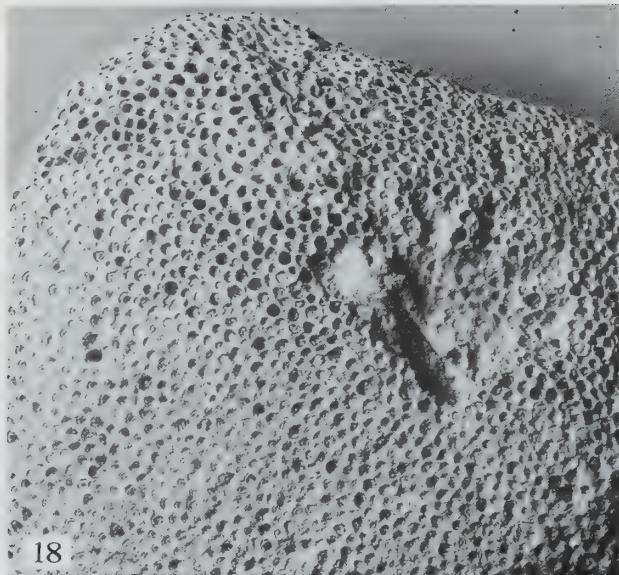
genus cannot be determined, nor can any useful comparisons be made with other species having the same general morphology. The multilamellar colony appears to result from eruptive budding of new subcolonies which grew as radial discs, covering the older zooids from previous layers, and prompting comparison with such species as '*Berenicea*' *sowerbyi* (Lonsdale) (see Pitt & Taylor 1990).

Genus *INCERTAE SEDIS*

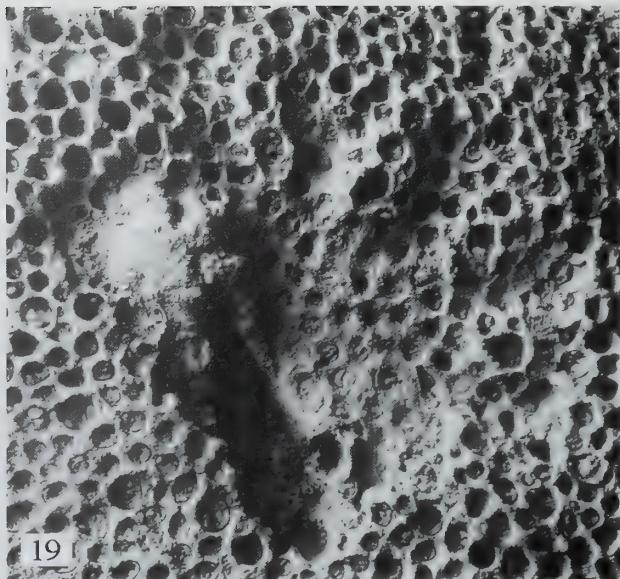
REMARKS. The Red Bluff Tuff collection contains two examples of the encrusting basal parts of erect tubuliporine species. In both



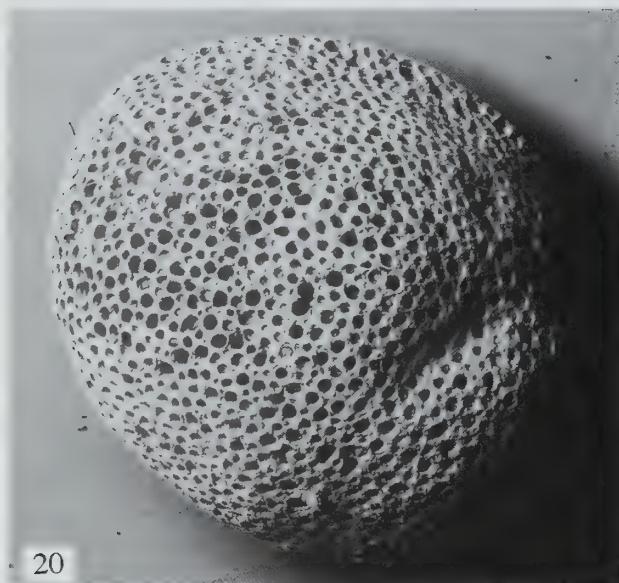
**Figs 14–17** Miscellaneous cyclostomes. **14–15**, Erect tubuliporine base sp. 1, NHM BZ 4775; **14**, extensive, ramifying basal encrustation with broken stump of erect branch arrowed,  $\times 13$ ; **15**, autozooids flanked by kenozooids forming branch edges,  $\times 54$ . **16**, Erect tubuliporine base sp. 2, NHM BZ 4776, encrusting zooids and stump of erect branch (top),  $\times 52$ . **17**, *?Tetrcycloecia* sp., NHM BZ 4778, detail of branch surface showing autozooidal and kenozooidal apertures with thick intervening walls,  $\times 170$ .



18



19



20



21

Figs 18–21 *Ceriopora rekohuensis* sp. nov. 18–19, IGNS BZ 204–1, holotype; 18, upper surface of colony,  $\times 10$ ; 19, abraded gonozooid with roof remnant on left,  $\times 35$ . 20–21, NHM BZ 4777, paratype; 20, entire colony,  $\times 16$ ; 21, autozooidal and kenozooidal apertures,  $\times 170$ .

cases only the broken stump of one erect branch remains, the arborescent parts of the colonies having been lost along with any taxon-diagnostic gonozooids. Characters of the basal zooids show quite clearly that the two specimens represent different species. However, it is unclear whether they are species whose erect branches have yet to be recovered in the Red Bluff Tuff, or if they are the bases of the three fixed-walled, erect species described above as ?*Idmidronea* sp., ?*Attinopora* sp. and 'Entalophorid' sp.

#### *Erect tubuliporine base* sp. 1

MATERIAL. NHM BZ 4775.

DESCRIPTION. Colony base encrusting, comprising narrow (0.5–1.0 mm wide), oligoserial branches, with 2–4 series of autozooids

bordered by kenozooids forming branch edges; branch profile low, gently convex; two branch bifurcations present, each at an angle of about 120°; stump of a broken erect branch, subcircular in cross-section, present at distal end of one of the encrusting branches. Autozooids with short, slightly convex frontal walls, about 0.4 mm long by 0.18 mm wide, their long axes divergent from branch mid-line; apertures more-or-less circular, 0.11–0.13 mm in diameter; pseudopores longitudinally elongate. Gonozooids absent.

REMARKS. The well-preserved colony, which encrusts an echinoid plate, has a maximum dimension of 7 mm and comprises three, long encrusting branches. The broken base of an erect branch is visible at the distal end of one of these three encrusting branches.

#### Figs 14–15

***Erect tubuliporine base* sp. 2**

Fig. 16

MATERIAL. NHM BZ 4776.

DESCRIPTION. Colony base encrusting, comprising a single oligoserital branch, about 1 mm wide, with 5–6 autozooidal series; branch profile high, well-rounded; stump of a broken erect branch, subcircular in cross-section, present at distal end of the encrusting branch. Autozooids with short frontal walls, about 0.5 mm long by 0.25 mm wide, attaining maximum width opposite the aperture; zooidal boundary walls slightly salient; apertures subcircular, small, 0.09–0.10 mm in diameter; pseudopores circular. Gonozooids absent.

REMARKS. This poorly-preserved specimen encrusts a pebble. Unlike the previous species, kenozooids do not appear to be developed at the edges of the branch, and the branch has a much more robust morphology.

Suborder CERIOPORINA von Hagenow, 1851

Family HETEROPORIDAE Waters, 1880

Genus **CERIOPORA** Goldfuss, 1826

TYPE SPECIES. *Ceriopora micropora* Goldfuss, 1826, by subsequent designation of Gregory (1896); Upper Cretaceous, locality uncertain (see Nye 1976: 56).

REMARKS. The genus *Ceriopora* is here interpreted to include cerioporids with a semi-erect, 'massive' colony-form. Colonies tend to be globular, dome or mound-shaped, pedunculate or columnar. They lack the bushy morphology seen in other cerioporid genera (e.g. *Tetrcycloecia*, *Heteropora* auctt.) in which colonies are constructed of bifurcating cylindrical branches having a well-marked internal differentiation between endozone and exozone.

***Ceriopora rekohuensis* sp. nov.**

Figs 18–25

HOLOTYPE. IGNS BZ 204–1, from Pukekio, Chatham Island.

PARATYPES. IGNS BZ 204–2 (thin sections plus remnants); NHM BZ 4777.

NAME. From Rekohu (Misty Skies), the Moriori name for Chatham Island.

DESCRIPTION. Colony small, the holotype measuring 8 mm in maximum width and the taller, sectioned paratype 10 mm high, pedunculate, a proximal stalk (broken-off in all available colonies) grading into an expanded head; head underside comprises exterior wall, upper surface covered by zooidal apertures of variable size, sometimes with larger autozooids distinct from smaller kenozooids but in other instances without obvious dimorphism in size; skeletal organization free-walled, apart from fixed-walled gonozooids. In thin section no clear distinction exists between endozone and exozone; budding apparently interzooecial in pattern; zooidal tubes long and gently curved in longitudinal section; walls variably moniliform, at least some of the constrictions marking positions of interzooidal pores, about 0.03–0.05 mm thick, not increasing appreciably in thickness from endozone to exozone; microstructure indistinctly laminated, cloudy, clotted in transverse sections of endozone; diaphragms present but extremely scarce; zooidal tubes disrupted by fouling organisms, including worm tubes, subsequently overgrown and embedded in colony structure. Autozooidal apertures subcircular, about 0.11–0.15 mm in diameter; kenozooidal apertures ovoidal, ranging down to 0.03 mm in diameter. Overgrown gonozooids visible in section (Fig. 25) and from one eroded example

seen on surface of holotype; stellate in frontal outline, chamber extending as lobes between radial series of autozooidal apertures; floor formed of occluded, undifferentiated zooidal apertures; roof remnant probably comprising calcified exterior wall but microstructure poorly-preserved and no obvious pseudopores visible; oocciopore not observed.

REMARKS. Most aspects of the morphology of this new species are very similar to the type species of *Ceriopora*, *C. micropora* Goldfuss, as redescribed by Nye (1976). These include the gently curved zooidal tubes with variably moniliform walls, and the indistinct dimorphism in zooidal aperture size. However, wall thickness and aperture diameter is slightly greater in the Red Bluff Tuff species. Whereas only questionable gonozooids in thin section were observed by Nye (1976) in *C. micropora*, the stellate frontal outline of the gonozooid in *C. rekohuensis* resembles that seen in *C. farringtonensis* Gregory (see Pitt & Taylor 1990: fig. 117D), an Aptian species in which dimorphism of zooidal aperture sizes is totally lacking. Judging from Cuffey & Sorrentino's (1985) redescription of three species of *Ceriopora* from the Pliocene of the eastern USA, all three species have zooids of distinctly larger diameter than *C. rekohuensis*.

Genus **TETRCYCLOECIA** Canu, 1917

TYPE SPECIES. *Tetrcycloecia dichotoma* Canu, 1917, = *Ceriopora dichotoma* Goldfuss, 1827, *sensu* Reuss 1848, by original designation; Miocene, Eisenstadt, Austria (see Nye 1976: 147).

**?*Tetrcycloecia* sp.**

Figs 7, 17

MATERIAL. NHM BZ 4778–4780.

DESCRIPTION. Colony erect, with cylindrical, bifurcating branches, 1.3–2.1 mm in diameter; skeletal organization free-walled; colony surface with autozooidal apertures surrounded and separated by smaller, more numerous kenozooidal apertures; interzooidal walls very thick at colony surface. Autozooids long and horn-shaped in branch longitudinal sections, budded within an axial endozone; apertures small, 0.07–0.09 mm in diameter, elongated parallel to growth direction. Kenozooids seemingly budded closer to colony surface; apertures subcircular, 0.02–0.05 mm wide, typically less than half the diameter of neighbouring autozooidal apertures. Gonozooid unknown.

REMARKS. An etched, off-centred longitudinally ground surface provides the only indication of internal morphology in this species. In the absence of well-oriented thin sections, and of a gonozooid, this species can be no more than questionably assigned to *Tetrcycloecia*. Ranging from the Aptian to the Miocene (Pitt & Taylor 1990: 120), the relatively narrow branches of *Tetrcycloecia*, for example in *T. dichotoma* and *T. multiporosa*, with kenozooidal apertures considerably outnumbering autozooidal apertures, are, however, characters also seen in the Red Bluff Tuff species.

## Suborder RECTANGULATA Waters, 1887a

Family LICHENOPORIDAE Smitt, 1867

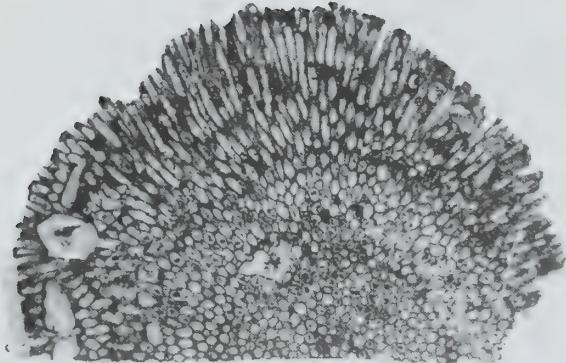
Genus **DISPORELLA** Gray, 1848

TYPE SPECIES. *Discopora hispida* Fleming, 1828, by original designation; Recent, Shetland Islands, U.K.

***Disparella* sp.**

Figs 26–29

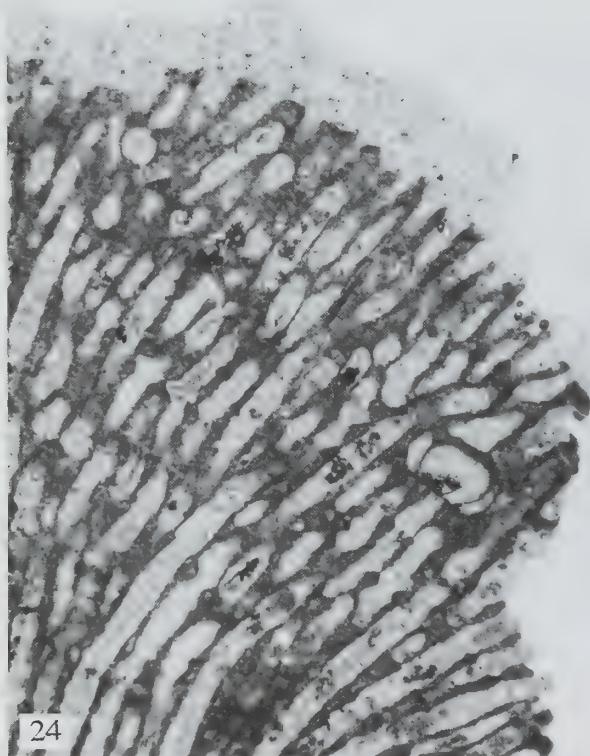
MATERIAL. IGNS BZ 205, a single colony encrusting the stylasterid *Sporadopora* cf. *marginata*, Pukekio, Chatham Island.



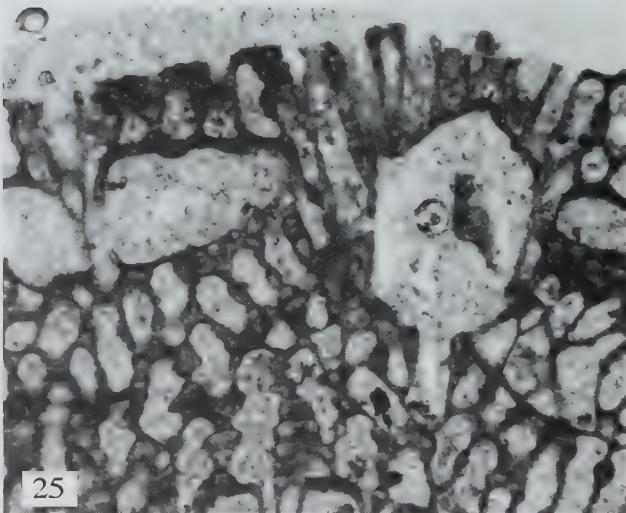
22



23



24

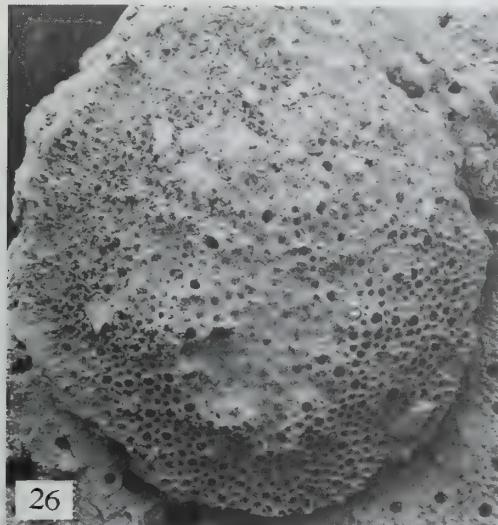


25

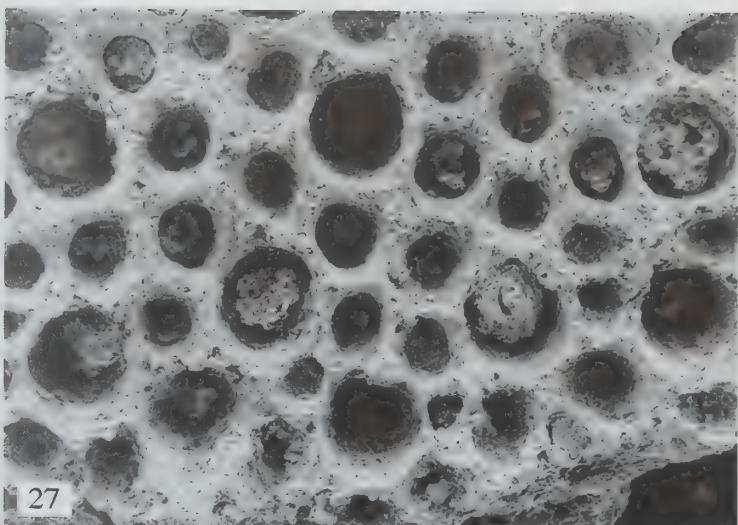
Figs 22–25 *Ceriopora rekohuensis* sp. nov., thin sections, IGNS BZ 204–2. 22, partial transverse section,  $\times 9.5$ . 23, oblique longitudinal section showing long, curved zooidal tubes  $\times 10.5$ . 24, detail of longitudinal section,  $\times 33$ . 25, overgrown gonozooids visible in the transverse section,  $\times 33$ .

**DESCRIPTION.** Colony encrusting, more-or-less circular, maximum diameter 4.43 mm, maximum height 0.84 mm, completely adnate or the margin, slightly elevated above the substratum; marginal basal lamina little apparent, 0.35 mm wide where present; behind marginal lamina is a 0.75–1.31 mm wide zone of autozooids and kenozooids. Autozooids without projecting peristomes, and not aligned in definite radii, although up to 3–4 non-connate apertures may occur in a radial row amongst

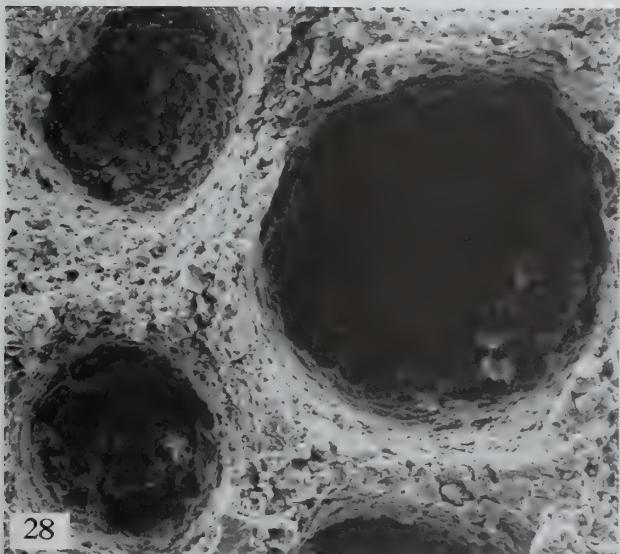
kenozooids; apertures 0.11 mm in diameter, the rim of even height all round. Kenozooid apertures 45–70% of the diameter of autozooidal peristomes, none closed by diaphragms. Brood chamber occupies most of colony centre, broken in the present colony; floor marked by thin layer of calcification over autozooids and kenozooids; almost none of the brood chamber roof remains except for a tiny area which indicates that thick-walled zooidal chambers may occur above the roof.



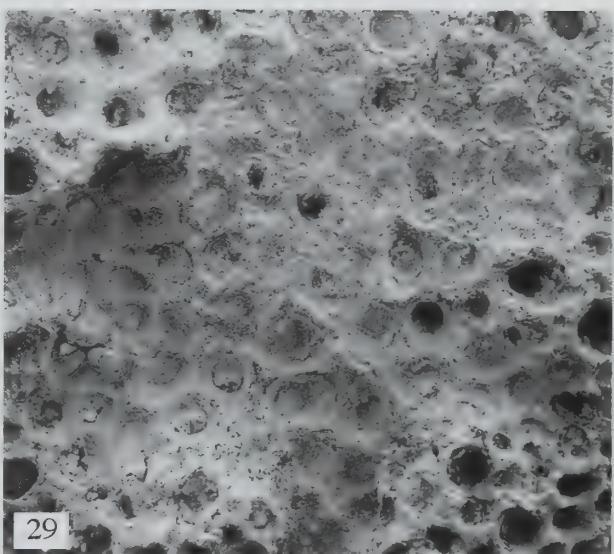
26



27



28



29

**Figs 26–29** *Dispora* sp., IGNS BZ 205. **26**, entire colony encrusting a stylasterid,  $\times 14$ . **27**, edge of disk showing autozooidal and kenozooidal apertures,  $\times 134$ . **28**, one autozooidal and two kenozooidal apertures,  $\times 465$ . **29**, floor of brood chamber, with part of roof (?overgrown) present at upper left,  $\times 29$ .

**REMARKS.** The loss of the brood chamber roof and the relative paucity of zooidal characters precludes naming this single specimen.

Class **GYMNOLEMATA** Allman, 1856

Order **CTENOSTOMATA** Busk, 1852

Suborder **EUCTENOSTOMATA** Jebram, 1973

Family **IMMERGENTIIDAE** Silén, 1946

Genus **IMMERGENTIA** Silén, 1946

**TYPE SPECIES.** *Immergentia californica* Silén, 1946; original designation; Recent, California.

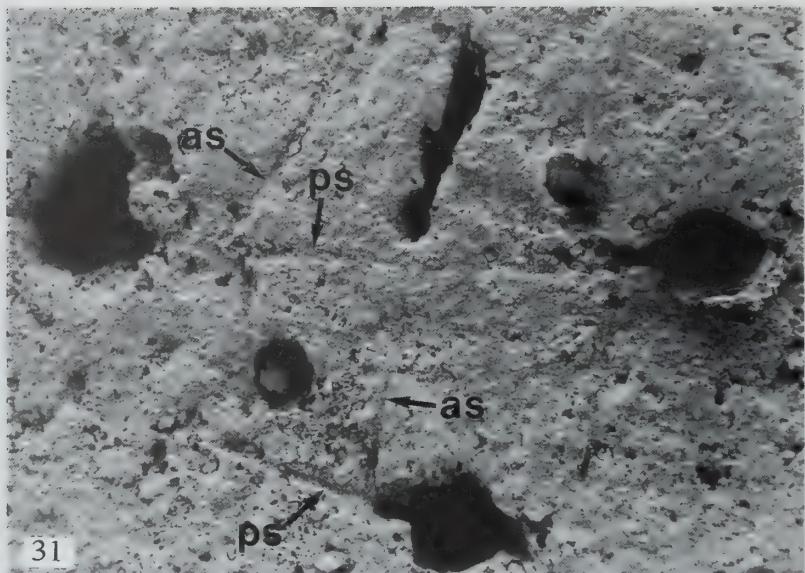
***Immergentia*** sp.

Figs 30, 31

**MATERIAL.** IGNS BZ 206, a single colony fragment from Pukekio, Chatham Island.

**DESCRIPTION.** Colony boring in molluscan shell, the positions of zooidal orifices indicated by perforations in the shell surface. Perforations circular or, where the shell surface is slightly eroded, spindle-shaped, giving evidence of each zoid being connected directly to a principal stolon on each side of the 'spindle'. Width of zoid at level of stolon connection 0.09 mm. Apparent distance between one zoidal opening and the next connected by the same principal stolon 0.65 mm. Zooids vertical in the shell substratum, 0.52–0.58 mm long measured from the depth of the excavation. Principal stolons connected by adventitious (secondary) stolons that arise quite close to the zooidal aperture or at varying distances between consecutive apertures.

**REMARKS.** The monogeneric Immergentiidae is first recorded from the Santonian of Germany (Taylor 1993), subsequently becoming widely distributed in the Miocene of Europe, the USA, southeastern Australia, and New Zealand, and extending through the remainder



Figs 30–31 *Immergentia* sp., NHM BZ 206. 30, portion of surface of eroded molluscan shell with bryozoan borings,  $\times 39$ . 31, close-up of borings made by three autozooids; furrows indicating some of the traces of former principal stolons (ps) and adventitious stolons (as) are labelled,  $\times 109$ .

of the Neogene to the present day. Three other boring ctenostome genera (Pohowsky 1978) have been accorded ranges coinciding with the age of the Red Bluff Tuff – these are *Orbignyopora* Pohowsky (?Silurian-Pliocene), *Penetrantia* Silén (?Lower Cretaceous-Recent), and *Spathipora* Fischer (nominally Jurassic-Recent, but the age and precise characters of the type species are uncertain). *Orbignyopora* can be discounted as a name for the Red Bluff Tuff specimen in that the zooids, although ‘non-pedunculate’ like *Immergentia* (i.e., separated from the principal stolon by a short connecting stolon), are disposed horizontally immediately beneath the shell surface. *Penetrantia* zooids are pedunculate, so this genus, otherwise common in the New Zealand Neogene, can also be ruled out. *Spathipora*, as understood, is also pedunculate and has never been recorded from the New Zealand region. No other genus of boring ctenostome accords with the characters of the form from Red Bluff Tuff and we are confident that the characters of the borings in the specimens correlate with the characters of *Immergentia*. We do not ascribe a species name to these borings, however, inasmuch as most of them are sediment-infilled, precluding polyester-resin casting which provides many more characters than are presently determinable.

Order CHEILOSTOMATA Busk, 1852  
Suborder FLUSTRINA Smitt, 1868

REMARKS. Smitt’s suborder included the families Flustridae, Cellariidae, and Membraniporidae (*sensu lato*, comprising later callopriids, chaperiids, etc.) but excluded many ‘cellularine anascans’ like *Aetea*, *Eucrata*, *Bugula*, etc. It is used here as an available taxon in a historically significant work (see Schopf & Bassett, 1973) in preference to Neocheilostomina d’Hondt (1985) which also included ascophorans.

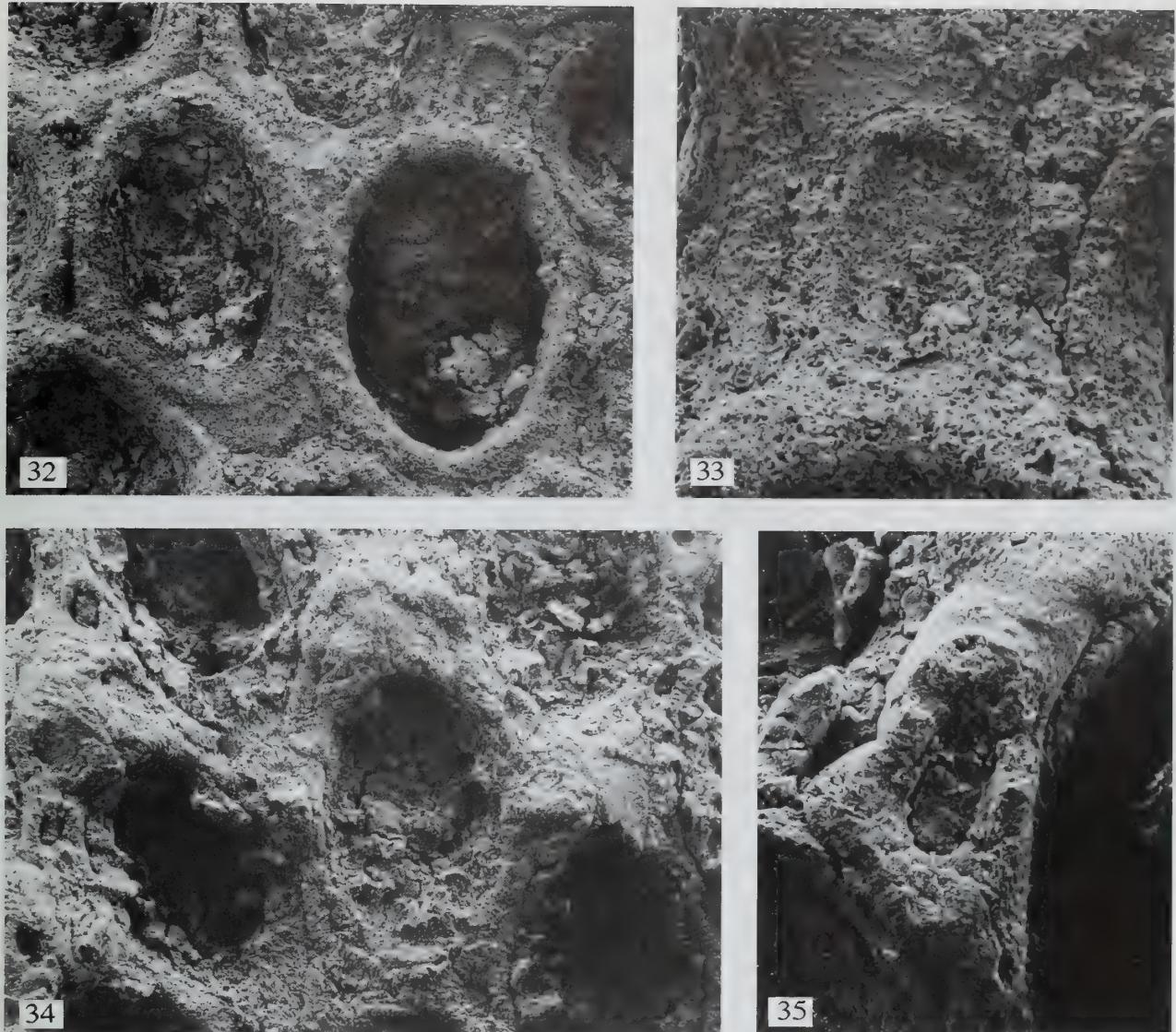
Family CALLOPORIDAE Norman, 1903

Genus *FLUSTRELLARIA* d’Orbigny, 1853

TYPE SPECIES. *Flustrellaria fragilis* d’Orbigny, 1853; by subsequent designation of Bassler (1935); Cenomanian, Le Mans, France.

REMARKS. According to the taxonomic criteria used by d’Orbigny (1851–54), based on colonial and zooidal characters, *Flustrellaria* was established for membraniporiform unilaminar fragments whose zooids lacked frontal ‘pores’ (i.e., adventitious avicularia). The first-named species, selected as type by Bassler (1935), was *F. fragilis*, based on unattached fragments. According to the illustrations of this species (d’Orbigny 1853, pl. 723, figs 5–9) there is a large, rimmed opercula occupying most of the zooidal length, with a small to vestigial gymnocyst, and a dependent prominent hyperstomial ovicell apparently not closed by the zooidal operculum in life. Oral and marginal spine bases were not illustrated, but according to Canu (1900: 372) there are 8–10 spine bases in the specimen he examined from the d’Orbigny Collection, and spine bases are visible in photographs of the type and another specimen loaned by Prof. E. Voigt. A similar, shell-encrusting species, *Flustrellaria ornata* d’Orbigny, 1853 was illustrated with marginal spines (d’Orbigny 1853, pl. 728, figs 11, 12). This was chosen as the type species of *Ornatella* Canu, 1900, a new subgenus of *Membranipora* de Blainville. D’Orbigny’s reliance on colonial characters, frequently superficial, was rejected by most late nineteenth- and early twentieth-century bryozoologists including Canu, and *Flustrellaria* and related genera were relegated to *Membranipora*, ironically already a very heterogeneous taxon as then used. Accordingly, *Flustrellaria* has been scarcely used as a genus, although it was listed by Bassler (1935, 1953), who cited *Ornatella* as a junior subjective synonym.

It appears possible to use *Flustrellaria* as a valid genus, although SEM examination of d’Orbigny’s material is desirable in order to



**Figs 32–35** Calloporid cheilostomes. 32–33, *Flustrellaria australis* sp. nov., IGNS BZ 184, holotype; 32, two entire autozooids, the one on the right with the base of a broken ovicell present on the gymnacyst of the distal zooid; note the lack of a proximal gymnacyst on some of the adjacent zooids,  $\times 96$ ; 33, close-up of the broken ovicell base,  $\times 287$ . 34–35, *Akatopora chathamica* sp. nov., IGNS BZ 185–1, holotype; 34, three ovicellate zooids,  $\times 107$ ; 35, a heterozooid on the lateral rim of an autozooid,  $\times 430$ .

give precision to the characters of the type species. One potential problem appeared in that d'Orbigny's family-rank taxon *Flustrellaradae* d'Orbigny, 1852 antedates the well-known equivalent taxon *Calloporidae* Norman, 1903. According to Sherborn (1899), however, the name *Flustrellaradae* was formally published in the year prior to its type genus, thus it may be treated as a *nomen nudum* and the current usage of family *Calloporidae* and superfamily *Calloporoidea* (Gordon 1989a) can remain unaffected.

An encrusting species from Chatham Island appears to conform to the characters of *Flustrellaria*, which, if the generic attribution is correct (the specimen appears to lack spine bases), would be the youngest species of the genus, extending the range beyond the KT boundary.

#### *Flustrellaria australis* sp. nov.

Figs 32, 33

**HOLOTYPE.** IGNS BZ 184, from Pukekio, Chatham Island. No paratypes.

**NAME.** From the Latin, *australis*, southern.

**DESCRIPTION.** Unique colony encrusting, unilaminate; multiserial but somewhat linear in form with maximum diameter 14 mm (ca. 10 mm on one side of the ancestral region) but, since the substratum is fractured, the original diameter may have been several mm longer; with pluriserial lobes 2–?8 zooids wide. Zooids arranged quincuncially, each being surrounded by 6 others, suboval to pyriform in shape; length = 0.29–0.39 mm, width = 0.28–0.30 mm in the zone of astogenetic change; length = 0.44–0.62 mm, width = 0.31–

0.47 mm in the zone of astogenetic repetition. Zooidal margin somewhat thick-rimmed; the presence of marginal spine bases in the present material equivocal owing to inadequate preservation. Proximal gymnocyst absent to infrequently present, occupying up to 20% of zooidal length, with the proximal ends of the lateral rim encroaching onto it; or the gymnocystal area slightly depressed, with the faint outline of the base of a broken ovicell on it. Avicularia not present. Complete ovicells absent, but the base of one broken ovicell (Fig. 33) clearly indicates a disproportionately small, dependent hyperstomial ovicell not closed by the zooidal operculum in life. Ancestrula unknown, the ancestrular region missing.

**REMARKS.** Better-preserved material is needed to determine if oral and marginal spines are truly lacking, and complete ovicells would give precise evidence of the relationship of the ovicell opening to the maternal zooid.

This is a rare species. The sole colony encrusts a stylasterid (*Sporadopora* cf. *marginata* Tenison-Woods).

#### Genus *AKATOPORA* Davis, 1934

**TYPE SPECIES.** *Akatopora clausentina* Davis, 1934, by monotypy; Lutetian, Southampton, England.

##### *Akatopora chathamica* sp. nov.

Figs 34, 35

**HOLOTYPE.** IGNS BZ 185-1, from Pukekio Hill, Chatham Island.

**PARATYPES.** IGNS BZ 185-2; NHM BZ 4781.

**NAME.** From the name of the main island in the Chathams group.

**DESCRIPTION.** Colony encrusting, unilaminate, multiserial, with maximum diameter 13 mm. Zooids arranged quincuncially, more or less elongate-oval in shape; length = 0.41–0.49 mm, width = 0.24–0.28 mm in the zone of astogenetic repetition. Zooidal opesia oval, bordered on each side by a narrow lateral cryptocyst, probably originally granular, broadening to a sloping shelf proximally. Boundaries between zooids concealed by contiguous adventitious avicularia or kenozooids that occur along the rims; these heterozooids variable in shape, generally elongate on the lateral rims in the direction of zooid growth, or more subquadrangular to subtriangular at the proximal corners of the zooid where they are paired and partly cover the cryptocyst; the frontal chamber walls elongated along the margins so that adjacent polymorphs are continuous. Heterozooid opesia oval; a cross-bar or distinct condylar pivots not evident. Ovicell hyperstomial, though somewhat recumbent on the proximal part of the cryptocyst of the succeeding zooid; the ectoecial surface smooth with a thin median suture line; becoming covered on both sides of the suture line by secondary calcification that may represent kenozooidal overgrowth. Ovicell probably closed by the zooidal operculum in life. Ancestrula unknown, the ancestrular region missing.

**REMARKS.** Preservation is generally poor but, because of the occurrence of ovicells and adventitious heterozooids, is adequate to show the distinctive characters of the genus and species. *Akatopora* was first described monotypically by Davis (1934) who interpreted the chambers of the interzooidal polymorphs as 'lacunae' in 'interoecial secondary tissue', applying the terminology used by Lang (1916, 1921) for cribrimorph cheilostomes. Because of their variable size he concluded that the lacunae could not be avicularia. Subsequently, Gordon (1986) recognised Pleistocene-Recent *Aplousina* (?) *circumsaepta* Uttley, 1951 from New Zealand as congeneric with *Akatopora*. Study of fresh specimens (deep purple

in life) and scanning electron micrographs make it clear that these variable-sized chambers are heterozooids comprising both avicularia and kenozooids. The avicularia are distinctly differentiated into a rostral area and opesia with proximal cryptocyst, whereas kenozooidal opesiae are entirely surrounded by a narrow granular cryptocyst (see Taylor *et al.*, 1989, fig. 9A). The ovicells of *A. circumsaepta* become covered over by thin kenozooidal chambers, and this appears to be the case in *A. chathamica*.

*Akatopora circumsaepta* has a much narrower proximal zooidal cryptocyst and lacks an ectoecial median suture, otherwise the two species are very similar. Additionally, *A. circumsaepta* has an obligate symbiotic relationship with hermit crabs in bryozoan-modified gastropod-shell extensions (Taylor *et al.*, 1989; Taylor 1994), whereas *A. chathamica* (two specimens) encrusted what appears to have been dead (disarticulated and broken) bivalve shell. No other fossil *Akatopora* species is known in the New Zealand region and *A. chathamica* is the earliest record of the genus globally.

#### Family CALESCHARIDAE Cook & Bock, in press

##### *Genus CALESCHARA* MacGillivray, 1880

**TYPE SPECIES.** *Eschara denticulata* MacGillivray, 1869, original designation; Recent, SE Australia.

##### *Caleschara* sp.

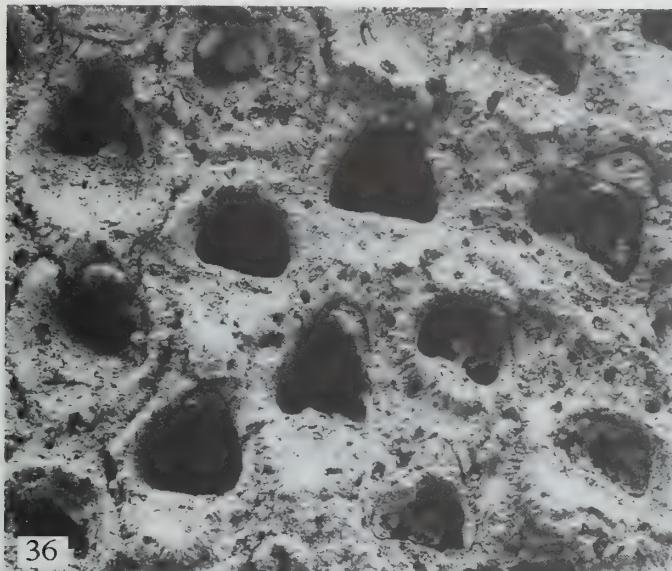
Figs 36, 37

**MATERIAL.** IGNS BZ 207, a single colony from Pukekio, Chatham Island.

**DESCRIPTION.** Colony of unique specimen encrusting, in places multilamellar owing to self-overgrowth. Zooids large, dimorphic, arranged quincuncially, length = 0.65–0.97 mm, width = 0.52–0.71 mm, with distinct interzooidal grooves. The cryptocyst shelf slopes inward from the proximal rim where it is highest to the mostly horizontal edge of the opesia where it appears to descend abruptly toward the zooidal interior; opesiae variable in shape depending on overall shape of zooid, ranging from a normally high-arched D shape to roundly triangular, widest proximally where it is 0.28–0.46 mm wide. Brooding zooids larger than autozooids overall, although some dimensions may overlap: 0.89–1.03 mm long including ovicell, 0.69–0.74 mm wide; easily distinguished not only by size but more especially by the distal ovicell chamber, which is not concealed by cryptocyst in the present material but, owing to poor preservation, it is not possible to say if this is because of breakage and loss of a cryptocyst cover; because there is no cryptocyst cover the opesiae appears very long; width of brooding zooids 0.46–0.50 mm. Avicularia not seen.

**REMARKS.** Thanks to a recent revision of the genus *Caleschara* and a better appreciation of its characters (Cook & Bock, in press) it is now possible to compare the present material with the known living and fossil species. Recent *Caleschara* is mostly Indo-West Pacific in distribution, and fossil species are predominantly Australian with the exception of the oldest-known species of the genus, *C. squamosa* Meunier & Pergens, from the Danian of Belgium. The present material thus constitutes the earliest occurrence of the genus in the Australasian region.

Although preservation of the Red Bluff Tuff specimen is poor, the generic attribution appears reliable. Owing to the imperfect expression of the characters of the brooding zooids, however, we prefer not to erect a new species name until better-preserved material is found. Pitting of the skeletal surface is pervasive and even gives the impression of holes where oral-spine bases might occur. This is



Figs 36–37 *Caleschara* sp., IGNS BZ 207. 36, autozooids with variably-shaped operiae,  $\times 33$ . 37, operiae and cryptocysts,  $\times 60$ .

almost certainly an artifact, especially since oral spines are not known in any other species of Calescharidae. The Red Bluff Tuff specimen most closely resembles the morphology expressed in some populations of Recent *C. minuta* Maplestone which lack a median process of the cryptocyst. Lack of this process is more typical of the calescharid genus *Tretosina* Canu & Bassler, 1927 which typically has longitudinally elongate-oval operiae, unlike those in *Caleschara* and the present specimen.

#### Family MICROPORIDAE Gray, 1848

##### Genus *MICROPORA* Gray, 1848

TYPE SPECIES. *Flustra coriacea* Johnston, 1847, non Esper, 1796, by monotypy; Recent, NE Atlantic.

##### *Micropora quadriporosa* sp. nov.

Figs 38, 39

HOLOTYPE. IGNS BZ 186, from Pukekio, Chatham Island. No paratypes.

NAME. Alluding to the number of opercular pores (four) in the zooidal cryptocyst.

DESCRIPTION. Colony encrusting, tiny, apparently with very short pluriserial groupings of zooids. Zooids oval to subpyriform, mostly contiguous, but some very slightly disjunct and thus separated by distinct interzooidal furrows; length = 0.33–0.45 mm, width = 0.24–0.28 mm. Zooids generally with smooth, steeply sloping gymnocystal sides and sometimes a short proximal gymnocyst, accentuating the appearance of a raised cryptocystal rim. Cryptocyst at a lower level than the rim, more or less flat and granular, with 4 circular operiules; one on each side proximal to the orifice, the other pair near the proximal end of the cryptocyst. Orifice more or less semicircular, but nearly twice as wide as long. No oral spines. Avicularia interzooidal, the combined rostral-operial area somewhat pyriform in shape, indented in the middle on each side, possibly lacking a complete cross-bar. Ovicell present (broken in the only specimen), hyperstomial, evidently not closed by the zooidal operculum in life,

the outer skeletal surface apparently smooth and imperforate when fresh. Basal pore-chambers present in distal half of zooids.

REMARKS. In its range of characters, the genus *Micropora* is quite variable. Species generally have a deep pair of recessed suboral operiules but a few have two to many accessory operiules (e.g., *M. variperforata* Waters, 1887b; *M. gracilis* (Uttley, 1949)); most lack oral spines, but a few species have them (e.g., *Micropora stenostoma* (Busk, 1854); *M. notialis* Hayward & Ryland, 1993); avicularia are generally present, but are lacking in some species (e.g., *M. coriacea* (Johnston, 1847); *M. inarmata* Soule, 1959); ovicells are characteristically imperforate, but *M. santacruzana* Soule, Soule & Chaney, 1995 is pseudoporous; how the genus may be split, if this is appropriate, is uncertain, although d'Hondt & Gordon (1999) have segregated as a new genus (*Promicra*) a strictly biserial form with pseudoporous ovicells and erect dichotomous branches. Because of occlusion of avicularian operiae in the present material it is uncertain whether *M. quadrispinosa* lacks complete cross-bars. If they are lacking, this character, the tendency to disjunct zooids separated by deep furrows, and especially the hyperstomial ovicell not closed by the zooidal operculum, may warrant future segregation at the generic level.

##### Genus *HOPLITAECHMELLA* Voigt, 1949

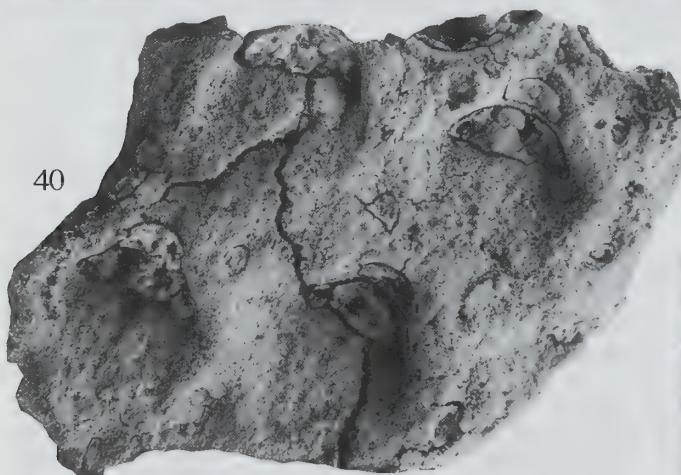
TYPE SPECIES. *Cellepora vespertilio* von Hagenow, 1839, by original designation; Upper Senonian, Rügen, Germany.

##### ?*Hoplitaechmella* sp.

Figs 40–42

MATERIAL. IGNS BZ 208, a single colony fragment from Pukekio, Chatham Island.

DESCRIPTION. Colony encrusting. Autozooids arranged quincuncially; length = 0.52–0.60 mm, width = 0.43–0.45 mm. Cryptocyst granular (preservation of granulation seen proximal to the orifice in one zooid). Operia-orifice wider (0.20–0.24 mm) than long, the proximal rim gently concave, with distinct rounded operiular indentations at the corners. Oral-spine bases not apparent. As many as three small avicularia occur along each lateral margin interzooidally,



**Figs 38–42** Microporid cheilostomes. **38–39**, *Micropora quadriporosa* sp. nov., IGNS BZ 186, holotype; **38**, part of a small colony, one zooid ovicelled and two interzooidal avicularia seen at left,  $\times 65$ . **39**, ovicelled zooid seen in 38, with an interzooidal avicularium at lower left,  $\times 152$ . **40–42**, *Hoplitaechmella* sp., IGNS BZ 208; **40**, colony fragment with ovicelled zooids,  $\times 60$ ; **41–42**, close-up of zooids in Fig. 40; note occluded openings of ovicells and probable avicularia interzooidally,  $\times 115$  and  $\times 130$  respectively.

obscuring interzooidal boundaries; in the poorly-preserved material at hand these appear to be elongate-oval, with a single central foramen surrounded by a concentric granular cryptocyst. Ovicell endozoooidal, immersed under the succeeding cryptocyst, the more-or-less semicircular opening occurring immediately distal to the opesia-orifice.

**REMARKS.** The single tiny specimen, imperfectly preserved, comprises only three complete zooids, all fertile, with parts of adjacent broken zooids. Most of the diagnostic characters are present but the generic attribution is uncertain. *Aechmella* Canu & Bassler, 1917 seems ruled out, as the interzooidal avicularia of the type species are relatively large and distinct with acute rostra. *Hoplitaechmella* species have numerous small avicularia, occasional vicarious avicularia, and endozoooidal ovicells as in the present material but distinct oral-spine bases occur in the type and other species (see Voigt 1949; Berthelsen 1962).

Known species include:

- H. antecedens* (Brydone, 1914), Upper Senonian, England  
*H. deshayesi* (von Hagenow, 1851), Upper Senonian, The Netherlands  
*H. nitescens* (Brydone, 1914), Upper Senonian, England  
*H. nonna* (von Hagenow, 1839), Upper Senonian, Germany  
*H. smitti* (Hennig, 1892), Danian, Sweden and Denmark  
*H. vespertilio* (von Hagenow, 1839), Upper Senonian, Germany  
*H. vespertilioides* Berthelsen, 1962, Upper Danian, Denmark.

If the present material is *Hoplitaechmella*, then it represents the first known occurrence of the genus outside Europe, and the youngest stratigraphical record.



43

### Microporid sp.

Figs 43, 44

**MATERIAL.** IGNS BZ 209, a unique specimen from Pukekio, Chatham Island.

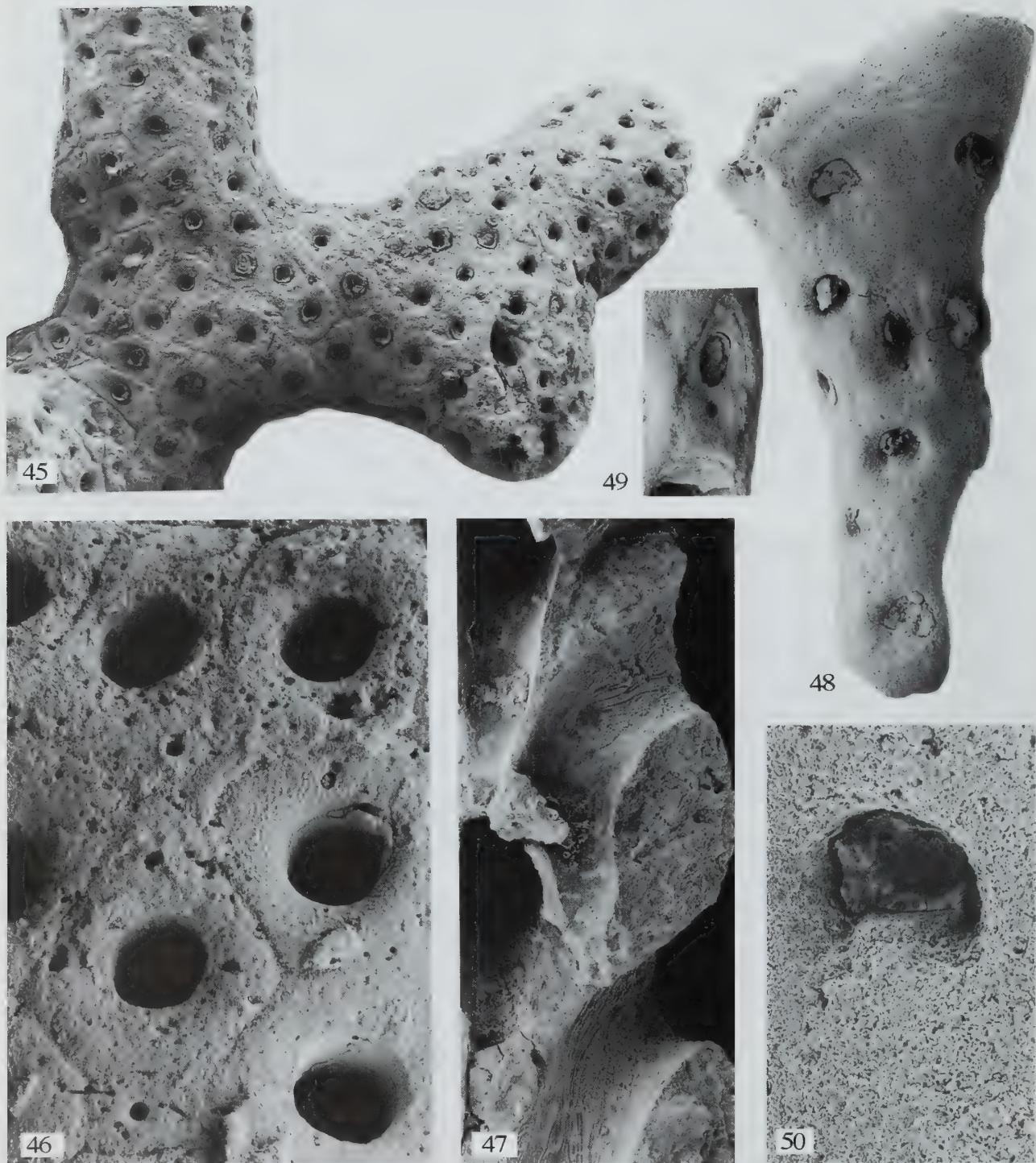
**DESCRIPTION.** Specimen erect, apparently slightly worn, comprising part of a narrow bilamellar branch, 1.75 mm long and up to 1.16 mm wide. Zooids sub-elongate, widest in the middle, tapering distally and proximally, length = 0.62–0.69 mm, width = 0.41–0.45 mm, arranged such that there are three alternating longitudinal rows facing frontally on each side of the branch, separated by a row along each branch margin that faces laterally. Zooidal frontal shields flattened with the rims slightly elevated above the shield centre, implying a cryptocyst. Faint paired excavations proximolateral to the orifice in several zooids indicate opesiae; additional faint excavations may occur along the margins and in the centre of the shields, indicating possible accessory opesiae as well as sparse pseudopores. Opesia/orifice generally transversely oval, wider (0.13–0.15 mm) than long (0.10–0.11 mm). Oral spine bases absent, with the possible exception of one orifice in which a faint pair of excavations occurs distally. Ovicells and avicularia not present in the sole fragment.

**REMARKS.** Owing to the paucity of diagnostic characters it is not possible to be certain of the genus. Maastrichtian *Puncturiella* Levinsen (type species *P. gudumensis* Levinsen, 1925) is characterised by cylindrical stems of zooids with coarsely perforated frontal shields and dimorphic opesiae/orifices. Species of the nominal subgenus *Puncturiellina* Voigt (type species *Puncturiella* (*Puncturiellina*) *subsculpta* Voigt, 1987) (Maastrichtian-Danian) exhibit a range of colony forms including erect-bilamellar, the frontal



44

**Figs 43–44** *Microporid* sp., IGNS BZ 209. **43**, part of erect bilamellar colony fragment,  $\times 59$ . **44**, close-up of an autozooid; positions of possible suboral opesiae and frontal pseudopores faintly indicated,  $\times 126$ .



Figs 45–50 Onychocellid cheilostomes. 45–47, *Inversaria gondwanae* sp. nov.; 45, IGNS BZ 187–1, holotype, erect branching colony,  $\times 14$ ; 46, IGNS BZ 187–2, autozooids and orifices; note the granulation of the cryptocyst in one zooid and circular holes indicating the location of possible heterozooids in some zooids,  $\times 65$ ; 47, IGNS BZ 187–3, longitudinal section of a branch showing interiors of two peristomes and parts of two autozooids,  $\times 116$ . 48–50, *Chondriovulum fossilis* sp. nov.; 48, IGNS BZ 188–2, part of a branch, proximally fractured,  $\times 38$ ; 49, IGNS BZ 188–1, holotype, vicarious avicularium,  $\times 67$ ; 50, IGNS BZ 188–3, autozooidal orifice,  $\times 180$ .

shields are less coarsely perforated, and opesiae/orifices are monomorphic and semicircular. Ovicells are lacking and, although characteristic small avicularia occur distally to the orifices, they do not occur on every zooid. Lutetian-Bartonian *Poropeltarion* Cheetham (type species *P. lebanonense* Cheetham, 1963) has frondose to narrow-branched bilamellar colonies of pseudoporous zooids. Both avicularia and ovicells are lacking. Recent *Promicroa* d'Hondt & Gordon, 1998 from the Norfolk and Kermadec Ridges in the Southwest Pacific produces erect, narrow-branched colonies, but these are unilamellar and the zooids have both semicircular orifices and ovicells; there are no avicularia. In the sum of the limited number of characters available, the Chatham Island specimen most closely resembles species of *Poropeltarion*, or possibly *Puncturiellina*.

#### Family ONYCHOCELLIDAE Jullien, 1882

##### Genus *INVERSARIA* von Hagenow, 1851

TYPE SPECIES. *Ceriopora tubiporacea* Goldfuss, 1826, subsequent designation by Gregory, 1899; Upper Maastrichtian, Maastricht, The Netherlands.

##### *Inversaria gondwanae* sp. nov.

Figs 45–47

HOLOTYPE. IGNS BZ 187–1, from Pukekio Hill, Chatham Island.

PARATYPES. IGNS BZ 187–2, 3. NHM BZ 4782, 4783 (sample).

NAME. Alluding to the first record of the genus in a part of former Gondwana.

DESCRIPTION. Colony erect, stout, irregularly branching, attached by a somewhat thickened base not greater than 4 mm in maximum width or diameter. Wide-angled bifurcations are usual but, as at a rare anastomosis of branches in a colony, 3–4 branches may originate; each branch pair of a bifurcation is in the same plane but other bifurcations are in other planes. Branches more or less cylindrical, ranging (among the broken fragments available) from 0.74–3.27 mm diameter, widening to ca. 4.5 mm before the widest bifurcation. Autozooids in 9–11 regularly alternating longitudinal series, increasing to 20 such series immediately proximal to a bifurcation; zooid outlines defined by shallow interzooidal grooves, diamond-shaped with four sides and widest at the lateral points or the distal and proximal and/or lateral points truncated so that the shape is unevenly 6–8 sided; often wider (0.46–0.63 mm across the width of the diamond) than long (0.37–0.58 mm). Zooidal cryptocyst evenly granular in the best-preserved example, sloping, initially shallowly then steeply, all around the opesia which is more distally placed, with a straighter proximal rim, in neanic zooids and centrally placed and circular in ephebic zooids with thicker frontal calcification. Opesial-peristomial shaft of equal longitudinal diameter, sloping inwards proximally and widening from 0.15 mm at the level of the primary orifice to 0.20 mm at the frontal opening. Simple avicularium-like heterozooids may occur between zooids in a longitudinal series (i.e., between the lateral points of adjacent zooids in transverse rows); more or less circular or transversely oval with a small concentric foramen. Ovicells not seen frontally or in section.

REMARKS. *Inversaria* is a relatively little-known genus, originally attributed to the Cyclostomata. Voigt and Williams (1973) reviewed the known species, described them, and gave stratigraphic ranges and geographic distributions as follows:

*I. tubiporacea* (Goldfuss, 1826), Campanian-Maastrichtian, ?Danian, The Netherlands, Belgium, Germany.

- I. crassipes* (Marsson, 1887), Lower Maastrichtian, Germany, Denmark, Poland.
- I. flabellula* (von Hagenow, 1846), Upper Campanian, Sweden.
- I. ramosissima* (Eichwald, 1865), Upper Maastrichtian, Lower Danian, Crimea, Ukraine.
- I. trigonopora* von Hagenow, 1851, Upper Maastrichtian, Belgium, The Netherlands.
- I. tuber* Voigt & Williams, 1973, Upper Maastrichtian, The Netherlands.
- I. verrucosa* Voigt, 1962, Upper Maastrichtian, Crimea, Ukraine.

Colonial morphology among these species ranges from mounded, through erect and branching to bilamellar-foliateous. Cryptocystal morphology is relatively similar throughout the species, which all have deep peristomial shafts. Calcified opercula and occlusor muscle scars have been preserved in some material of the type species (Voigt & Williams 1973). The present species most closely resembles *I. crassipes* in colonial and zooidal morphology, but has more-regularly arranged zooids in narrower branches and smaller, simpler avicularia.

The Chatham Island species is the youngest in the genus, extending its Upper Campanian-Lower Danian range by ca. 5 MY, and the first record outside Europe.

#### Genus *CHONDRIOVELEM* Hayward & Thorpe, 1988

TYPE SPECIES. *Labioporella adeliensis* Livingstone, 1928, by original designation; Recent, Antarctica.

##### *Chondriovulum fossilis* sp. nov.

Figs 48–52

HOLOTYPE. IGNS BZ 188–1, from Pukekio, Chatham Island.

PARATYPES. IGNS BZ 188–2, 188–3, 188–4, 188–5.

DESCRIPTION. Colony erect, dichotomously branching, the stems more-or-less cylindrical except for a slight flattening at a bifurcation, 0.44–0.76 mm in diameter, being widest before a bifurcation. Zooids more-or-less alternating, in 6–8 longitudinal series, the larger number occurring before a bifurcation, reducing to 6 immediately after. Autozooids relatively elongate, length = 0.44–0.74 mm, width = 0.20–0.32 mm, the boundaries marked by narrow grooves between adjacent raised cryptocystal margins. Cryptocyst shallow, sloping to the opesia-orifice, the imperforate surface lightly reticulated in the best-preserved zooids. Opesia-orifice wider (0.11–0.19 mm) than long (0.07–0.13 mm), more-or-less bean-shaped with the middle part of the proximal rim slightly projecting as an inverse crescent, the ends of which appear as denticles. Large avicularia occasionally present, shorter than autozooids but occupying their place in a longitudinal series, with the autozooid distal to an avicularium longer and/or wider than other autozooids; the rostrum acute, with an area of palate encircling a longitudinally oval palatal foramen that is separated by a bridge of calcification from a tiny circular opesial foramen; proximal end of the avicularium truncate, the boundary slightly curved around the proximal autozooid. Ovicells not definitely seen; one zooidal orifice has a distal depression occluded with debris but its nature is equivocal.

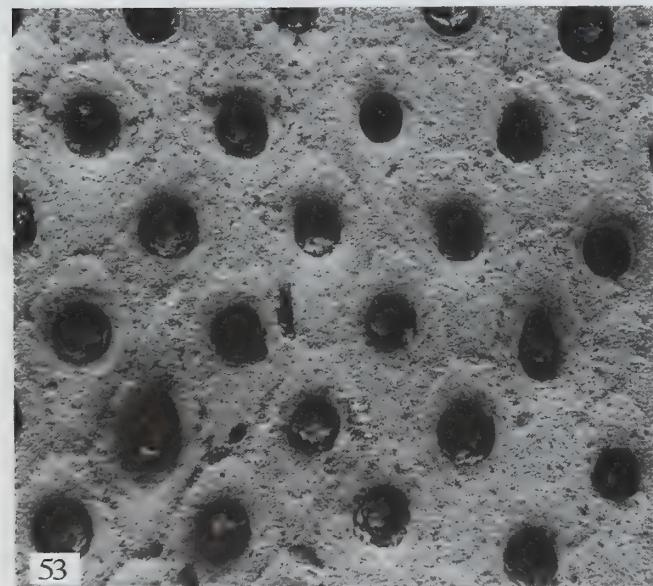
REMARKS. The generic placement of this species is problematic. The shape and size of the opesia-orifice and the equivocal ovicellular depression are indicative of a cellariid affinity; on the other hand, some onychocellids can have relatively small opesiae. The large avicularium is very similar to that seen in Recent *Chondriovulum adeliense* (Livingstone) and *C. angustilobata* (Moyano) (family Onychocellidae) from Antarctica and magellanica South America,



51



52



53



54

Figs 51–54 Onychocellid cheilostomes. 51–52, *Chondriovulum fossilis* sp. nov.; 51, IGNS BZ 188–4, branch fragment; notice reticulation of cryptocyst,  $\times 211$ ; 52, IGNS BZ 188–5, vicarious avicularium,  $\times 162$ . 53–54, *Ogiva incompta* sp. nov., IGNS BZ 189–1, holotype, part of large colony fragment showing disposition of autozooids and vicarious avicularia,  $\times 41$  and  $\times 87$  respectively.

respectively (Moyano 1974; Hayward & Thorpe 1988). In this genus the avicularium also has both rostral and opercular foramina, although they tend not to be regular in shape.

There are some similarities with the monotypic Antarctic

aspidoconularid genus *Larvapora* Moyano in the form of the orifice and the vicarious avicularium. *Larvapora mawsoni* (Livingstone) has folded bilamellar colonies, however, projections from the distal rim of the orifice, and elevated rostral rims. It also has distinctive

ovicells. When definite ovicells are discovered in *C. fossilis* they should clarify the taxonomic position of this species.

#### Genus *OGIVA* Jullien, 1882

TYPE SPECIES. *Eschara actaea* d'Orbigny, 1851; by original designation; Coniacian, Fécamp, France.

REMARKS. Originating in the Cenomanian (Taylor, 1993), the family Onychocellidae is especially well represented in the Late Cretaceous by a bewildering number of species whose colonial, autozooidal, and avicularian characters seem to intergrade to such an extent as to defy clear circumscription into genera. Such is also the case among the Cenozoic forms which are, however, relatively less diverse. In his voluminous work on the Cretaceous bryozoan faunas of France, d'Orbigny (1851–54) distributed the species, among which are encrusting, branching-cylindrical, and bilamellar forms, between several 'form-genera' based on colonial morphology. As Canu (1900) pointed out in his revision of this work, d'Orbigny often failed to account for ontogenetic variation in the appearance of zooids, and the illustrations accompanying the descriptions were often inexact, so that both he and Pergens (1889), who had attempted to revise the cyclostomes, frequently had difficulty in matching illustrations with specimens.

Jullien (1882) introduced the family Onychocellidae, the genera *Onychocella*, *Ogivalina*, *Floridina*, and *Smittipora* with Recent type species, and four other genera (*Ogiva*, *Dictuonia*, *Collura*, and *Rhebasia*) based on d'Orbigny species. The genera were distinguished, not primarily by colonial morphology, but by zooidal, opesial, and avicularian characters. A few years later, Koschinsky (1885) added *Rhagastoma*, with an Eocene type species. Canu (1900) merged *Dictuonia*, *Collura*, and *Rhebasia* in *Ogiva* (which has page priority in Jullien 1882) on the grounds that the range of zooidal morphologies represented by these genera varies according to the ontogenetic age of the zoid and more than one such morphology can occur in the same colony – 'La forme colluréenne est toujours un signe de vieillesse; une ogivaline passe rapidement soit en dictuonia soit en rhebasia; c'est encore un signe de vieillesse. Les formes dictuoniennes ou rhebasienne envahissent parfois tellement une espèce que la forme ogivalienne jeune est très rare' (Canu 1900: 387–388). Complicating an appreciation of the validity of the four Jullien genera based on species of d'Orbigny (1851) (and which influenced Canu's conclusions) is a lack of definitive knowledge of those species. *Eschara acesta* (type species of *Dictuonia*) was lacking from the collection when Canu revised it, and the specimen and illustrations of *E. actaea* (type species of *Ogiva*) did not correspond (Canu 1900: 420); *E. dorilas* (type species of *Rhebasia*) and *E. athulia* (type species of *Collura*) were represented by worn specimens only. A thorough revision of the d'Orbigny collection using scanning electron microscopy of all available material is critically needed. Pending such a revision, and its impact on the classification of onychocellids, the genus name *Ogiva* is used here for the following new species.

#### *Ogiva incompta* sp. nov.

Figs 53–56

HOLOTYPE. IGNS BZ 189–1, from Pukekio, Chatham Island.

PARATYPE. IGNS BZ 189–2.

NAME. From the Latin, *incomptus*, unadorned, referring the plain appearance of the zooids.

DESCRIPTION. Colony erect, comprising narrow to moderately wide bilamellar stems that broaden, in the two fragments available,

from 1.08 mm diameter to 3.70 mm wide. Autozooids generally 'dictuonian', i.e., regularly 4-sided, alternating and arranged very evenly in oblique rows in the narrow-based fragment; most zooids very slightly rounded at distal and proximal ends, with some drawn out proximally and approaching the 'rhebasian' form in the broader, more worn fragment; length = 0.41–0.65 mm, width = 0.33–0.43 mm. Zooidal boundaries marked by a shallow but distinct furrow, the cryptocyst neither smooth nor granular in the present material, sloping inwards on all sides to the more-or-less centrally placed circular to subcircular opesiae (0.14–0.19 mm long, 0.14–0.17 mm wide). No spine bases or other features. Avicularia vicarious, perfectly replacing autozooids in a series without disrupting the regularity of oblique rows, almost identical to autozooids in appearance and width (0.31–0.37 mm) but distinguished from them by: (1) their slightly greater relative length within rows (0.54–0.77 mm) such that the acute rostral tip overlaps the proximal end of the distal autozooid, making that end W- instead of V-shaped; and (2) a more longitudinally oval opesiae (0.18–0.22 mm long, 0.11–0.14 mm wide). Lateral margins of colony comprising both autozooids and avicularia. No enlarged brooding or oviolated zooids seen.

REMARKS. Although differing in size, the two fragments are sufficiently alike in zooidal characters to be considered as conspecific. The smaller, paratype fragment (Fig. 55) has an almost circular diameter proximally, broadening to bilamellar distally, with slightly smaller zooidal dimensions overall than the larger, holotype fragment (Fig. 53), which being broader and therefore certainly more distal in a colony would be expected to have incrementally larger zoid sizes. The larger fragment also lacks lateral margins so would have been broader in life than its current maximum breadth of 3.70 mm.

Brown (1958), without comment on the status of the genus, attributed two Tertiary Victorian species to *Ogiva*: *Membranipora concamerata* Waters, 1881 (Janjukian-Balcombian = Chattian-Langhian) and *Omoiosia elongata* Canu & Bassler, 1935 (Balcombian). The former species has slender, cylindrical branching stems and may represent a new genus of Onychocellidae; the latter species is definitely congeneric with *O. inornata*, from which it differs in having more longitudinally oval opesiae set in the distal half of the cryptocyst. (Based on the type species, *Omoiosia* Canu & Bassler, 1927, is, as Brown (1958) pointed out, a junior subjective synonym of *Chaperia* Jullien, 1881.)

#### Genus *ONYCHOCELLA* Jullien, 1882

TYPE SPECIES. *Onychocella marioni* Jullien, 1882, by original designation; Recent, Cape Verde Islands to France and the Mediterranean, = *Cellepora angulosa* Reuss, 1848; Badenian (Langhian-Serravallian), Nußdorf, Austria (see Harmer 1926).

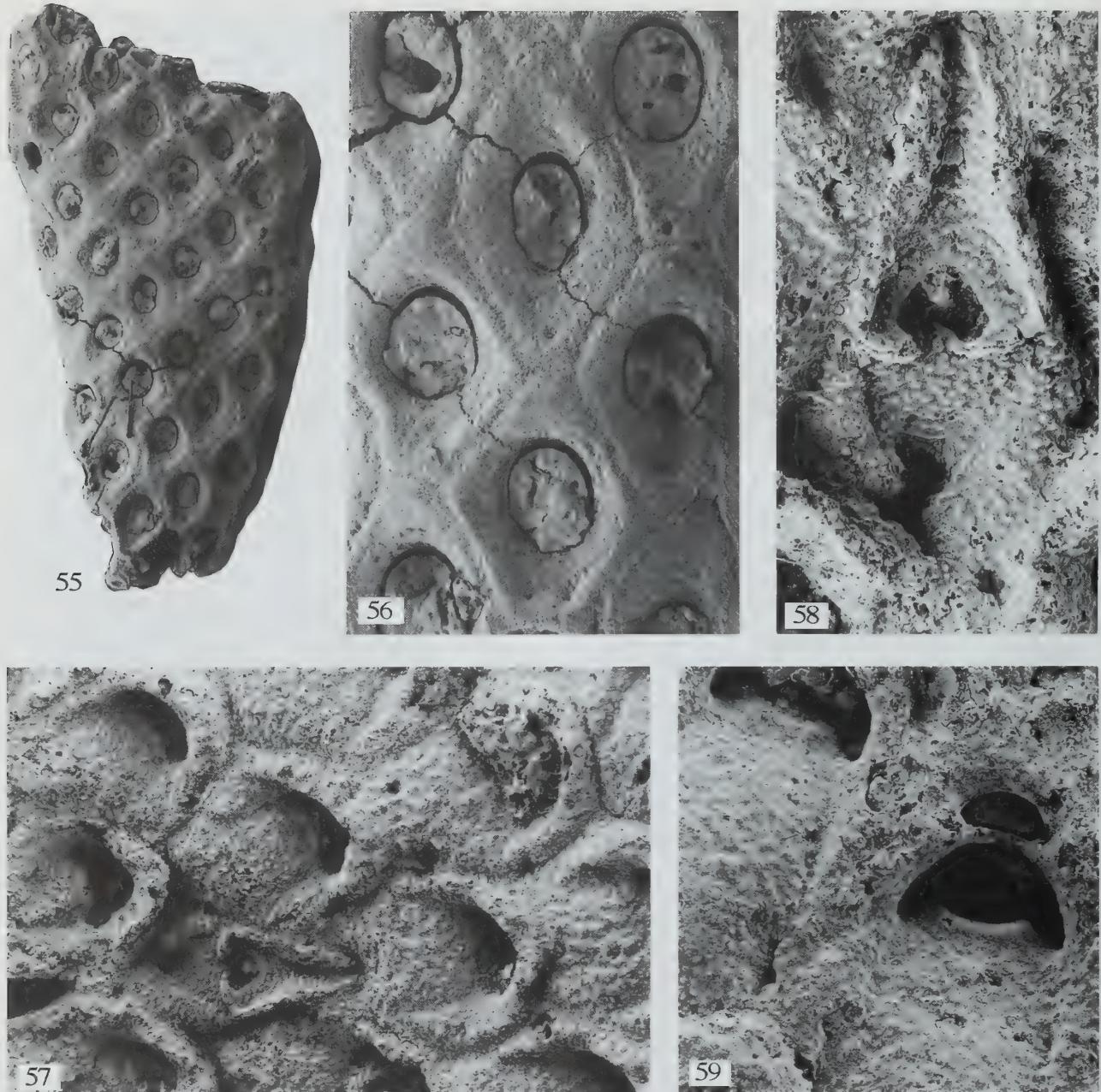
#### *Onychocella?* *lamellosa* sp. nov.

Figs 57–59

HOLOTYPE. IGNS BZ 190, from Pukekio, Chatham Island.

NAME. From the Latin *lamella*, a thin plate, veneer, alluding to the layered nature of the colony from self-overgrowth.

DESCRIPTION. Colony encrusting, self-overgrowing. Autozooids arranged quincuncially, sometimes almost as broad as long, length = 0.65–0.84 mm, width = 0.43–0.65 mm, with the lateral margins and especially the distal rim thickened and raised. Frontal cryptocyst granular, the opesia-orifice wider (0.21–0.26 mm) than long, the proximal rim broadly and narrowly anvil-like and slightly upturned, with rounded opesicular indentations at the corners. Avicularium



Figs 55–59 Onychocellid cheilostomes. 55–56, *Ogiva incompta* sp. nov., IGNS BZ 189–2, paratype, neanic colony showing disposition of autozooids and vicarious avicularia,  $\times 51$  and  $\times 84$  respectively. 57–59, *Onychocella?* *lamellosa* sp. nov., IGNS BZ 190, holotype: 57, autozooids and avicularium,  $\times 58$ ; 58, close-up of avicularium,  $\times 129$ ; 59, zooid with entrance to concealed ovicell,  $\times 109$ .

subvicarious, occurring sporadically at the bifurcation of zooid rows but not every new zooid row starts with an avicularium; 0.65–0.71 mm long and 0.35–0.45 mm wide, the acute rostral tip overlaps the proximal end of the distal autozooid, making that end W-instead of V-shaped; rostral foramen subtriangular, bordered proximally by a stout pair of ridge-like pivots that do not fuse medially to form a cross-bar; no opercular foramen. Ovicells immersed under the cryptocyst of the succeeding zooid, visible as a slight bulge, with a narrow transverse opening just distal to the opercular orifice of the

maternal zooid. Lateral communication pore areas recessed between slight buttresses of inner autozooidal walls.

**REMARKS.** The zooidal and especially the opercular characters of this species are as much aspidostomatid as onychocellid, and the generic and family attributions are uncertain. Nevertheless, it is clear from the literature that there has been (and remains) considerable difficulty in distinguishing generic and, hence, familial boundaries in the large range of fossil species attributed to *Onychocella* sensu

*lato*, related genera, and aspidostomatids. A perusal of a range of literature covering Late Cretaceous and Tertiary onychocellids and aspidostomatids (e.g., Brydone 1930; Voigt 1930, 1949, 1957, 1962, 1967, 1968, 1975, 1979, 1981, 1983, 1985b, 1987, 1989; Berthelsen, 1962) shows that a very wide range of colonial, zooidal, opesial, larval-brooding, and avicularian morphologies have been attributed to *Onychocella* alone. These include encrusting, erect uni- and bilamellar, and erect cylindrical and quadrilateral colony forms, broad subcircular to transversely narrow opesiae, nonexistent to vestigial to hyperstomial ovicells, and large and small, symmetrical to asymmetrical avicularia. Theoretically, heterochrony during zooidal ontogeny could account for all or most of this variation, but it is likely that, within the huge and bewildering array of species of *Onychocella* *sensu lato*, fine-grained statistical analysis would identify a number of clades, some of which would correspond to the variety of generic concepts within the family.

The type species of *Onychocella* is encrusting, the opesiae are relatively large and somewhat bell-shaped in outline, the 'ovicells' are endozoidal, and the avicularium is asymmetrical, with the rostral tip reflexed against the distolateral corner of an adjacent autozooid and the mandible unimembranous (i.e., on one side of the rachis only, the other half of the membrane being suppressed on the reflexed side of the rostrum). The nominal type species is *Onychocella marioni* Jullien, 1882, Recent, distributed from the Cape Verde Islands to France and the Mediterranean. Unquestionably this is a junior synonym of *O. angulosa* (Reuss, 1848), first described from the Austrian Tertiary (see Harmer 1926, and compare scanning electron micrographs of Recent (Hayward 1974) and fossil (Schmid 1989) material). Schmid's (1989) illustrations show more clearly than those of other authors that the avicularia have distinct, but weakly-developed mandibular pivots at the widest part of the avicularium. There is little information on the arrangement for larval brooding in *O. angulosa*. If it is the same as in *Floridina levinseni* Canu & Bassler (type species of *Velumella* Canu & Bassler, 1917), then there is no ovicell as such, just a cap-like overhang of the proximal end of the next zooid in the series (see Levinsen 1909: pl. 24, fig. 10). In the sum of their characters, *Semiescharella* d'Orbigny (type species *S. flabellata* d'Orbigny, 1852) and *Rhagastoma* Koschinsky (type species *R. hexagonum* Koschinsky, 1885) accord with those of *Onychocella* as conservatively based on *O. angulosa* and these genera may be considered as synonyms.

How stable are the above morphological characters? The form of the avicularium and mandible appear visually distinctive, but Hastings (1930) has shown remarkable variation in the form of the mandible, at least, in *O. alula* Hastings, confirmed by Cook (1985). In this species most avicularia are skeletally symmetrical and the majority of the mandibles straight but, surprisingly, unimembranous. Occasionally the rachis may be set obliquely with a slight development of a membrane opposite the larger membrane. In older parts of colonies the thin and fragile membrane is normally lacking altogether. The evidence from this species, then, is that symmetrical avicularia need not imply bimembranous mandibles (as in *Smittipora* Jullien, 1882 and *Rectonychocella* Canu & Bassler, 1917 (a probable synonym of *Smittipora*)). Skeletally, the distal deflection of the avicularian rostrum is a variable character also. In several Cretaceous species attributed to *Onychocella* the avicularium may be symmetrical with no distal curvature, or have varying degrees of curvature, within the same colony (see for example, Voigt 1989). Mandibular pivots are lacking in many species attributed to *Onychocella* – it may be that the occurrence and shape of these is a useful character, along with the shape of the avicularian opesiae, but little study has been made. Frequently, published photographs and micrographs are not of adequate quality or magnification to give

detailed information on some avicularian characters.

The presence of hyperstomial ovicells has been taken to be a 'good' character. Thus their occurrence in Recent '*Rectonychocella*' *disjuncta* Canu & Bassler, 1930 led Hayward (1974) to state that a new genus is required for this species. The presence of hyperstomial ovicells, and their consistent occurrence in erect cylindrical colonies in several species has allowed for the discrimination of *Latereschara* d'Orbigny, 1851 (Brydone 1930; Voigt 1959, 1967), which appears to be a 'good' genus. *Cheethamia* Shaw, 1967 also has hyperstomial ovicells but is encrusting. Scanning electron microscopy of the type species of both of these genera is needed to determine if they are congeneric. *Semiescharella* d'Orbigny, 1852 (type species *S. mumia* d'Orbigny, 1852) may also be a synonym. Voigt (1989: 54) used *Cheethamia* subgenerically for a species of *Onychocella*.

The present species is excluded from *Cheethamia* in having transversely narrow opesiae with distinct opesial indentations, well-developed articular ridges in the avicularium (lacking in *Cheethamia*), and a separate ovicell opening (not cucullate as in *Cheethamia*). Large subvicarious avicularia are not characteristic of *Aspidostoma* so the present species cannot be included in that genus – in the type species, *A. giganteum*, they are proportionately much smaller and interzoidal; they have similar articular ridges but a separated avicularian opesia (Hayward 1995).

### *Onychocella* sp.

Figs 60–63

MATERIAL. IGNS BZ 210, a single eroded colony from Pukekio, Chatham Island.

DESCRIPTION. Colony encrusting. Autozooids arranged quincuncially, mostly longer than wide; length = 0.44–0.62 mm, width = 0.20–0.22 mm, with the lateral margins and perioresial rim thickened and raised. Frontal cryptocyst of an even level below the rim, the opesia-orifice high-arched in regular autozooids, generally as wide as long (0.13–0.19 mm), proximal rim with rounded opesial indentations at the corners. Avicularium subvicarious, occurring sporadically at the bifurcation of zooid rows but not every new zooid row starts with an avicularium; 0.48–0.50 mm long, the broad lingulate rostrum either rounded distally or subacute, with an extensive palate; an indentation occurring on each side approximately half-way along the avicularium; a single, elongate-oval medial foramen. Ovicells hyperstomial, the narrow transverse opening separated from the zooidal opesiae by the distal rim of the zooid and apparently unable to be closed by the zooidal operculum in life.

REMARKS. As with the preceding species the generic and familial attributions of this species are uncertain. In both species the clear separation of the ovicellular opening from the opesia-orifice is not compatible with *Onychocella* *sensu stricto*.

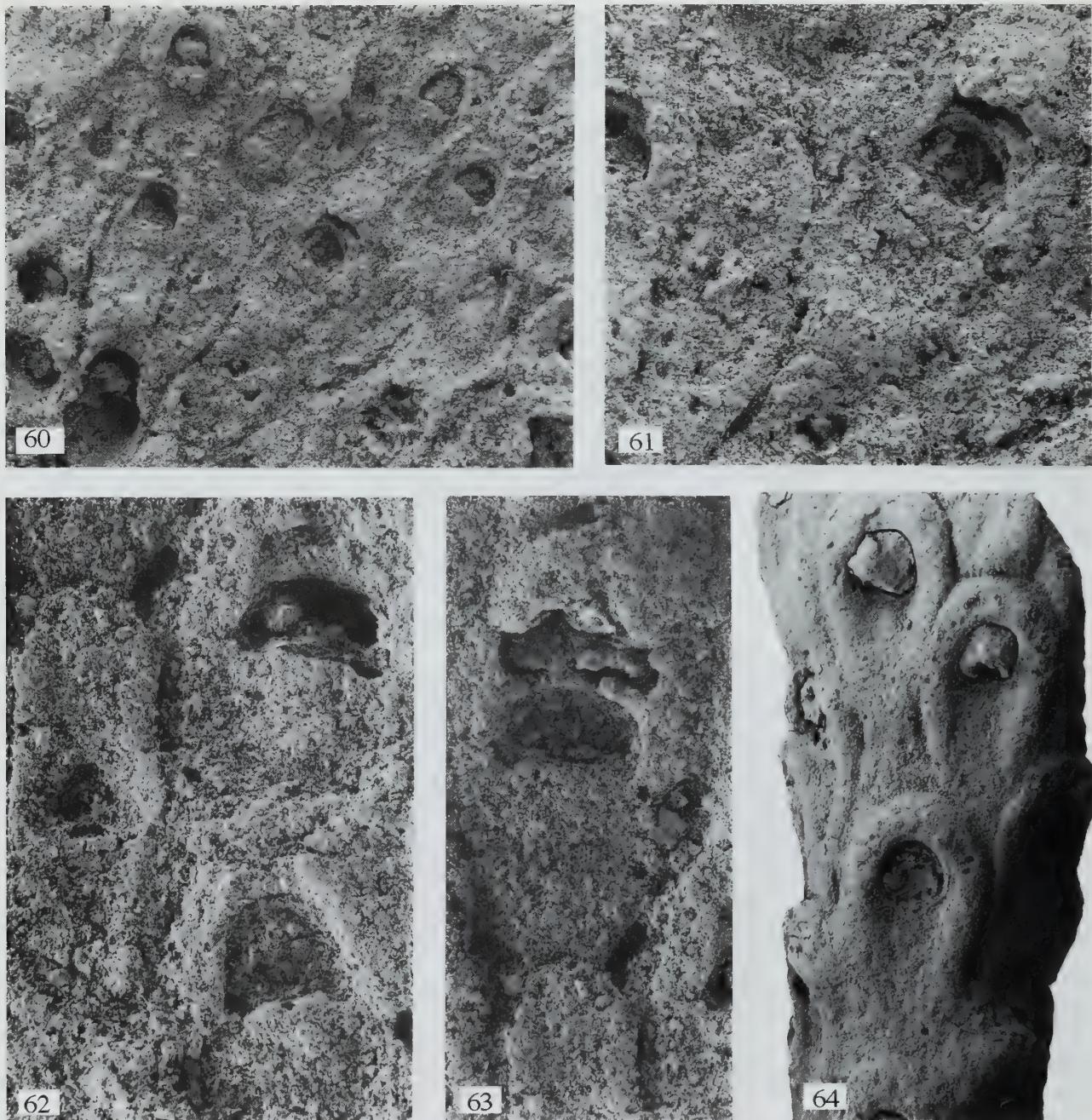
### Genus INCERTAE SEDIS

#### *Onychocellid* sp.

not figured

MATERIAL. IGNS BZ 211, a single colony fragment from Pukekio, Chatham Island.

DESCRIPTION. Colony encrusting? Autozooids large, exceedingly thick-walled. Measured from orifice to orifice at the colony surface the zooids are 0.73–0.92 mm long, but internally one zooid is only 0.52 mm long between orifices whose length at the surface is 0.73 mm. This appears to be a consequence of the convex colony surface in the sole fragment whereby, as the zooidal cryptocysts thickened frontally in life, the peristomial orifices became more separated.



**Figs 60–64** Onychocellid and aspidostomatid cheilostomes. **60–63**, *?Onychocella* sp., IGNS, BZ 210; **60**, eroded colony showing disposition of autozooids, ovicellate zooids and vicarious avicularia,  $\times 45$ ; **61**, vicarious avicularium and ovicellate zooid,  $\times 95$ ; **62**, vicarious avicularium, autozooidal and ovicelled orifices,  $\times 127$ ; **63**, ovicellate zooid (ovicell partly broken) and tip of avicularian rostrum proximally,  $\times 116$ . **64**, *Aspidostoma litotes* sp. nov., IGNS BZ 191, holotype, part of erect branch,  $\times 53$ .

Colony surface in the somewhat worn specimen rather featureless, with no trace of avicularia or other polymorphs. Peristomial and primary orifices more or less D-shaped or the proximal rim with a slight median convexity, 0.31–0.39 mm wide externally, 0.31–0.34 mm wide internally at the level of the primary orifice, with an indication in some orifices that slight opercular indentations at the proximal corners continue as grooves down the inside of the peristome

on each side. No indication of ovicells.

**REMARKS.** The generic affinities of this specimen are very obscure. The excessive thickness of the cryptocyst is reminiscent of *Inversaria*, but opercae and orifices in *Inversaria* species are typically subcircular and more centrally placed. More and better-preserved material is needed.

## Family ASPIDOSTOMATIDAE Jullien, 1888

Genus *ASPIDOSTOMA* Hincks, 1881

TYPE SPECIES. *Aspidostoma crassum* Hincks, 1881 = *Eschara gigantea* Busk, 1854, by monotypy; Recent, South Atlantic, Patagonia to Gough Island and the Antarctic Peninsula.

*Aspidostoma litotes* sp. nov.

Fig. 64

HOLOTYPE. IGNS BZ 191, from Pukekio, Chatham Island.

NAME. From the Greek, *litotes*, f., plainness, simplicity.

DESCRIPTION. Colony erect, cylindrical, evidently bifurcating, 0.54–0.80 mm diameter. Autozooids arranged in 5–8 longitudinal rows, the number of rows increasing distally, by row bifurcation, as a stem thickens. Autozooid length = 0.56–0.86 mm, width = 0.35–0.45 mm. Zoids widest in the vicinity of the orifice, each with thick, raised, rounded lateral rims that converge distally around the orifice. Frontal cryptocyst between the rims sloping towards the orifice, the surface granular where well-preserved. Opesia-orifice subrounded, the centre of the proximal rim gently concave with a tiny projection on each side defining a very small opesiular indentation. Avicularia and ovicells not seen.

REMARKS. Although lacking avicularia and ovicells, the zooidal and orificial characters of this species are similar to those of Runangan-Whaingaroan (Priabonian-Rupelian) *Aspidostoma curvatum* Uttley, 1949 and *A. turricula* Brown, 1952 from Oamaru which, however, have orifices opening on one face only. The lack of avicularia may be a genuine feature of *A. litotes*, or they may simply be rare as in *A. turricula*. There are some superficial similarities between *A. litotes* and a species from the Paleocene of Surinam described by Lagaaïj (1969) as '*Vincularia*' *cristata*. However, the opesiae of Lagaaïj's species have small pectinate denticles.

*Aspidostoma cinnabarina* sp. nov.

Figs 65–70

HOLOTYPE. IGNS BZ 192, from Pukekio, Chatham Island, encrusting a bivalve shell. No paratypes.

NAME. From the Latin *cinnabaris*, cinnabar, and Greek *kinnabarinos*, red like cinnabar, alluding to the red-coloured tuff at the type locality.

DESCRIPTION. Colony encrusting, large. Autozooids large, arranged quincuncially; length typically about 1 mm but ranging from 0.39 mm in zooids from zone of change to 1.14 mm in abnormal zooids; width usually 0.54–0.57 mm, but ranging from 0.45 mm in zooids from zone of change to 0.78 mm in zooids preceding row bifurcations. Frontal wall ventricose, sloping evenly all round, including distal to the orifice, into the deep interzooidal furrows, the surface regularly and evenly coarsely granular, the raised granules tending to be arranged into polygons so that the overall surface appears dimpled; there is a very slight elevation of the frontal wall immediately proximal to the orificial region. Opesia-orifice transversely narrow, the proximal rim straight with no or vestigial indentations at the corners, the distal rim and lateral peristome raised, with irregular tuberculation or processes; no oral spines. Small interzooidal avicularia occur generally sporadically, each at the junction of three autozooids, narrow with a narrow acute rostrum orientated proximally in the direction of the furrow; no apparent crossbar or condylar ridges. Ovicells hyperstomial, somewhat cucullate, the lateral margins raised, relatively straight and somewhat converging, the proximal rim tending to project over the opesia-orifice; external calcification interpreted as endooecium, relatively smooth. Basolateral septular

communication pores set in narrow-buttressed recesses that simulate pore-chambers, budding intrazonoidal in the terminology of Lidgard (1985). Reparative budding common, and autozooids with reversed orientation or completely closed and often kenozooidal.

REMARKS. *Aspidostoma cinnabarina* has virtually all of the characters typical of the Recent subantarctic type species of the genus, except for its overall robustness because of thick calcification, and appears easily accommodated in the genus. The interzooidal avicularia of the type species have a separate opesial foramen and are orientated obliquely distally, but these characters may be relatively trivial at the genus level in *Aspidostoma*.

## Family CELLARIIDAE Fleming, 1828

Genus *CELLARIA* Ellis & Solander, 1786

TYPE SPECIES. *Farcimia sinuosa* Hassall, 1841, by synonymy (see Ryland 1968); Recent, NE Atlantic.

*Cellaria minus* sp. nov.

Figs 71–73

HOLOTYPE. IGNS BZ 193, from Pukekio, Chatham Island. No paratypes.

NAME: From the Greek, *minus*, little, small, short.

DESCRIPTION. Colony erect, evidently articulated in life, the internodes extremely slender, straight, 0.27–0.28 mm diameter. Autozooids alternating, in six longitudinal series, proportionately elongate and spindle-shaped longitudinally, tapering at both ends; length = 0.46–0.48 mm, width up to 0.22–0.24 mm across the widest part of the spindle. Zooidal boundaries defined by a common, thin, raised line of calcification. Cryptocystal surface evenly granular at low magnification, the granules looking like small tubercles at higher magnification. A shallow, longitudinally crescentic cryptocystal ridge occurs on each side frontally between the opesia-orifice and the lateral angle of the spindle, these converging but not uniting. The cryptocystal most sunken in the vicinity of the opesia-orifice is bean-shaped and wider (0.09 mm) than long (0.05–0.06 mm), with a short, truncate median convexity in the proximal rim. Orificial denticles or condyles not seen owing to occlusion of orifices by sediment in the unique specimen. Avicularia and ovicells not seen.

REMARKS. The unique holotype internode is well preserved but, owing to its fragility, broke in two when transferring from an SEM stub to the welled slide in which it now resides. The distal end, possibly eroded, nevertheless appears to represent a branch locus owing to the angles of zooids on opposing faces of the internode.

Although this species is represented by a single specimen that is both infertile and lacks polymorphs, it is named here because of its excellent preservation and its distinctively tiny size. Only four Tertiary *Cellaria* species have been reported from New Zealand before (Brown 1952). The present material corresponds to none of these, nor to any of the approximately 21 species described from the Australian Tertiary (see Maplestone 1904; Brown 1958 – note that some of the species listed by Maplestone are now recognisable as belonging to other cellariid genera), most of which are larger.

*Cellaria perexigua* sp. nov.

Figs 74, 75

HOLOTYPE. IGNS BZ 194–1, from Pukekio, Chatham Island.

PARATYPE. IGNS BZ 194–2.

NAME. From the Latin, *perexiguus*, very small.

**DESCRIPTION.** Colony erect, evidently articulated in life judging from the slight but abrupt tapering of the proximal end of the holotype specimen, the internodes very slender with subparallel sides, more-or-less straight, and with or without a barely discernible sigmoid flexure, 0.31–0.37 mm diameter. Autozooids alternating, in six longitudinal series, proportionately elongate but fish- not spindle-shaped, i.e., with the distal end convexly rounded and the proximal end concavely rounded; length = 0.39–0.47 mm, width up to 0.22–0.24 mm at the widest part of the zooid. Zooidal boundaries worn in the present material, with no discernible raised boundary lines. Cryptocyst as in *C. minus*, but the lateral ridges converging to become continuous distally. Opesia-orifice more-or-less D-shaped, as wide as that in *C. minus* but proportionately longer (0.07–0.08 mm), with a small rounded denticle on either side of the proximal rim (but not in the corners) and lacking a median convexity. Avicularia not seen. Ovicells present, the opening somewhat semicircular (possibly eroded) and slanting upwards at an angle so that the distal rim of ovicellate zooids is higher than in autozooids; internode a little wider in diameter where ovicellate zooids occur.

**REMARKS.** *Cellaria peregrina* is almost as diminutive as *C. minus* and is likewise distinguished from the other Cenozoic Australasian species on the grounds of very small size. It closely resembles *C. minus* but may be distinguished from it by the shape of the autozooid (not spindle-shaped), the distal convergence of the cryptocystal ridges, and the lack of a median convexity in the proximal rim of the opesia-orifice, instead having a pair of small, separated denticles.

***Cellaria elementaria* sp. nov.** Figs 76–78

**HOLOTYPE.** IGNS BZ 195–1, from Pukekio, Chatham Island.

**PARATYPES.** IGNS BZ 195–2; NHM BZ 4784–4785.

**NAME.** From the Latin, *elementarius*, pertaining to first principles, i.e., a very typical *Cellaria*.

**DESCRIPTION.** Colony erect, probably articulated in life, the internodes 0.74–1.14 mm in diameter, parallel-sided for part of their length, but tending to widen distally where ovicells occur. Autozooids alternating, in 13–15 longitudinal series, unevenly hexagonal in shape with the proximal and distal sides shorter than the lateral angles of the hexagon; length = 0.29–3.47 mm, width up to 0.20–0.34 mm at the widest part of the zooid. Cryptocyst granular, the cryptocyst ridges confined to the zooidal margins, with thin furrows between adjacent zooids. Opesia-orifice more-or-less D-shaped, relatively large in proportion to the sunken part of the cryptocyst which it resembles in size, a little wider (0.13–0.19 mm) than long (0.09–0.11 mm), the median proximal rim slightly produced as a thin crescent (concave in the middle) whose ends delimit slight opesial indentations at the corners of the orifice. Avicularia not seen. Ovicellate zooids 0.37–0.45 mm long including the ovicell (broken in the present material), whose diameter is a little smaller than that of the opesiae from which it is separated only by the thin distal wall of the zooid.

**REMARKS.** This unremarkable species appears not to be conspecific with any of the other Australasian Cenozoic members of *Cellaria*.

***Cellaria aff. depressa* Maplestone, 1900** Figs 79–81

aff. 1900 *Cellaria depressa* Maplestone, 1900: 167, pl. 18, fig. 15.

aff. 1904 *Cellaria depressa* Maplestone; Maplestone: 193.

**MATERIAL.** IGNS BZ 212–214, from Pukekio, Chatham Island; two internodes definitely conspecific, with a third, somewhat larger, internode probably also of this species.

**DESCRIPTION.** The two smaller internodes: colony erect and articulated in life, internodes 2.19–2.40 mm long, widest distally (0.65 mm diameter), tapering proximally (0.41–0.52 mm diameter). Autozooids in 9–10 longitudinal series, rounded distally, truncate proximally; length = 0.32–0.47 mm, width = 0.24–0.30 mm, widest at mid-length where the lateral margins are acutely angled. Zooidal boundaries in the slightly eroded specimens marked by a thin shallow groove. Cryptocyst sunken for much of its length in the smaller, less-eroded, specimen, less so in the other specimen, surface granular, the cryptocyst ridges converging to become continuous distally. Opesia-orifice at the deepest part of the cryptocyst, a little wider (0.09–0.11 mm) than long (0.06–0.08 mm), the proximal rim with a thin, median, crescent-shaped section where the two ends of the crescent are expressed as small denticles. Avicularia not apparent. Fertile zooids sparse, marked by a conspicuous cavity (the front evidently broken) immediately distal to the zooidal orifice.

Third internode somewhat more eroded, 2.81 mm long, with a diameter of 0.70–0.84 mm, and 13 longitudinal series of autozooids. Zooidal dimensions as in the two smaller internodes, the orifices have an identical proximal rim but are slightly higher-arched, and the broken ovicells have the same appearance. One zooid near the proximal end of the internode may have been aviculiferous; it has an inverse pear-shaped opesia sunken in the centre, surrounded by concentrically arranged calcification.

**REMARKS.** If the larger, third internode obtained from the Red Bluff Tuff is conspecific with the two smaller internodes then the Chatham Island specimens have many of the characters of *Cellaria depressa* Maplestone, 1900 from Shelford and Campbell's Point, Victoria (Miocene) (Maplestone, 1904). Using the magnification scale in Maplestone (1900), a *C. depressa* internode measures 1.02 mm diameter and the zooids are 0.50–0.59 mm long, i.e., larger than the Red Bluff Tuff specimens, but the width of zooids and orifices is the same. It is likely that the Chatham Island material is not conspecific with *C. depressa*, but more specimens (with more characters) are needed of both the Chatham Island and Australian populations for a definite conclusion to be reached.

**Genus *SMITTICELLARIA* gen. nov.**

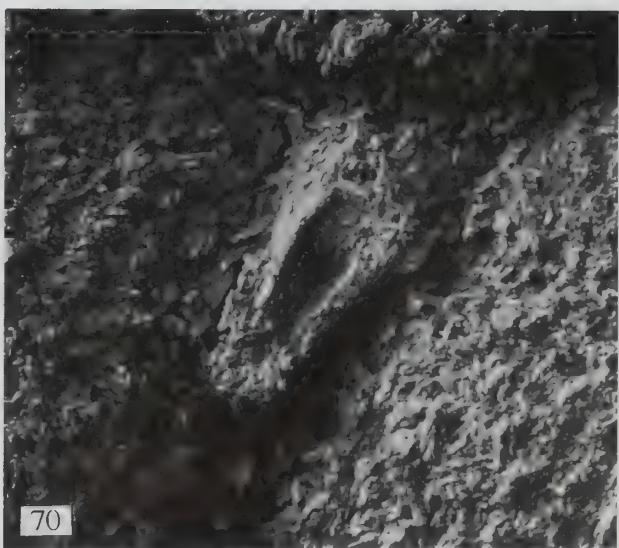
**TYPE SPECIES.** *Cellaria tectiformis* Hayward & Cook, 1979.

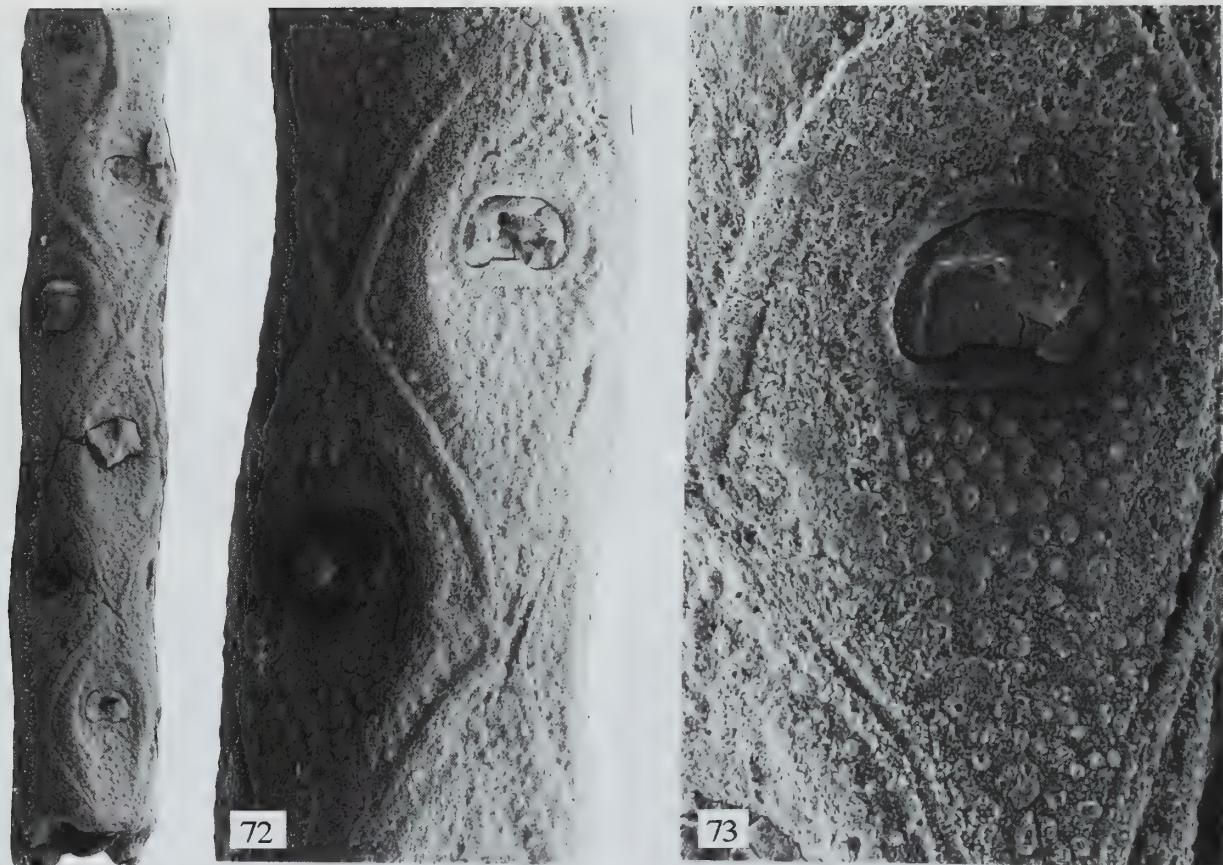
**DIAGNOSIS.** Colony erect, branching in one plane, unjointed or with secondarily developed fractures at bifurcations that are secured by frontally produced rhizoids. Autozooids *Cellaria*-like, with transversely bean-shaped opesia-orifices and proximal pivots. Avicularia vicarious, with one occurring on the upper side of each bifurcation and others scattered elsewhere. Ovicell with the opening small, occurring within the distal border of the maternal zooid.

**NAME.** The name is a composite of *Smittipora* and *Cellaria*, alluding to the combination of morphological characters of these genera.

**REMARKS.** As Hayward (1995) has remarked, the classification of

Figs 65–70 *Aspidostoma cinnabarinum* sp. nov., IGNS BZ 192, holotype. 65, disposition of autozooids and ovicellate zooids,  $\times 35$ . 66, autozooidal orifice,  $\times 290$ . 67, ovicellate zooids,  $\times 65$ . 68, ovicell,  $\times 170$ . 69, boundary between opposing zooids (some missing), some of which are incompletely formed,  $\times 32$ . 70, interzooidal avicularium,  $\times 250$ .





Figs 71–73 *Cellaria minus* sp. nov., IGNS BZ 193, holotype; 71, branch,  $\times 62$ ; 72, alternating zooids,  $\times 161$ ; 73, granular cryptocyst and opesia-orifice,  $\times 304$ .

the Cellariidae is unsatisfactory, both within the type genus *Cellaria* Ellis & Solander and among a number of other genera insofar as their limits are not well circumscribed. Beginning with Busk (1884), attempts have been made to segregate species of *Cellaria sensu lato* into informal, or even formal, groupings based on various combinations of autozooidal shape, method of branching, and size of avicularium. Hayward (1995) pointed out the limitations of some of these attempts, but *Cellaria* as presently circumscribed is too broad in relation to the characters of the northeastern Atlantic type species.

The following new species, although based on limited material, is regarded as sufficiently similar in branching and avicularian characters to Recent *Cellaria tectiformis* Hayward & Cook, 1979 as to justify the establishment of a new genus based on these two species. The characters are: (1) all branching in a single plane; (2) bifurcations lacking articulations or, if an articulation develops, it is based on a subsequent fracture (and securing of both sides of the fracture by frontally produced rhizoids); (3) axial vicarious avicularia; and (4) complete lack of any mandibular pivots, ridges, or condyles. It is possible that additional fossil species may be attributable to *Smitticellaria*: Maastrichtian-Danian *Vincularia microstoma* Mars-son, 1887 (Denmark and Germany) and Danian *Onychocella columella* Berthelsen, 1962 (Denmark and Germany) ought to be examined in this regard (see descriptions and illustrations in Berthelsen (1962) and Voigt (1987)).

Range. Thanetian to Recent.

#### *Smitticellaria morioriana* sp. nov.

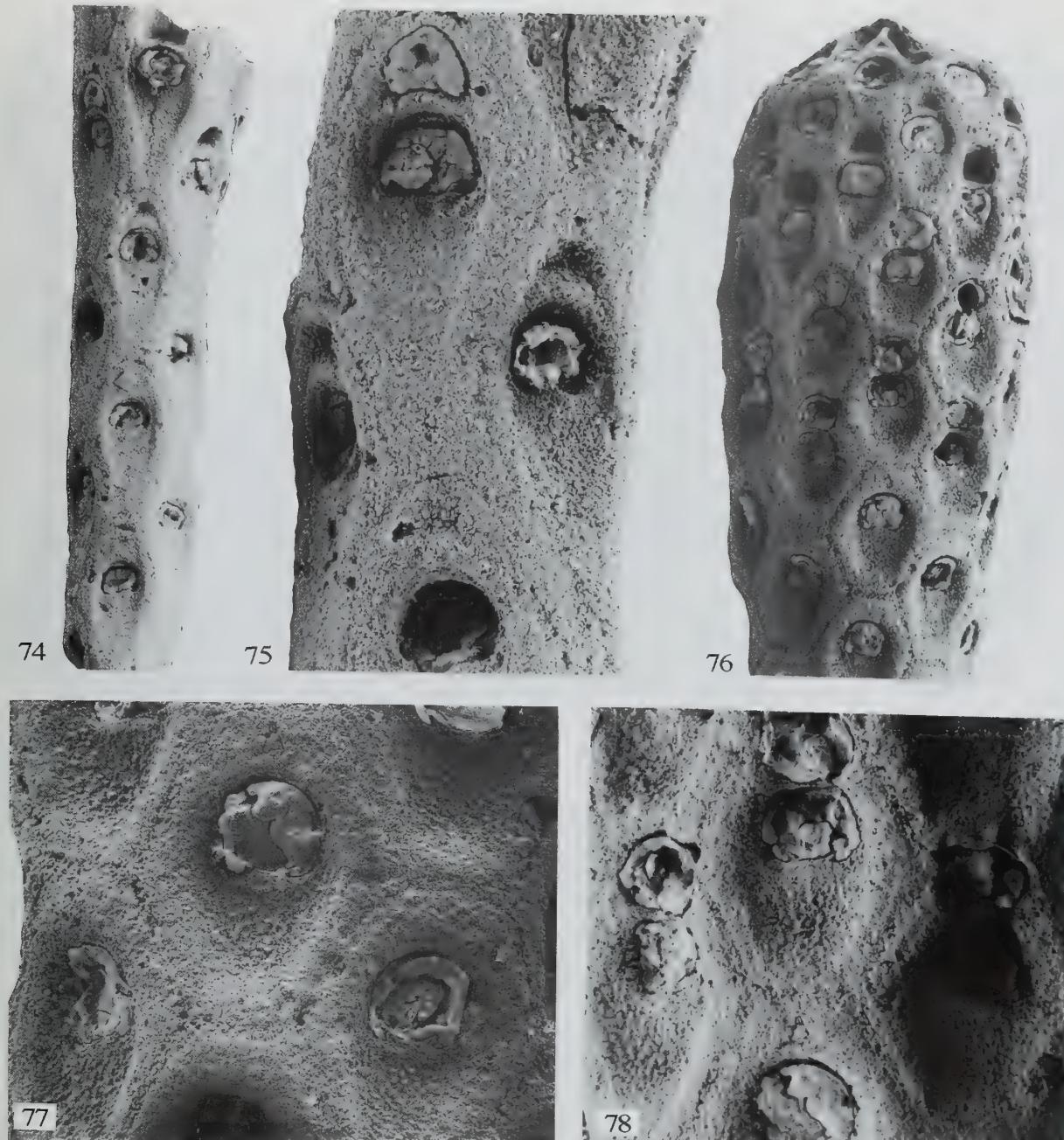
Figs 82–84

HOLOTYPE. IGNS BZ 196–1, from Pukekio, Chatham Island.

PARATYPES. IGNS BZ 196–2, 196–3, 196–4.

NAME. The name evokes the indigenous Polynesian inhabitants of the Chatham Islands, the Moriori.

DESCRIPTION. Colony erect, dichotomously branching, non-articulated, the stem and branches cylindrical, 0.33–0.49 mm in diameter. Autozooids alternating, disposed in 8 longitudinal series, reducing to 6 after a bifurcation, the boundaries evidenced by thin lines of calcification where well-preserved; shaped more-or-less like a 4-sided diamond with each corner acute or the distal and proximal ends very slightly rounded-truncate; length = 0.35–0.40 mm, width = 0.20–0.34 mm. Cryptocyst concave, more so towards the opesia-orifice, the surface minutely granular-tubercular where well-preserved. Opesia-orifice wider (0.09–0.10 mm) than long (0.06–0.07 mm), transversely bean-shaped, the proximal rim with an inversely crescentic part, the ends of which project as denticles. Vicarious avicularia occurring at a bifurcation in both the inner and outer angles; widest proximally, narrowing to a lingulate rostrum with an extensive palate and rounded tip; only a single subcircular foramen occurs in the centre of the avicularium. Ovicells with a small rounded opening occurring between the distal border and the opesia of the maternal zooid.



Figs 74–78 Species of *Cellaria*. 74–75, *Cellaria peregrina* sp. nov., IGNS BZ 194–1, holotype,  $\times 52$  and  $\times 135$  respectively. 76–78, *Cellaria elementaria* sp. nov., IGNS BZ 195–1, holotype; 76, distal end of internode showing widening diameter in the region of ovicelled zooids,  $\times 49$ ; 77, autozooids,  $\times 130$ ; 78, ovicellate zooids,  $\times 109$ .

**REMARKS.** *Smitticellaria morioriana* differs most notably from the nominated type species, *S. tectiformis*, in having 6–8 longitudinal zooidal series (instead of four), a concave proximal opercular rim, and a more lingulate avicularian rostrum.

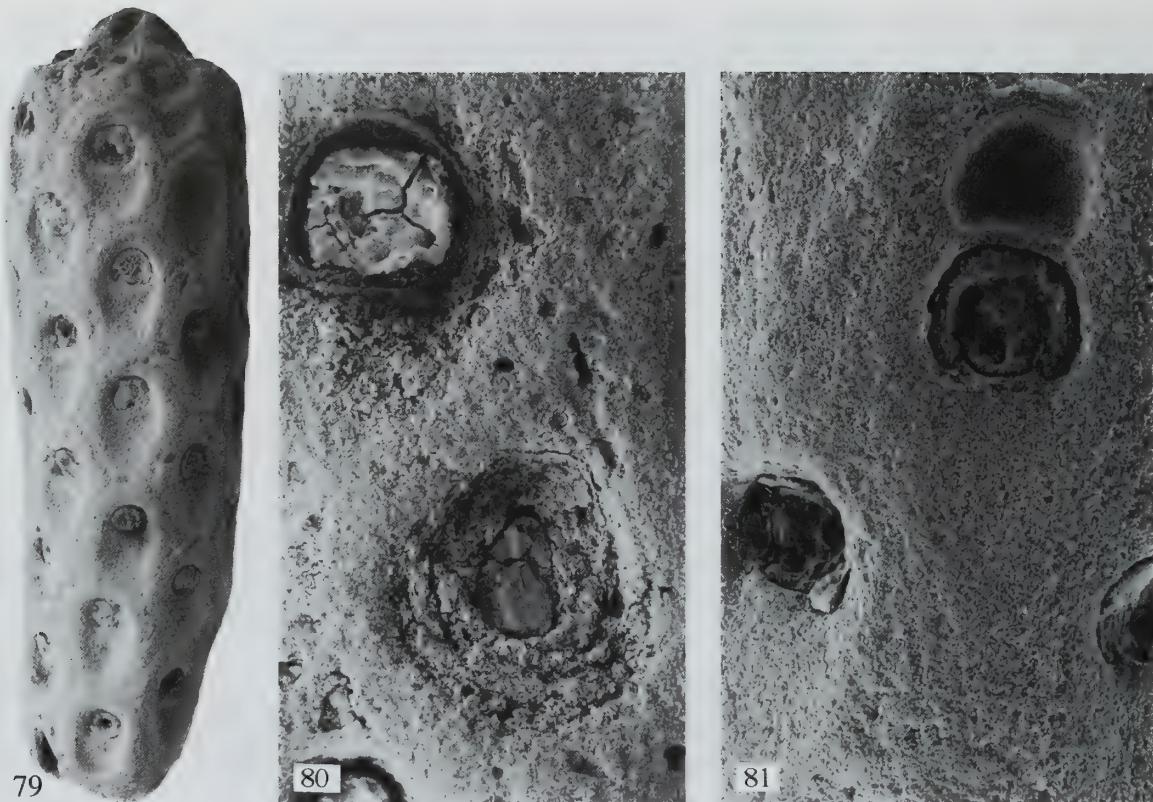
#### Genus *ESCHARICELLARIA* Voigt, 1924

**TYPE SPECIES.** *Escharicellaria polymorpha* Voigt, 1924, by monotypy; Senonian, Germany.

#### ?*Escharicellaria* sp.

Figs 85–87

**MATERIAL.** IGNS BZ 215, several specimens from Pukekio, Chatham Island.



Figs 79–81 *Cellaria cf. depressa* Maplestone, 1900, IGNS BZ 212. 79, internode,  $\times 50$ . 80, occluded autozooidal orifice and adjacent ?avicularium (lower right),  $\times 210$ . 81, orifice and cavity of an ovicell,  $\times 160$ .

**DESCRIPTION.** Colony erect, comprising proximally tapered, narrow bilamellar stems that periodically produce narrower side branches. The larger colony fragment is 1.60–3.00 mm wide, lensoidal in cross section, with side branches ca. 1.49–1.61 mm wide. Zoids regularly alternating such that opesia-orifices occur in straight oblique rows, interzoidal boundaries not clearly discernible; length = 0.52–0.75 mm, width = ca. 0.32 mm; cryptocyst depressed, sloping inwards to the external opesia-orifice which is more-or less D-shaped, 0.14–0.19 mm wide; primary orifice sunken, the proximal rim shallowly concave with narrow but distinct opesiular indentations at the corners. Avicularia not seen. Ovicells in the present worn material broken, indicated by relatively deep cavities, each immediately distal to the opesia-orifice and separated from it by the distal rim of the maternal zoid; these cavities almost twice the height (length) of the subjacent opesia-orifice.

**REMARKS.** The specimens of this bryozoan are not well-enough preserved to name as a new species, especially as some morphological characters are lacking, but the colony form is distinctive enough to allow recognition should additional material be found. It shares some of the attributes of erect bilamellar forms of *Aspidostoma* but the unequal mode of branching (not regular bifurcations) and form of the orifice are more suggestive of cellariid affinity.

#### Genus *MELYCHOCELLA* gen. nov.

TYPE SPECIES. *Melychocella cynura* sp. nov.

**DIAGNOSIS.** Colony erect, bilamellar, with somewhat hexagonal zooids arranged in continuous longitudinal series. Cryptocyst sunken, no ridges, the opesia-orifice wider than long with both proximal and distal condyles and small opesiular indentations. Scattered vicarious avicularia have rostral and opesial foramina. Ovicells large, the frontal surface not crossed by the outer angles of adjacent zooids.

**NAME.** The name is a composite of *Melicerita* and *Onychocella*, alluding to the combination of morphological characters of these genera.

#### *Melychocella cynura* sp. nov.

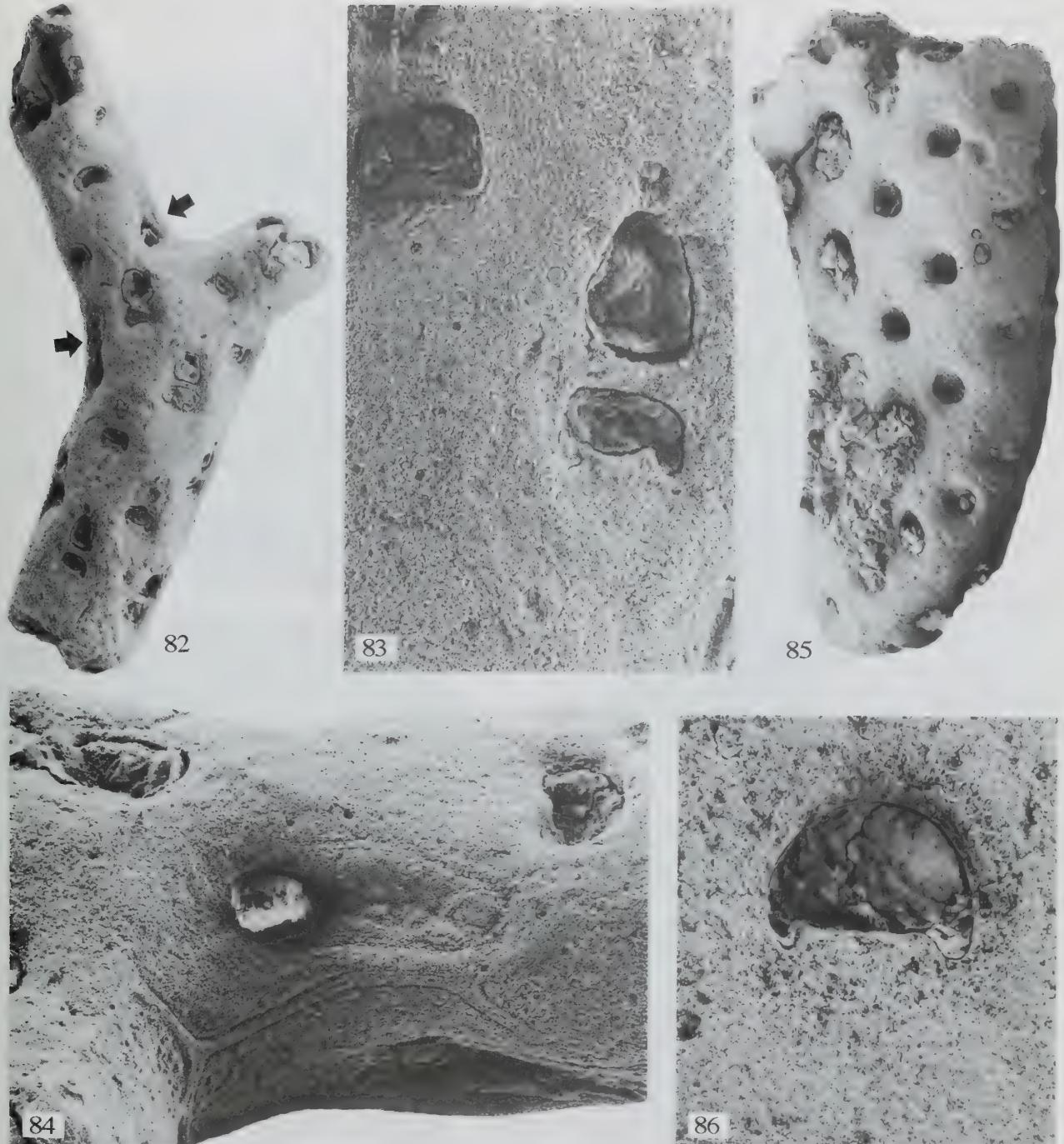
Figs 88–92

**HOLOTYPE.** IGNS BZ 197–1, from Pukekio, Chatham Island.

**PARATYPES.** IGNS BZ 197–2, 197–3, 197–4. NHM BZ 4786.

**NAME.** *Cynura* is a latinisation of the Greek *kynouron*, a sea-cliff, alluding to the type locality.

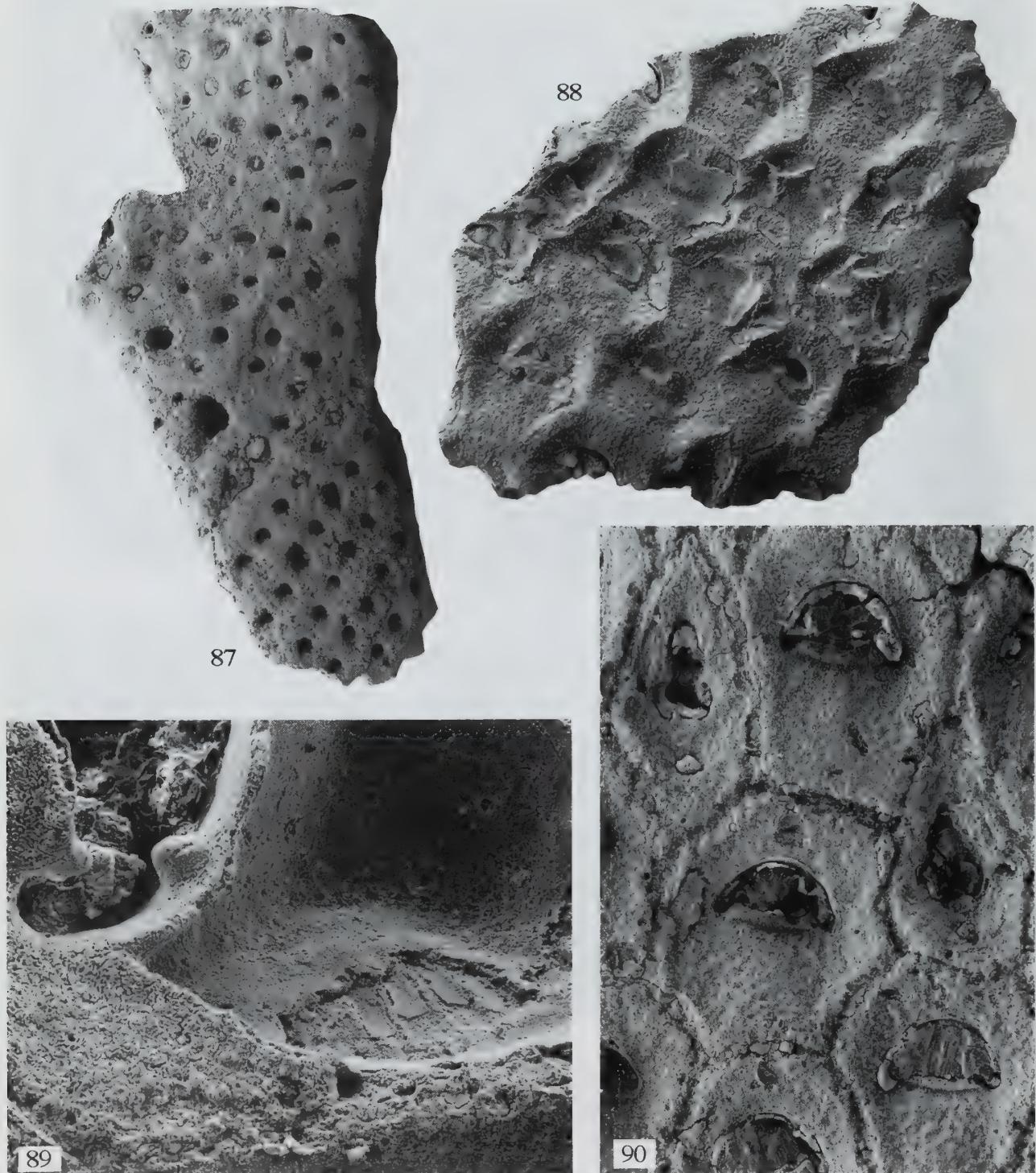
**DESCRIPTION.** Colony erect, bilamellar, 0.72–0.75 mm thick. Autozooids alternating, nearly hexagonal, averaging a little longer than wide (length = 0.44–0.56 mm, width = 0.37–0.52 mm) and clearly defined by the raised lateral margins, the longitudinal series continuous, not discontinuous. Cryptocyst completely sunken with no ridges, the surface distinctly granular. Opesia-orifice relatively large, wider (0.20–0.24 mm) than long (0.10–0.12 mm, as measured from middle to middle of each rim), with the corners extended a little proximally as rounded opesiular indentations, each being adjacent



**Figs 82–86** Cellariid cheilostomes. **82–84**, *Smitticellaria morioriana* sp. nov., IGNS BZ 196–1, holotype: **82**, part of colony, position of vicarious avicularia arrowed,  $\times 48$ ; **83**, ovicellate orifices,  $\times 209$ ; **84**, axillary vicarious avicularium,  $\times 169$ . **85–86**, *?Escharicellaria* sp., IGNS BZ 215; **85**, presumed small colony,  $\times 22$ ; **86**, autozooidal orifice,  $\times 173$ .

to a rounded condylar process; a pair of distal condyles oppose the proximal ones. Generally a transverse groove parallel to the proximal rim of the opesia-orifice. Vicarious avicularia mostly occurring at the bifurcation of a zooid row, sometimes merely replacing an autozooid in a longitudinal series, 0.46–0.52 mm long and 0.21–0.26 mm wide; in the best-preserved examples they are

granular-surfaced, widest at mid-length, with the rostrum parallel-sided before abruptly tapering acutely, the proximal end rounded; with a subtrifoliate palatal foramen and a very small circular or oval opesial foramen. Ovicells large, slightly recumbent on the distal zooid, the ovicellular chamber deep though not reaching the level of the basal walls of the maternal and distal zooids; frontal surface



**Figs 87–90** Cellariid cheiostomes. **87**, *?Escharicellaria* sp., IGNS BZ 215, moderate-sized colony fragment with the proximal end of a broken branch at left,  $\times 13$ . **88–90**, *Melychocella cynura* sp. nov.; **88**, IGNS BZ 197–2, autozooids and avicularia; note granularity of cryptocyst,  $\times 43$ ; **89**, IGNS BZ 197–3, part of ovicelled orifice showing proximal and distal denticles, and fabric of ovicell walls,  $\times 270$ ; **90**, autozooids and avicularia, IGNS BZ 197–1, holotype,  $\times 88$ .

unknown owing to loss through breakage, but apparently not crossed by the angles of adjacent zooids, the opening separate from the opesia-orifice.

**REMARKS.** This striking species represents a new genus of Cellariidae. It appears closest to *Melicerita* Edwards *sensu stricto* from which it differs, however, in the occurrence of elongate vicarious avicularia with separate rostral and opesial foramina, and much larger combined female zooid and ovicell. As presently constituted, the genus *Melicerita* appears to need splitting. The Pliocene type species, *M. charlesworthii* Morris, 1843, has vicarious avicularia, with a large longitudinally oval foramen and no pivots, scattered throughout the colony; the ovicell is relatively small with no elaboration of calcification either side of the opening, and the opesia-orifices are not dimorphic (see Bishop 1987). Recent Tierra del Fuegian *M. temaukeli* Moyano, 1997 shares a number of characters with the type species. Antarctic *Melicerita latilaminata* Rogick, 1956 and *M. flabellifera* Hayward & Winston, 1994 have similar features, except that the avicularian foramen in both species has a proximal sinus either side of which is a shoulder for pivoting of the mandible. These latter two species could possibly be regarded as constituting a subgeneric clade within *Melicerita*. Several Australasian species (*M. angustiloba* Tenison-Woods, 1862, *M. chathamensis* Uttley & Bullivant, 1972, *M. knoxi* Uttley & Bullivant, 1972, *M. ejuncida* Gordon, 1986) have smaller, interzooidal avicularia confined to the lateral margins of the colony and the fertile zooids have dimorphic orifices with a complex pattern of surface calcification adjacent to the opening, sometimes with perforations. These species may constitute another subgeneric clade, to which should be added Antarctic *M. obliqua* (Thornely, 1924) and *M. blancoae* López Gappa, 1981 (which lack avicularia), and *M. digeronimoi* Rosso, 1992, all three of which lack dimorphic orifices but have the complex surface calcification. *Melicerita atlantica* Busk, 1884 and *M. antarctica* d'Hondt, 1984 (which may be conspecific – see Rosso 1992) differ in too many features to be included in *Melicerita sensu stricto*.

Suborder ASCOPHORINA Levensen, 1909

Family ARACHNOPUSIIDAE Jullien, 1888

Genus ARACHNOPUSIA Jullien, 1888

TYPE SPECIES. *Lepralia monoceros* Busk, 1854, by original designation; Recent, Patagonia.

*Arachnopusia gracilis* sp. nov.

Fig. 93

HOLOTYPE. IGNS BZ 198, from Pukekio, Chatham Island. No paratypes.

NAME. From the Latin *gracilis*, slender, alluding to the narrow bilamellar stem.

DESCRIPTION. Colony erect, gracile, with thin bilamellar stem 0.93–1.22 mm wide. Autozooids arranged more or less quincuncially, each being surrounded by 5–7 others; length = 0.37–0.60 mm, width = 0.14–0.24 mm; interzooidal boundaries merging and not clearly defined. Frontal shield more-or-less evenly perforated by 15–20 small, simple, circular to subcircular or oval foramina. Orifice 0.09 mm wide, somewhat bean-shaped owing to a median convexity of the proximal rim; peristome low (or eroded), the entire colony surface being relatively flat. No trace of distal or intraoral spines or spine bases. In interzooidal areas and/or distal to some orifices are small polymorphs; these appear to be kenozooids, but some may

correspond to avicularia; of variable shape from oval to distally acute, with an inwardly sloping shelf of uniform width surrounding the central opesia, also of varying shape. Ovicells not apparent.

**REMARKS.** Only two other species attributed to *Arachnopusia* are known from the New Zealand Tertiary: *A. unicornis* (Hutton, 1873), ranging from Otaian (Lower Burdigalian) to Recent, and *A. bugei* Brown, 1952, occurring only in the Waiauan (Serravallian), Southland Series (Gordon *et al.*, 1994). *Arachnopusia unicornis* is known to produce erect bilamellar colonies from an encrusting base but they are broad and foliaceous, the zooids have fewer, larger foramina, and the aviculariferous proximal rim of the peristome is less convex (Gordon 1989b). From SEM examination of the holotype specimen, *Arachnopusia bugei* appears not to belong to this genus at all – it lacks foramina in the centre of the shield. The combined characters of the shield and proximal 1–2 intraoral avicularia (not spine bases as interpreted by Brown) suggest inclusion in the Desmacystidae or Rhamphostomellidae (see Gordon & Grischenco 1994).

#### Family KLEIDIONELLIDAE Vigneaux, 1949

##### Genus PAVOBIESELINA Voigt, 1964

TYPE SPECIES. *Eschara oblita* Kade, 1852, by original designation; Paleocene, Germany.

?*Pavobeisselina* sp.

Figs 94, 95

MATERIAL. IGNS BZ 216, a unique specimen from Pukekio, Chatham Island.

DESCRIPTION. Colony small, fan-shaped, bilamellar, evidently attached by rootlets in life; height of incomplete colony 3.6 mm; maximum width 4.1 mm; thickness 0.48–0.56 mm, being thicker towards base. Zooids appear to be arranged quincuncially based on the distribution of peristomial orifices but there are no zooidal boundaries at the colony surface; length = 0.41–0.47 mm (measured in longitudinal section on fractured part of colony), width not readily determinable. Peristomial orifices circular or subcircular, 0.14–0.17 mm in diameter, flush with colony surface. Other perforations comprise areolar pores (variable diameter); possible avicularia, lacking a crossbar but with a narrow concentric shelf below the surface; and the openings of possible spiraminal tubes, but, as is typical of this and related genera, the identity of the perforations is difficult to determine from their surface distribution alone.

**REMARKS.** The family and genus attributions are uncertain. One of us (DPG) has examined by SEM external and internal colony surfaces in the type species of *Kleidionella* Canu & Bassler, *Beisselina* Canu, and related genera of equivalent age. *Kleidionella* and *Beisselina* form erect colonies, often quite robust, from an encrusting base. Both genera have planar-spherulitic microstructure on the inner surface of the frontal shield; *Beisselina* has a characteristic suboral spiraminal pore and tube, lacking in *Kleidionella*. *Beisselina*, *Pavobeisselina*, *Pseudobieisselina* Wiesemann, *Beisselinopsis* Voigt, and a number of other Late Cretaceous-Paleogene genera have traditionally been attributed to the family Porinidae, but, based on an examination of the frontal shield of the Recent type species *P. gracilis* (Lamarck), *Porina* is characterised by a lepraliod ('cryptocystidean') frontal shield. Thus the so-called ascopore in *Beisselina* (see Wiesemann, 1963) is technically a spiramen since it does not open into a compensation sac. As indicated by Pouyet (1973), *Kleidionella* has some of the characters of several celleporiform genera (umbonuloid shield, large avicularia with cross-



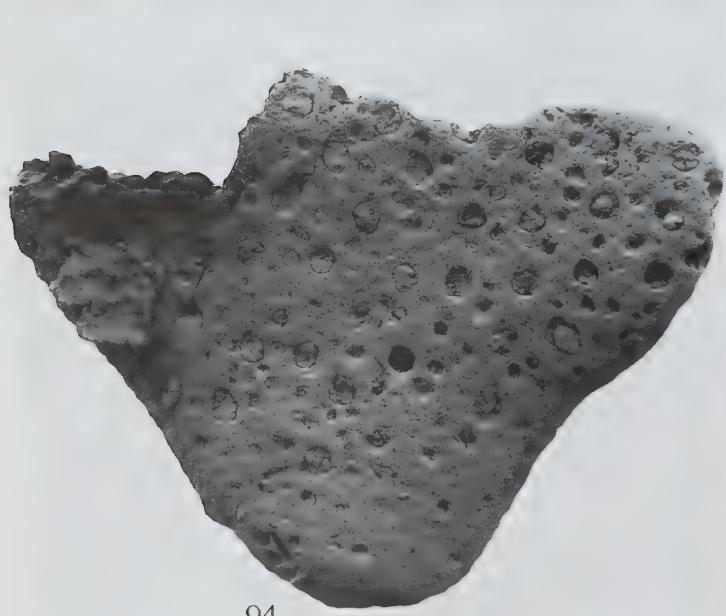
91



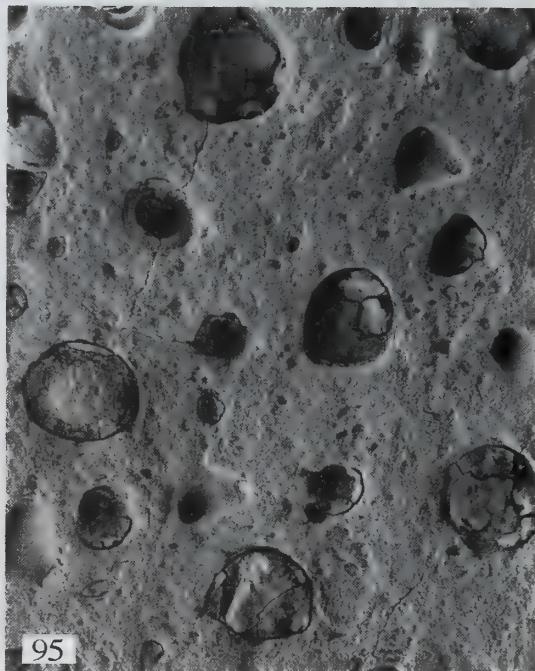
92



93



94



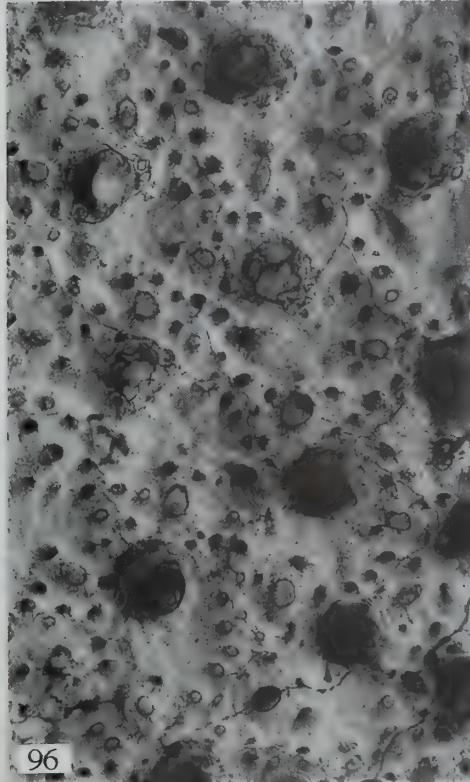
95

**Figs 91–95** Cheilostomes. **91–92**, *Melychocella cynura* sp. nov., IGNS BZ 197–4; **91**, autozooids, avicularia, and ovicellate zooids,  $\times 56$ ; **92**, vicarious avicularium,  $\times 193$ . **93**, *Arachnopusia gracilis* sp. nov., IGNS BZ 198, holotype: autozooids,  $\times 70$ . **94–95**, *?Pavobeisselina* sp., IGNS BZ 216; **94**, bilamellar colony, tapering proximally,  $\times 19$ ; **95**, zooidal orifices and other perforations on the colony surface,  $\times 79$ .

bars), but the surface expression of the peristomial orifices, areolar pores, and range of avicularian sizes of *K. grandis* Canu & Bassler has much in common with that of *Beisselina*. *Kleidionellidae* Vigneaux is therefore used here rather than create a separate family for *Beisselina* and similar forms.

*Beisselina* has not previously been associated with *Kleidionella* and the two genera would not historically have been associated because of the lack of a spiramen in the latter. The presence/absence of a spiramen need not require segregation at the family level, however, as evidenced by the following genus pairs: *Beisselina* / *Pseudobeisselina*, and *Beisselinopsis* / *Pavobeisselina*. *Pseudobeisselina compressa* (Goldfuss), type and only species of the genus,

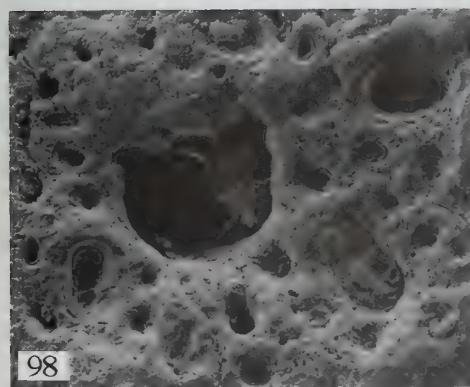
was formerly classified in *Beisselina* until it was discovered that it lacks an ‘ascopore’ – ‘Sinus oder Spiramen, keine Ascopore’ (Wiesemann, 1963: 51). *Beisselinopsis* and *Pavobeisselina* both have rooted fan-shaped colonies (by which they differ from *Beisselina*) but the former lacks a spiramen and the latter has one. In umbonuloid-shielded cheilostomes, however, it is a relatively simple matter to convert a peristomial pseudosinus into a spiraminal tube (this is how a spiraminal tube is formed ontogenetically) and there appears to be no intrinsic reason why, if other morphological characters conform, apparently related genera should be segregated on the basis of the spiramen alone. Traditionally, a pore associated with a peristome has been termed a spiramen, whereas a pore more



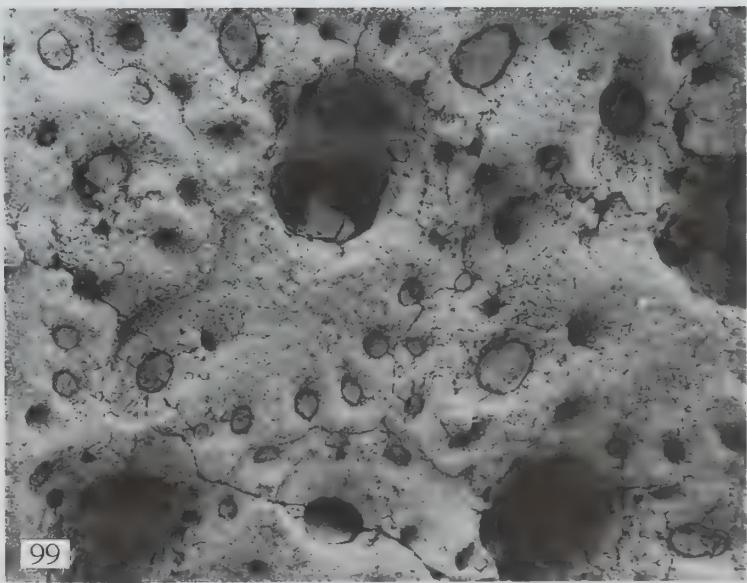
96



97



98



99

Figs 96–99 *Hippopleurifera australis* sp. nov. IGNS BZ 199, holotype. 96, disposition of zooids,  $\times 58$ . 97, autozooids; note the appearance of paired spine bases at the sides of the orifices,  $\times 106$ . 98, avicularia adjacent to the orifice (distal is towards the bottom of the photo),  $\times 119$ . 99, autozooids; note the areolar pores in the steeply descending cormidial orifices,  $\times 116$ .

proximally placed in the frontal shield has been called an ascopore (hence Wiesemann's distinction), but in umbonuloid-shields this positional distinction has not the same relevance.

The presence of spiraminal openings in the Red Bluff Tuff specimen is equivocal on the basis of the surficial distribution of perforations. Although it was possible to view the proximal part of the frontal-shield interior of some zooids at the fractured colony edge, a more distally occurring inner spiraminal opening would have been missed. Thus the specimen may lack spiramina, in which case it could be included in *Beisselopsis*. Voigt (1964: 452) describes young zooids in the type species, *B. hiltermanni* Voigt, as 'perforated by a considerable number of pores (?tremopores)' (see also Voigt 1962). More and better-preserved specimens from the Red Bluff Tuff are needed to settle the matter of generic assignment. Both of these genera are otherwise known only in the European Danian-Montian.

The French Paleocene species *Beisselina bigeyae* Braga & Bignot, 1986, shows some similarities with ?*Pavobeisselina* sp. but has smaller orifices.

#### Family ROMANCHEINIDAE Jullien, 1888

#### Genus HIPPOPLEURIFERA Canu & Bassler, 1925

TYPE SPECIES. *Eschara biauriculata* Reuss, 1848, by monotypy; Badenian (= Langhian (Serravallian), Eisenstadt, Austria (see Hastings 1966: 73).

REMARKS. *Hippopleurifera* is generally included in the family Umbonulidae (e.g., Hastings 1949; Bassler 1953; Cheetham 1968; David & Pouyet 1974; Schmid 1989); however, the occurrence of laterally emplaced avicularia (when present), general appearance of the frontal shield, and ovicellular calcification skeletally continuous with that of the frontal shield are much more characteristic of the closely related family Romancheinidae (cf. the genera *Escharoides* Edwards and *Exochella* Jullien).

#### *Hippopleurifera australis* sp. nov. Figs 96–99

HOLOTYPE. IGNS BZ 199, from Pukekio, Chatham Island. No paratypes.

NAME. From the Latin *australis*, southern, alluding to the first occurrence of this genus in the Southern Hemisphere.

DESCRIPTION. Colony encrusting. Autozooids arranged more-or-less quincuncially and as wide as long or longer; length = 0.26–0.47 mm, width = 0.46–0.56 mm; the interzooidal boundaries indicated by thin irregular suture lines that are difficult to see by light microscopy. Frontal shield centrally imperforate with numerous, fairly conspicuous areolar pores; these generally in one row around the margins but in places encroach 2–3 deep onto the frontal shield. Primary orifice sunken, with the distal oral shelf visible at a deeper level; secondary orifice generally a little wider (0.15–0.19 mm) proximally than distally, the proximal rim concave, gently convex, or more or less straight, generally with a spine base visible on each side. Secondary orifice cormidial, the distal rim being contributed by 1–2 distal zooids whose proximal edges descend to distal rim of primary orifice, above which is often a pair of areolar pores. Larger pores/foramina in frontal shield, either laterally, proximally, or interzooidally, have an inwardly sloping rim surrounding a central opesia – these are interpreted to be kenozooids or simple avicularia. Ovicells not seen.

REMARKS. This species accords well with the characters of

*Hippopleurifera*, as exhibited by the range of species attributed to this genus. The type species (clarified by Hastings 1966), *H. biauriculata*, has multiple areolar pores that give the frontal shield a more porous appearance than in most of the other species in the genus, but otherwise shield structure is probably umbonuloid in all of them. According to published descriptions, the type species lacks oral spines, but these are present in Recent *H. pulchra* (Manzoni) and several fossil species (Hastings 1949; Cheetham 1966). The genus is well represented in the European Tertiary, with as many as nine species occurring in the Badenian (Langhian-Serravallian) of Austria alone (Vávra 1977). The earliest-known occurrence of the genus was that of *H. canui* Cheetham, 1966 from the Lutetian of Sussex and southwest France, now antedated by *H. australis*, which is also the first record of the genus from the Southern Hemisphere.

#### Genus EXOCHELLA Jullien, 1888

TYPE SPECIES. *Mucronella tricuspidis* Hincks, 1881; Recent, Australia.

#### *Exochella?* *gracilis* sp. nov.

Figs 100, 101

HOLOTYPE. IGNS BZ 200, a single fragment from Pukekio, Chatham Island.

NAME. From the Latin *gracilis*, slender, referring to the erect, gracile colony form.

DESCRIPTION. Colony erect, forming gracile, bilamellar stems 0.80–1.23 mm wide, lensoidal in cross-section. Autozooids alternate in 2 longitudinal series on each side of the stem, separated by another series along each margin; length = 0.64–0.76 mm, width = 0.35–0.47 mm. Frontal shield increasing in convexity from the proximal end towards the orifice, the surface relatively smooth with 6–7 conspicuous areolar pores along each margin and 1–3 proximally. Orifice obscured by sediment, wider (0.18–0.22 mm) than long, the proximal rim possibly straight or gently concave. No oral spines. In some zooids, one of the midlateral areolar pores is larger than the others with an inwardly sloping rim surrounding an oval foramen; it appears to be directed outwards laterally and may be an avicularium. No ovicells present.

REMARKS. Owing to occlusion of the orifice by sediment particles it is difficult to be certain concerning generic and even familial attribution. The presence of a very convex frontal shield suborally and an apparent lateral avicularium allows inclusion in the Romancheinidae and possibly the genus *Exochella* (cf. Hayward 1995: Fig. 137E). More material is needed for confirmation.

#### Genus ESCHAROIDES Milne Edwards, 1836

TYPE SPECIES. *Cellepora coccinea* Abildgaard, 1806; Recent, North Atlantic.

#### *Escharoides?* *crassa* sp. nov.

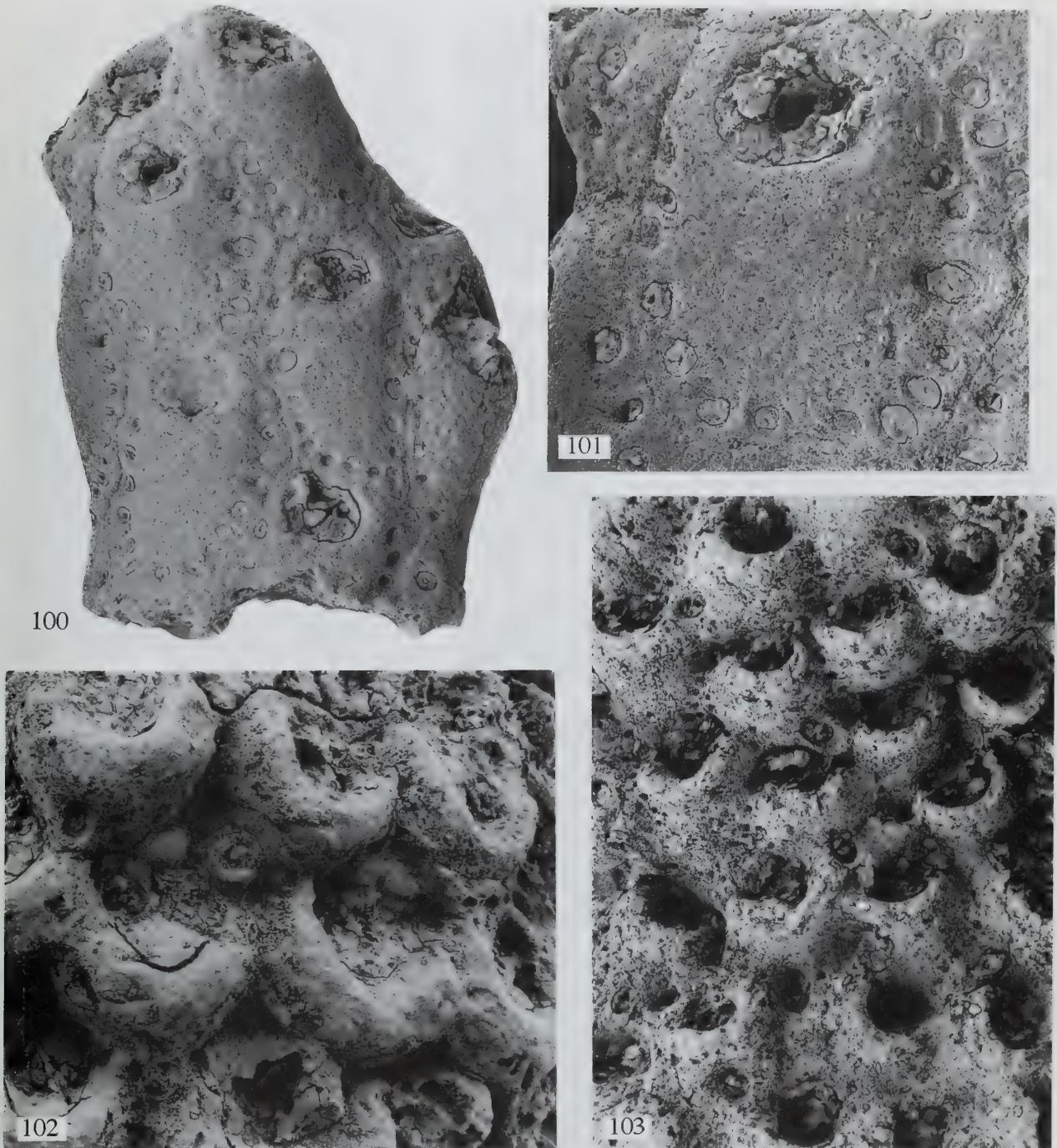
Figs 102, 103

HOLOTYPE. IGNS BZ 201, from Pukekio Hill, Chatham Island.

PARATYPE. NHM BZ 4787.

NAME. From the Latin, *crassus*, thick, referring to the thick frontal shield and peristome.

DESCRIPTION. Colony encrusting. Autozooids robust, length = 0.65–0.84 mm, width = 0.50–0.67 mm. Frontal shield thick-walled, imperforate except for marginal areolar pores, rising to the broadest

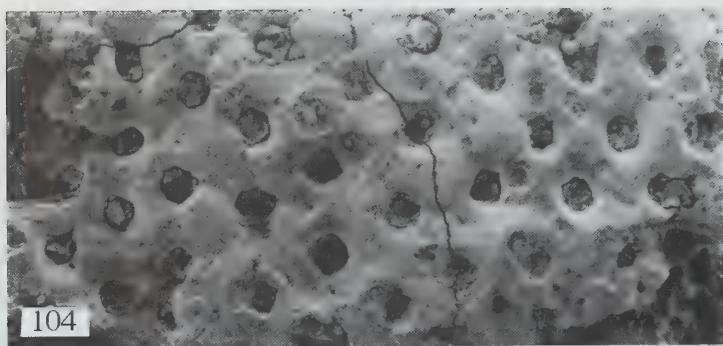


**Figs 100–103** Romancheinid cheilostomes. **100–101**, *Exochella?* *gracilis* sp. nov., IGNS BZ 200, holotype; **100**, zooids in bilamellar fragment,  $\times 62$ ; **101**, autozooid; probable avicularium at middle right of zooid,  $\times 124$ . **102–103**, *Escharoides?* *crassa* sp. nov., IGNS BZ 201, holotype; **102**, disposition of thick-peristomed autozooids and adventitious avicularia,  $\times 54$ ; **103**,  $\times 30$ .

part of the zooid where there is a high scoop-like peristome that surrounds a more-or-less distally facing secondary orifice. Primary orifice occluded by sediment, details not known. No oral-spine bases. Frequently an avicularium adjacent to one corner of the peristome, 0.18–0.24 mm long, elongate-oval with a rounded rostrum that slopes steeply inwards to a narrow palate, the avicularium

not as wide proximally; the preservation is inadequate to indicate whether there may have been a crossbar. Ovicells not present.

**REMARKS.** The generic attribution is uncertain. The species is most reminiscent of Recent *Escharoides angela* (Hutton, 1873) which also has a conspicuous scoop-like peristome. The origin of the



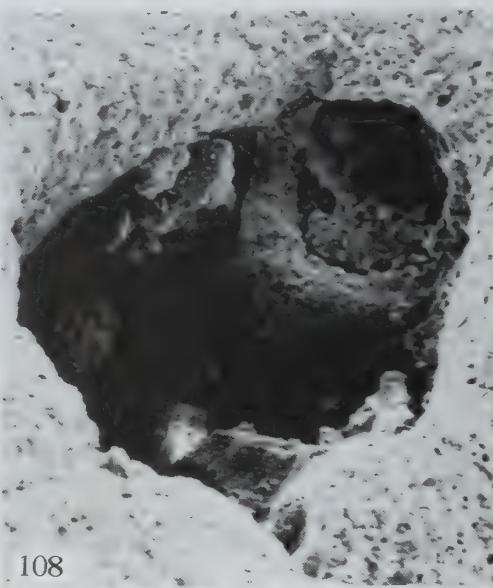
104



106



105



108



107

**Figs 104–108** Ascophoran cheilostomes. **104–106**, *Lepraliellid* sp. 1, IGNS BZ 217; **104**, disposition of autozooids,  $\times 32$ ; **105**, lingulate adventitious avicularia and adjacent zooidal orifices,  $\times 193$ ; **106**, zooidal orifices and a concavity probably indicating the position of a former hyperstomial ovicell,  $\times 154$ . **107–108**, *Chataimulosia primaeva* sp. nov., IGNS BZ 202, holotype; **107**, ovicelled zooids,  $\times 112$ ; **108**, peristomial orifice, showing median suboral avicularium with crossbar, and position of primary orifice at a deeper level,  $\times 470$ .

avicularium in *E. crassa* is equivocal, however. In species of *Escharoides*, one or a pair of lateral-oral avicularia occurs adjacent to the peristome. In the present material the single avicularium could have been budded from an areolar septula pore adjacent to the

peristome or, what appears more likely, from a septular pore in the proximal part of the shield of the distal zooid. *Escharoides* species typically have oral spines but there is no trace of oral-spine bases in the poorly preserved material at hand.

## Family LEPRALIELLIDAE Vigneaux, 1949

Genus *INCERTAE SEDIS**Lepraliellid* sp. 1

Figs 104–106

MATERIAL. IGNS BZ 217, from Pukekio, Chatham Island.

DESCRIPTION. Colony encrusting. Autozooids porcellanous, arranged somewhat irregularly with no discernible boundaries and even zooidal orientation is somewhat difficult to determine; length ca. 0.43 mm. Frontal shield convex, smooth-surfaced, imperforate except for tiny, sparsely distributed pores assumed to communicate with areolar septular pores. Peristomial orifice irregular in shape, often as wide as long and subrounded, the primary orifice occluded and concealed. No oral spine bases. Avicularia sparsely distributed, relatively large and more or less lingulate, the broad, rounded rostrum slightly broadening distally and with an extensive flat palate; there is a relatively large central foramen where the avicularium is slightly indented, and a narrow opercular shelf proximally; no evidence of a crossbar or distinct mandibular pivots. No complete ovicells present, but an excavation distal to one orifice appears to represent the inner endoecial surface of a hyperstomial ovicell unable to have been closed by the zooidal operculum.

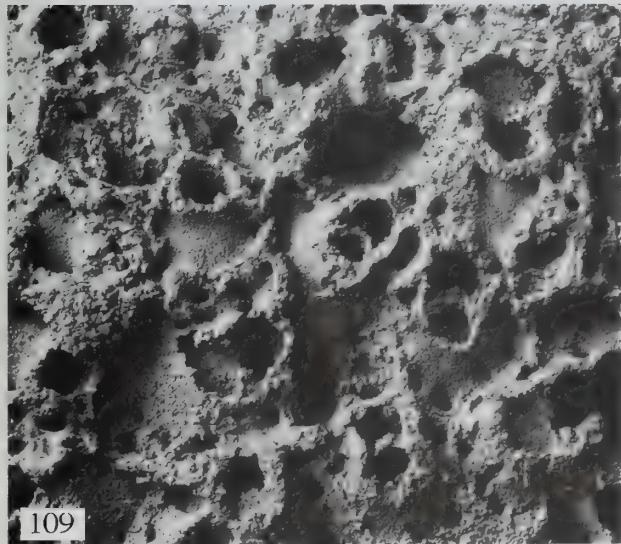
REMARKS. The generic affinities of the sole specimen are presently indeterminable.

*Lepraliellid* sp. 2

Figs 109, 110

MATERIAL. NHM BZ 4788, IGNS BZ 218, two 'bryoliths' from Pukekio, Chatham Island.

DESCRIPTION. Colony self-encrusting, multilamellar, forming free 'bryoliths' around a presumed nucleus (a small gastropod shell evident in one eroded colony). Autozooids relatively small, arranged irregularly, with merging boundaries; length = 0.33–0.37 mm, width = 0.28–0.30 mm. Frontal shield convex, more-or-less smooth-surfaced, imperforate except for 8–9 conspicuous areolar pores around the margin. Peristomial orifice about as wide as long (both 0.09–



Figs 109–110 *Lepraliellid* sp. 2, NHM BZ 4788; 109, zooids visible on abraded colony surface,  $\times 70$ ; 110, secondary orifice and chamber of median suboral avicularium,  $\times 300$ .

0.10 mm), the lateral margins continuous with the sides of a median suboral avicularium (broken in all zooids), the primary orifice at a deeper level and apparently with a straight proximal margin. Distal oral spine bases not readily apparent. Chamber of suboral avicularium broad, extending to a septular pore on either side. Ovicells not identifiable.

REMARKS. Only the larger of the two colonies is sufficiently well-preserved to show details of zooidal morphology. In overall appearance the colony and zooids are very typical of celleporids and many lepraliellids. The species is not determinable to genus, however, and is provisionally included here in the Lepraliellidae on the basis of the apparently straight proximal rim of the primary orifice. The lack of an orificial sinus suggests that the frontal shield might be umbonuloid in structure.

## Family BUFFONELLODIDAE Gordon &amp; d'Hondt, 1997

Genus *CHATAIMULOSIA* gen. nov.

TYPE SPECIES. *Chataimulosia primaeva* sp. nov., by monotypy; latest Teurian-Waipawan (latest Thanetian (earliest Ypresian), Chatham Island, New Zealand.

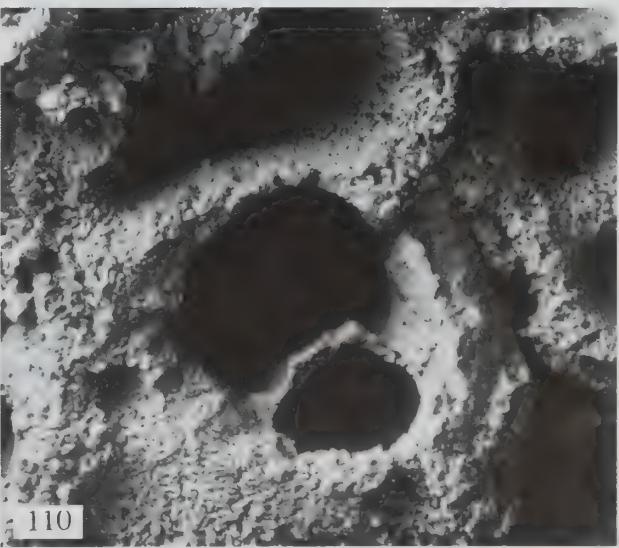
DIAGNOSIS. Colony encrusting. Autozooids with a smooth, imperforate frontal shield lacking areolar septular pores. Primary orifice sunken, the proximal rim straight, lacking a lyrula or denticle. Secondary orifice with a median suboral avicularium with crossbar. No oral spines. Ovicell hyperstomial, recumbent, smooth and imperforate with its calcification merging into that of the succeeding frontal shield.

NAME. A combination of Chatham and *Aimulosia*, a genus of Buffonellodidae.

*Chataimulosia primaeva* sp. nov.

Figs 107, 108

HOLOTYPE. IGNS BZ 202, from Pukekio, Chatham Island. No paratypes.



NAME. From the Latin *primaevus*, early, alluding to the earliest occurrence of the genus and family.

DESCRIPTION. Colony encrusting. Autozooids arranged regularly quincuncially, the interzooidal boundaries indicated by thin suture lines; length = 0.46–0.56 mm long, width = 0.22–0.36 mm. Frontal shield centrally imperforate, rather smooth, with no apparent areolar pores. Primary orifice somewhat sunken, the proximal rim more-or-less straight without either sinus or median convexity. Secondary orifice in most zooids longer than wide with a small, semi-concealed suboral avicularium below its proximal rim; avicularium circular with a complete crossbar. No oral spines. Ovicell hyperstomial, somewhat recumbent on the succeeding zooid, the external surface smooth and imperforate, the proximal margin defined by extensions of the lateral zooid margins that pass across it; secondary orifice of ovicellate zooids subpyriform.

REMARKS. This monotypic genus shares a number of characters with Miocene-Recent *Aimulosia* Jullien, 1888 (see Gordon 1989b; Hayward & Thorpe 1990). Significant differences include the lack of marginal areolar pores, sunken primary orifice, lack of median lyrula or denticle, lack of oral spines, and extensions of the lateral wall that cover the proximal rim of the ovicell. Collectively, these are deemed adequate for the recognition of a new genus. *Chataimulosia primaeva* is the earliest-known species of the austral family Buffonellodidae.

## DISCUSSION

Paleogene southern hemisphere bryofaunas are relatively poorly known so the likelihood of range extensions and new taxa is correspondingly high. Such is the case with the Red Bluff Tuff Bryozoa. Of the 22 species with characters adequate for the application of species names, 21 are new and the remaining species is equivocal, hence local and regional endemism are very high. Three genera are new – *Melychocella*, *Smitticellaria* (Cellariidae) and *Chataimulosia* (Buffonellodidae), the latter comprising the earliest occurrence of the Buffonellodidae, the only family in the collection representative of a ‘cryptocystidean’ frontal shield. Forward range extensions include *Flustrellaria*, *Inversaria*, and possibly *Escharicellaria* and *Pavobeisselina*. Backward range extensions include *Cinctipora* and Cinctiporidae (discounting the possible *Cinctipora* from the Late Cretaceous of South Africa), and *Akatopora*. Newly recorded for the southern hemisphere are *Flustrellaria*, *Inversaria*, *Hippopleurifera*, and possibly *Hoplitaechmella*, *Escharicellaria* and *Pavobeisselina*.

The overall taxonomic character of the bryofauna is mixed, both geographically and temporally, with genera reminiscent of northern hemisphere Maastrichtian and Danian bryofaunas co-occurring with families like Arachnopusiidae and Romancheinidae that are common in Neogene and Recent southern hemisphere bryofaunas. As with molluscs (Stilwell 1997), the Red Bluff Tuff bryofauna appears to bear little relationship to the bryofauna of the Late Cretaceous Kahuitara Tuff (Taylor 1996) which directly underlies it on Pitt Island.

ACKNOWLEDGEMENTS. The collection reported on here was made during a palaeontological field expedition to the Chatham Islands during 17–24 February 1997. Team members comprised Alan Beu, Hamish Campbell, Leonore Hoke (Institute of Geological and Nuclear Sciences, Lower Hutt), Philip Maxwell (Waimate), Michael Griffin (Buenos Aires, visiting scientist at IGNS), Daphne Lee, Richard Köhler (University of Otago, Dunedin), and the authors. We gratefully acknowledge the contribution of bryozoan samples

from other team members in the field. The British Council funded travel associated with this research through an academic link scheme. DPG's research was funded by the N.Z. Foundation for Research, Science & Technology Contract No. C01421. Professor E. Voigt is thanked for advice and the loan of photocards that helped to resolve some taxonomic problems.

## REFERENCES

- Abildgaard, P.C. 1806. In, Müller, O.F. *Zoologia Danica*, **4**: 1–46. Copenhagen.
- Allman, G.J. 1856. *A Monograph of the Freshwater Polyzoa, including all the known species, both British and foreign.* viii + 119 pp., 11 pls. The Ray Society, London.
- Balavoine, P. 1958. Nouvelle contribution à l'étude des Bryozoaires de la région de Dinard et de Saint-Malo. *Bulletin du Laboratoire Maritime de Dinard*, **43**: 52–68.
- Bassler, R.S. 1935. Bryozoa (generum et genotyporum index et bibliographia). *Fossilium Catalogus 1: Animalia*, **67**: 1–229. 's-Gravenhage.
- 1953. Bryozoa. In Moore, R. C. (ed.), *Treatise on Invertebrate Paleontology*, **G**: 253 pp. Geological Society of America, Lawrence.
- Berthelsen, O. 1962. Cheilostome Bryozoa in the Danian deposits of East Denmark. *Geological Survey of Denmark*, (2) **83**: 1–290, 28 pls.
- Bishop, J.D.D. 1987. Type and figured material from 'The Pliocene Bryozoa of the Low Countries' (Lagaaïj, 1952) in the collection of the Royal Belgian Institute of Natural Sciences. *Studiedocumenten, Koninklijk Belgisch Instituut voor Natuurwetenschappen*, **37**: 1–36.
- Boardman, R.S. 1998. Reflections on the morphology, anatomy, evolution, and classification of the Class Stenolaemata (Bryozoa). *Smithsonian Contributions to Paleobiology*, **86**: 1–60.
- , McKinney, F.K. & Taylor, P.D. 1992. Morphology, anatomy, and systematics of the Cinctiporidae, a new family (Bryozoa: Stenolaemata). *Smithsonian Contributions to Paleobiology*, **70**: 1–81.
- Borg, F. 1926. Studies on Recent cyclostomatous Bryozoa. *Zoologiska Bidrag från Uppsala*, **10**: 181–507, 14 pls.
- Braga, G. & Bignot, G. 1986. Les Bryozoaires de la formation d'Âge Paleocène (Danien probable) du Mont Aimé (Marne, Bassin Parisien). *Geobios*, **19**: 279–293.
- Brood, K. 1976. Cyclostomatous Bryozoa from the Paleocene and Maastrichtian of Majunga Basin, Madagascar. *Geobios*, **9**: 393–423.
- Brown, D.A. 1952. *The Tertiary cheilostomatous Polyzoa of New Zealand*. xii + 405 pp. Trustees of the British Museum (Natural History), London.
- 1958. Fossil cheilostomatous Polyzoa from south-west Victoria. *Memoirs of the Geological Survey of Victoria*, **20**: 1–83 + 5.
- Brydone, R.M. 1914. Notes on new or imperfectly known Chalk Polyzoa. *Geological Magazine*, London, ser. 6, **1**: 97–99, 345–347, 481–483, plates 4, 26, 35.
- 1930. *Further notes on new or imperfectly known Chalk Polyzoa. Part II.* (Vincularia, Onychocella, Rhagastoma, Porina, etc.). Pp. 39–60, pls 15–29. Dulan & Co., London.
- Busk, G. 1852. An account of the Polyzoa, and serularian zoophytes, collected in the voyage of the Rattlesnake, on the coasts of Australia and the Louisiade Archipelago, &c. In MacGillivray, J., *Narrative of the voyage of H.M.S. Rattlesnake*, Vol. I: 343–402, 1 pl. T.W. Boone, London.
- 1854. *Catalogue of the Marine Polyzoa in the Collection of the British Museum, II. Cheilostomata (part)*. viii 55–120, pls 69–124. Trustees of the British Museum (Natural History), London.
- 1884. Report on the Polyzoa collected by H.M.S. Challenger during the years 1873–76. Part 1. The Cheilostomata. *Report on the Scientific Results of the Voyage of H.M.S. Challenger, Zoology*, London, **10** (30): xxiv, 1–216, 36 pls.
- Campbell, H.J., Andrews, P.B., Beu, A.G., Maxwell, P.A., Edwards, A.R., Laird, M.G., Hornbrook, N. de B., Mildenhall, D.C., Watters, W.A., Buckridge, J.S., Lee, D.E., Strong, C.P., Wilson, G.J. & Hayward, B.W. 1993. Cretaceous-Cenozoic geology and biostratigraphy of the Chatham Islands, New Zealand. *Institute of Geological & Nuclear Sciences Monograph*, **2**: 1–269 + map.
- Canu, F. 1900. Revision des Bryozoaires du Crétacé figurés par d'Orbigny. Deuxième partie. (Cheilostomata. *Bulletin de la Société Géologique de France*, (3) **28**: 334–463.
- 1911. Iconographie des Bryozoaires fossiles de l'Argentine. *Anales del Museo Nacional de Buenos Aires*, **21**: 215–291, 9 pls.
- 1917. Études sur les Ovicelles des Bryozoaires cyclostomes. *Bulletin de la Société géologique de France*, (4) **17**: 345–347.
- 1918. Les ovicelles des Bryozoaires cyclostomes. Études sur quelques familles nouvelles et anciennes. *Bulletin de la Société Géologique de France*, (4) **16** [for 1916]: 324–335, pl. 9.
- 1920. Bryozoaires Crétacés des Pyrénées. *Bulletin de la Société Géologique de France*, (4) **19** [for 1919]: 186–210, 3 pls.
- & Bassler, R.S. 1917. A synopsis of American Early Tertiary cheilostome Bryozoa. *Bulletin, U.S. National Museum*, **96**: 1–87, 6 pls.
- & — 1925 [1924]. Contribution à l'étude des Bryozoaires d'Autriche et de Hongrie. *Bulletin de la Société Géologique de France*, (4) **24**: 672–690, 3 pls.

- & — 1927. Classification of the cheilostomatous Bryozoa. *Proceedings of the U.S. National Museum*, **69** (14): 1–42, 1 pl.
- & — 1930. Bryozoaires marins de Tunisie. *Annales. Station Océanographique de Salammbô*, **5**: 1–91, 13 pls.
- & — 1935. New species of Tertiary cheilostome Bryozoa from Victoria, Australia. *Smithsonian Miscellaneous Collections*, **93** (9): 1–54, 9 pls.
- Cheetham, A.H.** 1963. Late Eocene zoogeography of the eastern Gulf Coast region. *Geological Society of America Memoir*, **91**: 1–113, 3 pls.
- 1966. Cheilostomatous Polyzoa from the Upper Bracklesham Beds (Eocene) of Sussex. *Bulletin of the British Museum (Natural History), Geology*, **13**: 1–115.
- 1968. Morphology and systematics of the bryozoan genus *Metrarabdoto*. *Smithsonian Miscellaneous Collections*, **153**: iv + 1–121, 18 pls.
- & **Jackson, J.B.C.** 1998. The fossil record of cheilostome Bryozoa in the Neogene and Quaternary of tropical America: adequacy for phylogenetic and evolutionary studies. In Donovan, S. K. & Paul, C. R. C. (eds), *The Adequacy of the Fossil Record*; 227–242. John Wiley & Sons Ltd, Chichester.
- Cook, P.L.** 1985. Bryozoa from Ghana. *Koninklijk Museum voor Midden-Afrika, Zoologische Wetenschappen*, **238**: 1–315.
- & **Bock, P.E.** In press. Calescharidae, a new family for the genera *Caleschara* MacGillivray and *Tretosina* Canu & Bassler (Bryozoa: Cheilostomata). *Invertebrate Taxonomy*.
- Cuffey, R.J. & Sorrentino, A.V.** 1985. Globular *Ceriopora* species (Cyclostomida, Bryozoa) from the Virginia-Carolinas Pliocene, and the status of *Atelosopora*. In Nielsen, C. & Larwood, G. P. (eds), *Bryozoa: Ordovician to Recent*, 79–86. Olsen & Olsen, Fredensborg.
- David, L. & Pouyet, S.** 1974. Revision des Bryozoaires Cheilostomes miocènes du Bassin de Vienne (Autriche). *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, **60**: 83–257, 15 pls.
- Davis, A.G.** 1934. English Lutetian Polyzoa. *Proceedings of the Geologists' Association*, **45**: 205–245, pls 13–15.
- Eichwald, E.** 1865–68. *Lethaea russica ou Paléontologie de la Russie*. 2. Première section de la Période moyenâge [Bryozoa pp. 188–222, pls 8, 9, 14]. Stuttgart.
- Ellis, J. & Solander, D.C.** 1786. *The Natural History of Many Curious and Uncommon Zoophytes . . .* xii + 205 pp., 63 pls. Benjamin White & Son, London.
- Esper, E.J.C.** 1796. *Fortsetzungen der Pflanzenthiere in Abbildungen nach der Natur mit Farben erleuchtet nebst Beschreibungen*. Vol. 1, Parts 5–6, 117–168. Nürnberg.
- Fleming, J.** 1828. *A History of British Animals, exhibiting their descriptive characters and systematical arrangement of the genera and species of quadrupeds, birds, reptiles, fishes, Mollusca, and Radiata of the United Kingdom*. xxiii + 565 pp. Bell & Bradfute, Edinburgh.
- Goldfuss, G.A.** 1826–33. *Petrefacta Germaniae*. Vol. 1. 76 pp. Düsseldorf.
- Gordon, D.P.** 1986. The marine fauna of New Zealand: Bryozoa: Gymnolaemata (Ctenostomata and Cheilostomata Anasca) from the western South Island continental shelf and slope. *New Zealand Oceanographic Institute Memoir*, **95**: 1–121.
- 1987. The deep-sea Bryozoa of the New Zealand region. In Ross, J. R. P. (ed.), *Bryozoa: Present and Past*: 97–104. Western Washington University, Bellingham.
- 1989a. New and little-known genera of cheilostome Bryozoa from the New Zealand region. *Journal of Natural History*, **23**: 1319–1339.
- 1989b. The marine fauna of New Zealand: Bryozoa: Gymnolaemata (Cheilostomida Ascophorina) from the western South Island continental shelf and slope. *New Zealand Oceanographic Institute Memoir*, **97**: 1–158.
- & **Braga, G.** 1994. Bryozoa: Living and fossil species of the catenicellid subfamilies Ditaxiporinae Stach and Vasinyellinae nov. *Mémoires du Muséum National d'Histoire Naturelle*, **161**: 55–85.
- & **Grischenko, A.V.** 1994. Bryozoan frontal shields: the type species of *Desmacystis*, *Rhamphostomella*, *Rhamphosmittina*, *Rhamphostomellina*, and new genus *Arctonula*. *Zoologica Scripta*, **23**: 61–72.
- & **Hondt, J.-L. d'** 1997. Bryozoa: Lepraliomorpha and other Ascophorina, mainly from New Caledonian waters. *Mémoires du Muséum National d'Histoire Naturelle*, **176**: 9–124.
- , **Stewart, I.G. & Collen, J.D.** 1994. Bryozoan fauna of the Kaipuka Siltstone, northwest Nelson: a Miocene homologue of the modern Tasman Bay coralline grounds. *New Zealand Journal of Geology and Geophysics*, **37**: 239–247.
- & **Voigt, E.** 1996. The kenozooidal origin of the ascophorine hypostegal coelom and associated frontal shield. In Gordon, D. P., Smith, A. M. & Grant-Mackie, J. A. (eds), *Bryozoans in Space and Time*: 89–107. NIWA, Wellington.
- Gray, J.E.** 1848. *List of the Specimens of British Animals in the Collection of the British Museum. Part I, Centroniae or radiated animals* [Polyzoa pp. 91–151]. xiii + 173 pp. Trustees of the British Museum (Natural History), London.
- Gregory, J.W.** 1896. The Jurassic Bryozoa. *Catalogue of the Fossil Bryozoa in the Department of Geology, British Museum (Natural History)*. 239 p. Trustees of the British Museum (Natural History), London.
- 1899. The Cretaceous Bryozoa, I. Catalogue of the Fossil Bryozoa in the Department of Geology, British Museum (Natural History). viii + 457 pp., 17 pls. Trustees of the British Museum (Natural History), London.
- Hagenow, F. von** 1839. Monographie der Rügen'schen Kreide-Versteinerung. I. Abt. Phylolithen u. Polyparien. *Neues Jahrbuch für Geognosie, Geologie und Petrefaktenkunde*, **1839**: 253–296, pls 45.
- 1846. In Geinitz, H. B., *Grundriß der Versteinerungskunde* [Bryozoa pp. 586–631, pl. 23b]. Dresden & Leipzig.
- 1851. *Die Bryozoen der Maastrichter Kreidebildung*. xvi + 111 pp., 12 pls. Fischer, Cassel.
- Harmer, S.F.** 1926. The Polyzoa of the Siboga Expedition. Part 2. Cheilostomata Anasca. *Siboga-Expedition*, 28b: viii, 181–501, pls 13–34.
- Hassall, A.H.** 1841. Catalogue of Irish zoophytes. *Annals and Magazine of Natural History*, **6**: 166–175, pls 5–7.
- Hastings, A.B.** 1930. Cheilostomatous Polyzoa from the vicinity of the Panama Canal collected by Dr. C. Crossland on the cruise of the S. Y. 'St. George'. *Proceedings of the Zoological Society of London*, **1929** (47): 697–740, pls 1–17.
- 1949. On the Polyzoan *Cellepora pulchra* Manzoni and the genus *Hippopleurifera*. *Journal of the Linnean Society of London, Zoology*, **41**: 521–528, pls 12–13.
- 1963. Notes on Polyzoa (Bryozoa) V. Some Cyclostomata considered by R. C. Osburn in 1933 and 1953. *Annals and Magazine of Natural History*, **(13)6**: 113–127, pls 3, 4.
- 1966. Observations on the type-material of some genera and species of Polyzoa. *Bulletin of the British Museum (Natural History), Zoology*, **14**: 57–78, 1 pl.
- Hayward, P.J.** 1974. Studies on the cheilostome bryozoan fauna of the Aegean island of Chios. *Journal of Natural History*, **8**: 369–402.
- 1995. Antarctic Cheilostomatous Bryozoa. xi + 355 pp. Oxford University Press, Oxford.
- & **Cook, P.L.** 1979. The South African Museum's Meiring Naude cruises. Part 9. Bryozoa. *Annals of the South African Museum*, **79**: 43–130.
- & **Ryland, J.S.** 1985. Cyclostome bryozoans. Keys and notes for the identification of the species. *Synopses of the British Fauna*, n.s., **34**: 1–147.
- & — 1993. Taxonomy of six Antarctic anascan Bryozoa. *Antarctic Science*, **5**: 129–136.
- & **Thorpe, J.P.** 1988. New genera of Antarctic cheilostome Bryozoa. *Cahiers de Biologie Marine*, **29**: 277–296.
- & — 1990. Some Antarctic and sub-Antarctic species of Smittinidae (Bryozoa: Cheilostomata). *Journal of Zoology*, **222**: 137–175.
- & **Winston, J.E.** 1994. New species of cheilostomate Bryozoa collected by the US Antarctic Research Program. *Journal of Natural History*, **28**: 237–246.
- Hennig, A.** 1892. Studier öfver Bryozoen I Sveriges Kritsystem. I. Cheilostomata. *Acta Universitatis Lundensis*, **28**: 1–48, 2 pls.
- Hincks, T.** 1859. Additional list of Polyzoa. *Report of the Belfast Dredging Committee*, **1858**: 293.
- 1880. *A History of the British Marine Polyzoa*. Vol. 1, cxli + 601 p., Vol. 2, 83 pls. Van Voorst, London.
- 1881. Contribution towards a general history of the marine Polyzoa. VI. Polyzoa from Bass's Straits. VII. Foreign Membraniporina (third series). VIII. Foreign Cheilostomata (miscellaneous). *Annals and Magazine of Natural History*, **(5)8**: 1–14, 122–136, 5 pls.
- Hinds, R.W.** 1975. Growth mode and homeomorphism in cyclostome Bryozoa. *Journal of Paleontology*, **49**: 875–910.
- Hondt, J.-L. d'** 1984. Nouvelle contribution à la connaissance des Bryozoaires marins des Terres Australes Françaises. *Comité National Français des Recherches Antarctiques*, **55**: 95–116.
- 1985. Contribution à la systématique des Bryozoaires Eurystomes. Apports récents et nouvelles propositions. *Annales des Sciences naturelles*, **(13, Zoologie) 7**: 1–12.
- & **Gordon, D.P.** 1999. Entoproctes et Bryozoaires Cheilostomida (Pseudomalacostegomorpha et Cryptocystomorpha) des campagnes Musorstrom autour de la Nouvelle-Calédonie. *Mémoires du Muséum National d'Histoire Naturelle*, **180**: 169–251.
- Hutton, F.W.** 1873. *Catalogue of the Marine Mollusca of New Zealand, with Diagnoses of the Species*. xx + 116 pp., 1 pl. Government Printer, Wellington.
- Illies, G.** 1975. On the genus *Stomatoporina* Balavoine, 1958 (Bryozoa, Cyclostomata). *Documents des Laboratoire de Géologie de la Faculté des Sciences de Lyon*, Hors Série, **3**, 51–57.
- Jebram, D.** 1973. Stolon-Entwicklung und Systematik bei den Bryozoa Ctenostomata. *Zeitschrift für zoologische Systematik u. Evolutionsforschung*, **11**: 1–48.
- Johnston, G.** 1847. *A History of the British Zoophytes*, 2nd Edn. xvi + 488 pp. (Vol. 1), 74 pls (Vol. 2).
- Julien, J.** 1881. Remarques sur quelques espèces des Bryozoaires Cheilostomiens. *Bulletin de la Société Zoologique de France*, **6**: 163–168.
- 1882. Note sur une nouvelle division des Bryozoaires Cheilostomiens. *Bulletin de la Société Zoologique de France*, **6**: 271–285.
- 1888. Bryozoaires. *Mission scientifique du Cap Horn 1882–83*, Paris. **6** (Zoologie 3): 1–92, 15 pls.
- Kade, G.** 1852. *Die losen Versteinerung des Schanzengerges b. Meseritz*. Meseritz. [Bryozoa pp. 27–29]
- Koschinsky, C.** 1885. Ein Beitrag zur Kenntnis der Bryozoenfauna der älteren Tertiärschichten des südlichen Bayerns. (I. Abth. Cheilostomata). *Palaeontographica*, **32**: 1–73, 7 pls.
- Lagaaij, R.** 1969. Paleocene Bryozoa from a boring in Surinam. *Geologie en Mijnbouw*, **48**: 165–175.

- & Gautier, Y.V. 1965. Bryozoan assemblages from marine sediments of the Rhone delta, France. *Micropaleontology*, **11**: 39–58.
- Lamouroux, J.V.E. 1821. *Exposition méthodique des Genres de l'Ordre des Polypiers, avec leur description et celles des principales espèces figurées dans 84 planches; les 63 premières appartenant à l'Histoire naturelle des Zoophytes d'Ellis et Solander*. viii + 115 p., 84 pls. V. Agasse, Paris.
- Lang, W.D. 1916. A revision of the 'cribrimorph' Cretaceous Polyzoa. *Annals and Magazine of Natural History*, (8) **18**: 81–112, 381–410.
- 1921. Catalogue of the Fossil Bryozoa (Polyzoa) in the Department of Geology, British Museum (Natural History). *The Cretaceous Bryozoa (Polyzoa). Volume III. The Cribrimorphs; Part I. 12 + cx + 269 pp.*, 8 pls.
- Lee, D.E., Scholz, J. & Gordon, D.P. 1997. Paleoecology of a Late Eocene mobile rockground biota from North Otago, New Zealand. *Palaios*, **12**: 568–581.
- Levinse, G.M.R. 1909. *Morphological and Systematic Studies on the Cheilostomatous Bryozoa*. vii + 431 pp., 24 pls. National Forfatteres Forlag, Copenhagen.
- 1925. Undersøgelse over Bryozoen i den Danske Kridformation. *Kongelige Danske Videnskabernes Selskabs Skrifter*, (8) **7**: 283–445, 8 pls.
- Lidgard, S. 1985. Zoid and colony growth in encrusting cheilostome bryozoans. *Palaontology*, **28**: 255–291.
- Livingstone, A.A. 1928. The Bryozoa, supplementary report. *Australian Antarctic Expedition 1911–14, Scientific Reports, Series C, Zoology and Botany*, **9** (1): 1–93, 7 pls.
- Lonsdale, W. 1845. Report on the corals from the Tertiary formations of North America (*Anthophyllum lineatum*, *Columnaria sexradiata*, etc.). *Quarterly Journal of the Geological Society*, **1**: 495–533, pls.
- López Gappa, J.J. 1981. Una nueva especie de *Melicerita* de la plataforma Patagonica. *Neotropica*, **27**: 127–131.
- McKinney, F.K., Lidgard, S., Sepkoski, J.J. Jr & Taylor, P.D. 1998. Decoupled temporal patterns of evolution and ecology in two post-Paleozoic clades. *Science*, **281**: 807–809.
- MacGillivray, P.H. 1869. Descriptions of some new genera and species of Australian Polyzoa; to which is added a list of species found in Victoria. *Transactions and Proceedings of the Royal Society of Victoria*, **9**: 126–148.
- 1880. [Polyzoa] In McCoy, F. (ed.), *Prodromus of the Zoology of Victoria*: Vol. 1, Decade 5, 1–58, pls 41–50. Government Printer, Melbourne.
- MacLeod, N., Rawson, P.F., Forey, P.L., Banner, F.T., Boudagher-Fadel, M.K., Bown, P.R., Burnett, J.A., Chambers, P., Culver, S., Evans, S.E., Jeffery, C., Kaminski, M.A., Lord, A.R., Milner, A.C., Milner, A.R., Morris, N., Owen, E., Rosen, B.R., Smith, A.B., Taylor, P.D., Urquhart, E. & Young, J.R. 1997. The Cretaceous-Tertiary biotic transition. *Journal of the Geological Society*, London, **154**: 265–292.
- Mantell, G.A. 1850. Notice on the remains of the *Dinornis* and other birds, and of fossils and rock-specimens, etc. *Quarterly Journal of the Geological Society of London*, **6**: 319–343, pls 28, 29.
- Maplestone, C.M. 1900. Further descriptions of the Tertiary Polyzoa of Victoria. (Part III. *Proceedings of the Royal Society of Victoria*, (n.s.) **12**): 162–169, pls 17–18.
- 1904. Tabulated list of the fossil cheilostomatous Polyzoa in the Victorian Tertiary deposits. *Proceedings of the Royal Society of Victoria*, (n.s.) **17**: 182–219.
- Marsson, T. 1887. Die Bryozoen der weissen Schreibkreide der Insel Rügen. *Paläontologische Abhandlungen*, **4** (6): 3–112, pls 1–10.
- Milne Edwards, H. 1836. *Radiaires, vers, insectes*. In, Lamarck, J.B.P.A. de, *Histoire naturelle des animaux sans vertèbres*; vol. 3, deuxième édition revue et augmentée des notes, par Deshayes G.P. & Milne Edwards, H. 684 pp., J.B. Ballière, Paris & London.
- 1838. Mémoire sur les Crisies, les Hornères et plusieurs autres Polypes. *Annales des Sciences naturelles*, **9**: 193–238.
- Morris, J. 1843. *A Catalogue of British Fossils . . . x + 222 pp.* Van Voorst, London.
- Moyano, H.I.G. 1974. Bryozoos marinos chilenos II. Bryozoos de Chile Austral I. *Gayana, Zoología*, **30**: 1–41.
- 1997. Las especies chilenas de *Melicerita* (Bryozoa, Cellariidae) con la descripción de una nueva especie. *Gayana, Zoología*, **61**: 49–55.
- Norman, A.M. 1903. Notes on the natural history of East Finnmark. Polyzoa. *Annals and Magazine of Natural History*, (7) **11**: 567–598, pl. 13.
- Nye, O.B. Jr 1976. Generic revision and skeletal morphology of some cerioporid cyclostomes (Bryozoa). *Bulletins of American Paleontology*, **69** (291): 1–222, 51 pls.
- Orbigny, A. d' 1851–54. *Paléontologie française. Descriptions des Mollusques et rayonnés fossiles. Terrains Crétacés. V. Bryozoaires*. 1192 pp., pls 600–800. Victor Masson, Paris.
- Ostrovsky, A.N. & Taylor, P.D. 1996. Systematics of some Antarctic *Idmidronea* and *Exidmonea* (Bryozoa: Cyclostomata). *Journal of Natural History*, **30**: 1549–1575.
- Pergens, E. 1889. Revision des Bryozoaires du Crétacé figurés par d'Orbigny. I. Cyclostomes. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, **3**: 305–400, pls 11–13.
- & Meunier, A. 1886. La faune de Bryozoaires Garumniens de Faxe. *Annales de la Société Royale Malacologique Belge*, **21**: 187–242, 5 pls.
- Pitt, L.J. & Taylor, P.D. 1990. Cretaceous Bryozoa from the Faringdon Sponge Gravel (Aptian) of Oxfordshire. *Bulletin of the British Museum (Natural History) (Geology Series)*, **46**: 61–152.
- Pohowsky, R.A. 1978. The boring ctenostome Bryozoa: Taxonomy and paleobiology based on cavities in calcareous substrata. *Bulletins of American Paleontology*, **73** (no. 301): 1–192, pls 1–24.
- Ponyet, S. 1973. Révision systématique des Cellépores (Bryozoa, Cheilostomata) et des espèces fossiles européennes. Analyse de quelques populations à Cellépores dans le Néogène du bassin rhodanien. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, **55**: 1–266, 19 pls.
- Reuss, A.E. 1848. Die fossilen Polyparien des Wiener Tertiärbeckens. *Naturwissenschaftliche Abhandlungen*, **2**: 1–109, 11 pls.
- Rogick, M.D. 1956. Bryozoa of the United States Navy's 1947–1948 Antarctic Expedition, I–IV. *Proceedings of the U.S. National Museum*, **105**: 221–317, 35 pls.
- Rosso, A. 1992. *Melicerita digeronimoi* sp. nov.: A new Antarctic bryozoan. *Boletín de la Sociedad de Biología de Concepción*, **57**: 185–192.
- Ryland, J.S. 1968. *Cellaria* Ellis and Solander, 1786 (Polyzoa): its type, and the names of three species. *Bulletin of Zoological Nomenclature*, **24**: 344–352.
- Schmid, B. 1989. Cheilostome Bryozoen aus dem Badenien (Miozän) von Nußdorf (Wien). *Beiträge zur Paläontologie von Österreich*, **15**: 1–101.
- Schopf, T.J.M. & Bassett, E.L. 1973. F. A. Smitt, marine Bryozoa, and the introduction of Darwin into Sweden. *Transactions of the American Philosophical Society*, n.s., **63** (7): frontis., 1–30.
- Shaw, N.G. 1967. Cheilostomata from Gulfian (Upper Cretaceous) rocks of southwestern Arkansas. *Journal of Paleontology*, **41**: 1393–1432, pls 178–182.
- Sherborn, C.D. 1899. On the dates of the 'Paléontologie Française' of d'Orbigny. *Geological Magazine*, (4) **6**: 223–225.
- Silén, L. 1946. On two new groups of Bryozoa living in shells of molluscs. *Arkiv för Zoologi*, **38B**: 1–7.
- Smith, A.M. 1995. Palaeoenvironmental interpretation using bryozoans: a review. In Bosence, D. W. J. & Allison, P. A. (eds), *Marine Palaeoenvironmental Analysis from Fossils. Geological Society of London, Special Publication*, **83**: 231–243.
- Smitt, F.A. 1867. Kritisk forteckning öfver Skandinaviens Hafs-Bryozoor. *Översigt af Kongliga Vetenskaps-Akademien Förhandlingar*, **23**: 395–533, pls 3–13.
- 1868. Kritisk forteckning öfver Skandinaviens Hafs-Bryozoor. *Översigt af Kongliga Vetenskaps-Akademien Förhandlingar*, **24**: 279–429, pls 16–20.
- Soule, D.F., Soule, J.D. & Chaney, H.W. 1995. The Bryozoa. In Blake, J. A., Chaney, H. W., Scott, P. H. & Lissner, A. L. (eds), *Taxonomic Atlas of the Santa Maria Basin and Western Santa Barbara Channel*, Vol. **13**: 1–344. Santa Barbara Museum of Natural History, Santa Barbara.
- Soule, J.D. 1959. Results of the Puritan-American Museum of Natural History Expedition to western Mexico. 6. Anascan Cheilostomata (Bryozoa) of the Gulf of California. *American Museum Novitates*, **1969**: 1–54.
- Stilwell, J.D. 1997. Tectonic and palaeobiogeographic significance of the Chatham Islands, South Pacific, Late Cretaceous fauna. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **136**: 97–119.
- , Fordyce, R.E. & Rolfe, P.J. 1994. Paleocene isocrinids (Echinodermata) from the Kauri Formation, South Island, New Zealand. *Journal of Paleontology*, **68**: 135–141.
- Taylor, P.D. 1993. Bryozoa. In Benton, M. J. (ed.), *The Fossil Record*: 465–489. Chapman & Hall, London.
- 1994. Evolutionary palaeoecology of symbioses between bryozoans and hermit crabs. *Historical Biology*, **9**: 157–205.
- 1996. Cretaceous bryozoans from the Chatham Islands, New Zealand. *Alcheringa*, **20**: 315–327.
- , Schembri, P.J. & Cook, P.L. 1989. Symbiotic associations between hermit crabs and bryozoans from the Otago region, southeastern New Zealand. *Journal of Natural History*, **23**: 1059–1085.
- & Sequeiros, L. 1982. Toarcian bryozoans from Belchite in north-east Spain. *Bulletin of the British Museum (Natural History), Geology*, **36**: 117–129.
- Tenison-Woods, J.E. 1862. *Geological Observations in South Australia: Principally in the district south-east of Adelaide*. xviii + 404 pp., 6 pls. Longman, Green, Longman, Roberts & Green, London.
- Thornely, L.R. 1924. Polyzoa. *Scientific Reports. Australian Antarctic Expedition 1911–14, series C, Zoology and Botany*, **6** (6): 1–23.
- Uttley, G.H. 1949. The Recent and Tertiary Polyzoa (Bryozoa) in the collection of the Canterbury Museum, Christchurch. *Records of the Canterbury Museum*, **5**: 167–192, pls 34–39.
- 1951. The Recent and Tertiary Polyzoa (Bryozoa) in the collection of the Canterbury Museum, Christchurch. Part II. *Records of the Canterbury Museum*, **6**: 15–39.
- & Bullivant, J.S. 1972 [1971]. Biological results of the Chatham Islands 1954 Expedition. Part 7. Bryozoa Cheilostomata. *Memoirs of the New Zealand Oceanographic Institute*, **57**: 1–61.
- Vávra, N. 1977. Bryozoa tertaria. *Catalogus Fossilium Austriae*, **5**: 1–210.
- Vigneaux, M. 1949. Révision des Bryozoaires néogènes du Bassin d'Aquitaine et essai de classification. *Mémoires de la Société Géologique de France*, n.s., **28**: 1–153, 11 pls.
- Viskova, L.A. & Weiss, O.B. 1998. New stenolaematus bryozoans from the Paleocene of Kazakhstan. *Paleontological Journal*, **32**: 260–268.
- Voigt, E. 1924. Beiträge zur Kenntnis der Bryozofauna der subhercynen Kreidemulde. *Paläontologische Zeitschrift*, **6**: 93–173, 6 pls.

- 1930. Morphologische und stratigraphische Untersuchungen über die Bryozoaenfauna der oberen Kreide. I. Teil. Die cheilostomären Bryozoen der jüngeren Oberkreide in Nordwestdeutschland, im Baltikum und in Holland. *Leopoldina*, **6**: 379–579, pls 1–39.
- 1949. Cheilostome Bryozoen aus der Quadratenkreide Nordwestdeutschlands. *Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg*, **19**: 1–49, pls 1–11.
- 1957. Bryozoen aus dem Kreidetuff von St. Symphorien bei Ciply (Ob. Maastrichtien). *Mededelingen, Koninklijk Belgisch Instituut voor Natuurwetenschappen*, **33**: 1–48, pls 1–12.
- 1959. Revision der F. von Hagenow 1839–1850 aus der Schreibkreide von Rügen veröffentlichten Bryozoen. *Geologie*, **25**: 1–62, pls 1–10.
- 1962. Late Cretaceous Bryozoa from European parts of the USSR and some neighbouring districts. 127 pp. Moscow University Press, Moscow. [In Russian with German summary]
- 1964. A bryozoan fauna of Dano-Montian age from Boryszew and Sochaczew in central Poland. *Acta Palaeontologica Polonica*, **9**: 419–498, 16 pls.
- 1967. Oberkreide-Bryozoen aus den asiatischen Gebieten der UdSSR. *Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg*, **36**: 5–95, pls 1–34.
- 1968. On the Cretaceous age of the so-called Jurassic cheilostomatous Polyzoa (Bryozoa). A contribution to the knowledge of the Polyzoa-fauna of the Maastrichtian in the Cotentin (Manche). *Bulletin of the British Museum (Natural History), Geology*, **17**: 1–45, pls 1–8.
- 1975. Bryozoen aus dem Campan von Misburg bei Hannover. *Bericht der Naturhistorischen Gesellschaft zu Hannover*, **119**: 235–277.
- 1979. Bryozoen der Kunrader Schichten in Süd-Limburg (Oberkreide, Ob. Maastrichtium) I. Cheilostomata. *Grondboor en Hamer*, **2**: 33–88.
- 1981. Répartition et utilisation stratigraphique des Bryozoaires du Crétacé Moyen (Aptien-Coniacien). *Cretaceous Research*, **2**: 439–462.
- 1983. Zur Biogeographie der europäischen Oberkreide-Bryozoenfauna. *Zitteliana*, **10**: 317–347.
- 1985a. The Bryozoa of the Cretaceous-Tertiary boundary. In Nielsen, C. & Larwood, G. P. (eds), *Bryozoa: Ordovician to Recent*: 329–342. Olsen & Olsen, Fredensborg.
- 1985b. Bryozoaires du Crétacé supérieur trouvés dans les résidus du remplissage d'une fente karstique dans les gorges du Nant (Vercors). *Géobios*, **18**: 621–642, pls 1–6.
- 1987. Die Bryozoen des klassischen Dano-Montiens von Mons (Belgien). *Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique*, **17**: 1–161.
- 1989. Beitrag zur Bryozoen-Fauna des sächsischen Cenomaniums. Revision von A. E. Reuss' 'Die Bryozoen des unteren Quaders' in H. B. Geinitz 'Das Elbthalgebirge in Sachsen' (1872). Teil I: Cheilostomata. *Abhandlungen des Staatlichen Museums für Mineralogie und Geologie zu Dresden*, **36**: 8–87, 170–208 (pls 1–20).
- & Williams, A. 1973. Revision des Genus *Inversaria* v. Hagenow 1851 (Bryoz. Cheilst.) und seine Beziehungen zu *Solenonychocella* n. g. *Nachrichten der Akademie der Wissenschaften in Göttingen II. Mathematisch-Physikalische Klasse*, **8**: 140–178, 20 pls.
- Walter, B. 1970. Les bryozoaires jurassiques en France. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, **35** [for 1969]: 1–328.
- Waters, A.W. 1880. Note on the genus *Heteropora*. *Annals and Magazine of Natural History*, (5) **6**: 156–157.
- 1881. On fossil cheilostomatous Bryozoa from south-west Victoria, Australia. *Quarterly Journal of the Geological Society of London*, **37**: 309–347, pls 14–18.
- 1887a. On Tertiary cyclostomatous Bryozoa from New Zealand. *Quarterly Journal of the Geological Society of London*, **43**: 337–350, pl. 18.
- 1887b. On Tertiary cheilostomatous Bryozoa from New Zealand. *Quarterly Journal of the Geological Society of London*, **43**: 40–72, pls 6–8.
- Wiesemann, G. 1963. Untersuchungen an der Gattung *Beisselina* Canu 1913 und ähnlichen Bryozoen (Maastrichtian, Danien, Montien). *Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg*, **32**: 5–70, 12 pls.



# Bulletin of The Natural History Museum Geology Series

Earlier Geology Bulletins are still in print. The following can be ordered from Intercept (address on inside front cover). Where the complete backlist is not shown, this may also be obtained from the same address.

## Volume 34

- No. 1 Relative dating of the fossil hominids of Europe. K.P. Oakley. 1980. Pp. 1–63, 6 figs, 17 tables. £8.00
- No. 2 Origin, evolution and systematics of the dwarf Acanthoceratid *Protacanthoceras* Spath, 1923 (Cretaceous Ammonoidea). C.W. Wright & W.J. Kennedy. 1980. Pp. 65–107, 61 figs. £6.25
- No. 3 Ashgill Brachiopoda from the Glyn Ceiriog District, north Wales. N. Hiller. 1980. Pp. 109–216, 408 figs. £14.75
- No. 4 Miscellanea
- Type specimens of some Upper Palaeozoic Athyridide brachiopods. C.H.C. Brunton. 31 figs.
- Two new British Cretaceous Epitoniiidae (Gastropoda): evidence for evolution of shell morphology. R.J. Cleevely. 14 figs, 1 table.
- Revision of the microproblematicum *Prethocoproolithus* Elliott, 1962. G.F. Elliott. 4 figs.
- Basilicus tyrannus* (Murchison) and the glabellar structure of asaphid trilobites. R.A. Fortey. 12 figs.
- A new Lower Ordovician bivalve family, the Thoraliidae (? Nuculoidea), interpreted as actinodont deposit feeders. N.J. Morris. 7 figs.
- Cretaceous brachiopods from northern Zululand. E.F. Owen. 13 figs.
- Tupus diluculum* sp. nov. (Protodonata), a giant dragonfly from the Upper Carboniferous of Britain. P.E.S. Whalley. 1 fig.
- Revision of *Plummerita* Brönniman (Foraminiferida) and a new Maastrichtian species from Ecuador. J.E. Whittaker. 34 figs. 1980. Pp. 217–297. £11.00

## Volume 35

- No. 1 Lower Ordovician Brachiopoda from mid and south-west Wales. M.G. Lockley & A. Williams. 1981. Pp. 1–78, 263 figs, 3 tables. £10.80
- No. 2 The fossil alga *Girvanella* Nicholson & Etheridge. H.M.C. Danielli. 1981. Pp. 79–107, 8 figs, 3 tables. £4.20
- No. 3 Centenary miscellanea
- Reassessment of the Ordovician brachiopods from the Budleigh Salterton Pebble Bed, Devon. L.R.M. Cocks & M.G. Lockley. 35 figs.
- Felix Oswald's Turkish Algae. G.F. Elliott. 3 figs.
- J.A. Moy-Thomas and his association with the British Museum (Natural History). P.L. Forey & B.G. Gardiner. 3 figs.
- Burials, bodies and beheadings in Romano-British and Anglo-Saxon cemeteries. M. Harman, T.I. Molleson & J.L. Price. 5 figs, 7 tables, VI appendices.
- The Jurassic irregular echinoid *Nucleolites clunicularis* (Smith). D.N. Lewis & H.G. Owen. 4 figs.
- Phanerotinus cristatus* (Phillips) and the nature of euomphalacean gastropods. N.J. Morris & R.J. Cleevely. 12 figs.
- Agassiz, Darwin, Huxley, and the fossil record of teleost fishes. C. Patterson. 1 fig.

The Neanderthal problem and the prospects for direct dating of Neanderthal remains. C.B. Stringer & R. Burleigh. 2 figs, 1 table.

*Hippoporidra edax* (Busk 1859) and a revision of some fossil and living *Hippoporidra* (Bryozoa). P.D. Taylor & P.L. Cook. 6 figs. 1981. Pp. 109–252. £20.00

- No. 4 The English Upper Jurassic Plesiosauroidea (reptilia) and a review of the phylogeny and classification of the Plesiosauria. D.S. Brown. 1981. Pp. 253–347, 44 figs. £13.00

## Volume 36

- No. 1 Middle Cambrian trilobites from the Sosink Formation, Derik-Mardin district, south-eastern Turkey. W.T. Dean. 1982. Pp. 1–41, 68 figs. £5.80
- No. 2 Miscellanea
- British Dinantian (Lower Carboniferous) terebratulid brachiopods. C.H.C. Brunton. 20 figs.
- New microfossil records in time and space. G.F. Elliott. 6 figs.
- The Ordovician trilobite *Neseuretus* from Saudi Arabia, and the palaeogeography of the *Neseuretus* fauna related to Gondwanaland in the earlier Ordovician. R.A. Fortey & S.F. Morris. 10 figs.

*Archaeocidaris whatleyensis* sp. nov. (Echinoidea) from the Carboniferous Limestone of Somerset and notes on echinoid phylogeny. D.N. Lewis & P.C. Ensom. 23 figs.

A possible non-calcified dasycladalean alga from the Carboniferous of England. G.F. Elliott. 1 fig.

*Nanjinoporella*, a new Permian dasyclad (calcareous alga) from Nanjing, China. X. Mu & G.F. Elliott. 6 figs, 1 table.

Toarcian bryozoans from Belchite in north-east Spain. P.D. Taylor & L. Sequeiros. 10 figs, 2 tables.

Additional fossil plants from the Drybrook Sandstone, Forest of Dean, Gloucestershire. B.A. Thomas & H.M. Purdy. 14 figs, 1 table.

*Bintoniella brodiei* Handlirsch (Orthoptera) from the Lower Lias of the English Channel, with a review of British bintoniellid fossils. P.E.S. Whalley. 7 figs.

*Uraloporella* Korde from the Lower Carboniferous of South Wales. V.P. Wright. 3 figs. 1982. Pp. 43–155. £19.80

- No. 3 The Ordovician Graptolites of Spitsbergen. R.A. Cooper & R.A. Fortey. 1982. Pp. 157–302, 6 plates, 83 figs, 2 tables. £20.50
- No. 4 Campanian and Maastrichtian sphenodiscid ammonites from southern Nigeria. P.M.P. Zaborski. 1982. Pp. 303–332, 36 figs. £4.00

## Volume 37

- No. 1 Taxonomy of the arthrodire *Phlyctaenius* from the Lower or Middle Devonian of Campbellton, New Brunswick, Canada. V.T. Young. 1983. Pp. 1–35, 18 figs. £5.00
- No. 2 *Ailsacrinus* gen. nov., an aberrant millerigocrinid from the Middle Jurassic of Britain. P.D. Taylor. 1983. Pp. 37–77, 48 figs, 1 table. £5.90
- No. 3 Miscellanea

*Glossopteris anatolica* Sp. nov. from uppermost Permian strata in south-east Turkey. S. Archangelsky & R.H. Wagner. 14 figs.

The crocodilian *Theriosuchus* Owen, 1879 in the Wealden of England. E. Buffetaut. 1 fig.

A new conifer species from the Wealden beds of Féron-Glæeon, France. H.L. Fisher & J. Watson. 10 figs.

Late Permian plants including Charophytes from the Khuff formation of Saudi Arabia. C.R. Hill & A.A. El-Khayal. 18 figs.

British Carboniferous Edrioasteroidea (Echinodermata). A.B. Smith. 52 figs.

A survey of recent and fossil Cicadas (Insecta, Hemiptera-Homoptera) in Britain. P.E.S. Whalley. 11 figs.

The Cephalaspids from the Dittonian section at Cwm Mill, near Abergavenny, Gwent. E.I. White & H.A. Toombs. 20 figs. 1983. Pp. 79-171. £13.50

No. 4 The relationships of the palaeoniscid fishes, a review based on new specimens of *Mimia* and *Moythomasia* from the Upper Devonian of Western Australia. B.G. Gardiner. 1984. Pp. 173-428. 145 figs. 4 plates. 0 565 00967 2. £39.00

#### Volume 38

No. 1 New Tertiary pycnodonts from the Tilemsi valley, Republic of Mali. A.E. Longbottom. 1984. Pp. #1-26. 29 figs. 3 tables. 0 565 07000 2. £3.90

No. 2 Silicified brachiopods from the Viséan of County Fermanagh, Ireland. (III) Rhynchonellids. Spiriferids and Terebratulids. C.H.C. Brunton. 1984. Pp. 27-130. 213 figs. 0 565 07001 0. £16.20

No. 3 The Llandovery Series of the Type Area. L.R.M. Cocks. N.H. Woodcock, R.B. Rickards, J.T. Temple & P.D. Lane. 1984. Pp. 131-182. 70 figs. 0 565 07004 5. £7.80

No. 4 Lower Ordovician Brachiopoda from the Tourmakeady Limestone, Co. Mayo, Ireland. A. Williams & G.B. Curry. 1985. Pp. 183-269. 214 figs. 0 565 07003 7. £14.50

#### Miscellanea

Growth and shell shape in Productacean Brachiopods. C.H.C. Brunton.

*Palaeosiphonium* a problematic Jurassic alga. G.F. Elliott.

Upper Ordovician brachiopods and trilobites from the Clashford House Formation, near Herbertstown, Co. Meath, Ireland. D.A.T. Harper, W.I. Mitchell, A.W. Owen & M. Romano.

Preliminary description of Lower Devonian Osteostraci from Podolia (Ukrainian S.S.R.). P. Janvier.

*Hippurion* sp. (Equidae, Perissodactyla) from Diavata (Thessaloniki, northern Greece). G.D. Koufos.

Preparation and further study of the Singa skull from Sudan. C.B. Stringer, L. Cornish & P. Stuart-Macadam.

Carboniferous and Permian species of the cyclostome bryozoan *Corynotrypa* Bassler, 1911. P.D. Taylor.

Redescription of *Eurycephalochelys*, a trionychid turtle from the Lower Eocene of England. C.A. Walker & R.T.J. Moody.

Fossil insects from the Lithographic Limestone of Montsech (late Jurassic-early Cretaceous), Lérida Province, Spain. P.E.S. Whalley & E.A. Jarzembski. 1985. Pp. 271-412, 162 figs. 0 565 07004 5. £24.00

#### Volume 39

No. 1	Upper Cretaceous ammonites from the Calabar region, south-east Nigeria. P.M.P. Zaborski. 1985. Pp. 1-72. 66 figs.	£11.00
No. 2	Cenomanian and Turonian ammonites from the Novo Redondo area, Angola. M.K. Howarth. 1985. Pp. 73-105. 33 figs.	£5.60
No. 3	The systematics and palaeogeography of the Lower Jurassic insects of Dorset, England. P.E.S. Whalley. 1985. Pp. 107-189. 87 figs. 2 tables. 0 565 07008 8.	£14.00
No. 4	Mammals from the Bartonian (middle/late Eocene) of the Hampshire Basin, southern England. J.J. Hooker. 1986. Pp. 191-478. 71 figs. 39 tables. 0 565 07009 6.	£49.50

#### Volume 40

No. 1	The Ordovician graptolites of the Shelve District, Shropshire. I. Strachan. 1986. Pp. 1-58. 38 figs. 0 565 07010 X.	£9.00
No. 2	The Cretaceous echinoid <i>Boletoechinus</i> , with notes on the phylogeny of the Glyptocyphidae and Temnopleuridae. D.N. Lewis. 1986. Pp. 59-90. 11 figs. 7 tables. 0 565 07011 8.	£5.60
No. 3	The trilobite fauna of the Raheen Formation (upper Caradoc), Co. Waterford, Ireland. A.W. Owen, R.P. Tripp & S.F. Morris. 1986. Pp. 91-122. 88 figs. 0 565 07012 6.	£5.60
No. 4	Miscellanea I: Lower Turonian cirripede—Indian coleoid <i>Naefia</i> —Cretaceous—Recent Craniidae—Lectotypes of Girvan trilobites—Brachiopods from Provence—Lower Cretaceous cheilostomes. 1986. Pp. 125-222. 0 565 07013 4.	£19.00
No. 5	Miscellanea II: New material of <i>Kimmererosaurus</i> —Edgehill Sandstone plants—Lithogeochemistry of Mendip rocks—Specimens previously recorded as teuthids—Carboniferous lycopsid <i>Anabathra</i> — <i>Meyenodendron</i> , new Alaskan lepidodendrid. 1986. Pp. 225-297. 0 565 07014 2.	£13.00

#### Volume 41

No. 1	The Downtonian ostracoderm <i>Sclerodus</i> Agassiz (Osteostraci: Tremataspidae), P.L. Forey. 1987. Pp. 1-30. 11 figs. 0 565 07015 0.	£5.50
No. 2	Lower Turonian (Cretaceous) ammonites from south-east Nigeria. P.M.P. Zaborski. 1987. Pp. 31-66. 46 figs. 0 565 07016 9.	£6.50
No. 3	The Arenig Series in South Wales: Stratigraphy and Palaeontology. I. The Arenig Series in South Wales. R.A. Fortey & R.M. Owens. II. Appendix. Acritarchs and Chitinozoa from the Arenig Series of South-west Wales. S.G. Molyneux. 1987. Pp. 67-364. 289 figs. 0 565 07017 7.	£59.00
No. 4	Miocene geology and palaeontology of Ad Dabtiyah, Saudi Arabia. Compiled by P.J. Whybrow. 1987. Pp. 365-457. 54 figs. 0 565 07019 3.	£18.00

#### Volume 42

No. 1	Cenomanian and Lower Turonian Echinoderms from Wilmington, south-east Devon. A.B. Smith, C.R.C. Paul, A.S. Gale & S.K. Donovan. 1988. 244 pp. 80 figs. 50 pls. 0 565 07018 5.	£46.50
-------	---	--------

**Volume 43**

- No. 1 A Global Analysis of the Ordovician-Silurian boundary. Edited by L.R.M. Cocks & R.B. Rickards. 1988. 394 pp., figs. 0 565 07020 7. £70.00

**Volume 44**

- No. 1 Miscellanea: Palaeocene wood from Mali—Chapelcorner fish bed—*Heterotheca* coprolites—Mesozoic Neuroptera and Raphidioptera. 1988. Pp. 1–63. 0 565 07021 5. £12.00

- No. 2 Cenomanian brachiopods from the Lower Chalk of Britain and northern Europe. E.F. Owen. 1988. Pp. 65–175. 0 565 07022 3. £21.00

- No. 3 The ammonite zonal sequence and ammonite taxonomy in the *Douvilleiceras mammillatum* Superzone (Lower Albian) in Europe. H.G. Owen. 1988. Pp. 177–231. 0 565 07023 1. £10.30

- No. 4 Cassiopidae (Cretaceous Mesogastropoda): taxonomy and ecology. R.J. Cleevley & N.J. Morris. 1988. Pp. 233–291. 0 565 07024 X. £11.00

**Volume 45**

- No. 1 Arenig trilobites—Devonian brachiopods—Triassic demosponges—Larval shells of Jurassic bivalves—Carboniferous marattialean fern—Classification of Plectambonitacea. 1989. Pp. 1–163. 0 565 07025 8. £40.00

- No. 2 A review of the Tertiary non-marine molluscan faunas of the Pebasian and other inland basins of north-western South America. C.P. Nuttall. 1990. Pp. 165–371. 456 figs. 0 565 07026 6. £52.00

**Volume 46**

- No. 1 Mid-Cretaceous Ammonites of Nigeria—new amphisbaenians from Kenya—English Wealden Equisetales—Faringdon Sponge Gravel Bryozoa. 1990. Pp. 1–152. 0 565 070274. £45.00

- No. 2 Carboniferous pteridosperm frond *Neuropteris heterophylla*—Tertiary Ostracoda from Tanzania. 1991. Pp. 153–270. 0 565 07028 2. £30.00

**Volume 47**

- No. 1 Neogene crabs from Brunei, Sabah & Sarawak—New pseudosciurids from the English Late Eocene—Upper Palaeozoic Anomalodesmata Bivalvia. 1991. Pp. 1–100. 0 565 07029 0. £37.50

- No. 2 Mesozoic Chrysalidinidae of the Middle East—Bryozoans from north Wales—*Alveolinella praequoyi* sp. nov. from Papua New Guinea. 1991. Pp. 101–175. 0 565 070304. £37.50

**Volume 48**

- No. 1 '*Placopsilina*' *cenomana* d'Orbigny from France and England—Revision of Middle Devonian uncinulid brachiopod—Cheiostome bryozoans from Upper Cretaceous, Alberta. 1992. Pp. 1–24. £37.50

- No. 2 Lower Devonian fishes from Saudi Arabia—W.K. Parker's collection of foraminifera in the British Museum (Natural History). 1992. Pp. 25–43. £37.50

**Volume 49**

- No. 1 Barremian—Aptian Praehedbergellidae of the North Sea area: a reconnaissance—Late Llandovery and early Wenlock Stratigraphy and ecology in the Oslo Region, Norway—Catalogue of the type and figured specimens of fossil Asteroidea and Ophiuroidea in The Natural History Museum. 1993. Pp. 1–80. £37.50

- No. 2 Mobility and fixation of a variety of elements, in particular, during the metasomatic development of adinoles at Dinas Head, Cornwall—Productellid and Plicatiferid (Productoid) Brachiopods from the Lower Carboniferous of the Craven Reef Belt, North Yorkshire—The spores of *Leclercqia* and the dispersed spore morphon *Acinosporites lindlarensis* Riegel: a case of gradualistic evolution. 1993. Pp. 81–155. £37.50

**Volume 50**

- No. 1 Systematics of the meliceritid cyclostome bryozoans; introduction and the genera *Elea*, *Semielea* and *Reptomultilea*. 1994. Pp. 1–104. £37.50

- No. 2 The brachiopods of the Duncannon Group (Middle-Upper Ordovician) of southeast Ireland. 1994. Pp. 105–175. £37.50

**Volume 51**

- No. 1 A synopsis of neuropteroid foliage from the Carboniferous and Lower Permian of Europe—The Upper Cretaceous ammonite *Pseudaspidoeceras* Hyatt, 1903, in north-eastern Nigeria—The pterodactyloids from the Purbeck Limestone Formation of Dorset. 1995. Pp. 1–88. £37.50

- No. 2 Palaeontology on the Qahlah and Simsima Formations (Cretaceous, Late Campanian-Maastrichtian) of the United Arab Emirates-Oman Border Region—Preface—Late Cretaceous carbonate platform faunas of the United Arab Emirates-Oman border region—Late Campanian-Maastrichtian echinoids from the United Arab Emirates-Oman border region—Maastrichtian ammonites from the United Arab Emirates-Oman border region—Maastrichtian nautioids from the United Arab Emirates-Oman border region—Maastrichtian Inoceramidae from the United Arab Emirates-Oman border region—Late Campanian-Maastrichtian Bryozoa from the United Arab Emirates-Oman border region—Maastrichtian brachiopods from the United Arab Emirates-Oman border region—Late Campanian-Maastrichtian rudists from the United Arab Emirates-Oman border region. 1995. Pp. 89–305. £37.50

**Volume 52**

- No. 1 Zirconlite: a review of localities worldwide, and a compilation of its chemical compositions—A review of the stratigraphy of Eastern Paratethys (Oligocene–Holocene)—A new protorichthofenoid brachiopod (Productida) from the Upper Carboniferous of the Urals, Russia—The Upper Cretaceous ammonite *Vascoceras* Choffat, 1898 in north-eastern Nigeria. 1996. Pp. 1–89. £43.40

- No. 2 Jurassic bryozoans from Baltów, Holy Cross Mountains, Poland—A new deep-water spatangoid echinoid from the Cretaceous of British Columbia, Canada—The cranial anatomy of *Rhomaleosaurus thorntoni* Andrews (Reptilia, Plesiosauria)—The first known femur of *Hylaeosaurus armatus* and re-identification of ornithopod material in The Natural History Museum, London—Bryozoa from the Lower Carboniferous (Viséan) of County Fermanagh, Ireland. 1996. Pp. 91–171. £43.40

**Volume 53**

- No. 1 The status of '*Plesictis*' *croizeti*, '*Plesictis*' *gracilis* and '*Lutra*' *minor*: synonyms of the early Miocene viverid *Herpestides antiquus* (Mammalia, Carnivora)—*Baryonyx walkeri*, a fish-eating dinosaur from the Wealden of Surrey—The Cretaceous-Miocene genus *Lichenopora* (Bryozoa), with a description of a new species from New Zealand. 1997. Pp. 1–78. £43.40

- No. 2 Ordovician trilobites from the Tourmakeady Limestone, western Ireland—Ordovician Bryozoa from the Llandeilo Limestone, Clog-y-fran, near Whitland, South Wales—New Information on Cretaceous crabs. 1997. Pp. 79–139. £43.40

**Volume 54**

- No. 1 The Jurassic and Lower Cretaceous of Wadi Hajar, southern Yemen—Ammonites and nautiloids from the Jurassic and Lower Cretaceous of Wadi Hajar, southern Yemen. 1998. Pp. 1–107. £43.40

- No. 2 Caradoc brachiopods from the Shan States, Burma (Myanmar)—A review of the stratigraphy and trilobite faunas from the Cambrian Burj Formation in Jordan—The first Palaeozoic rhytidosteid: *Tricheosaurus major* (Woodward, 1909) from the late Permian of Australia, and a reassessment of the Rhytidosteidae (Amphibia, Temnospondyli)—The rhynchonellide brachiopod *Isopoma* Torley and its distribution. 1998. Pp. 109–163. £43.40

## **CONTENTS**

- 1 Latest Paleocene to earliest Eocene bryozoans from Chatham Island, New Zealand**  
*D.P. Gordon and P.D. Taylor*

Bulletin of The Natural History Museum

**GEOLOGY SERIES**

Vol. 55, No. 1, June 1999