AN EOCENE SEA-PEN FROM DUNEDIN, NEW ZEALAND

by D. HAMILTON

ABSTRACT. A new Upper Eocene pennatulid from the Burnside Mudstone, Dunedin, New Zealand, is described and named *Bensonularia spatulata*. It is assigned to the Family Veretillidae.

THIS is the first record of a pennatulid to be collected from Tertiary marine strata in New Zealand. The specimen was collected by the writer from a calcareous mudstone, the Burnside Mudstone, in the quarry operated by the Milburn Lime and Cement Co., Ltd., Burnside, Dunedin. Specimens of fossil pennatulids are relatively rare owing mainly to their delicate structure and the hazards of preservation. The Burnside specimen, however, consists of an almost complete rachis and is remarkably well preserved (Pl. 42, fig. 3). Bayer (1956, p. F224 et seq.) includes eleven families in the Suborder Sessiliflorae of the Pennatulacea, and the only fossil representatives of this suborder previously recognized are placed in the Family Renillidae. These forms show bilateral symmetry. The Burnside specimen lacks bilateral symmetry, so that it represents the most primitive evolutionary stage yet found in the fossil record.

Phylum COELENTERATA
Class ANTHOZOA
Subclass OCTOCORALLIA
Order PENNATULACEA Verrill 1865
Suborder SESSILIFLORAE Kükenthal 1915
Family VERETILLIDAE Herklots 1858
Genus BENSONULARIA gen. nov.

Type species *Bensonularia spatulata* gen. et sp. nov.

Diagnosis. Well-developed colony, compressed, but without bilateral symmetry, bearing zooids regularly arranged in sinistral and dextral spirals over the surface of the rachis. No calices. Spicules of the rachis are spindle-shaped.

Discussion. The compressed spatulate rachis of the specimen suggests an incipient bilateral symmetry, but the symmetry of the colony is dominantly radial as in the primitive Family Veretillidae. The zooids are arranged in a double spiral over the rachis, and this represents a considerable advance in symmetry over the irregular distribution of the zooids on the rachis so commonly found in the Family Veretillidae. This double spiral arrangement, however, is more primitive than the transverse rows of zooids characteristic of the Family Echinoptilidae. In that family incipient bilateral symmetry is shown by the trace of a groove or track on the rachis, and this groove is free of autozooids (Hickson 1918, p. 118). There is no trace of a groove on the surface of *Bensonularia*.

The spicules of the rachis of *Bensonularia* are constant both in form (i.e. spindles) and size (about 1 cm. long), as far as can be determined from the specimen. This constancy of spicule form contrasts with most of the sea-pens placed in the Family Vere-

[Palaeontology, Vol. 1, Part 3, pp. 226–30, pl. 42 (pars).]

tillidae. The primitive Veretillids show great variability in spicule shape and size, even between specimens of the same species collected from a similar locality (Hickson 1918, p. 126). The same author points out (1918, p. 123) that the spicules in the more advanced bilaterally symmetrical pennatulids 'are constantly of the same form and approximately of the same size'.

Though the arrangement of the zooids and the regular spicule form are comparatively advanced characters, these features are associated with radial symmetry only, so that *Bensonularia* is placed in the Family Veretillidae.

If *Bensonularia* is truly an advanced Veretillid, then the occurrence of an axis becomes at least probable. Hickson (1918, p. 119) points out that the occurrence of an axis in forms assigned to the Family Veretillidae is very variable, but in the higher forms, with stronger muscles to meet the needs of a free colony, the axis becomes a more constant feature. As the colony of *Bensonularia spatula* is large and in some respects advanced, it seems probable that an axis, possibly incomplete, was present in the living form.

The genus is named after the late Professor-Emeritus W. N. Benson, as a tribute to his contribution to the palaeontology and stratigraphy of the Dunedin district.

Bensonularia spatulata sp. nov.

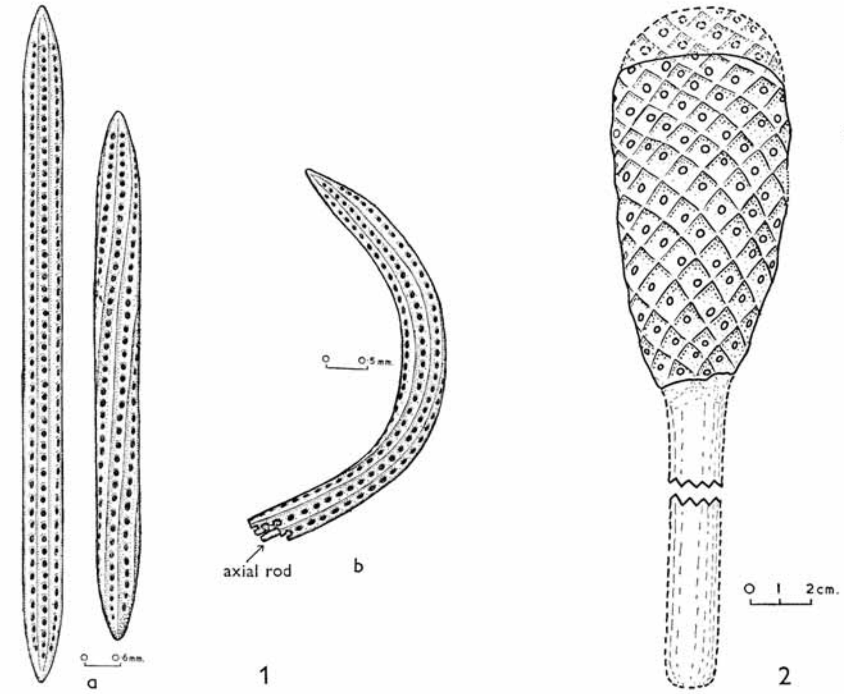
Plate 42, figs. 3, 4

Holotype. O.U. 5846. Specimen from Burnside Mudstone, Bortonian Stage (Upper Eocene), Burnside, Dunedin, New Zealand. In the Geology Department, University of Otago.

Diagnosis. Well-developed colony, compressed and spatulate in form. Zooids arranged in ascending sinistral and dextral spirals over the whole surface of the rachis. Zooid spirals separated by low ridges, which, on crossing, form diamond-shaped areas on the rachis. A single zooid occurs in each diamond-shaped area. Spicules are spindle-shaped, thickly pointed at each end, with six low hyaline ridges running the full length of the spicule, often in a slightly dextral spiral (text-fig. 1*a*). Between these hyaline ridges are single longitudinal rows of deep pits, which penetrate to a central axial rod in the spicule. Spicules of the coenenchyme lie parallel to the outer surface, interwoven, but with the longer spicules arranged longitudinally (Pl. 42, fig. 4).

Description. The specimen is preserved in a homogeneous, light-grey, calcareous mudstone matrix, and the filling of the gastric cavity is of the same lithology. The specimen (Pl. 42, fig. 3) consists of the major portion of the rachis and the mould of one side. The rachis is compressed. As other delicate fossils in the Burnside Mudstone show only slight or no distortion, it is probable that the preserved shape is that of the living colony. This interpretation is supported by the fact that the spicular arrangement on the specimen shows only slight signs of distortion along the flattened margins.

The precise nature of the spicules is rather difficult to determine, for, like some other calcareous remains in the Burnside Mudstone, they have been converted almost completely to marcasite and pyrite. However, fragmentary portions show an outer hyaline calcite layer with the six hyaline longitudinal ribs and also the pointed ends of the spicules. The fine mudstone matrix faithfully preserves the moulds, which clearly show the single row of pits between the ribs. Reconstructions of two rachis spicules are shown in text-fig. 1*a*. The structure is best shown by a partly altered C-shaped spicule taken from the supporting bundle around a zooid pore (text-fig. 1*b*). The broken end of the spicule reveals the pits penetrating to the central axial rod.



TEXT-FIGS. 1, 2. *Bensonularia spatulata* gen. et sp. nov. 1*a*, Spicules of the rachis. 1*b*, Scaphoid spicule from supporting bundle; broken end shows central axial rod. 2, Reconstruction.

Though Recent pennatulids invariably have dimorphic zooids, the pores on *Bensonularia spatulata* are all about 3 mm. in diameter. It is therefore not possible to distinguish between the distribution of the autozooids and siphonozooids on the rachis. The ridges separating the zooid spirals are low, and on the specimen the dextral spiral ridges are only weakly developed.

EXPLANATION OF PLATE 42

Figs. 1 and 2. *Archaias floridanus* (Conrad), Lower Miocene Tampa Formation, Tampa Island, Cherokee Sink, Wakulla County, Florida, U.S.A.; U.S.G.S. specimen f. 3838. 1, Shows the decorticated lateral surface; × 10. 2, The margin with the radial wave; × 15.

Figs. 3 and 4. *Bensonularia spatula* gen. et sp. nov., Eocene, Dunedin, New Zealand. 3, Shows the double spiral arrangement of the zooids and ridges on the rachis. 4, The spicular arrangement; note the longitudinal alignment of the long spicules.

Unfortunately the specimen is broken at both ends, so that the complete morphology of the colony is not known. However, the specimen does show a rounding towards the distal end and the rachis tapers regularly towards the proximal end, suggesting a smooth mergence of the rachis and stalk. A hypothetical reconstruction is shown in text-fig. 2.

In spite of the delicate preservation the broken ends of the specimen reveal no trace of an axis nor of any subdivision of the gastric cavity.

Measurements

Length of specimen	107 mm.
Maximum width	62 mm.
Minimum width	31 mm.
Distal section of broken end	58 mm. by 19 mm.
Proximal section of broken end	31 mm. by 10 mm. (approx.)
Diameter of zooid pores	3 mm.
Linear spacing of zooid pores	6 mm. to 12 mm.
Height of surface ridges	2 mm. to 3 mm.
Length of spicules	5 mm. to 15 mm.
Diameter of spicules	0·3 mm. to 0·6 mm.
Thickness of coenenchyme	5 mm.

From these measurements it is seen that *Bensonularia spatulata* is an unusually large pennatulid, and the spicules are also larger than those commonly present in this order.

Palaeoecology. As previously stated, the lithology of the Burnside Mudstone is homogeneous and fine-grained, having a median diameter of 0·006 mm. and a Trask sorting coefficient of 2·23. In fresh outcrop the mudstone is massive, having no sedimentary structures except filled borings. Though not abundant, the macrofossils include several thin-shelled mollusca as *Ctenamussium sp.*, *Ostrea sp. nov.*, *Lima* (*Callolima*) *sp.* cf. *L. regia* Suter (Marwick 1939, p. 59), together with thin-shelled indeterminate terebratulids, small echinoid spines, and sponge spicules. Chapman (1934, p. 119) has described a teleostean fish, *Eothyrsites holosquamatus*, from the Burnside Quarry, and fish scales are relatively common.

The sediment and macrofossils indicate continuous sedimentation in quiet waters. Many of the bivalves have both valves attached and the fossils are distributed throughout the mudstone. Of the foraminifera Mr. N. de B. Hornibrook, Senior Micropalaeontologist, N.Z. Geological Survey, writes (personal communication dated 13 January 1958): 'The Burnside Mudstone contains a very rich foraminiferal fauna characterized especially by a large and varied assemblage of Lagenidae. Polymorphinidae (several species of *Guttulina*, *Globulina*, and *Pyrulina*) are also common and large. The Heterohelicidae are represented only by large well-developed *Plectofrondicularia whaingaroica* (Stache) but Buliminidae are well represented and include abundant large *Bulimina* and *Uvigerina*. Anomalinidae include abundant *Cibicides* and *Anomalinoides*. *Pullenia*, *Sphaeroidina*, and *Gyroidinoides* are abundant and so are the pelagic forms *Globigerina linaperta* Finlay and *Globigerinoides index* Finlay.

'The almost complete absence of Miliolidae and Elphidiidae and other shallow-water forms makes it very unlikely that the Burnside Mudstone was deposited in shallow water.

'By analogy with Recent faunas, and especially because of the abundant Lagenidae and pelagic species, a fairly deep-water environment (of the order of 100 fathoms), such as that provided by the outer continental shelf, seems most likely.'

Such an environment corresponds closely with the present-day habitats of Veretillids, which, as Kolliker (1880, p. 31) notes, are the only group of Pennatulids found at such shallow depths, whilst 'all the others are, with very few exceptions, deep-sea forms'. Undisturbed conditions are necessary for the preservation of Pennatulids but in the case of *Bensonularia spatulata* this may have been aided by the presence of muscle fibres in the epidermis of the coenenchyme (Hyman 1940, p. 545). Probably these muscles were well developed in *Bensonularia spatulata* in order to support the relatively large rachis.

Acknowledgements. I wish to acknowledge the help and interest of Dr. Beryl Brewin, Department of Zoology, University of Otago, who first suggested the pennatulid relationship of this fossil. I also wish to thank Dr. D. A. Brown, Department of Geology, University of Otago, for much helpful discussion; Professor M. W. de Laubenfels, Department of Zoology, Oregon State College, who examined the specimen, and Mr. L. Seeuwen, Department of Geology, University of Otago, for photographic assistance.

REFERENCES

BAYER, F. M. 1956. In *Treatise on Invertebrate Paleontology*, ed. R. C. Moore. Part F. Coelenterata. Octocorallia, pp. F166–F190 and pp. F192–F231, figs. 134–8 and figs. 149–62.

CHAPMAN, F. 1934. Descriptions of fossil fish from New Zealand. *Trans. N.Z. Inst.* **64**, 117–21, pl. 12–14.

HICKSON, S. J. 1918. Evolution and symmetry in the order of sea-pens. *Proc. Roy. Soc. London*, B, **90**, 108–35.

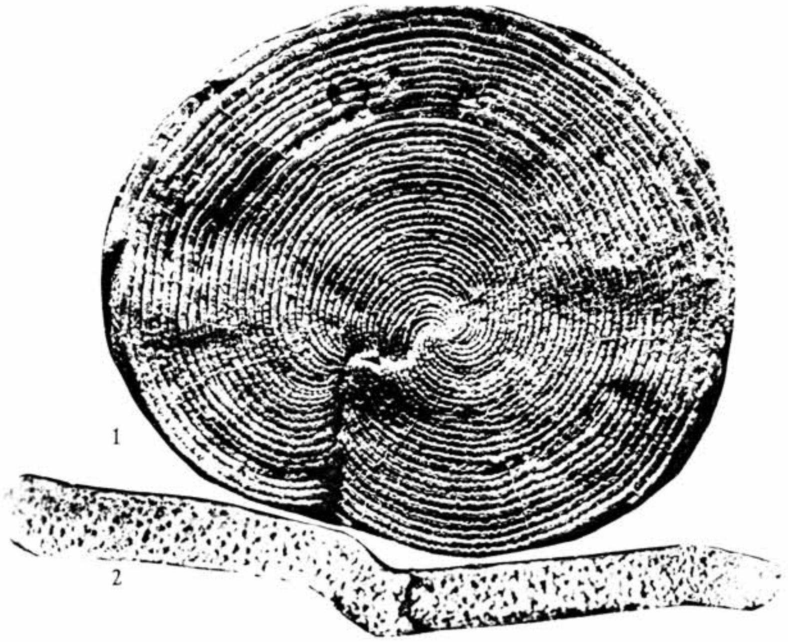
HYMAN, L. H. 1940. *The Invertebrates: Protozoa through Ctenophora*. McGraw-Hill (New York), xii+726.

KOLLIKER, A. 1880. Report on the Pennatulida. *Challenger Reports, Zoology*, **1**, pt. 2, 1–41, pl. 1–11.

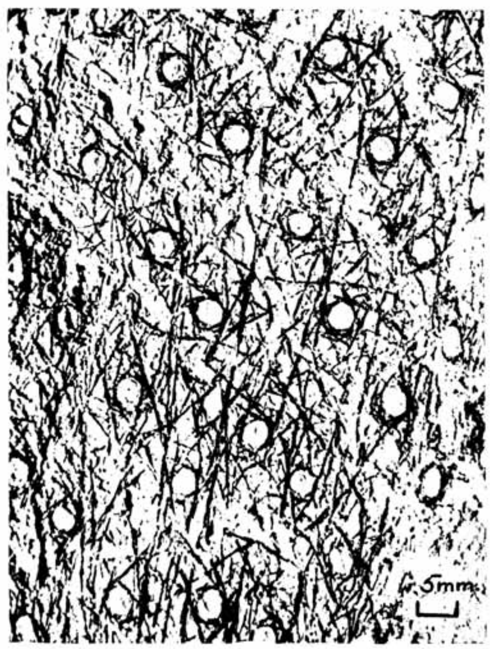
MARWICK, J. 1939. *In* The Geology of the Kaitangata-Green Island Subdivision by M. Ongley. *N.Z. Geol. Surv. Bull.* No. 38.

D. HAMILTON
Geology Department,
University of Otago,
Dunedin,
New Zealand

Manuscript received on 4 February 1958



3 

 4

SMOUT AND EAMES, *Archaias*
HAMILTON, Sea-Pen from New Zealand