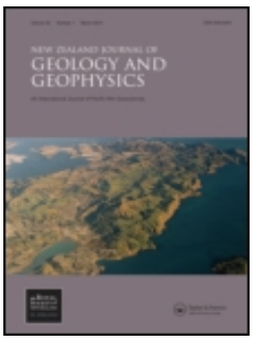

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A PRELIMINARY LIST OF NEW ZEALAND FOSSIL POLYCHAETES

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ABSTRACT

An annotated list of fossil "worm tubes" from New Zealand includes both published and new records from Mesozoic and Cenozoic deposits.

The binomen *Zoophycos plicatus* (Hutton) is proposed for the trace fossil long known as the Amuri fucoid, of unknown zoological affinity.

The following living species are recorded as New Zealand fossils for the first time: *Protula bispiralis* (Savigny), *Salmacina dysteri* (Huxley), *Hydroides norvegicus* Gunnerus, *Pomatoceras caniniferus* (Gray), *?P.* aff. *terranovae* (Benham), *Galeolaria hystrix* (Moerch), *Boccardia ? polybranchia* (Haswell); new records of fossil species are *Ditrupa* cf. *plana* (Sowerby), *Dorsoserpula lumbricalis* (Schlotheim), and *Neomicrorbis crenatostriatus* (Münster). The name *Hipponyx inexpectata* Mestayer 1929, applied to a serpulid operculum, is used in the combination *Temporaria inexpectata* for a tubeworm common in deep water off New Zealand that has also been identified, with associated operculum, from the bathyal Waitotaran (Pliocene) sediments of Palliser Bay. *Serpula wharfensis* Wilkens and *S. ougenensis* Chapman are placed in *Sclerostyla* Moerch. Two species of *Vermiliopsis* and two of *Spirorbis* are figured but not named specifically.

Although he devoted his life work almost entirely to the study of the Mollusca, Dr J. Marwick referred occasionally to other phyla represented in the fossil record by forms of actual or potential interest as index species, helpful in correlation. In correlating the Mangaotane Mudstone of East Coast district with the Nidd Mudstones of the Clarence Valley, for example, he commented that the correlation is "strengthened by the occurrence in both districts, at a lower horizon, of *Serpula wharfensis* Wilckens. This fossil has not been found at any other locality" (Marwick, 1926).

Polychaete Annelids of the Order Sedentaria, particularly the Serpulidae, build living-tubes that are conspicuous on modern shorelines and are reasonably common as fossils. Although the genera of Serpulids can often be discriminated by the form of the shelly tube and design of the operculum (Morton & Miller, 1968), zoologists have been chary of identifying fossil tubes, and no effort has hitherto been made in New Zealand to look for associated opercula which are abundant enough to be useful in the Eocene of Europe (Wrigley, 1951). Paleontologists, on the other hand, have not hesitated to apply Linnaean names to fossil worm tubes, some of which are useful in stratigraphy, while the resulting documentation of the geological history of this important group of animals is not without zoological interest. The studies of Austrian Tertiary species by Schmidt (1955), of German Jurassic species by Parsch (1956), and of European Eocene species by Wrigley (1951) are examples of this type of work.

New Zealand paleontologists have only paid intermittent attention to fossil Polychaeta, but several fossil "worm tubes" have been described or recorded during the past 110 years. By comparison with their prominence in early European monographs, however, it would seem that New Zealand fossil polychaetes are either scarce or neglected. The appearance of Howell's review of fossil worms (1962) stimulated the following summary, which will certainly be extended by further work; in particular, zoologists familiar with living New Zealand Polychaetes could undoubtedly refine the taxonomy of the Cenozoic fossils. For most Recent species, original references and synonymies are not given; most of them can be found in Hutton (1904), Dew (1959), or Straughan (1967).

Phylum ANNELIDA

Order POLYCHAETA

Order SEDENTARIA

[Family SABELLIDAE]

The arguments of Plicka (1969) that the "Amuri Fucoid" and other *Zoophycos* are fossil Sabellid worms have not proved acceptable to later investigators (Webby, 1969; Lewis, 1970) who have shown that they are trace fossils left by an organism that fed below the water-sediment interface; their biological relationships therefore remain uncertain. There seems no reason why the name *Pinna plicata* Hutton, applied to a fragment of the Amuri Fucoid from Culverden (Boreham, 1965), should not be used for this trace fossil, in the combination *Zoophycos plicatus* (Hutton).

Family SERPULIDAE

Form-genera in Serpulids.

The living Serpulids are classified from characters of the animal and operculum and several Recent genera produce essentially similar tubes, so that it is difficult to classify some fossil worm tubes in modern genera. For this reason Parsch proposed names (as subgenera of *Serpula*) to group tubes with common characters, among them *Dorsoserpula* for unicarinate tubes and *Tetraserpula* for tubes of quadrangular cross-section similar to *Sclerostyla*. The writer is unwilling to use such form genera for Cenozoic serpulids as this would obscure the close relationship some of them undoubtedly bear to living members of the family, a relationship that can only be firmly established by more detailed comparisons than have yet been possible. The Jurassic species listed below is, however, kept in the form genus *Dorsoserpula* Parsch, because its relationship with modern genera cannot be demonstrated. *Dorsoserpula* is ranked as a genus because its members seem closer to other genera of Serpulidae than to *Serpula* itself.

Opercula of Serpulids.

Many serpulid tube worms have chitinous opercula that are not fossilised, but in others the operculum is calcified, or partly calcified, preserving characters of shape and ornament that are diagnostic of genera or species.

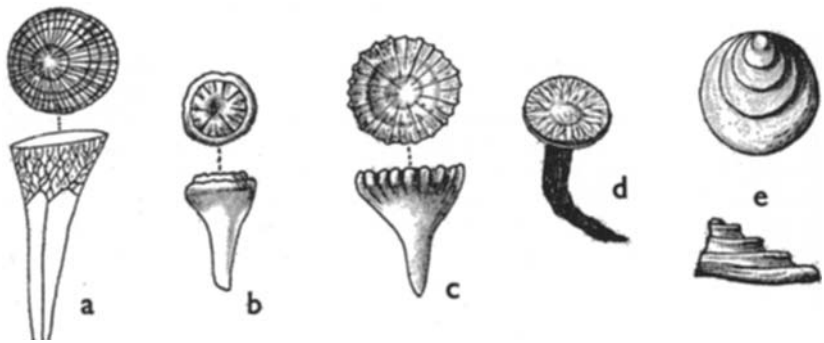

Fig. 1—Serpulid opercula (a–c after Wrigley, 1951). Enlarged, not to scale.
a. *Sclerostyla trochoides* (Nyst), Lattorfian, Belgium.
b. *Turbinia abbreviata* (Deshayes), Lutetian, England.
c. *Serpula* sp., Auversian, England.
d. and e. *Temporaria inexpectata* (Mestayer), Recent, off Otago, 500 m.

From the European Eocene and Oligocene Wrigley (1951) described opercula of *Sclerostyla, Turbinia* and *Serpula*, all of which have a calcified petiole or stalk (Fig. 1a–c) whereas most living serpulids have merely a calcified terminal disc, generally ornamented externally and with a concave inner surface to which a chitinous stalk is attached (Fig. 1d, e).

No serpulid opercula – even isolated ones – have hitherto been recorded from the New Zealand Tertiary, but one is recorded in this paper and they are so common in certain offshore Recent sediments that they have almost certainly been overlooked as fossils. A very characteristic operculum (Fig. 1e), with step-like growth stages, was described by Mestayer (1929) as a limpet-like gastropod *Hipponyx inexpectata* and identified as a polychaete by Dell (1956). Off Otago, in 500 m, it occurs with disc-shaped opercula (Fig. 1d) that might be interpreted as a different species. The two types, however, are associated with identical tubes and as both types of operculum occur in Australian specimens of the tubeworm described as *Pomatostegus polytrema* (Philippi) by Dew (1959, fig. 15), subsequently made the type of a new genus *Temporaria* Straughan (1967), they are tentatively considered conspecific. Fossil tubes associated with a disc-shaped operculum are therefore identified below as *Temporaria inexpectata* (Mestayer). Stalked opercula like those of the English Eocene *Sclerostyla, Turbinia* and *Serpula* should be looked for in early Tertiary deposits.

This note is published to draw the attention of New Zealand paleontologists to the nature of serpulid opercula. Students of living New Zealand serpulids could make a helpful contribution to paleontology by illustrating the calcareous opercula of Recent species, which have been described (if at all) in scattered papers in zoological literature, apart from the useful summary of the characteristics of a few common species by Morton and Miller (1968, p. 126). A few serpulid tubes have diagnostic shell characters, but others cannot be identified with confidence.

Subfamily FILOGRANINAE

Protula bispiralis (Savigny, 1820). Fig. 2a

Two specimens from the Lower Pleistocene of Castlecliff, Wanganui (GS 4102 and Suter Collection) have been identified by comparison with Recent examples. They are incomplete, lacking the juvenile portion, circular in cross-section, rather even in diameter (11 mm and 8 mm), with virtually no taper, and with irregular concentric growth striae. There are two additional specimens from Wanganui and one from Motunau (Pliocene) in Canterbury Museum. Two other specimens from the Lower Miocene (Otaian) Bluecliffs Siltstone in Pareora River (coll. P. A. Maxwell) are smaller (maximum diameter 7 mm) and may perhaps be separable when more specimens are compared.

Salmacina dysteri (Huxley, 1855)

This is a cosmopolitan gregarious species (Dew, 1959) characterised by fine flexuous intertwining white tubes of constant diameter (about 0·5 mm), with regular collar-like annulae. It is figured as *S. australis* Haswell by Morton & Miller (1968, fig. 47 (5)). The only fossil examples seen are on a valve of *Ostrea lutaria* Hutton, from Motunau (Pliocene), in the Canterbury Museum (Reg. no. zfw 55).

Subfamily SERPULINAE

Ditrupa chapmani Finlay (1924, p. 449, fig. 2a–d)

Slender tapering slightly curved tubes, 12·5 mm long, 1·25 mm wide just behind the aperture, resembling the scaphopod *Cadulus*. The type is from Clifden, Southland (Clifdenian) and Finlay recorded the species from other horizons at Clifden. *Ditrupa* occurs quite frequently in New Zealand Tertiary beds.

Ditrupa cf. **plana** (J. Sowerby, 1815)

Ditrupa fragments from Teschemaker's old quarry, Oamaru (GS 966, Runangan, Upper Eocene) are larger than *D. chapmani* (up to 3 mm diameter) and uneven in diameter, thus resembling *D. plana* from the Eocene of the London Basin (Wrigley, 1951, p. 190, fig. 53–5), although the largest exceed the dimensions of the specimens Wrigley figured.

Ditrupa parki Finlay (1924, p. 448, fig. 1a–b)

From outer crust of Moeraki Boulders (Teurian, Paleocene). Poorly preserved tubes (diameter 1·75 mm) with very thick walls; perhaps indeterminable.

Genus Sclerostyla Moerch, 1863

Wrigley (1951) described the characterstic calcified operculum of the living species *Sclerostyla ctenactis* Moerch from the Caribbean and justified the inclusion in the genus of European fossil species with similar opercula, one of which is here illustrated (Fig. 1a). The two species listed below resemble *Sclerostyla* in their tubes, but confirmation of their generic placing must await discovery of associated opercula.

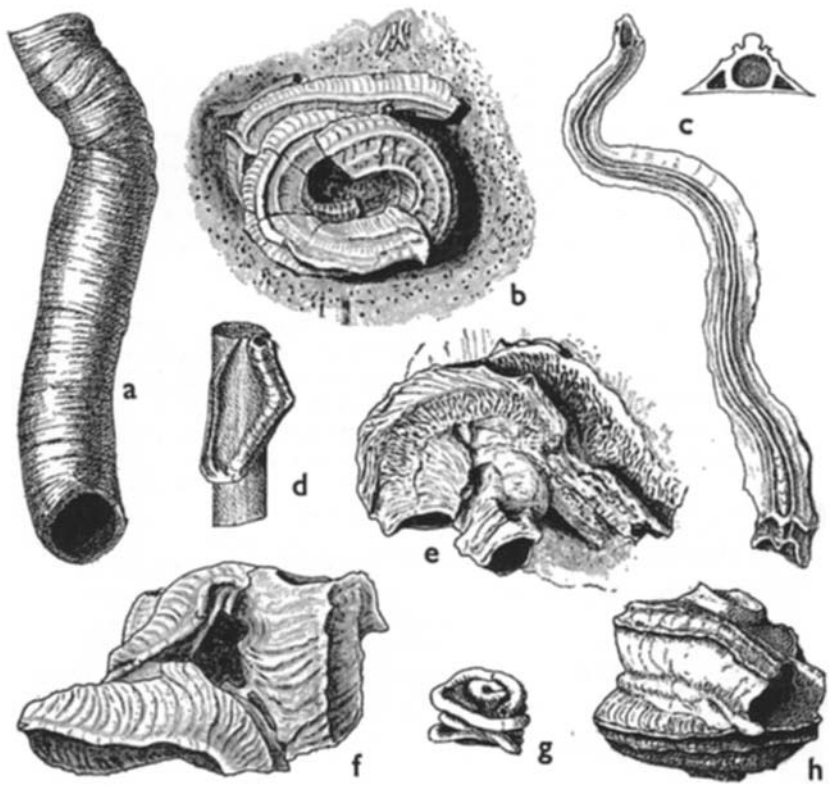

Fig. 2—a. *Protula bispiralis* (Savigny), Castlecliff, Wanganui (Lower Pleistocene) × 1.
b. *Hydroides norvegicus* Gunnerus, Tainui Shellbed, Castlecliff (Lower Pleistocene) × 3·5.
c. *?Vermiliopsis* sp., Clifden, Southland (Lower Miocene) and cross-section × 4.
d. *Dorsoserpula lumbricalis* (Schlotheim), GS 6480, Puti Point, Kawhia (Upper Jurassic) × 1.
e. *?Vermiliopsis* sp. Clifden, Southland (Lower Miocene) × 2.
f. *?Pomatoceros* aff. *terranovae* (Benham), GS 4060, Kai-iwi, Wanganui (Lower Pleistocene) × 3.
g. *Glomerula* sp., GS 5117, Broken River, Castle Hill Basin (Oligocene) × 2.
h. *Galeolaria hystrix* (Moerch), GS 10297, Leader River, North Canterbury (Lower Pleistocene) × 1·5.

Sclerostyla wharfensis (Wilckens, 1922, p. 35, pl. 5, fig. 17)

Slightly curved, tapering, unattached tubes with five equally spaced ridges, separated by concave interspaces, giving a pentagonal cross-section. Recorded by Wilckens from Ouse River, Coverham (Motuan Stage, Upper Albian) and by Marwick (1926) from Mangaotane Creek, Arowhana Survey District, presumably in beds of the same age.

Sclerostyla ouyenensis (Chapman, 1913)

Finlay (1924, p. 449) recorded this species from Pukeuri and from Clifden, Southland (Lower Miocene) on Chapman's identification. Chapman (1913) described his *Serpula ouyenensis* from the Kalimnan (?) and Janjukian of the Mallee Bores, Victoria. It is an unattached tube with six regularly spaced cords, giving a hexagonal cross section, with growth ridges nodulating the cords. The writer has not seen specimens.

Hydroides norvegicus Gunnerus 1768. Fig. 2b

The Castlecliff specimen attributed to this cosmopolitan species, from the Tainui Shellbed (Castlecliffian, Lower Pleistocene) agrees with illustrations of New Zealand specimens (Morton and Miller, 1968, fig. 47), but not particularly with that published by Howell (1962, fig. 97 (5)). It is a coiled tube, rather quadrangular in cross section, with irregular annular thickenings, and has a double keel but not dorsal apertural tooth. The specimen occupies the cup of a colonial bryozoan colony and itself bears a small *Spirorbis*. Fragments of a similar tube, probably *Hydroides,* were collected by Dr and Mrs M. T. Te Punga at Mingaroa, Rangitikei (Castlecliffian, Lower Pleistocene).

Dorsoserpula aff. **lumbricalis** (Schlotheim, 1820). Fig. 2d

Irregularly disposed attached tapering tubes with a prominent dorsal keel, triagonal in cross section, up to 6 mm in width.

The "*Serpula*" figured by Zittel (1864, pl. VIII, fig. 6) with *Placunopsis striatula* Zittel, adhering to a belemnite from Waikato South Head, is closely matched by another from Puti Point, Kawhia (Fig. 2d) and others from Kurutunu Stream (GS 6933) attached to bivalve fragments, all of Puaroan (Lower Tithonian) age. They are not separable, on available evidence, from "*Serpula sulcata* Sowerby", figured in "British Mesozoic Fossils" (Castell, 1962, pl. 4, fig. 1–2) from middle Jurassic beds in England. The name *Serpula (Vermilia?) sulcata* J. de C. Sowerby (1829, p. 225, pl. 608, fig. 1, 2) is, however, preoccupied by four earlier uses of the binomen *Serpula sulcata.* Closely similar worms from mud facies of the Dogger and Malm were figured in Goldfuss (1831, pl. 67, fig. 11, 12) as *S. grandis* and *S. limax,* names that are also preoccupied and are currently synonymised with *Serpulites lumbricalis* Schlotheim, 1820 (Parsch, 1956, p. 219).

The tube worms from Kurutunu Stream (GS 6933) differ from the other two in the development of cross folds, sometimes in pairs, thus approaching *Serpula limata* Münster and *Serpula plicatilis* Münster (*in* Goldfuss, 1831) but similarly transverse folds, less definite and less regularly spaced than the ribs in the two Münster species, are also reported from *Dorsoserpula lumbricalis* (Parsch, 1956, p. 220).

Pomatoceros cariniferus (Gray, 1843)

This common intertidal gregarious species of modern New Zealand coastlines, forming tangled manes of tubes, each with a dorsal keel prolonged by a spine above the aperture, has been identified by Professor G. A. Knox (Canterbury University) from fossil specimens collected by Mr Paul Rogers, University of Canterbury, in the upper part of the Greta Siltstone (Waitotaran, Pliocene), 600 yards north-east of Motunau River mouth, North Canterbury. The worm tubes were apparently transported from shallow water into a sub littoral environment. *Pomatoceros* has a chitinous operculum.

?Pomatoceros aff. **terranovae** (Benham, 1927). Fig. 2f

?Vermiliopsis sp. Fig. 2e

Worm tubes with a single carina, attached to molluscan shells, generally singly, or as a few individuals, and not massed gregariously like intertidal *Pomatoceros cariniferus,* occur sparingly in Cenozoic deposits, for instance in the Wanganui coast section (Castlecliffian, Lower Pleistocene) and at Calamity Point, Clifden (Altonian, Lower Miocene). Most are triangular in cross section, with an internal tube diameter up to about 2·5 mm. They have cellular lateral compartments on either side of the tube above its plane of attachment, segmented by partitions, so that they leave a characteristic scalariform scar where the tube is broken away from the substratum. Growth lines on the more or less foliaceous and undulating dorsal keel indicate that it projected as a tooth above the aperture. Below the dorsal keel the external lateral tube wall in Clifden specimens is ornamented by irregular branching grooves, normal to the keel, dying out on the lower part of the wall, but in others it is relatively smooth with broad concentric rugae (Kai-iwi). Occasionally, perhaps exposed by wear, a line of pores is visible parallel to and about a third the distance above the base of attachment, apparently penetrating to the ventro-lateral compartments. Probably more than one species is represented.

?Vermiliopsis sp. Fig. 2c

A different species appears to be represented by small tubes on the interior of *Pododesmus paucicostatus* Beu collected by Mr P. A. Maxwell from Calamity Point, Clifden (Altonian, Lower Miocene). They are small (internal diameter about a millimeter) and bear a tripartite keel, a narrow lateral thread bordering the medium tooth-forming keel on each side. The flanks, sloping to a broad area of attachment, bear a further weak longitudinal cord but are otherwise smooth. The flanks roof a regular series of lateral cellular compartments. Near the aperture, thickened varix-like flanges bearing a subdued tooth are developed. Professor G. A. Knox suggests that this is a species of *Vermiliopsis.*

Galeolaria hystrix Moerch, 1863. Fig. 2h

Galeolaria hystrix is a large attached worm tube, up to 12 mm in apertural width, characterised by two pronounced serrated dorsal ridges, separated by a groove.

A specimen from Castlecliffian beds in the Leader River near Mendip Hills, North Canterbury (GS 10297) consists of two incomplete double-keeled tubes coiled around a third tube (probably *Protula*). Several specimens in Canterbury Museum from Motunau (Pliocene) show the characteristic double keel on specimens that are not as tightly coiled as the Leader River specimen. Three tubes from the bathyal Pliocene sediments of Whangaimoana, Palliser Bay, associated with numerous tubes of *Temporaria,* also show the double carina of *Galeolaria hystrix.*

Temporaria inexpectata (Mestayer). Fig. 3a–h

1929 *Hipponyx inexpectata* Mestayer, p. 249, figs. 16–7.

In May 1971, Dr A. G. Beu collected 16 imperfect carinate serpulid tubes from the bathyal Waitotaran sediments at Whangaimoana, which he has suggested (Beu, 1967) were deposited at a depth of between 400 and 600 metres, probably near the upper limit of this range. This depth assessment is supported by the discovery of an operculum associated with one of the serpulid tubes, for both the tubes and the operculum match very closely a serpulid common in a dredging from 500 m in Papanui Canyon, Otago.

The commonest large serpulid from Papanui Canyon is uniformly orange in colour, with white interior, is at first attached to shells but commonly grows freely after about 2 cm of attached growth. It is triangular in cross section, with a projecting tooth at each angle, the three faces being essentially similar, about 7 mm wide, with irregular concave growth folds and a median or submedian suture-like groove. The three carinae gradually weaken in the adult tube, so that the apertural end is commonly cylindrical, about 6 mm in diameter, lacking carinae or projecting teeth. The operculum is either disc-shaped (as in Fig. 1d) or eccentric and stepped (as in *Hipponyx inexpectata* Mestayer); in this the Papanui species resembles the type species of *Temporaria* Straughan (1967), *Pomatostegus polytrema* (Philippi) illustrated by Dew (1959, fig. 15), but in eastern Australia *P. polytrema* is intertidal, has a pinkish to bluish mauve tube, with blue interior, and is characterised by two prominent parallel rows of depressions, leading to minute pores, which cancellate the flanks (Dew, 1959, fig. 16A). Although probably related, the New Zealand tube thus does not seem conspecific with the Australian material to which Philippi's name is applied. Philippi's *Vermilia polytrema* was described from the Mediterranean area. On the assumption that no earlier name is available for the New Zealand species, Mestayer's *Hipponyx inexpectata,* applied to a distinctive eccentric stepped operculum from 178 m off Great King Island, is used for the New Zealand species. Professor G. A. Knox, University of Canterbury, has examined the Papanui Canyon material and reports that it agrees with *Temporaria* in its trumpet-shaped abdominal setae.

The fragmentary Pliocene tubes from Whangaimoana, Palliser Bay (Waitotaran) agree closely with the Recent *Temporaria* tubes from Otago, and some even retain an orange pigmentation. The largest specimen is 35 mm long, 7·5 mm across the base, the lumen 4 mm in diameter. The tube

associated with an operculum shows the ridges weakening towards the almost cylindrical apertural end. The operculum is discoidal, 4 mm in diameter, 0·5 mm thick, porous in texture, externally concave, with a low central boss, surrounded by irregular branching radial striae, internally with a deep narrow marginal groove, surrounding broad central convexity to which the pedicel is attached (Fig. 3f–h).

Glomerula sp. Fig. 2g

This name is tentatively applied to a small coiled tube which agrees with the type species of *Glomerula* Nielsen (*Serpulites gordialis* Schlotheim, Upper Cretaceous, Europe) in its even diameter, labyrinthic coiling and lack of carinae. It has been noted from Trig. M, Totara (Runangan, Upper Eocene), from Broken River, Castle Hill Basin (Duntroonian, Oligocene), and from Alexander Street, Greymouth (Clifdenian, Lower Miocene). Similar tubes occur in Recent dredgings and the fossils will almost certainly prove to be a Recent species.

Subfamily SPIRORBINAE

Genus **Rotularia** Defrance

The genus *Rotularia* is quite abundant in the Jurassic shelf facies, at least from Ururoan (Upper Lias) onwards, and in the Cretaceous rocks of

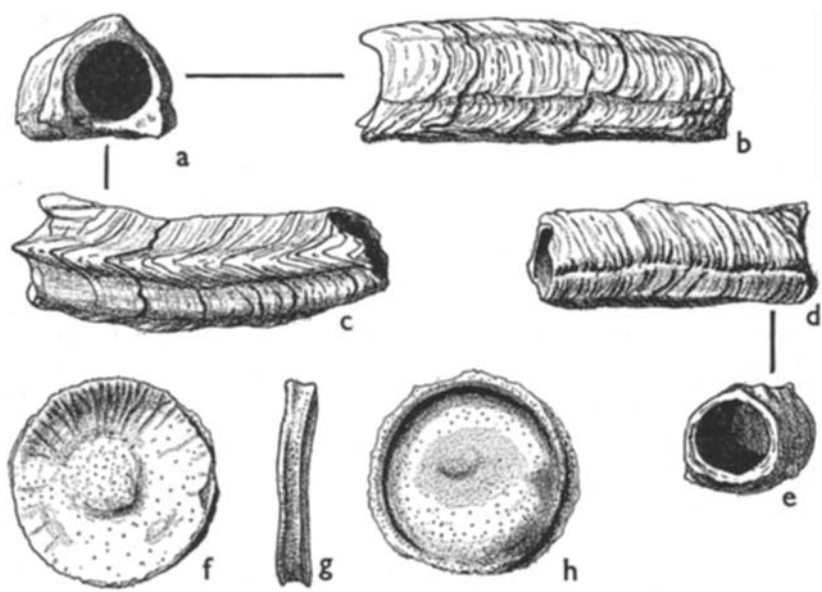

Fig. 3—*Temporaria inexpectata* (Mestayer). Whangaimoana, Palliser Bay.
a–c. Apertural, lateral and dorsal views of typical tube × 2·5.
d–e. Lateral and apertural views of specimen with obsolete carinae × 2·5.
f–h. External, lateral and petiolar views of operculum extracted from the tube shown in d–e × 8.

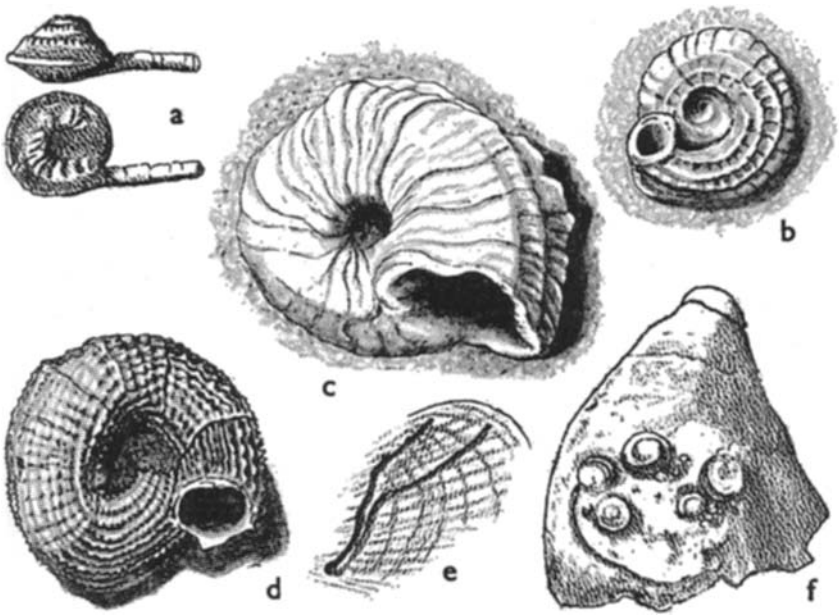

Fig. 4—a. *Rotularia* sp., GS 9937, Old Kihi Road, Kawhia (Upper Jurassic) × 1·35.
b. *Spirorbis* sp. A, GS 4186, Castlecliff, Wanganui (Lower Pleistocene) × 13.
c. *Spirorbis* sp. B, GS 9520, Awamoa Creek, Oamaru (Lower Miocene) × 13.
d. *Neomicrorbis crenatostriatus* (Münster), GS 6551, Towy River, Marlborough (Paleocene) × 6.
e. *Boccardia ? polybranchia* Haswell. Burrows in *Austrovenus*. GS 7966, Lower Hutt (Quaternary) × 13.
f. Silicified *Notostrea tarda* Hutton, with ?aff. *Spirorbis* or calcareous algae, GS 6895, Tioriori, Chatham Island (Paleocene) × 1·35.

Marlborough and Raukumara Peninsula. Stevens (1967) has briefly summarised the characters of New Zealand forms for comparison with Upper Jurassic specimens from Ellsworth Land, Antarctica. Detailed study will be necessary to determine the number and nomenclature of the species represented, particularly in the light of Ball's study (1960) of variation in Antarctic populations identified as *R. callosa* (Stoliczka). It seems likely, however, that additional species are represented, differing from the Cretaceous species that have been recorded. The specimen here figured (Fig. 4a) from the Puaroan (Lower Tithonian) of Old Kihi Road, Kawhia (GS 9937), appears to differ from named Cretaceous species in its elevated helicoid coiling, bicarinate periphery and uncoiled apertural section, but these characters are known to be variable in other species.

Although the genus is common in the Eocene of the Northern Hemisphere, no Tertiary specimens have so far been reported from New Zealand, but a badly preserved planispiral worm from the Chatham Islands (GS 792, Travers coll.), perhaps of Paleocene or Lower Eocene age, has many characters of *Rotularia* suggesting that the genus may yet be recorded in Tertiary deposits of the New Zealand region.

Rotularia chathamensis Boreham (1959, p. 122, pl. 11, fig. 4–9)

This species, described from Lower Cretaceous rocks of the Chatham Islands, is characterised by large size, involute planispiral coiling and weak sculpture. It may also include some of the involute, weakly sculptured specimens from the mainland Clarence series.

Rotularia ornata (Wilckens, 1922, p. 25, pl. 5, fig. 10–2)

Although Ball (1960) considered Wilckens' species from the Piripauan (Campanian) of Amuri Bluff to be the same as *R. callosa* Stoliczka, Stevens (1967) has argued for their distinctness.

Rotularia cf. **discoideum** (Stoliczka, 1868)

Wilckens (1924, p. 543, pl. 54, fig. 8a, b) recorded this species from the Haumurian (Maastrichtian) of Shag Point. It differs from other species in its discoidal biconcave shell.

Genus **Spirorbis** Daubin, 1800

Several subgenera of *Spirorbis* have been named, mainly on the basis of coiling direction, but although some are used by Schmidt (1955) in his review of Austrian Tertiary species, they are not widely accepted by students of Recent forms (e.g., Wisely, 1962; Ushakov, 1955; Riedl, 1963).

Discrimination of the numerous living species of *Spirorbis* depends to a large extent on characters of the animal. For this reason the two New Zealand fossil species recorded below are not attributed to named taxa.

Spirorbis sp. A. Fig. 4b

Minute sinistral spiral tubes with three spiral cords crossed by growth folds; widely umbilicate.

Mollusca from the Wanganui Series (Pliocene–Lower Pleistocene) quite commonly bear the sinistrally coiled shells of a *Spirorbis* identical with one of the common New Zealand living species, which does not differ appreciably in shell characters from some species of *Spirorbis* in other parts of the world, such as *S. catagraphus* Roverto (Howell, 1962, fig. 99/13), or the dextral *S. pagenstecheri* Quatref. (Riedl, 1963, pl. 73). Although dextral and sinistral species of *Spirorbis* occur in Eastern Australia (Wisely, 1962; *S. convexis* Wisely, *S. lamellosa* Lamarck), no dextral specimens have been seen among many New Zealand fossils examined.

Spirorbis sp. B. Fig. 4c

Shells of *Lima colorata* Hutton from Awamoa and *Pachymelon* sp. from Awamoa Creek (Altonian, Lower Miocene) bear numerous *Spirorbis* differing markedly from the New Zealand Recent and Pleistocene specimens seen, and a small specimen adhering to a *Ditrupa* tube from Teschemaker's Quarry, Oamaru (Runangan) is similar. Like the younger species the Tertiary species is sinistral, but reaches a large size, up to 3·5 mm in maximum diameter, and is involute, with a narrow umbilicus. Irregular sinusoidal growth folds are the dominant ornament, spiral elements being restricted to subdued ridges, one on the periphery and one on the

upper surface in the specimen figured, rather variably developed, generally only on the last quarter whorl. In its general lack of prominent sculpture the New Zealand Tertiary species resembles the North Pacific *Spirorbis validus* Verrill, 1876, described from Le Have Bank and illustrated adhering to a crab carapace by Ushakov (1955, pl. 18, fig. 4).

Involute *Spirorbis* with subdued or no spiral cords include, besides *validus*, *S. spirorbis* Linn. (sinistral) as figured by Gaevskoy (1948, pl. 39, fig. 18t) from the Arctic, and by Schmidt (1955, pl. 8, fig. 29) from the Pleistocene of Pellegrino, *S. vitreus* Fabricius (dextral) from the same region (Gaevskoy, 1948, pl. 39, fig. 23), *S. lamellosus* Lamarck (dextral, East Australia) and unidentified mainly sinistral specimens from Chile and Falkland Islands (on *Fissurella, Trophon* and *Concholepas*), South Africa (on *Dicithais* and *Cominella*) and California (on *Ceratostoma*). *S. convexis* Wisely (1962) from East Australia (sinistral) has a much more regular evenly coiled planorbid tube.

Spirorbis (?) sp. C. Fig. 4f

The *Gryphea*-like oyster, *Notostrea tarda* (Hutton) occurs abundantly in the Tutuira Greensand of Uppermost Teurian–Waipawan (Paleocene) age, near Tioriori, northern coast of Chatham Island (Hay *et al.*, 1970, p. 29). In one shelly layer the *Notostrea* shells have been replaced by silica. The silicified *Notostrea* bear abundant small circular bodies, also silicified, which Scott (*in* Hay *et al.*, 1970, p. 31) considered to be worm tubes, apparently of a serpulid similar to *Spirorbis* or *Glomerula*. Due to deposition of silica within the tubes and locally on their surface, few details can be seen. The best preserved show strong lateral carinae and suggestions of an aperture. Other specimens are closely crowded on the surface of the shells in a continuous layer of silica in which the outline of the individual spirals are scarcely discernible, raising the suspicion that the structures might have been calcareous algae similar to *Collenia*.

Genus **Neomicrorbis** Roverto, 1903

Neomicrorbis crenatostriatus (Münster). Fig. 4d

1829 *Serpula (? Spirorbis) granulata* Sowerby, p. 200 (not of Montagu, 1803).
1831 *Serpula crenato-striata* Münster, *in* Goldfuss, p. 239, Atlas, Pl. LXXI, fig. 2.

A beautifully preserved silicified specimen from the Towy River, Marlborough (GS 6551, Waipawan, Paleocene), collected with the type of the coral *Lochmaeotrochus micrommatus* Squires by G. J. Lensen, agrees very closely with the illustrations of Sowerby (1829), Goldfuss (1831), and Castell (1962) of the type species of *Neomicrorbis*, from the Upper Cretaceous (Turonian–Upper Senonian) of Europe, and with specimens from the Baltic island of Rügen, in the N.Z. Geological Survey. It is an attached small sinistrally coiled tube of about 2 whorls, 5 mm in diameter, its surface covered with longitudinal rows of prominent granules. The genus ranges from Cretaceous to Eocene in Europe according to Howell (1962); the New Zealand record extends its geographic distribution to the southern hemisphere and is a reminder that some polychaetes (such as *Hydroides norvegicus*) are cosmopolitan, justifying the use of a broad and open nomenclature.

Family TEREBELLIDAE

Terebellina sp.

Webby (1967) has reported on worm tubes tentatively identified as *Terebellina* from Upper Cretaceous Whangai Shale near Flat Point, near Tinui, and Castle Point, East Wellington, and from Port Awanui.

Torlessia mackayi Bather (1905, p. 537, fig. 1–3)

As *Torlessia* built its siliceous tube by the selection and aggregation of small grains of quartz from the greywacke-suite rocks in which it lived, it should be classed in the Terebellidae, along with the closely related *Terebellina* (Jurassic, North America) and *Titahia,* and not in the Serpulidae where it is placed by Howell (1962), as noted by Campbell & Warren (1965). The latter authors have summarised the wide distribution and the evidence for upper Triassic age of *Torlessia* in the Torlesse Group.

Titahia corrugata Webby (1958, p. 509, fig. 1–5)

Associated with *Torlessia* in Upper Triassic (?) sediments of the Torlesse Group in both North and South Islands (Campbell & Warren, 1965) and in the Tuapeka Group at Akatore, South Otago (Campbell & Campbell, 1970).

? Family AMPHICTENIDAE

The *Dentalium*-shaped tubes of *Pectinaria,* common off New Zealand coasts (Morton & Miller, 1968) have apparently not been found fossil. From the Duntroonian greensands of Puponga Point, Northwest Nelson, Dr F. Climo has collected smooth straight tapering rusty coloured tubes with very thin walls containing iron, calcium and phosphorous that may be the phosphatic (or phosphatised) glutinous tubes of an Amphictenid.

Family SPIONIDAE

Boccardia ?polybranchia Haswell. Fig. 4e

The characteristic U burrows formed by this boring polychaete in Recent bivalves (Morton & Miller, 1968, fig. 181) can be closely matched in Miocene, Pliocene, and Quaternary fossils (*Pododesmus, Chione, Tawera,* etc.). Similar borings occur in Permian and Lower Devonian Brachiopoda.

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