PRIMITIVE FORAMINIFERA AND XENOPHYOPHOREA IN IOS EPIBENTHIC SLEDGE SAMPLES FROM THE NORTHEAST ATLANTIC

BY
A.J. GOODAY

REPORT NO. 156
1983

NATURAL ENVIRONMENT RESEARCH COUNCIL

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When citing this document in a bibliography the reference should be given as follows:-

GOODAY, A.J. 1983 Primitive Foraminifera and Xenophyophorea in IOS epibenthic sledge samples from the northeast Atlantic. *Institute of Oceanographic Sciences, Report,* No. 156, 33pp.

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1. INTRODUCTION

The abundance of Foraminifera in many samples obtained by dredging in the deep-sea was well known to the Victorian naturalists who first obtained such material (Carpenter, 1869). They figure prominently, for example, in the narratives describing the three Porcupine cruises off Scotland and Ireland in 1869 (Carpenter, Jeffreys and Wyville Thomson 1870). Later deep-sea expeditions amplified these results and underlined the abundance at bathyal and abyssal depths of large agglutinated Foraminifera, particularly the primitive, single chambered types belonging to the superfamily Ammodiscacea (for example see Brady 1884, Goës 1896, Flint 1899, Pearcy 1914, Bandy and Rodolfo 1964, Saidova 1970, Murray 1973 p. 173, Gooday, in press). With such a long history of research, it might seem unlikely that any important group of Foraminifera could elude recognition. However, in 1977, Tendal and Hessler established a new superfamily, the Komokiacea (informally "komoki", singular "komok") for a group of agglutinated Foraminifera which, in abyssal oligotrophic environments, are more abundant by volume than all metazoans combined and equal in abundance to all other foraminifers. Previous knowledge of the komoki had been limted to the description of one species by Norman (1878). They had been overlooked "because they look like lint, nondescript organic detritus, poorly washed balls of sediment, or minor fragments from the surface of some unidentified larger organism" (Tandal and Hessler 1977, p.166).

Komokiaceans are common in many IOS epibenthic sledge residues. Examination of these samples has also brought to light other groups of primitive Foraminifera of generally nondescript appearance which are virtually undocumented in the deep-sea literature. Some of these groups probably represent undescribed genera or higher taxa. Another significant element in many samples are the xenophyophores, giant testate rhizopods related to the Foraminifera but occupying a separate class. Although recognised as a distinct group for almost 80 years, the importance of these (?) exclusively deep-sea protozoans was not appreciated until they were monographed by Tendal (1972). Since this publication some 13 papers, mainly by Tendal and his co-workers, have described various aspects of xenophyophore systematics, chemistry and ecology.

The main purpose of this report is to indicate the scope of the descriptive work necessary to adequately document these neglected rhizopods as they occur in IOS samples. A brief account is given of the morphology, diversity and abundance of the more important groups requiring taxonomic attention. There also exist a variety of undescribed foraminiferal types which are taxonomically fascinating but numerically rather insignificant. The "Hyperammina-like forms" are included in this report as an example of these minor groups. Taxonomic problems abound at the species level even among well-established taxa. Some of the genera in more obvious need of revision are mentioned below.

The work of Tendal (1972) and Tendal and Hessler (1977) has set high standards for xenophyophore and komokiacean taxonomy. It particularly needs to be stressed that an investigation of the structure and internal morphology of the test and the cytology of its contents by means of paraffin sections is now essential for the proper description of these kinds of rhizopods. Material which is fixed in formalin and preserved in alcohol (see below) is unsuitable for many cytological purposes. It is therefore recommended that selected specimens should in future be placed immediately after recovery in fixatives such as gluteraldehyde or Bouin's, Carnoy's, Flemming's or Zenker's fluids, before being preserved in 80% alcohol. (Tendal and Hessler 1977, p.170).

2. TERMINOLOGY

Two terms require definitions.

Tectinous: composed of tectin - "a general term implying a basic composition of glycoproteins" (Hedley 1964, p.2). Many primitive Foraminifera have test which are generally though to be wholly, or in part tectinous. However, note that quantitative chemical analyses have recently demonstrated a protenaceous-carbohydrate composition for the shell of Allogromia laticollaris (Schwab and Plapp 1983).

Stercomata: the "faecal pellets" which are retained within the tests of xenophyophores and some foraminifers.

3. MATERIALS AND METHODS

All the material examined for this report was obtained from RRS Discovery and RRS Challenger using various versions of the IOS epibenthic sledge (Aldred et al. 1976; Rice et al. 1982). The samples were taken in two main areas in the northeast Atlantic: off the coast of northwest Africa and in the Porcupine Seabight which is an embayment of the continental shelf southwest of Ireland. Samples were usually sieved on deck into fine (0.125-0.500mm), medium (0.5-2.0mm) and coarse (>2.0mm) residues, fixed for several days in buffered formalin and then preserved in 80% alcohol. The foraminifers and xenophyophores described here were picked out from the medium and coarse residues.

Samples from more than 70 stations, covering a vertical range of 997m to 6059m, have been examined. The sorting process has been carried out at different times, by different people, for different purposes and with varying degrees of thoroughness and hence lacks uniformity of approach. The resulting data are mainly qualitative or semi-quantitative. However, more precise counts of the relative abundance of all Foraminifera are available for several residues from both the main sampling areas. These results are set out in Tables 1 and 2. It must be appreciated that such data need to be interpreted with great caution because sledges and trawls are, at best, only semi-quantitative samplers and, in the case of Foraminifera, are notorious for being biased towards the selection of large, heavy species at the expense of small, light forms (Höglund 1947, Bandy 1963, Douglas and Woodruff 1982). The larger Foraminifera are, of course, further concentrated in the coarser residues. The figures given in Tables 1 and 2 merely provide a rough indication of relative abundances in these residues.

For full information about the stations mentioned below, reference should be made to N.I.O. Cruise Report No. 40, I.O.S. Cruise Reports, Nos. 10, 70, 79, 82, 107, 119 and SMBA Cruise Reports for Challenger Cruises 7/79 and 11/80.

4. GENERAL COMMENTS ON THE FORAMINIFERAL ASSEMBLAGES

The Foraminifera are a sparse to dominant component of the residues examined. The medium residues in particular (for example, Station 8540, see Table 2) are often extremely rich in foraminifers. Many of the tests contain protoplasm and were presumably alive when captured. The >0.5 and >2.0mm residues usually contain numerous agglutinated species among which single chambered ammodiscaceans of the genera *Astrorhiza*, *Bathysiphon*, *Crithionina*, *Hyperammina*, *Marsipella*, *Rhabdammina*, *Rhizammina* and *Saccorhiza* are particularly important. Examples of species which occur abundantly are *Astrorhiza arenaria*, *Hyperammina elongata*. *H. friabilis*, *Marsipella cylindrica* and *Saccorhiza ramosa* (all around 1000m - 1400m), *Rhizammina algaeformis* (2000-4000m), *Crithionina mamilla*, *Hyperammina crassatina*, *Rhabdammina irregularis*, *R. linearis* and *Saccorhiza atlantica* (3000-4000m).

Gooday (in press) describes the occurrence of Bathysiphon rusticus in vast numbers at 4000m (11°N - Station 8540) and of B. folini between 2500m and 3000m in the Porcupine Seabight (Stations 10112, 10113, 51111). Important new species or taxonomic ambiguities occur within the genera Bathysiphon, Rhabdammina and Rhizammina.

The multichambered lituolaceans are usually smaller than the ammodiscaceans and are therefore concentrated in the fine and medium residues. They are particularly common between 3000m and 4000m. Important species from this depth range include Alveophragmium scitulus, A. subglobulus, Hormosina carpenteri, H. globulifera, H. normani, Reophax spp., and Trochammina globigeriniformis. Deep-sea species of the genera Reophax and Trochammina are in need of revision.

Calcareous Foraminifera are numerous in the fine residues and include a wide variety of species (for example, at least 100 in four samples from off north-west Africa). However, in the coarser fractions they are limited to a few large forms such as Globobulimina spp., Hoeglundina elegans, Lenticulina spp., Dentalina spp. among the rotaliids and species of Biloculinella, Cornuspira, Discospirina, Planispirinoides and Pyrgo among the miliolids. The taxonomy of Pyrgo, one of the most important miliolid genera in the deep-sea, is confused and requires revision. At least one large and important species of Biloculinella awaits description.

5. FORAMINIFERAL GROUPS REQUIRING SPECIAL TAXONOMIC ATTENTION

5.1 Komokiacea.

The komokiacean test is a system of branching tubules, with or without a centre of organisation (Tendal and Hessler 1977). The tubule wall consists of two layers, a thin, inner tectinous layer overlain by a thicker agglutinated veneer. In a few genera, fine sediment may partly or completely fill the interstices between the tubules to form a mudball. Tendal and Hessler (1977) describe eleven new species belonging to seven genera and two families, a single species having been described previously. However, Tendal and Hessler (1977, p.166) suspect that the total number of species in their samples alone may be in the hundreds.

Komoki are common in most IOS samples obtained from deeper than 1000m and sometimes include more than half of all the Foraminifera (Tables 1 and 2). At least 32 species have so far been recognised in the medium and coarse residues and >25% of these belong to the genus Lana (Gooday and Cook in prep.), confirming the experience of Tendal and Hessler (1977, p. 185) that this genus is particularly diverse. Three species are provisionally identified as Baculella globofera, Lana neglecta and Septuma ocotillo, but the rest appear to be new. However, the komoki in these samples are less abundant, compared to the metazoan macrofauna, and less diverse than those from the abyssal, oligotrophic environment of the North Pacific Gyre which formed the core of Tendal and Hessler's (1977) collection. These authors also found (p. 175) that the "relative abundance of komoki seems to be less in the equatorial abyss and in the bathyal zone, as seen in the eastern equatorial Pacific and South California continental borderland, respectively" than in the oligotrophic abyss.

The IOS material is dominated, both in numbers and volume, by several species of Lana and in particular by a mudball-forming species of Edgertonia. These forms are very large for komoki and hence become concentrated in the coarser residues. Lana sp. reaches 11mm and Edgertonian sp.14mm, compared with the size range 1-5mm which is typical for komoki (Tendal and Hessler 1977, p. 171). The largest specimens were found off northwest Africa and their size may be related to high nutrient levels associated with upwelling. In coarse residues, Edgertonia sp. mudballs make up between 13.5% and 94.5% ($\bar{X}$ = 68.8%) of all komoki.

Samples obtained from between 5540m and 6059m off northwest Africa (Stations 9128, 9129) yielded a distinct and abundant komokiacean fauna. A casual examination of the deepest of these samples produced 12 species: Baculella globofera, Edgertonia sp. 1, E. sp. 2, Ipoa fragila, Komokia multiramosa, Normanina tyloda, Septuma sp., Lana sp. 1, L. sp. 2, L. sp. 3 and ?Lana sp. Most of these species did not occur in shallower samples. The whole assemblage seems rather similar in both its taxonomic composition and the size of individual specimens (<5mm) to komoki faunas from the Central North Pacific (Tendal and Hessler 1977, p. 176), although it is much less diverse.

Tendal and Hessler's (1977, p. 166) comment that "it will take years of laborious effort to bring the knowledge of komoki up to the level of that of other recent taxa" is amply borne out by the material in IOS collections.

5.2 Pelosina

This genus has a thick-walled test composed mainly of mud with a thin, basal organic layer. The test is elongate and fusiform, or shorter and rounded, often with a point or neck at one or both ends, and is filled with dense protoplasm. Root-like structures may be developed at one end (Fig. 4; Höglund 1947, pl. 6) and branch-like structures at the opposite end (Pearcy 1914, pl. 1, fig. 1). Compared with the other groups dealt with in this report, Pelosina has been widely reported from the deep-sea (for example Brady 1879, 1884, Flint 1899, Pearcy 1914, Earland 1933, 1934). Some species attain a considerable size: P. variabilis, 15mm; P. cylindrica, 20mm; P. variabilis var. constricta, 40mm; P. arborescens, 60mm. However, the importance and diversity of deep-sea pelosinids has never been clearly emphasised.

The IOS samples have yielded some 14 species which can be assigned either tentatively or confidently to Pelosina. They display a considerable variety of morphologies ranging from long threads (Fig. 1) to ball shaped forms (Figs. 4,5) while one species has a short trunk which breaks up into a system of branches (Pl. 2, fig. 4). Several have short filaments arising from their surfaces (Figs. 1,2). There are two species which are particularly abundant. One of them is large (up to 16mm) and has an elongate, fusiform shape (Fig. 2). This form is very common between 1000m and 1500m (Stations 9754, 10131, 10153, 50606) and is also a significant element in samples from 1980m (Station 50602), 2300-2440m (Stations 10106, 50613) and 3100m (Station 8532). The other species is smaller, shaped like a lemon (Fig. 5, Pl. 1, Fig. 6) and abundant at depths of 2000m to 3000m (Stations 8521, 8528, 9132, 10112, 10113, 50605, 50913). A turnip-shaped species (Fig. 4) is fairly common between 1500m and 2000m (Stations 9754 10111, 50602) and at 3150m (Station 8528).

Up to a fifth of all Foraminifera in the quantitative samples are attributable to Pelosina (Table 1). Some species contain a large mass of protoplasm and so must contribute significantly to the total foraminiferal biomass.

5.3 Mud-walled astrorhizinids.

In this group the test is thick-walled and composed of muddy sediment with a thin basal organic layer as in pelosinids. However, the basic shape is more complex, consisting of arms of variable width, which are sometimes branched, and radiate in all directions from a central region (Fig. 3). The overall morphology of many species is a ball with arms projecting from the surface (Pl. 2, figs. 1-3). These mudballs are sometimes quite large (up to 11mm). In other species

(?distinct genus) the arms, which are fairly narrow and branched, arise along an axis and tend to lie in a single plane. The mudballs, in particular, look rather like komokiaceans. However, the internal organisation is quite different, there being a central cavity with extensions into the arms, filled with dense protoplasm.

This group clearly belongs within the family Astrorhizidae, sub-family Astrorhizinae. However, its members differ from the genera Astrorhiza and Astrammina in having a thick walled, muddy test and from Astrorhiza in their essentially three dimensioned, ball or star-shaped morphologies. Mud-walled astrorhizinids, as described above, probably embrace more than one genus. The group almost certainly also includes Radicula in which narrow, branched arms composed of mud overlying an organic layer radiate from a central junction (Christiansen 1958). This monotypic genus has only been reported from depths 58m to 210m in the Oslo Fjord, but a probable specimen occurred at 2714m to the northwest of Scotland (Station 7709). Another related form may be Astrorhiza cornuta which resembles the forms having narrow arms arising from an axis but agglutinates sand rather than mud (Brady 1884).

The mud-walled astrorhizinids are a frequently conspicuous, but never dominant element of foraminiferal assemblages in epibenthic sledge samples. They were abundant at 2440m (Station 50613), where they for once outnumbered the komoki, and were also fairly common at depths of 1140-1120m (Station 50606), 1484m (Station 9754), 1942m (Station 9753) and 2650-2760m (Station 10112, 10113) in the Porcupine Seabight. In the area off northwest Africa, good collections have been obtained from 1065m (Station 10153) and between 2950m and 3150m (Stations 8521, 8532, 9132 and particularly 8528). The group is fairly diverse and includes at least 15 species.

5.4 Foraminifera, mainly allogromiids, with tectinous tests.

The suborder Allogromiina comprises a variety of foraminifers characterised by a tectinous test, occasionally with some foreign particles agglutinated externally. There are numerous reports of these Foraminifera occurring in near-shore, as well as fresh-water environments, but the group remains rarely documented from the deep-sea. The few published records are for the family Allogromiidae. Tendal (1979, Table 1) listed the deepest occurrence of allogromiids in his material as 4200m, Jumars and Hessler (1976) found allogromiids to be numerous in the meiofaunal fraction of a box-core taken at 7298m in the Aleutian Trench and Wolff (1979, p. 120) recorded them from 2288m off Georgia, U.S.A.

The IOS samples have yielded some good collections of typical allogromiids, with oval or elongate tests, transparent or transluscent walls enclosing a mass of dark grey stercomes, and a distinct "oral complex" (Hedley 1964, Fig. 1). However, some specimens are very large (up to 7.7mm long) with tough-looking walls that seem to be much thicker than the 1.5μm indicated by Hedley (1964, p.3) as typical for Allogromia.

Occasional specimens occurred in many epibenthic hauls from bathyal and abyssal depths. They were sometimes fairly abundant, for example in samples from 1942m (Station 9753), 1980m (Station 50602), 2440m (Station 50613) and 3000-3040m (Station 50913) in the Porcupine Seabight and 1320-1325m (Station 10131) and 2112-2160m (Station 9133) off northwest Africa. However,they are always a relatively minor component of the foraminiferal assemblages, and the available material seems to include relatively few species.

In addition to the typical allogromiids there are several enigmatic forms which, although apparently tectinous Foraminifera, do not fit into any described taxa. None of these forms appears to have an aperture.

(i) Thin walled, transparent tests, up to 3.9mm maximum dimension having the form of a branching tube 80-280μm in diameter. A few fine filaments may arise from the surface. The interior is usually filled with dark grey stercomata. These tubules bear some resemblance to those of the komokiacea but are wider, less extensively branched and do not have an outer agglutinated layer. Similar structures were observed by Gooday and Haynes (in press) attached to the interior of Bathysiphon tubes.

(ii) Approximately sphaerical tests, 1.6 - 2.5mm diameter, with a fairly thick, transparent wall and more or less surrounded by a variably developed envelope of whitish, filamentous material which is attached in some way to the test surface. The interior is filled with stercomata.

(iii) Large, flattened masses of stercomata, roughly circular in outline and up to 7.5mm diameter. Although not bounded by an obvious membrane, these masses have a clearly defined shape, considerable internal coherence and a somewhat spongy reaction to deformation. Long and very fine threads arise from parts of the surface and entangled among these is a large amount of indeterminate white material.

Specimens belonging to these curious groups occur in many of the samples studied but they are never common.

5.5 Tectinous chains.

The test consists of a long, flexible chain of chambers which is branched and extends for up to 2-3cm (Figs. 6-8). The chambers are joined by short necks and the walls are basically tectinous but with a fine-grained, agglutinated veneer. Many specimens are also dotted with large planktonic foraminiferal shells, the abundance of which tends to vary with locality rather than species. In some samples these shells obscure much of the surface. The chambers are usually between 0.4mm and 1.2mm long. They are often broader towards one end and in general shape range from spherical to pear-shaped, elongate, sub-triangular or irregular. Variation in chamber size and shape is considerable, even within an individual. The surface is lumpy and in many species is raised into tubercles which tend to be concentrated at, and directed towards one end of the chamber (Figs. 6B, 7B, 8B). The tubercles vary in different species from being rather subdued to prominent, flat-topped or spiky structures. In many species some of the tubercles on each chamber are produced out into long, narrow filaments which give the impression of being tubular. The test interior is filled with small stercomata.

Occurring much less commonly are specimens of similar overall morphology but with a wall which is basically agglutinated from mineral grains and has only a thin based organic membrane. These forms also lack tubercles and filaments. It is not clear whether they are related to the tectinous chains or represent a distinct group of convergent morphology.

A typical tectinous chain was illustrated by Brady (1884, pl. XXVIIA, Fig. 2) as Aschemonella catenata and one of the agglutinated forms is shown in Fig. 1 of the same plate. Hessler (1974, Fig. 1 top left) also figured what appears to be a tectinous chain but the group seems to be otherwise undocumented in the literature.

These strange Foraminifera are probably distinct at family level. Apart from having a basically organic test, they are quite different from the allogromiids and other simple tectinous foraminifers. The group may be more closely related to Rhizammina. This problematic genus has a similar wall structure but the test is a parallel sided tube rather than a series of chambers separated by necks. However, there are specimens which have poorly developed chambers and these seem to be intermediate between Rhizammina and the tectinous chains. Another problem concerns the apparent transition of forms with agglutinated chambers into Aschemonella catenata (see below). In addition to their fascinating detailed morphology, members of this group raise many taxonomic difficulties that would certainly repay a detailed study.

In the Porcupine Seabight numerous tectinous chains have been obtained from 2645-2760m (Stations 10112, 10113), 3550-3490m (Station 50604) and from 3900-3950m (Station 10115) where they make up >20% of all Foraminifera (Table 1). They also fairly common at 1484m (Station 9754), 1630-1640m (Station 10111), 1980m (Station 50602) and 2300-2315m (Station 50613). Good collections have also been obtained off northwest Africa, particularly around 3100m (Station 8521, 8532, 9132) and 3900m (Station 9131, 9541). The material so far examined in detail includes at least seven species. The agglutinated forms were much less abundant but include a similar number of species. Diverse and abundant assemblages of both tectinous and agglutinated chains also occurred in samples from 5590-6059m off NW Africa (9128, 9129). These include some 12 species, only one of which is known from shallower depths. As discussed above, these samples also yielded a distinctive komokiacean fauna.

5.6 New Group resembling Hyperammina.

The Foraminifera belonging to this group have long, narrow, tubular tests, curved or sinuous, and tapering slightly with the proximal end closed off blindly (Fig. 9). Arising at intervals along the length of the tube, and also from the proximal bulb, are short filaments comprising a main trunk and short side branches (Pl. 1, Figs. 1-4). The test is composed of fine-grained sediment dominated by coccoliths (Pl.1. Fig. 5) and probably has a basal organic layer.

There are at least three species with this general morphology (Fig. 9, Pl. 1, figs. 1-5) and a fourth which has a much shorter test composed of larger mineral particles (Fig. 10). A possibly related species to Bathysiphon argillaceus

Earland 1934. The group resembles *Hyperammina* in having a tubular test with a bulb-like proloculus but is clearly distinguished by the presence of side filaments and a blind distal end. It represents a new genus, and possibly a new subfamily of the family Astrorhiziidae. Scattered specimens occur over a wide depth range from 997m-4060m. They are never very common although reasonable collections of two distinct species have been obtained from 997-1037m to the south of the Canary Islands (Station 8519) and 1120-1140m in the Porcupine Seabight.

6. THE XENOPHYOPHOREA

Several characteristic features distinguish the Xenophyophorea from the Foraminifera. 1) The stercomata are retained within the test as string-like or columnar masses enclosed within organic membranes. 2) The protoplasm is multinucleate and bounded by a branched organic tube. 3) The protoplasm contains crystals of barium sulphate (barite).

Northeast Atlantic xenophyophores are now fairly well known. Samples from the area off northwest Africa have yielded 12 species belonging to four genera (Gooday and Tendal in prep). One of the genera, and all except two of the species are new. Photographs obtained in the same area have revealed the existence of additional species which have not been sampled (Tendal and Gooday 1981). In the Porcupine Seabight, xenophyophores are less diverse and the specimens are smaller and more fragile than off northwest Africa. The Seabight material does not inculde any obviously new species although an undescribed *Psammina* occurred at 2127-2720m off northwest Ireland (Station 7711). Xenophyophores are never as abundant in the Seabight as they are at some stations south of the Canary Islands (Gooday and Tendal in prep). However, these samples would repay further study in conjunction with 1) the numerous bottom photographs of xenophyophores *in situ* and 2) a number of undamaged specimens recovered with the SMBA multicorer.

The taxonomy of *Aschemonella* requries special attention. This genus includes three or four species which have always been regarded as primitive, multichambered agglutinated foraminifers (family Hormosinidae, subfamily Aschemonellinae). However, Gooday and Nott (1982) have recently shown that *A. ramuliformis* is a xenophyophore. The type species, *A. scabra*, is probably also a xenophyophore but A. catenata is a foraminifer, perhaps related to the agglutinated chains discussed above. There are at least two other undescribed xenophyophore-like species of Aschemonella in IOS samples. The genus clearly requires revision and proabably the establishment of a new family within the Xenophyophorea.

A. ramiliformis is common or abundant in many samples taken between 2600m and 4100m (for example at Stations 8532, 8540, 10112, 10113, 10115, 10141, 10143, 50603-50605, 50812, 50813) and shows considerable morphological plasticity (Figs. 11,12). A. scabra is common below 4000m (Stations 8524, 10145, 10148) and A catenata is fairly common at shallower depths (1400-2000m, for example at Station 9753, 9754, 10111).

7. NOTE ON NUTRITIONAL TYPES

The test contents of primitive agglutinated and tectinous Foraminifera are of at least two distinct types. 1) Dense, voluminous, granular protoplasm, often filling the entire test cavity, as for example, in Pelosina, mud-walled astrorhiziniids, Astrorhiza, Bathysiphon, Crithionina, Marsipella, Rhabdammina, Saccorhiza. 2) Masses of stercomata with protoplasm either not visible under the dissecting microscope or in form of fine strands of small volume, as in komokiaceans, allogromiids, tectinous chains and some species of Rhizammina (including R. algeformis, but not R. globigeriniformis). All the foraminifers belonging to this second group have tests which are either entirely tectinous or partly tectinous and partly agglutinated. The internal organisation of xenophyophores is similar except that the stercome masses are enclosed within an organic membrane and the protoplasm by an organic tube.

These groups must reflect different modes of nutrition. Some deep-sea foraminifers with voluminous protoplasm but no stercomata probably stand upright and feed on suspended material in the water (for example, Pelosina, Marsipella some species of Bathysiphon and Rhabdammina). Shallow-water species which are known to adopt this life-style include Bathysiphon sp. (Christiansen 1971, p. 475) Dendrophyra erecta and Marsipella arenaria (Christiansen 1958, Figs. 13, 22), Halyphysema tumanowiczii (Lister 1903, Fig. 19) Pelosina arborescens (Pearcy 1914, p. 1001), and Notodendrodes antarctikos (DeLaca et al. 1980). This last species is also able to feed on dissolved organic carbon (DeLaca et al. 1981). One shallow water species of Astrorhiza, however, is known to be an active carnivore

(Buchanan and Hedley 1960). Foraminifera belonging to the second group are probably basically deposit feeders. Tendal (1979) has proposed that xenophyophores and foraminifers which retain large stercomata masses within their tests, have also developed a modified form of deposit feeding which involves reingesting the stercomata and digesting the bacterial flora that they are presumed to harbour.

8. ACKNOWLEDGEMENTS

I thank Dr. M.V. Angel for his critical reading of the manuscript, Mr. D. Claugher, British Museum (Natural History) Electron Microscope Unit, who provided the photographs for Plate 1 and Mrs. C. Darter for drawing figures 1-3, 6-10.

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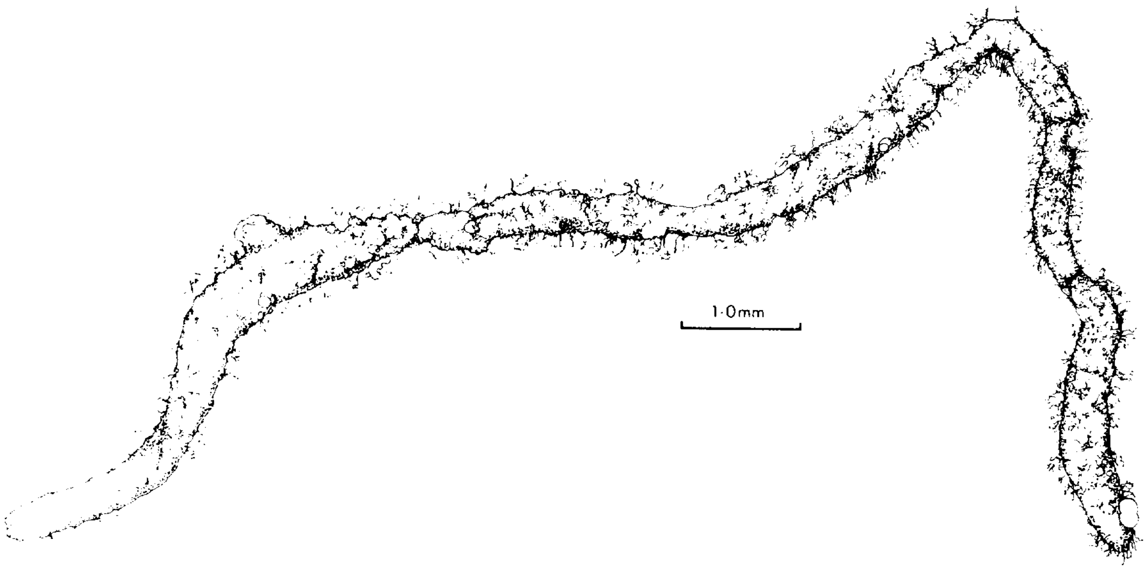

Figure 1. Thread-like species of Pelosina from Station 8521, haul 6, 3064-3070m.

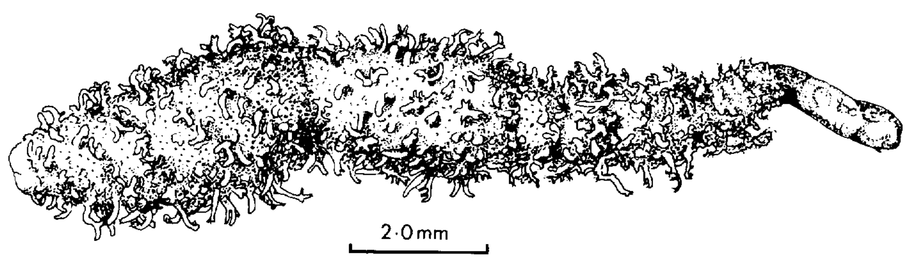

Figure 2. Fusiform species of Pelosina from Station 8532, haul 1, 3113-3119m.

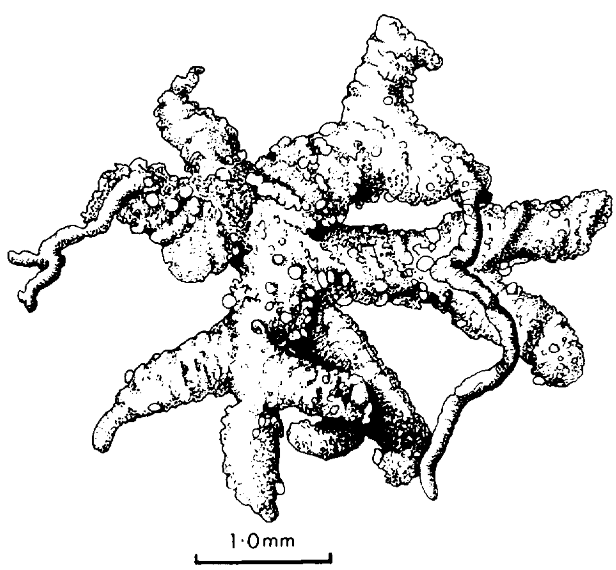

Figure 3. Star-shaped mud-walled astrorhizinid from Station 8519, haul 1, 997-1037.

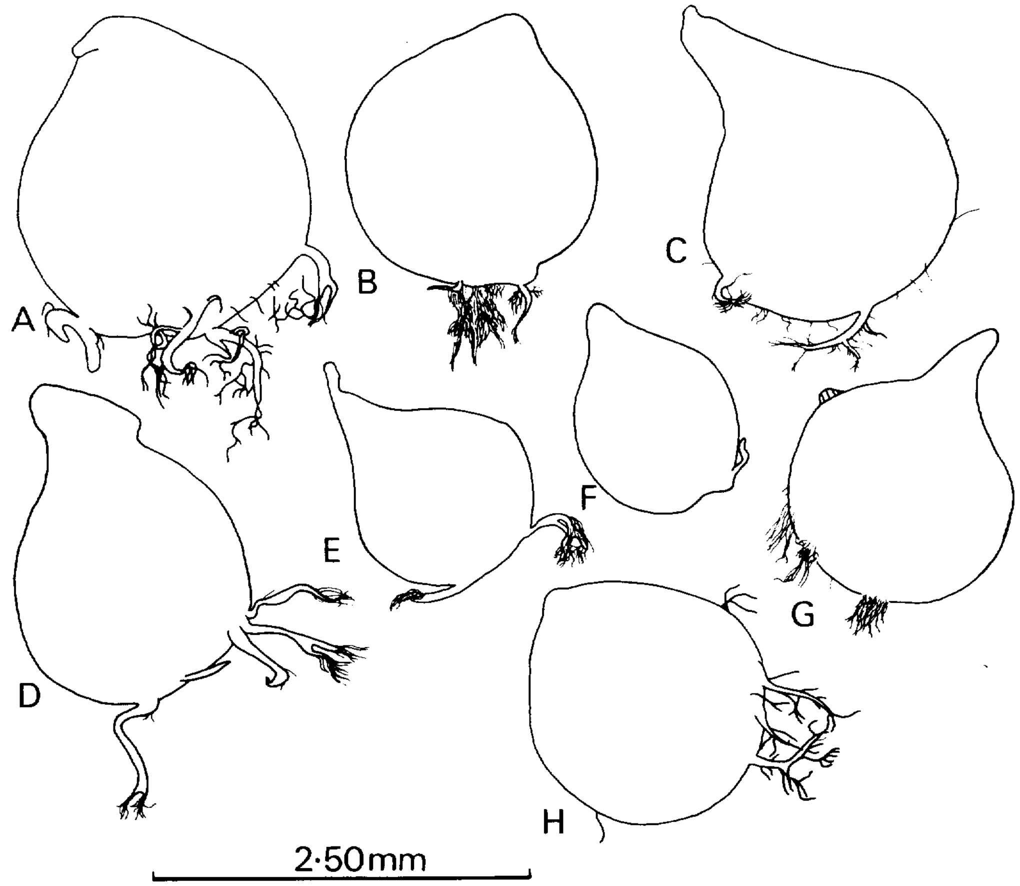

Figure 4. Turnip-shaped species of Pelosina from Station 8528, haul 1, 3150-3155m.

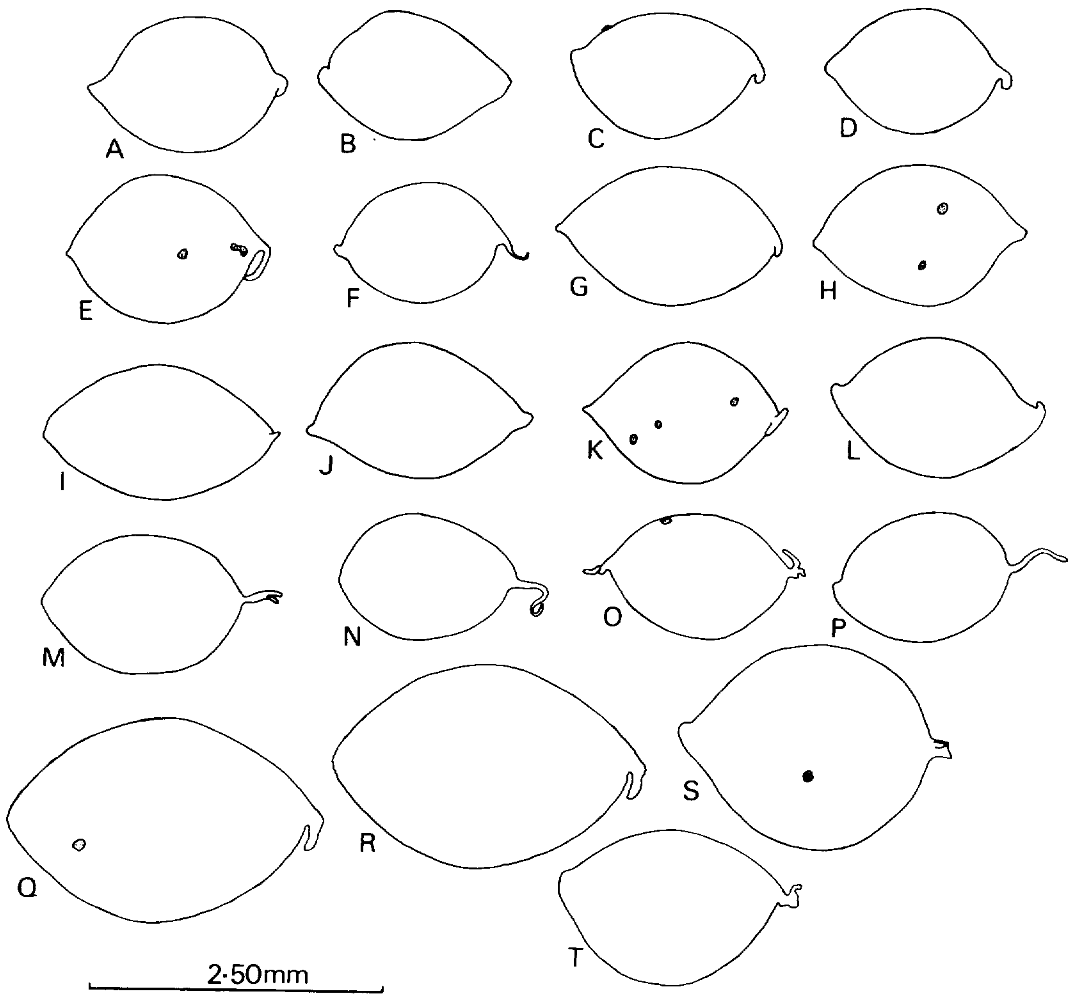

Figure 5. Lemon-shaped species of Pelosina from Station 8521, haul 1, 3053-3058m.

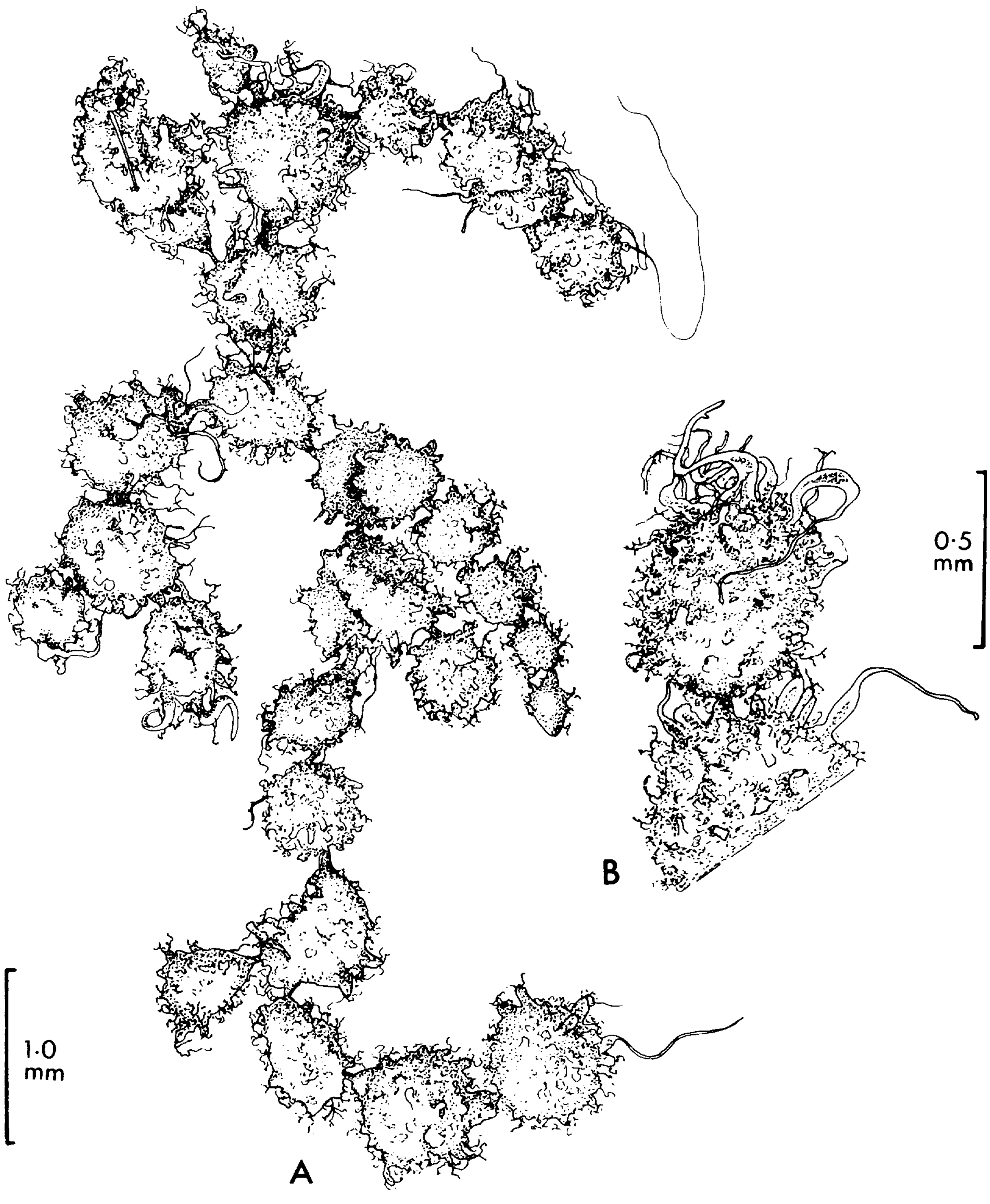

Figure 6. Tectinous chain from Station 8532, haul 1, 3113-3119m. A, General view. B, Detail of chamber showing tubercles and filaments.

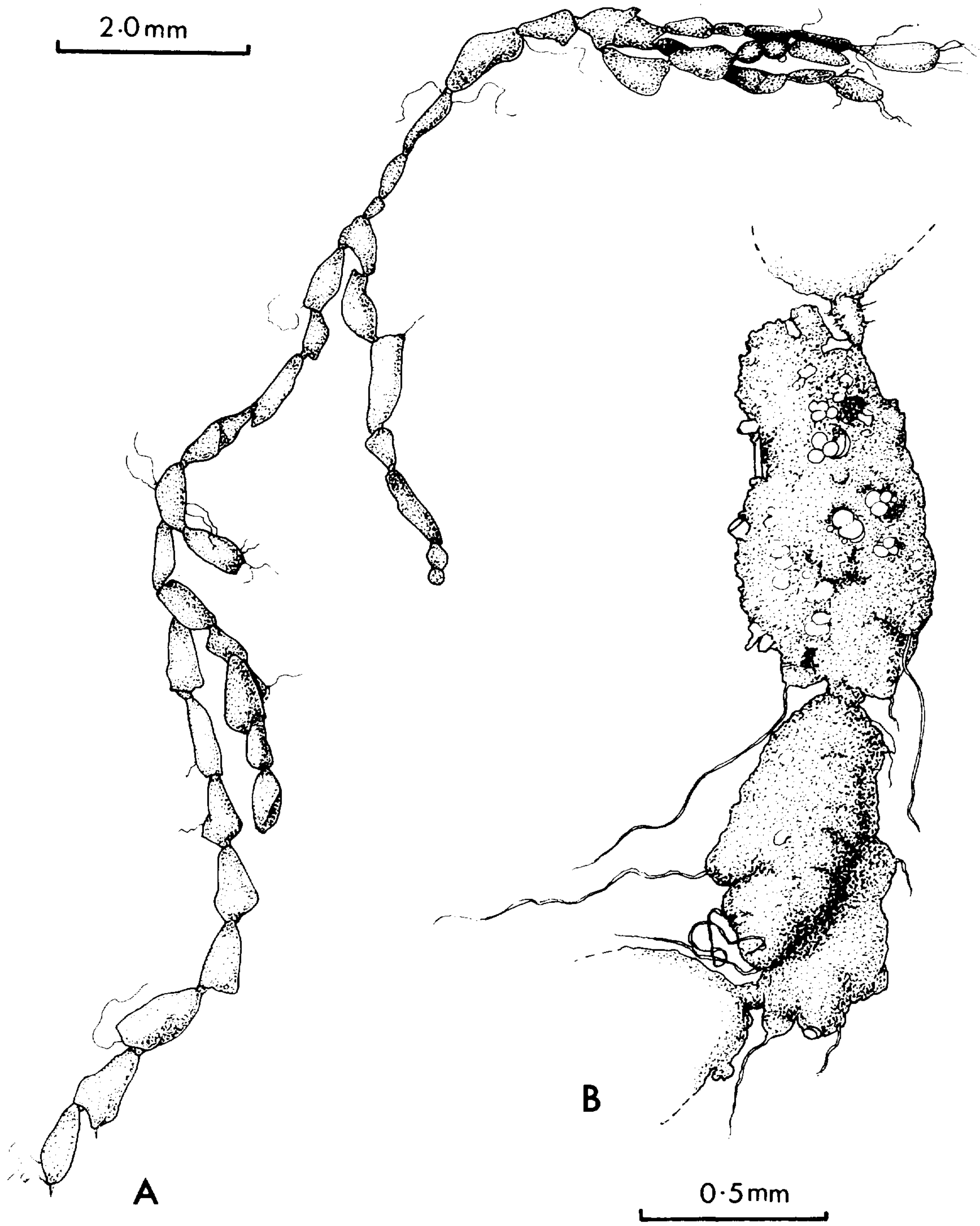

Figure 7. Tectinous chain from Station 8521, haul 1, 3053-3058m. A, General view. B, Detail of chambers showing tubercles and filaments.

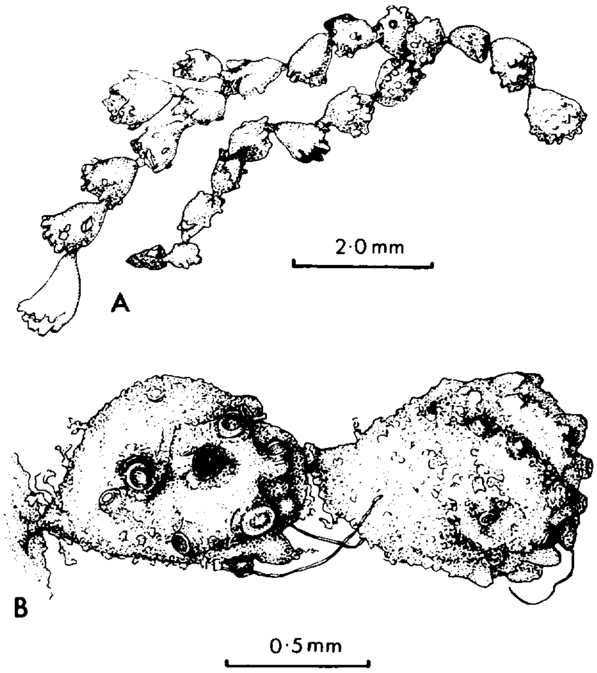

Figure 8. Tectinous chain from Station 8540, haul 1, 3994-4005m. A, General view. B. Detail of chambers showing tubercles and filaments.

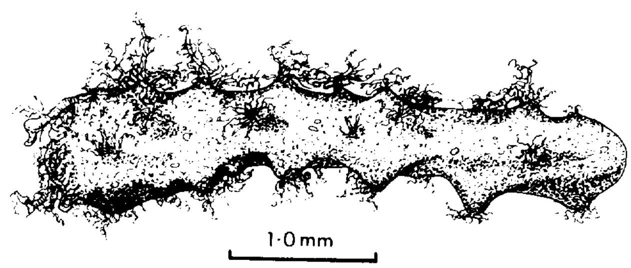

Figure 10. Hyperammina-like form with test composed of mineral grains from Station 8540, haul 1, 3994-4005m.

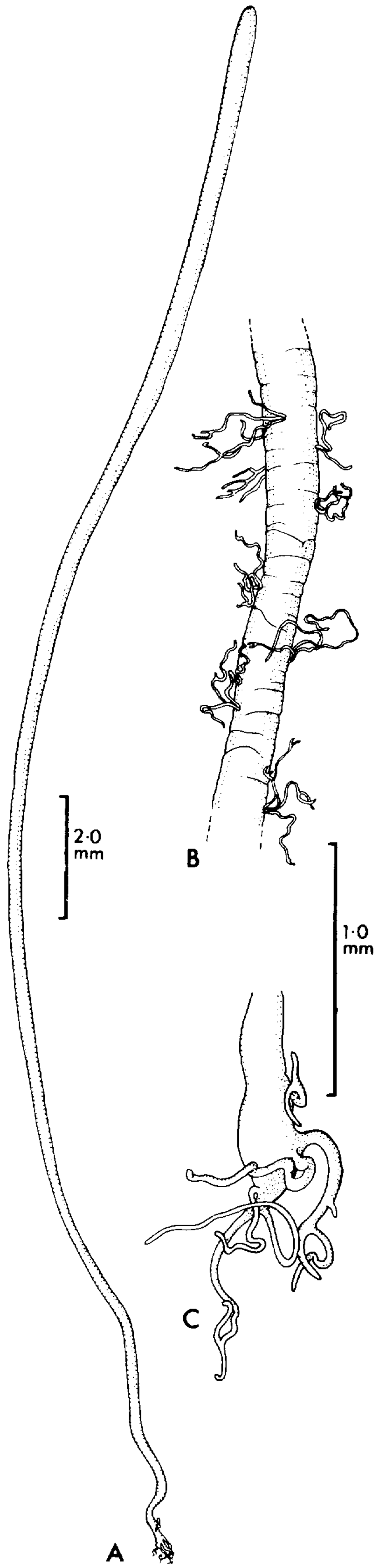

Figure 9. Hyperammina-like form from Station 8519, haul 7, 997-1037m. A, General view. B, Detail of proluculus. C, Detail of tube showing filaments.

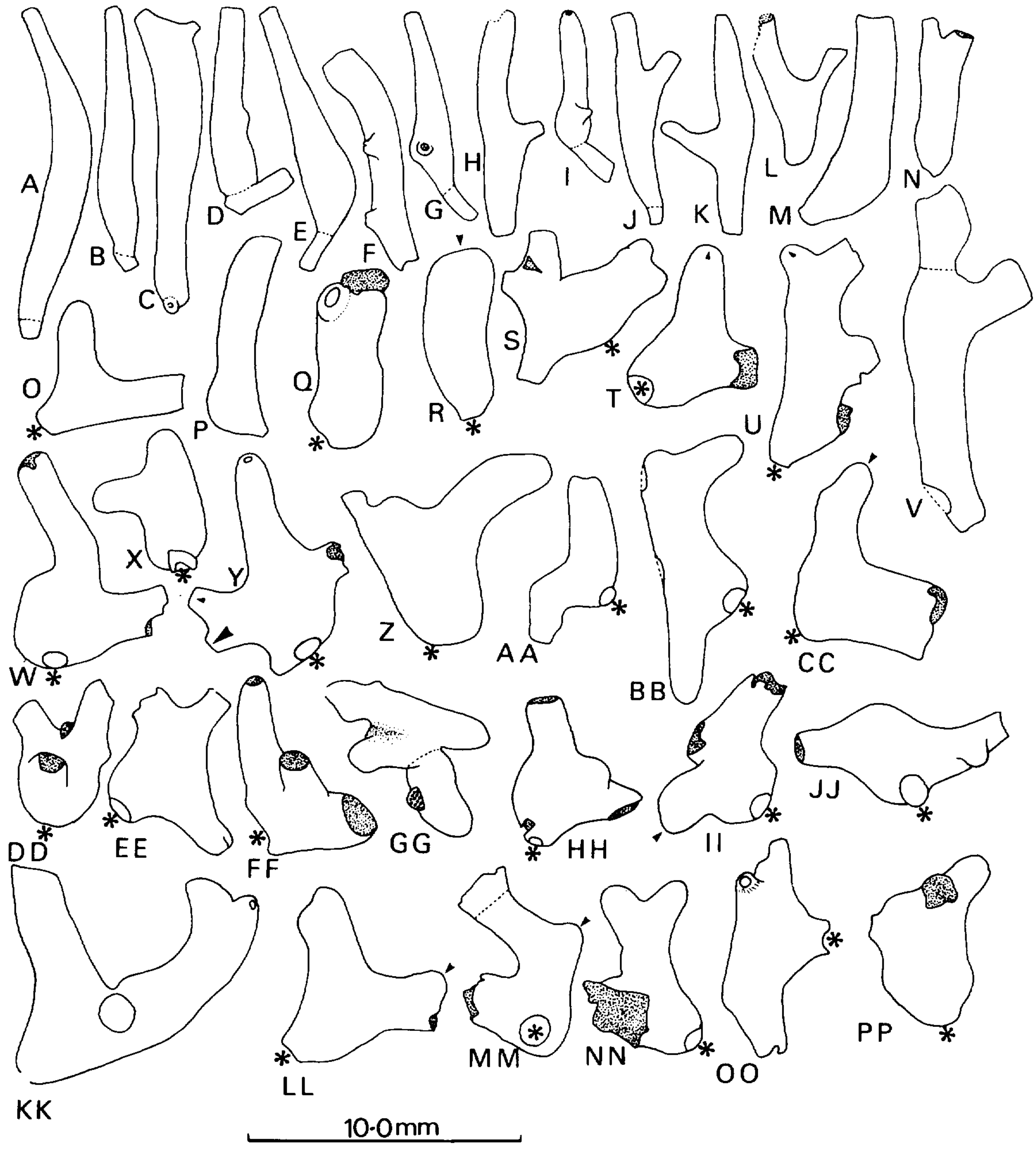

Figure 11. Aschemonella ramuliformis from Station 8540, haul 1, 3994-4005m. The stars indicate where an adjoining chamber has broken away; dotted lines mark chamber junctions; arrow heads indicate the positions of apertures.

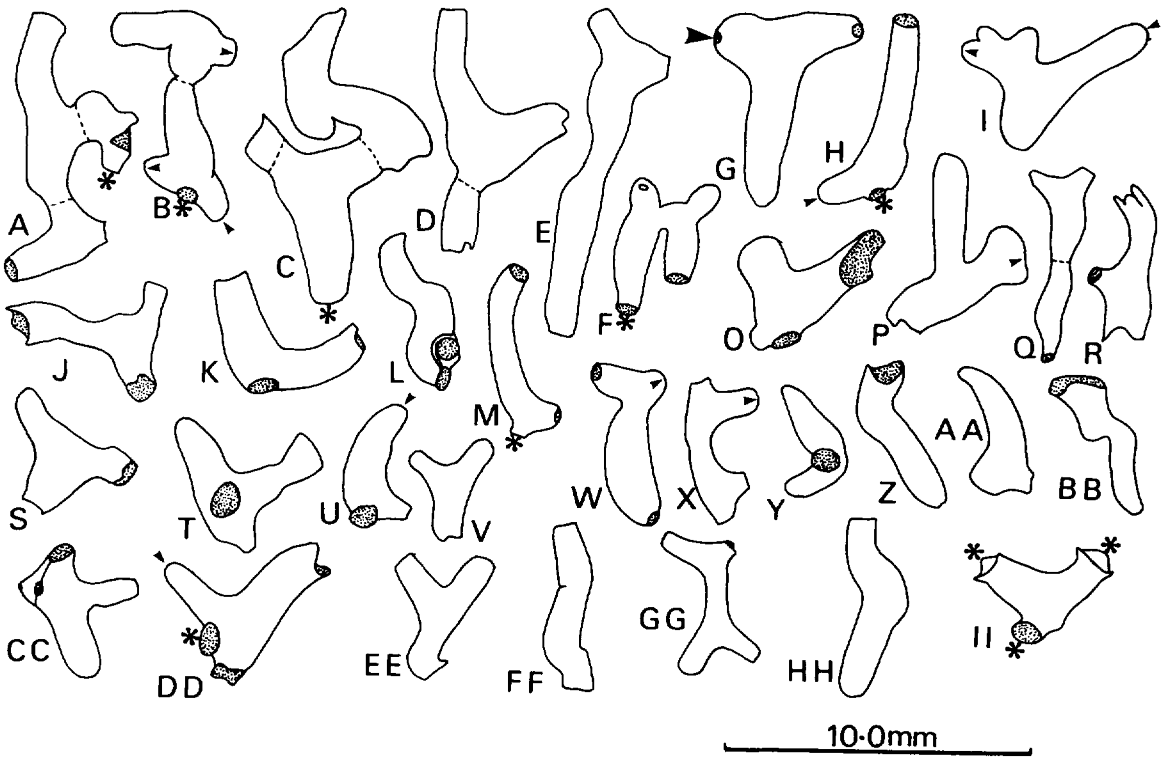

Figure 12. Aschemonella ramuliformis from Station 8524, haul 6, 4414-4416m. The stars indicate where an adjoining chamber has broken away; dotted lines mark chamber junction; arrow heads indicate the positions of apertures.

Table 1. Occurrence of foraminifers and xenophyophores (live and dead) in four samples from the Porcupine Seabight.

Station and haul	50606#5		9753#7		50605#1		10115#1	
Depth (m)	1140-1120		1942		2930-2820		3900-3950	
Fraction sorted	>2mm		>2mm		>2mm		>2mm	
Volume sorted (ml)	100		58		100		100	
	N	%	N	%	N	%	N	%
Allogromiids	3	<1.0	56	3.3	8	<1.0	6	<1.0
Komokiacea	65	3.0	523	30.4	147	13.0	504	38.8
Tectinous chains	28	1.3	101	5.9	20	1.8	265	20.4
Pelosina	439	20.0	89	5.2	149	13.2	6	<1.0
Mud-walled Astrorhizinids	145	6.6	92	5.3	8	<1.0	3	<1.0
"*Hyperammina*"-like forms	100	4.5	——		——		3	<1.0
Ammodiscaceans	1389	63.1	522	30.3	224	19.9	247	19.0
Rhizammina	13	<1.0	very abundant		293	26.0	abundant	
Lituolaceans	1	<0.1	183	10.6	36	3.2	96	7.4
Rotaliids	4	<1.0	7	<1.0	——		——	
Miliolids	13	<1.0	48	2.8	100	8.9	3	<1.0
Aschemonella	——		32	1.9	97	8.6	102	7.9
Other Xenophyophores	——		67	3.9	45	4.0	64	4.9
Totals	2200		1720*		1127		1299*	

* *excluding Rhizammina algaeformis* which is too abundant to count.

Table 2. Occurrence of foraminifers and xenophyophores (live and dead) in four samples from off northwest Africa.

Station and haul	8521#1		8540#1		8524#6		8524#6	
Depth (m)	3053-3058		3994-4005		4414-4416		4414-4416	
Fraction sorted	>2.0mm		0.5-2.0mm		1-2mm		>2mm	
Volume sorted (m)	460		5		25		460	
	N	%	N	%	N	%	N	%
Allogromiids	9	<1.0	4	<1.0	——		——	
Komokiacea	147	4.2	141	3.7	990	46.9	514	52.9
Tectinous chains	14	<1.0	10	<1.0	69	3.3	11	1.1
Pelosina	251	7.1	——		1	<1.0	——	
Mud-walled Astrorhiziniids	80	2.3	——		——		——	
"Hyperammina"-like forms	——		2	<0.1	——		——	
Ammodiscaceans	*2300	65.2	2499	66.0	316	15.0	222	22.8
Rhizammina	336	9.5	258	6.8	289	13.7	103	10.6
Lituolaceans	106	3.0	570	15.0	33	1.6	5	<1.0
Rotaliids	——		35	<1.0	1	<0.1	1	<1.0
Miliolids	82	2.3	18	<1.0	28	1.3	17	1.7
Aschemonella	3	<0.1	177	4.7	282	13.3	90	9.2
Other Xenophyophores	200	5.7	75	2.0	103	4.9	9	<1.0
Totals	3528		3789		2112		972	

* includes estimate for Rhabd. irregularis which is very abundant.

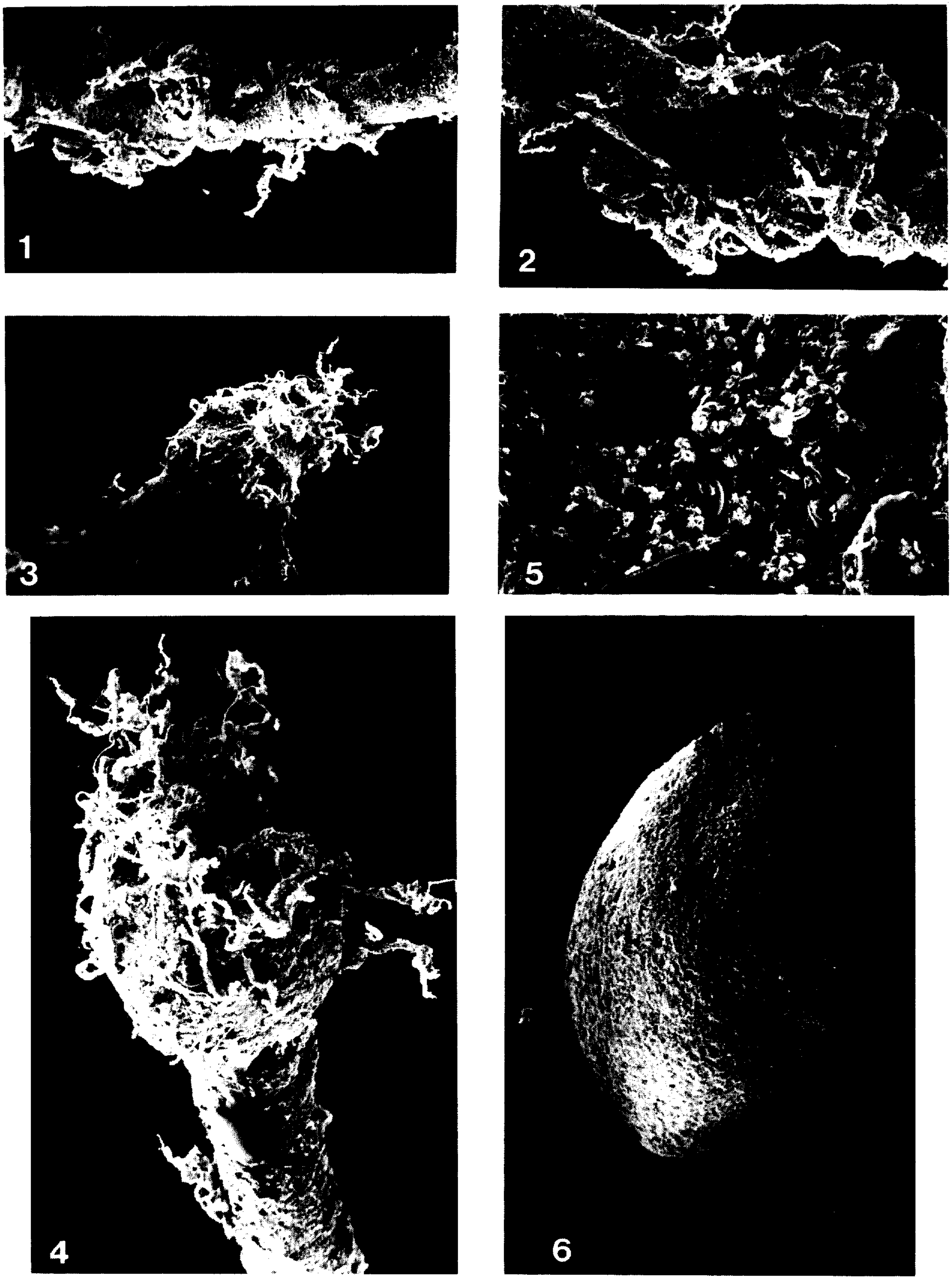

Plate 1. Figures 1-5, SEM photographs of <u>Hyperammina</u>-like form from Station 50606, haul 5. 1, Part of tube showing filaments, 62X. 2, Closer view, 80X. 3, Proloculus with filaments, 75X. 4, Closer view, 810X. 5, Detail of external test surface showing numerous coccoliths, 367X.

Figure 6, Lemon-shaped species of <u>Pelosina</u> from Station 50605, haul 1, 8X.

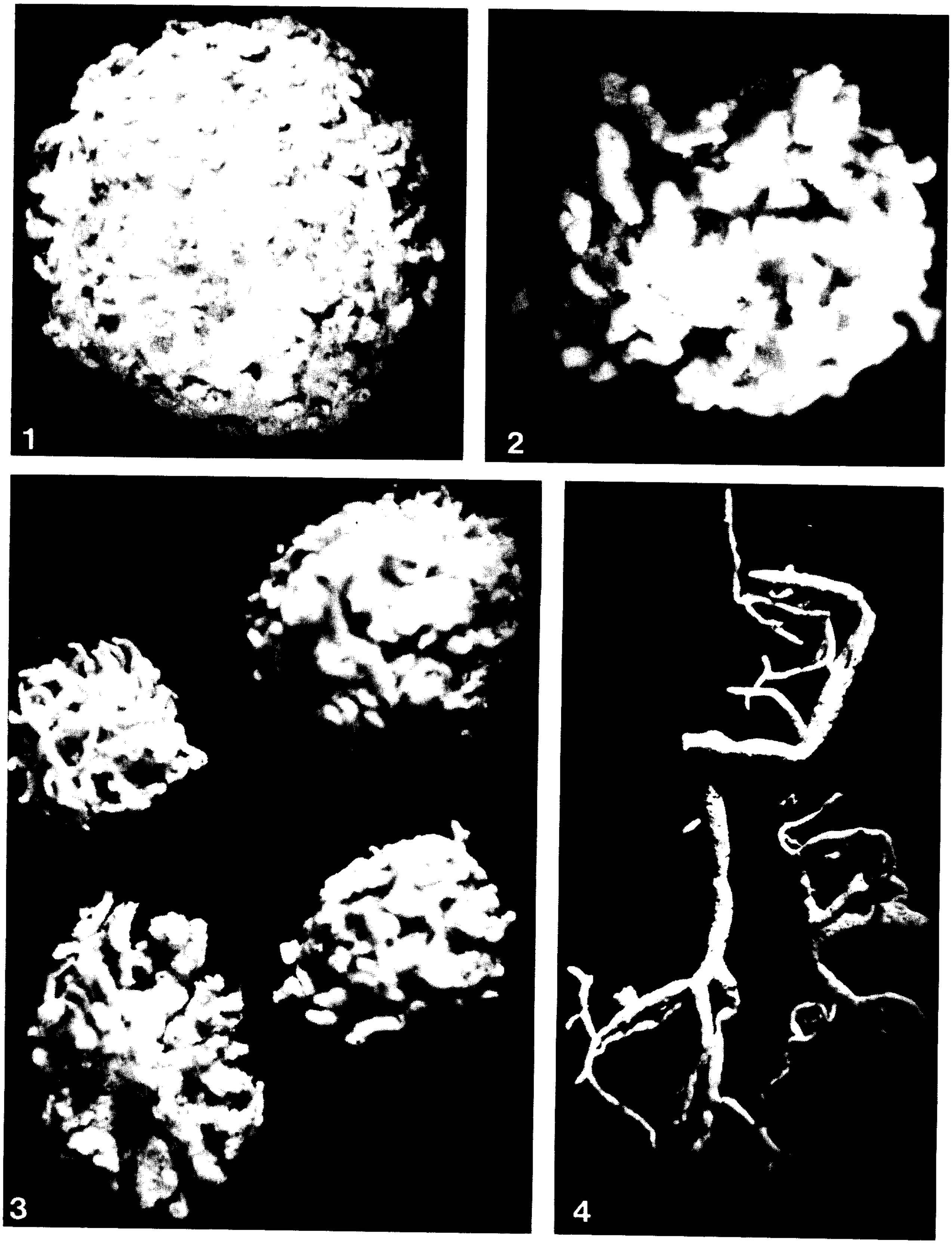

Plate 2. Figures 1-3, light photographs of mud-walled astrorhizinids from Station 8521, haul 6. 1, 7.6X. 2, 50X. 3, 25X.

Figure 4. Root-like species of Pelosina from Station 10131, haul 1, 66X.