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On Recent species of *Spiraserpula* Regenhardt, 1961, a serpulid polychaete genus hitherto known only from Cretaceous and Tertiary fossils

T. GOTTFRIED PILLAI

Marine Biological Services Division, Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD

HARRY A. TEN HOVE

Universiteit van Amsterdam, Instituut voor Taxonomische Zoölogie, Postbus 94766, 1090 GT Amsterdam, Nederland

CONTENTS

SYNOPSIS. A group of Recent serpulid species related to the genus *Serpula* Linnaeus, 1758, but differing from it in two important characters, is described in this paper. The first is a hitherto undescribed character, namely, the possession of internal tube structures which consist of longitudinal ridges and other structures, the form and arrangement of which, in combination with characters of the worms themselves, served to separate the various species. The second is that the thoracic membranes of the two sides in the worm do not unite ventrally at the end of the thorax to form a flap or apron as in *Serpula*. These characters are also common to 18 species, including three previously described ones. On the basis of the tube structures, these Recent species can be referred to the genus *Spiraserpula* Regenhardt, 1961, which was previously known only from fossils (Pillai, 1993). Scissiparity was observed in at least three of its species. A key to the known Recent species of *Spiraserpula* and a discussion on the systematics of the genus are included.

INTRODUCTION

In the course of a study of the serpulids currently referred to the genus *Serpula* Linnaeus, 1758, it was observed that the worms of larger species could frequently be extracted undamaged from the anterior ends of their tubes with a pair of fine forceps, while they were invariably damaged in the process in certain small species as, for instance, in the well-known Mediterranean species *Serpula massiliensis* Zibrowius, 1968. In almost every collection of the latter, the worms which had been previously extracted from their tubes were incomplete posteriorly, and the ends of their longitudinal musculature provided evidence of their having been forcefully broken off from the rest of the abdomen. The cause of the difficulty in extracting complete worms was revealed by opening their tubes carefully from their anterior ends all the way to their posterior ends. It was found that the posterior end of the abdomen was retracted very tightly into the posterior coiled part of the tube and, quite surprisingly, against a longitudinal row of sharp serrations projecting from the inside of the tube. Examination of more material showed that these were consistent for *S. massiliensis*.

Study of similar material from various other geographical localities revealed the existence of species with other forms of internal tube structures. Evidently, these serve for anchorage

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of the worm when withdrawn into the tube, and thereby, have an additional protective function. The form and arrangement of the internal tube structures, in combination with characters of the worms themselves, served to separate the various species. They are absent in *Serpula* Linnaeus, 1758, and have not been described in any of the other known genera of Serpulidae. They differ from the transverse tabulae of certain serpulids, an account of which is given by Lommerzheim (1979). Another important character common to the group is that, unlike in *Serpula*, the thoracic membranes of the two sides are not united posterior to the thorax to form a ventral flap or apron.

In the search for a name for this group, the genera *Pseudoserpula* Straughan, 1967 and *Protoserpula* Uchida, 1978, were considered, among others. The former was found to be invalid, and an account of the study which led to this conclusion is provided under *Spiraserpula minuta*, (Straughan, 1967), in this paper. It was not possible to examine the type specimen of *Protoserpula* to establish whether it has ITS or not. It is not in the National Science Museum, Tokyo, and other efforts to locate it were unsuccessful.

H. Zibrowius of Station Marine d'Endoume, Marseille, who went through the manuscript of this paper, and the second author discussed the group with M. Jäger of Rohrbach Zement, Dotternhausen, Germany,who re-examined the fossil serpulids studied by him (Jäger, 1983), and other material, and found that some of them too possessed internal tube structures, although they had not been reported earlier. The collaboration which followed (pers. comm.) led to a study of likely Cretaceous and Tertiary serpulid genera and species (Pillai, 1993), which revealed that the group belongs to the genus *Spiraserpula* Regenhardt, 1961, previously known only from fossil species. *Spiraserpula* Regenhardt, 1961, has priority over *Protoserpula* Uchida, 1978, even if the latter were to possess internal tube structures, henceforth referred to in the text as ITS (*vide* Jäger 1993)). Zibrowius (1972) described a Recent spirorbid species belonging to the genus *Neomicrorbis* Rovereto, 1904, which was previously known only from Cretaceous and Tertiary fossils.

In three of the Recent species of the genus *Spiraserpula* definite proof of asexual reproduction was found, in the form of branching tubes, corroborated by the presence of a parent with a schizont in one tube of *Spiraserpula snellii* sp. nov. Asexual reproduction had previously been reported for the genera *Filograna* Berkeley, 1835, *Filogranula* Langerhans, 1884, *Josephella* Caullery & Mesnil, 1896, *Salmacina* Claparède, 1870 and *Rhodopsis* Bush, 1905 (ten Hove, 1979; Ben-Eliahu & ten Hove,1989). Pillai (1993) reports the occurrence of tube branching in the fossil species *Spiraserpula versipellis* Regenhardt, 1961. It would not be surprising if it turns out that scissiparity takes place in most, if not all, species of the genus *Spiraserpula*, in view of their aggregated occurrence.

Nineteen species of *Spiraserpula*, including the three known ones referred to above and an unnamed one, are described. They come from the Mediterranean, Madeira, Canary and Cape Verde Islands, Gulf of Mexico, the Caribbean and Panama, the northern Red Sea, Mozambique, the eastern islands of Indonesia, Eastern Australia, Japan and New Caledonia.

METHODS AND MATERIALS

The tubes and their internal structures, as well as whole worms and parts were examined and drawn under a stereo microscope fitted with a drawing attachment. Measurements were taken with a pair of fine dividers against a scale having an accuracy of 0.5 mm, of total length of the tube when possible, external diameter of the tube, total length of the worm, width of the thorax just posterior to the pair of collar fascicles, length and diameter of operculum, length of the opercular peduncle, and length of the longest radiole and its pinnule-free tip when present. Radioles and thoracic segments were counted on both sides, while the abdominal uncinal tori of one side were counted to determine the number of abdominal segments. The chaetae were mounted in polyvinyl lactophenol or aquamount and figured under the oil immersion lens of a high power microscope fitted with a drawing attachment. Measurements of chaetae were made with an eyepiece micrometer standardised with a stage micrometer. Scanning electron micrographs of chaetae of some of the species are also provided (Plates 1–5).

The sources of material have been detailed under the respective descriptions as well as the acknowledgements. Full details of E. Atlantic stations surveyed by the 'Tydeman' Canary and Cape Verde Islands Expeditions of 1980, 1982 and 1986 (CANCAP–IV, VI and VII), (e.g. CANCAP 4.D14, 6.134) can be found in van der Land (1987); of E. Indonesian stations sampled during the Indonesian-Dutch Snellius II Expedition (e.g. Snellius II 4.051) in van der Land & Sukarno (1986). The following abbreviations have been used in the text: AM: Australian Museum, Sydney; AMNH: American Museum of Natural History, New York; BM(NH): British Museum (Natural History), London, presently, The Natural History Museum, London; FSBC I: Florida Department of Natural Resources, Invertebrate collection, St. Petersburg, Florida; HUJ: The Hebrew University, Jerusalem; MCZ: Museum of Comparative Zoology, Harvard; NNM: Nationaal Natuurhistorisch Museum, Leiden (formerly Rijksmuseum van Natuurlijke Historie); NSMT: National Science Museum, Tokyo; QM: Queensland Museum, Brisbane; RMNH: Collection numbers of NNM; SME: Station Marine d'Endoume, Marseille (most material will be deposited later in the Musée Nationale d'Histoire Naturelle,Paris); USNM: United States National Museum of Natural History, Washington DC; V.Pol: Polychaete collection numbers of ZMA; ZLU: Zoological Laboratory, Utrecht; ZMA: Zoölogisch Museum, Instituut voor Taxonomische Zoölogie, Amsterdam; ZMH; Zoologisches Institut und Zoologisches Museum, Hamburg; ZMK: Zoologisk Museum, København.

TERMINOLOGY

The terminology used in this paper is explained in Figs 1 and 2.

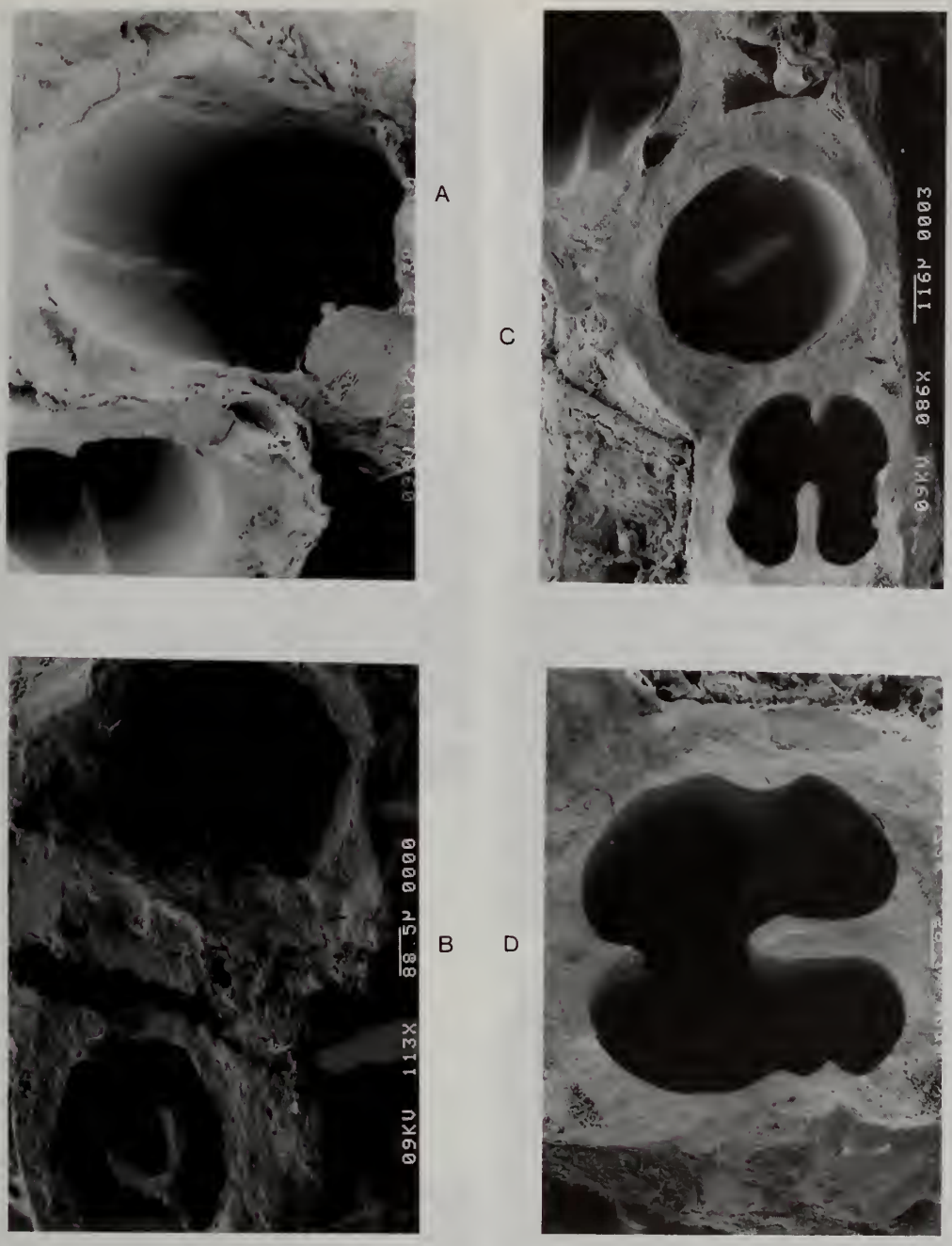


Plate 1 Scanning electron micrographs of fractured ends of tubes showing internal structures. A, C & D, *Spiraserpula lineatuba* (Straughan, 1967). B, *S. ypsilon* sp. nov.

DIAGRAMMATIC REPRESENTATIONS OF TUBES

The various arrangements of ITS in the species described are diagrammatically represented in Fig. 3.

DIAGNOSIS OF SPIRASERPULA Regenhardt, 1961

The original generic diagnosis of *Spiraserpula* was based only on the tube of its fossil type species, *S. Spiraserpula* Regenhardt, 1961. Pillai (1993) provides an emended definition for fossil species based on characters of the tube. However, the recent species described here are distinguishable not only by characters of their tubes but also of the worms themselves,

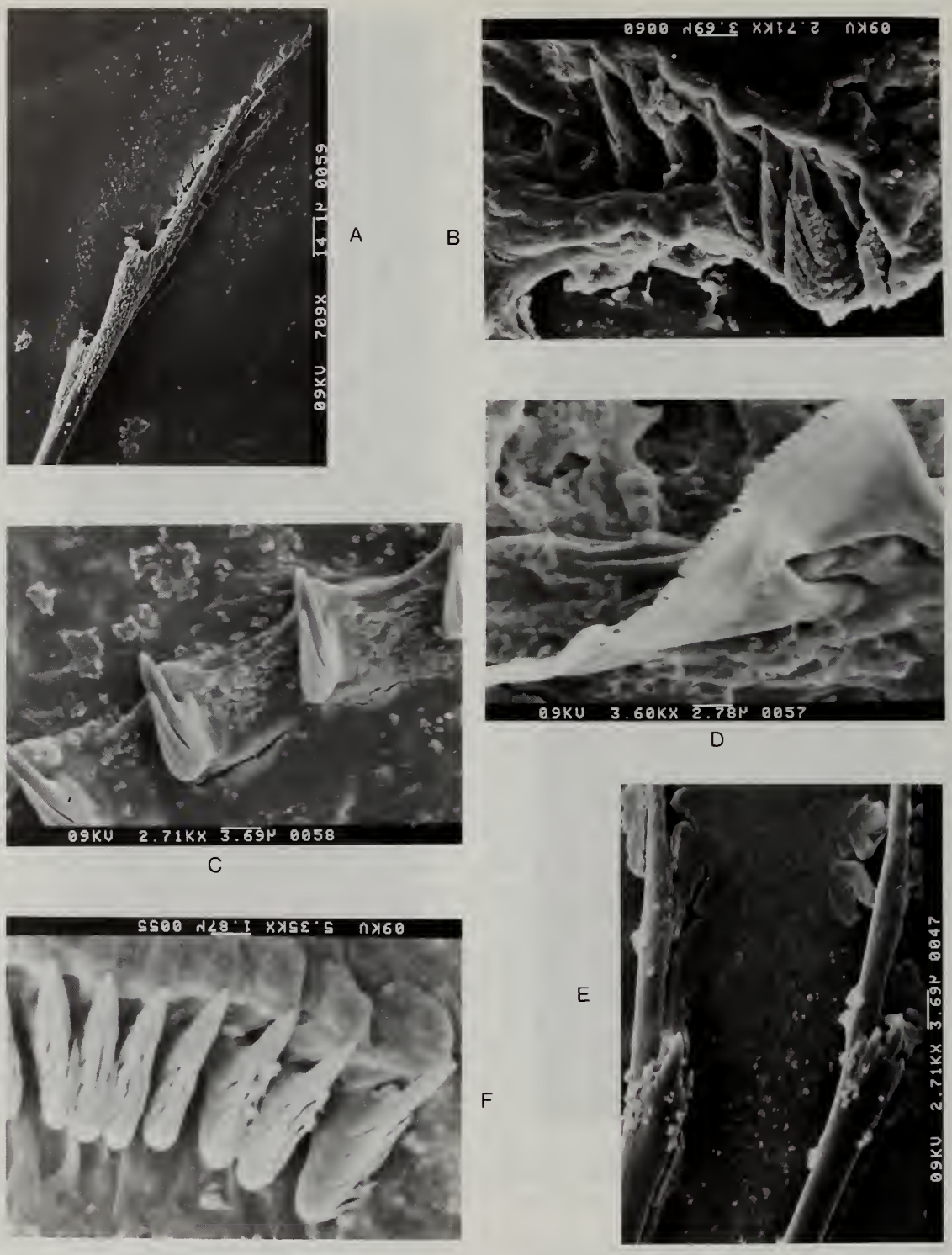


Plate 2 Scanning electron micrographs of chaetae. A–D, *Spiraserpula massiliensis* (Zibrowius, 1968): A, bayonet chaetae. B, thoracic uncini. C, anterior abdominal uncini. D, flat trumpet-shaped abdominal chaetae. E & F, *S. singularis* sp. nov.: E, bayonet chaetae. F, abdominal uncini.

and they have been taken into consideration in the following diagnosis:

Tube with internal structures, usually towards its earlier formed, coiled, posterior portions. They consist of internal longitudinal ridges which vary in form and complexity in the different species; they may be dorsal, along the convex inner wall of the tube, and/or ventral, along the opposite side. They may be laminar, serrated or unserrated, or have other forms, and accessory lateral ridges or other structures may also be present. An umbilicus and peristomes may be present. There is usually an external granular overlay which bonds together coils of individual tubes, or those of other tubes to form

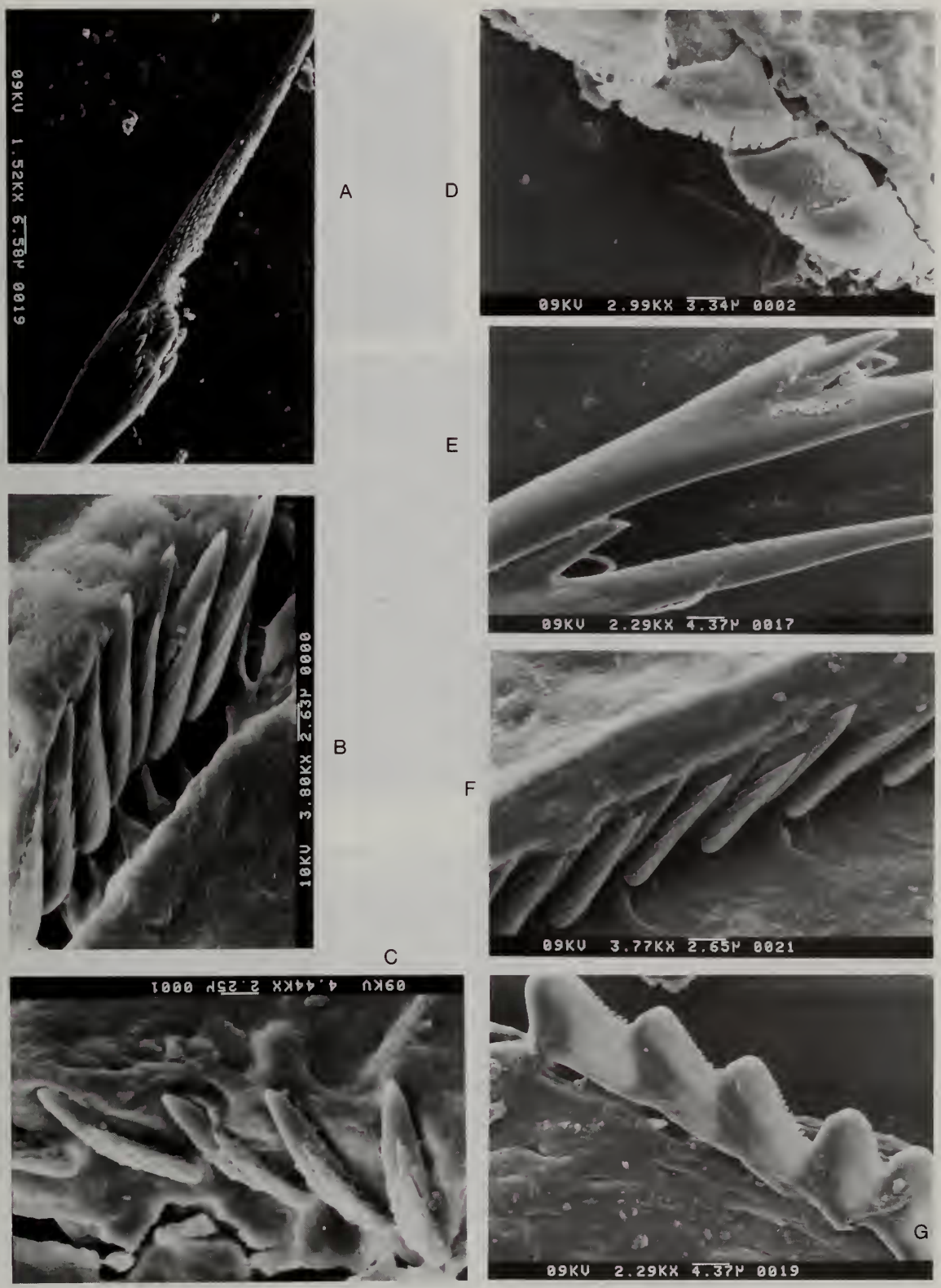
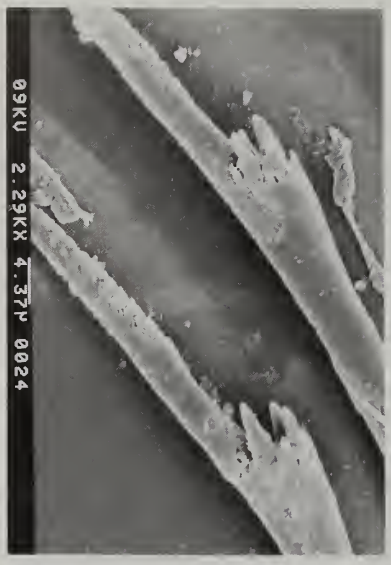
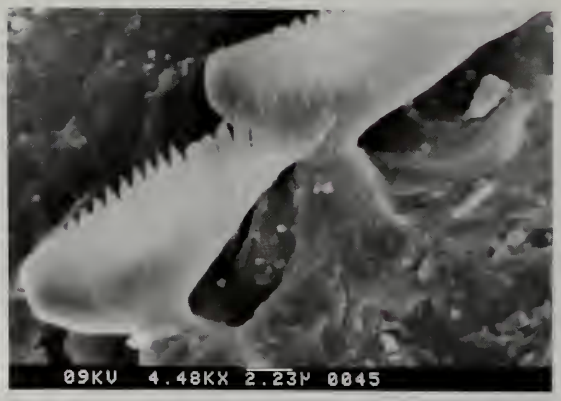


Plate 3 Scanning electron micrographs of chaetae. A–D, *Spirserpula nudicrista* sp. nov.: A, bayonet chaeta. B, thoracic uncini. C, abdominal uncini. D, flat trumpet-shaped abdominal chaetae. E-G, *S. lineatuba* (Straughan, 1967): E, bayonet chaetae. F, abdominal uncini. G, flat trumpet-shaped abdominal chaetae.



A

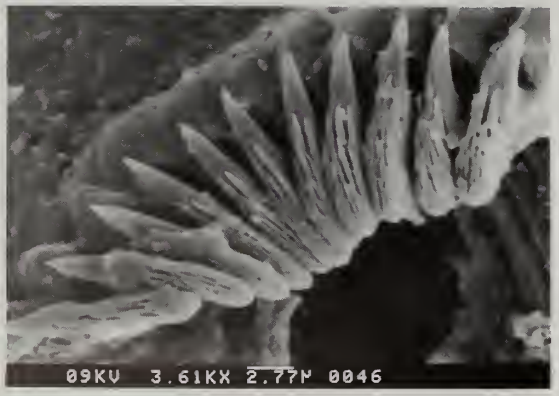


D

E

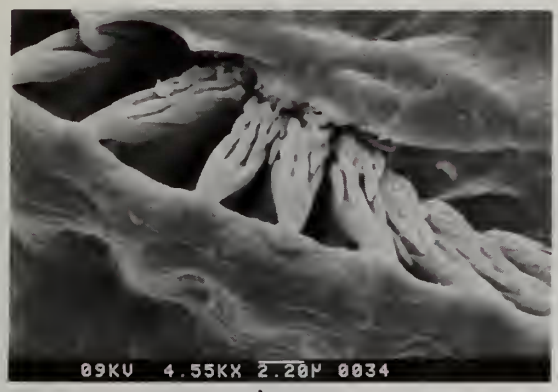
B

F



C

Plate 4 Scanning electron micrographs of chaetae. A–D, *Spiraserpula zibrowii* sp. nov.: A, bayonet chaetae. B, thoracic uncini. C, abdominal uncini. D, flat trumpet-shaped abdominal chaetae. E & F, *S. caribensis*, sp. nov.: bayonet chaetae.



A

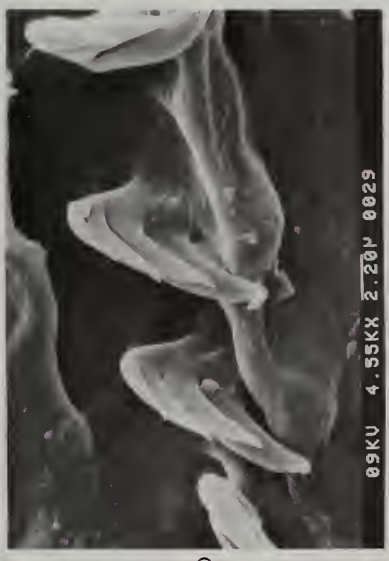
B

C

D

E

F



G

H

Plate 5 Scanning electron micrographs of chaetae. A–C, *Spiraserpula caribensis* sp. nov.: A, abdominal uncini. B, flat trumpet-shaped abdominal chaetae. C–E, collar chaetae from Grenada material. F–H, *S. snellii* sp. nov.: F, bayonet chaetae. G, abdominal uncini. H, flat trumpet-shaped abdominal chaetae.

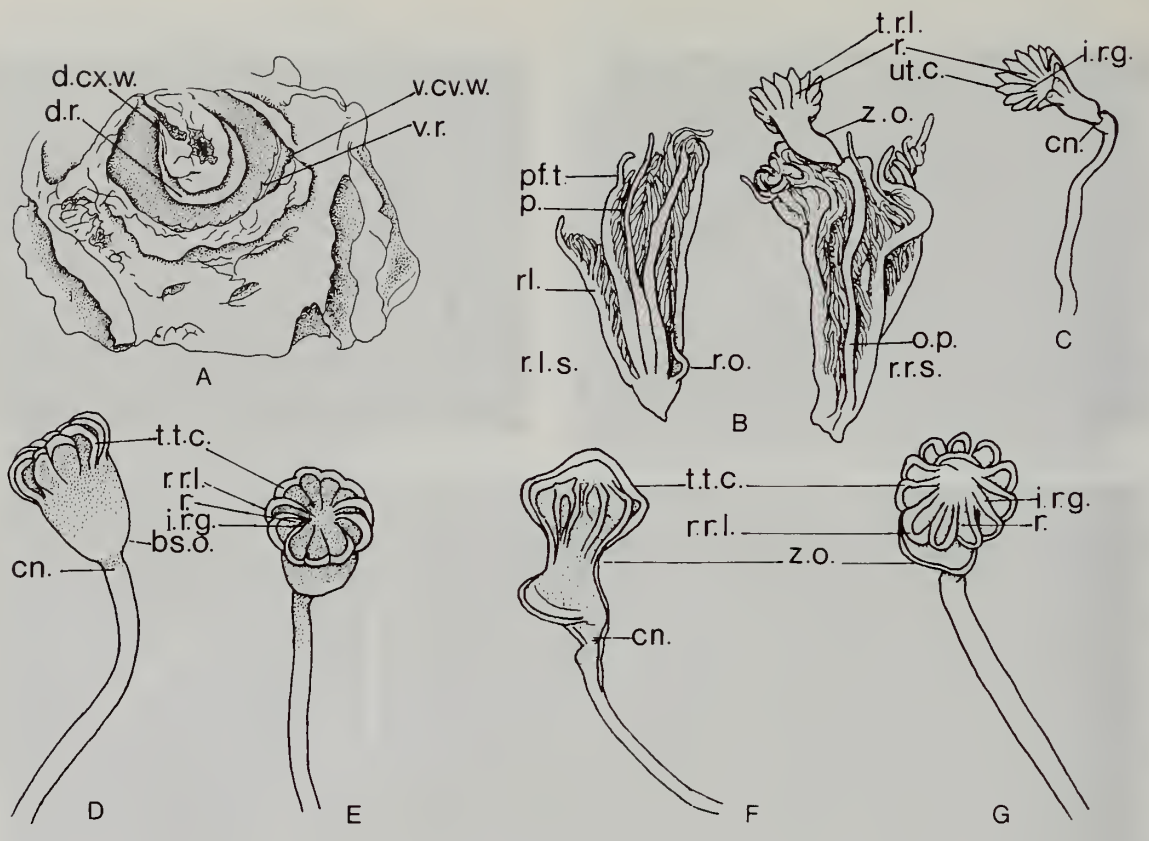


Fig. 1 Terminology. A, Tube: **d.cx.w.**, dorsal convex wall; **d.r.**, dorsal ridge; **v.cv.w.**, ventral concave wall; **v.r.**, ventral ridge. B, Radioles of both sides and operculum: **o.p.**, opercular peduncle; **p.**, pinnules; **pf.t.**, pinnule-free tip; **r.**, radius; **rl.**, radiole; **r.l.s.**, radioles of left side; **r.o.**, rudimentary operculum; **r.r.s.**,radioles of right side; **t.r.l.** triangular radial lobe; **z.o.**, zygomorph operculum. C–G, Opercula: **cn.**, constriction between operculum and peduncle; **i.r.g.**, inter-radial groove; **ut.c.**, unthickened cuticle. **bs.o.**, bell-shaped operculum; **r.r.l.**, rounded radial lobe; **t.t.c.**, thickened transparent cuticle.

mutually bonded aggregations of a few to numerous individuals.

An operculum similar to that in *Serpula*, which is a modification of the second most dorsal radiole, is often present on one side with, correspondingly, a rudimentary operculum on the other. There may only be a rudimentary operculum on each side in certain species, while they may be present in juveniles and completely lost in older specimens in others. The shape of the fully developed operculum is characteristic for a particular species; it may be funnel-shaped, bell-shaped, zygomorphic or spherical. Its distal end may be concave or convex and usually bears radii which end as triangular or rounded lobes at the rim; but radii may also be lacking in some species. Its cuticle may be unthickened or thickened and transparent.

The number of branchial radioles is usually small, rarely up to 14 pairs. Palps absent. A pair of prostomial ocellar clusters is usually present. The number of thoracic chaetal tufts may exceed the seven pairs commonly occurring in many genera of Serpulidae, including *Serpula*, and those of the two sides are more frequently asymmetrical than symmetrical. Up to 14 have been counted on each side. Histological work is needed to ascertain the real extent of the segments, and their relation to numbers of chaetal tufts and uncinal rows, etc. The term 'chaetiger' is, therefore, used here in the literal meaning of 'hair bearer' and not as a synonym of segment. The thoracic membranes end anterior to the last thoracic chaetigers, also more frequently asymmetrically than symmetrically. Unlike in most species of *Serpula sensu stricto*, therefore, a post-thoracic ventral flap (apron) is absent.

Collar fascicles bear chaetae of two kinds: bayonet chaetae and limbate chaetae, the blades of both of which are usually finely serrated. In the former, there are a few to several comparatively large teeth, located at the distal end of the shaft, separated from the bayonet-like blade by an unserrated area (unserrated notch). The range in the number of such teeth and the length of the unserrated notch varies in the different species. Limbate chaetae bear simple, more or less curved, blades. Thoracic and anterior abdominal uncini may bear teeth in a single row (saw-shaped), or are partly (saw- to rasp-shaped) or completely rasp-shaped. Abdominal chaetae bear distally flat trumpet-shaped ends, and are replaced by capillaries in the posterior segments. The distal ends of the abdominal chaetae of *Serpula* have been described as 'trumpet-shaped' in serpulid literature. We have discussed the inappropriateness of the comparison, as demonstrated by the scanning electron micrographs and drawings of these chaetae presented in this paper, and our attention has also been drawn to this by Zibrowius (pers. comm.). In order not to create confusion, it was decided to retain 'flat trumpet-shaped', for the present.

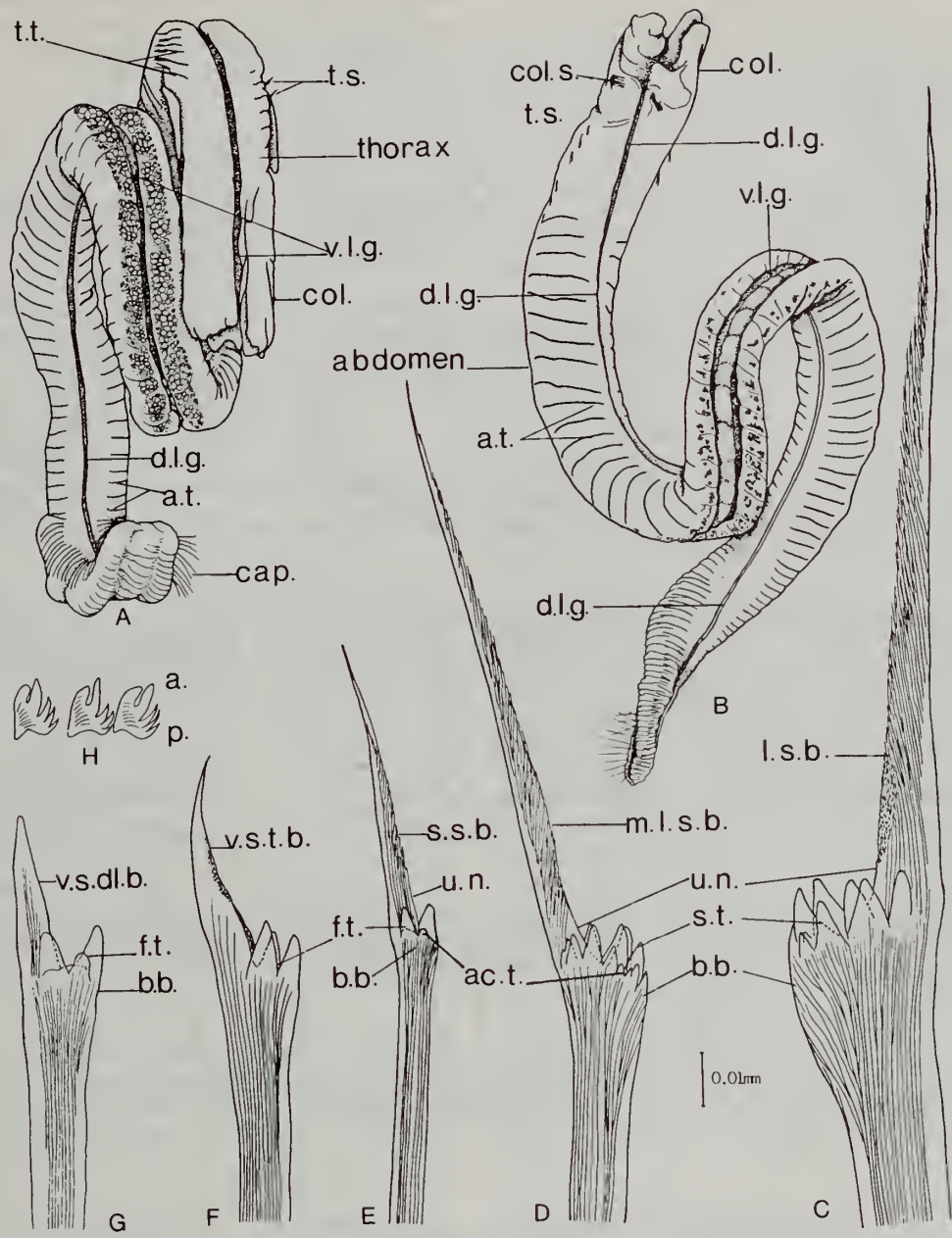


Fig. 2 Terminology. A & B, Body of worm: **a.t.**, abdominal tori; **cap.**, capillary chaetae; **col.**, collar; **col.s.**, collar chaetae; **d.l.g.**, dorsal longitudinal groove; **t.s.**, thoracic chaetae; **t.t.**, thoracic tori; **v.l.g.**, ventral longitudinal groove. C–G, Bayonet-shaped collar chaetae (after ten Hove & Jacobs, 1984; all same magnification): **ac.t.**, accessory teeth; **b.b.**, basal boss; **f.t.**, few teeth; **l.s.b.**,long serrated blade; **m.l.s.b.**, moderately long serrated blade; s.s.b., short serrated blade; **s.t.**, several teeth; **u.n.**, unserrated notch; **v.s.dl.b.**, very short dagger-like blade; **v.s.t.b.**, very short tapered blade. H, Uncini, showing orientation in relation to the body of the worm: **a.**, anterior; **p.**, posterior.

KEY TO THE KNOWN RECENT SPECIES OF *SPIRASERPULA* REGENHARDT, 1961

(See Figure 3 for terminology of ITS)

1. Tube with either dorsal or ventral internal longitudinal ridge only 2

   Tube with dorsal and ventral internal longitudinal ridges 7

2. Tube with dorsal longitudinal ridge only (Fig. 3, B–E) 3

   Tube with ventral longitudinal ridge only, exceptionally with few isolated teeth (Fig. 3, F) 6

3. Dorsal ridge unserrated, shaped like an inverted V (Fig. 3, B) ..... *S. singularis* sp. nov. p.62

   Dorsal ridge serrated (Fig. 3, C–E) 4

4. Serrations of dorsal ridge deltoid (Fig. 3, C) ..... *S. deltoides* sp. nov. p.80

   Serrations of dorsal ridge not deltoid (Fig. 3, D & E) 5

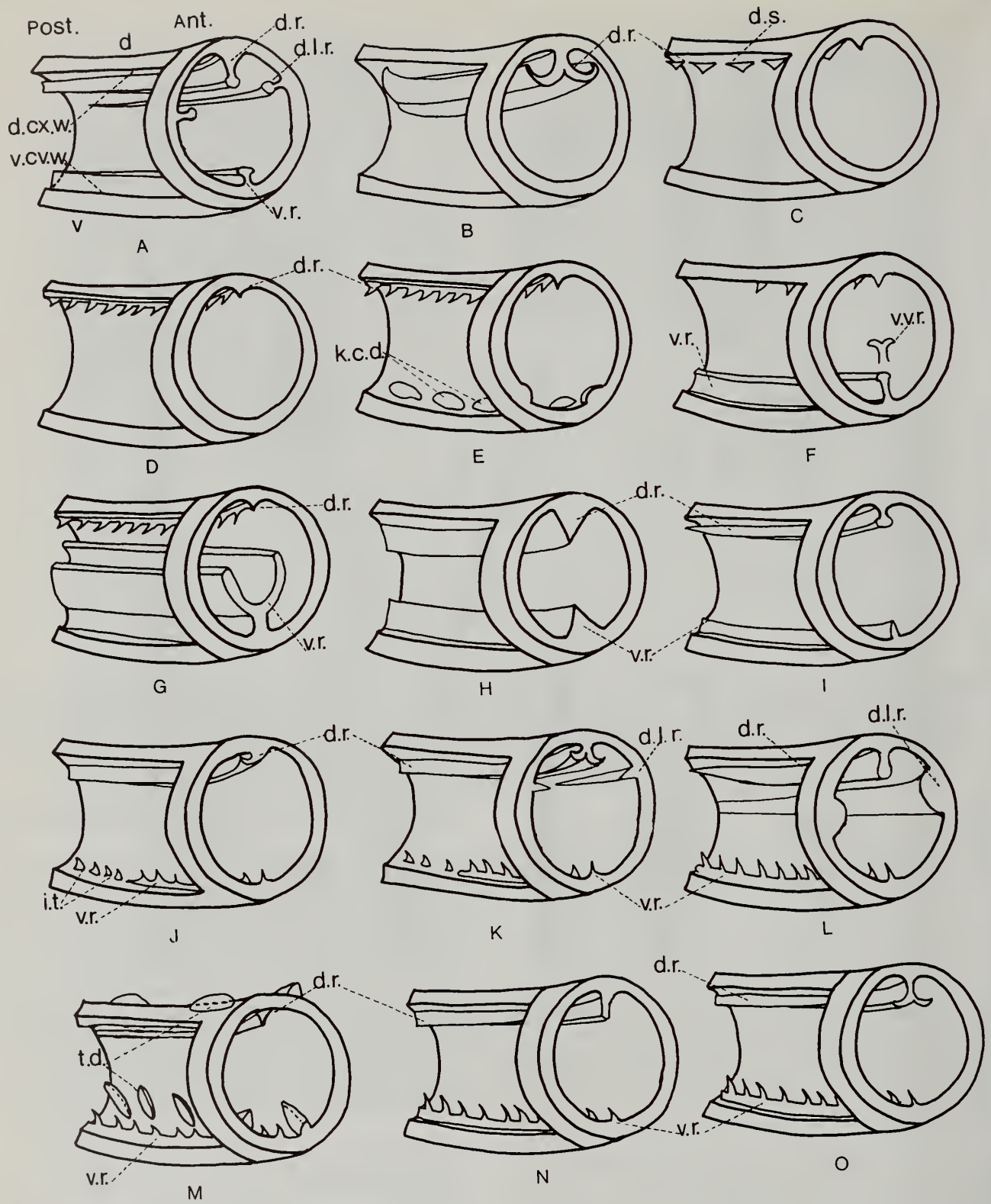


Fig. 3 Diagrammatic representations of ITS in the various species. A, Generalized drawing with all the main ITS. The orientation of the tube and terminology used are the same for all the diagrams. **Ant.**, anterior direction. **d**, dorsal side. **d.cx.w.**, dorsal convex wall.**d.l.r.**, dorso-lateral ridge. **d.r.**, dorsal ridge. v, ventral side.**v.cv.w.**, ventral concave wall. **v.r.**, ventral ridge. B, *S. singularis* sp.nov. C, *S. deltoides* sp. nov.; **d.s.**, deltoid serrations. D, *S. massiliensis* (Zibrowius, 1968). E, *S. capeverdensis* sp. nov.; **k.c.d.**, knob-like calcareous deposits. F, *S. nudicrista* sp. nov. & *S. snellii* sp.nov.; **v.v.r.**, variant form of ventral ridge. G, *S. ypsilon* sp. nov. & *S. paraypsilon* sp. nov. H, *S. sumbensis* sp. nov. I, *S. iugoconvexa* sp. nov. J, *S. vasseuri* sp. nov. K, *S. plaiae* sp. nov. L, *S. caribensis* sp. nov. & *S. lineatuba* (Straughan, 1967). M, *S. discifera* sp.nov.; **t.d.**, transparent discs. N, *S. karpatensis* sp. nov. & *S. minuta* (Straughan, 1967). O, *S. zibrowii* sp. nov.

5. Maximum number of radioles 6 pairs, abdominal segments about 50. Operculum may or may not be present. A shallow water species, down to about 60 m, rarely in deeper water ..... *S. massiliensis* (Zibrowius, 1968) p.49

   Maximum number of radioles 8 pairs, abdominal segments about 145. Operculum absent. A deep water species occurring at depths of about 75–200m ..... *S. capeverdensis* sp. nov. p.54

6. Tube creamish white, trapezoidal in cross-section. Operculum absent. Maximum number of radioles 9 pairs, pinnule-free tips very long. Prostomial ocelli prominently seen through collar. Unserrated notch of bayonet chaetae very short ..... *S. nudicrista* sp. nov. p.76

   Tube mustard coloured, circular in cross-section. Operculum present. Maximum number of radioles 5 pairs, pinnule-free tips short. Prostomial ocelli not seen through collar. Unserrated notch of bayonet chaetae moderately long ..... *S. snellii* sp. nov. p.84

7. Dorsal ridge serrated, ventral ridge Y-shaped (Fig. 3, G) ... 8

   Dorsal ridge unserrated, ventral ridge having other forms ... 9

8. Thoracic uncini without lateral tubercles. Maximum number of radioles 7 pairs, abdominal segments more than 100, about 130 ..... *S. ypsilon* sp. nov. p.56

   Thoracic uncini with lateral tubercles. Maximum number of radioles 11 pairs, abdominal segments less than 100, about 90 ..... *S. paraypsilon* sp. nov. p.60

9. Ventral ridge unserrated (Fig. 3, I) 10

   Ventral ridge serrated (Fig. 3, J–O) 11

10. Tube white to faintly pinkish, circular in cross- section, external longitudinal ridges absent; dorsal and ventral internal longitudinal ridges pink, wedge-shaped in cross-section (Fig. 3, H). Operculum with up to about 21 triangular radial lobes, cuticle unthickened. Maximum number of radioles 5 pairs, abdominal segments below 100 (about 70); bayonet chaetae with several teeth on the basal boss ..... *S. sumbensis* sp. nov. p.82

    Tube bright rose, quadrilateral to trapezoidal in cross-section, a pair of external longitudinal ridges, and a faint median one in places; dorsal and ventral internal longitudinal ridges white, dorsal ridge T-shaped in cross-section, ventral ridge very small (Fig. 3, I), may or may not be present. Operculum with up to about 12 rounded radial lobes, cuticle unthickened. Maximum number of radioles 14 pairs, abdominal segments over 100 (about 120); bayonet chaetae with two teeth on the basal boss ..... *S. iugoconvexa* sp. nov. p.82

11. Bayonet chaetae with long blades and several teeth on the basal boss ..... *S. vasseuri* sp. nov. p.78

    Bayonet chaetae with short to moderately long blades and few (2–7) teeth on the basal boss 12

12. Accessory lateral ridges present (Fig. 3, K & L) 13

    Accessory lateral ridges absent (Fig. 3, M–O) 15

13. Accessory ridges dorso-lateral. Dorsal ridge wedge- to Y-shaped in cross-section (Fig. 3, K), tube white ..... *S. plaiae* sp. nov. p.67

    Accessory ridges lateral. Dorsal ridge a simple plate, at most wedge to faintly T-shaped in cross-section (Fig. 3, L), tube pink or with pink longitudinal bands 14

14. Bayonet chaetae dagger-shaped, with short blunt blades. Operculum absent. Maximum number of radioles 6 pairs ..... *S. caribensis* sp. nov. p.68

    Bayonet chaetae with moderately long blades and tapering tips. Operculum present. Maximum number of radioles 5 pairs; ..... *S. lineatuba* (Straughan, 1967) p.91

15. Tube with transparent discs attached to the wall externally and internally (Fig. 3, M) ..... *S. discifera* sp. nov. p.94

    Tube without such discs (Fig. 3, N & O) 16

16. Operculum present ..... *S. karpatensis* sp. nov. p.64

    Operculum absent 17

17. Bayonet chaetae with 5–7 teeth on basal boss; maximum number of radioles 4 pairs, abdominal segments about 55 ..... *S. zibrowii* sp. nov. p.67

    Bayonet chaetae with 3–4 (rarely 5) teeth on basal boss; maximum number of radioles 6 pairs, abdominal segments about 80 ..... *S. minuta* sp. nov. p94

Although the ITS are very distinctive, the states of the characters need to be used with caution. In two species *S. lineatuba* (Straughan, 1967) and *S. caribensis* sp. nov., for example, 25–40 tube fragments had to be examined before the full extent of the development of dorsal and accessory ridges could be established; the latter are missing in most cross-sections. The shape of the distinctive inverted V, as in the dorsal ITS of *S. singularis* sp. nov. is only found in a small section in the earlier formed part of the tube; elsewhere, the ridge is a smooth plate only. Along this ridge, the rounded edge gradually becomes indented, gutter-shaped, and finally widening to form a V. This would apply to certain other characters as well. In *S. massiliensis* (Zibrowius, 1968) part of the sample from Marseille was operculate and part had rudimentary opercula only. However, all the specimens from a large sample from Portman had rudimentary opercula only. It may thus be expected that species which, on the basis of relatively few specimens, have been described as non-operculate, may turn out to be operculate when more material becomes available. As another example, two samples from Indonesia and Lizard Island (Queensland) initially appeared to belong to two distinct species, on the basis of differences in six character states. Additional material, however, yielded specimens with a full range of intermediate states, showing that they belong to one and the same species.

DESCRIPTION OF SPECIES

Spiraserpula massiliensis (Zibrowius, 1968) (Figs.4, A–O; 3, D; Pl.2, A–D)

SYNONYMY. *Serpula massiliensis* Zibrowius, 1968: 102–105, Pl.1, figs.24–37; Pl.14, fig.d.
Serpula massiliensis: Bianchi, 1981 : pp.51–52, fig.16. *Serpula massiliensis*: ten Hove & Aarts, 1986: 35 [not the tropical E. Atlantic record, see *S. ypsilon*].

MATERIAL EXAMINED. Unless otherwise mentioned, the material was collected and/or determined by Zibrowius.
Mediterranean:
France: Marseille: 1. Anse des Cuivres; below SME, overhang 6m, 21.vii.1987 (10 out of several specimens, BMNH ZB 1989, 43–53). 2. Île Plane; submarine cave, 6m, legit G. Harmelin, vi.1987 (4 specimens, SME). 3. Île Plane; 1987 (5 out of several specimens, BMNH 1989 101–150).4. Île Plane;

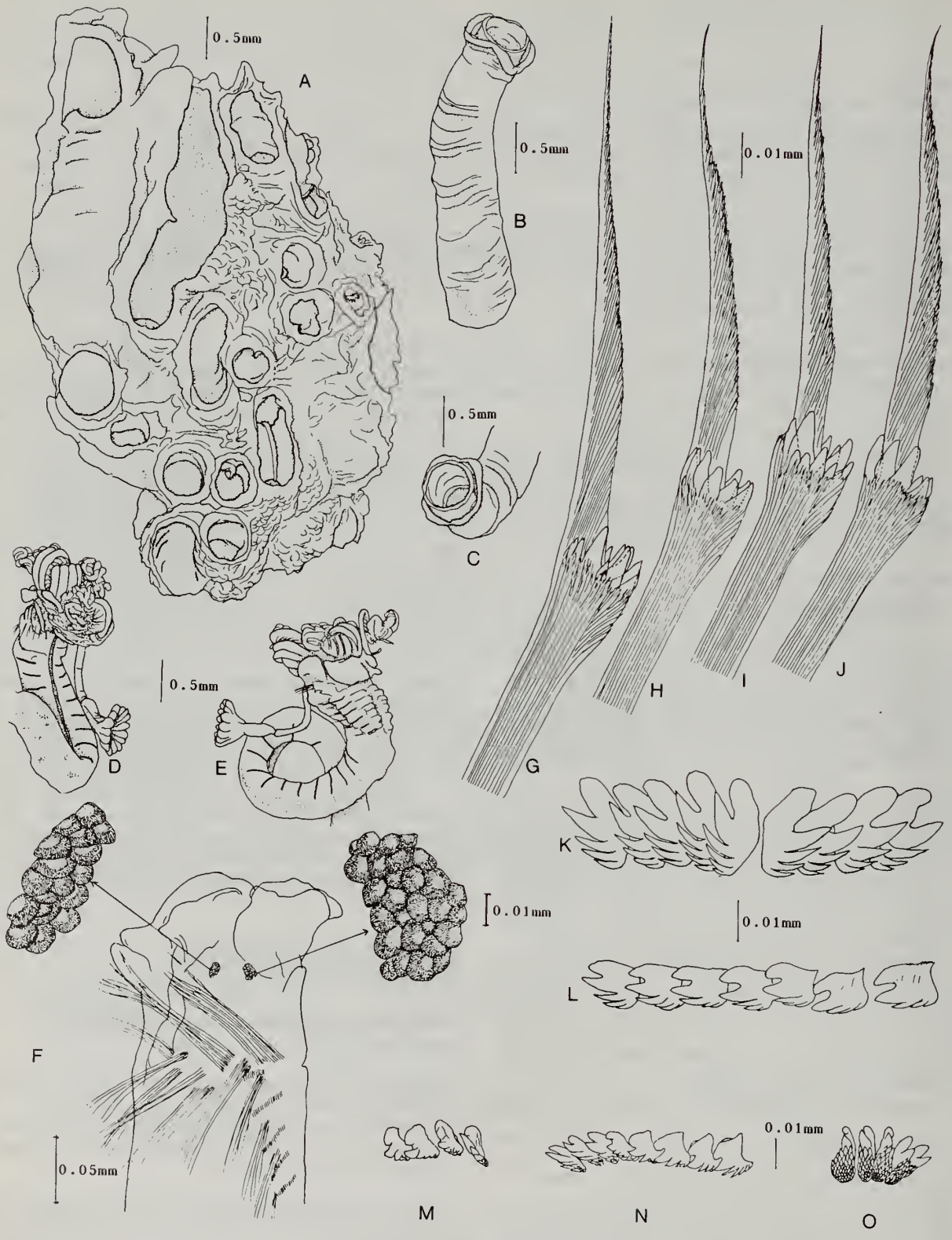


Fig. 4 *Spiraserpula massiliensis* (Zibrowius, 1968). A–O, From Marseille, Anse des Cuivres, BM(NH). ZB1989.43–53. A, Aggregation of tubes with fractured ends showing the serrated dorsal ridge along the convex inner wall, and granular overlay. B–C, Erect parts of tube with four-lobed peristome. D, Anterior part of operculate worm. E, Same specimen showing end of thoracic membrane. F, Thorax with pair of prostomial ocellar clusters, also enlarged. G–J, Four bayonet chaetae from the same fascicle. K, Row of thoracic uncini. L, Anterior abdominal uncini. M & N, Middle abdominal uncini. O, Posterior abdominal uncini.

submarine cave, 6m, legit G. Harmelin, vii.1971 (7 specimens, ZMA V. Pol.3159). 5. Friocil Harbour (5 out of several specimens, BMNH ZB 1989 54–100). 6. Grand Conglu; 1987 (5 out of several specimens, BMNH ZB 1989 151–200). 7. Martigues; ca. 50km W of Marseille, Ponteau Electric Plant, under stones, 1.3m, 5.iv.1977 (2 out of several specimens, SME). 8. La Ciotat; ca 30km E. of Marseille, Bec de l'Aigle, on concretions of sand, 40m, iii.1970 (3 specimens, SME). 9. Canyon de la Cassidaigne; about 20km E of Marseille, off Cassis, from 170–270m by dredging, 15.vi.1974 (tubes, 1 specimen, SME).

NW Corsica: 10. Revellata, 15m, calcareous algal masses, 8.iv.1978 (2 specimens, SME).

Italy: 11. S coast of Sorrento peninsula, 'Grotto Zaffiro', 10m, 29.v.1974 (3 specimens, SME). 12. Bari; 10m, cave, legit T.M.Griessinger, 8.vii.1968 (5 specimens, SME).

Greece: 13. Gulf of Corinth, Aspra Spitia, 5m, 26.ix.1977 (3 specimens, SME).

Malta: 14. Oxford University Underwater Exploration Group 1965, scrapings from roof of cave, det. Pillai (2 specimens, BMNH ZB1989 32–36).

Tunisia: 15. Tabarka; algal concretions, 31–36m, 24.iv.1969 (1 specimen, SME). 16. Zembra Islands, concretions, 35m, 30.iv.1969 (few tubes with portions of worms, SME). 17. 'Dauphin' Stn.24, 35°12′N 11°25′E, 73m, on Arca, legit Bane, Medit. Mar. Sorting Center, 28.viii.1967 (1 specimen, SME). 18. Gulf of Gabes; 'Calypso', 34°05′N 10°48′E, 23m, muddy sand with *Caulerpa* meadow, on shelly material, 20.iv.1965 (1 specimen, SME1887). 19. Gulf of Gabes; 'Calypso', 34°13′N 10°31.9′E, 31m, *Caulerpa* meadow, 27.iv.1965 (1 specimen, SME 1910).

SE Spain: 20. Cabo de Palos; ca 50km E of Cartagena, 6m, legit A. Ramos, 4.iv.1982 (3 specimens, SME). 21. Portman; 20km E of Cartagena, small overhang, 0.5–1.0m, on rock covered by dark brown sediment, the latter retained on the tube surfaces by oil pollution, 5.iv.1984 (20 out of several specimens, SME).

Portugal: 22. From a submarine cave near Sagres, Algarve, legit H. Zibrowius Sept. 1986 (BM(NH) 1992. 181–255).

NE Atlantic: 23. Gorringe Bank; 'Meteor' M9c, Stn.95, AT 29, 36°29.9′N 11°33.0′W, 150–430m, 24.vi.1967 (some empty tubes, SME). 24. Madeira Archipelago; Jean Charcot, Stn.42, SW of Porto Santo, approx. 33°0.4′N 16°24.5′W, 125–145m, 17.vii.1966 (empty tubes, information pers. comm. H.Zibrowius). 25. Canary Islands; W coast of Palma, Tijarafe, 28°42′N 17°58′W, 20m, CANCAP 4.D14, det. M. Aarts (5 out of several specimens, RMNH 18465, ZMA V.Pol.3739, BM(NH) 175–180). 26. NW Africa; off Point Elbow, ex Spanish Sahara, 'Tenace' D16, Stn. 23, 24°13′N 16°17′W, 50–60m, legit Marche-Marchard, 13.iv.1967 (4 specimens, SME).

TYPE LOCALITY. Marseille (France).

DESCRIPTION. In order to follow the variations within the genus *Spiraserpula* it was considered useful to have as complete a description as possible of one member of the group, *S. massiliensis* was selected because of the large amount of material available from various sources. The following updated species description is based on the original account as well as additional data obtained from a study of the above collections, which include much of Zibrowius' original material.

According to Zibrowius (1968), the tubes are white, circular in cross-section and, although difficult to measure because of their coiling, may attain a length of 50.0 mm for a diameter of about 0.5–1.0 mm. Their coiling is highly irregular and the direction may reverse. Sometimes many tubes are joined together, coiling in the same direction. They are relatively thick, except in their erect portions which are cylindrical. At intervals along the latter, there may be one to a few outwardly directed expansions, generally referred to as peristomes. They are sometimes in the form of four, somewhat symmetrically placed lobes. In dense populations, the erect tubes may form a kind of uniform meadow in submarine caves of the Mediterranean (Zibrowius, pers. comm.). The surface of the tube is covered by faint granulations which, very rarely, may form short longitudinal ridges.

It is difficult to remove the worms from their tubes. When removed, quite a number of specimens lacked their radiolar crowns. An operculum may be present or absent. When absent there is a rudimentary operculum on each side. When present, the operculum is small, and its diameter does not correspond with that of the tube. Its distal end is flattened to slightly funnel-shaped, bearing 13 to 23 obtuse lobes. The peduncle is more slender than the pinnulate radioles, and its attachment to the operculum is central and constricted. The corresponding radiole of the opposite side is reduced to a filamentous rudimentary operculum, about one-third the length of the radioles, and lacks pinnules.

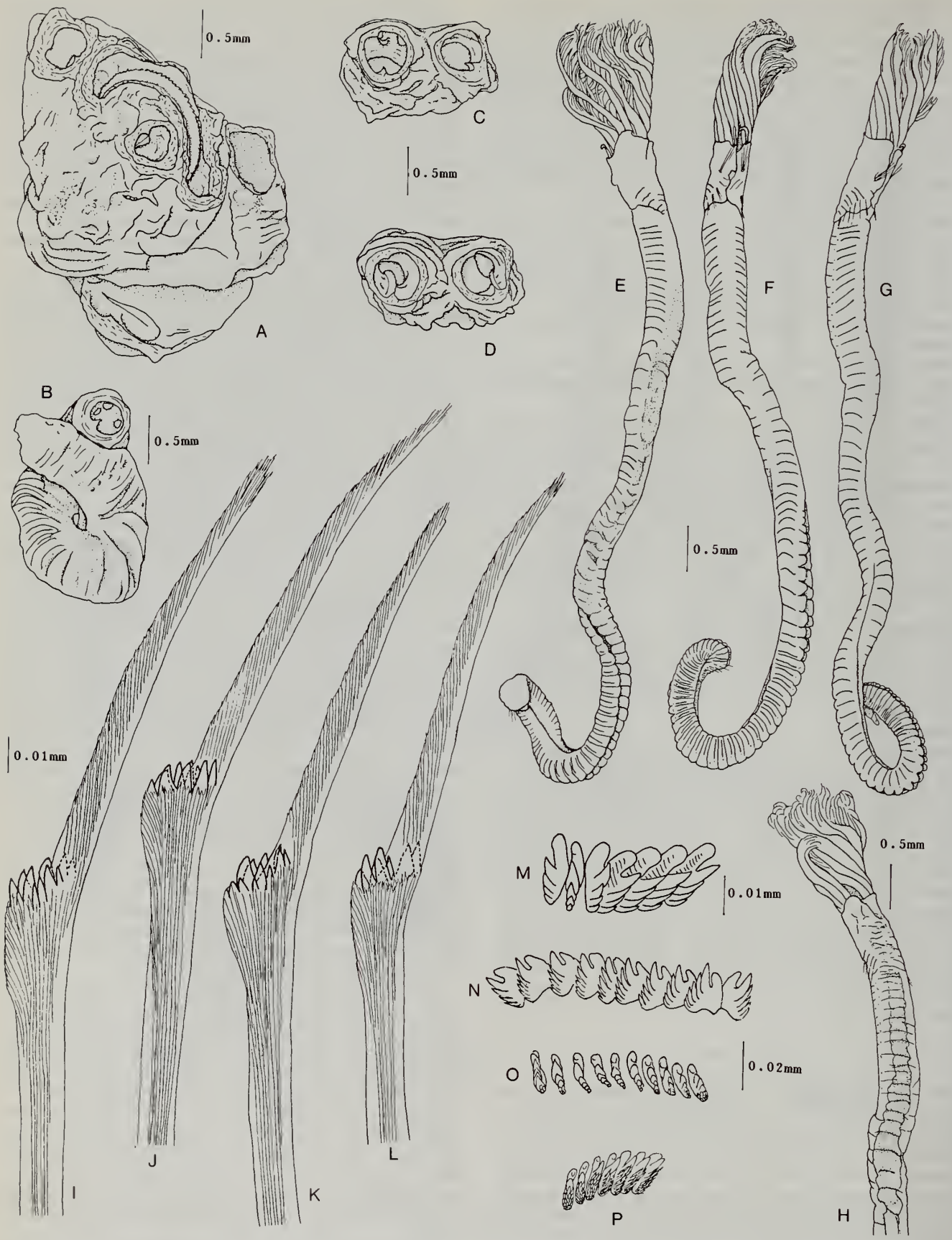
The collar consists of a large ventro-median lobe and a smaller one on either side of it, all of which are rounded. The thoracic membranes are broad and well developed up to about the fourth thoracic chaetiger, and reduced posteriorly. They are not united to form a post-thoracic ventral flap or apron. The number of thoracic segments may exceed the usual seven found in many other species of *Serpula*. Each collar fascicle generally possesses four bayonet-shaped chaetae and a similar number of simple bladed chaetae. Each bayonet chaeta has a striated blade distally, and several teeth on the basal boss. Thoracic uncini bear 3–5 teeth. Anterior abdominal bundles consist of 2–3 flat trumpet shaped chaetae. Uncini possess 2–5 teeth in a single row. The posterior abdominal segments bear long capillary chaetae, and rasp-shaped uncini with several rows of teeth.

Additional data obtained during the present study are as follows:

TUBES: White to faintly creamish, and may occur in closely intertwined masses of a few to several individuals (Fig. 4, A); sometimes solitary. Except for their free erect portions, they are mutually bonded to various extents, particularly at their bases. Their 'granular overlay' is shown in Fig. 4 A, and the four-lobed peristomes in Fig. 4, B & C.

An important character which had not been reported relates to the tube, which bears ITS. In its first formed portion, which is normally coiled, there is a serrated longitudinal ridge. Careful removal of numerous specimens from their tubes has shown that this serrated ridge is always on the convex side of the coils, as also found in masses consisting of several individuals (Fig. 4, A). The orientation of the worm within the tube is such that the posterior dorsal part of its abdomen is always applied to this serrated 'dorsal ridge' (Fig. 3, D). This, in addition to its tight coiling, accounts for the difficulties encountered in extracting complete worms from their tubes by Zibrowius (1968) and in the present study.

The numerous specimens in the collection from Portman show an apparent exception in lacking ITS. However, confir-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mation that the specimens belong to this species came from a very small number of old and empty tubes at the bottom of the aggregations having the characteristic serrated internal dorsal ridge. The population had been subjected to oil pollution, as evidenced by a thick deposit of it which covered the tubes externally, and even lined them thinly internally.

WORMS: The longest operculate specimen (from Île Plane, Marseille, BMNH ZB 1989 101–150) is 19.0 mm long; its thoracic width 1.1 mm. It has 5 pairs of radioles, in addition to an operculum on one side and a rudimentary operculum on the other. It also has the longest operculum and peduncle, 3.5 mm; its operculum is 1.0 mm long, 1.2 mm in diameter, bell-shaped, and with 11 rounded marginal lobes. The abdomen is 13.5 mm long and has 51 segments, the last four with capillaries. The longest non-operculate specimen, from the same locality, has a total length of 20.0 mm. Its abdomen is 15.5 mm long and has 43 segments, the last ten with capillaries. The two specimens indicate variations in abdominal length due to extent of contraction during fixation, and that the number of segments in the abdomen may not be always proportional to its length. In the other specimens studied, the length of the operculum together with the stalk ranges from 1.0–2.0 mm; the operculum from 0.5–0.6 mm in length and 0.3–1.5 mm in diameter.

The shape of the operculum varies from an elongate funnel in the majority of cases to a narrow bell in the others (Fig. 4, D, E).The opercular radii end in 10–16 rounded marginal lobes. The width of the peduncle, just before the constriction, is 3/5ths to 4/5ths that of the proximal end of the operculum. The number of radioles observed is 4–6 pairs, and their pinnule-free tips vary in length from 1/5th to2/3rd the total length of the radiole (i.e. radiole plus pinnule-free filament). Zibrowius (1968) reported a higher maximum number of up to 23 marginal lobes on the operculum. This high number, in one specimen, is apparently not representative of the species (Zibrowius, pers. comm.).

A total of 67 specimens from different localities (including 21 from the abnormal Portman material, *vide* below) were examined for various characters. All the Portman specimens possess only rudimentary opercula. Out of 46 specimens from the other collections 25 possess an operculum, 12 lack one, and the rest are indeterminate since they lack radiolar crowns. The majority of specimens from normal populations, therefore, possess an operculum.

Another character, hitherto not reported, is the presence of two light red to reddish-brown clusters of prostomial ocelli (Fig. 4, F). They can be seen when a worm with its radioles removed is viewed from the anterior end, or through the collar in mounted specimens. Each ocellus consists of a pigmented cup-shaped part, and a transparent anteriorly or antero-laterally directed lens-shaped part within it (Fig. 4, F). Thoracic glands, as found in other species of the genus, are absent.

The numbers of thoracic chaetal tufts, 6 to 9 on each side, may be symmetrical or asymmetrical. The condition in 26 specimens is summarized in Table 1. Likewise, the thoracic membranes may end symmetrically or asymmetrically, but always anterior to the last thoracic chaetiger; an apron is, therefore, absent (Fig. 4, E). The condition in 21 specimens is given in Table 2.

Table 1 *Spiraserpula massiliensis* (Zibrowius). Number of thoracic chaetal tufts on each side.

No. of individuals (n=26)	1	4	7	11	3
No. of thoracic chaetal tufts	6/7	7/7	7/8	8/8	8/9

Table 2 *Spiraserpula massiliensis* (Zibrowius). Extent of the thoracic membranes of the two sides.

No. of individuals (n=21)	1	2	10	2	3	3
Thoracic membrane ends	4/5	4/6	5/5	5/6	6/6	6/7

Collar fascicles bear 3 to 5 bayonet chaetae each. Bayonet chaetae consist of a long serrated blade, an unserrated notch of moderate length, and a basal boss with several teeth of variable size (Fig. 3, G–J; Pl. 2, A). Thoracic and anterior abdominal uncini usually have 4 or 5 teeth arranged in a single row (edge saw-shaped), (Fig. 4, K, L; Pl.2, B & C). In the intermediate abdominal region, the edge of each uncinus is saw-shaped anteriorly whereas several teeth are placed side by side (edge rasp-shaped) posteriorly. The number of teeth in a single row decreases and the rasp-shaped posterior portion increases as the posterior end of the abdomen is reached (Fig. 4, M–O). Although the posterior abdominal uncini are rasp-shaped, they have a single large tooth anteriorly (Fig. 4, O).

LIVE MATERIAL. (*Vide* Zibrowius, 1968)

HABITAT AND DISTRIBUTION. This species is commonly found in submarine caves and at depths accessible by diving (Zibrowius, 1968). The original description mentioned a depth of 10–22m, but subsequently the species was found to occur in shallower and deeper water (see list of material examined). Deeper water collections came from depths of 31–36m (Tunisia) and 58–60m (off Point Elbow, Western Sahara), the latter consisting of operculate and non-operculate specimens. Empty tubes of this and other serpulid species typical of shallow water have been obtained along the the steep slope of the Gorringe Bank at 150–430m. This occurrence may be due to slumping from shallower depths (Zibrowius, pers. comm.). The Madeira Archipelago material (125–145m) also consisted of dead material. The empty tubes and single specimen from Canyon de la Cassidaigne (170–200m) is also exceptional. In general, therefore, the species commonly occurs in depths to about 60m, rarely down to about 200m.

S. massiliensis is common in the Mediterranean (Greece,

Fig. 5 *Spiraserpula capeverdensis* sp. nov. A–P, From type locality (SW of São Vicente), CANCAP 6.148 & 6.146; A–L, From 6.148, M–P, from 6.146. A, Opened tube showing serrated internal dorsal ridge along the convex wall of coiled part; and granular overlay in places. B, Coiled part of tube with fine transverse growth wrinkles externally, and its fractured end showing dorsal ridge on convex inner wall, and two ventro-lateral longitudinal rows of smooth tubercles on opposite wall. C & D, Cross-section of two tubes, both with serrated internal dorsal ridge, and one with ventro-lateral rows of tubercles. E–G, Three views of same worm showing rudimentary opercula (F), condition of the thoracic membranes (G), and dorsal longitudinal groove (E & G), and ventral abdominal groove posteriorly (E). H, Anterior end of younger specimen. I–L, Bayonet collar chaetae, all from same fascicle. M, Thoracic uncini. N, Anterior abdominal uncini. O, Uncini from transitional region of abdomen. P, Posterior abdominal uncini.

Italy, France, Spain, Malta, and Tunisia). In the eastern Atlantic it is abundant in submarine caves, and has been recognized on Gorringe Bank, the Madeira Archipelago, Portugal and the coast of Sahara.

S. massiliensis has been erroneously reported from the Red Sea (Amoureux *et al.*, 1978). Examination of the specimens (HUJ) showed that their tubes lack ITS and they do not, therefore, belong to the genus *Spiraserpula*.

Spiraserpula capeverdensis sp. nov.
(Figs.5, A–P; 3, E)

MATERIAL EXAMINED.
Cape Verde Islands: All CANCAP stations. **Off São Vicente:** 1. 6.134; 110–120m, (2 PARATYPES and some empty tubes, RMNH 18197). 2. 6.135; 110–150m, (1 PARATYPE, BM(NH) 1992.8). 3. 6.137; 75–90m, (1 PARATYPE, BM(NH) 1992.9). 4. 6.146; 75m, (1 specimen, BMNH). 5. 6.148; 100–200m, (HOLOTYPE, 2 PARATYPES & 3 empty tubes (residual material) ZMA VPol. 3651). 6. 6.166; 78–85m, (1 PARATYPE, USNM 130995). **Off Razo:** 7 .7.117, 100–120m, (some empty tubes, RMNH 18198). 8. 7.123; 120m, (5 specimens, RMNH 18199, ZMA V.Pol.3733. **Scuba diving station : Boa Vista:** 9. 7.D06; down to 12m, (3 questionable specimens, ZMA V.Pol. 3871).

TYPE LOCALITY. Cape Verde Islands, São Vicente.

DESCRIPTION.
TUBES: White, nearly circular in cross-section, and occurring in aggregations of a few individuals, occasionally solitary. They are closely coiled amongst or upon themselves (Fig. 5, A), and mutually bonded by a granular overlay. Erect portions, when present, are very short, hardly rising above the rest of the tube, and may end in four lobes. Faint growth rings are sometimes present (Fig. 5, B), and anterior uncoiled portions may sometimes show a few transverse thickenings, representing peristomes. In their first formed parts, they possess an internal serrated dorsal ridge (Fig. 5, A, D) and, often, a short ventro-lateral longitudinal row of small smooth knob-shaped processes on each side (Figs.5, B, C; 3, E). A mid-dorsal longitudinal groove in the posterior part of the abdomen (Fig. 5, E, G) is applied to the serrated dorsal ridge when the worm is withdrawn into the tube. The maximum external diameter of the tube varies from 0.6 mm in a juvenile to 1.4 mm in older specimens.
WORMS: (Fig. 5, E–H). An operculum is absent in all the specimens examined. Instead, a filamentous rudimentary operculum is present on each side. The number of radioles in the larger specimens is often 7 or 8 per side, 4 in the smallest. They are about 2.0 mm long in the larger specimens, and have transverse specks at intervals. Their pinnule-free tips are slender, 1/5 to 1/6 the total length of the radioles. Two clusters of reddish to reddish-brown prostomial ocelli are present.

Table 3 *S. capeverdensis* sp. nov. Measurements and meristic data.

Stn. No.	TL (mm)	Width of thorax (mm)	No. of radiol.	Length of abdom. (mm)	No. of abdom. segs.	Caps. on
6.137	25.9	0.5	8/8	22.7	138	27
6.148	20.6	0.5	7/8	17.5	145	–
6.148	7.1	0.5	7/8	6.9	96	12
7.123	2.9	0.3	4/4	2.6	49	–
7.123	2.4	0.3	4/4	2.2	29	9

Table 4 *S. capeverdensis* sp. nov. Numbers of thoracic chaetal tufts and extent of thoracic membranes.

No. examined (n=12)	2	1	2	1	4	2
No. of thoracic chaetal tufts	9/8	8/8	8/7	8/5	7/7	7/6
No. examined (n=9)	1	4	2	2		
Thoracic membrane ends	6/6	5/5	5/?	4/4		

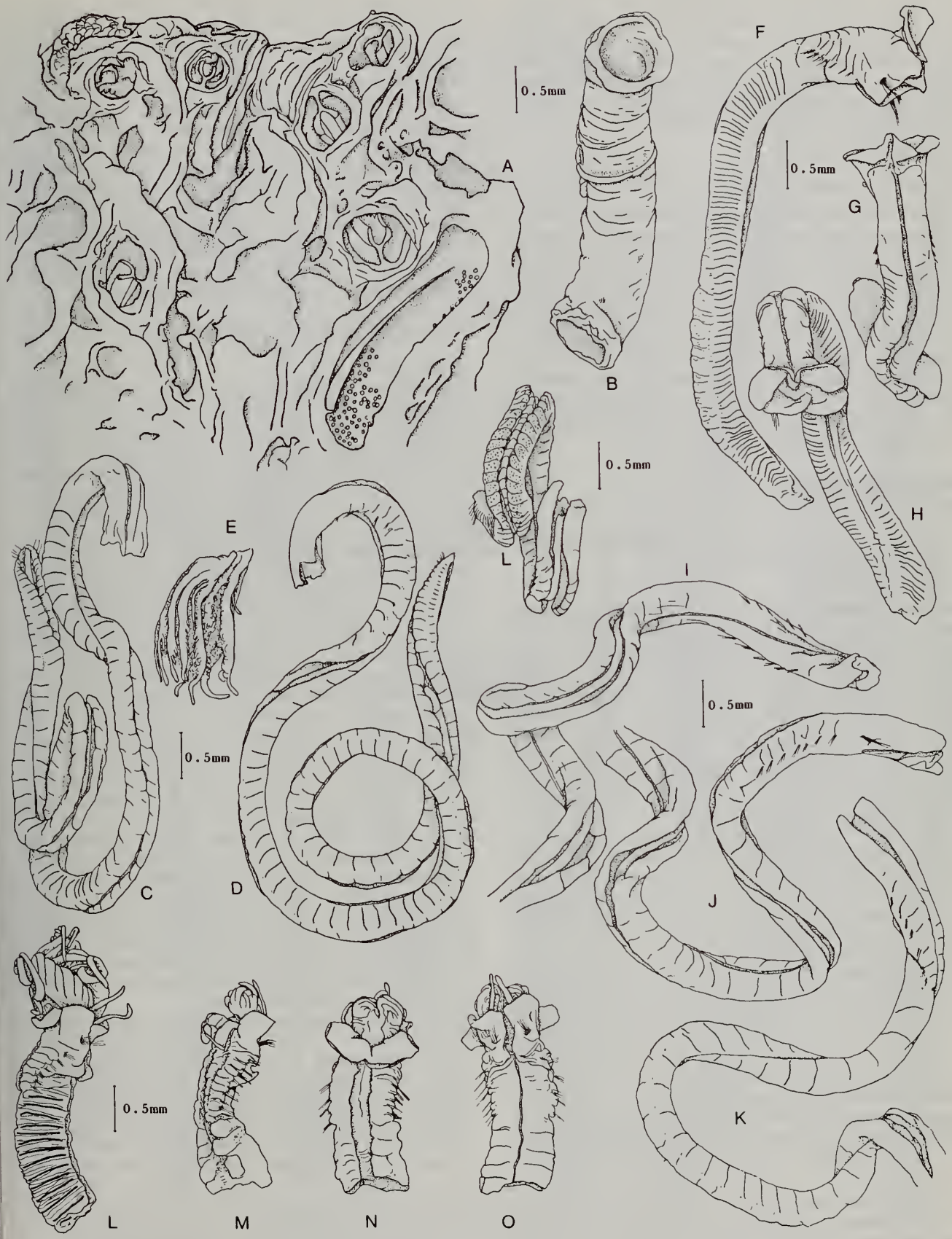
Measurements and other data from the two longest and three juvenile worms are presented in Table 3. The numbers of thoracic chaetal tufts and the extent of the thoracic membranes on the two sides is variable, as shown in Table 4.

The thoracic membranes do not extend to the last thoracic chaetigers (Fig. 5, F), and apparently end symmetrically, but further study of additional material is necessary for confirmation of the latter. Ventral thoracic glands are absent.

Each collar fascicle bears up to about 5 bayonet chaetae (Fig. 5, I–L). They have a long serrated blade, a short unserrated notch and several moderately large teeth on the basal boss. Thoracic uncini (Fig. 5, M) usually have 4 teeth in a single row. Anterior abdominal uncini are similar, with 4–6 teeth (Fig. 5, N). The posterior abdominal uncini are rasp-shaped, except for the single anterior tooth (Fig. 5, P). There is a transition (Fig. 5, O) between the condition found in the anterior and posterior abdominal uncini.

The differences between *S. capeverdensis* sp. nov. and *S. massiliensis* are as follows: The former has only rudimentary opercula, and higher maximum numbers of radioles (8 pairs) and abdominal segments (145). Its tubes do not form tall erect portions, and usually possess two ventro-lateral rows of knob-shaped tubercles internally, in addition to the serrated dorsal ridge. In *S. massiliensis*, however, an operculum may or may not be present, the maximum number of radioles is 6 per side, and of abdominal segments observed 51. There is also strong indication of an ecological difference (see below).

Fig. 6 *Spiraserpula ypsilon* sp. nov. From type locality material (SW coast of Island of Brava), CANCAP 6.D03. A, Aggregation of fractured tubes showing ITS, consisting of a Y-shaped ventral ridge along the concave wall and a serrated dorsal ridge along the convex wall. An oblique section (bottom right) shows the tapering anterior end of the ventral ridge. B, Erect portion of tube showing four-lobed peristome. C–E, Different views of complete worm showing showing rudimentary opercula, pinnule-free tips of the radioles (E), and dorsal and ventral longitudinal abdominal grooves. F–H, Same anterior end showing four-lobed collar (H), thoracic chaetigers and membrane (F), and ventral longitudinal groove. I–K, Three views of larger specimen, showing dorsal and ventral longitudinal abdominal grooves. Note the longitudinal cord-shaped structure within the ventral groove of the abdomen which fits into the gutter-shaped part of the Y-shaped ventral ridge of the tube. L, Anterior portion of of worm accidentally fixed outside its tube, showing filamentous rudimentary opercula and thoracic membranes. M–O, Three views of anterior part of another worm fixed outside its tube. Its thorax is considerably wider than those of specimens fixed within their tubes, and the longitudinal grooves may be stretched and shallow (N).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REMARKS. Although the few damaged specimens from Stn. 7.D06 are very similar to *S. capeverdensis* in most respects, only 2 tube parts (out of 10 recognizable fragments) showed a serrated dorsal ridge and possibly latero-ventral knobs. As opposed to all material of *S. capeverdensis* studied so far, a specimen in a tube without visible internal structures showed a bell-shaped operculum with 13 radii. Therefore the identification of this lot is left at ? *capeverdensis*.

LIVE MATERIAL. No records.

ETYMOLOGY. Named after the type locality.

HABITAT AND DISTRIBUTION. *S. capeverdensis* sp. nov. is known only from the Cape Verde Islands, mainly from depths of 75–200m where the bottom consists of various combinations of coarse sand, shell gravel, calcareous stones, calcareous nodules, calcareous algae and sponges, on which it occurs among the epifauna.

Scuba diving to 15–20m, in a total of 28 different stations off the Cape Verde Islands during CANCAP–VI and CANCAP–VII, did not yield this species from the shallower coastal waters. However, the dives yielded a different species, *S. ypsilon* sp. nov., from these depths which, in the Mediterranean, are typical for *S. massiliensis*.

Spiraserpula ypsilon sp. nov.
Figs. 6, A–K; 7, A–T; 34, G; Pl. 1, B)

SYNONYMY. *Serpula massiliensis*: ten Hove & Aarts, 1986: 35 (tropical E. Atlantic record only).

MATERIAL EXAMINED.
Cape Verde Islands: CANCAP stations. **Scuba diving stations:** 1. 6.D01; S coast of **São Tiago**, SE of Porto Praia, 15m (1 specimen, RMNH 18177). 2. 6.D02; S coast of **São Tiago**, Baía de Santa Clara, 20m, caves in rock (2 out of several specimens; RMNH 18187; BM(NH) 1992.85–115; FSBC I 39197 (1); AM W 20339 (1); NSMT (1)). 3. 6.D03; SW coast of **Brava**, Porto dos Ferreiros, 15m (30 specimens: HOLOTYPE & 5 PARATYPES, RMNH 18176. Other PARATYPES: ZMA V. Pol. 3650 (10); USNM 130993 (6) and BM(NH) 1992.73–82 (10)). 4. 6.D06; SW coast of **São Nicolau**, Baía do Tarrafal, 15m (4 specimens, RMNH 18188). 5. 6.D10; S. coast of **São Vicente**, 15m (5 out of several specimens, RMNH 18189). **Coastal stations**: 6. 6.K13; SW coast of **Ilha Razo**, (14 out of several specimens, RMNH 18190, ZMA V.Pol.3726, USNM). 7. 6.K15; SW coast of **Ilha de Santa Luzia**, (1 out of several specimens; bulk RMNH 18191; clusters of 10–15 tubes each BM(NH), 1992.116–120; ZMA V.Pol.3727; HUJ; Dr M. Jäger). 8. 6.K21; NE coast of **São Vicente**, Baía das Gatas, (3 specimens, RMNH 18192). **Scuba diving stations:** 9. 7.D03; **Cima**, SE coast, (1 specimen, RMNH 18193). 10. 7.D05; **Maio**, SW coast of Ponta Preta (2 out of few specimens, RMNH 18194). 11. 7.D06; **Boa Vista**, Ilhéu de Sal Rei, 12m (1 out of few specimens, ZMA V.Pol.3728). 12. 7.D10; **Razo**, S coast, 20m (1 out of few specimens RMNH 18195; BM(NH) 1992. 121–131; ZMH). **Dredging station:**13. 6.148: off **São Vicente**, 100–200m (1 empty eroded tube; RMNH 18196). **Tropical Western Atlantic, Gulf of Mexico:** 14. Florida, Stn. EJ66–460, 26°24′N 82°28′W, 18m, 6.xii.1966, 'Hourglass' Stn J, (20 out of several specimens, FSBC I, ZMA V.Pol.3729, BM(NH) 1992. 132–147). 15. Florida: Stn. EJ 67–76, 27°37′N 83°28′W, 39m, 2.iii.1967, 'Hourglass' Stn.C, (few specimens, FSBC I, ZMA V.Pol.3730. 16. Florida: Stn. EJ67–328, 27°37N 83°07W, 18m, 11.ix.1967, 'Hourglass' Stn. B (4 out of several specimens, ZMA V.Pol.3731). **Caribbean:** 17. **Aruba:** Andicuri, cape W of beach, windward side, rockpool, exuberant coral growth, strong wave action, 0.5m, legit H.A. ten Hove, 28.viii.1970, Stn.2034B (together with *S. caribensis* sp. nov.; ZMA V.Pol.3732). 18. **Colombia:** Santa Marta area, Cabo and Ojo del Aguja, 8–27m, legit J. W. Dulfer and M. J. C. Rozenmeyer 1986, ident. as *S. massiliensis* (1 damaged specimen, tube; ZMA V.Pol.3778). **Bermuda:** 19. Stn.14, legit Reed, with a note by Zibrowius in 1970 indicating that it is a new species (3 specimens, USNM 43244).

TYPE LOCALITY. Cape Verde Islands, Brava.

DESCRIPTION.
TUBES: Faintly pinkish, often with a more pronounced shade of light pink or light mauve in the granular overlay towards their anterior ends. They normally occur in mutually bonded highly coiled aggregations, occasionally also singly, adjacent to the aggregations. The granular overlay is fine, somewhat translucent and nearly uniform (partly shown in the top left portion of Fig. 6, A). External longitudinal ridges are normally absent, but up to three may be faintly developed on the less coiled tubes of solitary specimens. Their anterior portions are generally attached, often with their lateral borders extending somewhat over the substratum. Occasionally, they possess erect ends which attain an external diameter of up to 1.25mm, and may bear a few peristomes which are usually four-lobed and outwardly directed (Fig. 6, B).

The ITS are more complicated than those of the other known species of the genus, with the exception of the closely related species *S. paraypsilon* sp. nov. As seen in carefully opened tubes or through their fractured ends in an aggregation (Fig. 6, A), they consist of a serrated dorsal ridge, and a thin, very fragile, Y-shaped ventral ridge (Fig. 3, G; Pl.1, B). The gutter-shaped part and the stem of the latter gradually decrease anteriorly until they are represented only by a simple ventral ridge, which itself decreases in height and gradually disappears (Fig. 6, A, bottom right corner). These ridges commence in the first formed portions of the tube, but usually extend more anteriorly than in most of the other species of the genus. The inner translucent layer of the tube is faintly pinkish, as is the Y-shaped ventral ridge. In addition, the latter may possess one or two thin dark pink longitudinal stripes on the outside of the gutter-shaped part, one along the top and the other along the bottom.
WORMS: Some measurements and counts are provided in Table 5–8.

The worms attain a total length of about 27.5mm, a thoracic width of 0.6mm, a maximum of about 131 abdominal segments, with capillaries on the last 10 segments or so. The maximum number of radioles is 8 pairs. The two specimens with 4 pairs of radioles are juveniles. The pinnule-free tips are short to moderately long, up to about 1/5 the entire length

Fig. 7 *Spiraserpula ypsilon* sp. nov. A–0, From type locality, CANCAP 6.D03. P–T, From Florida Stn. EJ 66–460. A–E, Bayonet chaetae from same fascicle. F–I, Same, from second specimen. J, Thoracic uncini. K, Uncini from first abdominal torus. L, Uncini from third abdominal torus. M, Anterior abdominal uncini from another specimen. N, Uncini from mid-abdominal torus (transitional region). O, Posterior abdominal uncini. P–T, Bayonet chaetae of one fascicle.

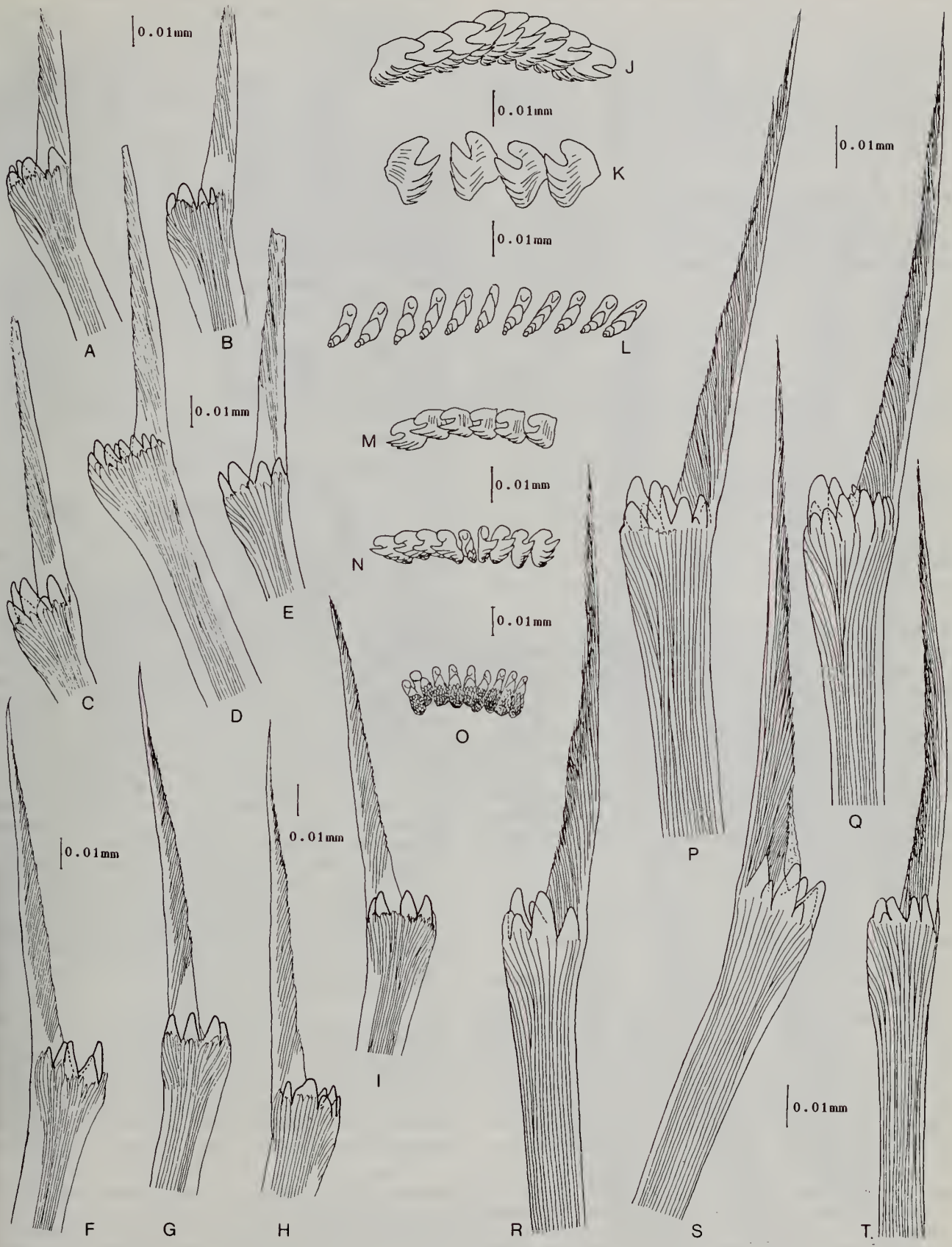
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Table 5 *S. ypsilon* sp. nov. Measurements (mm) and counts.

Total length	27.5	15.6	14.1	11.7	6.3	6.0	4.6
Thoracic width	–	0.6	0.6	0.4	0.5	0.5	0.4
No. of radioles	–	7/7	8/8	5/5	6/6	6/6	4/4
Abdominal length	25.5	11.0	11.3	8.5	4.6	4.3	2.6
No. of abdom. segs.	113	88	131	107	37	57	37
Capillaries from	103	80	124	99	24	44	30

Table 6 *S. ypsilon* sp. nov. Numbers of radioles.

No. of specimens (n=37)	1	6	15	13	2
No. of radioles (L/R)	8/8	7/7	6/6	5/5	4/4

Table 7 *S. ypsilon* sp. nov. Numbers of thoracic chaetal tufts in 69 specimens.

No. of specim.	1	2	1	9	2	2	16	23	3	8	1	1
Nos. of. tufts	10/9	10/8	9/9	9/8	9/7	9/6	8/8	8/7	8/6	7/7	7/6	7/5

Table 8 *S. ypsilon* sp. nov. Extent of thoracic membranes in 43 specimens.

Number of specimens	5	31	6	1
Thor. membranes end on	6/6	6/5	5/4	5/3

Table 9 *S. ypsilon* sp. nov. from Florida (EJ– 66–460). Measurements and meristic data from two longest specimens out of 22 measured.

	Total length (mm)	Thoracic width (mm)	No. of radioles	Abdomen Length (mm)	Abdomen No. of segs.	Abdomen Caps from
Specimen 1	22.7	0.6	7/7	18.5	110	97
Specimen 2	20.7	0.8	6/6	16.7	130	111

Table 10 Meristic and other data on *S. ypsilon* sp. nov. from Florida (EJ– 66–460).

No. of specimens (n = 14)	4	2	4	1	2	1			
No. of radioles	7/7	7/6	6/6	6/5	5/5	3/5			
No. of specim. (n = 29)	1	1	1	4	6	9	4	2	1
No. of th. chaetal tufts	10/9	10/7	9/9	9/8	8/8	8/7	7/7	7/6	7/5
No. of specimens (n = 20)	1	1	10	7	1				
Thor. membrane ends	7/5	6/5	5/5	5/4	4/4				

of the radioles (Fig. 6, E). Live material from Stns. 7.D03 and 7.D05 showed a pair of pigmented ocelli at the base of each radiole, externally. An operculum is absent; there is a filamentous rudimentary operculumon each side (Fig. 6, E, L, O).

Two clusters of reddish to reddish-brown prostomial ocelli are present. Although the width of the thorax ranges from 0.4–0.6 mm in specimens preserved within their tubes, it can be wider in anterior portions of worms accidentally preserved outside their tubes (Fig. 6, F–H, L–O). The median lobe of the collar is sub-rectangular, rounded laterally and with a smooth mid-ventral notch, giving the entire collar a four-lobed appearance (Fig. 6, F–H & L–O).

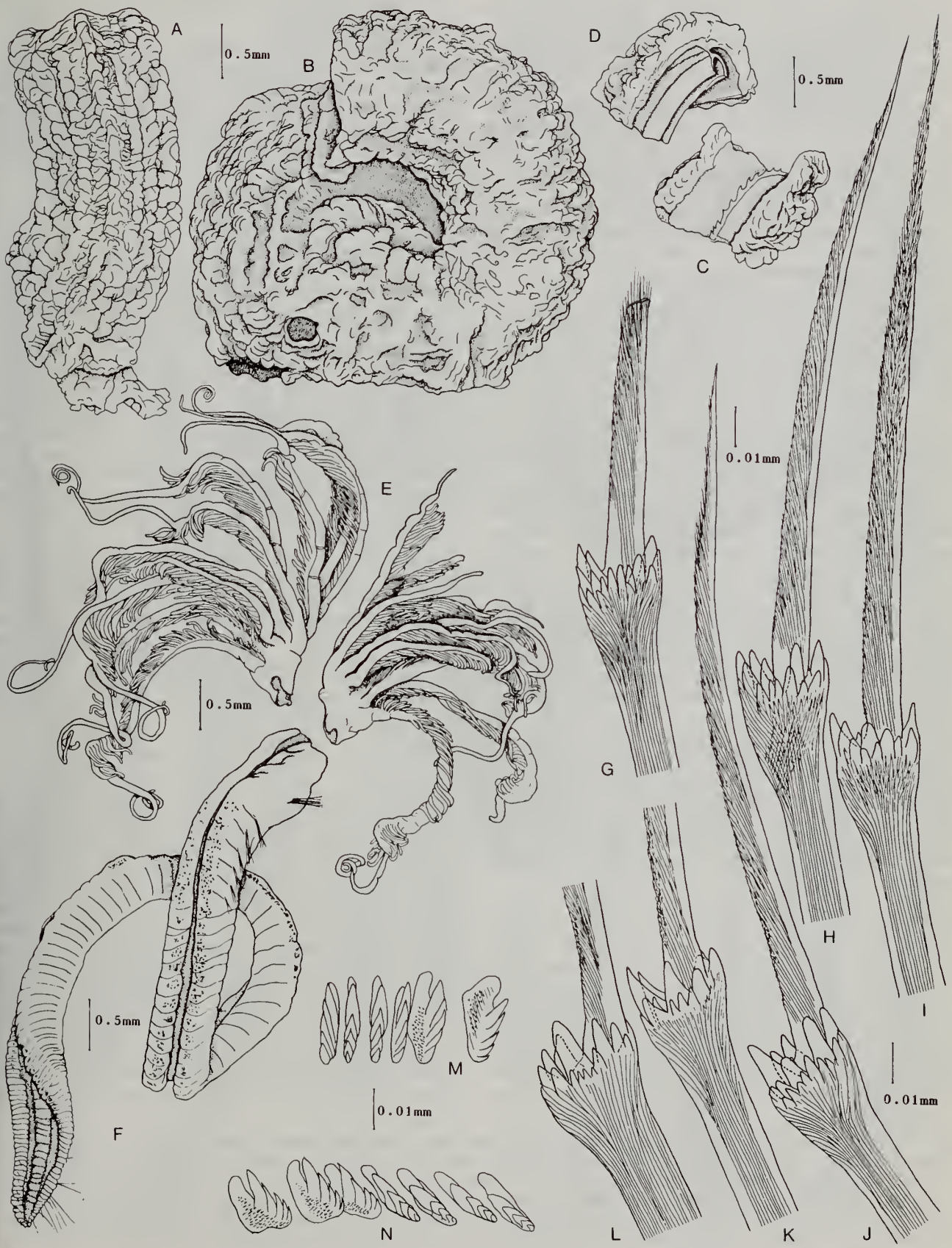
The numbers of thoracic chaetal tufts on the two sides range from 5 to 10, and may be symmetrical or asymmetrical, as are the endings of the thoracic membranes (Tables 7 & 8). Paired thoracic glands are absent.

Collar fascicles bear up to about four fully developed bayonet chaetae and two more being formed deep within the fascicle, with a similar number of simple bladed chaetae. Juveniles possess fewer, often two fully developed bayonets and two more being formed within the fascicle. Each bayonet chaeta has a long serrated blade, a short unserrated notch, and few to several moderately large somewhat conical teeth with smooth tips on its basal boss (Fig. 7, A–E, F–I). The serrations of the blade are short towards its proximal part, but somewhat pilose distally. Thoracic uncini are mostly with 6 teeth, but some have 4 or 5 (Fig. 7, J). Anteriorly there are up to 4 flat trumpet chaetae in each bundle, posteriorly there are 1 or two capillaries instead. Anterior abdominal uncini usually have 4 or 5 teeth arranged in a single row (Fig. 7, K–M). The posterior abdominal uncini are rasp-shaped, with a single anterior tooth and several (4–6) rows of teeth posterior to it (Fig. 7, O). In between, there is a progressive reduction in the number of teeth in a single row, and a corresponding increase in the rasp-shaped area (Fig. 7, N). The special adaptations of the body of the worm in relation to the internal structures of the tube are as follows: A narrow longitudinal groove extends along the mid-dorsal line of the abdomen and thorax (Fig. 6, C, D, H–K, O). The abdomen and thorax are also grooved ventrally, and within this longitudinal groove, forms a cord-shaped longitudinal ridge (Fig. 6, C, D, I–L). The orientation of the worms within their highly coiled tubes is such that the dorsal groove is applied to the serrated dorsal ridge of the tube, and the cord-shaped ventral abdominal ridge fits into the gutter-shaped part of the Y-shaped ventral ridge of the tube. The latter, in turn, fits into the ventral groove of the body.

COLLECTIONS FROM THE WESTERN ATLANTIC. *S. ypsilon* has also been collected from Florida, Bermuda and Aruba.

Study of material from Florida (EJ– 66–460) provided the following data: The external diameter of the tubes attains 1.1 mm. A granular overlay is present. The external colouration varies from faintly creamish to faintly pinkish. Their internal colouration and structures are similar to those from

Fig. 8 *Spiraserpula paraypsilon* sp. nov. A, Tube from Curaçao, NA, Cornelisbaai, showing granular overlay and longitudinal ridges. B–N, From Klein Bonaire Stn. 2105A. B, Tube with indistinct longitudinal ridges. C–N, From holotype. C, Tube fragment showing serrated dorsal ridge along convex wall. D, Tube fragment with Y-shaped ventral ridge along opposite wall. E & F, Adult worm; E, Radioles of both sides, with very long pinnule-free tips and lacking rudimentary opercula. F, Body showing dorsal and ventral longitudinal abdominal grooves and ventral pigment patches. G–L, Bayonet collar chaetae. M, Thoracic uncini of holotype showing lateral denticles. N, Anterior abdominal uncini, with more prominent denticles.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the Cape Verde Islands. The colouration of the worms in alcohol shows a difference. The radioles and body have an overall fleshy to dark reddish-brown colour, with blackish pigment clusters ventro-laterally in the abdominal segments. Whether this colour difference is due to different methods of fixation or not needs to be verified. Maximum sizes encountered have been given in Table 9.

An operculum is absent, but a pair of rudimentary opercula is present. Up to 10 thoracic chaetal tufts per side were counted, and the extent of the thoracic membranes is variable, however, never reaching the last thoracic chaetiger. Meristic and other data are given in Table 10.

The collar chaetae (Fig.6, P–T), are larger than those of the specimens from the type locality, but otherwise similar. In the abdomen, up to 10 flat trumpet shaped chaetae per fascicle were counted.

The other two Florida samples are similar. However, in sample EJ 67–76, one specimen lacking radioles has 12 thoracic chaetigers on the left and 11 on the right, with the thoracic membranes ending on the 6th and 5th chaetiger, respectively. The samples from Bermuda and Aruba are similar to those from Florida.

LIVE MATERIAL. There are some intra-specific colour variations in*S. ypsilon* sp. nov., as observed in collections from different stations in the Cape Verde Islands:

Stn.6.D02: Branchial radioles distally orange, proximally pinkish orange, except for a bright red spot where the radioles meet. Thorax is transparently reddish, with two subcutaneous brown spots laterally. Abdomen is pink or orange, with brown sides.

Stn.7.D03: Distal half of the short radioles banded white and yellowish orange, basal half bright red. Basal radiole parts with oval lens-shaped structures, apparently ocelli. However, after preservation no lenses could be found in this material, not even after staining in methylene blue. Thorax bright red, abdomen orange, with brownish-green granules laterally.

Stn.7.D05: Radioles transparent, hyaline, with a single row of pigmented spots at the base. No lenses visible, even with a compound microscope. Thorax and abdomen orange-brown. Sides of abdomen show brown granules (in four specimens). In two other specimens the radioles are hyaline, with transverse orange bands and red pigment spots at their bases. The rest of the body is red, otherwise similar to the other four specimens.

ETYMOLOGY. The specific name refers to the Y-shaped internal ridge.

HABITAT AND DISTRIBUTION. As revealed by several scuba dives and littoral surveys in the Cape Verde Islands, *S. ypsilon* sp. nov. occurs on various hard substrata in depths occupied by *S. massiliensis* (Zibrowius) in the Mediterranean. At Stn. 6.D02, for instance, the ceiling of a half metre deep cave, at a diving depth of 14m, was covered with crusts of partially erect tubes of *S. ypsilon*. However, *S. massiliensis* did not turn up in any of the collections from the Cape Verde Islands. The single, eroded tube of *S. ypsilon* sp. nov. from the dredging station 6.148 (100–200 m) was probably transported down the slope.

Although the Western Atlantic and Cape Verde Islands material show some differences, they appear inadequate to separate them into distinct species. The Western Atlantic range is from Bermuda to Aruba. A species from the Caribbean which has similar internal tube structures, but differs in other respects, is described next.

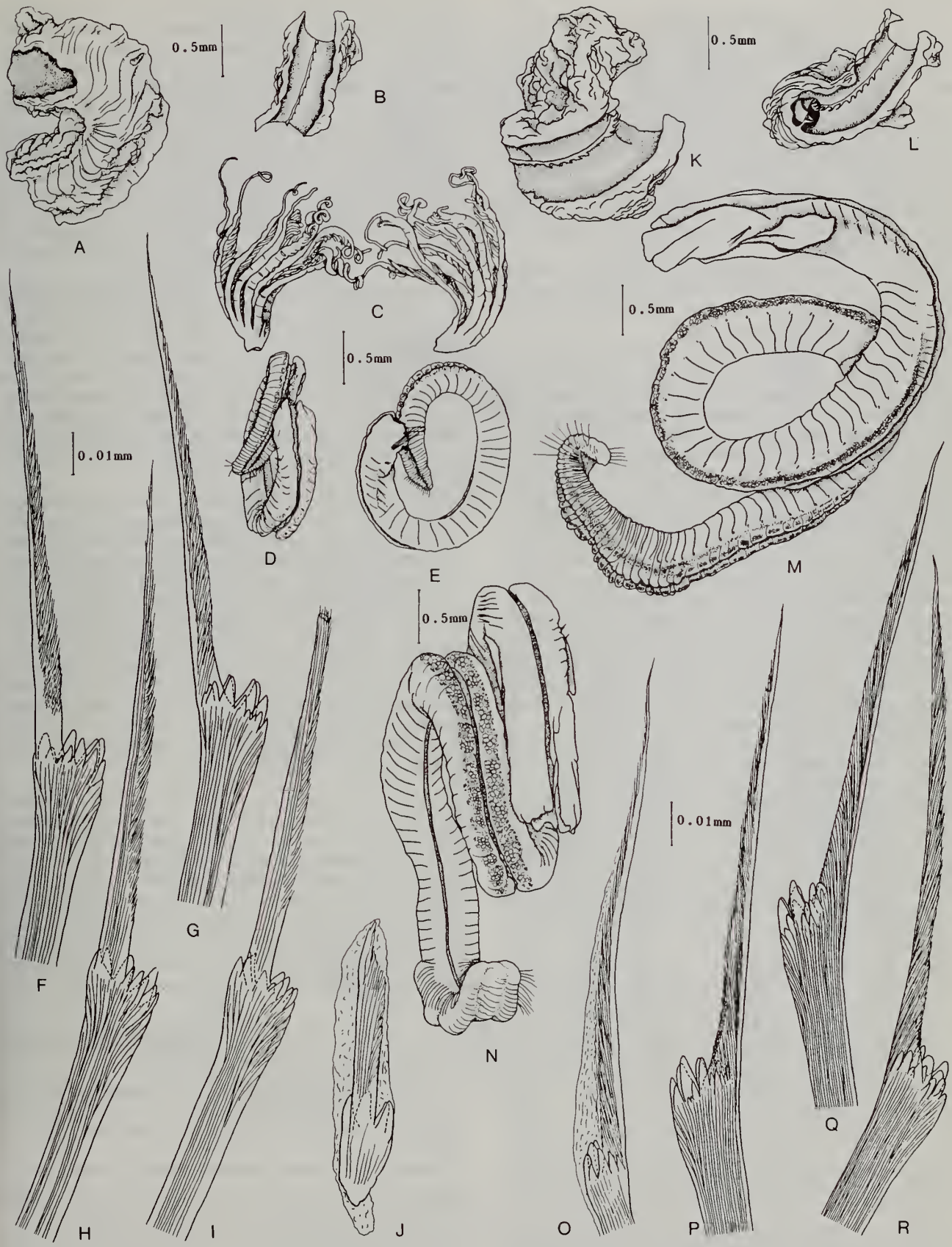
Spiraserpula paraypsilon sp. nov.
(Figs.8, A–N; 9, A–R; 3, G)

MATERIAL EXAMINED.
Bonaire (Neth. Ant.): 1. Klein Bonaire, N, half mile E of Westpunt, reef, little sand, corals, 38 m, legit H.A. ten Hove, 1.vii.1970, Stn. 2105A, HOLOTYPE & PARATYPE 2, ZMA V. Pol.3714; PARATYPE 1, BM(NH) 1992.156. 2. Lac, dam, pool in wash of plunging breakers, *Diploria, Millepora, Porites*, cobble in coarse sand, 50 cm, from corals, legit H. A. ten Hove, 15.vii.1970, Stn. 2122C, (PARATYPES 6–8, ZMA V.Pol.3717). 3. Plaja Frans, on dead coral covered with calcareous algae, little sand, 1.0–1.5 m, legit H. A. ten Hove, 16.vii.1970, Stn. 2110A (portions of tube, 1 incomplete worm, BM(NH) 1992.157). 4. Karpata, steep reef, drop off and flat above, 15–4 m, from living corals, legit H.A. ten Hove, 19.v.1987, Stn. 87–5 (PARATYPES 4–5, USNM 130992).
Curaçao (Neth. Ant.): 5. Cornelisbaai, sandy reef, from the underside of dead plate-shaped coral, 15 m, legit H. A. ten Hove, 15.xi.1988 (PARATYPE 3 USNM 130991) and 17.i. 1990 (4 specimens, AM W20338). 6. Piscaderabaai, outer bay in front of Carmabi, rubbish on reef, 10 m, legit H. A. ten Hove, 10–12.i.1990 (19 specimens, ZMA V.Pol.3718, BM(NH) 1992.158–165, FSBC I 39196. 7. Salinja Fuik, reef in front, 20–25 m, legit H. A. ten Hove, 18.i.1990 (25 specimens, NSMT).

TYPE LOCALITY. Klein Bonaire, Curaçao.

DESCRIPTION.
TUBES: White, flattened, and with a granular overlay. The maximum external diameter of the tube of the holotype is 2.0 mm. A median and about 3 pairs of lateral longitudinal ridges can be observed (Fig.8, A). In an empty tube from the type locality with a diameter of 1.5 mm,the number of ridges is less distinct (Fig.8, B). ITS, located within the first formed coiled parts, are translucent white, and very similar to those *S. ypsilon*. They consist of a serrated dorsal ridge along the convex wall (Fig.8, C) and a Y-shaped ventral ridge along the opposite side (Figs.8, D; 3, G). The serrations of the dorsal ridge are pointed and directed somewhat posteriorly. Tubes found on asbestos plates (Piscaderabaai) were clearly branching, as described in detail for *S. caribensis* (Fig.16, A & B).
WORMS: The total length of the holotype is 16.4 mm. With a thoracic width of 0.8mm, it is stouter than *S. ypsilon*. The

Fig. 9 *Spiraserpula paraypsilon* sp. nov. A–N, From Klein Bonaire Stn. 2105A; O–R, from Bonaire, Karpata Stn.87.5. A–J, From juvenile paratype. A, Tube showing start of external longitudinal ridge and shallow transverse growth markings. B, Posterior tube fragment with serrated dorsal ridge. C, Radioles with long pinnule-free tips, a rudimentary operculum on the left and none on the right. D & E, Two views of body showing pigment patches in both, dorsal an ventral longitudinal abdominal grooves (D), and extent of thoracic membrane (E). F–J, Bayonet chaetae, including one newly formed within the fascicle (J). K–N, From holotype. K & L, Tube fragments (K) and the other from a more posterior coil, with serrated dorsal ridge. M & N, Two views of body showing pigment patches, dorsal and ventral longitudinal abdominal grooves (M), and extent of thoracic membrane (N). O–R, Bayonet chaetae of one specimen.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abdomen is 9.9mm long, with about 98 segments, and capillaries in the last 20.

The pinnule-free tips (Fig.8, E) are quite conspicuous and much longer than those of *S. ypsilon*, being up to about 1.9 mm. They constitute nearly half to more than half the length of the radioles (about 3.7 mm). The number of radioles, 11 on each side, is higher than that of *S. ypsilon* (maximum 8). They bear at intervals what appear to be narrow, transverse, lenticular lacunae. Two pigmented prostomial ocellar clusters are present.

The rest of the body (Fig.8, F) is similar to that of *S.ypsilon* in many respects. In alcohol, the abdomen has an overall pinkish colour, with clusters of reddish-brown pigmented cells ventro-laterally.

Thoracic chaetigers number 7 on both sides. Thoracic membranes end on the third thoracic chaetiger (second uncinigerous segment) on both sides of the thorax. Paired ventral thoracic glands were not seen.

A collar fascicle of the holotype has five fully formed bayonet chaetae, and a developing one deep within. A paratype from Karpata has 6 fully formed bayonets and one newly forming one within the fascicle. Each bayonet chaeta consists of a long, narrow serrated blade, and a considerably expanded basal boss bearing several moderately large, somewhat pointed teeth (Fig.8, G–L). The serrations are short and fine proximally, but longer and pilose distally. The unserrated notch may be very short, up to about twice the length of the longest teeth, or almost lacking (Fig.8, I). The thoracic and anterior abdominal uncini bear 5 teeth in a single row. They differ from all the other known species of the subgenus in possessing minute denticles on their sides (Fig.8, M,N).

The adaptations of the worm in relation to ITS are similar to those of *S. ypsilon*. The dorsal longitudinal abdominal groove is applied to the serrated dorsal ridge of the tube, and the Y-shaped ventral ridge is enclosed within a ventral abdominal groove. Within the latter, a cord-shaped abdominal ridge fits into the gutter-shaped part of the Y.

The paratype from the type locality is a juvenile. Its tube (Fig.9, A) shows faint transverse grooves mainly, but the beginnings of a granular overlay and longitudinal ridges can also be seen. ITS and adaptations of the body are identical to those of the holotype (Fig.9, B,K,L). Measurements and counts of the worm are as follows: Length 6.2 mm, thoracic width 0.5 mm, radiolar length 2.1 mm, pinnules 1.1 mm, abdomen 4.2 mm, 53 segments, with capillaries on the last 10. The number of thoracic chaetigers, ending of the thoracic membranes (Fig.9,E), and colour, are the same as in the holotype.

The 7 pairs of radioles already approach the maximum number in other material, except the holotype, and their long pinnule-free tips are similar to those of the holotype (Fig.9, C). However, there is a very short and slender rudimentary operculum on one side, while it is lacking on the other (Fig.9, C), indicating that both may become completely lost in older specimens (holotype). A similar condition is found in one of the specimens from Karpata (below).

Collar fascicle with four fully formed bayonet chaetae (Fig.9, F–I) and a developing one deep within (Fig.9, J). Their basal bosses are not as expanded as in the holotype and the blades are shorter. The uncini are similar to those of the holotype.

The tubes of the three specimens from Karpata agree with those from the type locality in being white externally, pinkish internally,and bearing the Y-shaped ventral ridge and serrated dorsal ridge. The serrations of the latter bear posteriorly directed tapered tips (Fig.9, K,L). The radioles of all specimens are detached, highly contracted, and do not clearly show the extent of the pinnule-free tips. One crown has a short rudimentary operculum on each side, the second has a rudimentary operculum on one side but lacks it on the other, and the third half crown has a rudimentary operculum which is very reduced and filamentous. The thoracic width ranges between 0.5 mm and 0.7 mm.The abdomen of the longest specimen is 10.8 mm long and has about 59 segments, with capillaries on the last six; that of the shortest is 7.3 mm, but has about 86 segments, with capillaries on the last six. The numbers of radioles, thoracic chaetal tufts and the extent of the thoracic membranes in the three specimens is provided in Table 11.

In two specimens the broad thoracic membranes are folded outwards against the sides of the thorax (Fig.9, M,N). Bayonet collar chaetae (Fig.9, O–R) are similar to those of the holotype, but lack an unserrated notch. Thoracic and anterior abdominal uncini are also similar to those of the holotype, with 4 or 5 teeth in a single row. Flat trumpet chaetae number 6–8 in a bundle. Preserved in alcohol, the abdominal segments show clumps of reddish-brown pigmented cells ventrolaterally, and of larger yellowish or orangish cells ventrally (Fig.9, N).

The tube of the single juvenile paratype from Curaçao resembles that of the holotype; its diameter is 1.5 mm. The worm has 6 radioles on the left and 5 on the right. As in the specimens from Bonaire, the pinnule-free tips are very long. However, both rudimentary opercula have already been lost at this stage. The thorax is 0.5 mm wide and has 7 pairs of chaetigers. The thoracic membranes end on the third thoracic chaetiger. Two clusters of prostomial ocelli are present. Thoracic glands were not seen. The chaetae also agree with those of the specimens from Bonaire. In recently collected material (Curaçao, Piscaderabaai, 10.i.1990), thoracic membranes end at 4/5, 4/4 respectively; the pinnule-free tips generally are very long, rarely short; rudimentary opercula are present in four specimens, absent in three.

LIVE MATERIAL. According to the field notes, rudimentary opercula could not always be found, even in living specimens from Curaçao with radioles extended. The colouration of the radioles is somewhat variable, often (transparently) whitish to creamish, rarely yellowish to slightly orange or even completely hyaline. At the base of the radioles there is a series of up to six pairs of reddish spots, absent however in the dorsal- and ventralmost radioles. Body predominantly orange-brownish with up to 15 greenish-brown granules per segment ventro-laterally in the abdomen and dorsally in the thorax.

ETYMOLOGY. The specific name *paraypsilon* indicates the close resemblance of the species to *S. ypsilon*.

HABITAT AND DISTRIBUTION. Occurs in shallow, clear, oce-

Table 11 *S. paraypsilon* sp. nov. Meristic and other data from specimens.

Specimen nos.	1	2	3
No. of radioles	8/?	8/8	8/7
No. of thoracic chaetal tufts	?/?	8/9	7/7
Thoracic membrane ends	?/?	3/3	3/3

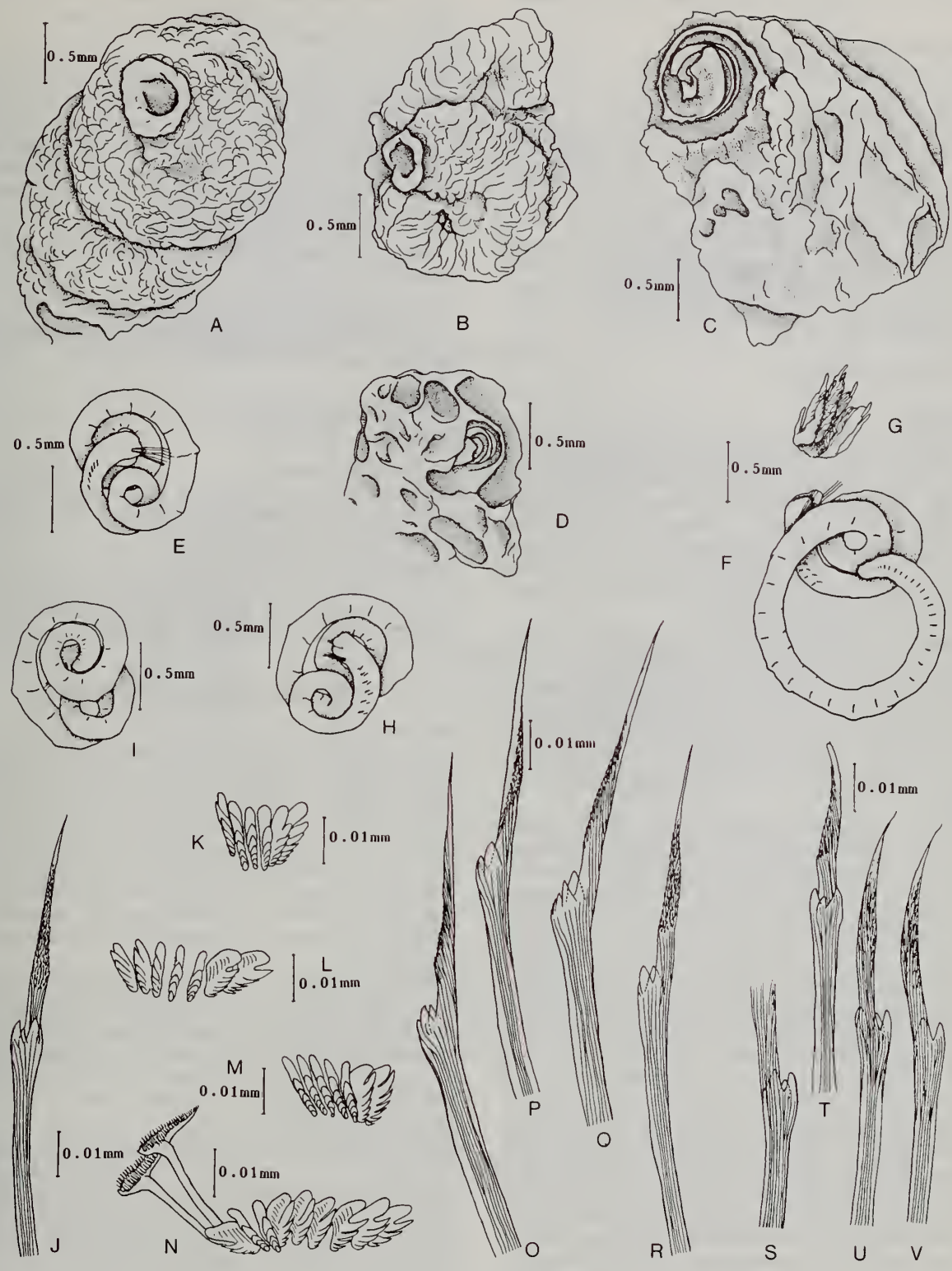

Fig. 10 *Spiraserpula singularis* sp. nov. From type series. A & B, Two tubes, the second one younger. C, Substratal view of first formed coil showing V-shaped dorsal ridge; a ventral ridge is absent. D, Same, smaller specimen. E, Paratype. F & G, Holotype and radioles. H–L, From whole mount of another paratype: H & I, Two views of worm; J, only available bayonet chaeta; K, L, thoracic uncini; M, anterior abdominal uncini. M–R, From whole mount of another specimen: N, anterior abdominal uncini and flat trumpet chaetae; O–R, Bayonet collar chaetae, two present per side. S–V, Bayonet chaetae from whole mount of third specimen.

anic waters, at depths of up to 40 m on coral reefs. Hitherto collected only from Bonaire, and Curaçao, in the Caribbean.

Spiraserpula singularis sp. nov.
(Figs.10, A–V; 3, B; Pl.2, E & F)

MATERIAL EXAMINED.
Puerto Rico : 1. Isla Matei, near buoy of Marine Institute, vertical reef with surge channels, no sand, from living corals, 29–33 m, legit H. A. ten Hove, 2.x.1970, Stn. 2136A, (HOLOTYPE & 3 PARATYPES, ZMAV.Pol.3710).
Curaçao, (Neth. Ant.): 2. Salinja Fuik, reef in front, marine park, 20–25 m, legit H. A. ten Hove, 18.i.1990 (2 specimens BM(NH) 1992.166–167). 3. Piscaderabaai, outer bay, W of entrance, sandy reef, 20 m, from underside of coral debris, not in sediment, legit H. A. ten Hove, 12.i.1990 (3 specimens, BM(NH) 1992.168–170).

TYPE LOCALITY. Puerto Rico.

DESCRIPTION.
TUBES: White, very tiny, one of the smallest species in the genus. They may occur in mutually bonded aggregations of a few individuals, or singly. Their coil diameters range from 1.2–1.3 mm. A granular overlay is present (Fig.10, A,B), which makes the external diameters of the tubes (0.5–0.6 mm) considerably larger than their internal diameters (0.2–0.25 mm). Their apertures bear small, somewhat lobed, peristome-shaped extensions (Fig.10, A,B), similar to those found in *S. massiliensis*.

ITS consist of a V-shaped dorsal ridge, actually an inverted V, along the convex side of the first formed coil (Figs.10, C,D; 3, B). The two arms of the V are broader and outwardly curved posteriorly, and their edges are smooth. Anteriorly the dorsal ridge is a smooth plate only. A ventral ridge is absent. When the worm is withdrawn into the tube, the posterior, mid-dorsal part of the abdomen is applied to the dorsal ridge.
WORMS: Four specimens were taken out of their tubes (Fig.10, E–I). The holotype (Fig.10, F), which is the largest, is only 5.7 mm long, 0.2 mm wide in the thorax, and its abdomen is 4.6 mm long. There are four pairs of radioles which, including the short and slender pinnule-free tips (Fig.10, G), are about 0.55 mm long. There is a rudimentary operculum on each side. Radioles are missing in the other three specimens. However, a detached operculum was found in the vial containing the specimens, and it is not certain whether it belongs to one of them or another species.

Two clusters of prostomial ocelli are present. Five or six globular ventral thoracic glands are present, more or less arranged in a V. The numbers of thoracic chaetigers on the two sides in the four specimens are: 9/9, 9/8, 8/8, and 7/7. It was not possible to establish the extent of the thoracic membranes due to the extremely small size of the worms. An apron is, however, absent. One paratype with an abdominal length of 1.95 mm has 29 segments, with capillaries on the last 5, and another 3.0 mm long with 39 segments, but the capillaries cannot be seen, having probably been damaged.

There are two bayonet chaetae in each collar fascicle. They have moderately long serrated blades and 2–4 teeth on the basal boss and some accessory ones (Fig.10, J, O–V; Pl.2, E). The unserrated notch is 1/5 the length of the blade. Thoracic uncini (Fig.10, K,L) and anterior abdominal uncini (Fig.10, M,N) have 6 and 4–6 teeth, respectively, all in a single row. The middle abdominal uncini are rasp-shaped (Pl.2, F), with up to 3 transverse rows of teeth above the single anterior tooth. The abdominal segments bear 1 or 2 flat trumpet chaetae in each bundle; one side is thickened into a claw-shaped process (Fig.10, N).

REMARKS. In the comparison with other Caribbean species, *S. singularis* would key out mainly on the absence of a ventral longitudinal ridge/row of teeth and probably also the absence of an operculum. So far, the presence of an operculum has been observed only in a doubtful field identification. The form of thoracic glands, shape of dorsal ridge and collar chaetae are similar to those in *S. plaiae*.

ETYMOLOGY. *singularis* (Latin)= unique; referring to the unique ITS.

HABITAT AND DISTRIBUTION. *S. singularis* sp. nov. appears to be a shallow water coral reef dweller. It has hitherto been collected only from Puerto Rico and Curaçao.

Spiraserpula karpatensis sp. nov.
(Figs.11, A–K; 3, N)

MATERIAL EXAMINED.
Bonaire (Neth. Ant.): 1. Karpata, reef, 10 m, cryptic, legit H. A. ten Hove, 9.xi.1988 (HOLOTYPE, ZMA V.Pol.3712; PARATYPE, BM(NH) 1992.171).
Curaçao (Neth. Ant.): 2. Reef in front of Salinja Fuik, buoy 13 of Marine Part, 20–30 m, corals and sandy/silty areas in equal amounts. From under side of coral debris, not in sediment, legit H. A. ten Hove, 18.i.1990 (1 specimen, ZMA V. Pol. 3875).

TYPE LOCALITY. Bonaire (Netherlands Antilles).

DESCRIPTION.
TUBES: Pink, quite small, and lack longitudinal ridges. A pink translucent granular overlay is present (Fig.11, A). The tubes of both the types are coiled upon themselves, one much more than the others (Fig.11, D). One has an erect part 2.0 mm long, and a funnel-shaped, outwardly curved peristome (Fig.11, A), while the other has a somewhat thickened anterior end (Fig.11, D,E). The pink colouration gradually fades to white towards the anterior end. The diameter of the tubes is 0.6–0.7 mm in the attached parts, 0.4–0.6 mm in the erect parts.

ITS consist of a serrated ventral ridge and an unserrated dorsal ridge, with a sharp edge in cross-section (Fig.3, N). The dorsal ridge may be absent (Fig.11, B,C), or greatly reduced (Fig.11, D). In the latter it can be seen as a short crescentic ridge through the broken end of one of the coils. The serrated ventral ridge is regularly present (Fig.11, B, C, and bottom left of D).
WORMS: The holotype is incomplete posteriorly (Fig.11, F), broken in three parts, with a total length of 4.3 mm. An operculum and 4 radioles are present on the left side; the radioles on the right are missing. The length of the radioles is approximately 0.8 mm, with a pinnule-free tip of 0.1 mm. The operculum (Fig.11, G,H), is 0.26 mm long, and 0.28 mm in diameter; inclusive of peduncle it is about 1 mm long. Although bell-shaped, it is slightly zygomorphic, and has numerous fine lobes, similar to that of *S. plaiae* described in this paper. Branchial eyes have not been observed in the fresh material. Two clusters of prostomial ocelli are present. The thorax has 8 chaetigers on each side. The thoracic membranes extend to the third chaetiger on the left (Fig.11,

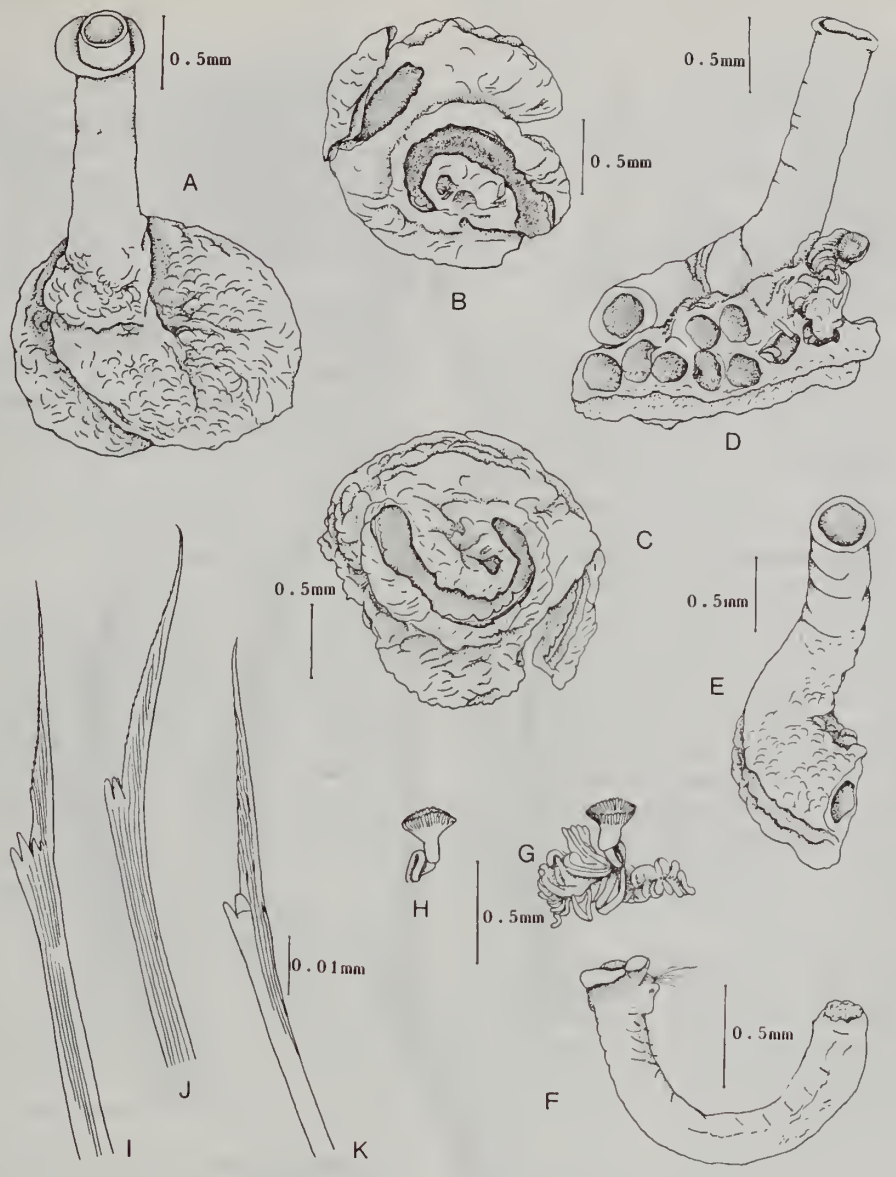

Fig. 11 *Serpula karpatensis* sp. nov. A, Tube with granular overlay, erect part and funnel-shaped peristome. B & C, Substratal view of two tubes, opened to show internal serrated ventral ridge along convex wall, but absence of dorsal ridge. D, Aggregation of tubes, some sections showing a very short crescentic dorsal ridge. E, Erect part from same aggregation showing somewhat thickened distal end; granular overlay. F, Anterior end of holotype showing collar and thoracic membrane. G & H, Two views of zygomorph operculum. I–K, Bayonet chaetae.

F) and the fourth on the right. It is not certain whether ventral thoracic glands are present, but see note on live material below.

Each collar fascicle bears 3 bayonet chaetae (Fig.11, I–K), with moderately long, finely serrated blades, a moderately long unserrated notch, and 3 teeth on the basal boss; the third tooth may sometimes be difficult to observe and may be reduced to a scar. Thoracic uncini have 6 (exceptionally 7) teeth, anterior abdominal uncini 5, arranged in a single row. The middle abdominal uncini are rasp-shaped, with 3–5 teeth above the single anterior tooth. At least 35 abdominal chaetigers are present, the last 7 with capillary chaetae. Abdominal flat trumpet chaetae number 2–3 per bundle.

The specimen from Curaçao agrees in most details with the type material. Its numbers of radioles are 5/5, a long filamentous rudimentary operculum is present opposite the operculum, and it has 38 abdominal chaetigers.

LIVE MATERIAL. As observed in material collected in 1990, radioles are transparently lemon. Thorax ventrally with 5 bright red globules arranged in a V, presumably thoracic glands.

ETYMOLOGY. named after the type locality, the coral reef in front of the Sentro Ekologiko, Karpata.

HABITAT AND DISTRIBUTION. A shallow water cryptic reef dweller. Has hitherto been recorded only from its type locality in Bonaire, and Curaçao.

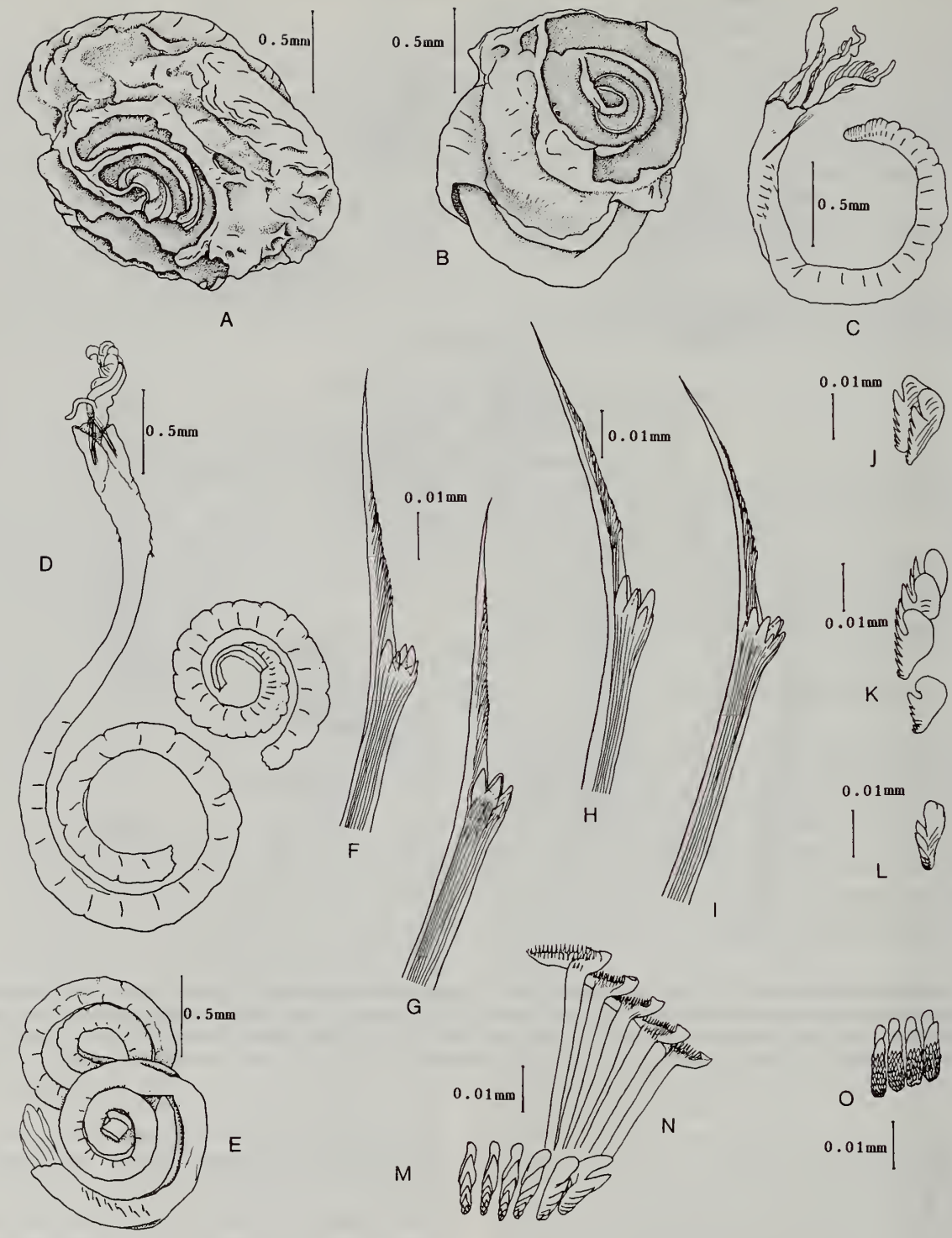

Fig. 12 *Spiraserpula zibrowii* sp. nov. From type specimens. A & B, Substratal view of two tubes opened to show the unserrated dorsal ridge. The serrated ventral ridge consists here of a row of isolated teeth, but is a continuous ridge in the remaining material. C, Juvenile paratype. D, Older specimen (holotype) broken in two. Anterior part with right rudimentary operculum; posterior abdomen with part of dorsal ridge attached to mid-dorsal groove. E, Paratype. F & G, Two bayonet chaetae from holotype; H & I, two bayonet chaetae from paratype. J–O from paratype. J, Thoracic uncini of small specimen with single row of teeth anteriorly and a cluster of more than one row posteriorly. K, Similar uncini from first abdominal torus. L, Uncini from second abdominal torus; there are less teeth in a single row. M & N, Anterior abdominal uncini, and flat trumpet chaetae with large lateral tooth. O, Posterior abdominal uncini; except for a single anterior tooth, the uncini are rasp-shaped, with teeth in several rows.

Spiraserpula zibrowii sp. nov.
(Figs.12, A–N; 3, O; Pl.4, A–D)

MATERIAL EXAMINED.
Curaçao (Neth. Ant.): 1. Lagoon of San Juan, E, raised reef, lagoon side, *Halimeda* present, limestone cobbles, 10–15 cm; from up to 20 cm deep crevices between cobbles, legit H. A. ten Hove, 29.vi.1970, Stn. 2043 [HOLOTYPE & PARATYPES 3–5: ZMA V.Pol.3707; PARATYPES 1 (slide), 2 (worm & tube fragments), and 7 (empty tube: BM(NH) 1992.148–150); PARATYPE 6: USNM 130980 (unopened tube)].
Bonaire (Neth. Ant.): 2. Kralendijk, Flamingo Beach Hotel, from corals, partly in sand, 45 m, legit H. A. ten Hove, 27.vii.1970, Stn. 2115D, (4 empty tubes, BM(NH) 1992.151–155). 3. 250 m N of Witte Pan, sandflat below reef, 47 m, mainly from the side of boulders, partly buried in sand, legit H. A. ten Hove, 3.vii.1970, Stn. 2117B (4 empty tubes, ZMAV. Pol. 3708).

TYPE LOCALITY. Curaçao (Netherlands Antilles).

DESCRIPTION.
TUBES: Whitish, very tiny, and coiled upon themselves like spirorbids, either individually (Fig.12, B), or in mutually bonded aggregations of a few individuals. The direction of coiling may reverse (see below). A fine granular overlay is present. Longitudinal ridges are absent, but fine, smooth, transverse growth markings are present. Juvenile tubes are white. Although older tubes are white posteriorly, they have a greyish-brown overlay anteriorly. The diameter of an individual coil is 0.73 mm, with a tube diameter of 0.18 mm. The maximum tube diameter is only 0.44 mm, which is the smallest among the known species of the genus.

ITS consist of a serrated ventral ridge and an unserrated dorsal ridge (Fig.12, A,B). The ventral ridge may consist either of a continuous row of serrations, or only of a short row of small separate teeth (Figs.12, A,B; 3, O). The dorsal ridge is colourless and transparent, wedge- to Y-shaped in cross-section, with its edges curved in places; it is spiral on a columella-shaped axis when the tube is coiled upon itself. Lateral ridges have not been found. The interior of the tube may have a creamish lining.

One tube is coiled in one direction proximally, and in the opposite direction distally. In the proximal coil the ITS are similar to those described above. However, the distal coil has only a columella-shaped axis with a dorsal ridge, which became detached from the tube and is shown *in situ* (Fig.12, E); a serrated ventral ridge is absent here.

The mid-dorsal and mid-ventral longitudinal grooves of the abdomen are applied to the unserrated dorsal ridge (Fig.12, D) and serrated ventral ridge of the tube, respectively.
WORMS: Measurements and meristic data are presented in Table 12.

The right branchial half of the holotype (left missing) shows a rudimentary operculum. The latter is present on both sides in the first paratype, but not in the second which is a juvenile. The numbers of radioles on both sides are ?/3, 4/4 and 3/4, respectively. The pinnule-free tips are about 1/5–1/7 of their total length.

Two clusters of prostomial ocelli are present. The numbers of thoracic chaetal tufts on both sides in the three specimens are: 7/7, 8/7 and 8/7, respectively. The thoracic membranes end on chaetigers 3/3 in the holotype and 4/4 in the juvenile paratype; they are damaged in the second paratype. Two translucent ventral thoracic glands are present, although not as easily discerned as in some of the other species.

Table 12 *S. zibrowii* sp. nov. Measurements and meristic data from Holotype and two paratypes.

	Total length (mm)	Thoracic width (mm)	Abdomen		
			Length (mm)	Number of segments	capillaries on
Holotype	9.7	0.23	8.5	54	4
Paratype 1	7.0	0.18	5.8	43	7
Paratype 2	3.4	0.18	2.1	27	9

There are 2 or 3 fully developed bayonet chaetae per side in the juvenile, 4 in the older specimens. They have moderately long serrated blades, an unserrated notch which is about 1/4–1/5 the length of the blade, and 4 or 5 somewhat large teeth and some accessory ones on the basal boss (Fig.12, F,I; Pl.4, A). The thoracic uncini have a single row of 6–7 teeth (Pl.4, B). Anterior abdominal uncini bear a cluster of small teeth in two to seven rows at their posterior ends, and a single row of larger teeth anteriorly; this type of uncini may occur in juvenile specimens also (Fig.12, J–M). The posterior abdominal uncini are, however, similar to those of the other species in being rasp-shaped, with 6 transverse rows of 2–5 teeth each, except for the single anterior tooth (Fig.12, O; Pl.4, C). The abdominal flat trumpet chaetae number about 5 per bundle. Their somewhat triangular, curved distal ends are thickened and hooked at one end, and drawn out into an acute angle at the other (Fig.12, N; Pl.4, D). Up to 54 abdominal segments are present, the last 4–9 with capillary chaetae.

REMARKS. The collections from Bonaire, a mere 50 km from Curaçao, consist of a total of 8 empty tubes whose ITS are identical with those of the present species. The largest tube from Witte Pan has a coil diameter of 2.2 mm; two tubes have erect portions with peristomes. Three tubes are white. The fourth is creamish in colour, with a creamish interior lining. Fine transverse growth markings are present on all. The serrations of the ventral ridge are arranged on a low longitudinal ridge in some of them.

In the absence of worms, and the markedly different habitat from which they were collected (at a depth of 45–47 m), these tubes cannot be conclusively identified as *S. zibrowii*.

ETYMOLOGY. named after H. Zibrowius, who recognized some of these small species as being new.

HABITAT AND DISTRIBUTION. Appears to be a shallow water species inhabiting crevices between boulders and their undersides in sandy areas close to coral reefs. Hitherto collected from Curaçao. Two uncertain records from Bonaire.

Spiraserpula plaiae sp. nov.
(Figs. 13, A–T; 3, K)

MATERIAL EXAMINED.
Curaçao (Neth. Ant.): 1. Salinja Fuik, near Ceru Preekstul, open reef, coral debris, 33 m, from limestone boulder on sand, legit H. A. ten Hove, 18.ix.1970, Stn. 2088A (HOLOTYPE & PARATYPES 1 & 5: ZMA V. Pol.3713;

PARATYPES 2, 4, & 6: BM(NH) 1992.173–174; PARATYPE 3: USNM 130990). 2. Reef in front of Salinja Fuik, buoy 13 of marine park, coral debris, 18–27 m, legit H. A. ten Hove, 18.i.1990 (4 specimens, ZMA V. Pol.3874). 3. Cornelisbaai, E, steep reef, coral debris, 18–26 m, legit H. A.ten Hove, 17.i.1990 (6 specimens, ZMA V. Pol.3873). 4. Piscaderabaai, outer bay W of entrance, sandy reef, coral debris, legit H. A. ten Hove, 12.i.1990 (5 specimens, ZMA V. Pol.3872).

TYPE LOCALITY. Curaçao (Netherlands Antilles).

DESCRIPTION.

TUBES: White to greyish-brown, occurring either individually coiled upon themselves (Fig.13, A), or in mutually bonded aggregations of a few individuals (Fig.13, B). They are sub-circular in cross-section, with faint lateral ridges, and bear fine smooth transverse ridges, and often have erect anterior ends (Fig.13, A,B). A fine opaque granular overlay is present (Fig.13, B), which can be seen under special illumination only. Their external diameter attains 1.0 mm, their erect portions somewhat smaller. The inside of one tube has a light caramel coloured lining.

ITS consist of a serrated ventral ridge along the concave side of the tube (Fig.13, C–E, H), which may not be well developed and represented only by a few isolated or coalesced teeth slanting backwards (Fig.13, F), and a smooth dorsal ridge on the convex side (Figs.13, F,G; 3,K). The latter is wedge-, T to Y-shaped in cross-section. In specimens coiled upon themselves, the dorsal ridge occurs spirally on a columella-shaped axis (Fig.13, I). A short accessory latero-dorsal ridge, which tapers anteriorly and posteriorly, may also be present on either side (Fig.13, F). Their edges are unthickened.

In life, the mid-ventral and mid-dorsal longitudinal grooves of the abdomen are applied to the serrated ventral and smooth dorsal ridges, respectively, of the tube (Fig.13, G).

WORMS: Six specimens were taken out of their tubes. The abdomen is complete in only one. Even though preserved in alcohol, the abdominal segments still show clusters of pigmented specks laterally, light yellowish in one specimen, light to bright orange in two, light to dark brown in two, and uniformly caramel coloured in another.

Five specimens have an operculum on one side and a rudimentary operculum on the other; the branchial crown is partly missing in the sixth. The length of the operculum and peduncle varies from 1.0 mm in a juvenile paratype to 1.8 mm in the holotype. The operculum itself is 0.4–0.5 mm long, 0.3–0.5 mm wide. It is zygomorph, attached to the peduncle eccentrically, and bears numerous (up to 50) radii (Fig.13, K–M). The distal diameter of the peduncle is 1/3 to 2/3 that of the opercular base. The numbers of radioles on both sides are 6/5, 5/4, 4/5, 4/4 and 4/3. They end in short slender pinnule-free tips, which are about 1/5 to 1/7 the length of the radioles (Fig.13, K). The only complete specimen (Fig.13, J), is 4.9 mm long, with 42 abdominal segments, the last 10 with capillaries. However, in another specimen, which is incomplete (Fig.13, M), 76 abdominal segments could be counted.

Two clusters of prostomial ocelli are present. The numbers of thoracic chaetal tufts are 11/7, 9/9, 9/8, 8/8, 6.6. Thoracic membranes extend to chaetigers 6/5, 4/4, 4/3, 4/?, and they are damaged on both sides in the fifth. Two groups of transparent to translucent ventral thoracic glands, arranged in a V, and of unknown function, are present. Further studies are needed to find out if they could be responsible for secreting the caramel coloured inner lining of the tube.

Collar fascicles bear 2 or 3 fully formed bayonet chaetae each, and a newly formed one deep within the bundle. Each bayonet chaeta consists of a moderately long blade, a moderately long unserrated notch which is 1/3 to 1/4 the length of the blade, and 2–4, seldom 5, teeth on the basal boss (Fig.13, N–T). The teeth are comparatively larger as their number decreases (Fig.13, Q–T), and they may be accompanied by one or two accessory teeth (Fig.13, O,P,S). Thoracic uncini possess 5–7 teeth in a single row (Fig.13, U). Abdominal uncini are similar, with 5–6 teeth; anteriorly saw- and rasp-shaped uncini may occur in a single row, posteriorly all uncini are rasp-shaped.

LIVE MATERIAL. As observed in material collected in 1990, radioles are faintly yellow to lemon, operculum is transparent, almost colourless. Thorax ventrally with 2–4 bright red to orange globules arranged in a V, presumably thoracic glands; body transparent with yellow tinge, brownish gut.

ETYMOLOGY. Named after Gayle Plaia who, when working at the Florida Marine Research Institute, first observed ITS in one of the species, *S. ypsilon*, from the Gulf of Mexico.

HABITAT AND DISTRIBUTION. *S. plaiae* is a shallow water species occurring in coral reefs, and has hitherto been collected only from the type locality.

Spiraserpula caribensis sp. nov.

(Figs. 14, A–M; 15, A–Y; 16, A–K; 3, L; Pl.4, E & F; Pl.5,A–E)

MATERIAL EXAMINED.

Curaçao (Neth. Ant.): 1. Awa Blancu, coral debris barrier, 20–30 cm, legit H.A. ten Hove, 15.ix.1975, Stn. 75–38 (HOLOTYPE & 3 PARATYPES: ZMA V.Pol.3715; 2 PARATYPES USNM 130987; 4 PARATYPES each: AM W20157, NSMT, ZMK). 2. Awa Blancu, 3–4m, legit H. A. ten Hove, 14.x.1975, Stn.75–37 (1 specimen, HUJ). 3. Awa Blancu, coral debris, near Lagoen Blancu, 30–50 cm, legit H. A. ten Hove, 30.vii.1970, Stn. 2090 (several subsamples BM(NH) 1992.25–31, FSBC I 39195, ZMA V. Pol. 3716, ZMB). 4. Lagoen Blancu, coral debris barrier, *Halimeda*, 20–30 cm, legit H. A. ten Hove, 15.ix.1975, Stn.75–36 (2 out of several specimens, RMNH 18174). 5. Awa di Oostpunt, coral debris barrier, 30–50 cm, legit H. A. ten Hove, 3.x.1975, Stn.75–77 (1 out of few specimens, BM(NH) 1992.10–11. 6. St. Jorisbaai, Peninsula Groot St.

Fig. 13 *Spiraserpula plaiae* sp. nov. A, Aggregation of tubes, showing fine transverse growth markings, granular overlay in places. B, Juvenile tube. C–E, Fragments of tubes showing serrated ventral ridge (C & D, paratype 3), (E, paratype 2). F, Holotype showing variant form of ventral ridge with isolated teeth, and ventro-lateral ridge. G–I, Paratype 4: G, posterior end of tube and worm. H, Portion of tube showing ventral ridge. I, Dorsal ridge on columella-shaped axis. J–L, Two views of paratype 4, and its operculum: J, (Operculum not seen), ventral longitudinal abdominal groove, and dorsal groove within 2nd coil; K, showing operculum; L, Another view of operculum. M, Paratype 2. N & O, Bayonet chaetae from holotype. P–T, Bayonet chaetae from paratype. U, Thoracic uncini from holotype.


A
0.5mm
B
0.5mm
C
0.5mm
D
0.5mm
E
F
0.5mm
H
0.5mm
I
J
0.5mm
G
L
0.5mm
K
M
0.5mm
N
O
0.01mm
U
0.01mm
P
Q
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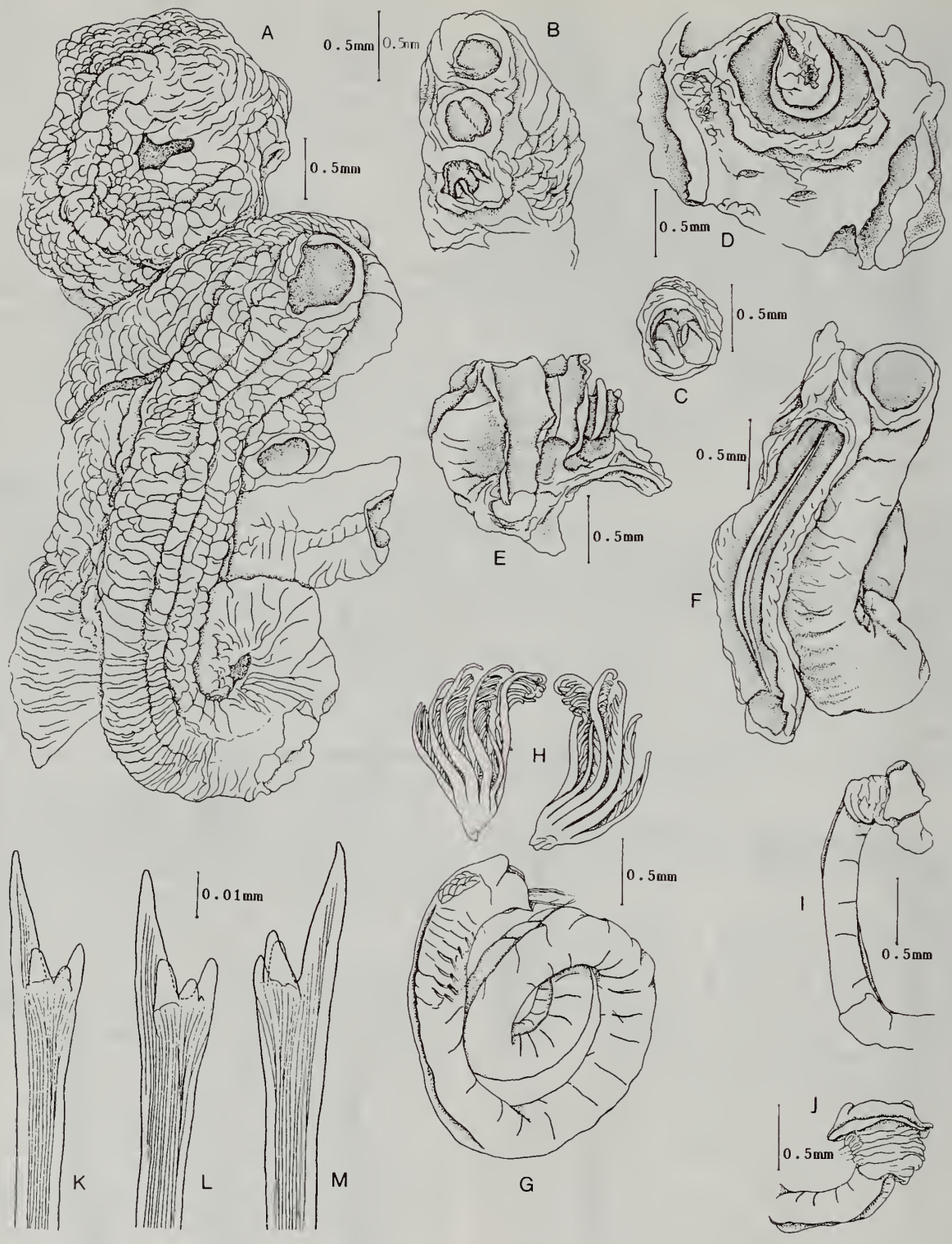


Fig. 14 *Spiraserpula caribensis* sp. nov. A–J, From Florida, Stock Island, Stn. 7B. A, Tube with granular overlay and longitudinal ridges. B–F, ITS seen in various tube fragments: B, bottom cross-section showing median dorsal ridge on convex wall, narrow lateral ridge on either side, and serrated ventral ridge (barely visible); middle cross-section with serrated ventral ridge along concave wall; C, ventral ridge in sectional view (barely visible), and dorsal and lateral ridges; D, substratal view of first formed coil of tube opened to show smooth dorsal and serrated ventral ridge; E, smooth dorsal ridge in the first formed coil, on the right; F, uncoiled part of tube showing smooth dorsal ridge tapering at both ends. G, Anterior end of specimen, with thoracic glands, and showing dorsal and ventral abdominal grooves. H, Radioles of same specimen with left and right filamentous rudimentary opercula. I & J, anterior end of a worm with two views of collar. K–M, Bayonet chaetae.

Joris, muddy pebbles, *Thalassia* flat, few corals, from limestone boulders, 30 cm, legit H. A. ten Hove, 10.ix.1970, Stn.2096 (2 out of several specimens, BM(NH) 1992.20–24, RMNH 18175). 7. St. Jorisbaai, Koraal Tabak, Punta Blanco, undersides of boulders, on rocky debris, 20–30 cm, legit H. A. ten Hove, 15.xi.1988, 9.i.1990, near Stn.75–30 (5 out of several specimens, MCZ, ZMH). 8. St. Jorisbaai, entrance channel, W, boulders and large metal poles in surf; from undersides crusts of *Spiraserpula*, legit H.A. ten Hove, 16.i.1990 (clusters, AM W20341, HUJ).

Aruba: 9. Spaans Lagoen, SE of bridge, rocks, etc., at floodgate, mud, *Rhizophora*, 0–2.0 m, legit P. Wagenaar Hummelinck, 24.iii.1970, Stn.1673 (2 specimens BM(NH) 1992.12–13). 10. Andicuri, cape W of beach, windward side, rockpool, exuberant coral growth, strong wave action, 0.5 m, legit H. A. ten Hove, 20.viii.1970, Stn.2034B (several fragments of tubes, 2 incomplete worms, ZMA V. Pol. 3719).

Barbuda: 11. Great Lagoon, Lobster Point, N. of Palm Beach, *Thalassia* and *Halophila*, 0–1.0 m, legit P. Wagenaar Hummelinck, 23.vii.1967, Stn.1534 (3 out of several specimens, ZMA V. Pol. 3725).

Bonaire (Neth. Ant.): 12. Lac, dam, beachrock in current behind surf, 5–10 cm, from crevices in beachrock, legit H. A. ten Hove, 15.vii.1970, Stn. 2123 (1 specimen, USNM 130986). 13. Lagun, N shore, 500 m from entrance, rock, boulders, 0–50 cm, from undersides of boulders, legit H. A. ten Hove, 23.vi.1970, Stn. 2129 (3 out of several specimens, ZMAV. Pol. 3720). 14. Bonaire, Karpata, reef, 10 m, cryptic, legit H. A. ten Hove, 9.xi.88 (1 tube, BM(NH) 1992.14).

Jamaica: 15. Drunkeman's Key, sandy debris, 0–0.5 m, legit P. Wagenaar Hummelinck, 15.vi.1973, Stn.1683, (ZMA V. Pol. 3723).

Puerto Rico: 16. La Parguera, E, glade in mangroves, *Thalassia* beds, muddy sand, from between boulders, 20–30 cm, legit H. A. ten Hove,1.x.1970, Stn.2135 (3 specimens, ZMA V.Pol.3724).

Panama: 17. Gatun Locks, walls of outer platform, lower W chamber, Pan. Survey, 20.iii.1972, Pacific Stn. 81–1, M. L. Jones coll., USNM No.58661 (2 specimens without their tubes). 18. Same, Stn.81–2, M. L.Jones coll., USNM No.58662, (1 specimen with its tube).

Florida: 19. Safe Harbour, Stock Island (near Key West), Florida Keys, 5 m, from chunks of calcareous materials (shells, barnacles, etc.) cemented together and covered with serpulids and small cirratulids, legit R. Chesher and C. Hamlin, 17.vii.1970 and 1.vi.1971, Stn.7B, (22 out of several specimens, USNM 130988, BM(NH) 1992. 15–19, ZMAV.Pol.3721 (10+ specimens from 1.vi.1971). 20. Off Egmont Key, 27. 0°37.0'N, 83°01.5'W, sea buoy, 18 m, scarce sponges and corals, 2 cm of soft sludge on limestone, many serpulids, legit H.A.ten Hove and T. Perkins, 2.i.1980, Stn.EJ.80002, (9 out of several specimens, ZMA V. Pol. 3722, FSBC I 39202).

TYPE LOCALITY. Curaçao (Netherlands Antilles).

DESCRIPTION.

TUBES: Light to bright pink or rose coloured. They form mutually bonded aggregations of a few to several individuals. Their external diameter is generally about 1.0 mm, maximally 1.5 mm. There are three longitudinal ridges, one median and one along each lateral margin, which may be indistinctly developed in places (Figs.14, A; 15, A). Narrow transverse ridges may be developed to various extents (Fig.15, A). Some of the tubes end anteriorly in 4 rounded, anteriorly-directed lobes. A transparent to translucent granular overlay is present. The granulations are larger and more densely laid along the ridges. The pink colour is faint along the longitudinal ridges, as seen through the transparent granules, but form of a pair of bright longitudinal bands between the ridges. Branching tubes, difficult to observe since they form dense aggregations, have been observed in material from Curaçao (Stn. 2090, 2096, 75–38), and from Bonaire (Stn. 2123).

ITS consist of a serrated ventral ridge along the concave wall (Figs.14, B,D; 15, P), and a smooth dorsal ridge opposite (Figs.14, B, D–F; 15, O,P). The dorsal ridge is nearly tongue-shaped in cross-section, with a gradual decrease of its height, thickness and width of the widest part both anteriorly and posteriorly. This is occasionally more clearly seen in the non-coiled portions of tubes (Fig.14,F). The dorsal ridge may be situated on a columella-shaped axis in tubes coiled upon themselves (Fig.14, E). They usually also possess a short accessory dorso-lateral ridge on either side of the dorsal ridge (Figs.14, B & C; 3, L). The inside of the tube may have a light caramel to light brown lining. The mid-ventral and mid-dorsal longitudinal abdominal grooves of the worm are applied to the serrated ventral and smooth dorsal ridges, respectively.

WORMS: The longest available complete worm is from Florida. It has a total length of 12.8 mm, thoracic width of 0.5 mm, abdominal length of 9.7 mm, and has 91 segments, with capillaries commencing on the 80th. There are four radioles and a rudimentary operculum on each side. Fully developed opercula are absent in all the specimens, being represented by a long and filamentous rudimentary operculum on each side (Fig.14, H). The highest number of radioles is 6 pairs, the longest measure about 2.1 mm, and end in slender pinnule-free tips which are 1/5–1/6 their entire length (Fig.14, H). Radioles have up to 12 pairs of pinnules each, as could be observed in living material. The smallest worm is a juvenile from Curaço (Stn. 75–77) which has a total length of 3.7 mm, a thoracic width of 0.45 mm, abdominal length of 2.0 mm, and has 20 segments, with capillaries in the last 5. It has 4 radioles on the left and 5 on the right, in addition to the rudimentary opercula.

Two reddish to reddish-brown clusters of prostomial ocelli are present. The median lobe of the collar is sub-rectangular, with rounded lateral borders and a smooth medial notch (Fig.14, I & J). Five to seven globular ventral thoracic glands are present (Fig.14, G), more or less arranged in a V. Whether they are responsible for secreting the brownish inner lining of the tube or not has to be further investigated.

A summary of data is presented in Table 13. Similar data from the Florida material are provided in Table 14.

The bayonet collar chaetae, which number 3 or 4 fully formed ones per fascicle and, usually, a developing one deep within, are unique among the species of *Spiraserpula* and of *Serpula* that have hitherto been described. Their blades are conspicuously short, unserrated and dagger-shaped (Figs.14, K–M; 15, B–I, Q–W; Pl.4, E & F). The number of large conical teeth on the basal boss is usually 3 or 4. Often there are 2 large teeth with 1 or 2 smaller ones in between (Fig.14, K–L; 15, B–I). In the specimens from Gatun Locks, Panama, the number of teeth is usually 4 or 5 (Fig.15, Q–W). These dagger-shaped bayonet chaetae were noted and figured in the

Table 13 *S. caribensis* sp. nov. A summary of data from four samples from Curaçao (Stns. 75–38, 75–36 and 75–77 and 2096).

No. of specimens (n=10)	2	7	1			
No of radioles per side	6/5	5/5	5/4			
No. of specimens (n=14)	2	1	3	3	4	1
No. of thoracic chaetal tufts	9/8	9/7	8/8	8/7	7/7	7/6
No. of specimens (n=10)	1	2	4	2	1	
Thoracic membrane ends	5/4	5/3	4/4	4/3	3/3	

Table 14 *S. caribensis* sp. nov. A summary of data from the Florida material.

No of specimens (n=11)			2		5		4			
No of radioles per side			6/6		5/5		4/4			
No. of specim.(n=29)	1	8	1	3	6	1	2	2	4	1
No. of thor. chaet.	10/6	9/8	9/7	8/8	8/7	8/6	7/7	7/6	7/5	6/6
No. of specimens (n=26)			3	3	4	9	7			
Thor. membranes end on			5/4	5/3	4/4	4/3	3/3			

unpublished research of M. van Vliet and R. Fijn (see acknowledgements).

The blades of developing bayonet chaetae deep within the fascicle are similar to the fully formed dagger-shaped bayonet chaetae, indicating that the latter have not resulted from wear and tear of bayonets with tapered tips. Occasionally, a developing chaeta with a truncated blade and tapered tip (Fig.15, F,S), occurs deep within a fascicle, which provides a clue to the origin of the former. Reduction in length of the blade together with extension of the unserrated notch has resulted in stout, truncated bayonet chaetae, with smooth and dagger-shaped blades.

Thoracic uncini (Fig.15, J) usually possess 6 teeth, and anterior abdominal uncini (Fig.15, K,X) 4 or 5, in a single row. Posterior abdominal uncini are rasp-shaped (Pl.5, A). Flat trumpet chaetae number up to about 5 in each bundle, and their triangular distal ends bear a hook-shaped process on one side, and the other side is drawn out into an acute angle (Fig.15, L–N, Y; Pl.5, B).

COLLECTIONS FROM OTHER LOCALITIES. The specimens from the other localities listed above agree with those from the type locality. However, the smaller size of the tube and chaetae of the specimens from Gatun Locks, Panama, and the highly branched tubes of the specimens from Grenada, are worth noting.

LIVE MATERIAL. As observed in material from Curaçao, radioles are colourless, transparent to transparently orange, sometimes with reddish pinnules. Base of branchial lobes and the collar may be tinged with purple. Branchial eyes not present. Body predominantly transparent orange, thorax ventrally reddish.

ETYMOLOGY. The name acknowledges the fact that this appears to be the most widely distributed species of Spiraserpula in the Caribbean.

HABITAT AND DISTRIBUTION. *S. caribensis* inhabits shallow water, intertidally down to a few metres in the Caribbean, to 18 m in the E. Gulf of Mexico (temperature submerged ?). It occurs in a variety of habitats, from rockpools to the undersides of boulders in mangrove glades. It is able to survive well in somewhat muddy environments, always, however, cryptic between piles of rock or similar hard substrata.

It appears to be widely distributed in the Caribbean and Gulf of Mexico, from Florida to Barbuda and Panama.

A population from Grenada, with frequently branching tubes and which is, for the present, regarded as belonging to *S. caribensis*, is described below (Fig.16, A–K):

MATERIAL EXAMINED.

Grenada (Caribbean), Hog Island, near Pt. Salines, 0–1.5 m, *Rhizophora*, mud, legit P. Wagenaar Hummelinck, 8.vii.1967, Stn. 1550 (5 specimens and 4 tubes, ZMA V.Pol. 3706, USNM 130985, BM(NH) 1992.32).

DESCRIPTION.

TUBES: Dark pink to rose coloured. Except for their posterior ends, they are all uncoiled, conspicuously branched, and attached to the substratum throughout (Fig.16, A). A granular overlay is present, larger granules constituting a median longitudinal ridge and a pair of lateral ridges (Fig.16, A,B). The colouration is darker pink between the median and lateral ridges. Fine transverse ridges may be present in places. The lumen of the tube is continuous with that of the branches.

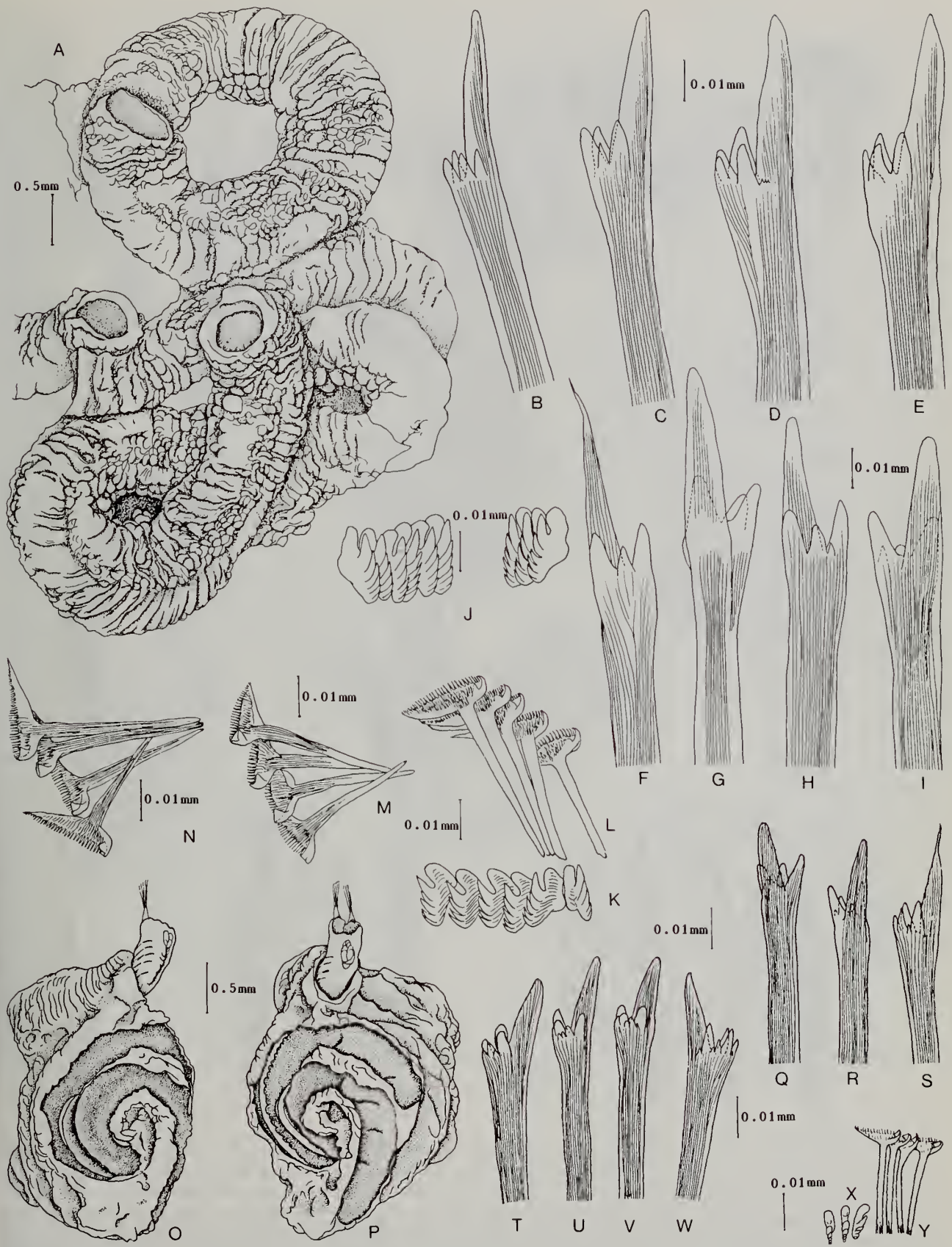
ITS are similar to those of *S. caribensis*. However, the tongue-shaped cross-section of the dorsal ridge is somewhat more pronounced.

WORMS: Three worms were taken out of the tubes, of which the longest (Fig.16, C,D), has a total length of 9.2 mm. There are up to 5 pairs of radioles and a rudimentary operculum on each side. The radioles are up to about 2.0 mm long, 1/6–1/8 of which constitute pinnule-free tips. Measurements and meristic data are given in Table 15:

Two clusters of prostomial ocelli are present. All three specimens bear 7 thoracic chaetal tufts on the left and 6 on the right. The thoracic membranes end on the third thoracic chaetiger on both sides in the first specimen, but are damaged in the others. A pair of ventral thoracic glands is present (Fig.16, C).

Each bayonet chaeta typically consists of a short, serrated blade, and an unserrated notch and a tapered tip (Fig.16, E–K). There are 2 or 3 large teeth on the basal boss, and a few accessory teeth. Older chaetae in a fascicle which have

Fig. 15 *Spiraserpula caribensis* sp. nov. A–E & J–N, From Curaçao, St. Jorisbaai, Stn. 2096. F–I, from Curaçao, Lagoen Blancu, Stn. 75–36. O–Y, From Panama, Gatun Locks: (O–S, from Stn. 81.1; T–Y, from Stn. 81.2). A, Tubes showing granular overlay, external ridges and transverse wrinkles. B–E, Bayonet chaetae from the same fascicle with short dagger-shaped blades. F–I, Bayonet chaetae from fascicle of another specimen: F, Newly formed, deep within fascicle; G–I, Older chaetae. J, Thoracic uncini. K, Anterior abdominal uncini, and L, flat trumpet chaetae, from same segment. M & N, Flat abdominal trumpet chaetae from other specimens. O & P, Tube opened substratally, viewed from two different angles, with worm in situ showing thoracic glands; O, with dorsal ridge only, and P, with both dorsal and ventral ridges. Q–S and T–W, Bayonets from two different fascicles. Note much smaller size compared with those of Florida (Fig. 14, K–L) and Curaçao (Fig. 15, B–I) material, although drawn under same magnification. X & Y, Anterior abdominal uncini and flat trumpet chaetae from same segment. Note much smaller size than in Curaçao material (Fig. 15, L–N).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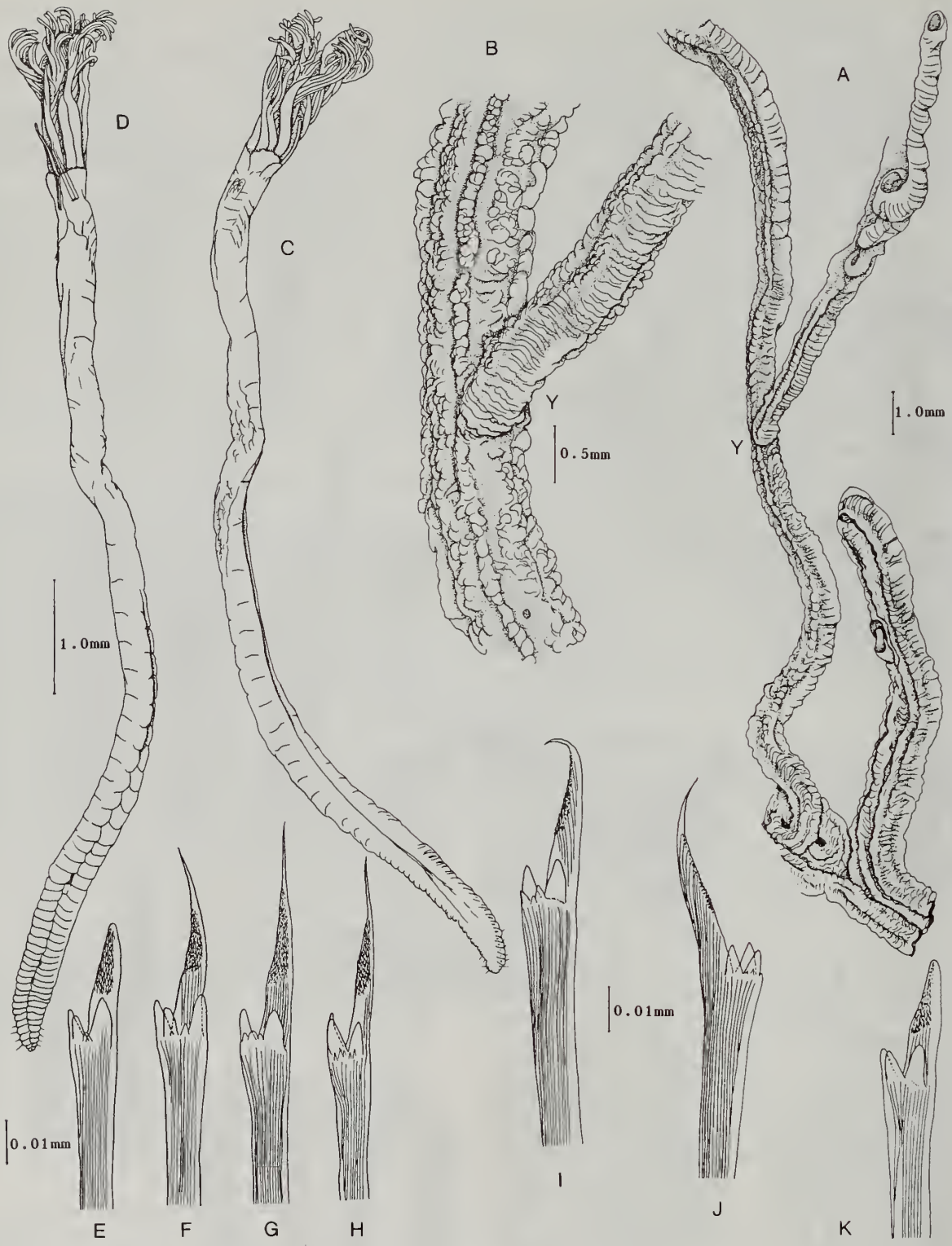

Fig. 16 *Spiraserpula caribensis* sp. nov. A–K, From Grenada. A, Branched tube with granular overlay and longitudinal ridges. B, Branching point marked Y in A, magnified. C & D, Two views of a worm showing rudimentary opercula, thoracic glands (C), and dorsal and ventral longitudinal abdominal grooves. E–H, Four bayonets from a small specimen: A, Older chaeta with worn out tip; F–G, Chaetae with intact tips. I–J, Bayonets from a larger specimen: the oldest (K) with a worn out tip, and the other two with intact tips.

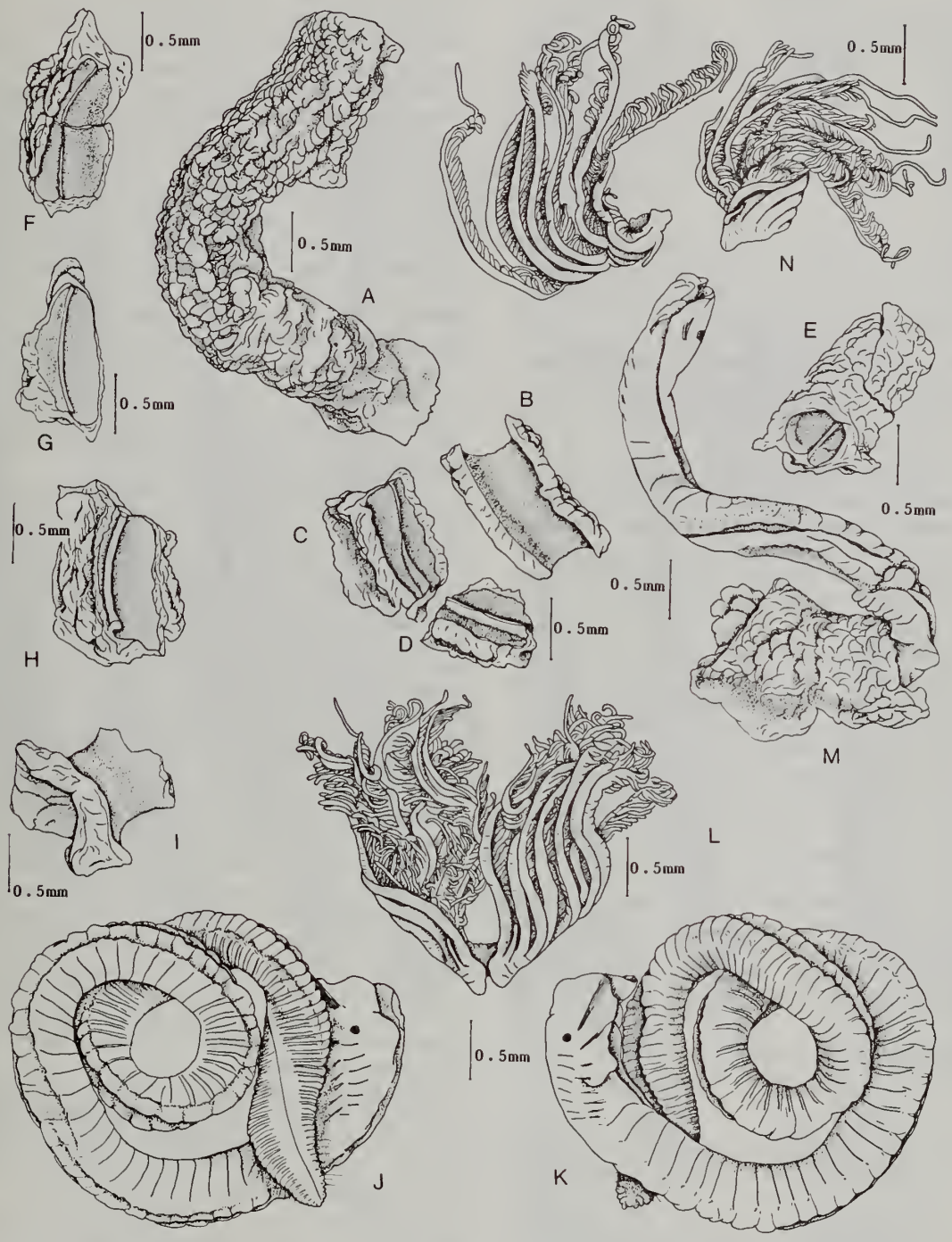

Fig. 17 *Spiraserpula nudicrista* sp. nov. From Bonaire. A, Tube, with granular overlay and longitudinal ridges. B–D, Tube fragments showing unserrated ventral ridge along concave wall and lack of a ridge on the opposite side. E–I, Other tube fragments showing a narrow ventral ridge anteriorly, and a smooth and rounded edge to it posteriorly. J, First formed coil, lacking a dorsal ridge. K–L, Two different views of holotype showing prostomial ocellar clusters, as seen through the collar, the ventral longitudinal groove of the abdomen, and extent of thoracic membrane on the left side (K); L, Radioles with a pair of short club-shaped rudimentary opercula and moderately long pinnule-free tips. M & N, Paratype: M, tube with granular overlay, prostominial ocellar cluster of one side, and longitudinal abdominal grooves; N, branchial crown with a pair of short club-shaped rudimentary opercula, and long pinnule-free tips.

Table 15 *S. caribensis* from Grenada. Measurements and counts.

Specimen no.	Total length (mm)	Thoracic width (mm)	Radioles Length (mm)	Radioles No.	Abdomen Length (mm)	Number of segments	Capillaries on
1	9.2	0.5	2.0	5/5	6.6	50	44
2	8.1	0.5	1.2	4/3	4.7	30	7
3	3.1	0.35	0.6	3/3	1.8	35	10

lost their tapered tips through abrasion may appear somewhat like the bayonets of *S. caribensis* from elsewhere (Fig.16, E, K; Pl.5, C–E), but the newly formed bayonets, within the fascicle, possess tapered tips.

HABITAT AND DISTRIBUTION. Appears to inhabit shallow water and capable of withstanding the silty conditions found in mangrove backwaters. It was found on the inside of a dead oyster shell covered with much silt.

REMARKS. The extensively branching tubes and differences in the collar chaetae initially led us to consider the Grenada material as possibly belonging to a distinct species. However, branching as such, although inconspicuous, was also subsequently observed in some specimens of *S. caribensis* from Bonaire (Stn. 2123) and Curaçao (Stns. 2090, 2096,75–38; see above), in *S. paraypsilon* from Curaçao (10.i.90). Moreover, *S. snellii*, described later in this paper, revealed a schizont with parent in one tube. By itself, therefore, branching cannot be a good character to separate the Grenada material as a distinct species. The fully formed bayonet chaetae, including those within the fascicle, of *S. caribensis* proper, have short dagger-shaped blades with blunt tips, while blades of the Grenada material typically end in tapered tips. Although the tip of a fully formed chaeta in the Grenada material might be lost through abrasion (Fig.16, E–K), those deep within the fascicle are tapered.

Further work on additional material is necessary to determine whether frequent branching of the tubes and the features of the bayonet chaetae are consistent, and whether there are other characters which would justify the separation of the Grenada material into a distinct species or not.

Spiraserpula nudicrista sp. nov.
(Figs.17, A–N; 18, A–O; 3, F; Pl.3, A–D)

MATERIAL EXAMINED.
Bonaire (Neth. Ant.): 1. Karpata, reef, cryptic, 10 m, legit H. A.ten Hove, 9.xi.1988, (HOLOTYPE & PARATYPE: ZMA V. Pol.3711).
Curaçao (Neth. Ant.): 2. Savonet, E of Boca Braun, reef, no sand, about 22 m, from corals, some dead, legit H. A. ten Hove, 28.xi.1970, Stn. 2101 (PARATYPES 2 & 3: BM(NH) 1992.61 & 62).

TYPE LOCALITY. Bonaire (Netherlands Antilles).

DESCRIPTION.
TUBES: White to creamish white and have a conspicuous granular overlay (Fig.17, A,E,M). They may be covered over by encrusting calcareous organisms. They are trapezoidal in cross-section, with two longitudinal ridges along the crest of the tube and one along each flank (Fig.17, A). The maximum external tube diameter of the holotype is 1.0 mm.

ITS consist of an unserrated ventral ridge which is rounded and smooth towards its middle (Figs.17, H; 3, F), from where it decreases in thickness and height both anteriorly and posteriorly (Fig.17,C–E, F–G). A dorsal ridge is generally absent, even on the convex pulley-shaped posterior end (Fig.17, I). However, paratype 1 from Bonaire showed some isolated dorsal teeth. The mid-ventral longitudinal groove of the abdomen (Fig.17, M) is applied to the unserrated ventral ridge.
WORMS: Only two worms were yielded by the tubes from Bonaire. The complete holotype has a total length of 15.6 mm, a thoracic width 0.7 mm, an abdominal length 11.9 mm and about 101 segments, with capillaries on the last 7. The radioles are 2.5 mm in length, and their pinnule-free tips of 0.6 mm are comparatively long (Fig.17, L, N). The paratype is incomplete posteriorly.

The holotype has 9 pairs of radioles while the paratype has 8 pairs. Both specimens have a short filamentous rudimentary operculum on each side (Fig.17, L). Two clusters of prostomial ocelli are present, and are seen as conspicuous brown patches through the collar (Fig.17, J,K,M). This is in contrast to the other known members of the genus in which they can be seen when viewed from the anterior end with the radioles removed or when mounted.

Both specimens have 8 pairs of thoracic chaetal tufts, and the thoracic membranes end on the fourth chaetiger on the left (Fig.17, K) and the 5th on the right. Ventral thoracic glands appeared to be absent.

The collar fascicles of the holotype possess four bayonet chaetae with long serrated to pilose blades and several conical teeth on the basal boss (Fig.18, A–D; Pl.3, A). There may be a number of accessory teeth arranged around the bases of the larger teeth, which are lacking in the paratype (Fig.18, E–G). The unserrated notch is short. Thoracic uncini (Fig.18, H; Pl.3, B) and anterior abdominal uncini (Fig.18, I; Pl.3, C) possess 4 or 5 teeth arranged in a single row. There are about 4 flat trumpet chaetae in each abdominal fascicle (Fig.18, J;Pl.3, D). An anterior hook, as in most of the species of the group, cannot be discerned, all distal teeth appearing more or less equally developed.

Tubes of the specimens from Curaçao are similar to those from Bonaire with regard to colour, form and ITS (Fig.18, K). Their maximum external diameters are 1.1–1.2 mm. Two of them yielded worms which are incomplete posteriorly. Some data from them are presented in Table 16.

Both specimens possess a rudimentary operculum on each side (Fig.18, L,M). Bayonet collar chaetae (Fig.18, N,O), are similar to those of the specimens from Bonaire, although their basal bosses are somewhat stouter.

REMARKS. A small fragment from the inside of the coil of

Fig. 18 *Spiraserpula nudicrista* sp. nov. A–J, From Bonaire. A–D, Bayonet chaetae, holotype. E–G, Three, out of five, bayonet chaetae from paratype. H–J, from paratype: H, Thoracic uncini; I & J, flat trumpet-shaped chaetae and uncini from anterior abdomen. K–O, From Curaao. K, Tube, with granular overlay, external longitudinal ridges, and internal ventral longitudinal ridge seen through fractured end. L, Branchial crown of older specimen with pair of rudimentary opercula. M, Branchial crown of younger specimen, with pair of shorter rudimentary opercula. N & O, Two, out of four, bayonet chaetae.

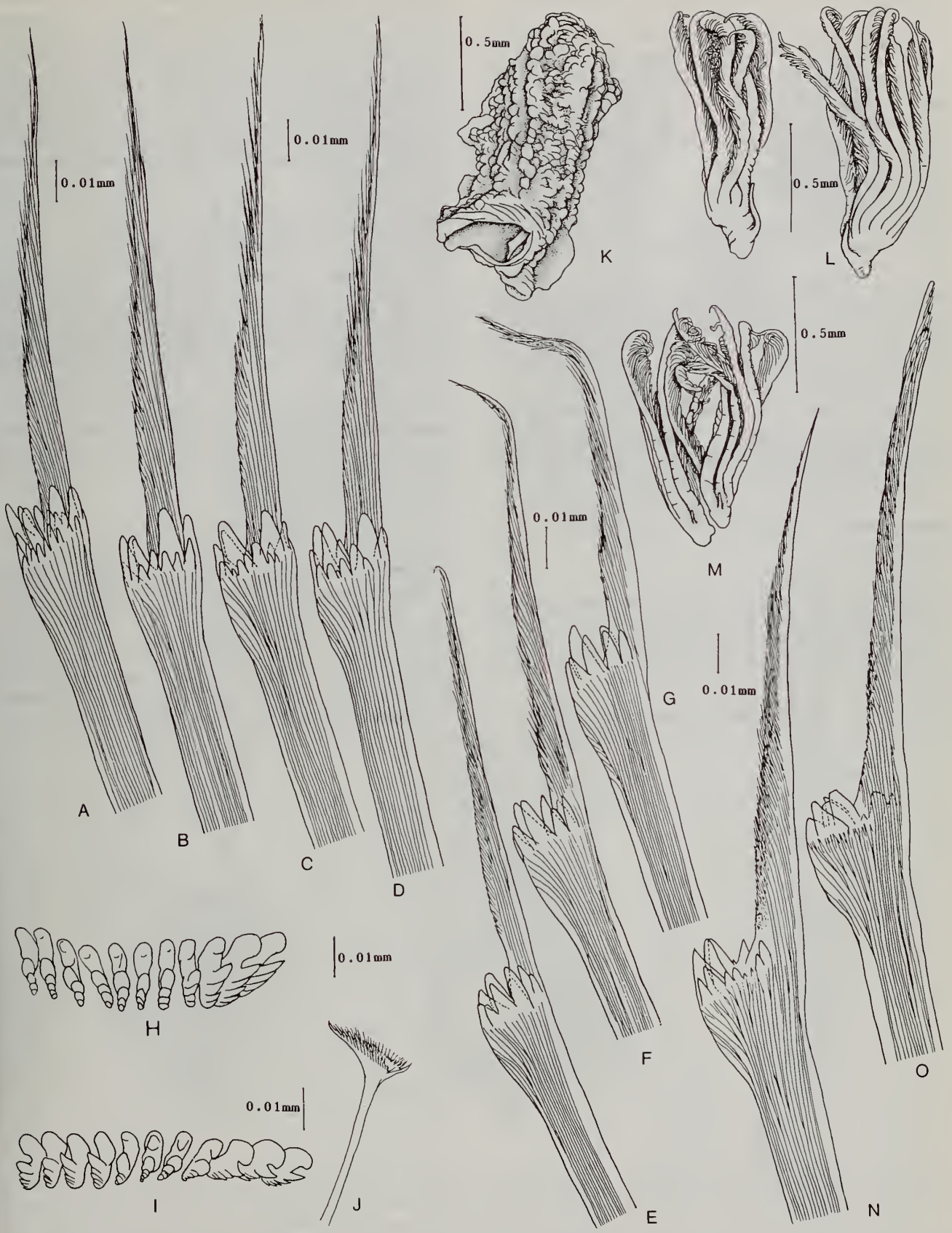
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Table 16 *S. nudicrista* sp. nov. Some data on two specimens from Curaçao.

	Specimen 1	Specimen 2
Width of thorax	0.5 mm	0.6 mm
Length of radioles	2.1 mm	2.6 mm
Pinnule-free tips (Figs.17L,M)	short	short
No. of radioles (L/R)	7/8	9/8
No. of thoracic chaetal tufts (L/R)	9/7	8/6
Thoracic membrane ends	?/?	4/4
Length of abdomen	?	9.7 mm
No. of abdominal segments	?	about 60

paratype 1 showed a slightly concave to asymmetrical cross-sectional edge to the ventral ridge, and a few isolated teeth in the location of the dorsal ridge, somewhat similar to the condition in *S. paraypsilon*. There is also some similarity in the collar chaetae.

ETYMOLOGY. nudus (L) = unadorned; crista = crest, ridge.

HABITAT AND DISTRIBUTION. *S. nudicrista* is a shallow water cryptic species inhabiting coral reefs. It has hitherto been collected from Bonaire and Curaçao.

Spiraserpula sp.
(Fig.19, A–C)

MATERIAL EXAMINED.
Curaçao (Neth. Ant.): Piscadera Baai, outer bay in front of CARMABI, muddy reef, many sand spots, about 40 m, from dead corals, legit H.A.ten Hove, 9.vi.1970, Stn. 2054B (3 empty tubes, and some abdominal fragments, ZMA V. Pol. 3883).

DESCRIPTION. Tubes are white, circular in cross-section. An erect portion shows a granular overlay, and an encrusting sponge at its base (Fig.18,A). ITS characteristic of this genus are present in the coiled parts, and consist of an unserrated dorsal ridge and a serrated ventral ridge. The dorsal ridge is transparent, somewhat high, and has a smooth, somewhat T–shaped edge; it is spiral, on a columella-shaped axis in the spiral proximal portions of the tube (Fig.18, B,C). The available portions of the worms were inadequate to assign the material to any of the other Caribbean species or a new species.

Spiraserpula vasseuri sp. nov.
(Figs.20, A–H; 21, A–K; 3, J)

Helmut Zibrowius requested (pers. comm.) that the material on which he based his preliminary description of the present species in an unpublished manuscript be examined, and that it be included in this paper if it belonged to the present group. ITS are indeed present in this species, and its description follows:

MATERIAL EXAMINED.
Europa Island (Mozambique Channel): North Reef, Gabriel Cove grotto, 55 m, on oysters, legit Pierre Vasseur, scuba diving, 28.xii.1965 (HOLOTYPE: USNM 46475, 6 PARATYPES USNM 46476).

TYPE LOCALITY. Europa Island.

DESCRIPTION.
TUBES: The colour is mostly whitish, with a very faint pinkish to orangish tinge seen in places at certain angles of illumination. They are sinuous, coiled and bonded together, especially at their bases. A granular overlay is present. The anterior portions are squarish to trapezoidal in cross-section (Fig.20, A–C). The dorso-lateral angles may be incompletely developed in places and represented by a pair of incomplete longitudinal ridges; an additional incomplete ridge may be

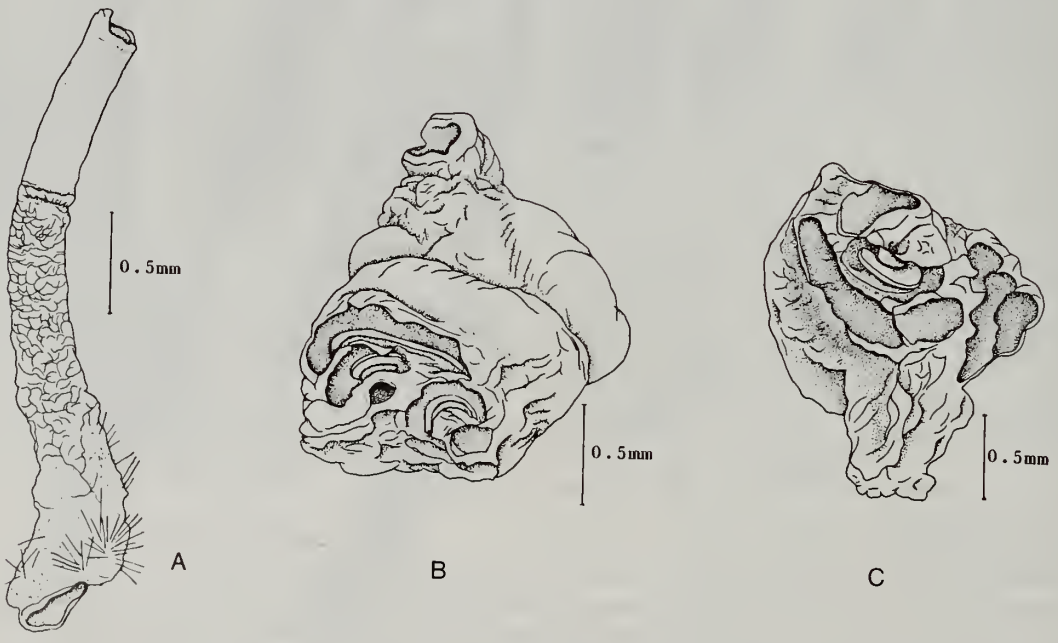

Fig. 19 *Spiraserpula* sp. A–C, Three specimens from Curaçao. A, Erect part of tube with encrusting sponge on its base. B, A tube opened to show spiral dorsal ridge in its first formed coil. C, Aggregation of tubes opened to show variations of dorsal ridge.

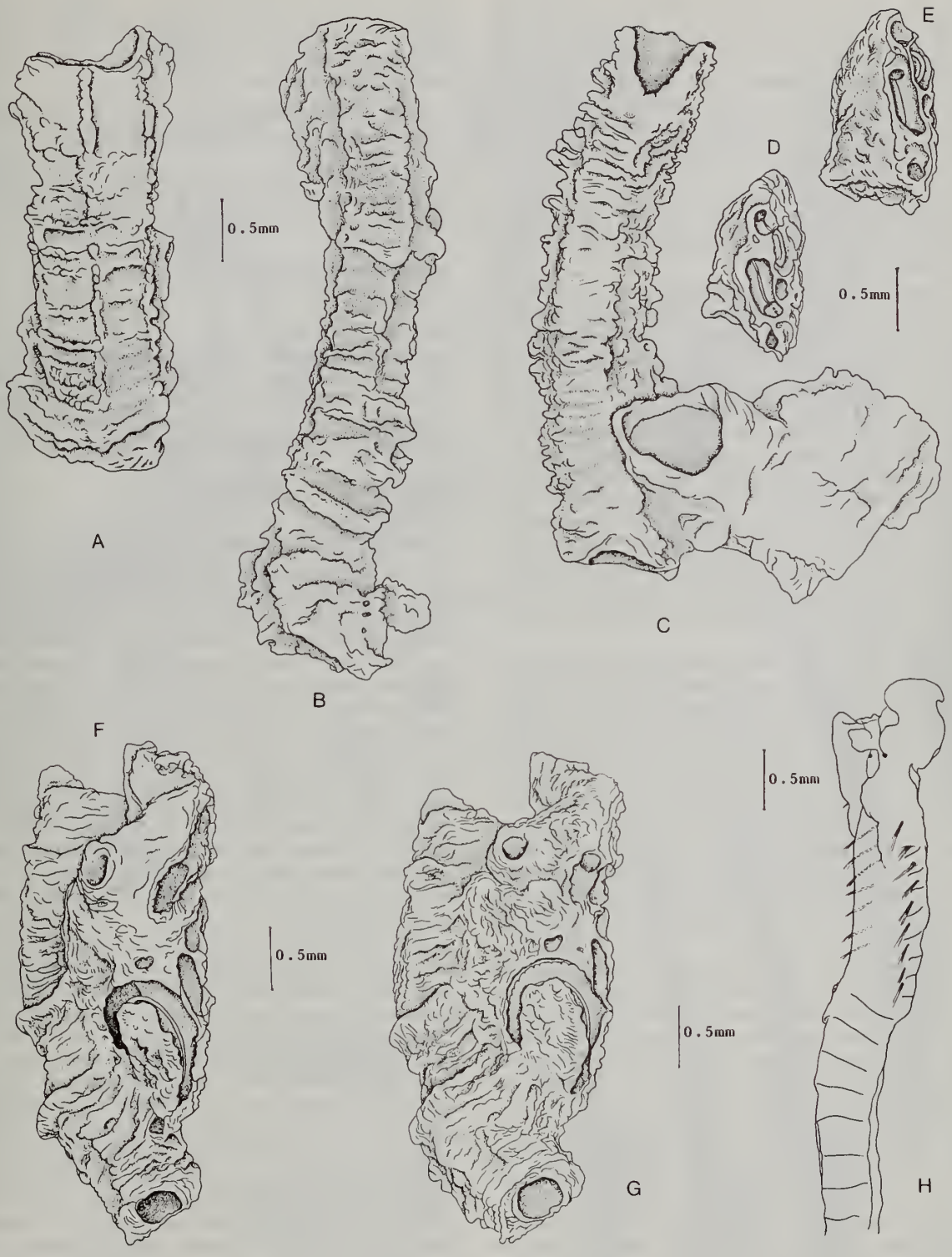

Fig. 20 *Spiraserpula vasseuri* sp. nov. A–H, paratypes. A–C, Anterior tube fragments showing granulations, transverse ridges and roughly trapezoidal external outline. A, Shows incompletely formed external longitudinal ridges, and a thickened peristome towards the posterior end of B. D & E, Two views of same posterior coil showing the unserrated dorsal ridge in both, and a serrated ventral ridge consisting of separate teeth in D. F & G, Two views of same anterior tube fragment with an attached posterior coil opened (on the right). The anterior tube fragment has two peristomes; the posterior coiled part (G)has been opened to expose the unserrated dorsal ridge and serrated ventral ridge (G). H, Thorax showing prostomial ocelli, collar, thoracic membranes and chaetigers.

present along each flank (Fig.20, A). Transverse ridges are present, which may be thickened in places, representing peristomes (Fig.20, B,F,G). Although broken into fragments during collection, total lengths appear to have been between 30–40 mm, and their maximum external diameters up to about 3.0 mm. Their fractured ends show two concentric layers of different consistency and thickness, an inner one that is more vitreous and transparent than the outer which is white and opaque. Their lateral margins are fragile and chambered, with thin walls.

The posterior ends of the tubes are coiled. ITS consist of a low unserrated dorsal ridge, and a serrated ventral ridge (Fig.20, D–G). The latter may be represented by a row of separate teeth (Figs.20, D; 3, J).

WORMS: The total length of the worms, based on the fragments, exceeds 15.0 mm. The branchial crown is 4.0–5.0 mm long, and each side bears 8–10 radioles and an operculum or a rudimentary operculum. The opercular peduncle is long and slender, of the same thickness as the radioles. One of the specimens has a well-developed operculum on one side, and another, much smaller, but similar operculum on the other. The operculum is big and short, massive, bell-shaped, and slightly concave distally. The radii end in large, rounded marginal lobes, and range from 10 to 15 in number (10 in 1, 11 in 3, 12 in 1, and 15 in 1). The number of thoracic segments per side varies from 10 to 14. A pair of small ocellar clusters is present. Collar large, roughly divided into three large ventral lobes and a pair of latero-dorsal lobes. Thoracic membranes are broad up to the third segment, after which they narrow, and do not form an apron.

The longest opercular peduncle (holotype) together with its operculum is 5.5 mm long. The operculum (Fig.21, A,C,D) is separated from the peduncle by a faint constriction, where the peduncle is only 1/2–1/3 the diameter of the base of the operculum. The variations in the dimensions of opercula of the older specimens are as follows: length: 0.6–0.7 mm; width: 0.55–0.6 mm. They are bell-shaped, with a small shallow concavity distally. They have a thick and transparent cuticle (Fig.21, A,C,D). The second radiole of the opposite side is modified into a rudimentary operculum (Fig.21, B). The radioles end in short pinnule-free tips which are about 1/10–1/15th the total length of the radioles (Fig.21, A–C).

One of the specimens, a juvenile, provides an indication of the possible ontogenetic changes in the operculum of this species. Unlike in the adults, where peduncle and operculum are markedly separated from each other, the slender peduncle of the juvenile merges gradually into the base of the operculum. In addition, the shape of the latter is an elongated funnel, and its distal end is convex (Fig.21, E).

The collar fascicles may bear up to about 5 fully formed bayonet chaetae and one developing deep within. Each possesses a long serrated blade, a short unserrated notch, and several moderately large teeth on the basal boss (Fig.21, F–K). Thoracic uncini show 5–6 teeth in side view; however, in oblique edge view it is evident that they are saw-rasp shaped, with an anterior single row and a posterior cluster of teeth (Fig.21, L). This is more clearly seen in the anterior abdominal uncini (Fig.21, M). In side view, the number of teeth in the latter vary from 4 or 5 towards the lateral end of the torus to 7 at the dorsal end. Flat trumpet chaetae number 9–11 per bundle. Their distal ends terminate in a slender hook-shaped process on one side and are drawn out into an acute angle on the other (Fig.21, N).

ETYMOLOGY. As suggested by Zibrowius (pers. comm.), the species is named after its collector, P. Vasseur.

HABITAT AND DISTRIBUTION. A reef dweller found on oyster shells in submarine caves at depths of around 55 m. Hitherto collected only from the Mozambique Channel.

Spiraserpula deltoides sp. nov.
(Figs.22, A–N; 3, C)

MATERIAL EXAMINED.
Lesser Sunda Islands, Sumba (Indonesia): Snellius II 4.051, NE coast of Sumba, E. of Melolo 09°53.5'S 120°42.7'E, 75–90 m. (HOLOTYPE & 1 PARATYPE (empty tube): RMNH 18296; 3 PARATYPES: ZMA V. Pol. 3736; 2 PARATYPES: BM(NH) 1992.37 & 38).

TYPE LOCALITY. Sumba (Indonesia).

DESCRIPTION.
TUBES: White, small, and spirally coiled upon themselves. They are squarish in cross-section, smooth and rounded dorso-laterally, and with a shallow longitudinal depression in between (Fig.22, A). They have an extremely fine granular overlay, which can only be seen at certain angles of illumination, and very fine transverse grooves. The coil diameter is generally about 3 mm, maximally 9 mm; the maximum external tube diameter is generally 0.7 mm, maximally 1.3 mm. In two of the tubes an inner transparent lining was observed.

ITS consist only of a serrated dorsal ridge along the convex wall of the tube (Figs.22, B,C; 3, C). The serrations are delta-shaped, mostly separate, and opaquely white in colour.
WORMS: The holotype (Fig.22, D) is 5.0 mm long, 0.35 mm wide in the thorax and its abdomen is 3.2 mm long. One paratype is incomplete posteriorly, the other is 8.0 mm long, with an abdomen of 3.5 mm. Some measurements and counts are given Table 17:

The operculum is bell-shaped, with a shallow distal concavity extending inwards as far as the inter-radial grooves. The radii end in rounded marginal lobes, the constriction between operculum and peduncle is sharp, and the diameter of the distal end of the peduncle is about 1/2–3/4 that of the proximal part of the operculum (Fig.22, D–G).The rudimentary operculum is 1.5 mm long, thread-shaped. The radioles end in short pinnule-free tips, about 1/7 the total length of the radioles. Two clusters of prostomial ocelli are present. It is difficult to determine whether ventral thoracic glands are present. Thoracic membranes do not extend to the end of the thorax, but exactly where they end cannot be located, it may be at the 7th chaetiger in one paratype. The abdomen of the holotype has about 67 segments, with capillaries on the last 8 or 9; the complete paratype has 85 abdominal segments, 24 with capillaries. The abdomen of the incomplete paratype is

Fig. 21 *Spiraserpula vasseuri* sp. nov. A, Holotype. B–N, Paratypes. A, The left branchial crown and three views of the operculum and its slender peduncle. B, Left branchial crown and rudimentary operculum from another specimen. C & D, branchial crowns and differrent views of the opercula of two other specimens. E, Two views of the convex operculum of a juvenile. F–K, Bayonet collar chaetae bearing several teeth on the basal boss, and a short unserrated notch. L, Thoracic uncini, with more than one row of teeth towards their posterior ends. M, Anterior abdominal uncini. N, Bundle of anterior abdominal chaetae with flat trumpet-shaped ends.


0.5mm
A
0.5mm
B
0.5mm
C
0.5mm
0.02mm
E
F
0.02mm
D
L
0.02mm
N
0.02mm
M
G
H
I
J
K

Table 17 *S. deltoides* sp. nov. Some measurements and counts on the holotype and 2 paratypes.

	Holotype	Paratype 1	Paratype 6
Length of operculum and peduncle	0.94 mm	1.2 mm	3.2 mm
Length of operculum	0.38 mm	0.52 mm	0.48 mm
Diameter of operculum	0.44 mm	0.35 mm	0.41 mm
No of opercular lobes	22	26	22
No. of radioles (L/R)	5/6	6/6	7/7
No. of thoracic chaetal tufts (L/R)	8/7	6/8	7/7

12.5 mm long, has about 75 segments, and the latter bear reddish-brown granular material ventro-laterally.

The collar fascicles bear 2–6 bayonet chaetae. Each has a long serrated blade, a short unserrated notch, and about 2–6 teeth on the basal boss (Fig.22, H–I, L–N). Thoracic uncini bear about 5 teeth in a single row (Fig.22, J,K); anterior abdominal uncini are similar and bear 5–7 teeth.

ETYMOLOGY. The specific name refers to the delta-shaped serrations of the internal dorsal ridge.

HABITAT AND DISTRIBUTION. Found on calcareous stones at depths of 75–90 m. Hitherto collected only from Sumba (Indonesia).

Spiraserpula sumbensis sp. nov.
(Figs. 23, A–U; 3, H)

MATERIAL EXAMINED.
Sumba (Indonesia): Snellius II 4.051, NE coast of Sumba, E of Melolo, 09°53.5'S 120°42.7'E, 75–90 m, (HOLOTYPE: RMNH 18297; 1 PARATYPE: ZMA V. Pol. 3737; 1 PARATYPE: BM(NH) 1992.72).

TYPE LOCALITY. Sumba (Indonesia).

DESCRIPTION.
TUBES: White to very faintly pinkish. A small species with external tube diameter only up to about 0.5 mm, and a lumen of about 0.25 mm wide. A granular overlay consisting of extremely fine granules can be seen under special illumination. Tubes are circular in cross-section and bear faint transverse wrinkles (Fig.23, A–C, O).

ITS consist of a dorsal ridge and a ventral ridge, which are both unserrated, wedge-shaped in cross-section (Fig.3, H), and partially divide the lumen into somewhat asymmetrical left and right halves (Fig.23, C,D). The two ridges are light pink and opaque. In cross-section they consist of a lens-shaped whitish kernel in the inner hyaline tube layer; the outer tube layer is opaque.

WORMS: The holotype (Fig.23, E–G), has a total length of 7.0 mm, thoracic width of 0.26 mm, an abdominal length of 5.1 mm and 66 segments,with capillaries on the last 17. The length of the operculum plus peduncle is 1.3 mm, the length and diameter of the operculum 0.38 mm and 0.26 mm, respectively. The operculum is zygomorphic (Fig.23, E,F). It has a distal concavity which extends as far as the inter-radial grooves. The 15 radii end in somewhat acutely triangular marginal lobes with smooth tips. The peduncle is slender, but somewhat expanded before the constriction below the operculum. There are 5 radioles on each side, with the operculum on the left side and a short filamentous rudimentary operculum on the right (Fig.23, E). The short pinnule-free tips are about 1/7–1/8 the total length of the radioles. Thoracic chaetal tufts number 8 on each side. The thoracic membrane ends on the fifth chaetiger on the left, but it is difficult to determine its extent on the right. One tiny prostomial eye appears to be present on the right side, the left side is damaged. Thoracic glands could not be detected in the material.

One paratype (Fig.23, O–Q) has an incomplete abdomen. It is the first specimen encountered in this genus with two equally well-developed opercula (Fig.23, O,P). The thorax of the second paratype is missing, the remaining abdomen has 54 segments, 12 of them with capillaries. Some measurements and other data are given in Table 18:

The paratypes agree with the holotype with regard to the tube, operculum, radioles, and chaetae. The opercula are somewhat zygomorphic.

Collar fascicles bear 4 fully formed bayonet chaetae in the holotype; 3 fully formed bayonet chaetae and a newly formed one deep within the fascicle in paratype 1. Each bayonet chaeta (Fig.23,H–K, R–U) consists of a long serrated blade, a moderately long unserrated notch, which is about 1/6–1/7 the length of the blade, and several teeth on the basal boss. Thoracic uncini appear to have a row of 7–9 teeth in side view, but more than one row as seen in edge view (Fig.23,L). Anterior abdominal uncini are similar, but appear to have fewer teeth in side view (Fig.23, M). Flat trumpets number four in each anterior bundle, their curved distal ends have a poorly developed hook on one side and are comparatively elongated on the other (Fig.23, N). Capillaries occur in the posterior 12–17 chaetigers.

Table 18 *S. sumbensis* sp. nov. Measurements and counts.

	Paratype 1		Paratype 2
	Left side	Right side	
Length of op. & peduncle (mm)	1.2	1.0	1.2
Length of operculum (mm)	0.36	0.36	0.35
No. of lobes	19	21	17
No. of radioles	5	5	4/4
No. of thoracic chaetal tufts	8	8	–
Thoracic membrane ends (Fig.23,Q)	3	5	–

ETYMOLOGY. Named after the type locality.

HABITAT AND DISTRIBUTION. Found on calcareous stones at depths of about 75–90 m. Hitherto collected only from Sumba (Indonesia).

Spiraserpula iugoconvexa sp. nov.
(Figs. 24, A–K; 25, A–Q; 3, I)

MATERIAL EXAMINED.
NE Flores Sea to SW Banda Sea (Indonesia): 1. **Taka Bone Rate**(Tiger Islands), Snellius II 4.139B, S of Tarupa Kecil, 06°30'S 121°8'E,depth –30 m, (HOLOTYPE: RMNH 18295; PARATYPE I: ZMA V.Pol.3735). 2.**Tukang Besi Island, Binongko**, Snellius II 4.044B, SW of Taipabu, Banda Sea, 5°56'S 123°58.5'E, down to 25 m, (PARATYPE II: BM(NH) 1992.39). **Queensland (Australia)**: 3. Lizard Island, S. South Island, sloping silty reef, little coral cover, legit H. A. ten

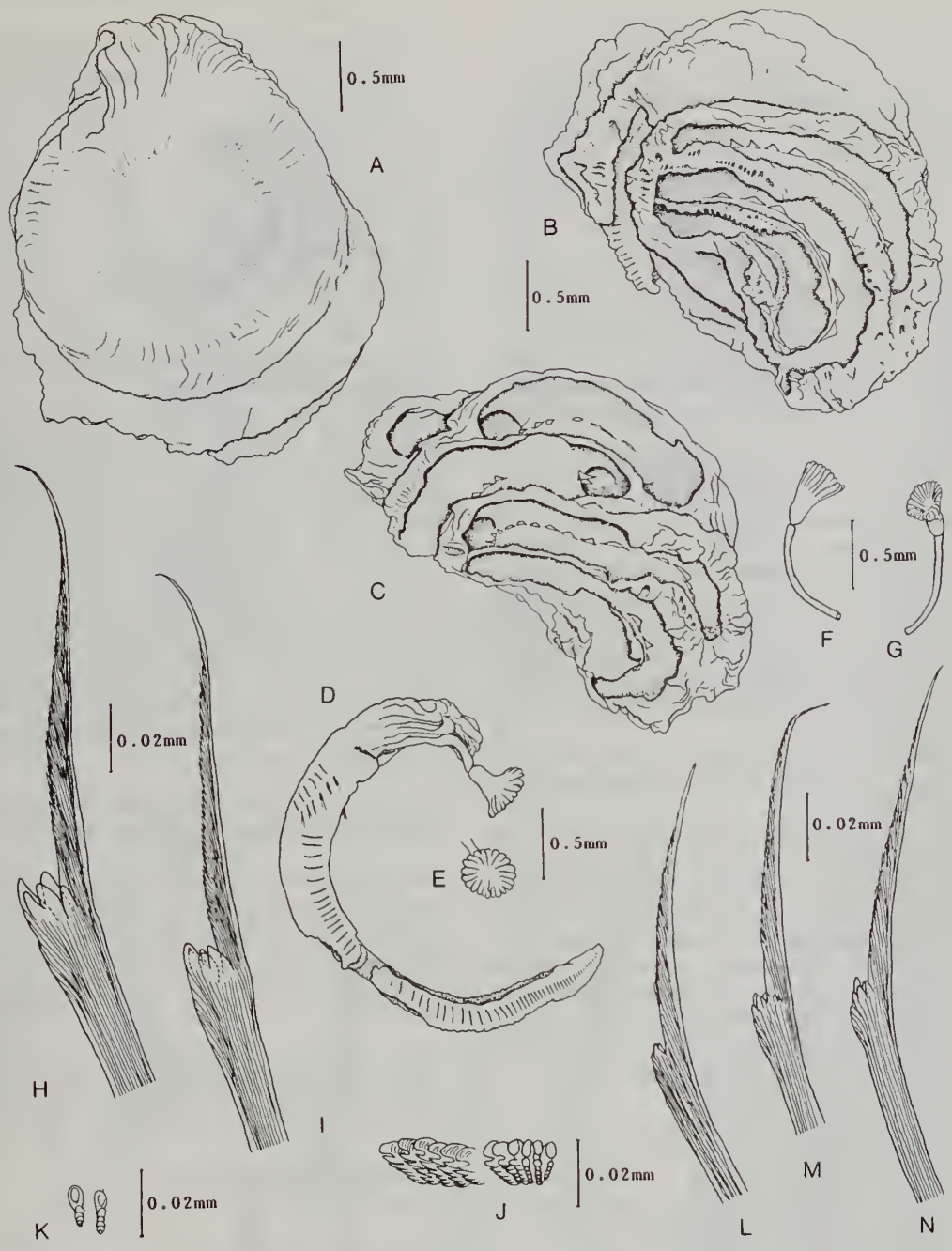

Fig. 22 *Spiraserpula deltoides* sp. nov. A–E & H–K, From holotype; F–G & L–N, from paratype. A, Tube viewed from above. B & C, Two views of same tube opened substratally to show deltoid dorsal ridge. D, Worm, showing operculum and dorsal abdominal groove. E, Anterior view of operculum. F & G, Two views of operculum. H & I, L–N, Bayonet chaetae. J, Thoracic uncini. K, Anterior abdominal uncini. L–N, Bayonet chaetae.

Hove *et al.*, Stn. 21,6.iii.1986 (1 specimen, tube; AM, W21676).

TYPE LOCALITY. NE Flores Sea (Indonesia).

DESCRIPTION.

TUBES: Bright rose, red in fresh material, with a translucent granular overlay, coiled posteriorly but not anteriorly. All three tubes of the type series were partially overgrown by encrusting bryozoans, making their surfaces irregular. At irregular intervals, there are also peculiar elongated structures with a semilunar opening, which appear to be a hydrozoan commensal, akin to *Protulophila* Rovereto, 1901 (*vide* Scrutton, 1975). These sparsely occurring structures are directed longitudinally or transversely as shown on the specimen from from Stn. 4044B (bottom end of Fig.24, A). The anterior end of the tube from Tukang Besi Island is not attached to the substratum. Viewed dorsally, it is squarish to trapezoidal in cross section. It has two fairly distinct dorsolateral ridges and a faint median one in places, transverse wrinkles which are occasionally thickened, and an expanded

peristome at its anterior end (Fig.24, A). The ventral side of the unattached part, which commences from a swollen attachment to the substratum, does not show the granular overlay but only faint transverse wrinkles (Fig. 24, B). The peristome consists of a broad triangular dorsal lobe which is continuous with two narrow ventro-lateral lobes (Fig.24, A,B).The inside of the tube is quite shiny. It attains a diameter of 1.6 mm at the peristome, and 1.5 mm at the swollen commencement of the unattached part.

ITS, which are present only in the posterior part of the tube, consist of an unserrated dorsal ridge (Figs.24, C; 25, B,C), and a very short smooth ventral ridge (Fig.3, I), which is very short in the holotype (Fig.25, D); in the specimen from Lizard Island the ventral ridge is smooth to scalloped. The dorsal ridge may be T-shaped in cross-section in places (Fig.25, C) but appears irregular if damaged (Fig.24, C, middle). In the middle region of the tube, tear-shaped depressions are present in the inner wall, up to 0.2 mm in size.

WORMS: The holotype from Taka Bone Rate, broken in three parts (Fig.25, E–G), has a total length of 31.5 mm, a thoracic width of 0.5 mm, an abdominal length of 27.0 mm and 117 segments, with capillaries on the last 8. Its radioles are 2.7–3.0 mm long, of which the slender pinnule-free tips constitute 0.3 mm. Paratype I lacks its branchial crown; it has a length of 5.0 mm, a thoracic width of 0.4 mm, an abdominal length of 4.3 mm, and has 61 segments, with capillaries on the last 15 or16. Paratype II, from Tukang Besi Island, lacks its radioles on the right side, and its abdomen is in several parts. Its thorax, however, is intact (Fig.24, G,H).

The operculum and peduncle measure 3.0 mm long in the holotype, 4.1 mm in paratype II. Other measurements and counts are given Table 19.

The operculum is zygomorphic, and its distal end is quite different from that of other known species of the genus in being markedly convex (Figs.24, D–F; 25, G–J). The cuticle is thickened and transparent, particularly in its convex distal end, the marginal lobes of the radii, and the asymmetrical projection at the base of the operculum. The number of radial lobes reaches about a dozen. There is a sharp constriction between the operculum and the peduncle, the latter being slender, except for a slight expansion before the constriction (Figs.24, E,F; 25, J). A filamentous rudimentary operculum is present on the side opposite to that of the operculum (Fig.25, G).

The number of radioles per side reaches 14. Their short pinnule-free tips are about 1/7–1/8 the entire length of the radiole. Prostomial eyes were not found. Thoracic glands are present, transparent in the holotype and paratype II, light brown in paratype I. The number of thoracic segments per side is 7–8, and the thoracic membranes do not reach the last thoracic segment (Fig.24, G–I).

The abdomen of the holotype appears glandular ventrally, packed with eggs, and bears peculiar swellings (Fig.25, E) which fit into corresponding depressions in the tube. It was not possible to find them in the damaged abdomen of paratype II, although this is a mature specimen too, and the inner tube wall shows tear-shaped depressions (0.32 × 0.22 mm); they are absent in the juvenile paratype I. Possibly, these abdominal swellings are developed in older worms only.

Table 19 *S. iugoconvexa* sp. nov. Measurements and other data on type specimens.

	Holotype	Paratype I	Paratype II
Length of operculum (mm)	0.7	?	1.0
Diameter of operculum (mm)	0.5	?	0.7
No. of radii	12	?	11
No. of radioles(L/R)	10	?/?	14/?
No. of thoracic chaetal tufts	8/7	7/7	7/7
Thoracic membrane ends	?/?	1/3	5/4

Collar fascicles of the holotype bear 4 bayonet chaetae each (Fig.25, K–N). Each possesses a long serrated blade, a short unserrated notch and two teeth on the basal boss, one of which may be difficult to observe in side view since it lies directly behind the other. The number of teeth is clearly seen in one of the bayonets of paratype I which has its blade broken off at its base (Fig.24, J), although it is difficult to observe in a newly formed chaeta from within the same fascicle (Fig.24,K). Thoracic uncini bear 5 or 6 teeth (Fig.25, O), and anterior abdominal uncini 4 or 5 teeth in a single row (Fig.25, P). There are up to about a dozen flat trumpet chaetae in each bundle (Fig.25, Q). Their distal ends bear a claw-shaped process on one side and are drawn out into an acute angle on the other.

ETYMOLOGY. Iugum (L) = yoke; convexus (L) = bulbous; refers to the zygomorphic, convex operculum.

MATERIAL FROM OTHER LOCALITY. The material from Lizard Island agrees closely with that of the type series with regard to collar chaetae, operculum and tear-shaped depressions in the inner tube wall. However, the ventral internal ridge has a scalloped edge, not smooth as in the Indonesian material.

HABITAT AND DISTRIBUTION. A reef dweller occurring at depths of about 25 m. Hitherto collected from Indonesia (Flores Sea and Banda Sea) and Australia (Queensland).

Spiraserpula snellii sp. nov.
(Figs.26, A–X; 27, A–L; 28, A–V; 3, F)

MATERIAL EXAMINED.

Flores Sea, (Indonesia): 1. **Taka Bone Rate** (Tiger Island), Snellius II 4.139B, S. of Tarupa Kecil, 06°30′S 121°8′E, edge of reef flat, 30 m, (HOLOTYPE & 4 PARATYPES: RMNH 18298; 4 PARATYPES (+ one abdomen & internal tube ridge): BM(NH) 1992.66–71; 5 PARATYPES & tube material: ZMA V. Pol. 3738; 3 PARATYPES & fragmentary tube material: USNM 130983 & 130984).

Fig. 23 *Spiraserpula sumbensis* sp. nov. A–M, Holotype. O–U, Paratype. A–D, O, Tubes showing granular overlay and faint transverse growth ridges; A, An erect part; B, also showing body, operculum & radioles *in situ*; C & D, two views of same tube fragment showing wedge-shaped dorsal and ventral ridges, both unserrated. E, Operculum. F & G, Holotype. F, Radioles showing zygomorph operculum on left, rudimentary operculum on right. G, Worm showing extent of thoracic membrane. H–K, Bayonet collar chaetae. L, Thoracic uncini. M, Anterior abdominal uncini. N, Bundle of anterior abdominal flat trumpet chaetae. O, Tube of paratype, also showing worm with its two opercula *in situ*. P, Radioles with two well-developed opercula. Q, Two views of thorax showing extent of thoracic membranes. R–U, Bayonet collar chaetae.


A
0.5mm
B
C
0.5mm
O
0.5mm
P
Q
D
0.5mm
E
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0.02mm
I
J
K
R
S
T
U
G
0.5mm
H
L
M
0.02mm
N

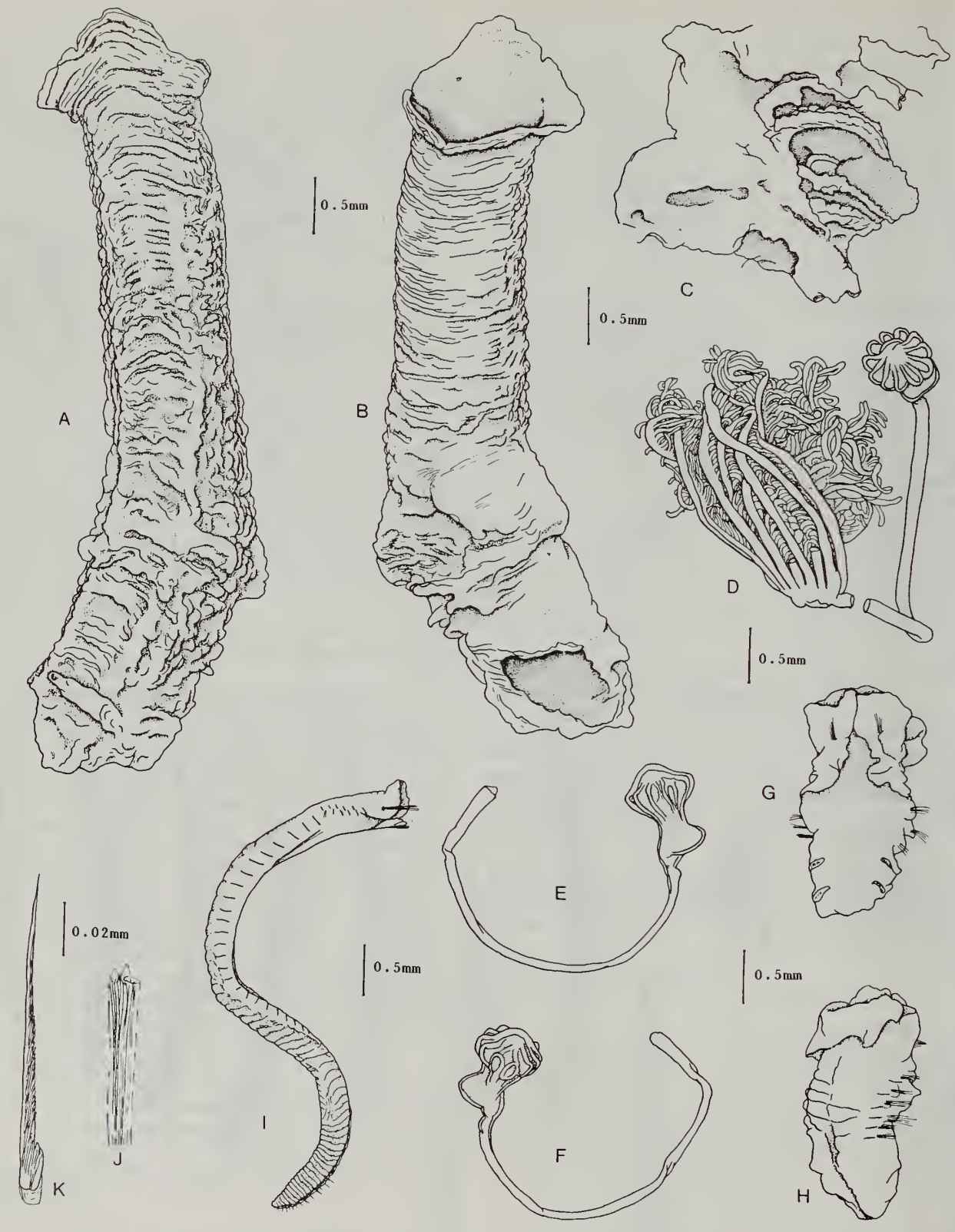


Fig. 24 *Spiraserpula iugoconvexa* sp. nov. A–K, Paratypes. A, Dorsal view of erect tube part showing longitudinal external ridges, granular overlay, transverse ridges, triangular dorsal lobe of its aperture, and an unidentified transverse epibiont at its base. B, Ventral view of same tube showing the two small ventral lobes of the aperture, rounded ventral side and fine transverse growth ridges. C, Posterior coil of tube showing a damaged dorsal ridge. D, Radioles and operculum of the right side. E & F, Same operculum showing its zygomorphy and convex distal end. G & E, Dorsal and ventral views of thorax showing the collar and extent of the thoracic membranes. I, Juvenile paratype. J, Bayonet collar chaeta, lacking blade, but showing two teeth on the basal boss. K, Newly formed chaeta from within the fascicle.

Fig. 25 *Spiraserpula iugoconvexa* sp. nov. Holotype. A, Tube fragment showing irregular surface and peculiar structure with a semilunar opening (? *Protulophila*). B & C, Views of the opened tube showing the unserrated dorsal ridge, with a somewhat flatened ridge (C, bottom left). D, Tube fragment showing ventral ridge. E–G, Entire holotype, in three parts. E & F, Body showing the dorsal longitudinal groove, the apparently glandular ventral side of the abdomen and its peculiar outpouchings. G, Radioles with operculum on the left and rudimentary operculum on the right. G–J, Four views of the zygomorph operculum with convex distal end. K–N, Bayonet collar chaetae with long slender blade, short unserrated notch and two teeth (seemingly one tooth) on the basal boss. O, Thoracic uncini. P, Anterior abdominal uncini. Q, Bundle of anterior abdominal flat trumpet chaetae.

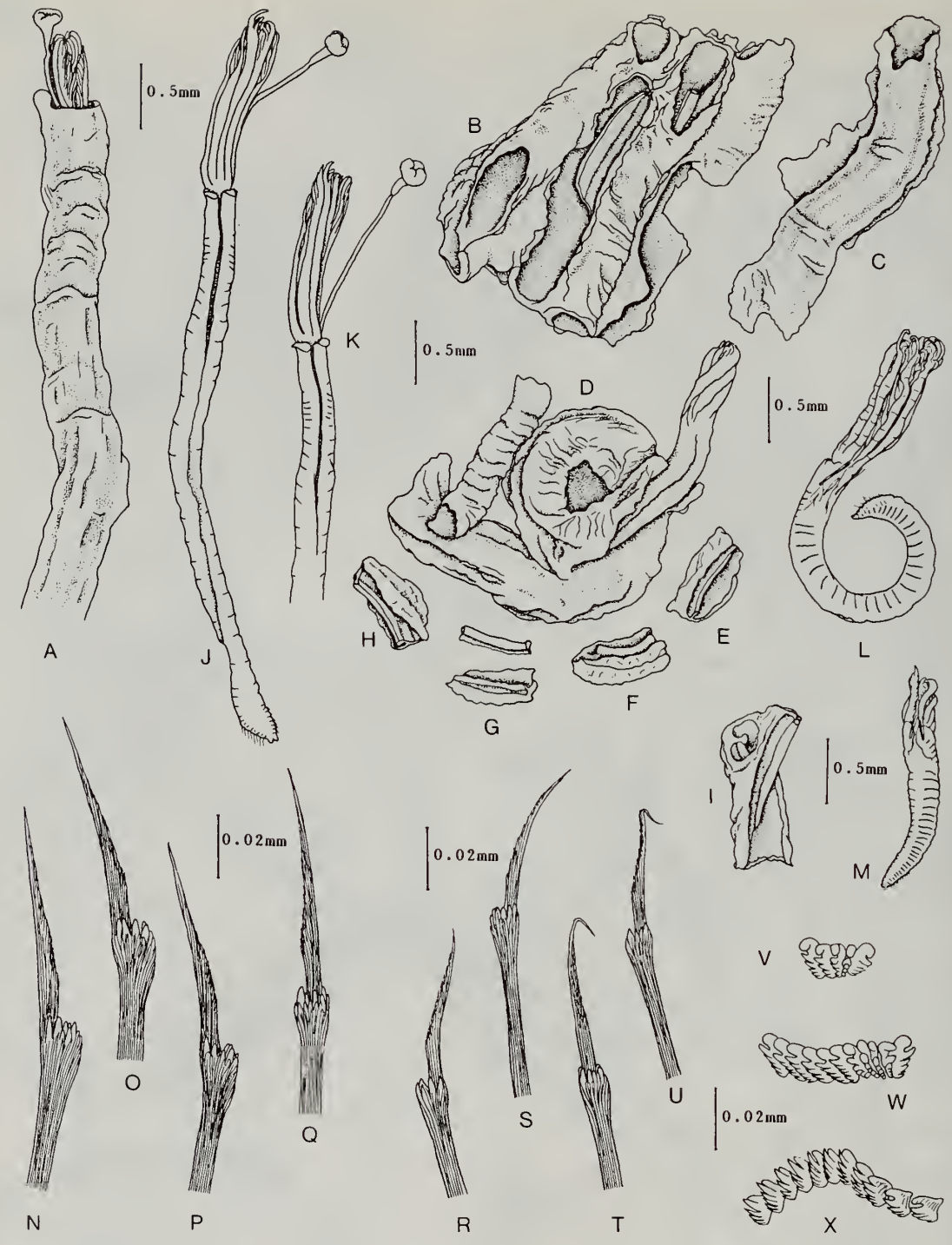


Fig. 26 *Spiraserpula snellii* sp. nov. A, J–K, N–Q, V–W, Holotype. B–L, R–U, Paratypes. M, Juvenile. A & C, Tubes showing longitudinal pigment bands, transverse bands and thickenings (A). B, Tube fragment showing unserrated ventral ridge. E–H, tube fragments in their relative positions to the unopened tube (D) showing the unserrated ventral ridge which is thickened towards the middle of the tube (G,H). I, Tube fragment showing T-shaped ventral ridge. J–K, Holotype, showing operculum, radioles, and dorsal longitudinal groove along its body. L, Paratype, juvenile without operculum. M, Smaller juvenile worm, also without operculum. N–U, Bayonet collar chaetae. V & W, Thoracic uncini. X, Anterior abdominal uncini.

Queensland (Australia): 2. **Lizard Island**, N of South Island, 14.4°S 145.3°E, reef front, sloping reef outside of lagoon and sandy bottom below, 10–17m, legit H. A. ten Hove, P. Hutchings and M. Reid, 5.iii.1986, Stn.20 (3 specimens, ZMA V. Pol. 3734, AM W20342). 3.**Lizard Island,** Palfrey Island, S. of light-house; coral heads on sandy bottom, 7 m, legit H. A. ten Hove, 2.iii.1986, Stn.17 (1 specimen in four fragments, BM(NH) 1992.65). 4. **Lizard Island,** S. South Island; sloping silty reef, little coral cover, legit H. A. ten Hove *et al*, Stn.21, 6.iii.1986 (8+ specimens, ZMA V. Pol.

3830, BM(NH) 1993.17, AM W21677). 5. **Boulton Reef**, on scleractinian coral (*Thecopsammia regularis* Gardiner 1899), USNM 78572, dry material, legit J. C. Lang, 31.vii.1973. H. Zibrowius, who identified this, kindly drew our attention to its serpulid epifauna.

Loyalty Islands, E. of New Caledonia: 6. SW Pacific Lagoon of Beautemps-Beaupré Atoll; overhang 8 m, on heavily encrusted dendrophylliid scleractinian coral, scuba diving, dry material; MUSORSTOM 6 cruise, legit H. Zibrowius, 17.ii.1989.

Okinawa (Japan): 7. W. side of Sesoko Island, 2–3 m, on cliffside, in caves and grooves, scuba diving, on unidentified coral, legit S. Nakamura, 10.i.1989, dry material, USNM . H. Zibrowius kindly drew our attention to the serpulid epifauna.

Sinai (Egypt): 8. Strait of Tiran, at Sharks Observatory, 20–25 m; Nos. 210–213, legit H. A. ten Hove, 8.vi.1990 (2 specimens, tubes, HUJ, ZMA V. Pol. 3886).

Elat (Israel): 9. In front of Marine Biological Laboratory, 20–25 m, coral rubble; Nos. 154, a–d, legit H. A. ten Hove, 4.vi.1990. 10. Oil port, S. pier, 6–25 m, coral rubble and pillars of pier; Nos. 181,244, 311, 339, 340, legit H. A. ten Hove, 6.vi.1990 (3 specimens, several tubes, HUJ).

TYPE LOCALITY. Taka Bone Rate (Flores Sea, Indonesia).

DESCRIPTION.

TUBES: Mustard coloured, with a pair of darker longitudinal bands in places along each flank, joined by transverse bands, especially just anterior to the thickenings found at intervals (Fig.26, A,C). They may be coiled more or less parallel to one another in the horizontal plane, mutually bonded together or spread out on the substratum and branched in places. Their external diameter is quite small, only up to about 0.6 mm. Earlier formed portions of tubes may show narrow transverse wrinkles (Fig.26, B,D). In fresh material the colour of the tube may be more brownish, and appears to fade to mustard after a few months in alcohol.

ITS consist of an unserrated ventral ridge only (Fig.26, B,E–I), which is T-shaped in cross-section towards its middle (Figs.26,G,I; 3, F), and becomes progressively less thickened both anteriorly and posteriorly (Fig.26, E,I).

WORMS: The total length of the worms ranges from 2.2 mm in the case of a juvenile, to a little more that 12.3 mm in an older individual which lacks its radioles. The complete holotype (Fig.26, J) is only 5.8 mm long. The thoracic width in all the specimens is around 0.3 mm.

An operculum may or may not be present. Younger specimens have radioles but lack opercula (Fig.26, L,M); apparently opercula appear only in older worms (Fig.26, A,J,K). The length of the operculum and peduncle in the holotype is 1.5 mm, the operculum 0.3 mm long and its diameter 0.2 mm. Its distal part is nearly globular (Fig.26,A,J,K) and, unlike the opercula of the other known members of the group, its margin is not divided into lobes, but shows about four pseudo-lobes, apparently caused by contraction in alcohol. Its proximal part is shaped like a narrow funnel, separated by a sharp constriction from the slender peduncle. A short filamentous rudimentary operculum was observed in one specimen only. It appears likely that, like the operculum, they are developed in older worms. Pinnule-free tips of radioles short. Thoracic glands were not found. Some counts and meristic data are given in Table 20:

The abdominal length in eight specimens ranged between 11.2 and 1.0 mm, and the number of segments between 48 and 22, respectively, with capillaries on the last 6 or 7.

Table 20 *S. snellii* sp. nov. Some meristic and other data of type series.

No. of specimens (n=6)	3	3			
No. of radioles	5/5	4/4			
No. of specimens (n=8)	2	1	2	2	1
No. of thoracic chaetal tufts	8/7	8/6	7/7	7/6	7/5
No. of specimens (n=3)	1	1	1		
Thoracic membrane ends	4/4	4/3	3/3		

Collar fascicles of older specimens bear about four fully formed bayonet chaetae and a developing one deep within. Each bayonet chaeta possesses a long serrated blade, a moderately long unserrated notch (1/3–1/4 the length of the entire blade), and several teeth on the basal boss (Fig.26, N–U; Pl.5, F). Thoracic uncini (Fig.26, V,W) and anterior abdominal uncini (Fig.26, X; Pl.5, G) bear 4–6 and 4–5 teeth, respectively, in a single row. Flat trumpet-shaped chaetae are typical (Pl.5, H).

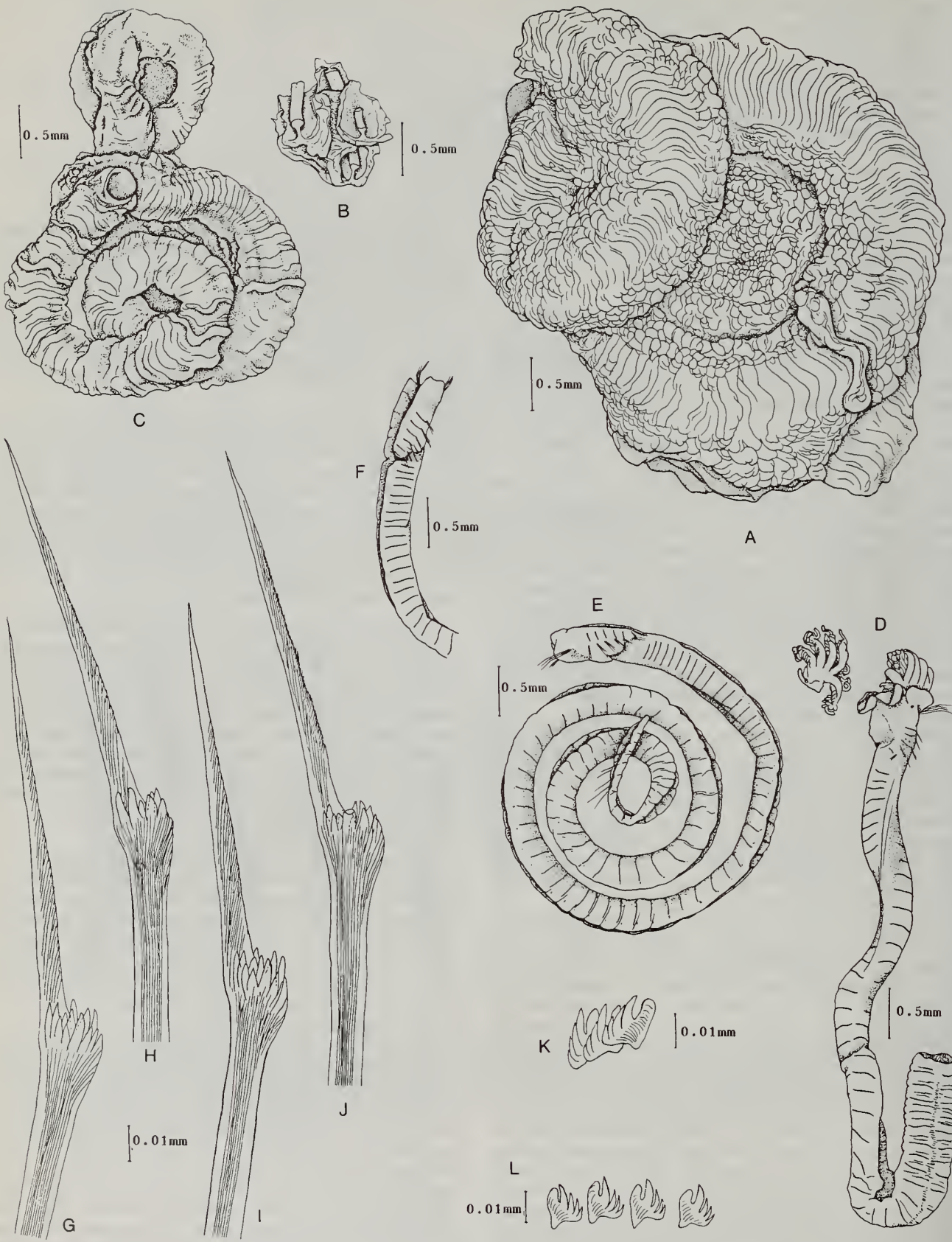
REMARKS. One single tube revealed 2 specimens: a parent with schizont closely appressed to its posterior end. Posteriorly, the abdomen of the parent was abruptly tapering (dorso-ventrally), with long capillaries. Lying between those, the three pairs of radioles of the schizont could be found. It had a narrow, still not fully developed thorax with 7/6 chaetal tufts, followed by a well-formed abdomen with 17 chaetigers (the last 7 with capillaries). The entire schizont was folded over the ventral internal ridge.

COLLECTIONS FROM OTHER LOCALITIES. The specimens in sample 2 from Queensland agree with those in the Indonesian sample with regard to the overall mustard colour. Against this background colouration there are darker mustard to brown longitudinal bands, which are variable. One of the three available tubes has a pair of lateral longitudinal bands, lacking in places. The second tube has a thin median longitudinal stripe in addition. The third has a pair of mustard yellow longitudinal bands laterally, and a broad brownish median band which is partially divided into two bands by a narrow, yellow longitudinal band.

They are coiled upon themselves either individually or mutually bonded together. The coils are more or less concentric, low, flattened against the substratum, and bonded together (Fig.27, A). The maximum external tube diameter is 1.2 mm. The granular overlay consists of a median longitudinal band made up of broad, transverse, forwardly-directed scutes, and a narrow band of smaller granules laterally (Fig.27, A). At irregular intervals there are wavy, thickened, peristome-shaped transverse ridges.

ITS agree with those of the Indonesian specimens. They consist of only an unserrated ventral ridge. Its edge is smooth and, in cross-sectional appearance, varies from being wedge-shaped to thickened and T-shaped at its maximal development (Fig.27, B). The cross-bar of the T may also be curved outwards and bear a shallow longitudinal depression. The mid-ventral longitudinal abdominal groove is applied to this ridge.

Three worms were removed from the tubes. One has a damaged thorax and an incomplete abdomen, while the second lacks the radioles of both sides, the third is broken in 4 fragments. The former (Fig.27,D), is 0.4 mm wide in the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0.01mm

thorax, and has 6 radioles and a short club-shaped rudimentary operculum on each side. The radioles are about 0.4 mm long and end in short pinnule-free tips. Two clusters of dark brown prostomial ocelli are present. There are 7 thoracic chaetal tufts on one side, but the number on the other side and the extent of the thoracic membranes cannot be determined due to the damaged thorax.

The first worm is spirally coiled along the substratal plane (Fig.27, E). The length of the thorax and abdomen is 13.8 mm, of which the posterior portion of about 1.18 mm is abruptly narrower than the rest of the abdomen. The entire length of the third worm is about 7.0 mm, radioles 1.3 mm, thorax and abdomen 5.7 mm; it has 7/6 radioles, and thoracic width of 0.35 mm.

There are 7 thoracic chaetal tufts on each side in one worm, 6/7 in the other. The thoracic membranes end between chaetal tufts 6 and 7 on the left, and 5 and 6 on the right (Fig.27, E,F). Thoracic glands are absent. The number of abdominal segments is 102, with capillaries on the last 6. A mid-ventral longitudinal groove traverses the entire abdomen and thorax (Fig.27, E, F).

Each collar fascicle bears about 4 bayonet chaetae. They have long serrated blades, a short unserrated notch, and several teeth on the basal boss (Fig.27, G–J). Thoracic uncini usually bear 4 teeth in a single row (Fig.27, K). The anterior abdominal uncini also possess 4 teeth in a single row, but the 3 posterior teeth are not closely appressed, as in the Indonesian specimens (Fig.27, L). Flat trumpet chaetae number about 3 per bundle. Since their edge is curved, details on the anterior tooth cannot be observed.

The third sample from Lizard Island, Queensland agrees with the first and the Indonesian specimens in all important characters (Fig. 27, A–J). The fully formed operculum is an unlobed funnel with a shallow distal concavity (Fig.28, C,D), while in the earlier stages it is spherical or nearly spherical (Fig.28, E–G).

The dry tubes from Loyalty Islands (Fig.28, K–Q) appeared to be brownish, but regained the typical mustard colouration when immersed in alcohol. One fragment shows branching (Fig.28, K). Internally there is only a smooth ventral ridge (Fig.28, N–Q), which is clearly T-shaped in places (Fig.28, Q); it is markedly so and occupies a larger part of the lumen in some tubes which are comparatively very thick-walled (Fig.28, N).

The collection from Ras Mohammed, Sinai, consists of tubes with fragments of worms (Fig.28, R–V). The tubes have an overall mustard colour, but the anterior portions (Fig.28, R,S) have pinkish peristomes, and a conspicuous granular overlay along the lateral borders of the attached portions (Fig.28, S). The medial overlay is scute-shaped, but not as prominent as in the first Lizard Island sample. A smooth ventral ridge is present (Fig.28, T–W), which is T-shaped in its fully formed condition (Fig.28, T,U,W). Those details of the worm that still could be observed (collar chaetae, ends of thoracic membranes) agree with the data given above.

The samples from Elat, Israel, agree with regard to tube colouration, the smooth ventral longitudinal ridge and other important characters. No.154 is a single specimen on a piece of coral rubble. The granular overlay is translucent in places; transverse scutes are not seen medially, but this may be because it is a juvenile. The worm has a total length of 3.6 mm; reddish prostomial ocellar clusters are present; its thorax is 0.2 mm wide; gills 1.0 mm long, with short pinnule-free tips; the number of thoracic chaetal tufts L?/R7; its abdomen 1.9 mm long, with 24 segments and capillaries on the last 4. There are 3 bayonet chaetae per fascicle, each with an elongated blade, a short unserrated notch and several teeth on the basal boss. Anterior abdominal uncini bear 4 teeth in a single row. An operculum had yet to be developed. However, an operculum was observed in sample 311. A schizont was separated from sample 244.

ETYMOLOGY. Named after the Indonesian-Dutch Snellius II Expedition which enabled the second author to collect extensively in Indonesian waters.

HABITAT AND DISTRIBUTION. A reef dweller occurring at depths of about 15–30 m. Appears to be the most widely distributed species of the genus. Hitherto collected from the northern Red Sea, Indonesia (Flores Sea), Australia (Great Barrier Reef) and W. Pacific (S. Japan to New Caledonia).

Spiraserpula lineatuba (Straughan, 1967) (Figs.29, A–O; 30, A–M; 3, L; Pl.1, A, C & D, Pl.3, E–G)

SYNONYMY. *Serpula lineatuba* Straughan, 1967, pp. 211–212, Fig.5a–g.

MATERIAL EXAMINED.
New South Wales: 1. Sydney, Long Reef, underside of rocks, LWS,27.ii.1965, legit D. Straughan (HOLOTYPE, AM4018). 2. Sydney, Long Reef, rocks just below LWS, Colloroy, Stn. 30, 27.i.1964 (Topotypical material, 2 specimens and several tubes, AM4019, ZMA V. Pol. 3450, BM(NH) 1992.51). 3. Norah Head, at foot of light house, from bottom of tidal pools at low-tide, from undersides of boulders, legit H. A. ten Hove, 12.iv.1986, Stn.31 (5 out of several specimens, AM W20340). 4. Split Solitary Island, rocky island area with corals, algae and little sand, from ceiling of small cave, 12–19 m, legit H. A. ten Hove, P. Hutchings and R. Phipps, 26.iv.1986, Stn.36 (18 out of several specimens, ZMA V.Pol. 3709, USNM 130996, BM(NH) 1992.40–50, AM W20163, QM, NSMT). 5. South Solitary Island, S of light house, rocky area, cobbles and corals, little sand, 12–20 m, legit H. A. ten Hove, P. Hutchings and R. Phipps, 27.iv.1986, Stn.37 (3 out of several specimens, BM(NH) 1992.52–60).

TYPE LOCALITY. Sydney, Long Reef (Australia).

DESCRIPTION.
According to the original description (Straughan, 1967), the tube is circular in cross-section, white, with a pair of dark pink lateral longitudinal stripes, pale pink dorsal surface. The

Fig. 27 *Spiraserpula snellii* sp. nov. From Stn. 20, Lizard Island, Australia: A, Adult tube showing flattened coil form, granular overlay, which is scutate medially, granular laterally and has a transverse thickened peristome. B, Aggregation of tube fragments with unserrated ventral ridge, T-shaped in cross-section. C, Scutate juvenile tube with some transverse thickenings; granular overlay not yet developed. D, worm showing radioles, rudimentary operculum and collar. E, worm from tube figured in A, showing thoracic membrane, ventral longitudinal groove. F, Anterior part of latter, showing lack of apron and thoracic membrane ending on the 6th chaetiger on the left side. G–J, Bayonet chaetae, all from same fascicle. K, Thoracic uncini. L, Anterior abdominal uncini.

total length of the worm ranges from 4.5–6.5 mm. There are 4–6 pairs of branchiae with pinnule-free tips. A hollow operculum with about 22 lobes is present on one side, with a pseudoperculum on the other. The collar has a pair of lateral elongations on the median lobe. The thorax has 9 or 10 segments on each side, and the bayonet collar chaetae have 2 conical processes at the base of the blade.

The holotype (AM W4018) is in very poor condition. When it was examined by the second author in 1979, the poorly preserved worm, still within its tube, lacked both an operculum and a rudimentary operculum, although there appeared to have been one on one side and none on the other. Other observations were as follows: A cluster of pigmented ocelli present at the base of each branchial lobe; bayonet collar chaetae possess 2 conical teeth, with 1–3 accessory conical teeth; the anterior abdominal uncini of two types: some with a single row of teeth, others in which the posterior tooth is split into two; middle abdominal uncini appeared to possess 7 simple teeth in side view; in edge view, however, four anterior teeth are single and the rest are rows of 3 minute teeth each.

However, examination of topotypical material collected on the same date as the holotype and determined by Straughan (AM 4019, ZMA V.Pol. 3450) yielded the following additional data: The tube has a pair of light pink longitudinal bands (Fig.29, A), not clearly defined dark pink stripes as mentioned and figured in the original description. It is coiled, somewhat flattened against the substratum, but the free surface is rounded. The coils are bonded together. A granular overlay is present, but it is extremely fine and can only be seen in places, under special illumination (Fig.29, F). A short erect portion is present (Fig.29, A,B), with a four-lobed peristome similar to that of *S. massiliensis*.

The most important data obtained during the present study of this topotypical material is that *S. lineatuba* has ITS. They consist of an unserrated dorsal ridge along the convex wall (Fig.29, B,C,E,F), and a serrated ventral ridge along the opposite wall (Figs.29, D,F; 3,L). The former may be high in the first formed coil (Fig.29, E, F, bottom left), or low anteriorly (Fig.29, B,C), and is wedge-, tongue- to somewhat T-shaped in cross-section.

The worm is 6.5 mm long, its thorax is 0.5 mm wide, and its abdomen is 4.5 mm long. There are 5 radioles and a slender rudimentary operculum on one side. The median lobe of the collar has only one forwardly directed process, in contrast with the original description, indicating that this is a variable feature. There are 7 pairs of thoracic chaetal tufts, and the abdomen has 49 segments, with capillaries on the last 19. Two clusters of prostomial ocelli are present and the thoracic membranes do not extend to the last thoracic chaetigers, but end on the fourth and fifth.

There are 5 bayonet chaetae in each collar fascicle, each with a moderately long serrated blade, a moderately long unserrated notch which is 1/3–1/4 the length of the blade, and 2 or 3 conical teeth on the basal boss (Fig.29, G–J; Pl.3, E). In bayonets with two large teeth, a single accessory tooth may be present between them (Fig.29, G,H,J). Thoracic uncini bear 5 or 6 teeth. As seen in edge view, in the outermost uncini of the row, 3 to 5 of the anterior teeth are single, while the remaining teeth are subdivided into 2 or more smaller teeth which form a short, rasp-shaped posterior cluster (Fig.29,L). Anterior abdominal uncini are similar (Fig.29, N). However, SEM of anterior abdominal uncini of another specimen showed a single row of teeth in edge view (Pl.3, F). It appears, therefore, that both types of uncini may sometimes be present. Posterior abdominal uncini are rasp-shaped, except for the single anterior tooth. The uncini of the intermediate region show a transition between the two types. Flat trumpet chaetae number about 5–7 per fascicle (Fig.29, N; Pl.3, G).

A more complete account of the species, however, was obtained from numerous well-preserved specimens collected in 1986 from Split Solitary Island.

TUBES: Have the colouration described above, including the pair of light to somewhat darker pink lateral longitudinal bands. They occur in aggregations of a few to numerous individuals, highly coiled amongst themselves and mutually bonded together, particularly at their bases (Fig.29, O). Erect parts are sometimes present, and they may bear four-lobed peristomes (Fig.30, A). The uncoiled part of one of the longest tubes measures 26.7 mm; together with its coiled part it is approximately 30.0 mm long, and its maximum external width is 1.1 mm.

ITS consist of an unserrated dorsal ridge, a serrated ventral ridge and, usually, a pair of accessory dorso-lateral ridges (Figs.29,O, middle left; 30, B,C; 3, L; Pl.1, A,C,D). The dorsal and ventral ridges of the tube are applied to corresponding longitudinal mid-dorsal and mid-ventral abdominal grooves (Figs.30, D–F).

Eighteen worms from Split Solitary Island provided important additional data. Measurements and other meristic data from 8 complete specimens of total lengths ranging between 15.9 mm and 1.3 mm presented in Table 21 show that the worms can attain two and a half times the length mentioned in the original description. The maximum number of abdominal segments counted is 89:

Thirteen complete anterior ends all possess an operculum on one side, a rudimentary operculum on the other, and 5 pairs of radioles. The pinnule-free tips are about 1/4 the length of the radioles and are as thick as the pinnules (Fig.30, D,E). The length of the operculum together with its peduncle ranges between 0.8 mm in the smallest specimen to 1.6 mm in the largest; the length of the operculum itself from 0.3 mm to 0.7 mm, and its diameter from 0.4 mm to 0.6 mm, respectively. All the opercula are zygomorph (Fig.30, D,F), their distal ends are concave and the radii end in somewhat pointed lobes. Many of the latter are actually double, the sub-dividing grooves being only about 1/3 the length of the main interradial grooves which extend to about half the opercular length. Thus the total number of about 17–23 radii end in about double the number of marginal lobes (Fig.30, D–F). The constriction between the peduncle and the operculum is

Fig. 28 *Spiraserpula snellii* sp. nov. A–J, from Stn. 21, Lizard Island, Australia. K–Q, From Loyalty Is. R–W, from Egypt. A–B, Tube lacking scutes and granular overlay, but with faint transverse grooves between transverse areas (representing scutes ?). D–E, Same worm with fully formed operculum. E–G, worms showing early vesicular operculum. H, Bayonet chaetae. I, Thoracic uncini. J, Anterior abdominal uncini. K, Anterior fragment of a tube showing branching and a peristome. L, Another fragment showing transverse ridges. M, Juvenile tube. N, Fractured end of a tube showing a thick wall and a T-shaped ventral ridge occupying most of its lumen. O–Q, Tube fragments with varying form and thickness of the T-shaped ventral ridge. R & S, Anterior tube fragments, R with peristomes. T–W, tube aggregations with fractured ends showing the T-shaped ventral ridge. W, V, with longitudinal view of ventral ridge.

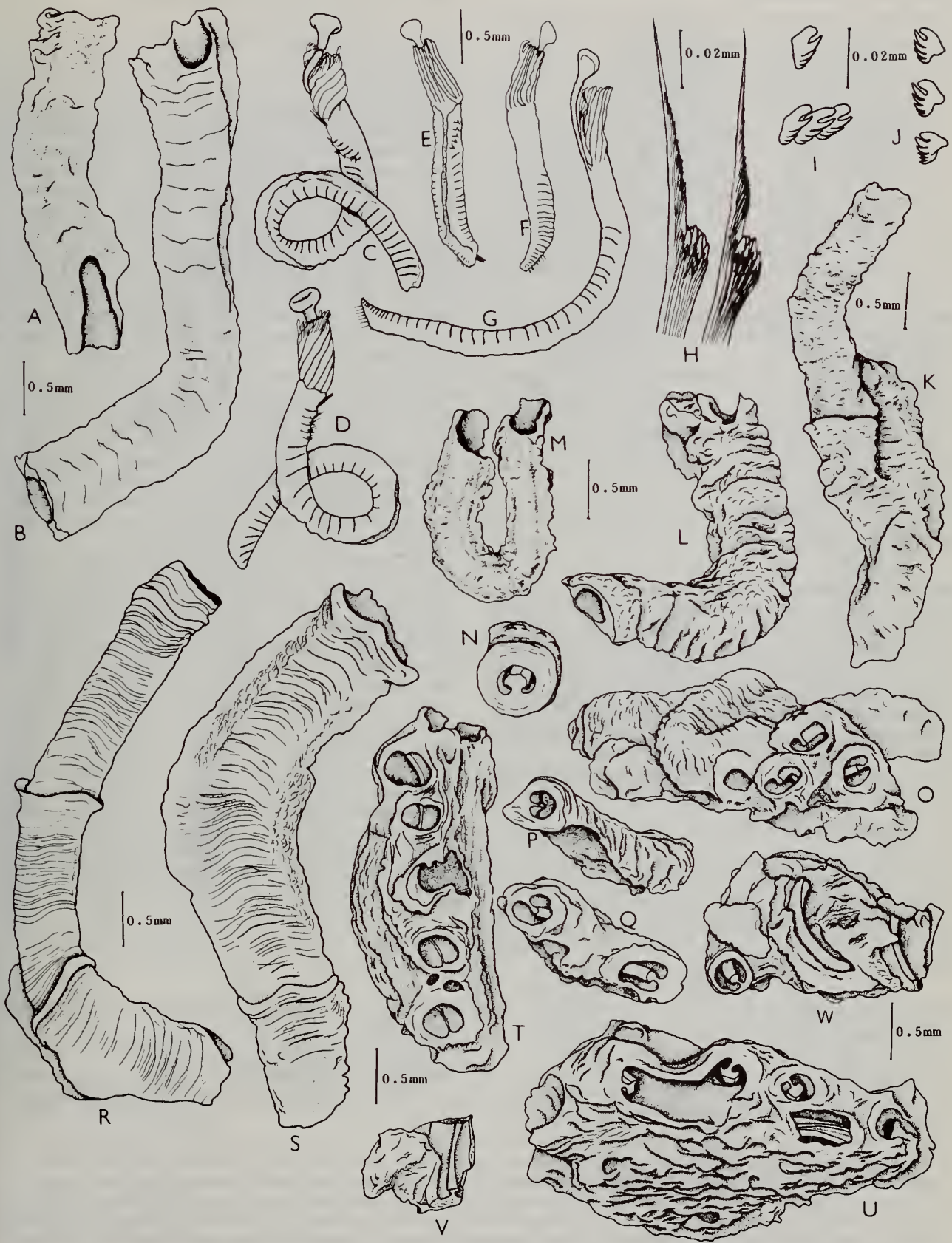
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Table 21 *S. lineatuba* (Straughan). Measurements and counts from Split Solitary Island material.

Specimen no.	Total length	Width of thorax (mm)	Length of abdomen (mm)	No. of abdominal segments	Capillaries on
1	15.9	0.6	13.2	89	13
2	15.7	0.6	12.6	85	13
3	15.7	0.5	12.7	81	12
4	13.9	0.5	10.9	58	17
5	13.0	0.5	12.7	81	13
6	10.1	0.5	10.9	58	17
7	9.3	0.5	6.8	78	16
8	1.3	0.5	0.4	45	25

Table 22 *S. lineatuba* (Straughan). Number of thoracic chaetal tufts and extent of the thoracic membranes in specimens from Split Solitary Island.

No. of specimens (18)	1	1	4	4	1	4	2	1		
No. of thor. chaetal tufts	10/10	10/9	10/8	9/9	9/8	8/8	8/7	7/7		
No. of specimens (15)	1	1	1	4	1	1	2	1	2	1
Thoracic membr. ends	7/5	6/4	5/5	5/4	5/3	4/4	4/3	4/2	3/3	3/2

sharp, and the diameter of the distal end of the former varies from 1/3 to 2/3 that of the base of the latter.

The median lobe of the collar shows one or more anteriorly directed processes in some specimens, none in others. Up to 8 bayonet chaetae have been counted in a collar fascicle. A pair of ventral thoracic glands is present (Fig.30, E). The number of thoracic chaetal tufts on each side varies from 7–10, and the thoracic membranes end on the 3rd to 6th chaetigers, as shown in Table 22.

The specimens from South Solitary Island and Norah Head agree with the above description.

LIVE MATERIAL. No records.

HABITAT AND DISTRIBUTION. The species occurs from the tidal zone down to about 20 m. It was very abundant on a ceiling of a small cave at a depth of 12–19 m, forming aggregations of up to 35 mm thick, and superficially resembles *S. ypsilon* from a similar habitat in the Cape Verde Islands. It has hitherto been collected only from N.S.W.

Spiraserpula discifera sp. nov.
(Figs.31, A–M; 3, M)

MATERIAL EXAMINED.
New South Wales: Sydney, Long Reef, from undersides of rocks in and bottom of tidal pools, mats of *Serpula rubens* Straughan, 29.iii.1986, legit H. A. ten Hove and P. Hutchings, Stn. 30 (HOLOTYPE, AM W20390).

TYPE LOCALITY. Sydney, Long Reef (Australia).

DESCRIPTION.
TUBE: Pink, with whitish lateral attachment areas and very fine transverse wrinkles. The median tube parts are of a paler pink colour than the medio-lateral parts, in fresh material. A fine granular overlay is present, which can be seen at certain angles of illumination. The lateral borders of the tube are glassy and transparent. Irregularly laid along the outer surface of the tube, and more or less perpendicular to it, are small semilunar to crescentic discs (Fig.31, A–C,E). They are very thin, pink, glassy and transparent, and their axes are at various angles to the longitudinal axis of the tube. Some of them are even attached to the substratum just outside the tube (Fig.31, B). The maximum external diameter of the tube is 0.85 mm.

ITS consist of a serrated ventral ridge along its concave wall (Fig.31, E), and a smooth dorsal ridge. In addition, pink disks are found on the inside too, on either side of the serrated ventral ridge (Figs.31, D; 3, M). In some cases the discs appear to be through and through the wall. The mid-ventral longitudinal groove of the abdomen (Fig.31, F) is applied to the serrated ventral ridge. The worm appears to have a remarkable ability to adjust its abdominal segments in relation to these sharp discs within the tube.
WORM: Although only one specimen is available, it is complete (Fig.31, F). Its total length is 7.7 mm, thoracic width 0.56 mm; the abdomen is 6.6 mm long and has about 56 segments, the last 20 with capillaries. There are 6 radioles and a rudimentary operculum on each side. A cluster of blackish prostomial ocelli is present at the base of the radioles on each side. There are 8 pairs of thoracic chaetal tufts. Where the thoracic membranes of the two sides end precisely is not clear since the thorax is highly contracted (Fig.31, F,G), but an apron is absent. No thoracic glands were discernible.

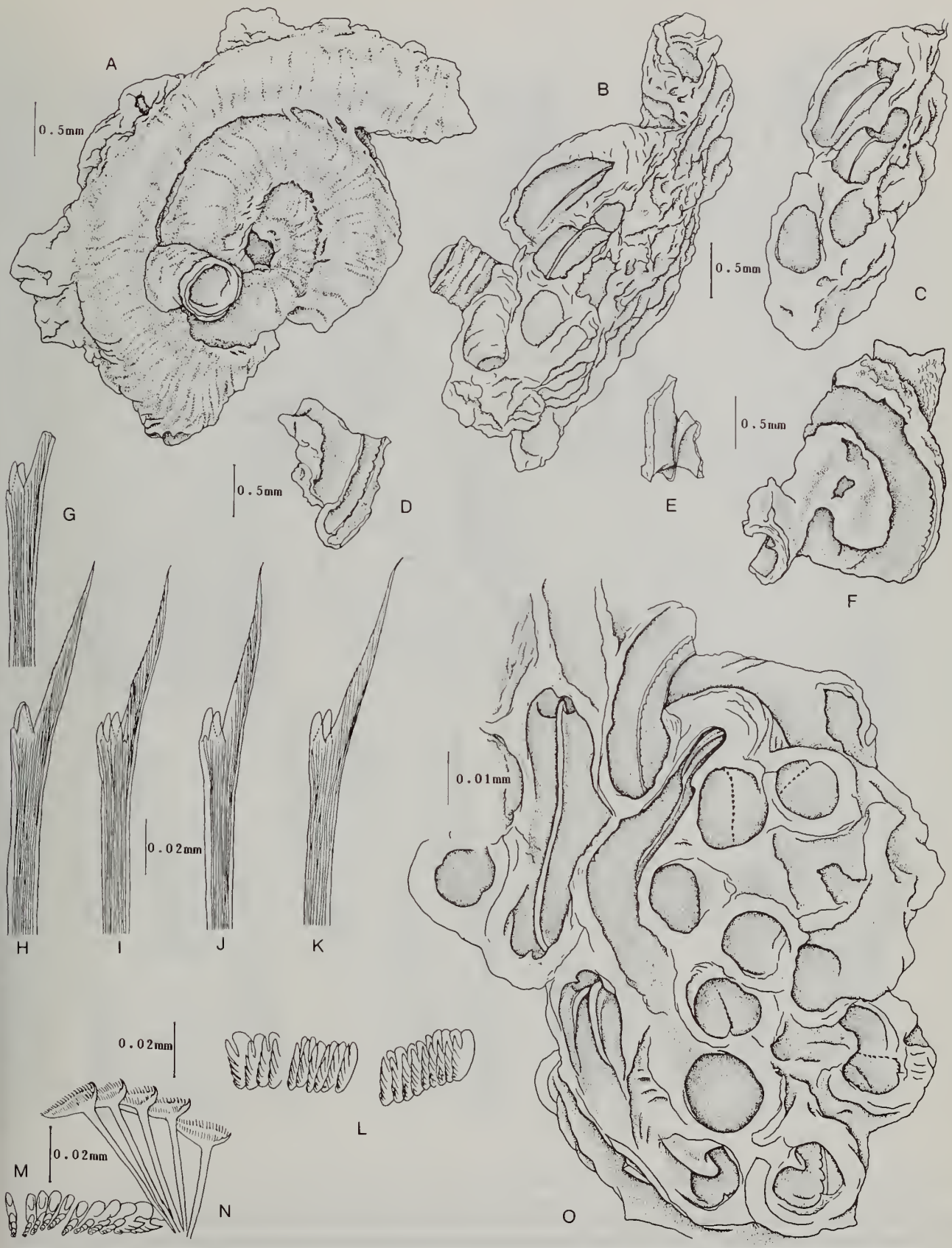
The number of bayonet chaetae, 6 in each collar fascicle, is high in relation to the size of the worm. Their serrated blades are moderately long, the unserrated notch is about 1/3 the length of the blade, and there are only 2–4 teeth on the basal boss (Fig.31,H–M). A few small accessory teeth may be present. Thoracic and anterior abdominal uncini bear about 6 and 5 teeth, respectively, in a single row.

ETYMOLOGY. diskos (Gr.) = discus; pherein (Gr.) = to carry.

LIVE MATERIAL. Animal is orange in colour, with transparent branchiae.

HABITAT AND DISTRIBUTION. *S. discifera* occurs intertidally on rocks. It has hitherto been collected only from Sydney.

Fig. 29 *Spiraserpula lineatuba* (Straughan, 1967). A–N, From topotypical material, Straughan's original collection, NSW, Long Reef, AM4019, ZMA V. Pol. 3450. O, From NSW, Split Solitary Island. A & B, Two views of same coiled tube with an erect part ending in peristome, with longitudinal colour bands in A. B & C, Same tube with posterior coils opened to show the dorsal ridge. D & F, Tube fragments with serrated ventral ridge. E, Posterior tube fragment with unserrated dorsal ridge. G–K, Bayonet collar chaetae. L, Thoracic uncini with more than one row of teeth posteriorly. M, Anterior abdominal uncini. N, Bundle of flat trumpet chaetae from same abdominal segment. O, Aggregation of tubes showing serrated ventral ridges along concave walls, unserrated dorsal ridges along convex walls, and accessory dorso-lateral ridges (bottom left).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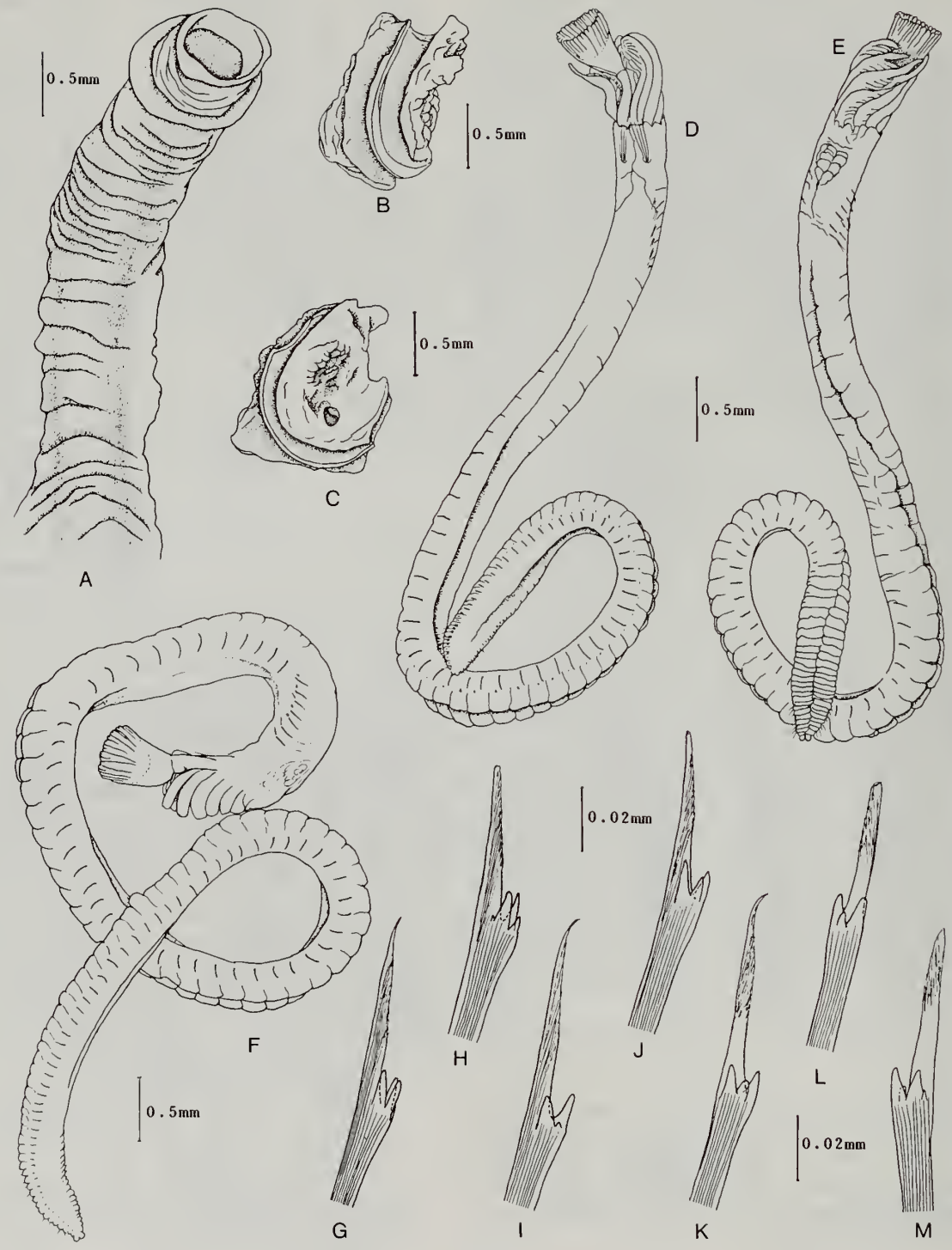


Fig. 30 *Spiraserpula lineatuba* (Straughan, 1967). A–M, From NSW, Split Solitary Island. A, Erect tube part showing fine transverse wrinkles and longitudinal colour bands. B & C, Views of same posterior coil, opened, exposing unserrated dorsal ridge. D & E, Two views of the same worm, and F, another worm, showing zygomorph operculum, extent of thoracic membranes, and dorsal and ventral abdominal grooves. G–M, Bayonet chaetae showing variations in the teeth on the basal boss.

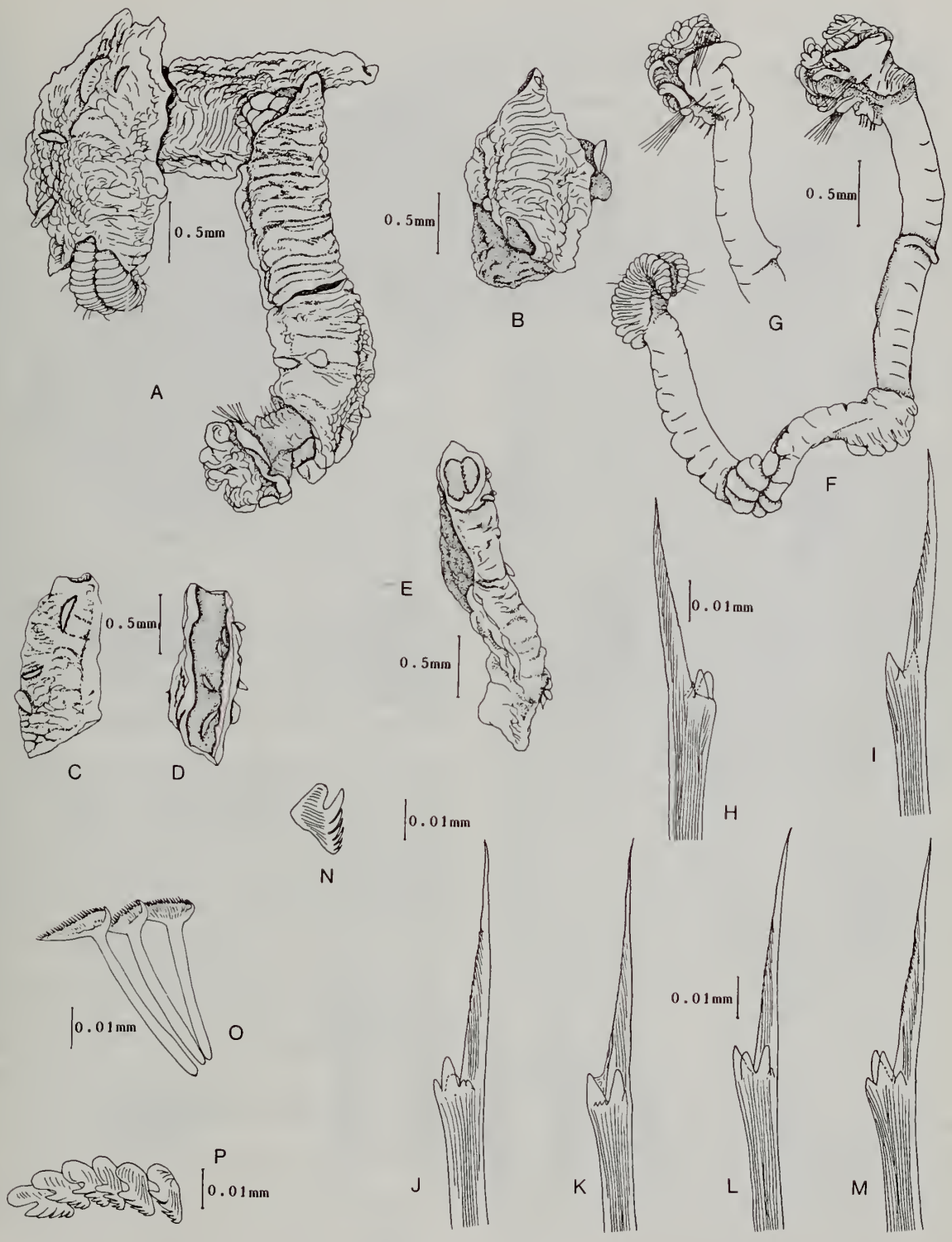


Fig. 31 *Spiraserpula discifera* sp. nov. From holotype. A, Fractured tube showing transverse wrinkles, granular overlay, and characteristic sharp crescentic discs on outer surface. B, Tube fragment, with one of the discs fixed to the substratum, adjacent to the tube. C & D, Opposite halves of tube fragment split open to show the ITS: a serrated ventral ridge (in longitudinal view), and a lateral row of transparent crescentic discs. E, Tube fragment with internal serrated ventral ridge and external crescentic discs. F, Worm, showing ventral abdominal groove. G, Anterior part of worm showing thorax, collar and thoracic membrane. H–M, Bayonet chaetae, all from same fascicle. N, Thoracic uncinus. O, Abdominal chaetae. P, Anterior abdominal uncini.

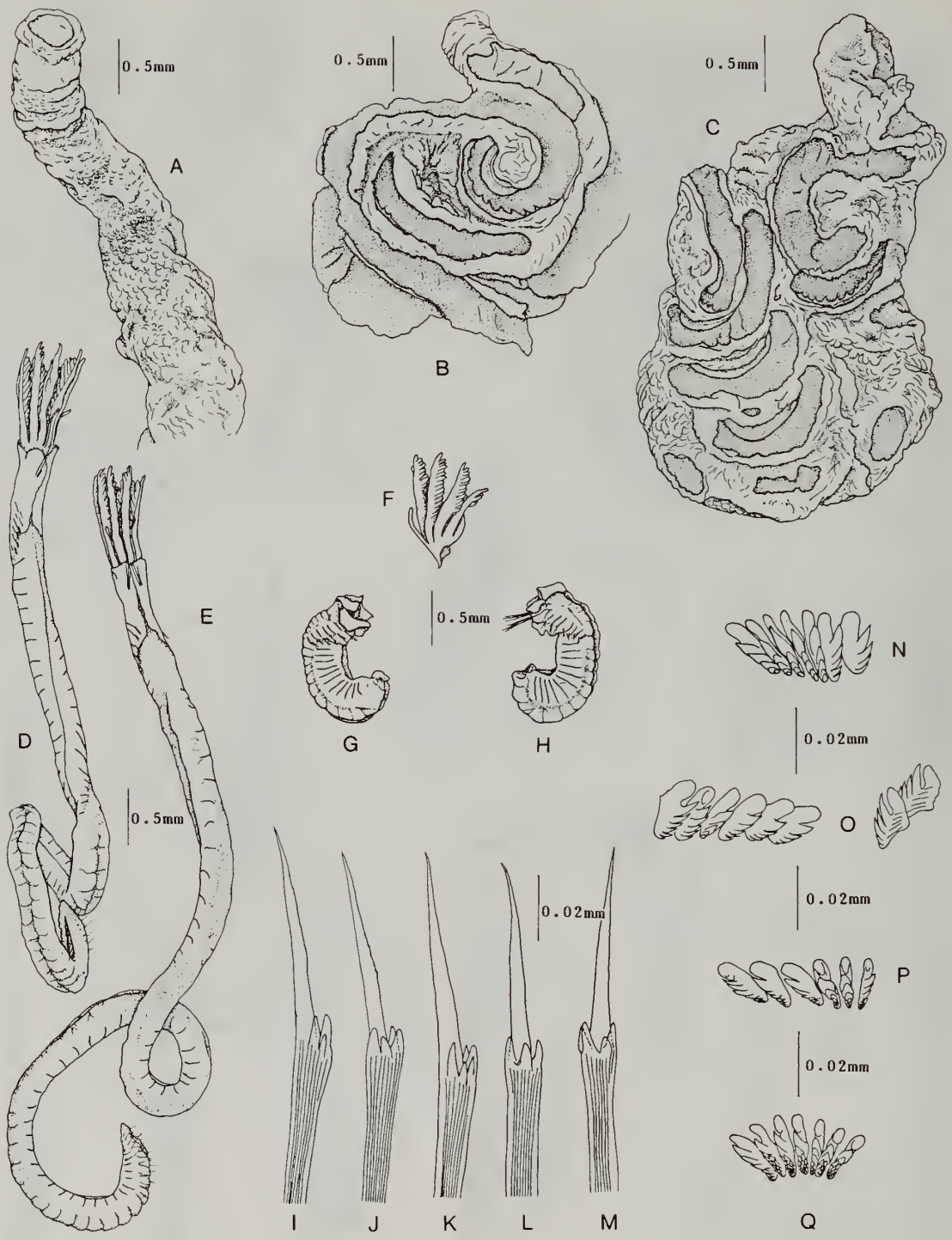


Fig. 32 *Spiraserpula minuta* (Straughan, 1967). A–Q, From Port Douglas, N. Queensland. A, Erect part of tube showing granular overlay. B & C, Substratal view of tubes opened to show ITS: an unserrated dorsal ridge along the convex wall, and a serrated ventral ridge opposite. D & E, Complete worm showing filamentous rudimentary opercula, extent of thoracic membranes and dorsal and ventral longitudinal abdominal grooves. F, Branchial crown and rudimentary operculum of right side from another worm. G, Two views of the anterior part of a worm fixed outside the tube, collar and thoracic membranes. I–M, Five bayonet chaetae from one fascicle. N, Thoracic uncini. O, Anterior abdominal uncini. P, Uncini from a torus middle abdominal region. Q, Posterior abdominal uncini.

Spiraserpula minuta (Straughan, 1967)
(Figs.32, A–Q; 3, N)

Synonymy: *Pseudoserpula minuta* Straughan, 1967, p.216, Fig.6, h–l.

MATERIAL EXAMINED.
Queensland (Australia): 1. Port Douglas, sheltered side of rocks, near LWM, legit D. Straughan, 17.i.1963 (HOLOTYPE AM W4062). 2. Same locality and date, legit D. Straughan: (25 studied out of numerous specimens, AM W4059).

TYPE LOCALITY. Port Douglas, Queensland (Australia).

DESCRIPTION. According to the original description, the tubes are white, round, and may have a pink tinge. An operculum or pseudopercula (=rudimentary opercula) are absent, there are 5 pairs of radioles, the number of thoracic chaetigers is 7 or 8, and bayonet collar chaetae have 2 or 3 blunt teeth on the basal boss (Straughan, 1967). *Vide* discussion on the taxonomy which follows this description.

The holotype (AM W4062) was examined by the second author in 1979. Upon removal of the worm from its tube, it lacked a branchial crown and its abdomen consisted of 48 segments, the last 6 with capillaries. However, the present study revealed that AM W4059, which was collected from the same locality and on the same date by Straughan, contains several well-preserved specimens, and the following description is based on 25 of them.

TUBES: Whitish in juveniles, with a very faint overall pinkish tinge in adults but, unlike *S. lineatuba* (Straughan), lacking a pair of pink longitudinal bands. They occur in aggregations of a few to several individuals which are mutually bonded at their bases (Fig.32, C). Their anterior ends are often free and erect (Fig.32, A). A very fine granular overlay is present (Fig.32, A).

ITS, located in the first formed parts of the tube, consist of an unserrated dorsal ridge, which is somewhat T–shaped in cross-section, along its convex wall, and a serrated ridge along the opposite side (Figs.32, B,C; 3, N). The posterior end of the abdomen often shows a short mid-dorsal longitudinal groove, into which the unserrated dorsal ridge of the tube fits (Fig.32, D). The serrated ventral ridge of the tube fits into a mid-ventral longitudinal groove in the abdomen (Fig.32, D).

WORMS: Out of the 25 specimens only 11 are complete. Three have total lengths of over 10 mm, three between 8.0 and 10.0 mm, and five between 6.4 and 8.0 mm. Measurements and meristic data of the longest and two smallest specimens are presented in Table 23:

Quite in contrast to the original description, nineteen specimens with complete anterior ends all possess a pair of rudimentary opercula (Fig.32, D–F). A fully formed operculum is absent. The length of the radioles, ranges between 1.0 mm and 1.3 mm, and they end in short pinnule-free tips which are about as long and as thick as the pinnules (Fig.32, D–F). Some meristic data on the population are given Table 24.

Table 23 *S. minuta* (Straughan). Measurements and meristic data of three specimens.

Specimen no.	Total length	Thoracic width (mm)	Length of abdomen (mm)	No. of segments	Capillaries on
1	13.7	0.5	11.3	82	11
2	7.5	0.5	5.5	48	8
3	6.5	0.5	5.2	78	10

Table 24 *S. minuta* (Straughan). Meristic and other data.

No. of specimens (n=19)	2	14	3				
No. of radioles	6/5	5/5	5/4				
No. of specimens (n=20)	1	2	8	4	2	2	1
No. of thor. chaetal tufts	9/8	9/7	8/8	8/7	8/6	7/7	7/6
No. of specimens (n=17)	2	3	5	6	1		
Thor. membranes end	6/5	6/4	5/4	4/4	4/3		

The thorax is somewhat wider in specimens that had been accidentally removed from their tubes prior to fixation (Fig.32, G,H). Two clusters of prostomial ocelli are present. Ventral thoracic glands were not discernible.

The numbers of bayonet chaetae in 8 collar fascicles from different specimens, including a developing one deep within are: 4 in 1, 5 in 6, and 6 in 1. Their blades are moderately long and faintly serrated. The unserrated notch is about 1/3 the length of the blade. The tooth counts in the above 40 bayonet chaetae are: 3 in 18 (Fig.32,I,L), 4 in 17 (Fig.32, J,M), 5 in 1 (Fig.32, K), and indeterminate in the remaining 4. The usual number of teeth is, therefore, 3 or 4. In some chaetae two teeth may be large, while the third is much smaller (Fig.32,I).

Thoracic uncini (Fig.32, N) bear 4–5 teeth in a single row. Anterior abdominal uncini (Fig.32, O) are similar, with 4–6 teeth. Posterior abdominal uncini bear 1–3 teeth in a single row anteriorly, followed by a rasp-shaped cluster of smaller teeth posteriorly (Fig.32, Q). In the intermediate region there is a gradual reduction of the number of anterior teeth in the single row and a corresponding increase in the posterior cluster (Fig.32, P).

ETYMOLOGY. Renamed after its discoverer, D. Straughan.

HABITAT AND DISTRIBUTION. *S. minuta* occurs in shallow water, where it may form 'dense mats on the sheltered side of vertical rocks near L.W.M.' (Straughan, 1967).

It has hitherto been reported only from the type locality, Port Douglas, Queensland.

DISCUSSION

Spiraserpula Regenhardt 1961 differs from the remaining genera of its clade, namely *Serpula* Linnaeus 1758, *Hydroides* Gunnerus 1768 and *Crucigera* Benedict 1887, with regard to an important character, namely, the presence of ITS. In addition, the worm lacks an apron. The tubes of the other three genera lack ITS and, with a few exceptions, their worms possess an apron.

Straughan (1967) erected the the genus *Pseudoserpula* for *P. rugosa* (type species) and *P. minuta*, believing an operculum to be absent in both, and distinguished between them on the grounds that the former possessed a pair of pseudopercula (= rudimentary opercula) which were said to be absent in the latter. Ten Hove and Jansen-Jacobs (1984:162–165)

synonymized *Pseudoserpula rugosa* Straughan, 1967, with *Crucigera inconstans* Straughan, 1967, stating that the type of *Pseudoserpula* is a pseudoperculate individual of *C. inconstans*, but the evidence was incomplete. Moreover, there still remained the problem of the actual generic identity of *P. minuta* Straughan, 1967. Hence it was considered necessary to re-examine the types of *P. rugosa* and *P. minuta* and compare them with other collections, including those of *Crucigera inconstans*.

The holotype of the nominal species *Pseudoserpula rugosa* (AM W4027) yielded the following data: The tube is white, 2.0 mm in external diameter, and has conspicuous transverse wrinkles (Fig.33, A–C). It lacks ITS. An operculum is absent, but a rudimentary operculum is present on each side (Fig.33, C). An apron is present (Fig.33,B). The bayonet chaetae typically possess two conical teeth on the basal boss, as seen in developing chaetae deep inside the fascicle (Fig.33,H,I); one of the conical teeth may be smaller than the other or abraded in the older chaetae (Fig.33, D–F). A short, unserrated notch is present; the chaetal shaft is smooth below the teeth.

Additional material of *Crucigera inconstans* (NSW, Sandy Beach, 21 km N. of Coffs Harbour, legit H. A. ten Hove, 27.iv.1986, Stn. 38 [8 specimens, ZMA V. Pol. 3741] and Sydney, Long Reef, intertidal rockpools, legit H. A. ten Hove and P. Hutchings, 29.iii.1986, Stn 30. [1specimen, ZMA V. Pol. 3740]) gave the following data: The tube is smooth and has transverse wrinkles (Fig.33, J). Only three specimens, two from Sandy Beach and one from Long Reef, possess opercula; the remaining five only rudimentary opercula. The opercula (Fig.33, J–L, S–V) agree fully with Straughan's description and figures of *C. inconstans*. The bayonet collar chaetae (Fig.33, M–P) agree with those of the holotype of *Pseudoserpula rugosa*. The rudimentary opercula show different stages of development: both club-shaped, with somewhat tapering ends in the holotype (Fig.33, C); one long and tapering, the other more bulbous (Fig.33, W); and a clearly developing operculum (Fig.34, A). While the holotype of *Crucigera inconstans* has 10 or 11 pairs of radioles (Straughan, 1967), an operculate individual in our material shows 15/16. The bayonet chaetae (Fig.34, D–M) are similar, although they may occasionally possess a small third tooth (Fig.34, J). A well developed apron is present in non-operculate and operculate specimens (Fig.34, B), and in the holotype of *P. rugosa* (Fig.33, B).

Some of the specimens bearing rudimentary opercula have regenerating radioles and/or operculum, which appear to have been nipped off on one side or the other (Figs.33, W; 34, C). In one of the operculate specimens too some of the radioles are regenerating (Fig.33, J). It appears, therefore, that opercula and radioles in *Crucigera inconstans* are favoured as food by certain predators. Whether this is the sole reason for a large number of specimens possessing only rudimentary opercula or not, has to be determined through further studies. It is worth noting, however, that the radioles of both sides in the holotype of *Pseudoserpula rugosa* are disproportionately small for the size of the worm, and show every indication of being in a state of regeneration (Fig.33, B,C).

Meanwhile, *Pseudoserpula minuta* Straughan, 1967, lacks an apron and has ITS and, therefore, belongs to the genus *Spiraserpula* Regenhardt, 1961.

Another nominal genus, *Protoserpula* Uchida, 1978, needs to be discussed. Its original description does not mention if and where any material has deposited. It is not in the National Science Museum, Tokyo, and other efforts to obtain it were unsuccessful. Among the generic characters mentioned are the following: An operculum is absent, the number of thoracic chaetigers is 9 or 10, and capillary chaetae are absent towards the posterior end of the abdomen. The latter is emphasized in the statement 'All the species of *Serpula* and its related genera have their long hair-like abdominal posterior segments, but the new genus has not such kind of setae in abdomen' (Uchida, 1978: p.23).

The more important characters described under *P. pacifica*, the type species, are as follows: 'Tube calcareous white opaque, cylindrical form, attached throughout its length, curved irregularly . . Operculum absent. Branchiae consisting of 5 pairs of filaments and a pair of palpi. . . The ventral-most one pair of branchiae are much reduced (0.3mm long). . . The thoracic membrane developed in the anterior region but suddenly reduced in width from the 5th segment, and it becomes to continue to the abdominal body surface without any structures in the last thoracic segment. Abdomen . . . consisting of about 20 setigerous segments, 2.5 mm long and 0.2 mm wide. . . Bayonet-shaped seta has a basal process with about 8 large teeth arranged into a circle. . . Each abdominal segment has 1–3 spatulate setae and 8–11 uncini on one side. . . The spatulate setae arranged to the last setigerous segment, and without substitution to the long hair-shaped setae as occurred in every species in *Hydroides, Serpula, Vermiliopsis*, and other many genera' (Uchida, 1978, p.23–24).

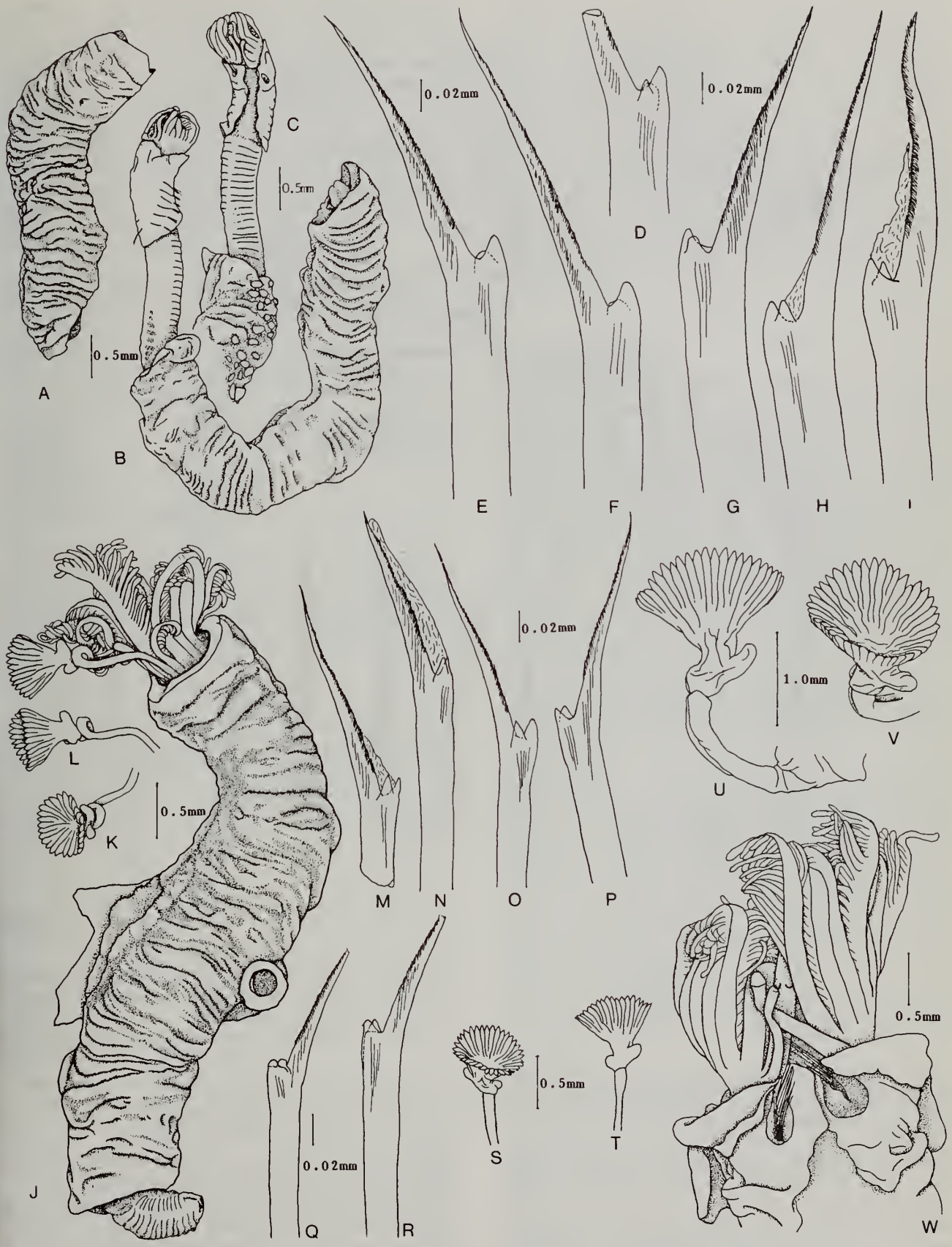
Protoserpula appears to be based on a juvenile serpulid (ten Hove, 1984, p. 193). A juvenile specimen would not be sound for erecting a genus since the adult characters could be different, particularly with regard to the presence or absence of an operculum.

In the development of operculate serpulids, the operculum appears after a certain number of radioles have already been formed (ten Hove 1984, p.183, and Fig. 3). This appears to be in keeping with the greater importance of feeding and respiration over closure of the tube against predators at this stage. The dorsalmost pair of radioles remains simple and palp-shaped, and forms the lateral appendages of the dorsal lip (mouth palps). In this process they may decrease in size. The operculum develops as a modification of the second most dorsal radiole of one side.

As seen from the species of *Spiraserpula* described in this account, some possess an operculum, some may or may not possess one, and others lack one but possess a rudimentary operculum on each side. Some agree with regard to the number of radioles, but none of them show palps.

It appears unlikely that rudimentary opercula (=pseudopercula) were mistaken for 'a pair of palpi' since, in the same paper, Uchida clearly distinguishes between pseudo-

Fig. 33 *Crucigera inconstans* Straughan, 1967. A–I, From holotype of *Pseudoserpula rugosa* Straughan, 1967, with only rudimentary opercula. A, Anterior part of tube. B & C, Worm within posterior part of tube, showing apron (B), presence of rudimentary opercula (=pseudopercula, C). D–I, Bayonet chaetae. J–W, *Crucigera inconstans* Straughan, 1967 from Long Reef, Sydney. J & K, Operculate specimen within its tube and three views of its operculum. M–R, Bayonet chaetae from same fascicle, M & N newly formed deep within fascicle. S & T, Two views of small operculum. U & V, Two views of large operculum. W, Anterior end of large non-operculate specimen with two rudimentary opercula.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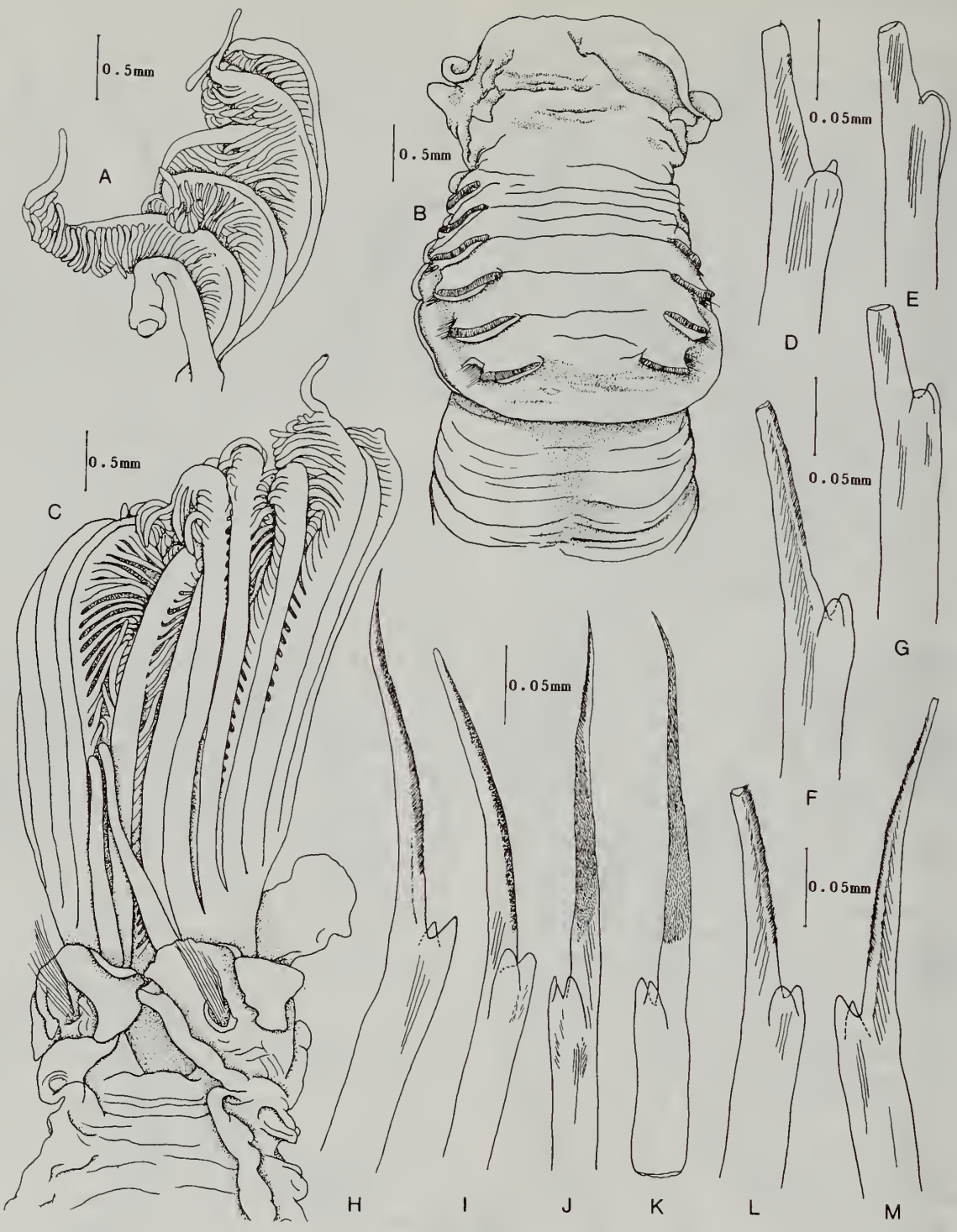

Fig. 34 *Crucigera inconstans* Straughan, 1967. A–M, From Sandy Beach, 21 km from Coff's Harbour. A, Right radioles of non-operculate specimen with rudimentary, but developing, operculum. B, Ventral view of large specimen showing apron. C, A large non-operculate individual with rudimentary opercula. D–M, Bayonet chaetae from the same fascicle of a large non-operculate specimen.

percula and opercula while defining the genera *Serpula, Crucigera, Hydroides* and *Protohydroides*. However, there is some inconsistency in terminology since he explicitly refers to the 'much reduced ventral most one pair of branchiae', and branchiae are also referred to as 'filaments' (= radioles). There is, therefore, room for doubt, and one might infer that his 'palpi' are located on the dorsal side, and may actually be elongated rudimentary opercula.

The condition of the thoracic membranes in *P. pacifica* is not clear from the description. They sharply decrease in width posteriorly from the 5th chaetiger onwards and are insignificant or lacking as they approach the end of the thorax.

A range of specimens, including very small ones (Table 25), were covered under the species of *Spiraserpula* described in the present paper. The nominal species *P. pacifica*, therefore, has the same number of abdominal segments as the smallest juvenile among the other three species. The anterior abdominal chaetae of *Serpula* and related genera are frequently described as being trumpet-shaped or flat trumpet-shaped in serpulid literature. Uchida characterizes *P. pacifica* as lacking capillaries, but having spatulate chaetae in the terminal abdominal segments. However, all the species described in the present paper, including juveniles, possess capillary chaetae in the terminal abdominal segments, although there may occasionally be an individual in which they are lost (see condition in *S. singularis* sp. nov.).

Table 25 Some abdominal characters of the smallest juveniles of three new species, compared with those of *Protoserpula pacifica*.

Species	TL (mm)	Length of abdomen (mm)	No. of Abdom. segs.	Capillaries from
S. caribensis	3.7	2.0	20	16
S. zibrowii	3.4	2.1	27	19
S. capeverdensis	2.4	2.2	29	21
Protoserpula pacifica	5.1	2.5	20	–

The bayonet collar chaetae are similar to those of some species of *Spiraserpula*, but such chaetae are also found in *Serpula* sensu stricto species, such as *Serpula japonica* Imajima, 1979. It is not known whether *Protoserpula* possesses ITS or not, but they had also been overlooked until now in *S. massiliensis* (Zibrowius, 1968), *S.lineatuba* (Straughan, 1967), and *S. minuta* (Straughan, 1967).

It appears, therefore, that *Protoserpula pacifica* was a juvenile serpulid, and its true identity can only be established with more studies to determine the following: Whether it has a pair of true palps and an apron; if so, it does not belong to *Spiraserpula*. If, however, it has rudimentary opercula and ITS, and lacks an apron, it is likely to belong to *Spiraserpula* Regenhardt, 1961, which has priority over *Protoserpula* Uchida, 1978.

PHYLOGENY

Spiraserpula Regenhardt, 1961, is a member of the *Serpula/Crucigera/Hydroides* clade. A cladistic analysis of *Spiraserpula* Regenhardt, 1961, based on the above species (Hove & Pillai) was presented at the Fourth Polychaete Conference, and the paper is due to be published.

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