SERPULIDAE (ANNELIDA, POLYCHAETA) OF THE ARCTIC OCEAN

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SARSIA

KUPRIYANOVA, ELENA K. & IGOR A. JIRKOV 1997 10 06. Serpulidae (Annelida, Polychaeta) of the Arctic Ocean. – *Sarsia* 82:203-236. Bergen. ISSN 0036-4827

This paper is an account of Serpulidae (Annelida, Polychaeta) collected from the Arctic and Northern Atlantic Oceans by Soviet expeditions. This material is part of the collection of the Department of Hydrobiology at Moscow State University and the Zoological Museum of the Russian Academy of Sciences in St. Petersburg. We redescribe eleven species: *Chitinopoma serrula*, *Ditrupa arietina*, *Filograna implexa*, *Hyalopomatus claparedii*, *Hydroides norvegicus*, *Placostegus tridentatus*, *Pomatoceros triqueter*, *Protula globifera*, *P. tubularia*, *Protis arctica*, and *Serpula vermicularis*. A new species from this collection, *Metavermilia arctica*, was described in a previous publication. Original illustrations and distribution maps accompany all descriptions. We provide two separate taxonomic keys to specimens and tubes. The previous records of arctic serpulids and the present state of the taxonomy of the family are discussed. Based on the operculum-bearing specimens of *Protis arctica* found, and on previous similar records, the taxonomic significance of the operculum in serpulids is further re-evaluated. As a result, *Salmacina* and *Apomatus* are considered synonyms of *Filograna* and *Protula*, respectively. We believe that many of the species and genera considered in this paper need revision.

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KEYWORDS: Polychaeta; Annelida; Serpulidae; Arctic.

INTRODUCTION

The Serpulidae is a family of polychaetes abundant mostly in tropical and subtropical regions, with only a few genera known from arctic and boreal regions. Whereas the Eastern Arctic and Scandinavian polychaete fauna has been extensively investigated, less is known about the fauna of the Western and Central Arctic. The most comprehensive account of arctic Serpulidae was given by WOLLEBÆK (1912), who provided descriptions and illustrations of 12 species. Several faunistic works from the Arctic and adjacent regions include serpulids (i.e. MCINTOSH 1923; ZATSEPIN 1948; USCHAKOV 1957; WESENBERG-LUND 1950a, b, 1953; KNOX 1959; ZIBROWIUS 1969; HARTMANN-SCHRÖDER 1971; KIRKEGAARD 1982).

Recently, HOLTHE (1992) compiled references for identification of polychaetes from northern European waters. Despite a relatively low number of species of arctic serpulids, the identification still presents difficulties, mainly because of the confused state of the family's taxonomy in general. As a result, many identifications in the literature cannot be trusted.

In the former Soviet Union, abundant material on arctic polychaeta has accumulated after decades of sampling during numerous arctic expeditions. However, much of this material has remained unpublished and unknown to the scientific community. Most of the problem stems from the lack of domestic taxonomists specializing in certain groups and decades of political isolation preventing the exchange of material between Russian and Western taxonomists. The goal of this paper is to provide a regional revision of arctic Serpulidae based on mostly unpublished material from Russian collections.

MATERIAL AND METHODS

This study is based on extensive material collected by Soviet arctic expeditions and deposited in the collection of the Department of Hydrobiology at Moscow State University, Russia (abbreviated here as DHMSU), and the Zoological Institute of the Russian Academy of Sciences (ZIN RAS).

The sampling area covered most of the Arctic Ocean, from the Faroe Islands and Iceland to the Bering Strait, from the upper shelf to abyssal depths. The Barents Sea was the most investigated area, but samples from the Norwegian and Siberian Seas were numerous as well.

Samples were taken mainly by Agassiz trawl or 'Ocean' grab of 0.25 m^2. Specimens were fixed in 4 % formaldehyde in sea water and transferred to 70 % alcohol (ethanol or isopropanol). Tubes were partly dissolved in HCl.

Before examination, all serpulids were removed from their tubes and stained with methylene blue to reveal specific glandular fields. Setae and uncini were dissected and mounted in glycerin jelly. Drawings were made with the help of a camera lucida under a light microscope. For all species in the collection, we report the variability of the main taxonomic characters.

Since much of the material is represented by empty tubes, we constructed two separate keys: one for worms without

tubes and another for empty tubes. The former key allows identification of both complete specimens and specimens with a lost or damaged operculum.

The taxonomic value of serpulid tubes varies from group to group and correct identification of some species requires the examination of a specimen removed from the tube and/or setae and uncini. Because it is rarely possible to remove a worm without damaging the tube, we recommend first using the tube structure for identification, then to confirm the identification with soft body structures.

We tried to limit species synonymies to papers in which detailed descriptions and/or informative illustrations accompany the species records.

KEY TO ARCTIC SERPULID SPECIES BASED ON TUBE MORPHOLOGY

1. Tube unattached, tusk-shaped, white, consisting of 2 layers: external transparent, internal white opaque (Fig. 2D) ..... *Ditrupa arietina*
– Tube attached to substratum at least in the proximal part, white or pink, opaque or vitreous 2
2. Tubes forming colonies consisting of numerous grayish branching wire-like tiny tubes with diameter up to 1 mm, not encrusting substrate (Fig. 3C) ..... *Filograna implexa*
– Tubes solitary, or may form gregarious formations encrusting substrate 3
3. Tube triangular in cross section or with longitudinal keel 4
– Tube circular in cross section 6
4. Tube triangular in cross section, vitreous, thick-walled, usually attached to substratum only by proximal part; tube opening with three elongated spines (Fig. 6B) ..... *Placostegus tridentatus*
– Tube with a median keel, white opaque, attached to the substratum throughout its entire length; tube opening is round, without spines 5
5. Tube smooth, without distinct striations, median keel smooth (Fig. 7B) ..... *Pomatoceros triqueter*
– Tube with distinct striations, median keel denticulate (Fig. 1B) ..... *Chitinopoma serrula*
6. Surface of tube more or less smooth, sometimes with distinct growth rings 7
– Surface of tube pitted by shallow indentations, each bounded by ridges ..... *Metavermilia arctica*
7. Growth rings wavy, tubes white, usually attached to the substratum throughout its length; distinct tube collars always absent (Fig. 5B) ..... *Hydroides norvegicus*
– Growth rings straight; tubes white or pink, attached to substratum only by proximal end, distal end free; tube collars sometimes present 8
8. Tubes pink; wide collars usually present at distal end of tube; several denticulate longitudinal ridges sometimes present at proximal part of tube (Fig. 11B) ..... *Serpula vermicularis*
– Tubes white or grayish, smooth or rugose, ring-shaped thickening sometimes present 9
9. Tube surface very smooth, shiny (Fig. 4C) ..... *Hyalopomatus claparedii*
– Tube surface rugose 10
10. Tube surface with 'honeycombed' structure (Fig. 9B) ..... *Protula globifera*
– Tube surface without 'honeycombed' structure (Fig. 8B; 10B) ..... *Protis arctica*, *Protula tubularia*

KEY TO ARCTIC SERPULID SPECIES BASED ON SPECIMENS

1. No distinct peduncle differing from normal pinnulate radioles, operculum present or absent 2
– Peduncle smooth, non-pinnulate, operculum present or lost (when lost, place of its insertion usually obvious) 5
2. Two equally developed spoon-shaped membranous opercula; worms are very small (up to 6 mm). Form colonies of grayish tubes (Fig. 3A) ..... *Filograna implexa*
– One (rarely more) membranous, globular transparent operculum or operculum absent. Worms are usually much larger (up to 60 mm), not colonial 3
3. Thoracic membranes ending at 7th thoracic segment and not forming ventral apron; collar setae fin-and-blade in addition to simple limbate; thoracic uncini with up to 7 teeth in one row (Fig. 8A) ..... *Protis arctica*
– Thoracic membranes forming ventral apron; collar setae simple limbate; thoracic uncini with more than 15 teeth in several rows 4
4. Collar entire, not divided into lobes; thoracic neuropodial tori several times longer than abdominal notopodial tori (Fig. 9A) ..... *Protula globifera*
– Collar trilobed; length of thoracic neuropodial tori similar to that of abdominal notopodial tori (Fig. 10A) ..... *Protula tubularia*

5. Collar setae absent 6
– Collar setae present 7
6. First and second pairs of thoracic neuropodia widely separated laterally (Fig. 2A) ..... *Ditrupa arietina*
– First and second pairs of thoracic neuropodia not widely separated laterally (Fig. 6A) ..... *Placostegus tridentatus*
7. Six thoracic setigers (including collar setae); operculum pear-shaped, membranous, without distal plate (Fig. 4A) ..... *Hyalopomatus claparedii*
– Seven thoracic setigers (including collar setae); operculum at least partly calcified or chitinized 8
8. Pseudooperculum present; operculum composed of shallow funnel of fused radii with or without distal verticil of chitinized spines 9
– Pseudooperculum absent; operculum inverted cone with chitinous or calcareous distal plate 10
9. Operculum without distal verticil of chitinized spines; bayonet collar setae widely limbate distally (Fig. 11A) ..... *Serpula vermicularis*
– Operculum with distal verticil of chitinized spines; bayonet collar setae finely denticulate distally (Fig. 5A) ..... *Hydroides norvegicus*
10. Peduncle with distal wings, very thick, triangular in cross section, inserted dorsally at the base of branchial radioles; operculum with calcified distal plate (Fig. 7A) ..... *Pomatoceros triqueter*
– Peduncle without distal wings, cylindrical or flat, formed from second dorsal radiole; operculum conical with chitinous distal plate 11
11. Peduncle cylindrical, smooth; collar setae fin-and-blade (Fig. 1A) ..... *Chitinopoma serrula*
– Peduncle flat, ribbon-like, with regular annulations; collar setae simple limbate ..... *Metavermilia arctica*

TAXONOMIC ACCOUNT

The family Serpulidae was traditionally subdivided into two subfamilies Serpulinae and Filograninae based mainly on the structure of the operculum-bearing branchial radiole, which is not modified in the Filograninae and is transformed into a smooth peduncle in the Serpulinae. However, the presence of pinnules is a plesiomorphic (or, in some cases, juvenile) character state in the Sabellida (Hove 1984) and therefore it cannot justify the separation of taxa. Other characters used to support this subdivision, such as operculum structure (simple, membranous in the Filograninae versus complex, chitinized or calcified in the Serpulinae) and thoracic uncini (mostly rasp-shaped versus saw-shaped) vary significantly within the group and therefore cannot be used either. Since no synapomorphies support the subfamilies, we subscribe the opinion of ten Hove (1984) and Smith (1991) and propose not to use this taxonomic category until phylogenetic relationships within the Serpulidae are clarified.

Genus *Chitinopoma* Levinsen, 1883 emend. Zibrowius (1969)

Type species: *Vermilia serrula* Stimpson, 1854

Tube with brood chambers. Seven thoracic setigers. Operculum inverted cone with distal plate made of chitin-like material. Peduncle cylindrical, smooth, without wings; formed from second dorsal radiole on one side. Pseudooperculum and interradiolar membrane absent. Thoracic membranes end at second thoracic setiger. Collar setae fin-and-blade and simple limbate. Thoracic *Apomatus*-setae present. Abdominal setae with large distal triangular blade. Thoracic uncini saw-shaped; abdominal uncini rasp-shaped; anterior tooth not bifurcate.

Chitinopoma serrula (Stimpson, 1854)
(Fig. 1; Map 1)

Chitinopoma groenlandica – Nelson-Smith 1967:37, fig. 29.
Chitinopoma serrula – Zibrowius 1969:2-6; Hartmann-Schröder 1971:533, Add. 185.
Chitinopoma fabricii – Zatsepin 1948:166; Gurianova 1957; Slastnikov 1957.
Microserpula inflata – Wesenberg-Lund 1950a:61; 1950b:136; Nelson-Smith 1967:36, figs. 27-28.

Material. DHMSU, R/V *Alaid*, Stn. 30.6 (tubes); Stn. 30.13 (6 spec.).
ZIN RAS, identified as *Placostegus tridentatus* Reg. N 8, Murman coast, 75 m, 19 Aug. 1936 (10 spec.).

Tubes (Fig. 1B) white, opaque, almost triangular in cross section, with more or less denticulate median keel; attached to substratum throughout their entire length. Tube of adults with one or more pairs of brooding chambers. Anterior aperture of tube sometimes widened into uneven lobes.

Body length less branchial crown 7-15 mm (n = 6, mean 11.2, SD 2.95). Five to seven pairs of branchial

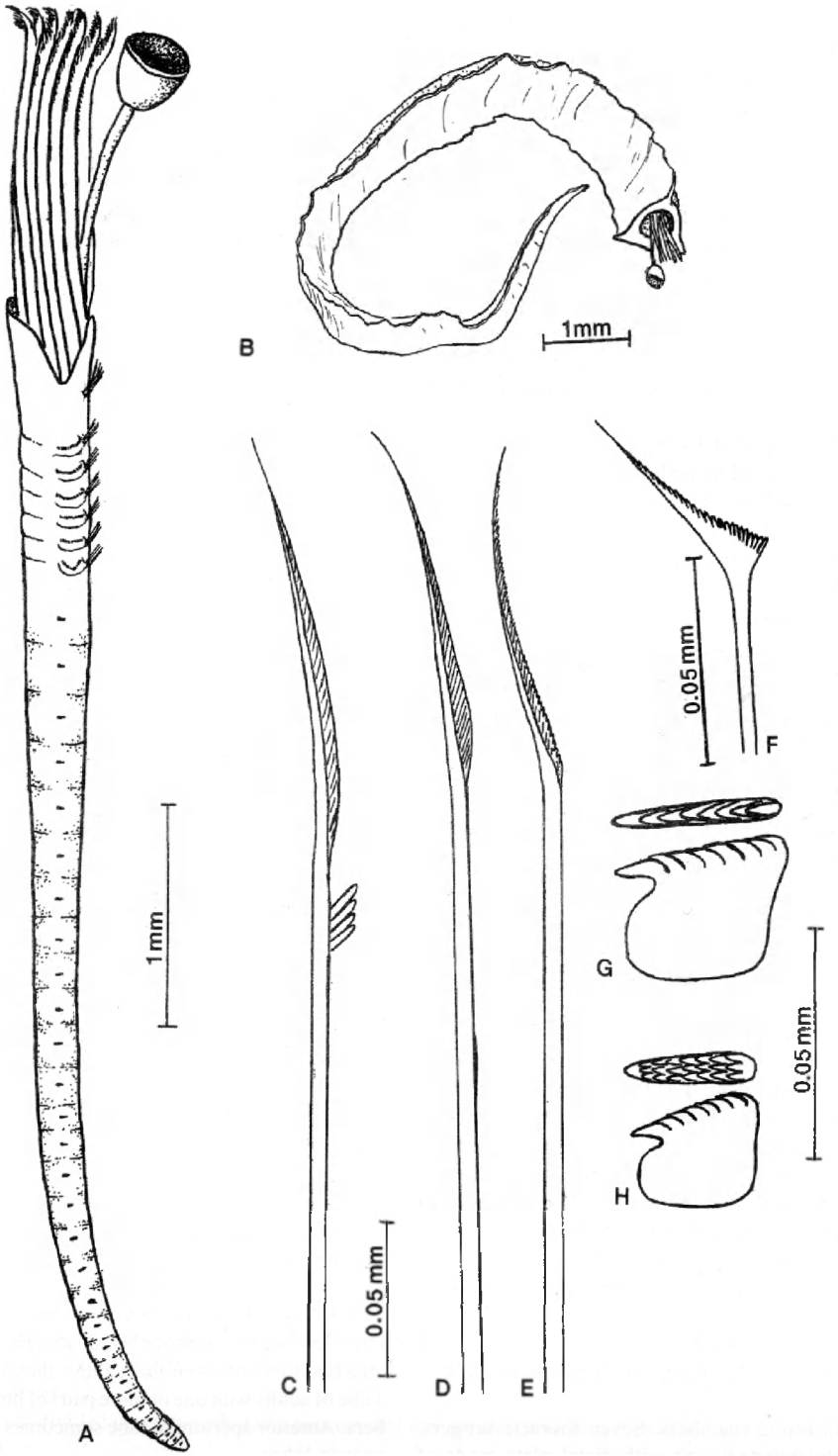
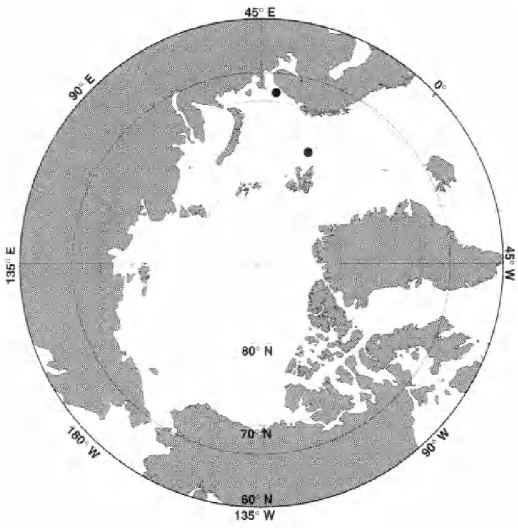


Fig. 1. *Chitinopoma serrula*. A. Lateral view. B. Tube. C. Collar seta. D, E. Thoracic setae. F. Abdominal seta. G. Thoracic uncinus. H. Abdominal uncinus.



Map 1. *Chitinopoma serrula*

radioles (n = 6, mean 6.2, SD 0.75) not connected by a membrane at base. Second branchial radiole forming smooth peduncle. Operculum inverted cone covered with brown distal plate of chitin-like material (Fig. 1A). Operculum separated from peduncle by constriction.

Collar large and trilobed, lateral notches deep, ventral lobe longer than lateral lobes. Thoracic membranes short, ending at second thoracic setiger. Rows of thoracic uncini 5-6 times longer than rows of abdominal uncini.

Collar setae of two types: capillary and fin-and-blade, with distal limbate and proximal denticulate parts, separated by a gap (Fig. 1C). Remaining thoracic setae limbate (Fig. 1D), capillary and *Apomatus*-setae with short distal limbate zone (Fig. 1E). Abdominal setae geniculate, with wide triangular denticulate blade (Fig. 1F). Thoracic uncini (Fig. 1G) saw-shaped with 9-12 teeth, abdominal uncini (Fig. 1H) similar, but rasp-shaped.

Remarks. The partial revision of the genus conducted by Zibrowius (1969) showed that the tube-incubating *Chitinopoma serrula* is the only species widely distributed in the Arctic and boreal North Atlantic.

Genus *Ditrupa* Berkely, 1835; emend. Hove & Smith (1990)

Type species: *Dentalium arietinum* Müller, 1776

Tube not attached to substratum, tusk-like. Six thoracic setigers. Operculum inverted cone with distal plate of chitin-like material. Peduncle cylindrical, smooth, without wings; appears to be formed from first dorsal radiole on one side. Thoracic membranes ending at first thoracic setiger. Collar and *Apomatus*-setae absent. Abdominal setae geniculate. Thoracic uncini saw/rasp-shaped or rasp-shaped with numerous teeth per row; abdominal uncini rasp-shaped; anterior tooth bifurcate.

Ditrupa arietina (Müller, 1776)
(Fig. 2; Map 2)

Ditrypa arietina – McIntosh 1923:380-383, pl. CXXII, figs 5-6, pl. CXXXII, fig. 1.
Ditrupa arietina – Wollebæk 1912:119, pl. XLVI; Wesenberg-Lund 1950a:60-61; 1953:6; Nelson-Smith 1967:39; Zibrowius 1968a:169-171; 1968b:383-385; Hartmann-Schröder 1971:527; Hove & Smith 1990:104-107.
Ditrupa groenlandica – Wesenberg-Lund 1950b:136.

Material. DHMSU, Appendix, N 73 (1 spec. and tubes); N 89 (3 spec.); N 90 (98 spec.); N 95 (tubes); N 101 (4 spec.); N 119 (tubes); N 120 (1 spec. and tubes); N 126 (94 spec. and tubes); N 127 (2 spec. and tubes); N 130 (tubes); N 131 (3 spec. and tubes); N 134 (tubes); N 135 (tubes); N 143 (tubes); N 144 (tubes); N 145 (1 spec. and tubes); N 146 (tubes); N 148 (tubes); N 163 (1 tube); N 164 (1 spec.); N 170 (tubes); N 177 (89 spec.); N 183 (3 spec. and tubes); N 188 (3 spec. and tubes); N 195 (3 spec. and tubes); N 198 (tubes); N 199 (1 tube); N 202 (12 spec. and tubes); N 203 (1 tube); N 206 (tubes); N 231 (3 spec. and tubes); N 237 (2 spec. and tubes); N 238 (1 spec.).

Tubes (Fig. 2D) tusk-shaped, circular in cross section, white, without distinct growth marks, consisting of 2 layers: external transparent, internal white opaque.

Body length without branchia 11-20 mm (n = 19, mean 15.9, SD 2.96). Eleven to fifteen pairs of branchial radioles (n = 19, mean 12.4, SD 0.90) not connected by an interradiolar membrane at base (Fig. 2A). Collar (Fig. 2C) entire, long, very thin, with longitudinal thickenings and denticulate edge, covering up to one-half of length of branchial radioles.

Operculum (Fig. 1A, B) inverted cone, covered with flat or slightly convex brown distal plate of chitin-like material. Peduncle cylindrical, smooth, appears to be formed from first dorsal radiole. Thoracic membranes ending at second thoracic setiger. Thoracic neuropodia shifted ventrally, those of sixth thoracic setiger meeting ventrally. Lateral distance between first and second pair of thoracic neuropodia several times longer than that between other pairs of neuropodia. Abdominal notopodia very short rows of uncini. Collar setae absent. Thoracic setae capillary and limbate (Fig. 2E, F). Thoracic and abdominal uncini rasp-shaped (Fig. 2G, H) with numerous teeth in each row. Abdominal setae very small, capillary, 1-3 per bundle.

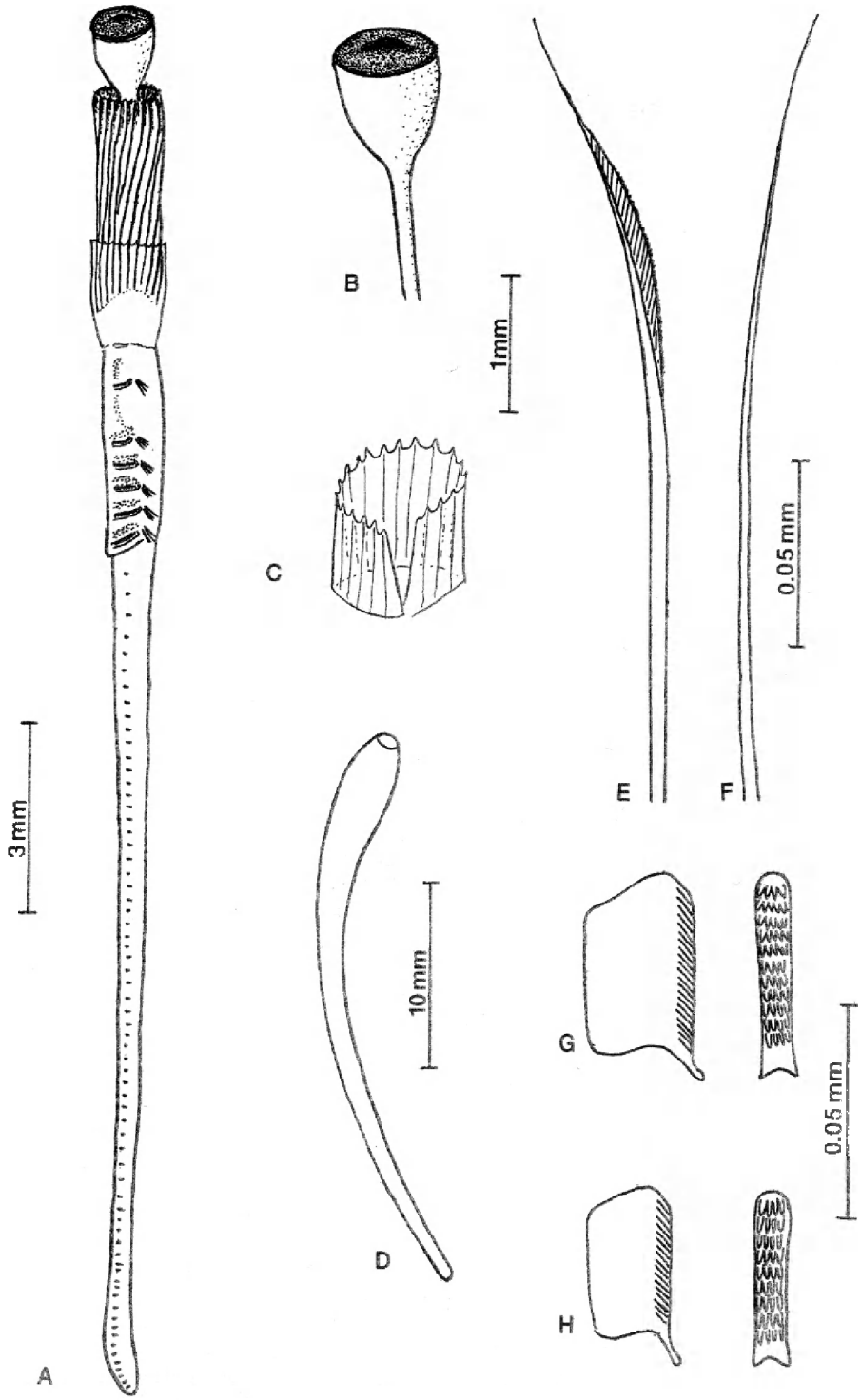
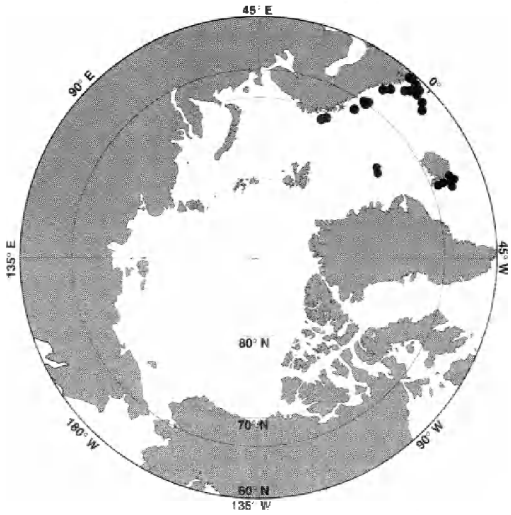


Fig 2. *Ditrupa arietina*. A. Lateral view. B. Operculum. C. Collar. D. Tube. E. Thoracic setae. F. Abdominal seta. G. Thoracic uncinus. H. Abdominal uncinus.



Map 2. *Ditrupa arietina*

Remarks. Until recently, most authors considered *Ditrupa arietina* a single species in the genus. The partial generic revision undertaken by Hove & Smith (1990) showed that the distribution of *D. arietina* is restricted to the East Atlantic and Mediterranean, whereas a separate species, *D. gracillima* Grube, inhabits the Indo-Pacific.

Genus *Filograna* Berkeley, 1835 emend. Zibrowius 1968
(including *Salmacina* Claparede, 1870)

Type species: *Filograna implexa* Berkeley, 1828

Worms forming lattice-like colonies consisting of large number of grayish tubes. Six to twelve thoracic setigers. Two spoon-shaped opercula on first non-modified pinnulate branchial radioles, one on each branchial lobe, or opercula absent. Collar setae fin-and-blade and simple limbate. *Apomatus*-setae present. All uncini rasp-shaped with numerous teeth.

Remarks. The genera *Filograna* and *Salmacina* are distinguished mainly by the presence of two (rarely one) membranous opercula in the former and absence of the operculum in the latter. Some authors consider them distinct genera (Iroso 1921; Fauvel 1927; Hartman 1959; Pillai 1960; Straughan 1967), whereas others regard them the same species (McIntosh 1923; Faulkner 1930; Day 1955, 1967). More recent workers (Nelson-Smith 1967; Gee 1973; Zibrowius 1968, 1973; Uchida 1978) regard operculate and non-operculate forms separate species within the genus *Filograna*. This latter approach is followed in this account.

Evidence has accumulated in the last several decades strongly suggesting that the operculum absence cannot be used even for separating serpulids to species, let alone genera. Some serpulids are known to shed and regenerate opercula (Okada 1932; Schochet 1973; Lang & le Calvez 1982; Bubel & al. 1985a, b). As a result, non-operculate specimens sometimes can be found in populations of normally operculate species (Hove 1984). On the other hand, representatives of traditionally non-operculate groups such as *Protula*, *Protis* and *Paraprotis* have been shown occasionally to possess opercula (Imajima 1979; Hong 1984; Kupriyanova 1993, see also remarks on *Protis arctica* in this paper). Based on preserved material only, it is difficult to determine whether animals belonging to these groups never had opercula or 'operculate specimens … shed opercula when killed' (Hove & Wolf 1984).

In the case of *Filograna*, colonies are formed by means of asexual budding, so the colony may arise from one or a few settled larvae. More work is needed on the reproductive biology and genetics of these organisms. It should be determined whether the intra-colonial variability in these clonal organisms is in fact the reflection of polymorphism on this character and whether the development or non-development of opercula is environmentally induced before the systematics of the much confused *Filograna*/*Salmacina*-complex is resolved.

Filograna implexa Berkeley, 1828
(Fig. 3; Map 3)

Filograna implexa – Wollebæk 1912:pl. XL; McIntosh 1923:339-346, pl. CXVI, figs 5, 8, pl. CXVII, fig. 2, pl. CXXI, fig. 8, pl. CXXXVII, fig. 20-21; Augener 1925; Fauvel 1927:376; Ditlevsen 1929; Zatsepin 1948:165; Wesenberg-Lund 1950a:61; 1950b:136; Hartmann-Schröder 1971:538.

Material. DHMSU, Appendix, N 2 (300 spec.); N 3 (1 spec.); N 66 (15 spec.); N 69 (100 spec.); N 77 (350 spec.); N 90 (300 spec.); N 92 (50 spec.); N 96 (300 spec.); N 99 (2 spec.); N 103 (15 spec.); N 112 (20 spec.); N 115 (25 spec.); N 121 (200 spec.); N 122 (200 spec.); N 124 (300 spec.); N 129 (70 spec.); N 136 (400 spec.); N 159 (1000 spec.); N 169 (25 spec.); N 174 (3125 spec.); N 175 (25 spec.); N 180 (400 spec.); N 181 (500 spec.); N 192 (40 spec.); N 194 (10 spec.); N 195 (20 spec.); N 196 (120 spec.); N 198 (70 spec.); N 199 (200 spec.); N 200 (10 spec.); N 204 (50 spec.); N 208 (30 spec.); N 234 (50 spec.).

(ZIN RAS), Reg. N 7, 69°58'N 32°31'E, 140-174 m (150 spec.); Reg. N 8, Kola Bay, 220 m (400 spec.); R/V *Persei*: Reg. N 1, Stn. 1222, 69°28'N 34°17'E, 107 m (20 spec.); Reg N 2, Stn. 989, 69°00'N 38°00'E, 171 m (5000 spec.); R/V *Akademik Bergman*: Reg. N 3, Stn. 7, 61°58'N 6°58'E, 265m,

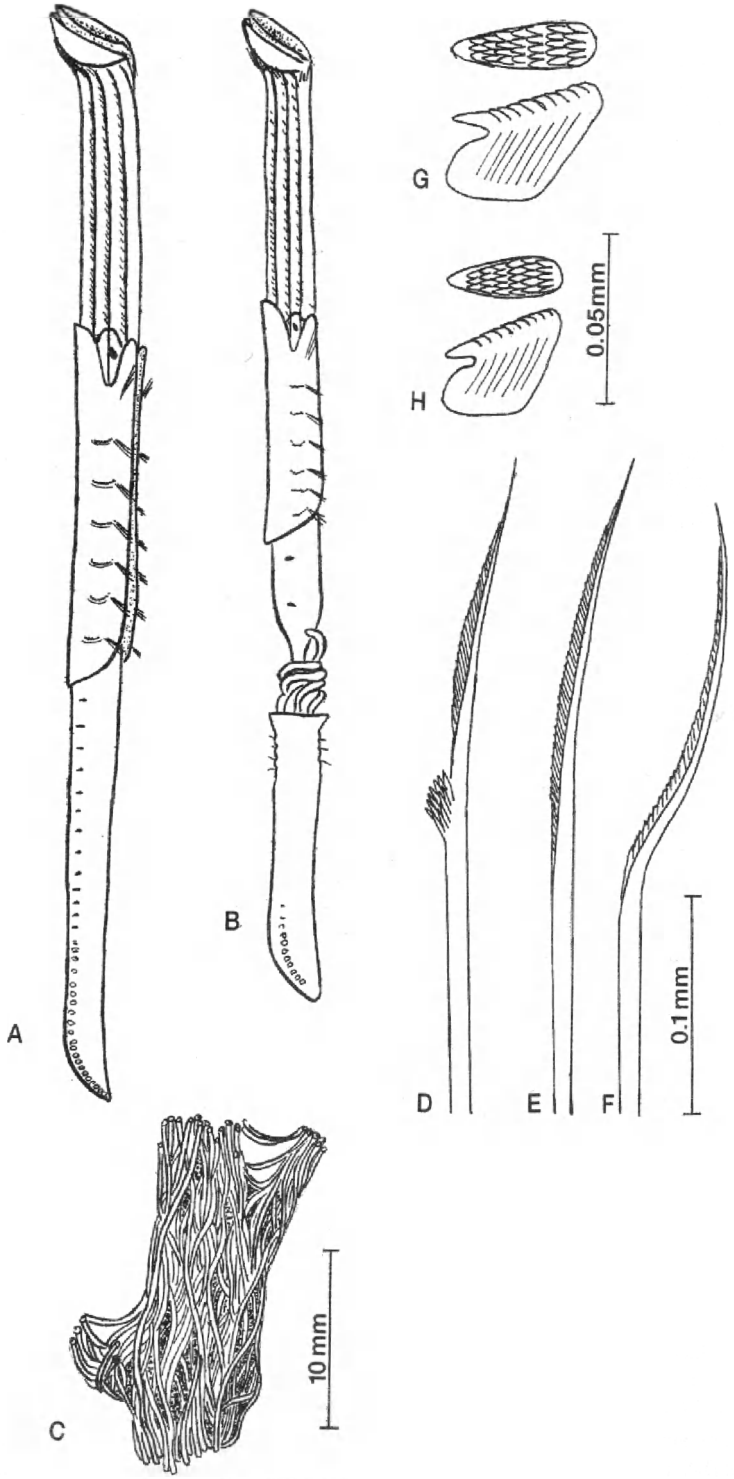
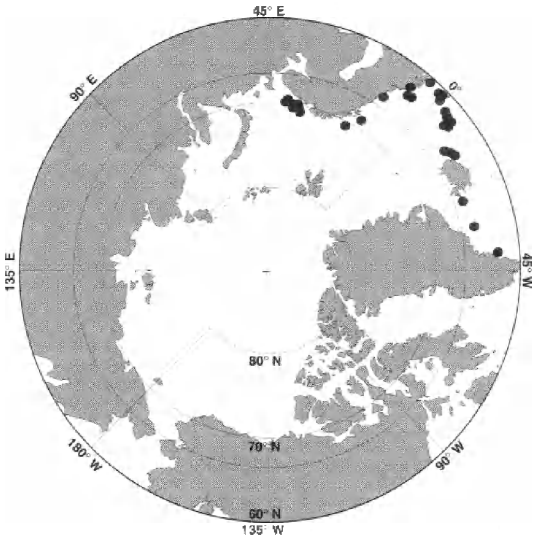


Fig 3. *Filograna implexa*. A. Lateral view. B. Lateral view of asexually reproducing specimen. C. Colony of tubes. D. Collar setae. E. Thoracic setae. F. *Apomatus*-setae. G. Thoracic uncinus. H. Abdominal uncinus.



Map 3. *Filograna implexa*

19 July 1930 (400 spec.); R/V *Andrey Pervozvanny*: Reg. N 4, Stn. 12, 69°40'N 35°15'E, 190 m, (80 spec.); Reg. N 5, Stn. 556, 69°46'N 35°10'E, 207 m, 1 July 1931 (300 spec.); Reg. N 6, Stn 330, 69°35'N 33°23'E, 270 m (300 spec.).

Tubes (Fig.3C) form characteristic lattice-shaped colonies consisting of numerous branching grayish tubes up to 1 mm in diameter. Three or four pairs of branchial radioles not connected by interradiolar membrane at base. Two palps. Peristomium elongate with two brown eye spots laterally. Six to seven thoracic setigers (n = 54, mean 6.9, SD 0.43).

Body length without crown 4.9-6.0 mm (n = 10, mean 5.3, SD 0.42). Four pairs of branchial radioles. Most dorsal pairs of branchial radioles bearing two well-developed membranous opercula, but some specimens in the same colony may have only one operculum. Opercula usually spoon-shaped (degree of operculum development may vary and some specimens have only leaf-shaped membranous operculum).

Collar covering peristomium and base of branchial radioles. Deep lateral notches subdivide collar into two narrow, short lateral lobes, and one wide, long ventral lobe. Ventral lobe may have small median notch.

Thoracic membranes reaching end of thorax and forming a short apron ventrally. Thoracic neuropodia located at mid-lateral line of thorax, not shifting ventrally. Abdominal notopodia short rows of uncini, approximately 3-4 times shorter than thoracic neuropodia.

Collar setae (Fig. 3D) fin-and-blade, with distal striated denticulate blade and proximal fin consisting of several rows of numerous teeth. Rest of thoracic setae (Fig. 3E) limbate, with striated denticulate limba and sickle-shaped *Apomatus*-setae (Fig. 3F). Thoracic uncini (Fig. 3G) and abdominal uncini are rasp-shaped with numerous teeth in each row. Abdominal setae small, geniculate, with thin distal limba (Fig. 3H).

Genus *Hyalopomatus* Marenzeller, 1878 emend. Kupriyanova (1993)
(including *Cystopomatus* Gravier, 1911; *Hyalopomatopsis* Saint-Joseph, 1894)

Type species:
Hyalopomatus claparedii Marenzeller, 1878

Six thoracic setigers. Operculum membranous, vesicular, globular or elongate, without distal plate. Peduncle thin, cylindrical, smooth, without wings; appears to be formed from first dorsal radiole on one side. Pseudooperculum absent. Thoracic membranes ending at first or second thoracic setiger. Collar setae more or less fin-and-blade (sometimes only a shallow incision separating distal and proximal parts) and simple limbate. *Apomatus*-setae absent. Abdominal setae geniculate. All uncini rasp-shaped; anterior tooth bifurcate.

Hyalopomatus claparedii Marenzeller, 1878
(Fig. 4; Map 4)

Hyalopomatus claparedii – Uschakov 1957:1668; Knox 1959:111-112.

Material. DHMSU, Appendix, N 209 (1 spec.); N 210 (1 spec.); N 211 (2 spec.); N 213 (1 spec.); N 217 (2 spec.); N 218 (46 spec.); N 219 (2 spec.); N 220 (24 spec.); N 221 (28 spec.); N 225 (8 spec.); N 226 (6 spec.); N 227 (9 spec.).

ZIN RAS, R/V *Sadko*: Reg. N 1, Stn. 9/30, 78°37'N 3°52'E, 2300 m, 31 July 1935 (2 spec. and tubes); Reg. N 2, Stn. 10/ 2, 80°02'N 8°19'E, 2380 m (10 spec.); Reg. N 3, Stn. 6/24, 78°04'N 3°51'E, 2460 m, 21 July 1935 (2 spec.); Reg. N 4, Stn. 18/50, 80°46'N 29°57'E, 445 m (1 spec.); Reg. N 5, Stn. 59/99, 82°42'N 87°03'E, 2365 m, 13 Sept. 1935 (20 spec.); Reg. N 6, Stn. 1/34, 80°02'N 9°17'E, 500 m (1 spec.); Reg. N 7, Stn. 24, 78°27'N 39°01'E, 142 m, 25 Sept. 1936 (1 spec.); Reg. N 8, Stn. 99, 81°15'N 140°35'E, 1630-1900 m (10 spec.); R/V *Litke* : Reg. N 10, Stn. 138, 79°02'N 107°01'E, 371 m, 31 Aug. 1948 (3 spec.); Reg. N 11, Stn. 137, 79°26'N 107°48'E, 1073 m, 30 Aug. 1948 (1 spec.); Reg. N 12, Stn. 133, 79°45'N 104°52'E, 432 m, 30 Aug. 1948 (1 spec.); Reg. N 13, Stn. 132, 79°55'N 103°32'E, 348 m, 29 Aug. 1948 (3 spec.); Reg. N 14, Stn. 145, 78°31'N 113°03'E, 1367 m (2 spec.); Reg. N 15, Stn. 10, 77°25'N 118°17'E, 869 m, 16 Aug. 1937 (3 spec.); identified as *Apomatus globifer*: R/V *Litke*: Reg N 75, Stn. 41, 82°02'N 34°58'E, 1747 m (1 spec.); R/V *Ob*: Reg. N 107, Stn. 17, 79°31'N 13°31'W, 212 m (1 spec.).

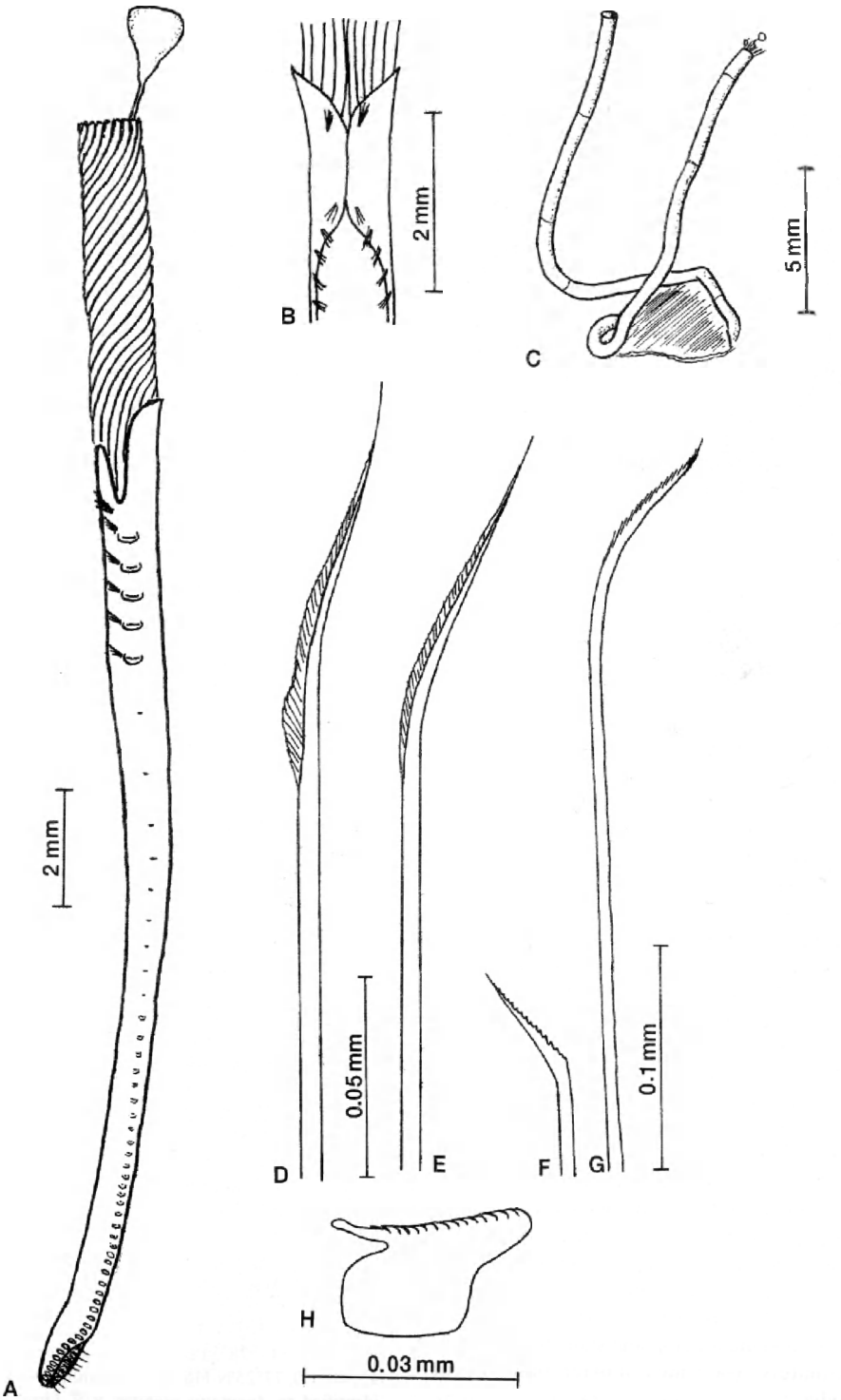
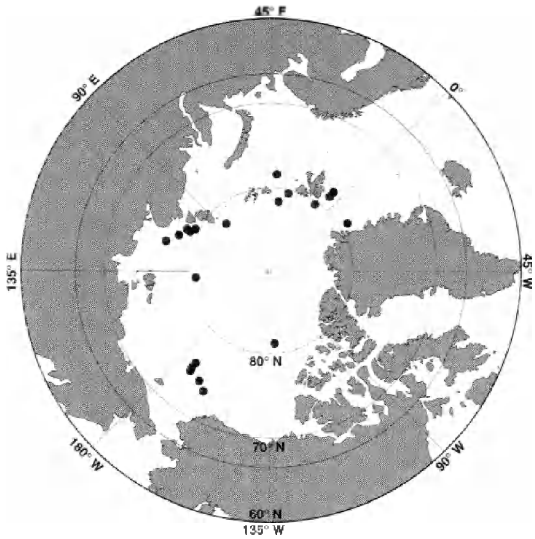


Fig. 4. *Hyalopomatus claparedii*. A. Lateral view. B. Dorsal view of thorax. C. Tubes. D. Collar seta. E. Thoracic seta. F. Anterior abdominal seta. G. Posterior abdominal seta. H. Thoracic uncinus.



Map 4. *Hyalopomatus claparedii*

Tubes (Fig. 4C) white, with smooth shiny surface, circular in cross section, sometimes with small peristomes. Attached to substratum at proximal end only, distal end free.

Body length without branchia 6-22 mm (n = 15, mean 10.0, SD 4.34). Three to nine pairs of branchial radioles (n = 16, mean 8.5, SD 0.73) not connected by interradiolar membrane at base. Operculum small, pear-shaped, membranous vesicle without distal plate. Peduncle thinner than normal radioles, appears to be formed from first dorsal radiole on one side. Collar trilobed, lateral notches deep. Dorsal and lateral lobes of same length, dorsal lobe twice as wide as lateral lobes. Collar covers branchial lobes and very proximal part of branchial radioles. Collar edge smooth. Thoracic membranes (Fig. 4B) ending at third thoracic segment, gradually narrowing at second setiger. Thoracic neuropodia at mid-lateral line of thorax.

Collar setae (Fig. 4D) with denticulate blade, distal and proximal parts of which are separated by shallow notch, thus intermediate between simple limbate and specialized fin-and-blade setae. Thoracic setae (Fig. 4E) denticulate limbate. Abdominal setae geniculate, with dentate proximal blade on anterior abdominal segments (Fig. 4F); long capillaries on far posterior setigers (Fig. 4G). Uncini (Fig. 4H) rasp-shaped, about 20 teeth per row.

Remarks. *Hyalopomatus claparedii* is a deep-water species known exclusively from the Arctic basin. Zibrowius (1969) gave a detailed overview of previous records of the species. However, his description is based on literature accounts only.

Genus *Hydroides* Gunnerus, 1768

Type species:
Hydroides norvegica Gunnerus, 1768

Seven thoracic setigers. Operculum composed of basal funnel of fused radii and distal verticil of chitinized spines. Peduncle cylindrical, smooth, without wings; appears to be formed from first dorsal radiole on one side. Pseudooperculum and interradiolar membrane present. Thoracic membranes forming ventral apron at end of thorax. Collar setae bayonet and simple limbate. *Apomatus*-setae absent. Abdominal setae trumpet-shaped. Uncini saw-shaped; anterior teeth not bifurcate.

Hydroides norvegicus Gunnerus, 1768
(Fig. 5; Map 5)

Hydroides norvegica – Wollebæk 1912:115-116, pl. XLIII, XLIV fig.1-4; Derjugin 1915; McIntosh 1923:346-351, pl. CXVI, fig. 3; Fauvel 1927:356-357, fig. 122, i-o; Ditlevsen 1929:733; Zatsepin 1948:167; Wesenberg-Lund 1950a:60; 1950b:135; 1953; Hartmann-Schröder 1971:536; Zibrowius 1971b.

Material. DHMSU, Appendix, N 65 (1 spec.); N 16 (tubes); N 17 (1 spec. and tubes); N 35 (tubes); N 67 (tubes); N 70 (1 spec.); N 72 (1 spec. and tubes); N 77 (7 spec.); N 78 (10 spec.); N 79 (1 spec.); N 84 (7 spec.); N 86 (3 spec.); N 87 (1 spec.); N 89 (1 spec.); N 91 (17 spec. and tubes); N 92 (15 spec.); N 92 (9 spec.); N 94 (1 spec.); N 95 (1 spec. and tubes); N 96 (6 spec.); N 100 (1 spec. and tubes); N 101 (2 spec.); N 103 (2 spec.); N 120 (6 spec. and tubes); N 122 (2 spec.); N 123 (tubes); N 125 (108 spec.); N 126 (tubes); N 128 (9 spec.); N 129 (6 spec.); N 130 (7 spec.); N 131 (7 spec.); N 132 (2 spec.); N 133 (2 spec.); N 134 (1 spec.); N 137 (tubes); N 149 (1 spec.); N 168 (1 spec.); N 169 (20 spec.); N 171 (16 spec.); N 172 (9 spec.); N 173 (18 spec.); N 174 (31 spec. and tubes); N 175 (2 spec.); N 177 (1 spec.); N 179 (25 spec.); N 180 (1 spec.); N 181 (79 spec.); N 182 (17 spec.); N 186 (1 spec.); N 188 (15 spec.); N 189 (17 spec.); N 190 (tubes); N 191 (1 spec.); N 192 (64 spec.); N 193 (tubes); N 195 (5 spec.); N 196 (tubes); N 197 (9 spec.); N 198 (7 spec.); N 199 (2 spec.); N 200 (57 spec.); N 201 (1 spec.); N 202 (13 spec. and tubes); N 204 (12 spec.); N 205 (2 spec.); N 206 (1 spec.); N 207 (71 spec.); N 231 (71 spec. and tubes); N 233 (4 spec.); N 236 (7 spec.); N 237 (2 spec.); N 238 (3 spec.); N 245 (2 spec. and tubes).

Tubes (Fig. 5B) up to 3 mm in diameter, white, circular in cross section; attached to substratum throughout their length, very distal end sometimes free. Can cover sizable parts of substrate due to gregarious settlement. Surface of tube with characteristic wavy growth rings. Tube peristomes or ring-shaped thickening absent.

Body length without branchia 9-29 mm (n = 25, mean 16.8, SD 6.02). About 10 pairs of branchial radioles

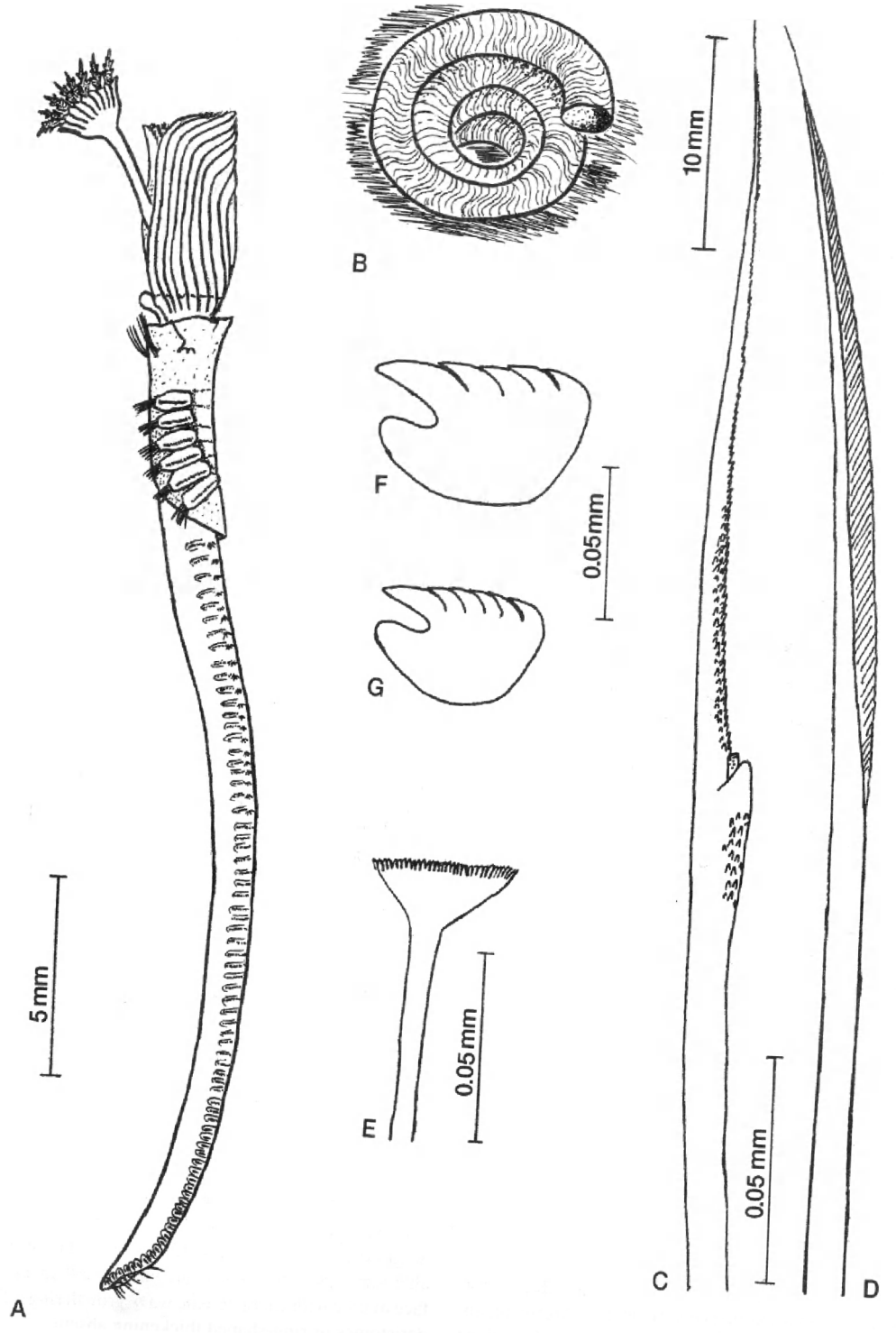
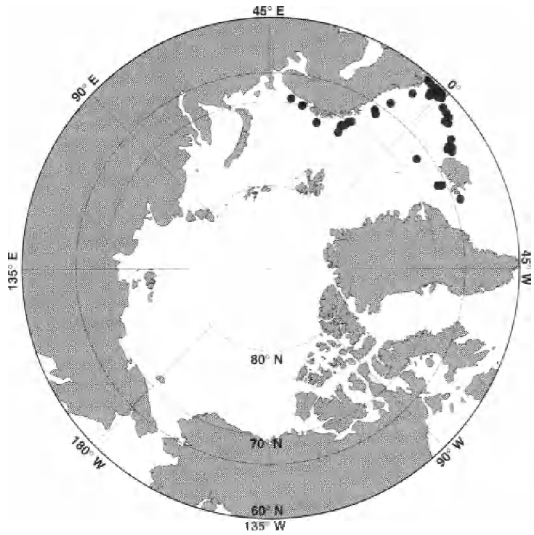


Fig. 5. *Hydroides norvegicus*. A. Lateral view. B. Tube. C. Collar seta. D. Thoracic seta. E. Abdominal seta. F. Thoracic uncinus. G. Abdominal uncinus.



Map 5. *Hydroides norvegicus*

(n = 25, mean 12.8, SD 3.26) connected by short membrane at base. Operculum consists of two parts: distal verticil inserted without a stalk at center of proximal funnel. Distal verticil formed of spines of chitin-like material, each spine bearing 2-4 pairs secondary lateral spines. Peduncle cylindrical, thicker than normal radioles, appears to be formed from first dorsal radiole on one side. Opercular radiole opposite to peduncle short, underdeveloped, bearing rounded pseudooperculum. Some specimens with two equally developed opercula.

Collar trilobed with deep lateral notches and small, wart-like protuberances at base of junction of lateral and ventral lobes. Collar not covering branchial lobes, with smooth edge. Thoracic membranes thick, well developed, continuing to end of thorax and forming a long ventral apron covering 2-4 anterior abdominal setigers. Lobes of thoracic membranes almost touch each other on dorsal side. Rows of thoracic neuropodia located almost at mid-lateral line of thorax or shift slightly ventrally. Abdominal notopodia shifted dorsally where touching each other.

Collar setae (Fig. 5C, D) of two types: simple limbate and bayonet. Bayonet setae with denticulate zone proximal to double basal bosses. Distal blade of bayonet setae finely denticulate. Thoracic setae simple limbate. Abdominal setae of anterior and middle setigers (Fig. 5E) very small, trumpet-shaped, denticulate distally, radiating fan-like, replaced by long capillary setae on posterior setigers. Thoracic uncini (Fig. 5F) saw-shaped, 5-6 teeth per row. Abdominal uncini (Fig. 5G) similar to thoracic uncini, but smaller.

Genus *Metavermilia* Bush, 1904 sensu Zibrowius 1971a

Type species: *Vermilia multicristata* Philippi, 1844

Seven thoracic setigers. Operculum with horny, noncalcified distal plate. Peduncle flat, ribbon-like, without wings; formed from second dorsal radiole on one side. Collar setae simple limbate. *Apomatus*-setae present. Abdominal setae geniculate. Thoracic uncini saw-shaped; abdominal uncini saw or rasp-shaped; anterior tooth simple.

Metavermilia arctica Kupriyanova, 1993

Type material. Zoological Museum of Moscow State University, R/V *Sevastopol* Stn 5.1170, 66°29'N, 32°55'W, 300 m, holotype; Stn 2589, 62°47'N, 6°26'W, 350 m, paratype; Stn 9.1664, 63°56'N, 38°11'W, 210 m, 4 paratypes; Institute of Oceanology, Russian Academy of Sciences, R/V *Tunets* Stn 105.2, 70°26'N, 17°56'E, 120 m, paratype.

Tube opaque, white, circular in cross-section and irregularly coiled; attached to substratum throughout its length. Surface of tube pitted by numerous shallow indentations, each bounded laterally by inconspicuous ridges arranged somewhat irregularly, not forming longitudinal keels. Operculum simple inverted cone covered with yellowish distal plate which may be flat or slightly concave in the center. Collar trilobed with wide dorsal lobe and two narrow lateral ones. Spotty pigmented thoracic membrane short, it reaches to about second or third segment. Collar setae are similar to other thoracic setae. Abdominal setae geniculate, with a triangular denticulate blade, replaced by long capillary setae in posterior segments. Thoracic uncini saw-shaped with 10 teeth; the most anterior tooth simple (not bifurcate). All abdominal uncini rasp-shaped with about 12-15 rows of teeth.

Remarks. For the complete description and illustrations, see Kupriyanova (1993).

Genus *Placostegus* Philippi, 1844

Type species: *Serpula tridentata* Fabricius, 1780

Tubes triangular in cross section, semi-transparent (opalescent). Six thoracic setigers. Operculum inverted cone with distal plate of chitin-like material. Peduncle cylindrical, smooth, without distal lateral wings. Pseudooperculum absent. Thoracic membranes with ventral apron across anterior abdominal segments. Collar setae and *Apomatus*-setae absent. Abdominal setae with large distal triangular blade. All uncini saw-shaped; anterior tooth not bifurcate.

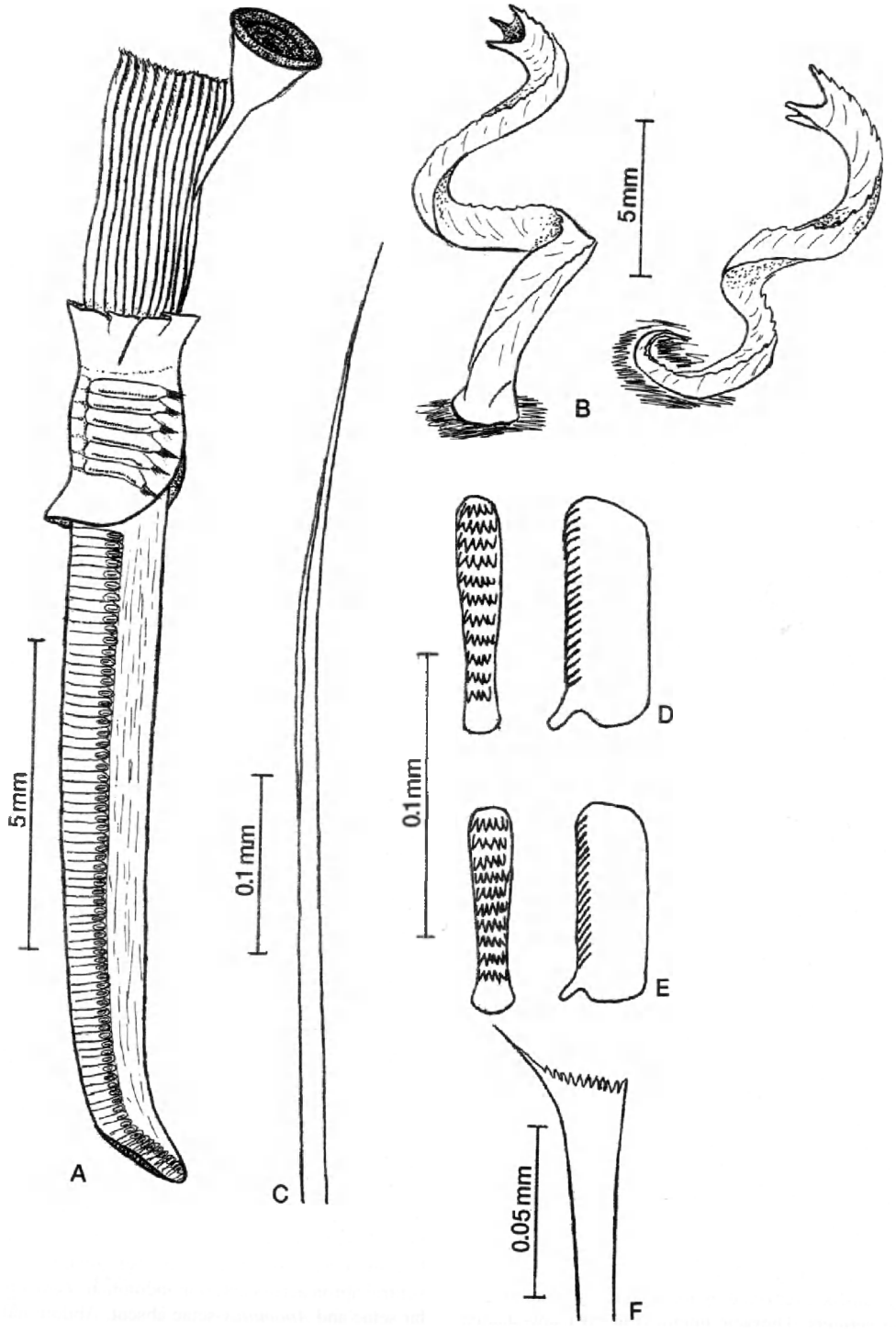
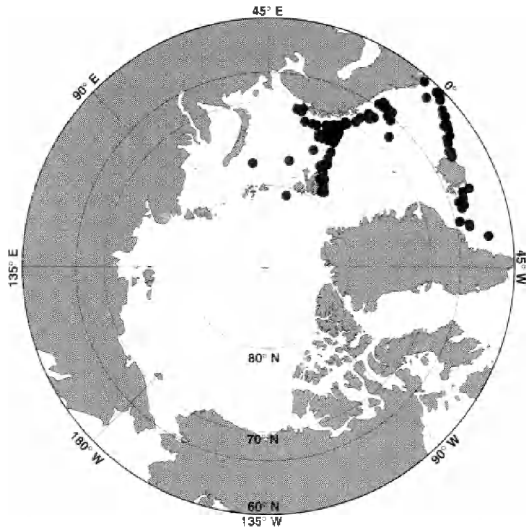


Fig. 6. *Placostegus tridentatus*. A. Lateral view. B. Tubes. C. Thoracic seta. D. Thoracic uncinus. E. Abdominal uncinus. F. Anterior abdominal seta.



Map 6. *Placostegus tridentatus*

Placostegus tridentatus Fabricius, 1780
(Fig. 6; Map 6)

Placostegus tridentatus – Wollebæk 1912: pl. XLVII; McIntosh 1923:370-374, pl. CXXII, Fig. 3, pl. CXXXI, fig. 8; Fauvel 1927:373; Zatsepin 1948:167; Wesenberg-Lund 1950a:60; 1950b:135; Hartmann-Schröder 1971:529, Add. 184; Nelson-Smith 1967:38, figs. 30-33.

Material. DHMSU, Appendix, N 4 (tubes); N 5 (1 spec.); N 6 (1 spec. and tubes); N 7 (2 spec.); N 8 (1 spec. and tubes); N 10 (tubes); N 12 (tubes); N 13 (tubes); N 14 (tubes); N 15 (tubes); N 18 (1 spec.); N 19 (tubes); N 18 (1 spec.); N 20 (1 spec.); N 21 (1 spec. and tubes); N 22 (tubes); N 23 (tubes); N 24 (2 spec.); N 25 (2 spec. and tubes); N 26 (1 spec. and tubes); N 29 (tubes); N 31 (tubes); N 34 (1 spec. and tubes); N 33 (tubes); N 35 (tubes); N 37 (tubes); N 39 (tubes); N 38 (2 spec. and tubes); N 40 (tubes); N 41 (tubes); N 42 (1 spec. and tubes); N 48 (tubes); N 49 (tubes); N 50 (1 spec. and tubes); N 53 (tubes); N 55 (2 spec. and tubes); N 57 (tubes); N 58 (1 spec. and tubes); N 60 (1 spec.); N 61 (tubes); N 63 (2 spec. and tubes); N 68 (tubes); N 71 (15 spec.); N 72 (1 spec.); N 73 (2 spec.); N 74 (4 spec.); N 77 (tubes); N 80 (15 spec.); N 81 (1 spec.); N 82 (2 spec.); N 83 (1 spec.); N 96 (9 spec.); N 99 (1 spec.); N 101 (1 spec. and tubes); N 102 (1 spec.); N 103 (150 spec. and tubes); N 104 (5 spec.); N 106 (2 spec. and tubes); N 111 (tubes); N 112 (3 spec. and tubes); N 116 (1 spec.); N 120 (tubes); N 129 (1 spec.); N 130 (tubes); N 136 (6 spec.); N 137 (2 spec. and tubes); N 140 (tubes); N 142 (tubes); N 148 (1 spec. and tubes); N 151 (2 spec. and tubes); N 152 (3 spec.); N 153 (1 spec. and tubes); N 161 (tubes); N 162 (1 spec.); N 163 (2 spec. and tubes); N 165 (1 spec.); N 172 (1 spec.); N 175 (4 spec.); N 176 (8 spec. and tubes); N 188 (1 spec.); N 190 (tubes); N 192 (8 spec. and tubes); N 196 (tubes); N 201 (3 spec.); N 204 (35 spec. and tubes); N 205 (2 spec. and tubes); N 231 (5 spec.); N 232 (tubes); N 233 (3 spec.); N 234 (1 spec.); N 235 (4 spec.); N 236 (12 spec.); N 238 (2 spec.); N 240 (tubes); N 241 (tubes); N 242 (2 spec. and tubes); N 243 (1 spec. and tubes); N 244 (1 spec. and tubes); N 246 (1 spec. and tubes).

ZIN RAS, Reg. N 1, Spitsbergen, 4 m, 28 June 1936 (2 spec. and tubes); Reg. N 2, Spitsbergen, 28 June 1936 (1 spec.); Reg. N 3, Spitsbergen (tube); Reg. N 5, R/V *Sadko* Stn. 22.53, 81°10'N 30°01'E, 157 m, 15 Aug. 1935 (tubes); Reg N 7, R/V *Ob* Stn. 1, 78°05'N 9°48'E, 214 m, 16 Aug. 1956 (1 spec.); Reg. N 9, R/V *Andrei Pervozvanny* Stn. 417, 76°13'N 32°37'E, 148 m (3 spec.); Reg. N 11, R/V *Sadko* Stn. 28, 78°08'N 9°40'E, 225 m, 30 July 1935 (tubes); identified as *Apomatus globifer*: Reg. N 120, 70°12'N 31°50'E, 307 m (1 spec. with an underdeveloped vesicular operculum on a short peduncle).

Tubes (Fig. 6B) triangular in cross section, thick-walled, opalescent (semi-transparent). Keels of tube continuing into large spines at tube opening. Tubes usually attached to substratum by the proximal part only, distal part is free, often spirally coiled.

Body length without branchia 6-23 mm (n = 20, mean 11.1, SD 3.54). Fifteen to 24 branchial radioles (n = 21, mean 24.8, SD 56.89) not connected by membrane at base. Operculum a narrow cone covered with concave (sometimes almost flat) brown distal plate of chitin-like material with concentric growth rings. Peduncle smooth, cylindrical; wider than normal branchial radioles and slightly narrower at base. It inserted medio-dorsally at base of either branchial lobe, covering 2-3 normal radioles.

Collar trilobed, thin, long, covering branchial lobes and proximal part of branchial radioles. Lateral notches of collar deep, lobes approximately of same length, dorsal lobe wider than lateral lobes. Collar margin is smooth.

Thorax short, compact, thoracic notopodia close to each other, not shifting ventrally. Thoracic membranes continuing to end of thorax forming free apron ventrally.

Collar setae absent. Thoracic setae (Fig. 6C) simple, with narrow distal blade. Setae in anterior and middle abdominal setigers (Fig. 6F) small, with denticulate margin widening distally and long lateral spine at one side. Setae of posterior abdominal segments simple capillary, slightly longer than more anterior setae. Thoracic uncini (Fig. 6D) rasp-shaped, with numerous teeth per row, anterior tooth simple, rounded. Abdominal uncini (Fig. 6E) similar to thoracic uncini, but smaller.

Remarks. The species is well known in the Mediterranean and Northern Atlantic. The only record from Japan was reported by Imajima (1978). However, the author stressed that he referred his material to *P. tridentatus* only tentatively and that a revision of the genus is needed.

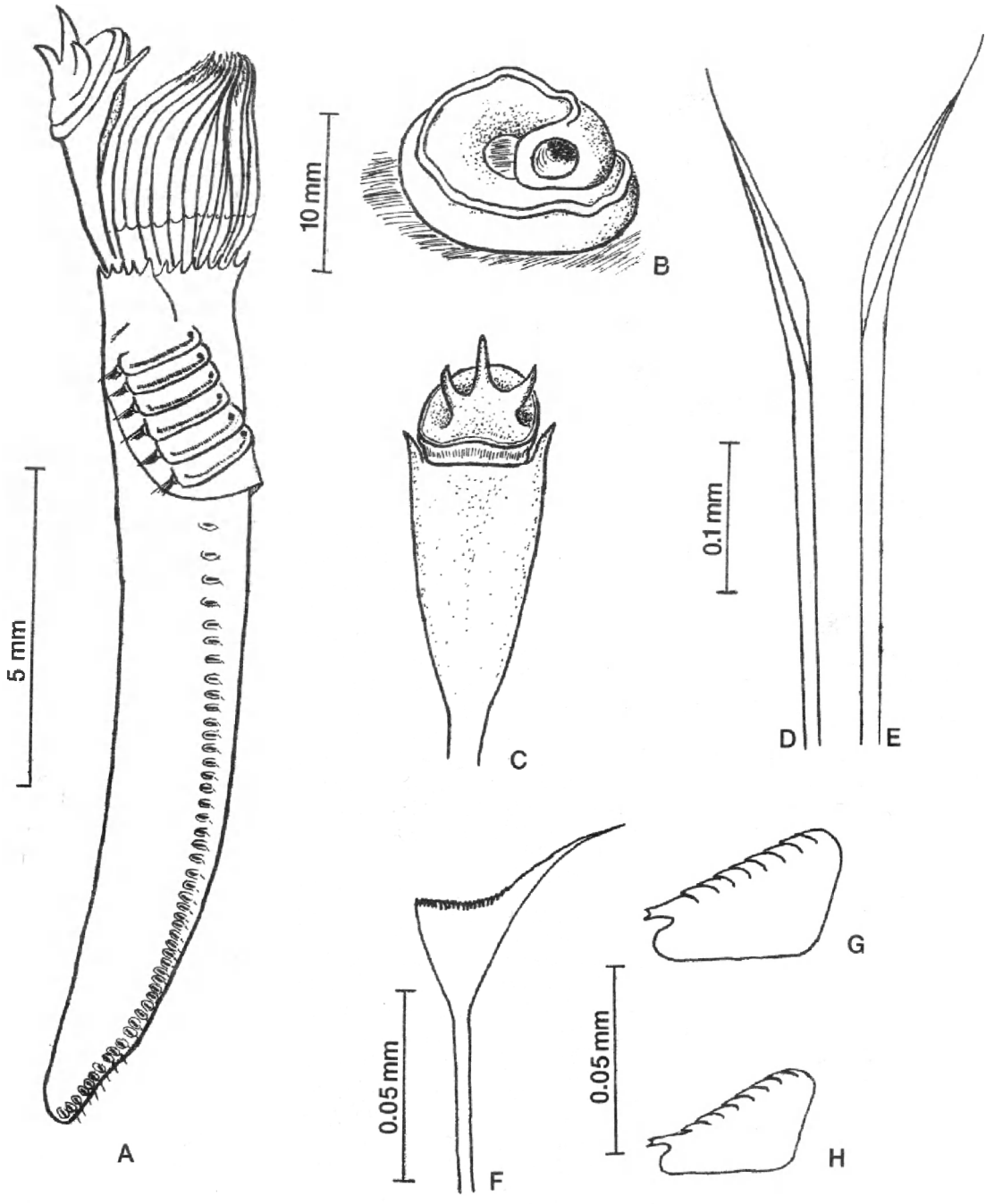
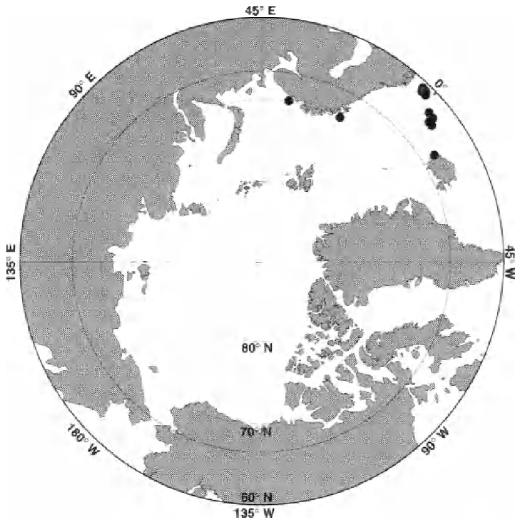


Fig. 7. *Pomatoceros triqueter*. A. Lateral view. B. Tube. C. Operculum. D. Collar seta. E. Thoracic seta. F. Abdominal seta. G. Thoracic uncinus. H. Abdominal uncinus.



Map 7. *Pomatoceros triqueter*

Genus *Pomatoceros* Philippi, 1844

Type species: *Serpula triquetera* Linnaeus, 1767

Seven thoracic setigers. Operculum inverted cone with calcified distal plate. Peduncle thick, almost triangular in cross section with distal lateral wings. Pseudooperculum absent. Thoracic membranes forms ventral apron on last thoracic segment. Collar setae small, simple limbate. *Apomatus*-setae absent. Abdominal setae trumpet-shaped with long lateral spine. All uncini saw-shaped; anterior tooth bifurcate.

Pomatoceros triqueter (Linnaeus, 1767)
(Fig. 7; Map 7)

Pomatoceros triqueter – Hansen 1878; Wollebæk 1912: pl. XLII; Wesenberg-Lund 1950a:60; 1950b:135; Zibrowius 1968: pl.8; Hartmann-Schröder 1971:529, Add. 183.

Material. DHMSU, Appendix, N 18 (2 spec.); N 77 (tubes); N 83 (1 spec.); N 85 (6 spec. and tubes); N 92 (1 spec.); N 123 (26 spec. and tubes); N 125 (392 spec.); N 126 (3 spec. and tubes); N 127 (tubes); N 129 (14 spec.); N 130 (tubes); N 173 (114 spec.); N 174 (25 spec. and tubes); N 177 (tubes); N 192 (1 spec. and tubes); N 193 (5 spec. and tubes); N 207 (57 spec.); N 246 (tubes).

Tube (Fig. 7B) up to 5 mm in diameter, nearly triangular in cross section, white, without distinctive growth rings. Median keel wavy, not denticulate.

Body length without branchial crown 7-16 mm (n = 20, mean 10.5, SD 2.80). Eleven to 20 short branchial radioles (n = 20, mean 15.5, SD 2.18) connected by the membrane at the base. Operculum (Fig. 7C) oblique cone covered with distal plate of chitin-like material. Peduncle inserted medio-dorsally, at base of branchial radioles, 2-3 times thicker than normal branchial radioles, and roughly triangular in cross section. Distal end of peduncle with a pair of wings.

Collar thick, short, covering only base of branchial lobes. Collar divided into three lobes of uniform length; the dorsal lobe distinctly wider than lateral lobes. Thorax short, compact, with neuropodia closely spaced laterally. Thoracic neuropodia shifted ventrally, so that neuropodia of the seventh thoracic segment often touch each other. Distinct black spots on ventral margins of thoracic neuropodia. Thoracic membranes continues to end of thorax, forming a long free ventral apron covering first 3-4 abdominal segments.

Collar setae (Fig. 7D) small, simple capillary. Thoracic setae (Fig. 7E) larger than collar setae, distally limbate. Abdominal setae (Fig. 7F) trumpet-shaped with denticulate edge and long lateral spine. Posterior abdominal setae capillary. Thoracic uncini (Fig. 7G) saw-shaped with 9-10 teeth per row. Abdominal uncini (Fig. 7H) similar to thoracic uncini, but smaller.

Remarks. Zibrowius (1968) distinguished two species inhabiting the Eastern Atlantic and Mediterranean, the intertidal *Pomatoceros lamarckii* (Quatrefages), 1865 and the subtidal *P. triqueter*. These species are separated by the shape of the operculum. The status of these species was later confirmed by enzyme electrophoresis (Ekarathe & al. 1982; Crisp & Ekarathe 1984).

Genus *Protis* Ehlers, 1887, emend. Kupriyanova 1993

Type species: *Protis simplex* Ehlers, 1887

Seven thoracic setigers. One or more membranous globular opercula on pinnulate branchial radioles may present. Thoracic membranes long, may form apron ventrally. Collar setae simple limbate and fin-and-blade; *Apomatus*-setae present. Thoracic uncini saw-shaped with about 6 teeth. Abdominal uncini rasp-shaped; anterior teeth not bifurcate.

Remarks. According to the original diagnosis, the lack of an operculum is considered a characteristic feature of *Protis* (Hansen 1878). However, *Protis polyoperculata* (Kupriyanova 1993), described from the Kurile-Kamchatka trench, fits the diagnosis of the genus, except that it possesses various numbers (0-6) of *Apomatus*-like opercula. This finding allowed us to emend the generic diagnosis. It also confirmed the opin-

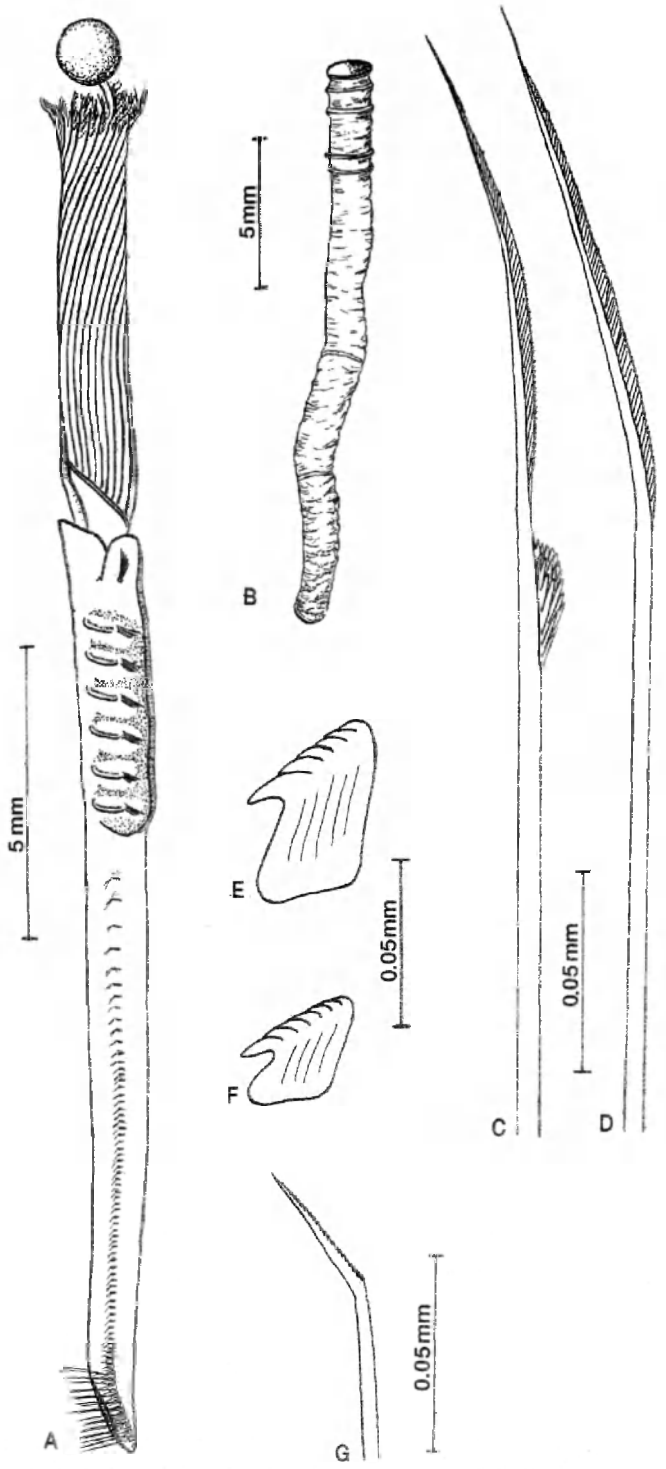
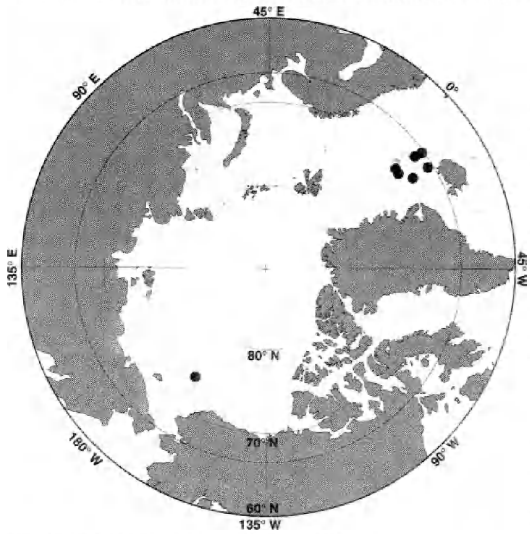


Fig. 8. *Protis arctica*. A. Lateral view. B. Tube. C. Collar setae. D. Thoracic seta. E. Thoracic uncinus. F. Abdominal uncinus. G. Anterior abdominal seta.



Map 8. *Protis arctica*

ion of many authors that the presence or absence of the operculum in serpulids is not a sufficient criterion to separate serpulids at the generic level.

Two species, *Protis simplex* Ehlers, 1887 and *Protula arctica* Hansen, 1878, were originally referred to the genus. The former species, *P. simplex* was designated the type species by Hartman (1959). Eliason (1951) and Zibrowius (1969) suggested *Protis simplex* as a synonym of *Protis arctica*. In this case, *Protis arctica* should be the type species. However, since the synonymy is questionable (see the discussion below), we continue to recognize Hartman's designation.

The genera *Protis* and *Protula* have been often confused, but are easily distinguished by the fin-and-blade collar setae and saw-shaped thoracic uncini with about 6 teeth in the former versus the limbate collar setae and rasp-shaped thoracic uncini with numerous teeth in the latter.

Protis arctica (Hansen, 1878)
(Fig. 8; Map 8)

Protis arctica – Kirkegaard 1982:257, fig. 2A-C.
Protula arctica – Wollebæk 1912:120-122; pl. XLVIII; Wesenberg-Lund 1950a:61; 1950b:137.

Material. DHMSU, Appendix, N 114 (1 spec. and tubes); N 117 (9 spec.); N 118 (3 spec.); N 167 (1 spec. and tubes); N 185 (6 spec. and tubes); N 186 (56 spec.); N 214 (4 spec.).

Tubes (Fig. 8B) up to 3.5 mm in diameter, circular in cross section, attached to substratum only at base, distal end free. Tube surface rugose, with transverse growth rings.

Body length less branchia 5-25 mm (n = 19, mean 14.6, SD 4.58). Seventeen to twenty pairs of branchial radioles (n = 20, mean 19.4, SD 1.35) not connected by interradiolar membrane at base. Base of branchial lobes elongate. Operculum, if present, a membranous globular vesicle on normal second branchial radiole. Sometimes a second operculum present. In our material we found 6 specimens with one operculum and one with two opercula.

Collar trilobed, long, not covering branchial lobes. Lateral collar notches deep, with small bosses at base of notches. Dorsal lobe of collar slightly higher and distinctly wider than lateral lobes.

Thorax elongate, thoracic membranes extending to the last thoracic setiger, but not forming ventral apron. Surface of thoracic membranes and surface between thoracic notopodia with distinct pigment spots.

Collar setae (Fig. 8C) fin-and-blade, distally blade separated from proximal dentate zone by wide gap. Thoracic setae (Fig. 8D) limbate. Abdominal setae short geniculate, with denticulate blade on anterior and middle setigers (Fig. 8G), replaced by long capillary ones on posterior abdominal setigers. Thoracic uncini (Fig. 8E) saw-shaped with 5-7 teeth, abdominal uncini (Fig. 8F) similar to thoracic uncini, but smaller and rasp-shaped.

Remarks. The species was originally described (Hansen 1878) based on two specimens from the North Atlantic (between Iceland and Norway) from 2127 m. The same specimens were later redescribed by Wollebæk (1912). Wesenberg-Lund (1950) reported new specimens from the Arctic Atlantic; however, at least part of her material re-examined by Zibrowius (1969) turned out to be *Protula tubularia*. Zibrowius (1969) suggested that the remaining specimens in Wesenberg-Lund's collection taken from depths less than 100 m also belong to *P. tubularia*. Kirkegaard (1982) reported two specimens of *Protis arctica* collected from the abyssal depths of the Central Arctic. He provided an illustration of an entire specimen, but did not give a diagnosis or details of setae and uncini structure. Fauvel (1914) reported *Protis arctica* from the North Atlantic (Azores, Madeira) and provided a description accompanied by illustrations of setae and uncini.

Zibrowius (1969) summarized all previous records of the species and described one specimen from the abyssal equatorial Atlantic. According to his description, the specimen differs from our material by a developed apron of the thoracic membranes, a character not mentioned in the original description. A large specimen of *Protis arctica* lacking branchial crown from the abyssal equatorial Atlantic was also reported by Eliason (1951). He

compared it with the type material, but did not provide a detailed description. The report of the species from 30 m in the Gulf of Suez, Red Sea was made by Amoureux & al. (1978), who gave a short description of one specimen. This record is rather doubtful because the location is too shallow and warm compared to all previous locations of the species.

Protis simplex Ehlers, described from a single specimen found in the Gulf of Mexico was later considered a juvenile of *P. arctica* by Eliason (1951) and Zibrowius (1969). No comparative study was performed, and the only reason for synonymizing the species was the absence of 'confirmed features which allow a specific distinction between the forms' (Zibrowius 1969). However, no reliable characters exist to distinguish species within *Protis* at all. Obviously, a critical reexamination of all records is necessary before the distribution of *P. arctica* and the validity of *P. simplex* can be confirmed.

Genus *Protula* Risso, 1826 (including *Apomatus* Philippi, 1844)

Type species: *Serpula tubularia* Montagu, 1803

Seven thoracic setigers. Operculum, if present, a membranous globular vesicle on second pinnulate branchial radiole. Thoracic membranes forms ventral apron. Collar setae simple limbate. *Apomatus*-setae present. Thoracic and abdominal uncini rasp-shaped with numerous teeth. Abdominal setae with dentate or sickle-shaped blades.

Remarks. The recognition of *Apomatus* and *Protula* is similar to that of *Filogarana* and *Salmacina*: the genera are separated mainly by the presence of the operculum. In this account we consider *Apomatus* a synonym of *Protula* based on the reasoning given above (see remarks for *Filograna* and *Protis*).

Hanson's (1948) studies on the pattern of blood vessels showed that *P. tubularia*, *Apomatus ampulliferus* and *A. similis* are similar to each other, but dissimilar to *P. interstinum*. He suggested that these genera should be fused into one. Hove & Pantus (1985) suggested, also based on the study of blood vessel patterns, that *Protula* and *Apomatus* are valid genera. Their analysis did show consistent differences between operculate and non-operculate animals. This should be expected if they belong to separate species, but does not necessarily indicate that these species should be placed in separate genera. Once again, a thorough revision which takes into account population and ontogenetic variability within the *Protula*/*Apomatus* complex is the only way to resolve the present taxonomic confusion.

Protula globifera (Theel, 1876) comb. nov.
(Fig. 9; Map 9)

Apomatus globifer – Levinsen 1887; Marenzeller 1892; Wollebæk 1912:112, pl. XLI; Tanasiichuk 1928; Friedrich 1940; Wesenberg-Lund 1950b:137; Zatsepin 1948:167; Uschakov 1957:1669.

Material. DHMSU, Appendix N 28 (2 spec.); N 37 (2 spec.); N 44 (1 spec.); N 54 (2 spec. and tubes); N 59 (1 spec. and tubes); N 76 (1 spec.); N 88 (1 spec.); N 96 (4 spec.); N 97 (1 spec.); N 101 (1 spec.); N 103 (1 spec.); N 105 (2 spec.); N 108 (1 spec.); N 109 (1 spec.); N 110 (2 spec. and tubes); N 111 (4 spec. and tubes); N 113 (2 spec.); N 130 (1 spec.); N 136 (3 spec.); N 137 (1 spec. and tubes); N 138 (3 spec.); N 147 (1 spec.); N 150 (3 spec.); N 154 (1 spec.); N 160 (1 spec.); N 179 (1 spec. and tubes); N 183 (1 spec.); N 186 (1 spec.); N 190 (2 spec.); N 196 (1 spec.); N 207 (1 spec.); N 208 (1 spec.); N 212 (5 spec.); N 213 (2 spec.); N 214 (8 spec.); N 215 (4 spec.); N 216 (1 spec.); N 220 (3 spec.); N 222 (17 spec.); N 223 (44 spec.); N 224 (11 spec.); N 226 (3 spec.); N 227 (1 spec.); N 228 (5 spec.); N 229 (1 spec.); N 230 (1 spec.); N 235 (3 spec.); N 238 (5 spec.).

ZIN RAS, Reg N 1, Franz Joseph Land, 300 m, 25 Aug. 1929 (1 spec.); Reg N 2, 78°38'N 63°10'E, 363m, 10 July 1922 (7 spec.); Reg N 3, 78°40'N 58°00'E, 162 m (5 spec.); Reg. N 4, 82°14'N 52°10'E, 165 m (3 spec.); Reg. N 5, 80°26'N 64°14'E, 204 m, (4 spec.); Reg N 6, Spitsbergen Isl., 145m, 19 Sept. 1936 (1 spec.); Reg. N 7, 73°33'N 62°37'E, 120 m, 19 Sept. 1931, (2 spec. and tubes); Reg. N 8, 73°36'N 59°42'E, 345 m, 19 Sept. 1931 (1 spec. and tubes); Reg. N 113, 79°16'N 103°20'E, (4 spec.); Reg. N 115, 76°20'N 95°14'E (1 spec.); R/V *Sedov*: Reg. N 10, Stn. 58.28, 80°26'N 88°57'E, 170 m, 31 Aug. 1930 (8 spec.); Reg N 12, Stn. 57.27, 79°55'N 88°58'E, 180 m (10 spec.); Reg. N 14, Stn. 49.19, 78°55'N 79°15'E, 148 m, 19 Aug. 1930 (12 spec.); Reg. N 15, Stn. 59.29, 80°47'N 89°50'E, 31 Aug. 1930, (4 spec.); Reg. N 16, Stn. 60.30, 79°00'N 87°07'E, 180 m (3 spec. and tubes); Reg. N 17, Stn. 44.14, 78°58'N 68°25'E, 350 m (2 spec.); Reg. N 18, Stn. 57.21, 77°53'N 79°45'E, 102 m, 20 Aug. 1930 (tubes); Reg. N 19, Stn. 61.31, 78°33'N 86°20'E, 119 m (8 spec. and tubes); Reg. N 20, Stn. 62.32, 78°02'N 86°30'E, 108 m (1 spec.); Reg. N 21, Stn. 60.38, 76°36'N 74°48'E, 157 m (4 spec. and tubes); R/V *Sadko*: Reg. N 22, Stn. 16.49, 80°49'N 34°34'E, 115 m (1 spec.); Reg. N 24, Stn. 52.91, 80°27'N 88°15'E, 279 m (1 spec.); Reg. N 25, Stn. 25.55, 80°10'N 34°00'E, 280 m, 16 Aug. 1935 (4 spec.); Reg. N 26, Stn. 29.64, 78°33'N 73°21'E, 410 m, 25 Aug. 1935 (tubes); Reg. N 27, Stn. 31.66, 79°17'N 76°08'E, 54 m, 26 Aug. 1935 (4 spec.); Reg. N 28, Stn. 7.26, 78°02'N 9°12'E 820 m, 22 July 1935 (1 spec. and tubes); Reg. N 30, Stn. 40.74, 80°45'N 69°46'E, 560 m, 30 Aug. 1935 (1 spec.); Reg. N 31, Stn. 63.104, 76°57'N 65°21'E, 283 m, 16 Sept. 1935 (3 spec.); Reg. N 32, Stn. 1.12, 76°18'N 16°24'E, 99-136 m, 17 July 1935 (1 spec.); Reg. N 33, Stn. 53.15, 80°30'N 85°09'E, 297 m (15 spec.); Reg. N 34, Stn. 35.71, 81°11'N 66°53'E, 520 m, 28 Aug. 1935 (3 spec.); Reg. N 35, Stn. 49.84, 79°57'N 79°11'E, 140 m (4 spec.); Reg. N 36, Stn. 51.88, 80°11'N 86°24'E, 250 m (1 spec.); Reg. N 38, Stn. 44, 80°58'N 80°26'E, 74 m

(tubes); Reg. N 39, Stn. 39.73, 80°44'N 68°08'E, 542 m, 30 Aug. 1935 (tubes); Reg. N 40, Stn. 50.87, 79°47'N 84°32'E, 200 m (2 spec.); Reg. N 41, Stn. 61.102, 80°21'N 81°19'E, 115 m, 14 Sept. 1935 (3 spec.); Reg. N 42, Stn. 55.95, 81°32'N 83°06'E, 300 m (2 spec.); Reg. N 43, Stn. 62.103, 80°33'N 77°48'E, 105 m, 15 Sept. 1935 (1 spec.); Reg. N 44, Stn. 29.64, 78°33'N 73°21'E, 410 m, 25 Aug. 1935 (1 spec. and tubes); Reg. N 45, Stn. 47.82, 81°11'N 75°20'E, 124 m (5 spec.); Reg. N 46, Stn. 43.77, 81°35'N 75°57'E, 225 m (12 spec.); Reg. N 47, Stn. 32.68, 80°19'N 72°47'E, 360 m, 26 Aug. 1935 (tubes); Reg. N 50, Stn. 5, 77°50'N 104°07'E, 203 m, 13 Aug. 1937 (9 spec.); Reg. N 51, Stn. 4, 77°43'N, 102°58'E, 40 m (2 spec. in tubes); Reg. N 52, Stn. 2, 77°16'N 96°54'E, 75 m (6 spec.); Reg. N 53, Stn. 93, 79°3'0N 150°10'E, 90 m (21 spec. and tubes); Reg. N 54, Stn. 92, 79°05'N 151°45'E, 81 m (13 spec.); Reg. N 55, Stn. 94, 79°38'N 150°00'E, 158 m, 16 Sept. 1938 (2 spec. and tubes); Reg. N 62, Stn. 24, 77°07'N 151°33'E, 38 m, 24 Aug. 1938 (1 spec.); Reg. N 65, Stn. 9, 80°58'N 73°32'E, 444 m (1 spec. and tubes); R/V *Persei*: Reg. N 57, Stn. 185, 77°33'N 40°58'E, 220 m (1 spec. and tubes); Reg. N 58, Stn. 574, 78°3'9N 38°40'E, 190 m, 29 Aug. 1926 (1 spec. and tubes); Reg. N 59, Stn. 96, 79°10'N 40°30'E, 380 m, 29 Aug. 1923 (3 spec.); Reg. N 60, Stn. 29, 72°14'N 62°04'E, 121m, 27 Aug. 1921 (6 spec.); Reg. N 61, Stn. 573, 78°59'N 40°16'E, 182 m, 29 Aug. 1926 (2 spec.); Drifting polar station *SP-4*: Reg. N 66, Stn. 2, 76°47'N 173°17'E, 19 June 1954 (8 spec. and tubes); *SP-3*: Reg. N 67, Stn. 17, 88°14'N 64°54'E, 25 Sept. 1954 (tubes); R/V *Litke*: Reg. N 71, Stn. 26, 82°00'N 42°00'E, 415 m, 18 Sept. 1956 (4 spec.); Reg. N 72, Stn. 13, 82°11'N 60°57'E, 323 m, 15 Sept. 1955 (2 spec.); Reg. N 73, Stn. 11, 82°23'N 54°14'E, 318 m, 14 Sept. 1955, (1 spec.); Reg. N 74, Stn. 12, 82°24'N 58°25'E, 276 m, 14 Sept. 1955 (tubes); Reg. N 76, Stn. 9, 82°20'N 47°17'E, 384 m, 14 Sept. 1955 (8 spec.); Reg. N 77, Stn. 145, 78°31'N 113°03'E, 469 m (55 spec.); Reg. N 78, Stn. 136, 79°28'N 105°12'E, 120 m, 30 Aug. 1948 (1 spec.); Reg. N 79, Stn. 129, 80°04'N 99°48'E 121 m, 28 Aug. 1948 (1 spec.); Reg. N 80, Stn. 144, 78°34'N 110°09'E, 96 m (4 spec.); Reg. N 81, Stn. 119, 78°49'N 100°30'E, 257 m, 27 Aug. 1948 (1 spec.); Reg. N 82, Stn. 135, 79°28'N 103°20'E, 116 m, 30 Aug. 1948 (2 spec.); Reg. N 83, Stn. 175, 78°17'N 104°52'E, 44 m (tubes); Reg. N 84, Stn. 114, 78°43'N 97°55'E, 78 m, 26 Aug. 1948 (1 spec.); Reg. N 85, Stn. 138, 79°02'N 107°01'E, 371 m, 31 Aug. 1948 (4 spec.); Reg. N 86, Stn. 132, 79°55'N 103°32'E, 348 m, 29 Aug. 1948 (10 spec.); Reg. N 87, Stn. 109, 77°52'N 99°23'E, 51 m, 26 Aug. 1948 (5 spec.); Reg. N 88, Stn. 127, 79°35'N 101°17'E, 252 m, 27 Aug. 1948 (7 spec.); Reg. N 89, Stn. 133, 79°45'N 104°52'E, 432 m, 30 Aug. 1948 (17 spec.); Reg. N 90, Stn. 37, 79°28'N 57°21'E, 170 m, 18 July 1948 (2 spec.); Reg. N 91, Stn. 73, 79°38'N 60°45'E, 124 m (9 spec., one with 2 opercula); Reg. N 92, Stn. 75, 79°58'N 65°34'E, 458 m (1 spec.); Reg. N 93, Stn. 83, 79°04'N 69°56'E, 509 m (1 spec.); Reg. N 94, Stn. 92, 77°26'N 67°20'E, 314 m, 14 Aug. 1948 (1 spec.); Reg. N 95, Stn. 113, 78°32'N 97°55'E, 112 m, 26 Aug. 1948 (3 spec.); Reg. N 96, Stn. 117, 78°35'N 99°33'E, 132 m, 26 Aug. 1948 (1 spec.); Reg. N 97, Stn. 131, 80°00'N 102°05'E, 271 m, 29 Aug. 1948 (8 spec.); Reg. N 98, Stn. 136, 79°28'N 105°12'E, 120 m, 30 Aug. 1948 (1 spec.); Reg. N 99, Stn. 138, 79°02'N 107°01'E, 371 m, 31 Aug. 1948 (1 spec.); Reg. N 100, Stn. 139, 78°39'N 106°06'E, 226 m, 31 Aug. 1948 (3 spec.); Reg. N 101, Stn. 185, 80°26'N 85°36'E, 313 m, 30 Sept. 1948 (3 spec.); Reg. N 102, Stn. 189, 80°14'N 80°12'E, 64 m (1 spec.); Reg. N 103, Stn. 195, 68°32'N 68°32'E, 580 m (3 spec.); R/V *Ob*: Reg. N 104, Stn. 9, 78°04'N 8°34'W, 207 m, 19 Aug. 1956, (1 spec.); Reg. N 105, Stn. 13, 77°58'N 17°43'W, 368 m, 20 Aug. 1956 (tubes); Reg. N 106, Stn. 14, 78°34'N 15°34'W, 56 m, 22 Aug. 1956 (1 spec.); Reg. N 108, Stn. 40, 79°56'N 5°17'W, 1135 m, 30 Aug. 1956 (1 spec.); R/V *Lena*: Reg. N 109, Stn. 28, 77°54'N 5°59'W, 388 m, 25 March 1958 (8 spec.); Reg. N 110, Stn. 1, 76°30'N 15°02'E, 608 m (1 spec.); Reg. N 111, Stn. 7, 76°30'N 10°34'W, 294 m, 14 March 1958 (1 spec. and tubes); R/V *Tajmyr*: Reg. N 116, Stn. 21/66, 76°20'N 95°14'E, 44 m (2 spec.); R/V *Arctic* : Reg. N 118, Stn. 17, Bay Medvezhy, 68 m, 15 Sept. 1934 (6 spec.); identified as *Hyalopomatus claparedii*: R/V *Sadko*: Reg N 4, Stn. 18/50, 80°46'N 29°57'E, 445 m (2 spec.); identified as *Protula tubularia*: Reg N 3, 76°59'N 100°20'E, 20 m,. 1 Aug. 1924. (1 spec.); R/V *Litke* : Reg. N 9, Stn. 135, 79°28'N 103°20'E, 116 m, 30 Aug. 1948 (6 spec.).

Tubes (Fig. 9B, C) up to 5 mm in diameter, circular in cross section, white opaque. Tubes usually attached to substratum at base only, distal part free.

Body length without branchia 5-26 mm (n = 17, mean 16.6, SD 5.15). Number of branchial radioles varying from 10-40 pairs (n = 17, mean 24.9, SD 11.01) depending on animal size. Branchial radioles connected by interradiolar membrane at base. Branchial lobes long, pectiniform.

Collar entire, short, not covering bases of branchial lobes. Operculum a globular membranous transparent vesicle on a normal branchial radiole. Sometimes an additional similar operculum present.

Thorax elongate, thoracic neuropodia at least three times longer than abdominal notopodia. Thoracic neuropodia situated at mid-lateral line of thorax, not shifting ventrally. Ventral glandular shield very distinct. Thoracic membranes wide; continuing to last thoracic segment and forming wide apron ventrally. Wide asetigerous region between thorax and abdomen.

Collar setae (Fig. 9D) simple limbate. Thoracic setae of two types: simple limbate (Fig. 9E) and *Apomatus*-setae (Fig. 9F). Abdominal setae (Fig. 9H) short, knife-shaped on anterior and middle setigers, long capillaries posteriorly (Fig. 9G). Thoracic uncini (Fig. 9I) rasp-shaped, with numerous teeth per row; anterior teeth very long, not bifurcate. Abdominal uncini similar, but smaller (Fig. 9J).

Remarks. *Protula globifera* and *P. tubularia* can be easily distinguished, besides by the presence of opercula, by the length of thoracic notopodia and collar structure. Thoracic neuropodia (rows of uncini) are of the same length as abdominal notopodia (rows of uncini) and the collar is trilobed in *Protula globifera*, whereas the thoracic notopodia are several times longer

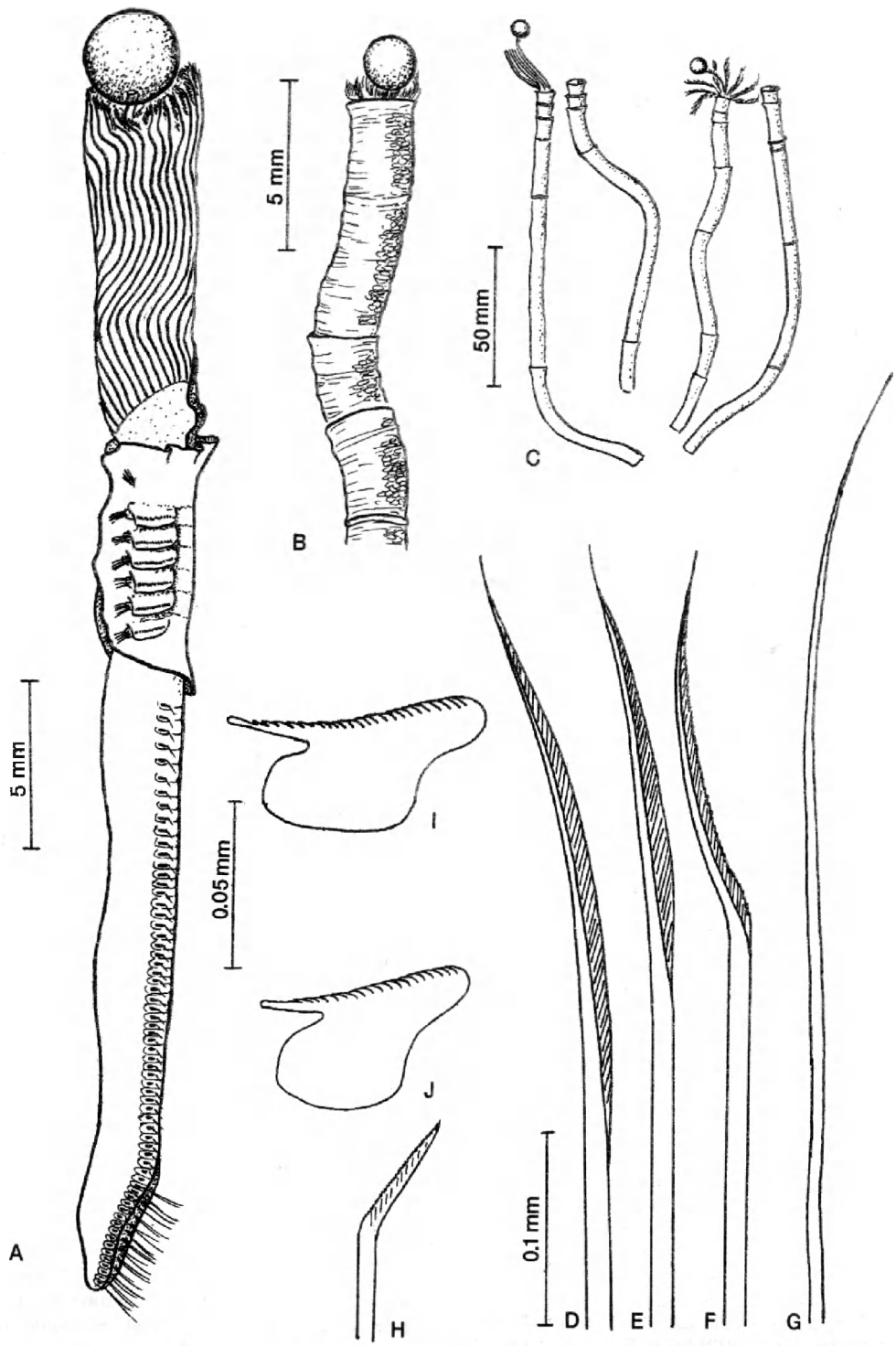
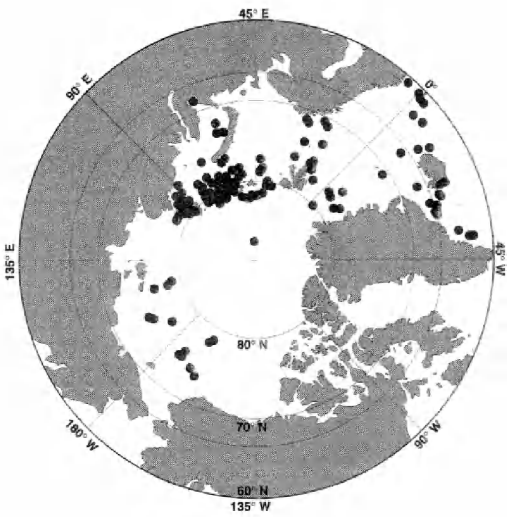


Fig. 9. *Protula globifera*. A. Lateral view. B, C. Tubes. D. Collar seta. E. Thoracic seta. F. *Apomatus*-seta. H. Anterior abdominal seta. G. Posterior abdominal seta. I. Thoracic uncinus. J. Abdominal uncinus.



Map 9. *Protula globifera*

than the abdominal neuropodia and the collar is entire in *P. tubularia*.

The tentative record of *Apomatus similis* from the Central Arctic (Knox 1959) is based on empty tubes and tube fragments from three stations. The information provided (cylindrical tubes with 'circular ridges at intervals') is insufficient to attribute these tubes to *Protula globifera*, *P. tubularia*, or *Protis arctica*. Fauvel (1927) and Hartmann-Schröder (1971) placed *Protula globifera* (as *Apomatus globifer*) into synonymy of *Apomatus similis* Marion & Bobretzky, 1875. As in the case with *Protis simplex* and *P. arctica*, without a comparative study, and based on literature only, we cannot tell with confidence whether the material from the Arctic and that from more southern locations belong to the same species. Therefore, we maintain *Protula globifera* as a separate species.

Protula tubularia (Montagu, 1803)
(Fig.10; Map 10)

Protula tubularia – McIntosh 1923:330-338, pl. CXV, fig. 6, pl. CXVI, fig. 2, pl. CXXI; fig. 5. pl. CXXX, fig. 7; Fauvel 1927:382, fig. 130a-l; Zatsepin 1948:167.

Material. DHMSU, Appendix, N 2 (3 spec.); N 9 (1 spec.); N 11 (2 spec.); N 12 (1 spec.); N 17 (1 spec.); N 20 (1 spec.); N 27 (1 spec.); N 28 (2 spec.); N 30 (1 spec.); N 32 (2 spec.); N 33 (3 spec.); N 35 (tubes); N 42 (2 spec.); N 43 (1 spec.); N 45 (1 spec.); N 46 (1 spec.); N 47 (5 spec.); N 50 (1 spec.); N 51 (1 spec.); N 52 (1 spec.); N 53 (2 spec.); N 54 (1 spec.); N 56 (2 spec.); N 58 (1 spec.); N 59 (1 spec.); N 62 (1 spec.); N 64 (3 spec.); N 73 (3 spec.); N 75 (2 spec.); N 96 (1 spec.); N 98 (1 spec.); N 107 (1 spec.); N 112 (10 spec.); N 136 (tubes); N 141 (1 spec.); N 154 (3 spec.); N 155 (3 spec.); N 157 (8 spec.); N 158 (4 spec.); N 160 (2 spec.); N 163 (1 spec.); N 169 (3 spec.); N 171 (4 spec.); N 177 (3 spec.); N 183 (2 spec.); N 184 (1 spec.); N 187 (1 spec.); N 190 (1 spec.); N 234 (1 spec.); N 239 (1 spec.).

ZIN RAS, Reg. N 1, 78°40'N 58°00'E, 102 m (2 spec.); Reg. N 4, 78°08'N 9°40'E, 225 m, 30 July 1935 (2 spec.); Reg. N 5, 69°34'N 32°26'E (6 spec.); Reg. N 6, 78°07'N 54°17'E, 250 m (2 spec. and tubes); Reg. N 7, 69°18'N 33°42'E, 72 m (2 spec.); Reg. N 8, 79°38'N 60°45'E, 124 m (3 spec.); Reg. N 10, 79°28'N 57°21'E, 170 m, 18 July 1948, (1 spec.); Reg. N 11, 78°04'N 9°48'E, 214 m, 16 Aug. 1956 (2 spec.); Reg. N 22, 69°18'N 33°42'E, 72 m (2 spec.); Reg. N 24, 67°55'N 47°25'E, 53 m (2 spec.); Reg. N 25, 69°23'N 32°47'E, 27-104 m (2 spec.); Reg. N 26, 69°27'N 32°23'E, 9-31 m (1 spec.); R/V *Andrei Pervozvanny*: Reg. N 14, Stn. 470, 70°10'N 34°11'E, 146-218 m, 1 June 1925 (5 spec.); Reg. N 15, Stn. 304, 69°47'N 30°57'E, 127 m (1 spec.); identified as *Apomatus globifer*: Reg. N 120, 70°12'N 31°50'E, 307 m (1 spec.); R/V *Sadko*: Reg N 23, Stn. 18/50, 80°45'N 29°57'E, 445 m (2 spec.); Reg. N 29, Stn. 20/52, 81°09'N 26°40'E, 160 m (1 spec.); R/V *Perset*: Reg. N 56, Stn. 1239, 77°17'N 35°36'E, 138 m, 18 Aug. 1929 (1 spec.); Reg. N 58, Stn. 574, 78°39'N 38°40'E, 190 m, 29 Aug. 1926; identified as *Hyalopomatus claparedii*: R/V *Litke*: Reg. N 75, Stn. 41, 82°02'N 34°58'E, 1747 m (1 spec.); R/V *Ob*: Reg. N 107, Stn. 17, 79°31'N 13°31'W, 212 m (1 spec.).

Tubes (Fig.10B) up to 5 mm in diameter, circular in cross section, white opaque. Tubes usually attached to substratum at base only, distal part of tube free, cylindrical.

Body length without branchia 10-43 mm (n = 13, mean 23.9, SD 9.19). Number of branchial radioles varies from 15-50 pairs (n = 11, mean 31.5, SD 8.09) depending on size of worm. Branchial radioles connected by short interradiolar membrane at base.

Collar trilobed, short, dorsally not covering base of branchial radioles. Lateral collar notches shallow, one-half collar length. Lobes of equal length, dorsal lobe wider than lateral ones. Collar margin smooth.

Thorax elongate, bundles of thoracic notopodia large, while thoracic neuropodia much smaller, equal to abdominal notopodial tori in length. Lateral distance between thoracic neuropodia significant; they are not in contact.

Thoracic membranes extend to end of thorax and forming wide apron ventrally. Short asetigerous region between thorax and abdomen. Tori of thoracic neuropodia at midlateral line of thorax. Tori of abdominal notopodia shifted ventrally, almost touching each other on ventral side.

Collar setae (Fig. 10C) simple with wide blade. Thoracic setae limbate in anterior thoracic setigers (Fig. 10D); complemented by *Apomatus*-setae in posterior setigers (Fig. 10E). Abdominal setae of anterior and middle

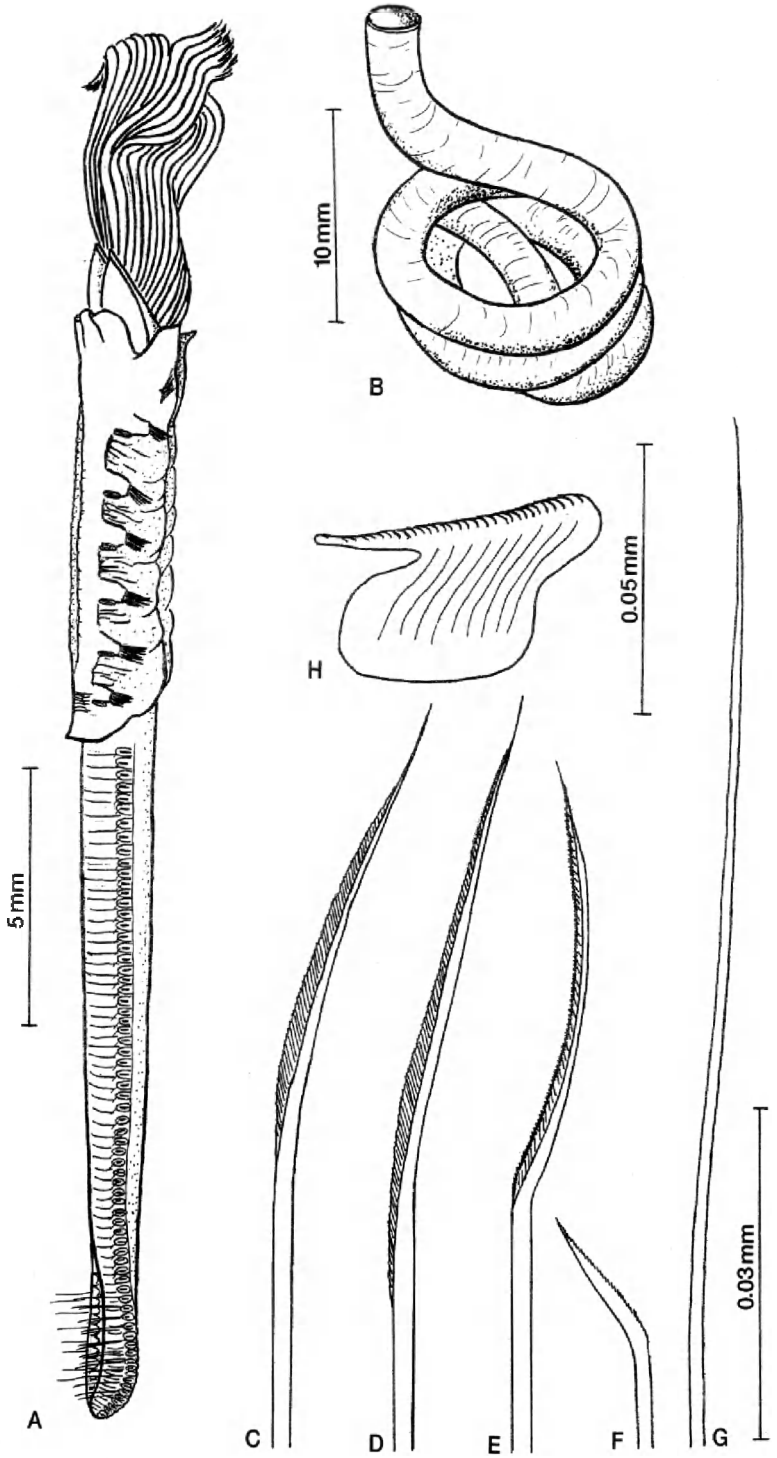
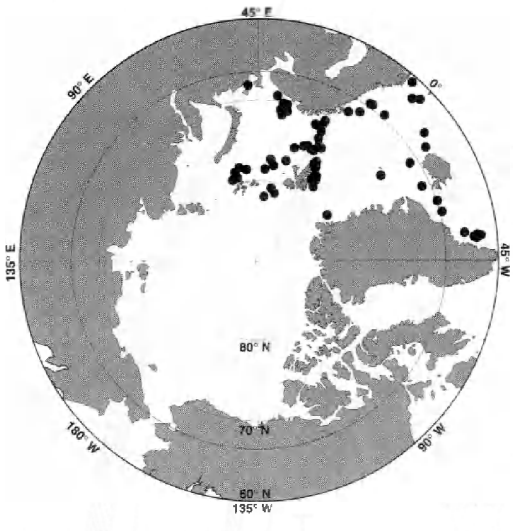


Fig 10. *Protula tubularia.* A. Lateral view. B. Tube. C. Collar seta. D. Thoracic seta. E. *Apomatus*-seta. F. Anterior abdominal seta. G. Posterior abdominal seta. H. Thoracic uncinus.



Map 10. *Protula tubularia*

setigers (Fig. 10F) short, with curved limbate distal end; replaced by long capillary setae (Fig. 10G) in posterior setigers. Thoracic uncini rasp-shaped, with numerous teeth in each row; anterior tooth long, simple, not bifurcate (Fig. 10H). Abdominal uncini similar to thoracic uncini, but smaller.

Remarks. In addition to the records indicated in the synonymy, the nominal species *Protula tubularia* has been recorded from all over the world; i.e., the Mediterranean (Zibrowius 1968, Red Sea (Amoureux 1978; Vine & Bailey-Brock 1985), South Africa (Day 1961; 1967), India (Tampi 1960), Australia (Day & Hutchings 1979), Japan (Okuda 1938; Uchida 1978), Korea (Hong; 1984), Pacific coast off Mexico (Zibrowius 1962), and Ceylon (Pillai 1972). Unfortunately, based on the literature one cannot determine whether this species really has such a distribution or whether some of these records refer to other species. Species in the genus have been distinguished on the basis of size differences and setal structure without any indication of variability. Neither can the presence of branchial ocelli serve as a reliable character because pigments are often not retained in preserved material. The operculum is absent according to all observations except of Hong (1985), who commented on the presence of an operculate *Protula* specimen in his material. Similar to the situation encountered in many serpulids, a comparative worldwide revision of *Protula* seems to be the only way to resolve this taxonomic confusion.

Genus *Serpula* Linnaeus, 1767

Type species: *Serpula vermicularis* Linnaeus, 1767

Seven (rarely 9) thoracic setigers. Operculum funnel-shaped, formed from fused radii. Peduncle smooth, cylindrical, appears to be formed from first dorsal radiole on one side. Pseudooperculum and interradiolar membrane present. Thoracic membrane usually forming ventral apron across anterior abdominal setigers. Collar setae bayonet and capillary. Thoracic setae simple limbate, *Apomatus*-setae absent. Abdominal setae flat trumpet-shaped. Uncini saw-shaped, anterior tooth simple.

Serpula vermicularis Linnaeus, 1767
(Fig. 11; Map 11)

Serpula vermicularis – Wollebæk 1912:pl. XLV, 1-5; Saemundsson 1918; Augener 1925; Ditlevsen 1929; Einarsson 1941; Wesenberg-Lund 1950a:59-60; 1950b:134; 1953:4-5, fig. 1; 1953:4-5; Nelson-Smith 1967:24, figs 1, 2; Hartmann-Schröder 1971:528-529, Add. 186; Blake & Dean 1973.

Material. DHMSU, Appendix, N 83 (1 spec.); N 91 (2 spec.); N 100 (2 spec.); N 115 (1 spec.); N 120 (1 spec.); N 125 (3 spec.); N 126 (tubes); N 129 (3 spec. and tubes); N 130 (3 spec. and tubes); N 132 (1 spec. and tubes); N 136 (2 spec.); N 152 (tubes); N 166 (1 spec.); N 169 (3 spec.); N 174 (1 spec.); N 175 (2 spec.); N 177 (2 spec.); N 178 (2 spec.); N 179 (1 spec.); N 180 (19 spec.); N 181 (7 spec.); N 192 (22 spec.); N 201 (2 spec.); N 202 (tubes); N 204 (2 spec.); N 205 (1 spec.); N 207 (tubes).

Tubes (Fig. 11F) up to 7 mm, pink, circular in cross section, surface wrinkled, with growth rings as wide collars. Proximal part of tube usually with several additional longitudinal denticulate ridges.

Body length without branchia is 8-25 mm (n = 24, mean 14.7, SD 4.41). Twenty to 38 pairs of branchial radioles (n = 24, mean 29.7, SD 4.01) connected by short membrane at base. Peduncle smooth cylindrical, 1.5-2 times wider than normal branchial radioles, appears to be formed from first dorsal radiole on one side. Operculum simple shallow funnel of fused radii (n = 39, mean 50.8, SD 9.50) with a denticulate edge, not separated from peduncle by constriction. Opercular radiole opposite to peduncle short, underdeveloped, bearing rounded pseudooperculum.

Collar trilobed, with shallow lateral notches and small bosses at base of notches. Dorsal and lateral lobes similar in length and width. Collar short, not covering branchial lobes ventrally. Thoracic membranes extends to end of thorax and forms free apron, covering one or two abdominal setigers.

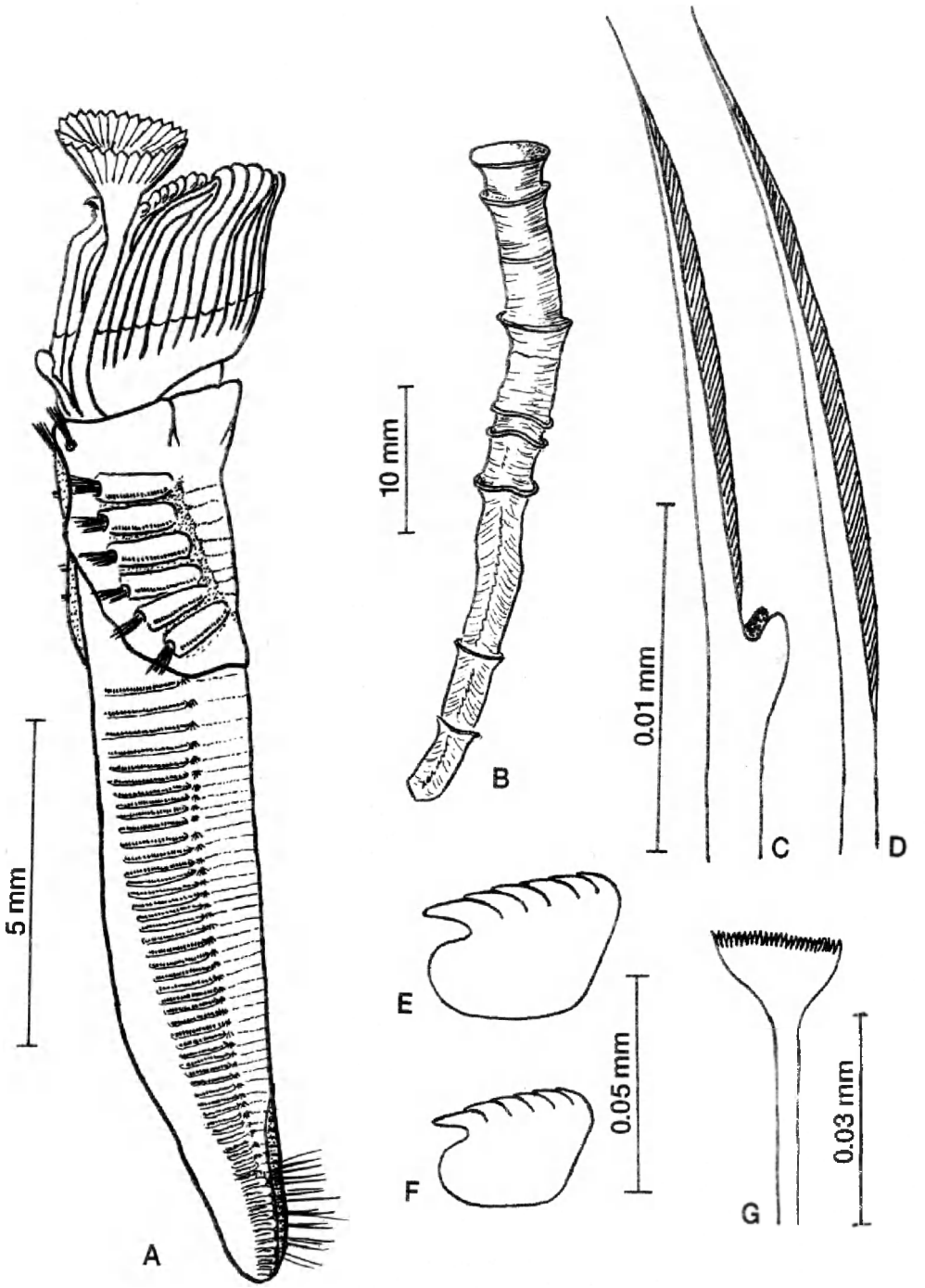
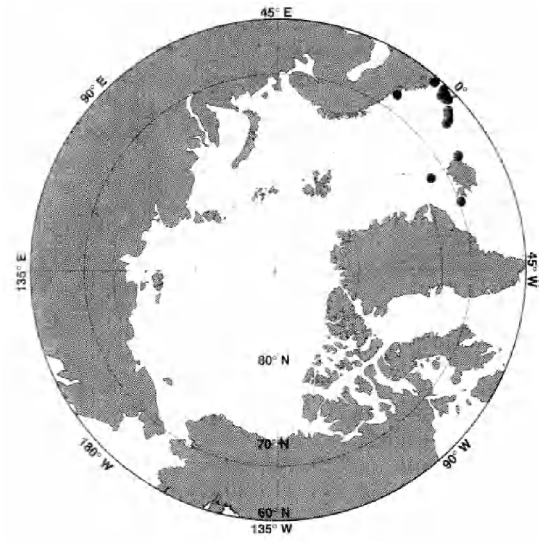


Fig. 11. *Serpula vermicularis*. A. Lateral view. B. Tube. C. Collar seta. D. Thoracic seta. E. Thoracic uncinus. F. Abdominal uncinus. G. Abdominal seta.



Map 11. *Serpula vermicularis*

Thorax short; thoracic neuropodia located close to each other and shifting ventrally from mid-lateral line of thorax, so that neuropodia of seventh thoracic segment meeting ventrally.

Abdominal notopodia (tori) very long, covering entire dorsal surface of worm. Collar setae of two types: simple limbate, and bayonet, with two large proximal bosses at base of distal blade (Fig. 11C). Thoracic setae (Fig. 11D) simple limbate. Setae of anterior and middle abdominal setigers (Fig. G) trumpet-shaped, denticulate distally, radiating fan-like. They are replaced by long capillaries in posterior segments. Thoracic uncini (Fig. 11E) saw-shaped, with 5-6 teeth per row, abdominal uncini (Fig. 11F) similar to thoracic uncini, but smaller.

Remarks. *Serpula vermicularis* is poorly defined and its cosmopolitan status is questionable (see also Hove & Jansen-Jacobs 1983, Imajima & Hove 1984). Most records in the literature are not accompanied by descriptions; when diagnoses are present, they are usually short and uninformative because the generic characters (such as funnel-shaped operculum or bayonet collar setae) are used to characterize the species. As a result, it is impossible to compare records from different geographic locations.

Recent studies have shown that *Serpula vermicularis* previously recorded from the Russian Far-Eastern Seas belongs to other species (Kupriyanova & Rzhavsky 1993). It is also very likely that close reexamination will reveal a number of species previously referred to the nominal species *S. vermicularis*. In this account, we report our material as *S. vermicularis* mainly because the studied region is close to the type locality. However, until a world-wide revision of *Serpula* is completed, the specific name *S. vermicularis* should be used only with a great caution.

ACKNOWLEDGMENTS

This study was supported by grants from the Russian Foundation for Basic Research (project # 95-04-11992), the Governmental Program on Science and Technology (project # 2.1.63 'Biodiversity'), and International Science Foundation to IAJ. We would like to express our gratitude to Galina Buzhinskaya and Vyacheslav Potin (Zoological Institute of the Russian Academy of Sciences) for letting us study the collections. Daniel Tappan, Carmen Lanciani, Larry McEdward, and Kirk Fitzhugh read early versions of the manuscript and made very helpful suggestions. We thank Harry ten Hove and an anonymous reviewer for the constructive criticism of the manuscript. Daniel Tappan also wrote a computer program to map the species distributions. Laurie Walz helped with editing maps and figures.

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Accepted 26 February 1997

Appendix. List of stations for the material deposited in HDMSU collection. Gear: 1 - Agassiz trawl, 2 - 'Ocean' grab. Substrate: (first column corresponds to main susbstrate, second to additional substrate) 0 - no data, 1 - clay, 2 - silty clay, 3 - silt, 4 - sandy silt, 5 - silty sand, 6 - fine sand, 7 - coarse sand, 8 - gravel, 9 - large stones and rocks.

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
1	1	*Alaid*	30.6	01 Jul 80	74°14'N	19°20'E	64	0.91	34.82	0	0
2	1	*Alaid*	30.13	11 Jul 80	68°51'N	37°20'E	75	2.68	33.96	0	0
3	2	*Atlantida*	9.1384	30 Apr 72	70°22'N	17°50'E	148	6.08	34.98	7	3
4	1	*Atlantida*	9.1386	30 Apr 72	70°12'N	17°16'E	220	6.03	35.15	7	3
5	2	*Atlantida*	9.1395	02 May 72	69°41'N	16°24'E	80	6.42	35.00	7	3
6	1	*Atlantida*	9.1396	02 May 72	69°40'N	16°02'E	200	5.92	35.15	7	3
7	2	*Atlantida*	9.1398	03 May 72	69°00'N	13°50'E	108	6.52	34.97	9	3
8	2	*Atlantida*	9.1403	03 May 72	68°15'N	12°12'E	165	6.75	35.10	9	3
9	1	*Maslov*	1.183	29 Nov 68	70°45'N	33°30'E	260	-	-	3	3

Appendix (continued)

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
10	1	*Maslov*	1.186	29 Nov 68	70°00'N	33°30'E	190	-	-	5	0
11	1	*Maslov*	1.187	29 Nov 68	69°45'N	33°30'E	240	-	-	3	2
12	1	*Maslov*	5.169	16 Aug 69	71°00'N	22°15'E	260	5.6	35.20	0	0
13	1	*Maslov*	5.170	16 Aug 69	70°40'N	19°45'E	175	7.0	34.80	5	0
14	1	*Maslov*	5.171	17 Aug 69	70°40'N	19°00'E	300	6.6	35.20	4	3
15	2	*Maslov*	5.172	17 Aug 69	70°30'N	18°30'E	180	7.0	34.90	7	3
16	1	*Maslov*	5.173	17 Aug 69	70°01'N	17°20'E	100	7.4	34.40	7	0
17	1	*Maslov*	5.175	17 Aug 69	69°40'N	16°30'E	75	7.7	34.30	9	3
18	2	*Maslov*	5.175	17 Aug 69	69°40'N	16°30'E	75	7.7	34.30	9	3
19	1	*Maslov*	5.177	18 Aug 69	69°42'N	16°10'E	715	5.5	34.70	7	3
20	1	*Maslov*	5.178	18 Aug 69	69°50'N	16°30'E	270	5.6	35.20	7	3
21	2	*Maslov*	5.178	18 Aug 69	69°50'N	16°30'E	270	5.6	35.20	7	3
22	2	*Maslov*	5.179	18 Aug 69	70°13'N	17°04'E	560	6.2	-	0	0
23	1	*Maslov*	5.180	19 Aug 69	70°40'N	17°27'E	510	5.2	35.20	9	3
24	1	*Maslov*	5.182	19 Aug 69	71°30'N	16°46'E	300	5.9	35.20	1	0
25	1	*Maslov*	5.183	19 Aug 69	72°02'N	17°02'E	360	5.4	35.20	1	0
26	1	*Maslov*	5.184	20 Aug 69	72°28'N	17°00'E	370	5.0	35.20	1	0
27	1	*Maslov*	5.187	20 Aug 69	73°20'N	17°00'E	500	2.2	35.10	2	3
28	1	*Maslov*	5.189	20 Aug 69	73°30'N	15°30'E	500	2.2	35.10	0	0
29	1	*Maslov*	5.190	21 Aug 69	73°40'N	16°15'E	440	2.1	-	1	3
30	1	*Maslov*	5.193	21 Aug 69	74°10'N	18°00'E	160	2.1	35.00	9	3
31	1	*Maslov*	5.198	22 Aug 69	74°34'N	16°00'E	525	7.2	35.20	1	3
32	1	*Maslov*	5.203	23 Aug 69	74°00'N	21°30'E	290	1.5	35.00	2	3
33	1	*Maslov*	5.208	25 Aug 69	72°30'N	19°00'E	365	4.0	35.10	2	3
34	1	*Maslov*	5.209	25 Aug 69	72°00'N	19°00'E	320	6.6	35.00	2	5
35	1	*Maslov*	5.210	25 Aug 69	71°30'N	19°00'E	210	-	34.90	5	3
36	2	*Maslov*	5.210	25 Aug 69	71°00'N	19°00'E	190	6.6	35.20	5	3
37	2	*Maslov*	5.211	25 Aug 69	71°00'N	19°00'E	190	6.6	35.20	5	3
38	1	*Maslov*	5.212	25 Aug 69	71°01'N	21°30'E	155	6.1	35.00	9	3
39	2	*Maslov*	5.212	25 Aug 69	71°01'N	21°30'E	155	6.1	35.00	9	3
40	1	*Maslov*	5.213	26 Aug 69	71°30'N	21°30'E	325	4.0	-	2	3
41	1	*Maslov*	5.215	26 Aug 69	72°30'N	21°30'E	350	3.6	35.10	0	0
42	1	*Maslov*	5.221	27 Aug 69	74°14'N	23°28'E	265	1.4	35.00	2	3
43	1	*Maslov*	5.232	29 Aug 69	76°40'N	25°47'E	30	0.7	-	9	3
44	1	*Maslov*	5.234	30 Aug 69	76°26'N	25°30'E	110	-0.2	-	3	3
45	1	*Maslov*	5.237	30 Aug 69	74°30'N	25°30'E	300	1.2	35.00	3	3
46	1	*Maslov*	5.239	31 Aug 69	75°00'N	27°30'E	310	1.2	35.00	2	3
47	1	*Maslov*	5.269	07 Sep 69	75°11'N	15°56'E	250	2.6	-	3	3
48	1	*Maslov*	5.270	07 Sep 69	75°10'N	15°18'E	310	2.4	-	3	3
49	1	*Maslov*	5.271	08 Sep 69	78°00'N	10°00'E	160	2.4	-	3	3
50	1	*Maslov*	5.279	09 Sep 69	77°38'N	11°10'E	300	2.4	-	3	3
51	1	*Maslov*	5.280	09 Sep 69	77°25'N	11°30'E	230	4.1	-	0	0
52	1	*Maslov*	5.282	10 Sep 69	77°36'N	12°49'E	70	-0.3	-	7	3
53	1	*Maslov*	5.283	10 Sep 69	76°57'N	12°50'E	215	1.8	-	1	3
54	1	*Maslov*	5.285	11 Sep 69	77°04'N	13°30'E	300	2.1	-	9	3
55	1	*Maslov*	5.288	11 Sep 69	77°10'N	14°10'E	55	-0.6	-	9	3
56	1	*Maslov*	5.295	12 Sep 69	76°08'N	16°00'E	290	2.4	-	9	3
57	1	*Maslov*	5.299	13 Sep 69	75°45'N	17°33'E	210	3.0	-	9	3
58	1	*Maslov*	5.306	16 Sep 69	75°30'N	16°30'E	210	3.8	-	3	3
59	1	*Maslov*	5.311	16 Sep 69	76°01'N	15°00'E	350	2.5	35.00	1	3
60	2	*Maslov*	5.312	17 Sep 69	76°12'N	15°00'E	505	3.0	35.10	7	3
61	1	*Maslov*	5.313	17 Sep 69	76°20'N	15°00'E	240	1.8	-	5	3
62	1	*Maslov*	5.329	24 Sep 69	78°30'N	50°00'E	230	-1.1	34.80	1	3
63	2	*Maslov*	5.334	25 Sep 69	77°10'N	50°00'E	335	-1.5	34.90	2	0
64	1	*Maslov*	5.396	09 Oct 69	78°00'N	33°30'E	165	-0.5	34.50	1	3
65	1	*Maslov*	10.35	16 Aug 70	69°29'N	59°35'E	23	-0.96	-	1	0

Appendix (continued)

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
66	1	*Molchanov*	14.801	-	68°51'N	37°20'E	96	-	-	-	0
67	1	*Otkupshikov*	181.9	05 Jul 78	69°10'N	36°00'E	84	2.4	33.31	7	0
68	1	*Otkupshikov*	181.42	21 Jul 78	89°28'N	34°11'E	111	2.3	34.52	5	0
69	1	*Otkupshikov*	181.75	05 Jul 78	69°10'N	36°00'E	84	2.4	33.31	7	0
70	2	*Sevastopol*	5.1046	09 Jul 57	67°30'N	11°26'E	115	5.65	34.34	4	2
71	1	*Sevastopol*	5.1047	09 Jul 57	65°45'N	10°20'E	333	6.78	35.12	4	2
72	1	*Sevastopol*	5.1049	09 Jul 57	65°40'N	8°30'E	405	6.76	35.16	2	0
73	1	*Sevastopol*	5.1050	09 Jul 57	65°45'N	7°29'E	360	6.8	35.08	3	0
74	1	*Sevastopol*	5.1052	10 Jul 57	65°46'N	5°58'E	435	7.09	-	4	2
75	1	*Sevastopol*	5.1056	12 Jul 57	65°47'N	2°32'E	1590	-0.9	-	2	0
76	1	*Sevastopol*	5.1073	14 Jul 57	65°27'N	12°39'W	135	2.64	34.79	4	0
77	1	*Sevastopol*	5.1076	15 Jul 57	64°08'N	14°00'W	110	8.42	35.17	5	2
78	2	*Sevastopol*	5.1076	15 Jul 57	64°08'N	14°00'W	110	8.42	35.17	5	2
79	1	*Sevastopol*	5.1078	15 Jul 57	63°55'N	13°03'W	650	3.38	34.99	5	2
80	1	*Sevastopol*	5.1081	15 Jul 57	63°37'N	11°37'W	385	3.68	34.99	5	2
81	1	*Sevastopol*	5.1083	15 Jul 57	63°20'N	10°47'W	395	2.38	34.97	5	2
82	1	*Sevastopol*	5.1088	16 Jul 57	62°40'N	8°18'W	485	5.66	35.12	4	2
83	2	*Sevastopol*	5.1089	16 Jul 57	62°30'N	7°48'W	150	8.78	35.19	7	2
84	1	*Sevastopol*	5.1089	16 Jul 57	62°30'N	7°48'W	150	8.78	35.19	7	2
85	1	*Sevastopol*	5.1090	16 Jul 57	62°30'N	7°10'W	90	9.04	35.17	8	2
86	2	*Sevastopol*	5.1090	16 Jul 57	62°30'N	7°10'W	90	9.04	35.17	8	2
87	2	*Sevastopol*	5.1094	17 Jul 57	61°42'N	4°50'W	235	7.92	35.25	5	0
88	2	*Sevastopol*	5.1099	18 Jul 57	61°08'N	2°13'W	520	6.96	35.17	5	3
89	2	*Sevastopol*	5.1100	18 Jul 57	61°10'N	1°36'W	140	9.04	35.39	7	2
90	1	*Sevastopol*	5.1100	18 Jul 57	61°10'N	1°36'W	140	9.04	35.39	7	2
91	1	*Sevastopol*	5.1102	18 Jul 57	60°35'N	0°36'W	135	9.24	35.39	6	0
92	2	*Sevastopol*	5.1103	18 Jul 57	60°35'N	0°00'E	105	9.30	35.35	0	0
93	1	*Sevastopol*	5.1104	18 Jul 57	60°35'N	0°45'E	130	8.16	35.37	5	0
94	1	*Sevastopol*	5.1105	19 Jul 57	60°35'N	1°21'E	130	7.72	35.37	5	2
95	1	*Sevastopol*	5.1108	19 Jul 57	60°35'N	3°27'E	295	8.18	35.32	5	0
96	1	*Sevastopol*	5.1110	19 Jul 57	60°36'N	4°35'E	340	6.89	35.03	5	2
97	2	*Sevastopol*	5.1123	22 Jul 57	63°01'N	3°41'W	2386	-0.9	-	4	2
98	2	*Sevastopol*	5.1130	23 Jul 57	63°02'N	9°18'W	500	-0.06	34.87	7	2
99	2	*Sevastopol*	5.1132	24 Jul 57	62°39'N	7°47'W	375	0	-	5	0
100	1	*Sevastopol*	5.1157	31 Jul 57	64°56'N	24°25'W	155	8.17	35.08	5	0
101	2	*Sevastopol*	5.1157	31 Jul 57	64°56'N	24°25'W	155	8.17	35.08	5	0
102	2	*Sevastopol*	5.1160	31 Jul 57	65°15'N	26°41'W	180	6.62	35.08	7	2
103	1	*Sevastopol*	5.1161	31 Jul 57	65°23'N	27°17'W	370	6.35	35.07	4	2
104	2	*Sevastopol*	5.1161	31 Jul 57	65°23'N	27°17'W	370	6.35	35.07	4	2
105	1	*Sevastopol*	5.1162	31 Jul 57	65°28'N	27°47'W	775	5.71	35.01	4	2
106	1	*Sevastopol*	5.1163	01 Aug 57	65°37'N	28°35'W	1035	4.39	34.96	7	2
107	2	*Sevastopol*	5.1165	01 Aug 57	65°52'N	29°39'W	300	0.88	34.72	9	2
108	2	*Sevastopol*	5.1167	01 Aug 57	66°08'N	30°56'W	438	0.56	34.87	4	2
109	1	*Sevastopol*	5.1168	01 Aug 57	66°16'N	31°35'W	345	1.84	34.69	4	2
110	1	*Sevastopol*	5.1169	01 Aug 57	66°23'N	32°14'W	330	1.65	34.74	4	3
111	1	*Sevastopol*	5.1170	01 Aug 57	66°29'N	32°55'W	300	2.38	34.72	5	2
112	1	*Sevastopol*	5.1172	02 Aug 57	65°28'N	33°53'W	212	4.10	34.81	5	2
113	1	*Sevastopol*	5.1212	07 Aug 57	67°39'N	22°36'W	650	-0.47	34.99	0	0
114	1	*Sevastopol*	5.1235	10 Aug 57	70°04'N	12°50'W	1690	-0.9	-	3	2
115	1	*Sevastopol*	8.1352	25 Mch 58	65°18'N	10°29'E	198	6.61	35.14	4	2
116	1	*Sevastopol*	8.1357	25 Mch 58	66°16'N	6°46'E	342	5.78	35.14	4	0
117	1	*Sevastopol*	8.1374	29 Mch 58	70°05'N	10°00'W	1820	-0.85	34.90	2	0
118	1	*Sevastopol*	8.1378	30 Mch 58	68°54'N	15°33'W	1520	-0.90	-	2	0
119	1	*Sevastopol*	8.1403	05 Apr 58	63°26'N	6°42'E	265	7.55	35.25	4	0
120	1	*Sevastopol*	8.1411	06 Apr 58	61°50'N	1°45'E	185	7.37	35.34	7	2
121	1	*Sevastopol*	8.1427	09 Apr 58	64°45'N	12°31'W	157	1.34	34.78	7	3

Appendix (continued)

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
122	1	*Sevastopol*	8.1428	09 Apr 58	64°22'N	13°29'W	160	5.81	35.10	0	0
123	1	*Sevastopol*	8.1443	11 Apr 58	62°30'N	7°12'W	94	6.38	35.26	0	0
124	1	*Sevastopol*	8.1446	11 Apr 58	62°44'N	6°24'W	350	5.38	-	8	3
125	1	*Sevastopol*	8.1453	16 Apr 58	62°00'N	6°14'W	112	6.34	35.23	9	3
126	1	*Sevastopol*	8.1462	17 Apr 58	61°01'N	1°38'W	175	8.2	35.34	7	0
127	1	*Sevastopol*	8.1463	17 Apr 58	60°56'N	0°59'W	115	7.16	35.19	9	3
128	1	*Sevastopol*	8.1464	17 Apr 58	60°34'N	0°36'W	145	6.2	35.32	0	0
129	1	*Sevastopol*	8.1465	17 Apr 58	60°35'N	0°01'W	110	6.18	35.26	0	0
130	1	*Sevastopol*	8.1466	18 Apr 58	60°35'N	0°47'E	128	5.89	35.35	9	3
131	1	*Sevastopol*	8.1467	18 Apr 58	60°35'N	1°23'E	140	5.95	35.23	0	0
132	1	*Sevastopol*	8.1468	18 Apr 58	60°35'N	2°05'E	127	5.91	35.32	9	3
133	1	*Sevastopol*	8.1469	18 Apr 58	60°36'N	2°52'E	107	6.88	35.32	0	0
134	1	*Sevastopol*	8.1470	18 Apr 58	60°36'N	3°31'E	312	6.72	35.30	3	0
135	1	*Sevastopol*	8.1471	18 Apr 58	60°36'N	4°12'E	302	6.41	35.26	2	0
136	1	*Sevastopol*	8.1472	19 Apr 58	60°36'N	4°36'E	372	6.63	35.32	4	3
137	1	*Sevastopol*	8.1485	27 Apr 58	71°16'N	25°36'E	315	4.27	34.78	9	3
138	1	*Sevastopol*	8.1486	27 Apr 58	71°33'N	25°00'E	300	4.12	35.07	3	2
140	1	*Sevastopol*	8.1488	28 Apr 58	72°29'N	23°07'E	335	3.58	35.10	3	3
141	1	*Sevastopol*	8.1494	29 Apr 58	74°16'N	19°09'E	55	-0.97	34.70	0	0
142	2	*Sevastopol*	9.1555	20 Jun 58	62°58'N	9°01'W	420	6.73	35.10	4	2
143	1	*Sevastopol*	9.1574	25 Jun 58	63°10'N	23°48'W	390	6.96	35.16	4	0
144	1	*Sevastopol*	9.1576	25 Jun 58	62°40'N	24°55'W	560	6.40	35.21	0	0
145	1	*Sevastopol*	9.1583	27 Jun 58	63°12'N	24°30'W	262	6.98	-	4	2
146	1	*Sevastopol*	9.1584	27 Jun 58	63°20'N	25°18'W	320	6.02	35.14	3	0
147	1	*Sevastopol*	9.1586	27 Jun 58	64°10'N	24°42'W	210	6.64	-	7	2
148	2	*Sevastopol*	9.1586	27 Jun 58	64°10'N	24°42'W	210	6.64	-	7	2
149	1	*Sevastopol*	9.1591	28 Jun 58	66°19'N	23°54'W	125	5.7	-	7	0
150	1	*Sevastopol*	9.1609	01 Jul 58	66°52'N	29°58'W	425	0.46	-	4	2
151	1	*Sevastopol*	9.1615	03 Jul 58	65°48'N	26°47'W	490	5.93	35.05	0	0
152	1	*Sevastopol*	9.1616	03 Jul 58	65°35'N	27°10'W	425	6.0	-	5	2
153	1	*Sevastopol*	9.1644	16 Jul 58	63°35'N	37°33'W	230	-	-	0	0
154	1	*Sevastopol*	9.1649	17 Jul 58	62°36'N	40°32'W	245	4.42	34.90	8	2
155	1	*Sevastopol*	9.1652	18 Jul 58	62°27'N	40°20'W	300	4.56	34.79	4	2
156	1	*Sevastopol*	9.1655	18 Jul 58	62°13'N	40°30'W	430	4.66	34.99	0	0
157	1	*Sevastopol*	9.1657	19 Jul 58	62°07'N	40°53'W	184	4.16	34.69	5	2
158	1	*Sevastopol*	9.1659	19 Jul 58	61°50'N	40°54'W	240	4.4	34.72	8	2
159	1	*Sevastopol*	9.1662	20 Jul 58	63°14'N	40°04'W	215	4.98	34.78	5	0
160	1	*Sevastopol*	9.1664	21 Jul 58	63°56'N	38°11'W	210	4.5	-	4	2
161	2	*Sevastopol*	9.1669	22 Jul 58	65°27'N	33°22'W	340	5.26	34.97	8	2
162	2	*Sevastopol*	10.1696	26 Sep 58	65°29'N	9°50'E	320	7.24	35.23	4	2
163	1	*Sevastopol*	10.1698	26 Sep 58	65°50'N	8°32'E	410	6.22	35.17	2	0
164	1	*Sevastopol*	10.1699	26 Sep 58	66°02'N	7°52'E	370	6.3	35.17	3	0
165	1	*Sevastopol*	10.1702	27 Sep 58	66°38'N	4°59'E	1125	-0.94	34.90	3	0
166	1	*Sevastopol*	10.1723	02 Oct 58	68°34'N	14°04'W	1280	-0.81	34.90	3	2
167	1	*Sevastopol*	10.1730	04 Oct 58	66°37'N	9°05'W	1475	-0.8	34.92	2	0
168	1	*Sevastopol*	10.1753	12 Oct 58	61°32'N	2°04'E	350	7.26	35.25	4	0
169	2	*Sevastopol*	10.1754	13 Oct 58	61°33'N	1°07'E	176	9.48	35.37	0	0
170	1	*Sevastopol*	10.1754	13 Oct 58	61°33'N	1°07'E	176	9.48	35.37	0	0
171	2	*Sevastopol*	10.1774	19 Oct 58	66°51'N	22°10'W	130	7.04	35.08	5	3
172	2	*Sevastopol*	10.1776	21 Oct 58	64°08'N	13°48'W	120	8.46	35.21	8	2
173	1	*Sevastopol*	10.1790	22 Oct 58	62°32'N	7°00'W	100	9.42	35.21	7	3
174	1	*Sevastopol*	10.1792	24 Oct 58	62°00'N	6°14'W	115	9.47	35.14	0	0
175	1	*Sevastopol*	10.1793	24 Oct 58	61°55'N	5°49'W	264	8.48	35.23	0	0
176	1	*Sevastopol*	10.1795	24 Oct 58	61°42'N	4°50'W	320	8.17	35.28	5	0
177	1	*Sevastopol*	10.1801	25 Oct 58	60°56'N	1°34'W	134	10.3	35.39	8	2
178	1	*Sevastopol*	10.1802	25 Oct 58	60°58'N	0°52'W	115	11.4	35.23	8	3

Appendix (continued)

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
179	1	*Sevastopol*	10.1803	25 Oct 58	60°35'N	0°34'W	140	11.32	35.25	9	3
180	1	*Sevastopol*	10.1804	26 Oct 58	60°35'N	0°02'E	110	11.1	35.32	0	0
181	1	*Sevastopol*	10.1805	26 Oct 58	60°35'N	0°35'E	138	9.18	35.39	0	0
182	1	*Sevastopol*	15.2419	28 Oct 58	69°20'N	15°30'E	160	8.48	34.73	8	2
183	1	*Sevastopol*	15.2454	06 Nov 59	70°58'N	12°29'W	450	-0.12	34.92	4	2
184	1	*Sevastopol*	15.2473	09 Nov 59	66°52'N	14°00'W	220	5.34	35.03	8	2
185	1	*Sevastopol*	15.2474	09 Nov 59	66°35'N	14°22'W	150	5.99	34.97	9	2
186	1	*Sevastopol*	15.2479	11 Nov 59	67°30'N	9°00'W	1680	-0.79	34.92	8	2
187	1	*Sevastopol*	15.2500	15 Nov 59	67°30'N	9°30'E	255	7.66	35.21	5	2
188	1	*Sevastopol*	15.2502	16 Nov 59	67°30'N	11°30'E	125	8.95	34.69	8	2
189	1	*Sevastopol*	15.2508	17 Nov 59	65°45'N	8°30'E	420	7.32	35.26	3	0
190	1	*Sevastopol*	15.2535	27 Nov 59	64°01'N	13°30'W	190	8.11	35.21	8	2
191	1	*Sevastopol*	15.2540	27 Nov 59	63°25'N	11°00'W	420	3.40	35.05	8	3
192	1	*Sevastopol*	15.2547	28 Nov 59	62°36'N	7°40'W	185	9.09	35.19	0	0
193	1	*Sevastopol*	15.2548	28 Nov 59	62°30'N	7°15'W	95	9.01	35.19	0	0
194	1	*Sevastopol*	15.2563	08 Dec 59	62°57'N	4°30'E	605	6.05	35.16	8	2
195	1	*Sevastopol*	15.2564	08 Dec 59	62°56'N	5°25'E	125	9.62	34.99	0	0
196	1	*Sevastopol*	15.2568	09 Dec 59	60°34'N	4°33'E	330	8.12	35.25	5	2
197	1	*Sevastopol*	15.2571	10 Dec 59	60°35'N	2°50'E	95	9.56	35.35	0	0
198	1	*Sevastopol*	15.2574	10 Dec 59	60°36'N	0°45'E	130	9.22	35.34	0	0
199	1	*Sevastopol*	15.2575	10 Dec 59	60°37'N	0°02'E	125	9.85	35.3	0	0
200	1	*Sevastopol*	15.2576	11 Dec 59	60°35'N	0°35'W	130	9.62	35.28	0	0
201	1	*Sevastopol*	15.2577	11 Dec 59	60°56'N	1°00'W	103	9.95	35.23	8	2
202	1	*Sevastopol*	15.2578	11 Dec 59	61°01'N	1°36'W	150	9.96	35.30	0	0
203	1	*Sevastopol*	15.2581	11 Dec 59	61°21'N	3°10'W	1320	-0.76	34.88	1	0
204	1	*Sevastopol*	15.2584	12 Dec 59	61°42'N	4°51'W	220	8.5	35.21	0	0
205	1	*Sevastopol*	15.2585	12 Dec 59	61°49'N	5°21'W	175	8.84	35.23	0	0
206	1	*Sevastopol*	15.2586	12 Dec 59	61°54'N	5°45'W	290	8.98	35.25	0	0
207	1	*Sevastopol*	15.2587	12 Dec 59	61°54'N	5°45'W	290	8.98	35.25	0	0
208	1	*Sevastopol*	15.2589	12 Dec 59	62°47'N	6°26'W	350	7.27	35.19	0	0
209	1	*SP-22*	21	-	81°07'N	128°24'W	3550	-	-	0	0
210	1	*SP-22*	50	-	73°48'N	125°35'W	2990	-	-	0	0
211	1	*SP-22*	58	-	73°35'N	160°00'W	2100	-	-	0	0
212	1	*SP-22*	60	-	73°43'N	161°50'W	300	-	-	0	0
213	1	*SP-22*	69	-	74°25'N	164°08'W	445	-	-	0	0
214	1	*SP-22*	72	07 Jan 79	74°35'N	164°00'W	795	-	-	0	0
215	1	*SP-22*	74	03 Jan 79	74°38'N	164°00'E	465	-	-	0	0
216	1	*SP-22*	76	12 Jan 79	74°56'N	166°10'E	460	-	-	0	0
217	1	*SP-22*	94	-	74°55'N	170°2'W	230	-	-	0	0
218	1	*SP-22*	98	-	75°00'N	170°20'W	260	-	-	0	0
219	1	*SP-22*	101	-	75°00'N	170°10'W	250	-	-	0	0
220	1	*SP-22*	103	-	75°11'N	170°05'W	315	-	-	0	0
221	1	*SP-22*	105	-	75°11'N	170°05'W	315	-	-	0	0
222	1	*SP-22*	108	-	75°13'N	170°30'W	370	-	-	0	0
222	1	*SP-22*	111	-	75°15'N	170°45'W	390	-	-	0	0
223	1	*SP-22*	112	-	75°14'N	171°10'W	455	-	-	0	0
224	1	*SP-22*	115	-	75°02'N	171°30'W	382	-	-	0	0
225	1	*SP-22*	120	-	74°54'N	171°37'W	330	-	-	0	0
226	1	*SP-22*	122	-	74°55'N	171°40'W	345	-	-	0	0
227	1	*SP-22*	124	-	74°55'N	171°55'W	355	-	-	0	0
228	1	*SP-23*	77.1	-	78°37'N	161°00'W	177	-	-	0	0
229	1	*SP-23*	77.2	-	78°43'N	160°44'W	160	-	-	0	0
230	1	*SP-23*	77.3	-	78°53'N	160°55'W	199	-	-	0	0
231	1	*Tunets*	105.2	08 Jun 78	70°26'N	17°56'E	120	5.83	34.32	9	3
232	1	*Tunets*	105.5	13 Jun 78	67°30'N	9°30'E	260	6.06	35.06	5	0
233	1	*Tunets*	105.7	15 Jun 78	67°50'N	10°30'E	201	6.18	35.00	0	0

Appendix (continued)

N	Gear	R/V	Station	Date	Latitude	Longitude	Depth (m)	Temp. (°C)	Salinity	Substrate main	Substrate add.
234	1	*Tunets*	105.8	16 Jun 78	68°25'N	12°56'E	167	6.10	34.95	0	0
235	1	*Tunets*	105.11	21 Jun 78	71°10'N	17°00'E	356	4.16	-	0	0
236	1	*Tunets*	105.12	21 Jun 78	71°10'N	19°00'E	202	5.33	35.00	3	3
237	1	*Tunets*	105.13	28 Jun 78	70°32'N	18°20'E	225	6.09	-	0	0
238	1	*Tunets*	105.14	28 Jun 78	70°41'N	18°56'E	328	5.05	34.99	3	0
239	1	*Tunets*	105.19	02 Jul 78	70°58'N	21°23'E	168	4.38	34.88	0	0
240	1	*Vodnik*	25.23	06 Jun 68	71°15'N	30°00'E	325	-	-	4	0
241	1	*Vodnik*	25.26	08 Jun 68	71°21'N	27°00'E	245	-	-	5	3
242	1	*Vodnik*	25.39	10 Jun 68	71°30'N	25°30'E	275	-	-	2	0
243	1	*Vodnik*	25.43	12 Jun 68	72°15'N	23°30'E	285	-	-	5	0
244	1	*Vodnik*	25.44	12 Jun 68	72°30'N	23°30'E	300	-	-	5	3
245	1	*Yuksporit*	1.3	25 Aug 78	69°49'N	31°51'E	50	-	-	8	3
246	1	*Yuksporit*	1.4	26 Aug 78	69°52'N	31°35'E	47	-	-	7	3