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Faunistics, Taxonomy and Ecology of Moss and Soil Ciliates (Protozoa, Ciliophora) from Antarctica, with Description of New Species, Including *Pleuroplitoides smithi* gen. n., sp. n.

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Summary. Fifty nine moss and soil samples from the maritime and continental Antarctic were investigated for their ciliate fauna using the non-flooded Petri dish method. Collections were made from a variety of biotopes covering most principal soil and vegetation types of the region following a cline from 60°-78°S, i.e. of increasing climatic severity. Sixty four species were found: 51 in region A (Signy Island and Livingstone Island), 16 in region B (Antarctic Peninsula), and 14 in region C (continental Antarctic, viz. Ross Island and South Victoria Land). Twenty nine out of the 64 species were first records for the region, and 5 of them were new species. Mean species number per sample was markedly higher in region A (9.6) than in region B (1.0) and region C (0.9), reflecting a dramatic faunal pauperization with increasing climatic severity and, respectively, decreasing soil fertility. This is strengthened by the observation that all samples from region A contained ciliates, whereas they were lacking in half of the collections from regions B and C. This highly patchy distribution, as yet not found elsewhere, is very likely caused by the severe environment allowing few pioneers to establish permanent populations. As compared with temperate and tropical regions, the Antarctic ciliate species richness is decreased by at least one order of magnitude. The fauna is dominated by *r* - selected, bacteria and fungi feeding colpodids. The most frequent species were *Colpoda ecaudata*, *C. steini*, *C. inflata*, *Pseudocyrtolophosis alpestris*, *Pseudoplatyophrya nana*, and *Cyclidium muscicola*, clearly proving Smith's (1973a) bi-polar biogeography of *Colpoda* to be a methodological artifact. Nine ciliate species are described or redescribed using standard methods: *Pleuroplitoides smithi* sp. n., *Protospathidium serpens*, *Cyclidium glaucoma*, *Notohymena antarctica* sp. n., *Sterkiella thompsoni* sp. n., *Urosomoida granulifera* sp. n., *U. antarctica* sp. n., *Oxytricha lanceolata*, and *Paruroleptus notabilis*. The genera *Pleuroplites* Foissner, 1988 and *Pleuroplitoides* gen. n. (dorsal brush isomorphic and composed of 2 rows with paired, shortened cilia) are united in the family Pleuroplitidae fam. n. (Acropisthiina with extracytostomal extrusome bundle on ventral side; dorsal brush composed of few isomorphic or many heteromorphic kineties).

Key words: Antarctica, biogeography, community structure, faunistics, soil and moss ciliates.

INTRODUCTION

Reliable investigations on soil and moss ciliates from Antarctica are very sparse. The most detailed studies were performed by Smith (1978), who reviewed the older literature and recorded about 50 species, many of which were determined, however, to genus level only. More recently, some small contributions were published, mainly describing new species (Blatterer and Foissner 1988, Ryan et al. 1989, Eigner and Foissner 1993, Foissner 1993).

The present study, which is based on a large collection of samples, is thus the first which provides reliable data on soil and moss ciliates from Antarctica. The results show that Antarctic terrestrial biotopes contain a

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rather diverse, but highly patchily distributed ciliate fauna and unmask Smith's (1973a, 1978) bi-polar biogeography of *Colpoda* as a methodological artifact.

MATERIALS AND METHODS

Samples. Collections were obtained from three regions, all located in the maritime and continental Antarctic, following a cline from 60°-78°S, i.e. of increasing climatic severity (Fig. 1). Collections were made from a great variety of biotopes covering most principal soil and vegetation types of the region. Details, as far as were available, of each site including date of collection, location, dominant associated plant species, and pH are given in the faunistic section of the results. pH was measured in probes rewetted with distilled water for at least five hours. See Smith (1978) and Block (1994) for a concise description of geology, topography, climate, habitats, soils, and vegetation of the area.

Signy Island, South Orkney Islands and Livingstone Island, South Shetland Islands (60°40'-62°38'S, 45°40'-61°04'W; Region A). Samples were obtained by H. G. Smith (Coventry Polytechnic, England) and collected and investigated in 1984 (No. 1-3) and 1985 (No. 4-7). Sample 8 from Livingstone Island was collected in 1981 by R. I. L. Smith and investigated in 1987 (cp. next paragraph).

Antarctic Peninsula (63°-68°S, 55°-69°W; Region B). Samples (No. 9-45) were collected 1981 by R. I. L. Smith, stored at 4°C in sterile polythene bags, and dispatched to me in 1985 by W. Block (British Antarctic Survey). They were inspected for ciliates in 1987. These samples were studied also for nematophagous fungi (Gray and Lewis Smith 1984).

Ross Island and South Victoria Land (77°-78°S, 160°-168°E; Region C). Samples (No. 46-59) were collected by W. Block (British Antarctic Survey) at the turn of years 1984/85. In 1986 they were dispatched and investigated by me. Most of these collections were very small. Thus, several were bulked to some larger samples, uniting similar habitats and locations.

Faunistic methods. All samples obtained were stored at 4°C in Salzburg in the original package and air-dried for four weeks before investigation. Then they were treated with the non-flooded Petri dish method as described by Foissner (1987a, 1992). Briefly, this simple method involves placing 10-50 g of air-dried moss, litter and/or soil in a Petri dish (10-15 cm in diameter) and saturating but not flooding it with distilled water. Such cultures were grown at room temperature and analyzed for ciliates on days 2, 7, 14, 21 and 28 by inspecting about 2 ml each of the run-off. The non-flooded Petri dish method is not perfect, i.e. not all species present can be reactivated from the resting cysts, but probably the most efficient method available. Repeated investigations of some soils showed that 2-5 samples distributed over one year produced 50-80% of the species found in 10 samples investigated

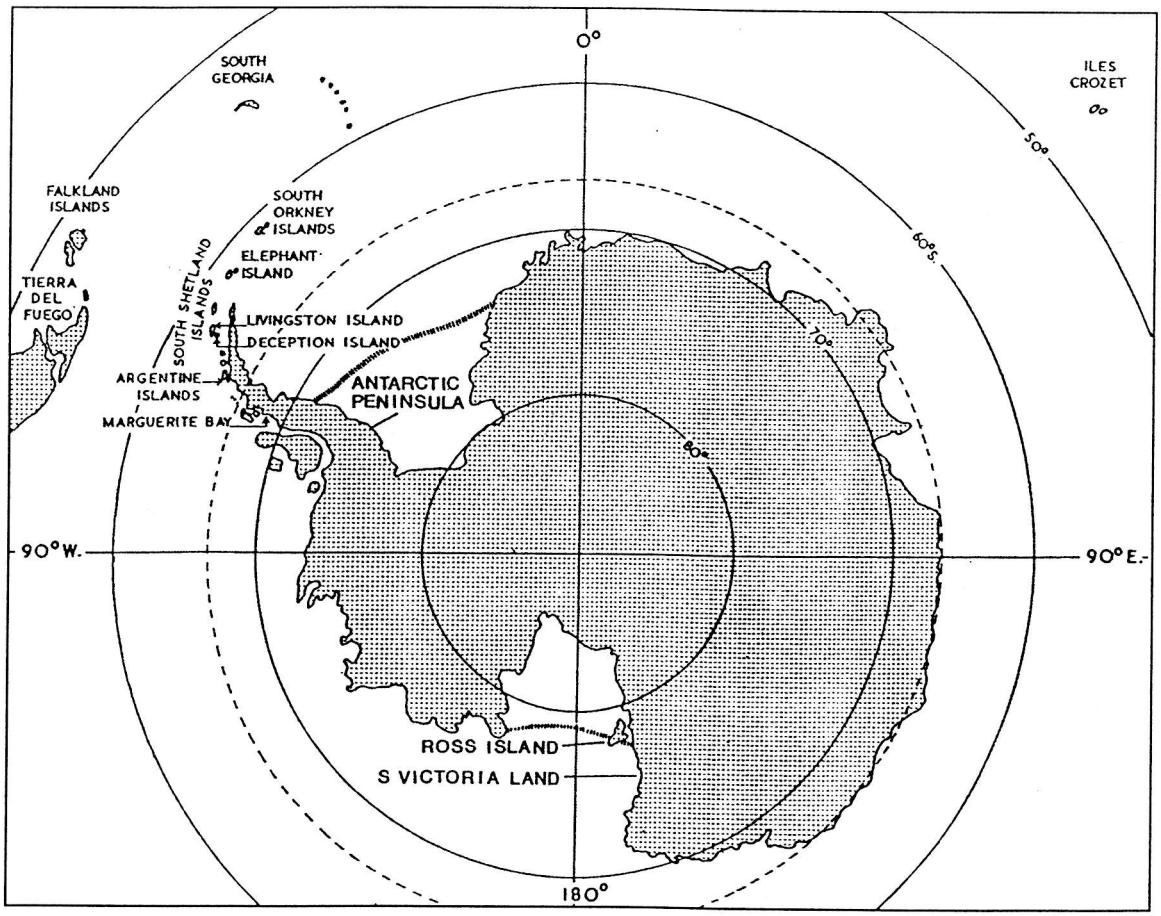


Fig. 1. Sketch map of the Antarctic zone showing sites included in the present study (from Smith 1978, modified)

over two years (Foissner 1987a). Thus, the samples investigated very likely contain more species than shown in Table 1. Furthermore, transportation and storage of the samples may have caused some loss of species.

Identification, terminology and nomenclature are according to literature cited in Foissner (1987a, 1993) and Foissner et al. (1995). Most of the species found were described by myself and my students. Thus, determinations were done on live specimens using a high-power oil immersion objective. However, difficult species were checked in silver slides.

Cytological methods. The species described were studied *in vivo* using a high-power oil immersion objective. The ciliary pattern (infraciliature) was revealed by various silver impregnation techniques, preferably protargol, all described in detail by Foissner (1991). The descriptions are based on raw material obtained with the non-flooded Petri dish method mentioned above, i.e. no pure cultures were set up.

Counts and measurements on silvered specimens were performed at a magnification of x 1000. *In vivo* measurements were conducted at a magnification of x 40-1000. Although these provide only rough estimates it is worth giving such data as specimens usually shrink in preparations or contract during fixation. Standard deviation and coefficient of variation were calculated according to statistics textbooks. Illustrations of live specimens are based on free-hand sketches and micrographs, those of impregnated cells were made with a camera lucida. All figures are orientated with the anterior end of the organism directed to top of page.

Type slides. Two type slides each of the new species described and at least one voucher slide of the species redescribed have been deposited in the Oberösterreichische Landesmuseum in Linz (LI), Austria. The slides contain many protargol impregnated cells, relevant specimens are marked by a black ink circle an the cover glass.

RESULTS AND DISCUSSION

Sample description and ciliates recorded

No. 1: January 1984; Signy Island (60°40'S, 45°40'W); *Drepanocladus* moss. Ciliates recorded: ***Colpoda steinii*** (very abundant).

No. 2: January 1984; Signy Island (60°40'S, 45°40'W); *Chorisodontium aciphyllum* moss. Ciliates recorded: *Cyclidium glaucoma*, *Gonostomum affine*, *Platyophyra macrostoma*, *Pleuroplitoides smithi*, *Pseudocyrtolophosis alpestris*, *Pseudoplatyophrya nana*.

No. 3: January 1984; Signy Island (60°40'S, 45°40'W); grass sward *Deschampsia antarctica* on loamy soil. Ciliates recorded: *Platyophrya macrostoma*, *Protospathidium serpens*.

No. 4: March 6, 1985; Signy Island (60°40'S, 45°40'W); *Andreaea* moss, pH 4.8. Ciliates recorded: *Acineria uncinata*, *Cyclidium muscicola*, *Fuscheria terricola*, *Hemisincirra gellerti*, *Holosticha sigmoidea*, *Leptopharynx costatus*, *Pseudochilodonopsis mutabilis*.

No.5: March 6, 1985; Signy Island (60°40'S, 45°40'W); grass sward from *Deschampsia antarctica* patch of a sheltered north-facing slope, pH 4.4. Ciliates recorded: *Amphisiella* (?) sp. (very likely a new species but only 1 specimen found), *Blepharisma hyalinum*, *Bresslaua* sp., *Bryometopus pseudochilodon*, *Colpoda inflata*, *C. henneguyi*, *C. lucida*, *C. steinii*, *Cyclidium muscicola*, *Cyrtolophosis mucicola*, *Dileptus alpinus*, *Dimacrocaryon amphileptoides*, *Drepanomonas pauciciliata*, *Enchelys* (?) sp., *Epispathidium terricola*, *Frontonia depressa*, *Gonostomum affine*, *G. kuehnelti*, *Grossglockneria acuta*, *Halteria grandinella*, *Hemisincirra gellerti*, *H. polynucleata* (?), *Holosticha bergeri*, *H. multistilata*, *H. sigmoidea*, *Leptopharynx costatus*, *Nivaliella plana*, *Notohymena antarctica*, *Oxytricha ophistomuscorum*, *Paraenchelys terricola* (with unusually short, 5µm, extrusomes), *Platyophrya vorax*, *Pleuroplites australis*, *Pseudochilodonopsis mutabilis*, *Pseudocyrtolophosis alpestris*, *Pseudoplatyophrya nana*, *Sathrophilus muscorum*, *Sterkiella histriomuscorum*, *Vorticella astyliformis*.

No. 6: March 6, 1985; Signy Island (60°40'S, 45°40'W); *Polytrichum alpestre* and *Chorisodontium aciphyllum* moss, pH 4.0. Ciliates recorded: *Cyclidium muscicola*, *Gonostomum affine*, *Holosticha sigmoidea*, *Pseudocyrtolophosis alpestris* (very abundant).

No 7: March 6, 1985; Signy Island (60°40'S, 45°40'W); *Drepanocladus uncinatus* moss, pH 5.2. Ciliates recorded: *Cyrtolophosis mucicola*, *Leptopharynx costatus*, *Microdiaphanosoma arcuatum* (very abundant), *Opercularia* sp., *Oxytricha ophisthomuscorum*, *Pleuroplitoides smithi*, *Sterkiella thompsoni*.

No. 8: March 28, 1981; Byers Peninsula (Sealer Hill), Livingstone Island, South Shetland Islands (62°38'S, 61°04'W); *Drepanocladus uncinatus* moss, pH 6.9. Ciliates recorded: *Blepharisma hyalinum*, *Colpoda cucullus*, *Cyclidium muscicola*, *Cyrtolophosis acuta*, *C. mucicola*, *Dileptus alpinus*, *Gonostomum affine*, *Paraenchelys terricola*, *Paruroleptus notabilis*, *Pleuroplitoides smithi*, *Pseudocyrtolophosis alpestris*, *Urosomoida granulifera*.

No. 9: March 27, 1981; Mt. Alexander, Hadden Bay, Joinville Island (63°18'S, 55°48'W); *Drepanocladus uncinatus* moss, pH 5.1. Ciliates recorded: *Vorticella astyliformis*.

No. 10: March 27, 1981; Mt. Alexander, Hadden Bay, Joinville Island (63°18'S, 55°48'W); *Polytrichum alpestre* moss, pH 5.8. Ciliates recorded: *Colpoda steinii* (very abundant), *Cyclidium muscicola*.

No. 11: March 28, 1981; Active Sound, Joinville Island (63°25'S, 56°09'W); *Andreaea* sp. moss. No ciliates found.

No. 12: March 26, 1981; Scar Hills, Hope Bay (63°25'S, 57°01'W); gull nest material, mainly *Usnea antarctica* and feathers, pH 6.8. No ciliates found.

No. 13: March 26, 1981; Near Lake Boeckella, Hope Bay (63°24'S, 56°59'W); Adélie penguin guano/mud, pH 6.5. No ciliates found.

No. 14: March 24, 1981; Near Sherrell Point, Astrolabe Island (63°20'S, 58°41'W); *Drepanocladus uncinatus* moss with some soil, pH 6.6. No ciliates found.

No. 15: March 24, 1981; Near Sherrell Point, Astrolabe Island (63°20'S, 58°41'W); *Polytrichum alpestre* moss with some soil, pH 6.1. Ciliates recorded: *Colpoda inflata* (very abundant), *C. steinii*, *Platyophrya vorax*.

No. 16: March 24, 1981; Cape Roquemaurel (63°33'S, 58°57'W); *Drepanocladus uncinatus* moss, pH 5.3. Ciliates recorded: *Nivaliella plana*.

No. 17: March 23, 1981; Andrée Island, Charlotte Bay (64°31'S, 61°30'W); *Brachythecium austro-salebrosum* moss, pH 5.9. Ciliates recorded: *Acineria uncinata*, *Colpoda ecaudata*, *Cyclidium glaucoma*, *Grossglockneria acuta*, *Lamtostyla edaphoni*.

No. 18: March 23, 1981; Andrée Island, Charlotte Bay (64°31'S, 61°30'W); *Bryum argenteum* moss. Ciliates recorded: *Colpoda ecaudata*, *Crytohymena quadrinucleata*.

No. 19: March 23, 1981; Meusnier Point, Charlotte Bay (64°32'S, 61°37'W); *Drepanocladus uncinatus* moss, pH 6.0. Ciliates recorded: *Platyophrya vorax*.

No. 20: March 23, 1981; Meusnier Point, Charlotte Bay (64°31'S, 61°30'W); *Polytrichum alpinum* moss, pH 5.2. No ciliates found.

No. 21: March 23, 1981; Meusnier Point, Charlotte Bay (64°32'S, 61°37'W); *Brachythecium austro-salebrosum* moss, pH 6.7. Ciliates recorded: *Kahlilembus* sp. (single specimen).

No. 22: March 21, 1981; Cuverville Island, north side (64°41'S, 62°38'W); *Polytrichum alpestre* moss, pH 5.7. Ciliates recorded: *Pseudoplatyophrya nana*.

No. 23: March 22, 1981; Gamma Island, Melchior Islands (64°20'S, 63°00'W); *Drepanocladus uncinatus* moss, pH 6.8. Ciliates recorded: *Cyrtohymena candens*.

No. 24: March 19, 1981; Cape Tuxen, Graham Coast (65°16'S, 64°08'W); *Polytrichum alpestre* moss, pH 5.2. Ciliates recorded: *Pseudocyrtolophosis alpestris*, *Pseudoplatyophrya nana*.

No. 25: March 19, 1981; Cape Tuxen, Graham Coast (65°16'S, 64°08'W); *Chorisodontium aciphyllum* moss, pH 4.4. Ciliates recorded: *Pseudocyrtolophosis alpestris*.

No. 26: March 19, 1981; Cape Tuxen, Graham Coast (65°16'S, 64°08'W); *Drepanocladus uncinatus* moss, pH 6.2. No ciliates found.

No. 27: March 20, 1981; Island off Takaki Promontory, Graham Coast (65°33'S, 64°13'W); *Drepanocladus uncinatus* moss, pH 6.6. Ciliates recorded: *Colpoda ecaudata*, *Cyclidium glaucoma*.

No. 28: March 20, 1981; Island off Takaki Promontory, Graham Coast (65°33'S, 64°13'W); *Polytrichum alpestre* moss, pH 4.9. Ciliates recorded: *Pseudocyrtolophosis alpestris* (very abundant).

No. 29: March 15, 1981; Piñero Island (north end) (67°33'S, 67°50'W); *Drepanocladus uncinatus* moss, pH 6.4. No ciliates found.

No. 30: March 14, 1981; Jenny Island (north side), Marguerite Bay (67°44'S, 68°23'W); *Polytrichum alpestre* moss, pH 5.3. Ciliates recorded: *Pseudocyrtolophosis alpestris*.

No. 31: March 14, 1981; Jenny Island (north side), Marguerite Bay (67°44'S, 68°23'W); *Drepanocladus uncinatus* moss, pH 6.2. Ciliates recorded: *Colpoda ecaudata*, *C. steinii*.

No. 32: March 14, 1981; Courtier Island, Dion Islands, Marguerite Bay (67°52'S, 68°43'W); *Drepanocladus uncinatus* moss, pH 6.9. No ciliates found.

No. 33: March 14, 1981; Emperor Island, Dion Islands, Marguerite Bay (67°52'S, 68°43'W); *Prasiola crispa* algal mat on soil (partly Adélie penguin guano), pH 6.0. No ciliates found.

No. 34: March 14, 1981; Emperor Island, Dion Islands, Marguerite Bay; *Prasiola crispa* algal mat on soil (partly on shag guano), pH 6.3. No ciliates found; remoistened sample soon became putrid.

No. 35: March 10, 1981; Lagotellerie Island (north side), Marguerite Bay (67°53'S, 67°24'W); *Drepanocladus uncinatus* moss, pH 5.9. No ciliates found.

No. 36: March 10, 1981; Lagotellerie Island (north side), Marguerite Bay (67°53'S, 67°24'W); *Brachythecium austro-salebrosum* moss, pH 5.8. Ciliates recorded: *Colpoda ecaudata*, *Microdiaphanosoma arcuatum*.

No. 37: March 10, 1981; Lagotellerie Island, Marguerite Bay (67°53'S, 67°24'W); *Bryum algens* moss, pH 5.8. Ciliates recorded: *Colpoda ecaudata*, *C. inflata*.

No. 38: March 10, 1981; Lagotellerie Island (north side), Marguerite Bay (67°53'S, 67°24'W); Adélie penguin guano, pH 7.3. No ciliates found.

No. 39: March 10, 1981; Lagotellerie Island, Marguerite Bay (67°53'S, 67°24'W); *Pohlia nutans*. Ciliates recorded: *Microdiaphanosoma arcuatum*.

No. 40: March 13, 1981; Dismal Island, Faure Islands, Marguerite Bay (68°06'S, 68°50'W); *Drepanocladus uncinatus* moss, pH 5.0. No ciliates found.

No. 41: March 13, 1981; Dismal Island, Faure Islands, Marguerite Bay (68°06'S, 68°50'W); *Andreaea regularis* moss, pH 7.0. Ciliates recorded: *Colpoda inflata* (very abundant).

No. 42: March 12, 1981; Roman Four Promontory, Marguerite Bay (68°13'S, 66°56'W); *Phormidium* sp. (dry cyanobacteria mat which quickly became active when the sample was remoistened; many fungal hyphae and bacteria developed). No ciliates found.

No. 43: March 11, 1981; Refuge Islands, Marguerite Bay (68°21'S, 67°10'W); *Drepanocladus uncinatus* moss. No ciliates were found, but abundant growth of testate amoebae (*Trinema lineare*, *Assulina muscorum*, *Corythion dubium* and *Euglypha* sp.) occurred.

No. 44: March 11, 1981; Refuge Islands, Marguerite Bay (68°21'S, 67°10'W); *Bryum algens* moss, pH 5.9. Ciliates recorded: *Colpoda ecaudata*, *C. inflata*.

No. 45: March 11, 1981; Refuge Islands, Marguerite Bay (68°21'S, 67°10'W); *Cephaloziella varians* moss, pH 7.0. No ciliates found.

No. 46: December 10, 1984; Cape Bird, Ross Island, Keble Valley (168°E, 77°50'S); 4 small samples bulked: dry ridge area, open mineral soil with salt crust, moist; dry ridge area, mineral soil under rock, moist; dry ridge, mineral soil, dry; dry ridge, mineral soil under stone, moist. pH of bulked sample: 9.5. No ciliates found.

No. 47: December 10, 1984; Cape Bird, Ross Island, Keble Valley (168°E, 77°50'S); 5 small samples bulked: dry moss patch (*Bryum* sp.) beside meltstream; wet moss patch (*Bryum* sp.) beside meltstream; algae from flowing meltstream; stream side, soil algal crust between stones; stream side, wet *Bryum* with algal growth. Ciliates recorded: *Homalogastra setosa*, *Lamtostyla perisincirra* (?), *Nassula picta*, *Sphaerophrya terricola*.

No. 48: December 31, 1984; Cape Royds, Ross Island (168°E, 77°50'S); 3 small samples bulked: dry soil from "badlands" near NZARP camp; moist soil from near snow patch at Blue Lake; soil from under *Bryum* moss at Collembola Heights. No ciliates found.

No. 49: December 30, 1984; Garwood Valley, S Victoria Land; 3 small samples bulked: dry soil from stone pavement surface; soil from Polygon edge ("dyke"); wet soil from stone pavement surface. Ciliates recorded: *Pseudoplatyophrya nana*.

No. 50: December 30, 1984; Garwood Valley, S Victoria Land; 3 small samples bulked: "salt" soil from near Garwood glacier; dry soil from "flood plain" of meltstream; rock flour from glacial outflow stream. Ciliates recorded: *Urosomoida antarctica*.

No. 51: December 30, 1984; Garwood Valley, S Victoria Land; 3 small samples bulked: wet *Bryum* moss from edge of meltstream; algae from meltstream; *Bryum* moss from dry area near stream. Ciliates recorded: *Colpoda steinii*, *Leptopharynx costatus*, *Oxytricha lanceolata*, *Vorticella astyliformis*.

No. 52: January 2, 1985; Lake Fryxell, Taylor Valley, S Victoria Land (160°E, 78°S); 3 small samples bulked: damp soil near Burn's Pool; wet moss and *Nostoc* from near Burn's Pool; dry *Bryum* moss away from meltstream near Burn's Pool. Ciliates recorded: *Colpoda cucullus*, *Drepanomonas sphagni*, *Fuscheria lacustris*, *Homalogastra setosa*, *Oxytricha opisthomuscorum*.

No. 53: January 2, 1985; Lake Bonney, Taylor Valley, S Victoria Land (160°E, 78°S); moist soil and glacial debris with salt from stream side. No ciliates found.

No. 54: January 3, 1985; Lake Vanda, Wright Valley, S Victoria Land (160°E, 78°S); 4 small samples bulked: dry soil from shore of lake; damp granitic soil from shore of lake; very wet soil from shore of lake; clay soil from shore of lake. No ciliates found.

No. 55: January 6, 1985; West Beacon Mountains, S Victoria Land (160°E, 78°S); 2 small samples bulked: soil from near camp site; soil from ridge site. Ciliates recorded: *Colpoda steinii*.

No. 56: January 12, 1985; Cape Crozier, Ross Island (168°E, 77°50'S); 2 small samples bulked: *Prasiola* alga from snow melt area near Post Office Hill; *Prasiola* alga near penguin rookery. No ciliates found.

No. 57: January 13, 1985; Cape Crozier, Ross Island (168°E, 77°50'S); 2 small samples bulked: soil from moss (*Bryum*) patch near snow patch at *Xanthoria* site; soil from *Xanthoria* site, snow melt area. No ciliates found.

No. 58: January 10, 1985; Cape Crozier, Ross Island (168°E, 77°50'S); 4 small samples bulked: *Bryum* moss from *Xanthoria* site; *Bryum* moss and *Xanthoria* (lichen) from *Xanthoria* site; mineral soil and soria from *Xanthoria* site; soil beneath old skua nest near *Xanthoria* site. No ciliates found.

No. 59: January 10 - 12, 1985; Cape Crozier, Ross Island (168°E, 77°50'S); 2 small samples bulked: *Xanthoria* (lichen) from *Xanthoria* site; *Prasiola* alga from near *Xanthoria* site. No ciliates found.

Table 1. Species recorded, their frequency and distribution in 59 moss and soil samples from Antarctica

Species	Region[1]			Total frequency[2] (%)	Habitats[3]						
	A	B	C		I	II	III	IV	V	VI	VII
Acineria uncinata Tucolesco, 1962	+	+	-	3.4	+	-	+	-	+	-	-
Amphisiella (?) sp.	+	-	-	1.7	+	-	-	-	-	-	-
Blepharisma hyalinum Perty, 1849*	+	-	-	3.4	+	+	-	-	-	-	-
Bresslaua sp.	+	-	-	1.7	+	-	-	-	-	-	-
Bryometopus pseudochilodon Kahl, 1932*	+	-	-	1.7	+	-	-	-	-	-	-
Colpoda cucullus (Müller, 1773)	+	-	+	3.4	-	+	-	-	-	+	-
Colpoda ecaudata (Liebmann, 1936)	-	+	-	11.9	-	+	+	-	-	+	-
Colpoda inflata (Stokes, 1884)	+	+	-	8.5	+	-	-	+	+	+	-
Colpoda henneguyi Fabre-Domergue, 1889*	+	-	-	1.7	+	-	-	-	-	-	-
Colpoda lucida Greeff, 1888*	+	-	-	1.7	+	-	-	-	-	-	-
Colpoda steinii Maupas, 1883	+	+	+	11.9	+	+	-	+	-	+	+
Cyclidium glaucoma Müller, 1773	+	+	-	5.1	-	+	+	-	-	+	-
Cyclidium muscicola Kahl, 1931	+	+	-	8.5	+	+	-	+	+	-	-
Cyrtohymena candens (Kahl, 1932)*	-	+	-	1.7	-	+	-	-	-	-	-
Cyrtohymena quadrinucleata (Dragesco & Njiné, 1971)*	-	+	-	1.7	-	+	-	-	-	+	-
Cyrtolophosis acuta Kahl, 1926*	+	-	-	1.7	-	+	-	-	-	-	-
Cyrtolophosis mucicola Stokes, 1885	+	-	-	5.1	+	+	-	-	-	-	-
Dileptus alpinus Kahl, 1932*	+	-	-	3.4	+	+	-	-	-	-	-
Dimacrocaryon amphileptoides (Kahl, 1931)	+	-	-	1.7	+	-	-	-	-	-	-
Drepanomonas pauciciliata Foissner, 1987	+	-	-	1.7	+	-	-	-	-	-	-
Drepanomonas sphagni Kahl, 1931*	-	-	+	1.7	-	-	-	-	-	+	-
Enchelys (?) sp.	+	-	-	1.7	+	-	-	-	-	-	-
Epispathidium terricola Foissner, 1982*	+	-	-	1.7	+	-	-	-	-	-	-
Frontonia depressa (Stokes, 1886)	+	-	-	1.7	+	-	-	-	-	-	-
Fuscheria lacustris Song & Wilbert, 1989*	-	-	+	1.7	-	-	-	-	-	+	-
Fuscheria terricola Berger, Foissner & Adam, 1993*	+	-	-	1.7	-	-	-	-	+	-	-
Gonostomum affine (Stein, 1859)	+	-	-	6.7	+	+	-	+	-	+	-
Gonostomum kuehnelti Foissner, 1982*	+	-	-	1.7	+	-	-	-	-	-	-
Grossglockneria acuta Foissner, 1980	+	-	-	3.4	+	-	+	-	-	-	-
Halteria grandinella (Müller, 1773)	+	-	-	1.7	+	-	-	-	-	-	-
Hemisincirra gellerti (Foissner, 1982)	+	-	-	3.4	+	-	-	-	+	-	-
Hemisincirra polynucleata (?) Foissner, 1984	+	-	-	1.7	+	-	-	-	-	-	-
Holosticha bergeri Foissner, 1987*	+	-	-	1.7	+	-	-	-	-	-	-
Holosticha multistilata Kahl, 1928*	+	-	-	1.7	+	-	-	-	-	-	-
Holosticha sigmoidea Foissner, 1982*	+	-	-	5.1	+	-	-	+	+	-	-
Homalogastra setosa Kahl, 1926*	-	-	+	3.4	-	-	-	-	-	+	-
Kahlilembus sp.	-	+	-	1.7	-	-	+	-	-	-	-
Lamtostyla edaphoni Berger & Foissner, 1987*	-	+	-	1.7	-	-	+	-	-	-	-
Lamtostyla perisincirra (?) (Hemberger, 1985)	-	-	+	1.7	-	-	-	-	-	+	-
Leptopharynx costatus Mermod, 1914	+	-	+	6.7	+	+	-	-	+	+	-
Microdiaphanosoma arcuatum (Grandori & Grandori, 1934)	+	+	-	5.1	-	+	+	-	-	-	-
Nassula picta Greeff, 1888*	-	-	+	1.7	-	-	-	-	-	+	-
Nivaliella plana Foissner, 1980	+	+	-	3.4	+	+	-	-	-	-	-
Notohymena antarctica sp. n.*	+	-	-	1.7	+	-	-	-	-	-	-
Opercularia sp.	+	-	-	1.7	-	+	-	-	-	-	-
Oxytricha lanceolata Shibuya, 1930	-	-	+	1.7	-	-	-	-	-	+	-
Oxytricha opisthomuscorum Foissner et al., 1991*	+	-	+	5.1	+	+	-	-	-	+	-
Paraenchelys terricola Foissner, 1984*	+	-	-	3.4	+	+	-	-	-	-	-
Paruroleptus notabilis Foissner, 1982*	+	-	-	1.7	-	+	-	-	-	-	-
Platyophrya macrostoma Foissner, 1980	+	-	-	3.4	+	-	-	-	-	+	-
Platyophrya vorax Kahl, 1926	+	+	-	5.1	+	+	-	+	-	-	-
Pleuroplites australis Foissner, 1988*	+	-	-	1.7	+	-	-	-	-	-	-
Pleuroplitoides smithi gen. n., sp. n.*	+	-	-	5.1	-	+	-	-	-	+	-
Protospathidium serpens (Kahl, 1930)	+	-	-	1.7	+	-	-	-	-	-	-
Pseudochilodonopsis mutabilis Foissner, 1981*	+	-	-	3.4	+	-	-	-	+	-	-
Pseudocyrtolophosis alpestris Foissner, 1980	+	+	-	13.6	+	+	-	+	-	+	-
Pseudoplatyophrya nana (Kahl, 1926)	+	+	+	8.5	+	-	-	+	-	+	+
Sathrophilus muscorum (Kahl, 1931)	+	-	-	1.7	+	-	-	-	-	-	-
Sphaerophrya terricola Foissner, 1986*	-	-	+	1.7	-	-	-	-	-	+	-

Table 1. (con.)

Sterkiella histriomuscorum (Foissner et al., 1991)	+	-	-	1.7	+	-	-	-	-	-	-
Sterkiella thompsoni sp. n.*	+	-	-	1.7	-	+	-	-	-	-	-
Urosomoida antarctica sp. n.*	-	-	+	1.7	-	-	-	-	-	-	+
Urosomoida granulifera sp. n.*	+	-	-	1.7	-	+	-	-	-	-	-
Vorticella astyliformis Foissner, 1981	+	+	+	5.1	+	+	-	-	-	+	-

[1]See Materials and Methods. [2]All samples, i. e. including those without ciliates. [3]I *Deschampsia antarctica* grass sward (2 sites), II *Drepanocladus uncinatus* and *Drepanocladus* sp. moss (16 sites), III *Brachythecium austro-salebrosum* moss (3 sites), IV *Polytrichum alpinum* and *P. alpestre* moss (8 sites), V *Andreaea* sp. moss (3 sites), VI other mosses (11 sites), VII barren soil (7 sites). *First record for the maritime and continental Antarctic. Other species have been recorded previously by Sudzuki (1964, 1979), Smith (1978) and/or Foissner (1996)

Faunistics and community structure (Tables 1, 2)

Sixty four species were found (Table 1): 51 in region A (Signy Island and Livingstone Island; 8 samples), 16 in region B (Antarctic Peninsula; 37 samples), and 14 in region C (continental Antarctic; 14 samples). These figures are comparable to those reported from islands in the Southern Ocean (Foissner 1996; Table 2) and alpine grassland and shrub soils above the timberline (Foissner 1981a; Table 2), but much smaller than those reported from temperate grassland and lowland sites (Foissner et al. 1985; Table 2) and certain tropical forests where a single sample may contain 80 species (Foissner 1995). However, because the total number of species is an ambiguous measure if sample sizes differ, the mean number of species per sample was calculated (Table 2). This showed that the samples from Signy Island, which is least severe as concerns the climate, contained the highest number of species (9.6), followed by the Antarctic Peninsula (1.0) and the continental Antarctic (0.9). On average, 2.2 species occurred in the Antarctic samples, which was an order of magnitude lower than in alpine (12.3) and temperate (12.7) soils from Austria (Table 2). There is thus a distinct pauperization of the ciliate fauna with increasing latitude and environmental severity, as known also for many other organism groups (Franz 1975). For testate amoebae Smith and Wilkinson (1987) found a loss of 3.3 species for every 1°C drop in mean January temperature.

Of the habitats investigated, those with a grass sward and/or moss contained the richest fauna, whereas few species could be isolated from barren soils, lichens, and

Table 2. Main characteristics of ciliate communities in Antarctic (this study), sub-Antarctic (Gough and Marion Islands), alpine, and temperate terrestrial biotops

Region/Habitat	Number of species	Mean species number per sample[1]	Number of new species	C/P quotient[2]	No. of samples investigated
Region A (Signy Island)	51	9.6	4	1.0	8
Region B (Antarctic Peninsula)	16	1.0	0	2.7	37
Region C (Continental Antarctic)	14	0.9	1	0.8	14
Habitat I [3]	39	-	1	1.1	2
Habitat II[3]	25	1.8	3	1.3	18
Habitat III[3]	7	-	0	3.0	3
Habitat IV[3]	8	1.7	0	2.5	8
Habitat V[3]	8	-	1	0.5	3
Habitat VI[3]	21	2.5	1	1.6	11
Habitat VII[3]	3	0.4	1	2.0	7
Antarctic sites combined	64	2.2	5	0.7	59
Gough Island[4]	39	14.0	2	2.5	7
Marion Island[4]	39	5.7	2	1.4	20
Gough and Marion combined[4]	60	7.8	4	1.4	27
Alpine soil sites in Austria[5]	81	12.3	-[6]	0.8	58
Temperate soil sites in Austria[7]	132	12.7	-[6]	0.5	70

[1]Calculated only if sample size ≥ 7. [2]Ratio of colpodid/polyhymenophorid (hypotrichs, heterotrichs, oligotrichs) ciliates (Lüftenegger et al. 1985). [3]As defined in footnote 3 of Table 1. [4]From Foissner (1996). [5]From Foissner (1981a). [6]Many, because terrestrial ciliates were very insufficiently known at that time. [7]From Foissner et al. (1985)

bird-influenced sites (Tables 1, 2). This is in accordance with previous investigations (Smith 1973b, 1978, Foissner 1996). In many samples only 1-3 species occurred, however, often with great abundances, possibly due to the lack of competition. No ciliates could be isolated from many samples of the Antarctic Peninsula and the continental Antarctic although they consisted of moss and humic soil (e. g. samples 11, 14, 20, 29, 35, 48, 58), which is usually an unfailing indication for the presence of ciliates. I very rarely found such samples in other regions of the world, not even in arid deserts. Thus, the patchy distribution of the ciliates is a conspicuous peculiarity of the Antarctic region and very likely related to the extreme environmental conditions allowing few pioneers to establish stable populations.

Most species with medium and high frequency values (≥ 8%, Table 1) belonged to the class Colpodea (*Pseudocyrtolophosis alpestris*, *Colpoda ecaudata*, *C. steinii*, *C. inflata*, *Pseudoplatyophyra nana*), except for *Cyclidium muscicola*, a very tiny (14-20 µm) hymenostome. All are small to medium-sized bacteria feeders, except for *P. nana*, an obligate fungal sucker, and are widespread in soils worldwide (Foissner 1987a, 1993). The dominance of colpodids was reflected by the high values of the C/P quotient (Table 2), which has been suggested as a measure of biotope extremity (Lüftenegger et al. 1985). Although there was some bias in detail, most quotients were near or above 1, indicating that the habitats investigated favoured *r* - selected "reproducers" (colpodids) rather than *K* - selected "persisters" (polyhymenophorans).

Twenty nine of the 64 species found have been not reported previously from the maritime and continental Antarctic; and most others have been recorded very recently (Foissner 1996), showing our ignorance regarding the Antarctic soil and moss ciliate fauna. Very likely, many other species will be found in other regions of the Antarctic and if a larger sample collective is carefully analysed. However, very few new species were found, indicating a predominance of ubiquists and an absence of endemits.

Smith's bi-polar biogeography of *Colpoda* is a methodological artifact

Colpoda is the most widespread and most abundant of all genera of ciliates in terrestrial biotopes (Smith 1978, Foissner 1987a, 1993). Very likely, this is due to its *r* - selected survival strategy (Lüftenegger et al. 1985, Foissner 1993): it can increase its population density very quickly by multiple division and excyst or encyst within one hour if the environmental variables become favourable or adverse, respectively.

Smith (1973a, 1978) and Smith and Crook (1995) concluded from a detailed literature survey and many original investigations that *Colpoda* is present in Arctic and sub-Antarctic but absent in maritime Antarctic biotopes. As a possible explanation, Smith (1973a) and Smith and Crook (1995) suggested that Antarctic summers are too cold, and each day has too few degree-hours above critical threshold temperature, to permit *Colpoda* to establish permanent populations. He corroborated this hypothesis not only by meteorological data but also by some laboratory experiments indicating that *Colpoda* does not grow and survive at 0°C, which was later supported by Kracht (1982).

Smith's hypothesis of a bi-polar distribution of the genus *Colpoda* is clearly disproven by the present results which show not only the occurrence of several *Colpoda* species in terrestrial biotopes of the maritime and continental Antarctic but also that they are among the three most frequent species found (*Colpoda ecaudata*, *C. steinii*, *Pseudocyrtolophosis alpestris*). Furthermore, active cells of *Colpoda* were observed by Petz (unpubl.) in freshly sampled soils of the continental Antarctic.

How can this discrepancy be explained ? I suggest that it is mainly caused by methodological shortcomings. Smith (1978) used very small quantities (1-2 g) of soil, moss, etc. and inoculated them on agar plates amended with a single strain of bacteria, *Aerobacter aerogenes*. This is very different from the non-flooded Petri dish method applied in this study, where huge amounts of material without additives, except for water, were used. Thus, a more natural biotope was simulated, giving even small populations a fair chance to develop and grow on the natural microflora and microfauna.

Although the field results of Smith must be rejected, his basic idea is very likely correct. It was indeed surprising and most uncommon that several soil and/or moss samples did not contain a single species of *Colpoda* or any ciliate at all (see Sample description and species recorded). This patchy distribution might well be caused by the unfavourable climate allowing few specimens to establish permanent populations, i.e. local extinction possibly occurs frequently. However, this certainly applies not only to members of the genus *Colpoda* but also to most other species, possibly even to a greater extent because they were less frequent (Table 1). Furthermore, such a patchy distribution of the ciliates was also observed in soil and

moss samples from Marion and Gough Island (Foissner 1996).

Description of new and insufficiently known species

Morphometric data shown in Tables 3-8 are repeated in this section only as needed for clarity. All observations are from field material, i.e. not from clone cultures. Thus, it cannot be excluded that similar, but different, species were mixed, although this is unlikely because I excluded all specimens which deviated in at least one prominent character. Certainly, this can generate some bias in the data if used too uncritically. However, I usually exclude only such specimens which have, e.g., a different nuclear structure (very likely often postconjugates), a distinctly deviating ciliary pattern (very likely often injured, regenerating or malformed specimens), or an unusually small size (very likely often degenerating, just excysted or divided specimens). The inclusion of such individuals, which sometimes might belong to another species, would artificially increase variability.

Family Pleuroplitidae fam. n.

Diagnosis: Acropisthiina Foissner and Foissner, 1988 with subapical, i.e. extracytostomal extrusome bundle on ventral side. Dorsal brush composed of few isomorphic or many heteromorphic rows. Type genus: *Pleuroplites* Foissner, 1988.

Comparison with related families: *Pleuroplites* Foissner, 1988 and the new genus *Pleuroplitoides*, described below, are unique among gymnostomatids (= haptorids) in having the extrusomes located not within and/or around the oral basket but in a distinct subapical bundle on the ventral side (Figs. 2, 5). Certainly, this is an extraordinary evolutionary branch which needs to be separated at family level at least. Formerly, I classified *Pleuroplites* with the Trachelophyllidae, simply to avoid establishing a monotypic family (Foissner 1988).

The Pleuroplitidae are very likely related to the Acropisthiina because of distinct homologies in the structure of the oral basket, which is composed of nematodesmata originating not only from the oral dikinetids (as is usual) but also from ciliated oralized somatic monokinetids (Fig. 7). On the other hand, *Pleuroplitoides* (and very likely *Pleuroplites*, too, but this species is so small that details are hardly recognizable light microscopically) has bifurcated nematodesmal bundles (Fig. 7), a character typical of the suborder Lacrymariina (Grain 1984). However, bifurcated nematodesmata are widespread also in prostomatids (e. g. Dragesco et al. 1974, Hiller 1991) and thus possibly a weaker character than the oralized somatic monokinetids.

Genus *Pleuroplitoides* gen. n.

Diagnosis: Pleuroplitidae with isomorphic dorsal brush composed of 2 rows of paired, shortened cilia.

Type species: *Pleuroplitoides smithi* sp. n.

Etymology: composite of *pleuroplites* (laterally armed soldier) and *oides* (similar, to *Pleuroplites*). Masculine gender.

Comparison with related genera: *Pleuroplitoides* is distinguished from *Pleuroplites*, the sole other member of the family, by the structure of the dorsal brush. It consists of 2 rows in *Pleuroplitoides* and more than 3 rows in *Pleuroplites*. Furthermore and more importantly, the rows of *Pleuroplitoides* are isomorphic, i.e. consist of pairs of basal bodies (dikinetids), while those of *Pleuroplites* are heteromorphic, i.e. composed of normal somatic cilia (monokinetids) interspersed between dikinetids with shortened cilia (Foissner 1988).

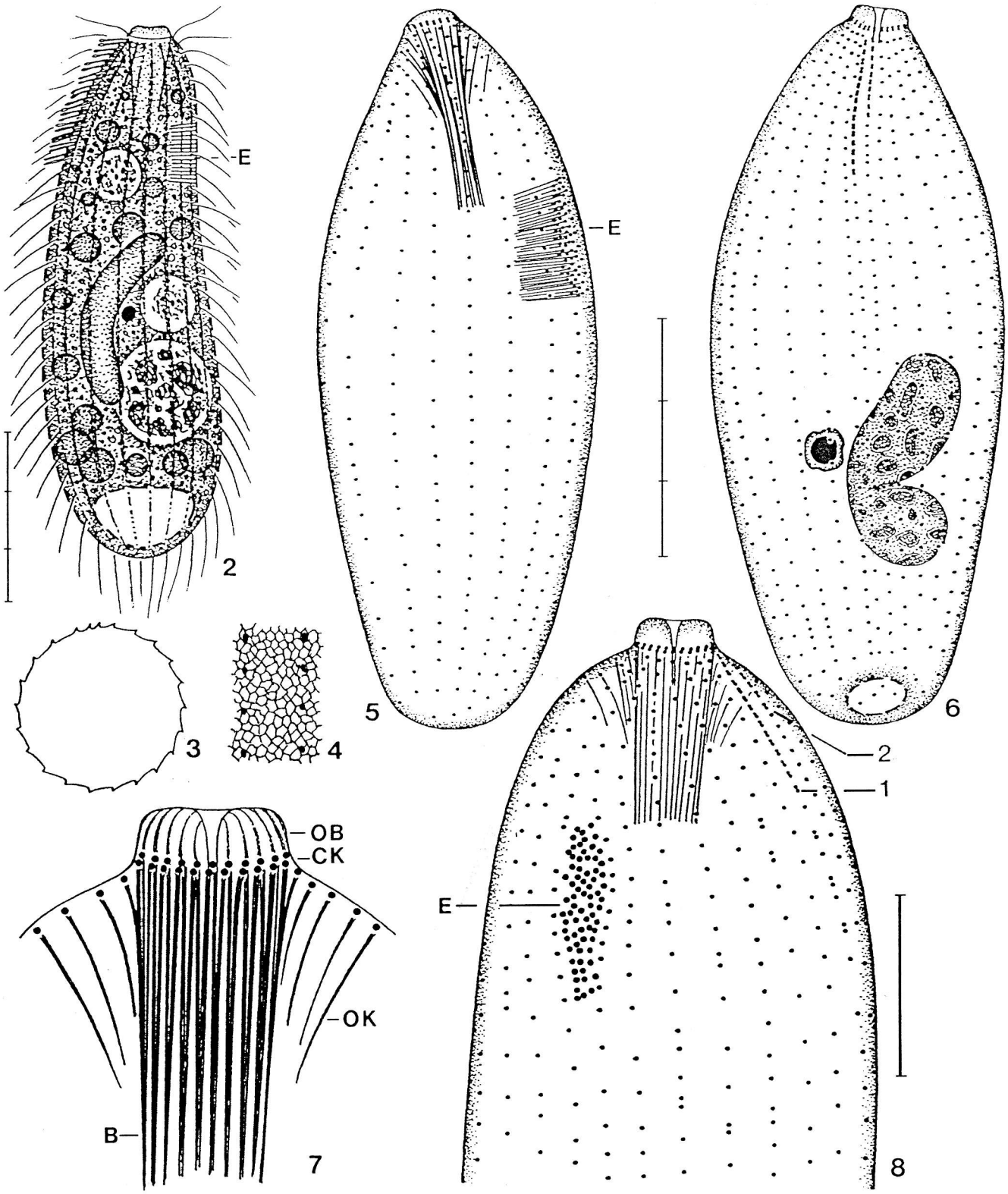
Pleuroplitoides smithi sp. n. (Figs. 2-9, Table 3)

Diagnosis: size *in vivo* about 70-110 x 30-40 µm. Twenty three ciliary rows on average, 2 of them differentiated to brush in anterior quarter. Extrusomes rod-shaped, very slender, about 5 µm long, form elliptical patch between two ventrolateral ciliary rows. Macronucleus reniform, micronucleus globular.

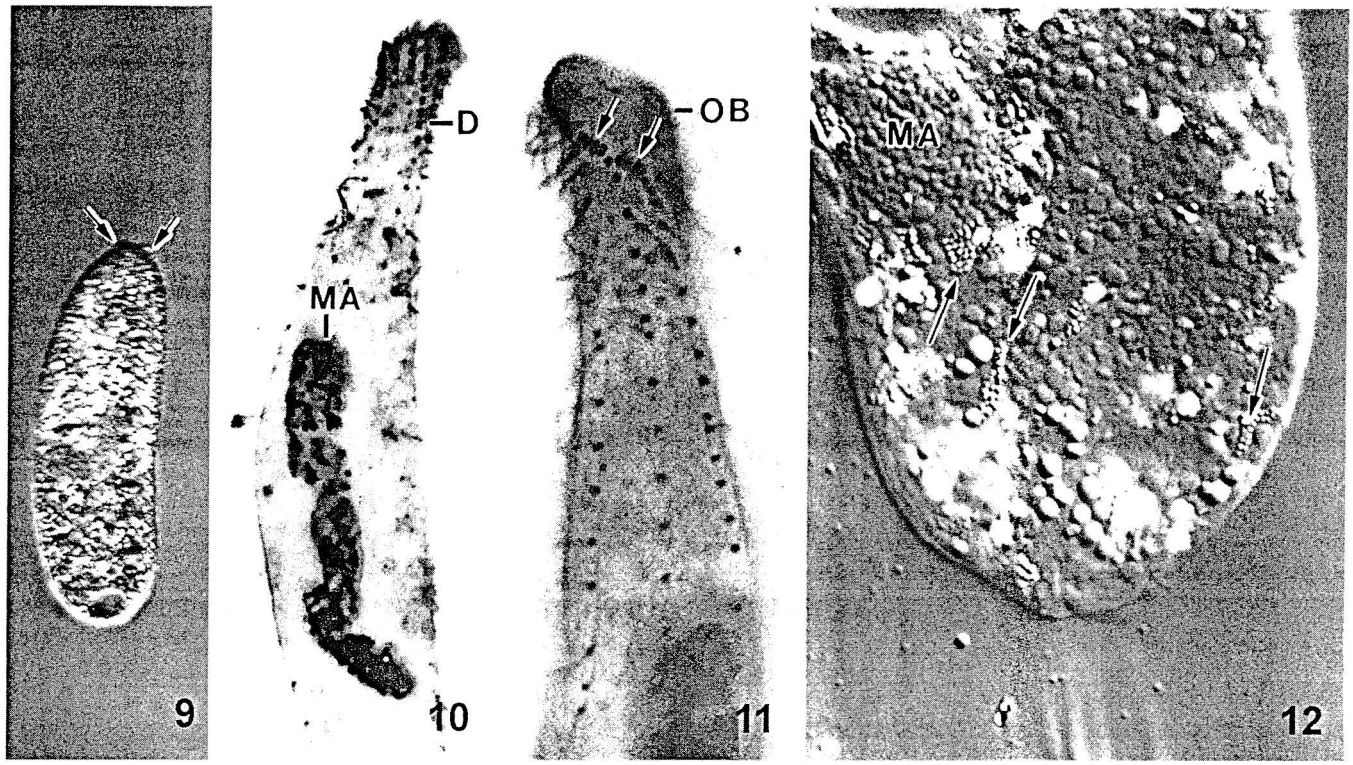
Type location: *Chorisodontium aciphyllum* moss from Signy Island, South Orkney Islands, Antarctica (60°40'S, 45°40'W).

Dedication: named in honour of Professor Dr H. G. Smith (Coventry Polytechnic, England), who undertook many interesting studies on Antarctic soil protozoa.

Description: slightly reniform to bursiform, dorsal side convex, ventral slightly concave (Figs. 2, 9); prepared specimens ellipsoid or pyriform, i.e. inflated in mid-body (Fig. 6) or at posterior end. Anterior end transverse truncate, posterior broadly rounded. Transverse section roundish, with sharp ribs left of ciliary rows (Fig. 3). Macronucleus in or near centre of cell, with many globular and ellipsoidal nucleoli. Micronucleus near macronucleus. Contractile vacuole in posterior end. Fifty to hundred extrusomes in dense, elliptical bundle located ventrolaterally, i.e. about 130° clockwise from dorsal brush, between two slightly widened ciliary rows; individual toxicysts very fine and thus easily overlooked in live cells, distal



Figs. 2-8. *Pleuroplitoides smithi* from life (2-3), after dry silver nitrate (4) and protargol impregnation (5-8). 2 - right lateral view of typical specimen; 3 - anterior polar view; 4 - silverline system; 5-6 - infraciliature of ventral and dorsal side; 7 - fibrillar system of oral apparatus; 8 - dorsolateral view showing extrusome bundle between two somatic ciliary rows. B - oral basket, CK - circumoral kinety, E - extrusome bundle, OB - oral bulge, OK - oralized somatic kinetids, 1-2 - dorsal brush rows. Scale bar division 10 µm



Figs. 9-12. Light micrographs of some of the species described. 9 - Freely moving specimen of *Pleuroplitoides smithi*. Arrows mark inconspicuous oral bulge; 10-11 - *Protospathidium serpens*, dorsal and right lateral views. Arrows mark circumoral kinety composed of isolated dikinetidal fragments; 12 - *Urosomoida granulifera*, surface view of posterior region showing patches of cortical granules (arrows). D - dorsal brush, MA - macronucleus, OB - oral bulge

end however strongly argyrophilic and thus very prominent in prepared specimens (Figs. 1, 5, 8). Cortex flexible, distinctly furrowed by ciliary rows. Cytoplasm usually with many 2-5 µm sized, colourless fat globules and few, large food vacuoles containing residues of ingested ciliates (*Gonostomum affine*). Swims rather slowly by rotation about main body axis.

Cilia 8-10 µm long, rather widely spaced, arranged in longitudinal rows commencing closely underneath circumoral kinety. Dorsal brush cilia very closely spaced, *in vivo* about 4 µm long and slightly inflated at distal end (Fig. 2). Oral bulge very similar to that of *Papillorhabdos*, i.e. flat, inconspicuous and slightly depressed in centre (Figs. 2, 7, 9). Circumoral kinety at base of oral bulge, composed of dikinetids having only posterior basal body ciliated. Oral basket inconspicuous in live cells, but rather distinct in protargol impregnated specimens, composed of bifurcated nematodesmata originating from oral dikinetids. Nematodesmata also originate from 3-5 monokinetids at anterior end of all somatic kineties and extend obliquely to oral basket (Figs. 5, 7, 8).

Silverline system very fine-meshed, as in other gymnostomatids (Fig. 4).

Comparison with related species: *Pleuroplitoides smithi* differs from *Pleuroplites australis* Foissner, 1988, which also occurs in Antarctica (site 5), not only by the generic characters mentioned but also by its larger size (70-100 µm vs. 35-50 µm) and extrusomes (5 µm vs. 2.5 µm) as well as by the reniform (globular in *P. australis*) macronucleus and the higher number of somatic kineties (23 vs. 14). These species are thus easily distinguished even in live condition. However, *P. smithi* is easily confused with *Fuscheria terricola*, also occurring in Antarctica (site 4). This species highly resembles *P. smithi* in all characters, except for the extrusomes, which are located in the centre of the oral bulge, a very useful character for distinguishing *P. smithi* and *F. terricola* in live condition.

Distribution: found at three mossy sites, viz. in samples 2, 7, and 8, but also in a subalpine grassland soil in Austria (Foissner 1987b; designated "genus non det." in Table 1); thus, very likely distributed worldwide, but rare. The unusual location of the extrusomes suggests a special mode of predation.

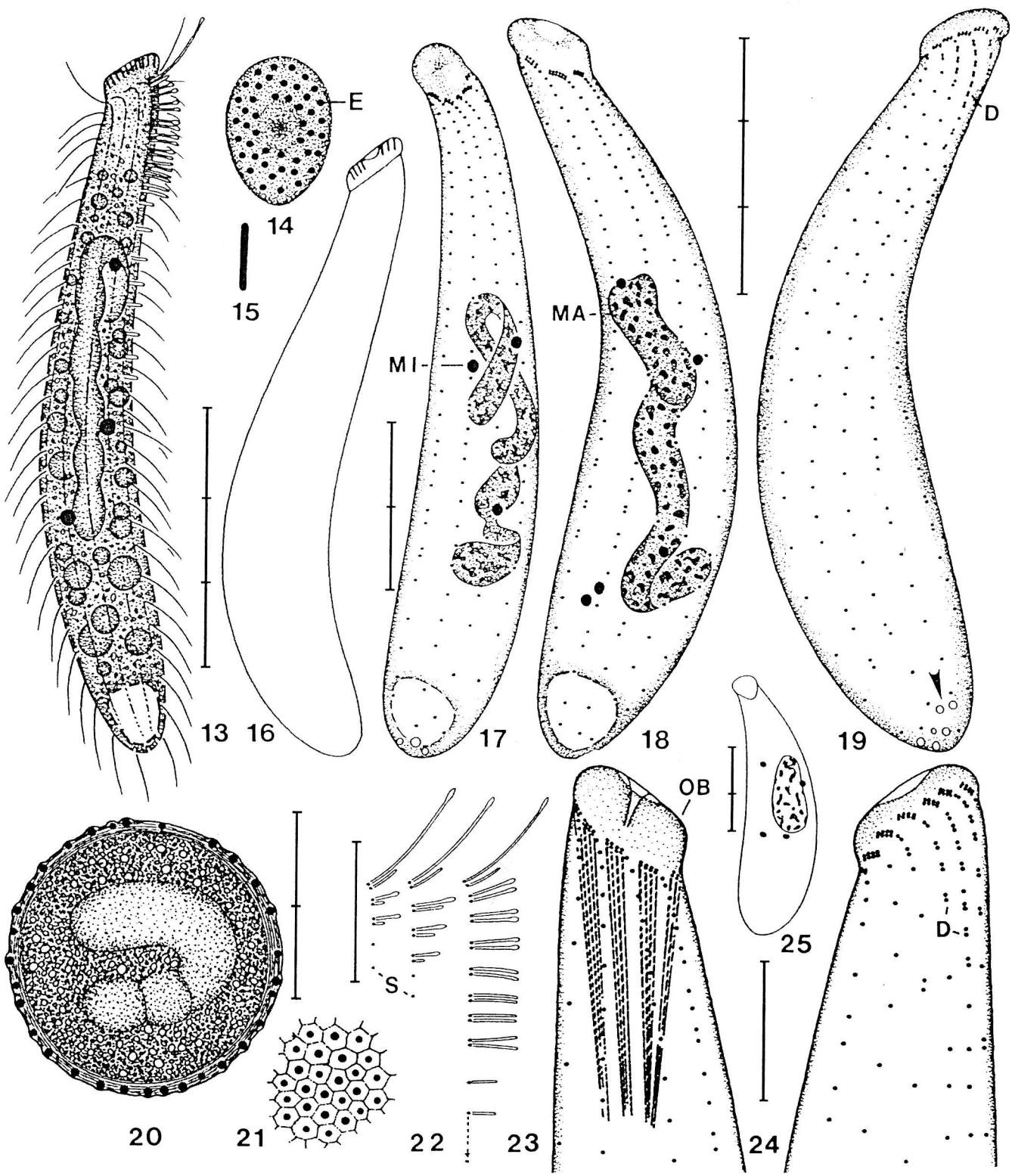
Table 3. Morphometric data from *Pleuroplitoides smithi* (upper line) and *Protospathidium serpens* (lower line)*

Character	x̄	M	SD	SD x̄	CV	Min	Max	n
Body, length	77.7	74.5	9.0	2.9	11.6	65	90	10
	78.8	77.0	9.0	2.3	11.5	63	95	15
Body, maximum postoral width	31.7	32.0	4.1	1.3	12.9	24	37	10
	18.5	18.0	2.5	0.7	13.7	13	22	15
Distance anterior end to macronucleus	22.9	23.0	5.1	1.6	22.2	17	31	10
	27.9	25.0	6.9	1.8	24.9	20	46	15
Distance anterior end to extrusome patch	14.3	14.0	3.6	1.1	24.9	9	22	10
	-	-	-	-	-	-	-	-
Distance anterior end to end of extrusome patch	26.2	26.0	5.1	1.6	19.4	18	36	10
	-	-	-	-	-	-	-	-
Oral bulge, width at circumoral kinety	6.1	6.0	0.9	0.3	14.4	5	7	10
	7.6	8.0	1.0	0.3	13.0	6	9	15
Chord of macronucleus, respectively, nuclear figure, length	29.5	29.0	5.1	1.6	17.2	22	42	10
	31.3	30.0	6.1	1.6	19.6	20	42	15
Macronucleus, width	9.2	9.0	1.3	0.4	14.3	7	11	10
	5.1	5.0	1.2	0.3	24.3	4	8	15
Micronucleus, diameter	4.9	5.0	0.5	0.2	10.1	4	6	10
	1.7	1.8	0.2	0.1	8.9	1.5	2	15
Macronucleus, number	1.0	1.0	0	0	0	1	1	10
	1.0	1.0	0	0	0	1	1	15
Micronucleus, number	1.0	1.0	0	0	0	1	1	10
	3.3	3.0	1.2	0.3	35.6	2	5	15
Somatic kineties, number in mid-body	23.7	23.0	1.6	0.5	6.6	22	27	10
	11.6	11.0	0.7	0.2	6.4	11	13	15
Basal bodies in a ventral somatic kinety, number	32.1	31.0	5.0	1.6	15.6	25	40	10
	30.7	30.0	5.6	1.4	18.2	20	40	15
Dorsal brush, number of rows	2.0	2.0	0	0	0	2	2	10
	3.5	4.0	-	-	-	3	4	15
Brush kinety 1, length	14.0	14.0	1.5	0.5	10.6	13	18	10
	3.4	3.0	0.6	0.2	18.6	2	4	15
Brush kinety 2, length	6.1	6.0	0.7	0.2	12.1	5	8	10
	4.3	4.0	1.2	0.3	27.3	3	7	15
Brush kinety 3, length	-	-	-	-	-	-	-	-
	10.5	11.0	2.1	0.6	20.3	7	14	15
Brush kinety 4, length	-	-	-	-	-	-	-	
	9.4	10.0	1.6	0.4	16.5	7	11	15
Dikinetids in brush kinety 1, number	14.2	14.0	1.7	0.5	11.9	12	17	10
	1.9	2.0	0.5	0.1	27.7	1	3	15
Dikinetids in brush kinety 2, number	6.4	6.0	1.4	0.5	22.3	5	10	10
	3.0	3.0	0.8	0.2	25.2	2	4	15
Dikinetids in brush kinety 3, number	-	-	-	-	-	-	-	-
	8.5	8.0	1.5	0.4	17.2	7	12	15
Dikinetids in brush kinety 4, number	-	-	-	-	-	-	-	-
	5.2	5.0	0.7	0.2	13.0	4	7	15

*Data based on protargol-impregnated and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD x̄ - standard deviation of mean, x̄ - arithmetic mean

Protospathidium serpens (Kahl, 1930) Foissner, 1981 (Figs. 10, 11, 13-24, Table 3)

Protospathidium serpens belongs to a group of small spathidiids which are poorly known and thus difficult to identify. The Antarctic population basically matches the original description (Kahl 1930) and the redescription by Foissner (1981b). The population studied by Berger et al. (1984) agrees with Kahl's and Foissner's descriptions in size, shape and number of ciliary rows, but has 15-30 ellipsoidal macronuclear nodules. Thus it might be a race of *P. muscicola* Dragesco and Dragesco-Kerneis, 1979, which, however, has 10-12 ciliary rows, similar to the Antarctic population of *P. serpens*. Obviously, the macronuclear configuration is rather variable in *P. serpens* and some other spathidiids. Thus detailed data are needed from several populations for a reasonable conclusion on the systematic status of *P. serpens*



Figs. 13-25. *Protospathidium serpens* from life (13-16, 20-22) and after protargol impregnation (17-19, 23 - 25). 13 - left lateral view of typical specimen; 14 - frontal view of oral bulge; 15 - extrusome; 16 - broad specimen; 17-19 - infraciliature of ventral, right and left side. Arrowhead marks pores of contractile vacuole; 20-21 - optical section and surface view of resting cyst; 22 - dorsal brush; 23-24 - infraciliature of anterior right and left side (cp. Figs. 10-11); 25 - specimen with ellipsoidal macronucleus. D - dorsal brush, E - extrusomes, MA - macronucleus, MI - micronucleus, OB - oral bulge, S - somatic monokinetids with normal cilia. Scale bar division 10 µm

and *P. muscicola*. The following description is based, if not stated otherwise, on the population found at site 3.

Description (Figs. 10, 11, 13-24, Table 3): size *in vivo* about 70-100 x 12-18 µm. Shape slender, slightly to distinctly sigmoidal, inconspicuously flattened laterally, general appearance thus cylindroid. Macronucleus rather variable, three modifications were found in 79 specimens analyzed: nodular (48 cases; Fig. 17), rod-like (27 cases; Fig. 18), ellipsoidal (4 cases; Fig. 25). Micronuclei of variable position, i.e. not at fixed site and attached to or rather distant from macronucleus. Contractile vacuole terminal, with 3-6 excretory pores. Extrusomes invariably rod-shaped with rounded ends (Fig. 15), 3 µm long in population from site 3, 2 µm in specimens from USA and 2-2.5 x 0.5 µm in Greek population; arranged in 2-3 rough circles around central depression of oral bulge (Fig. 14). Cortex colourless, flexible, in population from Marion Island (Antarctica) with about 5 rows of minute (< 0.3 µm), pale granules between each 2 ciliary rows. Cytoplasm rather hyaline, contains some 1-4 µm sized, colourless fat droplets, obviously digestion products from ingested heterotrophic flagellates and/or bacteria because no ciliates were present when *P. serpens* flourished. Moves slowly.

Somatic infraciliature without peculiarities, dorsal brush, however, highly differentiated (Figs. 10, 13, 19, 22, 24). Anterior cilium of first dikinetid distinctly elongated in each brush row, easily confused with cilia from circumoral kinety segments which, however, lack distal inflation; kinety 3 extends above mid-body, as indicated by shortened cilia, although basal bodies not paired in posterior brush half.

Oral bulge conspicuous, i.e. refractile and compact because packed with extrusomes, oval in frontal view (Fig. 14), centre usually distinctly depressed, rarely almost most flat. Segments of circumoral kinety distinctly separate, adhere to somatic ciliary rows, associated with long, fine nematodesmata forming wedge-shaped bundles (Figs. 11, 17, 18, 23, 24).

Resting cysts 28-32 µm (x = 29.8, n = 8) in diameter, brownish, wall about 2 µm thick, highly refractile, contains conspicuous, compact granules causing cyst surface to become studded and, respectively, honeycombed in lateral and surface view (Figs. 20, 21). Cytoplasm finely granulated, macronucleus tortuous.

Distribution: *Protospathidium serpens* is very likely distributed worldwide and not strictly associated with terrestrial biotopes because the type population was found in a small, flooded trench. However, all populations mentioned above are from mosses and soils, suggesting that *P. serpens* prefers such biotopes.

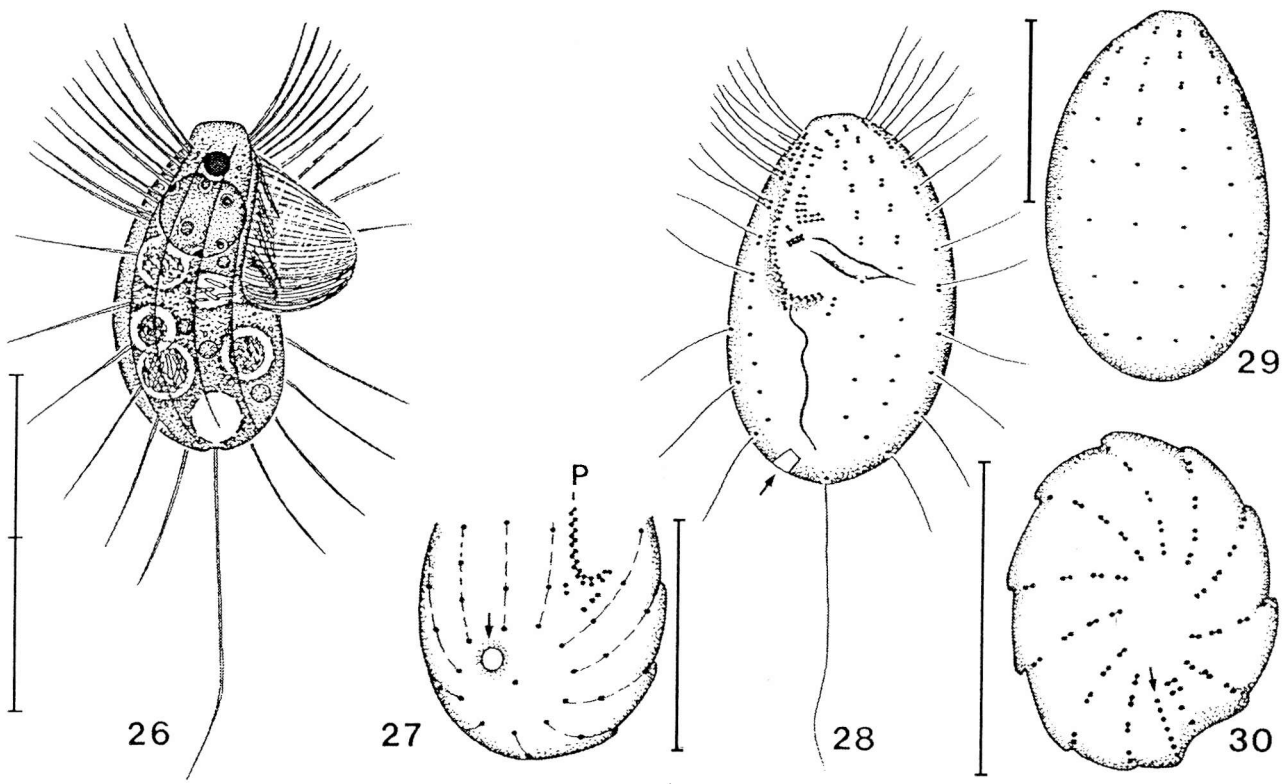
Cyclidium glaucoma Müller, 1773 (Figs. 26-30, Table 4)

This species has been frequently reported from terrestrial biotopes worldwide, including Antarctica (Smith 1978). However, most records are very likely misidentifications because *C. glaucoma* is a typical freshwater ciliate and thus very rare in moss and soil,

Table 4. Morphometric data from *Cyclidium glaucoma*[*]

Character	$\bar{x}$	M	SD	SD $\bar{x}$	CV	Min	Max	n
Body, length	18.2	18.0	1.9	0.6	10.7	15	21	11
Body, width in lateral view	11.5	11.0	1.4	0.4	11.9	10	15	11
Body, width in ventral view	10.0	10.0	1.1	0.3	11.0	8	12	11
Distance anterior end to proximal vertex of paroral membrane	10.4	10.0	0.5	0.2	4.9	10	11	11
Distance anterior end to adoral membranelle 1	1.6	1.5	0.4	0.1	24.0	1	2	11
Distance anterior end to proximal end of adoral membranelle 3	7.2	7.0	0.6	0.2	8.4	6	8	11
Distance anterior end to macronucleus	2.8	3.0	0.3	0.1	12.0	2	3	11
Distance anterior end to excretory pore	17.3	17.0	1.3	0.4	7.8	15	19	11
Macronucleus, length	4.7	5.0	0.5	0.1	9.9	4	5	11
Macronucleus, width	4.3	4.0	0.8	0.2	18.4	3	5	11
Macronuclei, number	1.6	1.0	0.9	0.2	56.5	1	4	14
Somatic kineties, number	10.0	10.0	0.6	0.2	6.3	9	11	11
Kinetids, number in somatic kinety 8	10.4	11.0	0.8	0.2	7.8	9	11	11

[*] Data based on silver nitrate-impregnated (wet method) and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD $\bar{x}$ - standard deviation of mean, $\bar{x}$ - arithmetic mean



Figs. 26-30. *Cyclidium glaucoma* from life (26) and after wet silver nitrate impregnation (27-30). 26 - right lateral view of typical specimen; 27 - oblique posterior polar view. Arrow marks pore of contractile vacuole; 28-29 - infraciliature of ventral and dorsal side. Arrow marks pore of contractile vacuole; 30 - anterior polar view. Arrow marks paroral membrane. P - paroral membrane. Scale bar division 10 μm

where *C. muscicola* and *C. terricola* are much more frequent (Foissner 1987a; Table 1). These species differ from *C. glaucoma* by the distinctly subterminal location of the contractile vacuole (Foissner 1995).

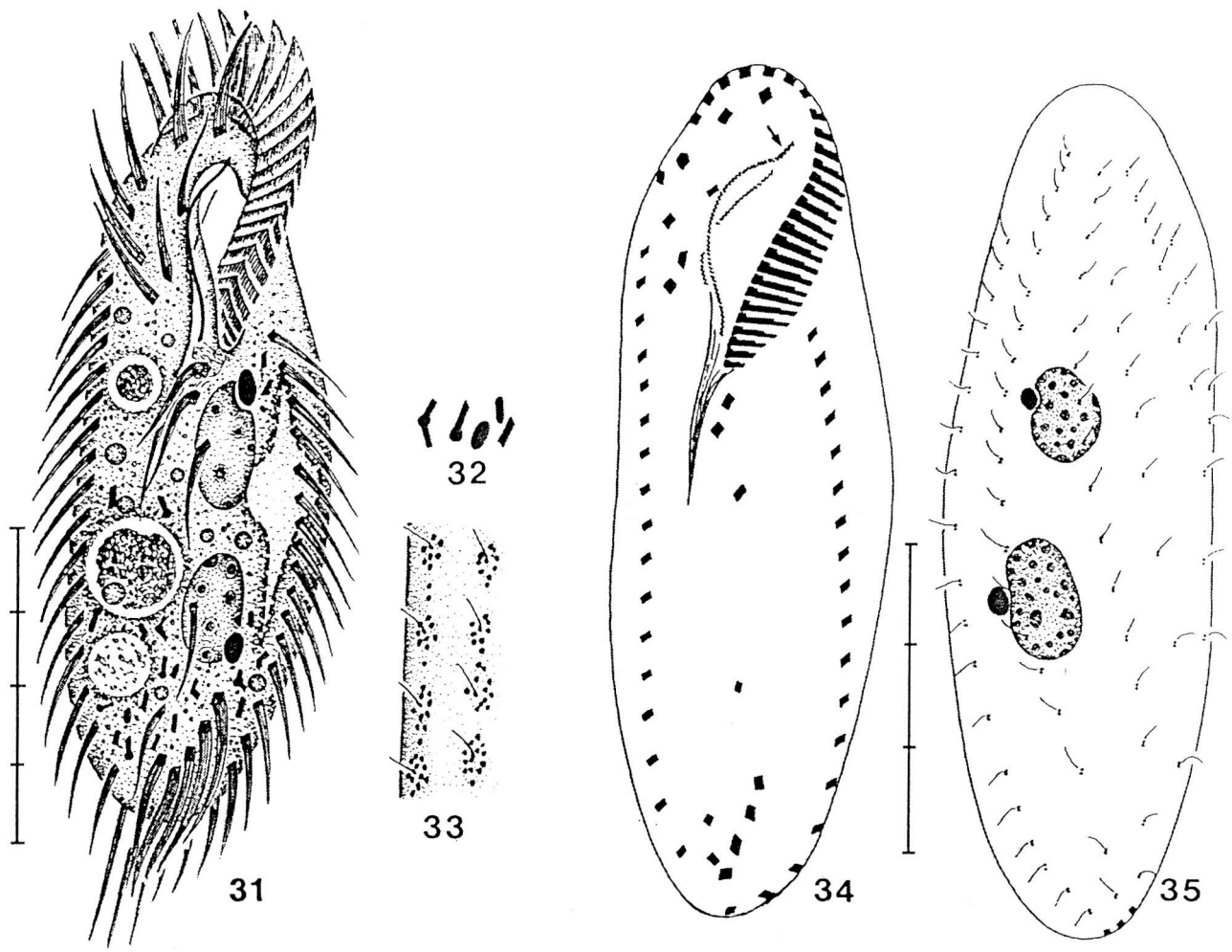
The Antarctic specimens from sites 17 and 27 largely match the freshwater populations studied so far (for review see Foissner et al. 1994). Thus, only a brief description is provided which should, in connection with the detailed morphometry and figures, suffice to recognize and characterize the terrestrial populations from Antarctica.

Size *in vivo* about 17-22 x 8-11 μm, usually 19 x 9 μm. Ellipsoid with narrowed, rather distinctly set off anterior end (frontal plate), laterally slightly flattened (Fig. 26). Macronucleus invariably in anterior third of cell, disintegrated to 2-4 small globules in about half of specimens (Table 4). Micronucleus in anterior indentation of macronucleus, compact and thus conspicuous in live cells, rarely and only faintly impregnates with protargol. Contractile vacuole invariably in posterior end of cell, with single excretory pore (diameter about 1 μm) at end of kinety 2, rarely between kineties 2 and 3 (Fig. 27).

Somatic cilia *in vivo* about 8 μm long, basal bodies paired in anterior third of cell, however, not all dikinetids have both basal bodies ciliated (Fig. 28). Caudal cilium conspicuous, about 20 μm long. Cilia not condensed in posterior half of first kinety left of oral apparatus, unlike some, but not all, freshwater populations (Foissner et al. 1994). Oral structures very much like described by Didier and Wilbert (1981) and Foissner et al. (1994); basal bodies not paired in anterior half of paroral membrane.

Notohymena antarctica sp. n. (Figs. 31-35, Table 5)

Diagnosis: size *in vivo* 80-110 x 30-40 μm. Cortical granules yellow, mainly around cirral bases and dorsal bristles. On average 31 adoral membranelles, 17 right marginal cirri, 18 left marginal cirri, 5 transverse cirri, 3 caudal cirri, and 6 dorsal kineties.



Figs. 31-35. *Notohymena antarctica* from life (31-33) and after protargol impregnation (34-35). 31 - ventral view of typical specimen; 32 - cytoplasmic crystals; 33 - cortical granulation on dorsal side; 34-35 - infraciliature of ventral and dorsal side. Arrow marks hooked anterior portion of paroral membrane, i. e. the genus character. Scale bar division 10 µm

Type location: *Deschampsia antarctica* grass sward from Signy Island, South Orkney Islands, Antarctica (60°40'S, 45°40'W).

Etymology: named after the continent found.

Description: shape prolate ellipsoidal, right side straight or slightly concave, left rather distinctly convex, both ends broadly rounded, flattened laterally up to 3 : 1 (Figs. 31, 34). Flexible like, e. g., *Oxytricha granulifera*. Macronuclear nodules distinctly ellipsoidal (2 : 1), rather close ($\bar{x}$ = 7 µm) together in middle third of body to left of midline. Usually one globular micronucleus attached to each macronuclear nodule. Contractile vacuole in mid-body at left margin, with two inconspicuous collecting canals. Cytopyge in posterior end between transverse cirri and left marginal cirral row; fecal balls contain yellowish globules like those found in cytoplasm. Pellicle colourless, flexible; cortical granules arranged in groups around cirral bases and dorsal bristles (Fig. 33), yellow to yellow-green, give cell yellowish colour at low magnification (≤ x 100), do not stain with protargol. Cytoplasm colourless, contains some 1-4 µm sized, yellowish fat globules and rather many 1-3 µm long crystals, mainly in posterior half (Figs. 31, 32). Feeds on ciliates, heterotrophic flagellates and, possibly, on bacteria. Scrabbles rather fast amongst soil particles.

Marginal cirri about 15 µm long, frontal, transverse and caudal cirri about 20 µm long. Gap between posterior end of marginal rows indistinct because left row extends to midline of cell and indistinctly separate from caudal cirri. Arrangement of ventral cirri oxytrichid, cirral number very constant, i.e. 18, unlike as in *N. australis* (Foissner and O'Donoghue, 1990). Dorsal cilia about 3 µm long *in vivo*,

Table 5. Morphometric data from *Notohymena antarctica* (upper line) and *Sterkiella thompsoni* (lower line)*

Character	x̄	M	SD	SD x̄	CV	Min	Max	n
Body, length	85.5	87.0	5.8	1.7	6.7	70	91	11
	97.0	97.0	10.3	2.7	10.7	82	115	15
Body, width	30.4	31.0	2.1	0.6	7.0	28	34	11
	40.1	38.0	7.1	1.8	17.7	31	56	15
Anterior somatic end to proximal end of adoral zone, distance	32.4	32.0	2.2	0.7	6.8	28	35	11
	40.3	41.0	3.0	0.8	7.4	35	48	15
Posterior somatic end to posteriormost transverse cirrus, distance	3.0	3.0	0.6	0.2	21.1	2	4	11
	-	-	-	-	-	-	-	-
Distance between macronuclear nodules	6.5	7.0	1.7	0.5	26.3	4	9	11
	-	-	-	-	-	-	-	-
Macronuclear nodules, length	12.9	13.0	2.1	0.6	16.0	11	18	11
	13.1	13.0	3.5	0.9	26.5	9	24	15
Macronuclear nodules, width	7.1	7.0	0.4	0.1	5.6	7	8	11
	8.9	9.0	1.5	0.4	17.0	7	12	15
Micronuclei, length	3.2	3.0	0.3	0.1	10.6	3	4	11
	2.4	2.1	0.4	0.1	16.6	2	3	14
Micronuclei, width	2.8	3.0	0.3	0.1	9.4	2.5	3	11
	1.9	2.0	0.2	0.1	11.6	1.5	2.1	14
Macronuclear nodules, number	2.0	2.0	0	0	0	2	2	11
	3.0	3.0	0.2	0.1	7.5	2	4	120
Micronuclei, number	2.4	2.0	0.7	0.2	28.5	1	3	11
	2.0	1.0	1.7	0.5	84.2	1	6	13
Adoral membranelles, number	30.2	31.0	1.9	0.6	6.4	27	33	11
	34.4	34.0	2.1	0.5	6.0	32	39	15
Right marginal cirri, number	16.8	17.0	1.2	0.4	6.9	15	19	11
	22.3	22.0	1.8	0.5	8.2	19	25	15
Left marginal cirri, number	17.9	18.0	1.3	0.4	7.3	16	20	11
	17.8	17.0	2.2	0.6	12.4	15	24	15
Anterior frontal cirri, number	3.0	3.0	0	0	0	3	3	11
	3.1	3.0	-	-	-	3	4	15
Posterior frontal cirri, number	4.0	4.0	0	0	0	4	4	11
	4.0	4.0	0	0	0	4	4	15
Buccal cirri, number	1.0	1.0	0	0	0	1	1	11
	1.0	1.0	0	0	0	1	1	15
Postoral cirri, number	3.0	3.0	0	0	0	3	3	11
	3.1	3.0	0.6	0.2	19.3	2	5	15
Ventral cirri ahead of transverse cirri, number	2.0	2.0	0	0	0	2	2	11
	2.0	2.0	0	0	0	2	2	15
Transverse cirri, number	5.0	5.0	0	0	0	5	5	11
	5.1	5.0	-	-	-	5	6	15
Caudal cirri, number	3.0	3.0	0	0	0	3	3	11
	2.0	2.0	0	0	0	2	2	15
Dorsal kineties, number	6.0	6.0	0	0	0	6	6	11
	4.0	4.0	0	0	0	4	4	15

*Data based on protargol-impregnated and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD x̄ - standard deviation of mean, x̄ - arithmetic mean

arranged in 6 rows (Fig. 35): rows 1 and 4 slightly shortened anteriorly, rows 2 and 3 as long as body, row 5 terminates sub-equatorially, row 6 consists of about 5 dikinetids only and ends pre-equatorially.

Oral apparatus and adoral zone of membranelles conspicuous, occupy about 37% of body length. Buccal field rather large and deep, anterior portion semicircularly curved, similar as in *Cyrtohymena*. Paroral and endoral membrane conspicuously curved, intersect optically in mid-portion, paroral distinctly longer than endoral, its distal end hooked (main genus character), both very likely composed of dikinetids (Fig. 34).

Comparison with related species: *Notohymena antarctica* is very similar to *N. australis* (Foissner and O'Donoghue, 1990) Blatterer and Foissner, 1988 as concerns size, shape, and cortical granules. However, it has fewer adoral membranelles and marginal cirri and, more importantly, only 3 caudal cirri. The unusual high

number, viz. 6-8, of caudal cirri in *N. australis* has been confirmed in a German population (Foissner, unpubl.) and is thus a constant character.

Notohymena australis is also easily confused with *Cyrtohymena citrina*, which is very similar in all characters, except for the undulating membrane, which lacks the anteriorly directed hook (Fig. 34). This character, which is rather difficult to recognize, has been confirmed by ontogenetic studies (Voss 1991).

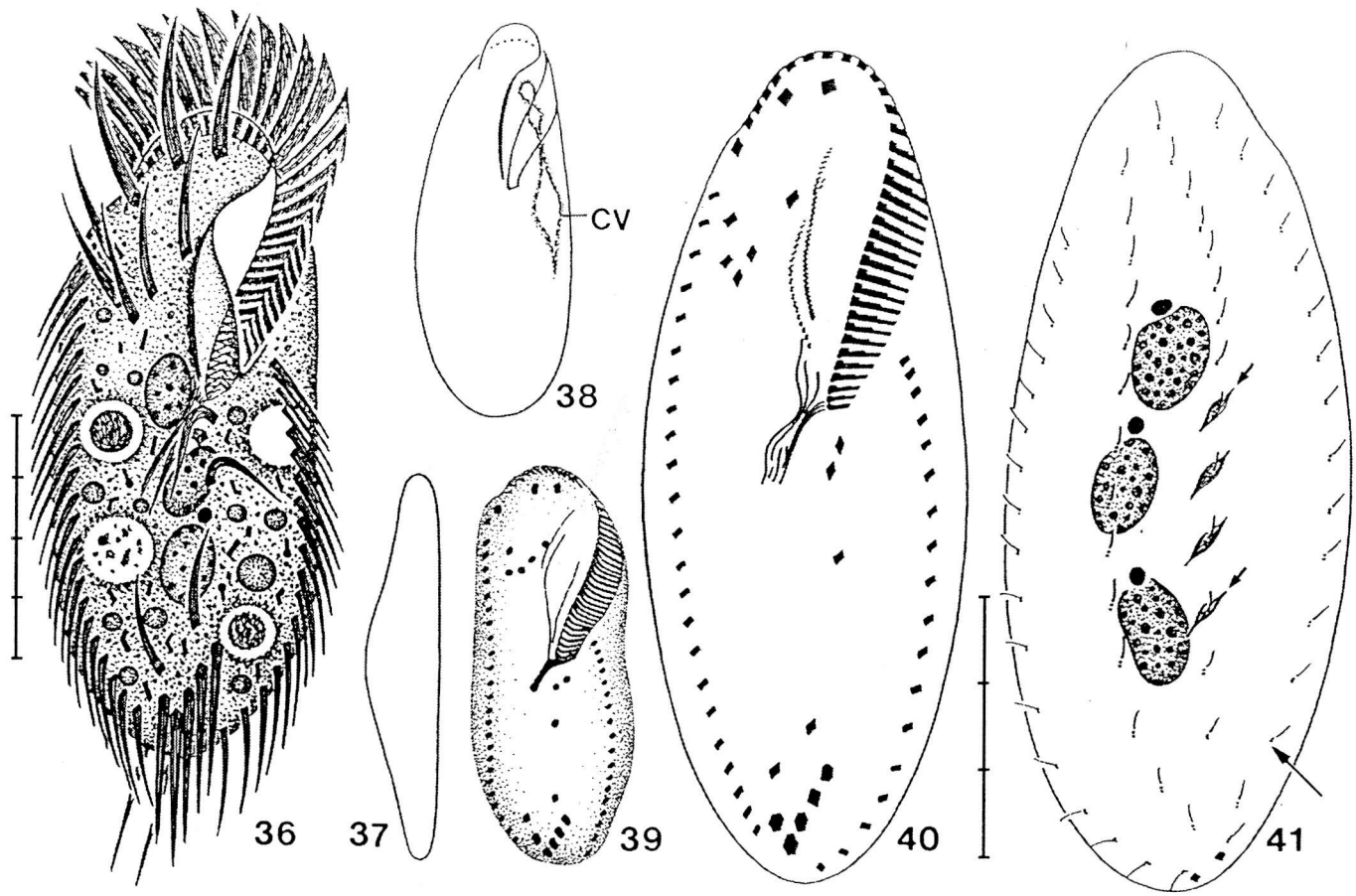
Sterkiella thompsoni sp. n. (Figs. 36-41 , Table 5)

Diagnosis: size *in vivo* about 90-130 x 40-60 µm. Three macronuclear nodules. On average 34 adoral membranelles, 22 right marginal cirri, 17 left marginal cirri, and 5 transverse cirri. Four dorsal kineties with 1 caudal cirrus each associated with kineties 1 and 3.

Type location: *Drepanocladus uncinatus* moss from Signy Island, South Orkney Islands, Antarctica (60°40'S, 45°40'W).

Dedication: named in honour of Jesse C. Thompson Jr. (Roanoke College, Virginia, USA), who provided the first reliable description of this species, but did not establish it as a new taxon because he considered his data as insufficient (see species comparison); an honourable practice which should be applied more often!

Description: usually broadly parallel-sided, rarely slightly bursiform (Fig. 36, 38), anterior end broadly rounded, posterior narrowly rounded and often inconspicuously pointed. Rather rigid like, e. g., *Sterkiella histriomuscorum* and *Stylonychia pustulata*, dorsoven-



Figs. 36-41. *Sterkiella thompsoni* from life (36-38), after wet silver nitrate impregnation (39) and protargol impregnation (40-41). 36-ventral view of typical specimen; 37-38 - lateral and ventral view of oviform specimen; 39 - ventral infraciliature of *Oxytricha* sp. (from Thompson 1972), length about 100µm; 40-41 - infraciliature of ventral and dorsal side. Note that *S. thompsoni* has only three macronuclear nodules, which is its main species character. Fusiform fibre bundles surround dorsal bristles (short arrows). Dorsal kinety 4 is shortened posteriorly (long arrow). CV - contractile vacuole. Scale bar division 10µm

trally flattened up to 2 : 1. Usually 3, very rarely 2 (in 6 out of 120 specimens, Table 5; possibly postdividers) or 4 slightly to distinctly ellipsoidal macronuclear nodules in median of middle third of cell; middle nodule often slightly smaller than anterior and posterior ones. Micronuclei globular, number highly variable, however, most specimens have only one (Table 5). Contractile vacuole in mid-body at left margin, with 2 long collecting canals extending anteriorly and posteriorly, anterior canal often with small dilatations at level of buccal cavity (Fig. 38). Cortex colourless, rigid, without special granules. Cytoplasm colourless, contains many small, yellowish crystals, some 2-6 µm sized, colourless fat globules, and food vacuoles up to 10 µm in diameter. Feeds on bacteria, heterotrophic flagellates, green algae, diatoms and wheat starch. Moves moderately fast, often resting for some time and thus easy to observe.

Anterior frontal cirri, transverse cirri and caudal cirri about 30 µm, other cirri 25 µm long. Marginal rows open at posterior end, gap occupied by caudal cirri right of cell median. Ventral cirral pattern as in other oxytrichids *s. str.* Dorsal cilia *in vivo* about 3 µm long, associated with distinct, oblique fibrillar structures (Fig. 41); arranged in 4 rows which, according to some divisional stages found, originate as follows: row 1 slightly shortened anteriorly and associated with right caudal cirrus; row 2 as long as body; row 3 also extends along whole body length but is associated with left caudal cirrus; row 4 slightly but invariably shortened posteriorly, originates close to right marginal row. Dorsal rows 1-3 simply divide, i.e. none originates by fragmentation as in many other oxytrichids, for instance, *S. histriomuscorum* (Berger et al. 1985).

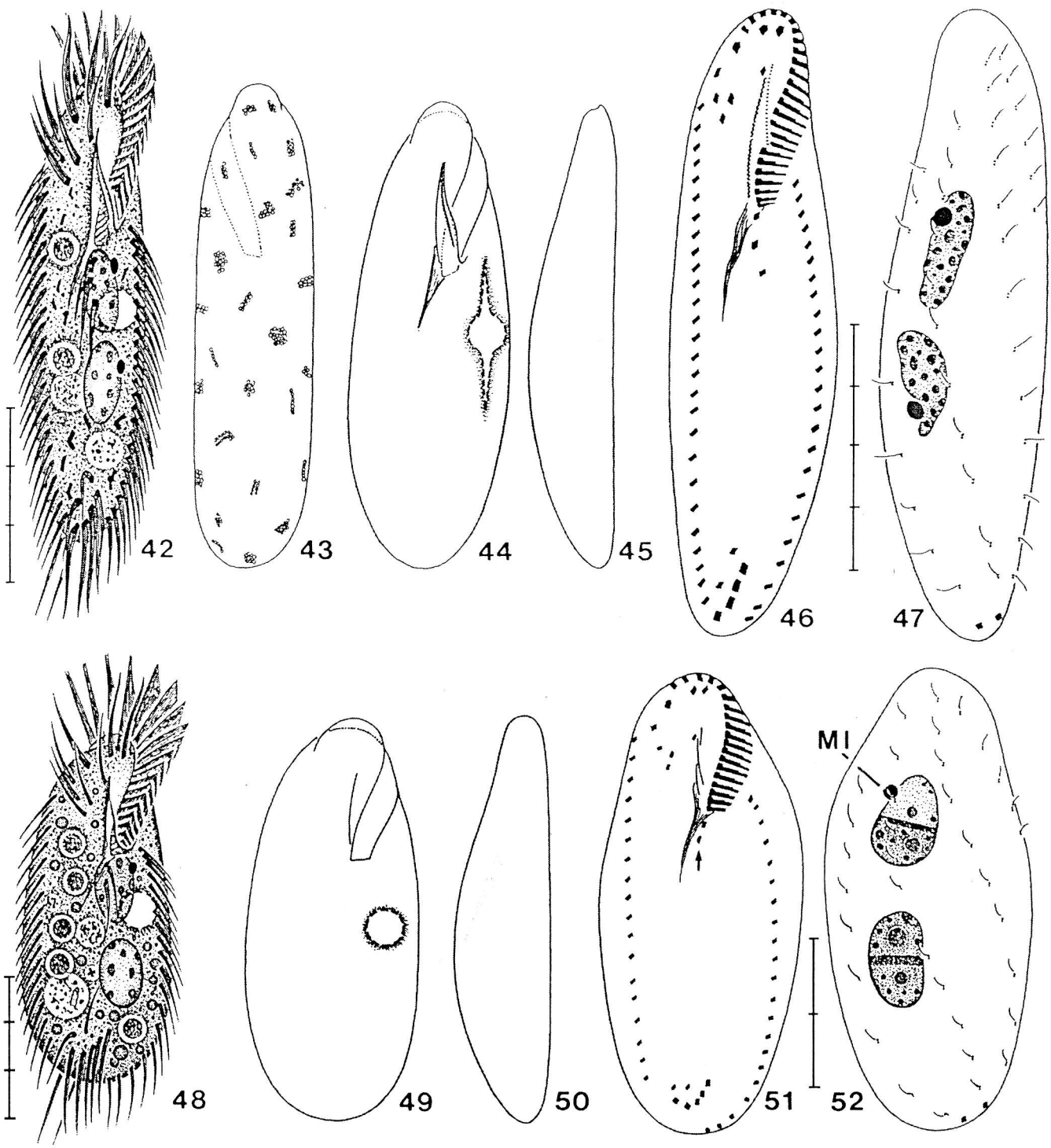
Oral apparatus and adoral zone of membranelles conspicuous, occupy about 42% of body length. Buccal cavity rather large and deep, right margin thickened, possibly by fibres or backwardly directed endoral cilia, right half of cavity covered by hyaline lip. Paroral and endoral membrane slightly curved, inconspicuously to distinctly intersecting optically, both very likely composed of dikinetids. Pharyngeal fibres inconspicuous.

Comparison with related species and generic classification: *Sterkiella thompsoni* differs from its congeners by the unusual number, viz. 3, of macronuclear nodules. All other oxytrichids *s. str.* either have 2, 4 or more nodules. Thus, at first I supposed that *S. thompsoni* could be a teratological population of *S. histriomuscorum* (2 nodules) or *S. cavicola* (4 nodules), especially because some specimens with 2 or 4 macronuclei were found (see description). However, some variability is also apparent in binucleate and quadrinucleate species, when a large number of cells is analysed (Berger and Foissner 1987). Furthermore, the Antarctic population remained constant over 4 weeks and some dividing cells showed that only 3 macronuclear nodules are generated.

Finally, a detailed literature search showed that oxytrichids with 3 macronuclear nodules have been reported several times and, most surprisingly, mainly from Antarctica. Thompson (1972) described and figured (Fig. 39) an *Oxytricha* sp. from a rock pool of the Antarctic Peninsula having the same characteristics as my specimens. Likewise, Sudzuki (1964) mentions an Antarctic *Opisthotricha* with 2-3 macronuclei and a size of 96-120 x 40-80 µm. All these forms are very likely conspecific and *S. thompsoni* is thus obviously widespread in Antarctica.

Seshachar and Kasturi Bai (1963) described an *Oxytricha* sp. from a fish tank in India, which "differs markedly in its nuclear constitution from the other known species of the genus". This still unnamed and very briefly described population has, like *S. thompsoni*, 3 macronuclear nodules propagated through many generations in ordinary laboratory cultures. However, the Indian species is much larger than *S. thompsoni*, viz. 200-450 x 100-150 µm. It is thus very likely that several distinct oxytrichids with 3 macronuclear nodules exist.

The generic classification of *S. thompsoni* is difficult and tentative because it possesses characters of several oxytrichid genera, and *Sterkiella* (formerly *Histriculus*; Foissner et al. 1991) is still vaguely separated from *Stylonychia* and *Oxytricha* (Wirnsberger et al. 1986). However, at least the general appearance, the inflexibility of the body, and the structure of the oral apparatus strongly resemble *S. histriomuscorum* (Foissner 1982, Berger et al. 1985) and *S. cavicola* (Berger and Foissner 1987). On the other hand, the simple dorsal infraciliature of *S. thompsoni* is completely different from that of *Sterkiella* (Berger et al. 1985), *Stylonychia* (Wirnsberger et al. 1986) and *Oxytricha* (Foissner and Adam 1983a), but highly reminiscent of *Urosomoida* (Foissner and Adam 1983b, Ganner et al. 1987) and *Urosoma* (Foissner 1983). Finally, the distinct fibres around the dorsal bristles and the rigidity of the cortex resemble stylonychid oxytrichids and *Stylonychia* which, however, has parallel undulating membranes. To sum up, *S. thompsoni* is a further example of the bewildering and still poorly understood diversity of oxytrichid hypotrichs.



Figs. 42-47. *Urosomoida granulifera* from life (42-45) and after protargol impregnation (46-47). 42 - ventral view of typical specimen; 43 - dorsal view showing cortical granule patches, i. e. the species character; 44-45 - ventral and lateral view of broad specimen; 46-47 - infraciliature of ventral and dorsal side. Scale bar division 10μm

Figs. 48-52. *Urosomoida antarctica* from life (48-50) and after protargol impregnation (51-52). 48 - ventral view of typical specimen; 49-50 - ventral and lateral view of broad specimen; 51-52 - infraciliature of ventral and dorsal side. Note that *U. antarctica* has only two postoral cirri (arrow). MI - micronucleus. Scale bar division 10μm

Urosomoida granulifera sp. n. (Figs. 12, 42-47, Table 6)

Diagnosis: size *in vivo* about 70-100 x 20-30 µm. Cortical granules colourless, about 1 µm in diameter, form small, irregularly arranged patches. On average 23 adoral membranelles, 24 right marginal cirri, 23 left marginal cirri, 4 transverse cirri, and 2 caudal cirri.

Type location: *Drepanocladus uncinatus* moss from Livingstone Island, South Shetland Islands, Antarctica (62°38'S, 61°04'W).

Etymology: *granulifera* (bearing granules) refers to the main species character, viz. the cortical granules.

Description: shape highly variable, slenderly to broadly elliptical or parallel-sided, sometimes slightly fusiform, both ends narrowly to broadly rounded (Figs. 42-44). Flexible like, e. g., *U. agiliformis* and *Oxytricha granulifera*, dorsoventrally flattened up to 2 : 1. Usually 2, very rarely 3 distinctly ellipsoidal macronuclear nodules in middle third of cell to left of midline. Micronuclei ellipsoidal, number highly variable, however, most specimens have 2 (Table 6). Contractile vacuole in mid-body at left margin, with 2 inconspicuous collecting canals extending anteriorly and posteriorly. Cortex colourless, flexible, cortical granules inconspicuous because colourless, minute and sparse, form irregular groups composed of up to 30 granules (Figs. 12, 43). Cytoplasm colourless, contains many small, yellowish crystals. Possibly feeds on bacteria. Movement moderately rapid, scrabbling amongst soil particles.

Anterior frontal cirri, transverse cirri and caudal cirri about 18 µm, other cirri 12 µm long. Marginal rows open at posterior end, gap occupied by posteriormost transverse cirrus and caudal cirri. Ventral and dorsal infraciliature very similar, if not to say identical to that of *U. agiliformis* (cp. Ganner et al. 1987). Dorsal cilia 4 µm long *in vivo*.

Oral apparatus and adoral zone of membranelles also very similar to that of *U. agiliformis*, i.e. inconspicuous, occupy about 34% of body length, bases of largest membranelles *in vivo* about 7 µm wide. Buccal cavity narrow and flat, right half and posterior third of adoral zone covered by hyaline lip. Paroral and endoral membrane almost straight, extend side by side diverging posteriorly. Pharyngeal fibres inconspicuous.

Comparison with related species: the new species is most similar to *U. agiliformis* Foissner, 1982 as concerns size, shape and most morphometric and morphologic characteristics of the infraciliature. However, *U. agiliformis* and other similar oxytrichids discussed by Ganner et al. (1987) lack cortical granules. In this respect, *U. granulifera* resembles *U. agilis* whose granules, however, usually have a yellowish to reddish colour. Furthermore, *U. agilis* has 3 caudal cirri and its posterior portion is always more or less distinctly elongated (Berger and Foissner 1987, Foissner 1982). *Urosomoida minima* Hemberger, 1985 has only 14-15 adoral membranelles and an unusual number, viz. 5, of posterior frontal cirri. *Urosomoida perthensis* Foissner and O'Donoghue, 1990 has 3 caudal cirri and a single micronucleus interposed between the macronuclear nodules.

Urosomoida antarctica sp. n. (Figs. 48-52, Table 6)

Diagnosis: size *in vivo* about 60-75 x 25-35 µm. Two postoral ventral cirri, 2 caudal cirri, 4 dorsal kineties. On average 20 adoral membranelles, 17 right marginal cirri, 19 left marginal cirri, and 5 transverse cirri.

Type location: soil from Garwood Valley, South Victoria Land, Antarctica (about 160°E, 78°S).

Etymology: named after the continent found.

Description: shape broadly elliptical, posteriad usually slightly widened, both ends broadly rounded (Figs. 48, 49). Flexible like, e. g., *Oxytricha granulifera* and *U. granulifera*, and dorsoventrally flattened up to 2 : 1. Macronuclear nodules distinctly ellipsoidal, in middle third of cell to left of midline. Micronuclei slightly ellipsoidal, number rather variable, if only 1 is present it is usually attached to the anterior macronuclear nodule. Contractile vacuole in mid-body near left margin, without distinct collecting canals. Cortex colourless, flexible, without special granules. Cytoplasm colourless, contains many 2-3 µm sized, colourless fat globules, some small vacuoles with yellowish, crystalline content, and many 4-6 µm sized food vacuoles. Feeds on bacteria and, possibly, also on heterotrophic flagellates and small naked amoebae. Moves slowly.

All cirri strikingly thin, anterior frontal cirri, transverse cirri and caudal cirri about 18 µm, other cirri 12 µm long. Marginal rows open widely at posterior end, gap occupied by posteriormost transverse cirri and caudal cirri. Ventral and dorsal infraciliature very similar to that of *U.agiliformis* (cp. Ganner et al. 1987), except for the lacking third postoral cirrus and the normal set of transverse cirri (Fig. 51). Dorsal cilia 3 µm long; kinety 1 shortened anteriorly, kinety 4 terminates pre-equatorially (Fig. 52).

Oral apparatus and adoral zone of membranelles inconspicuous, occupy about 32% of body length, bases of largest membranelles *in vivo* about 6 µm wide.

Table 6. Morphometric data from *Urosomoida granulifera* (upper line) and *U. antarctica* (lower line)*

Character	$\bar{x}$	M	SD	SD $\bar{x}$	CV	Min	Max	n
Body, length	73.9	72.5	9.2	2.7	12.4	59	90	12
	61.6	62.0	5.4	1.5	8.9	52	70	13
Body, width	21.5	21.5	3.1	0.9	14.6	17	29	12
	27.3	28.0	3.3	0.9	12.1	22	33	13
Anterior somatic end to proximal end of adoral zone, distance	24.8	24.5	2.2	0.6	8.7	22	29	12
	19.6	20.0	1.0	0.3	5.3	18	21	13
Distance between macronuclear nodules	2.9	3.0	2.2	0.6	73.8	0	7	12
	5.4	5.0	2.2	0.6	41.2	2	10	13
Macronuclear nodules, length	15.6	15.5	2.5	0.7	16.3	12	20	12
	13.5	13.0	1.6	0.4	11.6	11	17	13
Macronuclear nodules, width	5.7	5.5	0.8	0.2	13.7	5	7	12
	7.6	7.0	1.0	0.3	13.7	6	10	13
Micronuclei, length	3.0	3.0	-	-	-	3	3.5	12
	2.8	2.8	0.3	0.1	11.8	1.8	3	13
Micronuclei, width	2.4	2.2	0.5	0.1	18.7	2	3	12
	2.4	2.5	0.4	0.1	17.3	1.6	2.8	13
Macronuclear nodules, number	2.1	2.0	-	-	-	2	3	12
	2.0	2.0	0	0	0	2	2	13
Micronuclei, number	3.1	2.0	2.1	0.6	67.0	2	8	12
	1.5	1.0	0.7	0.2	45.2	1	3	13
Adoral membranelles, number	23.7	23.0	1.9	0.5	7.9	21	27	12
	19.5	20.0	0.8	0.2	4.0	18	21	13
Right marginal cirri, number	24.1	24.0	3.7	1.1	15.2	16	30	12
	17.0	17.0	1.2	0.3	7.2	14	19	13
Left marginal cirri, number	23.3	23.0	3.2	0.9	13.7	17	29	12
	19.9	19.0	2.1	0.6	10.3	17	24	13
Anterior frontal cirri, number	3.0	3.0	0	0	0	3	3	12
	3.0	3.0	0	0	0	3	3	13
Posterior frontal cirri, number	3.9	4.0	-	-	-	3	4	12
	4.0	4.0	0	0	0	4	4	13
Buccal cirri, number	1.0	1.0	0	0	0	1	1	12
	1.0	1.0	0	0	0	1	1	13
Postoral cirri, number	2.9	3.0	-	-	-	2	3	12
	2.0	2.0	0	0	0	2	2	13
Ventral cirri ahead of transverse cirri, number	2.0	2.0	0	0	0	2	2	12
	2.0	2.0	0	0	0	2	2	13
Transverse cirri, number	3.9	4.0	-	-	-	3	4	12
	5.1	5.0	-	-	-	5	6	13
Caudal cirri, number	2.0	2.0	0	0	0	2	2	12
	2.0	2.0	0	0	0	2	2	13
Dorsal kineties, number	4.0	4.0	0	0	0	4	4	12
	4.0	4.0	0	0	0	4	4	13

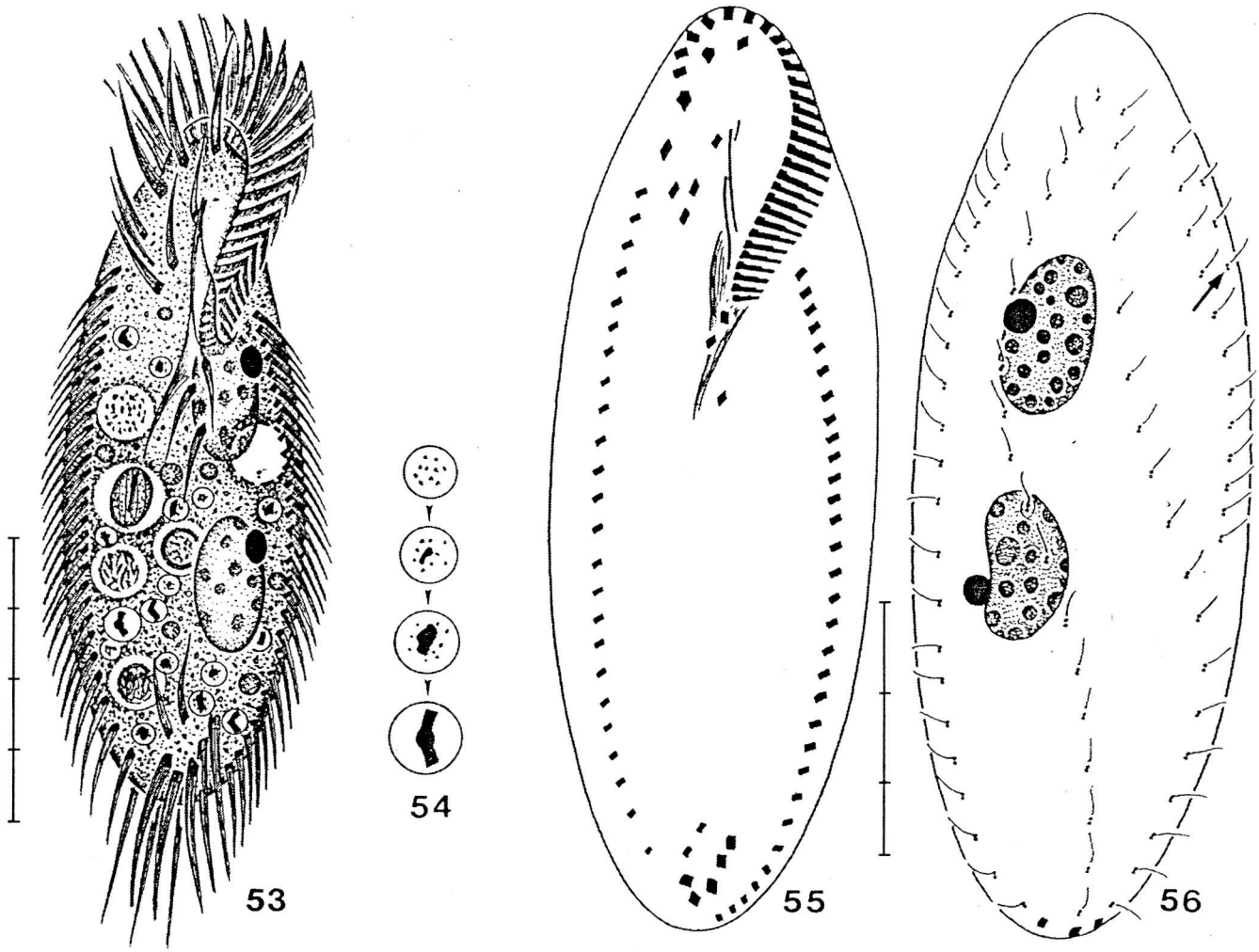
* Data based on protargol-impregnated and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD $\bar{x}$ - standard deviation of mean, $\bar{x}$ - arithmetic mean

Buccal cavity narrow and flat. Paroral and endoral membrane almost straight, slightly intersecting optically. Pharyngeal fibres inconspicuous.

Comparison with related species: the generic classification of *U. antarctica* is uncertain and requires ontogenetic data. The arrangement of the undulating membranes and the full set of transverse cirri indicate that it might belong to *Oxytricha*, whereas the reduced number of postoral and caudal cirri and the simple dorsal infraciliature resemble *Urosomoida*. In any case, this species has a unique combination of characters (see diagnosis) not found in any other known species.

Oxytricha lanceolata Shibuya, 1930 (Figs. 53-56, Table 7)

This species is well-known (Berger and Foissner 1987, 1989) and mentioned in some detail only because it is one of the many examples that geographically widely distant ciliate populations are often sur-



Figs. 53-56. *Oxytricha lanceolata* from life (53-54) and after protargol impregnation (55-56). 53 - ventral view of typical specimen; 54 - development of cytoplasmic crystals; 55-56 - infraciliature of ventral and dorsal side. Arrow marks a short, fifth dorsal kinety found in few specimens. Scale bar division 10 µm

prisingly similar. This is sustained by recent molecular biological data (Bowers and Pratt 1995). The Antarctic population of *O. lanceolata* is morphologically and morphometrically inseparable from the European populations. The median values of the main characters (see below) match exactly (Table 7).

Taking the 3 populations investigated so far, *O. lanceolata* can be characterized as follows: length *in vivo* 80-120 µm (75-110 µm in protargol slides), 2 macronuclear nodules, 2 micronuclei, 23-30 (M = 27-28) adoral membranelles, 25-33 (M = 28-29) right marginal cirri, 25-35 (M = 31-32) left marginal cirri, 5 transverse cirri, 3 caudal cirri, 4 dorsal kineties. The most important character, as compared with the typical oxytrichid ventral cirral pattern and number, is the reduced number of dorsal kineties with kinety 4 distinctly shortened posteriorly. Furthermore, all populations lack special cortical granules, which greatly facilitates *in vivo* separation from an other frequent and rather similar soil species, viz. *O. granulifera*.

Paruroleptus notabilis Foissner, 1982 (Figs. 57-63, Table 8)

Description of Antarctic population: size *in vivo* 90-140 x 15-20 µm. Slenderly ellipsoid to slightly sigmoidal and/or pisciform, i.e. rather distinctly narrowed posteriorly (Figs. 57, 59). Very flexible and dorsoventrally inconspicuously to distinctly (up to 2 : 1)

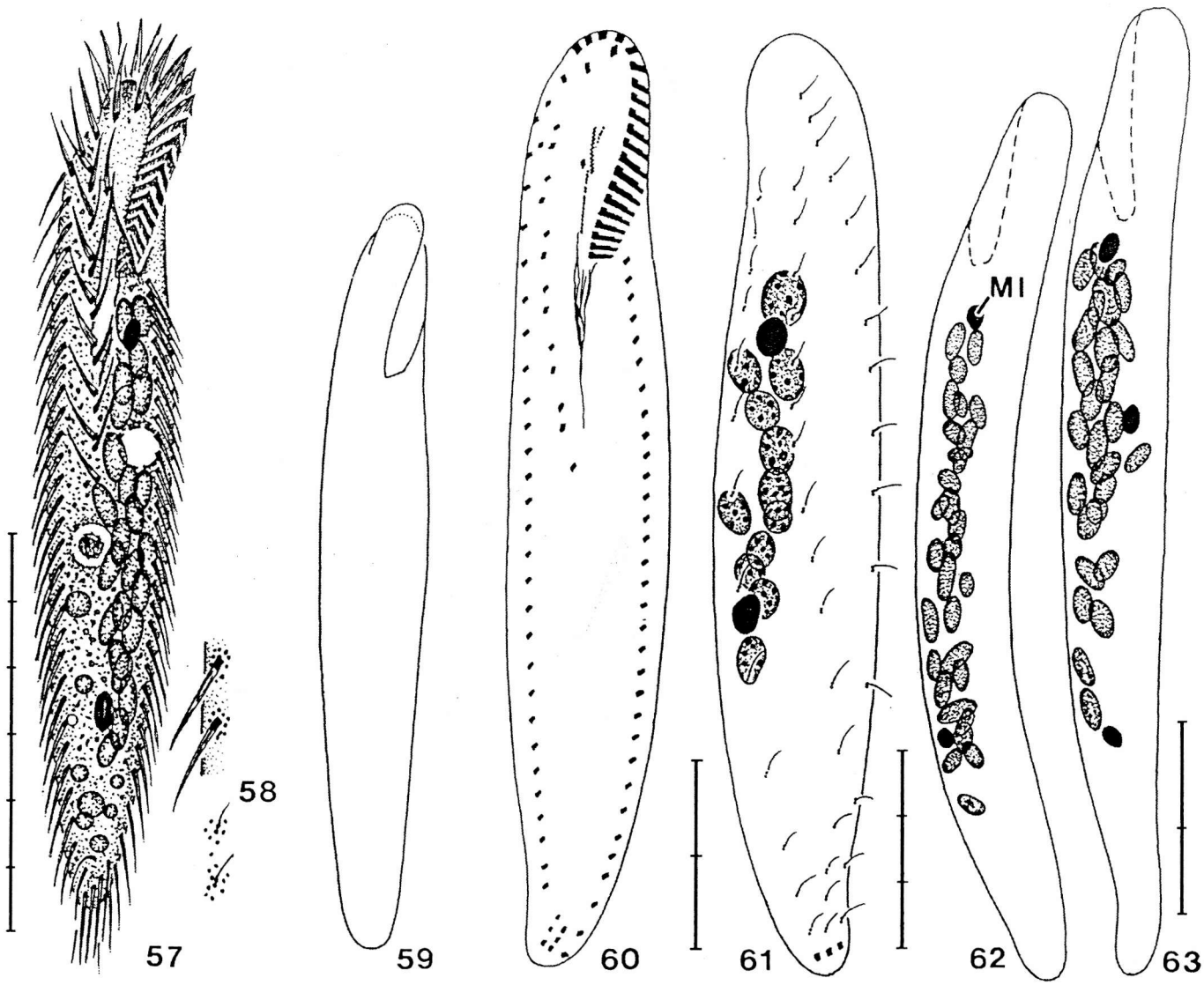
Table 7. Morphometric data from *Oxytricha lanceolata*. Upper line: Antarctic population; middle line: Austrian population (from Berger and Foissner 1987); lower line: population from Madeira, Portugal (from Berger and Foissner 1989)*

Character	$\bar{x}$	M	SD	SD $\bar{x}$	CV	Min	Max	n
Body, length	93.5	91.0	7.1	2.2	7.6	87	110	11
	87.9	89.5	7.3	2.1	8.3	75	100	12
	94.5	96.0	12.2	3.8	12.9	70	108	10
Body, width	34.9	34.0	4.8	1.5	13.8	28	46	11
	30.8	30.0	3.5	1.0	11.4	27	39	12
	34.2	34.5	3.4	1.1	10.0	29	42	10
Anterior somatic end to proximal end of adoral zone, distance	29.4	29.0	1.4	0.4	4.6	27	32	11
	27.5	27.5	1.1	0.3	3.9	25	29	12
	30.1	31.5	3.5	1.1	11.6	24	34	10
Distance between macronuclear nodules	4.5	4.0	1.5	0.5	33.2	2	7	11
	3.9	3.0	3.0	0.9	77.3	1	12	12
	8.5	10.0	2.7	0.7	32.0	3	11	10
Macronuclear nodules, length	16.5	16.0	2.3	0.7	14.2	13	20	11
	15.3	14.5	2.3	0.7	14.9	13	21	12
	13.9	14.5	1.6	0.5	11.5	10	15	10
Macronuclear nodules, width	9.0	9.0	1.3	0.4	14.9	7	11	11
	7.8	7.0	1.1	0.3	13.6	7	10	12
	6.9	7.0	0.9	0.3	12.7	5	8	10
Micronuclei, length	4.0	4.0	0.3	0.1	7.6	3.5	4.5	11
	2.8	2.8	0.2	0.1	5.7	2.5	3	12
	2.8	2.8	0.1	0.1	2.2	2.8	3	10
Micronuclei, width	3.7	3.5	0.2	0.1	6.7	3.5	4.2	11
	2.7	2.7	0.1	0.1	5.3	2.5	3	12
	2.6	2.6	0.2	0.1	6.0	2.4	2.8	10
Macronuclear nodules, number	2.0	2.0	0	0	0	2	2	11
	2.0	2.0	0	0	0	2	2	12
	2.0	2.0	0	0	0	2	2	10
Micronuclei, number	2.0	2.0	0	0	0	2	2	11
	2.1	2.0	0.7	0.2	32.1	1	3	12
	1.8	2.0	0.6	0.2	35.1	1	3	10
Adoral membranelles, number	27.9	28.0	1.4	0.4	5.2	26	30	11
	26.5	27.0	1.5	0.4	5.5	23	28	12
	27.6	28.0	0.8	0.3	3.1	26	29	10
Right marginal cirri, number	28.8	29.0	2.2	0.7	7.6	25	33	11
	28.4	29.0	2.0	0.6	7.1	25	32	12
	28.5	28.0	1.9	0.6	6.7	26	32	10
Left marginal cirri, number	30.0	31.0	2.6	0.8	8.8	25	34	11
	31.4	31.5	2.6	0.8	8.4	27	35	12
	31.7	32.0	3.6	1.1	11.3	25	36	10
Anterior frontal cirri, number	3.0	3.0	0	0	0	3	3	11
	3.0	3.0	0	0	0	3	3	12
	3.0	3.0	0	0	0	3	3	10
Posterior frontal cirri, number	4.6	4.0	1.0	0.3	22.1	4	7	11
	4.0	4.0	0.4	0.1	10.7	3	5	12
	4.0	4.0	0	0	0	4	4	10
Buccal cirri, number	1.0	1.0	0	0	0	1	1	11
	1.0	1.0	0	0	0	1	1	12
	1.0	1.0	0	0	0	1	1	10
Postoral cirri, number	3.0	3.0	0	0	0	3	3	11
	3.0	3.0	0	0	0	3	3	12
	3.0	3.0	0	0	0	3	3	10
Ventral cirri ahead of transverse cirri, number	2.1	2.0	-	-	-	2	3	11
	2.0	2.0	0	0	0	2	2	12
	2.0	2.0	0	0	0	2	2	10
Transverse cirri, number	5.2	5.0	-	-	-	5	6	11
	5.1	5.0	-	-	-	5	6	12
	5.0	5.0	0	0	0	5	5	10
Caudal cirri, number	3.0	3.0	0	0	0	3	3	11
	3.6	3.0	1.3	0.4	36.6	2	6	12
	3.0	3.0	0	0	0	3	3	10

Table 8.(con)

Dorsal kineties, number	4.1	4.0	-	-	-	4	5	11
	4.0	4.0	0	0	0	4	4	12
	4.0	4.0	0	0	0	4	4	10

*Data based on protargol-impregnated and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD $\bar{x}$ - standard deviation of mean, $\bar{x}$ - arithmetic mean



Figs. 57-63. *Paruroleptus notabilis* from life (57-59) and after protargol impregnation (60-63). 57-59 - ventral views of typical specimens; 58 - cortical granulation around cirri and dorsal bristles; 60-61 - infraciliature of ventral and dorsal side of specimen with few macronuclear nodules; 62-63 - variability of nuclear apparatus. MI - micronucleus. Scale bar division 10µm

flattened. Macronuclear nodules globular to ellipsoidal, arranged in 2-3 loose rows mainly in left half of cell (Figs. 61-63). Micronuclei conspicuous because compact and large, *in vivo* up to 7 x 3 µm, usually 1 each near end of macronuclear chain, stain weakly with protargol. Contractile vacuole slightly above mid-body. Cortex flexible, contains tiny (diameter < 0.5 µm), colourless granules mainly around cirral bases and dorsal bristles. Cytoplasm colourless, without crystalline inclusions, posterior portion usually filled with 2-5 µm sized, colourless fat globules. Glides and swims rather slowly.

Somatic and oral infraciliature as described in the other populations, differing mainly in some morphometric characteristics (Table 8). Transverse and caudal cirri distinct; 1 isolated cirrus at end of midventral row (n = 10). Oral apparatus inconspicuous, adoral zone of membranelles occupies only about 24% of body length, bases of largest membranelles 6 µm wide *in vivo*. Buccal cavity narrow and flat, almost entirely covered by very hyaline lip. Paroral and endoral membrane slightly curved, intersect optically, paroral conspicuously short, i.e. about half the length of endoral (Fig. 60). Pharyngeal fibres conspicuous but not surrounded by special structures as in Austrian and Australian populations.

Comparison with other populations (Table 8): as Blatterer and Foissner (1988) mentioned, *P. notabilis* is a difficult species. As yet, four populations have been studied (Table 8). All differ in some important details. The Antarctic specimens resemble the German population best, especially in the inconspicuous cortical granules. However, they have slightly more adoral membranelles, a distinctly higher number of marginal cirri, and fewer macronuclear nodules and dorsal kineties. Furthermore, the macronuclear nodules are more regularly arranged than in the other populations in which they are irregularly distributed. Similar differences are found also between the other populations. Thus, it seems reasonable to consider all populations as conspecific, at least at the present state of knowledge.

Table 8. Morphometric data from *Paruroleptus notabilis*. 1st line: Antarctic population; 2nd line: Australian population (from Blatterer and Foissner 1988); 3rd line: German population (from Berger and Foissner 1987); 4th line: Austrian type population (from Foissner 1982)*

Character	$\bar{x}$	M	SD	SD $\bar{x}$	CV	Min	Max	n
Body, length	103.5	101.5	11.4	3.6	11.0	87	130	10
	158.8	153.0	21.8	6.6	13.7	136	198	11
	93.6	94.0	11.2	3.4	11.9	74	110	11
	163.3	-	-	-	-	150	180	3
Body, width	14.9	15.0	1.4	0.5	9.7	13	17	10
	36.5	38.0	6.9	2.1	18.8	23	46	11
	16.5	15.0	3.9	1.2	23.3	13	25	11
	17.3	-	-	-	-	13	20	3
Anterior somatic end to proximal end of adoral zone, distance	23.8	24.0	2.0	0.6	8.4	20	26	10
	40.4	41.0	4.1	1.2	10.1	35	47	11
	21.2	21.0	2.3	0.7	10.9	18	27	11
	32.7	-	-	-	-	32	33	3
Anterior somatic end to proximal end of midventral row, distance	54.7	54.0	8.0	2.5	14.6	42	71	10
	80.2	83.0	9.3	2.8	11.6	67	95	11
	32.5	32.0	4.3	1.3	13.3	25	39	11
	74.0	-	-	-	-	67	81	2
Macronuclear nodules, length	5.0	5.0	1.3	0.4	24.9	3.5	7	10
	5.0	4.6	1.9	0.6	37.8	3	7.6	11
	4.9	5.0	1.0	0.3	20.4	3	6	10
	5.0	-	-	-	-	3.9	6	3
Macronuclear nodules, width	2.9	3.0	0.2	0.1	7.3	2.5	3	10
	3.1	3.0	0.2	0.1	6.5	2.8	3.5	11
	2.7	2.9	0.4	0.1	14.6	2	3	10
	2.2	-	-	-	-	1.7	2.7	3
Micronuclei, length	3.5	3.5	0.5	0.2	15.1	3	4	10
	4.0	3.9	0.9	0.3	23.0	2.8	6	11
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Micronuclei, width	2.8	3.0	0.3	0.1	11.8	2	3	10
	2.4	2.3	0.6	0.2	27.2	1.5	3.2	11
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Table 8.(con.)

Macronuclear nodules, number	23.4	24.5	5.5	1.7	23.3	12	30	10
	55.5	55.0	6.9	2.1	12.5	47	69	11
	30.6	31.0	3.1	0.9	10.2	25	35	11
	about 70							3
Micronuclei, number	2.4	2.5	0.7	0.2	29.1	1	3	10
	2.2	2.0	0.8	0.2	34.4	1	4	11
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Adoral membranelles, number	21.3	21.5	1.6	0.5	7.4	19	23	10
	31.6	31.0	3.2	1.0	10.0	26	36	11
	16.7	17.0	0.7	0.2	3.9	16	18	11
	29.7	-	-	-	-	28	35	3
Right marginal cirri, number	30.5	30.0	4.4	1.4	14.4	24	39	10
	33.5	33.0	3.7	1.1	11.0	28	41	11
	22.5	23.0	2.2	0.7	9.6	18	25	11
	36.3	-	-	-	-	32	42	3
Left marginal cirri, number	30.1	31.0	4.7	1.5	15.7	22	38	10
	39.5	39.0	6.4	1.9	16.3	32	55	11
	24.0	24.0	1.3	0.4	5.3	22	27	11
	39.5	-	-	-	-	32	45	4
Midventral pairs, number	8.0	8.0	1.2	0.4	14.4	6	10	10
	9.5	9.0	-	-	-	7	13	11
	6.5	6.0	-	-	-	4	7	11
	10.0	-	-	-	-	9	10	2
Anterior frontal cirri, number	3.0	3.0	0	0	0	3	3	10
	3.0	3.0	-	-	-	2	4	11
	3.0	3.0	0	0	0	3	3	11
	3.0	-	-	-	-	3	3	3
Frontoterminal cirri, number	2.0	2.0	0	0	0	2	2	10
	2.0	2.0	0	0	0	2	2	11
	2.0	2.0	0	0	0	2	2	11
	2.0	-	-	-	-	2	2	3
Buccal cirri, number	1.0	1.0	0	0	0	1	1	10
	1.0	1.0	0	0	0	1	1	11
	1.0	1.0	0	0	0	1	1	11
	1.0	-	-	-	-	1	1	3
Ventral cirri ahead of transverse cirri, number	1.6	1.5	0.7	0.2	43.7	1	3	10
	1.8	2.0	0.5	0.1	25.8	1	2	12
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Transverse cirri, number	4.1	4.0	0.7	0.2	18.0	3	5	10
	2.9	3.0	0.9	0.2	29.5	1	4	11
	1.7	2.0	0.7	0.2	37.4	0	2	11
	4.2	-	-	-	-	2	6	5
Caudal cirri, number	3.1	3.0	-	-	-	3	4	10
	3.0	3.0	0	0	0	3	3	11
	2.3	2.0	0.7	0.2	28.5	1	3	11
	3.0	-	-	-	-	2	4	3
Dorsal kineties, number	3.0	3.0	0	0	0	3	3	3
	4.0	4.0	0	0	0	4	4	11
	4.0	4.0	0	0	0	4	4	11
	3.0	-	-	-	-	3	3	3

*Data based on protargol-impregnated and mounted specimens from field. Measurements in µm. Abbreviations: CV - coefficient of variation in %, M - median, Max - maximum, Min - minimum, n - number of individuals investigated, SD - standard deviation, SD $\bar{x}$ - standard deviation of mean, $\bar{x}$ - arithmetic mean

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