Invertebr. Taxon., 1990, **3**, 661–96

Morphology and Infraciliature of Some Freshwater Ciliates (Protozoa: Ciliophora) from Western and South Australia

W. Foissner[A] *and P. J. O'Donoghue*[B]

[A] Institut für Zoologie, Universität Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria.
[B] Central Veterinary Laboratories, Department of Agriculture, Frome Road, Adelaide, S.A. 5000, Australia.

Abstract

Thirteen new or little-known freshwater ciliates from Perth, W.A., and Adelaide, S.A., are described: *Urotricha furcata* Schewiakoff, 1892; *Coleps amphacanthus* Ehrenberg, 1833; *Fuscheria nodosa* Foissner, 1983; *Lacrymaria australis*, sp. nov.; *Acineria uncinata* Tucolesco, 1962; *Litonotus lamella* (Müller, 1773); *Loxophyllum australe*, sp. nov.; *Naxella australis*, sp. nov.; *Microthorax australis*, sp. nov.; *Blepharisma americanum* (Suzuki, 1954); *Stenosemella lacustris*, sp. nov.; *Oxytricha australis*, sp. nov.; and *Urosomoida perthensis*, sp. nov. Descriptions are based on live observations, protargol and silver nitrate stained specimens and biometry. All species represent new records for the fauna of Australia. A new species, *Naxella faurei*, sp. nov., is established for *Nassula lateritia* Fauré-Fremiet, 1967 and a new diagnosis is given for *Litonotus lamella* (Müller, 1773).

Introduction

Information on the taxa of ciliated protozoa occurring in Australia is sparse and fragmentary and few studies have been conducted using modern taxonomic techniques such as silver staining and biometry. Early studies are based almost exclusively on live observations and the descriptions of species, when given, have varied in detail. Previous descriptions of ciliates in Australia have included five species of folliculinids (Andrews 1950), 14 species of *Lagenophrys* found on Parastacidae (Kane 1965) and, more recently, 14 species of ciliates described from a hypersaline lagoon (>12%) in Western Australia (Post *et al.* 1983). Similar studies have also recorded various ciliate taxa in neighbouring New Zealand (e.g. Maskell 1886, 1887; Bary 1950; Stout 1984). Unfortunately, closely related species (or even genera) can sometimes not be differentiated with certainty using characters obtained by live observation alone (Foissner 1987*a*). A range of taxonomic errors may therefore occur in many early lists of protozoan fauna.

The lack of knowledge about ciliates in Australia is regrettable and somewhat astonishing because studies on the fauna of such an ancient and isolated continent present an ideal opportunity to examine closely the biogeography and speciation of these organisms. Comprehensive studies recently performed in Africa revealed the existence of many new endemic species (Dragesco and Dragesco-Kerneis 1986) and similar results could be expected in Australia. Only recently, two new species of *Tetrahymena*, originally thought to belong to *T. pyriformis*, were described from material collected in Australia by Elliot (Nanney and McCoy 1976). Another productive area of research may include studies on soil ciliates because the examination of only a few samples by Niessen (1984) and ourselves (unpublished) resulted in the detection of many new species and genera.

0818-0164/90/060661$03.00

Modern taxonomic studies on the protozoan fauna of Australia have only recently commenced and it is of prime importance that such studies be continued to determine species (endemic and cosmopolitan) before they can be effectively incorporated into ecological or environmental impact studies. The present investigation is the first report on an Australian Biological Resources Study project concentrating on the taxonomy of freshwater free-living protozoa in Australia. A total of 13 new or little-known species of freshwater ciliates are described from Western and South Australia. All species are new records for the fauna of Australia.

Materials and Methods

Material was collected from two areas of Australia on two occasions. The majority of water and mud samples were collected by Professor Grell (Tübingen University) in 1984 from heavily vegetated standing waters and ponds in the metropolitan area of Perth, W.A. Precise details of the collection sites were not recorded. The samples were mainly small and contained few individuals when examined 12 weeks after collection. The samples were therefore transferred to petri dishes and filled to approximately 20 mL with mineral water (Volvic, France). A sterilised cracked grain of wheat and one of rice was added to each culture to provide nutrients for bacteria and flagellates which serve as food sources for many ciliates. Heavy concentrations of ciliates were observed in many cultures about 14 days later. The remainder of the material examined was collected from small dams, reservoirs and rivers in the Mount Lofty Ranges near Adelaide, S.A., in February 1987. Large populations of ciliates were detected in the samples so culturing was not deemed necessary. The type localities of the individual species are given with their descriptions.

Ciliate infraciliature and their silverline systems were stained by protargol impregnation according to Foissner (1982), Chatton–Lwoff silver impregnation according to Corliss (1953) and dry silver impregnation according to Foissner (1976). The ciliates were also subject to supravital staining with methyl green–pyronin to determine general cytological features as well as to locate extrusomes (Foissner 1979). Body shape was drawn from microscopic observations on live ciliates examined without coverslips. Fine details were then determined by examination under oil immersion after a coverslip had been applied and the ciliate lightly or heavily squashed. All drawings of silver impregnated material were made with a drawing tube and the key morphological features were stylised as little as possible.

The methods used for biometric characterisation, scanning electron microscopy and the construction of the kinety diagram for *Stenosemella* are described in detail by Foissner (1982), Berger *et al.* (1984), Schönborn *et al.* (1983), and Foissner and Wilbert (1979). In the accompanying tables, the following abbreviations are used: $\bar{x}$, arithmetic mean; M, median; SD, standard deviation; CV, coefficient of variation; Min, minimum; Max, maximum; n, number of individuals examined.

A single holotype preparation of each new species is deposited in the South Australian Museum (accession numbers E2004–E2010) whereas paratypes and neotypes of the other species are deposited in the 'Sammlung der mikroskopischen Präparate' in the Oberösterreichischen Landesmuseums in Linz.

Table 1. Biometric characterisation of *Urotricha furcata*

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	16·5	16·5	2·0	12·0	14	20	12
Body, width	12·6	12·5	1·3	10·4	11	15	12
Macronuclei, No.	1·0	1·0	–	–	1	1	12
Macronucleus, length	5·7	6·0	0·8	13·1	4	7	12
Macronucleus, width	3·8	4·0	0·8	21·8	3	5	12
Micronuclei, No.	1·0	1·0	–	–	1	1	8
Micronucleus, length of longest axis	1·6	1·6	0·2	15·7	1·4	2	8
Somatic kineties, No.	22·7	22·5	0·8	3·4	22	24	12
Somatic kinety, length	12·8	13·0	1·4	10·9	11	15	12
Somatic kinety, No. of basal bodies (without circumoral basal bodies)	16·6	16·5	2·0	12·2	13	21	12
Caudal cilia, No.	2·0	2·0	–	–	2	2	12
Circumoral basal body pairs, No.	11·3	11·0	0·5	4·3	11	12	12
Diameter of rhabdos at entrance	3·5	3·5	0·5	14·9	3	4	12

Description of Species

Order **PROSTOMATIDA** Schewiakoff

Family **PLAGIOCAMPIDAE** Kahl

Genus ***Urotricha*** Claparède & Lachmann

Urotricha furcata Schewiakoff, 1892

(Figs 1*a–d*; Table 1)

This species was originally found by Schewiakoff (1892, 1893) in a crater lake on the island of Oahu (Sandwich Islands) in mud between algae. Our population was obtained from a small pond in the metropolitan area of Perth, W.A. This species is characterised by the occurrence of two caudal cilia and a small mouth opening. A similar species is *U. macrostoma* Foissner, 1983 which also has two caudal cilia but the mouth opening is larger and the brush consists of three ciliary rows. Because the morphological characters determined by live observation are consistent with those reported by Schewiakoff (1892, 1893), only the infraciliature is described below.

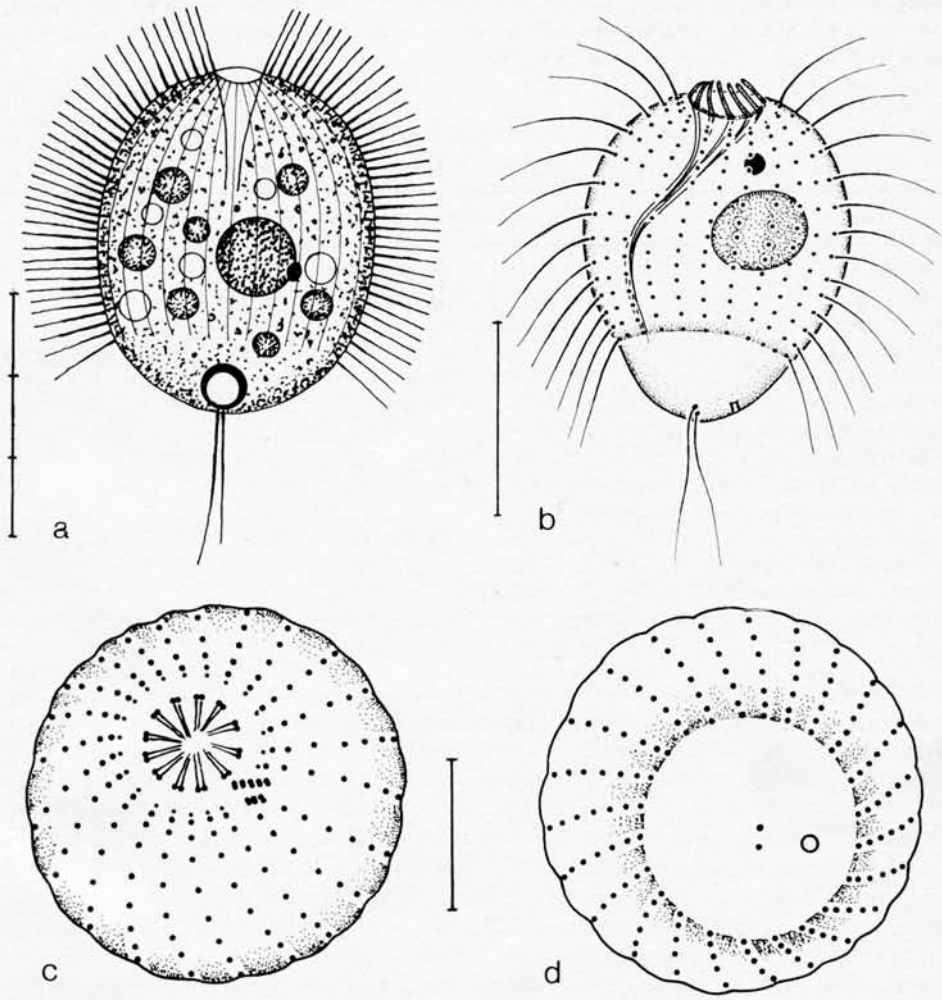


Fig. 1. *Urotricha furcata* following (*a*) live observation and (*b–d*) protargol-impregnation: *a*, lateral view (after Schewiakoff 1893); *b*, infraciliature, lateral view; *c*, infraciliature, oral area; *d*, infraciliature, aboral pole. Scale bar divisions, 10 μm.

Description

Somatic kineties longitudinal, terminating in posterior third of body. Anterior kinetid of each kinety associated with two different-sized argentophilic granules, only the larger posterior granule carrying a cilium. Two caudal cilia, centrally-located at posterior pole. Excretion pore of contractile vacuole near centre of posterior pole. Mouth surrounded by 11–12 dikinetids, each associated with a single valve (2–3 μm long) and long nematodesma which extend to the posterior third of the body forming the cytopharynx. Brosse composed of two kineties, anterior row with four to five dikinetids, posterior row with three dikinetids.

Family **COLEPIDAE** Ehrenberg

Genus *Coleps* Nitzsch

Coleps amphacanthus Ehrenberg, 1833

(Figs 2*a–d*; Table 2)

Our observations on live material coincide precisely with those of Ehrenberg (1833, 1838), Noland (1925) and Kahl (1930). The species is easily recognised owing to its large size, the three to four prominent posterior thorns and the many long caudal cilia. The Australian population examined originated from a small farm dam 1 km east of the Barossa Reservoir in South Australia. *C. amphacanthus* has not previously been described following silver impregnation and is therefore redescribed below.

Table 2. Biometric characterisation of *Coleps amphacanthus*

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	59·5	59·5	2·2	3·7	56	63	10
Body, width	33·5	31·5	4·2	12·7	28	41	10
Macronuclei, No.	1·0	1·0	–	–	1	1	10
Macronucleus, length	12·3	12·5	2·1	17·2	9	16	10
Macronucleus, width	9·6	9·5	1·0	10·1	8	11	10
Micronuclei, No.	1·0	1·0	–	–	1	1	7
Micronucleus, length of longest axis	2·6	2·5	0·2	6·1	2·5	2·8	7
Somatic kineties, No.	26·3	27·0	2·4	9·0	22	28	10
Somatic kinety, No. of basal bodies (without circumoral basal bodies and pectinelles)	17·5	18·5	2·3	13·3	14	21	10
Pectinelles, No. of basal body pairs	2·0	2·0	–	–	2	2	6
Circumoral basal body pairs, No.	26·3	27·0	2·4	9·0	22	28	10

Description

Size *in vivo* approximately 80×40 μm. Definite barrel shaped, typically asymmetrical, some plump symmetrical individuals observed. Number of windows in pellicular plates and number of basal bodies in somatic kineties very variable as indicated by high coefficient of variation (Table 2). Number of windows in three live individuals as follows: anterior and posterior side-plates ('nebenplatten') each with three windows, anterior mid-plate with seven or eight windows, posterior mid-plate with five or six windows. Plate structure the same as in *C. hirtus* (cf. Foissner 1984*a*). Anterior side-plates with three or four short thorns, anal-plates mostly with three but sometimes with four or five large thorns which are loosely arranged in a row. Circumoral plates with 5 μm long tooth-like continuations, which are highly motile when swimming. Continuations more conspicuous than those of *C. hirtus*, as also observed by Ehrenberg (1833, 1838). Mouth opening large, surrounded by loose arrangement of nematodesma and many long extrusomes (about 15 μm long). Mouth opening compression (first described by Noland 1925 and Kahl 1930) not recognised by us in live individuals and not as strongly marked in silver-impregnated material than in other

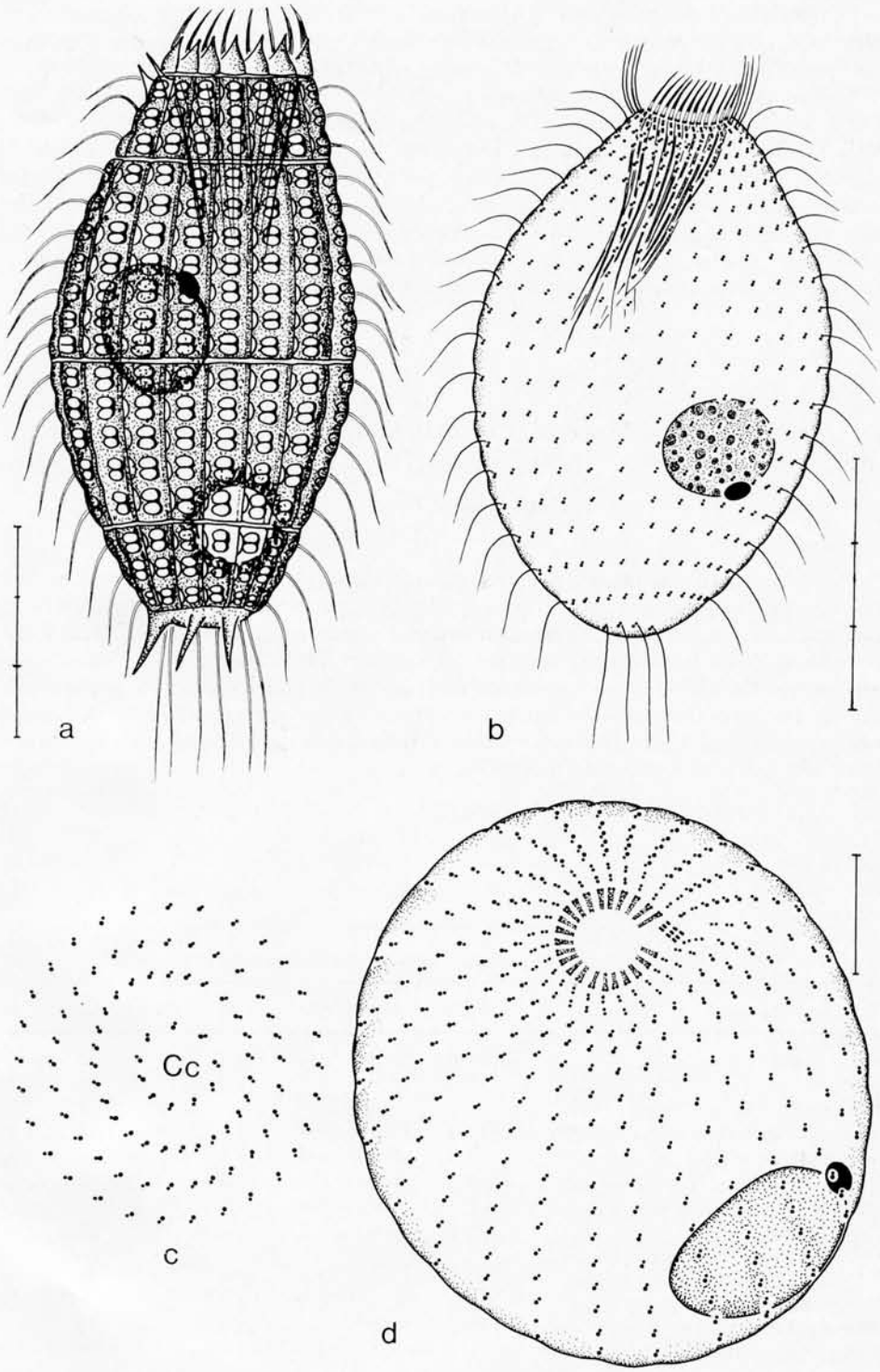


Fig. 2. *Coleps amphacanthus* following (*a*) live observation and (*b–d*) protargol-impregnation: *a*, lateral view; *b*, infraciliature, lateral view; *c*, infraciliature, aboral pole (Cc, caudal cilia); *d*, infraciliature, oral area. Scale bar divisions, 10 μm.

Coleps spp. (cf. Foissner 1984*a*), i.e., very small or almost absent. Macronucleus and micronucleus spherical to ellipsoidal. Contractile vacuole subterminal. About ten 20 μm long caudal cilia at posterior pole in wreath-like arrangement. Endoplasm colourless, with large food vacuoles containing ciliates (*Vorticella* sp., *Chilodonella uncinata*), flagellates and cyanobacteria (*Oscillatoria* sp.). Movement rapid, boring.

Somatic kineties longitudinal, composed 14–21 basal bodies (excluding pectinelles), each next to a somewhat larger argentophilic body (parasomal sac?). Four anterior basal bodies of each kinety arranged in pairs to form pectinelles. Basal body pairs perpendicular to pectinelles build a circumoral kinety, from which long and slightly irregularly-arranged nematodesma extend inwards and 7 μm long flame-like structures project outwards. Distal ends of 'flames' argentophilic. They are probably oral valves filled with extrusomes (cf. *Chilophrya terricola* description by Foissner 1984*a*). Brosse interrupts circumoral kinety, composed of three rows, each containing three dikinetids.

Family **ENCHELYIDAE** Ehrenberg

Genus ***Fuscheria*** Foissner

Fuscheria nodosa Foissner, 1983

(Figs 3*a–d*; Table 3)

The discovery of this species in a small pond in metropolitan Perth was surprising as it has only previously been described from a small puddle in the Austrian Alps (Foissner 1983). The clarity of our protargol-impregnated material demonstrated that Foissner (1983) had overlooked several features relating to the infraciliature. These features were evident in the original type material upon re-examination even though the preparations were not as clearly stained. The general organisation of the species, the nuclear apparatus and the extrusomes were consistent with the original descriptions, therefore only the infraciliature is redescribed below together with a new biometric characterisation.

Table 3. Biometric characterisation of *Fuscheria nodosa*

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	39·0	38·0	3·4	8·7	35	46	10
Body, width	22·7	23·0	2·5	11·2	18	26	10
Macronuclei, No.	1·0	1·0	–	–	1	1	10
Macronucleus, length	17·4	18·0	1·3	7·3	14	18	10
Macronucleus, width	5·6	5·6	0·4	6·9	5	6	10
Micronuclei, No.	4·7	5·0	0·9	20·2	3	6	10
Micronucleus, length of longest axis	1·7	1·6	0·4	22·0	1·4	2·7	10
Somatic kineties, No.	26·0	26·0	1·2	4·8	24	28	10
Somatic kinety, No. of basal bodies (without circumoral basal bodies)	27·0	27·0	4·8	17·9	20	35	10
Circumoral basal body pairs, No.	26·0	26·0	1·2	4·8	24	28	10
Pharyngeal plug, length	1·6	1·4	0·2	15·8	1·4	2	10
Brosse, No. of kineties	2·0	2·0	–	–	2	2	10
Brosse, length of kinety 1 (from circumoral kinety to lower end)	8·5	8·2	2·3	26·5	6	13	10
Brosse, length of kinety 2	5·8	6·0	0·9	15·8	4	7	10
Extrusomes, length	7·3	7·0	–	–	7	8	10

Description

Somatic kineties longitudinal. Anterior portions of two kineties differentiated to form brosse composed of paired basal bodies. Micronuclei spherical to ellipsoidal in shape. Mouth opening circular, surrounded by circumoral kinety composed of dikinetids. Long nematodesma arising from posterior basal body of each circumoral pair and anterior basal bodies of somatic kineties forming an irregular cytopharynx. This important character was overlooked in the original description but has since also been demonstrated in the closely-related species *F. terricola* (Foissner 1984*a*; Foissner and Foissner 1985).

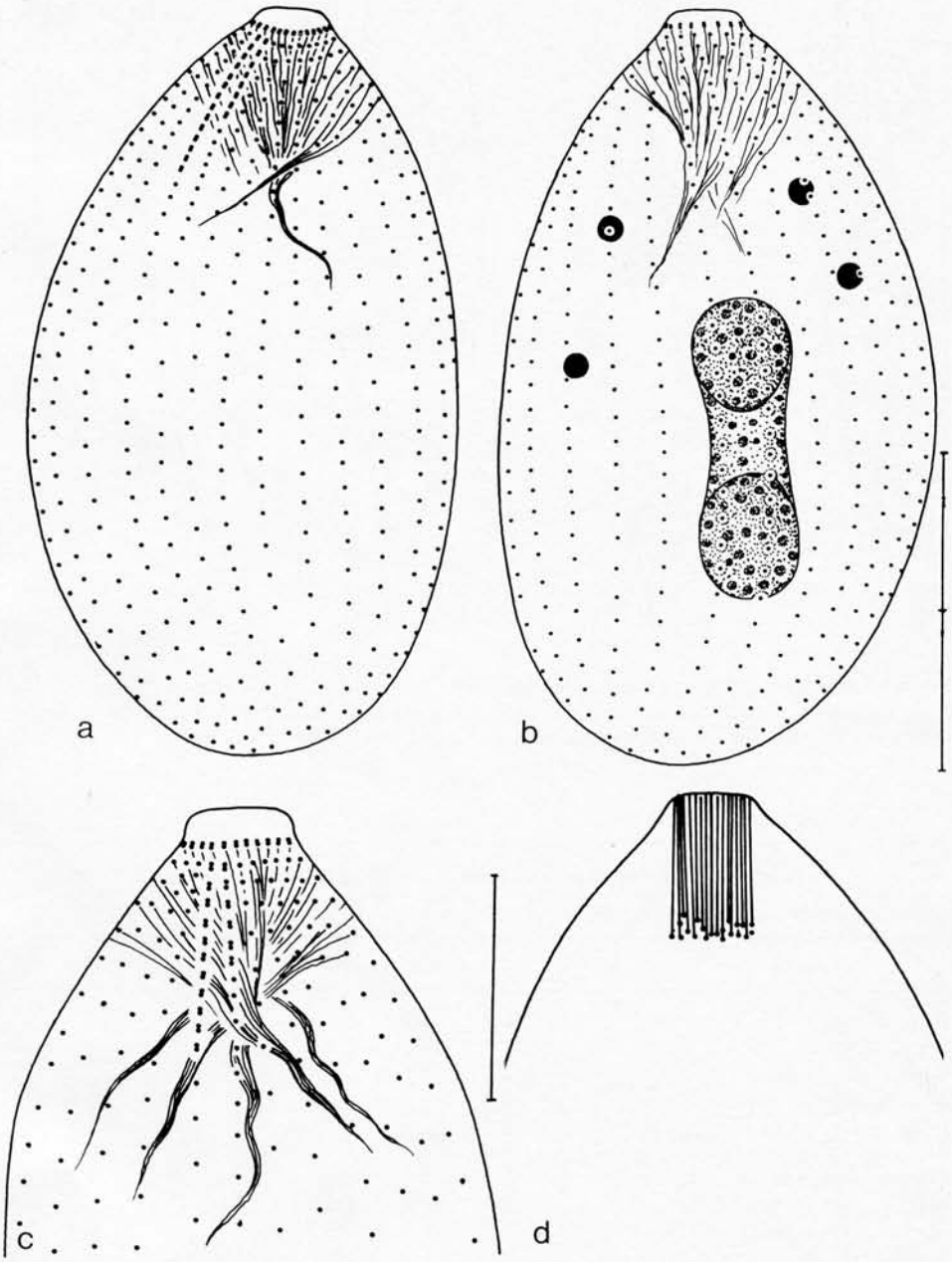


Fig. 3. *Fuscheria nodosa* following protargol-impregnation: *a*, infraciliature, dorsal view; *b*, infraciliature, ventral view; *c*, infraciliature detail, dorsal view, anterior end of body; *d*, extrusomes in oral area. Scale bar divisions, 10 μm.

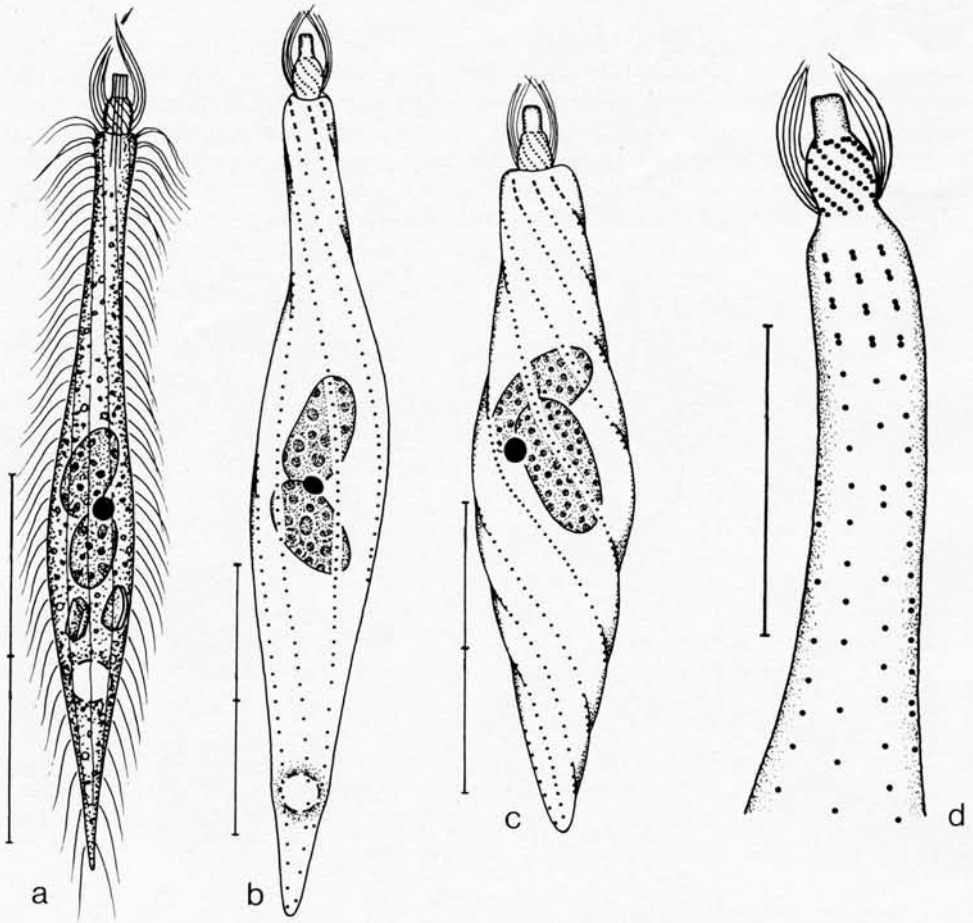


Fig. 4. *Lacrymaria australis*, sp. nov. following (*a*) live observation and (*b–d*) protargol-impregnation: *a*, elongate fast-swimming individual; *b*, infraciliature, elongate individual; *c*, infraciliature, contracted individual; *d*, infraciliature, anterior end of body. Scale bar divisions, 10 μm.

Table 4. Biometric characterisation of *Lacrymaria australis*, sp. nov.

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	52·9	55·0	6·4	12·1	40	60	11
Body, width	10·3	11·0	1·7	16·9	7	13	11
Body, width at neck	4·1	4·0	0·5	11·2	3	5	11
Head, length	2·4	2·4	0·2	8·3	2·2	3·0	11
Head, width	2·7	2·8	0·1	4·4	2·5	2·8	11
Pharyngeal plug, length	1·9	2·0	0·2	8·1	1·8	2·3	11
Macronuclear segments, No.	2·0	2·0	–	–	2	2	11
Macronuclear segment, length	9·2	10·0	1·2	13·0	7	11	11
Macronuclear segment, width	3·7	4·0	0·6	15·2	3	4·5	11
Micronuclei, No.	1·0	1·0	–	–	1	2	11
Micronucleus, length of longest axis	1·6	1·5	0·1	6·7	1·4	1·7	11
Somatic kineties, No.	6·0	6·0	–	–	6	6	13
Somatic kinety, No. of basal bodies	54·4	55·0	4·8	8·9	50	65	11

Family **LACRYMARIIDAE** de Fromentel

Genus ***Lacrymaria*** Bory de St Vincent

Lacrymaria australis, sp. nov.

(Figs 4*a–d*; Table 4)

Diagnosis. Size *in vivo* 40–60 × 5–10 μm, moderately contractile in longitudinal plane, relatively inelastic neck, pharyngeal plug tall and thin, two macronuclear segments, six somatic kineties, one contractile vacuole.

Type locality. Small pond in metropolitan Perth, W.A.

Description

Shape thin and spindle-like, tapering anteriorly and posteriorly, caudally pointed. Head distinct from neck. Body shape plump in appearance when contracted but still pointed caudally (Fig. 4*c*). Macronuclear segments ellipsoidal, positioned closely together or overlapping. Single micronucleus between or next to macronuclear segments. Contractile vacuole subterminal at beginning of caudal constriction. Endoplasm colourless, densely granulated, containing several 2–4 μm large yellowish crystals in posterior half of body. Movement rapid, rotating around long axis.

Conjugation by union at pharyngeal plug, one partner about 50% smaller than other and sometimes containing only one macronuclear segment.

Infraciliature typical for genus, without peculiarities. Somatic kineties longitudinal in fully stretched individuals but definitely spiral in contracted specimens. Three to four dikinetids with normal cilia at beginning of each somatic kinety.

Differential Diagnosis

Body shape and nuclear apparatus of *L. australis* similar to *L. olor* except the latter is much larger and has a very elastic neck and two contractile vacuoles (Kahl 1930). *L. parva* Vuxanovici, 1962 also has some general similarities but is plumper, flask-shaped and has a very broad and flat pharyngeal plug or no plug at all.

Order **PLEUROSTOMATIDA** Schewiakoff

Family **AMPHILEPTIDAE** Bütschli

Genus ***Acineria*** Dujardin

Acineria uncinata Tucolesco, 1962

(Figs 5*a–j*; Table 5)

Until recently there was only one certain species of the genus *Acineria* Dujardin, 1841; that of *A. incurvata* Dujardin, 1841 (Augustin *et al.* 1987). Our re-examination of *A. uncinata* Tucolesco, 1962, which has not been mentioned in the literature since the original description, demonstrates that it is in fact an *Acineria* sp. and that it can easily be differentiated from *A. incurvata* owing to its smaller number of somatic kineties. In the last few years, we have found *A. uncinata* in various localities in flowing and standing waters subject to moderate to heavy pollution. However we have reported this species in fauna lists as a *Litonotus* sp. because the typical bend in the anterior portion of the body is difficult to recognise owing to the small size of the organism. In fact *A. uncinata* is probably the most common and widely-distributed species of Amphileptidae. In spite of this, it does not appear in any fauna lists in the literature. It has probably been repeatedly misidentified as the irregular form of *Litonotus lamella* described by Kahl (1931).

Our observations on the morphology and biometry of *A. uncinata* are consistent with those of Tucolesco (1962) and there is no doubt that the separate studies were performed on the same species. However, because these observations relate to an important and widely distributed species, a new description is given below to supplement the original but rather incomplete one given by Tucolesco (1962). We examined two populations of

A. uncinata; one isolated from tree lichen in Freiburg (West Germany) and the other from a small pond in Perth (Western Australia). The morphological and biometric characters of both populations are very similar, therefore the following description applies equally to them.

Description

Size *in vivo* 30–60 × 10–15 μm, contractile for only about 20% of body length. Lance-like in shape, slender to broad depending on nutritional state. Anterior end narrow, rounded, exhibiting semicircular twist to left giving spoon-shaped appearance of anterior portion typical for genus. Anterior margin thickened, lustrous in appearance when viewed with transmitted light (good diagnostic character even at low magnification) due to numerous small extrusomes. Right ('dorsal') side flattened, left side distinctly convex, slightly flattened at margin with no or only slender hyaline hem. Dorsal bulge lance-like, only visible in anterior half of body. Macronuclear segments located approximately in middle of body, ellipsoidal, positioned closely together or overlapping. Micronucleus ovoid to ellipsoidal, close to macronuclear segments. Contractile vacuole terminal, surrounded by smaller vacuoles during diastole. Extrusomes rod-shaped, about 2 μm long, serially arranged only along

Table 5. Biometric characterisation of Australian and German (in brackets) populations of *Acineria uncinata*

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	34·5	33·5	4·7	13·6	28	41	10
	(38·9	39·0	5·2	13·3	31	50	15)
Body, width	8·4	8·0	1·1	12·8	7	10	10
	(9·4	9·0	1·6	17·0	7	13	15)
Distance between ant. end of cell and post. end of brush	8·2	8·0	1·0	12·6	7	10	10
	(10·6	10·0	2·0	18·8	8	14	15)
Distance between ant. end of cell and post. end of perioral kinety 1	8·4	8·0	1·3	15·1	7	10	7
	(9·2	9·0	1·9	20·2	7	13	15)
Distance between ant. end of cell and upper end of macronucleus	12·5	12·0	2·8	22·1	9	18	10
	(14·2	14·0	2·4	17·1	11	20	15)
Distance between macronuclear segments	0·0	0·0	–	–	0	0	10
	(0·0	0·0	–	–	0	0	15)
Macronuclear segments, No.	2·0	2·0	–	–	2	2	10
	(2·0	2·0	–	–	2	2	15)
Macronuclear segment, length	6·0	6·0	0·9	15·7	4	7	10
	(7·2	7·0	1·3	18·3	6	10	15)
Macronuclear segment, width	4·0	4·0	0·9	23·6	3	5	10
	(3·5	3·5	0·4	12·5	3	4	15)
Micronuclei, No.	1·0	1·0	–	–	1	1	10
	(1·0	1·0	–	–	1	1	15)
Micronucleus, length	2·1	2·0	0·5	24·0	1·6	3	10
	(2·5	2·5	0·4	16·0	2	3	15)
Micronucleus, width	2·1	2·0	0·5	25·1	1·6	3	10
	(1·9	2·0	0·3	15·4	1·5	2·5	15)
Somatic kineties, No. on right side	2·0	2·0	–	–	2	2	10
	(2·0	2·0	–	–	2	2	15)
Somatic kineties, No. on left side	2·0	2·0	–	–	2	2	10
	(2·0	2·0	–	–	2	2	15)
Perioral kineties, No.	3·0	3·0	–	–	3	3	10
	(3·0	3·0	–	–	3	3	15)
No. of basal bodies in 1st kinety on right to 3rd perioral kinety	25·2	23·5	6·9	27·3	16	35	10
	(20·3	19·0	3·9	19·1	15	28	15)
Brush, No. of basal body pairs	8·8	8·5	1·2	14·0	7	11	10
	(8·3	8·0	0·9	10·6	6	9	15)

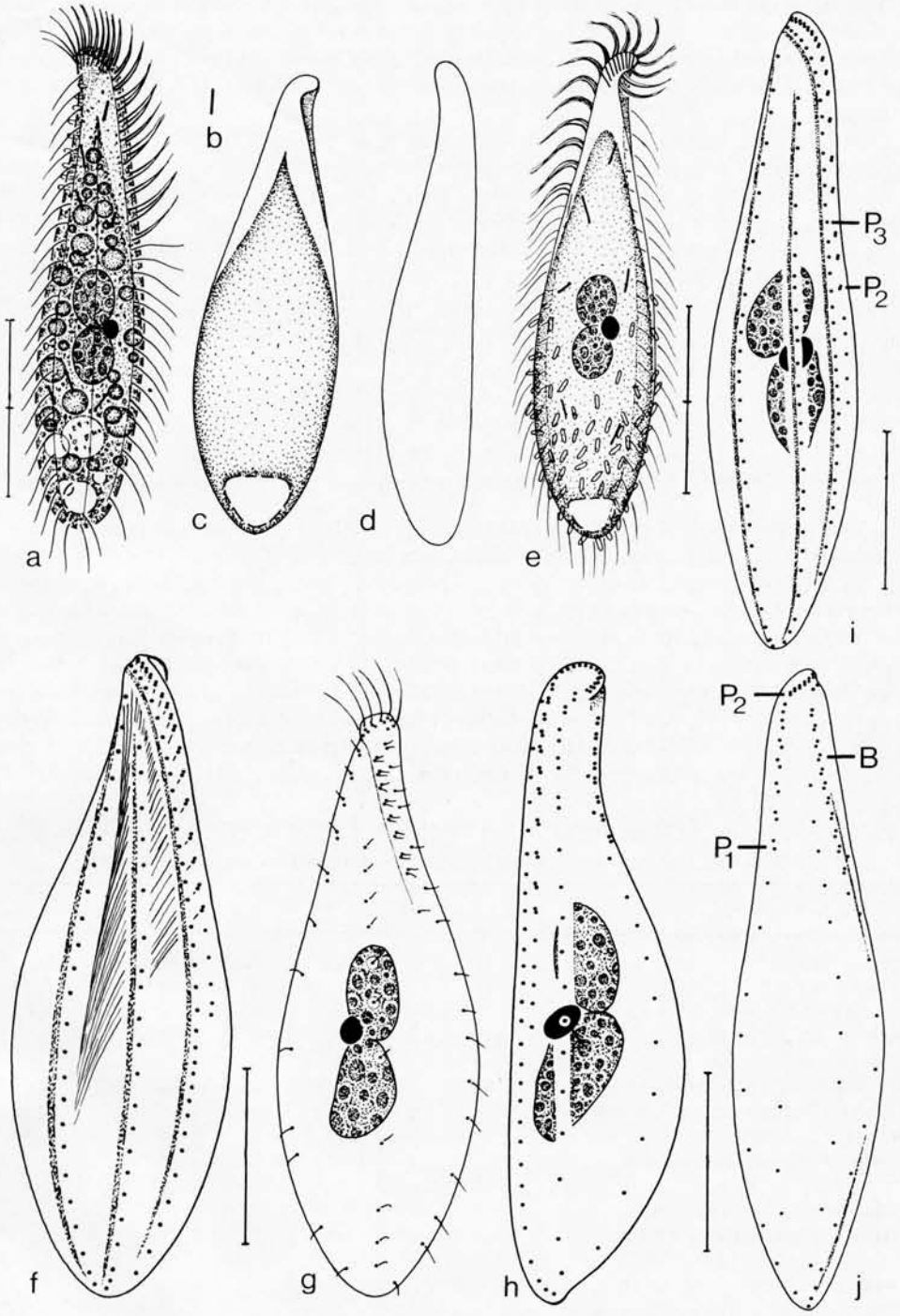


Fig. 5. *Acineria uncinata*, (*a–d*, *f–j*) German and (*e*) Australian populations, following (*a–e*) live observations and (*f–j*) protargol-impregnation: *a*, right lateral view; *b*, extrusome; *c*, left lateral view; *d*, ventral view; *e*, left lateral view; *f*, infraciliature, right side of broad individual; *g*, infraciliature, left side of broad individual; *h*, infraciliature, ventral view; *i*, infraciliature, right side of slender individual (P, perioral kineties); *j*, infraciliature, left side of slender individual (B, brosse). Scale bar divisions, 10 μm.

anterior end, few dispersed throughout endoplasm. Pellicle colourless. In Australian population, pellicle thickly covered with rod-like bacteria particularly in posterior half of body. Cytoplasm containing few to many colourless, fatty, shining spheres 1–3 μm in diameter depending on nutritional state. Several nearly empty food vacuoles often present in posterior third of body. Movement slowly gliding, very flexible crawling motion amongst detritus.

Infraciliature typical for genus (cf. Augustin *et al.* 1987). Cilia of second and third perioral kineties arranged very closely together, seemingly stiff, giving appearance of mane along mouth (as also shown by Tucolesco, 1962). Two right somatic kineties with 6 μm long cilia [Tucolesco (1962) described three right somatic kineties but erroneously included the third perioral kinety]. Two left somatic kineties (a short third kinety sometimes present) with short bristle-like cilia [overlooked by Tucolesco (1962)]. Cilia of brosse about 2 μm long and, like *A. incurvata*, noticably bubble-like. One to two single basal bodies at posterior end of brosse. Nematodesma very fine and only evident in silver-impregnated specimens.

Genus *Litonotus* Wrzesniowski

Litonotus lamella (Müller, 1773) Schewiakoff, 1886

(Figs 6*a–i*; Table 6)

This species is recorded in many fauna lists but its infraciliature has not previously been described nor has a biometric characterisation been performed. The description of *L. lamella* given by Fryd-Versavel *et al.* (1975) has subsequently been found to apply to *Acineria incurvata* (Augustin *et al.* 1987).

The determination of *L. lamella* is difficult because the original description is inadequate and cannot be used to identify a particular species of *Litonotus*. Redescriptions of *L. lamella* by Müller (1786), Ehrenberg (1838), Schewiakoff (1896), Kahl (1931) and others have not corrected this situation and it is probable that various species have been redescribed together. It was therefore deemed necessary to provide new diagnostic characters for this species. Our identification is based on an illustration (fig. IX 1, plate XIII) by Ehrenberg (1838)

Table 6. Biometric characterisation of *Litonotus lamella*

Data based on protargol-impregnated specimens and all measurements in μm

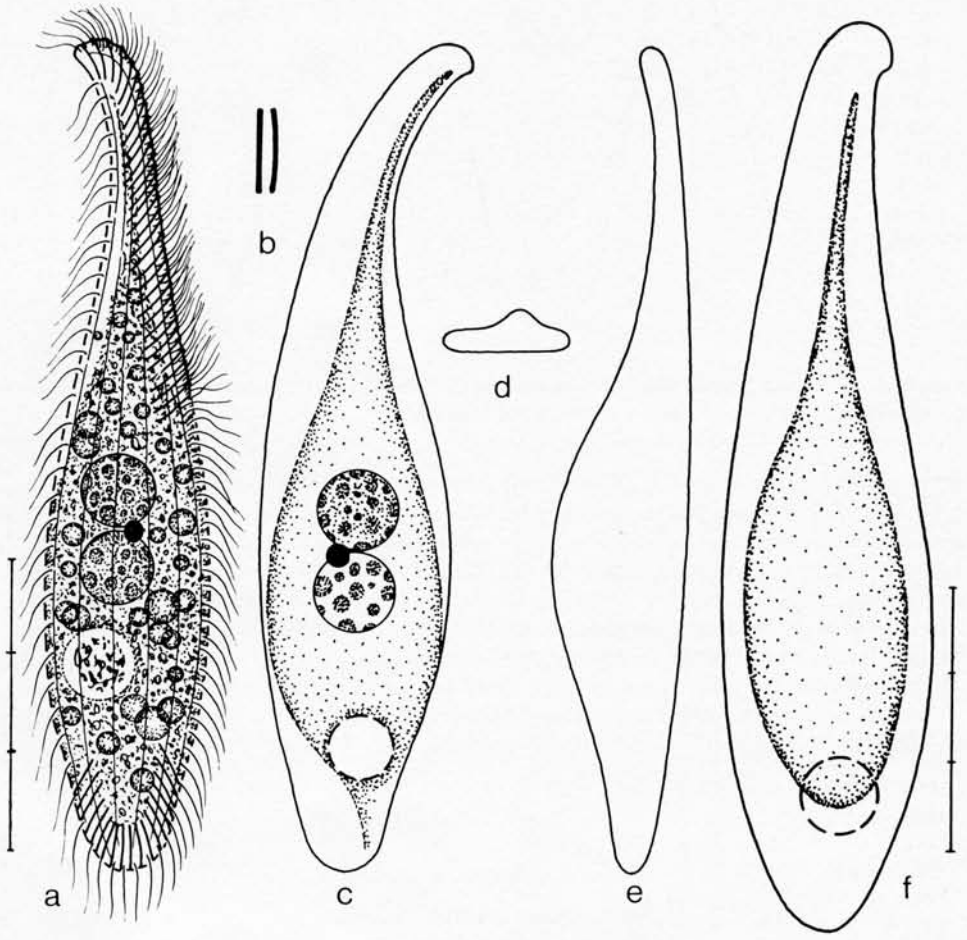
Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	56·3	56·0	7·0	12·5	48	67	15
Body, width	11·3	11·0	1·4	12·3	9	15	15
Distance between ant. end of cell and post. end of brush	21·9	22·0	3·5	15·8	15	28	15
Distance between ant. end of cell and post. end of perioral kinety 1	28·1	28·0	4·6	16·2	21	38	15
Distance between ant. end of cell and upper end of macronucleus	26·5	26·0	5·5	20·8	18	35	15
Distance between macronuclear segments	0·0	0·0	–	–	0	0	15
Macronuclear segments, No.	2·2	2·0	0·0	0·0	2	3	15
Macronuclear segment, length	7·8	7·0	1·7	21·8	6	11	15
Macronuclear segment, width	6·3	6·0	0·5	7·3	6	7	15
Micronuclei, No.	1·0	1·0	–	–	1	1	15
Micronucleus, length	1·7	1·7	0·2	13·7	1·5	2·2	15
Micronucleus, width	1·7	1·6	0·2	11·5	1·5	2·2	15
Somatic kineties, No. on right side	4·7	5·0	0·5	9·7	4	5	15
Somatic kineties, No. on left side	4·0	4·0	–	–	4	4	15
Perioral kineties, No.	3·0	3·0	–	–	3	3	15
No. of basal bodies in 4th kinety on right to 3rd perioral kinety	34·9	35·0	8·0	22·9	23	50	15
Brush, No. of basal body pairs	23·7	22·0	4·3	18·2	19	36	15

which demonstrates a *Litonotus* with a conspicuous 'thorn' on the left lateral margin of the anterior portion of the left side of the body. This character is also typical in the population we examined which originated from a small pond in metropolitan Perth, W.A. The dimensions and size ranges exhibited by this population are also consistent with those recorded by Ehrenberg (1838).

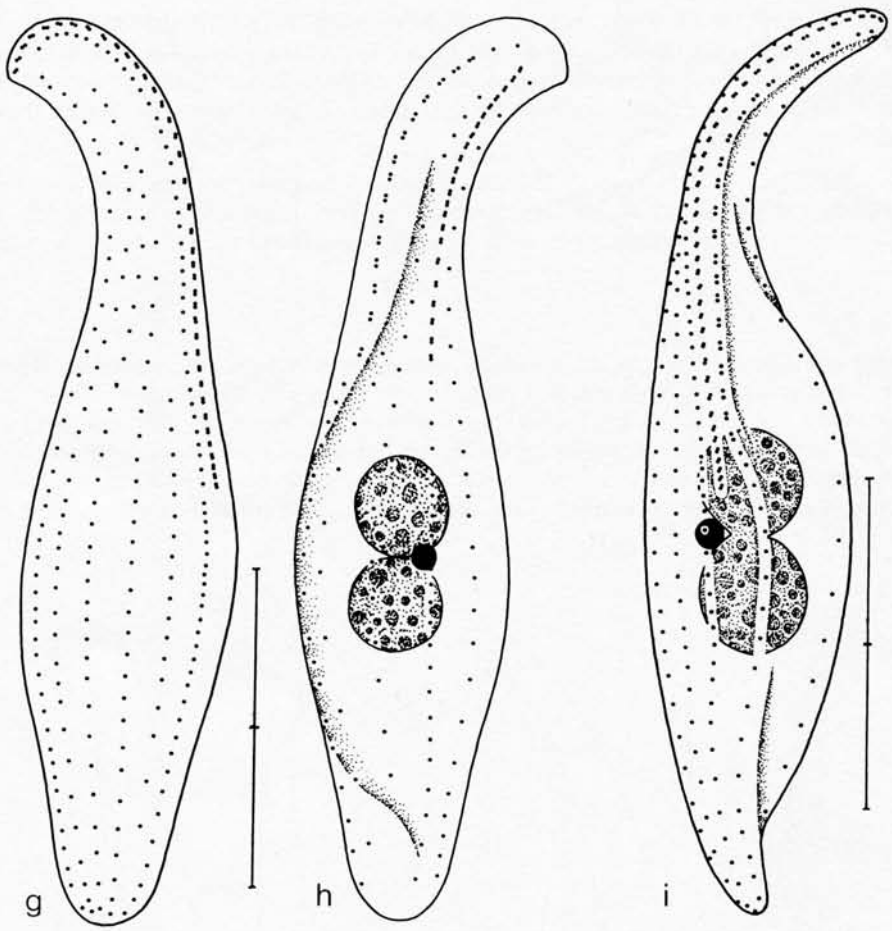
New diagnosis. Size *in vivo* 50–100 × 10–25 μm, moderately contractile, anterior left side with long thorny pellicular fold, extrusomes along oral region and at posterior end of body, single contractile vacuole subterminal, five right lateral and four left lateral somatic kineties.

Description

Shape slim and sigmoidal, broad in middle, elongate anterior taper, short posterior taper. Posterior end rounded, slightly indented subterminally where extrusomes insert. About one third of body contractile, causing broadening of neck region. Right side flattened, left side slightly to strongly convex in middle depending on nutritional state. Posterior often with longitudinal fold directed to dorsal margin, seldom simply rounded. Anterior thorny extension slightly to left of midline, very constant *in vivo* but often not noticeable in



Figs 6*a–f*. *Litonotus lamella* following live observation: *a*, right lateral view of slender individual; *b*, extrusome; *c*, left lateral view of slender individual; *d*, cross-section, anterior end of body; *e*, ventral view; *f*, left lateral view of broad individual. Scale bar divisions, 10 μm.



Figs 6*g–i*. *Litonotus lamella* following protargol-impregnation: *g*, infraciliature, right lateral view; *h*, infraciliature, left lateral view; *i*, infraciliature, ventral view. Scale bar divisions, 10 μm.

protargol-impregnated specimens. Macronuclear segments close together or overlapping, spherical to ellipsoidal. Micronucleus spherical, never between but always close to both macronuclear segments. Contractile vacuole subterminal, located close to dorsal margin of body. Extrusomes 5 μm long, gently curved. Pellicle and endoplasm colourless. Depending on nutritional state, cytoplasm containing few to many colourless spheres 1–5 μm in diameter and several larger food vacuoles about 10 μm in diameter with undefined content. Movement slowly gliding, very flexible crawler amongst detritus.

Cilia about 8 μm long, some forming mane near oral region. Infraciliature typical for genus (cf. Foissner 1984*b*). First perioral kinety with two to three simple basal bodies at anterior end. No somatic basal bodies at posterior end of second perioral kinety.

Genus ***Loxophyllum*** Dujardin

Loxophyllum australe, sp. nov.

(Figs 7*a–j*; Table 7)

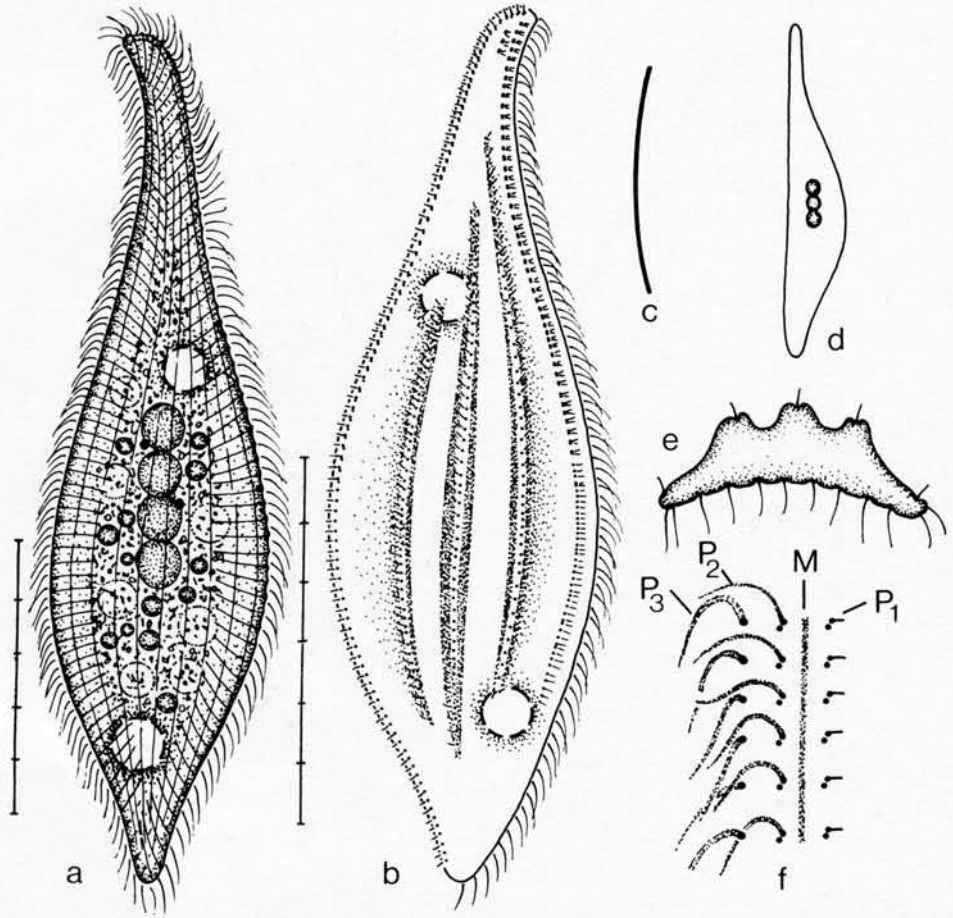
Diagnosis. Size *in vivo* 120–180×35–55 μm, highly contractile, four macronuclear segments on average, three raised ridges on left side, two diagonally opposed contractile vacuoles, 10–12 right lateral and three to four left lateral somatic kineties.

Type locality. Small pond in metropolitan Perth, W.A.

Table 7. Biometric characterisation of *Loxophyllum australe*, sp. nov.

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	103·7	101·0	10·9	10·6	90	126	10
Body, width	34·1	35·5	5·5	16·0	28	43	10
Distance between ant. end of cell and post. end of brush	43·9	42·0	8·1	18·5	28	60	10
Distance between ant. end of cell and post. end of perioral kinety 1	approximately length of body						10
Distance between ant. end of cell and upper end of macronucleus	48·3	45·5	7·9	16·4	39	64	10
Macronuclear segments, No.	4·4	4·0	1·1	24·2	1	8	100
Macronuclear segment, length	6·4	6·5	1·8	17·0	4·5	8·4	10
Macronuclear segment, width	6·2	6·0	0·8	13·5	4·5	7·0	10
Micronuclei, No.	2·0	2·0	–	–	1	3	10
Micronucleus, length	1·7	1·6	0·2	10·8	1·5	2·1	10
Micronucleus, width	1·6	1·6	0·2	11·9	1·4	2·1	10
Somatic kineties, No. on right side	11·1	11·0	0·7	6·6	10	12	10
Somatic kineties, No. on left side	4·0	4·0	–	–	3	4	10
Perioral kineties, No.	3·0	3·0	–	–	3	3	10
No. of basal bodies in 9th kinety on right to 3rd perioral kinety	43·8	43·5	7·5	17·2	32	58	10

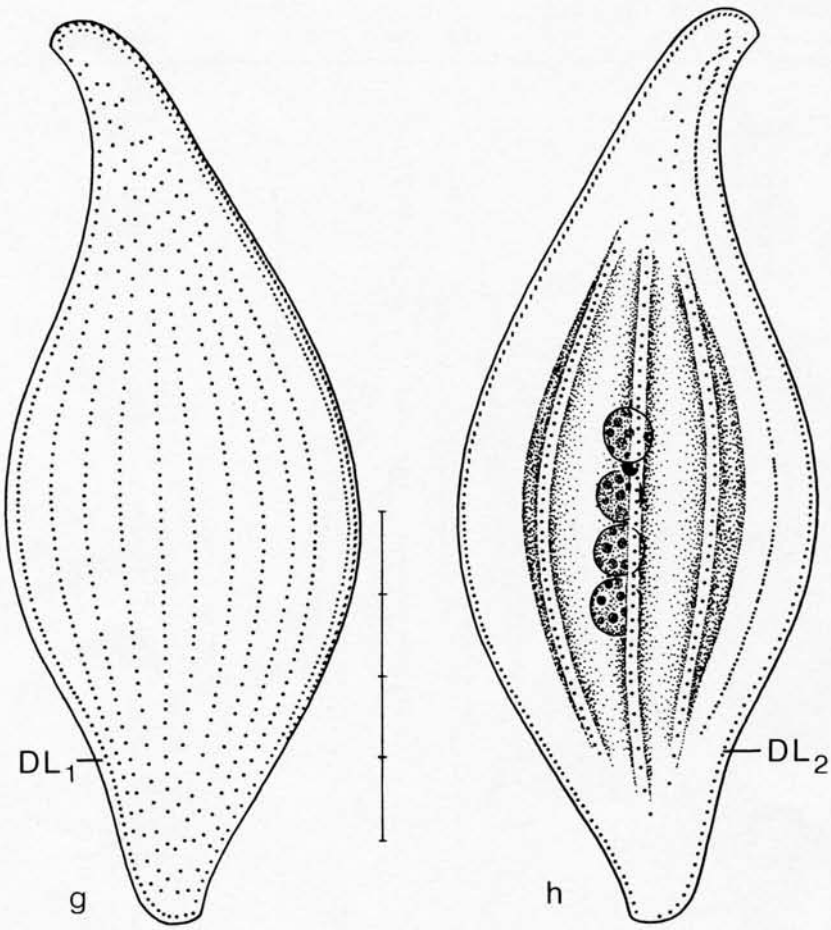


Figs 7*a–f*. *Loxophyllum australe*, sp. nov. following live observation: *a*, right lateral view; *b*, left lateral view; *c*, extrusome; *d*, dorsal view; *e*, cross-section, centre of body; *f*, detail of oral apparatus (P, perioral kineties; M, mouth). Scale bar divisions, 10 μm.

Description

Shape lance-like, broad in middle, tapering anterior and posterior, ends slightly rounded. Depending on nutritional state, slightly to heavily flattened (up to 1 : 4). Right side flat to slightly concave. Left side slightly to greatly convex in middle and with three raised ridges (separated by two depressions) bearing somatic kineties. Ridges very stable in form because also noticeable in protargol-impregnated specimens. Body highly flexible, about one third of body length contractile. Severe shrinkage during protargol preparation (Table 7). Macronuclear segments centrally-located, variable in number (most containing four), usually arranged in a single row along midline. Micronuclei spherical, located close to macronuclear segments, typically two present but occasionally with one or three (Fig. 7*i*). One contractile vacuole located right anterior at beginning of middle third of body, a second contractile vacuole located left posterior subterminal. Extrusomes about 7 μm long, gently curved, located along the entire margin of body. No trichocyst warts. Pellicle and endoplasm colourless. Body very hyaline in appearance, particularly at ends and along sides. Food vacuoles concentrated in middle portion of cell. In culture, observed to feed on ciliates (*Cinetochilum margaritaceum*, *Cyclidium* sp.). Movement slowly gliding and/or rotating around long axis.

Cilia of right side about 7 μm long. Right somatic kineties densely ciliated, becoming successively shortened anteriorly along mouth. Kineties also shortened left and especially

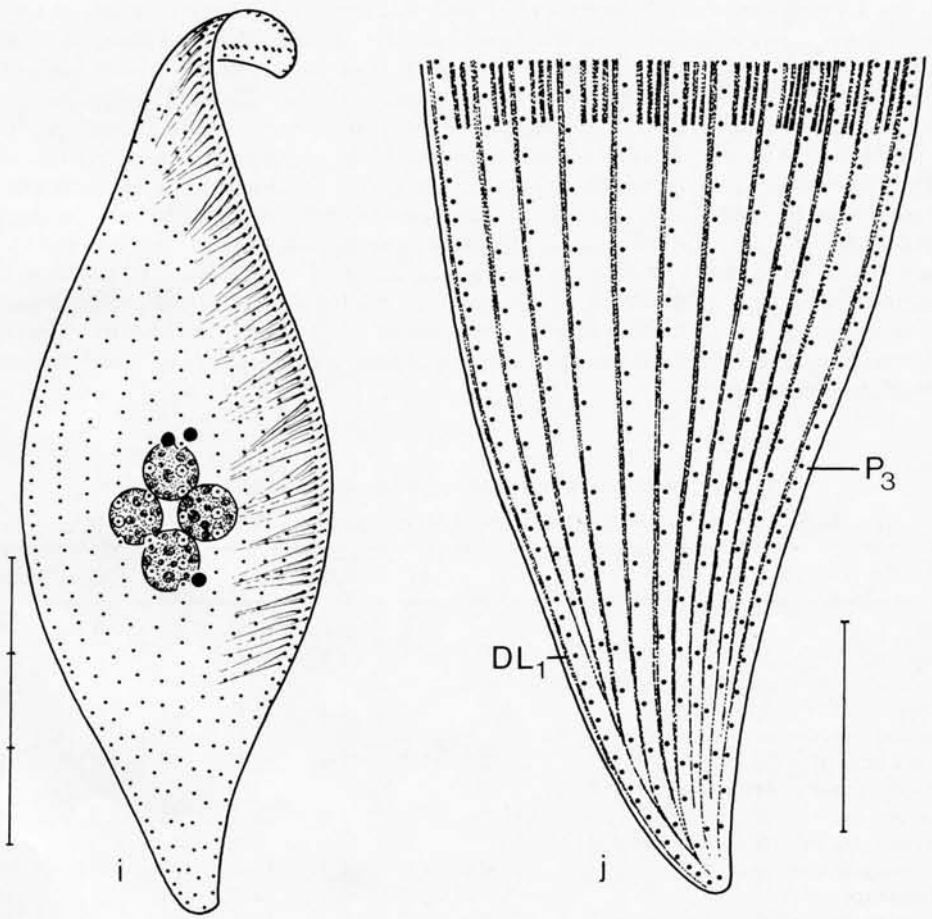


Figs 7*g*, *h*. *Loxophyllum australe*, sp. nov. following protargol-impregnation: *g*, infraciliature, right side (DL, dorsolateral kineties); *h*, infraciliature, left side. Scale bar divisions, 10 μm.

right posteriorly as evidenced by course of fibrillar system (Fig. 7*j*). Two unshortened dorsolateral kineties curving posteriorly around the kineties of right side and ending next to first and third perioral kineties. Four somatic kineties on left side strongly shortened posteriorly, bearing 2 μm long bristle-like cilia. Leftmost kinety densely ciliated, anterior portion with paired basal bodies forming brosse, anterior end of this kinety moderately to heavily fragmented. Three perioral kineties about three quarters length of body, two on right, one on left of mouth. Second perioral kinety shortened slightly posteriorly. First and second perioral kineties with paired basal bodies, cilia arising only from anterior basal body. Cilia of first kinety short and bristle-like about 2 μm long, those of second kinety normal in length. Third perioral kinety with single basal bodies, arranged closely together, with normal cilia. Nematodesma very fine.

Differential Diagnosis

L. australe is similar to *L. multinucleatum* except that the latter has about 20 macronuclear segments arranged in two rows and many contractile vacuoles along the ventral margin of the body (Kahl 1931; Dragesco and Dragesco-Kerneis 1986). The nuclear apparatus of *L. australe* resembles that of several marine *Loxophyllum* spp. (e.g. *L. setigerum*) except these species have a single dorsal row of contractile vacuoles and exhibit enigmatic oral papillae (Kahl 1931) which do not occur in *L. australe*.



Figs 7*i*, *j*. *Loxophyllum australe*, sp. nov. following protargol-impregnation: *i*, infraciliature, right lateral view; *j*, infraciliature detail, right lateral view, posterior end of body (DL, dorsolateral kinety; P, perioral kinety). Scale bar divisions, 10 μm.

Order **NASSULIDA** Jankowski

Family **NASSULIDAE** de Fromentel

Genus *Naxella* Fryd-Versavel, Iftode & Deroux

Naxella australis, sp. nov.

(Figs 8*a–f*; Table 8)

Diagnosis. Size *in vivo* approximately 65×40 μm, egg-shaped, lightly rounded posteriorly, oral depression moderately deep, about 45 somatic kineties, three adoral organelles, excretion pore of contractile vacuole located between second to fourth kinety right of paroral membrane.

Type locality. Small farm dam adjacent to Whispering Road, 1 km east of Barossa Reservoir, Williamstown, S.A.

Description

Shape in lateral and particularly ventral profiles egg-like, posterior often slightly pointed. Macronucleus and micronucleus ellipsoidal, located centrally. Single contractile vacuole, centrally-located, surrounded by small vacuoles during diastole. Excretion pore and cytoproct usually located between third and fourth somatic kinety to right of paroral membrane (= first kinety), sometimes between second and third kinety. Trichocysts spindle-shaped, about 5 μm long, arranged in rows between somatic kineties. Pellicle colourless, thick and gelatinous. Endoplasm colourless, filled with large food vacuoles containing only *Euglena* sp. (*E. viridis*?) thereby giving general green coloration. Conjugation by union at cytopharynx. Following conjugation, many individuals lack inner right adoral membranelle.

Somatic kineties more heavily ciliated anteriorly. Right lateral kineties longitudinal, left lateral kineties slightly slanting. Short preoral suture. A few shortened kineties underneath adoral organelles and to right of paroral membrane. Cytopharyngeal apparatus strongly directed dorsally, anterior half with argentophilic zone. Cytopharyngeal rods with anterior teeth (small projections). Paroral membrane consisting of paired basal bodies, curved arrangement around right side of cytopharynx and ending shortly before excretion pore of contractile vacuole. Adoral organelles composed of 3×3 to 4×3 basal bodies, forming a straight posteriorly directed band. Small non-ciliated zone about 3 μm broad beneath adoral membranelles.

Table 8. Biometric characterisation of *Naxella australis*, sp. nov.

Data based on Chatton-Lwoff silver-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	57·8	56·0	3·9	6·8	52	64	10
Body, width	39·8	39·0	4·4	11·0	34	46	10
Distance between ant. end of cell and upper end of cyrtos	8·2	7·5	2·2	26·8	6	13	10
Distance between ant. end of cell and post. end of AZM	18·2	17·5	2·9	15·7	16	23	10
Distance between ant. end of cell and upper end of macronucleus	19·2	19·5	3·6	18·5	14	25	10
Distance between ant. end of cell and contractile pore vacuole	28·6	28·5	3·4	11·8	25	34	10
Macronuclei, No.	1·0	1·0	–	–	1	1	10
Macronucleus, length	11·5	10·5	1·8	16·0	10	14	10
Macronucleus, width	9·6	10·0	0·8	8·8	8	11	10
Adoral membranelles/organelles, No.	3·0	3·0	–	–	3	3	10
Cytopharyngeal rods, No.	12·1	12·0	1·0	8·2	11	14	10

Differential Diagnosis

N. australis is separated from *N. lateritia* (Calparède & Lachmann, 1859), the type species for the genus (Foissner 1987*b*), by having a single contractile vacuole, a smaller oral depression and the absence of pigmentation. It is further differentiated from *N. faurei* (described below) by the different location of the excretion pore of the contractile vacuole.

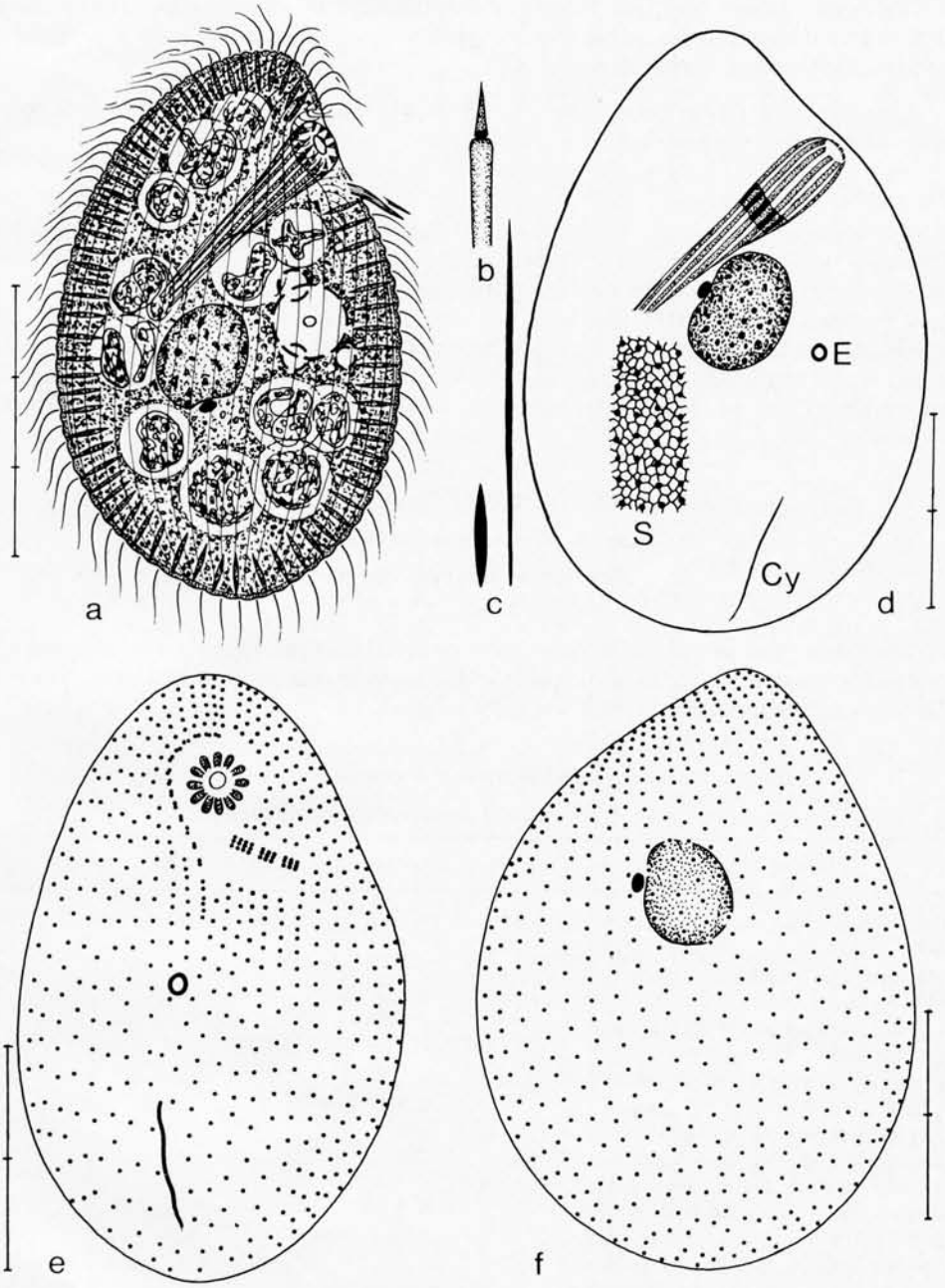


Fig. 8. *Naxella australis*, sp. nov. following (*a–c*) live observation, (*d*) protargol-impregnation and (*d–f*) silver nitrate-impregnation: *a*, right lateral view; *b*, cytopharyngeal rod, anterior end; *c*, quiescent and discharged extrusome; *d*, schematic representation of main cell organelles (Cy, cytoproct; E, contractile vacuole pore; S, silverline system); *e*, infraciliature, ventral view; *f*, infraciliature, left side. Scale bar divisions, 10 μm

No comparison was deemed necessary with *N. minuta* Dragesco & Dragesco-Kerneis, 1986 because we consider it to be a *Nassula* sp. owing to the nassulid-like (not naxellid) arrangement of its adoral membranelles.

Naxella faurei, sp. nov.

Diagnosis. Length 60–75 μm, broadly rounded posteriorly, 55–60 somatic kineties, three to four adoral organelles, excretion pore of contractile vacuole to left of paroral membrane underneath the adoral membranelles.

Type locality and description. See Fauré-Fremiet (1967, page 461) for *Nassula* (*Cyclogramma*?) *lateritia* Clap. et L.

Differential Diagnosis

The species in question was identified by Fauré-Fremiet (1967) as *Nassula lateritia* Claparède and Lachmann, 1859. However, the original diagnosis and description of *N. lateritia* states strongly that two contractile vacuoles are present. The species described later by Fauré-Fremiet (1967) has only one contractile vacuole and therefore cannot be identical to *Nassula lateritia*. Furthermore, the marked oral depression and the arrangement of the adoral membranelles indicates that this species does not belong to the genus *Nassula* but rather to that of *Naxella*. We therefore propose that it be named *Naxella faurei*, sp. nov.

Family **MICROTHORACIDAE** Wrzesniowski

Genus *Microthorax* Engelmann

Microthorax australis, sp. nov.

(Figs 9*a–d*; Table 9)

Diagnosis. Size *in vivo* 20–25 × 10–15 μm, posterior slightly truncated cone appearance, oral cavity with two inwardly projecting thorns, posterior portions of all somatic kineties markedly reduced, preoral kineties vertically oriented.

Table 9. Biometric characterisation of *Microthorax australis*, sp. nov.

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	18·7	18·0	1·3	6·7	17	21	10
Body, width	10·6	10·5	1·1	10·1	9	13	10
Macronucleus, length	4·3	4·2	0·4	8·1	4	5	10
Macronucleus, width	4·2	4·2	0·5	11·9	3	5	10
Distance between ant. end of cell and upper end of macronucleus	5·9	5·6	0·8	14·4	5	7	10
Distance between ant. end of cell and adoral membranelle 1	10·2	10·0	0·9	9·0	9	12	10
Somatic kineties, No. on right side	4·0	4·0	–	–	4	4	10
Somatic kineties, No. on left side	3·0	3·0	–	–	3	3	10
Somatic kinety 1, No. of basal bodies	3·0	3·0	–	–	3	3	10
Somatic kinety 2, No. of basal bodies	9·0	9·0	–	–	9	9	10
Somatic kinety 3, No. of basal bodies	8·0	8·0	–	–	8	8	10
Somatic kinety 4, No. of basal bodies	12·5	13·0	0·7	5·7	11	13	10
Somatic kinety 5, No. of basal bodies	5·0	5·0	–	–	5	5	10
Somatic kinety 6, No. of basal bodies	4·0	4·0	–	–	4	4	10
Somatic kinety 7, No. of basal bodies	2·0	2·0	–	–	2	2	10
Praeoral kineties, No.	3·0	3·0	–	–	3	3	10
Praeoral kinety 1, No. of basal bodies	2·8	3·0	0·0	0·0	2	3	10
Praeoral kinety 2, No. of basal bodies	4·0	4·0	–	–	4	4	10
Praeoral kinety 3, No. of basal bodies	4·2	4·0	0·0	0·0	4	5	10
x-kinety, No. of basal bodies	3·0	3·0	–	–	3	3	10

Type locality. Small pond in metropolitan Perth, W.A.

Description

Shape and size exhibiting little variation, left margin of body almost straight, right margin convex, body flattened 2 : 1 to 3 : 1. Macronucleus spherical, with several large irregularly distributed chromatin bodies. Micronucleus not recognised. Two contractile vacuoles to right of oral apparatus. Oral opening heart-shaped owing to thorn projecting inward from anterior oral margin. Second thorn projecting inward from left margin.

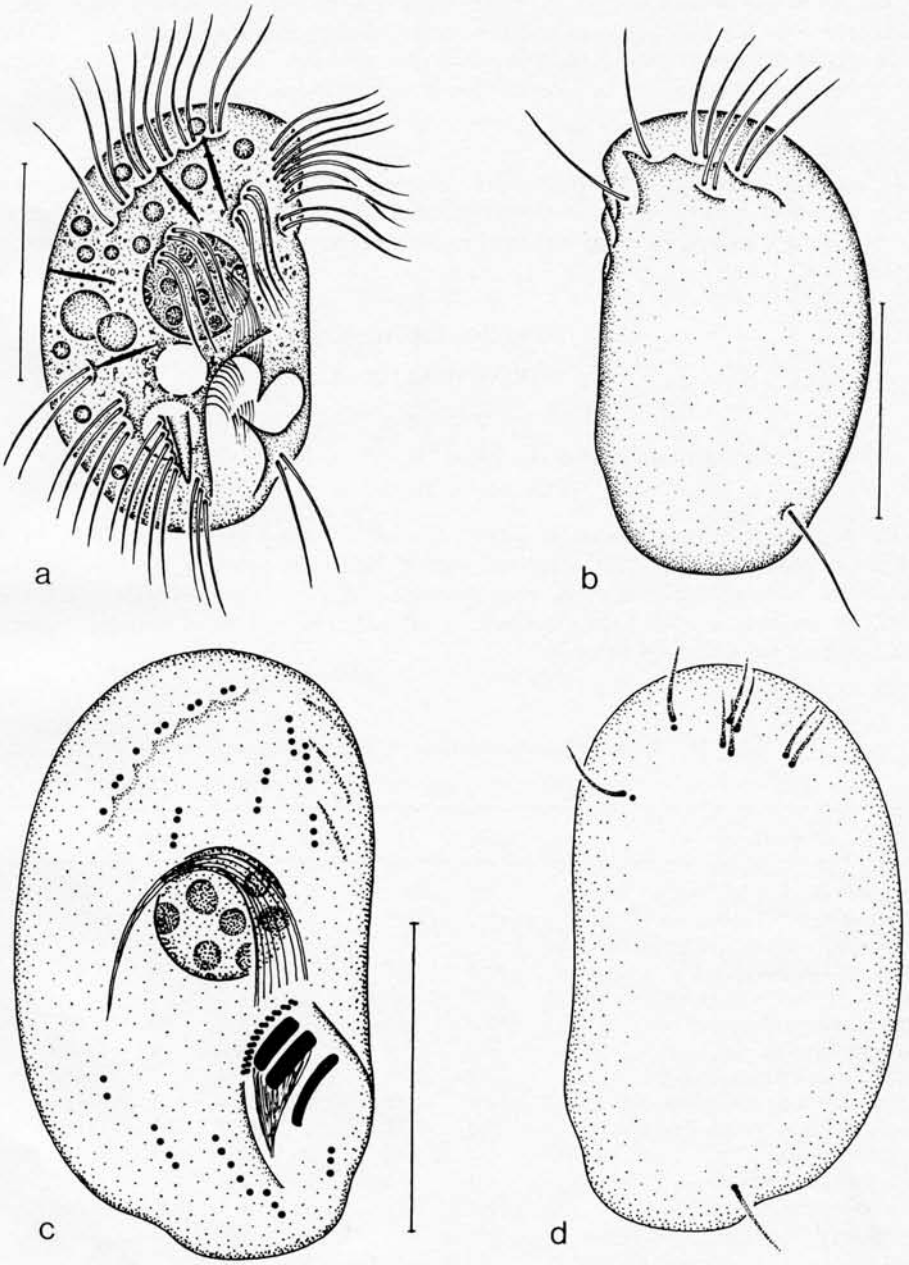


Fig. 9. *Microthorax australis*, sp. nov. following (*a*, *b*) live observation and (*c*, *d*) protargol-impregnation: *a*, right lateral view; *b*, left lateral view; *c*, infraciliature, right side; *d*, infraciliature, left side. Scale bar divisions, 10 μm.

Another larger thorn evident to right of oral cavity between first and second kinety. Trichocysts spindle-shaped, about 5 μm long. Pellicle and endoplasm colourless. Endoplasm very transparent, with some colourless spheres 1–3 μm in diameter. Feeds presumably on bacteria. Movement slow, crawling among detritus.

Cilia about 8 μm long, arising individually or in obscure pairs in posterior sections of all somatic kineties. Number and arrangement of basal bodies in kineties very constant (Table 9; Figs 9*c–d*). X-kinety (terminology of Foissner 1985) near left margin of body, only two of the three basal bodies ciliated. Second and third kinety anterior, each with two basal body pairs only, anterior portion of second kinety conspicuously located further forward in region of preoral kineties. Three basal bodies in first preoral kinety, only two ciliated. Only one ciliated basal body in posterior half of left side. Adoral membranelles not roofed over but free within cavity. First and second membranelle probably consisting of two rows of basal bodies, third membranelle probably of only one row. Paroral membrane at right margin of oral cavity closely above first adoral membranelle.

Differential Diagnosis

M. australis is similar to *M. transversus* Foissner, 1985 but can be easily differentiated by the truncated cone-like shape of the posterior end of the body, the reduced number of cilia on the right side of the body and the locations of the anterior portions of the somatic kineties.

Order **HETEROTRICHIDA** Stein

Family **SPIROSTOMATIDAE** Stein

Genus ***Blepharisma*** Perty

Blepharisma americanum (Suzuki, 1954) Hirshfield, Isquith & Bhandary, 1965

(Figs 10*a–h*; Table 10)

The population examined originated from a small pond in metropolitan Perth, W.A., and the morphological characters observed coincide well with those of the American type population. Although this species has been the subject of numerous investigations (cf. Giese 1973), no previous studies have described its infraciliature nor given detailed biometric data, so these are presented below.

Table 10. Biometric characterisation of *Blepharisma americanum*

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	172·6	168·0	14·7	8·5	155	200	13
Body, width	85·5	84·0	12·3	14·3	64	112	13
Distance between ant. end of cell and post. end of AZM	72·8	75·0	5·7	7·8	65	84	13
Distance between ant. end of cell and upper end of macronucleus	52·3	50·0	6·5	12·5	42	60	13
Macronuclear segments, No.	4·7	5·0	0·8	16·0	4	6	13
Maconuclear segment, length	13·2	14·0	2·4	17·8	7	15	13
Maconuclear segment, width	10·6	11·0	2·5	23·9	4	13	13
Length of macronuclear figure	78·5	75·0	13·4	17·1	65	102	13
Micronuclei, No.	6·7	6·0	2·2	33·1	3	11	13
Micronucleus, diameter	1·5	1·5	0·2	10·8	1·4	2	13
Somatic kineties, No. postoral	29·9	30·0	2·0	6·7	26	33	13
No. of basal bodies in a right lateral kinety		approx. 173			approx. 110–250		13
Adoral membranelles, No.	80·8	78·0	8·7	10·8	65	100	13
Length of base of longest membranelle	6·7	7·0	0·6	9·4	6	8	13

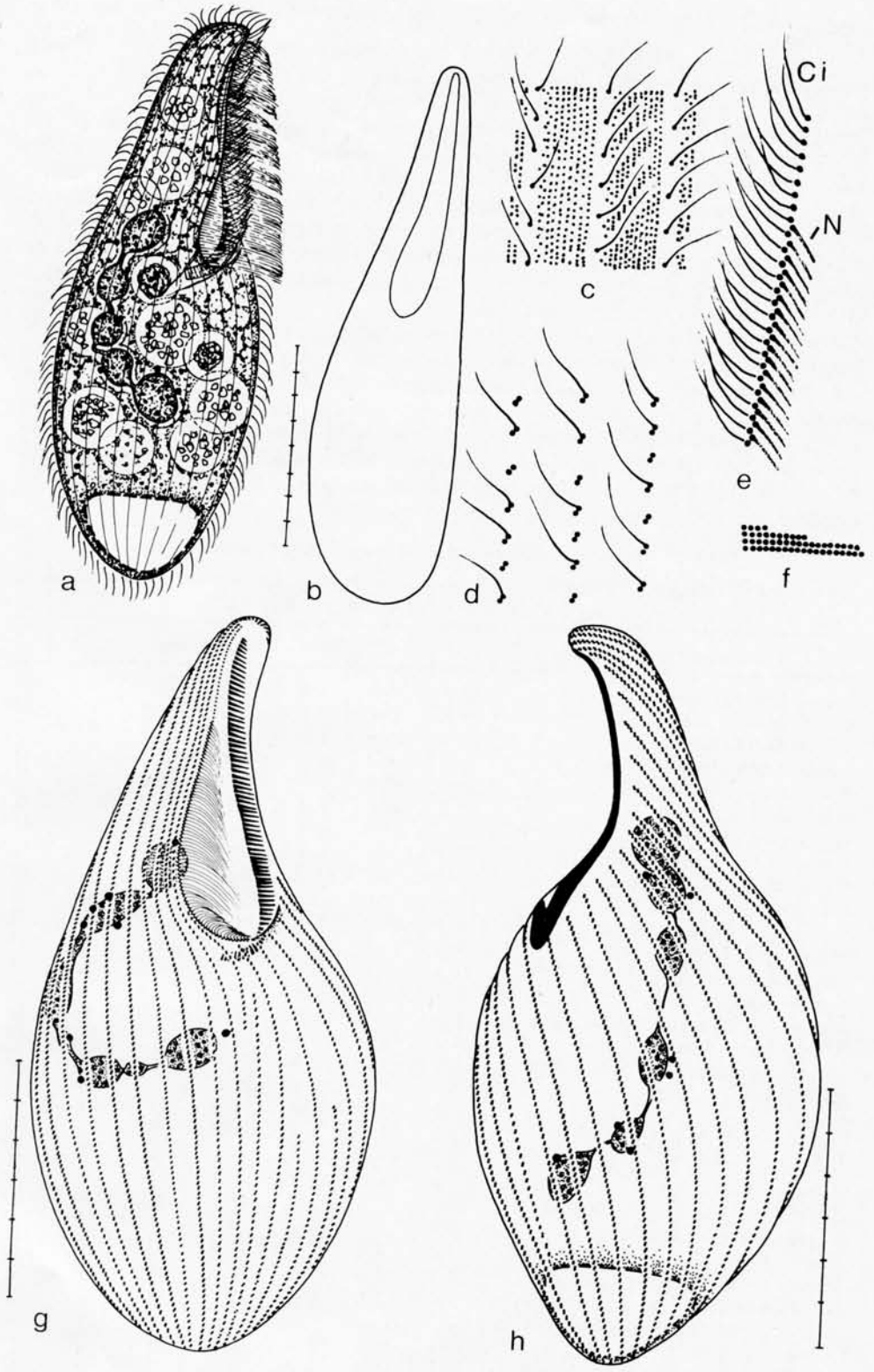


Fig. 10. *Blepharisma americanum* following (*a–c*) live observation and (*d–h*) protargol-impregnation: *a*, right lateral view; *b*, ventral view; *c*, detail of pellicle with subpellicular granules; *d*, detail of somatic infraciliature; *e*, detail of paroral membrane (Ci, cilia; N, nematodesma); *f*, detail of adoral membranelle; *g*, infraciliature, right side; *h*, infraciliature, left side. Scale bar divisions, 10 μm.

Description

Size *in vivo* 180–260 × 60–130 μm, larger cannibalistic forms (up to 500 μm) appearing when food in short supply. Shape ellipsoidal, posterior end slender to broadly rounded, never pointed or elongate. Adoral zone of membranelles slightly shorter than half body length. Left side of starved individuals straight, right side convex, both sides of well-fed individuals and cannibals convex. Macronucleus moniliform, terminal segments slightly larger, as also described in the type population (Suzuki 1954). Micronuclei spherical, located close to macronuclear segments. Contractile vacuole terminal. Pellicle flexible, numerous brick-red subpellicular granules arranged in approximately nine rows between somatic kineties. Endoplasm colourless, heavily vacuolated, well-fed individuals filled with large food vacuoles. Food uptake in culture including rice starch, bacteria, zooflagellates and ciliates (*Dexiotricha* sp.). Movement slow.

Somatic kineties longitudinal, those of left side slanting somewhat, some postoral (ventral) kineties shortened. Cilia about 10 μm long. Kineties consisting of paired basal bodies, only anterior basal body ciliated. Approximately half of basal body pairs unciliated. Adoral membranelles consisting of two long and two short rows of basal bodies. Anterior quarter of paroral membrane consisting of single basal bodies, remainder consisting of paired basal bodies, right basal body of each pair with single long cilium (approximately 25 μm), left basal body with single long fibril extending over buccal cavity and entering cytopharynx.

Table 11. Biometric characterisation of *Stenosemella lacustris*, sp. nov.

Data based on protargol-impregnated specimens, paired basal bodies counted as singles and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Lorica, length *in vivo* (incl. collar)	45·5	45·0	2·4	5·2	40	48	12
Lorica, width *in vivo*	46·6	47·0	2·4	5·0	42	50	12
Lorica, oral diameter *in vivo*	25·8	25·0	1·1	4·3	25	28	12
Lorica, height of collar *in vivo*	3·6	4·0	0·9	24·0	2	5	13
Body, length	31·0	32·0	3·9	12·6	24	35	13
Body, width	22·2	21·0	3·3	14·9	18	31	13
Adoral membranelles, No.	16·0	16·0	–	–	16	16	13
Somatic adoral membranelles, length	6·5	7·0	0·5	7·9	6	7	13
Buccal adoral membranelles, length	9·1	9·0	1·4	15·2	7	11	13
Macronuclear segments, No.	2·0	2·0	–	–	2	2	13
Macronuclear segment, length	9·7	10·0	1·5	16·0	7	13	13
Macronuclear segment, width	7·1	7·0	0·8	10·7	6	9	13
Somatic kineties, No.	31·4	32·0	1·3	4·2	30	34	9
Somatic kinety 1, length	1·9	1·0	1·9	99·5	1	7	10
Somatic kinety 1, No. of basal bodies	1·5	1·0	1·0	64·8	1	4	10
Somatic kinety 6, length	4·1	4·0	1·1	26·8	2	6	10
Somatic kinety 6, No. of basal bodies	2·9	3·0	0·6	19·6	2	4	10
Somatic kinety 9, length	6·8	7·0	2·0	29·2	4	10	10
Somatic kinety 9, No. of basal bodies	5·0	5·0	1·4	28·3	3	7	10
Somatic kinety 10, length	14·2	15·0	4·2	29·3	8	20	10
Somatic kinety 10, No. of basal bodies	14·6	13·5	4·8	33·1	8	25	10
Somatic kinety 15, length	5·8	6·0	1·5	25·4	4	8	10
Somatic kinety 15, No. of basal bodies	11·7	11·0	4·9	42·3	6	20	10
Somatic kinety 22, length	5·0	5·0	1·9	37·7	2	8	10
Somatic kinety 22, No. of basal bodies	4·2	4·0	2·0	47·4	2	8	10
Somatic kinety 29, length	5·0	4·5	1·2	23·1	4	7	10
Somatic kinety 29, No. of basal bodies	3·5	3·0	0·7	20·2	3	5	10
Somatic kinety 32, 'ventral kinety', length	24·2	24·5	4·4	18·0	16	31	10
Somatic kinety 32, No. of basal bodies	15·1	15·0	3·4	22·6	10	22	10
Ventrolateral kinety, length	13·1	14·0	3·1	24·0	8	17	10
Ventrolateral kinety, No. of basal bodies	7·0	6·5	1·5	21·3	5	10	10

Order **OLIGOTRICHIDA** Bütschli

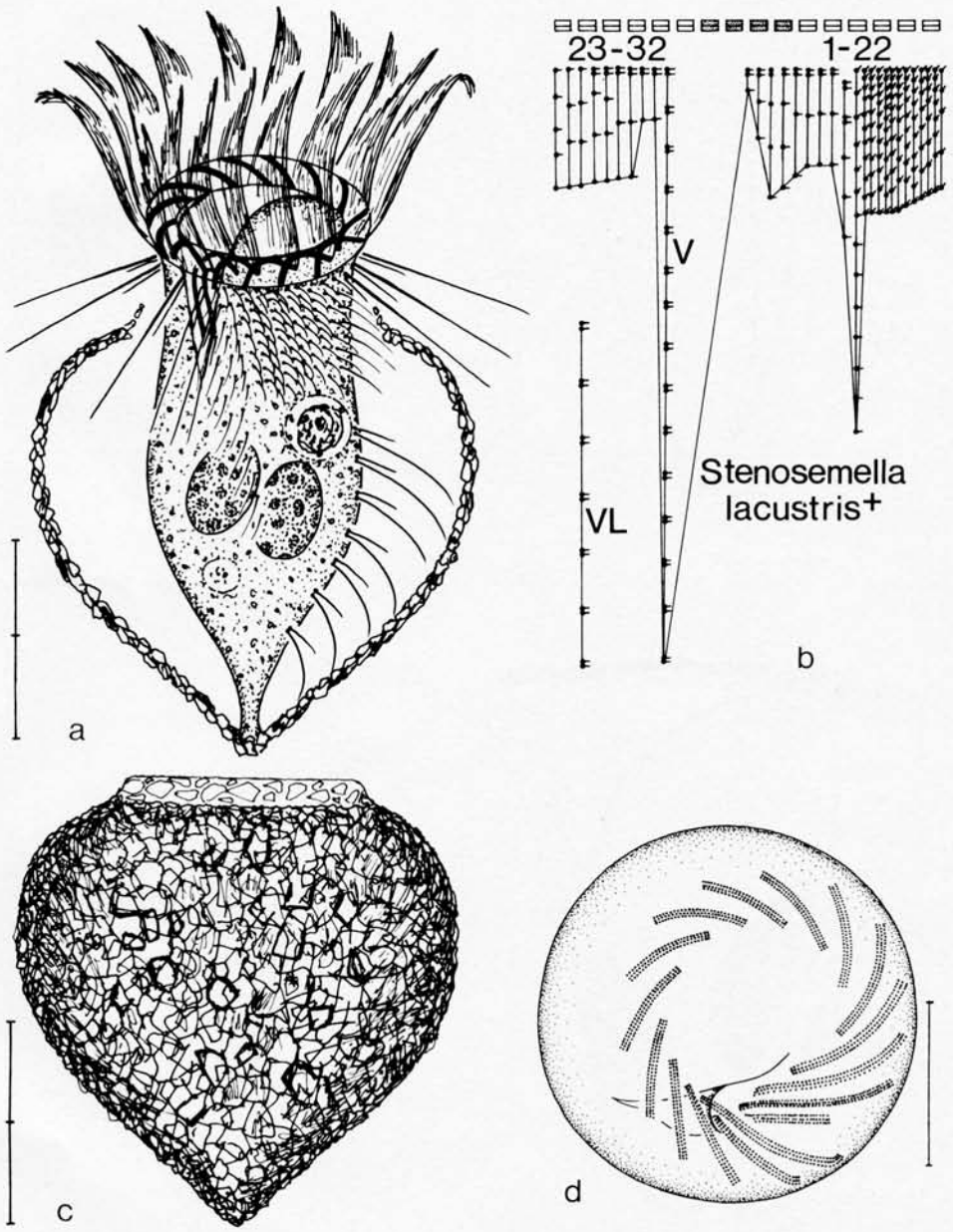
Family **CODONELLOPSIDAE** Kofoid & Campbell

Genus ***Stenosemella*** Jörgensen

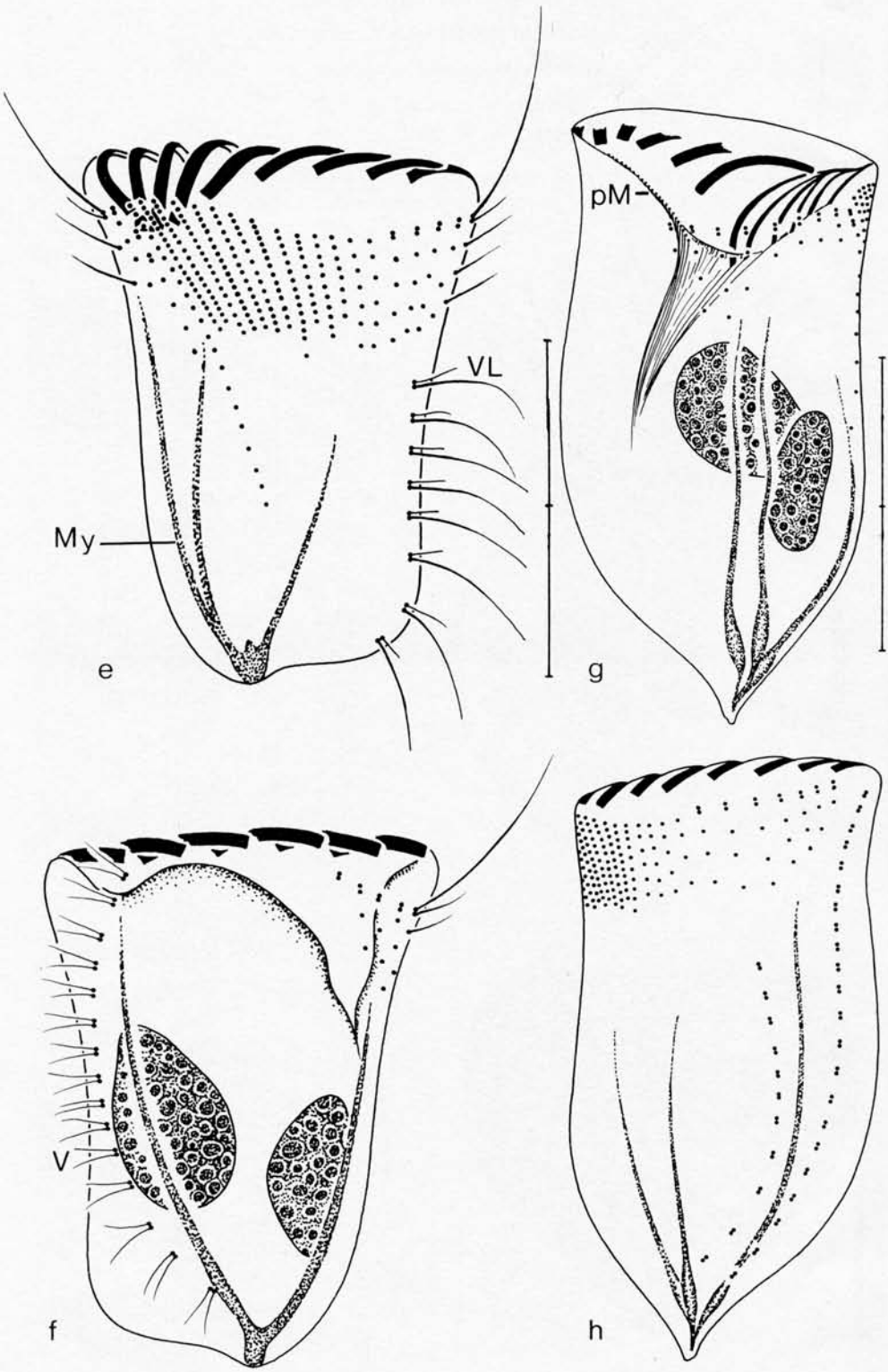
Stenosemella lacustris, sp. nov.

(Figs 11*a–h*, 12–21; Table 11)

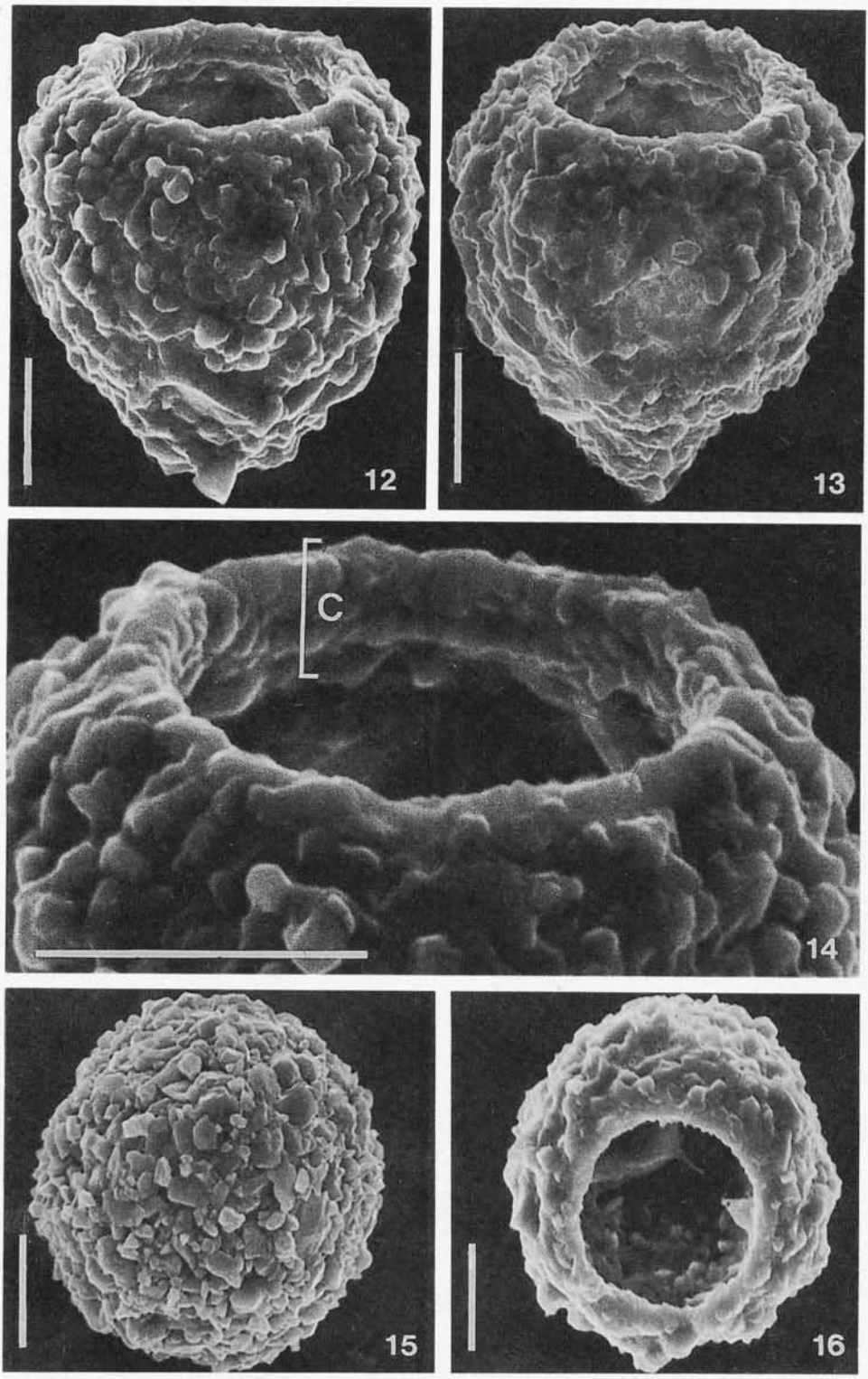
Diagnosis. Lorica heart-shaped, average size 45 × 47 μm, collar about 4 μm high, covered with foreign particles, with two to three very inconspicuous rings on inner wall, lorica



Figs 11*a–d*. *Stenosemella lacustris*, sp. nov. following (*a–c*) live observation and (*b*, *d*) protargol-impregnation: *a*, left lateral view; *b*, kinety diagram (V, ventral kinety; VL, ventrolateral kinety; cf. Foissner and Wilbert 1979 for construction and interpretation); *c*, lorica; *d*, oral infraciliature, frontal view. Scale bar divisions, 10 μm.



Figs 11*e–h*. *Stenosemella lacustris*, sp. nov. following protargol-impregnation: *e*, infraciliature, left lateral view (My, myoneme; VL, ventrolateral kinety); *f*, infraciliature, right lateral view (V, ventral kinety); *g*, infraciliature, ventral view (pM, paroral membrane); *h*, infraciliature, dorsal view. Scale bar divisions, 10 μm.



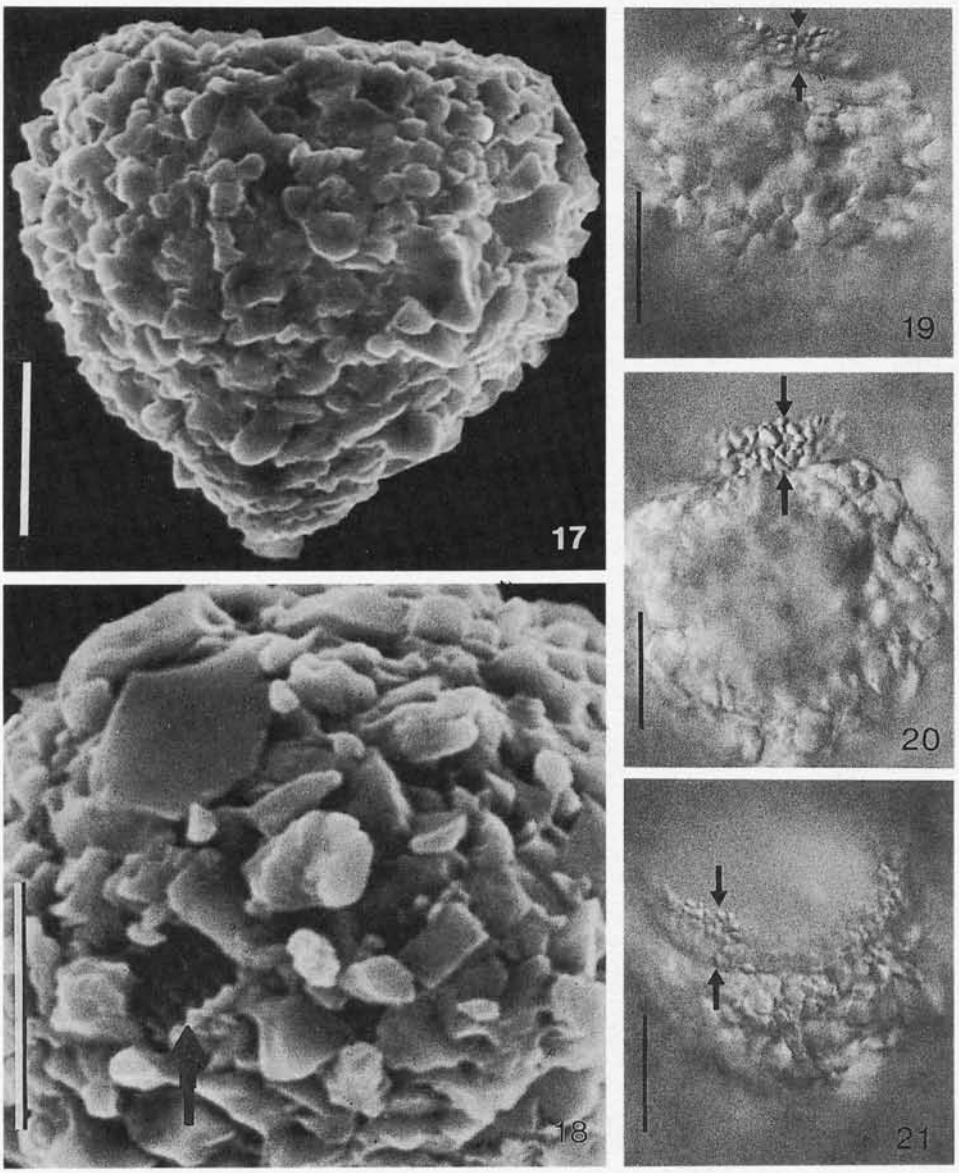
Figs 12–16. *Stenosemella lacustris*, sp. nov., scanning electronmicrographs of lorica; **12**, lateral view; **13**, lateral view; **14**, detail of lorica opening (C, collar); **15**, posterior view; **16**, anterior view. Scale bars, 15 μm.

opening 25 μm diameter on average. Ciliate about 70×20 μm, with 16 adoral membranelles and approximately 32 somatic kineties (organisation given in Figs 11*e–h*). Two macronuclear segments. Freshwater.

Type locality. Lake Alexandrina, Murray Mouth Barrages, S.A.

Description

Lorica prominently heart-shaped, rarely conical, circular in cross-section. Wall about 2 μm thick, formed by agglommerated mineral particles 1–5 μm in size, remains of diatom shells sometimes present in wall between mineral particles. Collar evident by light microscopy, thinner than lorica wall (<1 μm thick), covered with single layer of mineral particles (quartz?). Under scanning electron microscope, division between collar and lorica not clear



Figs 17–21. *Stenosemella lacustris*, sp. nov. (**17, 18**) scanning electron micrographs and (**19–21**) light micrographs of lorica: **17**, lateral view; **18**, detail or lorica (arrow indicates remains of diatom shell); **19–21**, lateral views (arrows mark boundary of collar). Scale bars, (**17, 18**) 15 μm, (**19–21**) 10 μm.

owing to apparent continuity of covering. Conversely, two to three flat rings seen on inner collar wall under scanning electron microscope not visible under light microscope.

Body of ciliate vase-shaped, about 50% contractile, only slightly longer than lorica, attached to posterior end of lorica by short stalk. Macronuclear segments ellipsoidal, located close together in centre of cell. Micronucleus and contractile vacuole not observed. Five to six myonemes arising from stalk, posterior end with ampoule-like swellings. Pellicle soft and flexible. Endoplasm colourless, hyaline, containing few granules and food vacuoles with unidentified content.

Somatic and oral infraciliature very complicated, therefore description best presented as illustrations rather than tedious description (six different views given in Figs 11*a*, 11*b*, 11*e–h*). Kinety arrangement similar in many respects to that of *Codonella cratera* and particularly *Tintinnopsis baltica* (Foissner and Wilbert 1979; Laval-Peuto and Brownlee 1986). Monokinetids and dikinetids present. Dikinetids at beginning of somatic kineties bearing 20 μm long cilia which are obliquely spread and very conspicuous *in vivo* (Fig. 11*a*).

Differential Diagnosis

S. lacustris closely fits the diagnostic characters given for the genus by Jörgenson (1924)—'Lorica . . . strongly covered with agglutinated bodies . . . Round the mouth is developed a low collar, thin-walled . . . and less closely covered with agglutinated bodies than the rest of the lorica, in rare cases perhaps consisting of two or three narrow turns of a helicoidal band'. This statement is very important because until now the genus *Stenosemella* consisted entirely of marine species (Kofoid and Campbell 1929; Foissner and Wilbert 1979). The inconspicuous appearance of the collar of *S. lacustris* under the scanning electron microscope is similar to that of the marine species *S. oliva* and *S. nivalis* (Hedin 1974; Gold and Morales 1976) owing to the almost complete covering with mineral particles. In contrast, the collars of *S. ventricosa* and *S. producta* are much more conspicuous because they are very hyaline and perforated by fenestrae (Hedin 1974; Gold and Morales 1976; Gold 1980).

The lorica of *S. lacustris* is very similar in size and shape to those of the marine species *S. nivalis* and *S. pacifica* (cf. Kofoid and Campbell 1929; Hedin 1974). However, the infraciliature of these species has not yet been described, therefore the single major difference recorded between them and *S. lacustris* to date is that of habitat, i.e. marine versus freshwater. Nevertheless we consider this difference to be of great significance and have erected a new species accordingly.

Some similarities also exist between the lorica of *S. lacustris* and those of various *Tintinnopsis* spp., particularly the freshwater species *T. rioplatensis* Souto, 1973. However, this species has been described as not having a collar and its dimensions (55–68 × 31–49 μm) also differ from those of *S. lacustris* (40–48 × 42–50 μm). Nevertheless, Souto (1973) did observe two individuals with a 5 μm high collar, e.g. 'Endos ejemplares se obervó un estrechamiento anterior que marcaba una especie de cuello rudimentario de aproximadamente 5 μm'. It is not known whether these individuals belonged to the same or a different species. Further comparisons cannot be made because the infraciliature of *T. rioplatensis* has not yet been described.

Order **HYPOTRICHIDA** Stein

Family **OXYTRICHIDAE** Ehrenberg

Genus ***Oxytricha*** Bory de St Vincent

Oxytricha australis, sp. nov.

(Figs 22*a–e*; Table 12)

Diagnosis. Size *in vivo* 80–140 × 30–45 μm, yellow-green subpellicular granules, average of seven caudal cirri in first, second and fourth dorsal kineties, six to seven dorsal kinety, average of 39 adoral membranelles.

Type locality. Small pond in metropolitan Perth, W.A.

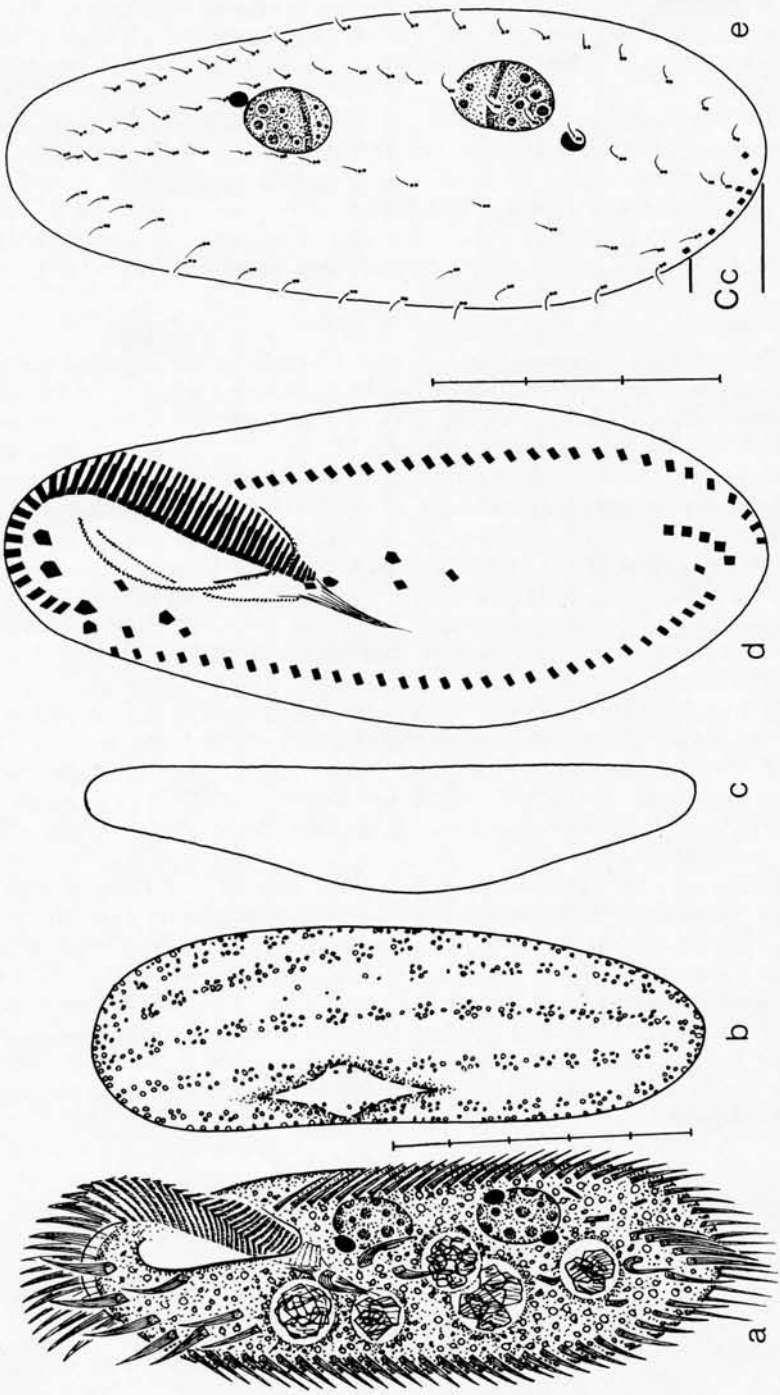


Fig. 22. *Oxytricha australis*, sp. nov. following (*a–c*) live observation and (*d*, *e*) protargol-impregnation: *a*, ventral view; *b*, dorsal view with subpellicular granules; *c*, side view; *d*, infraciliature, ventral view; *e*, infraciliature, dorsal view (Cc, caudal cirri). Scale bar divisions, 10 μm.

Description

Shape prolate ellipsoidal, posterior third sometimes smaller than anterior third, somewhat flattened (up to 2 : 1), ventral side flat, dorsal side convex. Slightly contractile, very flexible while scrabbling amongst detritus. Macronuclear segments ellipsoidal, located close to wide apart in middle third of body to left of midline. Micronuclei spherical, compact, refractile bright appearance *in vivo*, located close to macronuclear segments. Contractile vacuole located slightly above middle of body, two short canals evident during diastole. Pellicle colourless, very flexible. Subpellicular granules located mainly along rows of cirri and dorsal kineties, arranged in small groups, yellow-green to orange-green, give body greenish coloration when viewed at low magnification, do not impregnate with protargol. Endoplasm colourless, well-fed individuals containing many food vacuoles, numerous cloudy spheres 1–2 μm in diameter and several yellowish crystals 2–4 μm in size in posterior half of body. Feeding in culture on rice starch and bacteria.

Marginal cirri approximately 10 μm long, transverse and anterior frontal cirri approximately 18 μm long. Marginal rows widely separated posteriorly, right row ending near transverse cirri, left row ending at posterior end at midline. Gap between posterior ends of marginal rows filled with caudal cirri, appearing *in vivo* as conspicuous seam or hem. Arrangement of ventral cirri typical for genus but cirri unusually variable in number, therefore difficult to describe any individual as 'typical'.

Adoral zone of membranelles markedly developed, base of largest membranelle about 7 μm long *in vivo*, oxytrichid in structure. Buccal cavity large and deep, anterior end curved similar to *Steinia* spp. Paroral and endoral membranes curved, separated from each other and crossing over.

Dorsal cilia about 2 μm long *in vivo*. Three (sometimes four) unshortened dorsal kineties to right of midline. First and second kinety each with two caudal cirri, fourth kinety markedly shortened anteriorly and most with four (sometimes 2 or 3) caudal cirri. Fifth kinety ending approximately in middle of body. Sixth kinety consisting of only 2–5 basal body pairs. Fourth kinety probably arising by fragmentation of third dorsal kinety (cf. Foissner and Adam 1983).

Table 12. Biometric characterisation of *Oxytricha australis*, sp. nov.

Data based on protargol-impregnated specimens and all measurements in μm

Character	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	81·0	84·0	8·9	11·5	66	95	12
Body, width	31·4	32·0	4·5	14·4	22	29	12
Adoral membranelles, No.	39·0	39·0	3·6	9·3	30	44	12
Adoral zone of membranelles, length	31·1	31·5	2·7	8·8	27	35	12
Macronuclear segments, No.	2·0	2·0	–	–	2	2	12
Macronuclear segment, length	11·7	11·0	2·3	19·8	8	17	12
Macronuclear segment, width	8·4	8·0	1·3	15·6	7	11	12
Distance between macronuclear segments	10·5	10·5	4·2	40·3	3	18	12
Micronuclei, No.	3·1	3·5	1·1	35·2	1	4	12
Micronucleus, length	2·9	2·8	0·2	7·9	2·6	3·5	12
Micronucleus, width	2·8	2·8	0·3	10·6	2·4	3·5	12
Left marginal row, No. cirri	28·2	28·0	2·5	8·8	24	32	12
Right marginal row, No. cirri	29·5	29·5	3·9	13·3	24	38	12
Enlarged frontal cirri, No.	3·0	3·0	–	–	3	3	12
Buccal cirri, No.	1·0	1·0	–	–	1	1	12
Ventral cirri, No.	4·0	4·0	–	–	4	4	12
Postoral ventral cirri, No.	4·3	4·0	1·6	36·0	3	7	12
Transverse cirri, No.	5·2	5·0	0·6	11·8	4	6	12
Ventral cirri near transverse cirri, No.	1·7	2·0	0·2	35·5	1	3	12
Caudal cirri, No.	7·5	8·0	0·6	8·6	6	8	12
Dorsal kineties, No.	6·3	6·0	0·5	7·3	6	7	12

Differential Diagnosis

The subpellicular granules and dorsal infraciliature of *O. australis* is similar to that of the terrestrial species *O. granulifera* Foissner and Adam 1983 except that its granules are colourless and it only has five dorsal kineties. The coloration of the subpellicular granules of *O. australis* is similar to that of *Holosticha multistilata* and, in fact, these species are easily confused by superficial live observation. The large number of caudal cirri is unusual and only one other species in the genus has a similar number, namely *O. planctonica* (cf. Wilbert 1986). However, an increased number of caudal cirri is typical for the Family Oxytrichidae *sensu lato*, e.g. *Paraurostyla weissei* (Wirnsberger *et al.* 1986).

Genus *Urosomoida* Hemberger

Urosomoida perthensis, sp. nov.

(Figs 23*a–e*; Table 13)

Diagnosis. Size *in vivo* 50–70×20–30 μm, three transverse cirri, dorsal cilia 3 μm long, single micronucleus located between both macronuclear segments, average of 17 adoral membranelles.

Type locality. Small pond in metropolitan Perth, W.A.

Description

Shape with little variation, prolate ellipsoidal, ends markedly narrowed. Slightly flattened, ventral side flat, dorsal side convex. Body not contractile but very supple. Macronuclear segments spherical to slightly ellipsoidal, located in middle of cell to left of midline. Large micronucleus, spherical to ellipsoidal, located between or next to macronuclei. Contractile vacuole approximately in middle of body, without visible canals. Pellicle colourless, very flexible, without subpellicular granules. Endoplasm colourless, heavily granulated. Feeding in culture on rice starch and bacteria.

Infraciliature typical for genus. Cirri about 15 μm long and large in relation to body size. Marginal rows separated posteriorly, ending next to transverse cirri. Caudal cirri large, widely separated, inserted to left of midline. Adoral zone of membranelles short, bases of

Table 13. Biometric characteristation of *Urosomoida perthensis*, sp. nov.

Data based on protargol-impregnated specimens and all measurements in μm

Characer	$\bar{x}$	M	SD	CV	Min	Max	n
Body, length	42·6	42·0	4·4	10·2	38	51	10
Body, width	18·8	19·0	2·1	11·2	15	22	10
Adoral membranelles, No.	16·6	16·5	1·0	5·8	15	18	10
Adoral zone of membranelles, length	14·1	14·0	1·2	8·5	12	16	10
Macronuclear segments, No.	2·0	2·0	–	–	2	2	10
Macronuclear segment, length	7·3	7·0	0·6	7·6	7	8·4	10
Macronuclear segment, width	5·7	6·0	0·4	7·2	5	6	10
Micronuclei, No.	1·0	1·0	–	–	1	1	10
Micronucleus, length	2·7	2·8	0·1	4·9	2·5	2·8	10
Micronucleus, width	2·4	2·5	0·3	10·8	2·1	2·8	10
Left marginal row, No. cirri	16·4	16·0	2·1	12·6	14	21	10
Right marginal row, No. cirri	19·5	20·0	1·9	9·7	17	22	10
Enlarged frontal cirri, No.	3·0	3·0	–	–	3	3	10
Buccal cirri, No.	1·0	1·0	–	–	1	1	10
Ventral cirri, No.	4·0	4·0	–	–	4	4	10
Postoral ventral cirri, No.	3·0	3·0	0·0	0·0	3	4	10
Transverse cirri, No.	3·0	3·0	–	–	3	3	10
Ventral cirri near transverse cirri, No.	2·0	2·0	–	–	2	2	10
Caudal cirri, No.	3·0	3·0	–	–	3	3	10
Dorsal kineties, No.	4·0	4·0	–	–	4	4	10

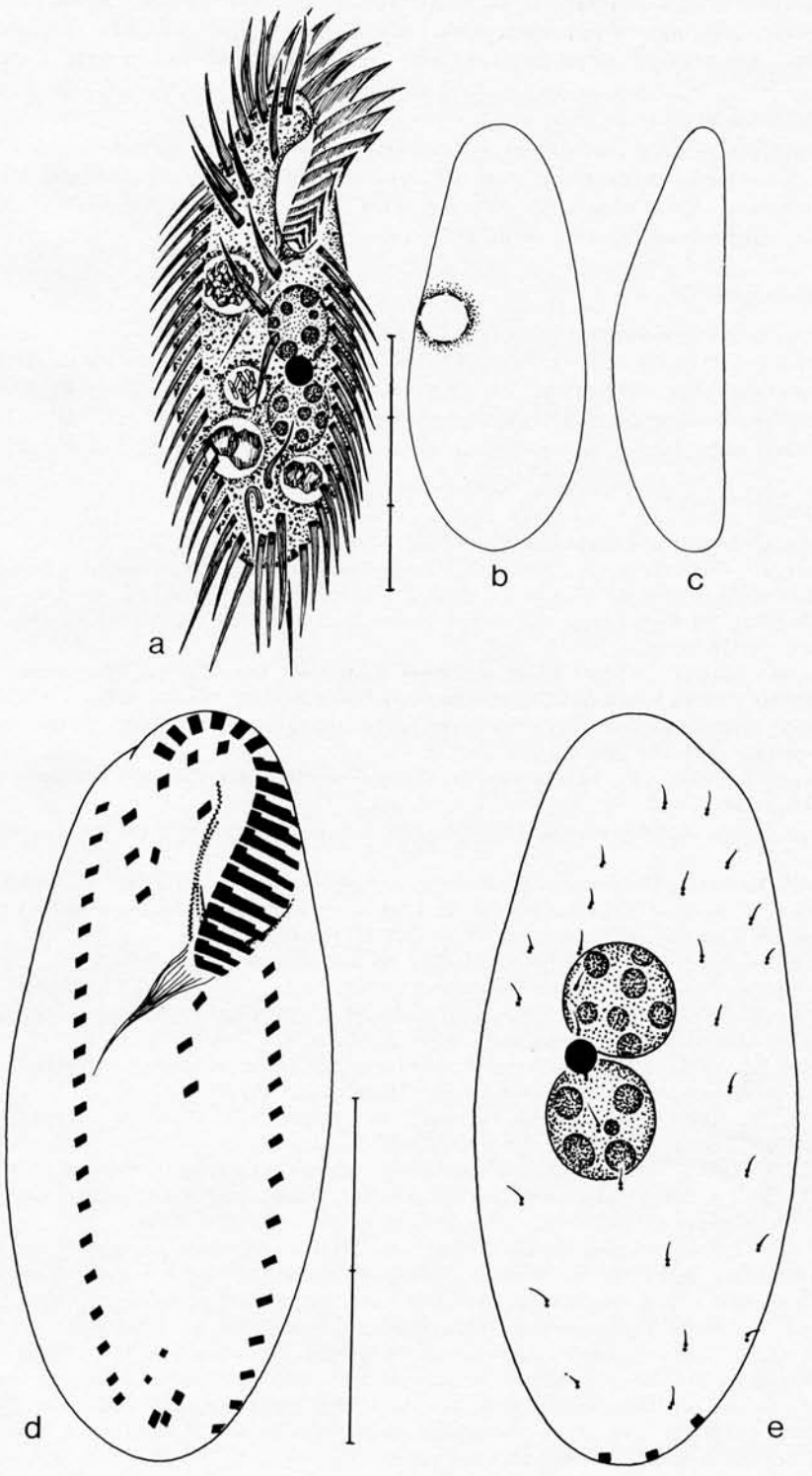


Fig. 23. *Urosomoida perthensis*, sp. nov. following (*a–c*) live observation and (*d*, *e*) protargol-impregnation: *a*, ventral view; *b*, dorsal view of broad individual; *c*, lateral view; *d*, infraciliature, ventral view; *e*, infraciliature, dorsal view. Scale bar divisions, 10 μm.

longest membranelles about 4 μm long, oxytrichid in structure. Buccal cavity small but deep, right anterior margin raggedly curved to adoral zone of membranelles. Paroral and endoral membranes lying almost over each other. Fourth dorsal kinety markedly shortened. Gap evident in anterior half of first dorsal kinety due to loss of about two basal body pairs.

Differential Diagnosis

U. perthensis is the first species in this genus to contain only one micronucleus located between the macronuclear segments (cf. Foissner 1982; Hemberger 1985). Numerous *Oxytricha* spp. have some similarities but they all have five transverse cirri and many have very long dorsal cilia (cf. Kahl 1932; Foissner 1982).

Acknowledgments

This study was supported in part by the Australian Biological Resources Study and the 'Fonds zur Förderung der wissenschaftlichen Forschung' (Project P 5889). The authors wish to thank Karin Bernatzky, Dr Christine Lenglacher and Wolfgang Petz (Salzburg University) for their excellent technical assistance and Professor K. G. Grell (Tübingen University) for collecting and providing specimens from Perth, W.A.

References

Andrews, E. A. (1950). Folliculinids in Australia. *Trans. Am. Microsc. Soc.* **69**, 413–21.

Augustin, H., Foissner, W., and Adam, H. (1987). Revision of the genera *Acineria*, *Trimyema* and *Trochiliopsis* (Protozoa, Ciliophora). *Bull. Br. Mus. Nat. Hist. (Zool.)* **52**, 197–224.

Bary, B. M. (1950). Four new species of fresh-water ciliates from New Zealand. *Zool. Publ. Victoria Univ. Coll.* **2**, 1–19.

Berger, H., Foissner, W., and Adam, H. (1984). Taxonomie, Biometrie und Morphogenese einiger terricoler Ciliaten (Protozoa : Ciliophora). *Zool. Jb. Syst.* **111**, 339–67.

Claparède, É., and Lachmann, J. (1859). Études sur les infusoires et les rhizopodes. *Mém. Inst. Natn. Génev.* **6** (1858), 261–482.

Corliss, J. O. (1953). Silver impregnation of ciliated protozoa by the Chatton–Lwoff technic. *Stain Technol.* **28**, 97–100.

Dragesco, J., and Dragesco-Kerneis, A. (1986). Ciliés libres de l'Afrique intertropicale. *Faune Tropicale* **26**, 1–559.

Dujardin, F. (1841). 'Histoire naturelle des zoophytes. Infusoires.' (Suites à Buffon: Paris.)

Ehrenberg, C. G. (1833). Dritter Beitrag zur Erkenntniss großer Organisation in der Richtung des kleinsten Raumes. *Abh. Dt. Akad. Wiss. Berl.* (1833), 145–336.

Ehrenberg, C. G. (1838). 'Die Infusionsthierchen als vollkommene Organismen.' (Voss: Leipzig.)

Fauré-Fremiet, E. (1967). Le genre *Cyclogramma* Perty, 1852. *J. Protozool.* **14**, 456–64.

Foissner, W. (1976). Erfahrungen mit einer trockenen Silberimprägnationsmethode zur Darstellung argyrophiler Strukturen bei Protisten. *Verh. Zool.-Bot. Ges. Wien* **115**, 68–79.

Foissner, W. (1979). Methylgrün-Pyronin: Seine Eignung zur supravitalen Übersichtsfärbung von Protozoen, besonders ihrer Protrichocysten. *Mikroskopie* **35**, 108–15.

Foissner, W. (1982). Ökologie und Taxonomie der Hypotrichida (Protozoa : Ciliophora) einiger österreichischer Böden. *Arch. Protistenkd.* **126**, 19–143.

Foissner, W. (1983). Taxonomische Studien über die Ciliaten des Großglocknergebietes (Hohe Tauern, Österreich). I. Familien Holophryidae, Prorodontidae, Plagiocampidae, Colepidae, Enchelyidae und Lacrymariidae nov. fam. *Annln. Naturh. Mus. Wien* **84/B** (1980), 49–85.

Foissner, W. (1984*a*). Infraciliatur, Silberliniensystem und Biometrie einiger neuer und wenig bekannter terrestrischer, limnischer und mariner Ciliaten (Protozoa : Ciliophora) aus den Klassen Kinetofragminophora, Colpodea und Polyhymenophora. *Stapfia, Linz* **12**, 1–165.

Foissner, W. (1984*b*). Taxonomie und Ökologie einiger Ciliaten (Protozoa, Ciliophora) des Saprobiensystems. I: Genera *Litonotus*, *Amphileptus*, *Opisthodon*. *Hydrobiologia* **119**, 193–208.

Foissner, W. (1985). Morphologie und Infraciliatur der Genera *Microthorax* and *Stammeridium* und Klassifikation der Microthoracina Jankowski, 1967 (Protozoa : Ciliophora). *Zool. Anz.* **214**, 33–53.

Foissner, W. (1987*a*). Soil protozoa: fundamental problems, ecological significance, adaptations in ciliates and testaceans, bioindicators and guide to the literature. *Progr. Protistol.* **2**, 1–144.

Foissner, W. (1987*b*). Miscellanea nomenclatorica ciliatea (Protozoa : Ciliophora). *Arch. Protistenkd.* **133**, 219–35.

Foissner, W., and Adam, H. (1983). Morphologie und Morphogenese des Boden ciliaten *Oxytricha granulifera* sp. n. (Ciliophora, Oxytrichidae). *Zool. Scr.* **12**, 1–11.

Foissner, W., and Foissner, I. (1985). Fine structure of the soil ciliates *Enchelydium polynucleatum* and *Fuscheria terricola* (Ciliophora, Haptorida). *VII Int. Congr. Protozool., Nairobi*, Abstr. 177, 97.

Foissner, W., and Wilbert, N. (1979). Morphologie, Infraciliatur und Ökologie der limnischen Tintinnina: *Tintinnidium fluviatile* Stein, *T. pusillum* Entz, *Tintinnopsis cylindrata* Daday und *Codonella cratera* (Leidy) (Ciliophora, Polyhymenophora). *J. Protozool.* **26**, 90–103.

Fryd-Versavel, G., Iftode, F., and Dragesco, J. (1975). Contribution à la connaissance de quelques ciliés gymnostomes. II. Prostomiens, Pleurostomiens: morphologie, stomatogenese. *Protistologica* **11**, 509–30.

Giese, A. C. (1973). '*Blepharisma*. The biology of a light-sensitive protozoan.' (Stanford Univ. Press: Stanford.)

Gold, K. (1980). SEM studies on the lorica of various Tintinnina. *Scanning Electron Microscopy/ 1980/III, SEM Inc., AMF O'Hare (Chicago), IL 60666, USA*, 537–41.

Gold K., and Morales, E. A. (1976). Studies on the sizes, shapes and the development of the lorica of agglutinated Tintinnida. *Biol. Bull.* **150**, 377–92.

Hedin, H. (1974). Tintinnids on the Swedish west coast. *Zoon* **2**, 123–33.

Hemberger, H. (1985). Neue Gattungen und Arten hypotricher Ciliaten. *Arch. Protistenkd.* **130**, 397–417.

Hirshfield, H. I., Isquith, I. R., and Bhandary, A. V. (1965). A proposed organization of the genus *Blepharisma* Perty and description of four new speices. *J. Protozool.* **12**, 136–44.

Jörgensen, E. (1924). Mediterranean Tintinnidae. *Rep. Danish Oceanogr. Exped., 1908–1910, Medit.* **2** (Biol.), 1–110.

Kahl, A. (1930). Urtiere oder Protozoa. I: Wimpertiere oder Ciliata (Infusoria). 1. Allgemeiner Teil und Prostomata. *Tierwelt Dtl.* **18**, 1–180.

Kahl, A. (1931). Urtiere oder Protozoa. I: Wimpertiere oder Ciliata (Infusoria). 2. Holotricha außer den im 1. Teil behandelten Prostomata. *Tierwelt Dtl.* **21**, 181–398.

Kahl, A. (1932). Urtiere oder Protozoa. I: Wimpertiere oder Ciliata (Infusoria). 3. Spirotricha. *Tierwelt Dtl.* **25**, 399–650.

Kane, J. R. (1965). The genus *Lagenophrys* Stein, 1852 (Ciliata, Peritricha) on Australasian Parastacidae. *J. Protozool.* **12**, 109–22.

Kofoid, C. A., and Campbell, A. S. (1929). A conspectus of the marine and fresh-water ciliata belonging to the suborder Tintinnoinea, with descriptions of new species principally from the Agassiz expedition to the eastern tropical Pacific 1904–1905. *Univ. Calif. Publs. Zool.* **34**, 1–403.

Laval-Peuto, M., and Brownlee, D. C. (1986). Identification and systematics of the Tintinnina (Ciliophora): evaluation and suggestions for improvement. *Ann. Inst. Océanogr.* **62**, 69–84.

Maskell, W. M. (1886). On the freshwater infusoria of the Wellington district. *Trans. Proc. N.Z. Inst.* **19**, 44–61.

Maskell, W. M. (1887). On the freshwater infusoria of the Wellington district. *Trans. Proc. N.Z. Inst.* **20**, 3–19.

Müller, O. F. (1773). 'Vermium terrestrium et fluviatilium, seu animalium infusorium, helminthicorum et testaceorum, non marinorum, succincta historia.' (Heineck & Faber: Havniae & Lipsiae.)

Müller, O. F. (1786). 'Animalcula infusoria fluviatilia et marina, quae detexit, systematice descripsit et ad vivum delineari curavit.' (Mölleri: Hauniae.)

Nanney, D. L., and McCoy, J. W. (1976). Characterization of the species of the *Tetrahymena pyriformis* complex. *Trans. Am. Microsc. Soc.* **95**, 664–82.

Niessen, R. (1984). Taxonomische und ökologische Untersuchungen an Ciliaten aus Salzböden. *Diplomarbeit Univ. Bonn*, 102 pp.

Noland, L. E. (1925). A review of the genus *Coleps* with descriptions of two new species. *Trans. Am. Microsc. Soc.* **44**, 3–13.

Post, F. J., Borowitzka, L. J., Borowitzka, M. A., Mackay, B., and Moulton, T. (1983). The protozoa of a Western Australian hypersaline lagoon. *Hydrobiologia* **105**, 95–113.

Schewiakoff, W. (1892). Über die geographische Verbreitung der Süsswasser-Protozoën. *Verh. Naturh.-Med. Ver. Heidelb. (N.S.)* **4**, 544–67.

Schewiakoff, W. (1893). Über die geographische Verbreitung der Süsswasser-Protozoën. *Zap. Imp. Akad. Nauk SSSR (Sér. 7)* **41**, 1–201.

Schewiakoff, W. (1896). Organization and classification of the infusoria Aspirotricha (*Holotricha auctorum*). *Zap. Imp. Akad. Nauk SSSR (Sér. 8)* **4**, 1–395. [In Russian.]

Schönborn, W., Foissner, W., and Meisterfeld, R. (1983). Licht- und rasterelektronenmikroskopische Untersuchungen zur Schalenmorphologie und Rassenbildung bodenbewohnender Testaceen (Protozoa : Rhizopoda) sowie Vorschläge zur biometrischen Charakterisierung von Testaceen-Schalen. *Protistologica* **19**, 553–66.

Souto, S. (1973). Contribucion al conocimiento de los tintinnidos de agua dulce de la republica Argentina. I. Rio de la Plata y delta del Parana. *Physis* **32**, 249–54.

Stout, J. D. (1984). The protozoan fauna of a seasonally inundated soil under grassland. *Soil Biol. Biochem.* **16**, 121–5.

Suzuki, S. (1954). Taxonomic studies on *Blepharisma undulans* Stein with special reference to the macronuclear variation. *J. Sci. Hiroshima Univ.* **15**, 205–20.

Tucolesco, J. (1962). Protozoaires des eaux souterraines. I. 33 espèces nouvelles d'infusoires des eaux cavernicoles roumaines. *Annals. Spéléol.* **17**, 89–105.

Vuxanovici, A. (1962). Contributii la sistematica ciliatelor (Nota III). *Studii Cerc. Biol. (Biol. Anim.)* **14**, 549–73.

Wilbert, N. (1986). Beitrag zur Morphologie und Ökologie einiger planktischer Ciliaten aus dem Poppelsdorfer Weiher in Bonn (BRD). *Arch. Protistenkd.* **131**, 59–69.

Wirnsberger, E., Foissner, W., and Adam, H. (1986). Biometric and morphogenetic comparison of the sibling species *Stylonychia mytilus* and *S. lemnae*, including a phylogenetic system for the oxytrichids (Ciliophora, Hypotrichida). *Arch. Protistenkd.* **132**, 167–85.

Manuscript received 17 August 1987; accepted 12 May 1988