Denisia 13 | 17.09.2004 | 369-382

Some new ciliates (Protozoa, Ciliophora) from an Austrian floodplain soil, including a giant, red "flagship", *Cyrtohymena* (*Cyrtohymenides*) *aspoecki*[1] nov. subgen., nov. spec.

W. Foissner

Abstract: One hundred and three ciliate taxa were found in soil from a single site of the Enns/Danube River floodplain in Upper Austria. Species were cultivated with the non-flooded Petri dish method and identified in vivo and after protargol impregnation. At least three of the 103 species were undescribed, viz., *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* nov. subgen., nov. spec., *Bakuella pampinaria oligocirrata* nov. subspec., and *Podophrya bivacuolata* nov. spec. The new subgenus *Cyrtohymenides* comprises large *Cyrtohymena* species with ≥ than three dorsomarginal kineties. *Cyrtohymena australis* Foissner 1995 is transferred to the new subgenus: *Cyrtohymena* (*Cyrtohymenides*) *australis* (Foissner 1995) nov. comb. *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* is a giant (300 x 140 µm), reddish ciliate not found in many other floodplain soils globally. Thus, it is probably a Laurasian endemic. *Bakuella pampinaria oligocirrata* differs from *B. pampinaria pampinaria* by the lower number of midventral pairs (4 vs. 9) and cirri comprising frontal row (1 vs. 2). *Podophrya bivacuolata* has two contractile vacuoles, of which one is in the swarmer's posterior end. A Hungarian population of *P. halophila* Kahl 1934 is described and compared, inter alia, with *P. bivacuolata*. This study adds evidence to soil ciliate endemism: of 128 new ciliate species found by Foissner et al. (2002) in Namibian soils, only one occurred in the Enns floodplain soil.

Key words: *Bakuella pampinaria oligocirrata* nov. subspec., biodiversity, *Cyrtohymenides* nov. subgen., Laurasian endemics, *Podophrya bivacuolata* nov. spec.

Introduction

Protozoan biodiversity and endemism are difficult to discern because (i) they are of microscopic size and thus difficult to recognize and identify, (ii) few talented and experienced scientists worked on alpha taxonomy because it is outside the mainstream, and (iii) many species are encysted and thus invisible most of their life (Foissner 2005). These peculiarities cause pronounced differences in the estimation of, for instance, free-living ciliate diversity: 3,000 according to Finlay (2001) and 30,000 according to Foissner et al. (2002).

Floodplain soils are impressive examples for biodiversity of free-living ciliates (Foissner et al. 2002, 2004). Usually, about 100 taxa are found in a kilogram of soil from a single site, and 5–25% of the species recognized are undescribed. This is emphasized by the present study: 103 taxa were found at a single site of the Enns/Danube River floodplain. Nine of these species could not be identified, but only three developed sufficient abundances to be studied in detail.

[1] Dedicated to Univ.-Prof. Dr. Horst Aspöck on the occasion of his 65th birthday.

Material and methods

See Steinberger & Thaler (1994) for detailed site description (site A2 in their paper). Briefly, samples were collected near the junction of the Enns River and the Danube River (E14° 30 N48°14'), that is, about 17 km east of the town of Linz, the capital of Upper Austria. Here, the floodplains of the two rivers merge and still bear an almost original vegetation, mainly composed of *Salix alba*, *Alnus glutinosa*, *Populus alba*, *Fraxinus excelsior*, *Sambucus nigra*, and *Urtica dioica*. The greyish, loamy soil was covered by mull humus and a thin litter layer. Samples were taken on 11.5., 2.7., and 13.8.1994 from the upper 0–5 cm of a rarely flooded, about 100 m² large area at the margin of the forest.

Sampling, sample processing, and taxonomic methods follow Foissner (1991) and Foissner et al. (2002). Briefly, the samples were processed with the non-flooded Petri dish method and species identified in vivo and after protargol impregnation. The species list is a composite of the three sampling occasions.

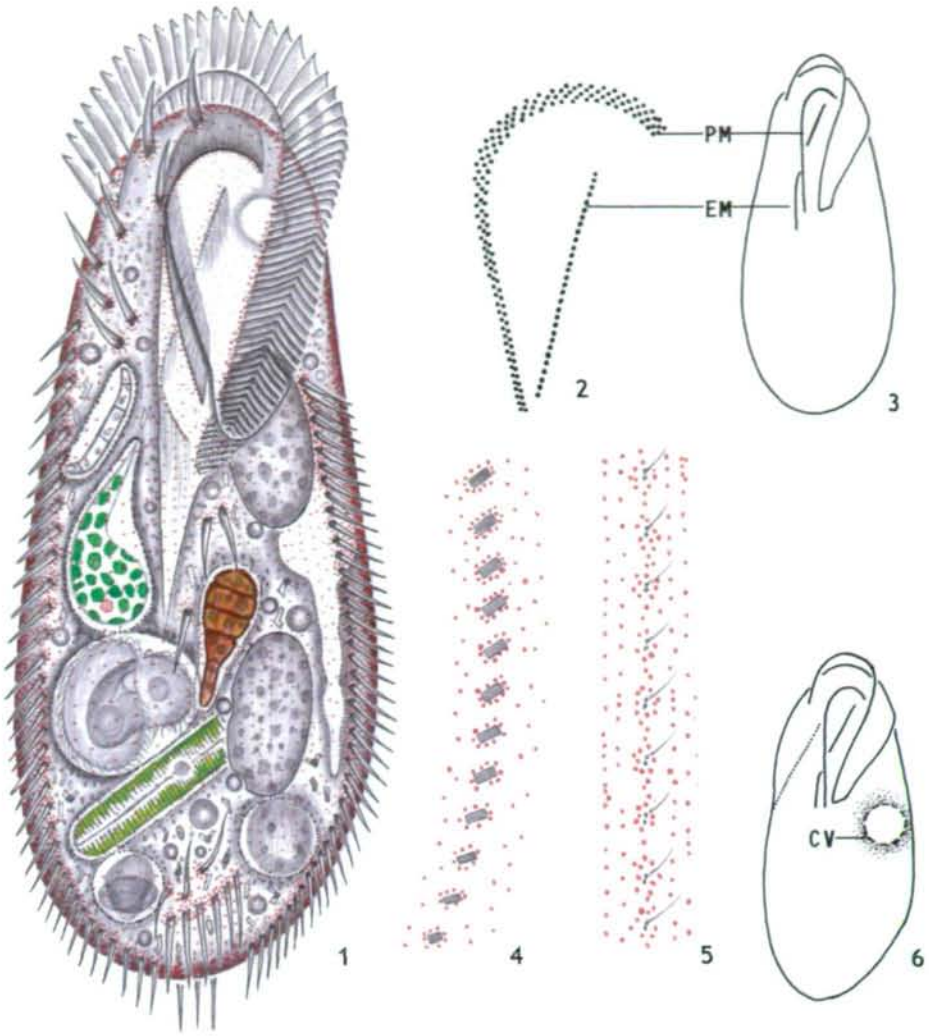


Fig. 1–6: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* from life (1, 3–6) and after protargol impregnation (2). 1: Ventral view of a representative, 300 µm long specimen containing a variety of food items, such as an *Euglena*, a diatom, colourless and brown fungal spores, ciliates, and colourless flagellates. The cell is brick red, especially at the margins, due to red cortical granules, a main feature of the species. Note the large oral apparatus with its deep buccal cavity. The anterior margin of the buccal cavity is semicircularly curved, which is the main feature of the genus *Cyrtohymena*. 2: Anterior portion of paroral and endoral membrane. The paroral is composed of minute ciliary rows in the curved anterior portion and of dikinetids in the straight posterior half (cp. figures 24–27). The endoral membrane consists of a single row of cilia. 3, 6: Shape variants. 4, 5: The red cortical granules accumulate around the bases of the cirri (4) and dorsal bristles (5). CV – contractile vacuole, EM – endoral membrane, PM – paroral membrane.

Results

Faunistics

The following 103 taxa were found at the three sampling occasions mentioned in the material and methods section (for nomenclature and combining authors, see FOISSNER 1998 and FOISSNER et al. 2002): *Arcuospathidium cultriforme cultriforme* (PENARD), *A. cultriforme scalpriforme* (KAHL), *A. muscorum* (DRAGESCO & DRAGESCO-KERNÉIS), *A. namibiense* FOISSNER, AGATHA & BERGER, *Bakuella pampinaria oligocirrata* nov. sspec., *Blepharisma bimicronucleatum* VILLENEUVE-BRACHON, *B. hyalinum* PERTY, *B. steinii* KAHL, *Bresslaua vorax* KAHL, *Bryometopus pseudochilodon* KAHL, *Bryophyllum loxophylliforme* (?) KAHL, *Chilodonella uncinata* (EHRENBERG), *Cinetochilum margaritaceum* (EHRENBERG), *Circinella filiformis* (FOISSNER), *Colpoda aspera* KAHL, *C. cucullus* MÜLLER, *C. ecaudata* (LIEBMANN), *C. henneguyi* FABRE-DOMERGUE, *C. inflata* (STOKES), *C. maupasi* ENRIQUES, *C. steinii* MAUPAS, *C. variabilis* FOISSNER, *Cyrtohymena* (*Cyrtohymena*) *citrina* (BERGER & FOISSNER), *C.* (*C.*) *quadrinucleata* (DRAGESCO & NJINÉ), *C.* (*C.*) *tetracirrata* (GELLÉRT), *C.* (*Cyrtohymenides*) *aspoecki* nov. spec., *Cyrtolophosis mucicola* STOKES, *Dileptus* sp., *Drepanomonas exigua bidentata* FOISSNER, *D. revoluta* PENARD, *Enchelys geleii* (FOISSNER), *E. polynucleata* (FOISSNER), *Enchelyodon* sp., *Epispathidium amphoriforme* (GREEFF), *E. ascendens* (WENZEL), *E. terricola* FOISSNER, *Euplotopsis muscicola* (KAHL), *Frontonia depressa* (STOKES), *Fuscheria terricola* BERGER, FOISSNER & ADAM, *Gastrostyla steinii* ENGELMANN, *Gonostomum affine* (STEIN), *Grossglockneria hyalina* FOISSNER, *Halteria grandinella* (MÜLLER), *Hemiamphisiella terricola* FOISSNER, *Hemisincirra gellerti verrucosa* (FOISSNER & SCHADE), *H. gracilis* (FOISSNER), *H. inquieta* HEMBERGER, *Holosticha adami* FOISSNER, *H. stueberi* FOISSNER, *H. tetracirrata* (BUITKAMP & WILBERT), *Holostichides chardezi* FOISSNER, *Homalogastra setosa* KAHL, *Kahliella simplex* (HORVATH), *Kahlilembus attenuatus* (KAHL), *Keronella gracilis* WIACKOWSKI, *Lamtostyla hyalina* (BERGER, FOISSNER & ADAM), *Leptopharynx costatus* MERMOD, *Litonotus fusidens* (KAHL), *L. muscorum* (KAHL), *Microthorax simulans* (KAHL), *Mykophagophrys terricola* (FOISSNER), *Nassulides pictus* (GREEFF), *Nivaliella plana* FOISSNER, *Notohymena antarctica* FOISSNER, *Odontochlamys gouraudi* CERTES, *Opercularia curvicaule* (PENARD), *Oxytricha granulifera* FOISSNER & ADAM, *O. opisthomuscorum* FOISSNER et al., *O. setigera* STOKES, *O. siseris* VUXANOVICI, *Paracineta lauterborni* SONDHEIM, *Parafurgasonia sorex* (PENARD), *P. terricola* FOISSNER, *Paramphisiella acuta* FOISSNER, *Platyophrya macrostoma* FOISSNER, *P. vorax* KAHL, *Plesiocaryon elongatum* (SCHEWIAKOFF), *Podophrya bivacuolata* nov. spec., *Protocyclidium muscicola* (KAHL), *Pseudocarchesium claudicans* (PENARD), *Pseudochilodonopsis mutabilis* FOISSNER, *P. polyvacuolata* FOISSNER & DIDIER, *Pseudocohnilembus putrinus*

(KAHL), *Pseudocyrtolophosis alpestris* FOISSNER, *Pseudoholophrya terricola* BERGER, FOISSNER & ADAM, *Pseudoplatyophrya nana* (KAHL), *P. saltans* FOISSNER, *Pseudovorticella mutans* (?) (PENARD), *Sathrophilus muscorum* (KAHL), *Spathidium spathula* (MÜLLER), *Sterkiella cavicola* (KAHL), *Terricirra livida* BERGER & FOISSNER, *Tetrahymena rostrata* (KAHL), *Trihymena terricola* FOISSNER, *Trithigmostoma bavariensis* (KAHL), *Uroleptus notabilis* (FOISSNER), *Urosoma emarginata* (STOKES), *Urosomoida agiliformis* FOISSNER, *U. agilis* (ENGELMANN), *Urostyla* sp., *Urotricha furcata* SCHEWIAKOFF, *Vorticella astyliformis* FOISSNER, *Wallackia* (?) sp.

103 taxa are a considerable number for a single site, but quite usual for floodplain soils globally (FOISSNER et al. 2002, 2004). The high diversity is caused by ecotone (limnetic and terrestrial transition zone) and disturbance effects (intermediate disturbance hypothesis). At least three out of the 103 taxa are new to science; six other species, most probably also undescribed, were too rare to be studied in detail. A high number of undescribed ciliate species is also typical for floodplain soils because they are heavily under-investigated.

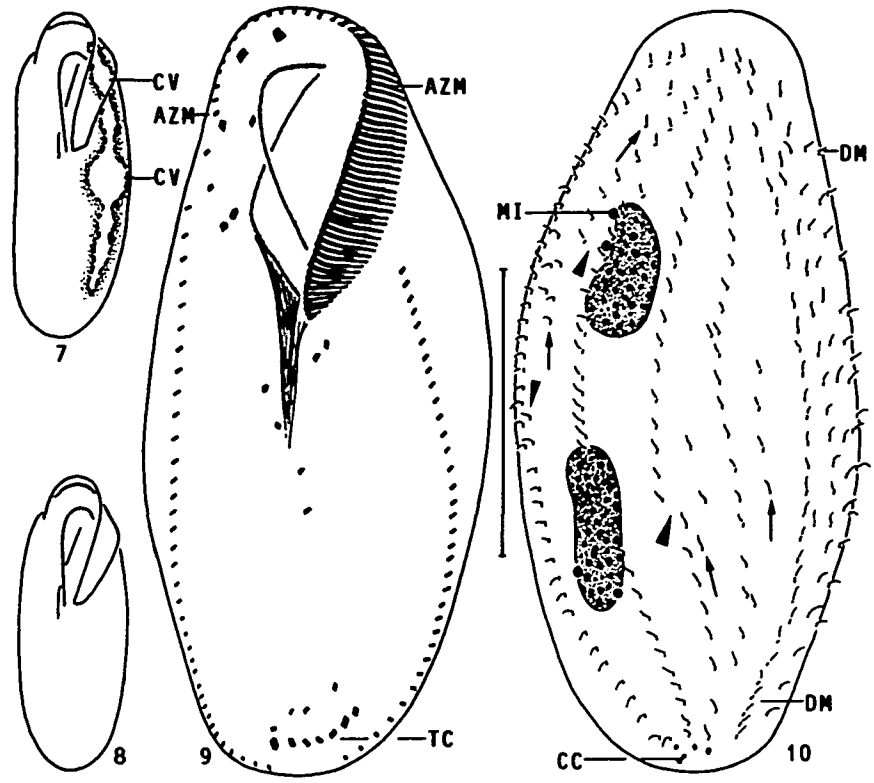


Fig. 7–10: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* from life (7, 8) and after protargol impregnation (WILBERT's method). 7, 8: Ventral views of shape variants. 9, 10: Infraciliature of ventral and dorsal side and nuclear apparatus of holotype specimen, length 270 µm. For detailed labels and a typical oxytrichid cirral pattern, see figures 15 and 17. Note the increased number of postoral, pretransverse, and transverse cirri and the large oral apparatus with the adoral zone of membranelles commencing far subapically at level of the buccal cirrus. The dorsal bristle pattern is rather turbulent, that is, several rows have overlapping breaks (arrowheads) and short (parental?) row fragments (arrows) are interspersed between the long rows. AZM – adoral zone of membranelles, CC – caudal cirri, CV – contractile vacuole, DM – dorsomarginal kineties, MI – micronuclei, TC – transverse cirri. Scale bar 100 µm.

Description and discussion of taxa

Cyrtohymenides nov. subgen.

Diagnosis: Cyrtohymenids with large body size (≥ 250 µm) and ≥ than three dorsomarginal kineties.

Type species: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* nov. spec.

Etymology: Composite of the generic name *Cyrtohymena* and the Greek suffix *ides* (similar to genus *Cyrtohymena*). Masculine gender.

Species assignable: *Cyrtohymena* (*Cyrtohymenides*) *australis* (FOISSNER 1995) nov. comb. (see comparison with related species).

Comparison with related genera (see BERGER 1999 for a comprehensive review of all taxa and features mentioned): The type species and C. (C.) *australis* have a classical cyrtohymenid oral apparatus (paroral membrane strongly curved anteriorly) and general body organization (cortex highly flexible and with coloured granules). Other features are different, viz., the large size (≥ 250 µm vs. ≤ 250 µm), the slightly increased number of fronto-ventral-transverse cirri (~ 20 vs. 18), the paroral membrane (anterior half composed of minute kineties vs. dikinetids), the dorsomarginal kineties (many vs. two; a most important feature because it is not related to body size, see C. *quadrinucleata*), the increased fragmentation of the dorsal kineties during ontogenesis (vs. fragmentation of only row 3), and the partial retention of parental dorsal kinetids (vs. all resorbed). Unfortunately, the two last mentioned features are still doubtful. If they apply, *Cyrtohymenides* may be raised to genus rank.

As concerns several other features, the picture is rather complex because, for instance, the minute kineties comprising the paroral membrane are found also in typical *Cyrtohymena* species, viz., C. (C.) *primicirrata* and C. (C.) *quadrinucleata*. Likewise, an increased number of fronto-ventral-transverse cirri occurs in several large, but otherwise typical oxytrichids, for instance, in *Australocirrus zechmeisterae* FOISSNER et al. 2004.

The general organization (large, highly flexible body and buccal cavity) and the dorsal ciliary pattern and

Table 1. Morphometric data on *Cyrtohymena (Cyrtohymenides) aspoecki*. Upper line: WILBERT's protargol method, size well preserved because specimens slightly under-bleached. Lower line: WILBERT's protargol method, specimens strongly inflated because slightly over-bleached.

Characteristics[1]	x̄	M	SD	SE	CV	Min	Max	n
Body, length	275.3	260.0	43.7	11.3	15.9	230.0	410.0	15
	375.0	370.0	38.7	10.0	10.3	305.0	425.0	15
Body, width	127.5	127.0	12.5	3.2	9.8	105.0	155.0	15
	171.0	170.0	18.5	4.8	10.8	140.0	200.0	15
Body length:width, ratio	2.2	2.2	0.3	0.1	15.9	1.6	3.2	15
	2.3	2.2	0.3	0.1	11.4	1.8	2.8	15
Anterior body end to proximal end of adoral zone, distance	105.6	100.0	17.5	4.5	16.6	82.0	150.0	15
	147.6	147.0	18.8	4.9	12.8	110.0	185.0	15
Body length:length of adoral zone, ratio	2.6	2.6	0.3	0.1	10.0	2.2	3.0	15
	2.6	2.5	0.2	0.1	7.8	2.2	3.0	15
Lowermost transverse cirrus to body end, distance	25.1	23.0	10.5	2.7	41.8	15.0	50.0	15
	31.8	30.0	9.5	2.5	29.8	20.0	55.0	15
Macronucleus nodules, length	51.8	54.0	9.8	2.5	18.9	31.0	71.0	15
	70.9	73.0	11.6	3.0	16.4	53.0	100.0	15
Macronucleus nodules, width	19.7	20.0	2.9	0.7	14.6	14.0	26.0	15
	30.0	29.0	5.5	1.4	18.4	21.0	40.0	15
Macronucleus nodules, number[b]	2.0	2.0	0.0	0.0	0.0	2.0	2.0	15
	2.0	2.0	0.0	0.0	0.0	2.0	2.0	15
Macronucleus nodules, distance in between	36.3	35.0	12.0	3.1	33.0	20.0	68.0	15
	58.0	54.0	13.7	3.5	23.6	35.0	85.0	15
Micronuclei, length	4.0	4.0	0.0	0.0	0.0	4.0	4.0	15
	5.0	5.0	0.7	0.2	13.1	4.0	6.0	15
Micronuclei, width	4.0	4.0	0.0	0.0	0.0	4.0	4.0	15
	5.0	5.0	0.7	0.2	13.1	4.0	6.0	15
Micronuclei, number	5.1	5.0	1.4	0.4	27.4	3.0	8.0	15
	4.7	4.0	2.4	0.6	50.2	2.0	10.0	15
Adoral membranelles, number	59.1	60.0	6.4	1.7	10.9	50.0	73.0	15
	62.9	62.0	6.1	1.6	9.6	55.0	76.0	15
Frontal cirri, number	2.9	3.0	0.5	0.1	15.6	2.0	4.0	15
	3.0	3.0	0.5	0.1	17.8	2.0	4.0	15
Frontoventral cirri, number	4.1	4.0	0.8	0.2	19.6	2.0	6.0	15
	4.1	4.0	0.5	0.1	11.3	3.0	5.0	15
Buccal cirri, number	1.0	1.0	0.0	0.0	0.0	1.0	1.0	15
	1.0	1.0	0.0	0.0	0.0	1.0	1.0	15
Postoral cirri, number	4.3	3.0	1.7	0.4	38.7	3.0	8.0	15
	3.9	3.0	1.5	0.4	36.6	3.0	8.0	15
Pretransverse cirri, number	2.4	2.0	0.5	0.1	21.1	2.0	3.0	15
	2.6	2.0	0.9	0.2	35.0	2.0	5.0	15
Transverse cirri, number	5.5	5.0	0.7	0.2	13.6	4.0	7.0	15
	5.9	5.0	1.3	0.3	21.2	5.0	9.0	15
Fronto-ventral-transverse cirri, number	20.2	20.0	2.2	0.6	10.8	17.0	25.0	15
	20.5	19.0	3.7	1.0	18.2	17.0	29.0	15
Right marginal cirri, number	35.3	35.0	1.8	0.5	5.2	31.0	38.0	15
	36.3	36.0	2.7	0.7	7.6	32.0	40.0	15
Left marginal cirri, number	42.9	43.0	2.6	0.7	6.2	38.0	48.0	15
	41.5	42.0	2.9	0.7	6.9	37.0	47.0	15
Caudal cirri, number	3.7	3.0	1.1	0.3	29.5	3.0	7.0	15
	3.8	3.0	1.5	0.4	39.0	3.0	8.0	15
Dorsal kineties, number[c]	12.4	12.0	–	–	–	9.0	16.0	15
	–	–	–	–	–	–	–	–

[a] Data based on protargol-impregnated (see Table head), mounted specimens from a non-flooded Petri dish culture. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of individuals investigated, SD – standard deviation, SE – standard error of arithmetic mean, x̄ – arithmetic mean.

[b] Very rarely occur specimens with 3–6 nodules.

[c] Rough values because difficult to count. The counts include the dorsomarginal rows and, possibly, also row segments from the previous generation.

ontogenesis of C. (C.) *aspoecki* resemble *Australocirrus*. However, the oral apparatus is cyrtohymenid in the former and oxytrichid in the latter (FOISSNER et al. 2004). As the oral apparatus is a main generic feature in oxytrichids (BERGER 1999), *Cyrtohymena* (*Cyrtohymenides*) *australis* and C. (C.) *aspoecki* cannot be assigned to *Australocirrus*.

Cyrtohymena (*Cyrtohymenides*) *aspoecki* nov. spec. (Fig. 1–12, 14, 18–32; Table 1)

Diagnosis: Size and colour conspicuous, that is, about 300 x 140 µm in vivo and reddish due to brilliant red granules dispersed throughout cortex and accumulated around bases of cirri and dorsal bristles. Outline elliptical to ovate with transverse cirri hardly projecting from body proper. Two macronucleus nodules, each with several micronuclei. On average 60 adoral membranelles, 20 fronto-ventral-transverse cirri, and 43 left and 35 right marginal cirri. About 12 rather irregular dorsal kineties, of which about half are dorsomarginal rows.

Type locality: Floodplain soil from the Enns River near the mouth to the Danube River, Upper Austria, E14°30' N48°14'.

Type slides: One holotype slide and four paratype slides with protargol-impregnated morphostatic and dividing specimens are deposited in the Oberösterreichische Landesmuseum in Linz (LI), Biologiezentrum. Relevant morphostatic and dividing specimens are marked by black ink circles on the cover glass.

Dedication: I dedicate this species to Univ.-Prof. Dr. Horst Aspöck (Vienna University) on the occasion of his 65th birthday. HORST ASPÖCK is an outstanding personality and scientist who published significant contributions ranging from parasitic protists to harmless insects (Neuroptera).

Description: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* is a large ciliate

and was thus impregnated with WILBERT's protocol, as described in FOISSNER (1991). However, this method may drastically change body size and shape, depending on the bleaching process. Table 1 shows that over-bleached specimens are longer by 100 µm (!) than slightly under-bleached cells. This is not an effect of different material because the countable features, such as the numbers of adoral membranelles and marginal cirri, are the same.

Size 250 – 450 x 110–170 µm in vivo, usually near 300 x 140 µm. Shape inconspicuous, that is, elongate to ordinarily ovate (Fig. 1, 3), ellipsoidal with both ends broadly rounded (Fig. 7, 8), or posterior end obliquely truncated left of midline (Fig. 6); dorsoventrally flattened 1.5 – 3:1, depending on nutrition state, well-nourished specimens with distinct slope left of midline in dorsal anterior half (Fig. 6). Nuclear apparatus in middle quarters of cell left of midline, usually consists of two large macronucleus nodules and four to five micronuclei (Fig. 1, 10, 24); rarely occur specimens with three, four, five, or even six nodules (Fig. 22). Macronucleus nodules broadly to slenderly ellipsoidal, on average 2.6:1, contain many small nucleoli. Micronuclei globular, about 5 µm across in vivo, that is, rather small as compared to size of macronucleus nodules (Fig. 10, 22). Contractile vacuole slightly above mid-body near left margin of cell, with two lacunar collecting canals, which may form small assistant vacuoles in the buccal and posterior area (Fig. 1, 6, 7, 19). Cortex very flexible and conspicuous because containing innumerable red granules in loose rows and accumulated around bases of cirri and dorsal bristles (Fig. 1, 4, 5, 18, 19); cells thus dirty to brick red at even small magnifications (X40–100). Individual granules 0.5–1 µm across, light to dark red, usually brick red, become colourless and dissolve in squashed specimens within 10 min (Fig. 4, 5, 18–21). Cytoplasm colourless, that is, lacks the red granules found in the cortex; contains some 3–6 µm-sized crystals of usual shape, some lipid droplets, and many food vacuoles 10–50 µm across. Polyphagous with heterotrophic food items forming bright, globular to irregular lipid-like masses in late digestion vacuoles. The following food items were observed (Fig. 1, 18, 22): ordinary and filamentous bacteria; colourless and dark brown

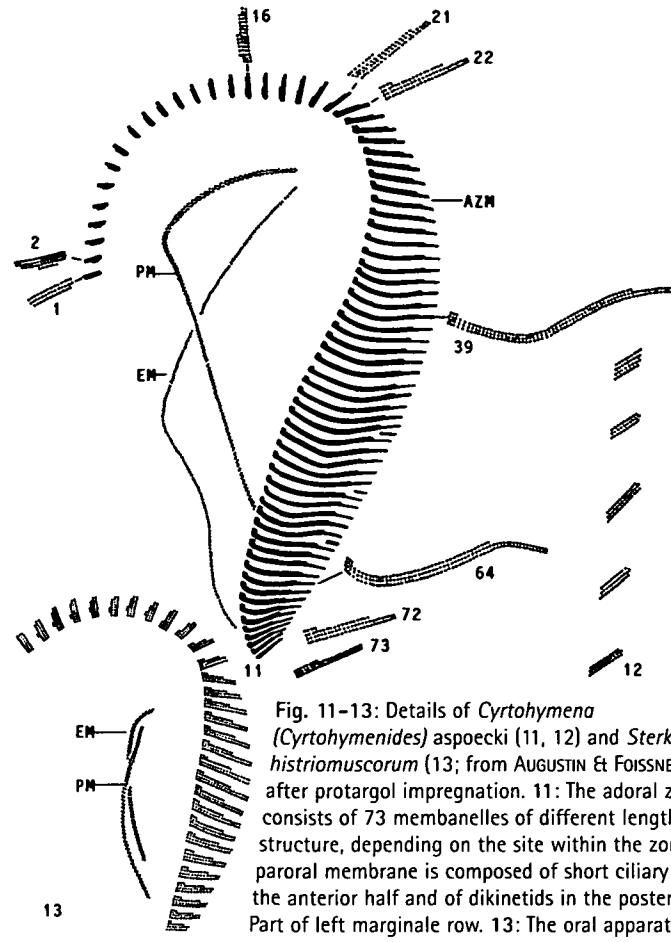


Fig. 11–13: Details of *Cyrtohymena (Cyrtohymenides)* aspoecki (11, 12) and *Sterkiella histriomuscorum* (13; from AUGUSTIN & FOISSNER 1992) after protargol impregnation. 11: The adoral zone consists of 73 membanelles of different length and structure, depending on the site within the zone. The paroral membrane is composed of short ciliary rows in the anterior half and of dikinetids in the posterior. 12: Part of left marginale row. 13: The oral apparatus of *S. histriomuscorum* has the *Oxytricha* pattern, that is, the anterior portion of the paroral membrane is not as semicircularly curved as in *Cyrtohymena* and *Cyrtohymenides*. Details of the adoral membranelles are also different. AZM – adoral zone of membranelles, EM – endoral membrane, PM – paroral membrane.

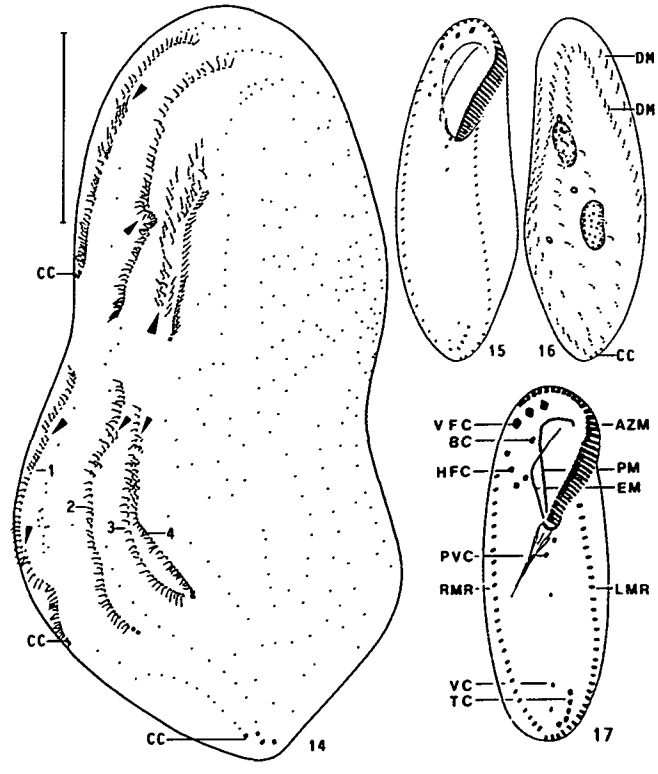
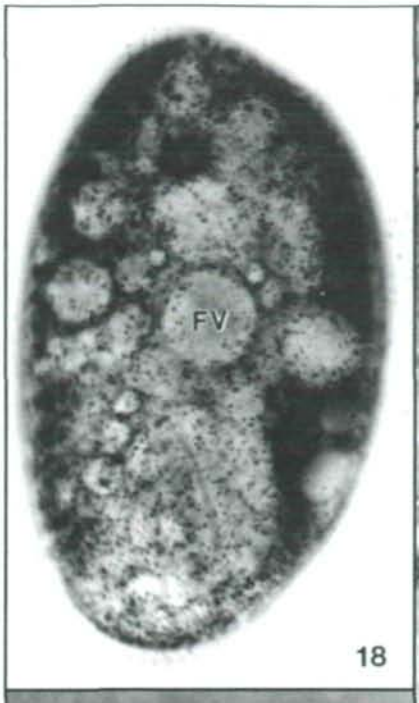
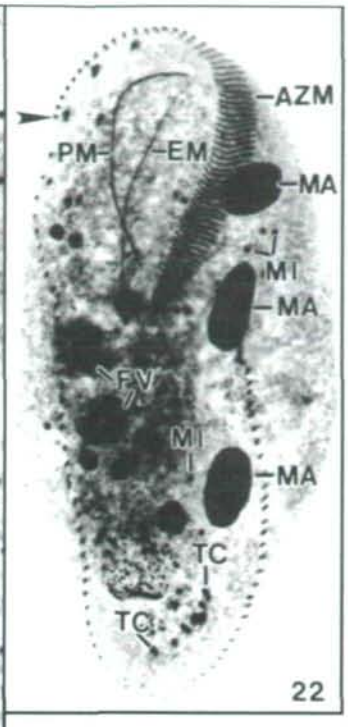
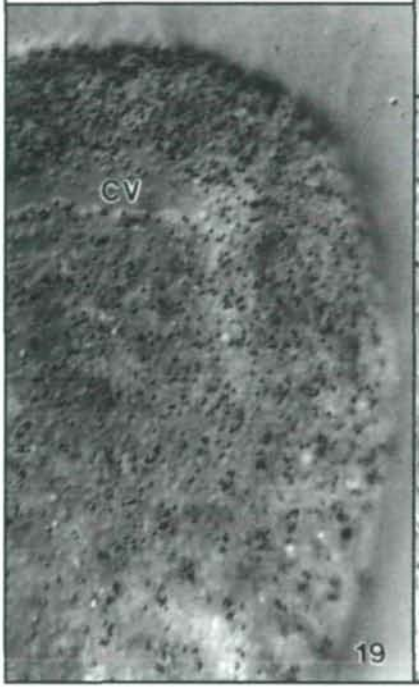


Fig. 14–17: *Cyrtohymena (Cyrtohymenides) aspoecki* and *C. (Cyrtohymena) muscorum* (15–17) after protargol impregnation. 14: Dorsal view of a late divider. Supposedly newly formed kinetids illustrated with cilia, while supposedly parental kinetids are shown as simple dots. The new kineties 1–4 each consist of several more or less overlapping fragments (arrowheads). 15–17: Ventral and dorsal infraciliature of an Austrian (15, 16; from BERGER & FOISSNER 1989) and a German (17; from VOSS 1991) population of *C. (C.) muscorum*. AZM – adoral zone, BC – buccal cirrus, CC – caudal cirri, DM – dorsomarginal kineties, EM – endoral membrane, HFC – frontoventral cirri, LMR – left marginal row, PM – paroral membrane, PVC – postoral cirri, RMR – right marginal row, TC – transverse cirri, VC – pretransverse cirri, VFC – frontal cirri. Scale bar 100 µm.







Figs. 18–22: *Cyrtohymena (Cyrtohymenides) aspoecki* from life (18–21) and after protargol impregnation (22). **18, 19**: Dorsal views. The dark areas are caused by the red cortical granules. **20, 21**: Part of the marginal cirral rows. The red cortical granules appear as dark dots (arrowheads) and are loosely arranged, except of conspicuous aggregates around the cirral bases. **22**: Ventral view of a specimen with three macronucleus nodules. Note the large oral apparatus with the adoral zone of membranelles commencing far subapically (arrowhead). AZM – adoral zone of membranelles, C – cirri, CV – anterior canal of contractile vacuoles, EM – endoral membrane, FV – food vacuoles, MA – macronucleus nodules, MI – micronuclei, PM – paroral membrane, TC – transverse cirri.

fungal spores and conidia; heterotrophic and autotrophic flagellates; and various small to middle-sized ciliates, such as *Leptopharynx costatus*, *Sathrophilus muscorum*, *Halteria grandinella*, *Euplotopsis muscicola*, *Colpoda maupasi*, *C. cucullus*, and several hypotrichs. Movement without peculiarities, creeps versatily on and between soil particles showing great flexibility.

Cirri basically in oxytrichid pattern and number, as shown by the median values (Table 1): 3 frontal, 4 frontoventral, 1 buccal, 3 postoral, 2 pretransverse, and 5 transverse cirri. However, variability ranges from 17 to 29 with an average of 20, and only 7 out of 30 specimens analysed show the classical 18 cirral pattern (for discussion, see comparison with related genera).

Cirral pattern turbulent due to the highly varying number of frontoventral-transverse cirri (Fig. 1, 9, 22, 24–29). Frontal cirri distinctly enlarged and about 25 µm long in vivo, first frontal cirrus in cell's midline, third one at or underneath distal end of adoral zone of membranelles. Postoral cirri underneath buccal vertex and distinctly separate from pretransverse and transverse cirri. Transverse cirri slightly enlarged, in vivo about 30 µm long, frayed distally, and only slightly projecting above body margin. Marginal rows composed of cirri consisting of three to four basal body rows with about 20 µm long cilia (Fig. 12), widely open posteriorly, right row commences far subapically, viz., distinctly below distal end of adoral zone of membranelles.

Dorsal bristles about 4 µm long in vivo, arranged in about 12 rows, of which at least half are dorsomarginal kineties (Fig. 5, 10, 23). Pattern turbulent due to many short row fragments and the narrowly spaced dorsomarginal kineties of varying length; likely, some of the extra kinetids are vestiges from the previous generation. Three to eight, on average almost four (but median is three, as typical for oxytrichids) inconspicuous caudal cirri in midline of posterior body end.

Adoral zone occupies 33–46%, on average 38% of body length, semicircularly curved anteriorly because commencing far subapically at level of buccal cirrus (Fig. 1, 9, 22, 24, 28; Table 1); composed of an average of 60 membranelles with highly different fine structure, depending on position within zone; bases of largest membranelles about 25 µm long in vivo (Fig. 1, 9, 11, 22, 24–28, 30–32). Buccal cavity conspicuous because large and deep, that is, extends to cell's midline and to near dorsal side. Buccal lip narrow and hyaline, covers proximal membranelles (Fig. 1, 3, 6–9, 22, 24, 25, 28). Undulating membranes in typical *Cyrtohymena* pattern, that is, widely separated with paroral membrane distinctly curved anteriorly and optically intersecting endoral membrane in mid-buccal cavity. Paroral membrane

inserted on buccal lip, conspicuous because long and semicircularly curved anteriorly, cilia about 20 µm long in vivo, dikinetidal in posterior half while composed of many short, oblique kineties, each consisting of three to six basal bodies, in curved anterior portion. Endoral membrane conspicuous only in preparations, composed of a long, curved row of mono-or dikinetids having about 10 µm long cilia; oblique anterior half on bottom of buccal cavity and widely separated from adoral zone, forming bow-like pattern with curved anterior portion of paroral membrane, posterior half on dorsal wall of buccal cavity and distinctly curved abutting to proximal end of adoral zone. Cytopharyngeal funnel conspicuous, extends to second body third, supported by fibres originating from endoral membrane and proximal adoral membranelles (Fig. 1, 2, 9, 11, 24–27, 31).

Ontogenesis: A few dividers are contained in the protargol preparations. They show that (i) the minute paroral kineties originate from a comparatively broad stripe of anarchic basal bodies (Fig. 32); (ii) the endoral membrane is generated at the left margin of the paroral stripe and consists of a row of mono-or dikinetids; (iii) the proximal portion of the adoral zone of membranelles is likely reorganized; (iv) five to seven dorsomarginal kineties are generated (Fig. 23); and (v) dorsal kineties 1–3 show more or less distinct (multiple?) fragmentation (Fig. 14). The last mentioned feature appears highly variable. For instance, in one specimen rows 1 and 2 of the proter show posterior fragmentation, while row 3 and all opisthe rows are unfragmented. Posterior fragmentation of row 2 is distinct in at least two specimens. The opisthe shown in Figure 14 has a typical oxytrichid division pattern, while the right portion of proter's kinety 3 shows multiple fragmentation; furthermore, all rows show more or less overlapping breaks possibly caused by the preparation procedures.

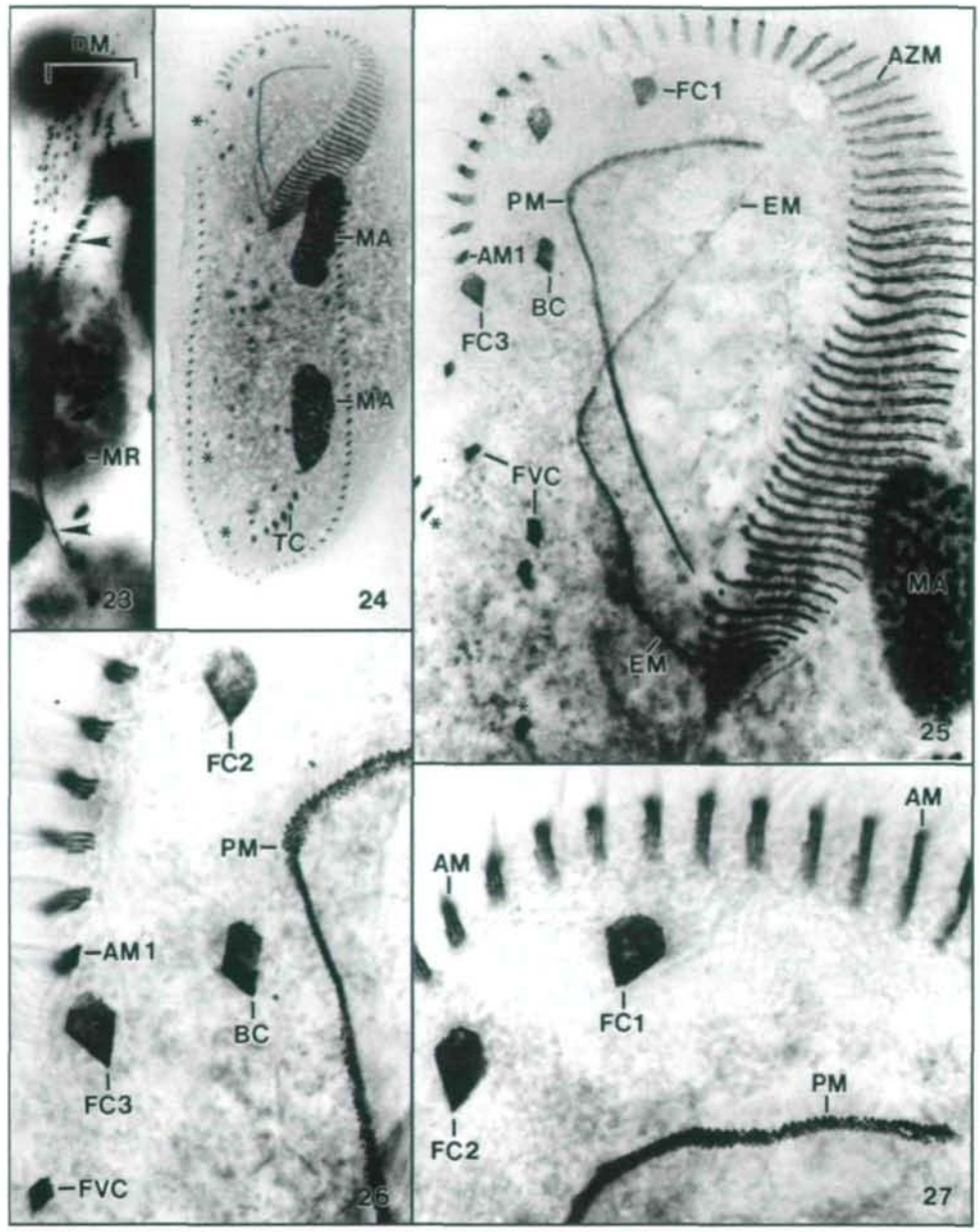
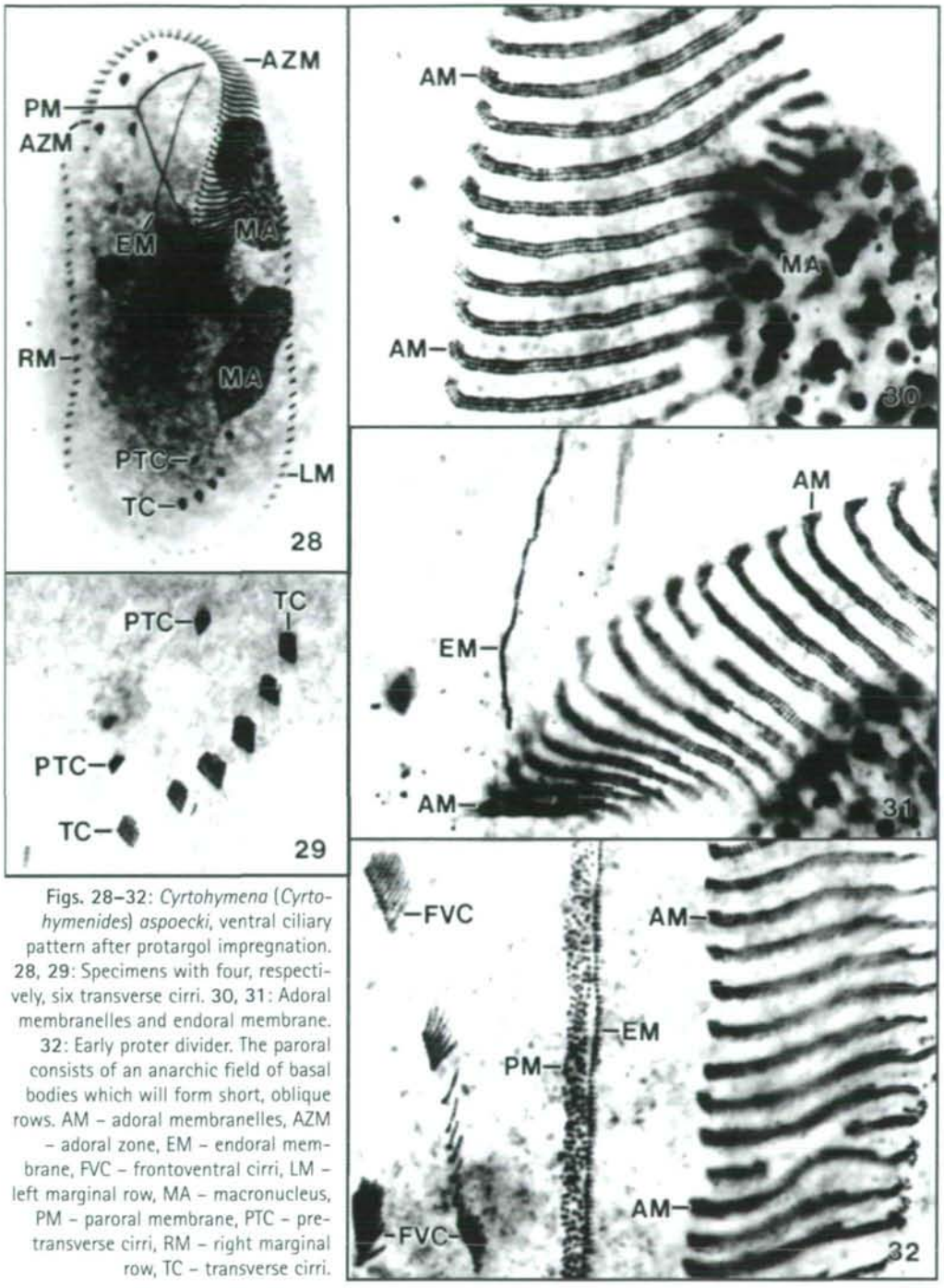


Fig. 23–27: *Cyrtohymena (Cyrtohymenides) aspoecki*, ventral views after protargol impregnation. Asterisks mark supernumerary cirri. 23: Opisthe divider showing seven dorsomarginal kineties (DM) right of the newly formed right marginal row (arrowheads). 24: Ventral overview. 25–27: Details of oral apparatus and frontoventral cirral pattern. AM1 – first adoral membranelle, AM – adoral membranelles, AZM – adoral zone, BC – buccal cirrus, DM – dorsomarginal kineties, EM – endoral membrane, FC1-3 – frontal cirri, FVC – frontoventral cirri, MA – macronucleus nodules, MR – parental marginal row, PM – paroral membrane.

Occurrence and ecology: As yet found only at type locality. In the non-flooded Petri dish cultures, C. (C.) *aspoecki* occurred only at one out of three sampling occasions. Individual numbers increased when the sample was slightly flooded, indicating that it prefers very wet or even limnetic conditions.

Cyrtohymena (*Cyrtohymenides*) *aspoecki* is a very conspicuous ciliate and thus a biogeographic "flagship". I did not find it in over 1000 other soil samples collected world-wide, including about 100 floodplain sites (FOISSNER 1998). Thus, it might be a Laurasian or even holarctic endemic. See FOISSNER et al. (2002) and FOISSNER (2005) for a detailed discussion on protist and soil ciliate endemism. Briefly, soil ciliate endemism has been well documented and is sustained by the present results: of the



Figs. 28–32: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki*, ventral ciliary pattern after protargol impregnation. 28, 29: Specimens with four, respectively, six transverse cirri. 30, 31: Adoral membranelles and endoral membrane. 32: Early proter divider. The paroral consists of an anarchic field of basal bodies which will form short, oblique rows. AM – adoral membranelles, AZM – adoral zone, EM – endoral membrane, FVC – frontoventral cirri, LM – left marginal row, MA – macronucleus, PM – paroral membrane, PTC – pretransverse cirri, RM – right marginal row, TC – transverse cirri.

128 new ciliate species found in Namibian soils (FOISSNER et al. 2002), only *Arcuospathidium namibiense*, previously often misidentified as *Protospathidium bonneti*, occurred in the Enns floodplain soil.

Comparison with related species: *Cyrtohymena* (*Cyrtohymenides*) *aspoecki* differs from the single congener, C. (C.) *australis* (FOISSNER 1995), mainly by the colour of the cortical granules (red vs. citrine) and the number of dorsomarginal kineties (about 6–7 vs. 3–4). The colour is very conspicuous (Fig. 1, 4, 5) and stable, that is, was observed in all specimens seen during a period of two months. Interestingly, both species were discovered in floodplain soil: C.(C.) *aspoecki* in Austria and C.(C.) *australis* in Peru, where it occurs in the Amazon floodplain near the town of Iquitos.

Cyrtohymena (*Cyrtohymenides*) *aspoecki* looks like a large C. (*Cyrtohymena*) *muscorum*, which also has a red colour and may reach a length of 250 µm in pure cultures (VOSS 1991). However, mean length (275 vs. 175 µm in protargol preparations) and the number of adoral membranelles (60 vs. 35) and dorsomarginal kineties (> 5 vs. 2) are highly different, excluding confusion (Fig. 15–17).

Bakuella pampinaria oligocirrata nov. sspec. (Fig. 33–36; Table 2)

Diagnosis: Three to seven, usually four pairs of midventral cirri; frontal row composed of a single cirrus on average.

Type locality: Floodplain soil from the Enns River near the mouth to the Danube River, Upper Austria, E14°30' N48°14'.

Type slides: One holotype and one paratype slide with protargol-impregnated specimens are deposited in the Oberösterreichische Landesmuseum in Linz (LI), Biologiezentrum. Relevant specimens are marked by black ink circles on the cover glass.

Etymology: Adjective composed of the Greek adjective *oligo* (few) and the Latin substantive *cirrus* (curl ~ cilia ~ cirri), referring to the decreased number (4 vs. 9) of midventral cirral pairs.

Description: Size 80–150 x 25–50 µm in vivo, usually near 115 x 35 µm. Shape inconspicuous, that is, oblong to elongate ellipsoidal with both ends broadly rounded (Fig. 33, 35; Table 2); occasionally slightly curved, that is, left margin concave, right convex; dorsoventrally flattened up to 2:1. Nuclear apparatus composed of an average of 90 macronucleus nodules and six globular micronuclei. Macronucleus nodules slightly concentrated along body margins, globular to ellipsoidal (Fig. 36; Table 2). Contractile vacuole slightly above

mid-body, two collecting canals. Cortex very flexible and yellowish at magnifications of X100–200 due to rows of citrine cortical granules (Fig. 33). Individual granules about 1 x 0.7 µm in size, citrine to yellowish with greenish shimmer, arranged in rather widely spaced, more or less distinct rows (Fig. 34). Cytoplasm colourless, usually packed with food vacuoles containing 20–40 µm long bacteria (fungi? found in most specimens), colourless and brown fungal spores, coccal green algae, heterotrophic flagellates, and various ciliates, such as *Colpoda* spp., *Vorticella astyliformis*, *Tetrahymena rostrata*, and *Leptopharynx costatus* (Fig. 33). Glides rather rapidly on microscope slides and soil particles showing great flexibility.

Cirral pattern constant and as typical for the genus, especially the *B. edaphoni* subgroup (FOISSNER et al. 2002, SONG et al. 1992). Number of fronto-ventral-transverse cirri highly variable (Table 2), as in other members of the genus (EIGNER & FOISSNER 1992, FOISSNER et al. 2002, SONG et al. 1992). Ontogenesis commences as in *B. pampinaria pampinaria* EIGNER & FOISSNER 1992 and *B. edaphoni* SONG et al. 1992, that is, an anarchic field of basal bodies develops in mid-body left and in connection with the oblique ventral cirral rows.

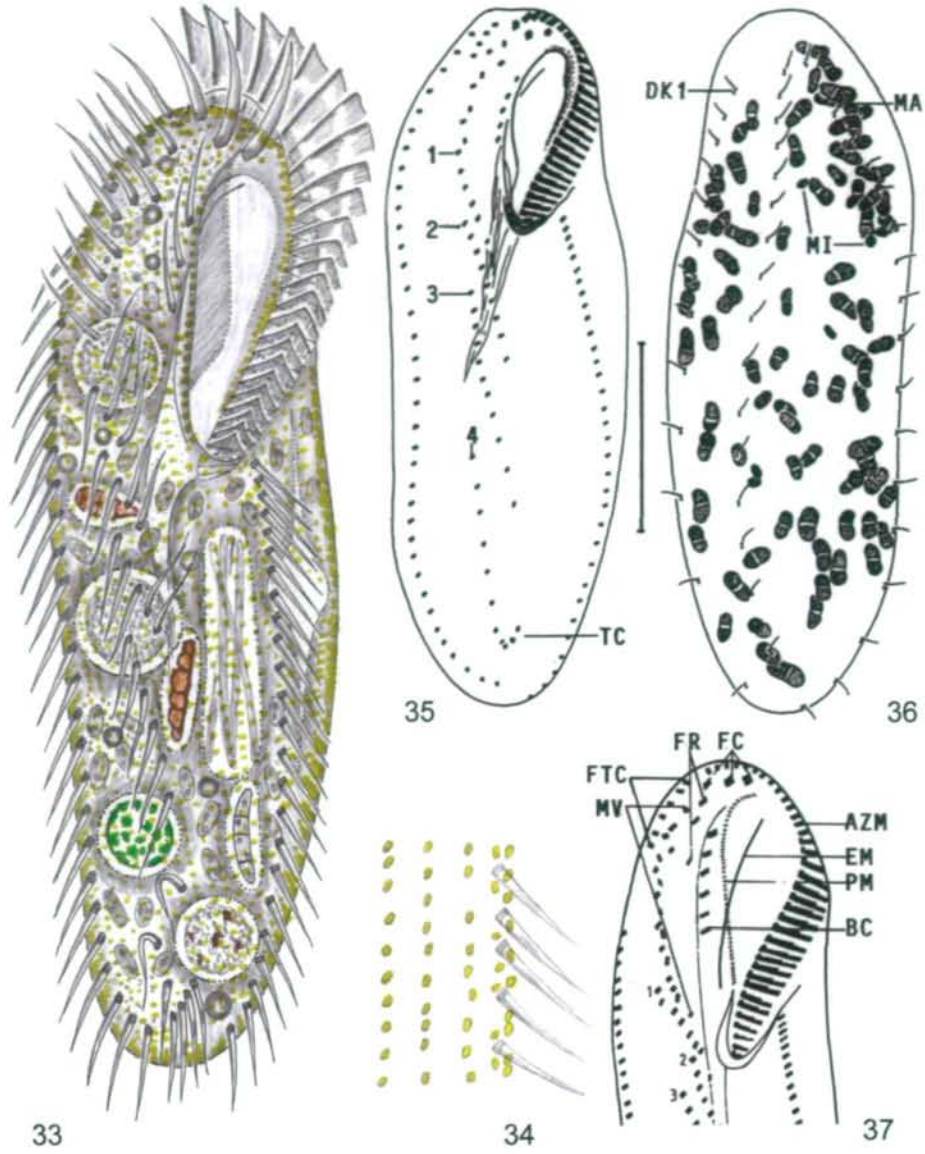


Fig. 33–37: *Bakuella pampinaria oligocirrata* (33–36) and *B. pampinaria pampinaria* (37; from EIGNER & FOISSNER 1992) from life (33, 34) and after protargol impregnation (35–37). **33, 34**: Ventral view (length 110 µm) and cortex. **35, 36**: Infraciliature of ventral and dorsal side of holotype specimen, scale bar 30 µm. **37**: Differs from *B. pampinaria oligocirrata* (35) by the higher number of midventral pairs. AZM – adoral zone, BC – buccal cirri, DK1 – dorsal kinety 1, EM – endoral, FC – frontal cirri, FR – frontal row, FTC – frontoterminal cirri, MA – macronucleus nodules, MI – micronuclei, MV – midventral row, PM – paroral, TC – transverse cirri.

Cirri about 10 µm long and of very similar size in vivo, except of the slightly enlarged frontal cirri. Transverse cirri inconspicuous, attached to posteriormost ventral row, slightly project above body margin. Marginal rows with minute but distinct gap posteriorly, right row ends subterminally, left terminally, a very constant and typical pattern found in over 90% of specimens (Fig. 35). Dorsal bristles about 3 µm long, arranged in three bipolar rows. Rows 1 and 2 left of midline, row 3 at right body margin (Fig. 36); thus, a broad, bare stripe occurs right of midline, as in *B. pampinaria pampinaria*, *B. edaphoni*, and *B. granulifera*. No caudal cirri.

Adoral zone conspicuous because occupying 34% of body length on average, only slightly curved because commencing in midline of cell; composed of an average of 27 membranelles about 6 µm wide in vivo (Fig. 33, 35; Table 2). Buccal cavity wide and deep extending almost to dorsal side, distinctly curved anteriorly; buccal lip inconspicuous. Paroral and endoral membrane slightly curved, optically intersect in mid-buccal cavity, both composed of very narrowly spaced cilia. Pharyngeal fibres of ordinary length and structure, probably mixed with long endoral cilia (Fig. 33, 35).

Occurrence and ecology: As yet found only at type location. Likely, *B. pampinaria oligocirrata* is a terricolous species, as the other members of the *B. edaphoni* subgroup (EIGNER & FOISSNER 1992, FOISSNER et al. 2002, SONG et al. 1992).

Table 2. Morphometric data on *Bakuella pampinaria oligocirrata*.

Characteristics[1]	x̄	M	SD	SE	CV	Min	Max	n
Body, length	98.2	95.0	15.7	3.6	16.0	69.0	127.0	19
Body, width	31.8	31.0	4.9	1.1	15.3	25.0	43.0	19
Body length:width, ratio	3.1	3.0	0.5	0.1	15.5	2.5	4.3	19
Anterior body end to proximal end of adoral zone, distance	33.6	34.0	4.6	1.1	13.6	26.0	45.0	19
Body length: length of adoral zone, ratio	2.9	2.9	0.4	0.1	12.6	2.4	3.7	19
Lowermost transverse cirrus to body end, distance	6.3	6.0	1.6	0.4	25.3	4.0	10.0	19
Anterior body end to end of midventral pairs, distance	25.0	24.0	6.1	1.4	24.4	16.0	38.0	19
Macronucleus nodules, length	4.6	4.0	1.4	0.3	30.0	3.0	8.0	19
Macronucleus nodules, width	2.8	3.0	0.5	0.1	18.6	2.0	4.0	19
Macronucleus nodules, number	91.0	90.0	20.3	4.7	22.3	58.0	125.0	19
Micronuclei, length	2.7	3.0	–	–	-	2.0	3.0	19
Micronuclei, width	2.7	3.0	–	–	-	2.0	3.0	19
Micronuclei, number	5.8	6.0	1.3	0.3	22.3	4.0	8.0	19
Adoral membranelles, number	27.3	27.0	2.9	0.7	10.6	22.0	34.0	19
Frontal cirri, number	3.0	3.0	0.0	0.0	0.0	3.0	3.0	19
Frontoterminal cirri, number	4.5	5.0	1.3	0.3	29.2	1.0	7.0	19
Buccal cirri, number	3.8	4.0	0.8	0.2	20.8	2.0	5.0	19
Midventral pairs, number	4.4	4.0	1.0	0.2	21.9	3.0	7.0	19
Cirri left of midventral pairs, number	1.1	1.0	–	–	–	1.0	2.0	19
Oblique ventral cirral rows, number	4.0	4.0	0.6	0.1	14.4	3.0	5.0	19
Transverse cirri, number	4.4	4.0	0.8	0.2	19.0	3.0	7.0	19
Right marginal cirri, number	33.5	34.0	4.3	1.0	12.7	25.0	42.0	19
Left marginal cirri, number	31.8	32.0	4.0	0.9	12.7	24.0	42.0	19
Dorsal kineties, number	3.0	3.0	0.0	0.0	0.0	3.0	3.0	19

[1]Data based on mounted, protargol-impregnated (FOISSNER's method), randomly selected specimens from a non-flooded Petri dish culture. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of individuals investigated, SD – standard deviation, SE – standard error of arithmetic mean, x̄ – arithmetic mean.

Comparison with related species: In spite of two revisions (FRANCO et al. 1996, SONG et al. 1992), the status of several *Bakuella* species is uncertain because they were described rather superficially. The specimens of the present population have citrine cortical granules and are highly similar to *B. pampinaria* EIGNER & H. FOISSNER 1992, differing mainly by the number of midventral cirral pairs (4 vs. 9 on average) and cirri comprising the frontal row (usually 1 vs. 2). Thus, it is classified as a subspecies of *B. pampinaria* (for discussion of the subspecies concept in ciliates, see FOISSNER et al. 2002). In vivo, *Bakuella* highly resembles *Holosticha* because the details of the postoral cirral pattern are difficult to recognize. For instance, *B. pampinaria oligocirrata* is very similar to *H. adami* FOISSNER 1982, and *B. granulifera* FOISSNER, AGATHA & BERGER 2002 resembles *H. muscorum* (KAHL), as redescribed by FOISSNER (1982). Further, I know of a *Bakuella* species which is highly similar to *H. multistilata* KAHL (redescribed in FOISSNER 1982), that is, has posteriorly overlapping marginal rows. Thus, these six species represent a nice example of convergent evolution.

Podophrya bivacuolata nov. spec. (Fig. 38–42; Table 3)

Diagnosis: Adults about 40 µm across, stalked, with two contractile vacuoles in posterior half and about 100 tentacles up to 60 µm long. Swarmers about 60 x 23 µm in vivo, ellipsoidal, with 10 ciliary rows on average and two contractile vacuoles: one above mid-body, the other in posterior body end.

Type locality: Floodplain soil from the Enns River near the mouth to the Danube River, Upper Austria, E14°30' N48°14'.

Type slides: One holotype and one paratype slide with protargol-impregnated specimens are deposited in Upper Austria, that is, in the Oberösterreichische Landesmuseum in Linz (LI), Biologiezentrum. Relevant specimens are marked by black ink circles on the cover glass.

Etymology: Latin adjective composed of *bi* (two) and *vacuus* (empty blister), referring to the main feature of the species, that is, the two contractile vacuoles.

Description: Adults 30–50 µm across in vivo, distinctly shrunken in protargol preparations (Table 3), usually globular, rarely ellipsoidal (Fig. 38, 39, 42). Stalk up to twice as long as body, 2–3 µm in diameter, attached to soil particles, frequently lost when specimens are transferred from the non-flooded Petri dish culture to the microscope slide (Fig. 38). Tentacles scattered over cell, numerous (about 100), up to 60 µm long, distal end capitate, proximal not conical (Fig. 38, 42). Macronucleus in centre of cell, globular to ellipsoidal, outline usually rather irregular in protargol preparations. Micronucleus attached to macronucleus, globular to ellipsoidal. Two contractile vacuoles, each with one, rarely two excretory pores, in stalked body third (Fig. 38, 39, 42). Cortex about 1 µm thick, flexible, smooth. Cytoplasm colourless, usually packed with lipid droplets up to 5 µm across.

All adults observed have a short kinety stripe. Thus, budding is external and part of the mother cell transforms into a motile swarmer. Swarmer ellipsoidal to indistinctly reniform and flattened, about 60 x 23 µm in vivo, unciliated areas studded with short, capitate tentacles (Fig. 38, 40; Table 3). Macronucleus in middle body third, oblong with irregularly lobate outline; few globular to oblong nucleoli. Micronucleus globular to ellipsoidal.

Two contractile vacuoles, each with one to two tube-shaped excretory pores, within ciliary stripe: one vacuole above mid-body, as usual; the other, uniquely, in posterior body end where the ciliary rows abut (Fig. 40, 41). Stalk precursor recognizable as a minute, striated knob in rear quarter of cell (Fig. 40). Ciliature as typical for the genus, that is, an average of 10 rows extend along the swarmer margin; cilia much more narrowly spaced in anterior than posterior third of swarmer (Fig. 40, 41).

Occurrence and ecology: As yet found only at type location, where it was very rare in the non-flooded Petri dish culture. As the habitat is floodplain soil, *P. bivacuolata* might occur also in limnetic environments. A re-evaluation of notes and drawings made by BLATTERER & FOISSNER (1988) showed that *P. bivacuolata* likely occurs on site 1 in Australia. However, identification is doubtful because swarmers were not observed.

Comparison with related species: *Podophrya bivacuolata* is clearly defined by the number and location of the contractile vacuoles: no other described *Podophrya* swarmer has a contractile vacuole in the posterior body end; however, the same pattern is found in *Paracineta lauterborni*, a loricate suctorian redescribed by FOISSNER (1995). Generally, there are few free-living bivacuolate *Podophrya* species. Of those mentioned by CURDS (1986) and FOISSNER et al. (2002), only *Sphaerophrya magna* MAUPAS 1881 (now *Podophrya*, see CURDS 1986) resembles *P. bivacuolata*. However, *S. magna* is stalkless, has the macronucleus positioned eccentrically, and the rugose swarmer bears cilia only anteriorly. We can be sure about MAUPAS' observations because they are very detailed and were confirmed by MASKELL (1886). Unfortunately, resting cysts of *P. bivacuolata* were not found.

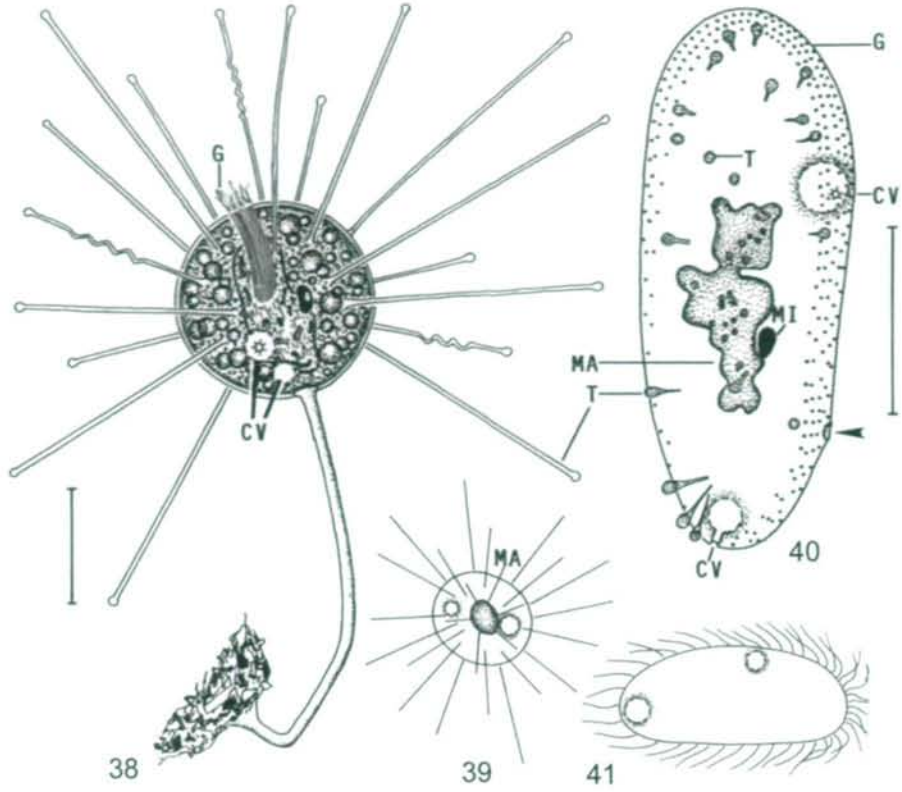


Fig. 38–41: *Podophrya bivacuolata* from life (39, 41), after protargol impregnation (40), and in a combination of observations from life and after protargol impregnation (38). **38**: Side view of a representative specimen. Note the two contractile vacuoles, the lower of which is at the back side of the organism. **39**: Posterior polar view showing the two contractile vacuoles. **40, 41**: Swarmers. Note the two contractile vacuoles; one of the vacuoles is in the posterior body end, which is the most important feature of the species. The arrowhead marks stalk precursor. CV – contractile vacuole, G – ciliary girdle, MA – macronucleus, MI – micronucleus, T – tentacles. Scale bars 20 µm.

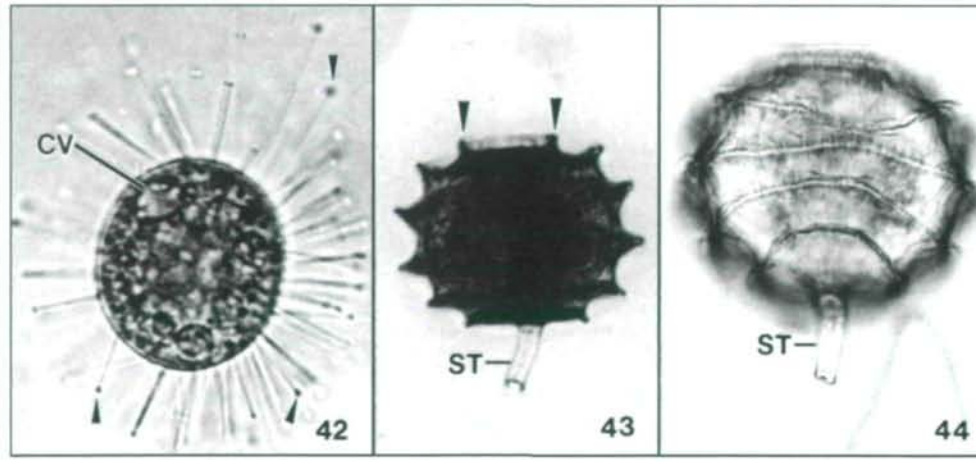


Fig. 42–44: *Podophrya bivacuolata* (42) and *P. halophila* (43, 44) from life. 42: Polar view showing one of the two contractile vacuoles and the many capitate tentacles, some marked by arrowheads. Size of cell 50 µm. **43**: Optical section of a resting cyst, length without stalk 21 µm. Arrowheads mark first ridge, showing that the escape opening is not closed by a plug. Note that the longitudinal cyst axis is shorter than the transverse one (21 x 28 µm). 44: Slightly squashed resting cyst showing the fine longitudinal striation of the wall.

Table 3. Morphometric data on *Podophrya bivacuolata* (PB) and *Podophrya halophila* (PH).

Characteristics[1]	x̄	Species	M	SD	SE	CV	Min	Max	n
ADULTS									
Body, length	PB	29.9	29.0	8.6	3.0	28.8	21.0	49.0	8
	PH	24.5	25.0	4.0	1.2	16.1	17.0	31.0	10
Body, width	PB	28.9	29.0	7.6	2.7	26.3	20.0	45.0	8
	PH	22.8	23.0	4.4	1.4	19.2	15.0	30.0	10
Macronucleus, length	PB	17.9	17.0	3.7	1.3	20.6	14.0	25.0	8
	PH	11.9	12.0	2.6	0.9	21.8	6.0	15.0	8
Macronucleus, width	PB	13.9	12.0	4.2	1.5	30.0	11.0	23.0	8
	PH	9.9	11.0	3.8	1.3	38.1	5.0	15.0	8
Micronucleus, length	PB	3.8	4.0	–	–	–	3.0	4.0	6
Micronucleus, width	PB	2.7	3.0	0.8	0.3	30.6	2.0	4.0	6
Excretory pores, number	PB	1.7	2.0	–	–	–	1.0	2.0	7
Ciliary rows in early dividers, number[2]	PB	10.7	10.0	–	–	–	8.0	14.0	3
SWARMERS									
Body, length	PB	53.9	55.0	11.9	4.0	22.0	39.0	71.0	9
	PH	39.3	36.5	8.0	4.0	20.4	33.0	51.0	4
Body, width	PB	21.4	20.0	4.0	1.3	18.5	17.0	30.0	9
	PH	19.5	19.5	2.4	1.2	12.2	17.0	22.0	4
Macronucleus, length	PB	23.1	20.0	9.6	3.2	41.5	11.0	45.0	9
	PH	14.5	14.0	2.6	1.3	18.2	12.0	18.0	4
Macronucleus, width	PB	11.9	11.0	2.7	0.9	22.4	9.0	16.0	9
	PH	9.8	10.0	–	–	-	9.0	10.0	4
Micronucleus, length	PB	3.7	4.0	–	–	–	3.0	4.0	8
Micronucleus, width	PB	3.0	3.0	–	–	–	3.0	3.0	8
Ciliary rows, number	PB	10.3	10.0	1.4	0.5	13.7	9.0	13.0	9
	PH	6.3	6.0	–	–	–	6.0	7.0	4
Contractile vacuoles, number	PB	2.0	2.0	0.0	0.0	0.0	2.0	2.0	9
Excretory pores, number	PB	2.6	3.0	–	–	–	2.0	3.0	9
	PH	2.0	2.0	–	–	–	1.0	3.0	5
RESTING CYSTS									
Body, length (height) without stalk	PH	31.5	31.0	7.6	2.4	24.1	22.0	44.0	10
Body, width	PH	42.7	43.5	6.1	1.9	14.2	33.0	55.0	10
Stalk, length	PH	16.8	16.5	2.3	0.7	13.4	13.0	20.0	10
Wall ribs, number (inclusive ring surrounding cyst opening)	PH	6.4	6.0	–	–	–	6.0	7.0	10

[1]Data based on mounted, protargol-impregnated (FOISSNER's method), randomly selected specimens from non-flooded Petri dish cultures. Measurements in µm. CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of individuals investigated, SD – standard deviation, SE – standard error of arithmetic mean, x̄ – arithmetic mean.
[2]Possibly only partially impregnated.)

Podophrya halophila KAHL 1934 (Fig. 43–52; Table 3)

Material: Rare in a non-flooded Petri dish culture with circumneutral soil from the Hortobágy Puszta near the town of Debrecen in NE-Hungary, E21° N47°. The sample, kindly provided by Dipl.-Biol. Wolfgang HEINISCH, consisted of greyish, dust-like mineral soil mixed with much grass litter and some mosses.

Voucher slides: Three slides with protargol-impregnated adults, swarmers, and cysts are deposited in the Oberösterreichische Landesmuseum in Linz (LI), Biologiezentrum. Relevant specimens are marked by black ink circles on the cover glass.

Description: Adults about 40 µm width and 35 µm high in vivo, distinctly shrunken in protargol preparations, but proportions maintained (Table 3). Stalk about as long as body and 2.5 µm thick, attached to soil particles, frequently lost when specimens are transferred from the culture to the microscope slide. About 50 tentacles scattered over cell; individual tentacles with clavate distal end, about 1 µm thick and up to 80 µm long. Macronucleus in centre of cell, globular to slightly ellipsoidal, about 18 µm across in vivo; contains many small and large, globular nucleoli. Micronucleus more or less distant from macronucleus and rather large, that is, about 6 x 3 µm. A single contractile vacuole with two to three excretory pores in or near mid-body. Cortex approximately 1 µm thick, flexible, smooth. Cytoplasm colourless, usually packed with lipid droplets 1 to 4 µm across (Fig. 47).

Swarmers indistinctly reniform and 2:1 flattened laterally, about 35–60 x 20–30 µm in vivo, unciliated areas with some short, distinctly capitate tentacles. Macronucleus in middle swarmer third, slightly to ordinarily ellipsoidal, contains many globular nucleoli. An average of two excretory pores in second quarter of cell. Unfortunately, I did not note whether the pores belong to a single, ellipsoidal contractile vacuole, as in *P. fixa* (FOISSNER et al. 1995), or to two closely spaced vacuoles, as in *P. halophila* (Fig. 46). Stalk precursor recognizable as a minute knob in rear body quarter. Ciliature as in congeners, that is, an average of six ciliary rows extend along the swarmer's margin; distance of cilia within rows gradually and distinctly increases from anterior to posterior (Fig. 51, 52; Table 3).

Resting cysts unique in being wider than high, viz., 20–50 x 30–65 µm in vivo; otherwise of typical *Podophrya* structure, that is, stalked and transversely ribbed (Fig. 33, 44, 48; Table 3). Cyst wall brownish and with six to seven, usually six ribs as conspicuous as in congeners; surface finely striated longitudinally. Cyst opening at anterior end, surrounded by a ring-like wall

rib, but without plug closing emergence pore. Stalk cylindroidal to conical, adheres cyst to soil particles, about half as long as cyst proper, hyaline (Fig. 33, 44, Table 3).

Occurrence and ecology: If identifications are correct (see below), *P. halophila* is cosmopolitan and almost ubiquitous because it has been recorded from brackish water (KAHL 1934) as well as from ordinary and saline soils globally (BLATTERER & FOISSNER 1988, FOISSNER 1998, FOISSNER et al. 2002). The sample contained also an other interesting suctorian ciliate, viz., *Brachyosoma brachyopoda mucosa*, described in FOISSNER (1999).

Identification and comparison with other populations: The Hungarian species is described here because its identity is uncertain and it looks, at first glance, very similar to *P. bivacuolata*. However, both the adults and swarmers have only a single contractile vacuole. Thus, identity with *P. fixa* cannot be excluded, as already mentioned by FOISSNER et al. (2002) and in the brief original description KAHL (1934): "Size 50–90 µm; differs from *P. fixa* by the asymmetric, bean-shaped swarmers, feeds on large *Holosticha* species; reproduces by swarmers and inequal division. Discovered in saline (15‰), organic mud of the Kaiser-Wilhelm-Kanal near Kiel, Germany". Unfortunately, swarmer shape differences are inconspicuous in *Podophrya*, though that of *P. fixa* is probably more oblong than bean-shaped (see CURDS 1986 and FOISSNER et al. 1995 for reviews on *P. fixa*).

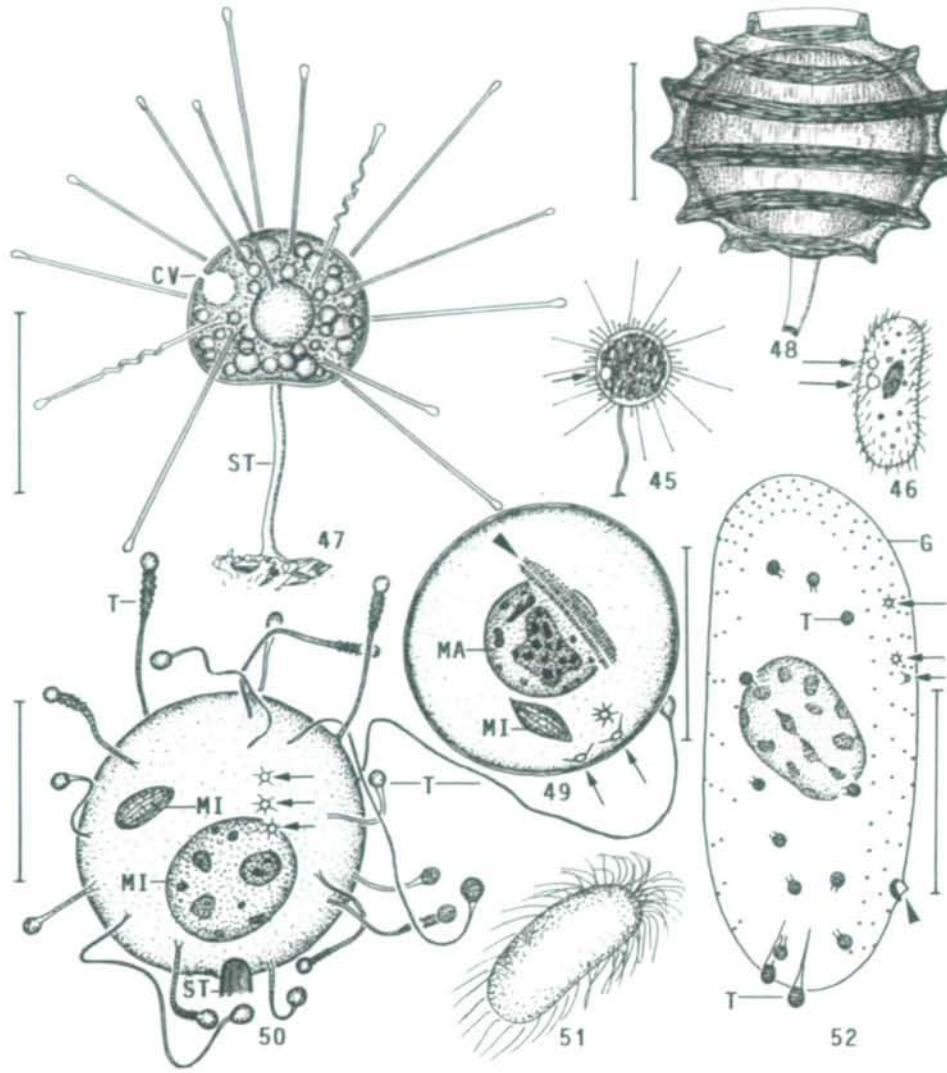


Fig. 45–52: *Podophrya halophila*, German (45, 46) and Hungarian (47–52) specimens from life (45–48, 51) and after protargol impregnation (49, 50, 52). **45, 46**: German type specimens, diameter of cell 50–90 µm (from KAHL 1934). The adult has one contractile vacuole, the swarmer two (arrows). **47, 50**: Adults have a single contractile vacuole with several excretory pores (arrows). **48**: Resting cysts are wider than high, a special feature of the Hungarian population. **49**: Early divider with developing ciliary girdle marked by arrowhead. Arrows mark excretory pores. **51, 52**: Swarmers. Arrowhead marks stalk precursor. Arrows denote excretory pores. CV – contractile vacuole, G – ciliary girdle, MA – macronucleus, MI – micronucleus, ST – stalk, T – tentacles. Scale bars 40 µm (47) and 20 µm (48–50, 52).

Two redescriptions of *P. halophila* are available from soil populations of Australia and Namibia (BLATTERER & FOISSNER 1988, FOISSNER et al. 2002). However, these populations differ considerably among each other and from KAHL's data (adult size < 50 µm vs. 50–90 µm, see above and Table 3). Thus, identity is questionable. The Hungarian specimens are rather similar to the Namibian population, but have more ciliary rows (6 vs. 4) and lack the conspicuous plug closing the cyst's emergence pore. The number of ciliary rows matches the Australian specimens which, however, have two narrowly spaced contractile vacuoles and a cyst plug. Furthermore, the Hungarian population differs from the Australian and Namibian ones in that the resting cysts are broader than high and lack a plug. These are rather pronounced differences indicating that it is a distinct species or *P. fixa* which, unfortunately, is still insufficiently known. At the present state of knowledge, naming of the three populations would be premature. However, I would be not surprised when further investigations show that each is a distinct species.

Acknowledgements

Thanks to Prof. Dr. Konrad Thaler and Prof. Dr. Erwin Meyer for inviting the study. I also acknowledge the help of Dr. Wolfgang Petz in sampling and identifying the more common species as well as the technical assistance of Dr.

Eva Herzog and Dr. Brigitte Moser. The study was supported by the Upper Austrian government and the Austrian Science Foundation (FWF project P-15017).

References

Augustin H. & Foissner W. (1992): Morphologie und Ökologie einiger Ciliaten (Protozoa: Ciliophora) aus dem Belebtschlamm. — Arch. Protistenk. **141**: 243–283.

Berger H. (1999): Monograph of the Oxytrichidae (Ciliophora, Hypotrichia). — Monographiae biol. **78**: XII + 1–1080.

Berger H. & Foissner W. (1989): Morphology and biometry of some soil hypotrichs (Protozoa: Ciliophora) from Europe and Japan. — Bull. Br. Mus. nat. Hist. (Zool.) **55**: 19–46.

Blatterer H. & Foissner W. (1988): Beitrag zur terricolen Ciliatenfauna (Protozoa: Ciliophora) Australiens. — Stapfia (Linz) **17**: 1–84.

Curds C. R. (1986): A revision of the Suctoria (Ciliophora, Kinetofragminophora) 4. *Podophrya* and its morphological relatives. — Bull. Br. Mus. nat. Hist. (Zool.) **50**: 59–91.

Eigner P. & Foissner W. (1992): Divisional morphogenesis in *Bakuella pampinaria* nov. spec. and reevaluation of the classification of the urostylids (Ciliophora, Hypotrichida). — Europ. J. Protistol. **28**: 460–470.

Finlay B. J. (2001): Protozoa. — Encyclopedia of Biodiversity **4**: 901–915.

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

Foissner W. (1991): Basic light and scanning electron microscopic methods for taxonomic studies of ciliated protozoa. — Europ. J. Protistol. **27**: 313–330.

Foissner W. (1995): Tropical protozoan diversity: 80 ciliate species (Protozoa, Ciliophora) in a soil sample from a tropical dry forest of Costa Rica, with descriptions of four new genera and seven new species. — Arch. Protistenk. **145**: 37–79.

Foissner W. (1998): An updated compilation of world soil ciliates (Protozoa, Ciliophora), with ecological notes, new records, and descriptions of new species. — Europ. J. Protistol. **34**: 195–235.

Foissner W. (1999): Notes on the soil ciliate biota (Protozoa, Ciliophora) from the Shimba Hills in Kenya (Africa): diversity and description of three new genera and ten new species. — Biodiv. Conserv. **8**: 319–389.

Foissner W. (2005): Biogeography of microorganisms: a brief review emphasizing protists. — Antonie van Leeuwenhoeck (in press).

Foissner W., Berger H., Blatterer H. & Kohmann F. (1995): Taxonomische und ökologische Revision der Ciliaten des Saprobiensystems – Band IV: Gymnostomatea, *Loxodes*, Suctoria. — Informationsberichte des Bayer. Landesamtes für Wasserwirtschaft **1/95**: 1–540.

Foissner W., Agatha S. & Berger H. (2002): Soil ciliates (Protozoa, Ciliophora) from Namibia (Southwest Africa), with emphasis on two contrasting environments, the Etosha Region and the Namib Desert. — Denisia **5**: 1–1459.

Foissner W., Berger H., Xu K. & Zechmeister-Boltenstern (2004): A huge, undescribed soil ciliate (Protozoa: Ciliophora) diversity in natural forest stands of Central Europe. — Biodiv. Conserv. (in press).

Franco C., Esteban G. F. & Téllez C. (1996): Description of *Metabakuella bimarginata* sp. n., and key to the ciliate subfamily Bakuellinae Jankowski, 1979. — Acta Protozool. **35**: 321–330.

Kahl A. (1934): Suctoria. — Tierwelt N.- und Ostsee **26** (Teil II. c_3): 184–226.

Maskell W. M. (1886): On the freshwater infusoria of the Wellington district. — Trans. Proc. N.Z. Inst. **19**: 49–61.

Maupas E. (1881): Contribution a l'étude des acinétiens. — Archs Zool. exp. gén. **9**: 299–368.

Song W., Wilbert N. & Berger H. (1992): Morphology and morphogenesis of the soil ciliate *Bakuella edaphoni* nov. spec. and revision of the genus *Bakuella* Agamaliev & Alekperov, 1976 (Ciliophora, Hypotrichida). — Bull. Br. Mus. nat. Hist. (Zool.) **58**: 133–148.

Steinberger K. H. & Thaler K. (1994): Fallenfänge von Spinnen im Kulturland des oberösterreichischen Alpenvorlandes (Arachnida: Araneae). — Beitr. Naturk. Oberösterreichs **2**: 131–160.

Voss H.-J. (1991): Die Morphogenese von *Cyrtohymena muscorum* (Kahl, 1932) Foissner, 1989 (Ciliophora, Oxytrichidae). — Arch. Protistenk. **140**: 67–81.

Address of the author:

Univ.-Prof. Dr. Wilhelm Foissner
Universität Salzburg
Fachbereich Organismische Biologie
Hellbrunnerstrasse 34
A-5020 Salzburg, Austria
E-Mail: eva.herzog@sbg.ac.at