A revision of the genus *Pseudovorticella* Foissner & Schiffmann, 1974 (Ciliophora: Peritrichida)

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Introduction

The genus *Pseudovorticella* was erected by Foissner & Schiffmann (1974) to include those peritrichs which are morphologically similar to *Vorticella* but which have a reticulate silver line system with lines running vertically as well as horizontally. The reticulate pattern of silver lines underlies a system of pellicular tubercles which covers the entire zooid surface except the disc and infundibulum.

Pellicular tubercles have been studied by several workers over the past century. Schröder (1906) showed that the tubercles of *Pseudovorticella monilata* are surface features, the distribution of which corresponds to that of the underlying striations. Ultrastructural studies by TEM (Kawamura, 1973) and SEM (Carey & Warren, 1983) have confirmed this observation. Kawamura (1973) also showed that each tubercle of *P. monilata* is a semisphere, about 2·0 μm in diameter, and contains a sphere of electron dense material. Further investigations using histochemical staining (Fauré-Fremiet & Thaureaux, 1944; Pratt & Rosen, 1983) and microanalysis (Pratt & Rosen, 1983) indicate that the tubercles contain paraglycogen. The function of the tubercles is not known although it has been suggested that they may aid predator avoidance (Spoon, 1975).

Foissner & Schiffmann (1974) noted that the silver line system is particularly useful for species diagnosis in *Pseudovorticella,* and biometric analyses have been carried out on several species (Foissner & Schiffmann, 1974 & 1975; Foissner, 1979). Parameters which are of particular taxonomic value include the total number of silver lines per zooid and dimensions of the grids formed by the intersecting vertical and horizontal lines. Morphological features traditionally used in vorticellid taxonomy are also useful diagnostic characters for the species of *Pseudovorticella*; these include the size and shape of the zooid, the number and position(s) of the contractile vacuole(s) and the shape and position of the macronucleus (Noland & Finley, 1931; Foissner, 1979; Warren, 1986).

Sixteen species of *Pseudovorticella* are recognised, twelve of which originally belonged to the genus *Vorticella*. A key to their identification is provided.

Systematics

In the scheme adopted by the Committee on Systematics and Evolution of the Society of Protozoologists (Levine *et al.,* 1980), the taxonomic position of the genus *Pseudovorticella* was given as follows:

Phylum:	Ciliophora Doflein, 1901
Class:	Oligohymenophora de Puytorac *et al.,* 1974
Subclass:	Peritrichia Stein, 1859
Order:	Peritrichida Stein, 1859
Suborder:	Sessilina Kahl, 1933
Family:	Vorticellidae Ehrenberg, 1838
Genus:	*Pseudovorticella* Foissner & Schiffmann, 1974

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Diagnosis

Solitary bell-shaped zooids borne upon a spirally contractile stalk. In all respects save one, the body and stalk of *Pseudovorticella* resemble those of *Vorticella* from which it cannot be differentiated until impregnated with silver, which reveals a reticulate silver line pattern quite unlike that of *Vorticella* (see Warren, 1986). In addition to *Vorticella* this genus could be mistaken for *Haplocaulis* in which the stalk contracts in a zigzag rather than a helical manner.

Key to the species of *Pseudovorticella*

1	With endosymbiotic zoochlorellae	2
—	Without endosymbiotic zoochlorellae	3
2	Zooid about 40 μm long; macronucleus C-shaped	***P. zooanthelligera*** (Fig. 9b)
—	Zooid 75–95 μm long; macronucleus J-shaped	***P. chlorelligera*** (Fig. 1a)
3	Diameter of peristomial lip less than or equal to maximum body width	4
—	Diameter of peristomial lip greater than maximum body width	10
4	Diameter of peristomial lip less than maximum body width	5
—	Diameter of peristomial lip equal to maximum body width	6
5	Macronucleus J-shaped	***P. difficilis*** (Fig. 1 c & d)
—	Macronucleus C-shaped	***P. papillata*** (Fig. 5c)
6	Body length less than × 2 maximum body width	7
—	Body length at least × 2 maximum body width	***P. micata*** (Fig. 2b)
7	One contractile vacuole	8
—	Two contractile vacuoles	***P. sphagni*** (Fig. 7b)
8	Macronucleus lies vertical with respect to major axis of zooid	9
—	Macronucleus lies horizontal with respect to major axis of zooid	***P. stilleri*** (Fig. 9a)
9	Zooid 65–80 μm long and with 44–54 transverse striations	***P. quadrata*** (Fig. 7a)
—	Zooid 35–45 μm long and with 20–33 transverse striations	***P. sauwaldensis*** (Fig. 8)
10	Zooid with two contractile vacuoles	11
—	Zooid with one contractile vacuole	13
11	Zooid with centrally located constriction; scopular region rounded	***P. margaritata*** (Fig. 2a)
—	Zooid without centrally located constriction; scopular region tapers towards stalk	12
12	Zooid 40–45 μm long; stalk length × 16–18 zooid length	***P. mollis*** (Fig. 3a)
—	Zooid 60–70 μm long; stalk × 3 zooid length	***P. monilata*** (Fig. 3b, c & d)
13	Diameter of peristomial lip less than body length	14
—	Diameter of peristomial lip greater than body length	***P. punctata*** (Fig. 6)
14	Zooid less than × 3 maximum body width	15
—	Zooid length greater than × 3 maximum body width	***P. mutans*** (Fig. 4 c & d)
15	Zooid 50–70 μm long × 22–48 μm wide; typically marine	***P. nebulifera*** (Fig. 4 a & b)
—	Zooid 32–50 μm long × 20 μm wide; typically freshwater	***P. pseudocampanula*** (Fig. 5 a & b)

Description of Species

P. chlorelligera (Kahl, 1935) Jankowski, 1976

V. margaritata f. *chlorelligera* Kahl, 1935
P. margaritata f. *chlorelligera* (Kahl, 1935) Foissner & Schiffmann, 1975

DIAGNOSIS (Fig. 1a & b). Zooid inverted bell-shaped, 78–95 μm long × 50 μm wide; peristomial lip 80 μm diameter; infundibulum reaches half body length; macronucleus J-shaped; numerous endosymbiotic zoochlorellae present in cytoplasm; zooid has a total of 33–53 (mean 47·7) transverse striations; grid size

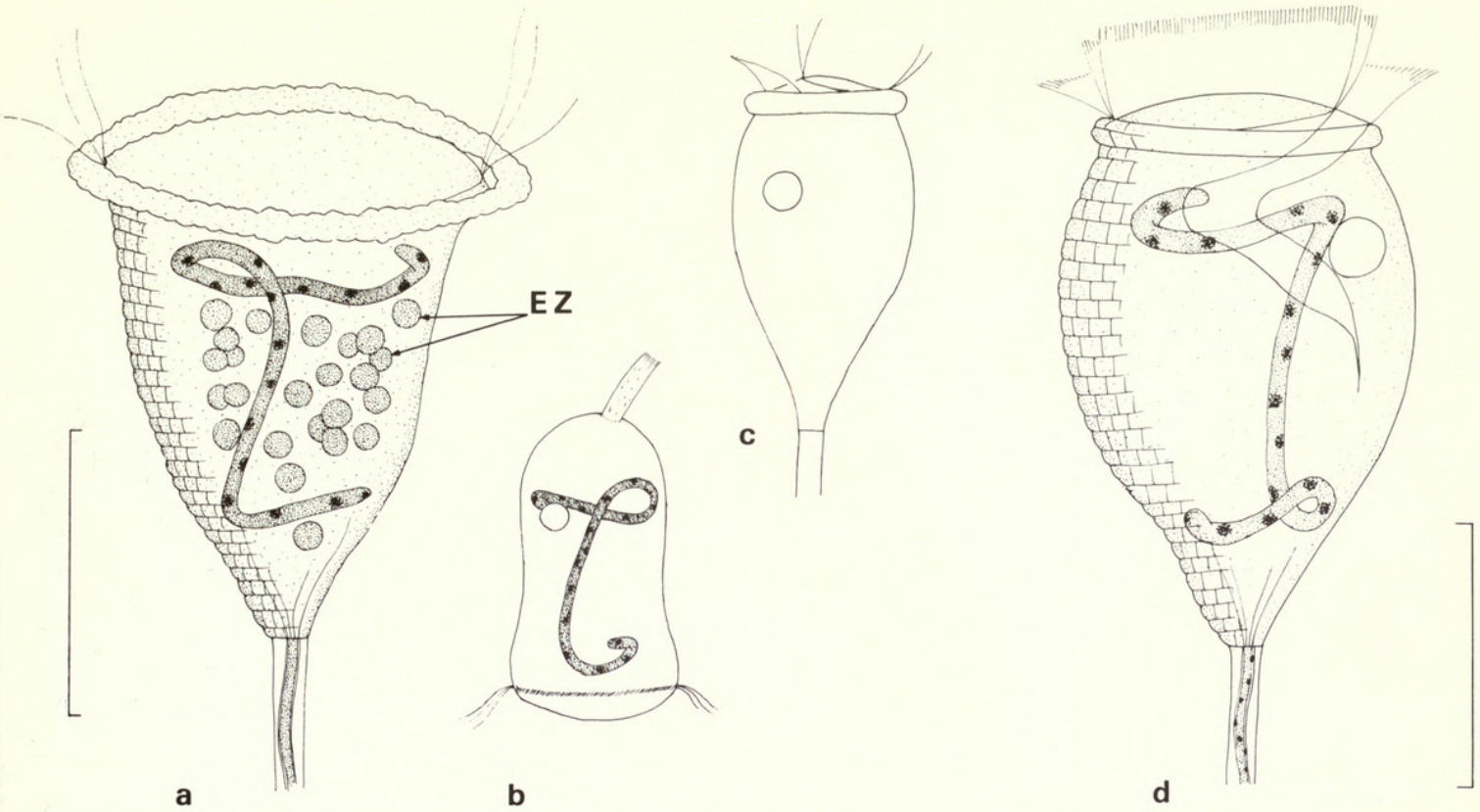

Fig. 1. (a) *P. chlorelligera* zooid, bar = 50 μm; (b) telotroch, bar = 25 μm (after Foissner & Schiffmann, 1975); (c) *P. difficilis* (after Kahl, 1935); (d) *P. difficilis,* bar = 50 μm (after Foissner & Schiffmann, 1975; called *P. difficilis* var. *magnistriata*).

1·3–3·2 μm × 2·0–4·5 μm; zooid surface with 15–28 (mean 22) pellicular pores per 100 μm^2; telotroch nearly cylindrical in shape and with a prominent epistomial membrane (Fig. 1b).

HABITAT. Freshwater.

P. difficilis (Kahl, 1933) Jankowski, 1976

V. difficilis Kahl, 1933
P. difficilis var. *magnistriata* Foissner & Schiffmann, 1974

DIAGNOSIS (Fig. 1c & d). Zooid 60–140 μm long × 40–70 μm wide; diameter of peristomial lip less than maximum body width; infundibulum reaches half body length; single contractile vacuole situated in upper part of zooid close to infundibulum; macronucleus J-shaped; 39–49 (mean 43·9) transverse striations per zooid; grid size 3·1–4·7 μm × 2·7–3·4 μm; spasmoneme with numerous thecoplasmic granules.

HABITAT. Freshwater or marine.

P. margaritata (Fromentel, 1874) Jankowski, 1976

DIAGNOSIS (Fig. 2a). Zooid inverted bell-shaped, 59–70 μm long × 50 μm wide, with a slight constriction in the central region and rounded at the scopular end; peristomial lip 70 μm in diameter; two contractile vacuoles situated in anterior part of zooid; macronucleus C-shaped and situated in centre of zooid.

HABITAT. Freshwater, particularly eutrophic lakes and stagnant water.

REMARKS. This species has been redescribed by Kahl (1935) and Stiller (1971).

P. micata (Kahl, 1933) nov. comb.

V. micata Kahl, 1933

DIAGNOSIS (Fig. 2b). Zooid elongate, 65 μm long × 25 μm wide; peristomial lip 25 μm in diameter; disc flat and slightly elevated above peristome; infundibulum reaches one third zooid length; contractile vacuole situated in upper part of zooid close to infundibulum.

HABITAT. Marine.

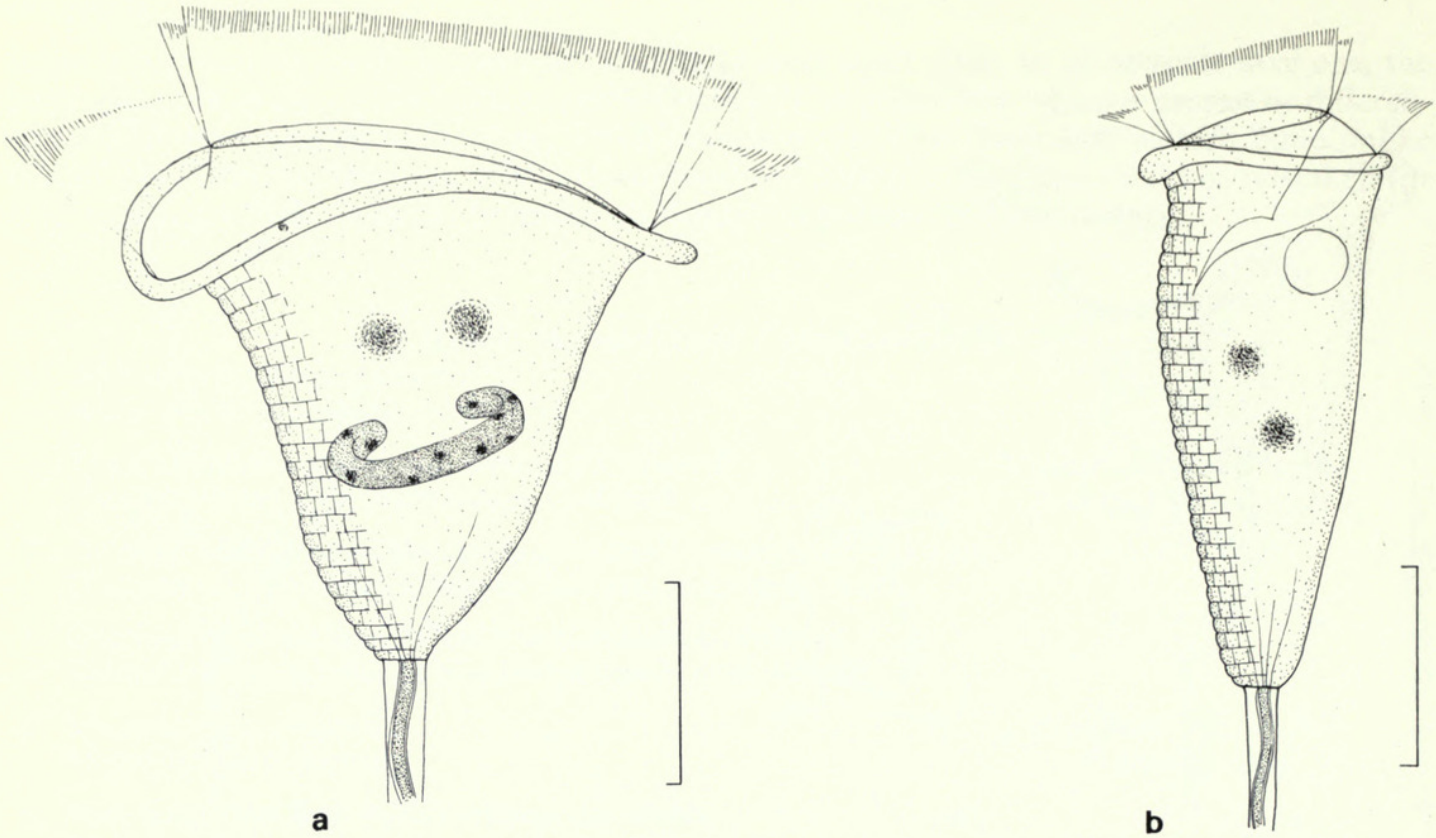

Fig. 2. (a) *P. margaritata* , bar = 25 μm (composite from Kahl, 1935 and Stiller, 1971); (b) *P. micata,* bar = 25 μm (after Kahl, 1935).

P. mollis (Stokes, 1887) nov. comb.

V. mollis Stokes, 1887

DIAGNOSIS (Fig. 3a). Zooid inverted bell-shaped, 40–45 μm long × 25 μm wide; peristomial lip 40 μm in diameter; infundibulum reaches one third body length; two contractile vacuoles situated in anterior part of zooid; stalk × 16–18 zooid length.

HABITAT. Freshwater

REMARKS. Although this species was not drawn by Stokes (1887), it has been observed and figured by Nenninger (1948).

P. monilata (Tatem, 1870) Foissner & Schiffmann, 1974

V. lockwoodii Stokes 1884
V. monilata Tatem, 1870

DIAGNOSIS (Fig. 3b, c & d). Zooid inverted bell-shaped, 45–70 μm long × 40–45 μm wide; peristomial lip 50 μm in diameter; infundibulum reaches half body length; two contractile vacuoles situated in anterior part of zooid; macronucleus J-shaped; 31–41 (mean 35·3) transverse striations per zooid; grid size 2·5–3·5 μm × 1·5–2·5 μm; stalk × 3 body length; spasmoneme with thecoplasmic granules; telotroch cone-shaped with prominent epistomial membrane.

HABITAT. Freshwater, often forming pseudocolonies; Pratt & Rosen (1983) reported large numbers of *Pseudovorticella (Vorticella) monilata* attached the Cyanobacterium *Anabaena flos-aquae*.

P. mutans (Penard, 1922) Foissner, 1979

V. mutans Penard, 1922

DIAGNOSIS (Fig. 4c & d). Zooid inverted bell-shaped, 65–95 μm long × 18–25 μm wide; peristomial lip 25 μm in diameter; disc convex; infundibulum reaches half body length; contractile vacuole situated in upper half of body close to infundibulum; macronucleus J-shaped; zooid has 40–47 (mean 43) transverse striations; grid

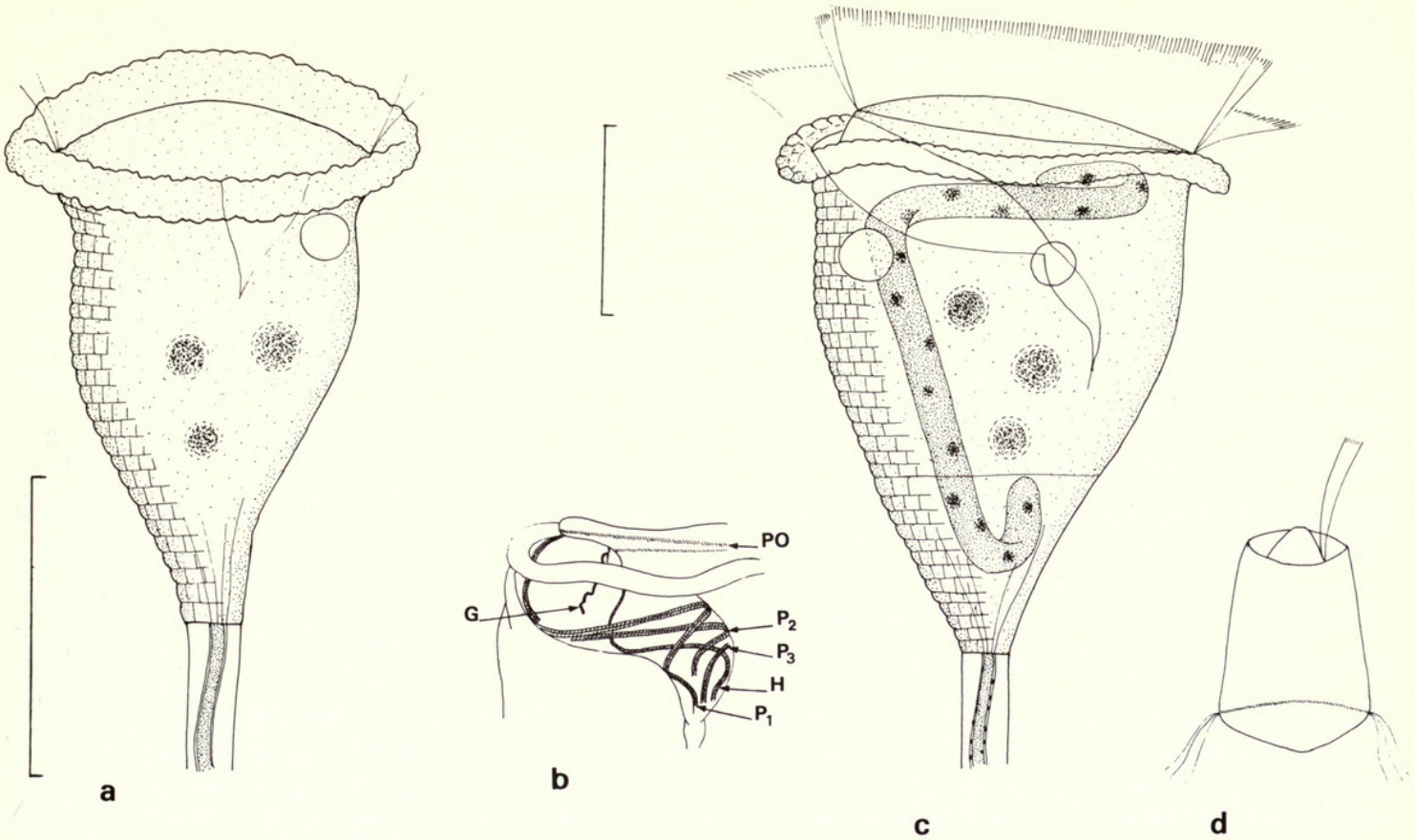

Fig. 3. (a) *P. mollis,* bar = 25 μm (after Nenninger, 1948); (b) *P. monilata* showing oral ciliation (detail from Pätsch, 1974); (c) zooid, bar = 25 μm; (d) telotroch (after Foissner, 1979). G = germinal kinety; H = haplokinety; P_1, P_2, P_3 = 1, 2, 3, peniculus; PO = polykinety.

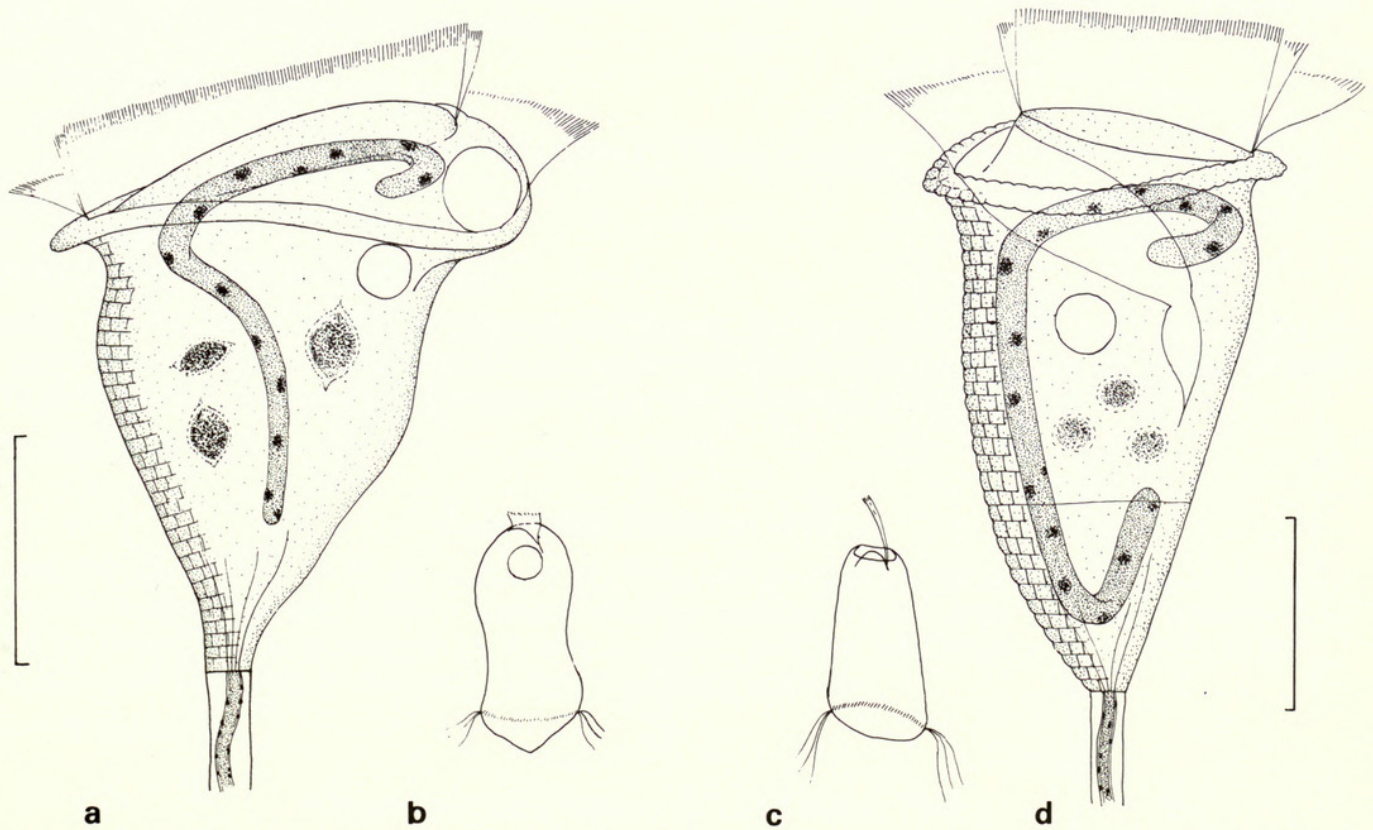

Fig. 4. (a) *P. nebulifera* zooid, bar = 25 μm (after Noland & Finley, 1931); (b) telotroch (after Barlow & Finley, 1976b); (c)*P. mutans* telotroch; (d) zooid, bar = 25 μm (after Foissner, 1979).

size 1·4–1·5 μm × 1·5–2·2 μm; stalk × 5 body length and 8·0 μm wide; spasmoneme with thecoplasmic granules; telotroch with prominent epistomial membrane.

HABITAT. Freshwater.

P. nebulifera (Müller, 1786) Jankowski, 1976

V. nebulifera Müller, 1786

DIAGNOSIS (Fig. 4a & b). Zooid inverted bell-shaped, 38–78 μm (mean 60 μm) long × 22–48 μm (mean 37 μm) wide; slightly constricted beneath peristomial lip which measures 32–66 μm (mean 53 μm) in diameter; single contractile vacuole situated close to infundibulum; macronucleus J-shaped; stalk 50–800 μm (mean 150 μm) long × 3·5–6·0 μm (mean 4·7 μm) wide; spasmoneme with thecoplasmic granules; telotroch 47–75 μm (mean 60 μm) long; cyst 37 μm in diameter.

HABITAT. Marine or freshwater.

REMARKS. Redescribed by Noland & Finley (1931); for telotroch and SEM studies, see Barlow & Finley (1976a & b).

P. papillata (Stiller) Jankowski, 1976

V. microstoma f. *monilata* Stiller (see Stiller, 1971)

DIAGNOSIS (Fig. 5c). Zooid 35–80 μm (mean 55 μm) long × 22–50 μm (mean 35 μm) wide, the maximum body width being the mid region of the zooid; peristomial lip 12–25 μm (mean 23 μm) in diameter; disc convex; infundibulum reaches one third body length; contractile vacuole situated in anterior part of zooid; macronucleus C-shaped and lies longitudinally with respect to major axis of zooid.

HABITAT. Freshwater, particularly under conditions of high biochemical oxygen demand (BOD_5).

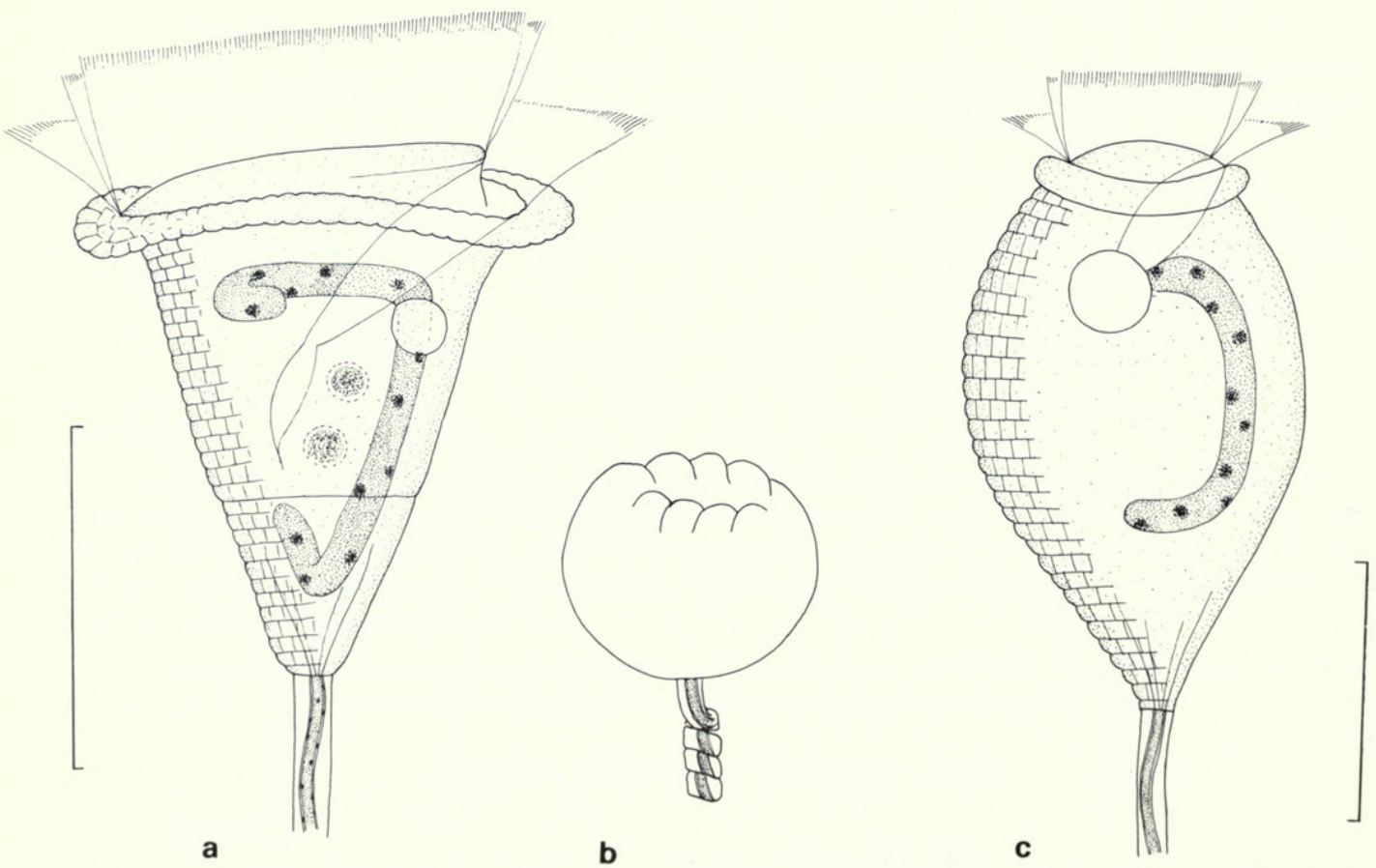

Fig. 5. (a) *P. pseudocampanula* relaxed zooid, bar = 25 μm; (b) contracted zooid (after Foissner, 1979); (c) *P. papillata*, bar = 25 μm (after Stiller, 1971).

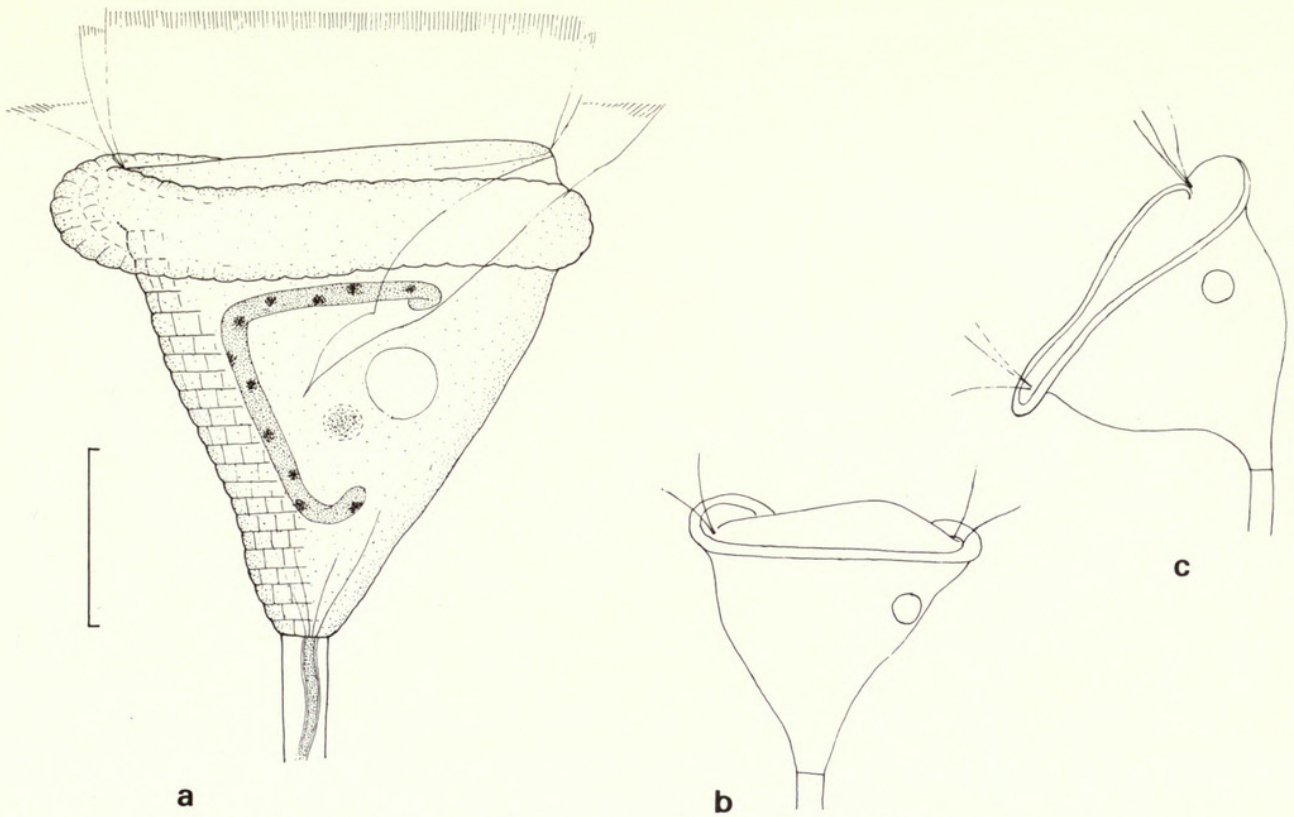

Fig. 6. *P. punctata,* (a) bar = 25 μm (after Dons, 1918); (b) after Stiller (1946) (called *Vorticella subconica*); (c) after Kahl (1935) (called *Vorticella perlata*).

P. pseudocampanula Foissner, 1979

DIAGNOSIS (Fig. 5a & b). Zooid conical/inverted bell-shaped, 32–50 μm (mean 40 μm) long × 20 μm wide; peristomial lip 35 μm in diameter; upon contraction, peristomial lip becomes puckered (Fig. 5b); infundibulum reaches half body length; contractile vacuole situated close to infundibulum; macronucleus J-shaped; zooid has 44–51 (mean 46·6) transverse striations; grid size 1·3–2·6 μm × 1·5–3·0 μm; stalk × 7 body length; thecoplasmic granules present on spasmoneme.

HABITAT. Freshwater.

P. punctata (Dons 1918) nov. comb.

V. punctata Dons, 1918
V. subconica Stiller, 1946
P. subconica (Stiller, 1946) Jankowski, 1976

DIAGNOSIS (Fig. 6). Zooid conical or inverted bell-shaped, 40–50 μm long × 40 μm wide; peristomial lip 50–55 μm in diameter; disc convex; infundibulum reaches one third body length; contractile vacuole situated in upper part of zooid; macronucleus J-shaped; stalk × 4–5 body length and 4·0 μm wide.

HABITAT. Marine.

P. quadrata Foissner, 1979

DIAGNOSIS (Fig. 7a). Zooid 65–80 μm (mean 70 μm) long × 55 μm wide; peristomial lip 60 μm in diameter; infundibulum reaches half body length; contractile vacuole situated in anterior part of zooid; macronucleus J-shaped; zooid has 44–54 (mean 48·3) transverse striations; grid size 1·5–2·8 μm × 1·3 × 2·7 μm; stalk × 7 body length and 9·0 μm wide; spasmoneme with thecoplasmic granules.

HABITAT. Freshwater.

P. sauwaldensis Foissner & Schiffmann, 1979

DIAGNOSIS (Fig. 8). Zooid shape variable, usually inverted bell-shaped 35–45 μm long × 20 μm wide; peristomial lip 20 μm in diameter and 3·0 μm thick; disc convex; infundibulum reaches half body length;

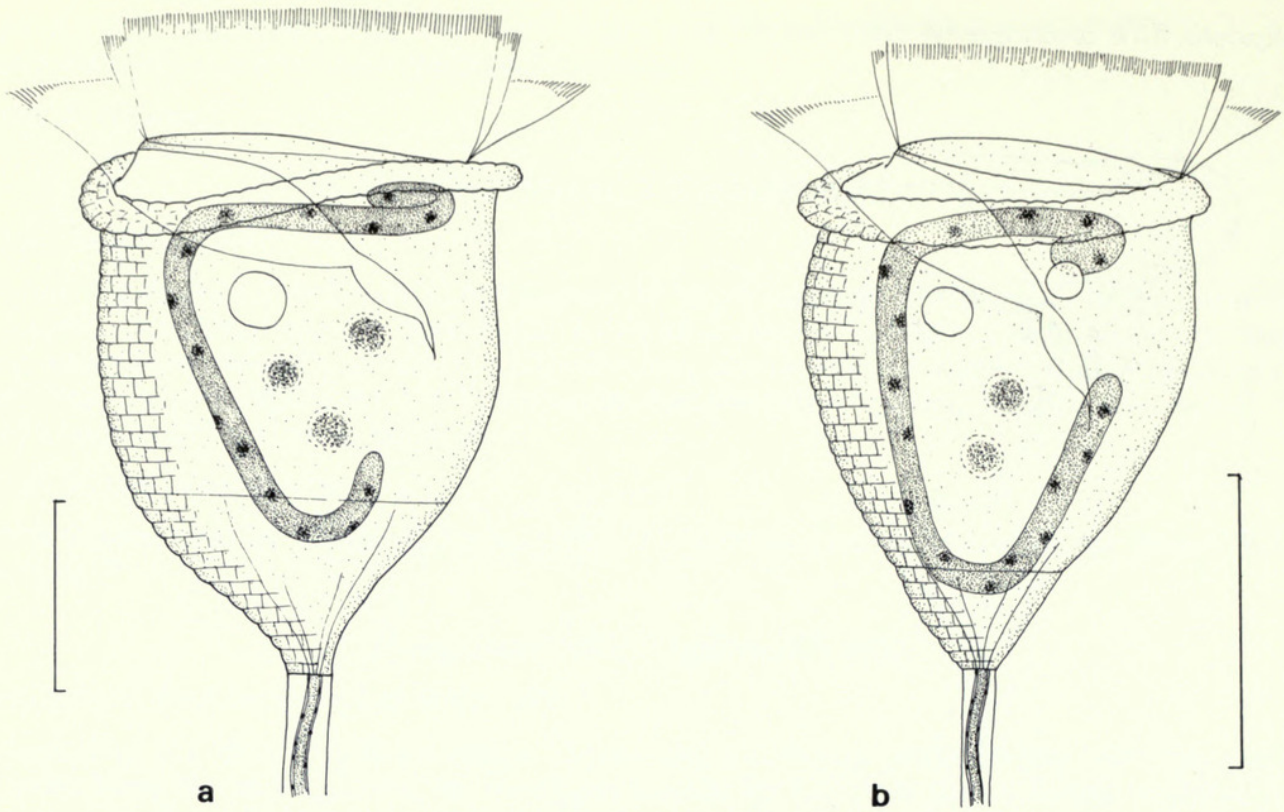

Fig. 7. (a) *P. quadrata,* bar = 25 μm; (b) *P. sphagni,* bar = 25 μm (after Foissner, 1979).

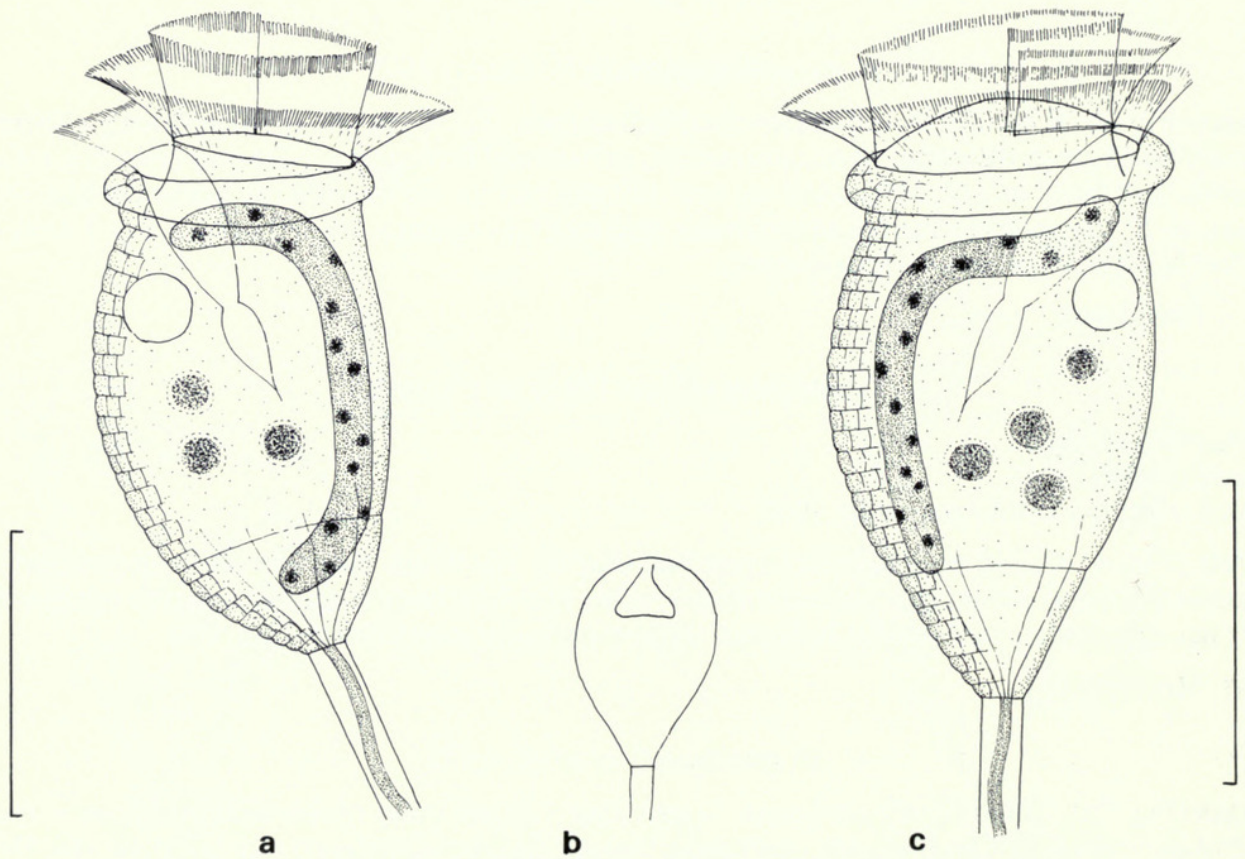

Fig. 8. *P. sauwaldensis* (a) normal zooid, bar = 20 μm; (b) contracted zooid; (c) showing variability of macronucleus and zooid shape, bar = 20 μm (after Foissner & Schiffmann, 1979).

contractile vacuole situated in upper part of zooid close to infundibulum; macronucleus vermiform, variable in shape and situated longitudinally with respect to major body axis; pellicle has 20–33 (mean 29) transverse striations; grid size 0·9–1·5 μm × 0·7–2·5 μm; stalk × 1–3 body length.

HABITAT. Freshwater.

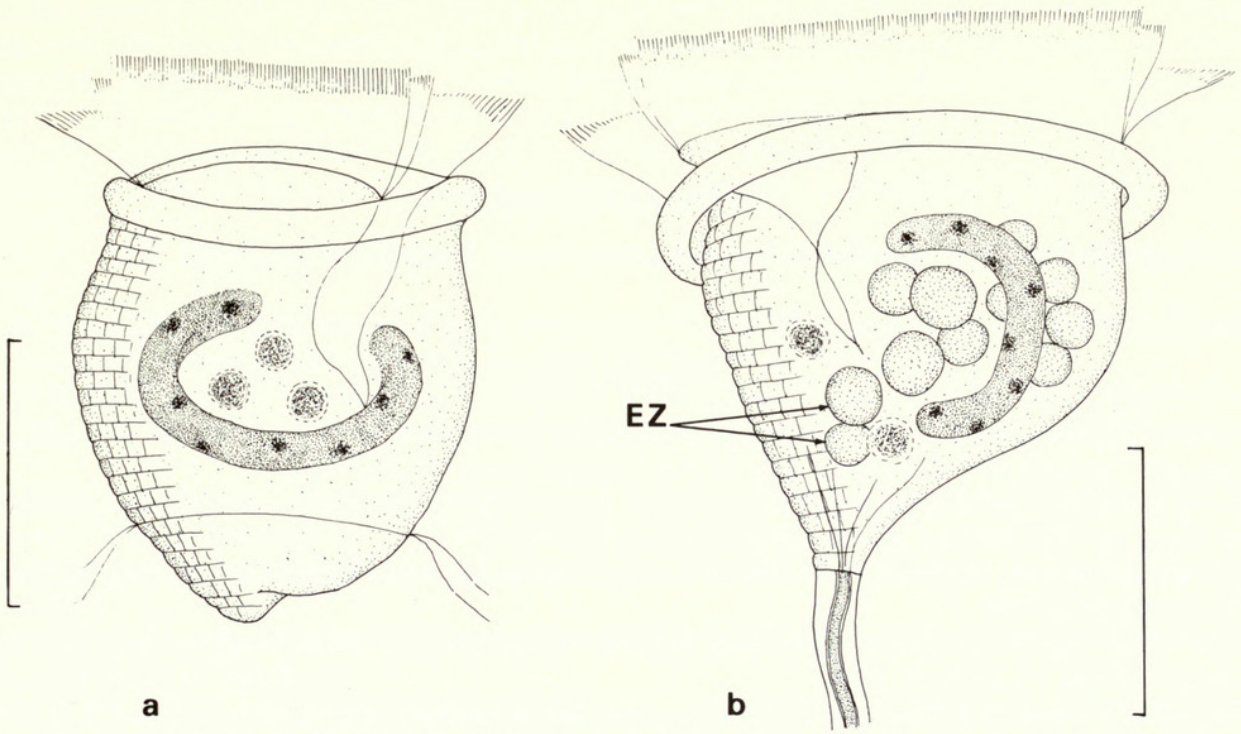

Fig. 9. (a) *P. stilleri,* bar = 50 μm (after Stiller, 1963); (b) *P. zooanthelligera,* bar = 25 μm (after Stiller, 1968). EZ = endosymbiotic zoochlorellae.

P. sphagni Foissner, 1979

DIAGNOSIS (Fig. 7b). Zooid inverted bell-shaped, 40–50 μm long × 30 μm wide; peristomial lip 30 μm in diameter; infundibulum reaches one third body length; two contractile vacuoles situated in anterior part of zooid; macronucleus J-shaped with elongate distal arm; zooid has 34–37 (mean 35·5) transverse striations; grid size 1·6–1·9 μm × 2·5–2·7 μm.

HABITAT. Freshwater, originally isolated from *Sphagnum* bogs.

P. stilleri n. sp.

V. campanula f. *monilata* Stiller, 1963

DIAGNOSIS (Fig. 9a). Zooid inverted bell-shaped, 85 μm long × 80 μm wide; peristomial lip 80 μm in diameter; infundibulum reaches half body length; macronucleus C-shaped and lies horizontally across centre of zooid.

HABITAT. Freshwater, attached to the duckweed *Lemna minor*.

P. zooanthelligera (Stiller, 1968) nov. comb.

V. zooanthelligera Stiller, 1968

DIAGNOSIS (Fig. 9b). Zooid inverted bell-shaped, 40–42 μm long × 40 μm wide; peristomial lip 50 μm in diameter; disc flat; infundibulum reaches one third body length; macronucleus C-shaped and lies longitudinally in zooid; cytoplasm contains numerous endosymbiotic zoochlorellae; stalk × 5 body length.

HABITAT. Freshwater.

Incertae sedis

Pseudovorticella sp. (Graham & Graham, 1978) nov. comb.

Vorticella sp. Graham & Graham, 1978

Graham & Graham (1978) made an ultrastructural study of a vorticellid (*Vorticella* sp.) furnished with pellicular tubercles and containing endosymbiotic zoochlorellae. The presence of pellicular tubercles suggests

that this organism should belong to the genus *Pseudovorticella*. However other important diagnostic features, for example the macronucleus, contractile vacuole(s) and shape of the relaxed zooid, were not recorded. Only when such data is available will it be possible to determine the exact status of this organism.

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Index

Index of extant species; annotated list of nominal species.

P. anabaenae (Stiller, 1940) Jankowski, 1976 was transferred to the genus *Haplocaulis* by Stiller (1971).
P. chlorelligera (Kahl, 1935) Jankowski, 1976 2
P. chlamydophora (Penard, 1922) Jankowski, 1976 = *Vorticella vestita* Stokes, 1883 (see Warren, 1986).
P. difficilis (Kahl, 1933) Jankowski, 1976 3
P. difficilis var. *magnistriata* Foissner & Schiffmann, 1974 = *P. difficilis.*
P. lima (Kahl, 1935) Jankowski, 1976. This species appears to have pellicular granules rather than tubercles; it should therefore remain in the genus *Vorticella (V. lima)* until it has been redescribed.
P. margaritata (Fromentel, 1874) Jankowski, 1976 3
P. micata (Kahl, 1933) nov. comb. 3
P. mollis (Stokes, 1887) nov. comb. 4
P. monilata (Tatem, 1870) Foissner & Schiffmann, 1974 4
P. mutans (Penard, 1922) Jankowski, 1976 4
P. nebulifera (Müller, 1786) Jankowski, 1976 6
P. papillata (Stiller) Jankowski, 1976 6
P. pelagica (Gajewskaja, 1933) Jankowski, 1976 was transferred to the genus *Haplocaulis* by Stiller (1971).

P. perlata (Kahl, 1933) Jankowski, 1976 = *P. punctata.*

P. plicata (Gourret & Roeser, 1886) Jankowski, 1976 appears to be identical to *Vorticella elongata* Fromentel, 1874 (Warren, 1986).

P. pseudocampanula Foissner, 1979 7

P. punctata (Dons, 1918) nov. comb.. 7

P. quadrata Foissner, 1979 7

P. sauwaldensis Foissner & Schiffmann, 1979 7

P. sphagni Foissner, 1979 9

P. stilleri (Stiller, 1963) n. sp. 9

P. subconica (Stiller, 1946) Jankowski, 1976 appears to be identical to *P. punctata.*

P. vestita (Stokes, 1883) Jankowski, 1976. A membranous alveolar covering overlays the pellicle of this species. There is, however, no evidence of pellicular tubercles or of an underlying reticulate pattern of silver lines. This species should therefore remain in the genus *Vorticella (V. vestita)* until it has been redescribed.

P. voeltzkowi (Sondheim, 1929) Jankowski, 1976. This species has spine-like projections on its pellicle. There is, however, no evidence that it has either pellicular tubercles or a reticulate pattern of silver lines. It should therefore remain in the genus *Vorticella (V. voeltzkowi)* until a redescription is available.

P. zooanthelligera (Stiller, 1968) nov. comb. 9

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