## CLASS PEDINOPHYCEAE
MOESTRUP 1991

By Øjvind Moestrup

Pedinomonads are very small green flagellates that differ from other green algae in details of the flagellar apparatus and in mitosis and cell division. The genus *Pedinomonas is* well known, while two additional genera of the class, *Resultor* and *Marsupiomonas,* were described recently. Only c. 10 species, distributed in fresh water and marine environments. The class was formally erected by Moestrup (1991), see also Jones et al. (1994).

### Key characters

1. All species uniflagellate, but a second basal body is present in the cell. At cell division the latter grows into a new flagellum and the cell forms two new basal bodies. The emergent flagellum is therefore no. 1 according to the flagellar numbering system for flagella introduced by Moestrup and Hori (1989) and Heimann et al. (1989). The flagellum inserts laterally and lacks scales. Thin hairs have been described on the flagella of *Pedinomonas* and *Marsupiomonas.* The flagellar basal bodies short, resembling those of more advanced green algae. They are inserted at opposite polarity to each other, shifted in a counterclockwise direction (resembling the green algal class Ulvophyceae) but not overlapping (resembling the Chlorophyceae).

2. Cells contain a single parietal chloroplast with a pyrenoid more or less directly opposite the flagellar insertion and an eyespot on the pyrenoid-containing part of the chloroplast. A contractile vacuole is present in the front end of freshwater species. Pigments include chlorophylls *a* and *b*, lycopene, carotenes, zeaxanthin, lutein, lutein 5,6-epoxide, violaxanthin, luteoxanthin, neoxanthin, and neochrome (Ricketts 1967).

3. The cell is without scales or cell wall. In *Marsupiomonas* the cell is located in a lorica-like close-fitting bowl, which opens anteriorly.

4. The cells are uninuclear.

5. Ejectile organelles are absent.

6. Starch is stored in the chloroplast.

7. Mitosis and cell division show very primitive traits, compared to other green algae: mitosis is closed throughout, without polar gaps. The mitotic spindle is therefore entirely internal. Cytokinesis takes place without a phragmoplast or phycoplast.

8. Cell division is by longitudinal fission. Sexual reproduction is unknown.

9. The monotypic genera *Resultor* and *Marsupiomonas* are members of the marine nanoplankton, while species of *Pedinomonas are* from fresh water. Cells of *Pedinomonas tenuis* from salt lakes in Middle Asia are surrounded by a lorica and almost certainly belong in *Marsupiomonas.* The generic affinity of *Pedinomonas noctilucae*, a symbiont of green *Noctiluca*, is uncertain.

10. Diagnostic features used for species identification are cell shape, size, etc. Electron microscopy is of little use.

With a single order Pedinomonadales Moestrup, 1991, and a single family Pedinomonadaceae Korshikov, 1938.

### Key to the genera

1. Cell surrounded by close-fitting bowl-shaped lorica with large aperture anteriorly . ..... ***Marsupiomonas***

1′. No lorica, cells naked ..... 2

2. Cells often non-motile with the flagellum curved around the cell. Cells jump by stretching the flagellum to full length..... ***Resultor***

2′. No jumping movements..... ***Pedinomonas***

Genus ***Pedinomonas*** Korshikov, 1923

Unicellular naked flagellate. Cells swim with the flagellum undulating behind the cell. Very thin hairs are present on the flagellum. With 0, 1, or 2 pyrenoids. Palmella stages known. Asexual cysts smooth walled or with warts.

Free-living in fresh water or symbiotic in *Noctiluca* or the radiolarian *Thalassolampe.* See Ettl & Manton (1964), Pickett-Heaps and Ott (1974).

*Pedinomonas minor* Korshikov (Fig. 1). Cells flattened, 2.5-7 μm long, 1.8-4.4 μm wide, and 1.2-2 μm thick. With single pyrenoid. Widely distributed.

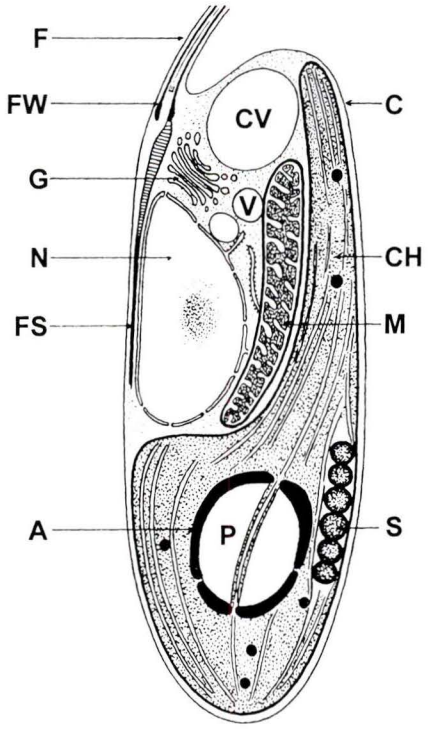


Fig. 1. *Pedinomonas minor.* A, starch grains; C, plasmalemma; CH, chloroplast; CV, contractile vacuole; F, emergent flagellum; FS, rhizoplast; FW, basal body; G, Golgi body; M, mitochondrion; N, nucleus; P, pyrenoid; S, eyespot; V, vacuole. Not to scale. (From Ettl, 1972).

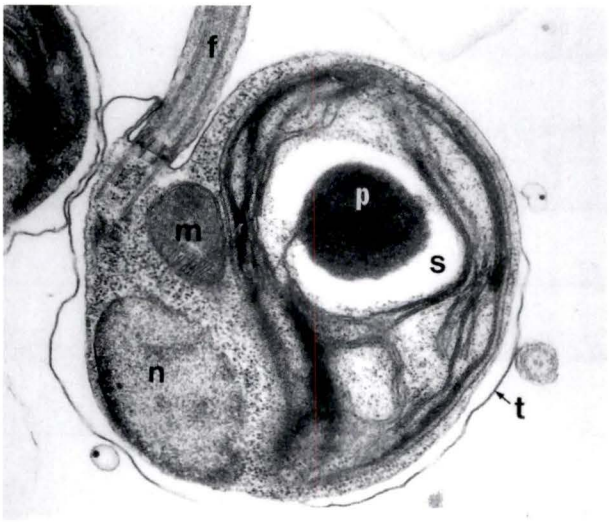


Fig. 2. *Marsupiomonas pelliculata.* Longitudinal section. f, flagellum; m, mitochondrion; n, nucleus; p, pyrenoid; s, starch grain; t, lorica. x23,500. (From Jones et al., 1994).

Genus ***Marsupiomonas***
Jones, Leadbeater & Green, 1994

Cells surrounded by close-fitting lorica, except at the anterior end, otherwise similar to *Pedinomonas.* The flagellum emerges tangentially from the cell near one side of the lorica aperture. See Jones et al. (1994).

*Marsupiomonas pelliculata* Jones, Leadbeater & Green (Fig. 2). Cells compressed, c. 3 μm long, 2.3 μm wide and 1.8 μm thick. Isolated from a salt marsh near Plymouth, England.

Genus ***Resultor*** Moestrup, 1991

Tiny flagellated cell, usually with the single emergent flagellum curved around the cell. The flagellum occasionally stretches out rapidly to full length but immediately recoils around the cell. Cells may swim for a short distance with the flagellum undulating behind the cell. Otherwise very similar to *Pedinomonas.* See Moestrup (1991).

*Resultor minutissima* (Throndsen) Moestrup (Fig. 3). Cells compressed, c. 3 μm long, 2 μm wide, and 1 μm thick. Widely distributed marine nanoplankton flagellate.

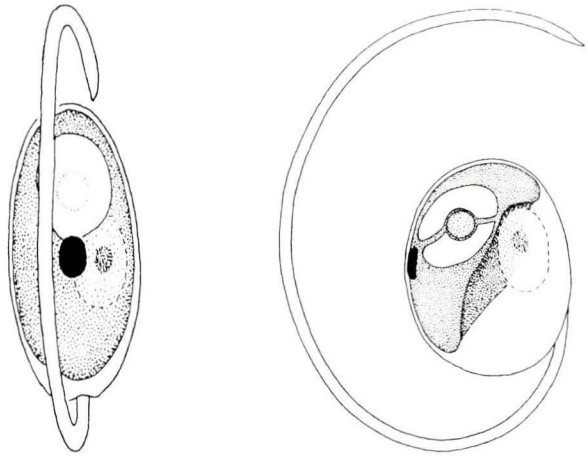

Fig. 3. *Resultor micron*, cells in two different views. x10,000. (From Moestrup, 1991).

## LITERATURE CITED

Ettl, H. & Manton, I. 1964. Die feinere Struktur von *Pedinomonas minor* Korschikoff. *Nova Hedwigia*, 8: 21-444.

Heiman, K., Reize, I. B. & Melkonian, M. 1989. The flagellar developmental cycle in algae: flagellar transformation in *Cyanophora paradoxa* (Glaucocystophyceae). *Protoplasma*, 148:106-110.

Jones, H. L. J., Leadbeater, B. S. C. & Green J. C. 1994. An ultrastructural study of *Marsupiomonas pelliculata* gen. et sp. nov., a new member of the Pedinophyceae. *Eur. J. Phycol.*, 29:171-181.

Moestrup, Ø. 1991. Further studies of presumedly primitive green algae, including the description of Pedinophyceae class nov. and *Resultor* gen. nov. *J. Phycol.*, 27:119-133.

Moestrup, Ø. & Hori, T. 1989. Ultrastructure of the flagellar apparatus in *Pyramimonas octopus* (Prasinophyceae). II. Flagellar roots, connecting fibres, and numbering of individual flagella in green algae. *Protoplasma*, 148:41-56.

Pickett-Heaps, J. D. & Ott, D. W.. 1974. Ultrastructural morphology and cell division in *Pedinomonas*. *Cytobios*, 11:41-58.

Ricketts, T. R. 1967. The pigments of the phytoflagellates, *Pedinomonas minor* and *Pedinomonas tuberculata*. *Phytochemistry*, 6: 19-24.

# CLASS **PELAGOPHYCEAE** ANDERSEN & SAUNDERS 1993

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The Pelagophyceae are a group of flagellated, coccoid, palmelloid, sarcinoid and filamentous organisms. Some of these were once placed in the Chrysophyceae (See chapter on Chrysomonada) but they differ from the chrysomonads in a significant number of features (Andersen et al., 1993, Saunders et al., 1997; Bailey and Andersen, 1999). The pelagophytes are marine and usually microscopic although a few reach macroscopic size. Eleven genera are presently known, but because the class was recognized only recently, it is likely that additional genera will be added. Cavalier-Smith et al. (1995) suggested that the Sarcinochrysidales be placed in a separate class, but more recently based upon additional molecular data, one class (Pelagophyceae) is recognized with two orders, the Pelagomonadales Andersen & Saunders 1993 and the Sarcinochrysidales Gayral & Billard, 1977 (Saunders et al., 1997). *Aureococcus, Pelagococcus*, and *Pelagomonas* are placed in the Pelagomonadales, and the remaining genera are placed in the Sarcinochrysidales.

The phylogenetic relationships of the Pelagophyceae, based upon the 18S rRNA and *rbc*L genes, have been addressed in several recent papers. They have a close relationship with the silicoflagellates, pedinellids, and the marine photosynthetic amoeba *Rhizochromulina* Hibberd & Chrétiennot-Dinet, 1979 (see Chapter Silicoflagellata; Saunders et al.,1995, Daugbjerg and Andersen 1997, DeYoe et al., 1997, Potter et al., 1997, Saunders et al., 1997, Andersen et al., 1998, Bailey and Andersen, 1999). These organisms, in turn, may have a sister relationship with the diatoms, possibly comprising a group of chromophytes ( = heterokont algae) with a 'reduced flagellar apparatus' and with similar photosynthetic pigments (Saunders et al., 1995). However, phylogenetic analyses based upon molecular data have not, to date, provided a clear phylogenetic relationship for the various classes of chromophytes.

## KEY CHARACTERS

1. Vegetative cells are free-swimming flagellates, planktonic, coccoid, single cells or attached filamentous, palmelloid, and sarcinoid masses. With the exception of zoospore formation, alternate life history stages are unknown.

2. Some genera are free-swimming, single-cell flagellates (*Ankylochrysis*, *Pelagomonas*, *Sulcochrysis*). Zoospores are produced by some nonflagellated genera (*Chrysocystis, Chrysonephos, Chrysoreinhardia, Nematochrysopsis, Sarcinochrysis*) while other genera have no known flagellated stage (*Aureococcus, Aureoumbra, Pelagococcus*). The flagellar basal bodies of all swimming cells are positioned on or very close to the nuclear envelope, and no evidence has been found for the presence of a rhizoplast. There is a transitional helix (typically two gyres) below the major transitional plate. Flagellar hairs are present on the immature (longer, anteriorly directed) flagellum, and the hairs are typically tripartite without lateral filaments although *Pelagomonas* appears to have bipartite hairs (Andersen et al.,