

Euglenophytes from Orissa State, East Coast of India

Sachitra Kumar Ratha, Mrutyunjay Jena and Siba Prasad Adhikary*

P.G. Departments of Botany & Biotechnology, Utkal University, Bhubaneswar - 751004, India

Sixty taxa of *Euglenaceae* belonging to 19 species of *Euglena*, 1 species of *Colacium*, 8 species of *Lepocinclis*, 22 species of *Phacus* and 10 species of *Trachelomonas* were reported from different habitats of Orissa state in the east coast of India. All the taxa were recorded for the first time from this region.

Key Words: *Colacium*, *Euglena*, India, *Lepocinclis*, *Phacus*, *Trachelomonas*

INTRODUCTION

The Euglenophyceae are a group of unicellular flagellated organisms found on moist soil, in freshwaters and also in marine environments. The class is characterized by solitary unicells (only one colonial genus exists) with two anteriorly inserted flagella of which one is emergent, condensed chromosomes throughout the cell cycle, a paraxial rod associated with one or both flagella, a proteinaceous pellicle composed of individual strips each of which is lined by microtubules and a beta-1,3 glucan storage product known as paramylum.

There are several publications on euglenophytes of India (Gonzalves and Joshi 1943; Hosmani 1976; Kamat and Frietas 1976; Patel and Waghodekar 1981; Hosmani and Bharati 1983; Bhoge and Ragothaman 1986; Prasad and Chaudhary 1986; Chaudhary and Prasad 1986; Hegde and Bharati 1986; Hegde and Isacs 1988; Srivastava and Odhwani 1990; Habib and Pandey 1990; Waghodekar and Patel 1991; Shaji and Patel 1991; Sinha 2002), however, all these work have been confined to certain specific localities of western and northern parts of India. Orissa state, located in the east coast of India (Lat. 17° 48'-23° 34' N & Long. 81° 24'-87° 29' E) has an area of 1,55,842 km² and is rich in water bodies due to its several diurnal and perennial rivers, reservoirs, lakes, ponds and ditches, cold springs, streams in the hilly terrain etc. Hence it was expected that many euglenophytes might be occurring in this part of India. Through intensive research for over a period of two years we for the first

time reported sixty taxa of *Euglenaceae* from this region.

MATERIALS AND METHODS

A total of 46 samples were collected from 30 different sites comprising of various habitats, e.g. sewage, roadside stagnant water, pond, ditch, lake, reservoir, river, stream and rice fields of Orissa during September 2003 to August 2005. The location of each site was determined with a Garmin 12 GPS receiver (Table 1). Samples were collected in sterilized Tarson specimen tubes using a plankton net (45 µm pore size). The samples were kept cool in an ice chest while being transported to the laboratory. After initial observation, materials were fixed in Lugol's iodine solution (0.5%) to immobilize the cells to facilitate microscopic examination. Each sample was assigned with a voucher number along with the date of collection, preserved in 4% (v/v) formaldehyde and deposited at the Department of Botany, Utkal University. Temperature, pH and conductivity of each collection site was measured on spot using portable thermometer, pH meter (131E, Electronics India) and conductivity meter (621E, Electronics India) respectively. Microphotograph of each specimen was taken using a Meiji Trinocular Research microscope fitted with Nikon FX-801 camera. Morphometric analysis was carried out using Erma micrometers. The organisms were identified following Huber-Pestalozzi (1955), Sinha (2002) and Marin *et al.* (2003).

RESULTS AND DISCUSSION

Details about the site of collection, habitat, pH, tem-

*Corresponding author (adhikary2k@hotmail.com)

Table 1. List of the sites of collection showing latitude, longitude, voucher no., nature of the habitat along with the temperature, pH and conductivity at the time of collection.

Station no. (S)	Place of collection	Latitude	Longitude	Voucher no.	Habitat	Temperature (°C)	pH	Conductivity (µS)
1	Similipal, Mayurbhanj	22°06'15.6"E	86°31'11.8"N	391	Pond	26	6.3	78
2	Baliapal, Balasore	21°40'9.36"E	87°04'7.56"N	404	Ditch	28	6.7	268
3	Chandipur, Balasore	21°26'9.27"E	87°00'4.33"N	399	Pond	29	8.1	546
4	Chandipur, Balasore	21°26'9.27"E	87°00'4.33"N	398	Muddy substratum	27	6.5	282
5	Balasore	21°28'76.2"E	86°57'10.6"N	401	Drain	28	8.1	412
6	Niali, Cuttack	20°13'29.6"E	86°05'11.1" N	89	Pond	27	8.6	782
7	Chandaka, Bhubaneswar	20°26'58.1"E	85°46'51.9"N	B-96	Stream, Tank	26	5.8	186
8	Daspur, Bhubaneswar	20°25'18.5"E	85°47'37.0"N	B-80	Flooded rice field	27	6.6	196
9	Acharya vihar, Bhubaneswar	20°17'47.8"E	85°49'59.3"N	B-103	Puddle	29	7.8	254
10	Nico Park, Bhubaneswar	20°17'7.14"E	85°50'3.43"N	B-105 & B-110	Sewage tank	30	8.2	349
11	Tnakapani road, Bhubaneswar	20°14'33.8"E	85°52'1.19"N	B-8	Sewage tank	29	8.4	378
12	Vani Vihar Lake, Bhubaneswar	20°17'54.5"E	85°50'38.4"N	B-22	Polluted lake	27	8.8	406
13	Bhejiput, Ganjam	19°42'24.6"E	85°11'37.7"N	458	Pond	27	9.2	679
14	Pathara, Ganjam	19°38'32.6"E	85°10'15.5"N	457	Pond	28	7.8	568
15	Nirmaljar, Khallikote, Ganjam	19°36'07.1"E	85°04'00" N	N1	Stream	27	5.6	123
16	Krushnaprasad, Puri	19°38'03.8"E	85°15'47.2"N	467	Pond	28	8.2	412
17	Krushnaprasad, Puri	19°38'14.3"E	85°15'42.2"N	468	Puddle	28	7.6	372
18	New bus-stand, Brahmaipur	19°18'52.6"E	84°47'56.5"N	158	Pond	28	9.2	780
19	Rushikulya river, Tara Tarini, Ganjam	19°31'03.8"E	84°53'19.6"N	284	River	32	8.1	328
20	Aska, Ganjam	19°38'5.11"E	84°41'36.5"N	288, 289	Effluent of sugar factory	31	7.8	1476
21	Maniakati, Ganjam	19°48'7.59"E	84°22'46.3"N	135	Drain at tube well	29	7.4	293
22	Pipalpanka, Ganjam	19°51'53.6"E	84°17'38.6"N	226	River	29	6.2	102
23	Sonapur, Ganjam	19°06'24.3"E	85°44'19.2"N	475	Pond	28	8.4	484
24	Sonapur, Ganjam	19°08'14.5"E	84°46'09.6"N	476	Drying pond			
25	Digapahandi, Ganjam	E 19°22'33.3"	84°34'24.8"N	495, 496, 497 & 499	Pond	29	8.4	741
26	Dharmipur, Ganjam	19°25'12.3"E	84°30'09.9"N	504 & 505	Pond	27	8.6	403
27	Maliguda, Koraput	18°49'53.4"E	82°39'51.6"N	315	Puddle	29	7.6	173
28	Bargarh	21°19'58.4"E	83°37'10.6"N	443	Puddle	27	7.4	198
29	Padmapur, Bargarh	21°19'26.2"E	83°36'42.3"N	450	Puddle	29	6.4	415
30	Bargarh	21° 19'58.3"E	83°37'11.6"N	449	Puddle	26	7.3	351

perature and conductivity of the water at the time of collection and voucher number of each sample has been depicted in Table 1. Description of each organism and systematic enumeration is presented.

Genus: *Euglena* Ehrenberg

Green, phototrophic, chloroplast discoid, shield-shaped or ribbon-shaped, entire or dissected, with or without pyrenoids, pyrenoid naked or sheathed with paramylum grains, one eyespot present at the anterior of the cell, cells never completely rigid, show some level of

euglenoid movement (metaboly) ranging from slight to extreme, cell body asymmetrical and somewhat flattened, cells with a single emergent flagellum, in some species the flagellum is short and not detectable with light microscope, contractile vacuole present and expels into the reservoir.

1. *Euglena acus* Ehrenberg var. *angularis* Johnson (Plate 1, fig. 1 & 2)

Cells green, solitary, long, cylindrical; curved at the middle; sharp pointed posterior end, truncate anterior end; chloroplast numerous, discoid; paramylum bodies

many, long, rod shaped; central nucleus; stigma prominent; cell 177-288 μm long, 7-18 μm broad. Occurred as green patch on moist soil, in pond water; voucher number, site and date: 476, Digapahandi, Ganjam (S-24; Temp. 28°C; pH 6.8; Conductivity 342 μs); June 5, 2005.

2. *Euglena agilis* Carter (Plate 1, fig. 3)

Cells green, fusiform, metabolic; anterior end rounded or truncate, posterior end tapered; central region widest; two small parietal chloroplast with double pyrenoids; paramylum numerous, rounded; nucleus central; stigma prominent; cell 42.3-43 μm long, 14-15 μm broad. Occurred as scum in puddle; voucher number, site and date: 468, Krushnaprasad, Puri (S-17; Temp. 28°C; pH 7.6; Conductivity 372 μs); June 4, 2005.

3. *Euglena bivittata* Conrad (Plate 1, fig. 4)

Cells dark green, spindle shaped; anterior narrow rounded end, posterior broad conical with a small tail (cauda), pointed; pellicle spirally striae, highly plastic; stigma anterior; chloroplast two, positioned at the anterior and the posterior end of the cell; paramylum bodies two; nucleus central; cell 40-60 μm long, 13-16 μm broad. Occurred as blackish bloom in pond; voucher number, site and date: 449, puddle, Bargarh (S-30; Temp. 26°C; pH 7.3; Conductivity 351 μs); March 28, 2005.

4. *Euglena caudata* Hübner (Plate 1, fig. 5)

Cells green, ovoid or spindle shaped; anterior end conical, posterior end pointed; chloroplasts numerous; paramylum bodies two; nucleus basal; flagellum equal to body length; cell 60-110 μm long, 15-38 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

5. *Euglena clara* Skuja (Plate 1, fig. 6)

Cells green, fusiform or spindle shaped, both ends rounded; anterior end tapered towards end; chloroplast saucer shaped; flagellum equal to body length; cell 52.6 - 69.6 μm long, 17.4-22.5 μm broad. Occurred as bloom in pond; voucher number, site and date: 475, Sonapur, Ganjam (S-23; Temp. 28°C; pH 8.4; Conductivity 484 μs); June 5, 2005.

6. *Euglena clavata* Skuja (Plate 1, fig. 7)

Cells dark green, ovoid, spindle shaped, fusiform; anterior elliptical to conical, posterior tapered into a tail (cauda); chloroplast numerous, small, rounded; paramylum ovoid or disc shaped, each contain a pyrenoid at the centre; flagellum 2-2.5 times longer than the body length; nucleus spherical; cell 72.7-80.6 μm long, 33.6 - 37.9 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH

7.8; Conductivity 568 μs); June 4, 2005.

7. *Euglena deses* Ehrenberg (Plate 1, fig. 8)

Cells green, cylindrical or fusiform; blunt towards the anterior end, conical, wide, posterior tapered, blunt; chloroplast numerous, discoid; cell 60-90 μm long, 15.2-30 μm broad. Occurred as bloom in pond; voucher number, site and date: 497, Digapahandi, Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug. 8, 2005.

8. *Euglena elastica* Prescott (Plate 1, fig. 9)

Cells green, spindle shaped, much swollen in mid region, both ends tapered; anterior end conical, posterior narrow, swollen and knob like; chloroplast discoid; paramylum bodies numerous; stigma prominent; cell 43-72 μm long, 15-20 μm broad. Occurred as bloom in pond; voucher number, site and date: 505, Dharmapur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); June 5, 2005.

9. *Euglena gracilis* Klebs (Plate 1, fig. 10)

Cells green, cylindrical or fusiform, highly plastic; anterior end rounded, posterior end narrow, blunt; chloroplast numerous; three large paramylum, discoid or rounded; flagellum short clear; stigma prominent; cell 60-62 μm long, 13-14.8 μm broad. Occurred as dark green bloom in pond; voucher number, site and date: 505, Dharmapur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

10. *Euglena haematodes* (Ehrenberg) Lemmermann. (Plate 1, fig. 11)

Cells green, ovoid to ellipsoid or fusiform; posterior end blunt, anterior end conical; chloroplast entire, parietal; paramylum bodies numerous, small, ovoid, grains like; cell 81.6-91 μm long, 20.4-35 μm broad. Occurred as bloom in pond, voucher number, site and date: 158, bus stand, Brahmapur, Ganjam (S-18; Temp. 28°C; pH 9.2; Conductivity 780 μs); Feb. 6, 2004.

11. *Euglena hemichromata* Skuja (Plate 1, fig. 12)

Cells green, elongate, metabolic, fusiform to cylindrical; anterior end truncated, posterior end slightly swelling and constricted into a short tail (cauda); chloroplast numerous, ovoid; two paramylum bodies, disc shaped; nucleus central; cell 90-93 μm long, 18-19 μm broad, tail 3-4 μm long. Occurred as plankton in pond; voucher number, site and date: 504, Dharmapur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug 8, 2005.

12. *Euglena ignobilis* Johnson (Plate 1, fig. 13)

Cells green, cells more or less cylindrical and curved; anterior end slightly narrow, posterior end tapered to a short tail; pellicle with prominent striae; chloroplast

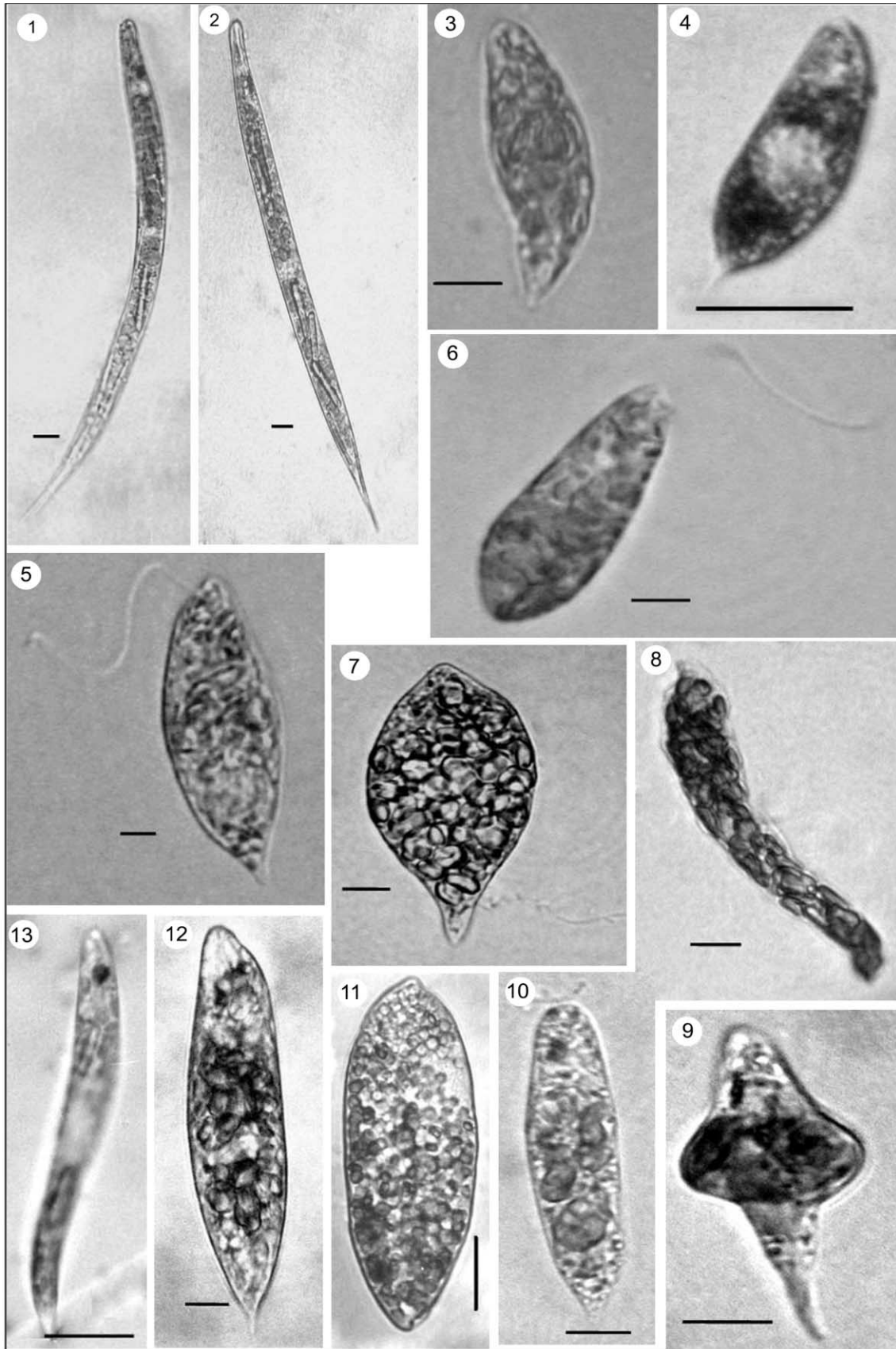


Plate 1. (Fig. 1-13) 1. & 2. *Euglena acus* Ehrb. var. *angularis* Johns., 3. *E. agilis* Cart., 4. *E. bivittata* Conr., 5. *E. caudata* Hüb., 6. *E. clara* Skuja, 7. *E. clavata* Skuja, 8. *E. deses* Ehrb., 9. *E. elastica* Presc., 10. *E. gracilis* Klebs., 11. *E. haematodes* (Ehrb.) Lemm., 12. *E. hemichromata* Skuja, 13. *E. ignobilis* Johns. (Scale bar: 1-3, 5-10, 12 = 10 μ m; 4, 11, 13 = 20 μ m)

numerous, small, rounded; paramylum two, oblong, one each in posterior and anterior ends; nucleus central, stigma prominent; cell 70-85 μm long, 5-8 μm broad. Occurred in rice field; voucher number, site and date: B80, Daspur, near Chandaka Forest, Bhubaneswar (S-8; Temp. 27°C; pH 6.6; Conductivity 196 μs); Jan. 29, 2004.

13. *Euglena oblonga* Scmitz. (Plate 2, fig 1)

Cells green, elongate or fusiform to cylindrical; anterior tapered into rounded end, posterior end broad, blunt; chloroplasts 16-25, parietal; paramylum numerous, rounded; cell 53-57.8 μm long, 11-17 μm broad. Occurred as green mat on mud surface in a drying pond; voucher number, site and date: 398, Chandipur, Balasore (S-4; Temp. 27°C; pH 6.5; Conductivity 282 μs); Jan.14, 2005.

14 *Euglena oxyuris* Schamarda var. *charkowiensis* Swirenko (Plate 2, fig. 2)

Cells green, elongated, cylindrical, bent but twisted; anterior end curved, posterior end blunt with a pointed tail; pellicle yellowish green with spiral rows; chloroplast numerous, small, ovoid; two large paramylum bodies (27-30 μm long, 13-16 μm broad) numerous; stigma prominent; cell 130.5-145.5 μm long (with tail), 17.6-21 μm broad, tail 24-31 μm long, Occurred as epiphytic; voucher number, site and date: B103, ditches, puddles, Acharya Vihar, Bhubaneswar (S-9; Temp. 29°C; pH 7.8; Conductivity 254 μs); April 25, 2004.

15. *Euglena platydesma* Skuja (Plate 2, fig. 3)

Cells green, elongated, triangular in cross section; pellicle twisted; anterior end rounded, posterior end with a long tail; chloroplast numerous, small, rounded; paramylum numerous; cell 137.3-152.3 μm long (with tail), 13.6-19 μm broad, tail 15-22 μm long. Occurred as bloom in sewage tank; voucher number, site and date: B105, polluted tank and slow running water; Nico park, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 15, 2004.

16. *Euglena proxima* Dangeard (Plate 2, fig. 4 & 5)

Cells green fusiform; blunt towards the anterior end, tapered gradually to a pointed posterior end; changing shape markedly by contraction or bulging, easily rounding up on irritation; chloroplast numerous, irregularly disc shaped; paramylum bodies numerous, small rod shaped and scattered throughout the cell; cell 50-95 μm long, 15-21 μm broad; cyst rounded, 23-30 μm diameter. Occurred as scum on distillery effluent canal; voucher number, site and date: 288 & 289, Aska sugar factory, Ganjam (S-20; Temp. 31°C; pH 7.8; Conductivity 476 μs); July 4, 2004.

17. *Euglena sociabilis* Dangeard (Plate 2, fig. 6)

Cells deep green, spindle shaped, or ellipsoid; anterior end conical, posterior end tapered to a tail (cauda), blunt; chloroplast numerous, spindle shaped; paramylum bodies discoid; cell 76 μm long and 25 μm broad. Occurred as slime on floor of a stream and also in pond; voucher number, site and date: B76, Chandaka, Bhubaneswar (S-7; Temp. 26°C; pH 5.8; Conductivity 186 μs); Jan. 29, 2004.

18. *Euglena trisulcata* Johnson (Plate 2, fig. 7)

Cells green, elongate; anterior rounded, posterior ending with a twisted tail (cauda); pellicle with clear twisted striae; triangular ridge at the middle and at the posterior end; chloroplast numerous, small, rounded; paramylum two long rods like structure, one in front and other behind the nucleus; stigma prominent; cell 75-88 μm long, 6-12 μm broad, tail 8 - 11 μm long. Occurred as epiphytic in river bed; voucher number, site and date: 226, stream, Rusikullya river, near Pipalpanka, Ganjam (S-22; Temp. 29°C; pH 6.2; Conductivity 102 μs); April 1, 2004.

19. *Euglena wangi* Chu (Plate 2, fig. 8)

Cells green, fusiform or sub cylindrical; anterior end conical, posterior end tapered into a caudal prolongation; central region wide; chloroplast numerous, small, disc shaped; paramylum grains just beneath the periplast, prominent; nucleus central; cell 57.3-82.4 μm long, 17-29.3 μm broad. Occurred as bloom in pond; voucher number, site and date: 467, Krushnaprasad, Puri (S-16; Temp. 28°C; pH 8.2; Conductivity 412 μs); June 4, 2005.

Genus: *Colacium* Ehrenberg

Cells colonial, attached to others by gelatinous stalk emerging from anterior end, stalk mucilaginous, cell with thin mucilaginous sheath, individual cell pyriform, ellipsoidal or cylindrical, without flagellum, chloroplast discoidal, numerous, with central pyrenoid, stigma present, pellicles soft, euglenoid movement rarely seen, multiplication by longitudinal fission; freshwater forms, epiphytic on filamentous algae and aquatic angiosperms.

1. *Colacium cyclopicola* (Gickelhorn) Bourrelly (Plate 2, fig. 9)

Cells yellowish, ovoid, elliptical or spindle shaped; paramylum bodies small, rounded; chloroplast numerous; stigma prominent; cell 11-26 μm long, 8.2-13.6 μm broad. Occurred as epiphytic in a ditch, attached to submerged dead plant materials; voucher number, site and date: B103, Acharya vihar, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

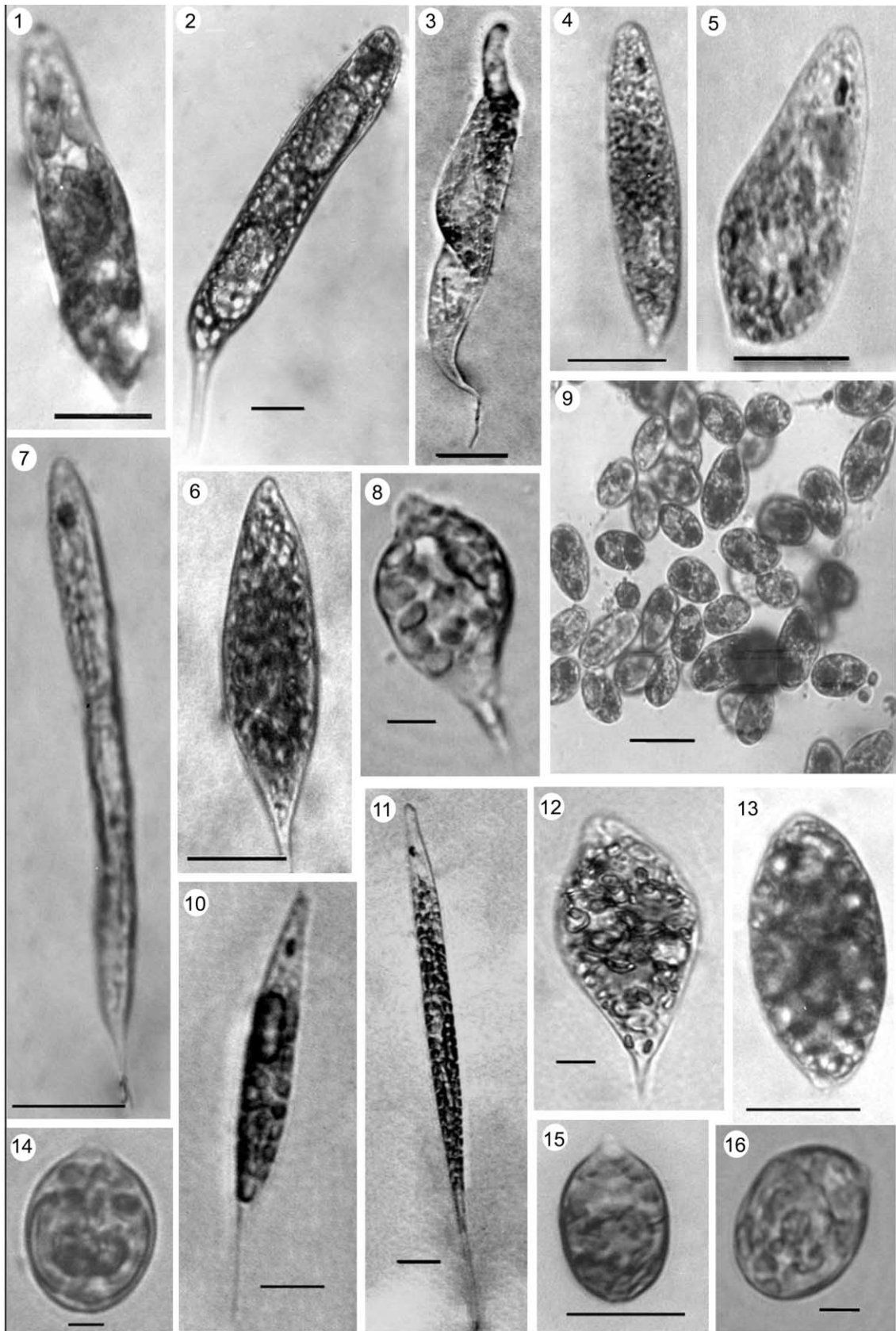


Plate 2. (Fig. 1-16) 1. *Euglena oblonga* Scmitz., 2. *E. oxyuris* Sch. var. *charkowiensis* Swir. 3. *E. platydesma* Skuja, 4. & 5. *E. proxima* Dang., 6. *E. sociabilis* Dang., 7. *E. trisulcata* Johns., 8. *E. wangi* Chu, 9. *Colacium cyclopicola* (Gickelh.) Bourr., 10 & 11. *Lepocinclis acus* Ehrb., 12. *Lepocinclis elongata* (Swir.) Conr., 13. *L. fusiformis* (Carter) Lemm., 14. *L. ovum* (Ehrb.) Lemm., 15. *L. ovum* (Ehrb.) Lemm. var. *bütschlii* (Lemm.) Conr., 16. *L. ovum* (Ehrb.) Lemm. var. *discrifera* Conr. (Scale bar: 1-7, 9, 13 = 20 μ m; 8, 10-12, 14-16 = 10 μ m)

Genus: *Lepocinclis* Perty

Phototrophic, solitary, without envelope, chloroplast small, discoid, without pyrenoid, eyespot and flagellar swelling present, cell rigid, euglenoid movement not seen, pellicular striations pronounced and running longitudinally; two large paramylum rings in many species, peripheral, lying opposite one another in the anterior half of the cell, contractile vacuole present.

1. *Lepocinclis acus* Ehrenberg (Plate 2, fig. 10 & 11)

Cells green, solitary, long, elongate, spindle shaped; sharply pointed posterior end, truncate anterior end; chloroplast numerous, disk shaped; paramylum bodies two to several, short rod shaped; nucleus central; stigma prominent; cell 170-230 μm long, 7-15 μm broad. Occurred as bloom in pond; voucher number, site and date: 497, Digapahandi, Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug. 8, 2005.

2. *Lepocinclis elongata* (Swirenko) Conard (Plate 2, fig. 12)

Cells green, spindle shaped; anterior end conical, posterior tapered into a long blunt end; chloroplast numerous; paramylum bodies ovoid; stigma prominent; cell 106-109 μm long, 35-50 μm broad. Occurred as dark green patch on mud surface; voucher number, site and date: 476, Sonpur, Ganjam, (S-24; Temp. 28°C; pH 6.8; Conductivity 342 μs); June 5, 2005.

3. *Lepocinclis fusiformis* (Carter) Lemmermann, Emend, Conrad (Plate 2, fig. 13)

Cells blackish green, ovoid to ellipsoid; anterior end blunt, posterior end rounded or slightly pointed; chloroplast numerous, discoid; paramylum bodies ring shaped, marginal; cell 44-49 μm long, 28-32 μm broad. Occurred as reddish scum in ditch; voucher number, site and date: 404, Gandji chhak, Baliapal road, Balasore, (S-2; Temp. 28°C; pH 6.7; Conductivity 268 μs); Jan. 14, 2005.

4. *Lepocinclis ovum* (Ehrenberg) Lemmermann (Plate 2, fig. 14)

Cells dark green, ovoid or ellipsoid; anterior end rounded, a small cauda present in posterior end; chloroplast numerous, discoid, marginal, without pyrenoids; paramylum large, ring shaped; nucleus central; cell 20-40 μm long, 14-17 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

5. *Lepocinclis ovum* (Ehrenberg) Lemmermann var. *bütschlii* (Lemmermann) Conrad (Plate 2, fig. 15)

Cells yellowish green, solitary ovo-cylindrical; anterior rounded, posterior straight with short projection cauda;

pellicle spirally striated; chloroplast discoid, numerous, without pyrenoids; paramylum ring shaped; cell 20-42 μm long, 17-23 μm broad. Occurred as bloom in pond; voucher number, site and date: 458, Bhejibuti, Khurda (S-13; Temp. 27°C; pH 9.2; Conductivity 679 μs); June 4, 2005.

6. *Lepocinclis ovum* (Ehrenberg) Lemmermann var. *dis-cifera* Conrad (Plate 2, fig. 16.)

Cells green, ovoid, both ends rounded; posterior end slightly projected out; chloroplast numerous, discoid, marginal; paramylum ring shaped; cell 20-41 μm long, 17-32.6 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

7. *Lepocinclis salina* Fritsch (Plate 3, fig. 1)

Cells green, ovoid; rigid, with spirally striated pellicle; a short projection present in the anterior end; stigma prominent; chloroplast numerous, discoid, marginal; paramylum body ring shaped, large; cell 30-43.3 μm long, 22-34.2 μm broad. Occurred as bloom in pond; voucher number, site and date: 505, Dharmpur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

8. *Lepocinclis wangi* Perty (Plate 3, fig. 2)

Cells green, more or less ovo-cylindrical; spirally striated pellicle; posterior end often with a spinous projection or sometimes tapered to small tail (cauda), anterior end rounded with small teat; stigma sometimes present; chloroplast numerous, discoid and marginal; paramylum bodies large and ring shaped, laterally disposed, without pyrenoids; nucleus central; cell 42-70 μm long, 21-27.3 μm broad. Occurred as bloom in pond; voucher number, site and date: B8, Tankapani road, Bhubaneswar (S-11; Temp. 29°C; pH 8.4; Conductivity 378 μs); Dec. 14, 2003.

Genus: *Phacus* Pochmann

Green, photosynthetic, solitary, highly flattened, pellicle firm, body form constant, paramylum bodies rounded, one or many, chloroplasts small, discoid, most species flat and leaf-shaped, often with ridges or fins running helically or longitudinally.

1. *Phacus acuminatus* Stokes (Plate 3, fig. 3)

Cells green, solitary, flattened, ovoid or triangular; anterior end slightly narrow and rounded, posterior end broader and ending with a conical tail (cauda); apical groove up to hind end; pellicle striae, longitudinal; chloroplast small, numerous; paramylum bodies two to several, ring like or several discs; cell 98-100.4 μm long, 70.2-71.6 μm broad. Occurred as plankton in pond;

voucher number, site and date: 458, Bhejiput, Khurda (S-13; Temp. 27°C; pH 9.2; Conductivity 679 μs); June 4, 2005.

2. *Phacus acuminatus* Stokes var. *granulata* (Roll) Huber - Pestalozzi (Plate 3, fig. 4)

Cells green, solitary, flattened, ovoid; anterior end rounded, posterior end wide and ending with a conical, short tail; pellicle longitudinally striated; chloroplast numerous; paramylum single, large, central; cells 27.2-37.5 μm long, 22.5-28.4 μm broad. Occurred as bloom in pond; voucher number, site and date: 89, Niali, Cuttack (S-6; Temp. 27°C; pH 8.6; Conductivity 782 μs); Oct.18, 2003.

3. *Phacus ankylonoton* Pochmann (Plate 3, fig. 5)

Cells green, cells ovoid or elliptical and slightly asymmetrical with a short tail; chloroplast numerous, discoid, marginal; paramylum usually two, unequal and arranged along the long axis; cell 21-25 μm long, 11-16 μm broad. Occurred as bloom in sewage water; voucher number, site and date: B103, Nico park, Acharya Vihar, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

4. *Phacus agilis* Skuja (Plate 3, fig. 6)

Synonym: *Cryptoglana skujai* Marin et Melkonian

Cells green, ovoid, laterally compressed with a median longitudinal furrow; lateral chloroplasts; two lateral paramylum, large and shell like; pellicle rigid; cell 25-51.2 μm long, 15-26.4 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

5. *Phacus anomalus* Fritsch (Plate 3, fig. 7)

Cells green, solitary, flattened, leaf shaped, asymmetrical, in two diagonal halves; posterior end with sharp pointed curved tail (cauda); chloroplast numerous, small, discoid; paramylum single, small at the posterior end without pyrenoids; pellicle longitudinally striated; cell 61-62 μm long, 20-35 μm broad. Occurred as plankton in pond; voucher number, site and date: 497, Digapahandi, Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug.8, 2005.

6. *Phacus caudatus* Hubner (Plate 3, fig. 8)

Cells green, solitary, flattened, ovoid; a straight tail (cauda) present at the posterior end, sharply pointed; pellicle longitudinally striated; chloroplast numerous; paramylum bodies two, unequal, arranged along the long axis, smaller one at the hind end; cell 40-43.2 μm long, 26.4-27.2 μm broad. Occurred as planktonic in pond; voucher number, site and date: 495, Digapandi,

Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug. 8, 2005.

7. *Phacus curvicauda* Swirenko (Plate 3, fig. 9)

Cells green, flattened, ovoid to suborbicular; anterior narrow, posterior broadly rounded with a blunt short tail (cauda), slightly curved; pellicle longitudinal striated; paramylum bodies two, rounded, axial; chloroplast numerous, discoid and marginal; cell 21-38.2 μm long, 18-25 μm broad. Occurred as plankton in pond; voucher number, site and date: 504, Dharpur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

8. *Phacus carinatus* Pochmann (Plate 3, fig. 10)

Cells green, ovoid, anterior rounded; posterior drawn out into a straight sharp tail; periplast longitudinally striated; paramylum usually two, unequal, smaller at the lower end; chloroplast numerous, small, rounded; cell 34-45 μm long, 25-35 μm broad. Occurred as scum or bloom in puddle; voucher number, site and date: 443, roadside puddle, Bargarh (S-28; Temp. 27°C; pH 7.4; Conductivity 198 μs); March 28, 2005.

9. *Phacus ephippion* Pochmann (Plate 3, fig. 11)

Cells green, pear shaped, curved like a saddle with folds along the margin; anterior end broadly rounded and notched; posterior end proceed into a tail about half of the body; paramylum seated; cell 40-55 μm long (without tail), 23-29 μm broad with 16-20 μm long tail. Occurred as bloom in pond; voucher number, site and date: 158, pond, new bus stand, Brahmapur, Ganjam (S-18; Temp. 28°C; pH 9.2; Conductivity 780 μs); Feb.6, 2004.

10. *Phacus gigas* Cunha (Plate 3, fig. 12)

Cells green, solitary, flattened; ovoid or rounded anterior end, a long pointed projection (cauda) in the posterior, curved; a small notch at the middle of lateral side; chloroplast numerous, small, irregular shaped; paramylum large, single at central of the cell; pyrenoid absent; cell 40-77 μm long, 21-38.4 μm broad. Occurred as greenish bloom in a drying pond; voucher, site and date: 476, Sonapur, Ganjam (S-24; Temp. 28°C; pH 6.8; Conductivity 342 μs); June 5, 2005.

11. *Phacus hamatus* Pochmann (Plate 3, fig. 13)

Cells green; cells with hind end ovoid or elliptical; periplast longitudinally striated; chloroplast numerous, small, rounded; paramylum two at the central of the cells; cell 35-49 μm long and 20-26.4 μm broad. Occurred as bloom in pond; voucher number, site and date: 89, Niali, Cuttack (S-6; Temp. 27°C; pH 8.6; Conductivity 782 μs); Oct.18, 2003.

12. *Phacus hispidulus* (Eickwald) Lemmermann (Plate 3,

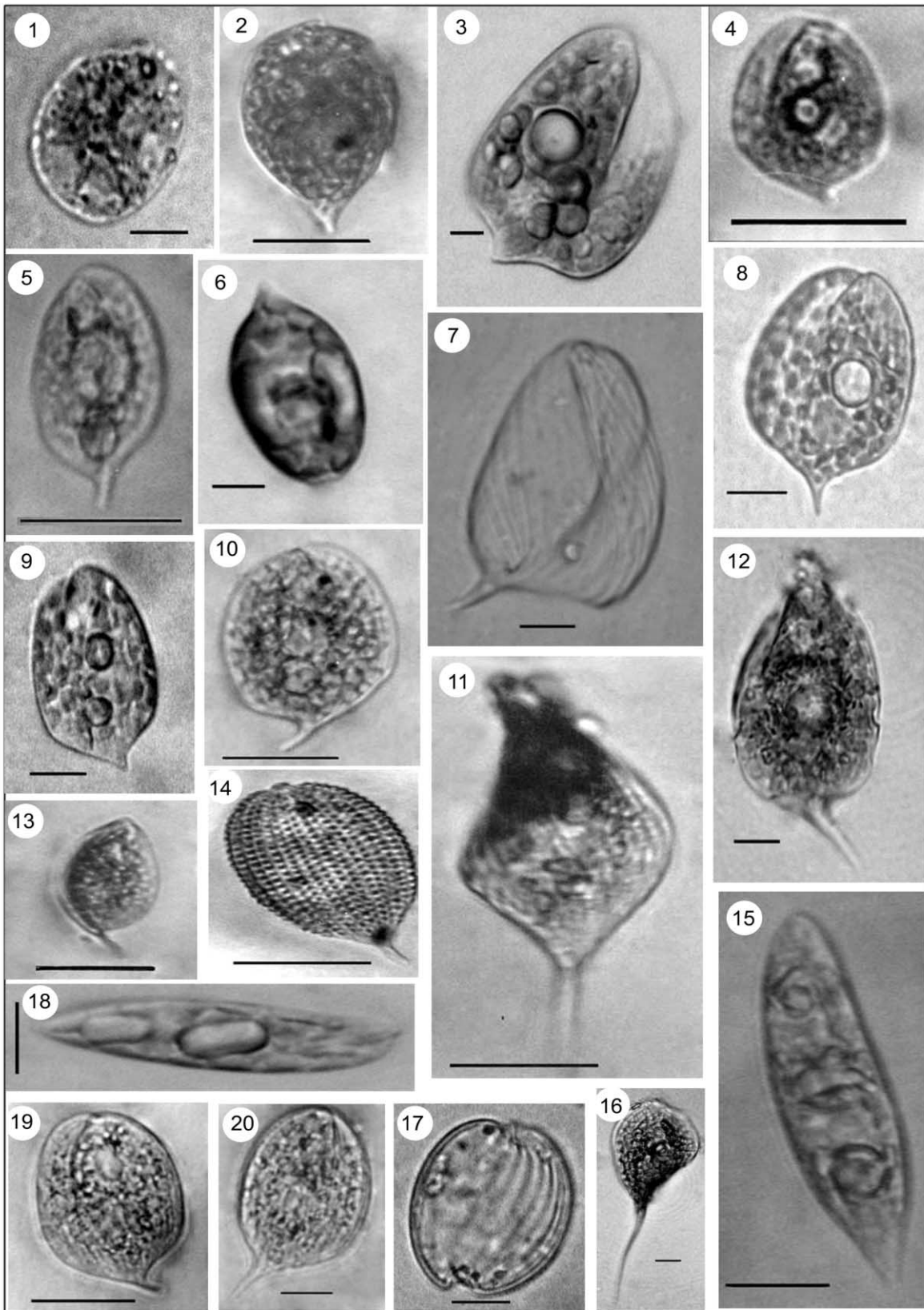


Plate 3. (Fig. 1-20) 1. *Lepocinclis salina* Fritsch., 2. *L. wangi* Perty, 3. *Phacus acuminatus* Stokes, 4. *P. acuminatus* Stokes var. *granulata* (Roll.) Huber - Pestal., 5. *P. ankylonoton* Pochm., 6. *P. agilis* Skuja, 7. *P. anomalus* Fritsch, 8. *P. caudatus* Hubn., 9. *P. curvicauda* Swir., 10. *P. crinatus* Pochm., 11. *P. ephippion* Pochm., 12. *P. gigas* Cunha, 13. *P. hamatus* Pochm., 14. *P. hispidulus* (Eich.) Lemm., 15. *P. ichthydion* Pochm., 16. 4. *P. longicauda* (Ehrb.) Duj., 17. *P. moraviensis* Pochm., 18. *P. oscillans* Klebs., 19. *P. peteloti* L efevre, 20. *P. platelea* Drez. (Scale bar: 1, 3, 6-9, 12, 15-18 = 10 μ m; 2, 5, 10, 11, 14, 19, 20 = 20 μ m; 4, 13 = 30 μ m)

fig. 14)

Cells green, ovoid; anterior end rounded, papilla small; posterior coined with shot tail (cauda), slightly bent; pellicle with minute knobs arranged in longitudinal rows; stigma prominent; cell 30-43.5 μm long, 17-24.4 μm broad, tail (cauda) 4-5 μm long. Occurred as plankton in sewage water tank; voucher number, site and date: B110, Nicco park, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

13. *Phacus ichthydion* Pochmann (Plate 3, fig. 15)

Cells green, solitary, cylindrical; posterior tapered into a tail (cauda) with blunt end; pellicle thin plastic; stigma anterior; chloroplast discoid; two paramylum bodies located on either side of nucleus, ovoid; cells 40-54 μm long, 11.7-12.3 μm broad. Occurred as plankton in pond; voucher number, site and date: 504, Dharmpur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

14. *Phacus longicauda* (Ehrenberg) Dujardin (Plate 3, fig. 16)

Cells green, solitary, ovoid to pyriform; anterior broadly rounded; posterior end tapered to form a long, slightly twisted and pointed tail (cauda) about equal to the body length; pellicle longitudinally striated; paramylum single, ring shaped; chloroplast numerous, small, discoid; cell 80-120 μm long, 25-43.5 μm broad. Occurred as epiphyte on submerged leaf surface of hydrophytes in pond; voucher number, site and date: 499, Digapahandi, Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug. 8, 2005.

15. *Phacus moraviensis* Pochmann (Plate 3, fig. 17)

Cells green, flattened, ovoid or spherical; anterior slightly grooved; a short tail (cauda) in the posterior end; paramylum bodies two; pellicle clearly striated; cell 37.6-40 μm long, 29.6-30.4 μm broad. Occurred as bloom in pond; voucher number, site and date: 496, Digapahandi, Ganjam (S-25; Temp. 29°C; pH 8.4; Conductivity 741 μs); Aug. 8, 2005.

16. *Phacus oscillans* Klebs (Plate 3, fig. 18)

Cells green, solitary, ovoid, elliptical, a broad flattened longitudinal furrow present; anterior broadly rounded, posterior slightly pointed; pellicle with longitudinal striae; paramylum bodies two, disc shaped; cell 18-38.2 μm long, 10-25.1 μm broad. Occurred as bloom in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

17. *Phacus peteloti* L  fevre (Plate 3, fig. 19)

Cells green, ovoid to orbicular; posterior end broader,

abruptly ending into a short sharp inclined tail; pellicle longitudinally striated; paramylum 1-2 ring shaped; cell 30-32 μm long, 25-27 μm broad. Occurred as plankton in sewage water; voucher number, site and date: B32, Vani vihar lake, Bhubaneswar (S-12; Temp. 27°C; pH 8.8; Conductivity 406 μs); Dec.11, 2003.

18. *Phacus platelea* Drezepolski (Plate 3, fig. 20)

Cells yellowish green, cells broadly ovoid, slightly longer than broad, asymmetrical; a pointed tail in the posterior end; periplast longitudinally striated; paramylum single, discoid at the centre; cell 30-35 μm long and 23-27 μm broad; tail 8-10 μm long. Occurred as plankton in sewage water; voucher number, site and date: B22, Vani vihar Lake, Bhubaneswar (S-12; Temp. 27°C; pH 8.8; Conductivity 406 μs); Dec.11, 2003.

19. *Phacus pusillus* Lemmermann (Plate 4, fig. 1)

Cells green, ovoid or spherical; anterior rounded, globular out growth; posterior with a tail (cauda); chloroplast numerous, small, rounded; paramylum body single, central, ring shaped; pellicle longitudinally striated; cell 27-28 μm long, 7-10.5 μm broad. Occurred as plankton in pond; voucher number, site and date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

20. *Phacus tortus* (Lemmermann) Skvortz (Plate 4, fig. 2)

Cells green, half of the cells spirally twisted, some times bilaterally asymmetrical; pellicle spiral; chloroplast numerous; cell 50-56 μm long with tail, 25.8-32.6 μm broad. Occurred as bloom in sewage; voucher number, site and date: B105, Sewage, Nico park, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

21. *Phacus triquter* (Ehrenberg) Dujardin (Plate 4, fig. 3)

Cells green, broadly ovoid or triangular; anterior end slightly narrow and rounded; posterior end with a short conical tail (cauda); apical groove usually reaching up to the hind end; paramylum single large ring shaped; periplast longitudinally striated; cell 42.1-46.2 μm long, 31.2-36.7 μm broad, and tail 6-8 μm long. Occurred as bloom; voucher number, site and date: B105, Polluted water, Tank, Nico park, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

22. *Phacus westisteini* Drezepolski (Plate 4, fig. 4)

Cells green, ellipsoidal; anterior end longitudinally bifurcated, posterior rounded; chloroplast discoid, paramylum bodies three, one big and two small; stigma prominent; cell 38.4-41 μm long, 10-23.6 μm broad. Occurred as bloom in pond; voucher number, site, and

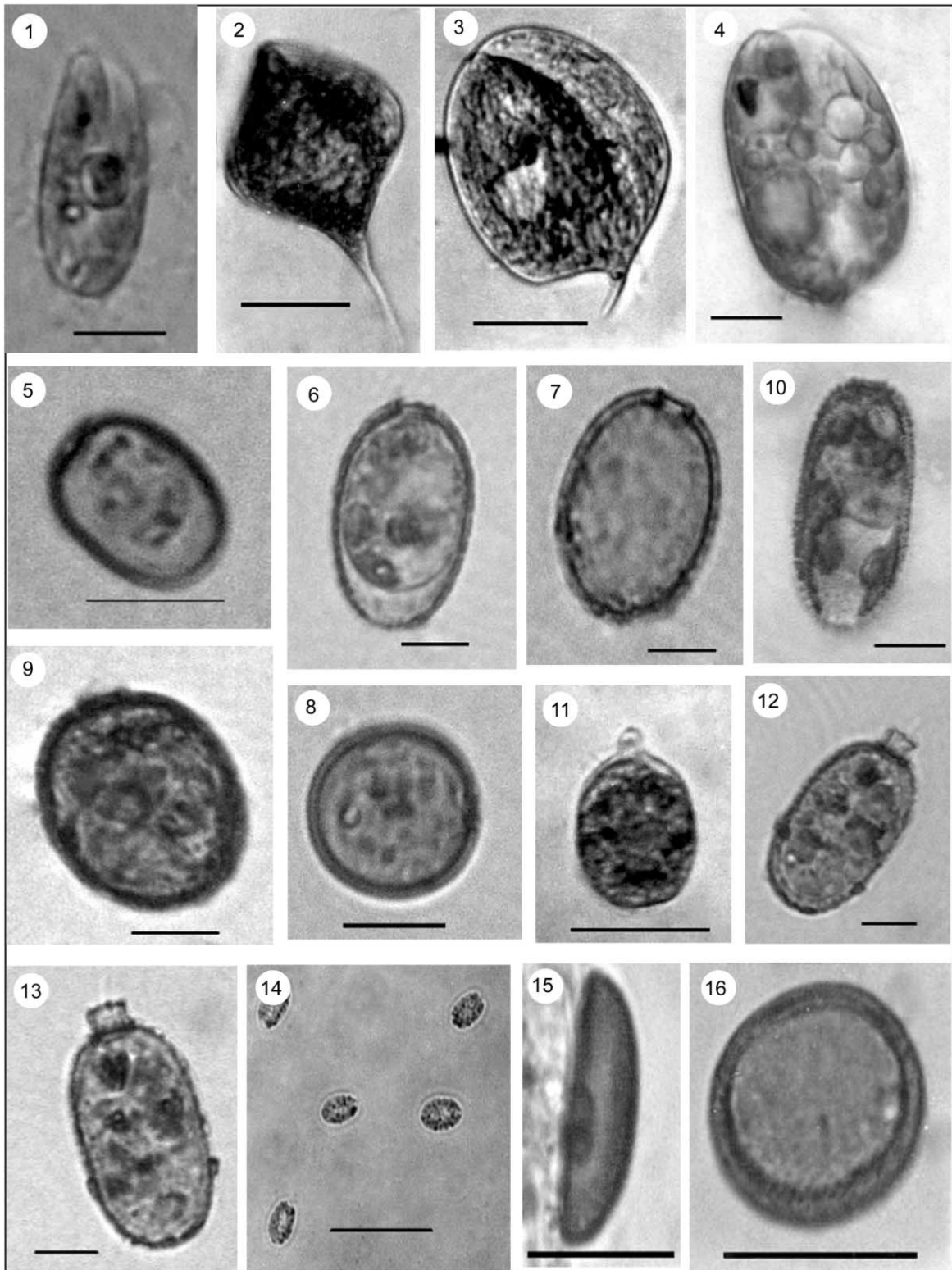


Plate 4. (Fig. 1-16) 1. *Phacus pusillus* Lemm., 2. *P. tortus* (Lemm.) Skv., 3. *P. triqueter* (Ehrb.) Duj., 4. *P. wetisteini* Drez., 5. *Trachelomonas abrupta* Swir. var. *minor* Defl., 6. *T. guttata* Middelh., 7. *T. hispida* (Perty) Stein, 8. *T. intermedia* Dang., 9. *T. kelloggii* Skov. var. *nana* Bal., 10. *T. orenburgica* Swir., 11. *T. placotica* Swir. var. *oblonga* Drez., 12. & 13. *T. splendidissima* Middelh., 14. *T. teres* Mask., 15 & 16. *T. volvocina* Ehrb. var. *punctata* Playf. (Scale bar: 1, 4-10, 12, 13 = 10 μ m; 2, 3, 11, 14, 15, 16 = 20 μ m)

date: 457, Pathara, Ganjam (S-14; Temp. 28°C; pH 7.8; Conductivity 568 μs); June 4, 2005.

Genus: *Trachelomonas* Ehrenberg

Photosynthetic, free-swimming, cells rigid, encased within lorica, spherical, shell-like envelope of minerals and mucilage, cells light green colour with discoid or shield-shaped chloroplast, a single flagellum emerge through an opening in the lorica and allow the cell to swim with a gliding motion, cytoplasm with paramylum granules.

1. *Trachelomonas abrupta* Swirenko var. *minor* Deflandre (Plate 4, fig. 5)

Cells slightly reddish brown, rectangular or ovoid; anterior rounded with a small opening, posterior rounded, lorica thick, collar small; chloroplast discoid, paramylum two to three; cell 10-14.2 μm long, 8-10 μm broad. Occurred as bloom in pond; voucher number, site and date: 505, Dharampur, Ganjam, (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

2. *Trachelomonas guttata* Middelshoek (Plate 4, fig. 6)

Cells reddish brown, spherical, oval or ellipsoid; anterior end rounded with short collar, posterior rounded, lorica thick, reddish, 34 μm long, 21.3 μm broad; chloroplast numerous discoid; cell 15-27.3 μm long, 8-18 μm broad. Occurred as bloom in pond; voucher number, site and date: 505, Dharampur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

3. *Trachelomonas hispida* (Perty) Stein (Plate 4, fig. 7)

Cells brown, ovoid, anterior end inwards, lorica thick, chloroplast numerous with two pyrenoids; cell 20-29.4 μm long, 17-22.3 μm broad and collar 1.5-2 μm long. Occurred as bloom in pond; voucher number, site and date: 505, Dharampur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

4. *Trachelomonas intermedia* Dangeard (Plate 4, fig. 8)

Cells brown, sub-spherical to ellipsoid, anterior punctate, pore with a ring like thickening; chloroplast numerous; lorica thick; cell 18-19 μm diameter. Occurred as bloom in pond, voucher number, site and date: 505, Dharampur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

5. *Trachelomonas keloggii* Skvortzow var. *nana* Balech (Plate 4, fig. 9)

Cells brown, ovoid or ellipsoid, both end rounded, anterior end with short collar, lorica thick, deep brown, chloroplast numerous, discoid, stigma prominent; cell 21-30.6 μm long, 15-23.3 μm broad. Occurred as bloom in pond; voucher number, site and date: 505, Dharampur,

Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

6. *Trachelomonas orenburgica* Swirenko (Plate 4, fig. 10)

Cells reddish to yellow, cylindrical or elliptical, lorica covered with short spine, anterior end rounded with very short collar, posterior slightly narrow, envelope reddish brown, regularly punctuated with acute shot spines; chloroplast numerous, discoid; cell 30-40 μm long, 10-16.4 μm broad. Occurred as bloom in pond; voucher no., site and date: 504, Dharampur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs), Aug. 8, 2005.

7. *Trachelomonas plactonica* Swirenko var. *oblonga* Drezepolski (Plate 4, fig. 11)

Cells green, lorica spherical, membrane thick, beset with tubercles; cell 24-26 μm long (with neck), 17.6-19 μm broad; collar 3.4-4 μm broad, 3.4 μm long. Occurred as blackish bloom in road side puddle; voucher number, site and date: 450, Padmapur, Bargarh (S-29; Temp. 29°C; pH 6.4; Conductivity 415 μs); March 28, 2005.

8. *Trachelomonas splendidissima* Middelshoek (Plate 4, fig. 12 & 13)

Cells brownish green, cylindrical or ovoid, both end rounded, anterior end with collar, collar outword, lorica thick, chloroplast discoid; cell 37.5-42.3 μm long, 18.7-23.8 μm broad; collar 3.8-5.2 μm long. Occurred as bloom in pond; voucher number, site and date: 505, Dharampur, Ganjam (S-26; Temp. 27°C; pH 8.6; Conductivity 403 μs); Aug. 8, 2005.

9. *Trachelomonas teres* Mask (Plate 4, fig. 14)

Cells green, lorica spherical or oval, pore with an annular ring, membrane smooth, yellowish or transparent; cell 5.4-8.8 μm long, 3.4-5.4 μm broad. Occurred as bloom in pond; voucher number, site and date: 391, ditch, Similipal, Mayurbhanj (S-1; Temp. 26°C; pH 6.3; Conductivity 178 μs); March 17, 2003.

10. *Trachelomonas volvocina* Ehrenberg var. *punctata* Playfair (Plate 4, fig. 15 & 16)

Cells reddish brown, lorica spherical or oval, membrane thick; cell 20-22 μm long, 19-20 μm broad. Occurred as bloom in sewage tank; voucher number, site and date: B110, Nico park, Bhubaneswar (S-10; Temp. 30°C; pH 8.2; Conductivity 349 μs); April 25, 2004.

ACKNOWLEDGEMENTS

The authors are grateful to Ministry of Environment and Forest, Govt. of India for financial support through an All India Coordinated Project on Taxonomy (AICOP-

TAX) of freshwater algae. We thank the Head of the Departments of Botany and Biotechnology, Utkal University for providing laboratory facilities.

REFERENCE

- Bhoge O.N. and Ragothaman G. 1986. Studies on the Euglenophyceae from Jalgaon region. *Phykos* **25**: 132-135.
- Chaudhary B.R. and Prasad R.N. 1986. Contributions to the Karyology of Euglenoid flagellates III. *Euglena* Ehrenberg. *J. Ind. Bot. Soc.* **65**: 369-372.
- Gonzalves E.A. and Josi D.B. 1943. The algal flora of temporary waters around Bombay. *J. Bombay Nat. Hist. Soc.* **11**: 34-95.
- Habib I. and Pandey U.C. 1990. The Euglenineae from Nakatia river, Bareilly (U.P.) India. *J. Ind Bot Soc.* **69**: 387-390.
- Hegde G.R. and Bharati S.G. 1986. Ecological studies in ponds and lakes of Dharwad - occurrence of Euglenoid blooms. *Phykos* **25**: 62-67.
- Hegde G.R. and Isacs S.W. 1988. Freshwater algae of Karnataka state - 1. *Phykos* **27**: 96-103.
- Hosmani S.P. 1976. A new species of the genus *Phacus*, *Phacus bharatii* sp. nov. *Phykos* **15**: 29-30.
- Hosmani S.P. and Bharati S.G. 1983. Euglenineae of polluted and unpolluted water. *Phykos* **22**: 130-135.
- Huber-Pestalozzi G. 1955. The phytoplankton of fresh water bodies. **XVI**: 606.
- Kamat N.D. and Freitas J.F. 1976. A check list of Euglenophyceae and Chlorophyceae of Nagpur, Maharashtra. *Phykos* **15**: 121-125.
- Marin B., Palm M., Klingberg M. and Melkonian M. 2003. Phylogeny and taxonomic revision of plastid-containing Euglenophytes based on SSU rDNA Sequence comparisons and synapomorphic signatures in the SSU rRNA secondary Structure. *Protist* **154**: 99-145.
- Patel R.J. and Waghodekar V.H. 1981. The Euglenophyceae of Gujarat, India I Genus *Phacus* Duj. *Phykos* **20**: 24-33.
- Prasad R.N. and Chaudhary B.R. 1986. *Trachelomonas godwardii* and *Lepocinclis sarmii* two new euglenoid taxa from India *Phykos* **25**: 75-78.
- Shaji C. and Patel R.J. 1991. Contributions to euglenoids of Kerala, India. *Phykos* **30**: 109-114.
- Sinha S. 2002. *Industrial effluents and organisms inhabiting them*. Pt. R.S. University Publications, Raipur, India. 174 pp.
- Srivastava P.N. and Odhwani B.R. 1990. *Trachelomonas* Ehr. (Euglenophyta) from semi arid region of Western Rajasthan *Phykos* **29**: 121-126.
- Waghodekar V.H. and Patel R.J. 1991. Euglenoides of Gujarat: Genera *Heteronema* Dujardin and *Anisonema* (Duji.) Stein. *Phykos* **30**: 81-86.

Received 16 November 2005

Accepted 22 February 2006

