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Floristic and Taxonomic Accounts of the Genus *Euglena* (Euglenophyceae) from Korean Fresh Waters

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This paper contains descriptions, illustrations and key to identify 22 taxa of the genus *Euglena* collected from 58 sites of Korean fresh waters. Of these, 12 taxa are recorded for the first time in the euglenoid flora of Korea: *E. archaeoplastidiata, E. caudata, E. granulata, E. oblonga, E. obtusa, E. deses* var. *deses, E. deses* var. *intermedia, E. ehrenbergii* var. *baculifera, E. limnophila, E. texta, E. truncata,* and *E. variabilis*. Most of the members are cosmopolitan, whereas *E. archaeoplastidiata, E. ehrenbergii* var. *baculifera, E. truncata,* and *E. variabilis* are the rare taxa in the world flora of euglenoids.

Key Words: *Euglena*, Euglenophyceae, flora, freshwater algae, Korea, taxonomy

INTRODUCTION

Previous studies on the genus *Euglena* in Korea have been carried out in some local areas, but few of them treated Korean members all. The description and illustrations have been given to the materials from Kyeonggi province by Skvortzov (1932), Chung (1956), and Chung and Chang (1957), from Yeongnam by Chung (1970, 1982), from Jeju by Chung *et al.* (1972), from Cheonnam by Wui and Kim (1987). Since knowledge of the green euglenoids in the fresh waters from Korea has still been incomplete in view of a lot of species unrecorded, the taxonomic and floristic studies are urgently needed for understanding further systematics and diversity of Korean euglenoids.

For easier identification of the taxa discussed here, a key to the subgenera, species, and varieties is included. Three subgenera — *Euglena, Calliglena* and *Discoglena* — have been distinguished based on the position of chloroplasts in cell (axial or parietal), their number, size and shape, as well as presence or absence of pyrenoid; paramylon grains features are sometimes correlated with the characters of chloroplasts. Since Zakrys' system of the *Euglena* taxonomy has been supported by numerical taxonomy methods (Batko and Zakrys 1995), the Korean members are arranged to three infragenera proposed by Zakrys (1986).

The purpose of this study is to give the floristic and taxonomic accounts of the genus *Euglena* with emphasis of morphological features. We provide the detailed descriptions and illustrations using specimens from various waters throughout the country. We treat here 22 taxa belonging to 21 species, that makes the total number of taxa for Korea to thirty-one.

MATERIALS AND METHODS

A total of 231 water samples were collected from May 1994 to June 1997 in 58 sites of fresh water throughout Korea. The specimens were concentrated with plankton net (20 μm in mesh size) at a depth of 10 cm and preserved in 100 m*l* bottles. The sample of each bottle was divided into two equal aliquots. The sample for observing the cell movement and cytological features was kept under low temperature of 4°C and observed at an interval of 5 days. The other was fixed with Lugol's solution for scrutinizing the intracelluar details.

All the specimens were observed under X 1,000 using a light microscope (Olympus VANOX AHBT3). The living materials were also observed under an inverted microscope (Olympus IX70). The illustrations were made using a drawing apparatus. Cell and organelle dimension were given as a mean from the measurement of 50-

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100 cells.

The voucher specimens of this study have been deposited as liquid samples, slides, iconographs and photographs in the herbarium of Chungnam National University, Daejon.

RESULTS AND DISCUSSION

A total of 22 taxa of the genus *Euglena* are recorded in the fresh waters of Korea, which were in details described and illustrated. Although 18 taxa are common in the world (Gojdics 1953; Zakrys 1986; Zakrys and Walne 1994), four taxa are apparently rare in the world flora of *Euglena: E. archaeoplastidiata, E. ehrenbergii* var. *baculifera, E. truncata,* and *E. variabilis*. Of these, 12 taxa are firstly recorded with description and illustrations in the Korean euglenoid flora: *E. archaeoplastidiata, E. caudata, E. granulata, E. oblonga, E. obtusa, E. deses* var. *deses, E. deses* var. *intermedia, E. ehrenbergii* var. *baculifera, E. limnophila, E. texta, E. truncata,* and *E. variabilis*.

The majority of Korean members were collected in turbid waters such as the swamps adjacent to the cultivated lands or the urban drainage basins polluted by human and industrial activities. It is generally known that the green euglenoids prefer waters including lots of the nutrient budget, especially the ammonium and nitrite salts (Munawar 1972; Xavier 1985).

The genus *Euglena* Ehrenberg

Abh. Berl. Akad. Wiss. Physik. Aus d. Jahre 1830, Berlin 1838

Unicellular flagellates, mostly green, with stigma, without lorica, usually free swimming or crawling (sometimes forming unmotile palmella); cells more or less metabolic with one visible external flagellum. Chloroplasts typically present in the cell, with or without pyrenoid, various shape, size and number.

Key to the subgenera

1a. Chloroplasts axial, 1-3 per cell, elongate or star-like with pyrenoids ..... *Euglena*
1b. Chloroplasts parietal or partly parietal 2
2a. Chloroplasts small, numerous, without pyrenoid ..... *Discoglena*
2b. Chloroplasts rather large, one to many per cell, with pyrenoid ..... *Calliglena*

The subgenus *Euglena*

Type: *Euglena viridis* Ehrenberg

The subgenus *Euglena* has been recognized by Chu (1946), Gojdics (1953), Pringsheim (1956) and Zakrys (1986), based on the position of the chloroplasts in the cell. The number of chloroplast clusters is 1-3 per cell. Chloroplasts are numerous, long bands, and arranged in stellate cluster. Axial structures or sometimes long flat bands have pyrenoids. Pyrenoids are centrally located, that makes a dense aggregation of monomorphic paramylon grains termed a paramylon center. The Korean specimens show the same features as the European and the Asian ones.

1. *Euglena geniculata* Dujardin **Fig. 2, Pl. I**

Hist. Nat. Zoophy.-Infusor., Paris: p. 362, 1841

Synonyms: *Euglena schmitzii* Conrad et Van Meel 1952, *E. geniculata* var. *dangeardii* Pringsheim 1953, *E. geniculata* var. *anglesia* Pringsheim 1953, *E. geniculata* var. *guttula* Playfair 1923, *E. geniculata* var. *juvenilis* Playfair 1923, *E. geniculata* var. *terricola* Dangeard 1901, *E. terricola* (Dangeard) Lemmermann 1910.

Cells 66-121 μm long, 9-25 μm broad, metabolic, spindle shaped to cylindrical, rounded anteriorly, posteriorly bluntly narrowed and ended into short and non-hyaline caudal projection. Pellicle finely and spirally striated (15-17 striae per 10 μm). Chloroplasts two, axial, stellate-shaped (although they look like numerous long bands arranged into two star-like figures), one anterior and one posterior to the nucleus. Nucleus spherical, located in the centre of the cell or slightly shifted to the back. Stigma present. Flagellum as long as the cell. Movement propelled by swimming and rotating in open waters and gliding on solid particles.

Occurrence in Korea: It was recorded as *E. schmitzii* in Seoul (Chang and Chung 1957), Jeju (Chung *et al.* 1972), Kyeongbook (Chung 1982), and Cheonnam (Wui and Kim 1987). Eighteen populations were collected here: in ponds — Duckjinmot Cheonju, 25 SEP 1996; Yesan Yesan, 9 MAR 1997; in lakes — Seoho Suweon, 16 FEB 1996; Bomunho Kyeongju, 22 APR 1997; Kyeongpoho Kangneung, 25 FEB 1997; in swamps — Nambangje Asan, 9 MAR 1997; Uncheonmot Kwangju, 29 DEC 1996; Ilweolji Suwon, 20 APR 1997; in a reservoir in Woncheon Suwon, 20 APR 1997; in urban drainages — Jeju Jeju, 15 JAN 1997; Samcheoncheon Cheonju, during the whole year, Kwangjucheon Kwangju, 29 DEC 1996, 5 APR 1997, 31 AUG 1997; Kumhogang Daegu, 25 DEC 1996, 6 APR 1997; Daejoncheon Daejon, from NOV 1996 to JAN 1997, 6 APR 1997; Gapcheon Daejon, 12 OCT 1996, 21

DEC 1996; Mihocheon Cheongju, 6 OCT 1996, 4 JAN 1997; Mushimcheon Cheongju, 6 OCT 1996, 4 JAN 1997; in rivers in Kumgang Buyeo and Napo, 15 DEC 1996.

World distribution: It is common and ubiquitous all over Europe, North and South America. The Asian records are from China (Chu 1946), Soviet Union, and Japan (Popova 1966).

Taxonomic considerations: *E. geniculata* was described by Dujardin (1841) on two stellate aggregations of chloroplast bands. In the light of transmission electron microscopy study (Zakrys and Walne 1998), *E. geniculata*, *E. tristella* and *E. viridis* have similar chloroplast structure, i.e., stellate and axial, with centrally located pyrenoids often obscured by a dense aggregation of paramylon grains termed a "paramylon center". The major difference among these species is chloroplast number: one per cell in *E. viridis*; two in *E. geniculata* and three in *E. tristella*. This species had been known as *E. schmitzii* according to Schmitz (1884) by Conrad and Van Meel (1952). Because Dujardin's description (1841) is the older one, we consider the name *E. geniculata* Dujardin (1841) to be valid.

Abundant Korean material represented the full range of cell shape and dimensions together with morphology of chloroplasts, sometimes with bulky and lobed bands. Also morphological variants with disturbed chloroplast bands, which were whirled and discoid, were observed in Korean samples. They were easily observed in starved specimens.

2. *Euglena viridis* Ehrenberg **Fig. 1, Pl. I**

Abh. Berl. Akad. Wiss. Physik. Aus d. Jahre 1830, Berlin, pp. 39, 82, 1832

Synonyms: *E. viridis* var. *lacustris* Franceé 1897, *E. viridis* var. *stagnalis* France 1897, *E. viridis* var. *mucosa* Lemmermann 1910, *E. viridis* var. *purpurea* Playfair 1921, *E. viridis* var. *lefevrei* Chadefaud 1937, *E. viridis* var. *cantabrica* Pringsheim 1956, *E. viridis* var. *maxima* Philipose 1982, *E. stellata* Mainx 1926.

Cells 55-68 μm long, 11-19 μm broad, metabolic, spindle-shaped, in front slightly extended and rounded, toward the back gradually narrowing and forming short, non-hyaline blunt caudal projection. Pellicle finely, densely, spirally striated (15-18 striae per 10 μm). Nucleus spherical (10-14 x 7-10 μm), shifted posteriorly. Chloroplast single, stellate, axial with centrally located pyrenoid. Pyrenoid in central portion of the chloroplast, covered by other cellular organelles, numerous, small, oval or rod-like paramylon grains. Stigma present. Flagellum as long as the cell. Movement rapidly propelled by swimming and rotating.

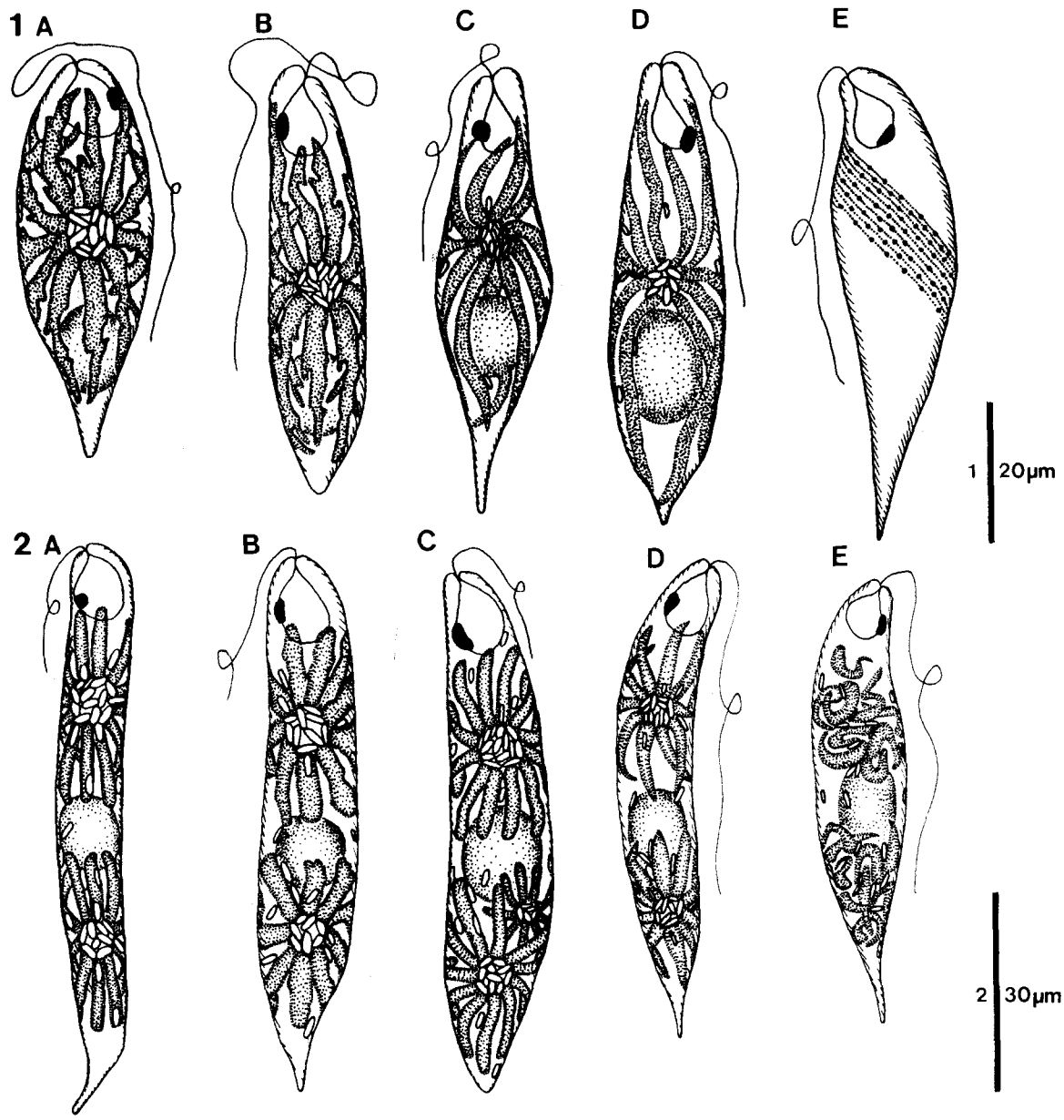
Occurrence in Korea: It was recorded by Chung (1956) from Seoul. Fifteen populations have been collected here: in a lake in Kyeongpoho Kangneung, 25 FEB 1997; in swamps in Yesan Yesan, 9 MAR 1997 and Nambangje Asan, 9 MAR 1997; in urban drainages — Samcheoncheon Cheonju, continuous occurrence in 1996 and 1997; Kumhogang Daegu, 25 DEC 1996; Kwangjucheon Kwangju, 29 DEC 1996; Mihocheon Cheongju, 4 JAN 1997, Gapcheon Daejon, 6 JUL 1994, 29 JUN 1995; Daejoncheon Daejon, from NOV 1996 to JAN 1997, 6 APR 1997; in a roadside ditch in Guryongpo Pohang, 22 APR 1997; in rivers — Kumgang Buyeo, 15 DEC 1996 and Napo, 15 DEC 1996; Namgang Jinju, 19 JAN 1996; in mountain streams in Pyeongna Boryeong, 19 AUG 1994 and Dohwadam Boryeong, 19 AUG 1994, 29 JUL 1995.

World distribution: It is common and ubiquitous. The Asian records are from China (Chu 1946), Soviet Union, Japan (Popova 1966), and India (Philipose 1982).

Taxonomic considerations: *E. viridis* was described by Ehrenberg (1832) based on cell color and stellate aggregation of chloroplast. In the light of transmission electron microscopy study (Dragos *et al.* 1979; Zakrys and Walne 1998), the species has single, stellate, axial chloroplast with centrally located pyrenoid often obscured by a dense aggregation of paramylon grains termed a "paramylon center".

Many varieties of *E. viridis* are described on minor differences of chloroplast morphology, shape and size of the cells. It is our opinion that such differences are more likely to be due to interpopulational or even interclonal diversity, as shown for another species, *E. agilis* Carter (= *E. pisciformis* Klebs) (Zakrys and Kucharski 1996; Zakrys *et al.* 1996), than to real variety differences.

The hypothesis that *E. stellata* and *E. viridis* are not different species but rather clones of the same species is strongly supported by precise measurements of cell size, as well as by the great degree of DNA polymorphism among clones of both species (Zakrys *et al.* 1997). Nevertheless, additional research is essential for the requisite taxonomic revision of the group of species termed "*Euglena viridis* group", the subgenus *Euglena*, in which *E. stellata* and *E. viridis*, and now *E. myxocylindracea*, *E. geniculata* and *E. tristella* are classified (all species with morphological and chloroplast attributes similar to *E. viridis*). Such investigations will be the focus of future research.



Figs 1-2. Morphology of the subgenus *Euglena* members.
Fig.1. *Euglena viridis* Ehrenberg. A and B. Cells with slightly lobed bands; C and D. Cells with even margined bands; E. Cytoplasmic granules spirally arranged under the pellicle. **Fig. 2.** *E. geniculata* Dujardin. The chloroplast bands of cells are even margined (A, D) or slightly lobed (B) and irregularly scattered (E) in different environments. C. Cell with three chloroplast aggregates.

The subgenus *Calliglena* Zakrys

Nova Hedwigia 42: 2-4: 499-500, 1986

The subgenus *Calliglena* was described based on the localization of the chloroplasts and the morphology. Chloroplasts are relatively few in number (rarely one), rather large, more or less rounded (seldom elongated) often with irregularly incised lobate margins (sometimes very deep), parietal or partly parietal (non-axial) with single pyrenoid (rarely two). Pyrenoids are double sheathed with paramylon caps or naked.

The key, descriptions, and detailed illustrations of 8 taxa are given here for the first time in Korea.

Key to the species

1a. Cells red, with haematochrome ……*E. sanguinea* (10)
1b. Cells green, without haematochrome ……2
2a. Chloroplast one, with two pyrenoids
……*E. archaeoplastidiata* (4)
2b. Chloroplast more than one per cell ……3

3a. Chloroplasts two per cell ·····*E. agilis* (3)
3b. Chloroplasts more than two per cell ·····4
4a. Cells long-cylindrical with parallel sides
·····*E. obtusa* (9)
4b. Cells others-shaped ·····5
5a. Cells short-cylindrical to ovoid or ellipsoidal, broadly rounded posteriorly with a short obtuse mucocysts
·····*E. oblonga* (8)
5b. Cells spindle-shaped to cylindrical ·····6
6a. Mucocysts arranged into spiral rows···*E. granulata* (7)
6b. Mucocysts absent or hardly visible ·····7
7a. Cells terminated by short, non-hyaline obtuse peak
·····*E. gracilis* (6)
7b. Cells terminated by a long, acute tail-piece
·····*E. caudata* (5)

3. *Euglena agilis* Carter **Fig. 3, Pl. II**

Ann. Mag. Nat. Hist. (II) 18: 240, 1856 and (IV) 16: 250, 1869

Synonyms: *E. pisciformis* Klebs 1883, *E. pisciformis* var. *minor* Hansgirg 1892, *E. pisciformis* var. *granulata* Playfair 1923, *E. pisciformis* var. *piriformis* Szabados 1936, *E. pisciformis* var. *fallax* Pringsh. 1956, *E. pisciformis* var. *lata* Pringsh. 1956, *E. pisciformis* var. *mucronata* Pringsh. 1956, *E. pisciformis* var. *obtusa* Pringsh. 1956, *E. pisciformis* var. *procera* Pringsh. 1956; *E. agilis* var. *apyrenoidea* Schiller 1956; *E. agilis* f. *coeruleoviridis* Schiller 1956, *E. agilis* var. *circumsulcata* Schiller 1956, *E. agilis* var. *praexcisa* Schiller 1956, *E. agilis* var. *varians* Schiller 1956, *E. bichloris* Schiller 1956, *E. bipyrenoidata* Proshkina-Lavrenko 1937, *E. nana* Johnson 1944, *E. van-goori* Deflandre 1925 (Zakrys 1997).

Cells 32-52 μm long, 7-12 μm broad, very metabolic, spindle or cylindrical shaped, bluntly rounded anteriorly, terminated in short blunt non-hyaline caudal projection. Pellicle very finely and spirally striated (22-25 striae per 10 μm). Chloroplasts two, partly parietal, large, irregularly lobed plates, each with incised margins and one pyrenoid doubly sheathed with paramylon cups. Paramylon grains few to fairly numerous, small, oval or rod-shaped, distributed throughout the protoplast. Nucleus spherical or elliptical, shifted posteriorly. Flagellum approximately twice the body length. Stigma distinct and relatively small (2-3 μm in diameter). Movement swimming and rotating.

Occurrence in Korea: It was recorded in Seoul (Chung and Chang 1957) and Cheonnam (Wui and Kim 1987). Eight local population were collected here: in a pond of the village Yeomiji Jeju, 15 JAN 1997; in a lake in Bomunho Kyeongju, 22 APR 1997; in swamps in Nambangje Asan, 9 MAR 1997 and Uncheonmot Kwangju, 29 DEC 1997; in urban drainages — Samcheoncheon Cheonju, 15 SEP 1996, 27 APR 1997; Daejoncheon Daejon, 6 APR 1997; Mihocheon Cheongju, 4 JAN 1997 and Kumhogang Daegu, 25 DEC 1996.

World distribution: It is common and ubiquitous. It was known as *E. pisciformis* from Soviet Union (Popova 1966) and China (Chu 1946).

Taxonomic considerations: *E. agilis* Carter is currently known under the name *E. pisciformis* Klebs. A few monographs of this genus (Huber-Pestalozzi 1955; Pringsheim 1956; Skuja 1956; Popova 1966) use the name *E. pisciformis*. Some authors (Gojdics 1953; Schiller 1956; Tell and Conforti 1986; Zakrys and Walne 1994) accept the priority of the *E. agilis* name because the drawing and the description by Carter (1856, 1869) show the most important characters allowing the identification of the species such as the presence of two chloroplasts, each of which possesses a pyrenoid, the small size and variable shape of the cell. The priority of these characters has been confirmed by morphological and genetic analysis (Zakrys *et al.* 1996; Zakrys and Kucharski 1996; Zakrys 1997).

4. *Euglena archaeoplastidiata* Chadefaud **Fig. 4, Pl. II**

Le Botaniste 28 (1-2): 86-185, 1937

Cells 31-56 μm long, 14-23 μm broad, metabolic, ovate with rounded posterior and anterior ends, broadly fusiform during swimming and the posterior end is slightly elongated. Pellicle finely but densely, spirally striated (18-20 striae per 10 μm). Chloroplast one, channeled to nearly cylindrical, parietal, curved under periplast, strongly fringed and rugged, open in front with two naked pyrenoids. Paramylon grains numerous, short rectangular rods (4-6 μm long), densely aggregated in the medial cell part. Nucleus big (9-13 x 7-11 μm), spherical or elliptical, screened by chloroplast bands, shifted posteriorly. Flagellum approximately one and a half times the body length. Stigma distinct but relatively small (2-4 μm in diameter). Movement swimming and rotating.

Occurrence in Korea: Two local populations were collected here: in a lake in Kyeongpoho Kangneung, 25 DEC 1996; in a urban drainage in Mihocheon Cheongju, 4 JAN 1997. It is recorded for the first time in Korea.

World distribution: It is a rare species recorded in France (Chadefaud 1937; Gojdics 1953) and Poland (Zakrys 1986).

Taxonomic considerations: *E. archaeoplastidiata* was described by Chadefaud (1937) based on the shape of the chloroplast. Although Chadefaud (1938) emended that this species was a form of *E. pisciformis* (= *E. agilis*), Gojdics (1953) reported the specific name to be preserved in having a single fringed chloroplast. Zakrys (1986) also approved the Gojdics' comments for Polish strain. Our specimens showed the same chloroplast with those of the previous studies. In our local collections, the chloroplast is parietal, deeply fringed, rugged and screened the nucleus. The blooming of this species were observed in winter in Kyeongpoho Lake.

5. *Euglena caudata* Hübner **Fig. 7, Pl. II**

Progr. Realg. Stralsund, p. 13, 1886

Synonym: *E. caudata* var. *minor* Deflandre 1924a.

Cells 58-102 μm long, 15-24 μm broad, metabolic, spindle-shaped, rounded anteriorly, toward the posterior end passing into a non-hyaline acute tail-piece. Periplast finely and distinctly spirally striated (9-11 striae per 10 μm). Chloroplasts relatively not numerous (5-12 per cell) and large, parietal, discoid, saucer-shaped in ventral view, with shallow incised margins. Paramylon grains small, oval or rod-like located throughout cell. Nucleus spherical or elliptical (10-16 x 8-12 μm), located in the cell center. Flagellum as long as the body. Stigma distinct and relatively small (3-6 μm). Movement swimming and rotating.

Occurrence in Korea: Six local populations were collected here: in a Lake in Bomunho Kyeongju, 22 APR 1997; in swamps in Nambangje Asan, 9 MAR 1997 and Goahm Hongsung, 22 JAN 1997; in a urban drainage in Samcheoncheon Cheonju, 27 APR 1997; in a river in Kumgang Buyeo, 22 SEP, 27 OCT 1996 and Napo, 22 SEP 1996. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. The Asian records are from Soviet Union (Popova 1966), China (Chu 1946), Japan (Kato 1982) and India (Philipose 1982).

Taxonomic considerations: *E. caudata* was described by Hübner (1886) based on cell shape and chloroplasts. The cells have been known as fusiform with the caudal tail-piece. Chu (1946) confirmed Hubner's diagnosis in Chinese strains but he also described metabolic variants and recognized *E. caudata* and *E. polymorpha* to be the synonyms. Korean populations presented the full range of chloroplast morphology (with slightly and more or less deeply margins), but the number is 5-12 comparing about 20 in *E. polymorpha*. Cells are variable in free swimming cell accompanying with size variations. A taxonomic revision of the group of species, which are very similar to each other like *E. caudata* Hubner, *E. polymorpha* Dangeard, *E. granulata* (Klebs) Schmitz, *E. flava* Dangeard, is urgently needed.

6. *Euglena gracilis* Klebs **Fig. 5, Pl. II**

Unters. Bot. Inst. Tubingen. 1: 303, 1883

Synonyms: *E. gracilis* var. *bacillaris* Pringsheim et Hovasse 1950, *E. gracilis* var. *luxurians* Pringsheim 1955, *E. gracilis* var. *saccharophila* Pringsheim 1955, *E. gracilis* var. *urophora* Chadefaud et Provasoli 1939, *E. gracilis* var. *zumsteinii* Lwoff 1932, *E. hiemalis* Matvienko 1938.

Cells 46-84 μm long, 7-16 μm broad, metabolic, cylindrical or spindle-shaped, slightly attenuated and rounded anteriorly, narrowing posteriorly and terminated by short, non-hyaline obtuse peak. Pellicle finely and densely spirally striated (18-20 striae per 10 μm). Chloroplasts rather few (5-10 in the cell), parietal, big, discoid with slightly lobed margins, saucer-shaped in ventral view; each with single pyrenoid doubly sheathed with paramylon caps. Paramylon grains small, oval, elliptical or rod-like, few to fairly numerous, scattered throughout the cell. Nucleus spherical or elliptical (12-16 x 5-12 μm), located in the center of the cell. Flagellum approximately equals to body length. Stigma distinct, relatively small. Movement swimming and rotating.

Occurrence in Korea: It was recorded in Seoul (Chung 1956). Three local populations were collected here: in a pond in Yeomiji Jeju, 15 JAN 1997; in an urban drainage in Samcheoncheon Cheonju, 28 FEB 1997, 29 JUN 1997; in a river in Kumgang Napo, 30 MAR 1997.

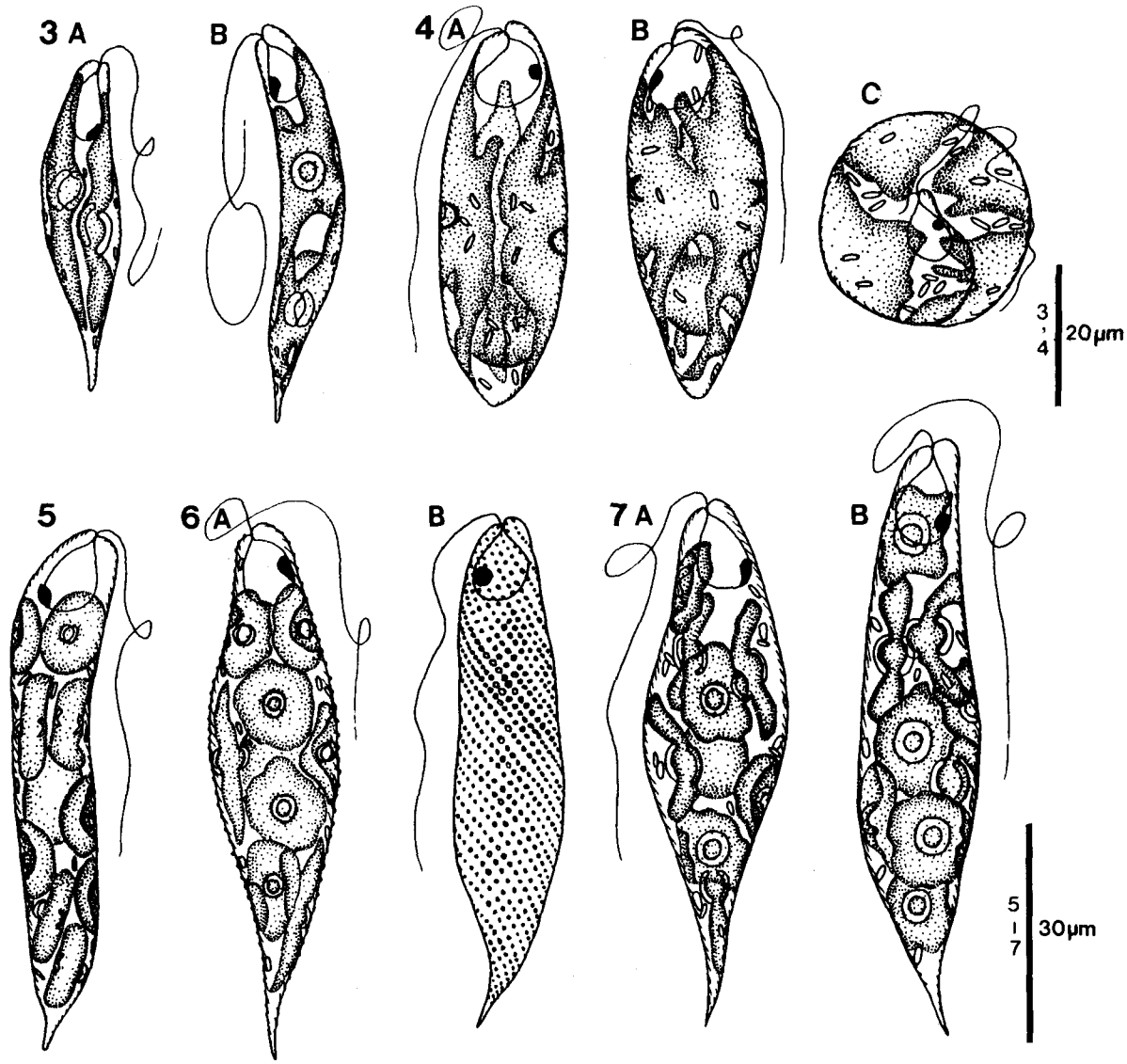
World distribution: It is common and ubiquitous. The Asian records are from China (Chu 1946) and India (Philipose 1982).

Taxonomic considerations: *Euglena gracilis* was described by Klebs (1883) based on the cell shape and pellicular striation. After that, several physiological and morphological varieties had been described (var. *bacillaris* Pringsheim, var. *luxurians* Pringsheim, var. *urophora* Chadefaud et Provasoli, var. *saccharophila* Pringsheim, var. *robusta* Ondratschek, var. *zumsteinii* Lwoff). Gojdics (1953), Pringsheim (1956), and Popova (1966) questioned the sense of distinguishing these varieties, that agree with the genetic analysis (Zakrys *et al.* 1997).

7. *Euglena granulata* (Klebs) Schmitz **Fig. 6, Pl. II**

Pringsh. Jahrb. wiss. Bot. 15: 16, 1884

Synonyms: *E. velata* var. *granulata* Klebs 1883, *E. granu-*



Figs 3-7. Morphology of the subgenus *Calliglena* members.
Fig. 3. *Euglena agilis* Carter. A. Side view showing paramylon caps; B. Dorsal view. **Fig. 4.** *E. archaeoplastidiata* Chadefaud. A. Side view showing two pyrenoids; B. Dorsal view; C. Apical view. **Fig. 5.** *E. gracilis* Klebs. **Fig. 6.** *E. granulata* (Klebs) Schmitz. A. Cell in the field; B. Mucocysts spirally arranged under the pellicle. **Fig. 7.** *E. caudata* Hübner. A and B. Metabolic forms in the field.

lata var. *luteo-viridis* Lemmermann 1910, *E. granulata* var. *tenuior* Huber-Pestalozzi 1929.

Cells 69-88 μm long, 13-21 μm broad, metabolic, spindle-shaped, slightly narrowed and rounded toward the anterior end, to the posterior end gradually tapering and terminated in a non-hyaline caudal tailpiece. Pellicle distinctly spirally striated (9-11 striae per 10 μm) with rows of spherical (below 2 μm in diameter) mucocyst bodies running along the striation. Chloroplasts relatively few (5-11 in the cell), partly parietal, large, discoid with shallow incised margins, saucer-shaped in ventral view. Paramylon grains small, oval or rod-like, scattered throughout the cell. Nucleus spherical or elliptical, located in the center of the cell (11-14 x 9-11 μm). Flagellum as long as the body length. Stigma distinct and relatively small (2-4 μm in diameter). Movement swimming and rotating.

Occurrence in Korea: Two populations were collected here: in a lake Bomunho Kyeongju, 22 APR 1997 and in an urban drainage in Samcheoncheon Cheonju, 30 MAR 1997. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous in Europe (Gojdics 1953; Pringsheim 1956). The Asian records are from China (Chu 1946), Soviet Union (Popova

1966), Japan (Kato 1982), and India (Philipose 1982).

Taxonomic considerations: *Euglena granulata* was described as the infraspecific variety under *E. velata* by Klebs (1883) and ranked to the specific name by Schmitz (1884). The most reliable feature of this species was the pellicular mucocyst bodies arranged in regular spiral rows along the striae. Mainx (1927) and Szabados (1950) justified the stability of such diagnostic character and described this species to be separated from *E. gracilis, E. caudata, E. velata* and *E. sociabilis*. That treatment was accepted by Gojdics (1953), Pringsheim (1956) and Zakrys (1986). We identified the mucocyst bodies in Korean specimens, which occurred in urban drainage basins.

8. *Euglena oblonga* Schmitz **Fig. 8, Pl. III**

Pringsh. Jahrb. f. wiss. Bot. 15: 28, 1884

Cells 39-65 μm long, 19-34 μm broad, metabolic, swimming cells broadly spindle shaped. Non-motile cells ellipsoidal, ovoid or short cylindrical. Both ends rounded, but at the posterior narrowed and passing into small, obtuse mucocyst. Pellicle finely, spirally striated (12-14 striae per 10 μm). Chloroplasts few (6-10 per cell) in front of concave discs, immersed in cytoplasm with deeply incised lobate margins which divide the chloroplasts into long ribbon-shaped lobes; the terminal parts of the lobes lying spirally under the periplast and arranging spiral rows. Pyrenoid one in center of each chloroplast doubly sheathed with paramylon caps. Paramylon grains small, numerous, short rod-shaped to ovoid, distributed all over the protoplast. Nucleus, spherical or elliptical, located in the center of the cell or slightly shifted posteriorly. Stigma distinct and relatively small. Flagellum approximately as long as the body length. Movement swimming.

Occurrence in Korea: Four local populations were collected here: in polluted pond in Haenam Haenam, 10 NOV 1996; in a swamp in Uncheonmot Kwangju, 29 JUN 1996; in urban drainages in Mushimcheon Cheongju, 4 JAN 1997 and Kumhogang Daegu, 25 DEC 1996. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. The Asian records are from Japan (Kato 1995) and India (Philipose 1982).

Taxonomic considerations: *E. oblonga* was described by Schmitz (1884) on the basis of the cell shape and the structure of chloroplasts. Cells were oval to fusiform. Zakrys (1986) and Zakrys and Walne (1994) illustrated this species from Poland and U.S.A. Korean specimens were oval or ovoid, cylindrical to spindle, depending on movement and metaboly. Chu (1946) mentioned that *E. oblonga* is related to *E. sanguinea, E. sociabilis, E. oblonga* and *E. splendens* in having the same features of chloroplasts. Recently, Zakrys (1986) and Zakrys and Walne (1994) categorized the members of group of similar species based on the number and morphology of chloroplasts, cell shape and mucocyst bodies presence. Observation of the Korean materials shows that *E. oblonga* is different from *E. sanguinea*.

9. *Euglena obtusa* Schmitz **Fig. 10, Pl. III**

Pringsh. Jahrb. f. wiss. Bot. 15: 24, 1884

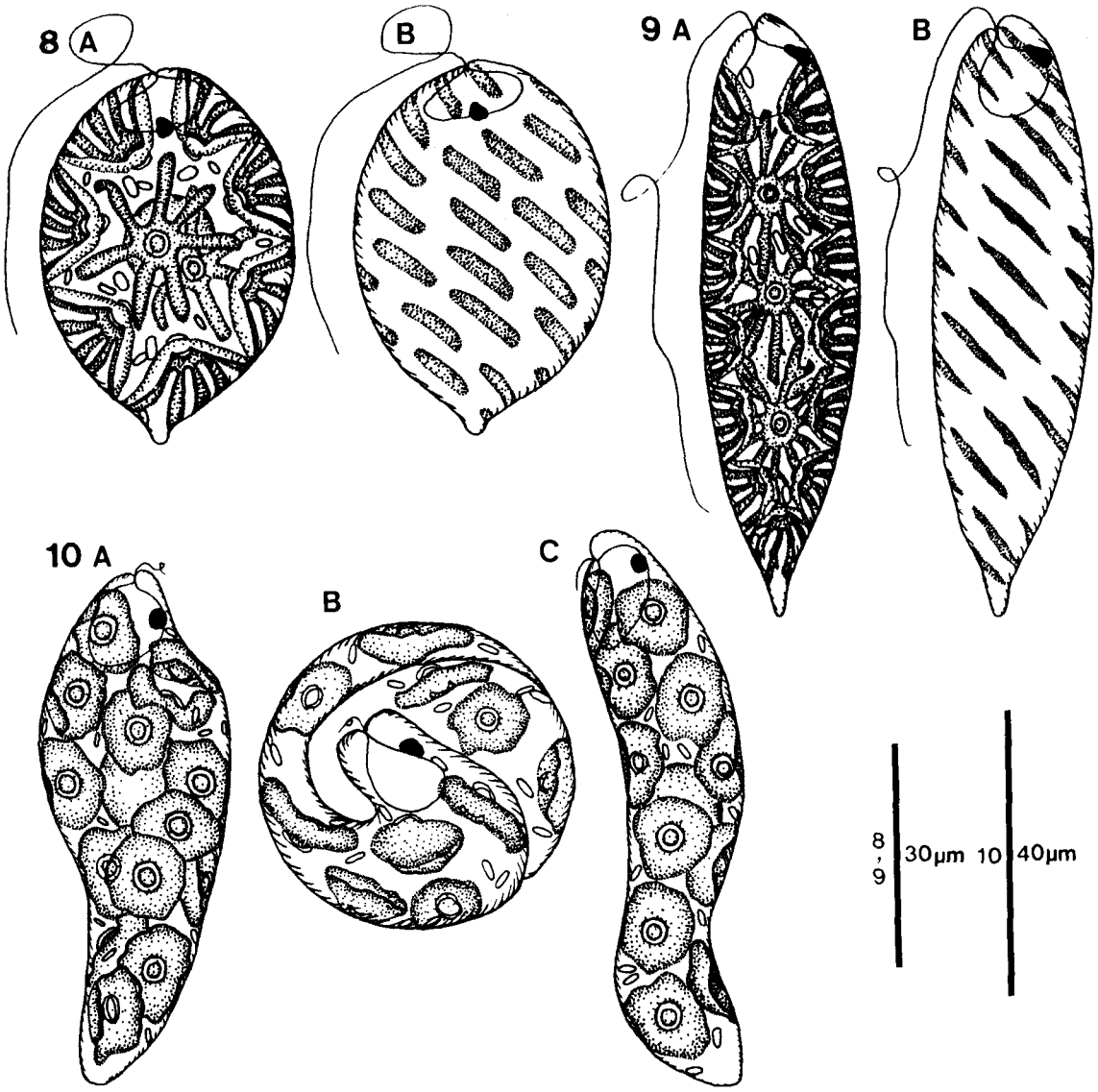
Synonyms: *E. limosa* Gard 1919, *E. fenestrata* Elenkin 1924.

Cells 80-111 μm long, 19-37 μm broad, metabolic, long cylindrical with parallel sides, rounded anteriorly and posteriorly. Pellicle finely, spirally striated (10-13 striae per 10 μm). Chloroplasts (15-21 per cell), parietal, disc-shaped with slightly incised margins; each with on pyrenoid, doubly sheathed with paramylon caps. Paramylon grains numerous, small, oval or rod-like, distributed all over the protoplast. Nucleus spherical or elliptical (16-21 μm length) located in the center of the cell. Flagellum absent. Stigma present. Movement creeping.

Occurrence in Korea: Five local populations were collected: in a lake in Bomunho Kyeongju, 22 APR 1997; in a swamp in Uncheonmot Kwangju, 10 NOV 1996; in urban drainages in Gapcheon Daejon, 29 JUN 1996, Kwangjucheon Kwangju, 29 DEC 1996, Samcheoncheon Cheonju, 29 JUN 1997. It is recorded for the first time in Korea.

World distribution: It is cosmopolitan (Gojdics 1953). It was recorded in England, and North America (Gojdics 1953). The Asian records are from Soviet Union (Popova 1966), Hungary (Németh 1997), and Poland (Czosnowski 1948 as *E. limosa*; Zakrys 1986),

Taxonomic considerations: *Euglena obtusa* was described by Schmitz (1884) based on the cell shape and movement. Gard (1919) and Elenkin (1924) reported that *E. obtusa* was different from *E. limosa* and *E. fenestrata* by the size and metaboly of cells, morphology of chloroplasts and pyrenoids. Monographs of the genus *Euglena* (Gojdics 1953; Pringsheim 1956; Popova 1966; Zakrys 1986) do not support Gard's and Elenkin's opinion and treat *E. limosa* and *E. fenestrata* as synonyms of *E. obtusa*. Our specimens crawled like an amoeba and clinged to the bottom or sides of the dishes.



Figs 8-10. Morphology of the subgenus *Calliglena* members.
Fig. 8. *Euglena oblonga* Schmitz. A. Cell in the field; B. Parietal view of chloroplast lobes. **Fig. 9.** *E. sanguinea* Ehrenberg. A. Cell in the field; B. Parietal view of chloroplast lobes. **Fig. 10.** *E. obtusa* Schimitz. A and C. Metabolic forms in the field; B. Apical view.

10. *Euglena sanguinea* Ehrenberg **Fig. 9, Pl. III**

Abh. Berl. Akad. Wiss. Physik aus d. Jahre 1830, Berlin, p. 71, 1832

Cells 67-107 μm long, 27-55 μm broad, metabolic, spindle to cylindrical shaped, rounded anteriorly, toward the posterior end passing into a short, blunt, non-hyaline projection. Pellicle finely and distinctly spirally striated (10-12 striae per 10 μm). Haematochrome granules, very tiny, irregularly scattered throughout the cell. Chloroplasts numerous, partly parietal, in the form of concave discs located deeply in the cytoplasm with very deep incisions which divide the chloroplasts into long ribbon-shaped, irregular lobes; terminal parts of the long lobes extending to the periplast and lying spirally along the periplast curvature and look like a spindle-shaped, single chloroplasts. In the middle part of each chloroplast, not divided into lobes, a pyrenoid occurs (doubly sheathed with paramylon caps). Paramylon grains numerous, oval or short rod-shaped, densely concentrated in the middle part of the cell. Nucleus spherical or elliptical (14-23 μm long), located in the center of cell or slightly shifted posteriorly. Flagellum 1-1.5 x the body length. Stigma distinct and relatively small. Movement swimming in open waters and creeping in solid surface.

Occurrence in Korea: It was recorded in Cheonnam (Wui and Kim 1987). Two local populations were record-

ed: in a swamp in Uncheonmot Kwangju, 29 JUN 1996; in a urban drainage in Gapcheon Daejon, 29 JUN 1996.

World distribution: It is cosmopolitan. The Asian records are from China (Chu 1946) and India (Philipose 1982).

Taxonomic considerations: *E. sanguinea* was described by Ehrenberg based on the cell color and chloroplast morphology. The morphology of chloroplasts of *E. sanguinea* is one of the most important and distinct features (Klebs 1883; Chu 1946; Gojdics 1953; Pringsheim 1956; Buetow 1968; Zakrys and Walne 1994). In our specimens, the very characteristic distribution of chloroplasts in the cell was constantly observed during cell movement.

The subgenus *Discoglena* Zakrys

Nova Hedwigia 42: 2-4: 514, 1986

The subgenus *Discoglena* has been described based on the presence of numerous, parietal, small, most often disc-shaped chloroplasts without pyrenoid. Five taxa of *Discoglena* have been reported in the floristic accounts (Chung 1956; Chung and Chang 1957; Chung 1970; Wui and Kim 1987). The key, descriptions, and detailed illustrations of 12 taxa are given here for the first time in Korea.

Key to the species

1a. Paramylon grains dimorphic: large and small ones ····2
1b. Paramylon grains monomorphic: only small ones ···9
2a. One large paramylon grain per cell ····3
2b. More than one large paramylon grain per cell····4
3a. Paramylon grains behind nucleus; cells long, cylindrical ····*E. ehrenbergii* var. *baculifera* (14)
3b. Paramylon grains near stigma; cells fusiform to cylindrical ····*E. variabilis* (22)
4a. Large paramylon grains two per cell····6
4b. Large paramylon grains more than two per cell ····5
5a. Cells fusiform, terminated by long, hyaline sharp tail-piece ····*E. acus* (11)
5b. Cells cylindrical, terminated by short, verrucal, non-hyaline projection ····*E. deses* var. *intermedia* (13)
6a. Paramylon grains rod-like ····7
6b. Paramylon grains ring-like ····8
7a. Cells spirally twisted, triangular in cross section ····*E. tripteris* (20)
7b. Cells straight, round in cross section ····*E. limnophila* (15)
8a. Pellicle spirally striated; spiral furrow visible ····*E. oxyuris* (16)
8b. Pellicle striae with papillae ····*E. spirogyra* (18)
9a. Cells round-ovate, rigid, periplast with distinct striation often turning into ribs ····*E. texta* (19)
9b. Cells spindle or cylindrical, metabolic, periplast with fine or faint striation ····10
10a. Cells spindle-shaped ····*E. proxima* (17)
10b. Cells cylindrical ····11
11a. Posterior end with non-hyaline projection ····*E. deses* var. *deses* (12)
11b. Posterior end rounded or transversely truncated ····*E. truncata* (21)

11. *Euglena acus* Ehrenberg **Fig. 14, Pl. IV**

Abh. Berl. Akad. Wiss. Physik aus d. Jahre 1830, Berlin, pp. 39, 62, 1832

Synonyms: *E. acus* var. *rigida* Hübner 1886, *E. acus* var. *minor* Hansgirg 1892, *E. acutissima* Lemmermann 1904, *E. acus* var. *lata* Swirenko 1915, *E. acus* var. *parva* Playfair 1921, *E. acus* var. *longissima* Deflandre 1924a, *E. acus* var. *vanoyei* Deflandre 1924a, *E. acus* var. *major* Lefevre 1933, *E. acus* var. *angularis* Johnson 1944, *E. acutissima* var. *longa* Johnson 1944.

Cells 125-163 μm long, 9-17 μm broad, nearly rigid, long-fusiform and slender to cylindrical, anteriorly narrow and truncate, backwards gradually tapering and ending into a long, hyaline sharp posterior tailipiece (17-45 μm long). Pellicle longitudinally striated (9-11 striae per 10 μm). Chloroplasts numerous, parietal, discoid, small (2-4 μm in diameter), without pyrenoids. Paramylon grains dimorphic: more or less numerous, rod-like, large (12-21 x 2-4 μm in dimension) and similar small grains, scattered in the whole protoplast. Nucleus spherical or elliptical, located in the middle cell part or shifted posteriorly. Flagellum one sixth to one third body length. Stigma present. Movement swimming and rotating straightly forward.

Occurrence in Korea: It was recorded in Seoul (Skvortzov 1932; Chung 1956) in Kyeongnam as var. *rigida* (Chung 1970). Eleven local populations have been collected here: in ponds in Duckjinmot Cheonju, 25 SEP 1996 and Yeomiji Jeju, 15 JAN 1997; in swamps - Nambangje Asan, 9 MAR and 4 APR 1997; Yeosan Yeosan, 26 MAY 1997; Sidong Hamahn, 6 JUN 1997; in a fish farm pond in Pyeongjang Iksan, 26 MAY 1997; in a reservoir in Woncheon Suwon, 20 APR 1997; in urban drainages — Mihocheon Cheongju, 6 OCT 1996; Samcheoncheon Cheonju, year-round from OCT 1996 to SEP 1997; in rivers — Kumgang Buyeo, 30 JUL 1994, 20

AUG 1994, 10 SEP 1994, 26 MAR 1995, 28 MAY 1995, 29 JUL 1995, 23 JUN 1996, 22 SEP 1996; Kumgang Napo, 21 JAN 1995, 23 JUN 1996, 25 AUG 1996, 22 SEP 1996.

World distribution: It is common and ubiquitous. The Asian records are from Burma and India (Skvortzov 1937), China (Chu 1946), Soviet Union (Popova 1966), and India (Philipose 1982).

Taxonomic considerations: *E. acus* is distinguished in having numerous rod-shaped, big paramylon grains. It is well known that the amount of accumulated storage material (the number of big and small paramylon grains) depends on the physiological state of the cell and that, in turn, on the habitat conditions (Kiss *et al.* 1987; Kiss and Triemer 1988; Conforti 1991). In our specimens the number of big paramylon grains was nine to numerous with locations and sampling periods.

12. *Euglena deses* Ehrenberg var. *deses* **Fig. 20, Pl. IV**

Abh. Berl. Akad. Wiss. Physik aus d. Jahre 1833, Berlin, pp. 248, 1835

Synonyms: *E. deses* var. *gracilis* Playfair 1921, *E. deses* var. *tenuis* Lemmermann 1910, *E. deses* var. *minuta* Playfair 1921.

Cells 105-161 μm long, 13-23 μm broad, very metabolic, long cylindrical, slightly attenuated and rounded anteriorly, at the back passing into a short verrucal, nonhyaline projection. Pellicle finely, spirally striated (16-19 striae per 10 μm). Chloroplasts disc-shaped, small (7-9 μm in diameter), parietal with naked pyrenoids. Paramylon grains small, rod-like (2-6 μm long), irregularly scattered throughout the protoplast. Nucleus oval, more or less central. Flagellum one sixth to one third of the body length. Stigma present. Movement wriggling and creeping.

Occurrence in Korea: Ten local populations were collected here: in a pond in Duckjinmot Cheonju, 25 SEP 1996; in a lake in Seoho Suwon, 16 FEB 1997; in swamps in Uncheonmot Kwangju, 29 DEC 1997 and Nambangje Asan, 9 MAR 1997; in urban drainages — Samcheoncheon Cheonju, year-round from OCT 1996 to SEP 1997; Kwangjucheon Kwangju, 5 APR 1997; Kumhogang Daegu, 25 DEC 1996; Mihocheon Cheongju, 9 OCT 1996; in a river in Kumgang Napo, 28 MAY 1995, 30 DEC 1995 and Buyeo, 21 MAY 1994, 30 DEC 1995. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. The Asian records are from China (Chu 1946), Japan (Kato 1984), India (Carter 1856; Gonzalves and Joshi 1946), and Soviet Union (Popova 1966).

Taxonomic considerations: *E. deses* is distinguished in having wriggling and creeping movement, naked pyrenoid and monomorphic paramylon grains. Our specimens showed that the paramylon grains were irregularly scattered throughout the protoplast as well as densely massed in posterior end of the cell. The Korean cells were common in the urban drainage basins and old stagnant waters.

13. *Euglena deses* Ehrenberg var. *intermedia* Klebs **Fig. 21, Pl. III**

Unters. Bot. Inst. Tubingen 1 (2): 303, 1883

Synonym: *E. intermedia* (Klebs) Schmitz 1884

Cells 104-144 μm long, 11-21 μm broad. Pyrenoids absent. Paramylon grains dimorphic, a few large (4-10 per cell), rod-shaped and numerous, small, rod-shaped or oval. Remaining features as in the type variety.

Occurrence in Korea: Four local populations were collected here: in a swamp in Uncheonmot Kwangju, 29 DEC 1996; in urban drainages — Samcheoncheon Cheonju, 25 SEP 1996, from JAN to AUG 1997; Kwangjucheon Kwangju, 29 DEC 1996 and 5 APR 1997; Kumhogang Daegu, 25 DEC 1996. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. The Asian records are from Soviet Union (Popova 1966), and India (Hortobágyi 1969).

Taxonomic considerations: *E. deses* var. *intermedia* is distinguished in having dimorphic paramylon grains and no pyrenoids (Zakrys 1986). Korean populations occur in urban drainage basins with turbid and hypertrophic water.

14. *Euglena ehrenbergii* Klebs var. *baculifera* (Thompson) Gojdics **Fig. 22, Pl. III**

Madison, The Univ.of Wisc. Press, p. 108-109, 1953

Synonym: *E. truncata* var. *baculifera* Thompson 1938.

Cells 139-214 μm long, 17-28 μm broad, very metabolic, long cylindrical with parallel sides, somewhat flattened, rounded at the anterior end, slightly narrowed and rounded at the posterior end. Pellicle almost longitudinally striated (10-14 striae per 10 μm). Chloroplasts disc-shaped, small (3-5 μm in diameter), numerous, parietal, without pyrenoids. Paramylon grains dimorphic: one, large (57-82 μm long), rod-shaped but curved, located after the nucleus; and many small, oval or rod-shaped ones scattered throughout the cell. Nucleus oval, lying in the cell center. Flagellum one sixth of the body length. Stigma present. Movement creeping.

Occurrence in Korea: Seven local populations were collected here: in swamps in Uncheonmot Kwangju, 10 NOV 1996 and Ilweolji Suweon, 20 APR 1997; in urban drainages — Samcheoncheon Cheonju, 15 SEP 1996, 30 MAR 1997, 27 APR 1997, 26 MAY 1997; Mihocheon Cheongju, 6 OCT 1996; Kumhogang Daegu, 25 DEC 1996; Kwangjucheon Kwangju, 29 DEC 1996, 5 APR 1997; Gapcheon Daejon, 25 JUN 1995. It is recorded for the first time in Korea.

World distribution: It is a very rare species in the world. It was originally described in USA (Kansas) by Thompson (1938), recorded in USA (Tennessee) by Zakrys and Walne (1994) and this is the third record in the world.

Taxonomic considerations: var. *ehrenbergii* is very similar to var. *baculifera*. The cells of var. *ehrenbergii* have a few paramylon grains, while var. *baculifera* only one large paramylon grain.

15. *Euglena limnophila* Lemmermann **Fig. 15, Pl. II**

Bot. Cbl. 76: 152, 1898

Synonyms: *E. swirenkoi* Arnoldi 1922, *E. limnophila* var. *minor* Drezepolski 1925, *E. limnophila* var. *lemmermannii* Drezepolski 1925, *E. limnophila* var. *swirenkoi* (Arnoldi) Popova 1955.

Cells 81-98 μm long, 10-14 μm broad, nearly rigid, cylindrical to spindle-shaped, slightly narrow and truncate anteriorly, gradually tapering and terminating into sharp, hyaline posterior tailpiece (20-27 μm long). Pellicle spirally striated (7-8 striae per 10 μm). Chloroplasts numerous small (2-4 μm in diameter), disc-shaped, parietal without pyrenoids. Paramylon grains dimorphic, two large (16-20 x 3-7 μm), rod-shaped, present before and behind the nucleus respectively; small ones (less than 4 μm long), rod-like or oval, scattered throughout the protoplast. Nucleus spherical, located in the cell center or slightly shifted to the back. Flagellum one third to one half the body length. Stigma present. Movement swimming and rotating forward.

Occurrence in Korea: Seven local populations were collected here: in swamps — Nambangje Asan, 9 MAR 1997; Yesan Yesan, 9 MAR 1997; Goahm Hongsung, 22 JUN 1997; Ilweolji Suwon, 20 APR 1997; in a lake in Bomunho Kyeongju, 22 APR 1997; in mountain streams in Pyeongna Boryeong, 21 JUL 1996 and Hwapyeong Boryeong, 21 JUL 1996. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. The Asian records are from Japan, Burma, Indonesia, Soviet Union (Popova 1966), and India (Hortobágyi 1969; Philipose 1982).

Taxonomic considerations: *E. limnophila* is distinguished in having slender body and two, big paramylon rods; the number is variable with 1-2 (Gojdics 1953), 2-3 (Zakrys 1986), and only 2 (Skuja 1939; Pringsheim 1956). In Korean specimens, cells were sometimes inflated with lots of small paramylon grains.

16. *Euglena oxyuris* Schmarda **Fig. 13, Pl. IV**

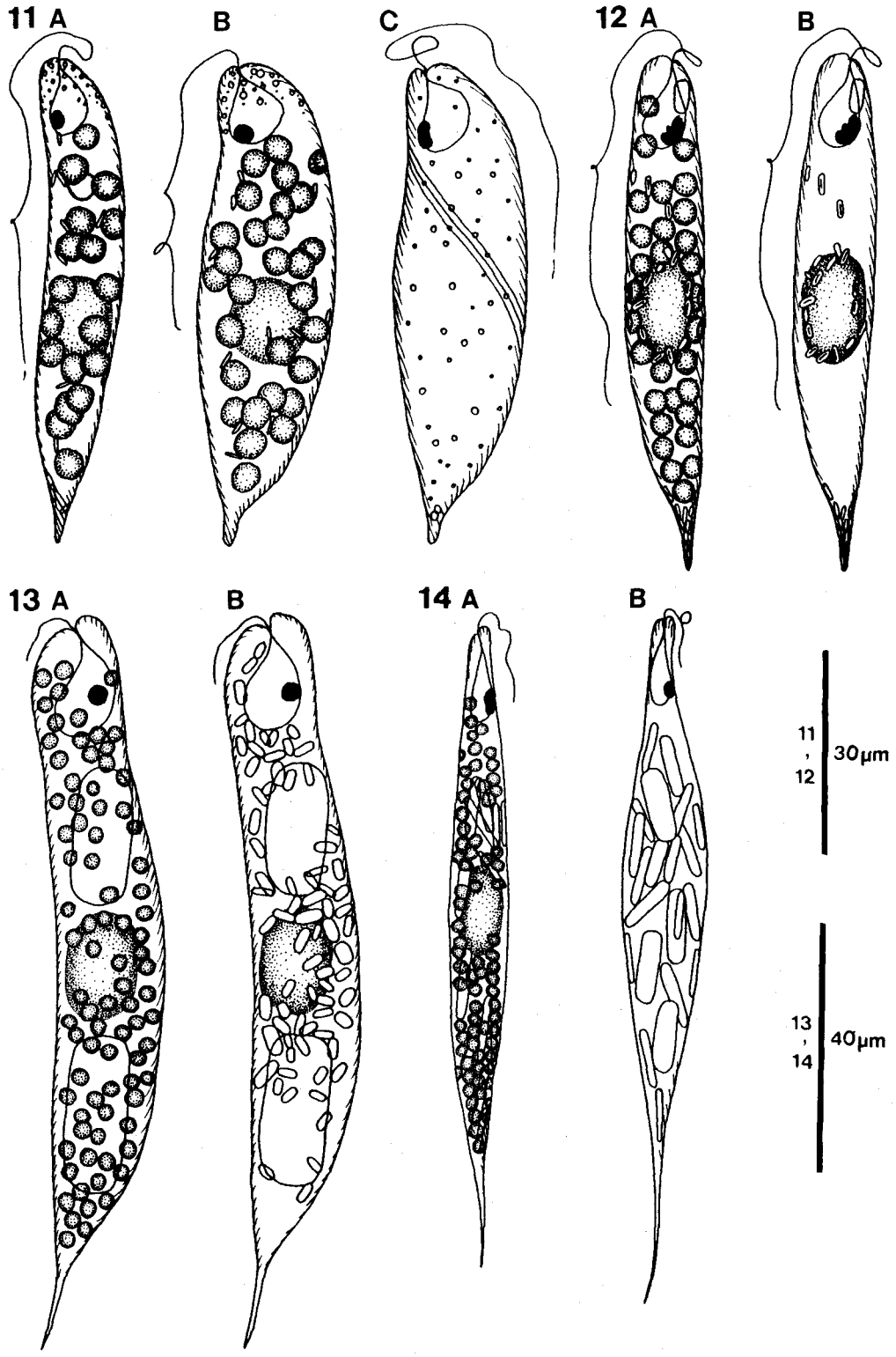
Kleine Beitrage zur Naturgeschichte der Infusorien, Wien, p. 17, 1846

Synonym: *E. oxyuris* var. *gracillima* Playfair 1921, *E. oxyuris* var. *minor* Deflandre 1924b, *E. oxyuris* var. *charkowiensis* (Swir.) Chu 1946, *E. oxyuris* var. *estonica* Bourrelly 1949, *E. oxyuris* var. *playfairii* Bourrelly 1949, *E. oxyuris* var. *minima* Bourrelly 1949.

Cells 142-169 μm long, 19-25 μm broad, slightly metabolic, long cylindrical, somewhat flattened and spirally twisted, rounded anteriorly, at the back sharply tapered into distinct and hyaline posterior tail-piece (20-29 μm); along the length of the body the spiral furrow is visible. Pellicle spirally, distinctly striated (8-9 striae per 10 μm). Chloroplasts parietal, disc-shaped, numerous, small (3-4 μm in diameter), without pyrenoids. Paramylon grains dimorphic: two large, ring-like (sometimes elliptical or rectangular), present before and behind the nucleus respectively; oval, ring-like or rod-like small ones, scattered throughout the cell. Nucleus oval, located in the centre of the cell. Stigma present. Flagellum one third to one half of the body length.

Occurrence in Korea: It was recorded in Kyeongbook by Chung (1970). Eleven local populations were collected here: in a pond in Yeomiji Jeju, 15 JAN 1997; in a lake in Bomunho Kyeongju, 22 APR 1997; in a swamp in Nambangje Asan, 9 MAR 1997; in a reservoir in Haenam Haenam, 10 NOV 1996; in a fish farm pond in Pyeongjang Iksan, 25 MAY 1997; in urban drainages — Gapcheon Daejon, 25 SEP 1995, 29 JUN 1996, 12 OCT 1996; Mihocheon, 6 OCT 1996; Samcheoncheon Cheonju, 15 SEP 1996 and 30 MAR 1997; in a roadside ditch in Guryongpo Pohang, 22 APR 1997; in rivers — Kumgang Buyeo, 20 AUG 1994, 10 SEP 1994, 21 JAN 1995, 29 JUL 1995, 30 DEC 1995, 29 FEB 1996, 21 JUL 1996, 25 AUG 1996, 22 SEP 1996; Kumgang Napo, 10 SEP 1994, 26 MAR 1995, 29 JUL 1995, 30 DEC 1995, 23 JUN 1996, 22 SEP 1996.

World distribution: It is common and ubiquitous. The Asian records are from Burma and India (Skvortzov



Figs 11-14. Morphology of the subgenus *Discoglena* members.

Fig. 11. *Euglena proxima* Dangeard. A and B. Cells in the field; C. Cytoplasmic granules scattered under the pellicle. **Fig. 12.** *E. variabilis* Klebs. A. Cell in the field; B. Organized paramylon bodies near the stigma and nucleus. **Fig. 13.** *E. oxyuris* Schmarda. A. Cell in the field; B. Dimorphic paramylon bodies, small grains and two bulky rods. **Fig. 14.** *E. acus* Ehrenberg. A. Cell showing long and acute anterior; B. Monomorphic paramylon rods.

1937; Philipose 1982), China (Chu 1946), and Soviet Union (Popova 1966).

Taxonomic considerations: *E. oxyuris* is distinguished in having large cells and two large ring-like or rectangu-

lar paramylon grains. Many varieties have been described on the basis of cell dimensions. Because the full range of the cell dimensions was reported by many authors (Gojdics 1953; Huber-Pestalozzi 1955; Popova 1966; Zakrys 1986; Zakrys and Walne 1994) and for many populations, as did Gojdics's (1953), the varieties are combined to a single species.

17. *Euglena proxima* Dangeard **Fig. 11, Pl. II**

Le Botaniste 8: 154, 1901

Synonyms: *E. proxima* var. *major* Huber-Pestalozzi 1929, *E. proxima* var. *amphoraeformis* Szabados 1936, *E. proxima* var. *piriformis* Szabados 1936, *E. proxima* var. *minima* Szabados 1949, *E. proxima* var. *dangeardii* Pringsheim 1953, *E. proxima* var. *anglesia* Pringsheim 1953.

Cells 62-81 μm long, 12-21 μm broad, metabolic, spindle-shaped, narrowed and rounded anteriorly, backwards gradually tapering and passing into bluntly peg-shaped end. Pellicle spirally striated (10-12 striae per 10 μm). Chloroplasts disc-shaped, small (4-6 μm in diameter), parietal, numerous, without pyrenoids. Paramylon bodies small, oval to short cylindrical. Nucleus spherical, somewhat shifted posteriorly. Stigma present. Flagellum approximately about the body length. Movement slowly swimming and rotating.

Occurrence in Korea: It was recorded by Chung and Chang (1957) in Seoul, Chung (1970) in Kyeongnam, Wui and Kim (1987) in Cheonnam. Six local populations were collected here: in urban drainages — Samcheoncheon Cheonju, 29 DEC 1996, 27 JAN 1997; Gapcheon Daejon, 25 JUN 1995; Kwangjucheon Kwangju, 29 DEC 1996; Daejoncheon Daejon, 28 NOV 1996; in rivers — Kumgang Buyeo, 10 SEP 1994, 26 MAR 1995, from JUN to SEP 1996; Kumgang Napo, 10 SEP 1994, from JUN to SEP 1996.

World distribution: It is cosmopolitan. The Asian records are from China (Chu 1946), Japan (Kato 1984), India (Gonzalves and Joshi 1943, 1946; Kamat 1968, 1974; Hortobágyi 1969; Philipose 1982), and Soviet Union (Popova 1966).

Taxonomic considerations: *E. proxima* is distinguished in having spindle-shaped cell with flexible caudal prolongation and monomorphic paramylon grains. Although many metabolic forms have been observed, the diagnostic features of the cell shape and paramylon grains are consistent (Chu 1946).

18. *Euglena spirogyra* Ehrenberg **Fig. 17, Pl. IV**

Abh. Berl. Akad. Physik aus d. Jahre 1830, Berlin, pp. 38, 1832

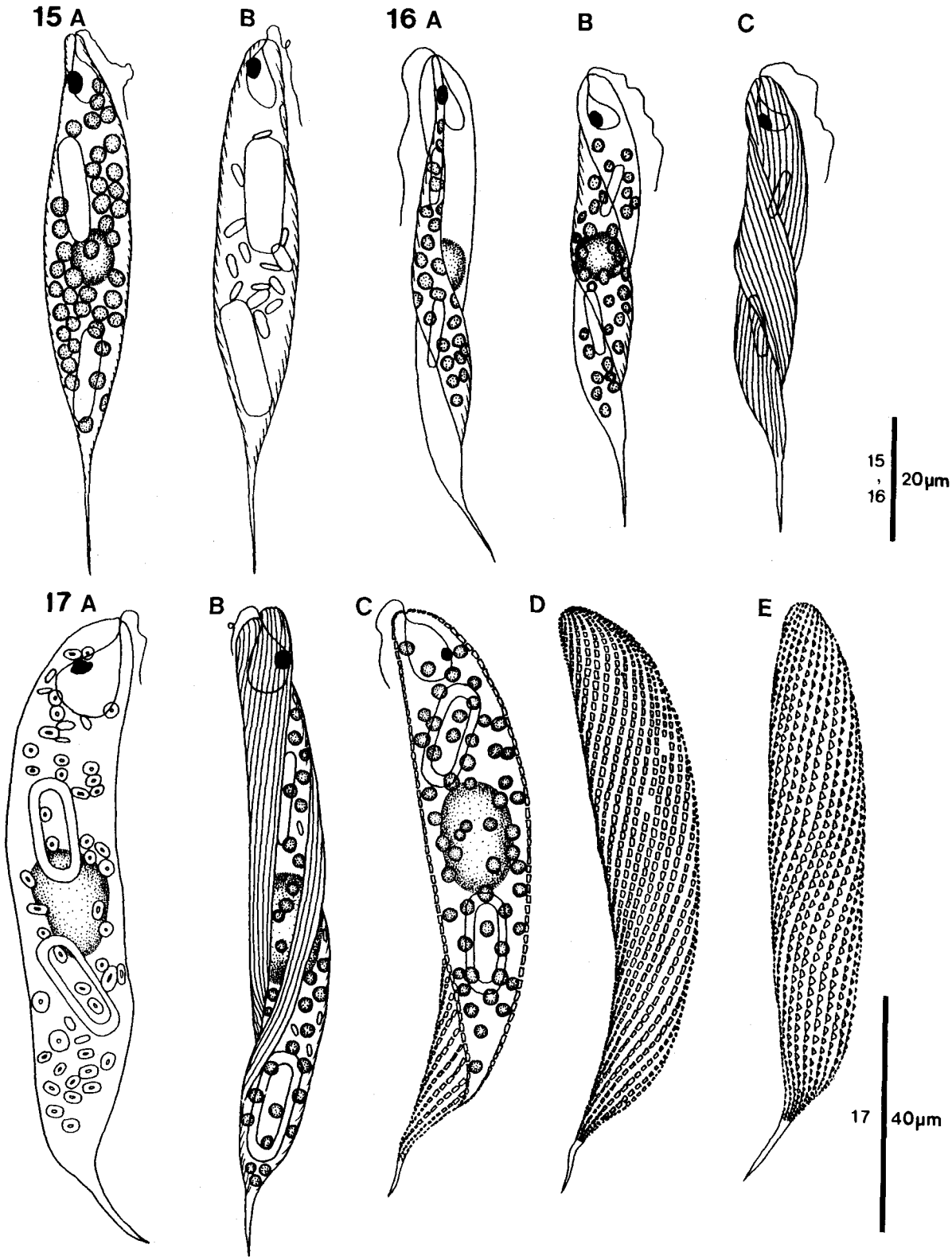
Synonyms: *E. spirogyra β fusca* Klebs 1883, *E. spirogyra* var. *laticlavius* Hübner 1886, *E. fusca* (Klebs) Lemmermann 1910, *E. fusca* var. *laticlavius* (Hubner) Lemmermann 1910, *E. fusca* var. *marchica* Lemmermann 1910, *E. spirogyra* var. *obrupte-acuminata* Lemmermann 1913a, *E. spirogyra* var. *marchica* Lemmermann 1913b, *E. spirogyra* var. *fusiformis* Deflandre 1924b, *E. spirogyra* var. *minor* Allorge & Lefevre 1925, *E. spirogyra* var. *suprema* Skuja 1932, *E. fusca* var. *minima* Szabados 1949.

Cells (67-97) - (142-172) μm long, (9-15) - (16-28) μm broad, slightly metabolic, long cylindrical, bluntly rounded and slightly truncated anteriorly; posteriorly sharply extended into distinct and hyaline tail-piece (14-27 μm). Pellicle yellow-green to brown, spirally striated (6-8 striae per 10 μm); striae ornamented with rectangular or triangular papillae except tailpiece part; papillae small, below 2 μm. Chloroplasts discoid, small (2-3 μm in diameter), parietal, numerous without pyrenoids. Paramylon grains dimorphic: two large grains ring-shaped or elliptical with parallel sides, one grain lying before and the another behind the nucleus; small grains oval or ring-shaped, numerous, scattered throughout the protoplast. Nucleus oval located in the middle of the cell. Flagellum one fifth to one half the body length. Stigma present. Movement twisting.

Occurrence in Korea: It was recorded by Skvortzov (1932) and Chung (1956) in Seoul. Nine local populations were collected here: in a pond in Yeomiji Jeju, 15 JAN 1997; in swamps — Uncheonmot Kwangju, 25 DEC 1996; Nambangje Asan, 9 MAR 1997; Daepyeong Hamahn, 6 JUN 1997; in urban drainages — Gapcheon Daejon, 25 MAY 1994; Samcheoncheon Cheonju, 28 FEB, 30 MAR and 27 APR 1997; in a river in Kumgang Buyeo, 20 JUN 1994, 21 OCT 1994 and Napo, 21 JUL 1996, 25 AUG 1996; in a mountain stream in Hwapyeong Boryeong, 19 AUG 1994, 3 NOV 1994. Materials from Samcheoncheon, Cheonju City had smaller cells of 67-97 x 9-15 μm than the other Korean populations.

World distribution: It is common and ubiquitous. The Asian records are from China (Chu 1946), Burma and India (Skvortzov 1937; Skuja 1949; Philipose 1982), and Soviet Union (Popova 1966).

Taxonomic considerations: *E. spirogyra* is distinguished in having large size of cell, ornamentation of periplast and two large ring-shaped paramylon grains. Differences in the ornamentation and color of the cell periplast have been caused a lot of taxonomical prob-



Figs 15-17. Morphology of the subgenus *Discoglena* members.

Fig. 15. *Euglena limnophila* Lemmermann. A. Cell in the field; B. Dimorphic paramylon bodies, small grains and two large rods. **Fig. 16.** *E. tripteris* (Dujardin) Klebs. A and B. Cells in the field; C. Pellicular strips of the twisted body. **Fig. 17.** *E. spirogyra* Ehrenberg. A. Dimorphic paramylon bodies, small grains and two rings; B. Cell with smooth pellicular strips; C. Cell having two paramylon rings and ornamented pellicular strips; D and E. Pellicular strips ornamented with rectangular (D) and triangular warts (E).

lems (Chu 1946; Gojdics 1953; Pringsheim 1956; Zakrys 1986).

19. *Euglena texta* (Dujardin) Hübner **Fig. 18, Pl. III**

Progr. Realgym. Strals., pp. 12, 1886

Synonyms: *Crumenula texta* Dujardin 1836, *Lepocinclis texta* (Duj.) Lemmermann 1901, *E. texta* var. *bullata* Playfair 1921, *E. texta* var. *obesa* Playfair 1921, *E. texta* var. *ovata* Playfair 1921.

Cells 33-48 μm long, 28-34 μm broad, slightly metabolic, ellipsoidal to ovoidal, broadly rounded posteriorly, rounded to slightly bulged posteriorly. Pellicle with distinct striations (8-10 striae per 10 μm). Chloroplasts numerous, disc-shaped, small (4-6 μm in diameter), parietal, without pyrenoids. Paramylon grains small and middle-sized, oval or rod-shaped, numerous. Nucleus globular, more or less central. Flagellum one and half to twice body length. Stigma occurs. Movement swimming and rotating.

Occurrence in Korea: Five local populations were collected here: in a swamp in Nambangje Asan, 9 MAR 1997; in urban drainages – Daejoncheon Daejon, 28 NOV 1996; Samcheoncheon Cheonju, 28 FEB, 30 MAR, 27 APR 1997; Kwangjucheon Kwangju, 5 APR 1997; Jeju Jeju, 15 JAN 1997. It is recorded for the first time in Korea.

World distribution: It is common and ubiquitous. It was recorded from India (Bombay) by Carter (1856) as *Crumenula texta* and Soviet Union (Popova 1966).

Taxonomic considerations: *E. texta* is distinguished in having oval cells without tail-pieces, periplast with distinct striations (often turning into ribs) and monomorphic paramylon grains. Huber-Pestalozzi (1955) recorded it as *Lepocinclis* but many authors (Gojdics 1953; Pringsheim 1956; Popova 1966), particularly Skuja (1948), pointed that this species belonged to the genus *Euglena* on the basis of periplast and paramylon features. Since *Lepocinclis* has a thick and rigid periplast and two large paramylon rings (Leedale 1967), we placed this species in the genus *Euglena*.

20. *Euglena tripteris* (Dujardin) Klebs **Fig. 16, Pl. II**

Unters. Bot. Inst. Tübingen I, 2: 306, 1883

Synonyms: *Phacus tripteris* Dujardin 1841, *E. torta* Stokes 1885 (fide Popova 1966), *E. tripteris* var. *klebsii* Lemmermann 1910, *E. pseudospiroides* Swirenko 1915, *E. tripteris* var. *major* Swirenko 1915, *E. tripteris* var. *szöregiensis* Szabados 1936.

Cells 83-109 μm long, 19-23 μm broad, weak metabolic, spindle-shaped in outline, triangular in cross section, spirally twisted (forming two coils), rounded anteriorly, toward the back gradually tapering and passing into a thin, long (17-22 μm) sharp, hyaline tail-piece (sometimes twisted or curved). Pellicle distinctly, spirally striated (8-9 striae per 10 μm); striae following the cell twists. Chloroplasts disc-shaped, small (3-4 μm in diameter), parietal, numerous, without pyrenoids. Paramylon grains dimorphic: two large rod-shaped, one lying before and the another behind the nucleus; small grains oval or rod-like scattered throughout the cell. Nucleus spherical, located in the centre of the cell. Stigma occurs. Flagellum attaining one half to two-third of body length. Movement twisting and rotating.

Occurrence in Korea: It was recorded by Chung (1956) in Seoul. Four local populations were collected here: in swamps in Nambangje Asan, 9 MAR 1997 and Jiral Hamahn, 6 JUN 1997; in an urban drainage in Samcheoncheon Cheonju, 29 DEC 1996, 30 MAR 1997; in a river in Kumgang Napo, 26 MAR 1995.

World distribution: It is common and ubiquitous. The Asian records are from India (Skuja 1949; Kamat 1975; Philipose 1982) and Soviet Union (Popova 1966).

Taxonomic considerations: *E. tripteris* is distinguished in having three spiral ridges of cell. Our specimens showed the three ridges and the constantly twisted forms. Some authors (Swirenko 1934; Popova 1966; Zakrys 1986) described var. *crassa*, in showing broadly fusiform and more strongly twisted shape and two large paramylon grains located in the cell center (side by side), but the variation was observed in a single population from Korean.

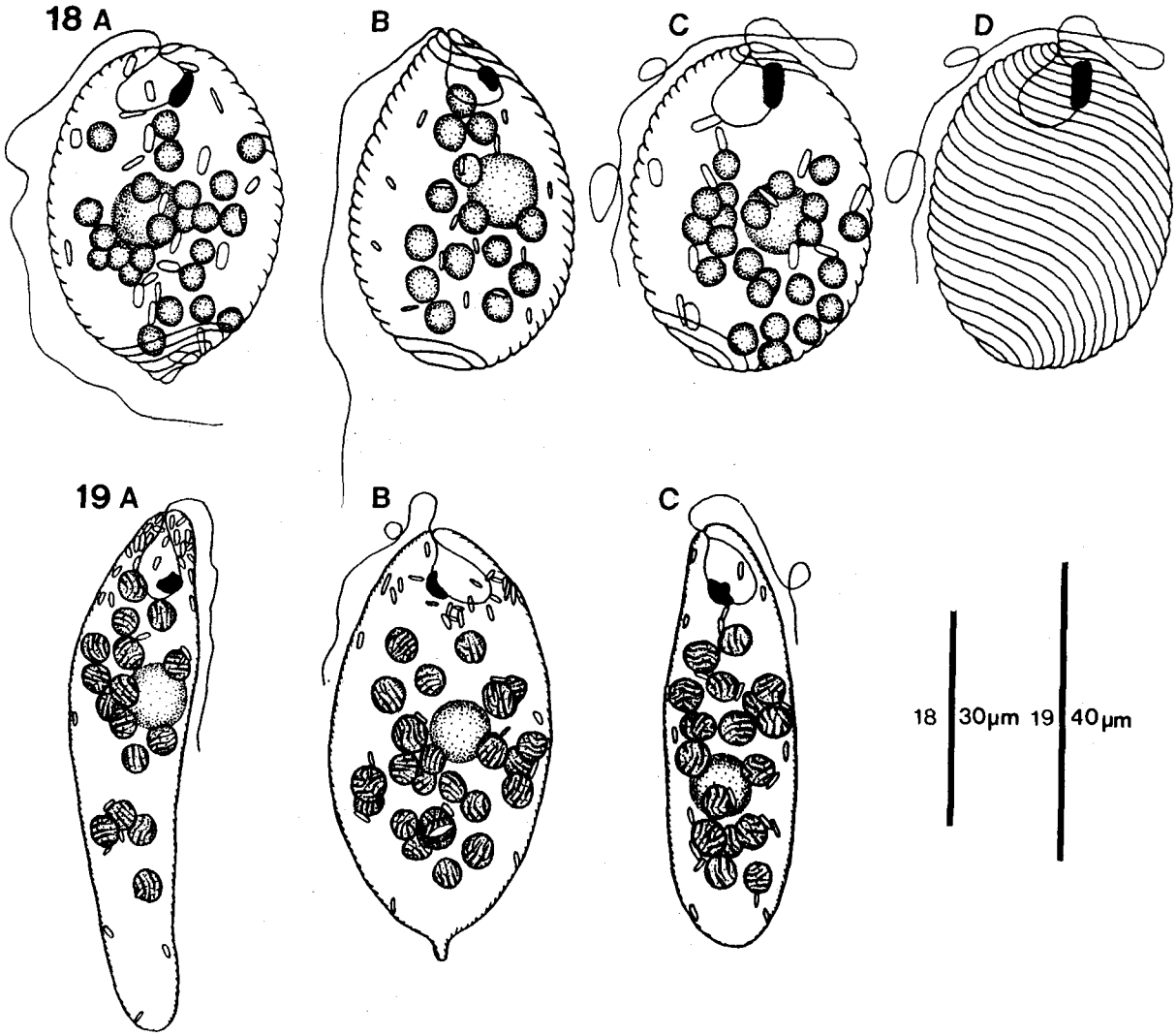
21. *Euglena truncata* Walton **Fig. 19, Pl. III**

Ohio State Univ. Bull. 1 (4): 373-374, 1915

Synonym: *E. subehrenbergii* Skuja 1948.

Cells 68-110 μm long, 8-12 μm broad, metabolic, long cylindrical, with parallel sides, slightly narrowed and rounded anteriorly, truncate or sometimes rounded posteriorly. Pellicle spirally striated (18-20 striae per 10 μm). Chloroplasts disc-shaped, parietal, small (4-6 μm in diameter), numerous. Paramylon grains small, oval or rod-like, scattered throughout the protoplast, often in large number, sometimes massed in posterior part of the cell. Nucleus oval, lying in the cell centre. Flagellum one third to one half the body length. Stigma present. Movement creeping.

Occurrence in Korea: Five local populations were collected here: in a swamp in Ilweolji Suwon, 20 APR 1997; in urban drainages — Samcheoncheon Cheonju, 27 JAN,



Figs 18-19. Morphology of the subgenus *Discoglena* members.
Fig. 18. *Euglena texta* (Dujardin) Hubner. A. Cell with protruded end; B and C. Metabolic forms in the field; D. Pellicular strips.
Fig. 19. *E. truncata* Walton. A and C. Metabolic forms in the field; B. Cell with protruded end.

28 FEB and 27 APR 1997; Gapcheon Daejon, 25 SEP 1995; Daejoncheon Daejon, 27 JAN 1997; Mushimcheon Cheongju, 6 OCT 1996. It is recorded for the first time in Korea.

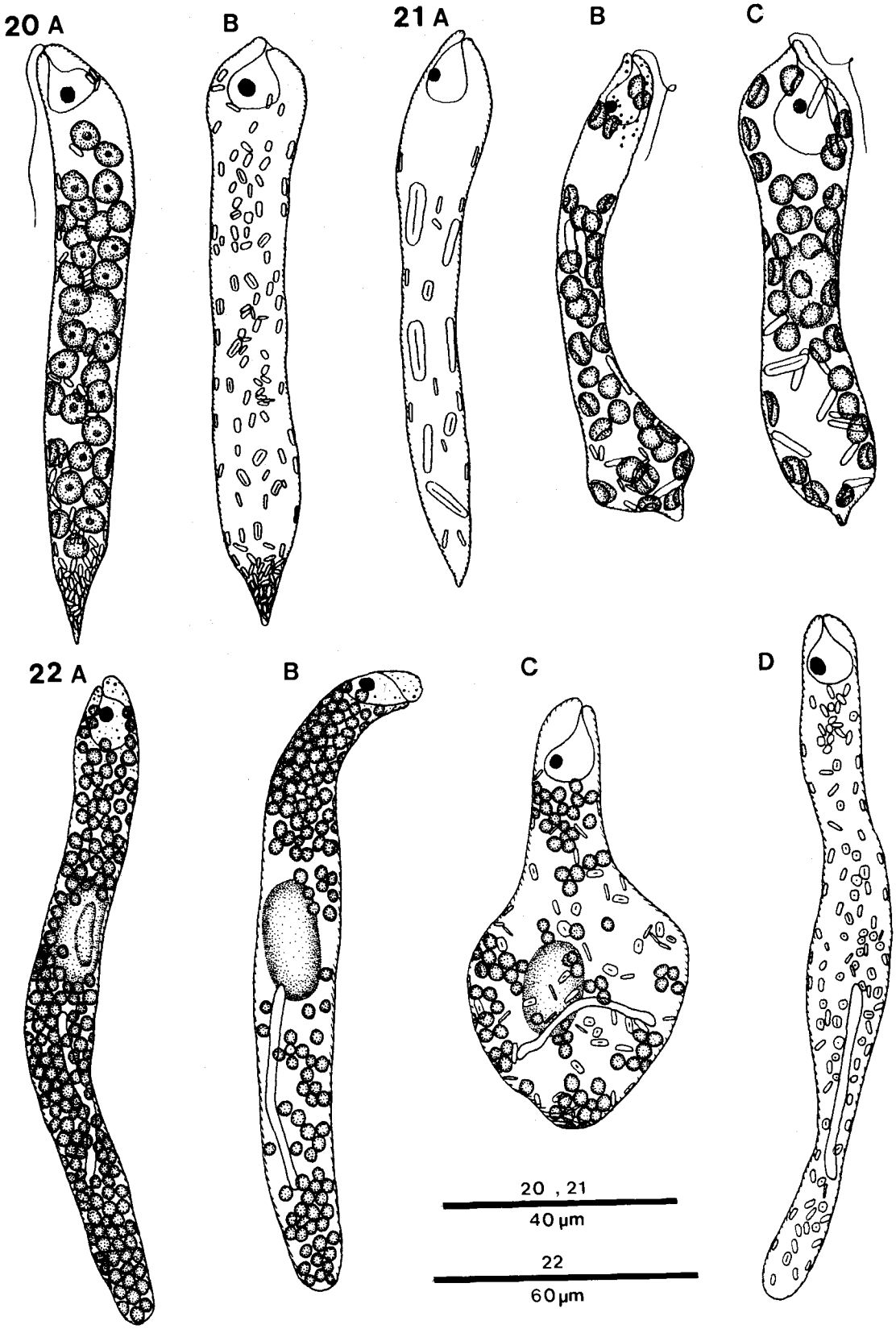
World distribution: It is a rare species recorded in Sweden (Skuja 1948), Poland (Zakrys 1986), Argentina (Tell and Conforti 1986), and USA (Walton 1915, Zakrys and Walne 1994).

Taxonomic considerations: *E. truncata* is similar to *E. subehrenbergii* in having spirally striated pellicle. The striae is continuous in *E. truncata*, whereas a row of dense discrete points in *E. subehrenbergii*. It is also confused to *E. spirogyra*, which of the pellicle is highly variable (Zakrys 1986). After observing Polish and American material (Walton 1915; Zakrys 1986; Zakrys and Walne 1994), Zakrys and Walne (1994) concluded that two names were attached to the same species. Because Walton's description (1915) is the oldest one, *E. truncata* has the priority of publication.

22. *Euglena variabilis* Klebs **Fig. 12 , Pl. II**

Unters. Bot. Inst. Tubingen 1: 70, 1883

Cells 48-83 μm long, 13-28 μm broad, very metabolic, elongate cylindrical or spindle-shaped, broadly rounded anteriorly, narrowed and passing into short, peg-shaped end posteriorly. Pellicle spirally striated (11-12 striae 10 μm). Chloroplasts disc-shaped, small (3-4 μm in diameter), numerous, parietal, without pyrenoids. Paramylon grains dimorphic: one bigger than the other ones, rod-like (5-7 x 2-3 μm), located near the stigma; small grains (2-3 μm), oval or rod-like, numerous, mostly circularly positioned on nucleus surface. Nucleus oval, lying in the



Figs 20-22. Morphology of the subgenus *Discoglena* members.

Fig. 20. *Euglena deses* var. *deses* Ehrenberg. A. Cell having naked pyrenoids; B. Monomorphic and small paramylon grains. **Fig. 21.** *E. deses* var. *intermedia* Klebs. A. Dimorphic, small and large paramylon rods; B and C. Metabolic forms in the field. **Fig. 22.** *E. ehrenbergii* var. *baculifera* (Thompson) Gojdics. A, B and C. Metabolic forms in the field; D. Dimorphic, small grains and very long paramylon rods.

cell center. Flagellum about the body length. Stigma present. Movement swimming and rotating.

Occurrence in Korea: Three local populations were collected here: in a swamp in Nambangje Asan, 9 MAR 1997; in urban drainages in Samcheoncheon Cheonju, 30 MAR, 27 APR 1997, 29 JUN 1997 and Kumhogang Daegu, 25 DEC 1996. It is recorded for the first time in Korea.

World distribution: It was recorded in America (USA) and Europe (Popova 1966) and in Asia: Japan (Kato 1984) and Soviet Union (Popova 1966).

Taxonomic considerations: *E. variabilis* is distinguished in having very metabolic cells and ordered arrangement of paramylon grains. In Korean material the single and big grain is positioned near the stigma but most of the smaller grains lie on the periphery of the nucleus.

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REFERENCES

Allorge P. and Lefevre M. 1925. Algues de la Sologne. *Bull. Soc. Bot. France* **72:** 122-150.

Arnoldi W.M. 1922. Dve ehkskursii na ozero Abrau. *Zhurn. Rusk. Bot. Obshch.* **7:** 56.

Batko A. and Zakrys B. 1995. Numerical proof of the subgeneric classification of Euglena. *Algol. Stud.* **79:** 1-18.

Bourrelly P. 1949. *Euglena oxyuris* Schmarda et formes affines. *Bull. Museum Nat. Hist. Nat. Ser.* **2:** 612-616. 2 figs.

Buetów E.D. 1968. The Biology of *Euglena*. Vol. I. Academic Press, Inc. New York.

Carter H.J. 1856. Notes on the freshwater infusoria on the Island of Bombay. I. Organization. *Ann. Mag. Nat. Hist. Ser.* II. **18:** 115-132, 221-248.

Carter H.J. 1869. Notes on filigerous green infusoria on the Island of Bombay. *Ann. Mag. Nat. Hist. Ser.* IV. **16:** 249-280.

Chadefaud M. 1937. Recherches sur l'anatomie comparée des Eugléniens. *Le Botan.* **28:** 86-185.

Chadefaud M. 1938. Nouvelles recherches sur l'anatomie comparée des Eugléniens: les Péranemines. *Rev. Algol.* **11:** 189-220.

Chadefaud M. and Provasoli L. 1939. Une nouvelle Euglene graciloide: *Euglena gracilis* Klebs var. *urophora* n. var. *Arch. Zool.* **80:** 55-60.

Chu S.P. 1946. Contributions to our knowledge of the genus *Euglena*. *Sinensia* **17:** 75-134.

Chung J. 1970. A taxonomic study on the freshwater algae from Yong-nam area. Kyungpook Natl. Univ. Press.

Chung J. 1982. Freshwater algae on the Bulkuk Temple area. *Korean J. Limnol.* **15:** 19-29.

Chung J., Kim S. D. and Lee K. S. 1972. Freshwater algae from Jae Ju Do Island (I). *Korean J. Limnol.* **5:** 13-23.

Chung Y.H. 1956. A study on the *Euglena* in the area of Seoul. *Univ. Seoul Coll. Thes. Sci. Natur.* **3:** 49-55.

Chung Y.H. and Chang Y.K. 1957. A study on the *Euglena* in the area of Seoul (II). *Univ. Seoul Coll. Thesis Sci. Natur.* **5:** 119-128.

Conforti V. 1991. Taxonomic study of the Euglenophyta of a highly polluted river of Argentina. *Nova Hedw.* **53:** 73-98.

Conrad W. and Van Meel L. 1952. Materiaux pour une monographie de *Trachelomonas* Ehr., *Strobomonas* Defl. et *Euglena* Ehr. *Mém. Inst. R. Sci. Nat. Belg.* **124:** 1-175.

Czosnowski J. 1948. Materialy do flory wiciowców Polski. *Poznán. Towarz. Przyjaciól. Nauk.* **11:** 1-46.

Dangeard P.A. 1901. Recherches sur les Eugléniens. *Le Botan.* **8:** 97-360.

Deflandre G. 1924a. A propos de l'*Euglena acus* Ehrb. *Rev. Algol.* **1:** 242.

Deflandre G. 1924b. Additions à la flore algologique des environs de Paris. III. Flagellées. *Bull. Soc. Bot. France* **71:** 115-1129.

Deflandre G. 1925. Algues d'eau douce du Venezuela. *Rev. Algol.* **3:** 212-241.

Dragos N., Peterfi L. S. and Craciun C. 1979. Fine structure of *Euglena*. II. *Euglena stellata* Mainx and *Euglena viridis* Ehrenberg. *Nova Hedw.* **31:** 223-246.

Drezepolski R. 1925. Supplement à la connaissance des Eugleniens de la Pologne. *Kosmos* **50:** 245, 268.

Dujardin F. 1836. Recherches sur les organismes inferieurs IV. *Ann. Sc. Nat. Zool. Ser.* II, 5.

Dujardin F. 1841. Historie naturelle des Zoophytes-Infusorires. Paris. 338 pp.

Ehrenberg C.G. 1832. Beitrage zur Kenntnis der Organisation der Infusorien und ihrer reographischen Verbreitung, besonders in Siberien. *Abh. Berl. d. Akad. Wiss. Physik aus d.Jahre 1830, Berlin* **1:** 1-88. 6 pls.

Ehrenberg C.G. 1835. Dritter beitrag zur erkenntnis grosser organisation in der richtung des kleinsten raumes. *Abh. Berl. d.Akad. Wiss. Physik aus d.Jahre 1833, Berlin* **3:** 145-336.

Ehrenberg C.G. 1838. Die Infusionstierchen als volkommene Organismen. Leopold Voss. Leizig.

Elenkin A.A. 1924. De Euglenarum sine flagello section nova. *Not. Syst. Inst. Crypto. Horti Bot. Rei Publ. Rossicae.* Leningrad **3:** 129-169.

France R. 1897. Protozoen resultate der wissenschaftlichen Erforschung des Balatonsees. Vol. 2. Die Fauna des Balatonsees.

Gard M. 1919. Biologie d'une nouvelle espèce d'Euglene. C.R. Acad. Sci. 169 pp. Paris.

Gojdics M. 1953. The genus *Euglena*. Madison, Univ. Wisc. Press.

Gonzalves E.A. and Joshi D.B. 1943. The algal-flora of temporary waters around Bombay-1. *J. Univ. Bombay* **11:** 121-128.

Gonzalves E.A. and Joshi D.B. 1946. Freshwater algae near Bombay. *J. Bombay Nat. Hist. Soc.* **46:** 154-176.

Hansgirg A. 1892. Prodomus der Algenflora von Böhmen. Zweiter Teil. *Arch. der Naturwiss. Durchforsch.* von Böhmen **8:** 173, 266.

Hortobágyi T. 1969. Phytoplankton organisms from three reservoirs on the Jamuna River, India. *Stud. Biol. Acad. Sci. Hung.* **8:** 1-80.

Huber-Pestalozzi G. 1929. Das plankton naturlicher und kunstlicher Seebecken Sudafrikas. *Intern. Vereinig. Theor. Angew. Limnol. (Alta. Congr. Int. Limnol., Rome)* **4:** 343-390.

Huber-Pestalozzi G. 1955. Das Phytoplankton des Süßwasser, 4. Teil: Euglenophyceen. *Die Binnengewasser* **16:** 1-606, Stuttgart.

Hubner E. 1886. Euglenaceenflora von Stralsund. Programm d. Realgymnasiums zu Stralsund. pp. 1-20.

Johnson L.P. 1944. *Euglenae* of Iowa. *Trans. Amer. Micr. Soc.* **63:** 97-135.

Kamat N.D. 1968. Algae of Alibag, Maharashtra. *J. Bombay Nat. Hist. Soc.* **65:** 88-104.

Kamat N.D. 1974. Algae of Marathwada. *Phycos* **13:** 22-32.

Kamat N.D. 1975. Algae of Vidarbh, Maharashtra. *J. Bombay Nat. Hist. Soc.* **72:** 250-256.

Kato S. 1982. Taxonomic studies on the genus *Euglena* in Japan (1), (2). *J. Jap. Bot.* **57:** 217-222, 278-286.

Kato S. 1984. Taxonomic studies on the genus *Euglena* in Japan (3). *J. Jap. Bot.* **59:** 149-153.

Kato S. 1995. Taxonomic studies on the genus *Euglena* in Japan (4). *J. Jap. Bot.* **70:** 48-51.

Kiss J.Z., Vasconcelos A.C. and Triemer R.E. 1987. The structure of the euglenoid storage carbohydrate, paramylon. *Am. J. Bot.* **74:** 877-882.

Kiss J.Z. and Triemer R.E. 1988. A comparative study of the storage carbohydrate granules from *Euglena* (Euglenida) and *Povlova* (Prymnesiida). *J. Protozool.* **35:** 237-241.

Klebs G. 1883. Über die Organisation einiger Flagellatengruppen und ihre Beziehungen zu ander Ifusorien. *Unters. Bot. Inst.* Tübingen I. **2:** 233-262.

Leedale G.F. 1967. Euglenoid flagellates. Prentice Hall, Englewood Cliffs, N.J.

Lefèvre M. 1933. Contribution a la connaissance des Flagellés d'Indochine. *Ann. Crypt. Exot.* **6:** 258-264.

Lemmermann E. 1898. Beitrage zur Kenntnis der Planktonalgen. II. Beschreibung neuer Formen. *Beih. Bot. Zbl.* **76:** 150-156.

Lemmermann E. 1901. Beitrage zur Kenntnis der Planktonalgen. XII. Notizen über einige Schwebealgen. *Ber. Deutsch. Bot. Gesellsch.* **19:** 85-95.

Lemmermann E. 1904. Das Plankton schwedischer Gewässer. *Ark. Bot.* **2:** 122.

Lemmermann E. 1910. Kryptogamenflora der Mark Brandenbrug 3, Algen I. Eugleninen. pp. 493, 497. Leipzig.

Lemmermann E. 1913a. Notizen uber Flagellaten. I-VIX. *Arch. Hydrobiol.* **8:** 574.

Lemmermann E. 1913b. Eugleninae. — In Die Süßwasserflora Deutschlands, Österreichs und der Schweiz. *G. Fischer, Jena.* pp. 115-174.

Lwoff A. 1932. Recherches biochimiques sur la nutrition des protozoaires. Le pouvoir de synthese. Monographies de l'Institut Pasteur, Paris. 160 pp.

Mainx F. 1926. Einige neue Vertreter der Gattung *Euglena* Ehrb. *Arch. Protistenkd.* **54:** 150-160.

Mainx F. 1927. Beiträge zur Morphologie und Physiologie der Eugleninen. I, II. *Arch. Protistenkd.* **60:** 305-414.

Matvienko O.M. 1938. Materiali do vivtchennia vodorostii. *Trudy N.D. Inst. Bot. Kharkov.* **3:** 29-70.

Munawar M. 1972. Ecological studies of Eugleninae in certain polluted and unpolluted environments. *Hydrobiologia* **39:** 307-320.

Nemeth J. 1997. Az ostoros algák (Euglenophyta) kishatározója 1. [A Guide for the Identification of Euglenophyta occurring in Hungary, 1.]. Vizi Természet-És Környezetvédelem, 319 pp.

Philipose M.T. 1982. Contributions to our knowledge of Indian algae. III. Euglenineae Part I. The genus *Euglena* Ehrenberg. *Proc. Indian Acad. Sci. (Plant Sci.)* **91:** 551-599.

Playfair G.I. 1921. Australian Freshwater Flagellates. *Proc. Linnean Soc. N.S. Wales* **46:** 99-146.

Playfair G.I. 1923. Notes on freshwater algae. *Proc. Linnean Soc. N. S. Wales* **48:** 206-228.

Popova T.G. 1955. Evglenovyje vodorosli. *Opred. Presnov. Wodor. USSR.* **7:** 170.

Popova T.G. 1966. Evglenovyje vodorosli vyp. 1. Flora sporovych rastenij SSSR. 8. Izd. Nauka. Moskwa-Leninggrad.

Pringsheim E.G. 1953. Salzwasser-Eugleninen. *Arch. Mikrobiol.* **18:** 149-164.

Pringsheim E.G. 1955. Kleine Mitteilungen über Flagellaten Algen, II: *Euglena gracilis* var. *saccharophila* n. var. und eine vereinfachte Nährlösung zur Vitamin B_{12}-Bestimmung. *Arch. Microbiol.* **21:** 414-419.

Pringsheim E.G. 1956. Contributions towards a monograph of the genus *Euglena*. *Nov. Acta Leopoldina*, N.F. **18:** 1-168. Leipzig.

Pringsheim E.G. and Hovasse R. 1950. Les relations de parenté entre Astasiacées et Euglénacees. *Arch. Zool.* **86:** 499-549.

Proshkina-Lavrenko A.I. 1937. Novye vidy *Euglenaceae* iz solenovodnych vodojemow SSSR. *Bot. Mater. Otd. Spor. Rast. Bot. Inst. USSR.* **4:** 8-9.

Schiller J. 1956. Untersuchungen an den planktischen Protophyten des Neusiedler Sees 1950-1954. III Teil. Euglenen. *Sitz.-Ber. Österr. Akad. Wiss.* **1:** 547-583.

Schmarda S.K. 1846. Kleine Beiträge zur Naturgeschichte der Infusorien. Wien. 17 pp.

Schmitz F. 1884. Beiträge zur Kenntnis der Chromatophoren. *Jahrb. F. wiss. Bot.* **15:** 1-175.

Skuja H. 1932. Beiträge zur Algenflora Lettlands. I. Materiali Latvijas alga florai II. *Acta Horti Botan. Univ. Larviensis, Riga* **7:** 25-85.

Skuja H. 1939. Beitrag zur Algenflora Lettlands II. *Acta Horti Bot. Univ. Latv.* **7:** 25-85.

Skuja H. 1948. Taxonomie des Phytoplaktons einiger Seen in Uppland, Schweden. *Symp. Bot. Upsal.* **9:** 1-399.

Skuja H. 1949. Zur Süßwasseralgenflora Burmas. *Nova Acta Reg. Soc. Sci. Upsal*, ser. **4:** 1-188.

Skuja H. 1956. Taxonomische und biologische Studien uber das Phytoplankton schwedischer Binnengewässer. *Nova Acta Reg. Soc. Sci. Upsal*, ser. **4:** 1-404.

Skvorzov B.W. 1932. Flagellaten aus Korea and Japan. *J. Chosen Nat. Hist. Soc.* **14:** 8-10.

Skvorzov B.W. 1937. Contributions to our knowledge of the freshwater algae of Rangoon, Burma, India. *Arch. Protistenkd.* **90:** 69-87.

Stokes A.C. 1885. Some apparently undescribed infusoria from fresh water. *Am. Natur.* **19:** 18-27.

Swirenko D.O. 1915. Zur Kenntnis der russischen Algenflora, II. Euglenaceae (excl. *Trachelomonas*). *Arch. Hydrobiol. Planktonkunde.* **10:** 321-340.

Szabados M. 1936. *Euglena* Vizsgálatok (*Euglena*-Untersuchungen). *Acta Biol. Szeged* **4:** 49-95.

Szabados M. 1949. A Fehér to Volvocales es Flagellata vegetációja. *Hidrol. Közlöny.* **1949:** 7-8.

Szabados M. 1950. Adatok az Euglena granulata (Klebs) Lemm. Fejlödéséhez. *Ann. Biol. Univ. Szeg.* **1:** 111-115.

Tell G. and Conforti V. 1986. Euglenophyta Pigmentadas de la Argentina. *Bibl. Phycol.* J. Cramer, Berlin, Stuttgart, 201 pp.

Thompson R. 1938. A preliminary survey of the freshwater algae of eastern Kansas. *Univ. Kansas Sci. Bull.* **25:** 5-83.

Walton L.B. 1915. The euglenoidina of Ohio. *Ohio Biol. Sur. Bull.* **4:** 343-450.

Wui I.S. and Kim B. H. 1987. The flora of the fresh-water algae in Chol-La nam-do, Korea (I) Euglenophyceae. *Korean J. Phycol.* **2:** 119-127.

Xavier M.B. 1985. Estudo comparativo da flora de Euglenaceae pigmentadas (Euglenophyceae) de lagos do parque Estadual das Fontes do Ipiranga, São Paulo, SP. p. 378. Tese de Doutoramento. Faculdade de Saude Publica da USP.

Zakrys B. 1986. Contribution to the Monograph of Polish Members of the Genus *Euglena* Ehrenberg 1830. *Nova Hedw.* **42:** 491-540.

Zakrys B. 1997. The taxonomic consequences of morphological and genetic variability in *Euglena agilis* Carter (*Euglenophyta*): Species or clones in *Euglena*?. *Acta Protozool.* **36:** 157-169.

Zakrys B. and Kucharski R. 1996. Microevolutionary in *Euglena pisciformis*. Genetic drift or adaptation?. *Algol. Stud.* **81:** 23-37.

Zakrys B., Kucharski R. and Moraczewski I. 1996. Genetic and morphological variability among clones of *Euglena pisciformis* based on RAPD and biometric analysis. *Algol. Stud.* **81:** 1-21.

Zakrys B., Moraczewski I., and Kucharski R. 1997. The species concept in Euglena in the light of DNA polymorphism analyses. *Algol. Stud.* **86:** 51-79.

Zakrys B. and Walne P.L. 1994. Floristic, taxonomic and phytogeographic studies of green Euglenophyta from the Southeastern United States, with emphasis on new and rare species. *Algol. Stud.* **72:** 71-114.

Zakrys B. and Walne P. 1998. Comparative ultrastructure of chloroplast in the subgenus *Euglena* (Euglenophyta): Taxonomic significance. Cryptogamie: (in press).

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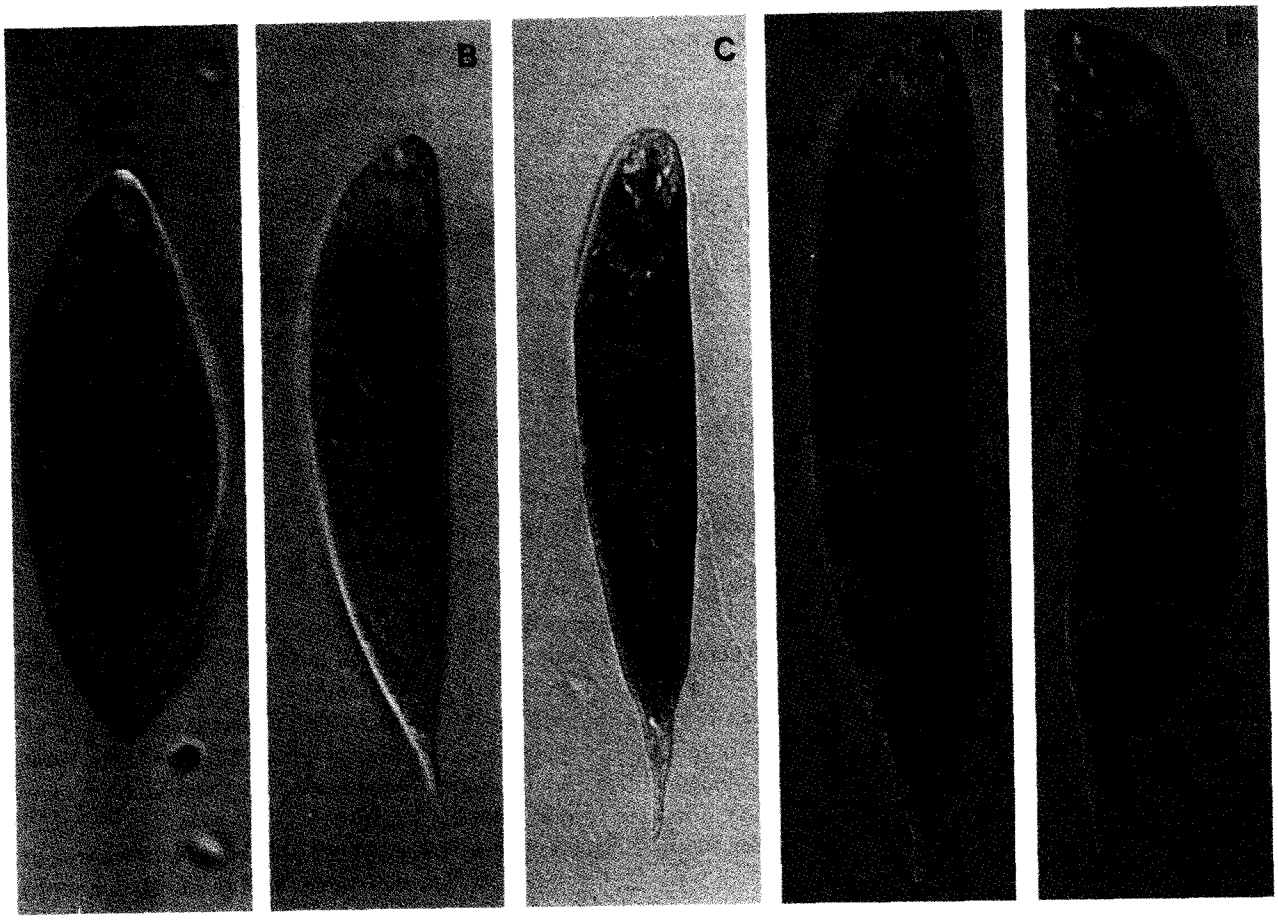

Plate I. Habits of *Euglena viridis* (A, B) and *E. geniculata* (C, D, E).

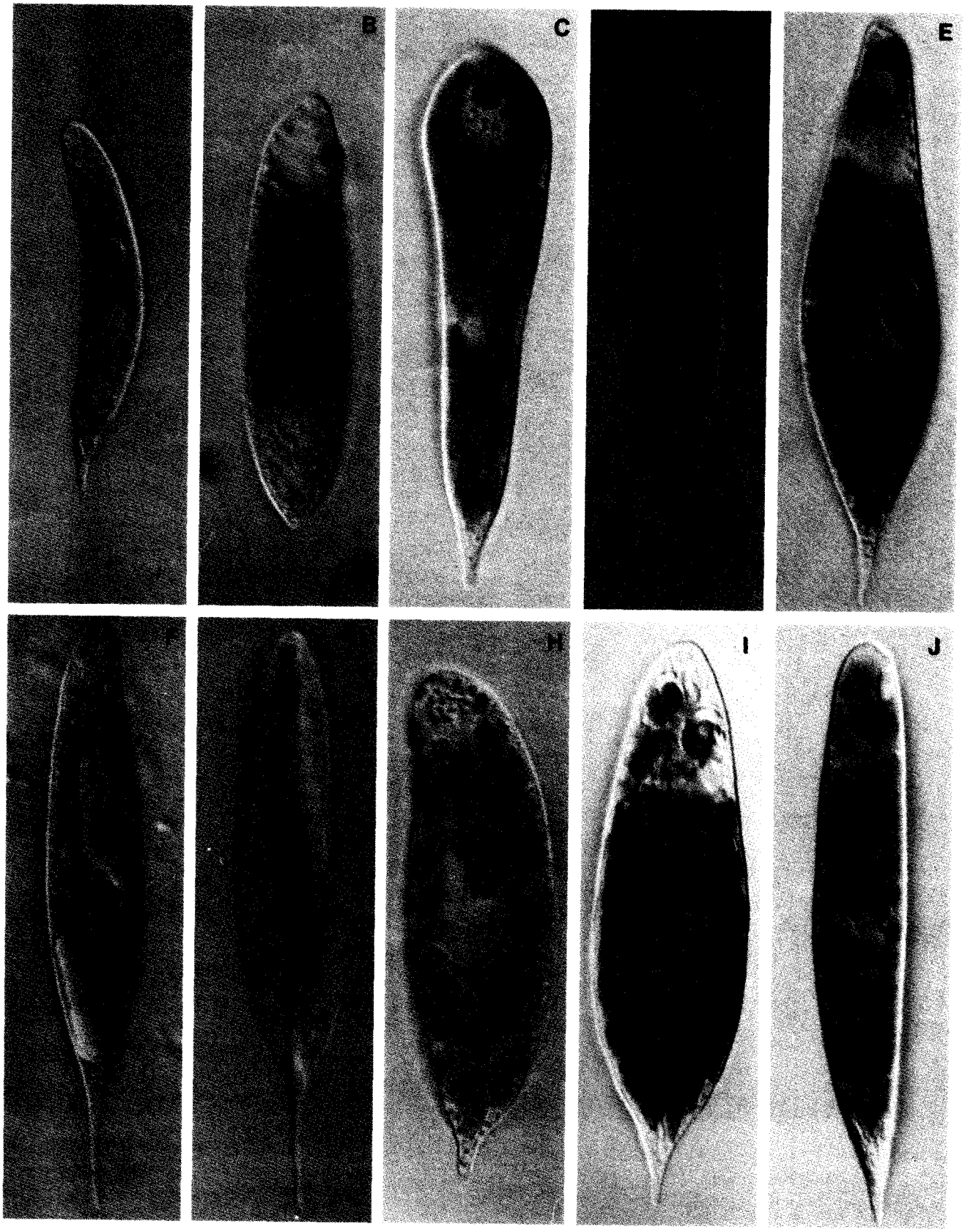

Plate II. Habits of *Euglena agilis* (A), *E. archaeoplastidiata* (B), *E. gracilis* (C), *E. granulata* (D), *E. caudata* (E), *E. limnophila* (F), *E. tripteris* (G), *E. proxima* (H, I), and *E. variabilis* (J).

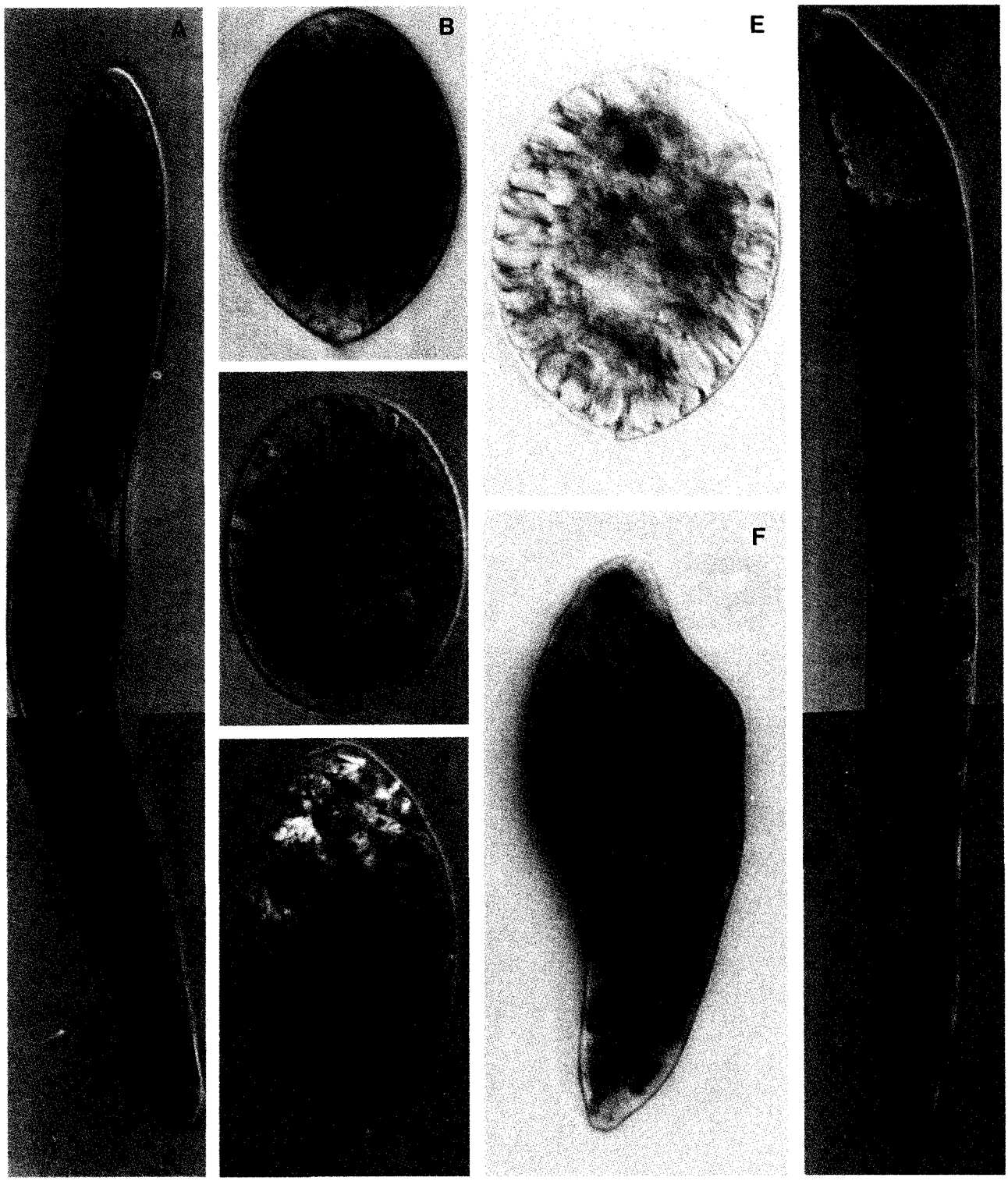

Plate III. Habits of *Euglena ehrenbergii* var. *baculifera* (A), *E. oblonga* (B), *E. texta* (C), *E. truncata* (D), *E. sanguinea* (E), *E. obtusa* (F), and *E. deses* var. *intermedia* (G).

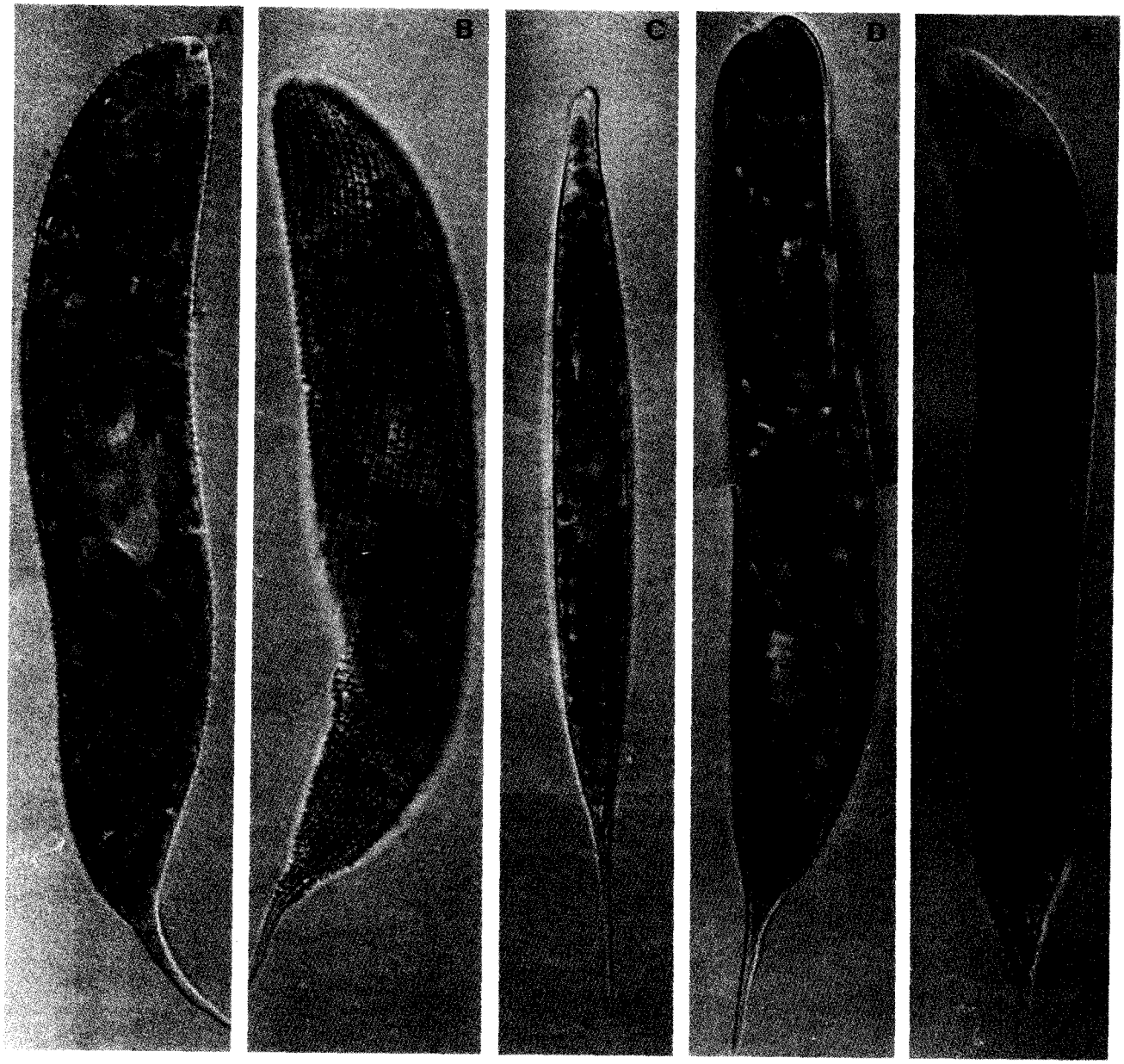

Plate IV. Habits of *Euglena spirogyra* (A, B), *E. acus* (C), *E. oxyuris* (D), and *E. deses* var. *deses* (E).