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EUGLENAE OF IOWA^{1,2}

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The genus *Euglena* Ehrenberg belonging to the family Euglenidae Stein and order Euglenoidina Blochman contains organisms with the following characteristics: chloroplasts, varied in number and shape; stigma, located anteriorly; single bifurcated flagellum of varied length; paramylum bodies, varied in number and shape, free in cytoplasm or attached to chloroplasts; pellicle, more or less plastic and usually marked with striae; gullet, open externally at anterior tip of organism and posteriorly into reservoir; contractile vacuole, near reservoir into which it opens; haematochrome granules free in cytoplasm in red species. The body may be elongated, spindle-shaped, ridged or spirally twisted and always possesses some metabolic movement. Nutrition is phototrophic or saprozoic, but not holozoic. Reproduction occurs asexually by longitudinal division of trophozoite or in temporary cyst.

Since Ehrenberg first described the genus *Euglena* in 1830 it has come to include approximately 100 species and numerous varieties. Euglenae have been collected from a variety of habitats, for example, *E. acus* in fresh water (Ehrenberg, 1838), *E. vermiformis* in brackish water (Carter, 1937), *E. sima* in marine water (Wermal, 1924), *E. elongata* in cold pools (Schewiakoff, 1893), *E. rubra* in warm pools (Hardy, 1911), and six species in soils (Sandon, 1927).

Various keys have been developed for the genus *Euglena*. Those written by Pascher and Lemmerman (1913) and Walton (1915) are the most

¹ Appreciation is expressed to Dr. T. L. Jahn for aid and direction during the course of the present investigation.

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widely used. These are inadequate for classroom use since the structure of chloroplasts is used as the diagnostic characteristic and the distinction often involves special techniques. Baker (1926) found the shape and arrangement of chloroplasts and the presence of pyrenoids to vary at different stages in the life cycle of *E. Agilis* Carter. Preliminary experiments also show that form, number and arrangement of chloroplasts may change with varying p^H of the culture medium (Baker, 1926). These facts cause one to question the advisability of using the chloroplasts as a diagnostic character in the classification of the genus *Euglena*.

The only key generally available to the euglenae in English is that of Walton (1915), which is modeled after the one in German by Pascher and Lemmerman (1913). Walton included nearly all of the euglenae recorded to that date but observed only about one-half those which he listed. Most of the illustrations included by Walton were sketches rather than detailed drawing and were copied from various authors. Szabados (1936), a European worker, reported on the euglenae of Central Europe. He presented excellent drawings of 31 species but failed to give detailed descriptions or present a key to those which he reported.

The purpose of the present investigation is to present a key to the euglenae of Iowa that may be of general use and to describe adequately and draw each species of *Euglena* reported.

HISTORY

Klebs (1883) credited Leeuwenhoek with observing *Euglena sanguinea*, and Dobell (1932) quoted an original passage from Leeuwenhoek (1674) who described a *Euglena* which fits the description of any of several of the more metabolic forms. Cole (1926) quoted from Harris (1696) an original description of a *Euglena* which closely resembles that of *E. viridis*.

Ehrenberg (1830) first described the genus *Euglena* to include organisms with the following characteristics: body fusiform to elongated fusiform or elongated cylindrical or elongated "band-shape," terminating in a more or less tail-like projection; body bounded by an elastic cuticulum; most organisms very metabolic; chloroplasts seldom lacking, usually numerous, disc-shaped or band-shaped; pyrenoids and haematochrome sometimes present; single flagellum extending from an anterior notch, from the bottom of which a gullet extends to a rounded vesicle; reproduction by longitudinal division in either trophozoite or in encysted stage.

Colorless Euglenidae without a stigma were first separated from the genus *Euglena* and placed in the genus *Astasia* by Ehrenberg in 1838. Dujardin (1841) differentiated these genera only on the basis of color. Dujardin separated the rigid forms from the more metabolic *Euglena* and placed them in the genus *Phacus*. He transferred the genus *Phacus* from the family

Eugleniens to the family Thecomonadiens. The family Eugleniens of Dujardin otherwise followed closely the family Astasiaea of Ehrenberg. Stein (1878) retained in the family Euglenidae only the genus *Euglena* from the family Eugleniens of Dujardin. The family Euglenidae was defined by Stein (1878) to include the genera *Euglena*, *Trachelomonas*, *Colacium*, *Phacus* and *Ascoglena*. Klebs (1883) followed botanical nomenclature and applied the family name Euglenaceae to the colored forms.

Blochman (1895) placed the groups in the order Euglenoidina and divided it into the families Euglenina, Astasina, and Peranemina. Calkins (1933) suggested placing the chlorophyll-bearing forms of the order in the plant kingdom and the colorless forms in those groups of the animal kingdom which they most resemble. The mechanics of species determination would be facilitated if suggestions by Calkins were followed, but it does not seem advisable to discard a classification based on natural relationships for a more artificial one.

Hall and Jahn (1929) suggested that colorless euglenoids with a stigma, bifurcated flagella and flagellar swellings be placed in the family Euglenidae Stein and those lacking these characteristics, in the family Astasiidae Bütschli. Jahn and McKibben (1937) described *Khawkinea halli*, a colorless stigma-bearing euglenoid with bifurcated flagellum, and proposed the new genus *Khawkinea* to include all forms with these characteristics. They suggested that all colorless stigma-bearing euglenoids probably should be placed in their new genus.

This would substantiate Ehrenberg's method of differentiating the genera *Euglena* and *Astasia* on the presence of a stigma rather than the presence or absence of chloroplasts alone as suggested by Dujardin.

Several notable studies have been made on Protozoa in the United States, and of these the studies of Stokes (1888), Conn (1905) and Walton (1915) should be mentioned. Stokes (1888) listed six species of *Euglena*: *E. viridis*, *E. spirogyra*, *E. oxyuris*, *E. deses*, *E. acus*, and *E. torta*. Conn (1905) listed three of the same species and three undetermined forms. Walton (1915) compiled the descriptions of 38 known species of *Euglena*, of which 17 were observed by him in the United States, and of these two were previously undescribed.

E. viridis was the first record of a *Euglena* from Iowa (Shimek, 1896). Fink (1904) reported *E. spirogyra* in an aquarium at Fayette, Iowa. *E. deses* and *E. acus* were added to the list of *Euglena* from Iowa by Edmundson (1906). Spencer (1916) described *E. viridis*, *E. rubra*, *E. acus*, *E. deses*, and an unnamed species whose description closely resembles that of flattened varieties of *E. spirogyra*. Prescott (1927) described ten species of *Euglena* from Iowa, adding *E. sanguinea*, *E. acutissima*, *E. elongata*, *E. pisciformis*, *E. proxima*, and *E. spiroides* to the previous species. *E. torta* and *E. ehrenbergii* were found by Gerhardt (1940) in a large kettle-hole in Northwest

Iowa. Thirteen is the total number of *Euglena* reported from Iowa prior to this investigation.

MATERIALS AND METHODS

Collections were made in pint or quart glass jars and taken to the laboratory where the contents of the jars were studied immediately and checked daily for approximately two weeks. The samples were left in the jars or placed in flat evaporating dishes and compressed air was forced through the cultures. Sparse bacterial contamination occurred in the latter cultures and it was possible to keep them in the laboratory indefinitely.

Observations were made on living material and on specimens fixed and stained with Noland's (1928) solution. The lens system used included 16 mm., 4 mm., and oil immersion apochromatic 1.8 mm. objectives and a 10x ocular. All measurements were made with the aid of a calibrated ocular micrometer, and a camera lucida was used in making all drawings.

Material was collected from the Mississippi River and back washes near Muscatine, the Cedar River on Highway U. S. Route 6, the Iowa River at Hills, Iowa City, and Amana colonies, the Des Moines River and the Racoon River near Des Moines, and the Little Sioux River near Milford, Iowa. Samples were also collected from Lake MacBride, Clear Lake, Spirit Lake, Hottes Lake, Lake East Okoboji, Silver Lake, Lake West Okoboji, and connecting Beck Canal. Other sources of materials were the Law Quarry, Lagoon, and Park Pond of Iowa City, Witmer Lake of Des Moines, and various springs, water tanks, and temporary pools in farm yards and along roadsides.

In the following key, each species of *Euglena* is numbered according to its order of appearance in the key. The same number is used for the complete description which follows the key and for the figures of each species.

A KEY TO EUGLENAE OF IOWA

- 1 *Euglena* attached to Microcrustacea or Hydracarina (16–32 μ long by 9–14 μ wide) 1. *E. cyclopicola* (Fig. 1, A–C)
 Euglena free swimming 2
- 2 (1) Body possessing definite ridges or grooves 3
 Body not possessing definite ridges or grooves 10
- 3 (2) Body: three or four ridged; often spirally twisted 4
 Body: cylindrical or flattened; pronounced single groove present 9
- 4 (3) Depressions between ridges difficult to observe, extreme body torsion, chloroplasts parallel to striations of pellicle (95–150 μ long by 15–22 μ wide)
 2. *E. pseudospiroides* (Fig. 2, A, B)
 Depressions between ridges easily evident, chloroplasts not parallel with striations of pellicle 5
- 5 (4) Ridges not equally spaced at anterior end of body (body Y-shaped in cross-section), dipping movement of anterior end during locomotion (42–53 μ long by 4–7 μ wide)
 3. *E. fronsundulata* n. sp. (Fig. 3)
 Ridges nearly equally spaced at anterior end of body, no dipping movement of anterior end during locomotion 6

- 6 (5) Flagellum over one-half body length 7
 Flagellum short, never approximating one-half body length 8
- 7 (6) Size: 90–120 μ long by 12–16 μ wide, elongated posterior spine usually curved 4. *E. tripteris* (Fig. 4, A)
 Size: 52–63 μ long by 11–15 μ wide, short posterior spine slightly curved 4. *E. tripteris* var. *klebsii* (Fig. 4, B, C)
- 8 (6) Body deeply three-ridged, body torsion pronounced, rounded anteriorly (205–220 μ long by 11–15 μ wide) 5. *E. trisulcata* n. sp. (Fig. 5)
 Body weakly three- or four-ridged, no body torsion, usually truncated anteriorly, (52–170 μ long by 8–18 μ wide) 14. *E. acus* var. *angularis*, n. var. (Fig. 14, D)
- 9 (3) Spiral groove extending the length of the body, two large annular paramylum bodies evident (140–450 μ long by 19–38 μ wide) 6. *E. oxyuris* (Fig. 6, A–C)
 Short groove at anterior end of body, two rod-like paramylum bodies evident (220–310 μ long by 23–30 μ wide) 7. *E. antefossa* n. sp. (Fig. 7, A, B)
- 10 (2) Haematochrome granules free in cytoplasm, often obscuring green of chloroplasts . . . 11
 Haematochrome granules usually not present in cytoplasm; if present, in reddish-brown clumps 13
- 11 (10) Body fusiform, colorless posterior tip pointed, haematochrome seldom obscuring green of chloroplasts (50–65 μ long by 18–30 μ wide) 8. *E. flava* (Fig. 8, A, B)
 Body cylindrical, colorless posterior tip blunt or absent, haematochrome usually obscuring chloroplasts 12
- 12 (11) Anterior end not appreciably narrowed, striations not easily evident, posterior colorless tip usually evident (76–168 μ long by 25–36 μ wide) . . . 9. *E. rubra* (Fig. 9, A, B)
 Anterior end appreciably narrowed, striations evident, posterior tip evanescent (90–170 μ long by 24–44 μ wide) 10. *E. sanguinea* (Fig. 10, A, B)
- 13 (10) Body length six or more times width, or pellicle possessing prominent processes . . . 14
 Body length less than five times width, pellicle not possessing prominent processes . . . 34
- 14 (13) Colorless posterior spine well developed, always present, body slightly metabolic . . 15
 Colorless posterior spine absent or if present short and usually evanescent, body usually actively metabolic 25
- 15 (14) Pellicle with prominent raised processes arranged spirally 16
 Pellicle without prominent raised processes 20
- 16 (15) Pellicular striations not close together 17
 Pellicular striations nearly touching 19
- 17 (16) Pellicular processes alike in size (80–126 μ long by 10–35 μ wide) 11. *E. spirogyra* (Fig. 11, A)
 Pellicular processes of two sizes 18
- 18 (17) Processes of alternating large and small rows (100–110 μ long by 6–8 μ wide) 11. *E. spirogyra* var. *elegans* (Fig. 11, B)
 Processes alternating one large and two small rows (140–180 μ long by 23–35 μ wide) . . . 11. *E. spirogyra* var. *suprema* (Fig. 11, C)
- 19 (16) Processes of the same size (85–165 μ long by 12–30 μ wide) 11. *E. spirogyra* var. *marchica* (Fig. 11, D)
 Processes of alternating large and small rows (130–145 μ long by 15–17 μ wide) 11. *E. spirogyra* var. *abrupte-acuminata* (Fig. 11, E)
- 20 (15) Body flattened, spirally twisted, one annular paramylum body anterior and one posterior to nucleus (75–164 μ long by 12–16 μ wide) . . . 12. *E. spiroides* (Fig. 12, A, B)
 Body usually cylindrical, not flattened or spirally twisted 21
- 21 (20) Posterior colorless endpiece sharp-pointed or extremely long, striations of pellicle evident, flagellar bifurcation often evident in vivo 22
 Posterior colorless endpiece with truncated tip, striations of pellicle obscure, chloroplasts hide flagellar bifurcation 23

- 22 (21) Colorless posterior endpiece less than 40μ long ($120\text{--}150\mu$ long by $9\text{--}11\mu$ wide) 13. *E. acutissima* (Fig. 13, A, B)
 Colorless posterior endpiece over 40μ long, ($220\text{--}350\mu$ long by $10\text{--}13.5\mu$ wide) 13. *E. acutissima* var. *longa*, n. var. (Fig. 13, C-E.)
- 23 (21) Body cylindrical, pellicle hyaline, weakly metabolic ($52\text{--}175\mu$ long by $8\text{--}18\mu$ wide) 14. *E. acus* (Fig. 14, A-C)
 Body weakly ridged or pellicle darkened, body nearly rigid 24
- 24 (23) Pellicle hyaline, body weakly three or four ridged ($52\text{--}175\mu$ long by $8\text{--}18\mu$ wide) 14. *E. acus* var. *angularis*, n. var. (Fig. 14, D)
 Pellicle amber colored, body cylindrical, ($109\text{--}126\mu$ long by $7\text{--}9\mu$ wide) 14. *E. acus* var. *rigida* (Fig. 14, E)
- 25 (14) Paramylum bodies not attached to chloroplasts; if present, free in cytoplasm 26
 Paramylum bodies attached to chloroplasts, additional paramylum bodies may be free in cytoplasm 32
- 26 (25) Body slightly metabolic, single chloroplast present ($60\text{--}70\mu$ long by $5\text{--}7\mu$ wide) 15. *E. elongata* (Fig. 15)
 Body metabolic, more than one chloroplast present 27
- 27 (26) Body cylindrical with posterior end truncated, or body flattened with posterior end rounded ($170\text{--}400\mu$ long by $13\text{--}40\mu$ wide) 16. *E. ehrenbergii* (Fig. 16, A-C)
 Body never flattened, posterior never truncated 28
- 28 (27) Chloroplast shape prolate discoidal 29
 Chloroplast shape discoidal 31
- 29 (28) Actively metabolic ($45\text{--}85\mu$ long by $5\text{--}8\mu$ wide) 17. *E. klebsii* (Fig. 17, A-D)
 Sluggishly metabolic, length over 85μ long 30
- 30 (29) Anterior end rounded, flagellum extends beyond gullet ($86\text{--}170\mu$ long by $11\text{--}21\mu$ wide) 18. *E. deses* (Fig. 18, A, B)
 Anterior end truncated, flagellum not extending beyond gullet ($95\text{--}140\mu$ long by $8\text{--}11\mu$ wide) 18. *E. deses* var. *tenuis* (Fig. 18, C-F)
- 31 (28) Rod-like paramylum bodies, annular paramylum bodies never present, striations not readily observed ($85\text{--}130\mu$ long by $8\text{--}12\mu$ wide) 19. *E. intermedia* (Fig. 19, A, B)
 Rod-like and annular paramylum bodies present, striations easily observed ($85\text{--}135\mu$ long by $8\text{--}12\mu$ wide) 20. *E. ignobilis* n. sp. (Fig. 20, A-C)
- 32 (25) Body posteriorly to mid-body region gradually narrowed, usually with small colorless tip ($68\text{--}93\mu$ long by $8\text{--}17\mu$ wide) 21. *E. terricola* (Fig. 21, A-H)
 Body posteriorly to mid-body region not gradually narrowed, posterior end rounded or if narrowed into tip, colored 33
- 33 (32) Size: $87\text{--}130\mu$ long by $17\text{--}27\mu$ wide, forms characteristic flask-like cysts 22. *E. tuba* (Fig. 22, A-H)
 Size: $35\text{--}55\mu$ long by $8\text{--}22\mu$ wide, flask-like cysts not formed 23. *E. gracilis* (Fig. 23, A, B)
- 34 (13) Body length more than 55μ (one eighth high power field) long, if approximately 55μ long, paramylum bodies not attached to chloroplasts, body broad 35
 Body length less than 55μ (one-eighth high power field) long, if approximately 55μ long part or all of the paramylum bodies attached to chloroplasts 46
- 35 (34) No paramylum bodies attached to chloroplasts (an oil immersion lens may be necessary) 36
 Some or all paramylum bodies attached to chloroplasts 38
- 36 (35) Chloroplasts not aligned spirally, body broadly fusiform, colorless posterior endpiece ($55\text{--}75\mu$ long by $19\text{--}30\mu$ wide) 24. *E. proxima* (Fig. 24, A, B)
 Chloroplasts aligned spirally, body cylindrical, colored posterior end usually blunt 37

- 37 (36) Flagellum two times body length, usually trailing, striations of pellicle continuous, (75–104 μ long by 22–30 μ wide).....25. *E. fundoversata* n. sp. (Fig. 25)
 Flagellum one and one-fourth body length, striations of pellicle irregularly spaced processes (74–110 μ long by 21–27 μ wide).....26. *E. splendens* (Fig. 26, A–C)
- 38 (35) Body broadest anterior to mid-body region.....39
 Body not broadest anterior to mid-body region, or if so, anterior end characteristically narrowed and colorless.....40
- 39 (38) Pellicle prominently spirally ridged, flagellum approximately body length (90–120 μ long by 27–50 μ wide).....27. *E. caudata* (Fig. 27, A, B)
 Pellicle delicately spirally striated, flagellum approximately one-third body length, (68–95 μ long by 8–17 μ wide).....21. *E. terricola* (Fig. 21, A–H)
- 40 (38) Body oval, posterior end rounded or with short tip colored (52–70 μ long by 25–40 μ wide).....28. *E. oblonga* (Fig. 28, A, B)
 Body not oval, posterior end tapered.....41
- 41 (40) Anterior end decidedly narrowed (snout-like), hyaline (90–140 μ long by 18–48 μ wide).....29. *E. rostrifera* n. sp. (Fig. 29, A–D)
 Anterior end not decidedly narrowed (snout-like), usually colored.....42
- 42 (41) Rod-like granules present, approximately six μ long, arranged perpendicularly to pellicle (80–115 μ long by 25–35 μ wide).....30. *E. velata* (Fig. 30, A, B)
 Rod-like granules not present.....43
- 43 (42) Striations of pellicle delicate, chloroplasts usually aligned spirally (65–112 μ long by 16–30 μ wide).....31. *E. sociabilis* (Fig. 31, A–C)
 Striations of pellicle easily discernible, chloroplasts arranged variously.....44
- 44 (43) Flagellum two times body length, body decidedly metabolic, heavy-walled cysts closely appressed (57–92 μ long by 15–25 μ wide).....32. *E. polymorpha* (Fig. 32, A–C)
 Flagellum approximately body length, metabolic, heavy-walled cysts not closely appressed.....45
- 45 (44) Spherical granules under pellicle parallel to striations, body fusiform, heavy-walled cysts spherical (60–95 μ long by 18–27 μ wide).....33. *E. granulata* (Fig. 33, A–D)
 Spherical granules lacking, body elongately cylindrical, heavy-walled cysts flask-like, (87–130 μ long by 17–27 μ wide).....22. *E. tuba* (Fig. 22, A–H)
- 46 (34) Paramylum bodies attached to chloroplasts, additional paramylum bodies may be free in cytoplasm (an oil immersion lens may be necessary).....47
 Paramylum bodies not attached to chloroplasts.....52
- 47 (46) Body length four times width, chloroplasts parallel with longitudinal axis.....48
 Body length not over three times width, chloroplasts variously arranged.....50
- 48 (47) More than three chloroplasts, each approximately one-fourth body length (35–55 μ long by 8–22 μ wide).....23. *E. gracilis* (Fig. 23, A, B)
 Two or three chloroplasts, slightly less than body length, body less than 35 μ long, active vibratile means of locomotion.....49
- 49 (48) Size: 21–34 μ long by 5–8 μ wide.....34. *E. pisciformis* (Fig. 34, A–F)
 Size: 15–20 μ long by approximately 5 μ wide.....34. *E. pisciformis* var. *minor* (Fig. 34, G, H)
- 50 (47) Chloroplasts quadrangular in shape, flattened (36–45 μ long by 16–22 μ wide).....35. *E. anabeana* var. *minor* (Fig. 35)
 Chloroplasts spindle-shaped.....51
- 51 (50) Two or three chloroplasts present, striations not readily evident (25–40 μ long by 10–15 μ wide).....36. *E. minima* (Fig. 36, A, B)
 More than three chloroplasts present, striations evident (40–65 μ long by 14–20 μ wide).....37. *E. viridis* (Fig. 37, A–G)

- 52 (46) Two chloroplasts present. 53
 More than two chloroplasts present. 54
 53 (52) Body length three or more times width, metabolic, flagellum usually projected anteriorly (24–35 μ long by 7–8 μ wide) 38. *E. vivida* (Fig. 38, A, B)
 Body length less than three times width, seldom metabolic, locomotion rapid (13–17 μ long by 6–9 μ wide) 39. *E. nana* n. sp. (Fig. 39, A, B)
 54 (52) Posterior end usually narrowed into a tip, usually hyaline, striations of pellicle evident, (30–45 μ long by 6–16 μ wide) 40. *E. chlamydophora* (Fig. 40, A–E)
 Posterior end blunt and colored, striations of pellicle not usually evident 55
 55 (54) Body metabolic during locomotion, direction of locomotion never posteriorly, resting cyst attached to Microcrustacea and Hydracarina (16–32 μ long by 9–14 μ wide) 1. *E. cyclopicola* (Fig. 1, A–C)
 Body not metabolic during locomotion, direction of locomotion often posteriorly, never attached to Microcrustacea or Hydracarina (18–34 μ long by 7–15 μ wide) 41. *E. retronata* n. sp. (Fig. 41, A–F)

DESCRIPTIONS OF SPECIES

1. *E. cyclopicola* Gichelhorn (Fig. 1, A–C)

Size: 16–32 μ long by 9–14 μ in diameter. Body: cylindrical, rounded anteriorly and posteriorly; anterior tip colorless. Pellicle: apparently smooth; allows active metabolic movement. Nucleus: spherical, approximately 5 μ in diameter, in mid-body region.

Flagellum: observed only in trophozoite; body length or slightly longer. Gullet: 3–4 μ long; opens into reservoir approximately 5 μ in diameter.

Chloroplasts: discoidal, 4 μ in diameter; 10–12 in number. Stigma: concave prolate discoidal; 1.5 μ long; often not observed. Paramylum bodies: numerous; oval; approximately 3 μ long.

Thin-walled cysts: attached to Microcrustacea and larval Hydracarina; attached with anterior end; allows slight metabolic movement. Division: not observed but attached cysts usually in groups of 2, 4, 6, or 8.

Collected: Kettle Hole, Dickinson County; Little Sioux River.

Gichelhorn reports *E. cyclopicola* attached to Cyclops and Daphnia. Cypris and larval Hydracarina were the only hosts observed by the present investigator.

2. *E. pseudospiroides* Swirenko (Fig. 2, A, B)

Size: 95–150 μ long by 15–22 μ through transverse axis. Body: elongate; three-ridged; spirally twisted, often to the point that grooves are hidden; extended posteriorly into prominent colorless tip. Pellicle: longitudinal striations 1.5 μ apart, aligned spirally secondarily; allows slight metabolic movement. Nucleus: spherical to prolate spheroidal; approximately 15 μ through longest axis; located in mid-body region.

Flagellum: approximately one-third body length. Gullet: short; straight; opens into reservoir 8–15 μ in diameter.

Chloroplasts: numerous; discoidal; 3 μ in diameter by 1.5 μ in thickness;

aligned parallel with striations; perpendicular to pellicle. Stigma: conspicuous; extremely concave (bowl-shaped); $6-8\mu$ through greatest diameter; lateral to body of reservoir. Paramylum bodies; usually one anterior and one posterior to nucleus; rod-shaped; $18-30\mu$ long.

Thin-walled cysts observed. No observation upon division.

Collected: Amana Lake; Iowa River; Law Quarry, Iowa City.

The *E. pseudospiroides* described here differs from the original description by Swirenko only in size, but the largest forms observed are well within the range described by him ($131-192\mu$ long by $13-22\mu$ through transverse axis).

3. *E. fronsundulata* n. sp. (Fig. 3)

Size: $42-53\mu$ long by $4-7\mu$ through transverse axis. Body: three-ridged, "Y"-shaped in cross section anteriorly, ridges equally spaced posteriorly; may be slightly twisted, rounded to truncate anteriorly; posteriorly extended into colorless tip. Characteristic dipping movement of anterior end during locomotion. Pellicle: delicately longitudinally striated; allows slight metabolic movement. Nucleus: spherical; $3-4\mu$ in diameter; in mid-body region.

Flagellum: approximately one-fourth body length. Gullet: 3μ long; opens into globular reservoir, 4μ long by 3μ in diameter.

Chloroplasts: numerous; discoidal to slightly prolate discoidal; 2.5μ in diameter; blue-green color. Stigma: evident; concave discoidal, edges often uneven; 3μ in diameter; lateral to region where gullet enters reservoir. Paramylum bodies: annular, slightly elongated; one anterior and one posterior to nucleus; $3-4\mu$ long.

Thin-walled cysts observed. Division not observed.

Collected: Beck's Canal, West Lake Okoboji; Iowa River, Johnson County.

E. fronsundulata differs from *E. tripteris*, the closest described species, in that it is smaller, possesses a relatively shorter flagellum; possesses dipping movement of anterior end during locomotion; blue-green chloroplasts rather than the typical green chloroplasts of *Euglena*, and the ridges are not equidistant apart at anterior end.

4. *E. tripteris* Dujardin (Fig. 4, A)

Size: $90-120\mu$ long by $12-16\mu$ through transverse axis. Body: elongate; three-ridged; slightly truncated anteriorly; extended posteriorly into prominent colorless curved tip. Pellicle: longitudinally striated; allows only slight metabolic movement. Nucleus: prolate spheroidal; approximately 10μ long; in mid-body region.

Flagellum: three-fourths body length. Gullet: short; opens into pyriform reservoir; 6μ through transverse axis.

Chloroplasts: discoidal; 4μ in diameter; numerous. Stigma: conspicuous;

deeply concave discoidal; $5-7\mu$ through longitudinal axis; lateral to anterior portion of reservoir. Paramylum bodies: rod-shaped; one anterior and one posterior to nucleus; $15-20\mu$ long; numerous scattered small granules.

Encystment and division not observed.

Widely distributed except in temporary ponds.

Differs from the accepted description only in size, being $90-120\mu$ rather than $70-80\mu$ long.

4. *E. Tripteris* var. *klebsii* Lemmerman (Fig. 4, B, C)

Size: $52-63\mu$ long by $11-15\mu$ throughout transverse axis. Differs from *E. tripteris*: body more rigid; less torsion; flagellum often less than three-fourths body length; posterior colorless endpiece shorter and straight to slightly curved.

Lemmerman (1913) states the var. *kelbsii* is decidedly smaller and during division possesses a mucus covering.

5. *E. trisulcata* n. sp. (Fig. 5).

Size: $205-220\mu$ long by $11-15\mu$ through transverse axis. Body: elongate; three-ridged; torsion one complete rotation; anterior end hyaline, rounded; narrowed posteriorly and extended into prominent colorless endpiece, curved near tip. Pellicle: delicately longitudinally striated; striations 1.5μ apart; allows slight metabolic movement. Nucleus: prolate spheroidal: approximately 15μ long; in mid-body region.

Flagellum: short, one-tenth body length. Gullet: short, opens into reservoir approximately 7μ in diameter.

Chloroplasts: discoidal; 1.5μ in diameter; scattered; often numerous hyaline granules of same size in anterior end. Stigma: evident; deeply concave (cup-shaped); $4-5\mu$ in diameter; with haematochrome granules 0.5μ in

EXPLANATION OF FIGURES

All figures are magnified $500\times$ unless otherwise stated.

PLATE I

1. A-C, *E. cylcopicola*. B, C, resting cysts attached to Microcrustacea.
2. A, B, *E. pseudospiroides*. A, trophozoite and adjacent chloroplasts; b, outline drawing showing body torsion.
3. *E. fronsundulata* n. sp., trophozoite and accompanying cross-sections.
4. A, *E. tripteris*, trophozoite and accompanying cross-section.
4. B, C, *E. tripteris* var. *klebsii*. C, trophozoite and accompanying cross-section.
5. *E. trisulcata* n. sp., trophozoite and accompanying cross-section.
6. A-C, *E. oxyuris*. A, outline drawing of flattened trophozoite and accompanying pellicular striae.
7. A, B, *E. antefossa* n. sp. A, outline drawing of trophozoite showing slight torsion; B, trophozoite.

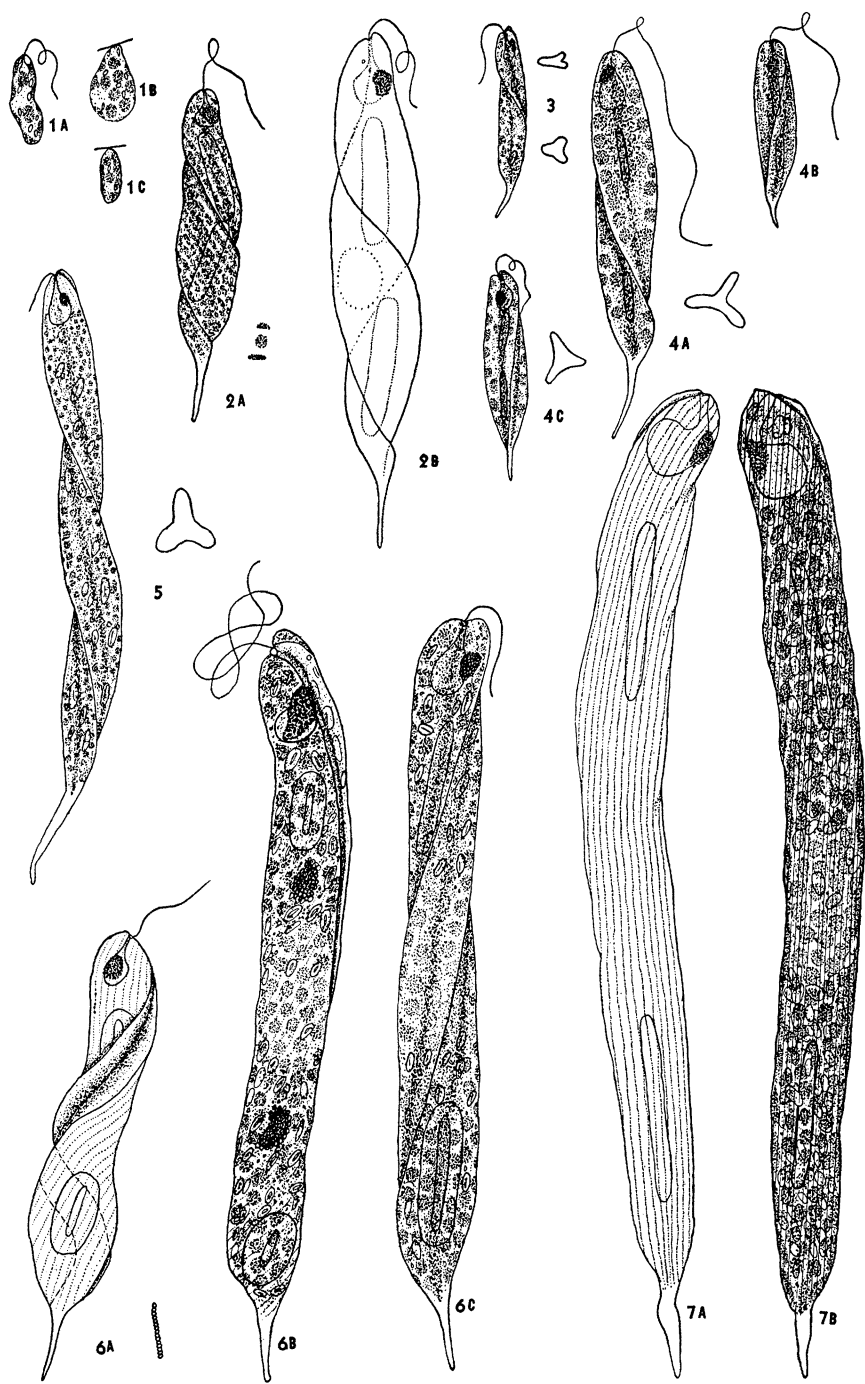


PLATE I

diameter; lateral to anterior region of reservoir. Contractile vacuole: 6–7 μ in diameter; lateral to posterior region of reservoir; side opposite stigma. Paramylum bodies: numerous; elongated annular; 4–12 μ long; scattered.

Encystment and division not observed.

Collected: Beck's Canal and Emerson's Bay, Lake West Okoboji.

E. trisulcata n. sp. can easily be distinguished from *E. tripteris* by the small chloroplasts, short flagellum, absence of rod-shaped paramylum bodies, greater body length and increased body torsion.

6. *E. oxyuris* Schmarda (Fig. 6, A–C)

Size: 140–450 μ long by 19–38 μ through transverse axis. Body: cylindrical or flattened, usually twisted; evident spiral groove, entire length of body; rounded anteriorly, slightly indented at opening of gullet; extended posteriorly into prominent colorless endpiece. Pellicle: striations prominent, due to series of short appressed processes 1 μ in diameter; allows varied metabolic movement, usually slight. Nucleus: prolate spheroidal; 31–48 μ long; in mid-body region.

Flagellum: one-third to one-half body length. Gullet: 6–20 μ long; slightly curved; opens into spherical reservoir 10–15 μ in diameter.

Chloroplasts: discoidal; 4–5 μ in diameter; numerous. Stigma: prominent concave discoidal; often appears apostrophic-shaped when viewed from side; 8–14 μ through longitudinal axis; lateral to body of reservoir. Paramylum bodies: one large elongated annular body anterior and one posterior to nucleus; 20–40 μ long; numerous small annular bodies scattered throughout cytoplasm. Hyaline granules: 0.5–1.0 μ in diameter; free in cytoplasm. Haematochrome granules: sometimes present in clumps other than stigma; reddish-brown in color.

Encystment and division not observed.

Widely distributed except in temporary ponds.

7. *E. antefossa* n. sp. (Fig. 7, A, B)

Size: 220–310 μ long by 23–30 μ in diameter. Body: elongately cylindrical; rounded anteriorly; extended posteriorly into prominent colorless endpiece approximately 20 μ long; endpiece often enlarged near base; short groove extends posteriorly from anterior tip, disappears within anterior sixth of body; usually straight, may be twisted. Pellicle: longitudinal striations unbroken; allows only weak metabolic movements. Nucleus: prolate spheroidal; 35–50 μ long; in mid-body region.

Flagellum: none observed. Gullet: approximately 10 μ long; opens into reservoir 12–18 μ in diameter, perpendicular to longitudinal axis of reservoir. Contractile vacuole: slightly posterior and lateral to stigma.

Chloroplasts: numerous; discoidal; 3–5 μ in diameter. Stigma: crescent-shaped; 7–10 μ in diameter; haematochrome granules less than 0.3 μ in diameter; reddish-brown; lateral to entrance of gullet into reservoir. Paramy-

lum bodies: rod-shaped; one anterior and one posterior to nucleus; 28–33 μ long; numerous scattered elliptical bodies usually present.

Encystment and division not observed.

Collected: Law Quarry, Iowa City; Amana Lake; in early summer.

E. antefossa n. sp. differs from *E. oxyuris* as follows: groove short, not body length; rod-shaped paramylum bodies, not annular; striations continuous, not beaded; less metabolic.

E. antefossa n. sp. differs from *E. charkiensis* Swirenko in that the present species is decidedly larger; possesses rod-shaped paramylum bodies instead of annular bodies; is longitudinally, not spirally striated.

8. *E. flava* Dangeard (Fig. 8, A, B)

Size: 50–65 μ long by 18–30 μ through transverse axis. Body: fusiform; narrowed anteriorly, bilabiate; extended posteriorly into colorless endpiece. Pellicle: weakly spirally striated; allows considerable metabolic movement. Nucleus: spherical; 10 μ in diameter; in mid-body region.

Flagellum: approximately body length. Gullet: approximately 5 μ long, slightly curved; opens into globular reservoir 5–8 μ in diameter.

Chloroplasts: 8–16 in number; fusiform; usually curved; approximately 15 μ long. Stigma: evident; concave discoidal; 4 μ in diameter; lateral to main body of reservoir. Paramylum bodies: double concave discoidal; usually two such annular bodies attached to each chloroplast; 5–6 μ in diameter. Haematochrome granules: numerous; diffuse or grouped centrally; often grouped in small clumps; 0.3–0.4 μ in diameter.

Thin-walled cysts observed. Division not observed.

Collected: Little Sioux River, and permanent pond, Dickinson County.

9. *E. rubra* Hardy (Fig. 9, A, B)

Size: 76–168 μ long by 25–36 μ in diameter. Body: cylindrical; rounded anteriorly; extended posteriorly into short colorless endpiece. Pellicle: delicately spirally striated, striations broken; allows considerable metabolic movement. Nucleus: spherical; 12–17 μ in diameter; posterior to mid-body region.

Flagellum: slightly longer than body length. Gullet: slightly curved; 10–15 μ long; opens into reservoir approximately 15 μ in diameter. Contractile vacuole; posterior and lateral to stigma.

Chloroplasts: numerous; spindle-shaped; aligned parallel with striations. Stigma: deeply concavo-convex; approximately 7 μ in diameter; lateral to gullet at junction with reservoir. Paramylum bodies: numerous; scattered; rounded rectangular. Haematochrome granules: 0.3–0.5 μ in diameter; diffuse in sunlight; located centrally in shade or darkness; often obscuring green of chloroplasts.

Thin- and thick-walled cysts observed. Division occurs in thin-walled cysts.

Widely distributed.

E. rubra Hardy exhibits a peculiar staining reaction when subjected to Noland's (1928) stain for pellicle and flagellum. The pellicle separates from the protoplast, which shrinks slightly, by a distance approximating one-half the diameter of the original organism. The original body shape, whether cyst or trophozoite, is retained, and the broken spiral striations are easily observed. All organisms in any sample seldom give such a response.

10. *E. sanguinea* Ehrenberg (Fig. 10, A, B)

Size: 90–170 μ long by 24–44 μ in diameter. Body: cylindrical; usually narrowed and rounded anteriorly; extended into a narrow tip posteriorly or becoming broadly rounded. Pellicle: prominently spirally striated, striations not broken; allows considerable metabolic movement. Nucleus: spherical; approximately 20 μ in diameter; posterior to mid-body region.

Flagellum: approximately one and one-half body length. Gullet: nearly straight, approximately 15 μ long; opens into reservoir approximately 10 μ in diameter.

Chloroplasts: numerous; usually spindle-shaped; aligned parallel with striations. Stigma: concave oblate discoidal; approximately 10 μ through greatest length; lateral to reservoir at junction with gullet. Paramylum bodies: free in cytoplasm, numerous, rounded rectangular; few attached to chloroplasts, concave discoidal, approximately 6 μ in diameter. Haematochrome granules: 0.3–1.0 μ in diameter; diffuse in sunlight obscuring chloroplasts; located centrally in shade and darkness.

Thin-walled cysts observed; most trophozoites form temporary cysts soon after a cover slip is placed on them. Division not observed.

Collected: Iowa River, Johnson County.

E. sanguinea may be distinguished from *E. rubra* by the evident and unbroken striations of pellicle, the more flexible, but not necessarily more metabolic body, the evanescent posterior tip, and temporary encystment when under a cover slip. Gojdics (1939) also found the movement of *E. sanguinea* decidedly diminished when placed under a cover slip.

PLATE II

8. A, B, *E. flava*.
9. A, B, *E. rubra*. A, in sunlight; B, in shade.
10. A, B, *E. sanguinea*, in sunlight.
11. A, *E. spirogyra*.
11. B, *E. spirogyra* var. *elegans*.
11. C, *E. spirogyra* var. *suprema*.
11. D, *E. spirogyra* var. *marchica*.
11. E, *E. spirogyra* var. *abrupte-accuminata*.
12. A, B, *E. spiroides*. A, trophozoite and accompanying cross-section; B, outline of trophozoite and accompanying cross-section.

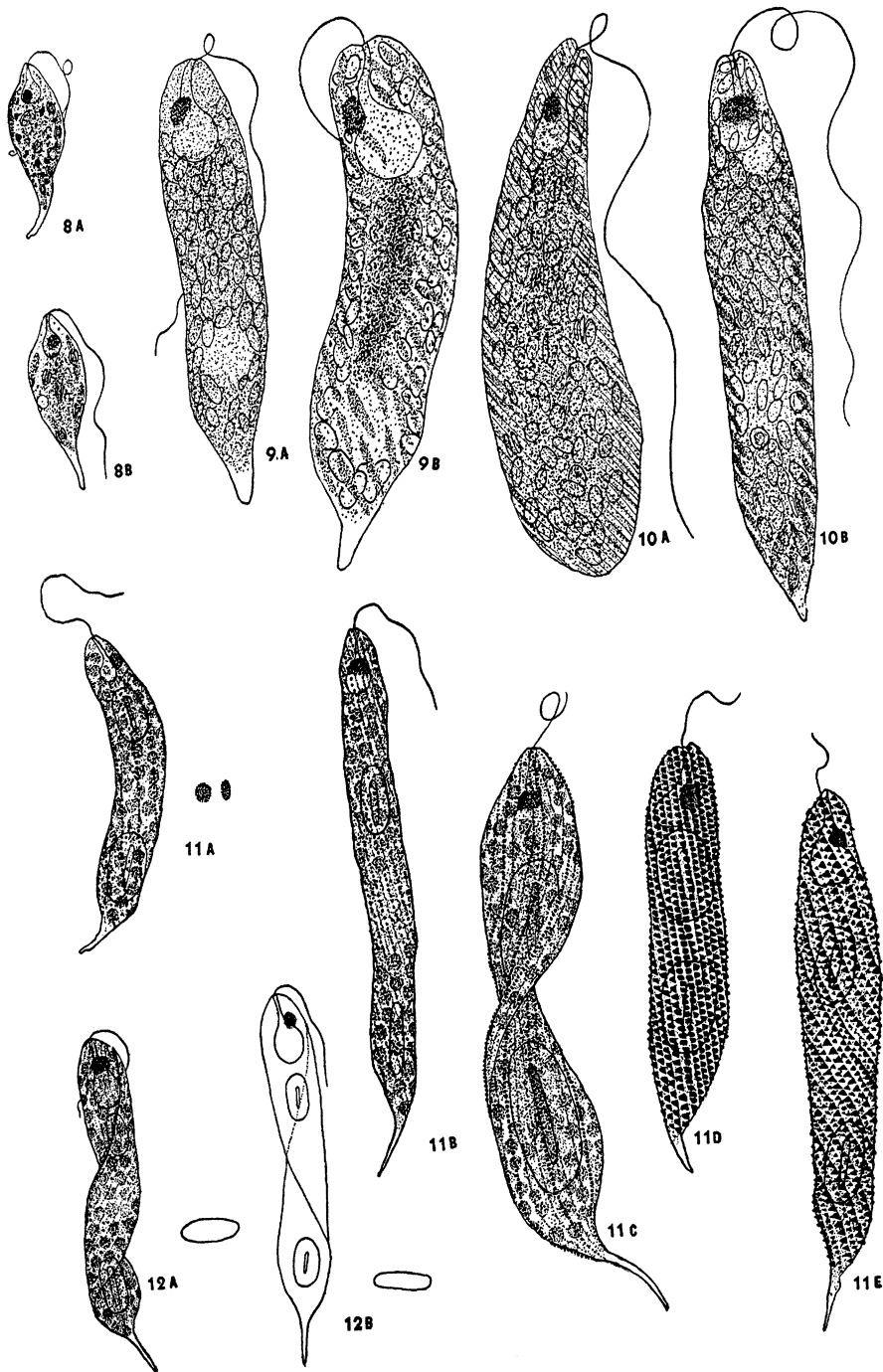


PLATE II

The body shape of *E. sanguinea* as described in (Fig. 10, A, B) is not typical as usually described for *E. sanguinea* but the characteristics so closely resemble those described by Ehrenberg and Gojdics that a new variety was deemed unnecessary.

11. *E. spirogyra* Ehrenberg (Fig. 11, A)

Size: 80–126 μ long by 10–35 μ in diameter. Body: cylindrical or flattened; narrowed slightly and rounded anteriorly; extended posteriorly into a prominent endpiece, often slightly curved. Pellicle: spirally striated with truncated pyramidal, pyramidal, truncated conical or conical processes, sometimes alternating prominent with less prominent rows; allows varied metabolic movement. Nucleus: prolate spheroidal; 15–20 μ long; located in mid-body region.

Flagellum: short, one-fourth body length or less. Gullet: approximately 10 μ long; opens into reservoir 7–12 μ in diameter.

Chloroplasts: discoidal to concavo-convex discoidal; 3–5 μ in diameter; numerous. Stigma: prominent; deeply concavo-convex; 4–8 μ through longitudinal axis; lateral to reservoir at junction with gullet. Paramylum bodies: elongated annular; one anterior and one posterior to nucleus; 18 μ \times 10 μ \times 4 μ to 45 μ \times 18 μ \times 5 μ in size; additional small annular rectangular bodies may be present.

Encystment and division not observed.

Widely distributed, but never in large numbers.

11. *E. spirogyra* var. *elegans* Playfair (Fig. 11, B)

Size: 100–110 μ long by 6–8 μ in diameter. Body: elongately cylindrical; posterior spine narrowly conical; slightly metabolic. Striations; alternating rows of prominent and less prominent conical processes.

11. *E. spirogyra* var. *suprema* Skuja (Fig. 11, C)

Size: 140–180 μ long by 23–35 μ throughout transverse axis. Body: flattened; usually twisted; metabolic. Striations: one prominent row alternating with two weaker rows; processes, truncated pyramidal.

11. *E. Spirogyra* var. *marchica* Lemmerman (Fig. 11, D)

Size: 85–165 μ long by 12–30 μ in diameter. Pellicle possesses truncated pyramidal processes; closely appressed striations; allows only slight metabolic movement. Color: very dark green, cytoplasmic details obscured. Posterior spine: conical; 7–10 μ long.

11. *E. spirogyra* var. *abrupte-acuminata* Lemmerman (Fig. 11, E)

Size: 130–145 μ long by 15–17 μ in transverse axis. Body: cylindrical or slightly flattened; only slightly metabolic. Striations: closely appressed alternating rows of prominent and less prominent pyramidal processes. Very dark green in color due in part to prominent pellicular processes.

12. *E. spiroides* Lemmerman (Fig. 12, A, B)

Size: 75–164 μ long by 12–16 μ through transverse axis. Body: elongated; band-shaped; always twisted; rounded anteriorly; extended posteriorly into a prominent colorless tip. Pellicle: longitudinally striated, striations evident; allows slight metabolic movement during locomotion, decidedly more at rest. Nucleus: prolate discoidal; 10–12 μ long; located in mid-body region.

Flagellum: one-fourth to one-third body length. Gullet: 8–11 μ long; relatively narrow; opens into spherical reservoir 7–9 μ in diameter.

Chloroplasts: numerous; discoidal; 3–4 μ in diameter. Stigma: deeply concavo-convex (bowl-shaped); approximately 5 μ in diameter; lateral to gullet at junction with reservoir. Paramylum bodies; slightly elongated annular; one anterior and one posterior to nucleus.

Thin-walled cysts observed. Division not observed.

Widely distributed except in temporary ponds.

The paramylum bodies of *E. spiroides* Lemmerman are small round bodies. Since other characteristics are similar in the two descriptions, it seems unnecessary to call this a new variety.

13. *E. acutissima* Lemmerman (Fig. 13, A, B)

Size: 120–150 μ long by 9–11 μ in diameter. Body: elongately cylindrical anteriorly narrowed, with anterior tip truncated or blunt; region anterior to posterior part of reservoir, hyaline; extended posteriorly into a prominent sharp-pointed colorless tip. Pellicle: longitudinally striated, striations evident and approximately 2 μ apart; allows only slight metabolic movement. Nucleus: prolate spheroidal; 10 μ long; located in mid-body region.

Flagellum: short; 16–20 μ long; bifurcation often observed in vivo. Gullet: narrowly elongate; 12–16 μ long; opens into reservoir approximately 10 μ long by 6 μ wide.

Chloroplasts: numerous, prolate discoidal; 4 μ in diameter. Stigma: prominent; concavo-convex; 5 μ in diameter; lateral to reservoir at entrance of gullet. Paramylum bodies: several; usually rod-like; 15–20 μ long; located anterior and posterior to nucleus.

Encystment and division not observed.

Collected: Little Sioux River; Beck's Canal of Lake West Okoboji; Hottes Lake.

Differs from the description by Lemmerman (1913) in that more than two paramylum bodies are present.

13. *E. acutissima* var. *longa* n. var. (Fig. 13, C–E)

Size: 220–350 μ long by 10–13.5 μ in diameter. Body: cylindrical; greatly elongated; narrowed anteriorly, with nearly round anterior tip; extended posteriorly into a pronounced spine, over 40 μ long. Pellicle: longitudinally striated; striations, evident raised ridges; movement, if present, slowly sinu-

ous. Nucleus: prolate spheroidal; approximately 25μ long; in mid-body region.

Flagellum: short; approximately 25μ long; flagellar swelling and bifurcation with inserted blepharoplasts usually observed in vivo. Gullet: straight; $15\text{--}20\mu$ long; opens into reservoir 10μ long by $7\text{--}8\mu$ at widest diameter.

Chloroplasts: slightly prolate discoidal; $5\text{--}7\mu$ long. Stigma: concavo-convex; $4\text{--}6\mu$ in diameter; lateral to reservoir at junction with gullet. Paramylum bodies: rod-shaped; numerous.

Encystment and division not observed.

Collected: Emerson's Bay of West Lake Okoboji.

Although *E. acutissima* var. *longa*, var. n. differs from *E. acutissima* in body size, nuclear size, spine length, striations, chloroplasts, and metabolic movement, it still resembles *E. acutissima* Lemmerman so closely that a new species would be superfluous. Therefore, this form is retained as a variety of *E. acutissima* Lemmerman.

14. *E. acus* Ehrenberg (Fig. 14, A-C)

Size: $52\text{--}175\mu$ long by $8\text{--}18\mu$ in diameter. Body: cylindrical to spindle-shaped; anterior end narrowed and truncate; narrowed posteriorly into colorless truncated tip. Pellicle: delicately spirally striated; allows weak metabolic movement. Nucleus: prolate spheroidal; $10\text{--}20\mu$ long; located in mid-body region.

Flagellum: approximately one-fourth body length. Gullet: $10\text{--}20\mu$ long; opens into reservoir $6\text{--}16\mu$ in diameter.

Chloroplasts: numerous; discoidal; 3μ in diameter. Stigma: usually evident; may appear as a hyaline body or with haematochrome granules at margin only; concavo-convex; $5\text{--}7\mu$ in diameter; lateral to gullet at junction with reservoir. Paramylum bodies: numerous; rod-shaped; $12\text{--}20\mu$ long.

Encystment and division not observed.

Widely distributed.

14. *E. acus* var. *angularis* n. var. (Fig. 14, D)

Differs from *E. acus* Lemmerman only in that the body is weakly three- or four-ridged and not cylindrical.

PLATE III

13. A, B, *E. acutissima*

13. C-E, *E. acutissima* var. *longa* n. var.

14. A-C, *E. acus*.

14. D, *E. acus* var. *angularis* n. var. trophozoite and accompanying types of cross-section,

14. E. *E. acus* var. *rigida*.

15. *E. elongata*.

16. A-C, *E. ehrenbergii*.

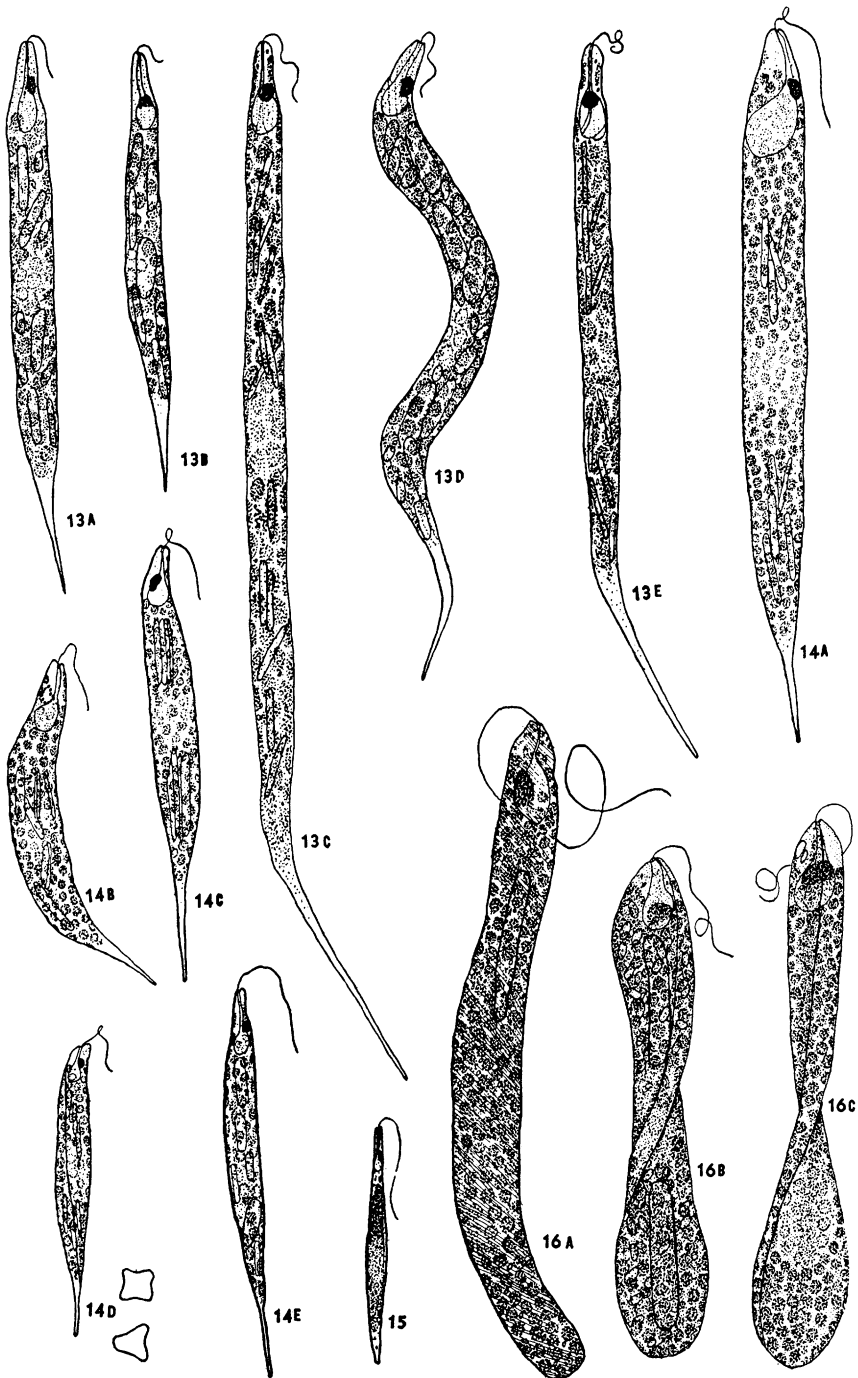


PLATE III

14. *E. acus* var. *rigida* Hubner (Fig. 14, E)

Size: 109–126 μ long by 7–9 μ in diameter. This variety is distinguished by the thick rigid amber-colored pellicle.

Collected: Amana Lake.

15. *E. elongata* Schewiakoff (Fig. 15)

Size: 60–70 μ long by 5–7 μ through largest diameter. Body: fusiform to spindle-shaped; truncated anteriorly; pointed posterior, usually hyaline. Pellicle: apparently smooth; allows only feeble metabolic movement. Nucleus: prolate spheroidal; approximately 10 μ long; located slightly posteriorly to mid-body region.

Flagellum: one-half body length. Gullet: narrow; 8 μ long; opens into reservoir 3 μ in diameter.

Chloroplast: one present; flattened fusiform; approximately 40 μ long. Stigma: evident; 2–3 μ long; lateral to reservoir at junction with gullet. Paramylum bodies: none observed. Granules: small; scattered.

Encystment and division, not observed.

Collected: Mud flat of Iowa River, Johnson County.

16. *E. ehrenbergii* Klebs (Fig. 16, A–C)

Size: cylindrical form, 190–400 μ long by 13–30 μ in diameter; flattened form, 170–330 μ long by 25–40 μ wide. Body: cylindrical or flattened, changes from one form into the other; narrowed slightly anteriorly; cylindrical form truncated posteriorly; flattened form rounded posteriorly and usually twisted. Pellicle: spirally striated; striations unbroken and evident; allows extensive metabolic movement. Nucleus: prolate spheroidal; 25–35 μ long; varied in position.

Flagellum: one-third to one-half body length. Gullet: approximately 10 μ long; opens into slightly elongated reservoir.

Chloroplasts: numerous; discoidal; 3–4 μ in diameter. Stigma; prominent; deeply concavo-convex (bowl-shaped); 7–10 μ in diameter; lateral to body of reservoir. Paramylum bodies: elongated rods, 30–110 μ long, seldom absent, usually one or two present; varied in position; numerous small rounded rectangular bodies usually present. Haematochrome granules: red-dish-brown clumps occasionally occur. Hyaline granules: numerous; 1 μ in diameter.

Encystment and division not observed.

Widely distributed, at times in large numbers.

17. *E. klebsii* Mainx (Fig. 17, A–D)

Size: 45–85 μ long by 5–8 μ in diameter, diameter may become much greater during metabolic movement. Body: elongately cylindrical; bluntly rounded anteriorly; rounded or extended into a colorless tip posteriorly. Pellicle: weakly striated; allows active metabolic movement. Nucleus: pro-

late spheroidal; approximately 10μ long; usually in mid-body region.

Flagellum: one-eighth body length. Gullet: $5-7\mu$ long; opens into a slightly elongated reservoir 6μ long.

Chloroplasts: prolate discoidal; $7-10\mu$ long. Stigma: evident; concavo-convex (saucer-shaped); $3-5\mu$ in diameter. Paramylum bodies: usually rod-shaped; seldom annular; approximately 10μ long; number varies from none to eight.

Thin-walled cysts observed. Division not observed.

Widely distributed.

Mainx (1926) states each chloroplast contains an uncovered pyrenoid, but none were observed in living material by the author.

18. *E. deses* Ehrenberg (Fig. 18, A, B)

Size: $86-170\mu$ long by $11-21\mu$ in diameter. Body: cylindrical, or may be slightly flattened; anteriorly rounded to weakly truncated; posteriorly blunt, colored. Pellicle: delicately spirally striated; allows definite sluggish metabolic movement. Nucleus: nearly spherical; $12-15\mu$ in diameter; varied in position, usually in mid-body region.

Flagellum: less than one-fourth body length. Gullet: slightly curved; $8-14\mu$ long; opens into reservoir $7-14\mu$ long by $6-12\mu$ in transverse section.

Chloroplasts: numerous; weakly concavo-prolate discoidal; approximately 15μ long. Stigma: evident; crescent-shaped; $4-7\mu$ in length; haematochrome granules 0.5μ in diameter. Paramylum bodies: scattered; rod-shaped or elongated annular. Numerous granules approximately 1μ in diameter present.

Encystment not observed. Longitudinal division observed.

Widely distributed except in temporary ponds.

18. *E. deses* var. *tenuis* Lemmerman (Fig. 18, C-F)

Size: $95-140\mu$ long by $8-11\mu$ in diameter. Body: cylindrical; actively metabolic, often moving anterior end from side to side. Paramylum bodies short, scattered. Nucleus; spherical; $7-10\mu$ in diameter; varied in position. Flagellum: short, usually not observed.

Collected: Sulphur pools, Silver Lake Bog, in relatively large numbers.

19. *E. intermedia* Klebs (Fig. 19, A, B)

Size: $85-130\mu$ long by $8-12\mu$ in diameter. Body: cylindrical; narrowed anteriorly with a blunt tip; extended posteriorly into short endpiece, colorless or hyaline. Pellicle: delicately spirally striated; allows active metabolic movement. Nucleus: prolate spheroidal; $9-14\mu$ long; usually in mid-body region.

Flagellum: less than one-fifth body length. Gullet: 10μ long; opens into reservoir $5-7\mu$ long.

Chloroplasts: numerous; discoidal; approximately 8μ in diameter. Stigma: evident; concavo-convex; circular or angular in outline; $4-5\mu$

through longitudinal axis; lateral to reservoir at junction with gullet. Paramylum bodies: rod-shaped; 3–10 in number; 8–15 μ long; may have few smaller bodies present.

Encystment and division not observed.

Widely distributed except in temporary pools.

20. *E. ignobilis*. n. sp. (Fig. 20, A–C)

Size: 85–135 μ long by 8–12 μ in diameter. Body: cylindrical: narrowed anteriorly, truncated or rounded; extended into a short colorless tip posteriorly. Pellicle: prominently longitudinally striated; striations unbroken; allows considerable metabolic movement. Nucleus: prolate spheroidal: 10–13 μ long; slightly posterior to mid-body region.

Flagellum: one-fourth to one-half body length. Gullet: narrow; 12 μ long; opens into reservoir 8–10 μ in diameter.

Chloroplasts: numerous; discoidal; 3–5 μ in diameter. Stigma: concavo-convex; edges often uneven; 4–5 μ in diameter; lateral to reservoir at junction with gullet. Paramylum bodies: elongated annular in shape; usually two, one anterior and one posterior to nucleus: additional small rod-like bodies present (usually few).

Encystment and division not observed.

Collected: Iowa River; Amana Lake; Amana Canals.

E. ignobilis n. sp. may be distinguished from *E. intermedia* Klebs by the longer flagellum, annular paramylum bodies, smaller chloroplasts and prominent striations.

It may be distinguished from *E. griseole* Deflandre by its larger size, its evident flagellum and unbroken longitudinal striations.

21. *E. terricola* Dangeard (Fig. 21, A–H)

Size: 68–93 μ long by 8–17 μ through transverse axis. Body: shape variable, greatest diameter usually anteriorly; rounded anteriorly, bilabiate condition usually observable; narrowed posteriorly into a short colorless tip. Pellicle: delicately spirally striated, striations 1 μ apart; allows active metabolic movement, decidedly less in smaller sized organisms. Nucleus: prolate spheroidal; approximately 10 μ in length; located in mid-body region.

PLATE IV

17. A–D, *E. klebsii*.

18. A, B, *E. deses*.

18. C–F, *E. deses* var. *tenuis*.

19. A, B, *E. intermedia*.

20. A–C, *E. ignobilis* n. sp.

21. A–H, *E. terricola*. E–H, series showing metabolic movement.

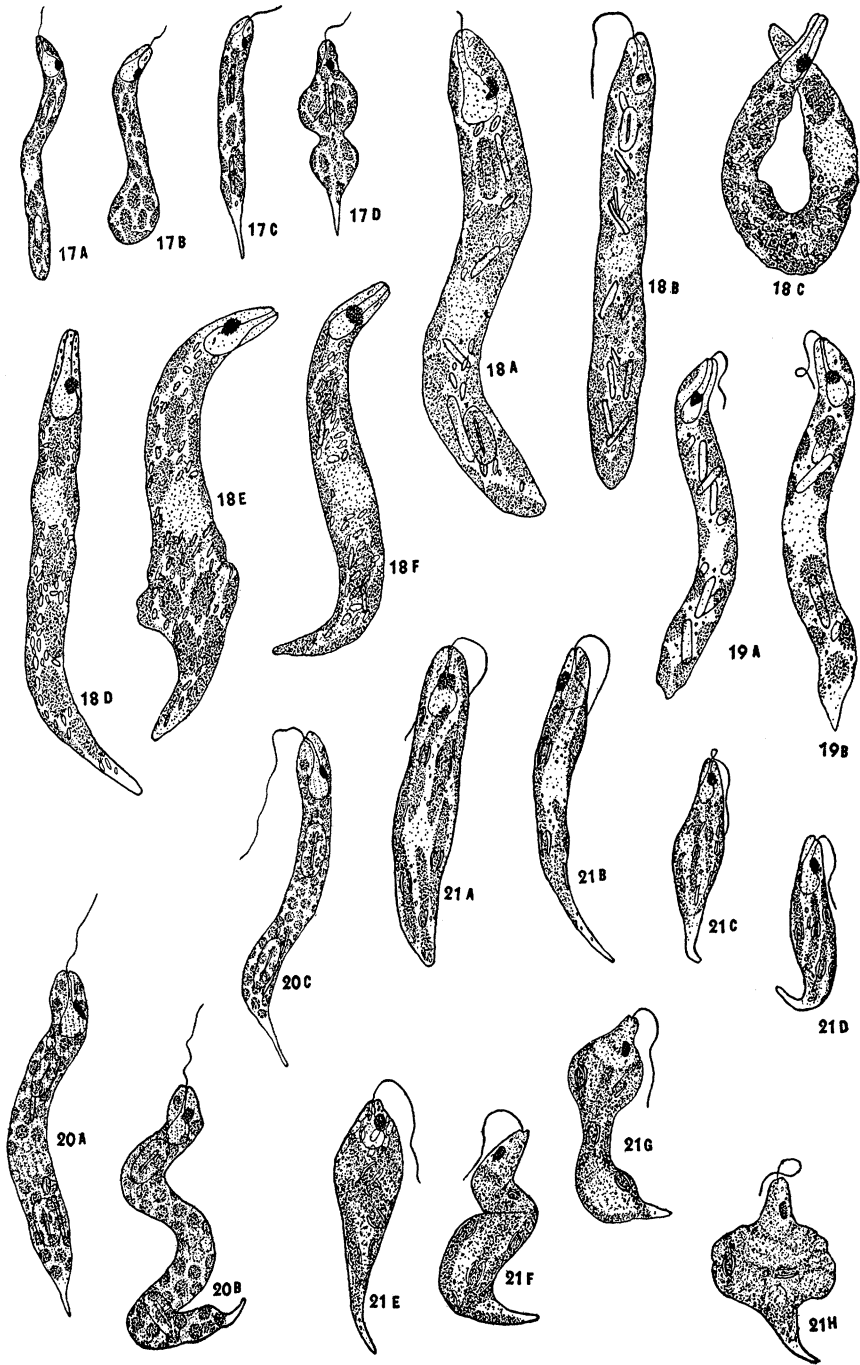


PLATE IV

Flagellum: one-third body length. Gullet: 6–8 μ long; opens into spherical reservoir 6–8 μ in diameter.

Chloroplasts: elongated bands or rods; 20–30 μ long; 8–15 in number, usually arranged parallel with longitudinal axis of organism when not actively metabolic. Stigma: shallowly concavo-convex, elongated with longitudinal axis; lateral to gullet at junction with reservoir. Paramylum bodies: two annular bodies attached to each chloroplast; 3–7 μ in diameter; oval or rounded rectangular bodies may also appear free in cytoplasm.

Temporary cysts observed. Division not observed.

Widely distributed except in temporary ponds.

22. *E. tuba* Carter (Fig. 22, A–H)

Size: 87–130 μ long by 17–27 μ in diameter. Body: cylindrical; rounded anteriorly, bilabiate condition may be observed; usually extended posteriorly into colored tip, or rounded posteriorly. Pellicle: delicately spirally striated; striations 0.5 μ apart; allows considerable metabolic movement. Nucleus: spherical; approximately 18 μ in diameter; one endosome observable in vivo; usually posterior in position.

Flagellum: approximately body length. Gullet: 5–9 μ long; usually curved; opens into spherical reservoir 15–16 μ in diameter.

Chloroplasts: numerous; in fresh samples, elongated lenticular, fusiform in side view, usually slightly curved, approximately 20 μ long; old cultures (after several days in laboratory) discoidal, 15–18 μ in diameter, quadrangular in side view. Stigma: evident; concave discoidal, often lobed; approximately 6 μ in diameter; lateral to reservoir. Paramylum bodies: discoidal; two attached to each chloroplast; approximately 6 μ in diameter; additional small oval bodies may be present in cytoplasm. Granules: 1 μ in diameter; numerous; free in cytoplasm.

Cyst: shape flask-like; basal attachment thickened, attached to surface film by means of narrowed neck-like portion (2–10 μ long); enlarged body portion 34–50 μ in diameter, thin-walled. Excystment involves metabolic movement with rupture of cyst wall. Division not observed.

Collected: Hottes Lake, Dickinson County.

23. *E. gracilis* Klebs (Fig. 23, A, B)

Size: 35–55 μ long by 8–22 μ in diameter. Body: cylindrically fusiform; rounded anteriorly; usually with blunt tip posteriorly, may be expanded due to metabolic movement. Pellicle: delicately spirally striated; allows metabolic movement. Nucleus: spherical; 8–10 μ in diameter; in mid-body region.

Flagellum: approximately body length. Gullet: 5 μ long; opens into reservoir 5–6 μ in diameter.

Chloroplasts: numerous, less than twenty; lenticular fusiform; 12–20 μ long. Stigma: prominent; deeply concavo-convex (cup-shaped); 4 μ in diameter; lateral to body of reservoir. Paramylum bodies: normally two annular

discoidal bodies attached on either side of chloroplast; 3μ in diameter; occasionally small annular bodies free in cytoplasm.

Cysts with thin walls observed in which division occurs.

Widely distributed except in temporary ponds.

24. *E. proxima* Dangeard (Fig. 24, A, B)

Size: $55\text{--}75\mu$ long by $19\text{--}30\mu$ wide. Body: broadly fusiform; rounded anteriorly; equally bilabiate condition observed as rotation occurs; extended posteriorly into pointed colorless tip. Pellicle: spirally striated; approximately 1.5μ apart. Nucleus: spherical; $10\text{--}12\mu$ in diameter; located in mid-body region.

Flagellum: one and one-half times body length. Gullet: short, $5\text{--}6\mu$ long; opens into spherical reservoir $7\text{--}8\mu$ in diameter.

Chloroplasts: numerous; prolate discoidal in shape; often arranged parallel to spiral striations; approximately 7μ long. Stigma: evident; concave discoidal; $6\text{--}7\mu$ in diameter; lateral to anterior portion of reservoir. Paramylum bodies: oval or rectangularly annular in shape; numerous; free in cytoplasm; never attached to chloroplast; $3\text{--}5\mu$ long.

Thin-walled resting cysts observed, in which division occurs.

Collected: Little Sioux River and Iowa River, never numerous.

25. *E. fundoversata* n. sp. (Fig. 25)

Size: $75\text{--}104\mu$ long by $22\text{--}30\mu$ through transverse axis. Body: broadly fusiform; bluntly conical anteriorly; opening of gullet slightly posterior to anterior tip; bluntly narrowed posteriorly. Pellicle: spirally striated; striations continuous (unbroken); allows metabolic movement. Locomotion: relatively slow; rotating; below water surface. Nucleus: spherical; approximately 20μ in diameter; posterior to mid-body region.

Flagellum: two times body length; usually trailing. Gullet: 6μ long; slightly curved; opens into reservoir $10\text{--}12\mu$ in diameter.

Chloroplasts: numerous; elongated concavo-convex, fusiform in side view; approximately 12μ long; parallel with striations. Stigma: prominent; deeply concavo-convex (cup-shaped); 6μ in diameter; located lateral to anterior portion of reservoir. Paramylum bodies: numerous; rounded rectangular; $3\text{--}9\mu$ long.

Division observed in thin-walled cysts.

Collected: Fresh water spring, Iowa Lakeside Laboratory; below surface of water. Organisms collect at bottom of sample when placed in laboratory.

The similar forms, *E. fundoversata* n. sp. and *E. splendens*, differ in that *E. fundoversata* possesses a longer flagellum, which usually trails behind posterior tip of organism, striations are unbroken minute ridges and not a series of individual pellicular processes. The present form dwells decidedly below the surface, and typically possesses numerous paramylum bodies which hide the chloroplasts except near the body margin.

26. *E. splendens* Dangeard (Fig. 26, A-C)

Size: 74–110 μ long by 21–27 μ in diameter. Body: cylindrical to broadly fusiform; usually rounded anteriorly, opening of gullet evident; extended posteriorly into a blunt (usually colored) tip. Pellicle; spirally striated; evident under favorable optical conditions or after exposure to Noland's (1928) stain; striations due to irregularly spaced conical processes; allows metabolic movement. Nucleus; easily evident with low power magnification, difficult to observe with high power magnification; spherical; approximately 15 μ in diameter.

Flagellum: approximately one and one-fourth body length. Gullet: usually not observed; 4–6 μ long; opens into reservoir 8–10 μ in diameter.

Chloroplasts: numerous; band-like with narrowed ends or spindle-shaped; 10–15 μ long; aligned parallel with striations. Stigma: evident; orange to dark red in color; concavo-convex (deep saucer-shaped); 6 μ in diameter. Paramylum bodies: rounded rectangular or oval; 3–11 μ long; numerous. Granules: numerous spherical bodies approximately 1 μ in diameter; usually free in cytoplasm.

Division occurs in thin-walled cysts accompanied with considerable metabolic movement.

Widely distributed.

27. *E. caudata* Hübner (Fig. 27, A, B)

Size: 90–120 μ long by 27–50 μ at largest diameter. Body: largest diameter anterior to mid-body region; often flattened obliquely anteriorly; narrowed posteriorly, posterior tip blunt or pointed, colored. Pellicle: prominently spirally ridged, 2 μ apart; allows metabolic movement, pronounced only during process of encystment. Trophozoite possesses characteristic rotating movement during locomotion. Nucleus: usually evident; spherical to prolate spheroidal in shape; 20–27 μ through largest axis; a single endosome evident in nuclei released from protoplasts.

Flagellum: approximately body length. Gullet: relatively short; opens into a spherical reservoir 15–18 μ in diameter.

Chloroplasts: numerous; fusiform to band-shaped; approximately 20 μ long; usually parallel to spiral striations. Stigma: evident; concavo-convex;

 PLATE V

22. A-D, *E. tuba*. C, organism from old culture with discoidal chloroplasts.
 22. E-H, *E. tuba*. G, tuba-like cyst; E, F, H, deserted cyst walls.
 23. A, B, *E. gracilis*. A, magnified 1500 \times .
 24. A, B, *E. proxima*.
 25. *E. fundoversata* n. sp., trophozoite and typical chloroplast.
 26. A-C, *E. splendens*, trophozoite and typical pellicular markings.
 27. A, B, *E. caudata*, trophozoites and typical chloroplast.

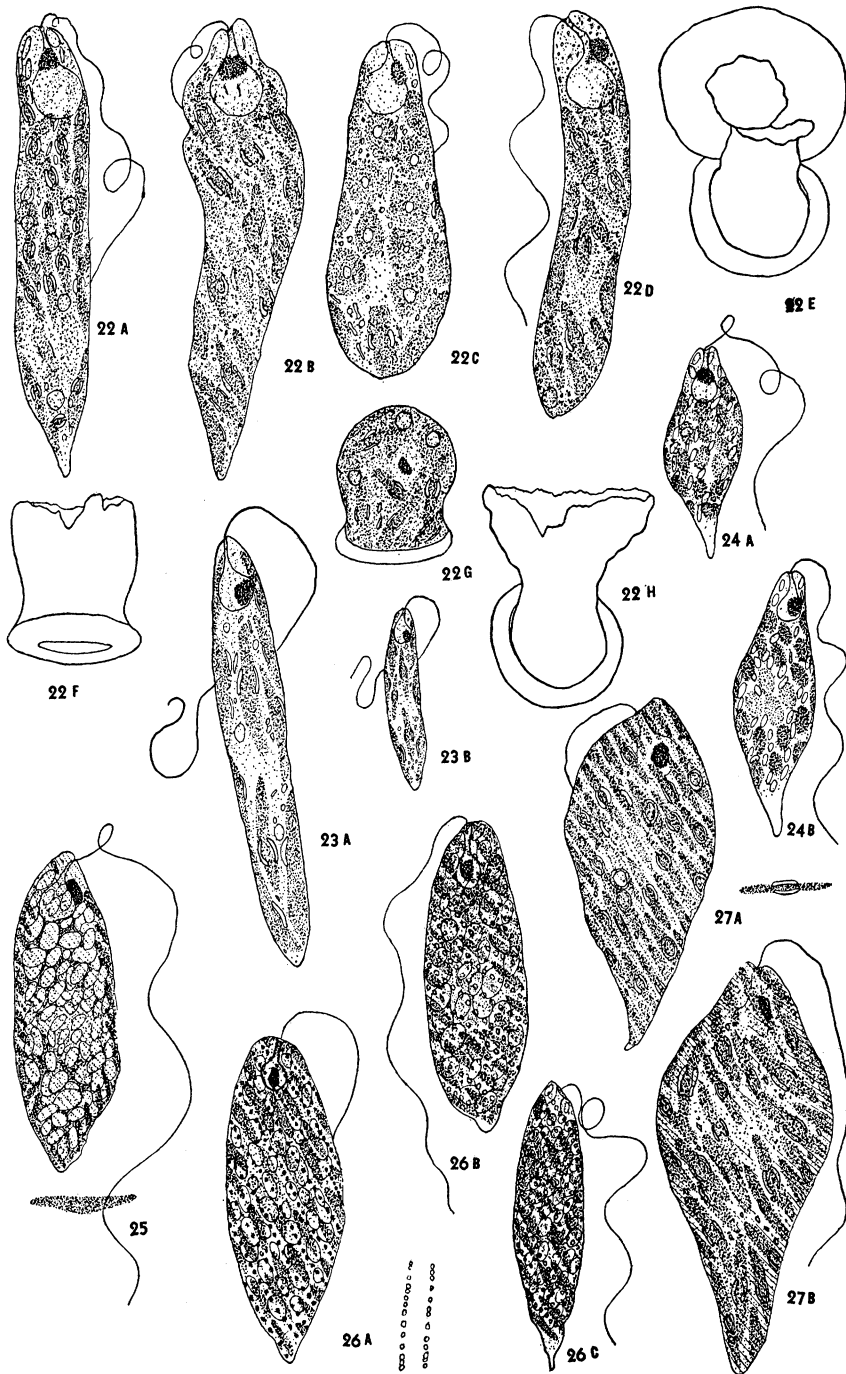


PLATE V

5–8 μ in diameter by 3–4 μ deep; lateral to reservoir. Paramylum bodies: usually two annular discoidal bodies attached near middle of each chloroplast; 7–8 μ in diameter; few free in cytoplasm.

Cysts: thin-walled observed; ridges of pellicle easily discernible. Division: occurs in thin-walled cysts; accompanied with metabolic movement; usually complete within one hour.

Widely distributed except in temporary ponds.

28. *E. oblonga* Schmitz (Fig. 28, A, B)

Size: 52–70 μ long by 25–40 μ wide. Body: oval to short cylindrical; usually rounded anteriorly; rounded posteriorly or a short tip evident. Pellicle: spirally striated, 1.5–2.0 μ apart; allows considerable metabolic movement at rest, slight during locomotion. Nucleus: spherical; approximately 10 μ in diameter; located in mid-body region.

Flagellum: approximately body length. Gullet: slightly curved; 7–8 μ long; opens into reservoir 7–9 μ in diameter.

Chloroplasts: numerous; usually aligned parallel to striations; fusiform to band-shaped in side view; 12–15 μ long. Stigma: lateral to gullet at junction with reservoir; shallow concavo-convex; 4–6 μ in diameter. Paramylum bodies: two annular discoidal bodies attached to each chloroplast, 4–6 μ in diameter; oval bodies may also be free in cytoplasm.

Thin-walled cysts observed. Division not observed.

Widely distributed except in temporary ponds.

29. *E. rostrifera* n. sp. (Fig. 29, A–D)

Size: 90–140 μ long by 18–48 μ in diameter. Body: usually bulged near middle; narrowed anteriorly to form a “snout” characteristic of species; extended posteriorly into an attenuated colorless process. Pellicle: spiral striations evident, 1.2 μ apart; allows metabolic movement but usually slight during locomotion. Nucleus: spherical; approximately 15 μ in diameter; located in mid-body region.

Flagellum: approximately body length. Gullet: elongated; 15–20 μ long; opens into an elongated (bulb-shaped) reservoir approximately 10 μ in diameter.

Chloroplasts: numerous; fusiform; not parallel with striations of pellicle; 15–25 μ long. Stigma; concavo-convex; 7–11 μ in diameter, usually lateral to reservoir at entrance of gullet. Paramylum bodies: annular discoidal in shape; 5–8 μ in diameter; two attached to each chloroplast; also rectangular oval bodies free in cytoplasm.

Division occurs in thin-walled cysts.

Collected: Little Sioux River and Little Miller’s Bay, West Lake Okoboji.

E. rostrifera n. sp. resembles *E. granulata* and *E. polymorpha* in body shape and shape of chloroplasts, but differs in that the flagellum is only body

length, always possesses a prominent colorless anterior end, gullet definitely longer, lacks granules in cytoplasm, striations of pellicle are more prominent, only slightly metabolic during locomotion, and usually found below the water surface.

30. *E. velata* Klebs (Fig. 30, A, B)

Size: 80–115 μ long by 25–35 μ in diameter. Body: cylindrical to broadly fusiform; rounded anteriorly; extended posteriorly into a short colored process. Pellicle: weakly spirally striated; allows metabolic movement, lackadaisical during locomotion, considerably at rest. Nucleus: spherical; 17–23 μ in diameter; posterior to mid-body region.

Flagellum: approximately body length. Gullet: approximately 10 μ long; opens into reservoir 10–12 μ in diameter.

Chloroplasts: parallel with striations of pellicle; numerous; some lobed, condition difficult to observe but indicated by apparent larger number of chloroplasts than double-shaped paramylum bodies; ribbon-like, various lengths and 3–4 μ in width. Stigma: weakly concavo-convex; edges often uneven; 5–6 μ in diameter; lateral to gullet at junction with reservoir. Paramylum bodies: double annular bodies attached to chloroplasts; numerous oval to obovate bodies free in cytoplasm. Granules: numerous; hyaline; rod-shaped; perpendicular to pellicle; 4–6 μ long; rows parallel with striations of pellicle; evident near anterior and posterior end during locomotion and over whole surface when in resting stage.

Thin-walled cysts observed. Division not observed.

Collected: Iowa River, Iowa City.

31. *E. sociabilis* Dangeard (Fig. 31, A–C)

Size: 65–112 μ long by 16–30 μ in diameter. Body: cylindrical; rounded anteriorly and bilabiate; usually narrowed posteriorly, sometimes into a colorless tip. Pellicle: delicately spirally striated, difficult to observe; allows considerable metabolic movement. Nucleus: prolate spheroidal; approximately 15 μ long; usually posterior to mid-body region; one endosome evident when stained with Noland's (1928) stain.

Flagellum: approximately one and one-third body length. Gullet: slightly curved; 6–8 μ long; opens into reservoir approximately 12 μ in diameter. Contractile vacuole: slightly posterior to stigma.

Chloroplasts: 10 to numerous; spindle to band-shaped; 12–17 μ long; variously arranged, usually spirally. Stigma: deeply concavo-convex (cup-shaped); 4–5 μ in diameter; lateral to anterior portion of reservoir. Paramylum bodies: double concave discs attached to each chloroplast; often lacking in organisms collected after several days of cloudy weather or left in dark.

Division observed in temporary cysts with slightly thickened wall and in trophozoite by longitudinal splitting.

Widely distributed.

32. *E. polymorpha* Dangeard (Fig. 32, A-C)

Size: 57–92 μ long by 15–25 μ in diameter. Body: fusiform to cylindrical; narrowed anteriorly, one lip extending slightly anteriorly; extended posteriorly into colorless tip, often a double narrowing posteriorly (Fig. 32, A). Pellicle: spirally striated, striations approximately 1.5 μ apart; allows active metabolic movement during locomotion. Decidedly phototropic. Nucleus: varied in position, usually in mid-body region; spherical; 13–20 μ in diameter; obscured by chloroplasts and inclusions.

Flagellum: approximately two times body length. Gullet: 8–12 μ long; opens into reservoir 8–10 μ in diameter.

Chloroplasts: fusiform to rod-shaped; approximately 15 μ long; numerous (more than 12). Stigma: lateral to gullet at junction with reservoir; concavo-convex, slightly elongated; 6–7 μ long. Paramylum bodies: annular discoidal body attached to each side of chloroplast; 4–5 μ in diameter; oval bodies free in cytoplasm, often numerous. Granules: if present, scattered.

Cysts: thin-walled, infrequent; thick-walled, numerous; appressed against one another, may cause a green film on surface of water; allows life during dry periods as indicated by temporary pools completely drying and appearance of heavy infestation after rain. Division: observed only in thick-walled cysts.

Widely distributed, nearly pure culture in temporary pools at Iowa City.

33. *E. granulata* Klebs (Fig. 33, A-D)

Size: 60–95 μ long by 18–27 μ wide. Body: fusiform to cylindrical; rounded anteriorly; extended posteriorly into short colorless process. Pellicle: spirally striated; striations approximately 1.5 μ apart; allows metabolic movement during locomotion. Nucleus: spherical; 10–12 μ in diameter; in mid-body region.

Flagellum: Body length or less. Gullet: approximately 10 μ long; opens into reservoir 10 μ in diameter.

Chloroplasts: numerous; surface view lenticular; side view fusiform to rod-shaped; 10–12 μ long. Stigma: lateral to gullet at junction with reservoir; concavo-convex; elongated; 6–7 μ long. Paramylum bodies: two annular discoidal bodies attached to each chloroplast; 6–8 μ in diameter; numerous oval rectangular bodies free in cytoplasm. Granules: numerous, located

PLATE VI

28. A, B, *E. oblonga*.

29. A-D, *E. rostrifera* n. sp.

30. A, B, *E. velata*. B, temporary cysts. Rod-shaped granules beneath pellicle evident.

31. A-C, *E. sociabilis*. B, typical chloroplast arrangement.

32. A-C, *E. polymorpha*. A, C, trophozoites and typical chloroplast; B, group of thick-walled cysts.

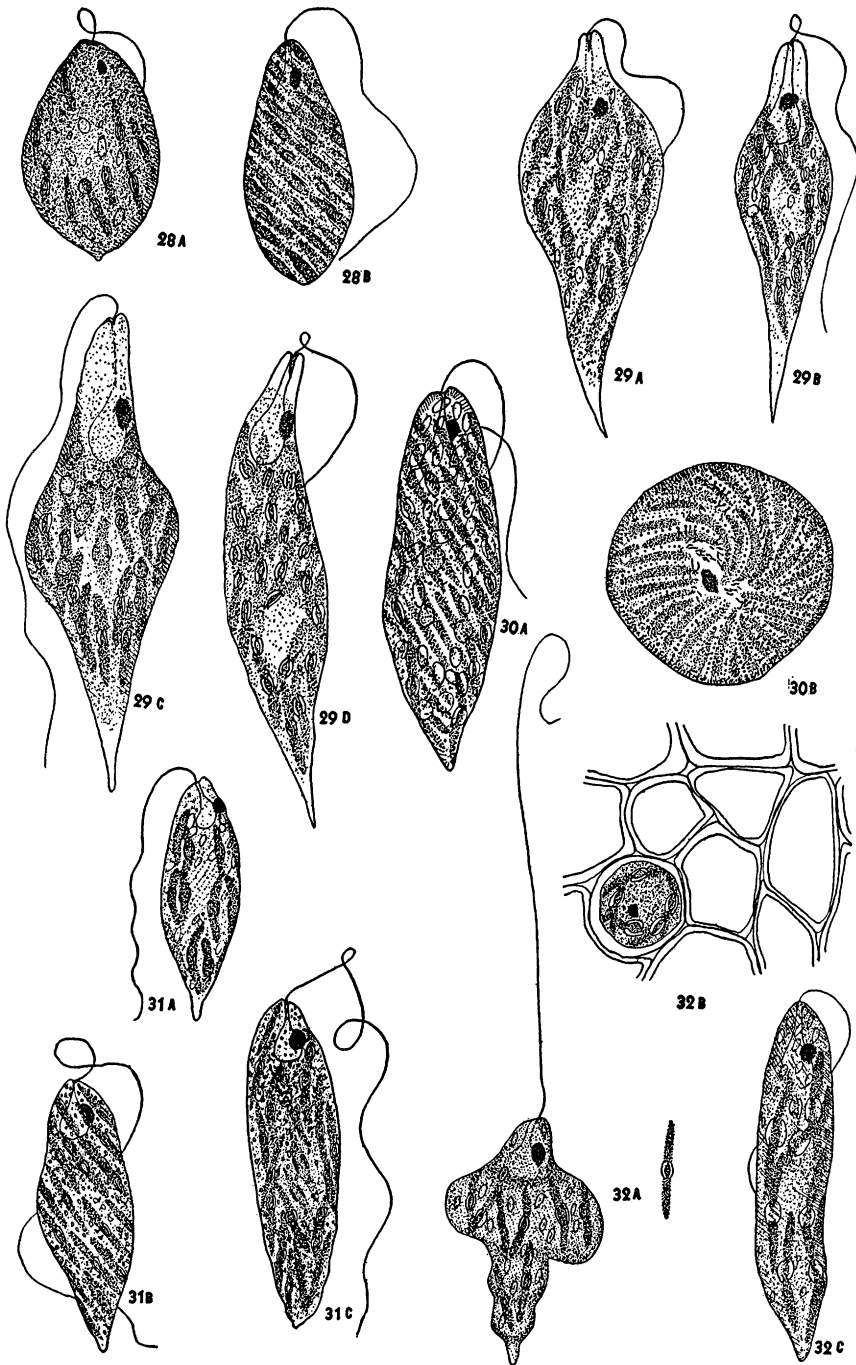


PLATE VI

under pellicle; aligned parallel with striations of pellicle; all same size or varied sizes (Fig. 33, D).

Cysts: isolated; thin- and thick-walled. Division not observed.

Widely distributed, including temporary ponds.

34. *E. pisciformis* Klebs (Fig. 34, A-F)

Size: 21–34 μ long by 5–8 μ in diameter. Body: nearly fusiform; rounded anteriorly or one lip projecting forward; extended posteriorly into short colorless tip. Pellicle: delicately spirally striated, usually not observed; allows considerable metabolic movement at rest, slight during locomotion. Locomotion accompanied with zig-zag movement (Fig. 34, D) Nucleus: spherical; approximately 4 μ in diameter; posterior to mid-body region.

Flagellum: approximately body length. Gullet: 3 μ long; opens into a reservoir 3–5 μ in diameter.

Chloroplasts: two or three; parallel to longitudinal axis of body; fusiform; nearly body length. Stigma: deeply concavo-convex; 4 μ in diameter; lateral to anterior portion of reservoir. Paramylum bodies: annular discoidal; two attached to each chloroplast; numerous oval-shaped bodies free in cytoplasm.

Cysts: thin- and thick-walled cysts observed. Division: occurs in thin-walled cysts; two or four daughter cells observed inside cyst wall.

Widely distributed except in temporary pools.

34. *E. pisciformis* var. *minor* Hansg. (Fig. 34, G, H)

Size: 15–20 μ long by 5 μ in diameter. Similar to *E. pisciformis* in all other respects. All gradations of size were found from the smallest *E. pisciformis* var. *minor* to the largest *E. pisciformis*.

35. *E. anabaena* var. *minor* Mainx (Fig. 35)

Size: 36–45 μ long by 16–22 μ in diameter. Body: broadest in mid-body region; rounded anteriorly; extended posteriorly into colorless process, usually bent from mid-line causing slight apparent flip at end of each rotation of body. Pellicle: weakly spirally striated; allows slight metabolic movement. Nucleus: usually posterior to mid-body region; spherical; 10 μ in diameter.

Flagellum: approximately one-half body length. Gullet: 5 μ long; opens into reservoir 7–10 μ in diameter.

Chloroplasts: 6–10 in number; flattened rounded quadrangular in shape; 10–15 μ through greatest length; located at body periphery. Stigma: pale red to orange; concave discoidal; approximately 5 μ in diameter; lateral to reservoir at junction with gullet. Paramylum bodies: concave discoidal, two attached to each chloroplast; none observed free in cytoplasm. Granules: hyaline; numerous; approximately 1.5 μ in diameter; scattered.

Cysts: thin-walled cysts observed. Division not observed.

Collected: Miller's Bay, West Lake Okoboji and Beck's Canal, West Lake Okoboji.

36. *E. minima* Francé (Fig. 36, A, B)

Size: 25–40 μ long by 10–15 μ wide. Body: fusiform; sometimes narrowed posteriorly into elongated colorless tip. Pellicle: delicately spirally striated; allows active metabolic movement. Nucleus: spherical; 4–6 μ in diameter; in mid-body region.

Flagellum: approximately three-fourths body length. Gullet: short; opens into reservoir, slightly elongated, 3–5 μ in diameter.

Chloroplasts: two or three; nearly body length; arranged longitudinally or spirally. Stigma: weakly concave discoidal; approximately 3.5 μ in diameter; lateral to reservoir at junction with gullet. Paramylum bodies: attached to chloroplasts, concavo-convex, 3 μ in diameter; free in cytoplasm, small, variously shaped.

Encystment and division not observed.

Collected: Iowa River and a marsh at Iowa City.

37. *E. viridis* Ehrenberg (Fig. 37, A–G)

Size: 40–65 μ long by 14–20 μ in diameter. Body: variously shaped; usually fusiform, largest diameter posterior of mid-body region; rounded or bilabiate anteriorly; usually extended posteriorly into colorless tip of varied length. Pellicle: spiral striations evident, approximately 1.2 μ apart; allows considerable metabolic movement. Locomotion: rapid. Nucleus: characteristically in posterior third of body; evident; spherical; 10–15 μ in diameter; located centrally in few.

Flagellum: three-fourths body length to body length. Gullet: 5–7 μ long; opens into elongated reservoir 4–5 μ in diameter.

Chloroplasts: six to numerous; spindle-shaped; 13–18 μ long; arranged variously. Stigma: lateral to reservoir at junction with gullet; deeply concavo-convex (cup-shaped); 4–5 μ in diameter. Paramylum bodies: two annular discoidal bodies attached to each chloroplast, 3–5 μ in diameter; oval and rectangular bodies may be free in cytoplasm. Granules: spherical; approximately 1 μ in diameter; diffuse.

Division in thin-walled cysts.

Widely distributed.

The apparent star-shaped chloroplast usually recorded for *E. viridis* was observed commonly in organisms viewed under low power magnification. However, when viewed under higher magnification, the star-shaped mass was found to be composed of individual chloroplasts as described.

38. *E. vivida* Playfair (Fig. 38, A, B)

Size: 24–35 μ long by 7–8 μ in diameter. Body: cylindrical or slightly flattened; rounded anteriorly; rounded or truncated posteriorly. Pellicle:

smooth; allows metabolic movement. Locomotion: (Peranema-like), gliding rather than typical locomotion of *Euglena*. Nucleus: spherical: $5-6\mu$ in diameter; mid-body region.

Flagellum: approximately body-length; usually extends anteriorly. Gullet: short, opens into an evident reservoir $3-4\mu$ in diameter.

Chloroplasts: two; parietal in position; ribbon-shaped, rounded at ends; nearly body length ($20-26\mu$ long by $6-8\mu$ wide by $1-2\mu$ thick). Stigma: lateral to reservoir; weakly concavo-convex; $3-4\mu$ in diameter. Paramylum bodies: if present, small oval bodies.

Thin-walled cysts observed. Division not observed.

Collected: Iowa River, Johnson County, Iowa.

The form described differs from the description of *E. vivida* by Playfair in that locomotion is not energetic. Only forms with two chloroplasts were observed rather than one or two.

39. *E. nana* n. sp. (Fig. 39, A, B)

Size: $13-17\mu$ long by $6-9\mu$ in diameter. Body: obovate, broadest near mid-body region; rounded anteriorly; narrowed to point posteriorly; with evident hyaline areas anteriorly and posteriorly. Pellicle: smooth; allows little metabolic movement; light amber-colored. Locomotion: darting movements. Nucleus: spherical; $4-5\mu$ in diameter; in mid-body region; usually obscured by chloroplasts.

Flagellum: three-fourths body length. Gullet: usually not observed; opens into reservoir $3-4\mu$ in diameter.

Chloroplasts: two; concavo-convex (saucer-shaped), slightly elongated; $9-12\mu$ in length; parietal in position; often overlap in mid-body region. Stigma: orange-red; shallow concavo-convex; $1-2\mu$ in diameter; lateral to reservoir. Paramylum bodies: oval; few; often two, one on either side of gullet anterior to reservoir.

Cysts: temporary cysts observed. Division not observed.

Widely distributed in Iowa except in temporary ponds.

PLATE VII

33. A-D, *E. granulata*. D, typical arrangement of large and small granules.
34. A-F, *E. pisciformis*. A, magnified $1500\times$; D, typical swimming movement.
34. G, H, *E. pisciformis* var. *minor*.
35. *E. anabaena* var. *minor*.
36. A, B, *E. minima*.
37. A-G, *E. viridis*. C, star-shaped arrangement of chloroplast; D, extreme metaboly.
38. A, B, *E. vivida*.
39. A, B, *E. nana* n. sp., B, magnified $1500\times$.
40. A-E, *E. chlamydophora*.
41. A-F, *E. retronata* n. sp.

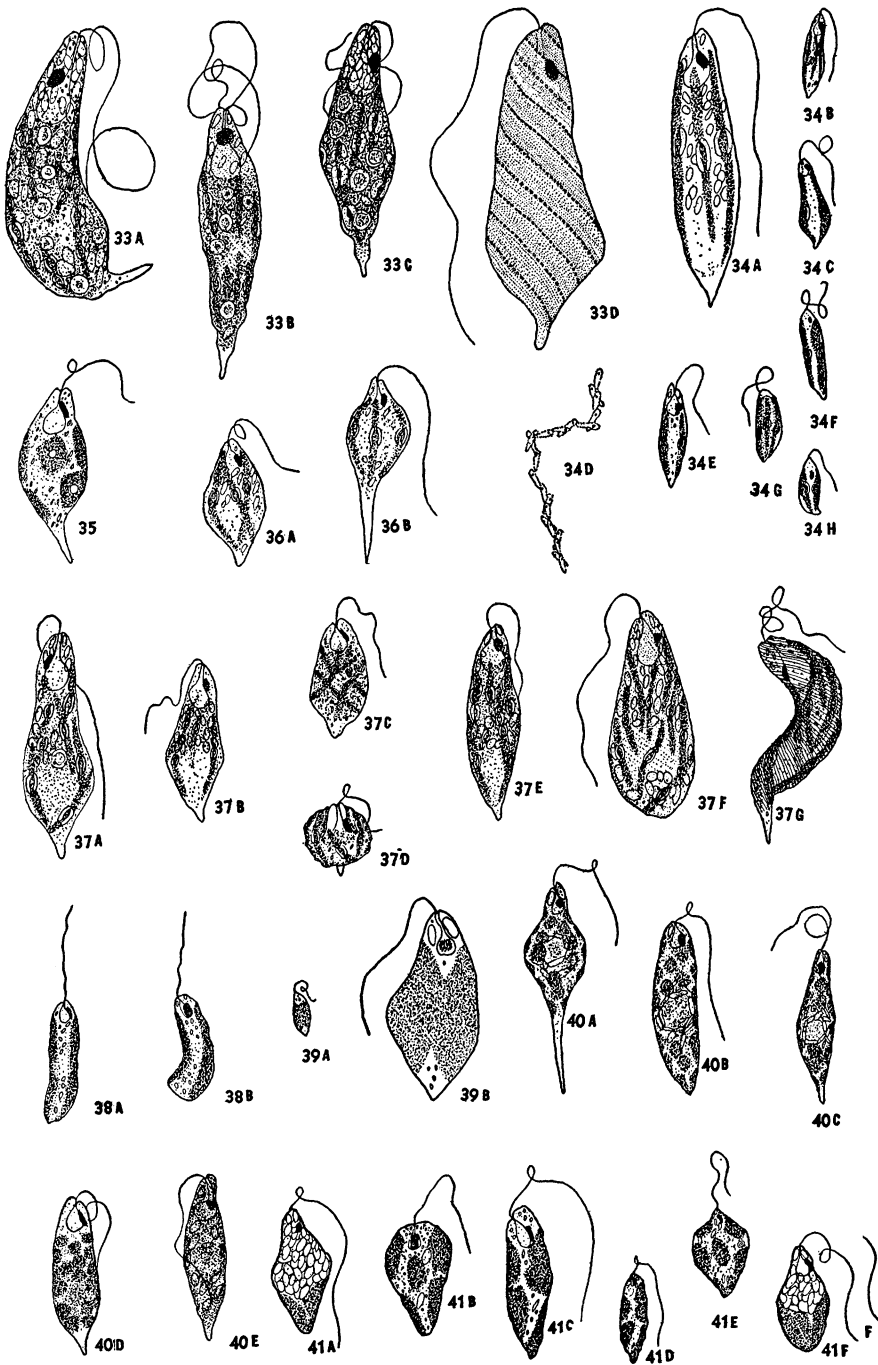


PLATE VII

E. nana. n. sp. most nearly resembles *E. pisciformis* var. *minor* but differs in that it lacks paramylum bodies attached to chloroplasts, is thicker through mid-body region, has darting movement unlike that of *E. pisciformis*, and possesses flattened chloroplasts.

40. *E. chlamydophora* Mainx (Fig. 40, A-E)

Size: 30–45 μ long by 6–16 μ in diameter. Body: fusiform or thickened in mid-body region, usually narrowed slightly anteriorly; narrowed posteriorly into a short colorless tip, occasionally pronounced. Pellicle: spirally striated, evident; allows considerable metabolic movement. Nucleus: spherical; 6–10 μ in diameter; in mid-body region; usually not evident.

Flagellum: body length or less. Gullet: curved; opens into spherical reservoir 4–7 μ in diameter.

Chloroplasts: numerous; weakly concavo-convex (saucer-shaped); 6–7 μ in diameter. Stigma: deeply concavo-convex (cup-shaped); approximately 3 μ in diameter; lateral to reservoir. Paramylum bodies: numerous; oval, rectangular or ellipsoidal; often collected in midbody region.

Division observed in thin-walled cyst.

Widely distributed except in temporary pools.

41. *E. retronata* n. sp. (Fig. 41, A-F)

Size: 18–34 μ long by 7–15 μ in diameter. Body: varied shape, fusiform or broadened anteriorly or broadest in mid-body region; usually narrowed posteriorly into a blunt tip. Pellicle: delicately spirally striated; allows metabolic movement, slight during locomotion. Locomotion: rapid, oscillating movement forward; may stop forward motion and spin rapidly; again may move backward, observed in all forms but more prevalent in organisms with a large diameter. Nucleus: in mid-body region; spherical; 5–6 μ in diameter; often not observed.

Flagellum: body length to one and one-fourth body length. Gullet: short; opens into slightly elongated reservoir, approximately 5 μ in diameter.

Chloroplasts: weakly prolate concavo-convex (elongate saucer-shaped); outlines often uneven; parietal in position; 8–12 in number; 5–9 μ in diameter; may be forced posteriorly with the accumulation of numerous paramylum bodies. Stigma; orange to light red; weakly concavo-convex; 3–5 μ in diameter; lateral to reservoir. Paramylum bodies; few to many; prolate spheroidal or oval; if numerous, usually located anteriorly.

Cysts: thin-walled cysts observed in which division occurs.

Collected: Iowa River and Lagoon, Iowa City.

E. retronata n. sp. most nearly resembles *E. chlamydophora* but differs in that it possesses a longer flagellum, weak striations of pellicle, smaller body size, fewer chloroplasts, clumping of paramylum anteriorly, and in that it may move backwards.

DISCUSSION

All but three *Euglena* studied in this investigation were found to be widely distributed in Iowa. *Euglena antefossa* n. sp. collected from Amana Lake and Law Quarry, Iowa City, appeared plentiful during the month of June, but sparsely after that time. It is supposed that *E. antefossa* n. sp. may also be general in distribution since collections were made from both a mud lake and a stone quarry. *E. trisulcata* n. sp. was collected in only a limited region from Emerson's Bay on West Lake Okoboji and Beck's Canal. Although it was not collected from the surrounding lake region, it would seem probable that this species is present, since the lakes of the Okoboji region covered outlying districts at the time of the Lewis-Clark Expedition. *E. fundoversata* n. sp., an under-water form, may possess a limited habitat. It was obtained only from a cold spring with a low mineral content at the grounds of the Lakeside Laboratory in Northwest Iowa.

E. granulata, *E. polymorpha* and *E. sociabilis* appeared in practically all collections. They have been observed to form a solid scum on the surface of temporary pools where there had been dusty soil a few days previously. One such temporary pond was approximately twenty-five yards north of the Lagoon at Iowa City.

Euglena sociabilis, *E. granulata* and *E. polymorpha* are morphologically similar, but differ in length of flagellum, in presence of spherical granules below the pellicle, in pellicular striations, and in shape of cyst walls. These differences are slight and difficult to distinguish except by thorough study. In view of the life history studies by Baker (1926) it would seem that these species should be studied in pure line culture to determine their validity. Dangeard (1902) suggested the need for such investigations and emphasized the difficulty in obtaining proper culture media. The author plans to conduct such an investigation on these species and a similar study on the varieties of *E. spirogyra*. It is hoped that the validity of all species of *Euglena* may be checked in a similar manner.

Various explanations have been offered regarding the function of the rod-shaped granules which are aligned perpendicularly to the pellicle in *E. velata*. Dangeard (1902) considered them to be mucus producing structures. Chadeaux (1937) named the granules trichotiques and homologized their function with the trichocysts of *Paramecium*. No evidence was obtained during this investigation to substantiate either conclusion.

The finding of *E. acus* var. *angularis* n. var. suggests a possible natural relationship among certain species of *Euglena*. It may be postulated that *E. acus* evolved in two divergent lines: one line toward metabolic euglenae like *E. ehrenbergii* and *E. deses* and the other through *E. acus* var. *angularis* n. var. toward rigid forms similar to *E. tripteris*. The euglenae were divided by Dangeard (1902) into two natural groups, one containing those with rod or ribbon-shaped chloroplasts and the other those with discoidal chloroplasts.

E. deses and *E. ehrenbergii* were placed in the latter group and *E. acus*, *E. tripteris* and *E. oxyuris* were placed in another section of the same group. The observations in the present investigation substantiate Dangeard's grouping. It is suggested that a form similar to *E. acus* var. *angularis* n. var. may have been one from which the ridged euglenae originated.

SUMMARY

1. Forty-one species and 11 varieties of *Euglena* are recorded and described.

2. Eight of these, *E. fronsundulata*, *trisulcata*, *antefossa*, *ignobilis*, *rostrifera*, *nana*, *retronata*, and *fundoversata* are described for the first time.

3. A newly-devised key to differentiate the species of *Euglena* in Iowa is presented and is applicable to most of the reported euglenae of North America.

4. Most euglenae of Iowa occur in a wide variety of habitats.

5. A need for life history studies is suggested.

6. *E. acus* var. *angularis* n. var. is suggested as a possible link in the development of the ridged euglenae.

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