

CLOSTERIUM IN PESHAWAR VALLEY

By

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Forty seven taxa of *Closterium* have been described from Peshawar valley. All these taxa are new records for the country. The description is accompanied with a key for identification and camera lucida drawings.

Introduction

Closterium belongs to the family Desmidiaceae of the order Zygnematales. The work was undertaken as a part of the programme in the Department to explore the algal flora of Pakistan. Prior to this work, not a single taxon of *Closterium* was known from this country.

The valley of Peshawar consists of Mardan and Peshawar districts. The valley lies between longitudes 71.25°E and 72.47°E and latitudes 34.31°N. The pH of the soil is between 7.0-9.6. The area of the valley is 6,053 sq. miles.

Climate of the Peshawar valley is more or less mediterranean type with rainfall mostly in Winter. The summers are hot and the temperature may go up 117°F, while winters are cold with temperature coming down to 28°F. The average annual rainfall in Mardan city is 20" and in Peshawar city is about 13.6". Humidity is comparatively high in the valley. The floor of the valley is made up of Attock slate. The soil of the valley is basic and is made up of clay and loam with some quantity of sand.

The desmids are difficult to identify. They are extremely variable and have indefinite shapes and forms. No language has enough words to describe all their forms and shapes. Most of the workers have avoided the preparation of identification keys of the taxa of desmids because they are difficult to prepare. In the absence of the identification keys and descriptive terms for shapes, reliance has to be placed on diagrams which are luckily readily available as most of the workers in this group are good in drawings. Photographs of the taxa do not help much in identifications, as they do not show all the characters necessary for diagnosis.

The taxa identified here are mostly based on the comparative study of the diagrams given by reliable workers along with the description.

In the identification keys, the extreme magnifications have not been taken into consideration. Young cells have smaller dimensions. These dimensions although included in the description have not been considered in the preparation of the key.

The numbers of the collection are of F.M. Sarim. All the specimens, preserved in formalin, have been deposited in the Herbarium of the Department of Botany, University of Peshawar. All the drawings are original. Due to unavoidable circumstances, the illustrations could not be standardised on one scale. To find out the size, the diagram has to be measured.

Materials and Methods

Plants were collected from ponds, drains, tanks, canal sides, marshy places, river margins, stagnant waters, rain pools and springs.

Collections were made by plankton net, squeezing and scrapping the aquatic vegetation. Plants were studied soon after collection, then they were preserved in 3% Formaline.

Characters of *Closterium* Nitzsch, 1817

Cells elongate, usually markedly attenuate, rarely straight, in most cases curved, often strongly, arcuate or lunate, without a median constriction; poles obtuse, truncate, rostrate or attenuate to fine needle like points; cell wall smooth, costate, or striate, colourless or yellow to brown in colour, often with one or more transverse lines either at middle of cell or at different points along cell; chloroplast entire or with a variable number of longitudinal ridges, one in each semicell; pyrenoids few or many, usually in a single axial row or more rarely scattered throughout chloroplast; with a terminal vacuole between cell apex and the end of the chloroplast, containing one or more crystals of gypsum which exhibit a constant Brownian movement. Conjugation between recently divided cells, or mature cells.

KEY TO THE SPECIES

- | | |
|---|---|
| 1. Cells straight | 2 |
| 1. Cells slightly curved | 5 |
| 1. Cells strongly curved | 14 |
| 2. Pyrenoids definite in number | 3 |
| 2. Pyrenoids variable in number | 4 |
| 3. Pyrenoid 1 in number | <i>C. navicula</i> |
| 3. Pyrenoids 10 in number | <i>C. libellula</i> ssp
<i>interruptum</i> |
| 4. Pyrenoids 3-4 in number, apex 2 um broad | <i>C. cornu</i> ssp. <i>croasdalei</i> |
| 4. Pyrenoids 4-6 in number apex 4-5 um broad | <i>C. acerosum</i> ssp. <i>minus.</i> |
| 4. Pyrenoids 5-10 in number, apex 13-20 um broad | <i>C. didymotocum</i> |
| 5. Striations present | 6 |
| 5. Striations absent | 9 |
| 6. Striations definite in number | 7 |
| 6. Striations variable in number | 8 |
| 7. Cell with 9 striations | <i>C. subscoticum</i> |
| 7. Cell with 10 striations, cell 8.2 um broad | <i>C. juncidum</i> ssp. <i>elongatum</i> |
| 7. Cell with 10 striations, cell 19-53 um broad | <i>C. acerosum</i> |
| 7. Cell with 10 striations, cell 16-31 um broad | <i>C. intermedium</i> |
| 8. Cell with 6-10 striations, cell 25-61 um broad | <i>C. braunii</i> |
| 8. Cell with 8-10 striations, cell 9-14 um broad | <i>C. juncidum</i> ssp. <i>brevior</i> |

8. Cell with 11-13 striations.....	<i>C. praelongum</i> ssp. <i>brevius</i>	
8. Cell with 9-17 striations, cell 10-12 um broad	<i>C. juncidum</i>	
8. Cell with 14-21 striations.....	<i>C. striolatum</i>	
8. Cell with 35-40 striations.....	<i>C. pritchardianum</i>	
9. Pyrenoids prominent.....		10
9. Pyrenoids not clear		13
10. Pyrenoids definite in number		11
10. Pyrenoids variable in number.....		12
11. Pyrenoids 2 in number.....	<i>C. abruptum</i> ssp. <i>brevius</i>	
11. Pyrenoids 4 in number, cell 7.5 um broad	<i>C. strigosum</i> ssp. <i>elegans</i>	
11. Pyrenoids 4 in number, cell 38.5-44 um broad.....	<i>C. pseudolumula</i>	
11. Pyrenoids 4 in number, cell 6 um broad	<i>C. cornu</i>	
11. Pyrenoids 5 in number, cell 28-35 um broad	<i>C. elenkenii</i>	
11. Pyrenoids 5 in number, cell 8 um broad.....	<i>C. subulatum</i>	
11. Pyrenoids 6 in number.....	<i>C. abruptum</i>	
12. Pyrenoids 2-3 in number	<i>C. tumidum</i>	
12. Pyrenoids 4-5 in number, cell 3.7-11 um broad	<i>C. acutum</i>	
12. Pyrenoids 5-7 in number, cell 3 um broad	<i>C. gracile</i>	
12. Pyrenoids 6-7 in number, cell 32-73 um broad.....	<i>C. lanceolatum</i>	
12. Pyrenoids 6-7 in number, cell 30 um broad	<i>C. pritchardianum</i> ssp. <i>leave</i>	
13. Cell 22-29 um broad.....	<i>C. angustatum</i>	
13. Cell 8.5-10 um broad	<i>C. angustatum</i> ssp. <i>gracilius</i>	
14. Cell wall colourless		15
14. Cell wall otherwise		22
15. Terminal granules present		16
15. Terminal granules absent.....		19
16. Terminal granules definite in number		17
16. Terminal granules variable in number		18
17. Cell with terminal granules 3, arc 130°-140°	<i>C. diana</i> ssp. <i>brevius</i>	
17. Cell with terminal granule 1, arc 100°-125°	<i>C. diana</i> ssp. <i>minus</i>	
17. Cell with terminal granule 1, arc 175°-200°	<i>C. incurvum</i>	
17. Cell with terminal granules 2.....	<i>C. venus</i> ssp. <i>croasadeli</i>	
17. Cell with terminal granules 3, arc 151°-160°.....	<i>C. venus</i> ssp. <i>maior</i>	
18. Cell with terminal granules 1-4, arc 65°.....	<i>C. diana</i> ssp. <i>pseudodiana</i>	
18. Cell with terminal granules 1-4, arc 140°-170°.....	<i>C. venus</i> ssp. <i>crassum</i>	
19. Pyrenoids definite in number		20

19. Pyrenoids variable in number.....	21
20. Cell with 2 pyrenoids, 11.7-16.8 um broad	
	<i>C. evisculatum</i>
20. Cell with 2 pyrenoids, 7-10.5 um broad	
	<i>C. venus</i>
21. Cell with 2-3 pyrenoids, 15-20 um broad	
	<i>C. leibleinii</i> ssp. <i>minimum</i>
21. Cell with 3-4 pyrenoids, 7-12 um broad	
	<i>C. venus</i> ssp. <i>incurvum</i>
21. Cell with 3-6 pyrenoids, 10.5-18 um broad	
	<i>C. parvulum.</i>
21. Cell with 6-7 pyrenoids, 30-68 um broad	
	<i>C. moniliferum</i>
21. Cell with 3-8 pyrenoids, 17-42 um broad	
	<i>C. leibleinii</i>
22. Pyrenoids definite in number	23
22. Pyrenoids variable in number.....	24
23. Cell apex truncate	<i>C. archerianum</i>
23. Cell apex swollen and rounded	<i>C. striolatum</i> ssp. <i>borgei</i>
24. Cell apex curved	<i>C. exile</i>
24. Cell apex bluntly rounded	<i>C. cynthia</i>

DESCRIPTION OF THE SPECIES

1. *Closterium abruptum* West.

Taylor, 1934, p. 242, pl. XLVI, fig. 9; Cedercreuts and Gronblad, 1936, p.1, pl. I, figs. 2-3; Irene-Marie, 1951, p. 209; Krieger and Scott, 1957, p. 130.

150-207 um long, 14-15 um wide; pyrenoids 6; cell wall smooth; inner part of the cell concave and outer convex; apex bluntly curved; cell slender (fig. 19).

Locality: Nawan Kali (Mardan), Sarim No. 13, Feb. 15, 1975.

2. *C. abruptum* West. ssp. *brevius* W. & W.

Gronblad, Scott and Croasdale, 1964, p. 152, pl. III, fig. 11; Croasdale, 1955, p. 521; Croasdale, 1962, p. 18, pl. II, fig. 29.

112-123 um long, (7.1 x)-15 um wide; 40° of arc; pyrenoids 2; terminal granule one; cell wall yellow to yellow brown and smooth; girdle bands not seen; cell less curved than the Wests; less slender. (fig. 15).

Locality: Peshawar, Sarim No. 15, Feb. 6, 1975.

3. *C. acerosum* (Shrank) Ehr.

Tiffany and Britton, 1951, p. 169, pl. LI, fig. 550; Croasdale, 1955, p. 521, pl. VII, fig. 1; Scott and Prescott, 1958, p. 22, pl. II, fig. 9; Taylor, 1934, p. 242, pl. XLV, fig. 20; Croasdale, 1962, p. 18, pl. I, fig. 15.

288-530 um long, 19-23 um wide; apices 4-5um wide; 8-16 times longer than wide; very slightly curved or almost straight; narrowly fusiform; outer margin slightly curved; about 30-38° of arc; inner margin almost straight or slightly convex; gradually tapering to the narrow and often slightly thickened rounded, truncate apices; cell wall smooth, colourless becoming delicately striate and yellowish brown in colour with age; with or without a median girdle; chloroplasts ridged; pyrenoids 7-12 in a median series; terminal vacuoles with a number of moving granules; zygote spherical, smooth, 62-87 um in diameter; 10 striae in 10 um. (fig. 18).

Locality: Mardan, Sarim No. 24, Feb. 1, 1975; Peshawar, Sarim No. 110, April 15, 1975.

4. *C. acerosum* (Shrank) Ehr. ssp. *minus* Hantzsch.
Croasdale, 1955, p. 521, pl. VII, fig. 3.

200-255 um long, (9.7-11.4 x)-18-23 um wide; W. at apex 4-5 um; cells nearly straight; ventral wall slightly tumid; pyrenoids 4-6; cell wall smooth: apex evenly tapered and rounded, not recurved. (fig. 6).

Locality: Peshawar, Sarim No. 20, Feb. 2, 1975.

5. *C. acutum* (Lyngb) Breb.

Tiffany and Britton, 1951, p. 173, pl. LII, fig. 555; Irene-Marie, 1951, p. 209; Croasdale, 1955, p. 521, pl. VIII, fig. 13; Gronblad, Scott and Croasdale, 1964, p. 11, pl. I, fig. 1.

60-180 um long, 3.7-11.0 um wide; apices 2.5-3.0 um wide; 15-33 times longer than wide; slightly curved; outer margin 30-60° of arc, inner margin not tumid; gradually attenuated to the acute apices; cell wall smooth and colourless; chloroplast without ridges; pyrenoids 4-5 in a median series; terminal vacuoles with several small moving granules; zygote 12-27 × 23-49 um, oblong to rectangular; sides concave or slightly convex; ends concave; angles produced into conical projections (fig. 5).

Locality: Panjtirath pond (Peshawar), Sarim No. 2, October 1, 1974.

6. *C. angustatum* Kg.

Croasdale, 1955, p. 521, pl. IV, fig. 10; Gronblad Scott and Croasdale, 1964, p. 154, pl. IV, fig. No. 18; Irene-Marie, 1951, p. 209; Taylor, 1934, p. 243.

330-540 um long, (13.7-16.5)-22-29 um wide; W. at apex 13 um (19 um); terminal granules many; 1.5-2.5 costae in 10 um; cell wall punctate, brown; apex sometimes bent back or swollen (fig. 9).

Locality: Peshawar, Sarim No. 19, Feb. 24, 1975.

7. *C. angustatum* Kg. ssp. *gracilius* Croasdale.
Croasdale, 1955, p. 521, pl. IV, fig. 12.

233-325 um long, 8.5-10 um-(27.4-32.5) um wide; w. at apex 6.5-7 um; 3 costae in 10 um; cell wall brown; cell slender; wall between the costae smooth; terminal granules present (fig. 10).

Locality: Peshawar. Sarim No. 26, February 25, 1975. This subspecies has been collected for the first time after the type.

8. *C. archerianum* Cleve.

Taylor, 1934, p. 243, pl. XLVI, fig. 10; Croasdale, 1955, p. 521, pl. IV, fig. 7; Krieger and Scott, 1957, p. 130, pl. I, fig. 1.

305 um long, 30 um wide; faintly and broadly striate and finely porous; apex faintly truncate; cell wall brown; at apex 4-5 um; 120-130° of arc; pyrenoids 8; striate 7 in 10 um (fig. 26).

Locality: Katlang (Mardan), Sarim No. 9, January 15, 1975.

9. *C. braunii* Reinsch.

Tiffany and Britton, 1951, p. 176, pl. LI, fig. 541.

450-800 um long, 25-61 um wide; 16-22 times longer than wide; very slightly curved; median portion cylindric, not tumid; tapering abruptly to obtusely rounded and slightly recurved apices; cell wall yellow to brownish with 4-6 costae, irregularly porous or with 6-10 more or less distinct striations; chloroplast with 4-5 ridges; pyrenoids 14-16 in a median series; terminal vacuoles with about 20 moving granules; zygote unknown (fig. 33).

Locality: Chirat (Peshawar), Sarim No. 90, April 1, 1975.

10. *C. cornu* Ehr.

Gronblad, Scott and Croasdale, 1964, p. 154, pl. XI, figs. 13-15; Taylor, 1934, p. 243, pl. XLVI, fig. 8; Croasdale, 1955, p. 522, pl. VII, fig. 13; Irene-Marie, 1951, p. 210, pl. III, figs. 6-7.

141 um long, 6 um-(23.5 x) wide; w. at apex 3 um; about 20° of arc; pyrenoids 4; cell wall smooth; older semicell brown in colour; cell cylinder and about straight; cells showing considerable range in size (fig. 12).

Locality: Peshawar, Sarim No. 7, January 6, 1975.

11. *C. cornu* Ehr. ssp. *croasdalei* Faridi ssp. nov.

Croasdale, 1955, p. 522, pl. VII, figs. 14-15; Croasdale, 1962, p. 18, (*C. cornu* forma a Croasdale).

Cellulae 160-200 um long., 7.2-11 um lat. (16.3-22 x); apex 2 um lat.; cellula recta; apex aequae attenuatae ad truncatum; pyrenoids 3-4; granula terminalia 3 vel nulla; membrana cellulae sine colore, levis.

160-200 um long, 7.2-11 um-(16.3-22 x) wide; w. at apex 2 um; cell straight; apex evenly tapered to truncate; pyrenoids 3-4; terminal granules 3; cell wall colourless and smooth (fig. 4).

Locality: Peshawar, Sarim No. 80, March 29, 1975.

12. *C. cynthia* De Not.

Croasdale, 1962, p. 18, pl. I, fig. 8; Croasdale, 1955, p. 522, pl. IV, fig. 6; Gronblad, Scott and Croasdale, 1968, p. 9, pl. II, fig. 26; Gronblad and Croasdale, 1964, p. 154, pl. V, fig. 4; Scott and Prescott, 1958, p. 23, pl. I, fig. 7; Taylor, 1934, p. 243; Irene-Marie, 1951, p. 210; Gronblad and Croasdale, 1971, p. 6.

100-165 μm long, (7.4-11 x)-12-20 μm wide; w. at apex 3.5-4 μm ; 135° - 165° of arc; pyrenoids 3-5; striae 7-10 μm ; terminal granules (rarely seen) 3-4; cell wall pale brown; cell stout and strongly curved; apex bluntly rounded (fig. 25).

Locality: Nawan Kali (Mardan), Sarim No. 35, Feb. 15, 1975.

13. *C. diana*e Ehr. ssp. *brevius* (Wittr.), Petkoff.

Croasdale, 1955, p. 522, pl. V, fig. 10; Croasdale, 1962, p. 18, pl. II, fig. 20; Gronblad, Scott and Croasdale, 1964, p. 156, pl. III, fig. 6.

90-139 μm long, (6.4-7 x)-14-20 μm wide; w. at apex 2-4 μm ; 130 - 140° of arc; inner margin slightly swollen; pyrenoids 3-5; terminal granules 3; cell wall smooth, colourless; granular thickening at apex rarely present (fig. 27).

Locality: Peshawar, Sarim No. 28, Feb. 2, 1975.

14. *C. diana*e Ehr. ssp. *minus* (Wille) Schröder.

Croasdale, 1955, p. 523, pl. V, figs. 8-9; Gronblad, Scott and Croasdale, 1964, pl. III, figs. 7-8; Gronblad, 1960, p. 34, pl. I, fig. 3; Gronblad, Scott and Croasdale, 1968, p. 9, pl. I, fig. 15; Croasdale, 1962, p. 18; Cook, 1963, p. 12, fig. 10.

125-140 μm long, (8-12 x)-10.5-18 μm wide; w. at apex 2-3 μm ; 100° - 125° of arc; pyrenoids 3; terminal granule 1; cell wall smooth and colourless; granular thickening at apex sometimes present; ventral surface of cell concave; inner margin slightly tumid; chloroplast surface irregular and definitely longitudinal ridges not present; several crystals in each terminal vacuole (fig. 42).

Locality: Mardan, Sarim No. 5, Dec. 3, 1974.

15. *C. diana*e Ehr. ssp. *pseudodiana*e (Roy) Krieger.

Croasdale and Gronblad, 1964, p. 158, pl. III, fig. 9; Gronblad, Scott and Croasdale, 1968, p. 9, pl. I, fig. 17; Taylor, 1934, p. 244, pl. XLVI, fig. 5; Gronblad, 1943, p. 13, pl. I, fig. 1; Gronblad, Scott and Croasdale, 1964, p. 11, pl. IX, fig. 206; Croasdale, 1962, p. 18, pl. II, fig. 19; Irene-Marie, 1951, p. 217.

225 μm long, 14 μm (16 x) wide; cell wall colourless, smooth; 65° of arc; cell with apical nodule; terminal granules 1-4; about 9 or 10 pyrenoids per semi cell (fig. 34).

Locality: Mardan, Sarim No. 85, April, 15, 1975.

16. *C. didymotocum* Ralfs.

Taylor, 1934, p. 243, pl. XLV fig. 19; Krieger and Scott, 1957, p. 130, pl. I, fig. 2; Tiffany and Britton, 1951, p. 169, pl. 52, fig. 560; Gronblad, 1919, p. 7.

295-672 μm long, 24-56 μm wide; apices 13-20 μm wide; 9-12 times longer than wide; slightly curved; outer margin 27-32° of arc; inner margin slightly concave or almost straight; median portion with subparallel sides; gradually and slightly attenuated to the broad, rounded, truncate apices but sometimes recurved; cell wall smooth or rarely with fine striations; reddish brown or yellow brown in colour; generally having a median girdle and with a annular, dark brown thickening at each apex; chloroplast with 5-10 large pyrenoids; terminal vacuoles with many moving granules; zygote unknown; intercalary segments usually present (fig. 3).

Locality: Charsadda, Sarim No. 3, Dec. 15, 1974.

17. *C. elenkenii* Kossinskaja.

Croasdale, 1962, p. 18, pl. II, figs. 22-23.

195-250 μm long, (6.7-8.3 x)-28-35 μm wide; apex 8-9 μm ; pyrenoids 5 in a median row; terminal granules 3-4; cell wall dark brown; thickened at apex; lightly to coarsely irregularly punctate.

NOTE: According to Croasdale (1962) this striking species in shape most closely resemble *C. ralfsii* Breb. and *C. laterale* Nordst, but differs in its smaller size and its walls which is irregularly punctate rather than striate. Kossinskaja described it from the Russian Arctic (fig. 7).

Locality: Peshawar University, leg. Safia and Shamsun Nisa and Sarim No. 83, April 4, 1975.

18. *C. evisculatum* Cook.

Cook, 1963, p. 8, figs. 4-6.

63-124 μm long, 11.7-16.8 μm wide; outer margin evenly curved; 130°-180° of arc; inner margin concave or slightly tumid; apex acutely rounded, 3 μm wide with pore on dorsal side; cell wall smooth; without girdle bands; pyrenoids 1-5 (usually 2) per plastid surface of plastid irregular or with 4 longitudinal ridges; several crystals present in each irregular terminal vacuole; conjugation involving mature or slightly immature cells; semicell not completely separating protoplasts escaping through pores formed at juncture of semicells; conjugation tube mucilaginous without a definite wall not persisting; zygosporos spherical, 23.3-33 μm in diameter (fig. 39).

NOTE: This species was described from U.S.A. in 1963 and this is the second collection of the species.

Locality: Nawan Kali (Mardan), Sarim No. 50, Feb. 18, 1975.

19. *C. exile* W. & W.

Croasdale, 1962, p. 19, pl. II, fig. 27; Gronblad, 1960: p. 34, pl. I, figs. 9-10.

55-67 um long, 8-9.2 um wide; apex curved; cell wider in the middle than the apices; inner margin of the cell concave and outer convex; cell stout (fig. 45).

Locality: Pabbi, Sarim No. 6, Jan. 24, 1975.

20. *C. gracile* Breb.

Gronblad and Croasdale, 1971, p. 6, pl. I, fig. 8; Gronblad, Scott and Croasdale, 1964, p. 11; Taft, 1945, p. 186, pl. I, fig. 13; Tiffany and Britton, 1951, p. 174, pl. LII, fig. 556; Gronblad, Scott and Croasdale, 1964, p. 156, pl. III, fig. 12; Croasdale, 1955, p. 523, pl. VIII, figs. 4-6; Irene-Marie, 1951, p. 213.

130-206 um long, 3 um wide; apices 1.2-2.5 um wide; slender, linear; 28-40 times longer than wide; almost straight for about 2/3 of length; margins parallel; gradually narrowed to the obtuse apices; cell wall smooth, colourless; chloroplast with a median series of 5-7 pyrenoids; terminal vacuole with 1 or several moving granules; zygote spherical, angular, globose or subquadrate with rounded angles, smooth, 20.0-25.7 um in diameter. (fig. 29).

Locality: Kalu Khan (Mardan), Sarim No. 46, Feb. 15, 1975.

21. *C. incurvum* Breb.

Gronblad and Croasdale, 1971, p. 7; Croasdale, 1955, p. 523, pl. VI, figs. 5-8; Cook, 1963, p. 9, figs. 8, 18; Croasdale, 1962, p. 19.

37-70 um long, (4.2-6.9 x) 7-12 um wide; w. at apex 1.5-2.5 um; 175-200 of arc; pyrenoids 1-3 (usually 2); terminal granule 1; cell wall smooth, colourless; cell strongly curved; zygospore spherical (fig. 41).

Locality: Peshawar, Sarim No. 40, Feb. 14, 1975.

22. *C. intermedium* Ralfs.

Gronblad Scott and Croasdale, 1964, p. 156, pl. IV, fig. 1; Croasdale, 1962, p. 19, pl. I, fig. 13; Tiffany and Britton 1951, p. 172, pl. 52, fig. 559; Irene-Marie, 1951, p. 214.

200-465 um long, 16-31 um wide; apices 8-11.5 um wide; 12-15 times longer than wide; moderately curved; outer margin 36°-56° of arc; inner margin slightly concave sometimes medianly straight; gradually attenuated to the rounded truncate apices; cell wall smooth or yellow or yellowish brown; strongly striate with 10 visible striations across the cell; with a median girdle; chloroplast with 5-6 pyrenoids; terminal vacuole with a single large moving granule or a few smaller ones; zygote smooth, spherical, 38-54 um in diameter; wall occasionally showing nodular thickening at apex (fig. 30).

Locality: Nawan Kali (Mardan), Sarim No. 43, Feb. 15, 1975. Peshawar, Sarim No. 113, April 17, 1975.

23. *C. juncidum* Ralfs.

Gronblad, Scott and Croasdale, 1964, p. 156, pl. III, figs. 16, 21; Taylor, 1934, p. 244; Irene-Marie, 1951, p. 214; Croasdale, 1955, p. 524.

188-310 μm long, 10-12 (18-26x) wide apex 4.5-5 μm ; 9-17 striae in 10 μm ; with or without girdle bands; apical wall unthickened; terminal granules present; cell slightly curved (fig. 28).

Locality: Chirat (Peshawar), Sarim No. 88, April 1, 1975. Peshawar, Sarim No. 115, April 20, 1975.

24. *C. juncidum* Ralfs. ssp. *brevior* Roy.

Croasdale, 1955, p. 524, pl. IV, fig. 15; Tiffany and Britton, 1951, p. 172, pl. LII, fig. 562.

80-275 μm long, 9-14 μm wide; 12-20 times longer than wide; moderately curved; gradually attenuated towards the obtusely rounded apices; cell wall brown or yellow; always with a median girdle and with 8-10 frequently obscure striations; chloroplast with 4-7 pyrenoids; terminal vacuole with several moving granules; zygote spherical or slightly ellipsoid, 36-40 μm in diameter; w. at apex 6.5 μm , 35° of arc (fig. 16).

Locality: Peshawar, Sarim No. 4, Dec. 10, 1974.

25. *C. juncidum* Ralfs ssp. *elongatum* Roy and Biss.

Croasdale, 1955, p. 524, pl. IV, fig. 16.

350 μm long, 8.2 μm (42.7 x) wide; w. at apex 6 μm ; 10 striae in 10 μm ; cell wall colourless; cell slightly curved always with a median girdle (fig. 22).

Locality: Peshawar, Sarim No. 72, March 27, 1975.

26. *C. lanceolatum* Kg.

Croasdale and Gronblad, 1971, p. 7, pl. I, fig. 6; Tiffany and Britton, 1951, p. 173, pl. LII, fig. 552; Irene-Marie, 1951, p. 214.

234-550 μm long, 32-73 μm wide; apices 7-8 μm wide; 5-10 times longer than wide; sublanceolate; almost straight, outer margin slightly curved, 30°-550° of arc; inner margin straight or slightly convex; gradually narrowed towards the acutely rounded apices; cell wall colourless, smooth; chloroplast with 7-8 ridges; pyrenoids 6-7 in a median series; terminal vacuoles with a number of moving granules; zygote subglobose or oblong ellipsoid, smooth, 81-104 μm in diameter (fig. 17).

Locality: Peshawar, Sarim No. 8, Jan. 15, 1975.

27. *C. leibleinii* Kg.

Taft, 1945, p. 186, pl. I, fig. 17; Cook, 1963, p. 5, figs. 3, 15; Croasdale, 1962, p. 19, pl. II, fig. 25; Tiffany and Britton, 1951, p. 172, pl. LII, fig. 547; Irene-Marie, 1951, p. 215; Croasdale, 1955, p. 524.

105-250 μm long, 17-42 μm wide; apices 5-7 μm wide; 6-8 times longer than wide; strongly curved; outer margin 124-190° of arc; inner margin strongly concave, tumid in the middle; gradually attenuated to the acutely rounded apices; cell wall

smooth and colourless; chloroplast with about 6 ridges; pyrenoids 3-8 in a median series; terminal vacuoles large with a number of moving granules; zygote subglobose, 40-50 um in diameter, smooth (fig. 36).

Locality: Charsadda, Sarim No. 81, April 2, 1975.

28. *C. leibleinii* Kg. ssp. *minimum* Schmidle.

Croasdale, 1955, p. 524, pl. VI, fig. 19.

76-92 um long, (4.7-5.8 x)-15-20 um wide; w. at apex 2.5-3.5 um; 141-155° of arc; pyrenoids 2-3; cell wall smooth and colourless; cell strongly curved; cell tumid in the middle (fig. 40).

Locality: Peshawar, Sarim No. 59, Feb. 27, 1975.

29. *C. libellula* Focke ssp. *interruptum* (W. & W.) Donat.

Scott and Prescott, 1958, p. 24, pl. I, fig. 6; Irene-Marie, 1951, p. 215.

105 um long, 18 um wide; pyrenoids 10; cell straight, stout; chloroplast plates interrupted at about the mid length of each semicell (fig. 2).

Locality: Peshawar, Sarim No. 77, March 2, 1975.

30. *C. moniliferum* (Bory) Ehr.

Taylor, 1934, p. 244, pl. XLVI, fig. 15; Croasdale, 1955, p. 525, pl. VI, fig. 21; Tiffany and Britton, 1951, p. 172, pl. LII, fig. 549; Croasdale and Gronblad, 1964, 157, pl. III, fig. 1; Krieger and Scott, 1957, p. 130, pl. I, fig. 4; Gronblad, 1960, p. 34, pl. I, fig. 4.

188-420 um long, 30-68 um wide; apices 8-13 um wide; 6-8 times longer than wide; moderately curved; outer margin 100°-130° of arc, inner margin inflated in the middle; uniformly narrowed to the obtusely rounded apices. Cell wall smooth and colourless; chloroplast with about 6 ridges; pyrenoids 6-7 in a median series; terminal vacuoles with numerous moving granules; zygote ellipsoid, smooth or with an outer mucous envelope (fig. 43).

Locality: Katlang (Mardan), Sarim No. 4, Jan. 15, 1975.

31. *C. navicula* (Breb.) Lutkem.

Croasdale, 1955, p. 525, pl. IV, figs. 2-3; Croasdale and Scott, 1968, p. 10, pl. I, fig. 11; Krieger and Scott, 1957, p. 131, pl. I, fig. 5; Croasdale and Gronblad, 1964, p. 157;

47-86 um long, (3.9-4.9 x)-12-17.5 um wide; w. at apex 5-6.5 um; pyrenoid 1; cell wall smooth; cell almost straight; median portion wide; cells not thick but appear stout (fig. 1).

Locality: Charsadda, Sarim No. 73, March 28, 1975.

32. *C. Parvulum* Naeg.

Croasdale, 1955, p. 525, pl. V, figs. 13-17; Gronblad and Croasdale, 1964, p. 157, pl. II, fig. 24; Taylor, 1934, p. 244, pl. XLVI, fig. 4; Taft, 1945, p. 188, pl. I, fig. 20; Tiffany and Britton, 1951, p. 173, pl. 51, fig. 543; Cook, 1963, p. 4, figs. 1, 13; Croasdale, 1962, p. 19; Gronblad, Scott and Croasdale, 1968, p. 10; Irene-Marie, 1951, p. 217.

92-140 μm long, (7-11 x)-10.5-18 μm wide; w. at apex 2-3 μm ; 9-15 times longer than wide; strongly curved; outer margin 100° - 140° of arc; inner margin not tumid, gradually attenuated to the acutely rounded apices; cell wall smooth, colourless; chloroplast with 4-5 ridges; pyrenoids 3-6 in a median series; terminal vacuoles with several moving granules; zygote ellipsoid or subglobose, smooth, $26\text{-}34.5 \times 30\text{-}40$ μm ; apical nodules on cell apices; the surface of the plastid irregular and well defined longitudinal ridges present; cell with conjugation tube persisting (fig. 32).

Locality: Nawan Kali (Mardan), Sarim No. 79, March 17, 1975.

33. *C. praelongum* Breb. ssp. *brevius* West.

Croasdale, 1955, p. 526, pl. VII, fig. 16; Croasdale, 1962, p. 19, pl. II, fig. 21; Irene-Marie, 1951, p. 217, pl. III, figs. 10-11.

170-227 μm long, (10-11 x)-17-20 μm wide; w. at apex 3-4 μm ; pyrenoids 6; terminal granules 2-9; apex abruptly tapered and slightly reflexed; cell wall smooth, colourless and finely striated, 11-13 striae in 10 μm (fig. 24).

Locality: Peshawar University, leg. Safia, Shamsun Nisa and Sarim No. 1, Dec. 6, 1974.

34. *C. pritchardianum* Archer.

Taylor, 1934, p. 244, pl. XLV, fig. 24; Croasdale, 1955, p. 526, pl. VII, fig. 8; Taft, 1945, p. 188, pl. XI, fig. 4; Tiffany and Britton, 1951, p. 170, pl. LII, fig. 554; Irene-Marie, 1951, p. 217; Croasdale, 1962, p. 19.

350-670 μm long, 21-55 μm wide; 12-17 times longer than wide; apices 7-12 μm wide; outer margin 24° - 43° of arc; inner margin straight or very slightly concave; gradually attenuated to the narrow truncate and slightly recurved apices; cell wall finely striate; 35-40 striations visible across the cell; striations composed of fine punctae and subspiral; yellowish or becoming reddish brown; rarely with a median girdle; chloroplast with 6-8 ridges; pyrenoids 7-8 in a median series; terminal vacuoles with many moving granules; zygote smooth, spherical to ovoid; 83-108 μm in diameter (fig. 21).

Locality: Peshawar, Sarim No. 38, Feb. 7, 1975.

35. *C. pritchardianum* Arch. ssp. *leave* Hughes.
Croasdale, 1955, p. 526, pl. VII, fig. 7.

330-525 μm long, (11-17.5 x)-30 μm wide; w. at apex 8-9 μm ; 20° - 35° of arc; apex abruptly tapered, somewhat recurved; pyrenoids 6-7; cell wall smooth and col-

ourless with or without a median girdle; inner margin slightly concave; zygote spherical; terminal vacuoles with many moving granules (fig. 20).

Locality: Peshawar, Sarim No. 36, Feb. 14, 1975.

36. *C. pseudohunula* Borge.

Gronblad, Scott and Croasdale. 1968, p. 10, pl. II, fig. 20; Croasdale, 1955, p. 526, pl. VII, fig. 6.

295-310 um long, (7-7.6 x)-38.5-44 um wide; w. at apex 8 um; 65° of arc; pyrenoids 4 in a median series; terminal granules 6-8; cell wall smooth and yellow (fig. 25).

Locality: Malmandi (Peshawar), Sarim No. 56, Feb. 14, 1975.

37. *C. strigosum* Breb. ssp. *elegans* Krieger.

Croasdale, 1955, p. 526, pl. VIII, fig. 3.

195.0 um long, 7.5 um-(26 x) wide; w. at apex 2 um; cell wall smooth and colourless; pyrenoids 4 (fig. 11).

Locality: Peshawar, Sarim No. 79, March 24, 1975.

38. *C. striolatum* Ehr.

Croasdale and Gronblad, 1964, p. 158, pl. IV, figs. 5-6; Tiffany and Britton, 1951, p. 170; pl. LI, fig. 546; Croasdale 1955, p. 526, pl. IV, fig. 14; Croasdale, 1962, p. 19 pl. I, fig. 9; Scott and Prescott, 1958, p. 24, Pl. I, fig. 11.

208-380 um long, (5.5-13.4 x)-20-40 um wide; apex 8-16 um; 52°-72° of arc; striae 14-21 across the cell; 8-12 times longer than wide; moderately curved; outer margin 36-69° of arc; inner margin concave or sometimes medianly straight; gradually attenuated to the broad rounded truncate apices; cell wall yellowish or yellowish brown; with a median girdle; chloroplast with 5-6 ridges; pyrenoids 5-6 in a median series; terminal vacuoles with many moving granules; zygote smooth, spherical, often enveloped in copious mucous; 65 um in diameter; wall often irregularly punctate between striae (fig. 23).

Locality: G. T. Workshop (Peshawar), Sarim No. 76, March 6, 1975.

39. *C. striolatum* Ehr. ssp. *borgei* (Borge) Krieger.

Croasdale, 1962, p. 20, pl. I, fig. 7; Scott and Prescott, 1958, p. 24, pl. I, fig. 11.

186-370 um long, (7-9 x)-22-50 um wide; w. at apex 7-13 um; 85°-95° of arc; pyrenoids 4; terminal granule 1; cell wall brown striate; 5-10 striae in 10 um; apex slightly swollen and obliquely rounded (fig. 31).

Locality: Tehkal Payan (Peshawar), Sarim No. 21, Feb. 3, 1975.

40. *C. subscoticum* Gutw.

Croasdale and Gronblad, 1964, p. 159, pl. III, fig. 20; Gronblad, 1945, p. 414, figs. 53-54

194-300 μm long, 9-13 μm -(22-27 \times) wide, apex 4-8 μm ; cell wall brown, striate, striae 9 in 10 μm ; varying from variously broken lines to rows of puncta; apex rounded truncate; pyrenoids 8 (fig. 13).

Locality: Mardan, Sarim No. 102, April 29, 1975.

41. *C. subulatum* (Kg.) De Breb.

Gronblad, 1956, p. 24, pl. I, figs. 3-4; Gronblad and Croasdale, 1971, p. 8, pl. I, fig. 12; Gronblad and Croasdale, 1964, p. 159, pl. II, fig. 9; Taylor, 1934, p. 245, pl. XLVI, fig. 6.

131 μm long, 8 μm -(16 \times) wide; w. at apex 2 μm ; outer margin 30° of arc; pyrenoids 5; (fig. 8).

Locality: Peshawar, leg. M.A.F. Faridi, Sarim No. 100, April 26, 1975.

42. *C. tumidum* Johnson.

Croasdale, 1955, p. 527, pl. VII, figs. 11-12; Gronblad and Croasdale, 1964, p. 159, pl. II, figs. 11-12; Krieger and Scott, 1957, p. 131; Irene-Marie, 1951, p. 220; Croasdale, 1962, p. 20.

162-165 μm long, (8.5-8.7 \times)-19 μm wide; w. at apex 4-5 μm , 20° - 30° of arc; pyrenoids 2-3; cell wall smooth and colourless; terminal granule 1; cell slightly curved (fig. 14).

Locality: Peshawar, Sarim No. 71, March 2, 1975.

43. *C. venus* Kg.

Croasdale and Gronblad, 1964, p. 159, pl. II, figs. 18-20; Croasdale, 1955, p. 527, pl. VI, fig. 11; Gronblad, Scott, and Croasdale, 1968, p. 12; Cook, 1963, p. 9, figs. 7, 17; Taylor, 1934, p. 246, pl. XLVI, fig. 2; Tiffany and Britton, 1951, p. 173, pl. LI, fig. 542; Taft, 1945, p. 188, pl. II, fig. 6; Irene-Marie, 1951, p. 220; Croasdale, 1962, p. 20.

50-87 μm long, 7-10.5 μm wide; apices 2.0-2.5 μm wide; 8-9 times longer than wide; strongly curved; outer margin 150° - 180° of arc; inner margin not tumid; gradually attenuated to the acute or acutely rounded apices; cell wall smooth and colourless; Chloroplast ridged; pyrenoids 2 or rarely only one; terminal vacuoles large with a number of moving granules; zygote 18-22 \times 23.6-28.5 μm , oblong, rectangular with rounded angles; shorter sides retuse, longer sides convex, inflated in the middle; often twisted, the 2 angles at one end lying in a plane at right angles to those of opposite end; zygote not secrete matrix and mature zygospore fills the conjugation tube; zygospore with 4 rounded corners extend in the parental semicell (fig. 38).

Locality: Lund Khwar (Mardan), Sarim No. 39, Feb. 18, 1975.

44. *C. venus* Kg. ssp. *croasdaeli* Croasdale

Croasdale, 1955, p. 527, pl. VI, fig. 17 (as forma a).

78-80 μm long, (7.3-7.8 x)-10-11 μm wide; w. at apex 1.8-2 μm ; 170° of arc; pyrenoids 2; cell wall smooth and colourless; terminal granules 2; strongly curved; apex acute (fig. 37).

Locality: Mardan, Sarim No. 104, April 22, 1975.

45. *C. venus* Kg. ssp. *incurvum* (Breb.) Krieger.

Taft, 1945, p. 188, pl. II, fig. 7; Irene-Marie, 1951, p. 221.

39-66 μm long, 7-12 μm wide; cell wall colourless; chloroplast with 3-4 pyrenoids; strongly curved (fig. 47).

Locality: Malmandi (Peshawar), Sarim No. 96, April 16, 1975.

46. *C. venus* Kg. ssp. *maior* Strom.

Croasdale, 1955, p. 527, pl. VI, fig. 15-16.

100-125 μm long, (6.3-6.7 x)-15-20 μm wide; w. at apex 3-4 μm ; 151°-160° of arc; pyrenoids 3-4; terminal granules 3; cell wall smooth and colourless; strongly curved (fig. 44).

Locality: Chirat, leg. M. A. F. Faridi, Sarim No. 119, March 27, 1974.

47. *C. venus* Kg. ssp. *crassum* Croasdale.

Croasdale, 1955, p. 527, pl. VI, figs. 12-14; Croasdale, 1962, p. 20.

76-92 μm long, (5-6.4 x)-13-15.5 μm wide; w. at apex 2-3 μm ; 140°-170° of arc; pyrenoids 1-5 (commonly 2); terminal granules 1-4; cell wall smooth; cell strongly curved (fig. 46).

Locality: Mardan, Sarim No. 92, April 12, 1975.

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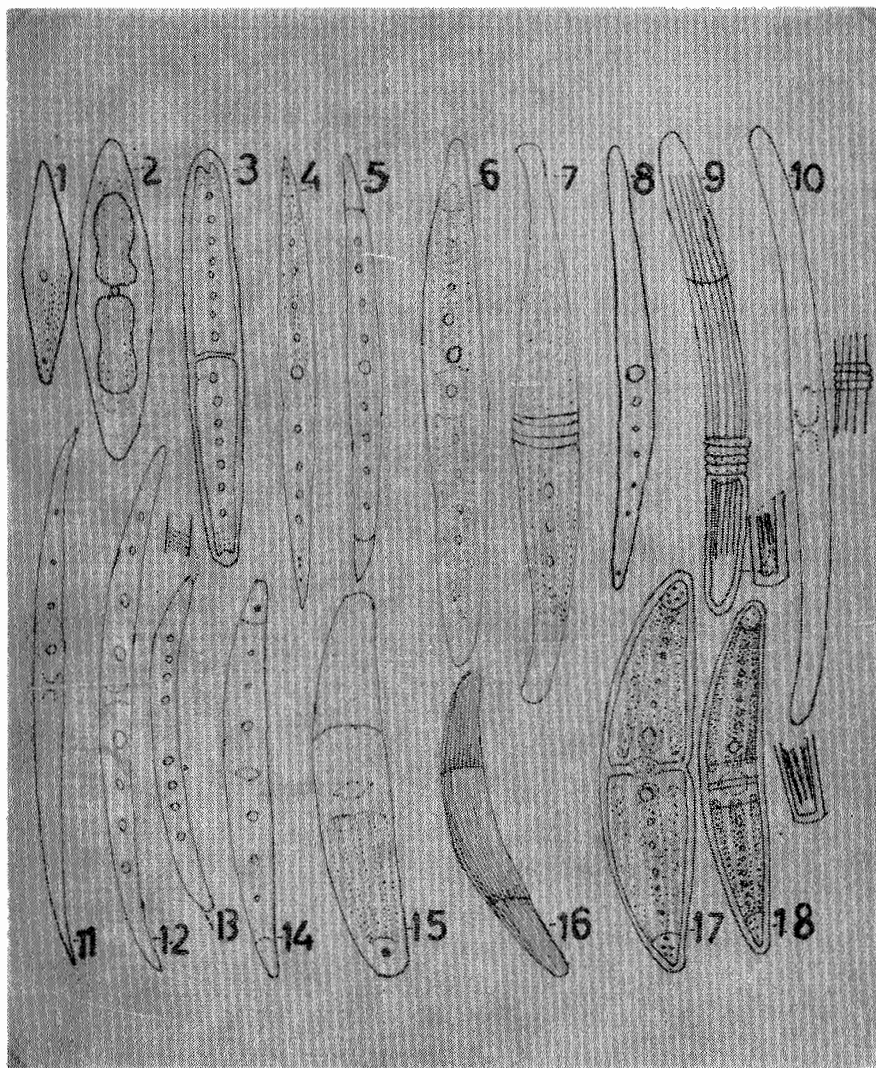


Plate I. Fig. 1, *Closterium navicula*; 2, *C. libellula* ssp. *interruptum*; 3, *C. didymotocum*; 4, *C. cornu* ssp. *croasdalei*; 5, *C. acutum*; 6, *C. acerosum* ssp. *minus*; 7, *C. elenkenii*; 8, *C. subulatum*; 9, *C. angustatum*; 10, *C. angustatum* ssp. *gracilius*; 11, *C. strigosum* ssp. *elegans*; 12, *C. cornu*; 13, *C. subscoticum*; 14, *C. tumidum*; 15, *C. abruptum* ssp. *brevius*; 16, *C. juncidum* ssp. *brevior*; 17, *C. lanceolatum*; 18, *C. acerosum*.

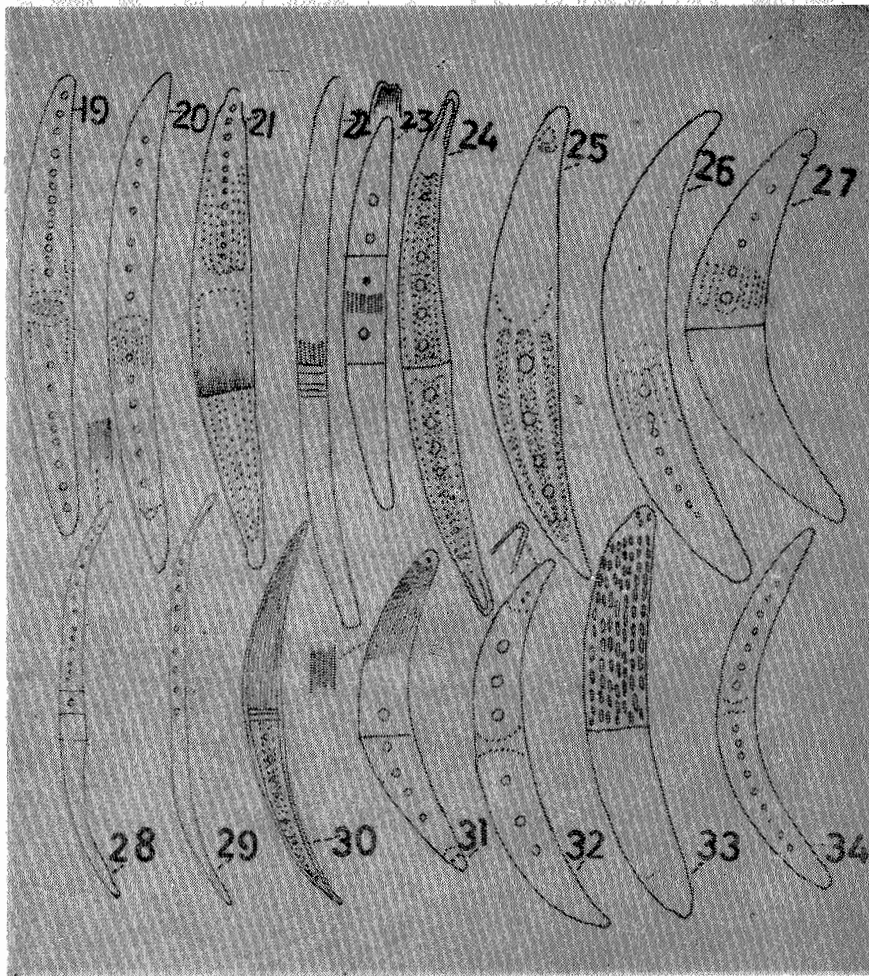


Plate II 19, *Closterium abruptum*; 20, *C. Pritchardianum* ssp. leaf; 21, *C. Pritchardianum*; 22, *C. juncidum* ssp. elongatum; 23, *C. striolatum*; 24, *C. praelongum* ssp. brevius; 25, *C. Pseudolunula*; 26, *C. acherianum*; 27, *C. diana* ssp. brevius; 28, *C. juncidum*; 29, *C. gracile*; 30, *C. intermedium*; 31, *C. striolatum* ssp. borgei; 32, *C. parvulum*; 33, *C. braunii*; 34, *C. diana* ssp. pseudodiana.

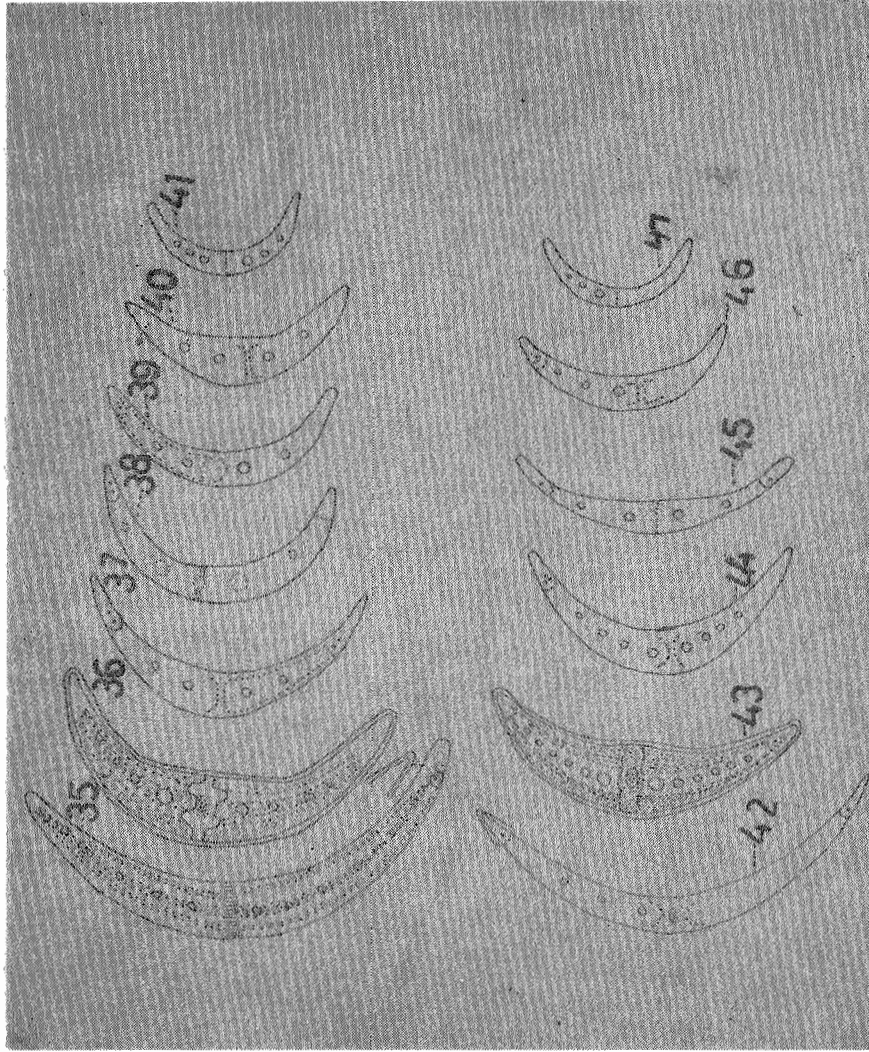


Plate III 35, *Closterium cynthia*; 36, *C. leibleinii*; 37, *C. venus* ssp. *croasdalei*; 38, *C. venus*; 39, *C. evisculatum*; 40, *C. leibleinii* ssp. *minimum*; 41, *C. incurvum*; 42, *C. dianae* ssp. *minus*; 43, *C. moniliferum*; 44, *C. venus* ssp. *maior*; 45, *C. exile*; 46, *C. venus* ssp. *crassum*; 47, *C. venus* ssp. *incurvum*.

References

- Cedercreutz, C. and R. Gronblad. 1936. Bemerkungen über einige Desmidiaceen von Åland; Soc. Scien. Fenn. Comm. Biol. 7 (2): 1—9.
- Cook, W. 1963. Variation in vegetative and sexual morphology among the small curved species of *Closterium*. Phycologia 3 (1): 1—18.
- Croasdale, H. 1955. Fresh-water of Alaska I. Some desmids from the interior part. Farlowia 4(4): 513—565.
- , 1962. Fresh-water of Alaska III. Desmids from the Cape Thompson Area. Trans. Amer. Micros. Society 81 (1): 12—42.
- , and R. Gronblad. 1964. Desmids of Labrador. Desmids of South Eastern Coastal Area: Trans. Amer. Micros. Society 83 (2): 142—212.
- Faridi, M.A.F. 1971. The genera of fresh-water algae of Pakistan and Kashmir. Biologia. 17 (2): 123—142.
- Gronblad, R. 1919. *Closterium didymotocum* Corda et *Closterium bailyanum* De Breb. Acta Soc. Pro. Fauna et Flora Fenn. 46 (5): 1—20.
- , 1943. Beiträge zur Kenntnis der Süßwasser-algen Gotlands und Olands. Soc. Scien. Fenn. Comm. Biol. 9 (2): 1—18.
- , 1945. De Algis Brasibensibus. Acta Soc. Scien. Fenn. Series B, 11 (6): 1—43.
- , 1956. Desmids from the U.S.A. collected in 1947-1949 by Dr. Hannah Croasdale and Dr. Edwin T. Mouf. Soc. Scien. Fenn. 15 (12)—38.
- , 1960. Contribution to the knowledge of the fresh-water Algae of Italy. Soc. Scien. Fenn. Comm. Biol. 22 (4): 1—85.
- , and H. Croasdale. 1971. Desmids from Namibia. Acta Bot. Fenn. 93: 1—40.
- , A.M. Scott and H. Croasdale. 1964. Desmids from Uganda and Lake Victoria. Acta Bot. Fenn. 66: 1—57.
- , A. M. Scott and H. Croasdale. 1968. Desmids from Sierra Leone. Acta Bot. Fenn. 78: 3—41.
- Irene-Marie. 1951. Desmidiées De La Région De Québec. "Le Naturaliste Canadien." Part II, 78 (7—8): 177—221.
- , 1952. Desmidiées De La Région De Québec. "Le Naturaliste Canadien." Part IV, 79: 11—45.
- Krieger, W. and A. M. Scott. 1957. Einige Desmidiaceen aus Peru. Acta Hydrobiologica, Hydrographica et Protistologica. 9 (2-3): 126—144.
- Scott, A. M. and G. W. Prescott. 1958. Some fresh-water Algae from Arnhem Land in the Northern Territory of Australia. Records of Amer. Aust. Scientific Expedition to Arnhem Land. 3: 9-136.
- Shah, S. 1974. Cosmarium in Peshawar valley. M. Sc. Thesis Botany Department, Peshawar University.
- Taft, E. C. 1945. The Desmids of the West End of Lake Erie. Ohio Journ. Science. 45 (5): 180—205.
- Taylor, W. R. 1934. The fresh water Algae of New Foundland Part I Mich. Acad. Sc. arts and letters 19: 217—278.
- Tiffany, L. H. and M. E. Britton. 1951. The Algae of Illinois, Chicago.