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 Artock 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 ............................... C. navicula
3. Pyrenoids 10 in number ............................... C. libellula ssp. interruptum

   4. Pyrenoids 3-4 in number, apex 2 um broad .............................. C. cornu ssp. croasdalei
   4. Pyrenoids 4-6 in number, apex 4-5 um broad .............................. C. acerosum ssp. minus
   4. Pyrenoids 5-10 in number, apex 13-20 um broad .............................. C. didymotocum

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 ............................... C. subscoticum
7. Cell with 10 striations, cell 8.2 um broad .............................. C. juncidum ssp. elongatum

7. Cell with 10 striations, cell 19-53 um broad .............................. C. acerosum

7. Cell with 10 striations, cell 16-31 um broad .............................. C. intermedium

8. Cell with 6-10 striations, cell 25-61 um broad .............................. C. braunii
8. Cell with 8-10 striations, cell 9-14 um broad .............................. C. juncidum ssp. brevior
8. Cell with 9-17 striations. cell 10-12 um broad .......... C. juncidum
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 ............... C. abruptum ssp. brevius
11. Pyrenoids 4 in number, cell 7.5 um broad .......... C. strigosum ssp. elegans
11. Pyrenoids 4 in number, cell 38.5-44 um broad .......... C. pseudolumula
11. Pyrenoids 4 in number, cell 6 um broad .......... C. cormi
11. Pyrenoids 5 in number, cell 28-35 um broad .......... C. cemenketti
11. Pyrenoids 5 in number, cell 8 um broad .......... C. subulatum
11. Pyrenoids 6 in number .......... C. abruptum
12. Pyrenoids 2-3 in number .......... C. tumidum
12. Pyrenoids 4-5 in number, cell 3.7-11 um broad .......... C. acutum
12. Pyrenoids 5-7 in number, cell 3 um broad .......... C. gracile
12. Pyrenoids 6-7 in number, cell 32-73 um broad .......... C. lanceolatum
12. Pyrenoids 6-7 in number, cell 30 um broad .......... C. pritchardianum ssp. leave
13. Cell 22-29 um broad .......... C. angustatum
13. Cell 8.5-10 um broad ................. C. angustatum ssp. gracilius
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° .......... C. diana ssp. brevius
17. Cell with terminal granule 1, arc 100°-125° .......... C. diana ssp. minus
17. Cell with terminal granule 1, arc 175°-200° .......... C. incurvum
17. Cell with terminal granules 2 .......... C. venus ssp. croasadeli
17. Cell with terminal granules 3, arc 151°-160° .......... C. venus ssp. major
18. Cell with terminal granules 1-4, arc 65° .......... C. diana ssp. pseudodiana
18. Cell with terminal granules 1-4, arc 140°-170° .......... C. venus ssp. crassum
19. Pyrenoids definite in number ......................... 20
19. Pyrenoids variable in number ........................................ 21
20. Cell with 2 pyrenoids, 11.7-16.8 um broad ............................... C. evisculatum
20. Cell with 2 pyrenoids, 7-10.5 um broad ................................. C. venus
21. Cell with 2-3 pyrenoids, 15-20 um broad ............................... C. leibleinii ssp. minimum
21. Cell with 3-4 pyrenoids, 7-12 um broad ................................. C. venus ssp. incurvum
21. Cell with 3-6 pyrenoids, 10.5-18 um broad ............................ C. parvulum
21. Cell with 6-7 pyrenoids, 30-68 um broad ................................ C. moniliferum
21. Cell with 3-8 pyrenoids, 17-42 um broad ............................... C. leibleinii
22. Pyrenoids definite in number ............................................. 23
22. Pyrenoids variable in number ............................................. 24
23. Cell apex truncate ...................................................... C. archerianum
23. Cell apex swollen and rounded ......................................... C. striolatum ssp. borgei
24. Cell apex curved ....................................................... C. exile
24. Cell apex bluntly rounded .............................................. C. cynthia

DESCRIPTION OF THE SPECIES

1. Closterium abruptum West.

Taylor, 1934, p. 242, pl. XLVI, fig. 9; Cedercreuts and Gronblad, 1936, p.1, pl. 1, figs. 2-3; Irenée-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).


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


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).


3. C. acerosum (Shrank) Ehr.

Tiffany and Britton, 1951, p. 169, pl. LII, fig. 550; Croasdale, 1955, p. 521, pl. VII, fig. 1; Scott and Prescoít, 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 4-5 um 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.

   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 turgid; pyrenoids 4-6; cell wall smooth; apex evenly tapered and rounded, not recurved. (fig. 6).


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


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 turgid; 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 x 23-49 um, oblong to rectangular; sides concave or slightly convex; ends concave; angles produced into conical projections (fig. 5).

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

6. *C. angustatum* Kg.


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).


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

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


Tiffany and Britton, 1951, p. 176, pl. L1, fig. 541.

450-800 μm long, 25-61 μm 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.


141 μm 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).


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


Cellulae 160-200 um long, 7.2-11 um lat. (16.3-22 x); apex 2 um lat.; cellula recta; apex aequo attenuate ad truncatum; pyrenoids 3-4; granula terminalia 3 vel nulla; membrane 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).

12. *C. cynthia* De Not.


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).


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).


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).


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; Irenée-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.

Taylor, 1934, p. 243, pl. XLY fig. 19; Krieger and Scott, 1957, p. 130, pl. 1, fig. 2; Tiffany and Britton, 1951, p. 169, pl. 52, fig. 560; Gronblad, 1919, p. 7.

295-672 um long, 24-56 um wide; apices 13-20 um 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 an 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).


17. *C. elenkenii* Kossinskaja.

Croasdale, 1962, p. 18, pl. 11, figs. 22-23.

195-250 um long, (6.7-8.3 x)-28-35 um wide; apex 8-9 um; 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. rafalsii* 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).


18. *C. evisculatum* Cook.

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

63-124 um long, 11.7-16.8 um wide; outer margin evenly curved; 130°-180° of arc; inner margin concave or slightly tumid; apex acutely rounded, 3 um 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 mucilageous with a definite wall not persisting; zygospores spherical, 23.3-33 um 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: Nawar Kali (Mardan), Sarim No. 50, Feb. 18, 1975.

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

Croasdale, 1962, p. 19, pl. 11, fig. 27; Gronblad, 1960: p. 34, pl. 1, 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; Ireneec-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 (unusually 2); terminal granule 1; cell wall smooth, colourless; cell strongly curved; zygospore spherical (fig. 41).


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; Ireneec-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 median 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).


23. C. junctidum Ralfs.

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).


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 striaions; 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).


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

350 μm long, 8.2 μm-(42.7 x) wide; w. at apex 5 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.


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°-55° 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).


27. *C. leibleinii* Kg.


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 subgbose, 40-50 μm in diameter, smooth (fig. 36).

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

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

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

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


   Scott and Prescott, 1958, p. 24, pl. 1, fig. 6; Irene-Marie, 1951, p. 215.

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


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. 1, fig. 4; Gronblad, 1960, p. 34, pl. I, fig. 4.

   188-420 μm long, 30-68 μm wide; apices 8-13 μm 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* (Brebr.) 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. 1, fig. 5; Croasdale and Gronblad, 1964, p. 157.

   47-86 μm long, (3.9-4.9 x)12-17.5 μm wide; w. at apex 5-6.5 μm; 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.


92-140 um long, (7-11 x)-10.5-18 um wide; w. at apex 2-3 um; 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, 26-34.5 x 30-40 um; apical nodules on cell apices: the surface of the plastid irregular and well defined longi tudinal ridges present; cell with conjugation tube persisting (fig. 32).

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


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


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. VII, fig. 554; Irenee-Marie, 1951, p. 217; Croasdale, 1962, p. 19.

350-670 um long, 21-55 um wide; 12-17 times longer than wide; apices 7-12 um 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 um in diameter (fig. 21).


35. *C. pritchardianum* Arch. ssp. *leave* Hughes.


330-525 um long, (11-17.5 x)-30 um wide; w. at apex 8-9 um; 20°-35° of arc; apex abruptly tapered, somewhat recurved; pyrenoids 6-7; cell wall smooth and s
ourless with or without a median girdle; inner margin slightly concave; zygote spherical; terminal vacuoles with many moving granules (fig. 20).


36. *C. pseudolunula* Borge.


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


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

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


38. *C. striolatum* Ehr.

Croasdale and Gronblad, 1964, p. 158, pl. IV, figs. 5-6; Tiffany and Britton, 1951, p. 170; pl. LII, 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 µm long, (5.5-13.4 x)-20-40 µm wide; apex 8-16 µm; 52°-72° of arc; striae 14-21 across the cell; 8-12 times longer than wide; moderately curved; outer 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 µm in diameter; wall often irregularly punctate between striae (fig. 23).

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


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

186-370 µm long, (7-9 x)-22-50 µm wide; w. at apex 7-13 µm; 85°-95° of arc; pyrenoids 4; terminal granule 1; cell wall brown striate; 5-10 striae in 10 µm; 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 um long, 9-13 um-(22-27 x) wide, apex 4-8 um; cell wall brown, striate. striate 9 in 10 um; varying from various 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. 1. figs. 3-4; Gronblad and Croasdale, 1971, p. 8, pl.1, fig. 12: Gronblad and Croasdale, 1964, p. 159, pl. II, fig. 9: Taylor, 1934, p. 245, pl. XLVI, fig. 6.

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


42. *C. tumidum* Johnson.


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


43. *C. venus* Kg.


50-87 um long, 7-05.5 um wide; apices 2.0-2.5 um 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 x 23.6-28.5 um, oblong, rectangular with rounded angles; shorter sides fuse. 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).

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).


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).


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


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 III  35, Closterium cynthia; 36, C. leibleinii; 37, C. venus ssp. croasdalei; 38, C. venus; 39, C. evisiculatum; 40, C. leibleinii ssp. minimum; 41, C. incurvum; 42, C. diana ssp. minus; 43, C. moniliferum; 44, C. venus ssp. major; 45, C. exile; 46, C. venus ssp. crassum; 47, C. venus ssp. incurvum.
References


