ZYGOSPORE FORMATION IN SOME DESMIDS OF GUJARAT, INDIA

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Abstract

The paper deals with zygospore formation in desmids in nature, collected from the different localities in Gujarat. The zygospores of 49 taxa, 2 of *Mesotaenium*, 2 of *Gonatozygon*, 4 of *Closterium*, 3 of *Pleurotaenium*, 5 of *Euastrum*, 2 of *Micrasterias*, 4 of *Actinotaenium*, 25 of *Cosmarium* and 2 of *Xanthidium*, have been described in detail.

Introduction

The literature on zygospore formation in desmids is very meagure particularly from India (Ramanathan, 1962; Bharati, 1971; Hegde & Bharati, 1980). Zygospores in 6 taxa of *Closterium*, 3 of *Staurasturm* and one each of *Triplastrum* and *Streptonema* have been described from Gujarat (Patel & Asoka Kumar, 1979, 1980, 1981; Patel, 1980).

During the extensive study of desmids, the authors observed the zygospore formation in number of collections made from different localities in Gujarat, particularly the collections made from Gamdi and Harni near Baroda were rich showing many genera in zygospore formation. Present paper includes the zygospore formation in 54 taxa belonging to 9 genera i.e. *Mesotaenium*, *Gonatozygon*, *Closterium*, *Pleurotaenium*, *Euastrum*, *Micrasterias*, *Actinotaenium*, *Cosmarium* and *Xanthidium*. Zygospores of a few new forms are also described here; the description of new taxa will be published separately.

Systematic description

MESOTAENIUM Nägeli, 1849

1. *M. caldariorum* (Lagerh.) Hansg. forma
Figs. 1-6

Zygospores completely filling the gametangia; spherical, ellipsoid or quadrate; wall with minute papillae, thick and hyaline, dimension 27-38 μm.

Occurrence—On wet bricks near river side, Balaram.

Taft (1937) reported the papillate projections on the spore walls of *M. apalnosporum* Taft. Involucrate wall has been described for *M. chlamydosporum* fa. *minor* (West & West, 1904).

2. *M. endlicherianum* Nägeli forma
Figs. 7-13

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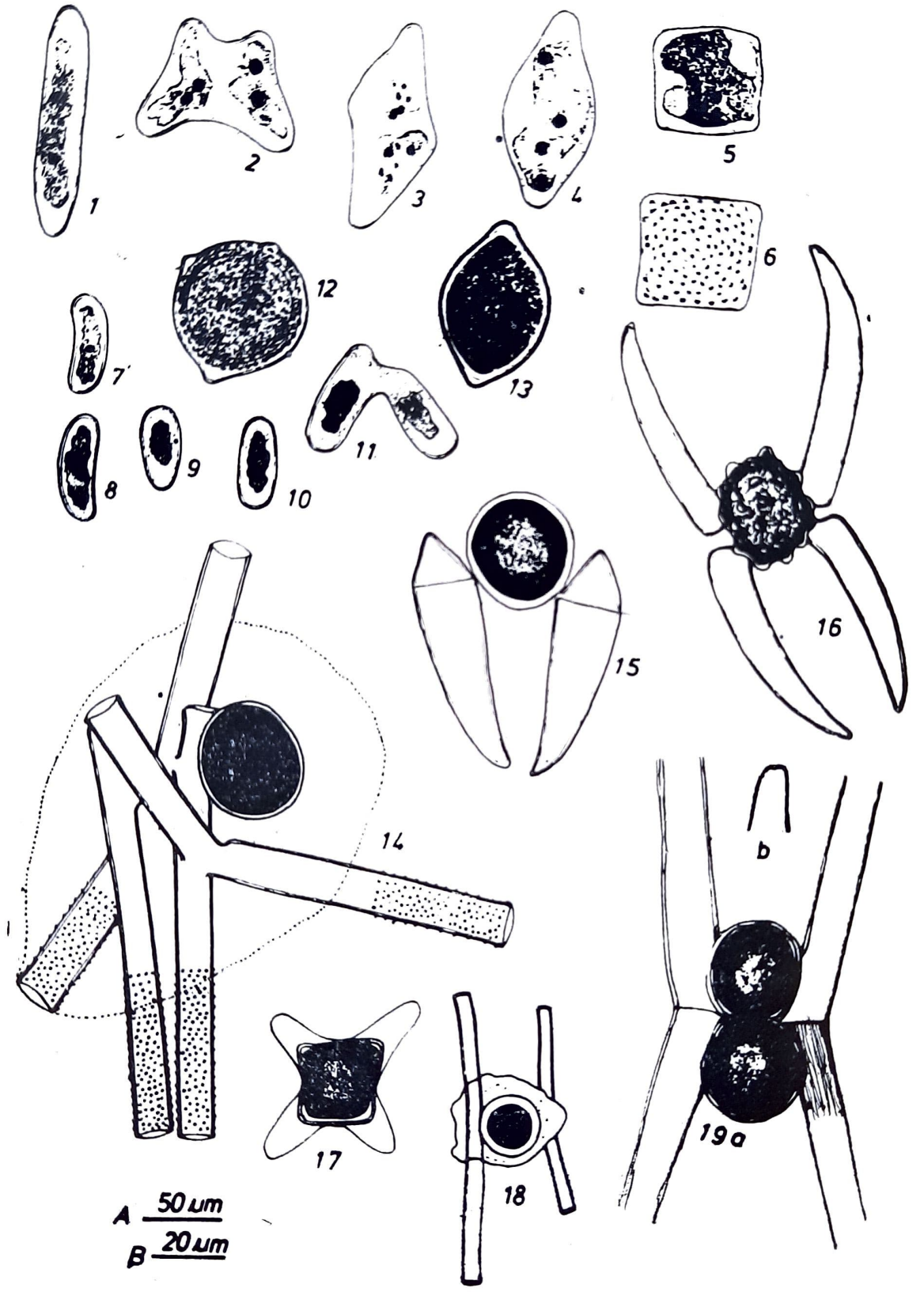


Figs. 1-19—Figs. 1-6. *Mesotaenium caldariorum* (Lagerh.) Hansg. forma; Figs. 7-13. *M. endlicherianum* Nägeli forma; Fig. 14. *Gonatozygon monotaenium* De Bary; Fig. 15. *Closterium ehrenbergii* Menegh; Fig. 16. *Cl. calosporum* Wittrock; Fig. 17. *Cl. navicula* (Breb.) Lutkem. var. *navicula* Scott *et al.*; Fig. 18 *Gonatozygon monotaenium* De Bary var. *pillosellum* Nordst.; Fig. 19a, b *Cl. lineatum* Ehrenb.
(Scale bars A-Figs. 15-16, 18-20; B-Figs. 1-14, 17)

Zygospores completely filling the gametangia; spherical or very rarely ellipsoid; spore wall with irregular minute papillae, 20-38 μm in diameter.

GONATOZYGON De Bary, 1856

3. *G. monotaenium* De Bary
Fig. 14

Zygospore globose; wall smooth and thick, zygospore and part of the conjugating cells enclosed in a mucilage envelope. One tetraploid, 26-33 μm in diameter.

Occurrence—Roadside ditches, Gamdi.

Spherical zygospores have also been reported by the previous workers (cf. West & West, 1904).

4. *G. monotaenium* De Bary var. *pillosellum* Nordst.
Fig. 18

Zygospore globose; wall thick, smooth; mid region of the conjugating cells and zygospore enclosed in a mucilage envelope, 30 μm in diameter.

CLOSTERIUM Nitzsch, 1817

5. *Cl. calosporum* Wittrock
Fig. 16

Zygospore depressed, globose with large number of conical warts, diameter with warts 75 μm and without warts 60 μm.

Occurrence—Harni pond, Harni.

Zygospores with lesser dimensions have also been described by West and West (1904) and Krieger (1935).

6. *Cl. ehrenbergii* Menegh.
Fig. 15

Conjugation between recently dividing cells. Zygospore formed in a round gelatinous envelope; spherical, wall thick, smooth, 64 μm in diameter.

Occurrence—Pond at Lunawada.

7. *Cl. lineatum* Ehrenberg
Fig. 19

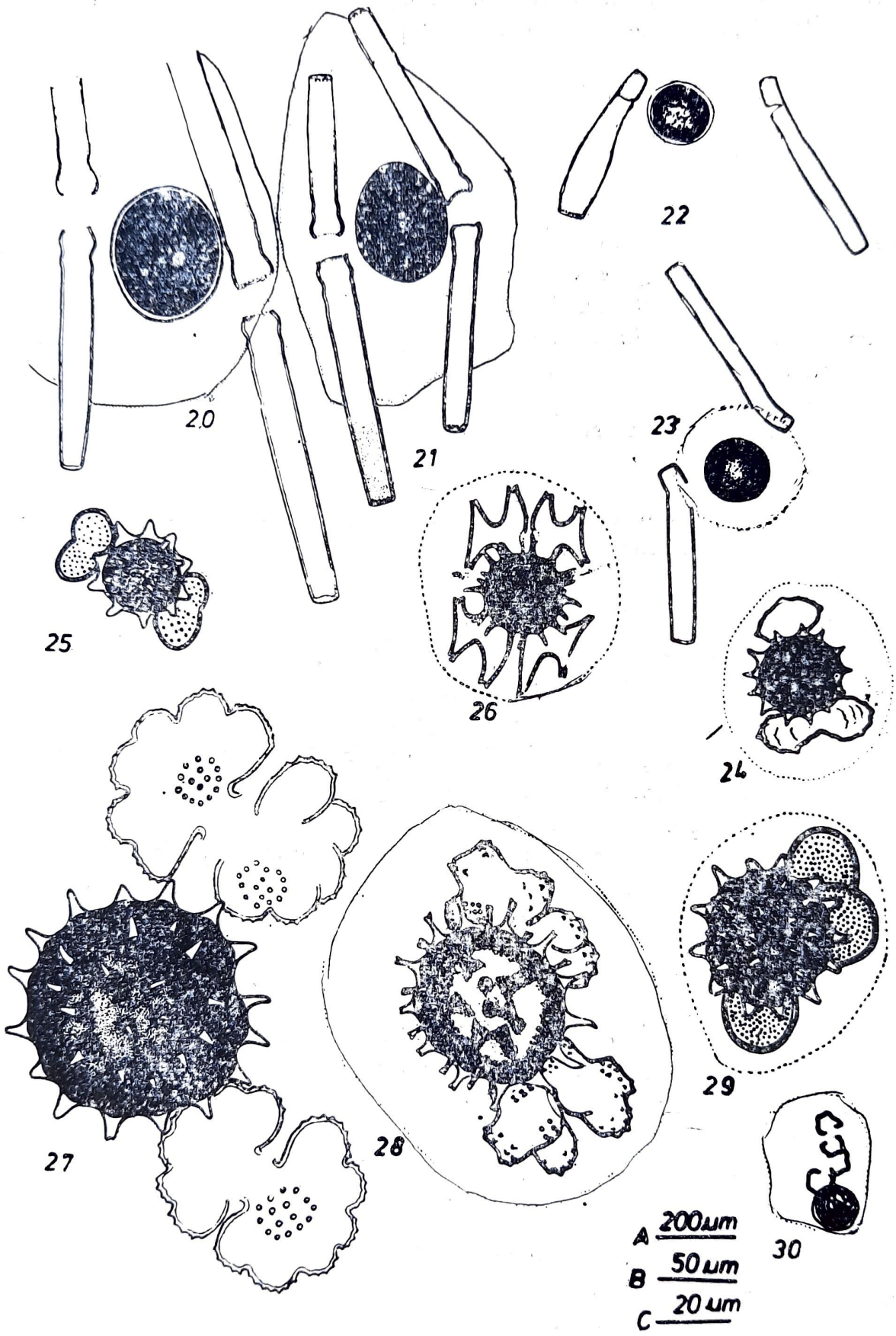
Zygospores double between two conjugating cells; globose to ovoid; wall thick, smooth, 53.5-56 μm in diameter.

Occurrence—Harni pond, Harni.

8. *Cl. navicula* (Bréb.) Lutkem. var. *navicula* Scott, Gronblad *et* Cröasdale
Fig. 17

Zygospore subquadrate with produced angles; wall thick, smooth; empty semicells attached to the produced angles, 20-22 μm in dimension.

Occurrence—Pond at Ankleshwar.



Figs. 20-30—Fig. 20. *Pleurotaenium trabecula* (Ehrenb.) Nageli; Fig. 21. *P. ehrenbergii* (Breb.) De Bary; Figs. 22-23. *P. wallichianum* (Turner) Krieger fa. *elongatum* Bicudo; Fig. 24. *Euastrum denticulatum* (Kricbn.) Gay var. *quadrifarium* Krieger; Fig. 25. *Actinotaenium* sp.; Fig. 26. *Micrasterias pinnatifida* (Kuetz.) Ralfs; Fig. 27. *Euastrum spinulosum* Delponte; Fig. 28. *E. platycerum* Reinsch; Fig. 29. *Actinotaenium cucurbita* (Bréb.) Teiling; Fig. 30. *Euastrum lutkemulleri* Ducellier.

(Scale bars; A-Figs. 22-23; B-Figs. 20, 21, 26, 30; C-24, 25, 27-29)

PLEUROTAENIUM Nägeli, 1849

9. *P. ehrenbergii* (Bréb) De Bary
Fig. 21

Zygospore ovoid or broadly ellipsoid with smooth wall; most part of the conjugating cells and zygospore enclosed in a mucilage envelope, dimension 56.5 ×66.0 μm.

Occurrence—Harni Pond, Harni.

10. *P. trabecula* (Ehrenb.) Nägeli
Fig. 20

Zygospore globose; wall thick, smooth; zygospore and part of the conjugating cells enclosed in a mucilage envelope, dimension 64-67 μm.

Occurrence—Harni Pond, Harni.

11. *P. wallichianum* (Turner) Krieger fa. *elongatum* Bicudo
Figs. 22, 23

Zygospore spherical; wall thick, smooth; enclosed in a mucilaginous envelope, dimension 143 μm.

Occurrence—Harni Pond, Harni.

The mode of conjugation is similar to the species described earlier by Ramanathan (1962).

EUASTRUM Ehrenberg, 1832

12. *E. denticulatum* (Kirchn.) Gay var. *quadrifarium* Krieger
Fig. 24

Zygospore spherical with a large number of small thick spines; conjugating cells at right angles to each other, enclosed in a mucilage envelope, dimension with spines 28 μm and without spines 25 μm.

Occurrence—Harni Pond, Harni.

13. *E. elegans* (Bréb.) Kuetz. var. *compactum* (Wolle) Krieger
Fig. 57

Zygospore spherical with mamillate projections from each of which 2-3 very small spines arise; conjugating cells at right angles to each other, dimension with spines 25 μm and without spines 20 μm.

Occurrence—Pond at Lunawada.

The ornamentation of the zygospore differs from that described by Kossinskaja (1960). He described the zygospore as having spherical margins with long and stout spines arising singly.

14. *E. lutkemulleri* Ducellier
Fig. 30

Zygospore globose, smooth walled; conjugating cells enclosed in a mucilage envelope, dimension 26 μm.

Occurrence—Koad side ditches, Gamdi.

This might be an immature one because smooth-walled zygospores are quite unusual for the genus.

15. *E. platycerum* Reinsch
Fig. 28

Zygospore spherical with a number of spines, usually bi-or quadrifurcated at the tip; conjugating cells and zygospore enclosed in a mucilage envelope, dimension with spines 44-50 μm and without spines 32-40 μm.

Occurrence—Harni Pond, Harni.

16. *E. spinulosum* Delponte
Fig. 27

Zygospore spherical with number of stout spines, very rarely bifurcated at the tip, dimension with spines 69 μm and without spines 55 μm.

Occurrence—Harni Pond, Harni.

Spherical zygospores with slender and narrow spines, which are bifurcated at the tip, have been reported by Kossinskaja (1960).

MICRASTERIAS Agardh, 1827

17. *M. pinnatifida* (Kuetz.) Ralfs
Fig. 26

Zygospore spherical with a number of long sharp spines; conjugating cells at right angles to each other enclosed in a mucilage envelope, dimension with spines 69-70 μm and without spines 45-60 μm.

Occurrence—Harni Pond, Harni.

18. *M. tropica* Nordstedt
Fig. 31

Zygospore spherical with a number of long spines, branched at the tips; conjugating cells at right angles to each other, enclosed in a mucilage envelope; dimension with spines 87.5 μm and without spines 48.6 μm.

Occurrence—Pond at Lunawada.

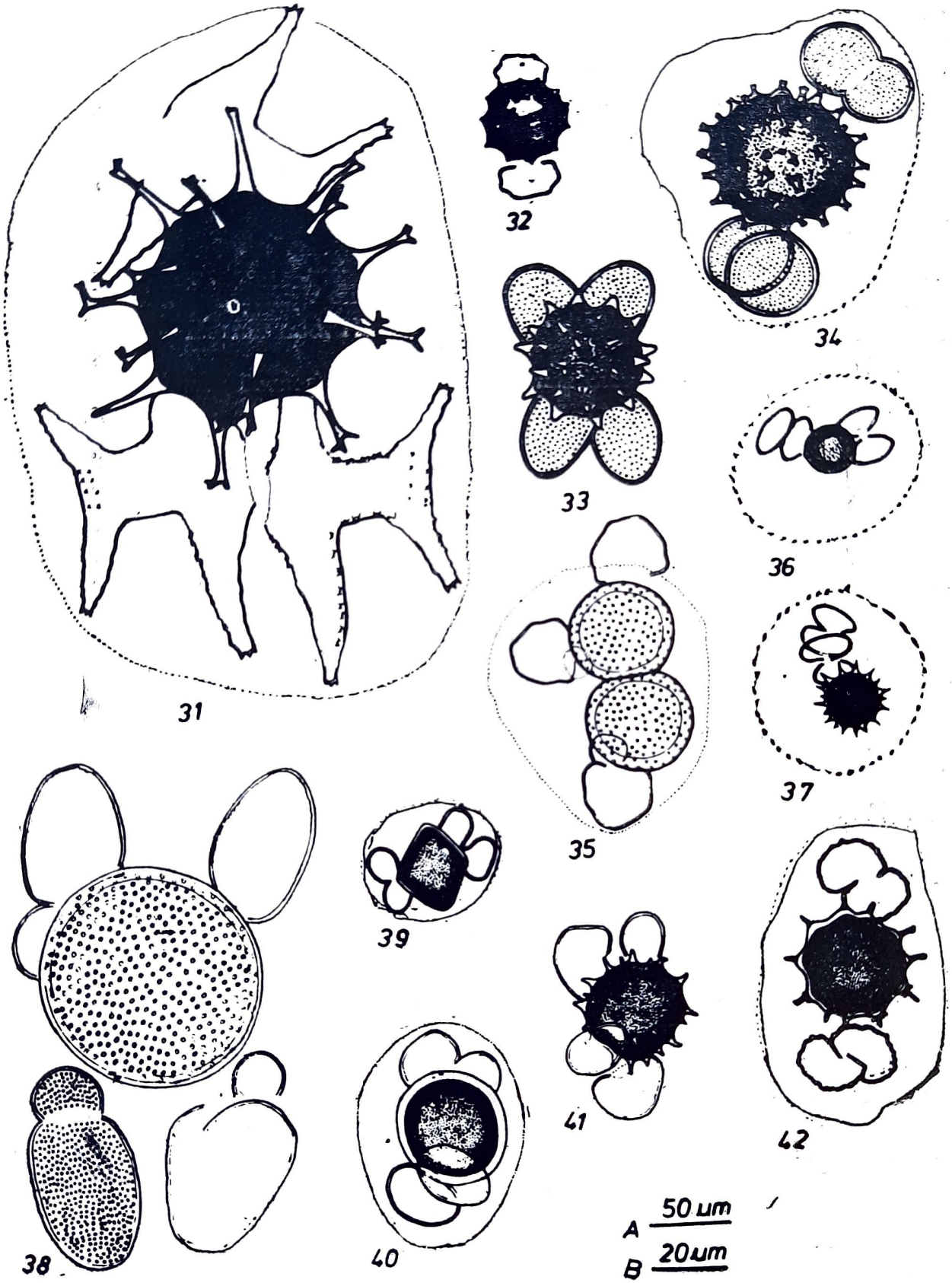
ACTINOTAENIUM Teiling, 1954

19. *A. cucurbita* (Bréb.) Teiling
Fig. 29

Zygospore spherical with thick blunt spines, conjugating cells enclosed in a mucilage envelope, dimension with spines 34-39 μm and without spines 29-31 μm.

Occurrence—Harni Pond, Harni.

Grönbland *et al.* (1968) have shown irregularly elongate pitted zygospore for one of the varieties of *A. cucurbita* but certainly that dose not belong to this species. Smooth-walled zygospores have been reported for var. *cucurbita* by Skuja (1964). However, we feel that smooth-walled zygospores are very unlikely for this genus. He might have observed the immature ones.



Figs. 31-42—Fig. 31. *Micrasterias tropica* Nordst.; Fig. 32. *Cosmarium regnellii* Wille var. *chondrophorum* Skuja; Fig. 33. *Actinotaenium cucurbita* (Bréb.) Teiling var. *attenuatum* (West) Teiling; Fig. 34. *A. globosum* (Bulnh.) Teiling; Fig. 35. *Cosmarium bengalense* Turner fa. Saxena & Venkateswarlu; Figs. 36-37. *C. apertum* Turner; Fig. 38. *C. bengalense* Turner var. *generosum* Hinode; Fig. 39. *C. bioculatum* Brebission; Fig. 40. *C. contractum* Kirchner; Fig. 41. *C. circulare* Reinsch; Fig. 42. *C. blyttii* Wille var. *australianum* Schmidle (Scale bars : A-Figs. 35-37, 41; B-31-34, 38-40, 42).

20. *A. cucurbita* (Bréb.) Teiling var. *attenuatum* (West) Teiling
Fig. 33

Zygospores similar to that of the earlier described species. Dimension with spines 34 μm and without spines 27-31 μm.

Occurrence—Harni Pond, Harni.

Skuja (1949) recorded smooth-walled zygospores for *Cosmarium cucurbita* var. *attenuatum*.

21. *A. globosum* (Bulnh.) Teiling
Fig. 34

Zygospore spherical with a number of mamillate projections from which bifurcated spines arise. Spines originating from a small protrusion bearing probably 3-4 pointed structures, dimension with projections 38 μm and without projections 33-34 μm.

Occurrence—Ditches, Rajpipla.

The zygospores of this species are quite interesting because of furcated spines. Such spiny zygospores are characteristic of some species of *Cosmarium*.

22. *Actinotaenium* sp.
Fig. 25

Zygospore with thick, stout blunt spines, dimension with spines 26 μm, dimension without spines 21 μm.

Occurrence—Harni Pond, Harni.

The cells resemble those of *A. globosum* var. *minor*. It can also be compared with *A. subtile* var. *majus* var. nov. (Asoka Kumar, 1972). However, it was difficult to assign it to any particular species because of very limited specimens.

COSMARIUM Corda, 1834

23. *C. apertum* Turner
Figs. 36-37

Zygospores spherical with long sharp spines, dimension with spines 35-40 μm and dimension without spines 29-31 μm.

Occurrence—Road side ditches, Gamdi.

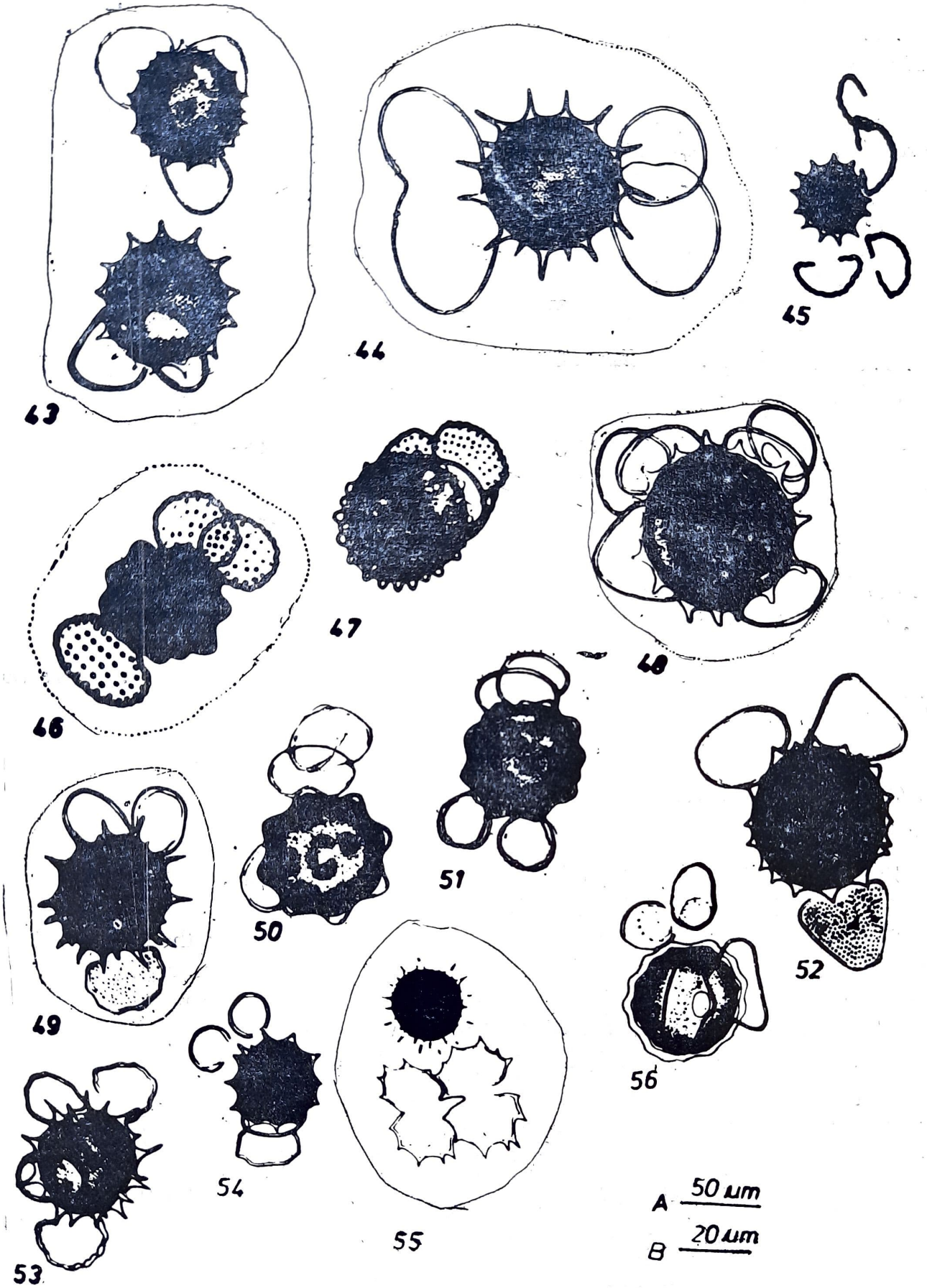
Hegde and Bharati (1980) have reported smooth-walled zygospores for *C. depressum* var. *apertum*. Smooth-walled zygospores have been observed but they were immature.

24. *C. bengalense* Turner fa. Saxena & Venkateswarlu
Fig. 35

Zygospore and azygospore spherical, spore wall thick, scrobiculate, dimension of zygospore and azygospore 56 μm, scrobiculations 2-4 μm in diameter.

Occurrence—Harni Pond, Harni.

References to zygospores with scrobiculate walls are rare in the literature. Taft (1945) showed one for *Cylindrocystis splendida* and Grönbland *et al.* (1968) for *Actinotaenium cucurbita*. Recently Hegde and Bharati (1980) reported spherical and smooth-walled and smaller zygospores for *C. bengalense* Turner. They might have observed immature ones.



Figs. 43-56—Figs. 43, 48. *Cosmarium granulatum* Bréb. Fig. 43. showing zygospore and azygospore; Fig. 48. showing triploid zygospore; Fig. 44. *C. panduriforme* Turner; Fig. 45. *C. cyclicum* Lund.; Figs. 46-47. *C. portianum* Archer; Fig. 49. *C. impressulum* Elfving var. *crenulatum* (Näg.) Krieger *et* Gerloff; Fig. 50. *C. sexangulare* Lund.; Fig. 51. *C. sexangulare* Lund. var. *minus* Roy *et* Bisset; Fig. 52. *C. granulatum* Breb. var. *pyramidale* Schmidle; Fig. 53. *C. impressulum* Elfving; Fig. 45. *C. regnellii* Wille; Fig. 55. *Xanthidium criusitatum* Bréb. var. *uncianatum* Bréb.; Fig. 56. *Cosmarium wittrockii* Lund. var. *quasidepressum* Skuja. (Scale bars : A-Figs. 45, 55; B-43-44; 46-54, 56).

25. *C. bengalense* Turner var. *generosum* Hinode
Fig. 38

Zygospore spherical, spore wall scrobiculate, dimension 52 μm. Only tetraploid zygospore has been observed. The wall is with close scrobiculations.

26. *C. bioculatum* Brébission
Fig. 39

Zygospore quadrate or trapezoid, smooth-walled, dimension 14×16 μm.
Occurrence—Gangda Pond, Valavao.

27. *C. blyttii* Wille var. *australianum* Schmidle
Fig. 42

Zygospore spherical with a large number of mamillate projections, each with a long spine, spine simple or bifurcated at the tip, dimension with spines 34.5 μm and without spines 24 μm.
Occurrence—Road side ditches, Gamdi.

28. *C. circulare* Reinsch
Fig. 41

Zygospore spherical with about 10-12 stout blunt spines at periphery. Spore wall thick, dimension with spines 64-66 μm and without spines 50-52 μm.
Occurrence—Harni Pond, Harni.

29. *C. contractum* Kirchner
Fig. 40

Zygospore globose, smooth, thick-walled, dimension 27.5 μm.
Occurrence—Kanka Pond, Lunawada.
Spherical and smooth-walled zygospore has been described for the species (Skuja, 1949). Bicudo (1969) reported globose, ellipsoid and angular zygospores. Hegde and Bharati (1980) collected triangular ones. While they have described smooth-walled zygospores for *C. contractum* var. *ellipsoideum* (Elfv.) West & West. Triangular zygospore (Hegde and Bharati, 1980, Pl. 1, Fig. 4) seems to be immature.

30. *C. cyclicum* Lund.
Fig. 45

Zygospore spherical with spines, dimension with spines 58 μm and without spines 47 μm.
Occurrence—Road side ditches, Gamdi.

31. *C. divergense* Krieger
Fig. 58

Zygospore spherical with a large number of mamillate projections, each with two small spines, dimension with spines 28 μm and without spines 25 μm.
Occurrence—Harni Pond, Harni.

32. *C. granulatum* Brébission
Figs. 43, 48

Zygospores and azygospores spherical with a large number of spines; conjugating cells enclosed in a mucilage envelope, dimension with spines 38-43 μm and without spines 32-35.5 μm.

Occurrence—Tiskari Pond, Dharampur; Harni Pond, Harni.

Hegde and Bharati (1980) have shown smooth-walled (immature?) zygospore for this species. Figure 43 shows zygospore and azygospore and Figure 48 shows triploid zygospore.

33. *C. granulatum* Bréb. var. *pyramidale* Schmidle
Fig. 52

Zygospore similar to that of the type species, dimension with spines 40 μm and without spines 36.8 μm.

Occurrence—Harni Pond, Harni.

34. *C. impressulum* Elfving
Fig. 53

Zygospore spherical with long sharp spines, dimension with spines 34-36 μm and without spines 27.5-29 μm.

Occurrence—Harni Pond, Harni.

35. *C. impressulum* Elfving var. *crenulatum* (Näg.) Krieger *et* Gerioff
Fig. 49

Zygospore similar to that of the type species, dimension with spines 37 μm and without spines 27 μm.

Occurrence—Harni Pond, Harni.

36. *C. libongense* West *et* West
Fig. 62

Zygospore spherical with large number of long spines, bifurcated at the tips, base of the spines broader, dimension with spines 50 μm and without spines 35 μm.

Occurrence—Harni Pond, Harni.

37. *C. lundellii* Delponte var. *sinense* Krieger *et* Gerloff forma
Fig. 63

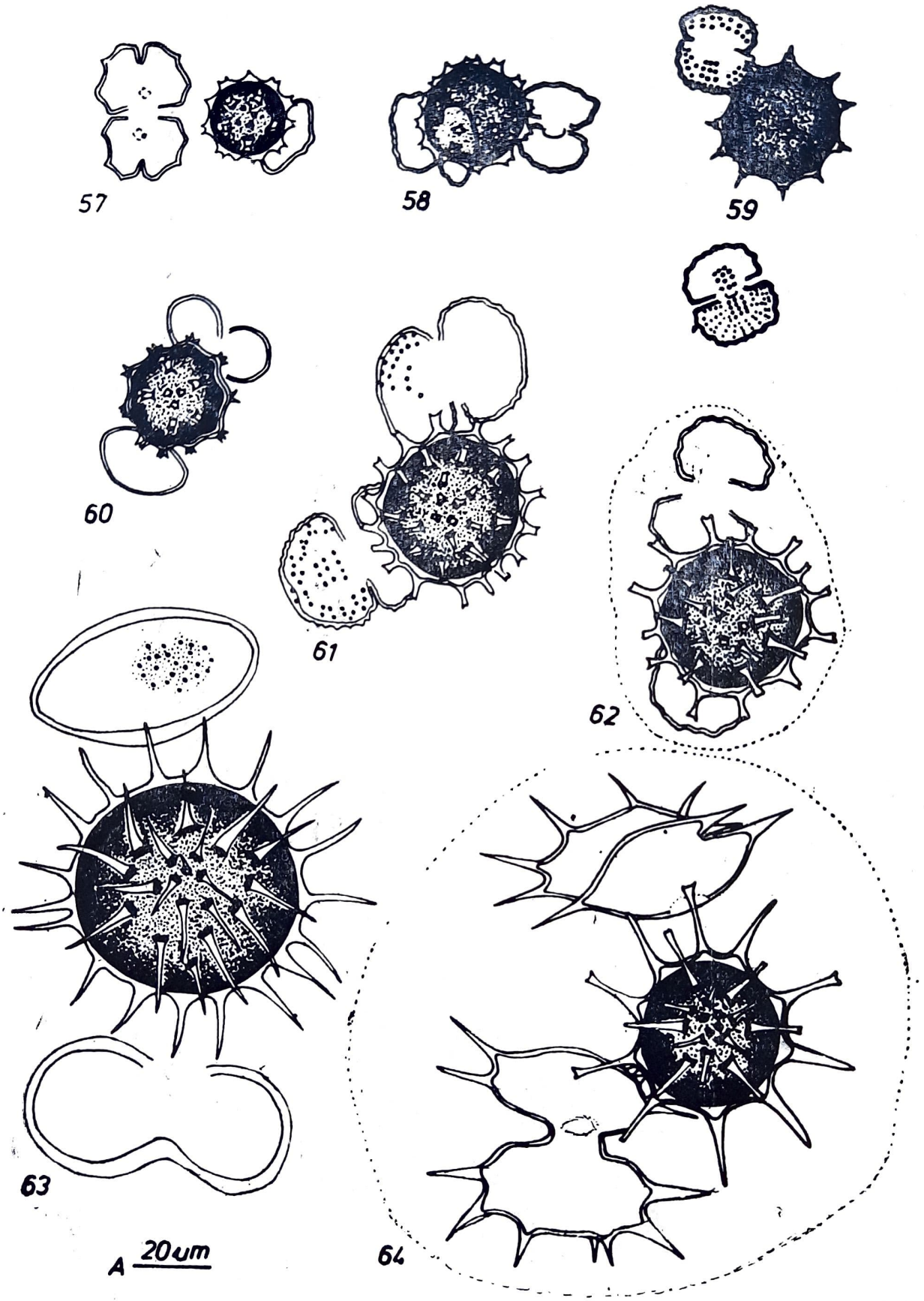
Zygospore spherical with large number of long sharp spines, demension with spines 84 μm and without spines 53 μm.

Occurrence—Pond at Lunawada.

38. *C. panduriforme* Turner
Fig. 44

Zygospore spherical with a large number of thick sharp spines, dimension with spines 47 μm and without spines 34 μm.

Occurrence—Harni Pond, Harni.



Figs. 57-64—Fig. 57. *Euastrum elegans* (Bréb.) Kuetz. var. *compactum* (Wolle) Krieger; Fig. 58. *Cosmarium divergense* Krieger; Fig. 59. *C. subcostatum* Nordst. fa. Krieger.; Fig. 60. *C. undulatum* Corda var. *minutum* forma; Fig.61. *C. punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Borg.; Fig. 62. *C. libonese* West & West; Fig. 63. *C. lundellii* Delponte var. *sinense* Krieger *et* Gerloff forma; Fig. 64. *Xanthidium hastiferum* Turner var. *javanicum* fa. *planum* Turner (Scale bars : A-Figs. 57-64)

39. *C. portianum* Archer
Figs. 46-47

Two types of zygospores, spherical with large number of conical blunt projections and polygonal with pointed projections, dimension with conical projections 34 μm, dimension without conical projections 29 μm, dimension of polygonal zygospore with angles 31 μm and without angles 25 μm.

Occurrence—Harni Pond, Harni; Road side ditches, Lambhvel.

Skŭja (1949) recorded two types of zygospores, one with polygonal shape and the other with spines. But Lenzenweger (1969) described zygospores with blunt conical spines. Bharati (1971) also reported globose zygospore with conical papillae.

40. *C. punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Borg.
Fig. 61

Zygospore spherical with a large number of thick short spines, bifurcated at the tip, dimension with spines 40.5 μm and without spines 35 μm.

Occurrence—Harni Pond, Harni.

41. *C. regnellii* Wille
Fig. 54

Zygospore spherical with small sharp spines, dimension with spines 23 μm and without spines 19 μm.

Occurrence—Harni Pond, Harni.

Hegde and Bharati (1980) have reported spherical smooth-walled zygospores.

42. *C. regnellii* Wille var. *chondrophorum* Skuja
Fig. 32

Zygospore spherical with small raised mounts, each with a small sharp papilla, dimension with papillae 21 μm.

Occurrence—Harni Pond, Harni.

43. *C. sexangulare* Lundell
Fig. 50

Zygospore spherical with mamillate projections, thick-walled, dimension of zygospore 33 μm.

Occurrence—Harni Pond, Harni.

44. *C. sexangulare* Lund. var. *minus* Roy *et* Bisset
Fig. 51

Zygospore similar to that of the species, dimension 32-34 μm.

Occurrence—Harni Pond, Harni.

45. *C. subcostatum* Nordstedt fa. Krieger
Fig. 59

Zygospore spherical with mamillate projections, each bearing a small slender spine;

about 3-5 very small spiny granules at the base of each spine in circle; dimension with spines 31.6 μm and without spines 27 μm.

Occurrence—Harni Pond, Harni.

46. *C. undulatum* Corda var. *minutum* forma
Fig. 60

Zygospore spherical with mamillate projections, each with 3-4 small spines, dimension with spines 27-29 μm and without spines 25.5 μm.

Occurrence—Road side ditches, Bhavanagar.

47. *C. wittrockii* Lund. var. *quasiderpressum* Skuja fa.
Fig. 56

Zygospore depressed globose, crenate, thick-walled, dimension 34 μm.

Occurrence—Pond at Tuwa.

XANTHIDIUM Ehrenberg, 1834

48. *X. cristatum* Bréb. var. *uncianatum* Bréb.
Fig. 55

Zygospore spherical with long, slender, unbranched spines, dimension with spines 64 μm and without spines 38 μm.

Occurrence—Pond at Lunawada.

Reinsch (cf. West & West, 1912) described zygospore of *X. cristatum* as having thick and emarginate spines. Ramanathan (1962) showed slender, elongate and bifurcated spines.

49. *X. hastiferum* Turner var. *javanicum* fa. *planum* Turner
Fig. 64.

Zygospore spherical with long simple or bifurcated spines, dimension with spines 69.6 μm and without spines 35.6 μm.

Occurrence—Harni Pond, Harni.

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