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## ZYGNEMA AND ZYGNEMOPSIS IN PESHAWAR

TAJ MALOOK KHAN AND M. A. F. FARIDI

*Department of Botany, Peshawar University, Peshawar, Pakistan.*

### Abstract

The paper deals with species *Zygnema* and *Zygnemopsis*. In all 14 species of *Zygnema* and three of *Zygnemopsis* have been collected from Peshawar Valley, Pakistan.

The description of a new species *Zygnema Pakistanica*, and an incompletely known species have been described. All these species are new records for Pakistan.

### Introduction

*Zygnema* and *Zygnemopsis* were not studied before in this country and their study was undertaken with a view to add to our knowledge of fresh-water algae of Pakistan. Some species of *Zygnema* and *Zygnemopsis* were inadequately described as they lacked illustrations. In this study complete descriptions of *Zygnema mirificum*, *Z. carterae*, *Z. ovedanum*, *Z. collinsianum*, *Z. mucigenum*, *Z. yunnanense*, *Z. subtile*, *Z. insignisporum*, *Zygnemopsis orientales* and *Zygnema pakistanica* which is new species has been given.

### Materials and Methods

Plants were collected by hand picking and were numbered. The numbers given in the text are those of Taj Malook Khan. Some species were collected in vegetative condition and were grown in soil-extract culture (Faridi, 1971) to see the range of variability and reproductive organs. To clear the specimens 2% potassium hydroxide or 5% acetic acid was used. Plants were examined in fresh condition as far as was possible. They were preserved in 3% formaline. The drawings are original and made from camera lucida. All the specimens are deposited in the Department of Botany, University of Peshawar.

### Occurrence

*Zygnema* and *Zygnemopsis* are widely distributed in the Valley of Peshawar. These are common throughout in fresh-water ponds, Puddles, paddy fields, lakes and streams. They are fairly abundant in permanent ponds. Reproduction in these species mostly occurs in winter and spring.

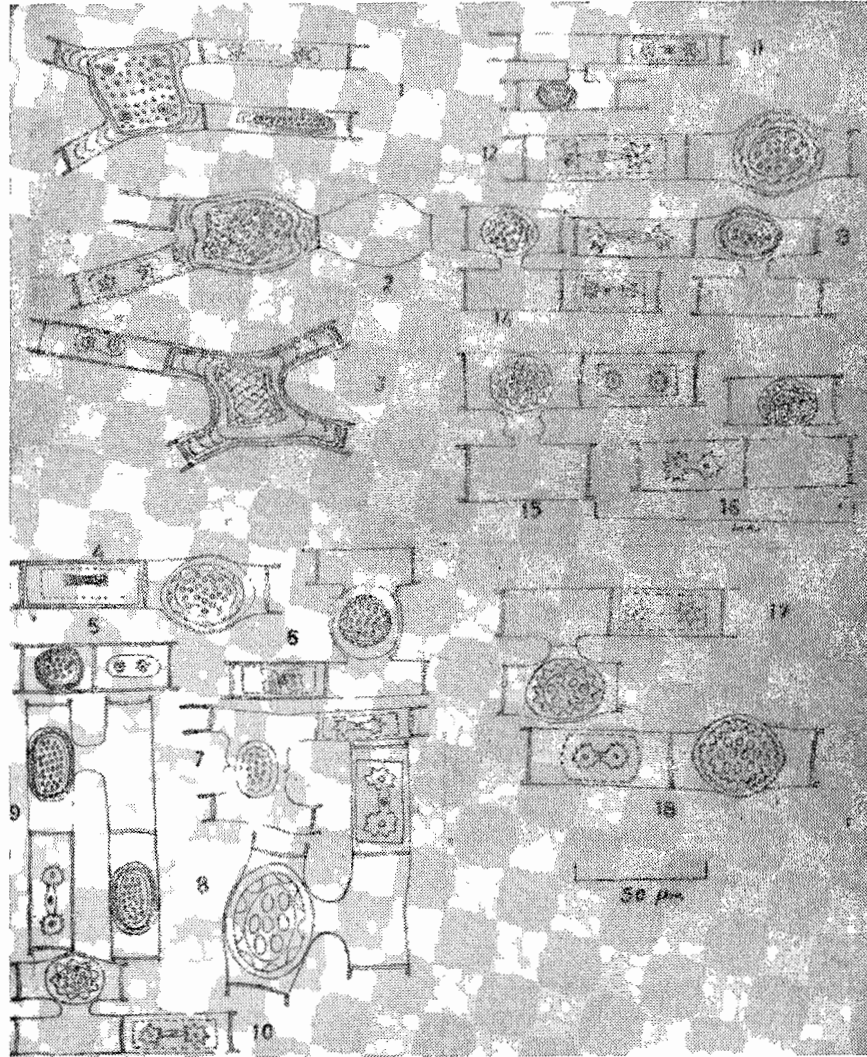


Fig. No. 1, *Zyngemopsis orientalis*; 2, *Z. sinensis*; 3, *Z. indica*; 4, *Zyngema mirificum*; 5, *Z. tenue*; 6, *Z. carterae*; 7, *Z. oveideum*; 8, *Z. collinsianum*; 9, *Z. mucigenum*; 10, *Z. pakistanica*; 11, *Z. stagnale*; 12, *Z. yunnanense*; 13, *Z. cylindrospermum*; 14, *Z. subtile*; 15, *Z. vaucherii*, 13, *B. tenue*; 17, *Z. extenua* and 18, *Z. insignisporum*.

## I. GENUS:—ZYGNEMA

## CHARACTERS OF ZYGNEMA

Filaments unbranched; cells cylindrical, uninucleate, 1-9  $\mu\text{m}$  long; chloroplast mostly two rarely 1 or 4; one central pyrenoid in each chloroplast; chloroplast connected by a cytoplasmic isthmus containing the nucleus. Reproduction by parthenospores, aplanospores; isogamous or anisogamous; conjugation scalariform or lateral; zygospore walls mostly three rarely four layered; inner and outer layers mostly thin and colourless; median layer chitinous, usually thick, smooth or ornamented, mostly coloured, colour varying from pale yellow to chestnut-brown or bright blue or blue black, blue spores are at first-yellow, then brown and finally blue.

## KEY TO THE SPECIES OF ZYGNEMA

1. Reproduction by aplanospore.....2
2. Reproduction by zygospore.....3
  2. Gametangia much dilated.....(1) *Z. mirificum*
  2. Gametangia almost cylindrical.....(12) *Z. tenue*
3. Zygote in conjugation tube.....4
3. Zygote in gametangia.....5
  4. Spore wall scrobiculate, cells 12—16  $\mu\text{m}$  thick.....(2) *Z. carterae*
  4. Spore wall punctate, cells 8—12  $\mu\text{m}$  thick.....(3) *Z. oveideum*
5. Mesospore blue.....6
5. Mesospore not blue.....8
  6. Gametangia cylindrical.....(5) *Z. mucigenum*
  6. Gametangia swollen.....7
7. Vegetative cell 18—24  $\mu\text{m}$  thick.....(4) *Z. collinsianum*
7. Vegetative cell 13—14.4  $\mu\text{m}$  thick.....(6) *Z. pakistanica*
  8. Vegetative cell less than 20  $\mu\text{m}$  thick.....9
  8. Vegetative cell 20—30  $\mu\text{m}$  thick.....12
9. Vegetative cell 9—12  $\mu\text{m}$  thick.....(7) *Z. stagnale*
9. Vegetative cell 12—20  $\mu\text{m}$  thick.....10
  10. Pits 3—4  $\mu\text{m}$  broad.....(8) *Z. yunnanense*
  10. Pits smaller.....11
11. Zygospore cylindrical.....(9) *Z. cylindrospermum*
11. Zygospore round.....(10) *Z. subtile*
  12. Pits 2—4  $\mu\text{m}$  broad.....13
  12. Pits more than 4  $\mu\text{m}$  broad.....14
13. Gametangia cylindrical.....(11) *Z. vaucherii*
13. Gametangia swollen on conjugation side.....(12) *Z. tenue*
  14. Vegetative cell 19—25  $\mu\text{m}$  thick; Zygote 23—32  $\mu\text{m}$  thick....(13) *Z. extenuum*
  14. Vegetative cell 24—28  $\mu\text{m}$  thick; Zygote 32—35  $\mu\text{m}$  thick.....(14) *Z. insignisporum*

### TAXONOMY

#### 1. *Zygnema mirificum* Jao 1947.

Transeau, p. 44; Randhawa, p. 253, fig. 220.

Vegetative cells 15—18  $\mu\text{m}$  X 25—63  $\mu\text{m}$ ; conjugation unknown; outer aplanospore wall similar in shape and just inside the dolioform sporangium wall, sporangium with outer wall 22-30  $\mu\text{m}$  X 30—60  $\mu\text{m}$ ; the medium wall varies from ellipsoid to ovoid in the bulge of the outer wall, sporangium with median wall 20—30  $\mu\text{m}$  X 25—30  $\mu\text{m}$ ; the space between the two walls filled with yellowish colloidal material; median wall irregularly and minutely scrobiculate, yellow-brown in colour. (fig. 4).

Wah Mughal Garden (leg. Mohammad Nazir), No. 12, Feb. 2, 1974.

*Distribution:* China, Pakistan.

*Note.*—The original description of the species indicate that colloidal material is present between the outer and the median walls but in our specimens the colloidal substance is absent. Probably the presence of the colloidal substance is not a specific character as stated by Transeau (1951).

#### 2. *Zygnema carterae* Czurda 1931.

Transeau p. 23; Randhawa, p. 257.

Vegetative cells 13—16 (16.8)  $\mu\text{m}$  in diameter; conjugation lateral or scalariform; zygospore formed in the conjugation tubes, globose, 30-35  $\mu\text{m}$ ; median spore wall brown, scrobiculate. (fig. 6).

Bara, No. 1, December 25, 1974.

*Distribution:* Europe, Pakistan.

The original description lacked diagrams.

#### 3. *Zygnema oveidanum* Transeau 1934.

Transeau, p. 22, pl. 2, fig. 3; Randhawa, p. 216, fig. 141.

Vegetative cells 8—12  $\mu\text{m}$  X (32—) 35—40 (—68)  $\mu\text{m}$ ; conjugation scalariform; zygospore formed in the conjugation tubes, ovoid to globose, 12—15 X 15—30  $\mu\text{m}$ ; median spore wall colourless to yellow, punctate, pits one  $\mu\text{m}$  in diameter. Lateral conjugation also present. (fig. 7).

Peshawar, near Shahrahi Pakistan Cold Storage, No. 7, March 3, 1975.

*Distribution:* U.S.A. Pakistan.

In this collection the median spore wall is sometimes subtracted from the outer wall with spetic substances. This species was described from the U.S.A. and this is the second collection of the plants. This species was incompletely known and its description has been completed.

4. *Zygnema collinsianum* Transeau 1914.

Transeau, p. 38, pl. 6, fig. 11—13; Randhawa, p. 248, fig. 209.

Vegetative cell 18—25 X 32—80  $\mu\text{m}$ ; conjugation scalariform, zygospore mostly in one of the gametangia; sometimes in filament, sometimes in the other, rarely not in conjugation tube; receptive gametangia enlarged on the conjugation side; zygospore globose to ovoid, sometimes slightly compressed and showing a distinct equatorial suture, 26—40 X 30—47  $\mu\text{m}$ ; pits 4—5  $\mu\text{m}$  in diameter, 1—2  $\mu\text{m}$  apart; aplanospore cylindrical-ovoid, 18—24 X 40—76  $\mu\text{m}$ ; scattered among the vegetative cells, similar in markings to zygospores. (fig. 8).

Warsak road No. 9, March 4, 1975.

*Distribution:* U.S.A., India, Pakistan.

Transeau (1951) reports that the zygospores are formed in the gametangium and the conjugation tube but in our specimens they are in the gametangium only.

5. *Zygnema mucigenum*: Randhawa 1938.

Randhawa, p. 243 fig. 199; Transeau, p. 43, pl. 41, fig. 6—7.

Vegetative cells 12—14 X 50—100  $\mu\text{m}$ ; conjugation both lateral and scalariform; zygospores in one of the gametangia, which is enlarged near the spore; zygospore compressed-globose, 20—22  $\mu\text{m}$  X 30—36  $\mu\text{m}$ ; median spore wall bluish-green, with scattered pits; pits 1—1.5  $\mu\text{m}$  in diameter, 3—4  $\mu\text{m}$  apart; aplanospore similar to zygospore also present (fig. 9).

Akbarpura, No. 13a, March 8, 1975.

*Distribution:* India Pakistan.

This species has been collected for the first time after the original.

6. *Zygnema Pakistanica*: Khan et Faridi sp. nov.

Cellula vegetative 13.2—14.4  $\mu\text{m}$  X 32—40  $\mu\text{m}$ ; due chloroplasti stellati; conjugatio scalariformis; zygospora in uno gametangio sita; gametangia receptiva amplificata inflataque; gametangia versus tubum conjugationis magis tumescentia; zygospora globosa ovoideave, gametangium complens; 18.2—25.2  $\mu\text{m}$  diam; membrana sporae exterior levis, media atrocaerulea scrobiculataque, lacunis 3.6  $\mu\text{m}$  diam. atque confertis; membrana sporae interior levis.

Vegetative cell 13.2—14.4  $\mu\text{m}$  X 32—40  $\mu\text{m}$ ; chloroplast 2, stellate; conjugation scalariform; zygospore in one of the gametangia; receptive gametangia enlarged or inflated; gametangia more bulging towards the conjugation tube; zygospore globose or ovoid, filling the gametangium, zygospore 18.2—25.2  $\mu\text{m}$  in diameter; outer spore wall smooth; median spore wall dark blue, scrobiculate; pits 3.6  $\mu\text{m}$  in diameter; pits close to one another; inner spore walls smooth. (fig. 10).

Peshawar, No. 10a March 3, 1975.

This species differs from *Z. atrocoeruleum* W. & W. in median spore wall, and from *Z. collinsianum* Transeau in smaller pits, which are close to one another and smaller size of vegetative cells. It differs from *Z. misrae* in smaller dimension and median spore wall. It differs from *Z. mucigenum* Randhawa in pits close to one another, large pits, shape of zygospore and the shape of chloroplast. The type specimen has been deposited in Botany Department, Peshawar University (no. T. 122).

7. *Zygnema stagnale* (Hassal) Kg. 1849.

Transeau, p. 31; Randhawa, p. 233, fig. 173.

Vegetative cell 9—12 X 20—50  $\mu$ m; conjugation scalariform; zygospore in one of the gametangia; receptive gametangia enlarged on the inner side; zygospore globose to subglobose, 14—18 X 14—20  $\mu$ m; median spore wall brown, punctate. (fig. 11).

Pabbi, No. 14, March 25, 1975; Malmandi, No. 27 February 4, 1975.

*Distribution:* U.S.A., Pakistan.

This species is variable, the zygospores are oval, globose to subglobose. The breadth of the vegetative filament is also variable from 9 to 20  $\mu$ m.

8. *Zygnema yunnanense* Li 1940.

Transeau, p. 31; Randhawa, p. 256.

Vegetative cells 16—18 X 50—104  $\mu$ m; conjugation lateral; receptive gametangia more or less enlarged; zygospores globose to ovoid, 32—40 X 38—48  $\mu$ m, median wall thick, deeply scrobiculate, with pits, 3—4.5  $\mu$ m in diameter, 2—3  $\mu$ m apart, yellow at maturity. (fig. 12).

Shabqadar, No. 4, January 22, 1975.

*Distribution:* China, Pakistan.

9. *Zygnema cylindrospermum* (W. & W.) Krieger 1941.

Transeau, p. 31, pl. 4, fig. 16; Randhawa, p. 233, fig. 174.

Vegetative cells 15—18  $\mu$ m in diameter; conjugation scalariform; zygospores formed in one of the gametangia; receptive gametangia cylindrical or slightly enlarged; zygospores ovoid, 15—19 X 23—54  $\mu$ m; median spore wall brown, punctate. (fig. 13).

University Town a pond, No. 14b, March 12, 1975.

*Distribution:* India, Scotland, Wales, South Africa.

10. *Zygnema subtile* Rg. 1849.

Transeau, p. 31; Randhawa, p. 258.

Vegetative cells 14—20 X 30—85  $\mu$ m; conjugation scalariform or very rarely lateral; zygospore in one of the gametangia; receptive gametangia greatly enlarged or inflated on the inner side; zygospore ovoid to subglobose, 20—92 X 22—30  $\mu$ m; median spore wall brown punctate. (fig. 14).

Malmandi No. 2, February 2, 1975 Mardan No. 29, January 1, 1975.

*Distribution:* U.S.A., Finland, Germany, Bohemia, Pakistan.

The illustration have been added to the unillustrated description. This species is commonest in Peshawar valley.

11. *Zygnema vaucheri* C.A. Ag. 1824.

Transeau, p. 33; Randhawa, p. 236. (fig. 181).

Vegetative cells 24–28 X 50–180  $\mu$ m; conjugation scalariform; zygosporangium in one of the gametangia; receptive gametangia gradually or abruptly inflated towards the middle; zygosporangia ovoid, 24–36 X 26–45  $\mu$ m; median spore wall brown, scrobiculate; pits 2–3  $\mu$ m in diameter. (fig. 15).

G. T. Workshop, No. 3, January 19, 1975.

*Distribution:* U.S.A. Europe, Pakistan.

12. *Zygnema tenue* Kg. 1849.

= *Z. spontaneum* Nordst. 1878.

Transeau, p. 32, pl. 4, fig. 14–15; Randhawa, p. 237, fig. 183.

Vegetative cells (16) — 18–24 X 20–90  $\mu$ m; conjugation scalariform; zygosporangium in one of the gametangia; receptive gametangia greatly enlarged or inflated towards the middle; zygosporangium globose to ovoid, often somewhat compressed, (18)–25–30 X (22)–25–40  $\mu$ m; median spore wall brown, scrobiculate; pits 2–3  $\mu$ m in diameter, 3–4  $\mu$ m apart, aplanospores, similar to zygosporangia, (fig. 5, 16).

Pabbi No. 5, December 10, 1974; Tarajabbi No. 8, February 2, 1975.

*Distribution:* U.S.A. China, Europe, Sri Lanka, South Africa, Java, Pakistan.

*Note.*—The plants with aplanospores were described as *Z. spontaneum* Norst. In our collection zygosporangia and aplanospores both are present.

13. *Zygnema extenua* Jao, 1935.

Transeau, p. 31, pl. 4, fig. 12; Randhawa, p. 238, fig. 186.

Vegetative cells 19–25 X 32–48  $\mu$ m; conjugation scalariform and sometimes lateral; receptive gametangia more or less enlarged; zygosporangium subglobose to ovoid, 23–32 X 26–39  $\mu$ m; median spore wall scrobiculate; pits (2)–4.5–6.5  $\mu$ m in diameter, 2–3  $\mu$ m apart, yellow brown at maturity. (fig. 17).

Peshawar, Pindi Road, Near truck stand, No. 11, March 7, 1975.

*Distribution:* China Pakistan.

This is the first report of the species after China.

14. *Zygnema insignisporum* Couch, 1944.

Transeau, p. 34; Randhawa, p. 257

Vegetative cells 24—28 X 39—71  $\mu\text{m}$ ; conjugation scalariform; receptive gametangia inflated on the conjugation side; zygospore globose to ovoid, 31—35 x 32—35  $\mu\text{m}$ ; outer wall of 2 colourless layers of the outermost is smooth, the median wall punctate yellow and the inner scrobiculate; with pits 4—5—(6)  $\mu\text{m}$  in diameter and about 7  $\mu\text{m}$  apart; (fig. 18).

Malmāndi No. 6, January 11, 1975.

*Distribution:* U.S.A., Pakistan.

In our collection pits are about one  $\mu\text{m}$  larger than the type. This is the first collection of the plant outside the United States of America. The original description was without illustrations.

## II. GENUS:—ZYGNEMOPSIS

### CHARACTERS OF ZYGNEMOPSIS

Filaments simple, cells 2—10  $\mu\text{m}$  long, with mostly two, rarely 3—6 stellate or pillow shaped chloroplast; each with a pyrenoid, connected by a cytoplasmic strand containing the nucleus; cell lengths during conjugation; gametangia swollen and filled with refractive dense lamellose and cellulose colloid; reproduction by zygospores or azygospores; conjugation scalariform; zygote formed within conjugation tube; some species with azygospore only.

### KEY TO THE SPECIES OF ZYGNEMOPSIS

1. Vegetative cell 6—7  $\mu\text{m}$  thick.....(15) *Z. orientalis*.
1. Vegetative cell 10—15  $\mu\text{m}$  thick.....2
  2. Spore wall scrobiculate.....(16) *Z. sinensis*
  2. Spore wall smooth.....(17) *Z. indica*

### TAXONOMY

15. *Zygnemopsis orientalis* (Carter) Transeau 1944, emend.

Transeau, p. 52, pl. 8, fig. 3—5; Randhawa, p. 191, fig. 117.

Vegetative cells 6—7 X 30—67  $\mu\text{m}$ ; conjugation scalariform; zygospore quadrangular, pillow-form 20—25  $\mu\text{m}$  on a side; filling the broad tubes and dividing the gametangia; outermost wall hyaline, smooth; median wall smooth light brown, inner wall smooth hyaline; aplanospore present. (fig. 1)

Akbarpura, No. 13b. March 8, 1975.

*Distribution:* India, Pakistan.

This species was reported from India and this is the second collection of the species. This species was previously inadequately known.

16. *Zygnemopsis sinensis* Transeau 1934.

Transeau, p. 54, pl.8 fig. 24; Randhawa, p. 194, fig. 123.



Vegetative cells 10—30 X 29—72  $\mu\text{m}$ ; with 2, more or less elongate stellate chloroplasts; conjugation scalariform; zygospores formed in the broad conjugating tubes and extending far into both gametangia; spores quadrate-ovoid, (24)—29—32 X 29—36  $\mu\text{m}$ ; median spore wall yellow, scrobiculate; pits 2—2.5  $\mu\text{m}$  in diameter, 2.5—3  $\mu\text{m}$  apart. (fig. 2).

University Town No. 15a, March 13, 1975.

*Distribution:* China, Pakistan.

This species has been collected for the first time after the original.

17. *Zygnemopsis indica* Randhawa, 1937.

Transeau, p. 54, pl. 8, fig. 26—27; Randhawa, p. 197, fig. 129.

Vegetative cells 10—15  $\mu\text{m}$  X 50—75  $\mu\text{m}$ ; with 2 rounded or stellate chloroplasts; each with a central pyrenoid; reproduction by zygospore and aplanospore; conjugation scalariform; zygospore compressed—quadrangular—ovoid or compressed—globose, 34—46  $\mu\text{m}$  X 40—53  $\mu\text{m}$ ; median wall yellow brown, smooth or undulate, with abundant granules between the outer and median walls; aplanospore and parthenospores with similar walls, 20—26  $\mu\text{m}$  X 40—46  $\mu\text{m}$ ; in sporangia to 80  $\mu\text{m}$  in length. (fig. 3).

Peshawar No.

*Distribution:* India, Pakistan.

This species was reported from India and this is the second collection of the species.

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