



ISSN (E): 2320-3862
ISSN (P): 2394-0530
<https://www.plantsjournal.com>
JMPS 2023; 11(6): 37-47
© 2023 JMPS
Received: 05-07-2023
Accepted: 04-08-2023

Deepak Kumar Jha
Department of Botany,
Phycology Lab, University L. N.
Mithila University, Darbhanga,
Bihar, India

Ram Naresh Jha
Department of Botany,
Phycology Lab, University, L.
N. Mithila University,
Darbhanga, Bihar, India

Taxonomic studies on the genus *Spirogyra* link (Zygnematales) from Supaul District of North Bihar, India

Deepak Kumar Jha and Ram Naresh Jha

DOI: <https://doi.org/10.22271/plants.2023.v11.i6a.1605>

Abstract

The present paper deals with the description of nineteen species of *Spirogyra* Link from Supaul district of North Bihar. of these, *S. caroliniana* Dilard & *S. woodsii* (Hassall) Czurda are being recorded for the first time from India, *S. circumlineata* TRANSEAU, *S. cylindrica* Czurda, *S. juergensii* Kütz., *S. longata* (Vaucher) Kützing, *S. majuscula* Kützing; *S. multiformis* Kadlubowska, *S. paraguayensis* BORGE, *S. variformis* TRANSEAU and *S. yunnanensis* Li are reported for the first time from Bihar and *S. nirmalensis* sp. nov. is new to science.

Keywords: New records, *spirogyra*, Supaul District, India

1. Introduction

Spirogyra Link (Conjugatophyceae: Zygnematales) is an unbranched filamentous genus that is ubiquitous in a broad range of freshwater habitats, including roadside ditches, streams, irrigation canal and lakes (Graham *et al.*, 2009) [2]. The genus *Spirogyra* Link is known to have more than 500 species (Transeau 1951; Yamagishi 1966; Kadlubowska 1984; Guiry & Guiry 2021) [21, 24, 6, 3] and out of which 302 species are reported from India (Randhawa 1959; Sarma & Khan 1980; Kargupta & Sarma 1992; Guiry & Guiry 2021) [15, 19, 10, 3]. Kamat 1962; Srinivasan 1965; Rattan 1967; Kothari 1971; Sarma *et al.*, 1982; Prasad & Mishra 1983; Sarma & Mustafa 1986; Kargupta *et al.*, 1987; Kargupta & Sarma 1992; Usha Devi & Panikkar 1994; Kargupta & Ahmad 1995; Kargupta & Jha 2004; Chalotra *et al.*, 2013; Kumari *et al.*, 2022 and Jha *et al.*, 2022 [11, 20, 16, 12, 17, 14, 18, 9, 10, 22, 8, 7, 1, 13, 5] made some important contributions on the taxonomy of *Spirogyra* Link from India. Kargupta & Ahmad (1995) [8] reported 23 taxa including a new species and two new varieties of the genus *Spirogyra* from Mithilanchal region (Bihar). Kargupta & Jha (2004) [7] described 80 taxa of *Spirogyra* from Bihar. Five species of *Spirogyra* were reported from Darbhanga district of North Bihar (Kumari *et al.*, 2022) [13]. Jha *et al.* (2022) [5] reported 3 taxa of *Spirogyra* from Supaul district of North Bihar. Still further exploration seems necessary keeping in view the vast and varied water bodies of the area and the world record (more than 500 spp.) of the genus. The present study was undertaken to study the biodiversity of the genus *Spirogyra* Link in this region. A total of 19 taxa of *Spirogyra* were identified from Supaul district of North Bihar.

Materials and Methods

Algal samples were collected from different localities of Supaul district (25°37' – 26°25'N Latitude and 86°22'–87° 10'E Longitude) of North Bihar, during January 2021 – January 2023. All specimens were preserved in FAA each litre of which contained: 40% commercial formalin - 100ml, 60% ethyl alcohol- 500ml, glacial acetic acid – 50 ml and water 350ml. To each litre of this solution 50cc of pure glycerine was added to avoid complete desiccation. Specimens were treated with 8% KOH solution and Lactic acid to observed sculpturing of zygospore wall (Kargupta & Jha 2004) [7]. pH and temperature were recorded at the collection sites. Observations were made on Olympus research microscope (Olympus 7213). Prism type camera Lucida was used for drawing and photographs of the material were taken by Olympus digital camera (Model no. E-420). Identification of the taxa was made with help of standard literature including monographs (Transeau 1951; Randhawa 1959; Kadlubowska 1984; Kargupta and Sarma 1992; Kargupta and Jha 2004) [21, 6, 15, 10, 7].

Corresponding Author:
Deepak Kumar Jha
Department of Botany,
Phycology Lab, University, L.
N. Mithila University,
Darbhanga, Bihar, India

Results

In the present study nineteen species of genus *spirogyra* Link have been identified.

Systematic position

Class: Conjugatophyceae

Order: Zygnematales

Family: Zygnemataceae

Genus: *Spirogyra* Link 1820

Genus character

Thallus filamentous, filaments unbranched, free floating,

rarely attached, without any base- apex differentiation, vegetative cells cylindrical, short or long with plane, colligate, semi-replicate, replicate or unduliseptate septa; chloroplasts 1-16 in number, spirally arranged, parietal band or ribbon shaped; each with numerous pyrenoids; reproduction by zygospores, aplanospores or parthenospores; conjugation usually scalariform sometimes lateral; zygospores formed in the female gametangia; receptive gametangia may be cylindrical or variously inflated or swollen; zoospores usually ellipsoid, rarely ovoid or lenticular; median spore wall smooth or variously ornamented.

Table 1: Key to the taxa investigated

1. Septum replicate	2
1. Septum plane	5
2. Conjugation only scalariform	3
2. Conjugation both scalariform and lateral	4
3. Vegetative cells 15-19 µm in diameter	(12) <i>S. pseudodepression</i>
3. Vegetative cells 28-30 µm in diameter	(2) <i>S. caroliniana</i>
4. Vegetative cells 12 µm in diameter	(16) <i>S. tenuissima</i>
4. Vegetative cells 14-16 µm in diameter	(4) <i>S. cylindrica</i>
5. Conjugation only lateral.	(18) <i>S. woodsii</i>
5. Conjugation only scalariform	6
5. Conjugation both scalariform and lateral	(7) <i>S. longata</i>
6. Chloroplast single	7
6. Chloroplasts more than one	9
7. Fertile cells inflated on the conjugation side only. (3) <i>S. circumlineata</i>	
7. Fertile cells cylindrical	8
8. Vegetative cells 24-26 µm in diameter	(6) <i>S. juergensii</i>
8. Vegetative cells 40-44 µm in diameter	(17) <i>S. variformis</i>
9. Sterile cells more or less swollen	(5) <i>S. hatillensis</i>
9. Sterile cells not swollen	10
10. Vegetative cells 26-28 µm in diameter	(14) <i>S. subcylindrospora</i>
10. Vegetative cells more than 30 µm broad	11
11. Vegetative cells less than 60 µm broad	12
11. Vegetative cells more than 60 µm broad	15
12. Fertile cells cylindrical or slightly inflated	13
12. Fertile cells inflated on both the sides but greatly inflated on the outside only	(10) <i>S. nirmalensis</i> sp. nov.
13. Zygospores polymorphic	(9) <i>S. multiformis</i>
13. Zygospores not polymorphic	14
14. Zygospores ovoid to ellipsoid, 44-48 µm × 56-72 µm, mesospore intricately reticulate	(1) <i>S. brunnea</i>
14. Zygospores ellipsoid, 40-56 µm × 64-76 µm, mesospore irregularly corrugate	(11) <i>S. paraguayensis</i>
15. Zygospores lenticular	(8) <i>S. majuscula</i>
15. Zygospores ellipsoid	16
16. Mesospore golden yellow with fine grooves	(15) <i>S. subforms</i> Kargupta & Sarma
16. Mesospore smooth	17
17. Zygospores 76-88 µm in diameter	(19) <i>S. yunnanensis</i>
17. Zygospores 88-95 µm in diameter	(13) <i>S. setiformis</i>

Spirogyra brunnea CZURDA (PLATE 1; Figs.1-3) (Randhawa 1959; P. 337; Fig. 333a-b)^[15].

Vegetative cells 48-56 µm in diameter, 180-200 µm long, with plane end walls; chloroplasts 3-4; conjugation scalariform; tubes formed by both gametangia; fertile cells shortened and slightly inflated on both side; zygospores ovoid to ellipsoid, 44-48 µm in diameter, 56-72 µm long; mesospore brown, intricately reticulate.

Habitat: Collection No. DK-43, Date-January 20, 2022, from a pond (pH-6.5, Temp. 16°C) of Pratapganj (Dist. Supaul) growing along with *S. variformis* TRANSEAU & *S. submaxima* TRANSEAU and *Oedogonium* species.

The present specimen has slightly shorter and narrower zygospores than the type species.

Distribution: Bihar, Punjab, U.P. (Gupta, 2012)^[4].

This is the second record of the species from Bihar after Kargupta & Jha (2004)^[7]

Spirogyra caroliniana Dilard (PLATE 1; Figs.4-7) (Kadlubowska 1984; P.449; Fig. 699)^[6]

Vegetative cells 28-30 µm in diameter, 160-220 µm long; end wall replicate; chloroplast 1; conjugation scalariform; tubes formed by male gametangia; female gametangia inflated upto 72 µm; zygospores ellipsoid, 36-44 µm in diameter, 56-84 µm long; mesospore light yellow, smooth.

The present specimen resembles the type species.

Habitat: Collection No. DK-61, February 17, 2022, from a canal (ph 6.0, Temp. 24 °C) of Harpur, Nirmali (Dist. Supaul) growing along with other *spirogyra* species.

Distribution: North America (Kadlubowska, 1984)^[6].

This is the first record of the species from India

Spirogyra circumlineata TRANSEAU (PLATE 1; Figs.8-9) (Randhawa 1959; P.406; Fig. 483) ^[15]

Vegetative cells 40-44 µm in diameter, 100-128 µm long, with plane end walls; chloroplasts 1; conjugation scalariform; conjugation tubes formed by both gametangia; fertile cells inflated on the conjugation side only; male gametangia slightly inflated towards conjugation side; zygospores ellipsoid, 40 µm in diameter, 72-84 µm long; mesospore yellowish brown, smooth; suture more or less prominent.

The present specimen resembles the type species.

Habitat: Collection No. DK-15, Date- April 16, 2021, from a canal (pH-8, Temp.30 °C) of Baijnathpur (Dist. Supaul) growing along with other *Spirogyra* and *Zygnema* species.

Distribution: USA (Randhawa 1959) ^[15]; Kerala, Punjab (Gupta 2012) ^[4].

This is the first record of the species from Bihar**4. *Spirogyra cylindrica*** Czurda (PLATE 1; Fig. 10)

(Randhawa 1959; P.365; Fig. 393) ^[15]

Vegetative cells 14-16 µm in diameter, 140-160 µm long, with replicate end walls; chloroplasts 1; conjugation lateral and scalariform; tubes formed almost wholly by the male gametangia; fertile cells inflated towards the centre to 24-32 µm; zygospores ellipsoid, 20-24 µm in diameter, 52-60 µm long; mesospore smooth, yellowish brown.

The present specimen tallies well with the type species in all essential features.

Habitat: Collection No.DK-122, March 3, 2022, from a ditch (pH-7.5, Temp.30°C) of Bijalpur (Dist. Supaul) growing along with *S. tenuissima* (HASSAL) KUTZING, *Oedogonium* and other *Spirogyra* species.

Distribution: Austria; Szechwan, China; South Africa; Czechoslovakia (In Randhawa 1959) ^[15], India: Himachal Pradesh, Punjab, West Bengal (Gupta 2012) ^[4].

This is the first record of the species from Bihar.**5. *Spirogyra hatillensis*** TRANSEAU (PLATE 1; Figs. 11-12)

(Randhawa 1959; P.322; Fig.303) ^[15]

Vegetative cells 108-124 µm in diameter, 126- 164 µm long, with plane septa, chloroplasts 6; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindrical, sterile cells more or less swollen; zygospores ellipsoid, 84-86 µm broad and 140-144 µm long; mesospore smooth and brown. The present specimen resembles the type species.

Habitat: Collection No. DK-58, Date- February 6, 2022, from a chaur (pH 6.5, Temp 26°C) of Barhatta, Kishanpur (Dist. Supaul) growing along with other *Spirogyra* species.

Distribution: U.S.A., Puerto Riw, Hatillo. (Randhawa 1959) ^[15]; India: U.P. (Randhawa 1959) ^[15], Bihar, Maharashtra, West Bengal (Gupta 2012) ^[4].

This is the second record of the species from Bihar.**6. *Spirogyra juergensii*** Kütz. (PLATE 2; Figs. 1-2)

(Randhawa 1959; P.294; Fig. 250) ^[15]

Vegetative cells 24-26 µm in diameter, 100-140 µm long; septa occasionally plane and swollen; each cell with one chloroplast making 2-4 turns; conjugation scalariform; fertile cells not swollen on either side; zygospores ellipsoid,

elongated, 28-32 µm in diameter, 44-64 µm long; mesospore smooth.

The present specimen is similar to the type species.

Habitat: Collection No. DK-54, February 6, 2022, from a ditch (pH 7.5, Temp. 26°C) of Dubiahi, kishanpur (Dist. Supaul).

Distribution: Pakistan; U.S.A.,South America, Australia; India: Gorakhpur, U.P.(Randhawa 1959) ^[15], Jammu & Kashmir, Punjab, West Bengal (Gupta 2012) ^[4].

This is the first record of the species from Bihar**7. *Spirogyra longata*** (Vaucher) Kützing (PLATE 2; Figs.3-6)

(Randhawa 1959; P.304; Fig.268a-d) ^[15]

Vegetative cells 20-22 µm in diameter, 60-80 µm long, with plane end walls; chloroplast 1; conjugation both scalariform and lateral; tube formed by both gametangia; zygospores ovoid, 24-26 µm in diameter, 40-48 µm long; median spore wall yellow, smooth.

The present specimen is similar to the type species in all the aspects.

Habitat: Collection No. DK- 122, March-3, 2022, from a ditch (pH 7.5, Temp. 30°C) of Bijalpur (Dist. Supaul) growing along with *Oedogonium* and other *Spirogyra* species.

Distribution: U.S.A., Europe; East and South Africa; Asia; South America, Australia (Randhawa 1959) ^[15]; India: Punjab, Uttarakhand, West Bengal (Gupta 2012) ^[4].

This is the first record of the species from Bihar.**8. *Spirogyra majuscula*** Kützing (PLATE 2; Figs.7-12)

(Randhawa1959; P.344; Fig.348a-b; Kadlubowska 1984; P.326; Fig.511) ^[6].

Vegetative cells 60-72 µm in diameter, 70-160 µm long; with plane end walls; chloroplasts 5-7; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindrical or inflated on the outer side only; zygospores lenticular, 48-60 µm in diameter, 60-64 µm long; mesospore brown, smooth; lenticular parthenospores also observed; ometimes rhizoid formation occurs.

The present specimen resembles the type species.

Habitat: Collection No.DK-69, Date- February 7, 2022, from a pond (pH-6.0, Temp.26°C) of Dighia, Kishanpur (Dist. Supaul) growing along with other *spirogyra* species.

Distribution: China; Brazil; Europe; Uruguay; South Africa; U.S.A. (Randhawa 1959) ^[15]; India: In a puddle at Kolwada, Bombay (Randhawa1959) ^[15], Punjab, West Bengal (Gupta 2012) ^[4].

This is the first record of the species from Bihar.**9. *Spirogyra multiformis*** (Rattan) Kadlubowska (PLATE 2; Figs. 13-16)

(Kadlubowska 1984; P.299; Fig.456) ^[6].

Vegetative cells 44-48 µm in diameter, 80-92 µm long, with plane end walls; chloroplast 2; conjugation scalariform; tubes formed by both gametangia, but conjugation tubes of various length; female gametangia cylindrical or slightly inflated on both the sides; zygospores polymorphic, ellipsoidal, ovate or globose; mesospore yellow, smooth; parthenospore is also seen, spherical in shape and much smaller than the zygospore.

Habitat: Collection No.DK-87, Date- March 3, 2022 from a ditch (pH-6.0, Temp. 30°C) of Nirmali (Dist. Supaul) growing

along with other *Spirogyra* species.

The present taxon tallies well with the type species, however, it differs from the latter in having lesser number of chloroplasts, various length of conjugation tube and presence of parthenospores.

Distribution: India: Punjab (Kadlubowska 1984) [6]

This is the first record of the taxon from Bihar and second record from India.

10. *Spirogyra nirmalensis* sp. nov. (PLATE 3; Figs.1-12; PLATE 4; Figs.1-10)

Vegetative cells 50-56 μm in diameter, 84-152 μm long, with

plane end walls; chloroplasts 2-5; conjugation scalariform, tube formed by both gametangia; female gametangia (72-136 $\mu\text{m} \times 64-100 \mu\text{m}$) inflated on both the sides but greatly inflated on the outside only; cells that remain vegetative often form a branched rhizoid without swelling; zygospores globose to ovoid, 44-56 $\mu\text{m} \times 52-56$; mesospore yellowish brown, irregularly minutely verrucose; parthenospores are formed in large numbers and shape and size are equal to zygospores.

Holotype: Collection No.DK-7, Date-April 4, 2021, from a ditch (pH 6.5, Temp. 28°C) of Nirmali (Dist. Supaul) growing along with *Oedogonium* and other *Spirogyra* species.

Table 1: xxxx

Species	Nature of Septum	Vegetative Cells	No. of Chloroplast	Zygospores		
				Shape	Size	Ornamentation
<i>S. submajuscula</i> Ling et Zheng	Plane	60 – 65 μm in diameter	7 – 9	Lenticular	70 – 85 $\mu\text{m} \times 56 – 65 \mu\text{m}$	Smooth
<i>S. majuscula</i> Kützing	Plane	54 – 100 μm in diameter	5 – 10	Lenticular	53 – 90 $\mu\text{m} \times 53 – 98 \mu\text{m}$	Smooth
<i>S. submajuscula</i> Jao	Plane	40 – 45 μm in diameter	4 – 7	Lenticular	55 – 62 $\mu\text{m} \times 55 – 62 \mu\text{m} \times 40 – 42 \mu\text{m}$	Smooth
<i>S. nirmalensis</i> sp. nov.	Plane	50 – 56 μm in diameter	2 – 5	Globose to Ovoid	44 – 56 $\mu\text{m} \times 52 – 56 \mu\text{m}$	Irregularly minutely verrucose

The present specimen is close to *S. submajuscula* Ling et Zheng but differs from the latter in width of vegetative cells, number of chloroplasts, shape and size of zygospores and ornamentation of zygospore wall. It is also somewhat close to *S. majuscula* Kützing but differs in number of chloroplast, shape of zygospores and ornamentation of mesospore wall. Also it differs from the *S. submajuscula* Jao in width of vegetative cells, shape of zygospores and ornamentation of zygospore wall. Hence it appears justified to give this taxon the rank of a separate species named as *S. nirmalensis* sp. nov.

11. *Spirogyra paraguayensis* BORGE (PLATE 5; Figs. 1-2) (Randhawa 1959; P.412; Fig. 498a-b) [15]

Vegetative cells 44-60 μm in diameter, 80-100 μm long; with plane end walls; 3-4 chloroplasts, nearly straight; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindrical, shortened; zygospores ellipsoid, 40-56 $\mu\text{m} \times 64-76 \mu\text{m}$ long; median spore wall irregularly corrugate, yellow brown.

The present specimen is similar to the type species.

Habitat: Collection No.DK-87, Date- March 3, 2022 from a ditch (pH-6.0, Temp. 30°C) of Nirmali (Dist. Supaul) growing along with other *Spirogyra* species.

Distribution: South America (Randhawa1959) [15]; India: West Bengal (Gupta 2012) [4].

This is the second record of the species from India and first record from Bihar.

12. *Spirogyra pseudodepression* Jao (PLATE 5; Fig.3) (Randhawa1959; P. 365; Fig.391) [15]

Vegetative cells 15-19 μm in diameter, 144-168 μm long, with replicate walls; chloroplast 1; conjugation scalariform; tubes formed by male gametangia; fertile cells inflated towards the middle up to 36 μm , especially on conjugation side; zygospores ellipsoid, 24-28 μm in diameter, 44-64 μm long; mesospore yellow-brown, smooth.

The present specimen is very close to the type species.

Habitat: Collection No.DK-123, Date- March 3, 2022, from a

ditch (pH 7.0, Temp. 30 °C) of Bela (Dist. Supaul).

Distribution: Szechwan, China (Randhawa 1959) [15]; Japan: Chichibu (Yamagishi 1960) [23]; India: Bihar, Punjab (Gupta 2012) [4].

This is the second record of the species from Bihar.

13. *Spirogyra setiformis* (ROTH) Kütz. (PLATE 5; Figs. 4-5) (Randhawa 1959; P.321; Fig.301) [15]

Vegetative cells 92-118 μm in diameter, 140-212 μm long, with plane end walls; chloroplasts 4, making 1-2 spirals; conjugation scalariform; tubes formed by both gametangia; fertile cells not swollen; zygospores ellipsoid, 88-95 μm in diameter; Exospore thin, smooth, colorless; mesospore thick, smooth, brown.

The present specimen resembles the type species.

Habitat: Collection No.DK-82, Date- February 17, 2022, from a ditch (pH 8, Temp. 24°C) of Mahua (Dist. Supaul) growing along with other *Spirogyra* species.

Distribution: U.S.A., European countries (Randhawa 1959) [15]; India: Hoshiarpur district (Punjab), Hoshangabad (M.P.), U.P., Bombay (Randhawa 1959) [15], Arunachal Pradesh, West Bengal, Bihar, Gujrat, Jharkhand, Kerala (Gupta 2012) [4].

This is the second record of the species from Bihar.

14. *Spirogyra subcylindrospora* JAO (PLATE 5; Figs.6-7) (Randhawa 1959; P.333; Fig. 325) [15]

Vegetative cells 26-28 μm in diameter, 72-116 μm long, with plane end walls; chloroplasts 2-3; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindrical or enlarged; zygospores cylindrical ellipsoid with rounded ends, 32-36 $\mu\text{m} \times 80-82 \mu\text{m}$; median spore wall brown and reticulate.

The present specimen similar to the type species.

Habitat: Collection No.DK-24, Date- January 30, 2021, from a pond (pH 7.5, Temp. 20°C) of Basantpur (Dist. Supaul) growing along with *Zygnema* and other *Spirogyra* species.

Distribution: U.S.A., China (Randhawa 1959)^[15]; India: Bihar, Kerala, Punjab (Gupta 2012)^[4].

This is the second record of the species from Bihar.

15. *Spirogyra subforms* Kargupta & Sarma (PLATE 5; Figs. 8-9)

(Kargupta & Sarma 1992, P.35, Figs.138-141; Usha Devi & Panikkar 1994; P.67; Figs.272-274)^[10, 22]

Vegetative cells 80-84 µm in diameter, 192-220 µm long; septa plane; chloroplasts 3-4; conjugation scalariform, tubes formed by both gametangia; female gametangia cylindrical; zygospores ellipsoid, 76-80 µm in diameter, 140-144 µm long; mesospore golden yellow with fine grooves.

The present specimen resembles the type species.

Habitat: Collection No.DK-37, Date- January 1, 2022, from a chaur (pH 6.5, Temp. 14 °C) of Dharhara (Dist. Supaul) growing along with *Zygnema* and other *Spirogyra* species

Distribution: Bihar, Kerala, West Bengal (Gupta 2012)^[4].

This is the second record of the species from Bihar.

16. *Spirogyra tenuissima* (HASSALL) KÜTZING (PLATE 5; Figs.10-11)

(Randhawa 1959; P.359; Fig. 379)^[15]

Vegetative cells 12 µm in diameter, 120- 160 µm long, with replicate end walls; chloroplast one; conjugation lateral and scalariform; tubes formed by both gametangia; fertile cells greatly inflated or enlarged towards the middle; zygospores ellipsoid, 24-28 µm in diameter, 44-48 µm long; median spore wall smooth, yellow.

The present specimen is similar to the earlier reported species in all the aspects.

Habitat: Collection No.DK-122, March 3, 2022, from a ditch (pH 7.5, Temp. 30 °C) of Bijalpur (Dist. Supaul). Growing along with *S. cylindrica* CZURDA, *Oedogonium* spp. and other *Spirogyra* species.

Distribution: Africa; Asia; Australia; Canada; Europe; New Zealand; South America; U.S.A. (Randhawa 1959)^[15]. India: Bihar, Punjab (Gupta 2012)^[4].

This is the second record of the species from Bihar after Kargupta & Jha (2004)^[7]

17. *Spirogyra variformis* TRANSEAU (PLATE 5; Figs.12-13) (Randhawa 1959; P.381; Fig.427a-b)^[15]

Vegetative cells 40-44 µm in diameter, 64-120 µm long, with plane end walls; chloroplast one; conjugation scalariform; tubes formed by both gametangia; some sterile cells inflated to 60-80 µm; fertile cells mostly cylindrical; zygospores ellipsoid 36-40 µm in diameter, 52-76 µm long; mesospore brown, smooth.

The present specimen is very close to the type species.

Habitat: Collection No.DK-43, Date- January 20, 2022, from a pond (pH 6.5, Temp. 16 °C) of Pratapganj (Dist. Supaul) growing along with *S. brunnea* CZURDA, *S. submaxima* TRANSEAU and *Oedogonium* species.

Distribution: Africa (Randhawa 1959)^[15]; India: Punjab (Gupta 2012)^[4].

This is the first record of the species from Bihar

18. *Spirogyra woodsii* (HASSALL) CZURDA (PLATE 5;

Figs. 14-15)

(Randhawa 1959; P.296; Fig.254)^[15]

Vegetative cells 40-42 µm in diameter, 44-48 µm long; chloroplast 1; conjugation lateral; fertile cells swollen on the conjugation side; zygospores ellipsoid, 32-36 µm in diameter, 44-52 µm long; mesospore yellowish-brown, smooth.

The present specimen is similar to the type species, but scalariform conjugation is not observed in our collection.

Habitat: Collection No.DK-42, Date- January 25, 2022, from a ditch (pH 5, Temp. 18 °C) of Pipra Khurd (Dist. Supaul) growing along with *Oedogonium*, *Coleochaete* and other *Spirogyra* species.

Distribution: China; Yugoslavia (Randhawa 1959)^[15]

This is the first record of the species from India.

19. *Spirogyra yunnanensis* LI (PLATE 5; Fig.16)

(Randhawa 1959; P.409; Fig.490)^[15]

Vegetative cells 86-120 µm in diameter, 180-300 µm long; end walls plane; 4-6 chloroplasts, making 2-3 turns in the cell; conjugation scalariform; tube formed by both gametangia; fertile cells cylindrical and shortened; zygospores ellipsoid, 76-88 µm in diameter, 120-132 µm long; median spore wall smooth, yellow.

The present specimen resembles the type species.

Habitat: Collection No.DK-61, February 17, 2022, from a canal (pH 6.0, Temp. 24 °C) of Harpur, Nirmali (Dist. Supaul) growing along with other *Spirogyra* species.

Distribution: China (Randhawa 1959)^[15]; India: Punjab (Gupta 2012)^[4].

This is the first record of the species from Bihar.

Discussion

During the present taxonomic investigation the authors have described total of 19 species of *Spirogyra* Link of the family Zygnemataceae. Out of nineteen taxa of *Spirogyra* investigated during present work, only 4 taxa have replicate septa and the remaining 15 taxa have plane septa. It seems that the species of *Spirogyra* with plane septa are more common than those with replicate or otherwise septa. Similar view has been expressed by Kargupta & Jha (2004)^[7].

Algal association has long been considered important in ecological studies. The most favourable associates of *Spirogyra* were *Oedogonium* and *Zygnema* species.

Out of total 19 species of *Spirogyra* Link identified in the present study, 15 species reproduce by only scalariform conjugation, one species (*S. woodsii* (HASSALL) CZURDA) reproduce by only lateral conjugation and remaining 3 species (*S. cylindrica* CZURDA, *S. longata* (Vaucher) Kützing and *S. tenuissima* (HASSALL) Kützing) reproduce by both scalariform and lateral conjugations. This indicates that scalariform conjugation is most common mode of reproduction but during unfavourable conditions, they employ other modes of reproduction like lateral conjugation, parthenospores etc.

The characteristics of the conjugation tube serve as a taxonomic criterion for this group. While the shape and dimension of the conjugation tube remain consistent in certain species of *Spirogyra*, in many instances, these characteristics exhibit significant variation among different gametangia within the same filament. For instance, *Spirogyra multiformis* (Rattan) Kadlubowska forms display conjugation tubes of

varying lengths.

In the conventional monograph, the shape of the zygospore holds significant importance. While it exhibits less variability in the other members of Zygnematales, it displays a greater range of variation within the genus *Spirogyra*. While the shape of the zygospore remains a constant character for

certain species of *Spirogyra*, it shows considerable variability in some other species. In the present study several such species exhibiting diverse zygospore shapes has been observed (*S. multiformis* (Rattan) Kadlubowska etc.) Kargupta and Jha (2004)^[7] have shared a similar perspective.

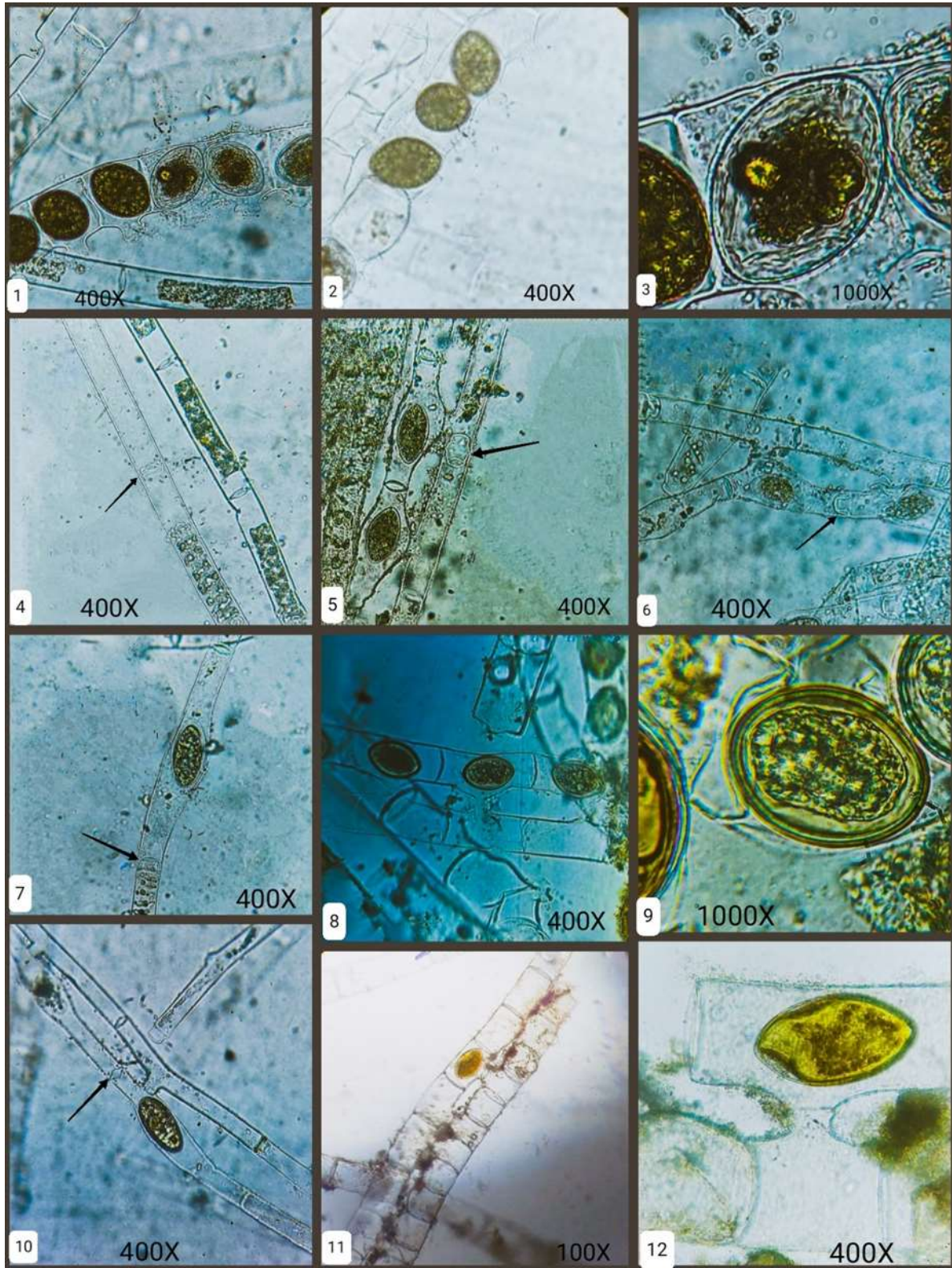


Plate 1: Figs.1-3: *S. brunnea* CZURDA; Figs.4-7: *S. caroliniana* Dilard; Figs.8-9: *S. circumlineata* TRANSEAU; Fig.10: *S. cylindrica* Czurda; Figs.11-12: *S. hatillensis* TRANSEAU

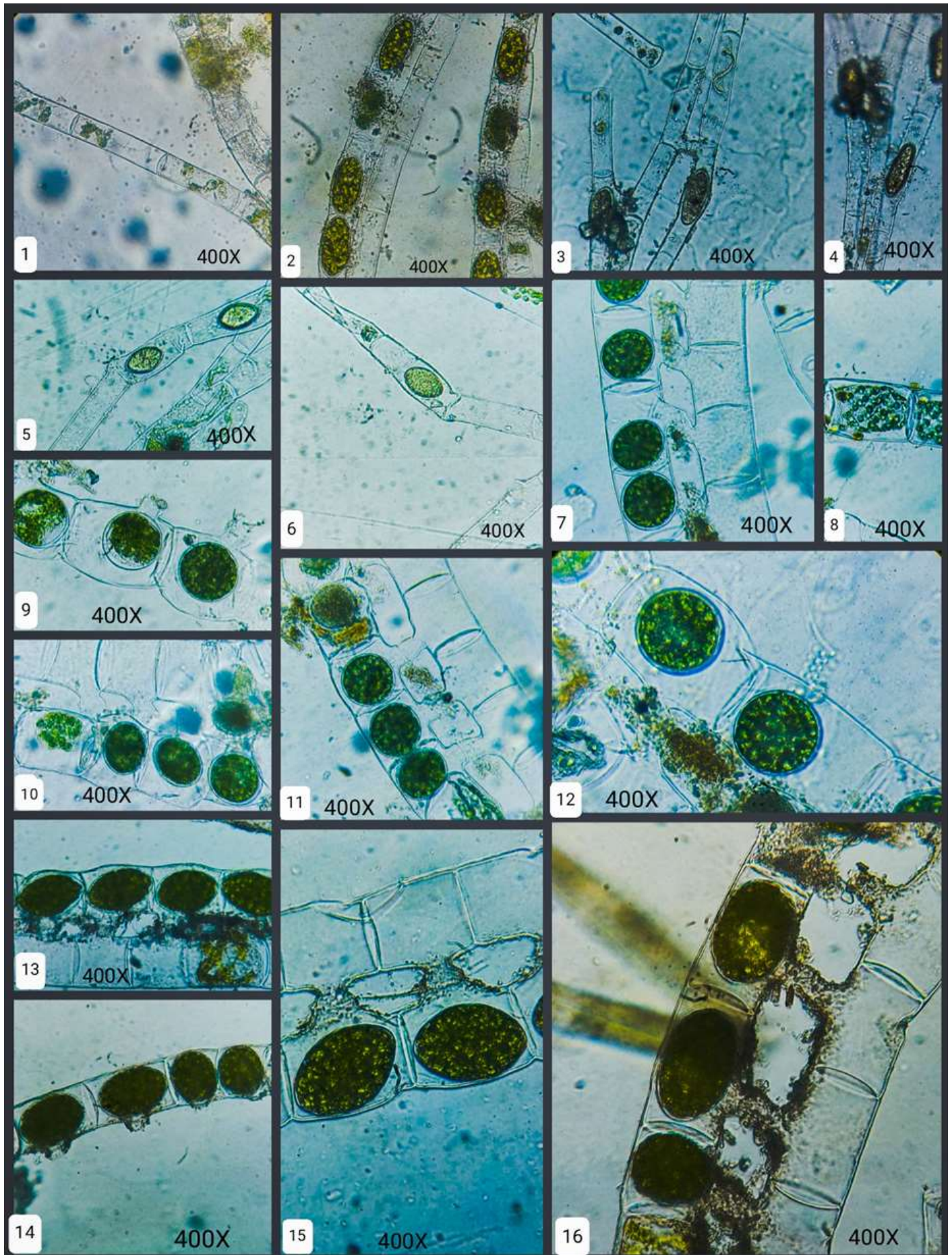


Plate 2: Figs.1-2: *S. juergensii* Kütz. Figs.3-6: *S. longata* (Vaucher) Kützing; Figs. 7-12: *S. majuscula* Kützing; Figs.13-16: *S. multiformis* (Rattan) Kadlubowska

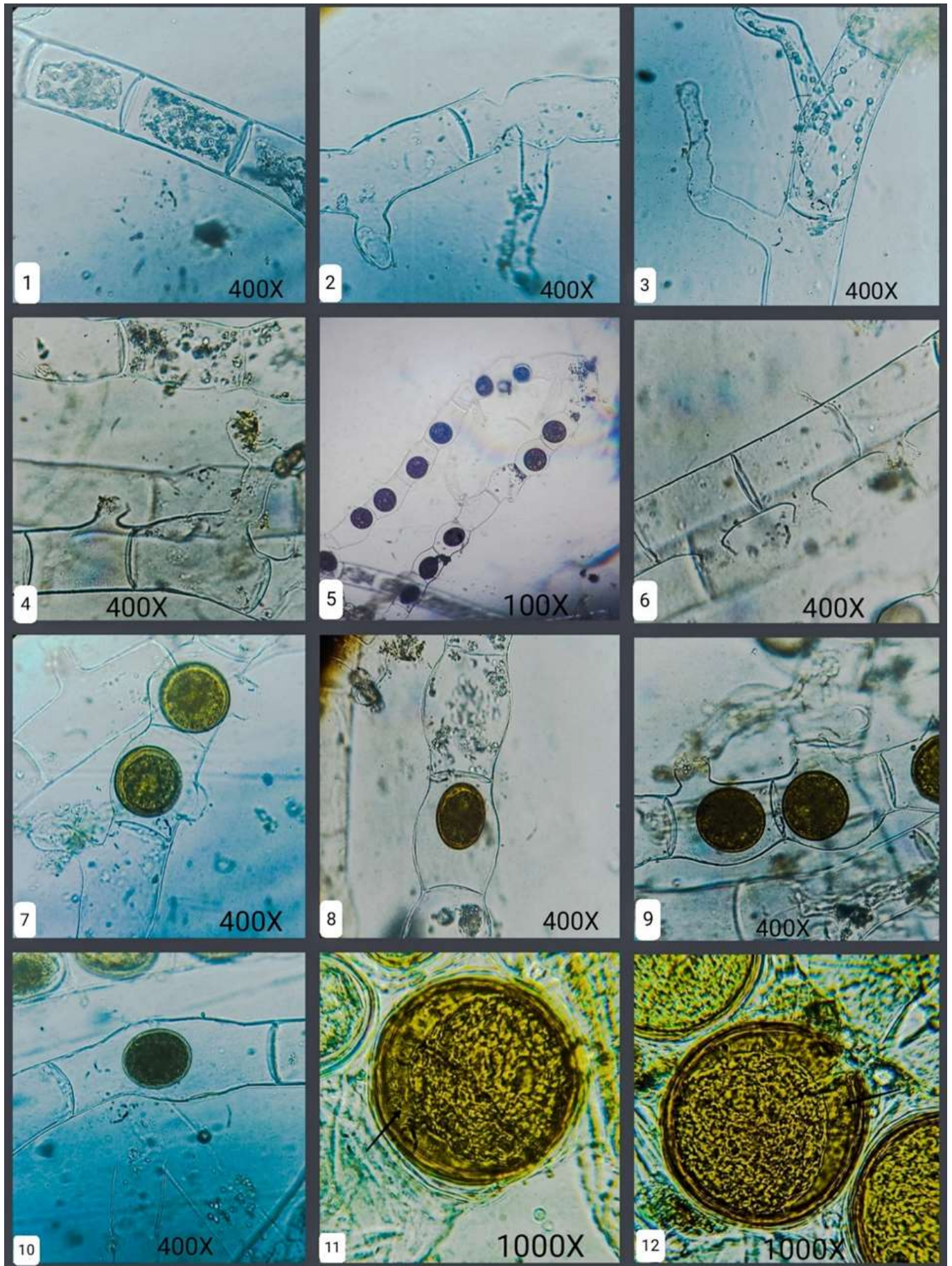


Plate 3: Figs. 1-12: *S. nirmalensis* sp. nov

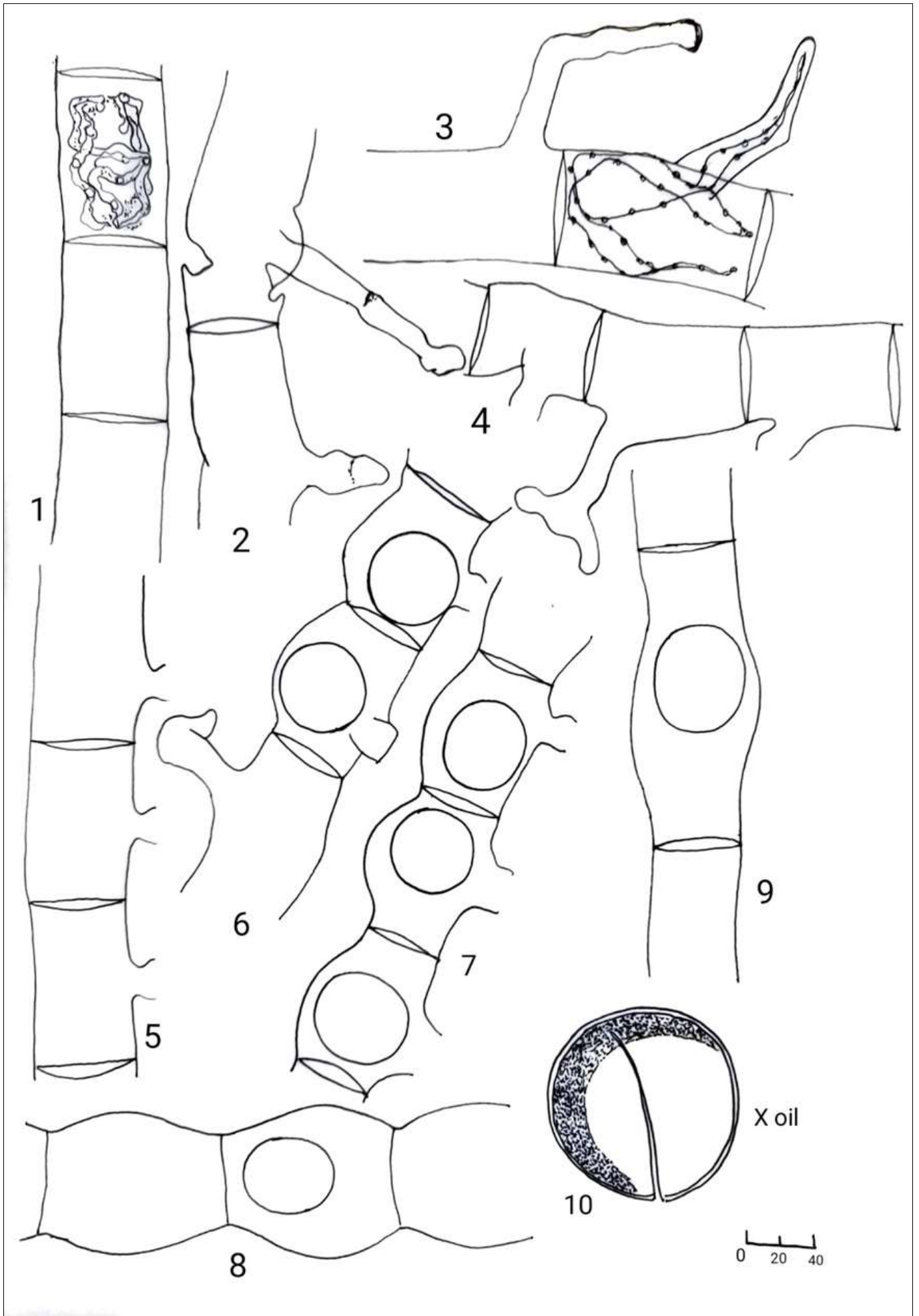


Plate 4: Figs. 1-10: *S. nirmalensis* sp. nov

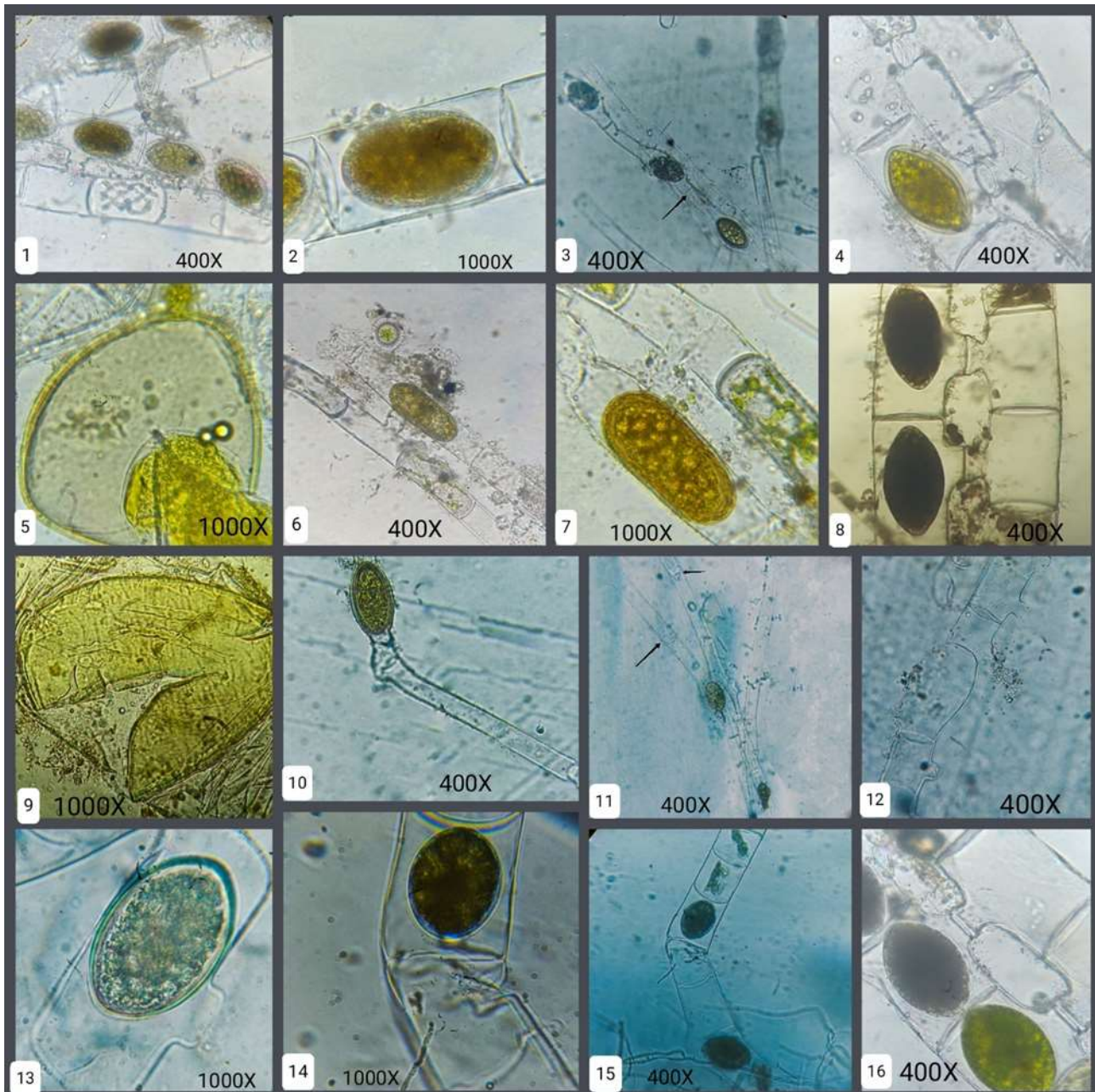


Plate 5: Figs.1-2: *S. paraguayensis* BORGE; Fig.3: *S. pseudodepression* Jao ; Figs.4-5: *S. setiformis* (ROTH) Kütz.; Figs.6-7:*S. subcylindrospora* JAO; Figs. 8-9: *S. subforms* Kargupta & Sarma; Figs. 10-11: *S. tenuissima* (HASSALL) KÜTZING; Figs. 12-13: *S. variformis* TRANSEAU; Figs. 14-15: *S. woodsii* (HASSALL) CZURDA; Fig.16: *S. yunnanensis* LI

Conclusion

In course of identification one taxon were new to science (*S. nirmalensis* sp. nov), two taxa (*S. caroliniana* Dilard & *S. woodsii* (HASSALL) CZURDA) as new record for India and 9 taxa as additions to algal wealth of Bihar.

Acknowledgment

The present authors are thankful to Prof. Shahnaz Jamil, head of the Botany Department for providing laboratory facilities and constant inspiration. They are also grateful to Prof. A. N. Kargupta for giving useful suggestions from time to time

References

- Chalotra P, Gains M, Anand VK. Morpho taxonomic studies on the genus *Spirogyra* Link (Chlorophyta) occurring in fresh water bodies of Jammu, Jammu and Kashmir. IOSR-JAVS. 2013;2(5):01-10.
- Graham LE, Graham JM, Wilcox LW. *Algae*. 2nd ed. Pearson Benjamin Cummings, San Francisco; c2009.
- Guiry MD, Guiry GM. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway; c2021. <http://www.algaebase.org>; searched on; c2021.
- Gupta RK. Algae of India – A Checklist of Chlorophyceae, Xanthophyceae, Chrysophyceae and Euglenophyceae, (B.S.I. Kolkata. India). 2012;2:1-428.
- Jha DK, Kumari A, Jha RN. Some rare species of *Spirogyra* (Chlorophyceae: Zygnematales) from Supaul District of North Bihar, India. Res. Jr. of Agril. Sci. 2022;13(5):1593-1595.
- Kadlubowska JZ. Conjugatophyceae I: Chlorophyta VIII-Zygnematales. Süßwasserflora von Mitteleuropa, Band 16; Fischer, New York, 1984, 532
- Kargupta AN, Jha RN. Algal Flora of Bihar (Zygnemataceae). Bishen Singh Mahendra Pal Singh, Dehra Dun, India; c2004.
- Kargupta AN, Ahmad MR. The genus *Spirogyra* (Chlorophyceae: Zygnematales) from Mithilanchal,

- Bihar. In: Biology of Conjugales (Eds) Vidyavati and Noor). Publ. Printwell, Jaipur (India); c1995. p. 195-218.
9. Kargupta AN, Kumari B, Verma AM. Two new species of the genus *Spirogyra* Link from eastern India. Science and Culture. 1987;53(5):149-151.
 10. Kargupta AN, Sarma P. The genus *Spirogyra* (Chlorophyceae: Zygnemataceae) in West Bengal, India. Bibliotheca phycologica. 1992;91:1-75.
 11. Kamat ND. Chlorophyceae of Ahmedabad, India. Hydrobiologia. 1962;20(3):248-279
 12. Kothari NM. Two new members of Zygnemataceae. Phykos. 1971;10(1/2):106-111.
 13. Kumari A, Jha DK, Jha RN. The genus *Spirogyra* (Chlorophyceae: Zygnematales) in Darbhanga, North Bihar. Phytomorphology. 2022;72(1&2):25-29.
 14. Prasad BN, Misra PK. Studies on the genus *Spirogyra* Link, from Andaman and Nicobar Island. Geophytology. 1983;8(1):63-71.
 15. Randhawa MS. Zygnemataceae. Indian Council of Agriculture Research; New Delhi, India, 1959, 478.
 16. Rattan RS. Notes on some Zygnemaceae from Punjab. Phykos. 1967;6:95-99.
 17. Sarma P, Mustafa G, Kargupta AN. New records of *Spirogyra* spp. from West Bengal-II (Abstract) Proceedings of 69th Indian Science Congress. Pt. 1982;3:12.
 18. Sarma PS, Mustafa G. New records of *Spirogyra* spp. from West Bengal. Bulletin of Botanical Society of Bengal. 1986;40:27-32.
 19. Sarma YSRK, Khan M. Algal taxonomy in India. Today and Tomorrow Book Agency: New Delhi, India, 1980, 1-153.
 20. Srinivasan KS. Algarum species ex India Oriundae. Bulletin of the Botanical Survey of India. 1965;7:188-266.
 21. Transeau EN. The Zygnemataceae - monograph. The Ohio State University Press, Columbus, 1951, 327.
 22. Usha Devi K, Panikkar MVN. Species of the genus *Spirogyra* from Kerala, India. Bibilotheca Phycologica, Berlin (Monograph). 1994;97:1-124.
 23. Yamagishi T. Zygnemataceae of the Chichibu Basin. bull. Chichibu Mus. Nat. Hist. 1960;10:53-66.
 24. Yamagishi T. Studies on the genus *Spirogyra* collected in Japan. Scientific Report of Tokyo Kyoiku Daigaku, Section. Biology. 1966;12:73-105.