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

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Abstract

The present paper deals with the description of nineteen species of *Spirogyra* Link from Supaul district of North Bihar. Of these, *S. caroliniana* Dillad & *S. woodsii* (Hassall) Czurda are being recorded for the first time from India, *S. circumlineata* TRANSEAU, *S. cylindrica* Czurda, *S. juergensii* Kütz., *S. longata* (Vascher) Kützing, *S. majuscula* Kützing, *S. multiiformis* Kadlbowska, *S. paraguayensis* BORGE, *S. variiformis* 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. 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; Czurda, 1984; BORGE, 1987), and out of which 302 species are reported from India (Randhawa 1959; Sarmna & 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, 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) [15] described 80 taxa of *Spirogyra* from Bihar. Five species of *Spirogyra* were reported from Darbhanga district of North Bihar (Kumari et al., 2022) [15]. Jha et al. (2022) [8] 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; Kadlbowska 1984; Kargupta and Sarma 1992; Kargupta and Jha 2004) [21, 6, 15, 10, 7].
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 parthenosporid; conjugation usually scalariform sometimes lateral; zygospores formed in the female gametangia; receptive gametangia may be cylindric 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 |
| 2. Septum plane                                 | 5 |
| 2. Conjugation only scalariform                  | 3 |
| 3. Vegetative cells 15-19 µm in diameter         | 4 |
| 3. Vegetative cells 28-30 µm in diameter         | (12) *S. pseudodepression* |
| 4. Vegetative cells 12 µm in diameter            | (2) *S. caroliniana* |
| 4. Vegetative cells 14-16 µm in diameter         | (16) *S. tenissima* |
| 5. Conjugation only scalariform and lateral      | (4) *S. cylindrica* |
| 5. Conjugation only scalariform                   | (18) *S. woodsii* |
| 6. Conjugation both scalariform and lateral      | 6 |
| 6. Conjugation both scalariform                   | (7) *S. longata* |
| 6. Chloroplasts more than one                     | 7 |
| 7. Chloroplasts more than one                     | 9 |
| 7. Chloroplasts more than one                     | 8 |
| 8. Vegetative cells 24-26 µm in diameter         | (6) *S. juergensi* |
| 8. Vegetative cells 40-44 µm in diameter         | (17) *S. variiformis* |
| 9. Sterile cells more or less swollen             | (5) *S. hatillensis* |
| 9. Sterile cells more or less swollen             | 10 |
| 10. Vegetative cells 26-28 µm in diameter        | (14) *S. subcyindrospora* |
| 11. 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 cylindric or slightly inflated  | 13 |
| 12. Fertile cells inflated on both the sides but  | (10) *S. nirmalensis* sp. nov. |
| 12. Fertile cells inflated on both the sides but  | 14 |
| 12. Fertile cells inflated on the conjugation side only | (9) *S. multiiformis* |
| 13. Zygospores polymorphic                       | 15 |
| 13. Zygospores not polymorphic                   | 16 |
| 14. Zygospores ovoid to ellipsoid, 44-48 µm × 56-72 µm, mesosporic intricately reticulate | (1) *S. brunnea* |
| 14. Zygospores ellipsoid, 40-56 µm × 64-76 µm, mesospore irregularly corrugate | (11) *S. paraguayensis* |
| 15. Zygospores lenticular                        | (8) *S. majuscula* |
| 15. Zygospores ellipsoid                         | 17 |
| 16. Mesospore golden yellow with fine grooves    | (15) *S. subiformis* Kargupta & Sarma |
| 16. Mesospore smooth                             | 17 |
| 17. Zygospores 76-88 µm in diameter              | (19) *S. yunnanensis* |
| 17. Zygospores 88-95 µm in diameter              | (13) *S. setiformis* |

*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. variiformis* 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 circinnutata* 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 Bajnathpur (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 Bajalpur (Dist. Supaul) growing along with *S. tenusissima* (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 cylindric, 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, Ki

**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 juergensi* 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.236a-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) [4].

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 cylindric 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 multiforis* (Ratan) Kadlubowska (PLATE 2; Figs. 13-16) (Kadlubowska 1984; P.299; Fig.456) [4].

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 cylindric 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 μm × 64-100 μm) 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 μm × 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>
<thead>
<tr>
<th>Species</th>
<th>Nature of Septum</th>
<th>Vegetative Cells</th>
<th>No. of Chloroplast</th>
<th>Zygospores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shape</td>
</tr>
<tr>
<td><em>S. submajuscula</em> Ling et Zheng</td>
<td>Plane</td>
<td>60 – 65 μm in diameter</td>
<td>7 – 9</td>
<td>Lenticular</td>
</tr>
<tr>
<td><em>S. majuscula</em> Kützing</td>
<td>Plane</td>
<td>54 – 100 μm in diameter</td>
<td>5 – 10</td>
<td>Lenticular</td>
</tr>
<tr>
<td><em>S. submajuscula</em> Jao</td>
<td>Plane</td>
<td>40 – 45 μm in diameter</td>
<td>4 – 7</td>
<td>Lenticular</td>
</tr>
<tr>
<td><em>S. nirmalensis</em> sp. nov.</td>
<td>Plane</td>
<td>50 – 56 μm in diameter</td>
<td>2 – 5</td>
<td>Globose to Ovoid</td>
</tr>
</tbody>
</table>

The present specimen is closest 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 cylindric, shortened; zygospores ellipsoid, 40-56 μm × 64-76 μm 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 (Randhawa 1959) [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 ellipsoidal, 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 cylindric or enlarged; zygospores cylindric ellipsoid with rounded ends, 32-36 μm × 80-82 μm; 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 *Zygmena* and other *Spirogyra* species.

| Table 1: xxxx |
**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 subformosa* 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 cylindric; 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- January1, 2022, from a char (pH 6.5, Temp. 14˚C) of Dharhar (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 replicative 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 cylindric; 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 woodsi* (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 cylindric 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 Zygmemataceae. 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. woodsi* (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

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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 et al.) Kargupta and Jha (2004) [7] have shared a similar perspective.
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) Kadtubowska
Plate 3: Figs. 1-12: *S. niralensis* sp. nov
Plate 4: Figs. 1-10: S. nirmalensis sp. nov
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.

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