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MORPHOTAXONOMIC STUDY OF SOME CHARALES PROCURED FROM SHEKHA LAKE OF ALIGARH, UTTAR PRADESH, INDIA

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Four taxa of Charales were collected from brackish water of Shekha Lake, situated 11 km on the eastern direction in the suburb of Aligarh, Uttar Pradesh, India. All the collected taxa were studied morphotaxonomically and were assigned their position under the order Charales of Charophytes. The four identified taxa were *Chara vulgaris* var. *vulgaris* f. *crassicaulis* RDW.; *C. vulgaris* var. *vulgaris* f. *gobiana* (Vilh.) RDW.; *C. globularis* var. *leptosperma* f. *leptosperma* RDW.; *C. globularis* var. *virgata* f. *viragata* RDW. Some physico-chemical properties of the brackish water collected from Shekha lake were also evaluated such as dissolved oxygen, conductivity, pH and temperature. The occurrence of different four taxa in the lake were studied morphotaxonomically with reference to the physico-chemical characters.

Key words : Axes, Branchlet, Charophytes, Coronula, Diplostichous, Striae and Tetrascutate.

The Charales, usually called as brass weeds or musk-grasses or stone-worts, constitute a small but sharply defined fascinating group of Algae. The Charophytes show no clear affinity with any other algal group because of their macrophyllous appearance and highly complex reproductive organs. They show resemblance with green algae on the basis of some vegetational characters, however, complexity of their sex organs particularly the structure with the osospores make them comparable to higher plants. Presence of helicoidal spermatozoids also connects them with the Bryophytes. So it very difficult to assign their position in any one particular group due to the amalgamation of so many characters. Their classification was, for a long time, a matter of discussion because of the relative fixity and abscure phylogenetical origin.

The first systematic account of Indian Charophytes was enumerated by Braun (1849). A comprehensive account of Indian Charophyta has further been furnished by Groves (1924) and Pal *et al*. (1962) and Wood and Imahori (1965). So many researchers from India and abroad have long been engaged in evaluating the systematic position of charophytes (Kundu 1929, Allen 1933, 1942, 1961; Iyenger 1951, 1958; Sundaralingam 1963, Agarkar 1963, 1967; Chacko 1966; Dixit 1966, Sinha and Verma 1970, Ramjee and Sarma 1971; Chatterjee 1975, 1979; Ramjee and Bhatnagar 1978; Bharathan and Sundaralingam 1984; Bhatnagar 1988; Bharti 1990; Chaturvedi & Habib, 1991; Pundhir and Chauhan 1998; Subramanian 2000, 2001; Qui 2008, Zviedre and Grinberga 2012). Some workers in the recent past have also shown the importance of systematic studies of Indian Charophytes (Maya *et al*. 2000; Abrol and Bhatnagar 2006, Pundhir *et al*. 2012, Roychoudhary *et al*. 2013; Satpati *et al*. 2013).

Their cytotaxonomic studies were initiated by Sundaralingam (1946) from India particularly with reference to *Chara zeylanica*. Cytotaxonomical study on different charophytes was further extended by workers of different leading institutes of national and international repute (Sinha & Chaudhary 1962, Chatterjee 1971, Bharti and Chennaveeraiah 1974 and Bhatnagar 1989).

Several workers investigated the charophytes from different regions of Uttar Pradesh, but Aligarh district of U.P. remains unexplored. However, some efforts regarding such exploration have also been made from Aligarh (Pundhir *et al*. 2012, Pal and Singh 2017). The main objective of the present research work is to systematize the charophytic

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position of the four sampled taxa of *Chara,* collected from the Shekha lake, on the basis of their morphotaxonomy.

MATERIALS AND METHODS

Sampling Sites : The Charophytes (*Chara* sp.) were collected from every side of the Shekha Lake (i.e. from east, west and central part) of the Aligarh district of Uttar Pradesh, India. Aligarh district is a fertile area and is stranded between the Ganga and Yamuna rivers, commonly known "*Doab*" Aligarh is located at the co-ordinates 27°53'N latitude, 78°05'E longitude/27°88'N latitude, 78°08'E longitude. It has an altitude (elevation) of approximately 178 metres (587 feet) above the sea level. Aligarh has a typical north-central Indian climate i.e. the humid sub-tropical climate usually influenced by Monsoons. The monsoon season starts in late June/early July every year with a slight fluctuation and remains continue till late September/early October, bringing high humidity.

From all three mentioned sides of the lake, the material was collected and procured physically by hands and put into polythene bags. Each bag was tagged with a particular sample number and brought to the phycological laboratory of the Botany Department, D. S. College, Aligarh for preservation and identification.

Preservation and Observation : Plant material, collected from different spots of Shekha Lake, was washed gently and thoroughly under the tap water for 3 to 5 times in order to remove the dust particles and other adhered contaminants. Certain important diagnostic features (e.g. plant monoecious/dioecious, plant height incrusted/unincrusted, length of internode and branchlet, number of branchlets, stipulodes, bract cells, and bracteoles, rudimentary/elongated) were recorded from the materials prior to the preservation. The morphological characters were determined through standard and guided methods. Such parameters were determined with the help of Olympus Compound Binocular Microscope (Model SP.22) using ocular micrometer.

The collected plant material was thereafter preserved in 4% formalin and then each transferred into large glass jar, labeled with same code numbers as studed on the polythene bags. The preserved material was further used for identification and morphological observations.

For morphological observations, the collected plant material was transferred from glass jar to water filled enamel tray for evaluating the parameters like length of internode and branchlet, the number of branchlets, stipulodes, bractcells, bracteoles, position of gametangia at branchlet nodes or base, nature of axis and branchlets branchlet segments or furcation and nature of antheridia. From amongst these parameters, some were evaluated under the 25-45 'prior' zoom stereomicroscope (Model Zs2500).

Microphotography: Before taking photographs, the whole mount (WM) of each of the collected taxa material was stained by using either sefranin or light green. The whole mounted slides were fixed on the clipboard of the research Binocular Microscope BLE-13 (manufactured by BIOCRAFT, Scientific System Private Limited) in order to snap the photographs. The photographs of the important identifying characters (viz. External morphology of a twig, stipulodes at the node, Cortication and spine clels, Antheridium and oogonium, Apex of branchlet, and oospores) of each *Chara* taxon were captured with the help of digital eye camera already installed on the referred as above Binocular Microscope.

Identification: All the studied morphological characters were tabulated and compared with the descriptions made in Standard Monographs of Wood and Imahori (1965). The identification through comparison is given in Table 1 to 4.

RESULT AND DISCUSSION

The morphotaxonomical characters of the collected Charales (*Chara* taxa) were described/discussed separately as sample 1, 2, 3 and 4.

Sample 1: Plants monoecious, upto 38 cm long, heavily incrusted. Axes stout, upto 1360 µm in diameter; internodes 2-3 times as long as branchlet length, to 6.5 cm long; cortex-diplocorticate; spine cells solitary, rudimentary. Stipulodes in 2-tiers, both are developed, upper ones larger than lowers, 2-per branchlet, 260-720 µm long. Branchlets 9 in a whorl, to 3.5 cm long; segments 9 in a branchlet, of which 7-8 diplostichous and 1-2 terminal segment ecorticate; basal segment shorter than others, diplo-corticated; end segment acute, to 680 µm long. Bract cells 6-8, unilateral, shorter than bracteoles, to 220 µm long. Bracteoles 3-4, bilateral, equal to mature oogonium, to 880 µm long. Gametangia conjoined at 1-2 lowest branchlet nodes, absent at the base of the whorl. Oogonia upto 880 µm long (excluded coronula), to 720 µm wide; convolutions 9; coronula upto 300 µm long, to 220 µm wide. Oospores are dark brown, to 640 µm long, to 540 µm wide; striae 7 ridges, to 180 µm long. Antheridia are upto 640 µm in diameter, tetrascutate (Plate-1(A-F).
Habitat : East side of Shekha Lake, Block – Dhanipur, District – Aligarh, U.P., India.

Ecological Parameters : D.O. 9.8,conductivity 0.95, pH 7.85, temp. 23.4°C.

On the basis of the comparison made in Table

Table 1: Comparative morphology of *Chara vulgaris* var. *vulgaris* f. *crassicaulis* (Sch. ex A.Br.) RDW with the present taxa

Plant parts	Present Investigation	Taxa described by Wood and Imahori (1965)
Plants sex	Monoecious, incrusted	Monoecious, incrusted
Height	Upto 38 cm high	10-32 cm high
Axial diameter	1360 µm	900-1500 µm
Internodes	2-3 times as long as branchlets, to 6.5 cm long	2-4 times as long as the branchlets, to 3-4 cm long
Axial cortex	2-corticate	2-corticate
Spine cells	Solitary, rudimentary	Solitary, rudimentary, obscure to ovoid
Branchlets	9 in a whorl, to 3.5 cm long	8-10 in a whorl, 0.4-1.0 cm long
Branchlet segments	9, of which 7-8 are 2-corticate and 1-2 are naked	4-5, of which 3-4 are 2-corticate and 1-2 are naked.
Bract cells	6-8, unilateral, shorter than bracteoles	3-5, unilateral, anteriors long and posteriors rudimentary
Bracteoles	3-4, bilateral, equal to mature oogonium	2, similar to the anterior bract cells
Stipulodes	In 2 tiers, both are well developed, 2 per branchlet	2 (-3) tiers, 2 sets per branchlet, cell ovoid
Gametangia	Conjoined at 1-2 lowest branchlet nodes	Conjoined or rarely sejoined at the 3-4 lowest branchlet nodes
Oogonia	To 880 µm long (excl. coronula), 720 µm wide	600 µm long (excl. coronula), 375-425 µm wide
Coronula	300 µm long, to 220 µm wide	105 µm long, 170 µm wide
Convolutions	9	12-13
Oospores	Dark brown, 640 µm long, 540 µm wide	Brown, 540-620 µm, 300-480 µm wide.
Striae	7 ridges	10-14 ridges
Antheridia	640 µm in diameter, tetrascutate	420-480 µm in diameter, octoscutate

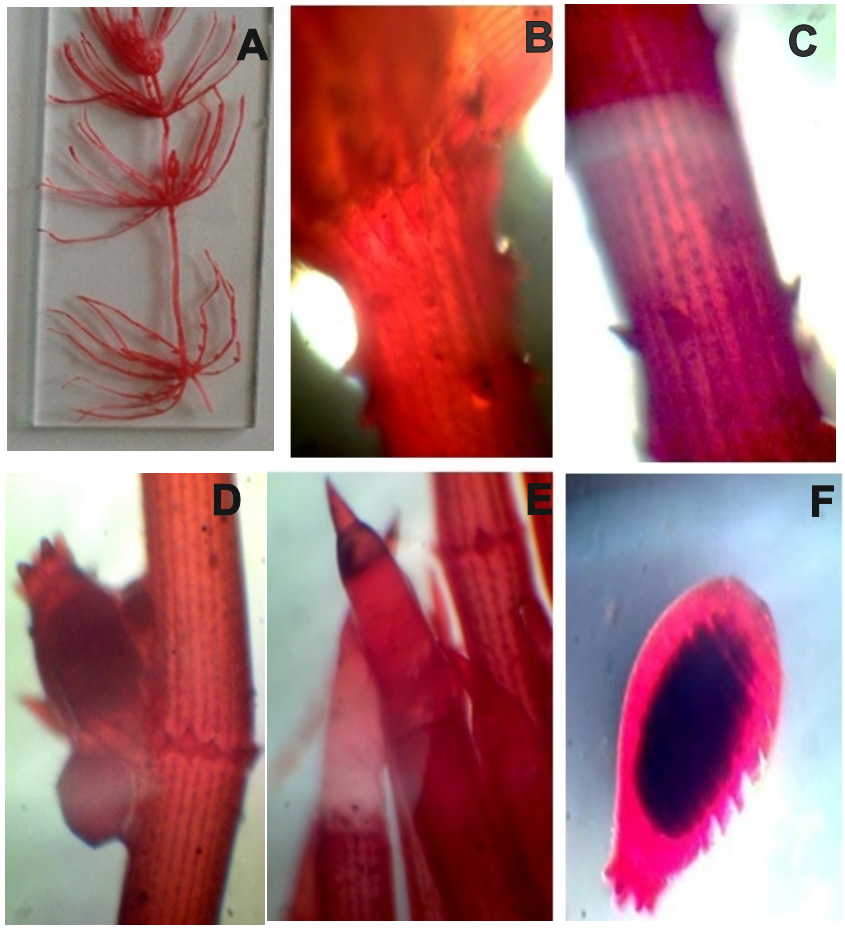

Plate- 1(A-F). Morphological features of *Chara vulgaris* var. *vulgaris* f. *crassicaulis* RDW are as follows : **1.** External morphology of a twig; **B.** Stipulodes at the node; **C.** Cortication and Spine cells; D**.** Antheridium and Oogonium; **F.** Apex of branchlet and F**6.** Oospore

1, the material of the sample 1 was identified as *C. vulgaris* var. *vulgaris* f. *crassicaulis* RDW as described by Wood and Imahori, 1965. (Mon. 97.). The systematic position assigned to the taxon can be presented as follows –

Division	Charophyta
Class	Charophyceae
Order	Charales
Family	Characeae
Tribe	Chareae
Genus	*Chara*
sps	*vulgaris*
var.	*vulgaris*
form.	*crassicaulis*
Syn.	***Chara vulgaris* f. *crassicaulis* (Schleich ex. A.Braun) Kutz**

Sample 2: Plants monoecious, upto 35 cm long, highly incrusted. Axes moderately stout, to 1560 µm in diameter; internodes 2-3 times as long as the branchlet length, to 7.0 cm long; cortex 2-corticate; spine cells solitary, rudimentary. Stipulodes in 2 tiers, both are well developed, upper ones larger than lowers, 2-per branchlet, 360-1060 µm long. Branchlets 9 in a whorl, to 3.0 cm long; segments 8-9 in a branchlet, of which 7-8 corticated and 1-terminal segment, ecorticate; basal segment shorter than others, diplo-corticate; end segment acuminate, to 740 µm long. Bract cells 4-5, unilateral, shorter than bracteoles, to 280 µm long. Bracteoles 3-4, bilateral, equal to mature oogonium, to 1560 µm long. Gametangia 2, conjoined at 1-4 lowest branchlet rodes, absent at the base of the whorl.

Table 2: Comparative morphology of *Chara vulgaris* var. *vulgaris* f. *gobiana* (Vilh.) RDW with the present taxa

Plant parts	Present Investigation	Taxa described by Wood and Imahori (1965)
Plants sex	Monoecious, incrusted	Monoecious, heavily incrusted
Height	Upto 28 cm high	10 cm high
Axial diameter	1520 µm	500-1000 µm
Internodes	2-3 times as long as branchlets	2 times as long as branchlets, 2-3 cm long.
Axial cortex	2-corticate, tylacanthous	2-corticate, aulacanthous or tylacanthous
Spine cells	Solitary, rudimentary	Solitary, rudimentary, often absent below.
Branchlets	10-12 in a whorl, 4.0 cm long	6-10 in a whorl, 1.5 cm long
Branchlet segments	9-10, of which 7-8 are 2-corticate, end segment 3-4 celled	3-4 (-6), of which 1-4 are 2-corticate, end segment 3-4 celled
Bract cells	6, unilateral	4-5, unilateral
Bracteoles	2, elongated, longer than mature oogonium	2, usually slightly longer than mature oogonium
Stipulodes	In 2 tiers, 2 sets per branchlet, upper whorls well developed	In 2 tiers, 2 sets per branchlet, upper slightly longer than lowers
Gametangia	Conjoined at 3-4 lowest branchlet nodes	Conjoined at 2-3 branchlet nodes.
Oogonia	1360 µm long (excl. coronula), 960 µm wide	675-800 µm long (excl. coronula), 480-645 µm wide
Coronula	To 300 µm long, 240 µm wide	180 to 210 µm high, 330-435 µm wide
Convolutions	11-12	11-13
Oospores	Brown to black, to 1160 µm long, 840 µm wide	Dark brown to black, 570-580 µm long, 300-435 µm wide
Striae	10-11 ridges	10-11, not prominent ridges
Antheridia	660 µm in diameter, octoscutate	(270-) 360-390 µm in diameter, octoscutate

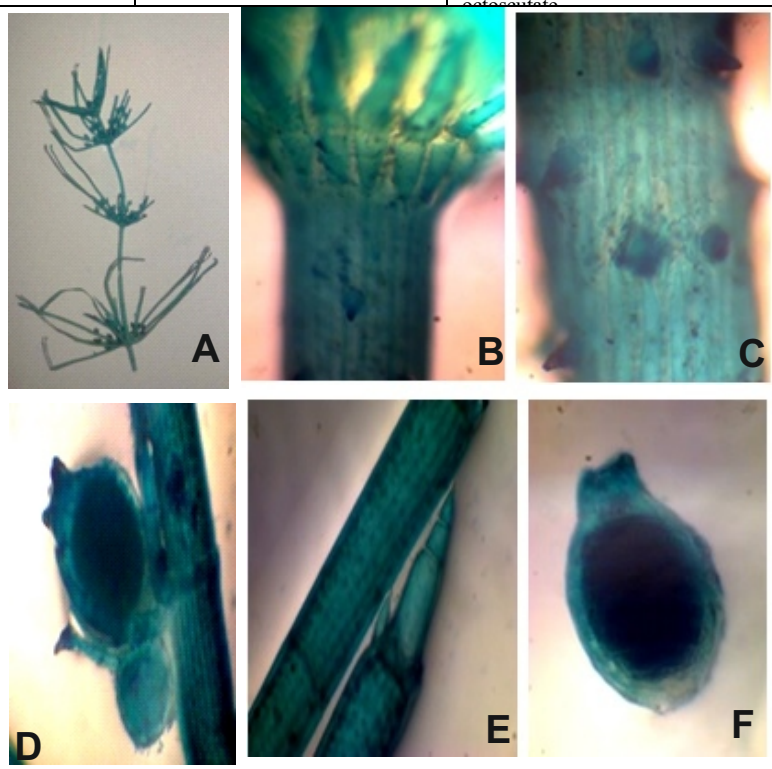

Plate 2 (A-F):- Morphological features of *Chara vulgaris* var. *vulgaris* f. *gobiana* (Vilh.) RDW. are as follows : **A.** External morphology of a twig; **B.** Stipulodes at the node; **C.** Cortication and spine cells; **D.** Antheridium and Oogonium; **E.** Apex of branchlet and **F.** Oospore.

Oogonia upto 1560 µm long (excl. coronula), to 1060 µm wide; convolutions 11; coronula upto 220 µm long, to 180 µm wide. Oospores are black, to 1440 µm long, to 960 µm wide; striae 7-8 ridges, 80-180 µm long. Antheridia are upto 820 µm in diameter, octosculate (Plate 2 (A-F).

Habitat : North-east side of Shekha lake, Block – Dhanipur, District – Aligarh, U.P. India.

Ecological Parameters: D.O. 10.2, conductivity 0.74, pH 7.84, temp. 23.8°C.

On the basis of the comparison made in Table 2, the sample 2 material was identified as *Chara vulgaris* var *vulgiars* f. *gobiana* (Vilh.) RDW as described by Wood and Imahori, 1965 (Mon. 103; Icon. 15). The systematic position assigned to the taxon can be presented as follows –

Division	Charophyta
Class	Charophyceae
Order	Charales
Family	Characeae
Tribe	Chareae
Genus	*Chara*
sps	*vulgaris*
var.	*vulgaris*
form.	*gobiana*
Syn.	**No**

Sample 3: Plants monoecious, upto 62 cm long; heavily incrusted. Axes moderately stout, to 1560 µm in diameter; internodes 3-4 times as long as branchlet length, to 7.2 cm long; cortex 3-corticate, tylacanthous, spine cells solitary, well developed, acuminate. Stipulodes in 2-tiers, upper ones larger than lowers, well developed, 400-1000 µm long; 2-per branchlets. Branchlets 9 in a whorl, to 5.5 cm long; segments 8-9 in a branchlet, of which 6-7 triplo-corticate and 2-3 terminal segments

Table 3: Comparative morphology of *Chara globularis* var. *virgata* f. *virgata* RDW with the present taxa

Plant parts	Present Investigation	Taxa described by Wood and Imahori (1965)
Plants sex	Monoecious, incrusted	Monoecious, slightly incrusted
Height	Upto 24 cm	To 25 cm
Axial diameter	To 1260 µm	250-500 µm
Internodes	2-3 times as long as branchlets, to 3.0 cm long	1-2 (-5) times longer than branchlets, to 2.5 cm long
Axial cortex	3-corticate, tylacanthous	3-corticate, isostichous to strongly tylacanthous
Spine cells	Solitary, well developed, acuminate	Spine-cells obscure to absent, globular or rarely elongate
Branchlets	9 in a whorl, upto 1.5 cm long	6-9 in a whorl, to 1.0 cm long
Branchlet segments	10 of which 8-9 are 3-corticate	6-9 (-11) of which 5-8 are 2-3 corticate
Bract cells	4-6, unilateral	5-7, unilateral
Bracteoles	3, bilateral, longer than mature oogonium	2, ¾ -2 times as long as mature oogonium
Stipulodes	In 2 tiers, 2 per branchlet, upper ones larger than lowers	In 2 tiers, 2 sets per branchlet, upper usually longer than lowers
Gametangia	Conjoined at 2-3 lowest branchlet nodes	Conjoined or sejoined at 1-3 (-4) lowest branchlet nodes
Oogonia	To 1360 µm long (excl. coronula), to 1160 µm wide	750-1000 µm long (excl. coronula), 500-675 µm wide
Coronula	Upto 300 µm long, to 220 µm wide	To 250 µm or variable in height, to 250 µm wide
Convolutions	9	14-15
Oospores	Black, to 1220 µm long, to 1180 µm wide	Dark brown to black, 560-720 µm long, 410-550 µm in wide
Striae	8 ridges	11-14 low ridges
Antheridia	Upto 660 µm in diameter, octoscutate	350-560 µm in diameter, octoscutate

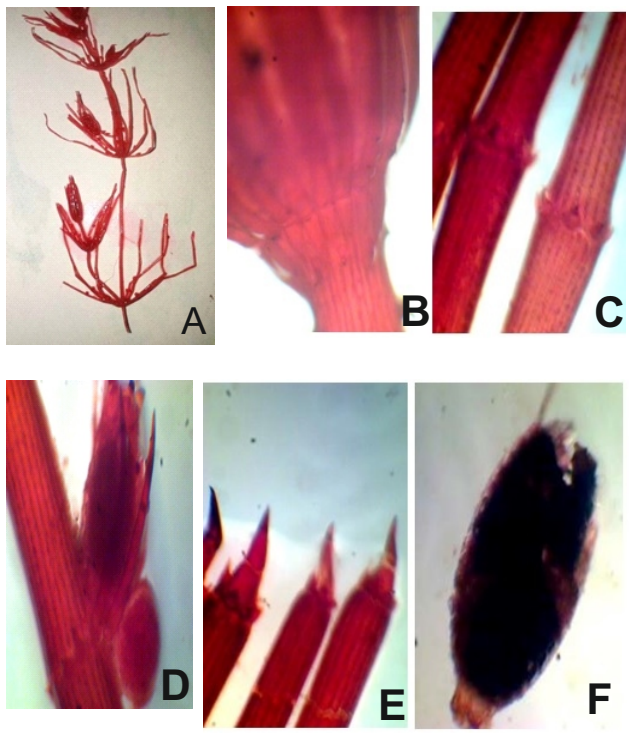

Plate-3 (A-F): Morphological features of *Chara globularis* var. *virgata* f. *virgata* RDW. are as follows:**A.** External morphology of a twig; **B.** Stipulodes at the node; **C.** Branchlet and bract cells; **D.** Antheridium and Oogonium; **E**. Apex of branchlet, and **F.** Oospore.

ecorticate; basal segment shorter than others, triplo-cortex; end segment acute, 700 µm long. Bract cells 5-6, unilateral, shorter than bracteoles, to 300 µm long. Bracteoles 3, bilateral, longer than mature oogonium; to 1360 µm long. Gametangia 2, conjoined at 1-3 lowest branchlet nodes. Oogonia upto 840 µm long (excl. coronula), to 540 µm wide; convolutions 9; coronula upto 280 µm long, to 240 µm wide. Oospores are black in colour, to 700 µm long, to 480 µm wide; striae 7, 80-160 µm long. Antheridia are upto 540 µm in diameter; octoscutate [Plate-3, Figures A-F).

Habitat : Central side of Shekha Lake, Block – Dhanipur, District – Aligarh, U.P., India.
Ecological Parameters : D.O. 14.8, conductivity 0.34, pH 6.26, temp. 22.6°C.

On the basis of the comparison made in Table-3, the sample-3 material was identified as *Chara globularis* var. *virgata* f. *virgata* RDW as described by Wood and Imahori, 1965. (Mon. 183; Icon. 61).The systematic position assigned to the taxon can be presented as follows –

Division	Charophyta
Class	Charophyceae
Order	Charales
Family	Characeae
Tribe	Chareae
Genus	*Chara*
sps	*globularis*
var.	*virgata*
form.	*Virgate*

Syns. ***Chara lamyana*** **(M. Soulal : Ribette),** ***Chara fragilis*** **f.** ***verrucosa*** **(Itzigsohn) W. Migula**

Sample 4 : Plants monoecious, upto 23 cm long, moderately incrusted. Axes moderately stout, to 1280 µm in diameter; internodes 2-3 times as long as the branchlet length, to 5.5 cm long; cortex 3-corticate, isostichous to partially tylacanthous; spine cells solitary, rudimentary. Stipulodes in 2 tiers, uppers larger than lowers, 2-per branchlet, well

Table-4 : Comparative morphology of *Chara globularis* var. *leptosperma* f. *leptosperma* (A. Br.) RDW with the present taxa

Plant parts	**Present Investigation**	**Taxa described by Wood and Imahori (1965)**
Plants sex	Monoecious, incrusted	Monoecious, slightly incrusted
Height	Upto 23 cm	To 16 (-more) cm
Axial diameter	1280 µm	1000 µm
Internodes	1-3 times as long as branchlets, to 5.5 cm long	1-2 time as long as branchlets, to 3.0 cm long
Axial cortex	3-corticate, isostichous to partially tylacanthous	Regularly 3-corticate, isostichous slightly tylacanthous
Spine cells	Solitary, rudimentary or obscure	Solitary, absent or obscure
Branchlets	8-10 in a whorl, spreading, to 1.5 cm long	6-9 (-11) in a whorl, to 1.5 cm long, spreading
Branchlet segments	9 of which 7-8 are 3-corticate, end segment naked	6-9 of which all are 3-corticate, except the end cell, end segment 1-celled
Bract cells	4-6, verticillate	4-6 (-8), unilateral to verticillate
Bracteoles	2, slightly longer than anterior bract cells	2, similar to anterior bract cells
Stipulodes	In 2 tiers, 2 sets per branchlet, upper 2-3 times longer than lowers	In 2 tiers, 2 sets per branchlet, ½-1 times as long as axis diameter
Gametangia	Conjoined at 3-4 lowest branchlet nodes	Conjoined at 3-4 lowest branchlet nodes.
Oogonia	Upto 1560 µm long (excl. coronula), to 980 µm wide	830-850 µm long (excl. coronula), 350-360 µm wide
Coronula	Upto 320 µm long, to 220 µm wide	180-190 µm high, 180-190 µm wide
Convolutions	12-14	-
Oospores	Dark brown to black, 1160 µm long, 740 µm wide	Golden brown, 540-600 µm long, 300-480 µm wide
Striae	10-11 with inconspicuous ridges	11-12 low ridges
Antheridia	Upto 680 µm in diameter, octoscutate	250- (320-600) µm in diameter, octoscutate

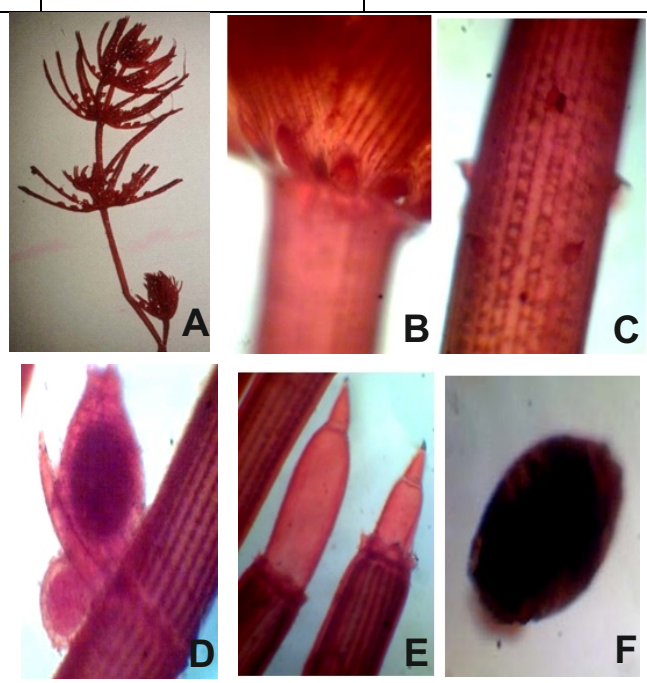

Plate-4 (A-F): Morphological features of *Chara globularis* var. *leptosperma* f. *leptosperma* RDW. are as follows : **A.** External morphology of a twig; **B.** Stipulodes at the node; **C.** Cortication and spine cells; **D.** Antheridium and oogonium; **E.** Apex of branchlet and **F.** Oospore.

developed, 460-1160 µm long. Branchlet 10 in a whorl, 1.0-3.2 cm long; segments 6-8, of which 4-5 diplo-corticate and 2-3 terminal segments 3-corticate, phloeopodous, ecorticate; basal segment shorter than others; end segment acute, to 400 µm long. Bract cells 4-5, verticillate, shorter than bracteoles, to 160 µm long. Bracteoles 3, shorter than mature oogonium, bilateral, to 840 µm long. Gametangia 2, conjoined at 1-3 lowest branchlet nodes, absent at the base of the whorl, present at the lowest node is one pair. Oogonia heavily incrusted, to 1040 µm long (excl. coronula), to 800 µm wide; convolutions 8-10; coronula upto 300 µm long, to 180 µm wide. Oospores are black or brown, to 900 µm long, to 660 µm wide; striae 7, upto 160 µm long. Antheridia are upto 560 µm in diameter, tetrascutate [Plate-4 (A-F)] .

Habitat : West side of Shekha Lake, Block – Dhanipur, District – Aligarh, U.P., India.
Ecological Parameters : D.O. 10.8, conductivity 0.51, pH 7.84, temp. 22.3°C.

On the basis of the comparison made in Table-4, the sample-4 material was identified as *Chara globularis* var. *leptosperma* f. *leptosperma* RDW as described by Wood and Imahori; 1965. (Mon. 192; Icon. 67-69). The systematic position assigned to the taxon can be presented as follows –

Division	Charophyta
Class	Charophyceae
Order	Charales
Family	Characeae
Tribe	Chareae
Genus	*Chara*
sps	*globularis*
var.	*leptosperma*
form.	*leptosperma*
Syn.	***Chara fragilis* (Desv.)**

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