International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

The Study of Charophytes from Behat Region, Saharanpur District, Western Uttar Pradesh, India

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ABSTRACT

Charophytes, also known as stonewort, are ecologically critical freshwater chlorophyllous macroalgae that are crucial to the health and water quality of aquatic ecosystems. Scientists have paid less attention to the Charophyte flora in the Behat region than in many other regions of India. Large portions of the region are still unexplored, and the current research is limited to a few localities and are based on field surveys carried out in ponds, rice and sugarcane fields, canals, and other freshwater habitats. The aim of the current research is to study the Charophytes from the Behat region of Saharanpur district, Wester Uttar Pradesh, India. The Plant sample were collected and preserved from their natural habitat and identified on the basis of morphological characters (traits). Four taxa, namely *Chara globularis* var. *laptosperma f. laptosperma*, *Chara hispida* var. *sibirica, Chara vulgaris* var. *vulgar*is *f. kieneri,* and *Chara hispida* var.*major f. rudis* were recorded based on detailed morphological characteristics. Physicochemical parameters such as water temperature, pH, dissolved oxygen, electrical conductivity and total dissolved solute were analyzed to determine habitat suitability.

Keywords: Branchlet apex, Cortication, Stipulodes, Charophytes, Oospore.

INTRODUCTION

The Characeae family is a distinctive group of freshwater green algae, known as charophytes, which are thought to be the closest surviving relatives of land plants. They are water green algae that important for understanding the evolution of plants from water to land. They have multicellular erect thallus differentiated into nodes and internodes. There are whorls of branchlets from each node, which gives the plant a characteristic appearence. They are often encrusted with calcium carbonate and have rhizoids for anchorage. The reproductive organs, the antheridia (male) and oogonia (female) are multicellular and are normally formed at the nodes. After fertilisation a resistant oospore is formed.Their presence helps to oxygenate the water, stabilize sediments, cycle nutrients and preserve aquatic biodiversity. They are also regarded as important bioindicators of the health of freshwater ecosystems as they are sensitive to changes in water quality.

The first systematic account of Indian Charophyta was enumerated by Braun (1849). A comprehensive account of Indian Charophyta has further been furnished by Pal et al. (1962) and that of the world by Wood and Imahori (1965). Since then various workers have been engaged in evaluating the systematic

position of Charophytes in India as well as abroad (Allen 1933, 1961, Iyanger 1951, Sinha and Verma, 1970; Chatterjee, 1979; Pundhir and Chauhan, 1998; Subramanian 2001; Qiu, 2008). Some recent workers have also shown the importance of systematic studies of Indian Charophytes (Pundhir et al., 2012; Roychoudhary et al., 2013; Satpati et al., 2013 and Pal, N. and Singh, K., 2017 and 2021).

Charophytes are ecologically significant, and can accumulate dense biomass in deep and shallow lakes and ponds, depending on water quality. These large outgrowths are an important food source for herbivorous waterfoul (Schmieder et al. 2006) and a food for aquatic animals and farm livestock. They also have a role in water cleaning (Schneider et al. 2015). These beds are crucial spawning places for fish as they provide protection from predators and current (Lake et al. 2002).Charophytes are sensitive to environmental changes and are useful bioindicators of the ecosystem status and play a crucial role in carbon and nutrient cycles, because they enhance water clarity and maintain oligotrophic conditions in habitats. Charophytes may absorb nutrients from the water into plant biomass, increase sedimentation and decrease sediment suspension, which is good for controlling nutrient cycles (Vermaat et al., 2000). Many species are perennial and their biomass decomposes slowly, so that carbon and nutrients are preserved for extended periods in their sediments. These algae may be more densely encrusted with calcium carbonate than aquatic vascular plants, and so have been key producers of carbonate deposits in freshwater lakes in the last few million years (Rodrigo et al. 2010). The main objective of the present research work is to study the charophytes from thr Behat region Saharanpur district,Western Uttar Pradesh India.

MATERIALS AND METHODS

Collection: Plants (Charophytes) samples were collected from diverse locality in Behat region of Saharanpur district, Western Uttar Pradesh, India. It is very rich (fertile) area and stratches between Yamuna and Ganga rivers popularly known as doab at the foot slopes of Shivalik range. Behat area is located in the co-ordinates 30.17° N latitude 77.61° E longitude about 30 km north of Saharanpur near the city Badshahibagh and Kalesar with all four states having boundary nearby. Average elevation (latitude) is roughly 345 m above the sea level. The Behat region has a sub-humid tropical climate, affected by the presence of the Himalayan foothills. The summer season are from March to June and the winter from October to February, with the coldest month being January.

Samples were gathered from different areas in the Behat region and procured physically by hands with particular sample number and brought to the phycological laloratory of Dept. of Botany, Dharam Samaj College, Aligarh for preservation and identification.

Preservation and Morpho-observation: Plants samples collected from diverse site of Behat region were washed gently and thoroughly with tap water 2 to 3 times to remove dust particle. Some distinctive diagnostic features (e.g., plant dioecious/monoecious, plant height, incrusted/unincrusted, length of internode and branchlet, number of branchlets, stipulodes, bract cells and bracteolet, rudimentary/elongated) were recorded from plant samples before preservation. Such characteristics were obtained with the help of Olympus Binocular Microscope (Model SP.22) by using ocular micrometer.

The collected plant material was then preserved in 4% formalin and moved to large plastic container with same code number as indicated on the polythene bags. Preserved plant sample was then used for morphological observation and identification. For morphological observations samples were transferred from plastic container to water filled enamel tray for evaluating the parameters such as length of

internode and branchlet, number of branchlets, stipulodes, bract cells, bracteoles, position of gametangia at branchlet nodes, nature of axis and branchlet, branchlet segments and nature of antheridia. Some of these metrics were tested using stereomicroscope (Model ZS 2500).

Micrography: Before micrography, the complete mount of each gathered plant material was stained with either sefranin/ light green. The full mounted slides were set on the clipboard of the Reseach Trinocular Microscope BLE-18-A (Manufactured by BIOCRAFT, Scientific System Private Limited) to shoot the images. The photograph of impotent identifying characters (viz., external morphology of a twig, stipulodes at the nodes, cortication and spine cell, antheridium and oogonium, apex of branchlet and oospores) of each taxon were taken with the help of digital eye camera installed on the referred as above Trinocular Microscope.

Identification: All the researched morphological features were tabulated and compared with the description made accessible in standard Monographs of Wood and Imahori (1965) Identification by comparison is given in table 1 to 4.

RESULTS AND DISCUSSION

The diagnostic features of the Charophytes (Chara taxa) are illustrated separately as samples 1, 2, 3 and 4.

Sample-1. Plants monoecious, upto 26 cm long, slightly incrusted. Axes moderately stout, to 1230 µm in diameter; internodes 1-2 times as long as the branchlets, to 5.2 cm long; cortex 3-corticate, isostichous to partially tylacanthous; spine cells solitary, rudimentary. Stipulodes in 2 tiers, 2 sets per branchlet; uppers 2-3 times longer than lowers, to 940 µm long; lowers to 415 µm long, opposite, incurved, acute Branchlets 8-10 in a whorl, spreading, to 1.5 cm long; segments 9, of which 7-8 segments, 2 corticate; basal segment phloeopodous, swollen, shorter than others; distal 2-segments ecorticate; end segment 1-celled, naked, terminated into 2-3 corona like cells. Bract cells 4-6,verticillate, anterior 2-elongate, 1-2 times longer than mature oogonium, posteriors bract cells slightly longer than anterior, 2-4 times longer than oogonia, to 1460 µm long. Gametangia conjoined at 3-4 lowest branchlet nodes, absent at the base of the whorl. Oogonia upto 1520 µm long (excl. coronula), to 960 µm wide; convolutions 11-14; coronula upto 310 µm long, to 210 µm wide. Oospores dark brown to black, to 1180 µm long, to 780 µm wide; striae 8-11 with inconspicuous ridges, 75-150 µm long. Antheridia are upto 700 µm in diameter, octoscutate [Table -1 and Plate -1, Figure (A-F)].

Table 1: Comparative morphological study of present taxa and *Chara globularis* var. *laptosperma* f. laptosperma (A.Br) R.D.W

Parameters	Present Observation	Taxa Described by Wood and Imahori (1965)
Plant sex	Monoecious, lightly incrusted	Monoecious, slightly incrusted
Height	Upto 26 cm	Upto 16 cm
Axial diameter	1230 µm in diameter	1000 µm in diameter
Internode	1-2 X as long as the branchlets, to 5.2 cm long	1-2 time as long as branchlet to 3.0 cm long

Axial cortex	cortex 3-corticate, isostichous to partially tylacanthous	3 corticate, isostichous and tylacanthous
Spine cells	solitary, rudimentary	Solitary, absent or obscure
Branchlets	8-10 in a whorl, streatching upto 1.5 cm long	6-9 (11) in a whorl, upto1.5 cm long,spreading
Branchlet segments	7-8 segments, 2 corticate; basal segment phloeopodous	6-9 of which all are 3 corticate,except the end cell, end segment 1-celled
Bract cell	Bract cells 4-6, verticillate	4-6 (8), unilateral to verticillate
Bracteoles	2, slightly longer than anterior bract cell	2, similar to anterior bract cells
Stipulodes	In 2 tiers, 2 sets per branchlet	Diplostichous, 2 set per branchlet
Gametangia	conjoined at 3-4 lowest branchlet nodes	Conjoined at 3-4 lowest branchlet nodes
Oogonia	Upto 1520 µm long (excl. coronula), to 960 µm wide	Upto 830-850 µm long (excl. coronula) 350-360 µm wide
Coronula	Upto 310 µm long, to 210 µm wide	Upto 180-190 µm long, 190-220 µm wide
Convolution	11-14	13-15
Oospore	Brown or black	Golden brown 540-560 µm long, 300-480 µm wide
Striae	8-11	11-12 low ridges
Antheridia	Upto 400 µm in diameter, octoscutate	225-250 µm in diameter, octoscutate

PLATE- 1

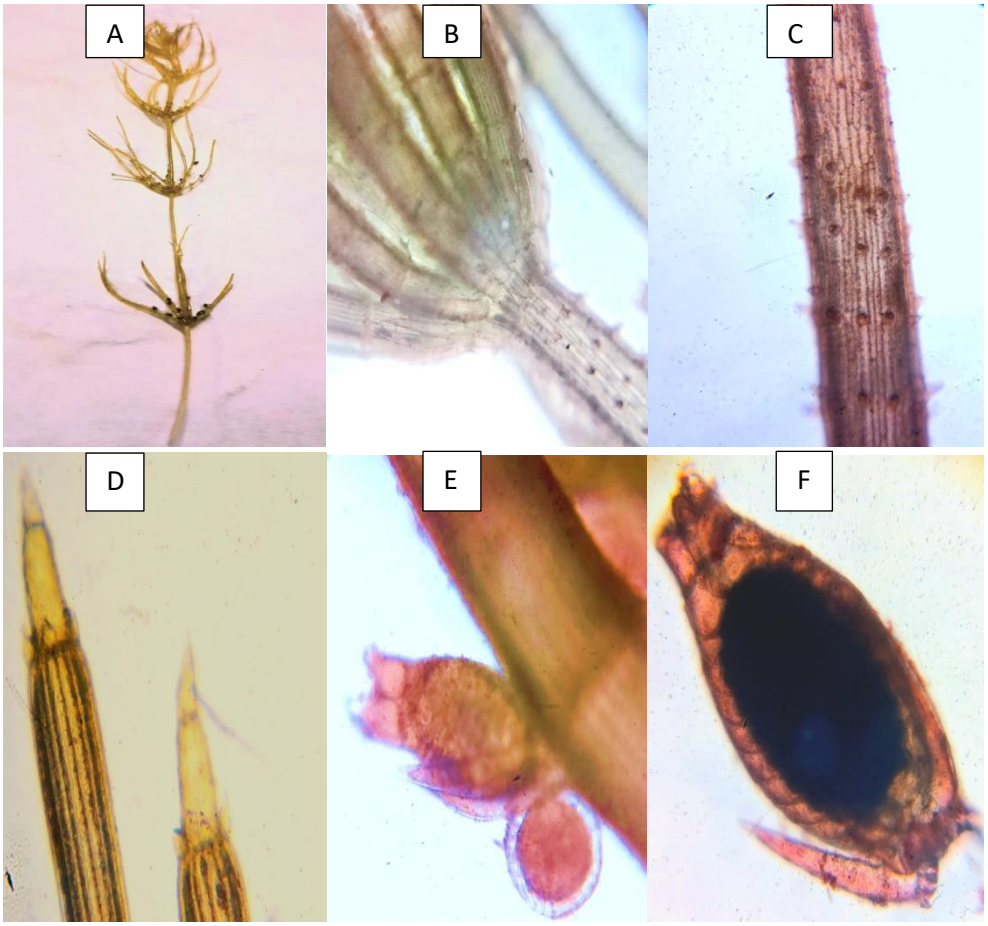


Figure (A-F) Morphological features of *Chara globularis* var. *leptosperma* f. *leptosperma* R.D.W are as follows **A.** External morphology of a twig, **B.** Stipulodes at the node, **C.** Cortication and spine cells, **D.** Apex of branchlet, **E.** Gametangia at node, **F.** Oospore

Habitat : Temporary pond of kalsiya, Behat, Saharnpur (S.No. SK 001).

Ecological parameters: Dissolved Oxygen- 6.11, Electrical Conductivity 233.10 µS/l, pH 7.72, Temperature. 24.8°C.

Identification: The present material resembles with *Chara globularis* var. *leptosperma f. leptosperma* R.D.W.as given by Wood and Imahori, 1965. (Mon.192 Icon.67-69)

SAMPLE-2

Plants monoecious, small, upto 12 cm long, unincrusted or slightly incrested. Axes moderately stout, upto 655 µ in diam; internodes 1.5 times as long as branchlet length, cortex 1-2 corticate; tylacanthous with lower internodes ecorticate, spine cells solitary, well developed, acuminate, 590-1170 µ long. Stipulodes in 2 tiers, 2-sets per branchlet, irregularly arranged, upper ones larger than lowers, upto 400-560 µ long. Branchlets 6-8 in a whorl, to 0.8 cm long; segments 5-6 in a branchlet, 6-7 segments, diplostichous, 1-3 terminal segment naked and much larger than corticated one, swollen, basal segment short and 2-corticated; end segment 1-2 celled acuminate. Bract cells 4-6, unilateral, well developed,

anterior 1.5 times oogonia length, 900 µ long, 120 µ wide acuminate. Bracteoles 2, rudimentary, frequently absent, length 1 times antheridium diameter. in length 220 µ long, 47 µ diam. tapering to rather obtuse tip. Gametangia conjoined at 3 lowest branchlet nodes. Oogonia immature, solitary upto 460 µ long (excl. coronula), to 280 µ wide; convolutions 13; coronula upto 80 µ long, 160 µ wide. Oospores slightly mature. Antheridia upto 240 µ in diameter, octoscutate (Table-2 and Plate-2, Figure (A-F).

Table 2: Comparative morphological study of present taxa and Chara hispida var. sibirica (Mig) R.D.W.

Character	Present observation	Taxa described by Wood and Imahori (1965)
Plant sex	Monoecious, slightly incrusted	Monoecious, slightly incrusted
Height	Upto 12 cm	Upto 3 cm
Axial diameter	upto 700 µm in diameter	600 µm in diameter
Internode	Internode as equal as the branchlet length	Internode as equal as the branchlet length
Axial cortex	1-2 corticate, tylacanthous	1-2 corticate, tylacanthous
Spine cells	spine cells solitary,700-1400 µm long, 170 µ wide	spine cells solitary,600-1200 µm long, 105 µ wide
Branchlets	7-8 in a whorl, streatching upto 1.5 cm long	6-8 in a whorl, upto 0.7 cm long
Branchlet segments	7-8 segments, terminal cell naked and swollen	5-6 of which 4 are corticate, end segment 1-2 celled
Bract cell	Bract cells 6-8, unilateral	4-5 unilateral,1.5 oogonia length
Bracteoles	2, slightly longer than anterior bract cell, 800-1200 µm long	2, rudimentary, frequently absent, equal to antheridium diameter,600-1000 µm long
Stipulodes	Diplostichous, 2 sets per branchlet	Double tier, 2 set per branchlet
Gametangia	conjoined at 3-4 lowest branchlet nodes	Conjoined at 3-4 lowest branchlet nodes
Oogonia	Slightly mature, Upto 550 µm long (excl. coronula), to 360 µm	Immature, solitary Upto 450 µm long (excl. coronula) 300 µm wide

	wide	
Coronula	Upto 310 µm long, to 210 µm wide	Upto 180-190 µm long, 190-220 µm wide
Convolution	14, 110 µm long, 250 µm wide	13, 75 µm long, 150 µm wide at base
Oospore	Dark black	Golden brown 540-560 µm long, 300-480 µm wide
Striae	8-12	8-10
Antheridia	upto 300 µm in diameter, octoscutate	225-250 µmin diameter, octoscutate

Plate-2

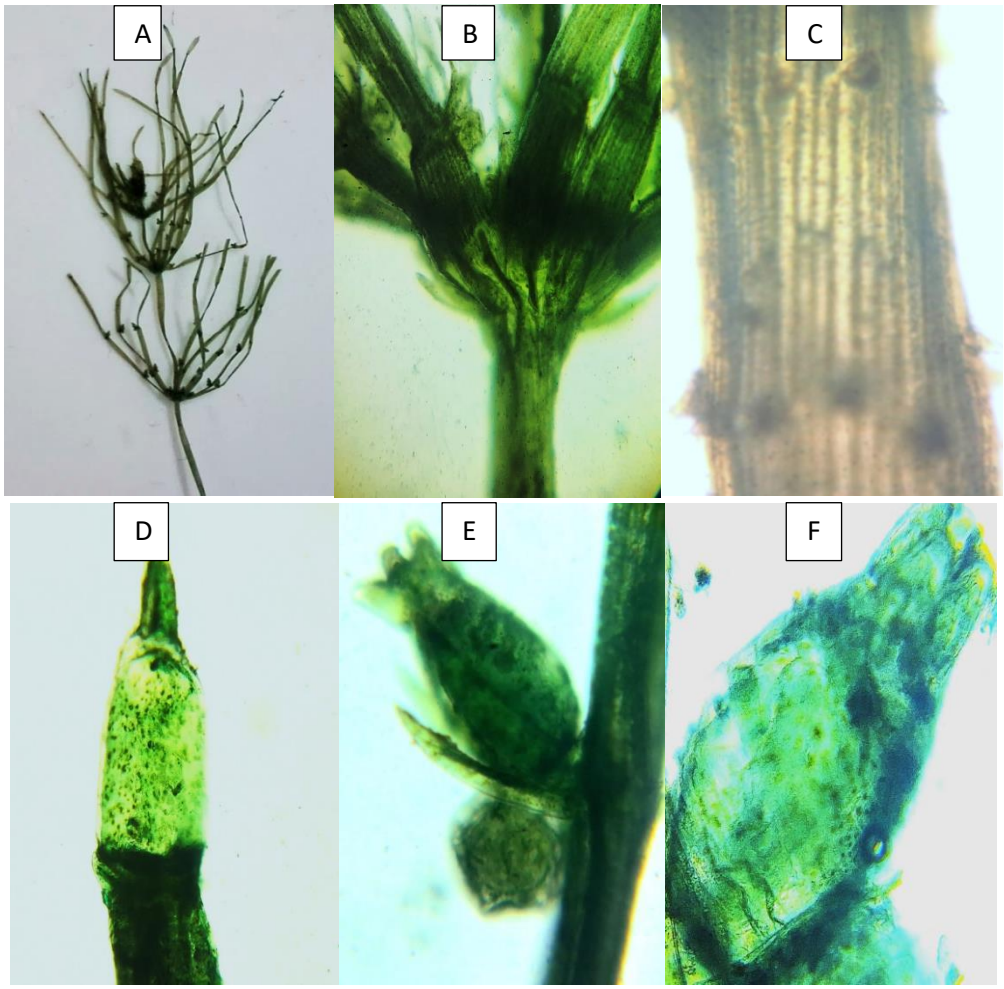


Figure (A-F) Morphological features of *Chara hispida* var. *sibrica* (Mig) RDW are as follows **A.** External morphology of a twig, **B.** Stipulodes at the node, **C.** Cortication and spine cells, **D.** Apex of branchlet, **E.** Gametangia at node, **F.** Oospore.

Habitat: From River water of Abdullapur, Block Sadholi Quadeem. Saharanpur (S.No. SK 008).

Ecological parameters: D.O. 6.36 mg/l, Electrical conductivity 230.24 µS/l, pH 8.72, Temperature. 22.8°C.

Identification: The present material resembles with *Chara hispida* var. *sibirica* (Mig.) R.D.W.as given by Wood and Imahori, 1965. (Icon.44))

Sample-3

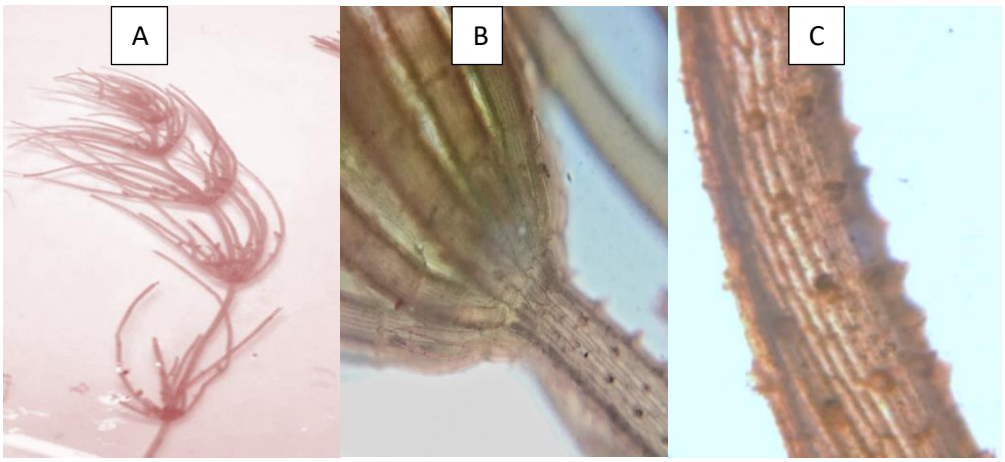
Plants monoecious upto 28 cm long, incrusted. Axs stout, up to 1060 µm in diam.; internodes 2-3 times the length of the branchlet, up to 7.5 cm long; cortical 2 corticate; spine cells single, 315 µm long, to 160 µm wide . Stipulodes 2-ranked, 2-seriate, regular, upper whorls highly developed, up to 350 µm long, lower indistinct. Branchlets 8 in a whorl, upto 4.0 cm long. Segments 6-8 in a branchlet, of which 4-5 are diplocorticate and 2-3 terminal segment ecorticate, basal segment shorter than others, diplo-cortex. End segment acuminate, upto 200 µm long. Bract cells 4-6, unilateral, shorter than bracteoles, up to 200 µm long. Bracteoles 2, bilateral, longer than oogonia, up to 1800 µm long. Gametangia connate at 1-2 lowermost branchlet nodes, absent at base of whorl. Oogonia to 600 µm long (excl. coronula), to 700 µm wide. Convolutions 9. 450 µm long, to 600 µm wide; Coronula to 150 µm long, to 250 µm wide. Oospores brown or black, up to 1220 µm long, up to 980 µm wide; striae 8 ridges; up to 160 µm long. Antheridia octoscutate up to 900 µm in diameter [Table -3 Plate -3, Figure (A-F)].

Table 3: Comparative morphological study of present taxa and Chara vulgaris var. vulgaris f. keineri (Daily) Norton ex.R.D.W.

Parameters	Present Observation	Taxa Described by Wood and Imahori (1965)
Plant sex	Plants monoecious incrusted	Monoecious, heavily incrusted
Height	Upto 36 cm long	Upto 28 cm long
Axial diameter	up to 1110 µm in diameter	820 µm in diameter
Internode	Internodes 2-3 times the length of the branchlet	2-4 time the length of branchlet
Axial cortex	Corticex 2 corticate	1-2-3 corticate, tylacanthous
Spine cells	315 µm long, to 160 µm wide	spine cells solitary, 92-250 µm long, 75-105 µ wide
Branchlets	Branchlets 8 in a whorl, upto 4.0 cm long	6-8 in a whorl, upto 0.7 cm long
Branchlet segments	Segments 6-8 in a branchlet 4-5 are diplocorticate and 2-3 terminal segment ecorticate	5-6 of which 4 are corticate, end segment 1-2 celled
Bract cell	Bract cells 4-6, unilateral	5-6 unilateral, 2-3 times of oogonia length

Bracteoles	Bracteoles 2, bilateral, longer than oogonia, up to 1800 µm long	2, rudimentary, frequently absent, equal 1700-2200 µm long, 160-200 µm wide at base, acuminate.
Stipulodes	Diplostichous, 2 sets per branchlet, up to 350 µm long	Double tier, 2 set per branchlet
Gametangia	Gametangia connate at 1-2 lowermost branchlet nodes	Conjoined at 3-4 lowest branchlet nodes
Oogonia	Oogonia to 600 µm long (excl. coronula), to 700 µm wide.	Immature, solitary Upto 450 µm long (excl. coronula) 300 µm wide
Coronula	Coronula to 160 µm long, to 250 µm wide	Upto 180-190 µm long, 190-220 µm wide
Convolution	14, 450 µm long, to 600 µm wide	13, 75 µm long, 150 µm wide at base
Oospore	Brown or black, up to 600 µm long, up to 720 µm wide;	Black, 480-560 µm long, 190-420 µm wide
Striae	8-11	10-12
Antheridia	upto 420-450 µm in diameter, octoscutate	375-420 µm in diameter, octoscutate

PLATE- 3



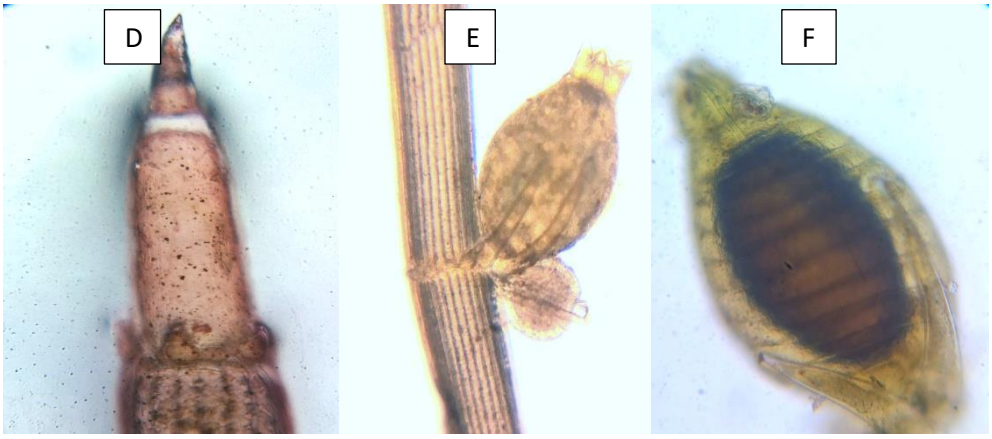


Figure (A-F) Morphological features of *Chara vulgaris* var. *vulgaris* f. *keineri* (Daily) Norton ex. R.D.W are as follows **A.** External morphology of a twig, **B.** Stipulodes at the node, **C.** Cortication and spine cells, **D.** Apex of branchlet, **E.** Gametangia at node, **F.** Oospore.

Habitat: Rice field, Ibrahimpur Must (S.No. SK 005)

Ecological Parameters: Dissolved Oxygen 5.21mg/l, Electrical Conductivity 230.15mg/l, pH 7.26, Temperature. 23.0^{o}C

Identification: The given material corresponds quite well to the description of *Chara vulgaris* var. *vulgaris* f. *kieneri* (Daily) Norton ex. R.D.W (Icon.03).

Sample-4

Description: Plant monoecious, upto 60 cm long, moderately incrusted. Axes stout 1400 µm diam. (branching frequently); cortex 2-aulacanthous, , elongated at the base of the plants cortex none, spine cells, 2-4 fasciculate, 1500 µm long, 220 µm wide; Stipulodes in 2 tiers,2 set per branchlet, slightly unequals 1100 µm long, 200 µm wide. Branchlet 9-12 in whorl 7 cm long, segment 8 of which 5 annd 3 corticated, end segment 2-3 celled, corticatd,. Bract cells 5-8 at the basal nodes, Bracteole 2, longer than the bract cells Gametangia conjoined at lowest branchlet nodes. Oogonia 1100-1200 µm long (excluding coronula). 750--800 µm wide; convolution 14-16; 100-170 µm wide at apex, .coronula 300 µm long, 440 µm wide. Oospore blackish 700-800 µm long, 510-540 µm wide; striae 12-13; Antheridia small, solitary upto 420 µm in diameter [Table 4 and Plate -4, Figure (A-F)].

Table 4: Comparative morphological study of present taxa and *Chara hispida* var. *major* f. *rudis* (A.Br.) R.D.W

Parameters	Present Observation	Taxa Described by Wood and Imahori (1965)
Plant sex	Plants monoecious incrusted	Monoecious, heavily incrusted
Height	Upto 36 cm long	Upto 50 cm long
Axial diameter	up to 1500 µm in diameter	1200 µm in diameter
Internode	Internodes 2-3 times the length of the branchlet	2 time the length of branchlet

Axial cortex	Corticex 2 corticate	2 corticate, aulacanthous
Spine cells	1300 µm long, to 220 µm wide	Spine cells verticillate,solitary, 1200 µm long, 180 µm wide
Branchlets	9-12 in a whorl, upto 6.0 cm long	8-10 in a whorl, upto 4.5 cm long
Branchlet segments	Segments 6-8 in a branchlet 4-5 are diplocorticate and 2-3 terminal segment ecorticate	5-6 of which 4 are corticate, end segment 2-3 celled
Bract cell	Bract cells 5-8 at basal nodes	5-6 equilateral and equal to the length of oogonia.
Bracteoles	Bracteoles 2, bilateral, longer than oogonia, up to 500µm long	2,similar the anterio pair of bract cells slightly longer,half equal to oogonia length.
Stipulodes	Diplostichous, 2 sets per branchlet, up to 1000 µm long, 210 µm wide.	Double tier, 2 set per branchlet
Gametangia	Gametangia connate at 1-2 lowermost branchlet nodes	Conjoined or solitary at all except distal branchlet nodes.
Oogonia	Oogonia to 970 µm long (excl. coronula), to 650 µm wide.	Solitary, upto 900-1050 µm long (excl. coronula) 600-930 µm wide
Coronula	Coronula to 300 µm long, to 415 µm wide	Upto 225 µm long, 375 µm wide
Convolution	13-14	12-13
Oospore	Black, up to 700 µm long, up to 510 µm wide;	Dark brown 645-705 µm long, 450-590 µm wide
Striae	9-13	10-12
Antheridia	Upto 450 µm in diameter	380 µm in diameter

PLATE-4

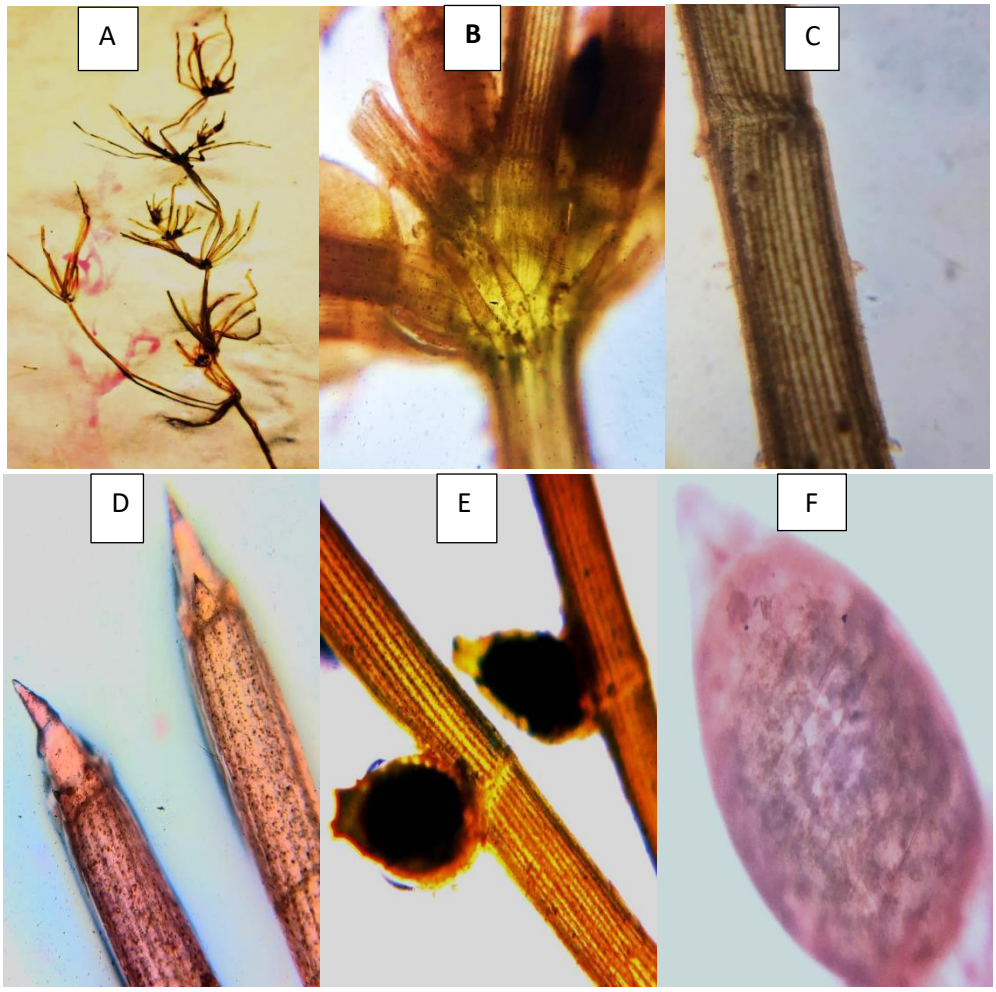


Figure (A-F) Morphological features of *Chara hispida* var. *major f. rudis* (A.Br.) R.D.W are as follows **A.** External morphology of a twig, **B.** Stipulodes at the node, **C.** Cortication and spine cells, **D.** Apex of branchlet, **E.** Gametangia at node, **F.** Oospore.

Habitat : Rice field, Sunheti, Behat region. (S.No. SK 004).

Ecological parameters: Dissolved Oxygen. 6.93 mg/l, Electrical Conductivity 231.08mg/l, pH 8.72, temp. 25.8^{o}C.

Identification: The present material resembles with *Chara hispida* var. *major f. rudis* R.D.W , was given by Wood and Imahori, (Icon-40).

ACKNOWLEDGEMENT

I express my sincere gratitude to Prof. M. K. Bhardwaj, Principal, D.S. College, Aligarh, for his valuable support, encouragement, and guidance throughout the completion of this work. I am deeply thankful to Prof. A. K. Buts, Head, Department of Botany, for their consistant encouragement, constructive suggestions, and academic guidance. I also extend my heartfelt thanks to all faculty members and staff of the Department of Botany for their cooperation and support.

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