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TAXONOMIC STUDIES OF ORTHOTRICHACEAE FROM MUZAFFARABAD DIVISION AZAD JAMMU & KASHMIR (WESTERN HIMALAYA) PAKISTAN

Sahibzada Ateeq Ur Rehman* and Ghulam Murtaza

Department of Botany, University of Azad Jammu and Kashmir Muzaffarabad-13100, Pakistan
***Corresponding author:** E-mail: sarehmanhashmi1986@gmail.com

ABSTRACT

This paper deals with the taxonomic descriptions of family Orthotrichaceae (bryophytes) from Muzaffarabad Division Azad Jammu and Kashmir (Western Himalaya). Many field surveys were conducted during March, 2015 to December, 2017 for the collection of bryophytes. During the study, two genera namely *Orthotrichum* and *Zygodon* with 9 species of Orthotrichaceae which are *Orthotrichum obtusifolium, Orthotrichum Striatum, Orthotrichum rogeri, Orthotrichum tenellum, Orthotrichum anomalum, Orthotrichum affine, Orthotrichum pulchellum, Orthotrichum urnigerum* and *Zygodon forsteri* were investigated. All these species of this family were first time reported from Muzaffarabad Division, Azad Jammu and Kashmir. Their general distribution, taxonomical descriptions and key to the identification have also been provided.

Key-words: Orthotrichaceae, *Orthotrichum, Zygodon*, Muzaffarabad, Western Himalaya, Pakistan

INTRODUCTION

Orthotrichaceae is the only moss family which is present in order Orthotrichales (Goffinent and Buck, 2004). It comprises of 22 genera and 380 species worldwide (Vitt, 1971). In Pakistan research on vascular plants exploration is greater in number while in contrast bryological exploration is much less intensive and mainly conducted by foreign researchers (Kashyap, 1932). only few scattered literature reports about (Orthotrichaceae) bryophytes such as, the checklist of the mosses (Asghar, 1957), bibliography of Pakistan mosses (Nishimura and Higuchi, 1993), first critical survey of *Orthotrichum* in Pakistan by Schafer-Verwimp and Gruber (2002) and checklist of mosses in District Mansehra are present in which some members of Orthotrichaceae are discussed (Ul-Islam *et al*., 2016) while in Muzaffarabad Division, Azad Jammu and Kashmir (Western Himalaya), listing of family Orthotrichaceae remains incomplete. To promote the bryological research and understanding about bryophytes in Azad Jammu and Kashmir firstly we provide complete outlines of this family along with generic and species key to identification.

MATERIALS AND METHODS

Available published literature was reviewed firstly. Along with this, various field surveys were conducted in different sites of the Muzaffarabad division during May 2015 to December 2017. During the field surveys, habitat photography was done through digital camera. After this, bryophytes samples were collected and temporarily stored in plastic zip bags with labeling. A little quantity of each specimen from collected specimens was alienated for identification. Each separated specimen was examined under compound microscope (MT4300H No. 1510646) and stereoscope (IM-SZ-500 IRMECO GmbH) at Research Laboratory Department of Botany, University of Azad Jammu and Kashmir and identified with the help of appropriate literature.

RESULTS AND DISCUSSION

Key to the genera

1a Plant small to medium sized, irregularly branched, capsule with eight ribbed, operculum conic apiculated with campanulated calyptra ……*Orthotrichum*

1b Plant small sized, regularly branched, capsule not with eight ribbed, operculum conic rostrate with cuculated calyptra……..*Zygodon*

Key to the species

1a Leaves length from 1.80 mm to 2.85 mm…….……...…….……2

1b Leaves length from 3.50 mm to 5.10 mm……..……...6

2a Plant with dark greenish to blackish green in color, leaves dimensions 1.88 x 0.52 mm, half emergent capsule having oblong cylindric shape……*Orthotrichum obtusifolium*

2b Plant with olive green to brownish green in color, leaves dimensions 2.61 x 0.53 mm, more or less emergent capsule with ovoid cylindric to cylindric shape……..……3

3a Leaves olive green to brownish green color, acute to acuminate apex, ribs present only on the neck and left over unribbed……..……..*Orthotrichum striatum*

3b Leaves olive green or green to dark green color, acute to obtused or blunt apex, marked ribs located on the whole capsule……..……..4

4a Acute to obtuse shaped apex, capsule having ovoid to cylindric shape, small and brownish color spores……...….*Orthotrichum rogeri*

4b Acute to bluntly acuted or apiculated shaped apex, capsule having cylindric to elliptic cylindric shape, small and brownish green color spores…….……..…5

5a Lingulated to oblong lanceolated shape leaves, capsule strongly eight ribbed that extended to the top…….*Orthotrichum tenellum*

5b Elongate lanceolated to lanceolated shape leaves, capsule eight ribs reaches half while eight reaches at the top…….*Orthotrichum anomalum*

6a Ovate lanceolated to lanceolated shaped leaves, campanulated shape calyptra, spores diameter11.65 µm…….…..*Orthotrichum affine*

6b Lanceolated or narrowly lanceolated to linear lanceolated shaped leaves, oblong conic to conic or campanulated shape calyptra, spores diameter 10.64 to 13.98 µm……..……....7

7a Lanceolated shape leaves, exserted or sometime half emergent capsule having oblong cylindric shape……...……*Orthotrichum pulchellum*

7b Lanceolated, narrowly lanceolated to linear lanceolated shape leaves, latterly emergent capsule having short cylindric to ovoid or ellipsoidal shape…….....8

8a Plant small to medium with lanceolated shape leaves, capsule with cylindrical to ovoid shape, spore brownish green with 13.98 µm in diameter…..….*Orthotrichum urnigerum*

8b Plant small with lanceolated to lingulated shape leaves, capsule with erect ellipsoidal shape, spore yellowish brown with 11.65 µm in diameter…….*Zygodon forsteri*

Orthotrichum affine Schrad. Ex Brid.

Specimens examined: Sir-Jagran (2710 m), Taobut Bala (2325 m) and Kasian Riat (1615 m) on Schist rocks. The plant is small to medium sized acrocarpous mosses. It is slightly branched and olive green to golden green in color while older portion of the plant is brownish in color. It grows in the form of loose or dense tufts. The plant is 17 mm tall. Rhizoids are sparsely branched, smooth, rises from the base of main stem, oblique type septa present, dark brownish in color and 1.84 mm in length. Stem small to medium sized, erect, usually branched, reddish brown in color and 12 mm in length. Central strand not present in the stem. Large cortical cells present with thin walled, rounded pentagonal in shape and brownish in color while single layer of epidermal cells are present outsidely. Leaves spirally arranged in lower portion of the stem while crowdly arranged on the upper portion of the stem. In moist conditions, they are erect spreading while in dry conditions they appressed from apices and neither twisted nor incurved. Leaves are ovate lanceolated to lanceolated in shape with sharply acute to acuminated apex, olive green to yellowish green in color and 3.52 x 0.88 mm in dimensions. Margins entire, papillosed, bordered, recurved and revoluted just below the apex. Coasta is smooth, robust and ending within few cells of apex. Basal leaf cells are rectangular in shape, nodose and 27.96 x 9.32 µm in size while medial and apical cells are isodiametric in shape with rounded lumens. The size of the middle cells is 9.32 x 13.98 µm while the size of apical cells is 11.65 x 16.31 µm. Seta short, erect, smooth and yellow to yellowish brown in color and 2.50 mm in length. Capsule half emergent to long cylindric at maturity while cylindric and constricted entirely in length when it became old and dry. The size of the capsule is 2.45 x 0.69 mm while the color of the capsule is yellowish brown. Capsule erect, strongly sulcated near the base and 8 ribbed. Operculum is conic-apiculated. Annulus is well defined. Calyptra is campanulate, lightly plicated and slightly hairy. Both types of peristome teeth are present. Exostome teeth are reflexed against the capsule in dry conditions while goes to initial conditions when wet. They are fused in the form of pairs and appear only 8 in number. They are pale brown in color and lanceolated in shape. They are 213.36 µm in length, coarsely and obscurely papillosed. Endostome teeth are also 8 in number, wide at base and reticulate papillosed. Spores are small,

rounded in shape, outer side brownish while inner side is yellowish green in color, coarsely papillosed and 11.65 µm in size **(**Fig. **1)**.

Fig. 1. ***Orthotrichum affine*** Schrad. Ex Brid. **A)** Patch of the moss plants on the habitat **B)** Single plant with capsules **C)** Cluster of rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (100X). **F)** Seta with capsule (40X). **G)** Peristome teeth with both exostome and endostome teeth (40X). **H)** Spores (400X). **I)** Calyptra (40X).

Orthotrichum anomalum Hedw.

Species examined: Mandal (1890 m), Nkote (2116 m), Taobut Bala (2355 m), Shakar Garh (2448 m) on sandy rocks.

Orthotrichum anomalum is small to medium in size or sometimes large, erect, usually branched, acrocarpous moss. The plant is bright green to yellowish green in color and grows in the form of cushions or in loose or dense tufts. The plant is 21 mm in length. Rhizoids are long thread like in shape, arises from stem base and green or brownish in

color. They are 5.73 mm in length and obliquely cross walled. Stem small, erect, sometimes branched, slightly reddish brown in color and 4 mm in length. Stem section lacking central strand. Cortical cells are large, irregular angled, rounded in shape, thin walled and brownish in color. Outer cortical and epidermal cells are not differentiated, small, reddish brown in color and forming 2-3 stereides bands. Spirally arranged leaves are present on the stem. Leaves are erect spreading when wet while stiff and erect appressed in dry conditions. They are elongate-lanceolated to lanceolated or narrowly ovate lanceolated in shape, bordered, having the size of 3.12 x 0.72 mm and bright green to yellowish green in color. Apex of the leaves is acute to bluntly acuted or narrowly obtused. Margins are entire, smooth and recurved to revoluted near apex. Coasta is strong, brownish in color and reaches near the apex or percurrent. Basal leaf cells are long rectangular to rectangular in shape and 46.60 x 11.65 µm in size while middle laminal cells are quadrate shaped having the size of 13.98 x 11.65 µm whereas apical cells are isodiametric rounded in shape and 11.65 x 9.32 µm in size. Seta is short, cylindrical, erect, smooth walled, brownish in color and 4 mm in length. Capsule is oblong-cylindric to cylindric in shape. The color of the capsule is light green when immature while reddish brown when mature. The size of the capsule is 3 x 1.49 mm. Sixteen ribs are present on the capsule in which 08 long ribs extending two third of the capsules and alternating 8 ribs are short. Operculum is conic-apiculate to rostrate in shape. Calyptra is oblong-conic and having many papillosed hairs. Peristome teeth are singled. Endostome is not present. Exostome are 16 in numbers, lanceolated in shape, reddish brown in color and 250 µm in length. Spores are small, papillosed, brownish green in color, spherical in shape and 13.98 µm in size **(**Fig. **2)**.

Fig. 2. ***Orthotrichum anomalum*** Hedw. **A)** Patch of the moss plants on the habitat **B)** Single plant with capsule **C)** Cluster of rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (400X). **F)** Capsule (40X). **G)** Seta (40X). **H)** Peristome teeth (100X). **I)** Spores (400X).

Orthotrichum obtusifolium Brid.
Specimens examined: Timber Gunchatter (1325 m) on tree bark.

Orthotrichum obtusifolium is small in size, erect and acrocarpous plant. The plant is shortly branched or unbranched and dark greenish to blackish green in color. They grow in the form of tiny tufts, forming upright narrow shoots and 6 mm in length. Rhizoids are sparsely branched, short, 1.12 mm in length, obliquely septate and brownish in color. Stem is small, erect, shortly branched near base, green to brownish in color and 3 mm in length. Central strand of medullary cells are not present in the section of the stem. Parenchymatous cells are large and irregular in shape while single layer of epidermal cells are present outside the cortical cells. Leaves are closely overlapped and spirally arranged or in julaceous form. They are erect appressed in dry form while erect spreading in wet form. Leaves are ovate to ovate lanceolated in shape, concave and 1.89 x 0.53 mm in dimensions and dark to blackish green in color. Apex is obtused. Margins are entire and erect incurved. Coasta is strong and reaches just below the apex and brownish in color. Laminal cells are unistratose and unipapillosed on both surfaces. Basal cells are more or less rectangular in shape, not nodose and thick walled. Middle laminal cells are rectangular to quadrate in shape while apex cells are hexagonal in shape. The size of the basal cells is 39.61 x 16.31 µm. The size of the middle cells are 23.30 x 20.97 µm while the size of apex cells are 13.98 x 20.97 µm. Seta is very short, erect and brownish in color having 0.5 mm length. Capsule is half emergent, oblong cylindric in shape, yellowish brown in color and 1.49 x 0.67 mm in size. Capsule is strongly ribbed at base. The ribs are 8 in number. Peristome teeth are double. Exostome teeth are 8 in number, with 240.03 µm in length, lanceolated in shape; brownish and reflexed while endostome having 8 segments, linear, well developed and smooth. Operculum is conical apiculated to rostrate in shape. Calyptra is short conical in shape, papillosed and naked. Spores are small, papillosed and rounded in shape. Exine of the spore is helix in shape and brownish in color while internal portion is greenish in color. The size of the spore is 13.98 µm **(**Fig. **3)**.

Orthotrichum pulchellum Brunt.
Specimens examined: Machal (2048 m) on Granite rocks.

Orthotrichum pulchellum is small to medium in sized and acrocarpous moss. The plant is slightly branched and grows in the form of loose tufts or patches. The color of the plant is yellowish green and 07 mm in length. Rhizoids are small in the form of fibrous clusters that are present at the base of the stem. They are obliquely septate, dark brownish in color and 0.89 mm in length. Stem is about up to 05 mm tall, erect, slightly branched and brownish in color. Central medullary strand is absent in the section of the stem. Inner cortical cells are large, regular pentagonal in shape, thin walled and slightly brownish in color. Single epidermal layer are present outsidely with small cells. Leaves are crowdly and densely arranged on the shoot. They are loosely twisted and crisped flexuose on drying while becomes normal when wet. Leaves are 05 x 0.34 mm in size, yellowish green in color, narrowly lanceolated to linear lanceolated in shape with sharply acuted apex. Margins are entire and recurved near apex. Distal laminal cells are unistratose and having small conical papillae. Coasta is strong, brownish in color and ends at the apex of the leaf. Basal cells of the lamina are rectangular in shape; non nodose and 67.57 x 9.32 µm. Middle laminal cells are short rectangular than basal cells to isodiametric in shape and 13.98 x 9.32 µm in dimensions while apex cells are isodiametric rounded in shape and 11.65 x 11.65 µm in size. Seta is erect, cylindrical, short 1.53 mm in length and brownish green in color. Capsule is exserted or sometime half emergent and oblong cylindric in shape. Eight ribs are present on the entire capsule. The color of the capsule is pale reddish brown and 2.32 x 1.07 mm in size. Operculum is conic-apiculated in type. Calyptra is naked and oblong conic to conic in shape. Peristome teeth are doubled. Exostome segments are 16 in number or united in to 08 pairs, 293.37 µm in length and lanceolated in shape with orange color. They are erect on maturity and latterly reflexed, densely papillosed. Endostome are linear in shape and 16 in segments. Spore is small, rounded in shape, brownish green in color, papillosed and 10.64 µm in size **(**Fig. **4)**.

Orthotrichum rogeri Brid.
Specimens examined: Machal (2048 m) on granite rocks.

Orthotrichum rogeri is short, smaller in size, acrocarpous plant. The plant is shortly branched, olive green in color, grows in the form of cushions and up to 9 mm tall. Rhizoids are smaller and rise from the base of the stem. They are forming fibrous cluster. The cluster is reddish brown in color. Each rhizoid is obliquely septate. They are 3.09 mm in length. Stem is erect or slightly branched, short, brownish in color and 6 mm in length. Central medullary cells are not present in the stem section while inner cortical cells are large, brownish in color and regular pentagonal in shape. Single epidermis layer is present outside the section. Leaves are dense and overlapped on the

stem. They are twisted when dry while erect and spreading when wet. Leaves on the stem are lanceolated or oval lanceolated to lingulated in shape, olive green in color and 2.83 x 0.48 µm in dimensions. They are scarcely or not widened at the basement. Apex is acute to obtuse in shape. Margins are plane, bordered or slightly recurved in their lower half. They are crinate papillosed. Laminal cells are smooth. Coasta is long, robust and brown in color. It is end at the tip of the leaf. Apical laminal cells are isodiametric to elliptic in shape and 11.65 x 9.32 µm in size. Middle laminal cells are elliptic rectangular to isodiametric in shape and 16.31 x 9.32 µm in dimensions while basal cells are rectangular in shape and 58.25 x 11.65 µm in size. Seta is short, erect, cylindrical and brownish in color and 1.12 mm in length. Capsule is variably emergent and having long neck. They are ovoid in shape when immature while cylindric in shape, somewhat urceolate when mature and empty. The size of the capsule is 2.35 x 1.07 mm and brownish in color. Eight well marked ribs are present on mature capsules. Peristome is double. Exostome is present in 8 pairs, not splitted into 16 and yellowish to brownish in color. The length of the exostome is 320.04 µm and conical in shape. Endostome is in 8 segments, thin and hyaline. They are slightly shorter than the exostome teeth. Operculum is conical in shape. Calyptra is long, oblong cylindric in shape, pale yellowish in color with dark hairy apex. Spores are small, rounded in shape with brownish in color. Scattered type of papillae is present on them. The size of the spores is 11.65 µm **(**Fig. **5)**.

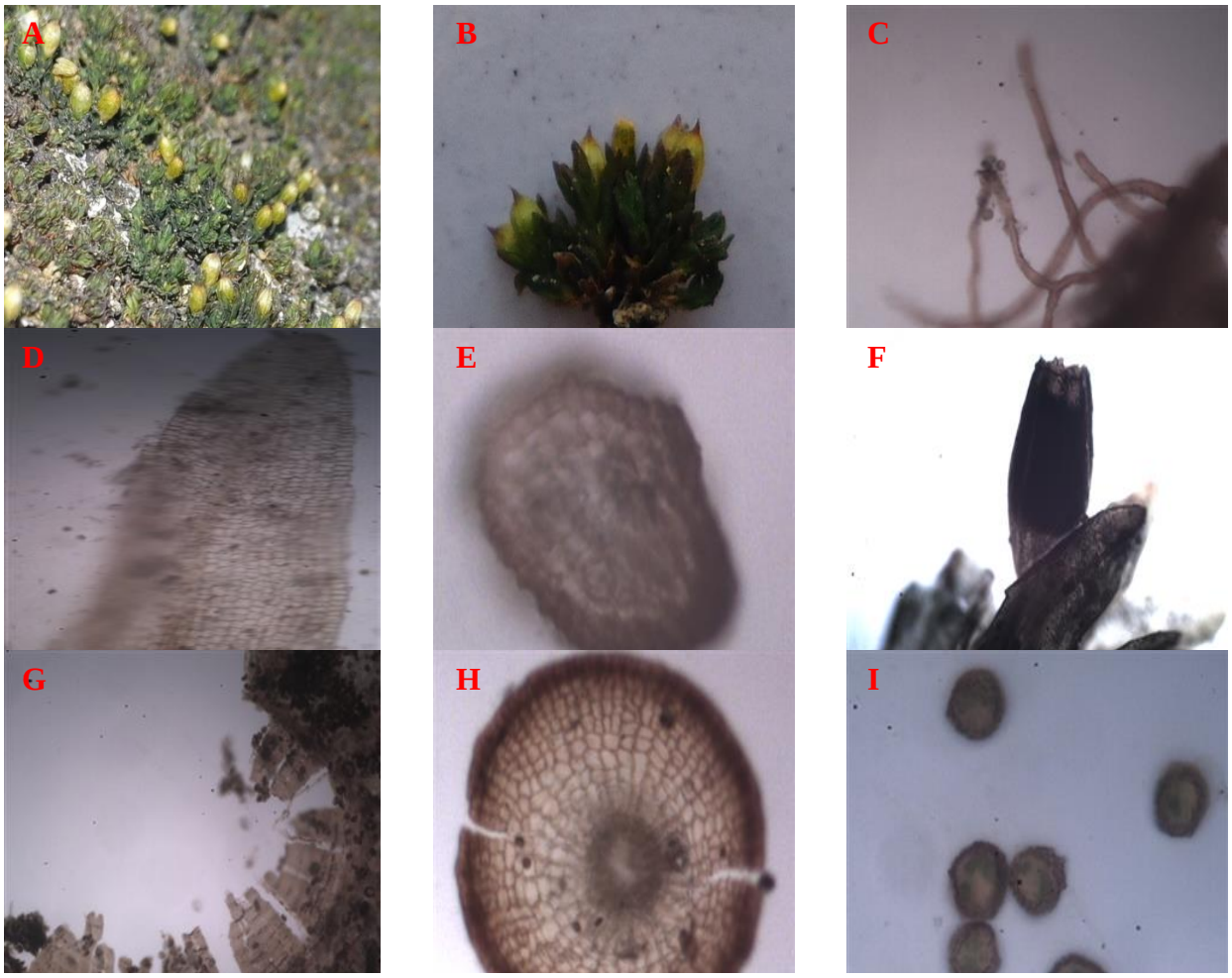

Fig. 3. ***Orthotrichum obtusifolium*** Brid. **A)** Plants patch on the habitat **B)** Plants with capsules **C)** Cluster of rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (100X). **E)** T.S. of the stem (100X). **F)** Capsule (40X). **G)** Peristome teeth (100X). **H)** Operculum (40X). **I)** Spores (400X).

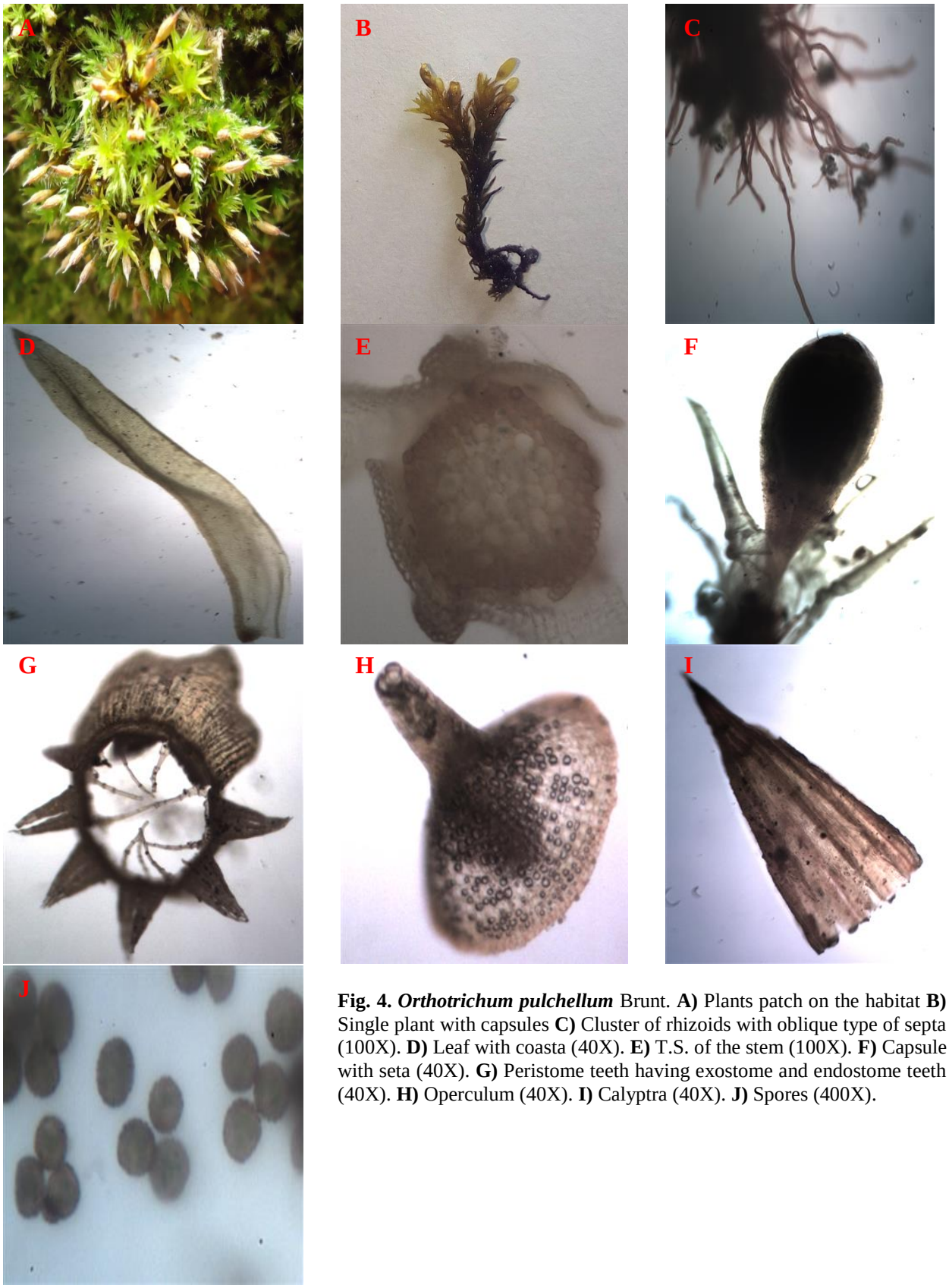

Fig. 4. ***Orthotrichum pulchellum*** Brunt. **A)** Plants patch on the habitat **B)** Single plant with capsules **C)** Cluster of rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (100X). **F)** Capsule with seta (40X). **G)** Peristome teeth having exostome and endostome teeth (40X). **H)** Operculum (40X). **I)** Calyptra (40X). **J)** Spores (400X).

Fig. 5. ***Orthotrichum rogeri*** Brid. **A)** Plants patch on the habitat **B)** Single plant with capsules **C)** Single rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (100X). **F)** Capsule with seta (40X). **G)** Peristome teeth (40X). **H)** Operculum (40X). **I)** Calyptra (40X). **J)** Spores (400X).

Orthotrichum striatum Hedw.
Specimens examined: Athmuqam (1435 m), Kasian Riat (1615 m) and Mirchi Neelum (1946 m) on tree bark.
Orthotrichum striatum is small to large sized, prostrate to erect moss. The plant is robust, grows in the form of tufts, cushions or patches. The color of the plant is olive green to brownish green while the length is 29 mm. Rhizoids are long, thread like in structure and arises from the lower base of the stem. They are smooth, abundant, sparingly branched and brownish in color, obliquely cross walled and 2.83 mm in length. Stem is robust, small to large, prostrate to erect, brownish in color, usually branched and up to 28 mm in length. Brownish color small cells of epidermis is present outsidely and forming a single layer. Beneath epidermal layer cortical cells are present. They are large and regular pentagonal in shape. Central medullary conducting strand is not present in the section. Leaves are densely present on the stem. They are erect-spreading when wet while appressed with recurved apices when wet. Leaves are lanceolated to narrowly lanceolated in shape. They are olive green to brownish green in color. The size of the stem leaves are 2.61 x 0.53 mm. Apex of the leaves are acute to acuminate. Margins are recurved and not revoluted from base to apex. They are slightly bordered and entire. Coasta is long, not prominently keeled and ending at the acumen base. Basal cells of the stem leaves are rectangular in shape and 34.95 x 6.99 µm in dimensions while middle cells are quadrate to short elliptic in shape and 9.32 x 9.32 µm in size. Apical cells are isodiametric in shape and 11.65 x 11.65 µm in size. Seta is smooth, erect and brownish in color. The seta on the stem is 0.80 mm tall. Capsule is more or less emergent, oblong ovate or narrowly cylindrical ovate in shape, yellow to yellowish brown in color and 2.75 x 0.93 mm in dimensions. When capsule is mature, ribs are only found on neck while remaining capsule is smooth and unribbed. Peristome teeth are doubled. Exostome teeth are present as eight fused pairs, pale brownish in color, narrowly lanceolated in shape and 220 µm in length. Endostome are present in 8 segments and as long as the exostome teeth. Operculum is short rostrate in shape. Annulus is well defined. Calyptra is campanulate and plicated. Hairs are present on the calyptra. Spores are small, spherical in shape, greenish brown in color, coarsely papillosed and 13.98 µm in size **(**Fig. **6)**.

Orthotrichum tenellum Bruch ex Brid.
Specimens examined: Shaunther (3150 m) on tree bark.

Orthotrichum tenellum is small to medium sized acrocarpous moss. The plant is sometimes branched and green to dark greenish in color. They are growing in the form of patches or tufts. The plant is up to 12 mm tall. Rhizoids are present near the base of the stem, smooth, repeatedly branched and reddish brown in color. They are straight lined septate. The length of the rhizoids is 3.79 mm and thread like in shape. Stem is small to medium, sometimes branched and reddish brown in color. The stem is up to 11 mm tall. Inner cortical cells are large, brownish in color, thin walled and polygonal in shape. Central medullary cells are absent. Outer epidermal layer of cells are single, small and reddish brown in color. Leaves are densely and spreadly arranged on the stem. Leaves are spreading when wet while stiff and erect appressed when drying. They are lingulated to oblong lanceolated in shape, green to dark green in color and 3.01 x 0.80 mm in size. Apex is acute to blunt or apiculated in shape. Margins are entire, papillosed and revoluted to below apex. Coasta is robust, long and smooth, ends just few cells before the apex. Leaf basal cells are rectangular in shape, not nodose having the size of 30.29 x 11.65 µm while middle and apical cells are isodiametric rounded in shape. Medial cell size is 9.32 x 9.32 µm while apical cell size is 13.98 x 9.32 µm. Seta is smooth walled, short, brownish in color and 0.53 mm in length. Capsule is two third emergent to short exserted. It is cylindric to cylindric elliptical in shape and yellow to yellow brownish in color. The capsule is strongly eight ribbed throughout the length at maturity. The dimensions of the capsule are 2.29 x 1.09 µm. Peristome teeth is double comprising of exostome and endostome. Exostome are conical in shape, fused in eight pairs; light brownish in color and 800.10 µm in length. Endostome is 8 or 16 segments and as long as exostome. Operculum is short rostrated. Annulus is well defined on the capsule. Calyptra is conical-oblong in shape and smooth or sparsely hairy. Color of the calyptra is yellowish brown while apex is reddish brown. Spores are green, smaller in size, rounded in shape, coarsely papillosed and 11.65 µm in dimensions **(**Fig. **7)**.

Orthotrichum urnigerum Myrin.
Specimens examined: Machal (2048 m) present on granite rocks.
Orthotrichum urnigerum is small to medium in size, sometimes branched and acrocarpous moss. The plant is green to brownish green in color. They are grows in the form of loose or dense turfs or patches. The plant is about up to 14 mm in length. Rhizoids are obliquely cross walled, long, multicellular, thread like in structure and red brownish in color. They are 3.57 mm in length. Stem is smaller to medium, erect or branched, brownish in color and 12 mm in length. Central medullary conducting cells are absent. Cortical cells are large, irregularly pentagonal in shape and hyaline. Outer cortical and epidermal cells are not differentiated, thick walled and brownish in color. Leaves are

erect spreading and densely arranged on the shoot. They are erect appressed in dry conditions but became normal in wet conditions. Leaves of the shoot are lanceolated in shape. Lower portion of the leaf is greenish while upper portion of the leaf is brownish green in color. The size of the leaf is 3.15 x 0.80 µm. acute type of apex is present in leaf. Margins are entire throughout, papillosed and recurved. Coasta is robust, brownish in color, smooth and reaches at the tip of the leaf. Tip of the leaves are dark brownish in color. Apical cells are isodiametric in shape, rounded and 6.99 x 11.65 µm in size while medial cells are 16.31 x 9.32 µm and short rectangular to isodiametric in shape whereas basal cells are rectangular in shape and 25.63 x 9.32 µm in dimensions. Seta is smooth, short erect, brownish in color, cylindrical and 4 mm in length. Capsule is latterly emergent, short cylindrical to ovoid in shape, yellowish to reddish brown in color. The size of the capsule is 2.64 x 1.33 mm and 8 ribs are present entire of its length on maturity. Peristome teeth are doubled. Exostome are strongly papillosed, sixteen in free segments, narrow lanceolated in shape and yellowish brown in color. The length of the exostome teeth are 320.04 µm. Endostome are sixteen in segments, smooth or striate and as long as exostome teeth. Annulus ring is well defined. Operculum is conical-rostrate in shape with long beak. Calyptra is long, campanulated and smooth. Hairs are not present on the calyptra. Spores are small, brownish green in color, rounded in shape, 13.98 µm in size and papillosed **(**Fig. **8)**.

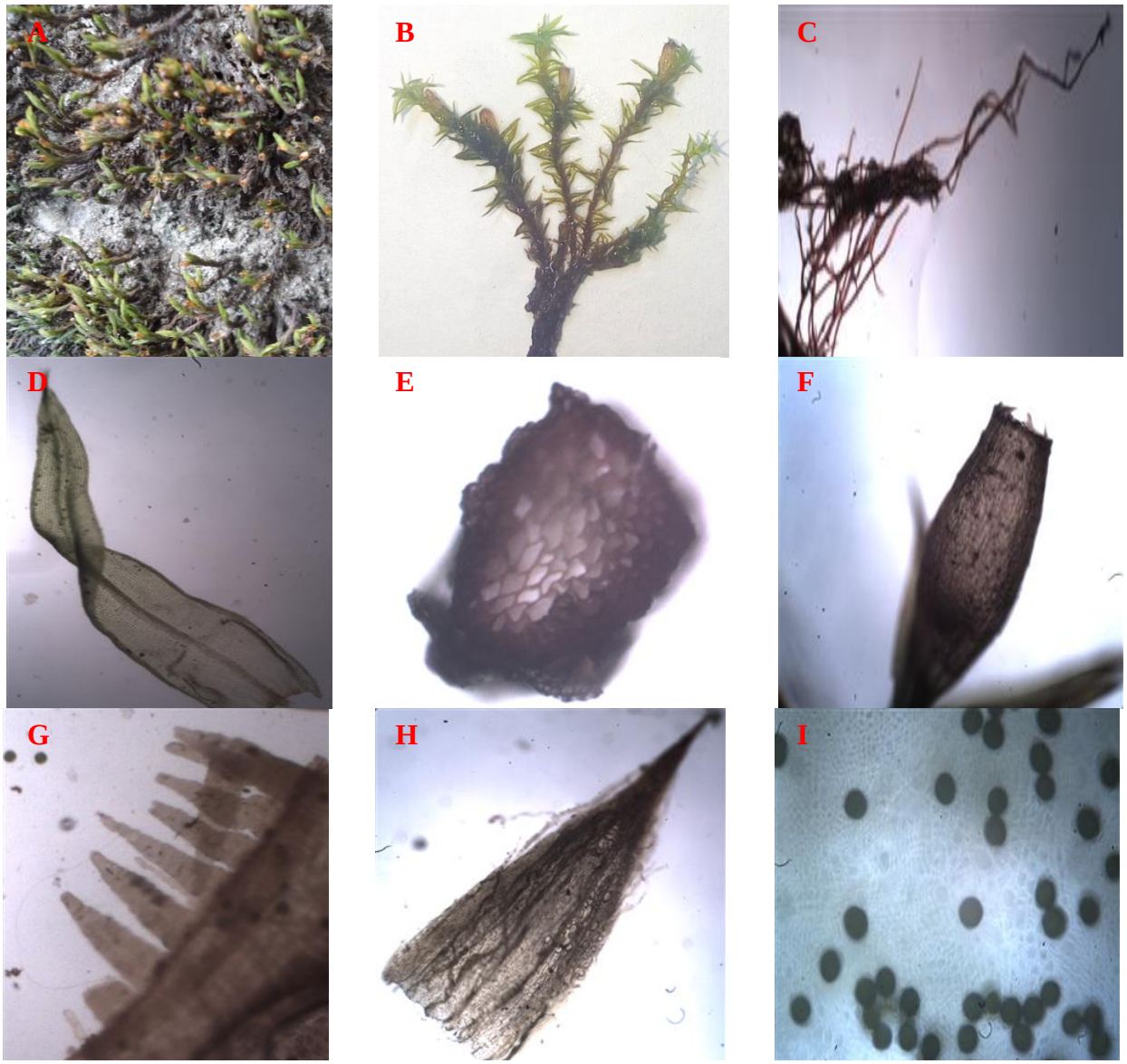

Fig. 6. ***Orthotrichum striatum*** Hedw. **A)** Plants patch on the habitat **B)** Plant with capsules **C)** Cluster of rhizoids (40X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (100X). **F)** Capsule with seta (40X). **G)** Peristome teeth (100X). **H)** Calyptra (40X). **I)** Spores (400X).

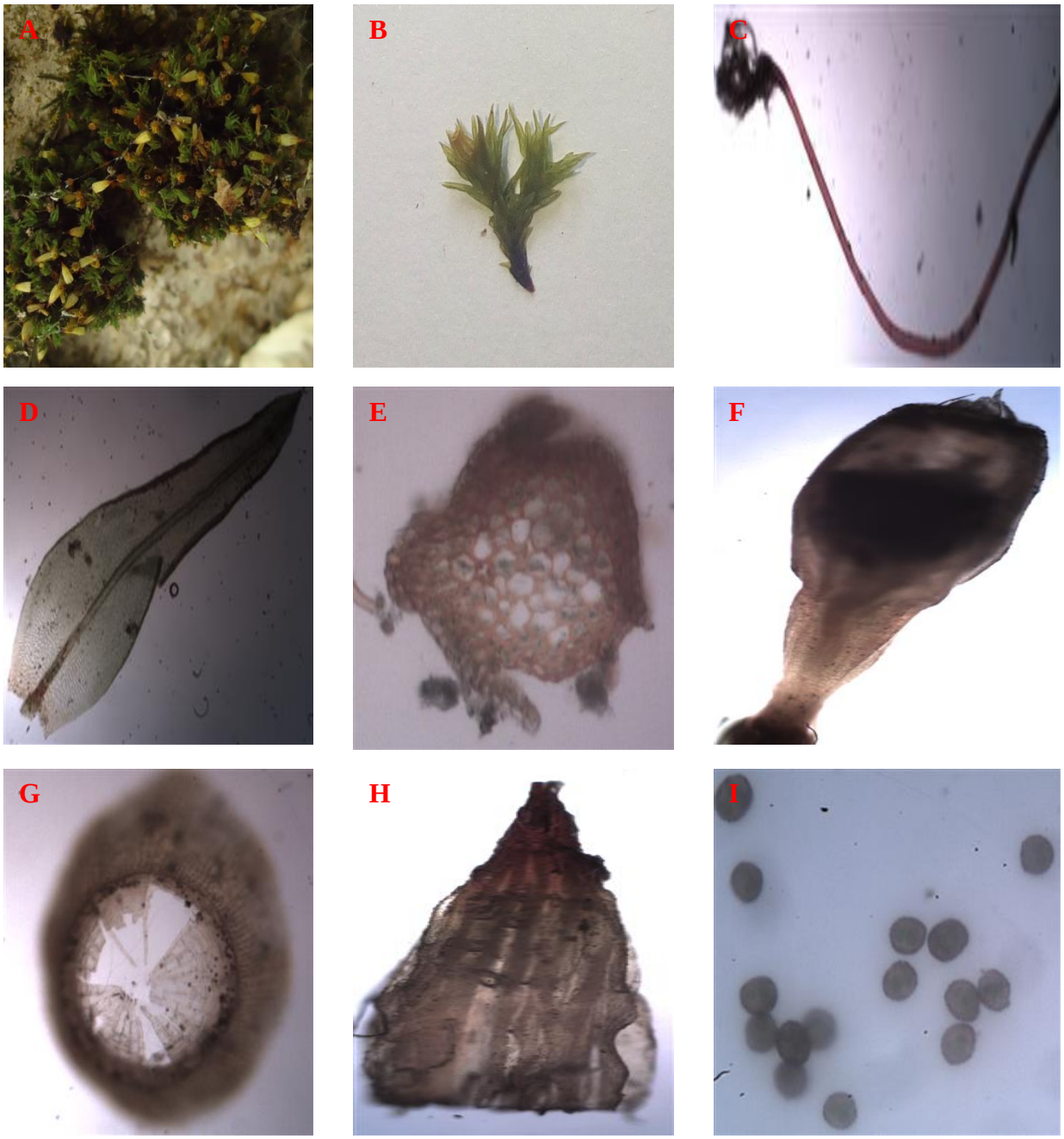

Fig. 7. ***Orthotrichum tenellum*** Bruch ex Brid. **A)** Patch of the moss plants on the habitat **B)** Single plant with capsule **C)** Single rhizoid with oblique type of septa (100X). **D)** Leaf with strong coasta (40X). **E)** T.S. of the stem (100X). **F)** Capsule with seta (40X). **G)** Peristome teeth having exostome and endostome teeth (40X). **H)** Calyptra (40X). **I)** Spores (400X).

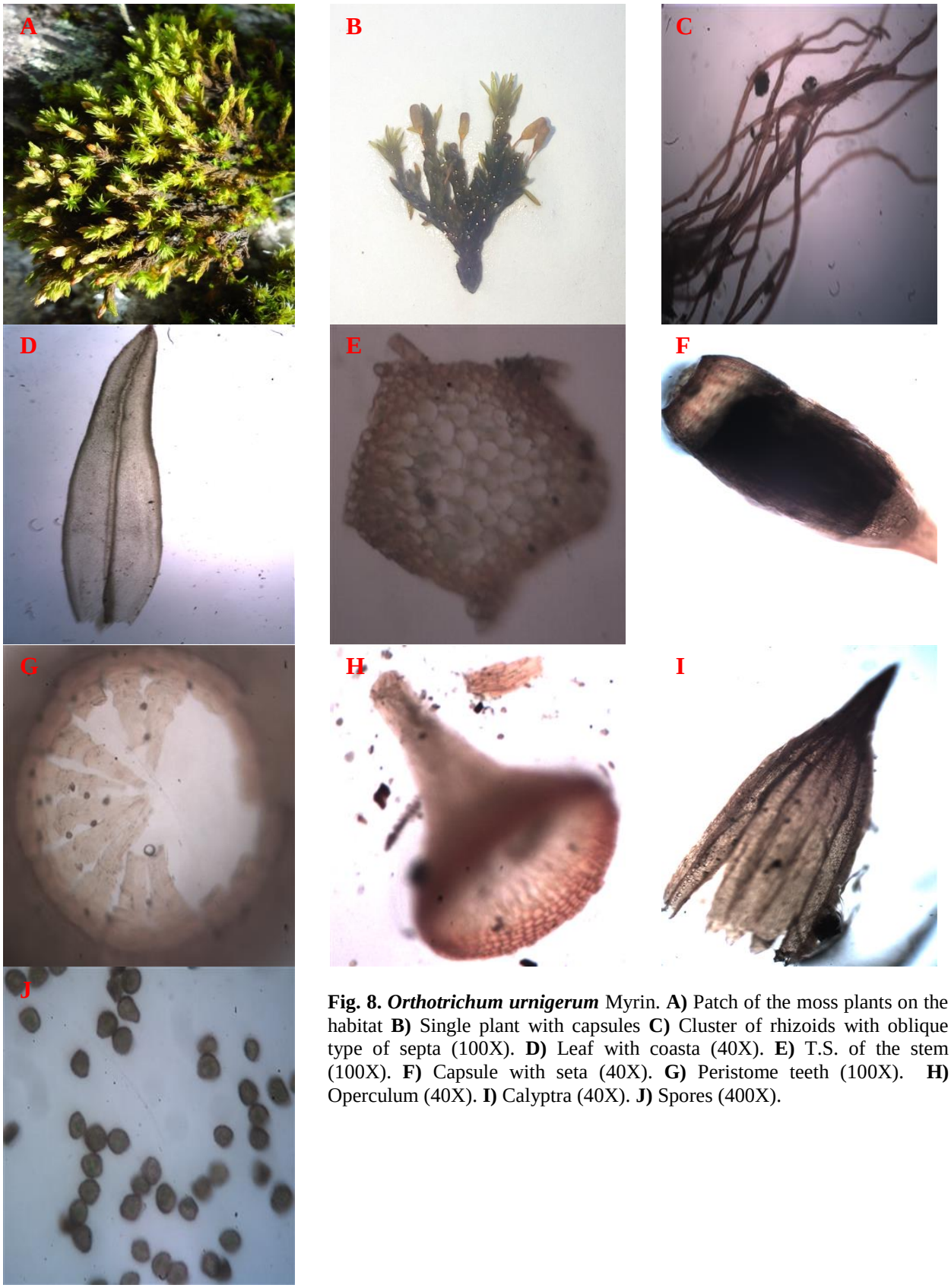

Fig. 8. ***Orthotrichum urnigerum*** Myrin. **A)** Patch of the moss plants on the habitat **B)** Single plant with capsules **C)** Cluster of rhizoids with oblique type of septa (100X). **D)** Leaf with coasta (40X). **E)** T.S. of the stem (100X). **F)** Capsule with seta (40X). **G)** Peristome teeth (100X). **H)** Operculum (40X). **I)** Calyptra (40X). **J)** Spores (400X).

Fig. 9. ***Zygodon forsteri*** (Dicks. ex With.) Mitt. **A)** Plants patch on the habitat **B)** Single plant with capsule **C)** Cluster of rhizoids (40X). **D)** Leaf with strong coasta (40X). **E)** T.S. of the stem (100X). **F)** Seta with capsule (40X). **G)** Operculum (40X). **H)** Calyptra (40X). **I)** Spores (400X).

Zygodon forsteri (Dicks. ex With.) Mitt.
Specimens examined: Noon Bagla (2034 m) and Pirchinasi (2836 m) on wet sandy soil.

Zygodon forsteri is small, perennial and acrocarpous moss. The plant is dark green above while reddish brown in color in lower portion. It grows in loose tufts or in the form of compact cushions. The plant is up to 12 mm in length. Rhizoids are obliquely cross walled, smooth, sparsely branched, dark brownish in color, frequently matted, arises at the base of the stem and 4 mm in length. Stem is erect, short, usually branched, brownish green in color and 8 mm tall. Central strand is not present. Parenchymatous cells are large, thin walled and irregular in shape while outer cortical cells are not differentiated from epidermal cells, smaller in size, irregular in shape and brownish in color. Leaves are crowdly arranged on the stem. They are slightly twisted and their tips became white in dry conditions while erect spreading in moist conditions. Leaves are lanceolated to lingulated in shape, 1.31 x 0.37 mm in dimensions and dark greenish in color. They are strongly keeled and not decurrent. Apex is acuted. Margins are plane and entire. Lamina is unistratose. Coasta is strong, robust, and smooth ends at the apex of the leaf. Basal cells

are rectangular to broadly ellipsoidal in shape, thin walled and 30.29 x 13.98 µm in size. Middle cells are quadrate in shape and 13.98 x 9.32 µm in size whereas apical cells are isodiametric, rounded hexagonal in shaped, thick walled and 9.32 x 6.99 µm in size. Perichaetial leaves are not well differentiated. Seta is smooth walled, long, erect and yellowish brown in color and 5 mm in length. Capsule is erect, ellipsoidal in shape, having eight longitudinal ribs, dark brownish green in color and 1.71 x 0.53 mm in dimensions. Operculum is conic at base, rostrate and reddish brown in color while upper portion consist of long beaked with yellowish brown in color. Calyptra is long and cuculated in shape. Peristome teeth are not seen. Spores are small, spherical, yellowish brown in color and 11.65 µm in size **(**Fig. **9)**.

The hilly regions of Pakistan and Azad Kashmir do not lend themselves to field research because of unreceptive environment, socio-economic problems and border line. Thus any new contribution of the area is very helpful to the knowledge of biology. In the present work we have new findings from our own research work to provide an up-to-date distribution of members of family Orthotrichaceae in Muzaffarabad Division, Azad Kashmir. Populations of *Orthotrichum* present at the edges of Pakistan are subjected to less favorable developmental conditions and fewer suitable locations Frahm (2001).

CONCLUSION

During the investigation, two genera namely *Orthotrichum* and *Zygodon* of family Orthotrichaceae were recorded. Genus *Orthotrichum* comprised of 8 species and Genus *Zygodon* consisted of only one species present in the area. All these species of both genera are first time reported from the Muzaffarabad Division, Azad Kashmir near Indian border. In these species, *Orthotrichum obtusifolium* is found only on the bark of *Ailanthus altissima* while *Orthotrichum tenellum* grows on the bark of *Betula utilis* whereas *Orthotrichum striatum* is only observed on the bark of *Quercus glauca. Orthotrichum pulchellum, Orthotrichum rogeri* and *Orthotrichum urnigerum* are present only on the Granite rocks while *Orthotrichum affine* is present on the Schist rocks. *Orthotrichum anomalum* and *Zygodon forsteri* are only observed on sandy rocks.

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