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Research Paper

Bryophytic flora of Muzaffarabad, Azad Jammu and Kashmir, Pakistan

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Abstract

Muzaffarabad is located at 34° 23′. 8″ N, 73° 28′. 11″ E and 704 m above the sea level. The bryophytic vegetation of four sites randomly selected from Muzaffarabad was investigated for morphological characters. Total 12 samples were collected and identified *viz*. *Funaria hygrometrica, Bryum argenteum, Rhodobryum giganteum, Tortula subulata, Tortula inermis, Ceretodon purpureus, Reboulia hemispherica, Marchantia paleacea, Riccia pathankotensis, Astrella multiflora, Porella pinnata* and *Phaeoceros laevis*. Measurements of the specimen were done by using millimeter scale with microscope swift. The slides were prepared to study the micro-morphological characters of gametophytes and sporophytes. The morphology of the specimens was also observed by using Stereo microscope. All the identified samples were preserved and submitted to the AKASH Herbarium of Department of Botany, University of Azad Jammu and Kashmir Muzaffarabad.

Introduction

Introduction

Muzaffarabad, District of Azad Jammu and Kashmir is located at confluence of Neelum and Jhelum rivers and is bounded to Khyber Pakhtunkhwa, in the West, to the north is Neelum District; District Bagh, forms the southern boundary and District Hattian is located at the southern side of Muzaffarabad. It is located at 34^0 23′. 8″ N latitude, 73^0 28′. 11″ E longitude and 704 m above the sea level. It is stretched over an area of 1642 km^2. The soil texture of the area comprises of loam, clay, sandy and silt. The soil of the area is enriched with minerals and organic matter. District Muzaffarabad mainly comprises of slopes, mountains and plane areas.

The bryophytes are small herbs like plants growing on rocks, soil and trunk of the trees forming cushion or mat like structures. Considered to be pioneers of the terrestrial vegetation and have immense ecological and aesthetic value. Bryophytes contribute as a core component of forest vegetation and having high soil binding capacity (Alam, 2011; Smith, 1982). Worldwide there are 18500 species and near about 1050 genera of bryophytes have been reported (Oren *et al*., 2007). According to Dandotiya *et al*., (2011) there are 355 genera of Mosses and 1786 species, 121 Liverworts genera with 675 species and 6 Hornworts genera with 25 species in India.

Bryoflora of Asia still has incomplete records. The total number of moss taxa in East Asia are more than 2000 species representing nearly 1/5 of the world's moss diversity (Shaw *et al*., 2005). Extensive work has been done on bryophytes of China with utilization of many species for various purposes of human benefits. A total of 2150 species of mosses and 889 species of liverworts had been recorded from China (Piippo, 1990) and (Zho and So, 1996). The next neighboring country India which borders to the Nepalese lowland has also been studied extensively on Bryophyte taxonomy and recorded 2584 species (O'Shea, 2003). The recent diversity of Bryophytes in Nepal reveals a total of 1217 species including 542 species of liverworts and 10 species of hornworts (Pradhan and Shreshta, 2021). Similarly, Bhutan has 235 species (Long and Grolle, 1990), Maldives with 298 species (Menzel and Passow-Schindhelm, 1990). Similarly the diversity of Bryophytes in Sri Lanka is 568 species (O'Shea, 2002) and Bangladesh with 183 species of moss (O'Shea, 2003).

The Bryoflora of Pakistan is least studied and only few reports had been published (Asghar, 1957) Higuchi and Nishimura, (2003) had been recorded 339 species of Bryophytes from Pakistan. Similarly, Townsend (1993) made a checklist of Pakistan mosses. During the year 1998 only fouteen species of genus *Orthotrichum* was reported from Pakistan (Verwimp and Gruber, 2002). The main objectives of the study were to explore the Bryophytic flora of District Muzaffarabad and to investigate the morphology and anatomy, this will provide building blocks for further bryophytic studies in the area.

Materials and Methods:

Sites selection:

Randomly four sites were selected for this study. These sites were Lungerpura Punjkot, Mianibandi and Timber Gunchatter, District Muzaffarabad, Azad Jammu and Kashmir (Figure 1).

Punjkot Punjkot is located in Tehsil Naseera Abad. The area located at 34° 28′ N latitude and 73° 43′ E longitude. Its few areas lies in subtropical zone and the upper areas are located in the temperate zone. It is 1911 meter above the sea level. Temperature of the area remains moderate in summer while in winter temperature drops to 0° C.

Mianibandi: Mianibandi is present in Tehsil Muzaffarabad. The area located at 34° 20′ N latitude and 73° 30′ E longitude. The site is 973 meter above the sea level. Temperature reaches up to 38° C in summer and 0° C in winter (Source: Pakistan Meteorological Department).

Lungerpura: Lungerpura located in Tehsil Muzaffarabad and present at 34° 20′ N latitude and at 73° 31′ E longitude. The area lies in subtropical zone and is 847 m elevated from the sea level.

Timber Gunchatter: Timber Gunchatter is a village in Tehsil Muzaffarabad. The area located in 34° 20′ N latitude and 73° 32′ E longitude (Figure 1). It is present at an elevation of 1470 meter and lies in subtropical zone.

Figure 1: Map of Study Area.

Surveys and sampling

Field trips were conducted at four selected sites to collect specimen *viz.* Punjkot, Mianibandi, Lungerpura and Timber Gunchatter during the period from April to September, 2020. The altimeter was used for measuring altitude of each site.

Collection, preservation and storage

The sample specimens were collected from different habitats like shaded marshy earth, exposed ground, tree trunks, etc. with the help of an iron fork and a simple knife to peel out from the substratum and a magnifying lens for quick identification in the field. They were collected in paper envelopes or in polythene bags for temporarily used (Keceli and Cetin, 2000). Before stepping the Herbarium process, the sample specimens were cleaned from soil and other debris attached on them and made dried at room temperature. The dried specimens were transferred in well labeled paper packets and tagged on the herbarium sheets for scientific studies (Rashid *et al.,* 2012). The duplicate Specimens were also preserved in 4% formalin for anatomical studies. Each packet was labeled with its Latin name, common names, family, voucher number, habit, habitat, date of collection, location, latitude, longitude, altitude and the name of collector or collectors (Pradhan and Joshi, 2009).

Macro and micro measurements

The size of the plants (viz. rhizoids, leaves, laminal cells, reproductive parts like seta capsule, peristome teeth, spores, elaters etc.) were measured by using Ocular micrometer by using Swift M7000MDN microscope. Fresh slides were prepared to study the micro morphological characters of rhizoids, caulid, phyllids, capsules and spores. Means were calculated from three observations for each parameter.

Semi-permanent slides:

Semi-permanent slides were prepared by mixing 20 g gum with 60 ml distilled water, let tube stand covered for several hours. Filter the mixture through coarse paper, added 10 ml of glycerin & 4 ml formalin then placed the specimens in the drop of mixture. Allow the slides to dry for 24 hours in flat condition at room temperature (Sayre, 1941).

Photography

The photography of specimen in field was carried out by Digital Camera (DSC-W610, Sony Corporation, Thailand). The e mounted slides were photographed by using Photomicroscope (IM-900 IRMECO GmbH Industries. 30a, 21493 Schwarzenbck, Germany).

Identification

Relevant books by Gangulee (1969-1980), Eddy (1988, 1990, 1996), Chopra (1975), Kashyap (1972), Long (2006), Pradhan (2000, 2018, 2023), Smith (1996), and Pradhan and Shrestha (2021) were consulted for identification besides tallying reference specimens at the Natural History Museum, Kathmandu, Nepal. Morphology of the samples was observed using Stereo microscope Model EMZ 130516 Tokyo, Japan. All the identified samples were deposited to the Herbarium of Department of Botany (AKASH), University of Azad Jammu and Kashmir Muzaffarabad.

Results and Discussion

The identified specimens consisted of 6 species of mosses, 5 species of liverworts and one species of hornwort. Six Moss species belonged to family *Funariaceae, Bryaceae, Pottiaceae* and *Ditrichaceae* while five liverworts species belonged to family *Aytoniaceae, Marchantiaceae, Ricciaceae* and *Porellaceae.* Hornworts contain single species that belonged to the family "*Anthocerotaceae. Funaria hygrometrica, Bryum argenteum, Rhodobryum giganteum, Tortula subulata, Tortula inermis, Ceretodon purpureus, Reboulia hemispherica, Marchantia paleacea, Riccia pathankotensis, Astrella multiflora, Porella pinnata* and *Phaeoceros laevis"* were first time reported from the study area. *Porella pinnata* was critically endangered (Natcheva *et al.*, 2006) and *Astrella multiflora* a rare species was recorded between 1430-1520 m (www.rufford.org) and was first time observed in the District Muzaffarabad.

The *Funaria hygrometrica* was found on shady soil, stone walls along the road banks and in the adjacent areas of sewerage water found on burnt ground, rocks and remnant surroundings (Figure 2). It acts as pollution indicator and fire indicator. These observations are similar to the results of Rooy (2001). The species was present in all selected localities at altitudes from 800-2400 m above the sea level. It is a medium sized acrocarpous plant and its rhizoids arise from superficial cells containing oblique type of septum. Two types of phyllids present, the smaller lower phyllids buried in the soil and the upper phyllids. Coasta subpercurrent, laminal cells rectangular in shape. Seta long and hollow. Capsule pyriform. Calyptra deciduous, cucculate.

Peristome 16 in number and their size is 350.58 µm. Spores ovate in shape 19.50 µm in size. These values are lower sides to the results of Banu-Fatah (2005).

Figure 2: *Funaria hygrometrica*

Bryum argenteum observed growing on road side, graveyard walls, concreted structures, rocks and stone walls, polluted and adjacent areas of sewerage water system (Figure 3). It was also observed on corners of the houses, roofs, cemented blocks and on tree trunks. This observation is similar to the work of (Tan and Pocs, 2000) indicating that the *Bryum argenteum* is nitrophilous, which has the ability to tolerate the polluted and drought. This species has been recorded from most of the localities of Muzaffarabad within the elevation range of 800 to 2400 m. This plant is medium sized and acrocarpous with smooth rhizoids. Phyllids ovate and laminal cells with the size 36.05 x 11.60 µm. Seta long and capsule is pendulous. The peristome number 16 with average size of 53.97 µm. Spore spherical and 26.28 µm in size. These observations are similar to the results of Li xing-Jiang (2007).

Figure 3: *Bryum argenteum* plants

Rhodobryum giganteum (figure 4) found growing on humus soil and wet rocks on northern slope of the mountain which resemble the work of Nair *et al.,* (2005). This is the first observation made within the range of 1400-2000 m of elevation. Plants were erect, acrocarpous with rosette of leaves at the apical region and cluster of rhizoids at the base of the stem. Phyllids vary in shape from oblong to lanceolate with serrate margin. These observations are similar to the results of Moss Flora of Taiwan (*Rhodobryum giganteum* in Moss Flora of Taiwan @ taibif. org. tw).

Figure 4: *Rhodobryum giganetum*

Tortula subulata (Figure 5) was found growing on rock crevices and shady areas between the altitudes of 1000-2000 m. This observation is similar to the results of Uyar (2001). The plant small, acrocarpous, 3.25 mm tall with expanded leaves; rhizoids pale white and measures 4.75 mm in length; Phyllid 2.75 mm in size, laminal cells papillose type; seta long and erect, capsule long cylindrical, peristome 32 in number, each tooth measures 373.08 µm in diameter, calyptra cuculate, smooth, spore small, spherical, 22.50 µm in diameter. These observations are slightly upper side to the reported values in California moss e-Flora (*Tortula subulata* in California moss e-Flora @ efloras.org).

Figure 5: *Tortula subulata*

Tortula inermis (Figure 6) was found at the dry temperate area of the western Punjkot. This is the first record from the dry temperate area of this region. It was recorded within the range of 1800-2250 m of elevation. Plant acrocarpous; long and smooth, phyllids lingulate, laminal cells slightly hexagonal; seta long, capsule long and cylindrical, peristome elongated measured 325.19 µm in length, calyptra smooth and cuculate, spores smooth, spherical measured 25.05 µm in diameter. These values are slightly lower to the values mentioned in the Flora of North America. Sporophytic portion of *T. inermis* show quickly responses to the climatic stress. (*Tortula inermis* in Flora of North America @ efloras.org).

Figure 6: Tortula inermis

Ceretodon purpureus (Figure 7) was commonly recorded in the all selected sites. It was found growing on different habitats like dry sandy soil, rocks, wood logs, stumps, old roofs, humus and cracks of side walk, on disturbed and forest fired grounds. It is an indicator of the fire destroyed areas and disturbs soil texture. These observations are similar to the results of Andersson and Hakan (1991). It was observed abundantly at the junction of the old and the new rock area. The micro morphological study revealed the presence of elater for the first time in this species. Plant acrocarpous, rhizoids smooth walled, Phyllids lanceolate, coasta percurrent occupied two-third of the leaf length; seta long. Capsule short, cylindrical. Peristome is 22.50 µm long. Calyptra long, cuculate and 0.25 mm in length. Spores spherical and 10.63 µm in diameter. These results are similar to the results of Flora of North America (*Ceretodon purpureus* in Flora of North America @ efloras.org).

Figure 7: *Ceretodon purpureus*

Reboulia hemispherica (Figure 8) was found in shady and humus soil habitats similar to the observation of Vashishta *et al. (*2004). Plant monoecious, rhizoids dense, both smooth walled and tuberculate types were recorded. Two rows of scales are present on the both sides of the thallus. Stalks long, female receptacles smooth, 3.9 x 3.6 mm in diameter with 4-6 valves. Spores spherical, 10.53 x 9.69 µm in diameter. It acts as pollution indicator, drying of water sources and anthropogenic activities are the major threats to this species, which coincides to the report of Dash and Saxena (2009).

Figure 8: Reboulia hemispherica

Riccia pathankotensis (Figure 9) had been recorded only in Timber Gunchatter (altitude 1460 meter). It was found on rocks, mesic soil and on walk tracks. *Riccia pathankotensis* grows abundantly on west side of the slope. *R. pathankotensis* is threatened by increasing anthropogenic activities. Plant small, monoecious and dichotomously branched. The ventral side of the thallus bears two rows of purple scales and tuberculated rhizoids around the midrib region.

Figure 9: *Riccia pathankotensis*

Asterella multiflora (Figure 10) a rare species of family Aytoniaceae had been recorded between 1430 to 1520 m altitudes in Sindhupalchowk District of Central Nepal (Pradhan, 2011), but this species is common in Timbergunchatter and recorded at the elevation of 1460 m. It was recorded abundantly on the Northern Slope on humus soil. It is also pollution sensitive plant which needs conservation approach. Plant is dioecious, rhizoids dense and long. Thallus not dichotomously branched. Gemmae cup absent. Androecia sessile and gynoecia stalk and hairy. Capsule rounded spores blackish and spherical, measured 15.17 x 15.35 µm in diameter.

Figure 10: *Astrella multiflora*

Porella pinnata (Figure 11) a leafy liverwort, was recorded in Upper Punjkot site that lies in temperate zone of the District Muzaffarabad. Plant is monoecious, only female plant was observed. Dorsal and ventral leaves were present. Ventral leaves bear amphigastria. The increasing pollution in Muzaffarabad has placed it under the threat level. The IUCN status of

Porella pinnata is under the critically endangered category (Natcheva *et al*, 2006). It is also a rare species in India (Dandotiya *et al.,* 2011).

Figure 11: *Porella pinnata*

Phaeoceros laevis (Figure 12) was recorded only from sub-tropical zone of the site punjkot. It was found mostly on road sides, moist calcareous rocks, near springs, shady and wet soil. It was observed abundantly on the north mountain slope. Plant is monoecious, thallus long and flatend with smooth walled rhizoids. No air pores on thallus. Capsule is long and slightly blackish in colour, spores in spore tetrads, pseudo-elaters present. Drought condition and anthropogenic activities are major threats to this species which is also supported by the report of Dash and Saxena (2009).

Figure 12: *Phaeoceros laevis*

Marchantia paleacea (Figure 13) was observed only in temperate zone of Punjkot. It was noticed upon wet rocks, damp soil, cool and shady habitats. It was abundant around water seepage and northern area besides the junction of old and new rocks. Plant thalloid, thallus dorsoventrally flattened, one celled thick, cells hexagonal, 24.68 x 14.15 µm in diameter. Gamma cups present on the apical region of the thallus; rhizoides are tuberculated and smooth walled types, both present on the ventral surface. Plant is dioecious, male receptacle flat, antheridiophore short; female receptacle slightly convex on long stalk. Sporophytes differentiated into foot, short seta and capsule; spores spherical, blackish browns in colour. Oil bodies present. It also acts as Chemo-systematic indicator and potential source of medicines, similar observations was made by He *et al.* (2013).

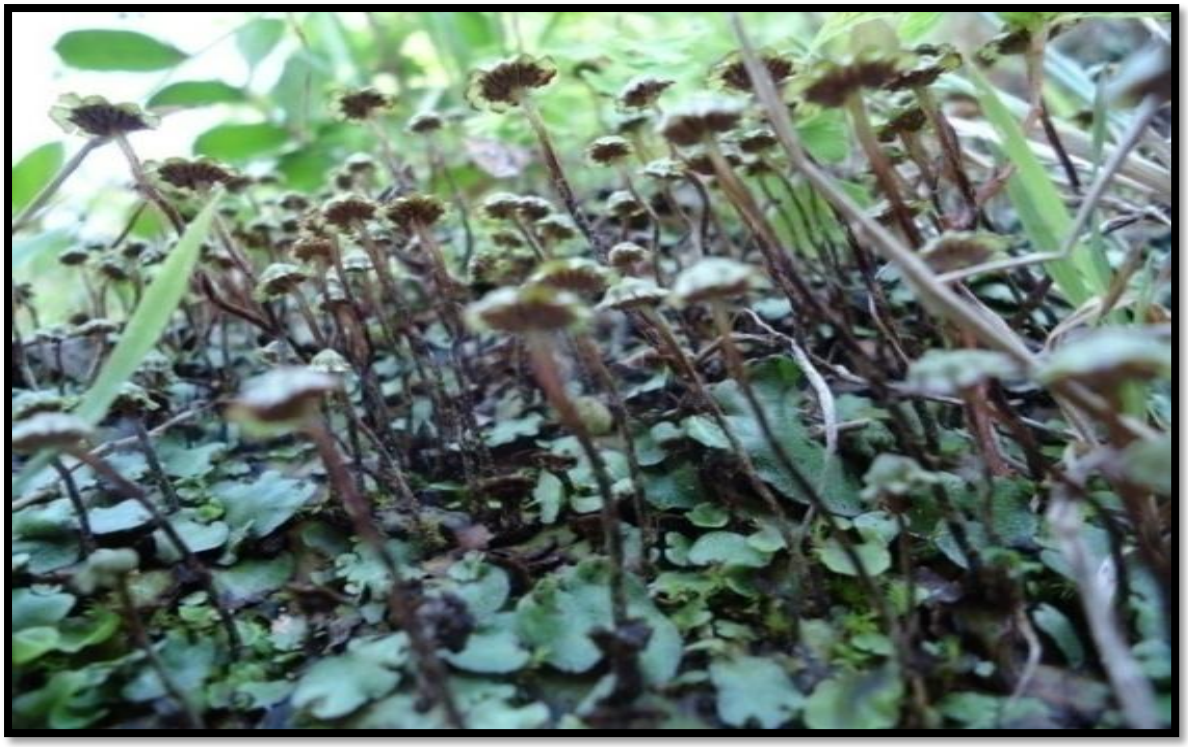

Figure 13: *Marchantia paleacea*

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