

Ecological Studies on Mosses of Chittorgarh District (Rajasthan)

Renu Singh¹, Arun Chaudhary²

¹Department of Botany, Seth R L Sahariya Government P G College Kaladera

²Maharana Pratap Government College Chittorgarh

ABSTRACT

The present study deals with the Ecological studies on the mosses of Chittorgarh district, 27 mosses from different habitats were collected from different places of the study area during rainy season and were identified. The range of ecological factors like moisture, temperature, forest types, soil and physiography were studied. It was revealed that Terricolous habitat is the dominating habitat and order Pottiales was the dominating order.

Key words: Chittorgarh, Terricolous and Pottiales.

INTRODUCTION

Bryophytes are the small nonvascular embryophytes that grow in damp and moist shady places. They are primitive and very simple land plants. Bryophytes are a heterogeneous group of plants unified by the lack of lignified vascular tissues and a life cycle with a long lived gametophyte and a short lived sporophyte. The sporophyte is dependent on the gametophyte for life. Though bryophytes live on the land, they require water for fertilization so they are called the “Amphibians of plant kingdom.”

According to Crum, 2001 there are about 25000 species of bryophytes found in world and they are next to Angiosperm in terms of species diversity. Bryophytes consist of three types Mosses (11,000-13,000 species), Liverworts (7,000-9,000 species) and Hornworts (200-250 species).

In dimension and biomass bryophytes have achieved great success in temperate and tropical rainforest. As a part of vegetative complex, bryophytes play an important role within the ecosystem, in soil conservation, reducing loss of nutrients, moisture retention of forest floor, as filter for purification of water. They help in nitrogen fixation by harbouring nitrogen fixing bacteria. They also provide food and shelter to various insects, birds, fishes and animals. Above all they act as significant bio-indicators of climate, heavy metals, pH quality of soil and water and are therefore being effectively used for monitoring air and water pollution (Chopra 1995).

Bryophytes play important role in ecological succession as they are early part of seral stages and are important for healthy ecosystem.

Besides ecological importance bryophytes have medicinal value too. Mosses are well known for their substantial medicinal uses they are used for cuts, bruises, external wounds, burns, fractures, swelling, blotches, and poisonous snake bite and as antipyretic and antiseptic agents (Pant 1998). The genus Sphagnum which covers 1% of the earth surface (American Bryological Society) is known for its economic and medicinal values in particular antiseptic property and its water holding capacity.

If we turn our focus towards the Chittorgarh district, we find that practically no work has been carried out with special reference to bryophytes and in particular mosses. The present exploration of the entire district was undertaken by following objectives;

1. To collect and identify and inventoried the Moss flora of district Chittorgarh.

2. To study the distribution pattern of Moss flora of the district.
3. To collect details regarding various ecological features like habit, habitat, distribution, ecological zonation and factors affecting their distribution.

MATERIAL AND METHODS

The fresh plants of mosses were collected during present investigation from the study area during the period 2018 to 2021. The main time of collection was monsoon season i.e. July to October. Surveys were carried out in all possible habitats and microhabitats, like dense forests, degraded forests, marshy pockets, wells, step wells, dams, canals, buildings, fluvial streams, non-fluvial streams, caves, crevices, etc. most of the places of study area were visited and various habitat types in the study area have been observed. Bryophytes flourish well due to high humidity and optimum temperature

Systematic collections were made periodically between month of June to September from various sites of the study area (see the map of study area). Plants from various habitats and localities were collected by scraping out from the substrate with the help of knife and bulk of soil particles were removed. The field data were recorded in the field book, such as the date of collection, locality, altitude, habitat etc. The material was brought to the laboratory in sealed polythene bags, plastic boxes and blotting paper packets. The soil samples were also collected for observing soil texture. After drying plants they are stored in standard size labeled packets as well as some of liverworts and hornworts were preserved in formo-aceto-alcohol (90 ml of 70% alcohol, 5 ml formalin and 5 ml glacial acetic acid), the universal fixative.

The classification systems proposed by Goff net and Buck (2004) for mosses have been adopted in the present investigation. The identified specimens are kept in in the Bryology Laboratory, Dept. of Botany, Maharana Pratap Government College, Chittorgarh. Alphabetical arrangements of the genera within each family and the species within each genus have been followed. A description of each species was prepared. The habitat, geographical distribution and the places of collection follow the morphological details of the plants. For anatomical studies of mosses hand cut sections of fixed material and fresh plants were taken. Dissected material and sections were mounted in glycerol (glycerol, water-1:1) and glycerin jelly and gum chloral for future references. Microscopic observations and Camera Lucida diagrams were made under trinocular microscope ch 2i TR. Field photographs were taken with Nikon D 610 field camera and microscopic photographs were taken by Nikon microscopic camera.

Taxonomic Enumeration

The division Bryophyta includes comparatively small and delicate group of plants, which are divided into three classes Hepaticopsida, Anthocerotopsida and Bryopsida generally known as liverworts, hornworts and mosses respectively.

In description and arrangements of taxa of liverworts, hornworts and mosses standard books by Nair *et al.* (2005), Lal (2005), Bapna and Kachroo (2000), Asthana and Srivastava (1991), Singh (2002), Gangulee (1969-80) and Chopra (1975) were consulted.

Key to the classes

A	Gametophyte thalloid or leafy, if leafy without midrib; rhizoids unicellular; capsule opens by 2 or 4 valves; elaters present usually or absent.	
	- Plant thalloid/leafy; numerous chloroplast per cell; capsule wall without stomata, opens by 4 valves.	Hepaticopsida
	- Plant thalloid; single chloroplast per cell; capsule wall with stomata and chloroplast; capsule opens by splitting into 2 valves.	Anthocerotopsida
B	Gametophyte leafy; leaves spirally arranged usually with costa; rhizoids multicellular with oblique septa; capsule opens irregularly or by 4 longitudinal slits or by operculum; elaters absent.	Bryopsida

Class: Bryopsida(Limpr.) Rothm.

Bryopsida is most diversified and the largest class of Bryophyta, in which all mosses are included. Gametophyte of two phases, a protonema and a leafy shoot (gametophore) arising as a lateral bud from the former. Protonema arises before gametophores production and it is highly branched filament. Gametophore is leafy, with spirally arranged leaves with costa. Sex organs usually with paraphyses. Gametophores produce archegonia and /or antheridia and the embryo develops within the archegonium. Sporophytes remain attached to the gametophyte and produce spores by meiosis. As in all Bryophyta, Bryopsida produces spores from sporophyte only once. Sporogonium a complex structure differentiated into foot, seta, and capsule; the wall of capsule several layered with stomata. Capsule opens irregularly or by 4 longitudinal slits or by operculum. Bryopsida have arthrodontous or nematodontous peristome. Elaters are fully absent.

Enumeration of Taxa

S.No.	Name of Moss Species Collected
1	<i>Funariahygrometrica</i> Hedw., Spec. Musc. 172, 1801.
2	<i>Physcomitriumcyathicarpum</i> Mitt.,MusciInd. Or. 54. 1859.
3	<i>Fissidenssylvaticus</i> Griff. Var. <i>zippelianus</i> (D. & M.) Gangulee
4	<i>Fissidenscrenulatus</i> Mitt.
5	<i>Fissidenscurvato-involutus</i> Dix.
6	<i>Erpodiummangiferae</i> C. Muell.,Linnaea37 : 178. 1873.
7	<i>Hyogoniumconsanguineum</i> (Thwait. et Mitt.) Hilp.,inBeih. Bot. Centrabl. 50(2);626, 1933.
8	<i>Hyogoniummarcuatum</i> (Griff.) Wijk. et Marg. In Taxon, 7 : 289 (1958).
9	<i>Hyophilainvoluta</i> (Hook). Jaeg.,Ber. S. Gall. Naturw. Ges. 1871–72:356, 1873.
10	<i>Hyophilarsea</i> Williams.in Bull. N.V. Bot. Card., 8: 341, 1941.
11	<i>Hyophilacomosa</i> Dix.et varde in Arch. bot. 1:166, 1927
12	<i>Hyophilaspatulata</i> (Harv.) Jaeg.inBer.S. Gall. Naturw. Ges. 1871-72: 353 (1873)
13	<i>Splachnobryumaquaticum</i> Mull.Hal.,Linnaea, 40:291. (1876).
14	<i>Splachnobryumindicum</i> Hamp. et C. Muell., Linnaea, 37:174. (1872).
15	<i>Weissiacontroversa</i> Hedw., Spec. Musc. 67 (1801).
16	<i>Weissialongifolia</i> Mitt., Ann. Mag. Nat. Hist., ser. 2. 8:317 (1851).
17	<i>Anoetangiumclarum</i> Mitt. In Musc. Ind. Or.: 31 (1859).
18	<i>Brachymerium exile</i> (Doz. etMolk.) Bosch. etLac.,Bryol. Jav. 1:139. 1860.
19	<i>Brachymeriumindicum</i> (Doz. etMolk.) Bosch. etLac., in Bryol. Jav. 1:141. 1860.
20	<i>Bryumcapillare</i> L.ex.Hedw., in Sp. Musc. 182, 1801.
21	<i>Bryumparadoxum</i> Schwaegr.,Spec. Musc. Suppl. 3(1) : 224 a, 1827.
22	<i>Bryumcellulare</i> Hook. Schwaegr., Spec. Musc. Suppl. 3 :1 : 214a.1827.
23	<i>Bryumcaespiticium</i> L.ex. Hedw., in Sp. Musc. 180, (1801).
24	<i>Stereophyllumanceps</i> (Bosch et Lac.) Broth. Nat.Pfl, 1(3) : 898, 1907.
25	<i>Stereophyllumligulatum</i> Jaeg.,Ber. S. Gall. Naturw. Ges. 1877-78; 277, 1880
26	<i>Entodonlaetus</i> (Griff.) Jaeg. inBer. S. Gall. Naturw. Ges. 1876–77:295 (1878
27	<i>Rhynchostegiumriparoides</i> (Hedw.) Cardot. Bull. Soc. Bot. France, 60: 231, 231,(1913).

Bryocology and Distribution

Lal (2005) divided Indian bryoflora into six bryoecological zones viz., Western Himalayan territory, Gangetic plains, Eastern Himalayan territory, Central Indian zone, Panjab plains and Rajasthan and South Indian zone (Fig. 1). The current study comes under the Central Indian zone and regarding the distribution of mosses in relation to environmental conditions the present study area can be divided into two different bryoecological zones.

BRYOECOLOGICAL ZONES

The present study area can be divided into two major bryoecological divisions on the basis of climatic conditions, forest types, soil and physiography. Each area having distinct climatic conditions resulting into variation of vegetation types and number of species. These are :-

1. The hilly area of Chittorgarh District
2. The plains of Chittorgarh District

The hilly area of Chittorgarh District

The South eastern part of Chittorgarh district is mostly hilly. This region includes subdivision of Bari sadri, Chittorgarh, begun and Rawatbhata. Hill ranges runs with intervening valleys parallel to each other. In Rawatbhata subdivision the gorges of Chambal are hotspots for bryodiversity. The hilly area of Chittorgarh experience dense vegetation and it is the major hot spot for Bryophytes. The major collection sites for bryophytes in this region are Niliya Mahadev, Jaleswar mahadev, Abhaypur Ghata, Shadi, Palka, Mindki Mahadev, Keljar Mahadev, SemlaPani, Amba Pani, Aamjar, Hansla, Bijaypur, Nahargarh, Jogniya Mata, Menal, JhariyaMahadev, Bassi wild life sanctuary, Dariba, KotdaBalaji, Padajhar, Sitamata wild life sanctuary, Bhainsrorgarh, Rawatbhata, and Mangdora.

BRYOGEOGRAPHICAL REGIONS OF INDIAN FLORA

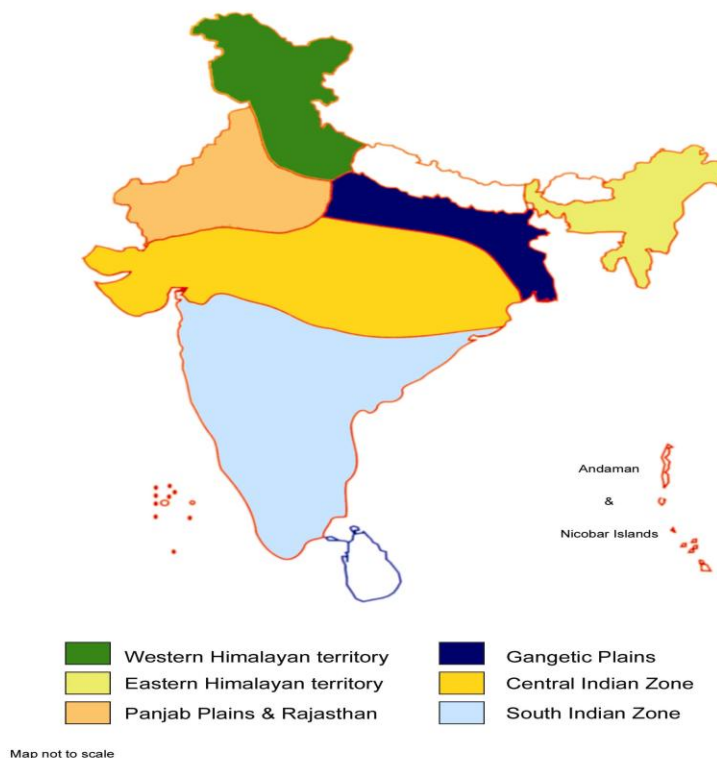


Figure 1: Bryoecological zones of India

The plains of Chittorgarh District

The Northern, western and southern part of Chittorgarh district is mostly plain and the environment is different from the hilly regions of Chittorgarh district. The main collection of this region is Chittorgarh Fort, College campus, Bhadesar, Rashmi, Hoda Hanuman Temple, Semalpura, Nagri, Nimbaheda and Gilund.

DISTRIBUTION

Distribution of the species is wider concept, which includes various aspects. To study the distribution, following parameters are taken into consideration, which are:-

Distribution in different habitats (Table. 1.1).

In the whole study area Moss species do not shows equal distribution, Only Menal, Jogniya Mata, Dariba, Padajhar and Sitamata wild life sanctuary shows the rich diversification.

In the study area major hot spots of bryophytes are: Sitamata Wild Life Sanctuary, Dariba, Padajhar, Jogniya Mata and Menal.

In present study 11mosses are found on rocks (Lithocolous), 13mosses on moist soil floors on clayey slopes on ditches (Terricolous), 04 mosses on brick, walls (Calcicolous) and 03mosses on other plants (Phycocolous). Habitats wise classification of the species is given in table 1.1.

Table 1.1: Showing distribution of the bryophytes in different habitats in the present study area

S. No.	Species	Lithocolous	Terricolous	Calcicolous	Phycocolous
1.	<i>Funariahygrometrica</i> Hedw.	+	-	+	-
2.	<i>Physcomitriumcyathicarpum</i> Mitt.	+	-	+	-
3.	<i>Fissidenssylvaticus</i> Griff. Var. <i>zippelianus</i> (D. &	+	+	-	-

S. No.	Species	Lithocous	Terricous	Calcicous	Phycocous
	<i>M.) Gangulee</i>				
4.	<i>Fissidenscrenulatus</i> Mitt.	-	-	-	-
5.	<i>Fissidenscurvato – involutus</i> Dix.	-	+	-	-
6.	<i>Erpodiummangiferae</i> C. Muell.	-	-	-	-
7.	<i>Hydrogoniumconsanguineum</i> (Thwait. et Mitt.) Hilp.	-	+	+	-
8.	<i>Hydrogoniummarcuatum</i> (Griff.) WijketMarg.	-	+	-	-
9.	<i>Hyophilainvoluta</i> (Hook.)Jaeg.	+	+	-	-
10.	<i>Hyophilarosea</i> Williams.	-	+	-	-
11.	<i>Hyophilacomosa</i> Dix. etvarde.	-	-	-	-
12.	<i>Hyophilaspatulata</i> (Harv.) Jaeg.	+	-	-	-
13.	<i>Splachnobryumaquaticum</i> Mull. Hal.	+	+	-	-
14.	<i>Splachnobryumindicum</i> Hamp.	-	+	-	-
15.	<i>Weissiacontroversa</i> Hedw.	+	-	-	-
16.	<i>Weissialongifolia</i> Mitt.	+	-	-	-
17.	<i>Anoetangiumclarum</i> Mitt.	+	-	+	-
18.	<i>Brachymenium exile</i> (Doz. etMolk) Bosch et Lac.	-	+	-	-
19.	<i>Brachymeniumindicum</i> Doz.etMolk.	-	+	-	-
20.	<i>Bryumcapillare</i> L. ex Hedw.	-	-	-	+
21.	<i>Bryumparadoxum</i> Schwaegr.	-	+	-	-
22.	<i>Bryumcellulare</i> Hook.	+	+	-	-
23.	<i>Bryumcaespitium</i> L.ex. Hedw.	-	+	-	-
24.	<i>Stereophyllumanceps</i> (Bosch et Lac.) Broth.	-	-	-	-
25.	<i>Stereophyllumligulatum</i> Jaeg.	-	-	-	+
26.	<i>Entodonlaetus</i> (Griff.) Jaeg.	-	-	-	+
27.	<i>Rhynchostegiumriparoides</i> (Hedw.) Cardot.	+	-	-	-
28.		11	13	4	3

(+) Present, (-) Absent.

FACTORS AFFECTING DISTRIBUTION AND SPECIES RICHNESS

Climate of a region is important determining factor for distribution and occurrence of mosses. Some of the important factors are described below:

Moisture

It is one of the most important factors that controls the occurrence and distribution of Mosses. They are most abundant and conspicuous in moist habitat, but are also found in grasslands, where they endure prolonged dry periods. The highest relative humidity is positively correlated at Menal, Jogniya Mata, Padajhar, Dariba and Sitamata Wild life sanctuary with the richest bryophyte flora. This area experience heavy rainfall and are covered with dense moist deciduous forest. Their canopy pattern maintains the humidity content and also provides various moist and shady habitats, which supports luxuriant bryophyte vegetation.

Temperature and Light

In terms of temperature moss species are found where relatively low temperature and high humidity conditions are present. Light affects temperature, as well as moisture conditions of a habitat. This is illustrated by the field study of Menal, Jogniya Mata, Padajhar, Dariba and Sitamata Wild life sanctuary the major hot spot of Moss vegetation in the study area. In hilly areas as we move upwards maximum number of species are found in those areas, which lie slightly interior to the pathways, covered with angiospermic vegetation. In such conditions forest floor are not directly exposed to sunlight. In an another situation some species on trees and other habitats, although occur on either sides of very narrow pathways but they are under shaded conditions with closely associated trees. Eldridge and Tozer (1997) also agree that the light factor affects the bryophyte distribution.

Elevation

The study area was divided in two Bryoecological zones, The hilly area of Chittorgarh district and plains of Chittorgarh District.

Regarding distribution along with altitudinal gradients, it was observed that Mosses shows maximum diversity at the elevation of above 550 m. In general Species go on increasing with increase in altitude. Lloret *et al.* (1997) also found that the maximum species richness decreased after a certain altitude.

Affinity of study area Mosses with rest of India

In current study, total 27 species of Mosses were collected (See table 1.2). which belongs to 5 orders, 8 families and 14 genera. The order Pottiales is the most dominant order represented by 11 species belonging to 5 genera.

Species common to:-

- Mosses of Chittorgarh and Eastern Himalayas = 15
- Mosses of Chittorgarh and Western Himalayas = 21
- Mosses of Chittorgarh and South India = 13

It was revealed that Mosses of Chittorgarh more resembles with Western Himalayas element.

Table 1.2: Comparative analysis of Mosses of chittorgarh with different regions of India

S. No.	Species	Eastern Himalayas	Western Himalayas	South India	Study area
1.	<i>Funaria hygrometrica</i> Hedw.	+	+	+	+
2.	<i>Physcomitrium cyathicarpum</i> Mitt.	+	+	-	+
3.	<i>Fissidens sylvaticus</i> Griff. Var. <i>zippelianus</i> (D. & M.) Gangulee	+	+	+	+
4.	<i>Fissidens crenulatus</i> Mitt.	-	-	+	+
5.	<i>Fissidens curvato – involutus</i> Dix.	+	+	-	+
6.	<i>Erpodium mangiferae</i> C. Muell.	+	+	+	+
7.	<i>Hydrogonium consanguineum</i> (Thwait. et Mitt.) Hilp.	+	+	+	+
8.	<i>Hydrogonium arcuatum</i> (Griff.) Wijk et Marg.	+	+	+	+
9.	<i>Hyophilainvoluta</i> (Hook.) Jaeg.	+	+	+	+
10.	<i>Hyophilarosea</i> Williams.	-	+	-	+
11.	<i>Hyophilacomosa</i> Dix. et varde.	+	+	+	+
12.	<i>Hyophilaspatulata</i> (Harv.) Jaeg.	+	+	-	+
13.	<i>Splachnobryum aquaticum</i> Mull. Hal.	+	+	-	+
14.	<i>Splachnobryum indicum</i> Hamp.	-	+	+	+
15.	<i>Weissia controversa</i> Hedw.	-	+	-	+
16.	<i>Weissia longifolia</i> Mitt.	+	-	-	+
17.	<i>Anoetangium clarum</i> Mitt.	+	+	-	+
18.	<i>Brachymenium exile</i> (Doz. et Molk) Bosch et Lac.	+	+	+	+
19.	<i>Brachymenium indicum</i> Doz. et Molk.	-	+	-	+
20.	<i>Bryum capillare</i> L. ex Hedw.	-	+	+	+
21.	<i>Bryum paradoxum</i> Schwaegr.	+	+	+	+
22.	<i>Bryum cellulare</i> Hook.	-	+	-	+
23.	<i>Bryum caespiticium</i> L. ex. Hedw.	+	+	-	+
24.	<i>Stereophyllum anceps</i> (Bosch et Lac.) Broth.	+	-	+	+
25.	<i>Stereophyllum ligulatum</i> Jaeg.	+	-	+	+
26.	<i>Entodon laetus</i> (Griff.) Jaeg.	+	-	-	+
27.	<i>Rhynchostegium riparoides</i> (Hedw.) Cardot.	-	-	-	+
		15	21	13	27

(+) Present, (-) Absent.

DISCUSSION AND SUMMARY

1. In the present work, morphological, anatomical work leads to generate keys to order, families, genera and species of Mosses of Chittorgarh district.
2. Field collections were made in four years from different localities of the study area. Plants were collected from different habitats like moist soil, forest floors, rocks, bricks, ditches, walls and trees.
3. At most of the places, plants appear just after the first showers of rains at end of June and complete their life cycle within three or four months. Sporogonia appear by the end of the September.
4. Microscopic studies of collected specimens were carried out. Camera Lucida drawings were made. Taxonomic description with special reference to identification characteristics, locality and field notes were made.
5. In anatomical studies hand cut sections of mosses were used for anatomical studies.
6. In the present study area total 27 species of Mosses belonging to 4 sub-classes, 5 orders, 8 families and 14 genera
7. The most dominating order was Pottiales represented by 11 species belonging to 5 genera, followed by order bryales with 6 species belonging to 2 genera.
8. *Splachnobryumaquaticum* Mull. Hal. and *Rhynchostegiumriparoides* (Hedw.) Cardot are reported for the first time from Rajasthan
9. On the basis of eco-climatic factors, investigator proposes that Chittorgarh district can be divided into two 'Bryecological zones' listed below.
 1. The hilly area of Chittorgarh District.
 2. The plains of Chittorgarh District.
10. Sitamata wild life Sanctuary, Dariba, Padajhar, Menal and Jogniya Mata having more favourable climate and being at higher altitude represented richest spot of Moss vegetation. The maximum numbers of species were collected from these regions.
11. Out of 27 species of Mosses reported from the study area, 15 species are common to Eastern Himalayas, 21 species are common to Western Himalayas and 13 species are common to South India.
12. Environmental factors like moisture, temperature, lights, elevation and biotic factor have a profound effect on the growth and richness of moss vegetation in the study area.
13. Of total 27 species are collected, 11 species are from lithocolous habitats, 13 from terricolous habitats, 04 from calcicolous habitats and 03 from phycolous habitats.
14. Regarding altitudinal distribution maximum species were found between 400-550 m. altitudes.

REFERENCES

- [1]. Alam, A., Pandey, S., Singh, V., Sharma, S. C., & Sharma, V. (2014). Moss flora of Mount Abu (Rajasthan), India: An updated checklist. *Trop Plant Res*, 1(1), 8-13.
- [2]. Alam, A., Rawat, K. K., Verma, P. K., Sharma, V., & Gupta, D. S. (2015). Moss flora of central India. *Plant science today*, 2(4), 159-171.
- [3]. Bapna, K.R. and Chaudhary, B.L. 1989. Mosses of Rajasthan II. Dicranales and Pottiales. *J. Indian Bot. Soc.* 68: 379-388.
- [4]. Chaudhary, B.L. and Bhagora, F.S. 2005. Diversity of Mosses in Malshej Ghats (North Konkan) Maharashtra – India. *Bulletin of Pure and Applied Sciences*, Vol. 24 B (No. 2) 2005 : 177-180.
- [5]. Chaudhary, B.L. and Bhagora, F.S. 2006 a. Epiphytic mosses of Malshej Ghats (North Konkan) Maharashtra-India. *Indian J. Environ and*
- [6]. Chaudhary, B. L. and Chaudhary, Arun 2009. Diversity of Mosses in Amboli (Sindhu Durg) Maharashtra, India. *Indian J. Applied & Pure Bio*: 24 (1), 1-3.
- [7]. Chaudhary, B. L. and Chaudhary, Arun 2009. Diversity of Mosses of Purandhar Fort (Maharashtra), India. *Pb. Univ. Res. J (Sci.)*: 59, 45-55.
- [8]. Chaudhary, B.L. and Deora G.S. 1993. Moss flora of Rajasthan (India). Himanshu Publications, Udaipur and New Delhi.
- [9]. Chaudhary, B.L. and Sharma, T.P. 2000. Epiphytic mosses of Udaipur, Rajasthan India. *Vasundhara*. Vol. 5: 85-89.
- [10]. Chopra, R.S. 1975. Taxonomy of Indian Mosses. *Botanical Monograph* .No. 10. CSIR New Delhi.
- [11]. Dabhade, G.T. 1969. Moss of Mahabaleshwar. *Maharashtra Vidhaya Mandir, Patrika*. Vol. 4, No. 2: 94-104.
- [12]. Dabhade, G.T. 1998. Mosses of Khandala and Mahabaleshwar in the Western Ghats (India). Published by A.S. Dalvi Sanman Co-op. HSg. Ltd. Thane India.
- [13]. Gangulee, H.C. 1974. Mosses of Eastern India and Adjacent Regions, face. 4 : 931-1134. Calcutta.
- [14]. Gangulee, H.C. (1969-80). Mosses of Eastern Indian and adjacent regions – Vol, I, II & III. Published by the author, Calcutta : India.

- [15]. Gangulee, H.C. 1985. Handbook of Indian Mosses. Amerind Publishing, New Delhi.
- [16]. Nath, V. and Gupta, R. 2006. *Hyophila involuta* (Hook.) Jaeg. New Addition to the Bryoflora of Pachamarhi Biosphere Reserve : 49.
- [17]. Nair, M.C., Madhusoodanan, P.V. and Rajesh, K.P. 2002. Bryophyte diversity in Kerala-an introduction In : Proc. Nat. Conf. Rec. Trends in Plant Sci. Res. Augustin, J. and Puthur, J.T. (eds) Nov. 14-15, pp. 116-121, Department of Botany, St. Thomas College, Pala.
- [18]. Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2005. Bryophytes of Wayanad in Western Ghats, Malabar Natural History Society (MNHS), Calicut, Kerala.
- [19]. Nath, V., Asthana, A.K. and Kapoor, R. 2007. Enumeration of the Mosses in Amarkantak (Madhya Pradesh), India-I. *Taiwania*, 52(2): 168-176.
- [20]. Nath, V., Bansal, P. and Chaturvedi, S.K. 2010. Morphotaxonomic study on the genus *Brachymenium* Schwaegr. from Nagaland (North-Eastern Hills), India, *Phytomorphology*, 60(3&4): 150-155.
- [21]. Pandey, S., & Alam, A. (2021). Molecular Markers (RAPD and SSR) Based Characterisation of Genetic Diversity and Population Structure of Moss *Hyophila involuta*. *Acta Botanica Hungarica*, 63(1-2), 171-193.
- [22]. Rawat, K. K., Alam, A., & Verma, P. K. (2015). Moss flora of Rajasthan and Punjab plains. *Plant Science Today*, 2(4), 154-158.
- [23]. Rawat, K. K., Sahu, V., & Paul, R. R. (2021). Bryophytes of Mount Abu, Rajasthan, India. *Nelumbo*, 63(1), 207-217.
- [24]. Sanadhya, C. 2004. Studies on the ecology of Bryophytes of Gujarat. Ph.D. Thesis, M.L.S. University, Udaipur.
- [25]. Sharma, T.P. 2002. Epiphytic mosses of South East Rajasthan and Gujarat. Ph.D. Thesis, M.L.S. University, Udaipur.