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## Seasonal variation in diversity and distribution of bryophytes in Madhepura, Bihar

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**Abstract-** Bryophytes are the second largest group of green plants and are widely spread in almost all climatic conditions. Bryophytes are good indicators of weather change and pollution. Diversity patterns and species composition of bryophytes can help us in understanding and planning natural conservation strategies. The study was conducted to understand the seasonal variation in the species composition of bryophytes in Madhepura District, Bihar. A total of eleven species representing seven families were recorded during the post-monsoon (PM) season and fifteen species representing eight families were recorded during the post-monsoon-to-winter (PwM) season in the Madhepura District. The values of Shannon- Wiener index and Simpson's index suggests that the diversity of bryophytes were almost similar during both the seasons. Margalef's index during PW season indicates that the species richness during the season is little disturbed, but is semi-disturbed during the PwM season. Pielou's Evenness index indicates that species were more homogeneously distributed during PW season than during PwM season

**Key words:** Bryophytes, Diversity, Diversity indices, Madhepura, Mosses, Species composition

### INTRODUCTION

Bryophytes, also known as the amphibians of the 'Plant Kingdom', and the second largest group of green plants next only to the angiosperms are widely spread in almost all climatic conditions and constitute a fascinating component of biodiversity. They comprise of diverse groups of primitive plants which are microscopic to macroscopic in size, and are the first land plants with about 25,000 species distributed worldwide with the capability to grow in various habitats as terricolous, corticolous, rupicolous and saxicolous population, making it the second largest group of land plants next to flowering plants and are the key component of biodiversity in different

ecosystems<sup>1</sup>. They collectively represent three different classes, viz., Marchantiophyta (liverworts) and the Anthocerotophyta (hornworts) and Bryopsida (mosses). India is rich in bryophyte diversity and is represented by 2562 taxa (887 liverworts and 39 hornworts, 1636 mosses<sup>2</sup>. Because of their preference for damp and shady conditions, they usually inhabit narrow ecological niches. The bryophyte diversity is rich and well represented in the Himalayas, Northeast and Peninsular India due to prevailing of high rainfall and humidity. Two genera and 168 species of liverworts, 19 species of hornworts and 547 species of mosses are endemic to India<sup>2</sup>.

The present study is conducted to understand the seasonal variation in the diversity and distribution of bryophytes in the Madhepura district of Bihar.

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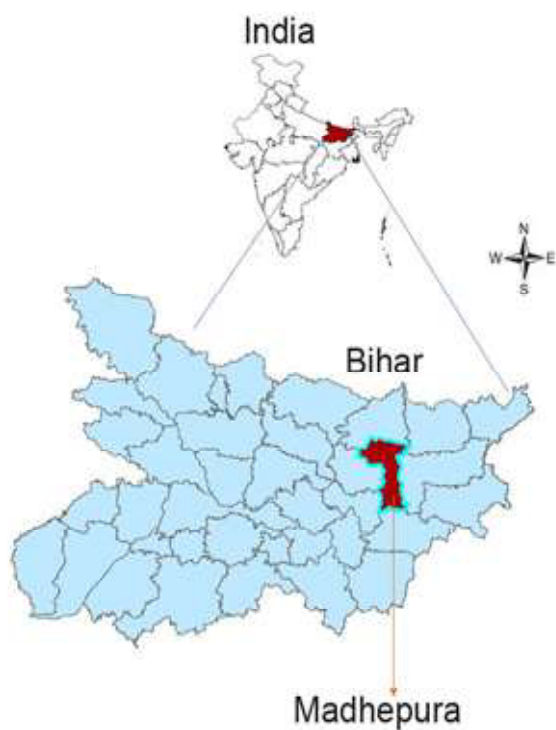
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**MATERIALS & METHODS**

**Study area**

The study is conducted in the Madhepura District located between 25°31' and 26°20' latitude and in the middle of 86°36' to 87°07' longitudes (Fig. 1). The district has a total of 3539 ha under the wetland areas with over 227 small wetlands with less than 2.25 ha area and in total it comprises of 2 percent of the total geographical area of the district. The maximum temperature of the district ranges from 35-45 degree Celsius and the minimum temperature ranges between 7-9 degree Celsius. The district receives an average rainfall of 1,300 mm<sup>3</sup>.



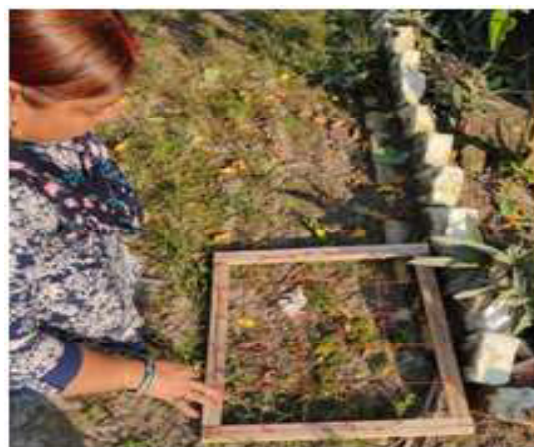
**Fig. 1. Map of the study area**

**Bryophyte samples collection and identification**

Bryophyte samples were collected pre-monsoon (PM) season (April-May, 2018) and post-monsoon to winter (PmW) season (November, 2018- January, 2019).

Collection of bryophyte samples were done following standard sampling protocols by BSI<sup>4</sup> and quadrats method by Ilić *et al.* (2018)<sup>5</sup> for ground-floor bryophytes in the Madhepura District. Ten quadrats of 50 x 50 cm<sup>2</sup> were used. Each quadrat was divided into twenty-five grids of size 10 x 10 cm<sup>2</sup> (Fig. 2). Bryophyte samples were collected

in paper bags and proper labelling was done. The samples were identified with authentic published literatures in-consultation with experts<sup>6,7</sup>. The phytosociological characters of species were evaluated by calculating the frequency, density, abundance and Importance Value Index (IVI) using standard methods<sup>8</sup>. Diversity indices were calculated using PAST v4.03 software. Environmental parameters like temperature, humidity, rainfall were collected with the help of weather instruments installed at Krishi Vigyan Kendra, Madhepura. Soil pH and moisture were analysed using standard methods.



**Fig. 2. : Picture of the 50 x 50 cm<sup>2</sup> quadrat**

**RESULTS & DISCUSSION**

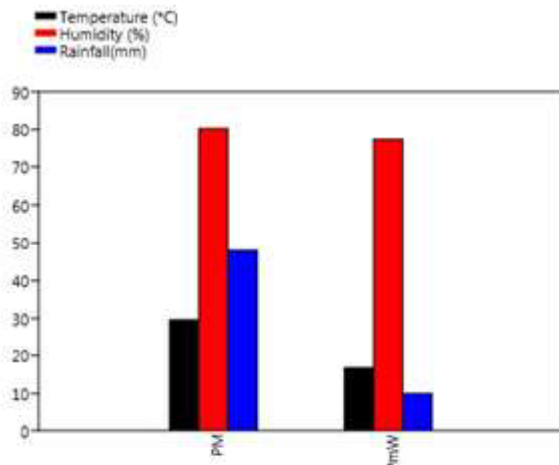
**Environmental parameters**

Average temperature during pre-monsoon (PM) and post-monsoon-to-winter (PmW) was 29.62 and 16.78 degree Celsius. Average humidity during PM and PmW was 80.23 and 77.5 percent. Average rainfall recorded during PM and PmW was 48 and 10 mm (Fig.3). Soil pH varied between 5.93 to 7.80 during PM and PmW between 6.09 to 7.90 during PwM at different collection sites in Madhepura District. Soil moisture (%) varied between 25.84 to 27.90 during PM and PmW between 29.01 to 31.50 during PwM at different collection sites in Madhepura District.

**Taxonomic composition and community structure of bryophytes**

A total of eleven species representing seven families were recorded during the post-monsoon (PM) season in Madhepura District (Table 1). *Physcomitrium eurystomum*, *Riccia billardierei*, *Hyophila involuta*, *Hydrogonium consanguineum* and *Riccia discolor* were dominating among the other species recorded.

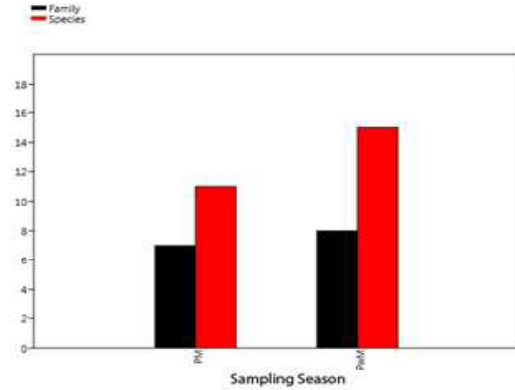
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**Fig.3. Graphical representation of environmental parameters during PM and PmW in Madhepura District**

A total of fifteen species representing eight families were recorded during the post-monsoon-to-winter (PmW) season in the Madhepura District (Table 2). *Physcomitrium*

*eurystomum*, *Cyathodium cavernarum* and *Riccia billardierei* were dominating among the other species recorded. Number of family and species recorded plotted graphically (Fig.4).



**Fig. 4. Graphical representation of number of family and species recorded during PM and PmW seasons in Madhepura District.**

**Table 1: List of bryophytes collected during PM season and community structural attributes**

Family	Species	RF	RD	RA	(IVI)
Pottiaceae	<i>Barbula arcuata</i>	8.51	2.63	3.17	11.14
Cyathodiaceae	<i>Cyathodium cavernarum</i>	8.51	10.66	12.84	19.17
Erpodiaceae	<i>Erpodium mangiferae</i>	6.38	1.61	2.58	7.99
Fissidentaceae	<i>Fissidens sylvatus</i>	4.26	2.26	5.45	6.52
Pottiaceae	<i>Hydrogonium arcuatum</i>	4.26	1.82	4.40	6.08
Pottiaceae	<i>Hydrogonium consanguineum</i>	12.77	14.38	11.55	27.15
Pottiaceae	<i>Hyophila involuta</i>	10.64	17.59	16.95	28.23
Meteoriaceae	<i>Meteoriopsis reclinata</i>	4.26	2.85	6.86	7.1
Funariaceae	<i>Physcomitrium eurystomum</i>	14.89	15.33	10.55	30.22
Ricciaceae	<i>Riccia billardierei</i>	14.89	14.89	10.25	29.78
Ricciaceae	<i>Riccia discolor</i>	10.64	15.99	15.41	26.62

(RF- relative frequency, RD- relative density, RA- relative abundance, IVI- important value index)

**Table 2: List of bryophytes collected during PmW season and community structural attributes**

Family	Species	RF	RD	RA	(IVI)
Pottiaceae	<i>Barbula arcuata</i>	8.47	3.97	3.84	12.45
Cyathodiaceae	<i>Cyathodium cavernarum</i>	10.17	15.92	12.84	26.09
Erpodiaceae	<i>Erpodium mangiferae</i>	6.78	3.4	4.12	10.18
Fissidentaceae	<i>Fissidens sylvatus</i>	5.08	3.33	5.38	8.42
Fissidentaceae	<i>Fissidens subpalmatus</i>	3.39	1.03	2.49	4.42
Pottiaceae	<i>Hydrogonium arcuatum</i>	3.39	1.42	3.43	4.81
Pottiaceae	<i>Hydrogonium consanguineum</i>	10.17	11.6	9.35	21.77
Pottiaceae	<i>Hyophila involuta</i>	8.47	13.72	13.29	22.2
Meteoriaceae	<i>Meteoriopsis reclinata</i>	3.39	2.91	7.04	6.3
Funariaceae	<i>Physcomitrium cyathicarpum</i>	3.39	1.17	2.83	4.56
Funariaceae	<i>Physcomitrium eurystomum</i>	11.86	15.21	10.52	27.08
Funariaceae	<i>Physcomitrium immersum</i>	3.39	0.85	2.06	4.24
Ricciaceae	<i>Riccia billardierei</i>	11.86	13.65	9.44	25.52
Ricciaceae	<i>Riccia discolor</i>	8.47	11.31	10.95	19.79
Stereophyllaceae	<i>Stereophyllum tavoyense</i>	1.69	0.5	2.41	2.19

(RF- relative frequency, RD- relative density, RA- relative abundance, IVI- important value index)

The values of Shannon- Wiener index and Simpson's index suggests that the diversity of bryophytes were almost similar during both the seasons. Margalef's index during PW season indicates that the species richness during the season is little disturbed, but is semi-disturbed during the PwM season. Pielou's Evenness index indicates that species were more homogenously distributed during PW season than during PwM season.

**Table 3: Diversity Indices of bryophyte during PW and PwM sampling seasons in Madhepura District**

Diversity Indices	PW	PwM
Shannon–Wiener index	2.236	2.306
Margalef's index	1.895	2.494
Simpson's index	0.881	0.883
Pielou's Evenness index	0.850	0.668

### DISCUSSION & CONCLUSION

Bryophytes are second largest component of biodiversity and are considered one of the most important indicators of pollution and climate change<sup>9,10</sup>. An updated record of 70 taxa representing 40 genera and 19 families from the gangetic plains have been reported earlier which includes most of the genera recorded in the Madhepura District<sup>11</sup>. A few species recorded in the Madhepura district (like *Hyophila involuta*) has also been reported from Karnataka and Uttar Pradesh<sup>12,13</sup>. Bryophyte diversity and community composition has been reported from the chakrata reserve forest, Uttarakhand<sup>14</sup>. Bryophytes are very important component of biodiversity and work related to the diversity and species composition of biodiversity needs more attention as they also serve as pollution indicators. A total of 241 species of bryophytes has been recorded from the state of Jammu & Kashmir<sup>15</sup>. In the present work, during post-monsoon (PW) season, less number of species were recorded as compared to post-monsoon-to-winter (PwM) season, the reason might be due to the dry weather conditions during pre-monsoon season and favourable weather condition during the PwM season.

Diversity analysis helps in understanding the species richness and diversity patterns of species in environment. The present work successfully concludes with recording of a total 15 species of bryophytes in the district of Madhepura representing eight families. The diversity indices suggest that the diversity of bryophytes were almost similar during both the seasons, except disturbed species richness during the PW season due to harsh/dry weather

conditions. However, there is future scope of detailed work to understand in effect of various environmental and anthropogenic factors on bryophyte diversity and species composition in the district.

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