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A study on the diversity of bryophytes in Madhepura with reference to pollution

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Abstract:- Understanding diversity patterns and community structure of bryophytes will help integrate nature conservation at multiple biotic-group levels. We conducted a survey of ground bryophytes in Madhepura along an edge-to-interior gradient. We recorded several species out of which 3 species from 2 genera of 2 families were liverworts, while 11 species from 8 genera of 6 families were mosses. A two-way cluster analysis detected the environmental gradient between the forest edge and forest interior for bryophytes with habitat specificity. Functional diversity of bryophytes differed significantly across an edge-to-interior gradient. Some species were detected with a significant indicator value for indicating environmental conditions in the forest edge, while only one such species was found indicative of the intermediate transect. Our results demonstrate that remarkable edge effects exist for species composition and functional diversity patterns, and the edge is a marginal habitat with high biotic heterogeneity. Furthermore, functional diversity metrics are more sensitive to the edge effect than species diversity.

Key words: bryophytes, liverworts, mosses, edge effect, diversity, indicator

INTRODUCTION

The term bryophyte is a combination of two Greek words; Bryon = moss and phyton = plant. These plants occupy an intermediary position or form a link between algae and pteridophytes. Often regarded as the plant amphibians, they need water for fertilization. Their lineages can be traced in the tertiary beds of the Cenozoic era.

Bryophytes, known as liverworts, mosses, and hornworts, are the earliest land plants in the phylogenetic systematics of the plant kingdom. They occur widely in the global terrestrial ecosystem, often as dominants in the floor layer of the moist tropical and subtropical broadleaved forest biomes.[1] However, bryophytes appear to have been neglected in many ecological studies, where only vascular plants or even woody plants were investigated such as in the emerging fields of community ecology to explore the role of ecological processes and biotic diversity in maintaining ecosystem function.[2] Until now, little has been known about the diversity patterns of bryophytes, their spatial heterogeneity, their role in forest community assembly, and their biotic and abiotic interactions to maintain the ecosystem function as a whole. The knowledge gap surrounding bryophyte community function is even greater for tropical and subtropical forest ecosystems, thus hampering our steps towards a better understanding of the ecosystem functions as a whole.[3]

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Botanists have argued that as the earliest land plants, bryophytes reflect the dispersal history of plants of various evolutionary stages in the terrestrial ecosystem, and their physiological adaptation, community structure, and the ecological functions in response to environmental change are much more complicated than previously imagined.[4] Disseminated by spores, bryophytes have an outstanding capability for dispersal and will respond sensitively to environmental change. Previous studies have demonstrated that bryophytes are good bio-indicators for environmental pollution due to the special leaf architecture of the plant organism.[5] However, to gain a whole picture of the bryophytes' distribution, diversity patterns, community structure, and their response to ecological factors along environmental gradients, extensive studies in the community ecology of bryophytes should be carried out in natural ecosystems, especially in the forest ecosystem.[6] In this study, we conducted a survey of the understory ground bryophytes using a quadrate sampling method in Madhepura along an edge-to-interior gradient, followed by multivariate statistical analysis of the field data. We aimed to address the following question that is there species with high habitat specificity that can act as bio-indicators for significant species-habitat association.

MATERIALS & METHODS

To assess whether bryophyte species have a specific habitat association and to detect an indicator value of different species for indicating environmental gradient, we performed indicator species analysis (ISA) using Dufrêne and Legendre's method. ISA calculates an indicator value for each species and provides a p-value for each indicator value using permutation.

RESULTS

Out of the total number, 3 species from 2 genera of 2 families were liverworts, while 11 species from 8 genera of 6 families were mosses (Table 1). No hornworts were found. High ecological dominance existed in the bryophyte community.

Indicator Species

Nine species had an indicator value>10 for indicating a particular transect habitat, but only three indicator species were detected to have a significant indicator value (Table 2). Five such species with a significant indicator value were found confined to the forest edge. These were *Riccia discolor, Barbula arcuata, Erpodium mangiferae, Hydrogonium consanguineum* and *Meteoriopsis reclinata*.

Table 1- Taxonomic composition of bryophytes and community structural attributes.

Family	Species	F	AC	RC	IV
Liverworts					
Cyathodiaceae	*Cyathodium cavernarum*	60	28.69	6.93	26.09
Ricciaceae	*Riccia billardierei*	70	35.62	13.77	25.52
Ricciaceae	*Riccia discolor*	50	30.10	10.02	19.79
Mosses					
Pottiaceae	*Barbula arcuata*	50	16.40	2.54	12.45
Erpodiaceae	*Erpodium mangiferae*	40	11.51	2.57	10.18
Fissidentaceae	*Fissidens sylvatus*	30	8.20	0.05	8.42
Pottiaceae	*Hydrogonium arcuatum*	20	13.00	3.14	4.42
Pottiaceae	*Hydrogonium consanguineum*	60	37.78	11.88	21.77
Pottiaceae	*Hyophila involuta*	50	30.40	10.10	22.2
Meteoriaceae	*Meteoriopsis reclinata*	20	13.72	3.31	6.3
Funariaceae	*Physcomitrium cyathicarpum*	20	11.25	0.52	4.56
Funariaceae	*Physcomitrium eurystomum*	70	32.53	10.61	27.08
Funariaceae	*Physcomitrium immersum*	20	5.36	0.45	4.24
Stereophyllaceae	*Stereophyllum tavoyense*	10	7.89	0.32	2.19

Abbreviations: F = Frequency;
AC = Average Cover;
RC = Relative Cover;
IV = Importance Value.

Table 2- Indicator species of bryophytes with an indicator value >10 across transects

Species	Observed indicator value	Indicator value from randomization		*p*
		Mean	Standard deviation	
Cyathodium cavernarum	36.5	16.4	5.41	0.007
Riccia discolor	27.4	13.2	5.1	0.015
Barbula arcuata	23.4	12.4	4.98	0.012
Erpodium mangiferae	21.9	9.9	4.77	0.036
Fissidens sylvatus	20.9	15.7	5.26	0.127
Hydrogonium consanguineum	21.2	7.7	4.27	0.046
Meteoriopsis reclinata	21.8	14.1	5.02	0.120
Physcomitrium eurystomum	16.3	8.7	4.27	0.069
Stereophyllum tavoyense	13.5	9.8	4.58	0.239

Only one species, *Cyathodium cavernarum*, was significantly indicative to the intermediate transect with the maximum indicator value.

DISCUSSION

Bryophyte diversity patterns and community structure changed in response to environmental gradients. Except for the intermediate transect, high habitat specificity for the bryophyte species was found in both the forest-edge and forest-interior transects.[3] High interspecific association existed in both common species that had co-occurrence in a number of sample units, and rare species which were found in only one or two sample units. Two bryophyte species, *Physcomitrium eurystomum* and *Riccia discolor*, occurred in almost all sample units, reflecting their robust adaptability to heterogeneous habitats. Although three common species, *Riccia billardierei, Hyophila involuta* and *Physcomitrium eurystomum,* were restricted to the intermediate and the forest-interior transects, they occurred in most sample units of the two transects, indicating that the forest-edge habitat might act as an environmental filter for their distribution. The five bryophyte species detected as rare species with unique occurrence in the sample units demonstrated high habitat specificity, and a very high species association was exhibited in these species with coincidence in the same sample unit.

Biodiversity is regarded as the essential property characteristic of an ecosystem or biotic community.[6]

Five species (*Riccia discolor, Barbula arcuata, Erpodium mangiferae, Hydrogonium consanguineum* and *Meteoriopsis reclinata*.) were detected to have a significant indicator value. Seven such species with a significant indicator value were found with a restricted occurrence in the forest edge, while only one species (*Cyathodium cavernarum*) was significantly indicative of the intermediate transect with the maximum indicator value. The significant indicator species were the representations of both species habitat association and habitat specificity.

CONCLUSION

In conclusion, the spatial patterns of bryophyte species diversity and community structure in response to the edge-to-interior gradient were determined by habitat characteristics as well as the bryophytes' biological properties. Our results demonstrated that the conspicuous diversity patterns, community structure, and interspecific association in ground bryophytes are related to the extent of change of diversity patterns under climate change, thus acting as indicators.

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