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Habitat Characterisation for the Macro Moth Fauna (*Lepidoptera*: *Heterocera*) of the Cachar District of Southern Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study conducted in the Cachar district involved a comprehensive characterisation of the local flora, identifying a total of 146 tree species from 50 families. The average species richness among tree species in moth habitats was estimated to be S=47.94±9.84. Dominant tree species found across all study sites in the Cachar district included Lagerstroemia reginae Roxb., *Michelia champaca* L., Tectona grandis L.f., *Bombax ceiba* L., Dalbergia sisoo Roxb., and others. Additionally, 74 shrub species from 28 families were identified across the study area, with an average species richness in moth habitats of S=23.31±5.34. Shrub species with higher density reported in this study included *Melastoma malabathricum* L., Triumfetta rhomboides Roxb., and others. Furthermore, the survey identified 87 herb species from 41 families across the study sites in

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the Cachar district. The average species richness of herb species in moth habitats was determined to be S=58.57±32.99. Herb species with higher density documented in Cachar district during the study included *Polygonum microcephala* (D. Don.) Sasaki, *Cynodon dactylon* (L.) Pers., and others. The study also highlighted food or host plants preferred by the Arctiidae, Geometridae, and Sphingidae moth families, belonging to various families such as Solanaceae, Moraceae, Poaceae, and others. This research significantly contributes to our understanding of the rich biodiversity of the Cachar district and the essential role played by plant species in supporting moth habitat.

Keywords: Habitat characteristics; moths; Cachar district; Assam; India.

1. INTRODUCTION

Among the world's 34 biodiversity hotspots, the Eastern Himalaya is renowned for its rich species diversity and endemism (Mittermeier et al., 2005). Situated at the confluence of the Indo-Malayan, Indo-Chinese, and Indian biogeographical realms, this region excels in hosting a wide range of habitat types, thereby supporting a diverse biota characterized by a high degree of endemism. Notably, a significant portion of its plant diversity remains intact; Rao and Murti, [1]. However, the escalating human population in this area has imposed severe anthropogenic pressures on its vegetation, including deforestation, grazing, tree branch cutting, and slash-and-burn practices for shifting cultivation [2]. These disturbances persist unabated, with the extraction of biomass from forests occurring without allowing sufficient recovery time. Consequently, these activities have triggered a gradual decline in habitat structure and a loss of biodiversity [2]. While forest diversity plays a pivotal role in sustaining livelihoods in the northeastern region, the population surge witnessed in recent decades has led to extensive exploitation of its natural flora and fauna, culminating in habitat degradation [2].

Moths, members of the Lepidoptera order, are primarily phytophagous, with their larval stages consuming plant tissues while adult moths mainly rely on nectar for sustenance. Their feeding habits often lean towards monophagy or oligophagy, meaning their population numbers are closely tied to the availability of suitable food plants or host plants [3]. Although moths inhabit a variety of environments, they are most abundant and diverse in forested areas. Within these habitats, woody plants, shrubs, and trees serve as the primary host plants for moth caterpillars, highlighting the economic significance of moths as key herbivores in forest ecosystems. Moths display a diverse range of behaviours and are adaptable to different conditions. Many herbivorous insects, including macro moths, demonstrate a strong affinity for a particular species or genus of host plant [4]. Because of their reliance on specific host plants, the distribution and abundance of macromoth species may closely mirror that of their host plants.

Herbivorous insects are particularly sensitive to the effects of deforestation and subsequent forest regeneration, given their close reliance on the vegetation they inhabit. The abundance and quality of host plants play a significant role in shaping the spatial and temporal dynamics of herbivorous insect populations (Murdoch, [5], White, [6]. Host plants serve as sustenance for herbivorous insects, with their structure influencing the distribution of these insects; Jones et al., [7], and potentially interacting with nutritional quality [8].

Moths offer an intriguing avenue for studying the impacts of habitat changes due to their diverse species composition, herbivorous larval stages, accessibility of adult moths for standardized sampling, and the extensive taxonomic knowledge available for most tropical specimens (Holloway, [9], Kitching et al., [10]. Research conducted in lowland habitats in other tropical regions has suggested that Arctiidae moths may thrive in response to anthropogenic habitat disturbance, possibly due to the broad dietary preferences of many arctiid species' larvae (Kitching and Rawlins, [10], Holloway et al., [9], Subenbach, 2003). While numerous studies have examined the response of tropical butterflies to habitat disturbance, moths, especially nocturnal species, also serve as valuable indicators for understanding and monitoring the effects of habitat changes (Holloway, [9], Chey et al., 1997; Willott, 1999; Kitching et al., [10], Schulze, 2000; Beck et al., 2002; Axmacher et al., [11]; Summerville et al., 2004). The present study focuses on the habitat characterisation, including vegetation composition, diversity, and richness, of moths in selected sites within the Cachar District of Southern Assam.

2. MATERIALS AND METHODS

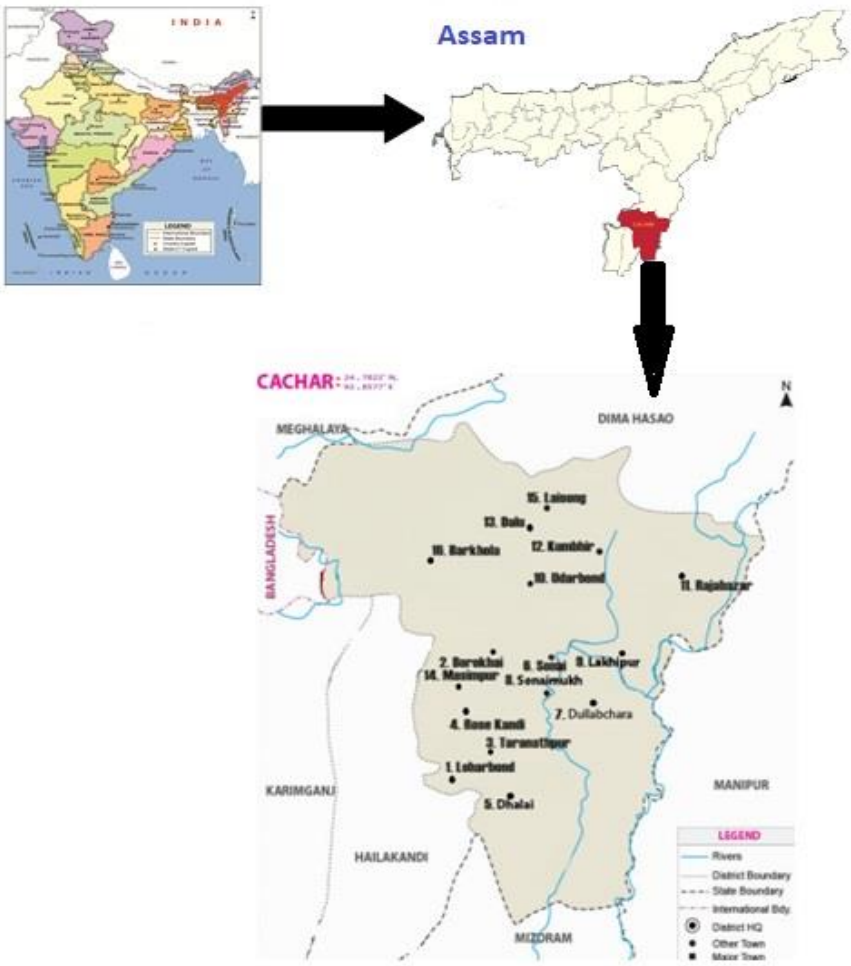
2.1 Study Area

The survey was carried out in the Cachar district of Assam, within the Barak Valley in the southern part of Northeast India. Encompassing approximately 3,786 square kilometers, the district is bordered by the N.C. hills and Jaintia hills of Meghalaya to the north, Manipur state to the east, Mizoram to the south, and the Hailakandi district of Assam and Bangladesh to the west (http://cachar.gov.in). Its geographic coordinates range between 24°22' N and 25°08' N latitude and 92°24' E and 93°15' E longitude. Habitat characterisation survey was conducted in 16 different selected sites (Loharbond, Borokhai, Taranathpur, Rosekandi, Dholai, Sonai, Dulabchera, Sonaimukh, Lakhipur, Udarbond, Rajabajar, Kumbhir, Dalu, Masimpur, Laisong, and Barkhola) where moth survey was done (refer to Map-1).

2.2 Methods of Data Collection

Habitat characterisation samplings were conducted during daylight hours using the Quadrat method, following the guidelines outlined by Sharma [12]. Throughout the survey, moths belonging to the Arctiidae, Geometridae, and Sphingidae families were observed across all 16 sites within the district.

To characterise the vegetation of these 16 sites, a comprehensive sampling approach was adopted. Sixty-four quadrates, measuring 20m x 20m, were systematically sampled for trees, while 5m x 5m quadrates were utilized for shrubs. Additionally, 1m x 1m quadrates were employed for herbaceous vegetation in each site within both districts, spaced at 500-meter intervals. Considering the relatively low tree density, 20m x 20m quadrates were used in each site within both districts, following the methodology proposed by Braun-Blanquet [13].



Map 1. Map of Cachar district showing sampling sites

In each plot, the following data were recorded: (1) Diameter at breast height (DBH) of all trees with a DBH ≥ 10 cm; (2) Local names of all measured trees, shrubs, and herbs (3) Total number of tree, shrub, and herb species present in each plot; (4) Identification of food trees, shrubs, and herbs for moths. Plant species were identified with the help of standard field guide following Hajra and Jain, [14] and Kanjilal *et al.,* [15] and also Dutta and Choudhury [16].

In all cases, the density, frequency, and dominance of each taxon were calculated. Vegetation characteristics were then averaged for each study site. Measures of species diversity were incorporated into the analysis, including species richness (defined by the number of tree species identified in each study site), Shannon-Wiener diversity index, and Simpson diversity index, calculated as described in Ganzhorn [17] and Doughlas [18]. Shannon-Wiener diversity index (Shannon and Wiener, [19], evenness index [20], Margalef index (Margalef, [21], and Simpson dominance index Simpson, [22] were computed using PAST [23] software to analyse species diversity and dominance in the community.

However, it's notable that the Sphingidae family was not universally present in all surveyed plots.

3. RESULTS

A total of 146 tree species, spanning 50 families, were identified across the 16 survey sites in the Cachar district. The average species richness observed in moth habitats was found to be S=47.94±9.84. Sites 3, 4, 5, and 9 exhibited the highest species richness, with values of S=61, S=72, S=57, and S=58, respectively. The dominant tree species found throughout the study sites in the Cachar district include *Lagerstroemia reginae Roxb., Michelia champaca L., Tectona grandis L.f., Bombax ceiba L., Dalbergia sisoo Roxb., Artocarpus lacucha Buch.-Ham., Artocarpus chama Buch.-Ham., Artocarpus heterophyllus Lam., Terminalia bellirica Roxb., Canarium benghalense Roxb., Ficus benghalensis L., Shorea robusta Gaertn., Syzygium cumini (L.) Skeels, Mangifera indica L., Gmelina arborea Roxb., Aporusa dioica (Roxb.) Muell., Vitex altissima L., Actinodaphne obovata (Nees.) Bl., Kayea floribunda Wall., and Terminalia arjuna*.

Across the study area, a total of 74 shrub species belonging to 28 families were identified. The average species richness of shrubs observed within moth habitats was determined to be S=23.31±5.34. Among the shrub species, those exhibiting higher density in this study include *Melastoma malabathricum* L.*, Triumfetta rhomboides Roxb., Combretum pilosum, Dendrocnide sinuata* (Bl.) *Chew., Glycosmis arborea* (Roxb.) *Corr., Asclepias curassavica* L.*, Murrya koenigii* (L.) *Spreng, Oxyceros longiflora* (Lamk.) *Yamazaki, and Vitex negundo* L.

During the survey period across all study sites in the Cachar district, a total of 87 herb species belonging to 41 families were identified. The average species richness observed within moth habitats for herbaceous species was S=58.57±32.99. Notable herb species with higher density recorded in the Cachar district during the study include *Polygonum microcephala (D. Don.) Sasaki, Cynodon dactylon (L.) Pers., Enhydra fluctuans Lour., Leonurus indica (L.) R. Br. ex Vatke, Mentha piperita L., Pothos scandens L., Commelina benghalensis L., Bacopa monnieri (L.) Pennel, Sansevieria roxburghiana Schult.f, and Vinca rosea L.*

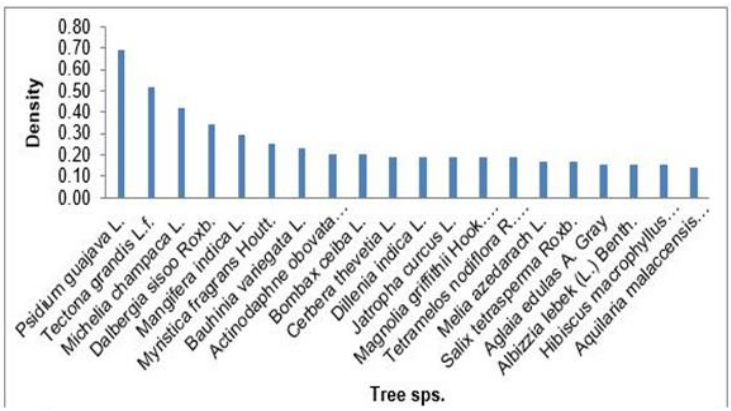


Fig. 1. Density (/m2) top 20 tree species in moth inhabited of cachar district

Table 1. Tree species richness and diversity at each study sites of Cachar district

Study site	Name of the location	GPS point	Species richness (S)	Simpson's index (C)	Shannon-Wiener index (H)	Evenness Index (J)	Margalef index
1	Loharbond	24^{0}35'26.25"N, 92^{0}43'48.75"E	45	0.9146	2.685	0.7716	4.729
2	Borokhai	24^{0}37'43.89"N, 92^{0}42'16.32"E	54	0.9396	2.946	0.8271	5.515
3	Taranathpur	24^{0}36'44.83"N, 92^{0}41'58.17"E	61	0.9196	2.646	0.8293	3.892
4	Rose kandi	24^{0}42'02.07"N, 92^{0}41'58.17"E	72	0.9047	2.533	0.7405	3.741
5	Dholai	24^{0}35'08.13"N, 92^{0}50'19.03"E	57	0.8347	2.186	0.6354	3.215
6	Sonai	24^{0}43'54.24"N, 92^{0}46'40.39"E	44	0.905	2.533	0.8394	3.7
7	Dulabchera	24^{0}32'11.60"N, 92^{0}49'54.30"E	39	0.9349	2.855	0.8685	5.186
8	Sonaimukh	24^{0}44'35.43"N, 92^{0}51'33.87"E	43	0.901	2.58	0.7334	4.52
9	Lakhipur	24^{0}47'40.19"N, 92^{0}51'33.87"E	58	0.9281	2.732	0.9035	3.94
10	Udarbond	24^{0}52'51.38"N, 92^{0}53'04.66"E	39	0.9402	2.899	0.9078	5.186
11	Rajabajar	24^{0}54'32.16"N, 92^{0}42'42.39"E	41	0.9268	2.714	0.8877	4.309
12	Kumbhir	24^{0}54'55.77"N 92^{0}57'54.59"E	41	0.8995	2.504	0.8154	3.77
13	Dalu	25^{0}01'50.17"N, 93^{0}10'10.25"E	43	0.9584	3.253	0.9241	7.179
14	Masimpur	24^{0}45'41.16"N, 92^{0}47'13.08"E	51	0.9343	2.811	0.8747	4.578
15	Laisong	24^{0}49'19.59"N, 93^{0}01'20.69"E	39	0.8797	2.284	0.8176	3.003
16	Barkhola	24^{0}55'19.59"N, 92^{0}44'28.72"E	40	0.9475	3.072	0.8992	6.235
		Mean	47.94± 9.8				

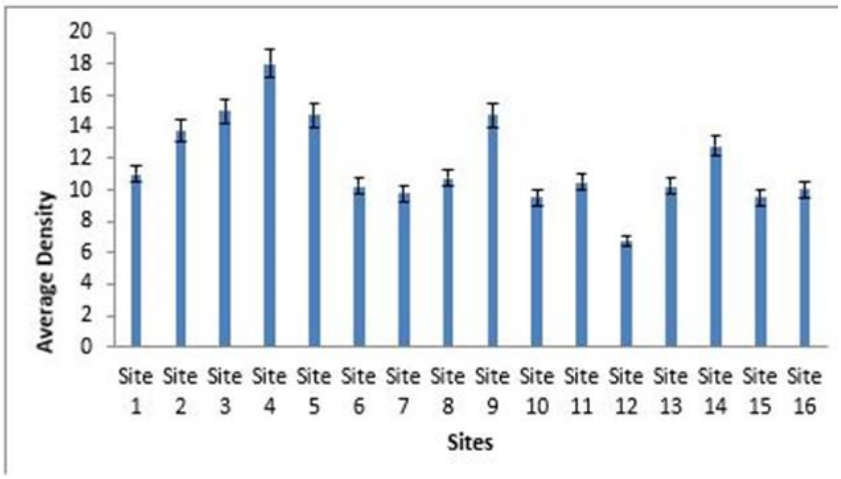


Fig. 2. Site wise average density and standard deviation of trees is month inhabited of Cachar district

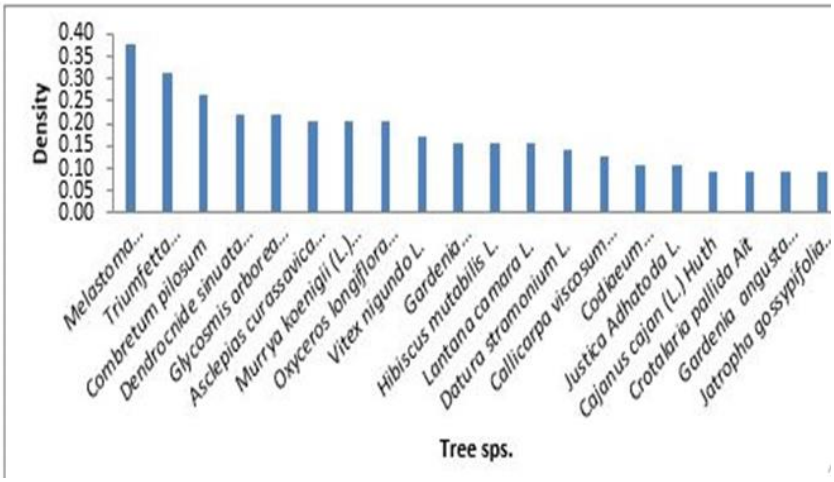


Fig. 3. Density (/m2) of Top 20 Shrub spicies in moth inhabited of Cachar district

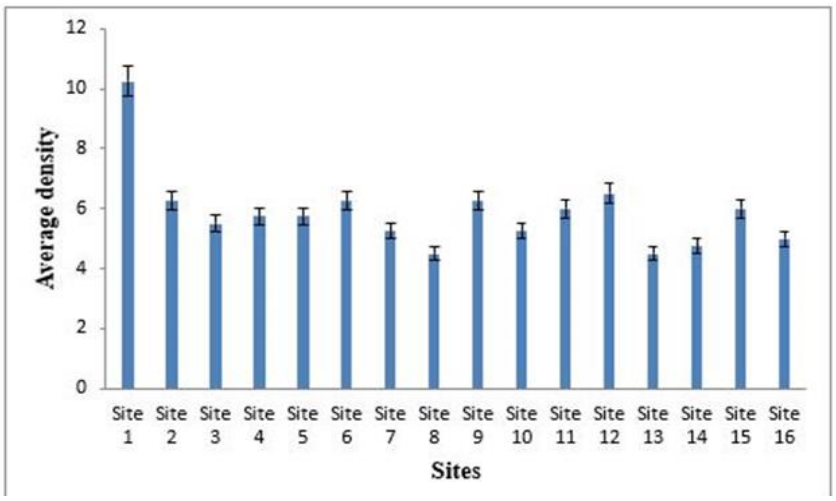


Fig. 4. Site wise average density and standard deviation of Shrubs in moth inhabited of Cachar district

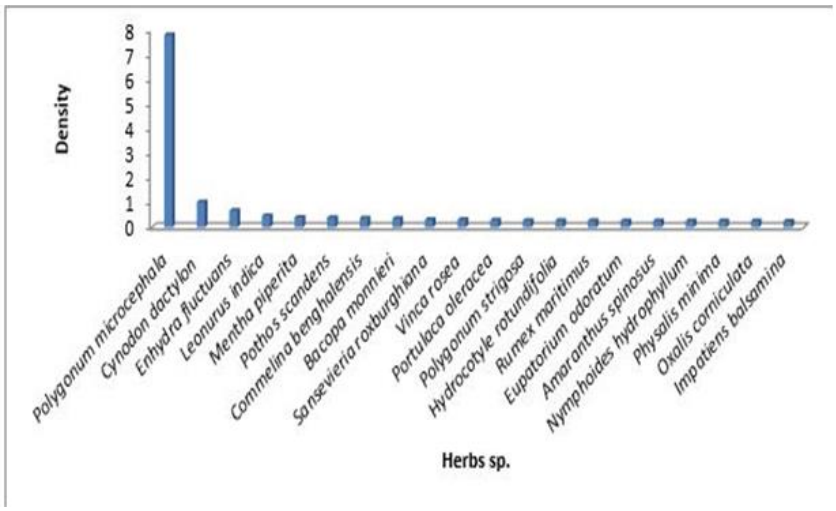


Fig. 5. Density (/m2) of Top 20 herbs in moth inhabitated of Cachar district

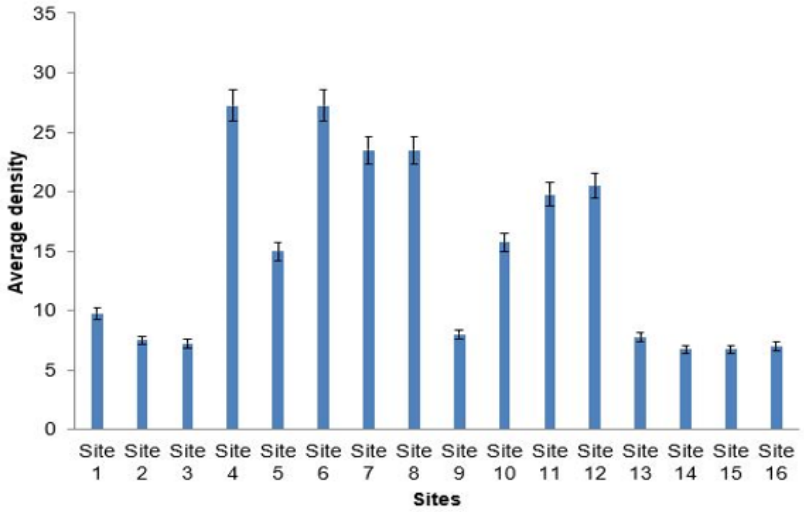


Fig. 6. Site wise average density and standard deviation of Herbs in moth inhabitated of Cachar district

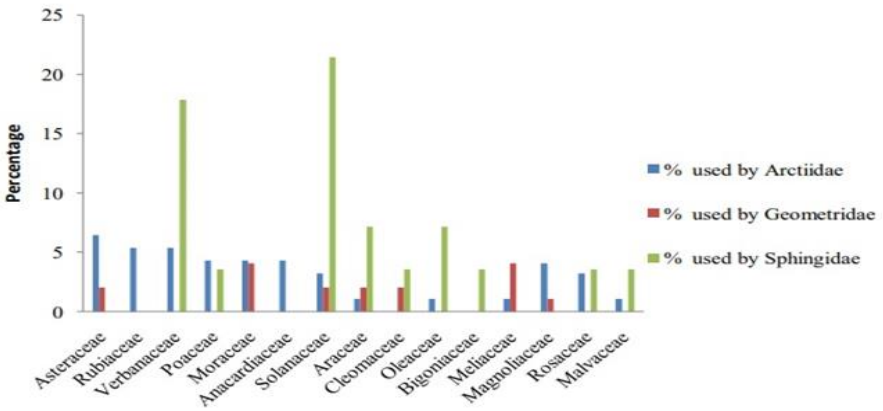


Fig. 7. Percentage of the most preferred food/host plants (top 15 families) used by Arctiidae, Geometridae and Sphingidae family in Cachar district

4. DISCUSSION

Herbivorous insects are known to exhibit a sensitive response to deforestation and subsequent forest regeneration, owing to their intimate functional relationship with the vegetation they inhabit. The abundance and quality of host plants significantly influence both the spatial and temporal variation in herbivorous insect populations (Murdoch, [5], White, [6]). Host plants serve as essential habitats for herbivorous insects, with plant structure impacting herbivore distributions; Jones et al., [7] and interacting with dietary quality [8]. Moths, belonging to the Lepidoptera order, primarily exhibit phytophagous behavior during their larval stages, feeding on plant tissues, while adult moths predominantly consume liquid, such as nectar. The abundance of moths is intricately tied to the availability of suitable food plants or host plants, given their monophagous or oligophagous feeding habits Majerus, [6]. Although moths can be found in a variety of habitats, they are most abundant and diverse in forested regions. Woody plants, shrubs, and trees serve as primary host plants for moth caterpillars, making them economically significant as primary herbivores in forest ecosystems.

Moths exhibit diverse habits and adaptations to various environmental conditions. Many herbivorous insects, including macro moths, often exhibit a strong association with a single species or genus as their host plant [23]. Due to their dependence on specific host plants, the abundance and distribution of macro moth species may mirror that of their host plants. Moths serve as an intriguing model group for studying the effects of habitat changes, given their rich species diversity, herbivorous larval stages, accessibility of adult moths for standardized sampling, and substantial taxonomic knowledge for the majority of tropical samples Holloway, [9], Kitching et al., [10]. Arctiidae, Geometridae, and Sphingidae moths in the Cachar district predominantly feed on tree species belonging to families such as Asteraceae, Meliaceae, Solanaceae, Rubiceae, Moraceae, and Verbanaceae. In both undisturbed and disturbed forests of the Barak Valley in Southern Assam, a comprehensive survey identified a total of 137 moth species. Among these, the main dominant species included *Cynometra polyandra, Palaquium polyanthus, Tetrameles nudiflora, Artocarpus chama, Dysoxylum binectariferum, Mitragyna rotundifolia, Schima wallichii, Stecospermum chelonoides, Castanopsis purpurella*, and others.

The study documented a rich diversity of plant species in the region. Notable dominant tree species in the Cachar district include *Lagerstroemia reginae* Roxb., *Michelia champaca* L., *Tectona grandis* L.f., *Bombax ceiba* L., *Dalbergia sisoo* Roxb., *Artocarpus lacucha* Buch.-Hum., *Artocarpus chama* Buch.-Ham., *Artocarpus heterophyllus* Lam., *Terminalia bellirica* Roxb., *Canarium benghalense* Roxb., *Ficus benghalensis* L., *Shorea robusta* Gaertn., *Syzygium cumini* (L.) Skeels, *Mangifera indica* L., *Gmelina arborea* Roxb., *Aporusa dioica* (Roxb.) Muell., *Vitex altissima* L., *Actinodaphne obovata* (Nees.) Bl., *Kayea floribunda* Wall., and *Terminalia arjuna* (DC) W., among others. Additionally, shrub species exhibiting higher density in the study area include *Melastoma malabathricum* L., *Triumfetta rhomboides* Roxb., *Combretum pilosum*, *Dendrocnide sinuata* (Bl.) Chew., *Glycosmis arborea* (Roxb.) Corr., *Asclepias curassavica* L., *Murrya koenigii* (L.) Spreng., *Oxyceros longiflora* (Lamk.) Yamazaki, and *Vitex negundo* L. Similarly, herb species with higher density documented in the Cachar district include *Polygonum microcephala* (D. Don.) Sasaki, *Cynodon dactylon* (L.) Pers., *Enhydra fluctuans* Lour., *Leonurus indica* (L.) R. Br. ex Vatke, *Mentha piperita* L., *Pothos scandens* L., *Commelina benghalensis* L., *Bacopa monnieri* (L.) Pennel, *Sansevieria roxburghiana* Schult.f, and *Vinca rosea* L., among others.

The tree, shrub, and herb species documented in the current study fall within the range reported for similar forests in other regions (Bhuyan et al., [24]; Upadhaya et al., 2004; Nath et al., 2005). However, the species richness values recorded in this study were lower compared to tropical wet evergreen forests, which reported 149 tree species, 74 shrub species, and 87 herb species, and 104 tree species, 62 shrub species, and 75 herb species in the Cachar district. Species richness was not evenly distributed across the study area, with lower average densities and standard deviations observed for tree, shrub, and herb species in disturbed sites (sites 12, 13, and 16) in the Cachar district. The species richness exhibited similarities with tropical forests in Luquillo Mountain, Puerto RicoWeaver and Murphy, [25], with a significant proportion of plant species represented by few individuals, consistent with findings in Barro Colorado Island, Panama Thorington et al., [26] and forests of the Western Ghats [27]. The distribution of tree size

classes can serve as indicators of changes in population structure and species composition [28]. The observed tree population structure in this study aligns with reports from forests in Costa Rica Nadakarni et al., [29], the Brazilian Amazon Campbell et al., [30], and subtropical humid regions of Meghalaya [31], indicating a dominance of young individuals.

5. CONCLUSION

In conclusion, the habitat characteristics of moths in the Cachar district, as explored through comprehensive surveys across 16 sites, reveal a diverse ecosystem supporting a rich variety of flora and fauna. The vegetation variables assessed, including species richness and diversity indices, provide valuable insights into the ecological dynamics of moth habitats. The average species richness of trees, shrubs, and herbs within moth habitats reflects the biodiversity present in the region, with certain sites exhibiting notably higher species richness. Dominant tree species such as *Lagerstroemia reginae, Michelia champaca, and Tectona grandis, among others, underscore the importance of these habitats for sustaining diverse moth populations. The density and diversity of shrub and herb species, including Melastoma malabathricum, Glycosmis arborea, Polygonum microcephala, and Cynodon dactylon*, further contribute to the richness of moth habitats. These findings highlight the intricate relationships between vegetation composition and moth biodiversity.

Overall, this study sheds light on the importance of preserving and managing diverse habitats to support healthy moth populations. Further research and conservation efforts are warranted to better understand and protect these crucial ecosystems for the benefit of both moths and broader biodiversity conservation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rao RR, Murti SK. North East India a major center for plants diversity in India. Indian Journal of Forestry. 1990; 13(3): 214-222.
2. Nath PC, Arunachalam A, Khan ML, Arunachalam K, Barbhuiya AR. Vegetation analysis and tree population structure of tropical wet evergreen forests in and around Namdhapha National Park, North-East India. Biodiversity Conversation. 2005;14:2109-2136.
3. Majerus M. Moths. *Harper Collins* (New Naturalist Series), London; 2002.
4. Hammond PC, Miller JC. Comparison of the biodiversity of Lepidoptera within three forested ecosystems. Annals of the Entomological Society of America. 1998;91:323-328.
5. Murdoch WW. Community structure, population control, and competition: A critique. American Naturalist. 1966;100:219-226.
6. White TCR. The inadequate environment: nitrogen and the abundance of animals. *Springer-Verlag*, Berlin, Germany; 1993;
7. Jones CG, Lawton JH, Shachak M. Organisms as ecosystem engineers. Oikos. 1994;69:373-386.
8. Thomas JA, Simcox DJ, Clarke RT. Successful conservation of a threatened Maculinea butterfly. *Science*. 2009;325:80-83.
9. Holloway JD. Moths as indicator organisms for categorizing rainforest and monitoring changes and regeneration processes. Tropical Rain Forest: The Leeds Symposium. 1985;235-242.
10. Kitching IJ, Cadiou JM. Hawk moths of the world. Comstock Publishing Associates, Cornell Univ. Press. Ithica, New York. 2000;227.
11. Axmacher JC, Fiedler K. Habitat type modifies geometry of elevational diversity gradients in geometrid moths (Lepidoptera Geometridae) on Mt Kilimanjaro, Tanzania. Tropical Zoology. 2008;21:243-251.
12. Sharma PD. Ecology and environment. 7th ed., New Delhi: Rastogi Publication; 2003.
13. Braun-Blanquet J. Plant Sociology: the study of plant communities. London: Hafner; 1965.
14. Hajra PK, Jain SK. Botany of Kaziranga and Manas. Surya International Publications. Dehradun, India; 1978.
15. Kanjilal UN, Das A. Flora of Assam, Vols. Calcutta, India; 1940;1-4.
16. Dutta BK, Choudhury P. Sustainable Biodiversity-in the 21st Century. (H. A. Barbhuiya, Ajit Kumar Das, B. K. Dutta and A. K. Baishya : Family Rubiaceae in Southern Assam with special reference to Threatened and Endemic Species). Assam University, Silchar, Assam, India; 2015.

17. Ganzhorn JU. Habitat description and phenology. In: Field and Laboratory Methods in Primatology. Setchell JM, Curtis DJ. (eds.), Cambridge University Press, Cambridge. 2003;40-56.
18. Doughlas,PH. Microhabitat variables influencing abundance and distribution of Primates (*Trachypithecus vetules* and Macacasinicaaurifrons) in a fragmented rainforest network in southwestern Sri Lanka. Msc. Dissertation, Oxford Brookes University; 2006.
19. Shannon CE, Wiener W. The mathematical theory of communication. University of Illinois Press, Urbana, USA; 1949.
20. Pielou EC. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology. 1966;13: 131-144.
21. Margalef R. Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine Biology (Buzzati-Traversoed), Berkeley, University of California Press, USA. 1958;323-347.
22. Simpson EH. Measurement of diversity. Nature (London). 1949;163:688.
23. Hammer Q. Spectral analysis of a Plio-Pleistocene multispecies time series using the Mantel periodogram. Palaeogeography, Palaeoclimatology, Palaeoecology. 2007;243:373-377.
24. Bhuyan P., Khan ML, Tripathi RS. The tree diversity and population structure in undisturbed and human impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas, India. Biodiversity and Conservation. 2003;12(8):1753-1773.
25. Weaver PL, Murphy, PG. Forest structure and productivity in Puerto Rico's Loquillo Mountains. *Biotropica*. 1990;22:69-82.
26. Thorington Jr RW, Tannenbaum B, Tarak A, Rudran R. Distribution of trees on Barro Colorado Island. A five hectaresaple. In: Leigh, Jr E. G., and A. S. and Winddror, D. M. (eds.), *The ecology of tropical Forest Seasonal Rhythms and long term Changes*. Smithsoman Institution Press, Washington, DC. 1982;83-94.
27. Parthasarathy N, Karthikeyam R. Plant biodiversity inventory and conservation of two tropical dry evergreen forests on Coromandal Coast, South India. Biodiversity and Conservation. 1997;6: 1063-1083.
28. Newbery DMCC, Gartlan JS. A structural analysis analysis of rain forests at Korup and Duoala-Edea, Cameroon. Proceedings of Royal Society Edinburgh. 1996;104:107-224.
29. Nadakarni NM, Matelson TJ, Haber WA. Structural characteristic and floristic composition of neotropical cloud forest, Montenerde, Costa Rica. Journal of Tropical Ecology. 1995;11:482-495.
30. Campbell DG, Stone JL, Rosas A. Jr. A comparison of the phytosociology and dynamics of three floodplain (Varzea) forest of known ages, Rio Jurua, Western Brazilian Amazon. *Botanical* Journal of Linnaean Society. 1992;108:213-237.
31. Upadhaya K, Pandey HN. Law PS, Tripathi RS. Diversity and population characteristics of woody species in subtropical humid forest exposed to cultural disturbance in Meghalaya, Northeast India. Tropical Ecology. 2004;45 (2):303-314.

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