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A survey on moth diversity (Lepidoptera: Heterocera) in and around the Bongaon region of the khumtai revenue circle, Golaghat district, Assam, India

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Abstract
A survey on moth diversity (Lepidoptera: Heterocera) in and around the Bongaon region of the Khumtai revenue circle, Golaghat district, Assam, India Abstract: Assam's diverse environments, which include grasslands, tropical forests, and wetlands, contribute to its immense biodiversity, which includes a broad spectrum of moth species. The present study examines the species richness and diversity of the moth fauna of the Bongaon region in the Khumtai Revenue Circle, Golaghat district of Assam, and gives a comprehensive list of all documented families. The survey was carried out between March 2021 and February 2022 using a light-sheet system and a light trap. During the study, 2277 individuals of 36 species belonging to 10 families and 34 genera were recorded. Based on the number of species, the family Erebidae was the most dominant at 40.6% followed by Noctuidae at 18.5%, Geometridae at 13.3%, Pyralidae at 6.11%, Zygaenidae with 4.92%, both Limacodidae and Pyrausdtidae each 4.75%, Crambidae 4.04%, Notodontidae 1.54% and Nolidae 1.45 each. The Shannon-Weiner index (Shannon H') indicated overall a higher moth diversity (3.39) in the study area with a seasonal higher diversity value (3.45) during pre-monsoon and least during retreating monsson (3.30). Again, increased values of the Simpson's Reciprocal Diversity Index imply increased biodiversity; however, the Simpson's Diversity (D) value is low in all the sites, indicating high community diversity. Based on the evenness index (J), it is found that all the study sites possess nearly even distribution (0.92-0.96) and dispersal of species that further emphasizes on their conservation importance.

Keywords: Moth, abundance, shannon-weiner index, Assam

Introduction
Over half of the estimated 1.5 million species that have been described are categorised as insects, making up a significant fraction of the biodiversity on Earth. Insects play a central role in all terrestrial ecosystems as herbivores, pollinators, nutrient cycling, and food and host organisms (Summerville & Crist, 2002, 2004) [1, 2]. Lepidoptera, one of the largest orders of the class Insecta, has 1,60,000 documented living species worldwide, divided into two widely recognised groups: 1,42,000 moths and 18,000 butterflies (Shubhalaxmi, 2018; Kawahara *et al.,* 2019) [3, 4]. The abundance, ease of sampling, and well-established taxonomy of moths and butterflies have made them popular in ecological and conservation research around the world (Fiedler & Truxa, 2012) [5]. They also serve as major herbivores, linking primary producers and consumers in ecosystems (Scoble, 1992) [6]. According to Shubhalaxmi (2018) [3], India is home to more than 12,000 different species of moths; however, this figure is far from accurate because a comprehensive list needs to be prepared. Moths play a major role in pollinating night-blooming flowers (Singh *et al.,* 2017) [7]. Moths, owing to their predominant nocturnal habits, are the least explored creatures of the insect world (Kehimkar, 2002) [8]. Because members of this faunal group are readily attracted to light traps, they are a suitable subject for ecological studies. This allows for an accurate and consistent estimation of species richness and abundance (Choi, 2008) [9]. Some studies are there on moth distribution and abundance in Barak Valley (Choudhury and Choudhury, 2015; Deb and Chakraborty, 2023) [10, 11], Central Assam (Rose, 2001) [12], Lower Assam (Choudhury and Choudhury, 2015; Ahmed *et al.,* 2024; Choudhury *et al.,* 2024a, b) [10, 13, 14, 15] and North Assam area (Parveen *et al.,* 2024) [16]. Studies also covered the Dhemaji district (Bora, 2001) [17] and Tinsukia district of Assam (Arandhara and Tariang, 2018) [18] in Upper Assam, and no survey was conducted till date in Baksa, Bongaigaon, Chirang, Dhubri, Goalpara, Nalbari, Kamrup and South Salmara-Mankachar area.

The Golaghat District, which includes Nambor Wildlife Sanctuary, Deopahar Hills, and Kaziranga National Park, is situated in the centre of Assam. Large agricultural plains, tea plantations, and tropical wet evergreen forests in the Golaghat district are home to a vast array of moths and butterflies. Even though the region has a high species richness, no comprehensive documentation of moth diversity encompassing the entire area has been attempted up until now. This study would be the first to document the species diversity and faunal composition of moths in Golaghat District, Assam, to the best of our knowledge. Considering the significance of moths, an effort has been undertaken to record the variety of moths in the Bongaon region of the Khumtai Revenue Circle, Golaghat district, Assam.

Materials and Methods
Study area
The Golaghat district, located in Central Assam, covers an area of 35022 km2 and is 100 m above sea level. It stretches between 25^0 50' and 26^0 47' N latitudes and 93^0 16' and 94^0 10' E longitudes. The region has a tropical environment with hot, humid weather, with an average annual rainfall of 1300 mm and a peak temperature of 38.0 °C in June and a minimum of 8.0 °C in December (Golaghat District-Assam

state portal) [19]. The district is surrounded by the Brahmaputra River to the north, Nagaland to the south, Karbi Anglong and Nagaon districts to the west, and Jorhat to the east. Bongaon is a rural settlement covering an area of 944.78 acres that falls under the Khumtai Revenue Circle. Bongaon is situated 2 km away from sub-district headquarters Khumtai and 30 km away from district headquarters Golaghat (Fig. 1).

Methodology

The survey was carried out between March 2021 and February 2022. Using a light-sheet system and a light trap, moths were caught between 18:00 a.m. and 2:00 p.m. A Mercury vapour lamp was used to operate the light sheet. During the field surveys conducted during the day, a few specimens were also gathered. The moths on the cloth screen were documented and photographed fortnightly. Following Hampson (1892, 1894, 1895, 1896) [20–23], Bell & Scott (1937) [24], Kirti & Singh (2015) [25], and Shubhalaxmi (2018) [3], the specimens were identified and classified. Diversity indices like Shannon (H/), evenness (J), Simpsons Diversity (D), and Simpsons Diversity (1/D) were calculated using Biodiversity Pro software version 2.0. The location map was prepared with the help of QGIS version 3.34.3-Prizren.

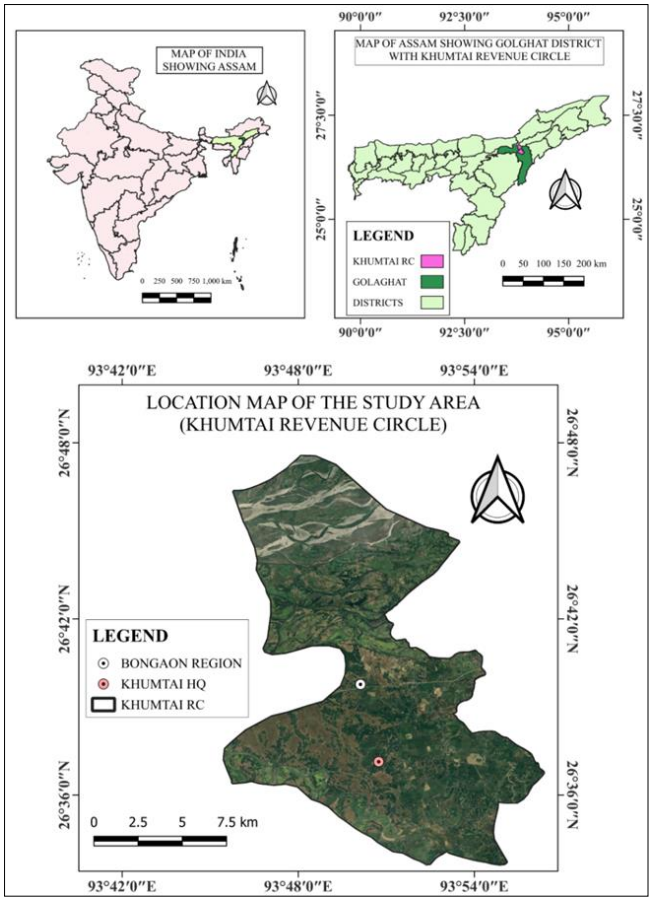

Fig 1: Map Khumtai Revenue Circle of Golaghat district of Assam, India where the present study was conducted

Results

Species composition

In the present study, 2277 individuals of 36 species belonging to 10 families and 34 genera were recorded (Table 1). Out of 36 species, family Erebidae is represented by the highest number of species (15), followed by Noctuidae (6 species), Geometridae (5 species), Crambidae (3 species), Pyralidae (2 species), Limacodidae, Nolidae, Notodontidae, Pyrausdtidae, and Zygaenidae (1 species each) (Fig. 2).

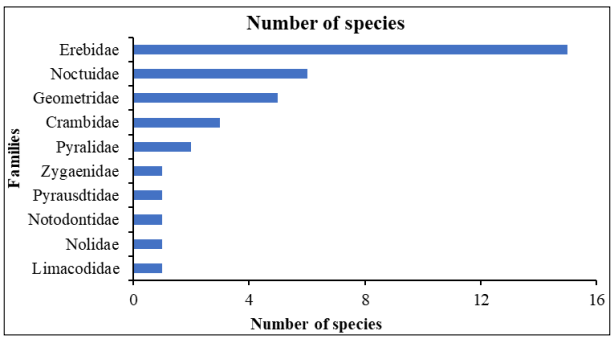

Fig 2: Number of species representing different families during study period

Interestingly, family Erebidae had the highest level of abundance (40.64%), followed by Noctuidae 18.50%, Geometridae 13.31%, Pyralidae at 6.11%, Zygaenidae with 4.92%, both Limacodidae and Pyrausdtidae each 4.75%, Crambidae 4.04%, Notodontidae 1.54% and Nolidae 1.45 each (Fig. 3). A similar trend was also found in the case of different seasons (Fig. 4). This clearly indicates that the Erebidae family consisted of a greater level of abundance (as compared to other families) irrespective of seasons. The study further illustrated a significant family-wise variation in species abundance ($t = 2.634$, $p \leq 0.05$) in the present study area. It also exhibited a statistical variation among family-wise abundance of species in pre-monsoon ($t = 2.584$, $p \leq 0.05$), monsoon ($t = 2.632$, $p \leq 0.05$), retreating monsoon ($t = 2.658$, $p \leq 0.05$), and winter ($t = 2.664$, $p \leq 0.05$) seasons. Annually, there is a statistical variation among species in their abundance as determined by the t-test ($t = 9.628$, $p \leq 0.05$). There is also a significant difference among species abundance in pre-monsoon ($t = 11.299$, $p \leq 0.05$), monsoon ($t = 9.602$, $p \leq 0.05$), retreating-monsoon ($t = 7.929$, $p \leq 0.05$), and winter ($t = 8.937$, $p \leq 0.05$) seasons. Additionally, there was a variation among different seasons ($F = 175.509$, $p \leq 0.05$) in species abundance illustrated in the present study.

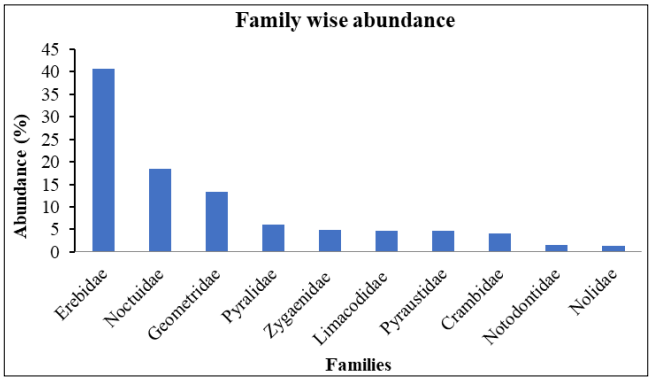

Fig 3: Family-wise abundance of moth species during the study period

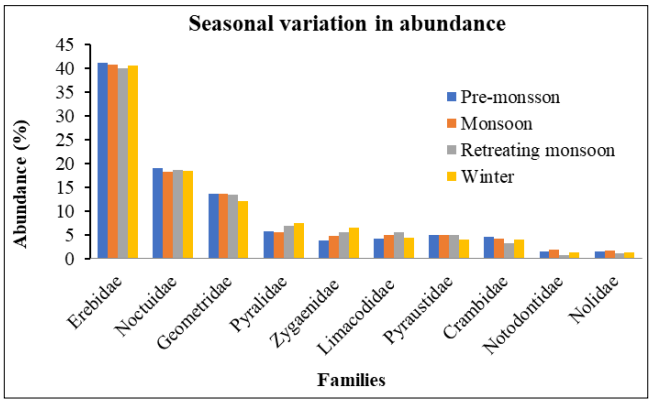

Fig 4: Seasonal variation of moth abundance with respect to different families

Table 1: List of moths found in Bongaon, Khumtai RC, Golaghat, Assam with taxonomic composition

Sl No	Family	Species	Common Name
1	Crambidae	*Chilo plejadellus* Zincken, 1821	Rice stalk borer
2	Crambidae	*Samea baccatalis* (Hulst, 1886)	--
3	Crambidae	*Diaphania Esmeralda* (Hampson,1899)	--
4	Erebidae	*Creatonotos transiens* (Walker,1855)	Clouded tiger moth
5	Erebidae	*Creatonotos gangis* (Linnaeus, 1763)	Baphomet moth
6	Erebidae	*Orvasca subnotata* Walker, 1865	Nygmiine tussock moth
7	Erebidae	*Orgyia leucostigma* (Smith, 1797)	White marked tussock moth
8	Erebidae	*Olepa ricini* (Fabricius, 1775)	Hairy caterpillar moth
9	Erebidae	*Spilarctia sp.* Butler, 1875	--
10	Erebidae	*Renia adspergillus* (Bosc, 1800)	Speckled renia moth
11	Erebidae	*Miltochrista undulosa* (Walker, 1854)	--
12	Erebidae	*Euproctis lutea* (Fabricius, 1775)	Yellow tussock
13	Erebidae	*Crambidia pallida* Packard, 1864	Pale lichen moth
14	Erebidae	*Euchromia polymena* (Linnaeus, 1758)	Wasp moth
15	Erebidae	*Anticarsia gemmatalis* Hubner, 1818	Velvetbean caterpillar moth
16	Erebidae	*Hypena proboscidalis* (Linnaeus, 1758)	The Snout
17	Erebidae	*Lycomorpha pholus* (Drury, 1773)	Black and yellow lichen moth
18	Erebidae	*Bertula abjudicalis* (Walker, 1859)	--
19	Geometridae	*Gymnoscelis rufifasciata* (Haworth, 1809)	Double striped pug
20	Geometridae	*Orthonama obstipata* (Fabricius, 1794)	The gem

21	Geometridae	*Argyrocosma inductaria* (Guenee, 1858)	--
22	Geometridae	*Eupithecia oxycedrata* (Rambur, 1833)	--
23	Geometridae	*Scopula limboundata* (Haworth, 1809)	Large lace border
24	Limacodidae	*Cheromettia apicata* (Moore, 1879)	
25	Noctuidae	*Spodoptera mauritia* (Boisduval, 1833)	Lawn army worm
26	Noctuidae	*Spodoptera litura* (Fabricius, 1775)	Tobacco cutworm
27	Noctuidae	*Mythimna unipuncta* (Haworth, 1809)	Rice army moth
28	Noctuidae	*Athetis tarda* (Guenee, 1852)	Slow poke
29	Noctuidae	*Leucania pseudargyria* Guenee, 1852	False wainscot
30	Noctuidae	*Mamestra brassicae* (Linnaeus, 1758)	Cabbage moth
31	Nolidae	*Earias cupreoviridis* (Walker, 1862)	Cotton green moth
32	Notodontidae	*Lochmaeus manteo* Doubleday, 1841	Oakleaf caterpillar moth
33	Pyralidae	*Achroia grisella* (Fabricius, 1794)	Lesser wax moth
34	Pyralidae	*Eurhodope cirrigerella* (Zincken, 1818)	Snout moth
35	Pyrausdtidae	*Scirpophaga incertulas* (Walker, 1863)	Rice stem borer
36	Zygaenidae	*Eterusia aedea* (Linnaeus, 1763)	Red slug caterpillar moth

Species diversity and eveneness

The Shannon-Weiner index (Shannon H') indicated overall a higher moth diversity (3.39) in the study area with a seasonal higher diversity value (3.45) during pre-monsoon and least during retreating monsson (3.30). The same trend was also found in the case of Eveness (Shannon J'), where a higher value was found for pre-mosoon and a lower for retreating monsoon. The Simpson diversity (D) also showed comparatively higher diversity (0.033) during pre-monsoon and lower diversity (0.041) during retreating monsson. The reciprocal Simpson diversity (1/D) also showed a higher value (30.067) for pre-monsson and a lower value (24.560) for retreating monsson (Fig. 5). This further indicates that moth diversity is comparatively higher during pre-monsoon, irrespective of the seasons in the study area. The Shannon H ($t=109.662$, $p\leq0.05$), Shannon J' ($t=109.546$, $p\leq0.05$), Simson D ($t=22.658$, $p\leq0.05$), and Simpson 1/D ($t=23.783$, $p\leq0.05$) indices varied statistically with different seasons. Further, a significant variation among different indices ($t=76.162$, $p\leq0.05$) with respect to seasons was also noted in this present study.

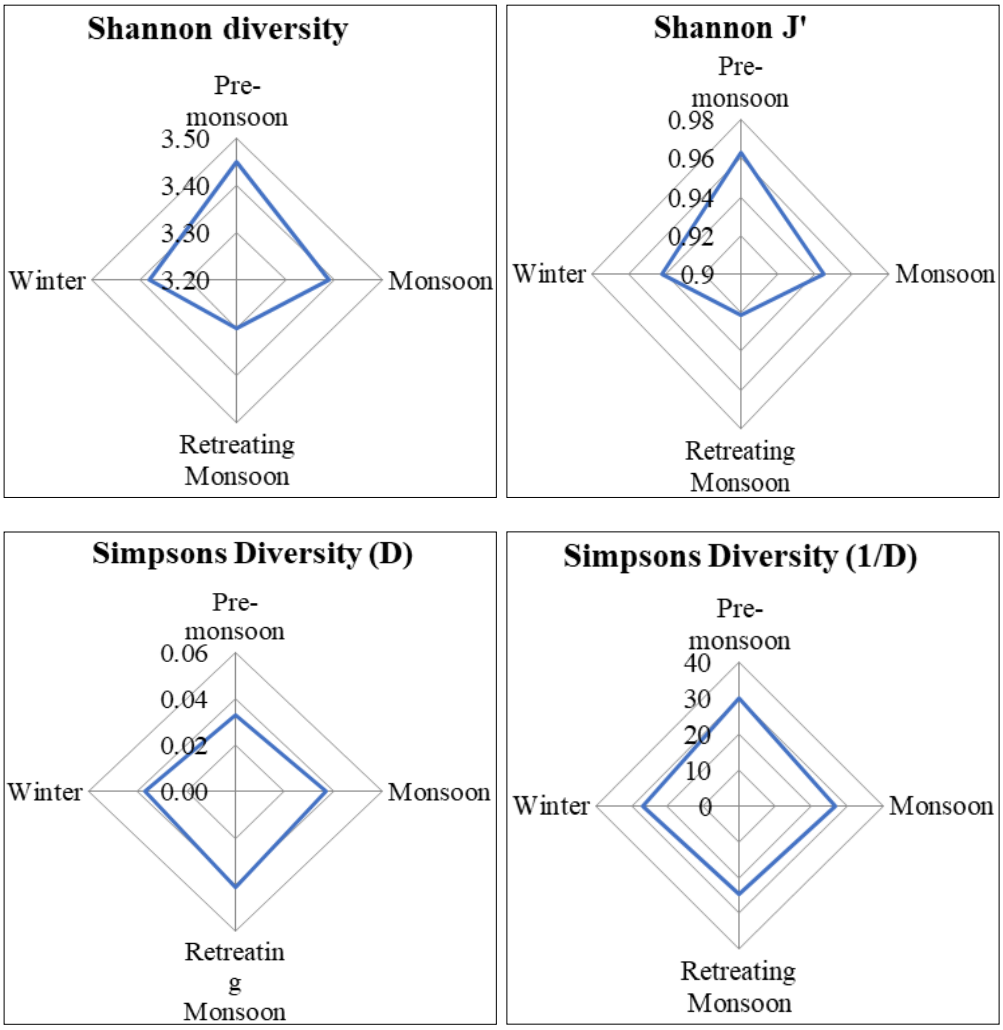

Fig 5: Biodiversity index values in different seasons

Discussion

Moths and butterflies are most important to the ecosystem because of their diversity, abundance, or occurrence, and they serve as bioindicators of the overall condition of the terrestrial ecosystem. The varied vegetation types in the study area might provide abundant food, cover and other necessary resources that make more niches for the moth community (Fox, 1983; Young, 1997; Wright *et al*., 2002; Ferro & Romanowski, 2012) [26, 27, 28, 29]. As a result, there is abundant moth species in the study area. From the current study, it was seen that the family Erebidae is dominant among all families which is similar to the findings of Zahiri *et al*. (2012) [30], Yattoo & Gadhikar (2016) [31] and Ahire & Khobragade (2021) [32]. However, the recent study conducted by Choudhury *et al.* (2024a) [14] found that the family Geometridae dominated with 48% of recorded species followed by Erebidae (26%) and Sphingidae (2%) in Barpeta district of Assam.

The overall Shannon-Weiner Index value (3.39) for moth indicates high diversity in the study area (Fernando *et al.*, 1998) [33]. This further signifies a rich habitat concordance in the study area. The presence of a mixed habitat might be the reason for the higher diversity level during the study period. There was a higher Shannon H/index value during the pre-monsoon season, which further indicates favourable climatic conditions in the study area. A higher Simpson diversity value during pre-monsoon further supports the fact of higher diversity during that season. A higher Simpson's reciprocal diversity index implies increased biodiversity; however, a lower Simpson's Diversity (D) value during the pre-monsoon further supports higher moth diversity. Further, the evenness index J showed nearly even distribution (0.905 to 0.98) and dispersal of moth species irrespective of seasons (Yattoo & Gadhikar, 2016) [31]. The vast diversity of moth communities in the study area is supported and ensured by a variety of factors, including the area's distinctive climate, mixed habitats, a good range of flowering and nectar plants, a sufficient supply of water etc. However, there are several disturbances to the moth population in the studied area. There have been reports of anthropogenic disturbances such as gathering medicinal plants, gathering fuel wood and feed, trampling, scraping, and grazing, which are familiar to the observations of Verma *et al.* (2015) [34]. Certain moths and other invertebrate species that rely on these essential structural habitat features for their existence may be impacted by these actions.

Conclusion

This study just provides an initial assessment of both the number and variety of moth species in the Bongaon region, Khumtai Revenue Circle, Golaghat, Assam. The results are remarkable and encouraging because there is a lot of moth fauna in this study region. The health, long-term viability, and functioning of the ecosystem of the Bongaon region could potentially be monitored with the use of this analysis. Thus, the current study will serve as a foundational study for upcoming investigations. However, more research on the moth variety across a wider range of vegetation will be needed to fully understand the ecology of the local moths.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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