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Diversity and distribution of *Lepidopteran* moths in tropical ecosystems insights from Cuddalore district, Tamil Nadu, India

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Abstract
Lepidopteran moths are ecologically significant insects that contribute to pollination, trophic interactions and nutrient cycling and serve as reliable bioindicators of environmental change. This study examines the diversity, distribution and community structure of moths in and around Cuddalore District, Tamil Nadu, India, representing a tropical coastal ecosystem. Systematic sampling across multiple habitats revealed considerable species diversity, with dominant representation from families such as *Noctuidae* and Erebidae. Diversity indices indicated moderate to high species diversity, suggesting relatively stable ecological conditions, while temporal variations in abundance reflected the influence of climatic factors and habitat heterogeneity. The observed patterns are consistent with previous studies emphasizing the sensitivity of moth assemblages to vegetation structure, environmental gradients and nanthropogenic disturbances. The findings highlight the ecological importance of moth communities and their potential as bioindicators for ecosystem monitoring and conservation planning. This study provides baseline data for tropical moth diversity and underscores the need for long-term ecological assessments under changing environmental conditions.

Keywords: *Lepidoptera*, moth diversity, distribution, tropical ecosystem, bioindicators

Introduction

Pulses provide an excellent protein supplement to human vegetarian diets and play an important role in correcting widespread malnutrition in the country. Pulses provide nutritious food while maintaining soil fertility and productivity and boosting India's agricultural economy (Sujata *et al*., 2017). India cultivates more than a dozen types of pulses and is considered the world's largest producer of pulses (Singh *et al*., 2020). Lepidoptera, comprising moths and butterflies, represents one of the most diverse insect orders, with over 127,000 moth species recorded globally and more than 12,000 species documented from India (Alfred *et al*., 1998; Chandra and Nema, 2007) [1, 2]. These organisms play a fundamental role in ecosystem functioning as primary herbivores, linking producers to higher trophic levels and contributing significantly to nutrient cycling and energy transfer (Scoble, 1992) [16]. Due to their sensitivity to environmental changes, Lepidopteran moths are widely recognized as effective bioindicators for assessing habitat quality, ecological stability and biodiversity patterns (Kitching *et al*., 2000; Summerville *et al*., 2001) [10, 19].

Biodiversity operates across multiple hierarchical levels, from genes to ecosystems and is essential for maintaining ecological integrity and resilience (Solbrig, 1991; Heywood, 1995) [5, 18]. Ecosystems are dynamic systems structured by complex interactions among species and their physical environment. The concept of ecological resilience describes the ability of ecosystems to withstand disturbances and recover while maintaining functional stability (Connell, 1978) [3]. Tropical ecosystems, which harbor a substantial proportion of global biodiversity, are particularly important for ecological studies due to their high species richness and complex ecological interactions (Kareiva and Levin, 2003) [8].

Lepidopteran communities are strongly influenced by environmental variables such as vegetation structure, climatic conditions and habitat heterogeneity. Several studies have demonstrated that moth assemblages respond sensitively to environmental gradients, including altitude, temperature and habitat disturbance, making them valuable tools for monitoring ecological changes (Holloway, 1997). Additionally, moth diversity patterns are closely linked to plant diversity and habitat complexity, which determine species richness and community composition (Sawchik *et al*., 2003) [15].

Previous research on Lepidopteran diversity has been extensively conducted in regions such as the Western Ghats, Himalayan ecosystems and northeastern India (Mathew and Rahamathulla, 1993; Kirti *et al*., 2005; Chandra, 2007) [2, 9, 13]. These studies have highlighted the ecological importance of moths and their potential as indicators of environmental quality. Therefore, the present study aims to assess the diversity, distribution and community structure of Lepidopteran moths in and around Cuddalore District, Tamil Nadu, India. By generating baseline data on species

composition and ecological patterns, this study contributes to a better understanding of tropical insect biodiversity and provides a scientific basis for long-term ecological monitoring and conservation planning in coastal ecosystems.

Materials and Methods

The study was conducted in and around Cuddalore District, Tamil Nadu, India, with specific sampling locations including Veppur and Kotteri Lake in Vriddhachalam Taluk. The study area is geographically situated at approximately 11.50° N latitude and 79.33° E longitude, with an elevation of 42.67 m above mean sea level. The region lies within 50 km of the eastern coastal line and experiences a tropical climatic regime. The temperature in the study area ranges from 19°C to 42°C, while the average annual rainfall is approximately 1020.26 mm, contributed by both the Southwest monsoon (403.22 mm) and Northeast monsoon (580.50 mm). These climatic conditions support diverse vegetation and habitat heterogeneity, providing suitable environments for *Lepidoptera*n diversity.

Macro*Lepidoptera*n moths were collected during the study period from January to June 2025 using standard insect collection nets (250 mm × 250 mm) with a nylon mesh size of 1.0 mm. Sampling was carried out across different habitat types to ensure representative coverage of moth diversity. Larval stages, where encountered, were also collected to supplement species identification and ecological observations.

Collected specimens were immobilized using carbon tetrachloride (CCl_4) and subsequently processed following standard entomological procedures. Specimens were carefully pinned, spread on mounting boards and air-dried to preserve morphological characteristics. All specimens were labeled and stored in insect collection boxes for taxonomic analysis. Identification was carried out using standard taxonomic keys and reference literature (Holloway, 1993) [6]. Naphthalene balls were used as a fumigant to protect preserved specimens from pest infestation. The total number of individuals recorded for each species was used to assess diversity patterns. Ecological indices were calculated to evaluate species diversity and community structure, including: Shannon–Wiener diversity index (H′); Species richness indices (Margalef, 1969 and Menhinick,1964) [12, 14]; Evenness index. All statistical analyses were performed using the PAST software package (version 2.02).

Results

A total of 1,390 individuals of *Lepidoptera*n moths were recorded during the study period (January–June 2025), comprising 15 species belonging to 10 genera under three families, namely Erebidae, Sphingidae and *Noctuidae*. Among these, the family Erebidae was the most dominant, represented by seven species under four genera, followed by Sphingidae with six species under five genera, while *Noctuidae* was least represented with two species under a single genus. The overall taxonomic composition revealed a clear dominance pattern of Erebidae > Sphingidae > *Noctuidae*. All recorded species were observed consistently throughout the study period, indicating stable species persistence and favorable habitat conditions (Table-1, Table-2, Fig-1).

Table 1: Checklist of moths from Cuddalore District

Sl. No.	Family and Species Name	January	February	March	April	May	June
	Erebidae						
1.	*Bastilla crameri*	+	+	+	+	+	+
2.	*Eudocima phalonia*	+	+	+	+	+	+
3.	*Eudocima materna*	+	+	+	+	+	+
4.	*Ischyja inferna*	+	+	+	+	+	+
5.	*Ischyja manlia*	+	+	+	+	+	+
6.	*Spirama helicina*	+	+	+	+	+	+
7.	*Spirama retorta*	+	+	+	+	+	+
	Sphingidae						
8.	*Hippotion rosetta*	+	+	+	+	+	+
9.	*Hippotion echeclus*	+	+	+	+	+	+
10.	*Theretra nessus*	+	+	+	+	+	+
11.	*Agrius convolvuli*	+	+	+	+	+	+
12.	*Acherontia styx*	+	+	+	+	+	+
13.	*Achrontia lachesis*	+	+	+	+	+	+
	Noctuidae						
14.	*Asota caricae*	+	+	+	+	+	+
15.	*Asota product*	+	+	+	+	+	+

Table 2: Composition of Moths genera and species in respective families

Sl. No.	Family	Genus	Species
1.	Erebidae	4	7
2.	Sphingidae	5	6
3.	*Noctuidae*	1	2
	03	10	15

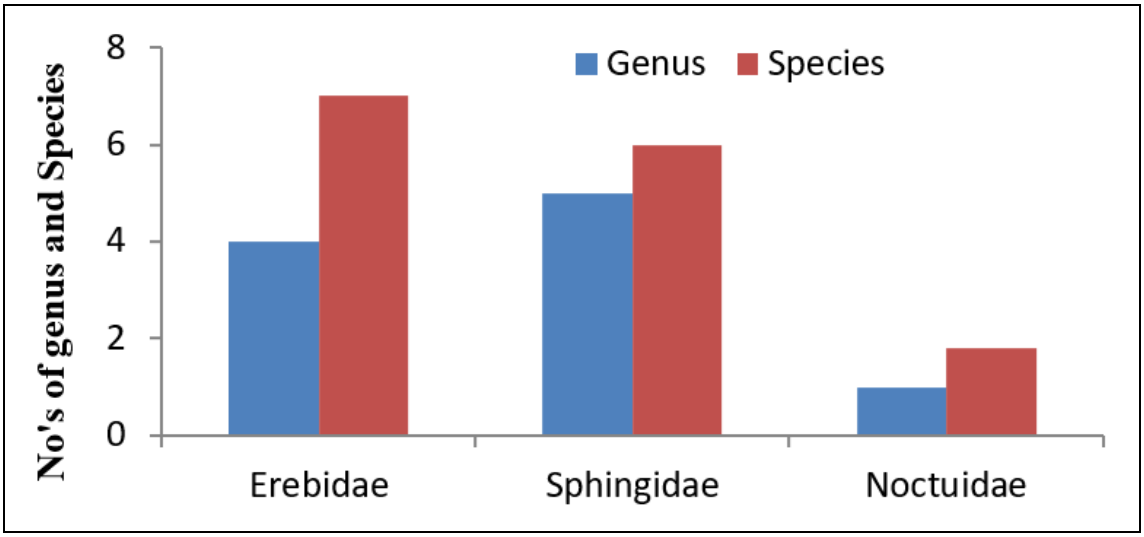

Fig 1: Composition of moth's genera and species in respective families

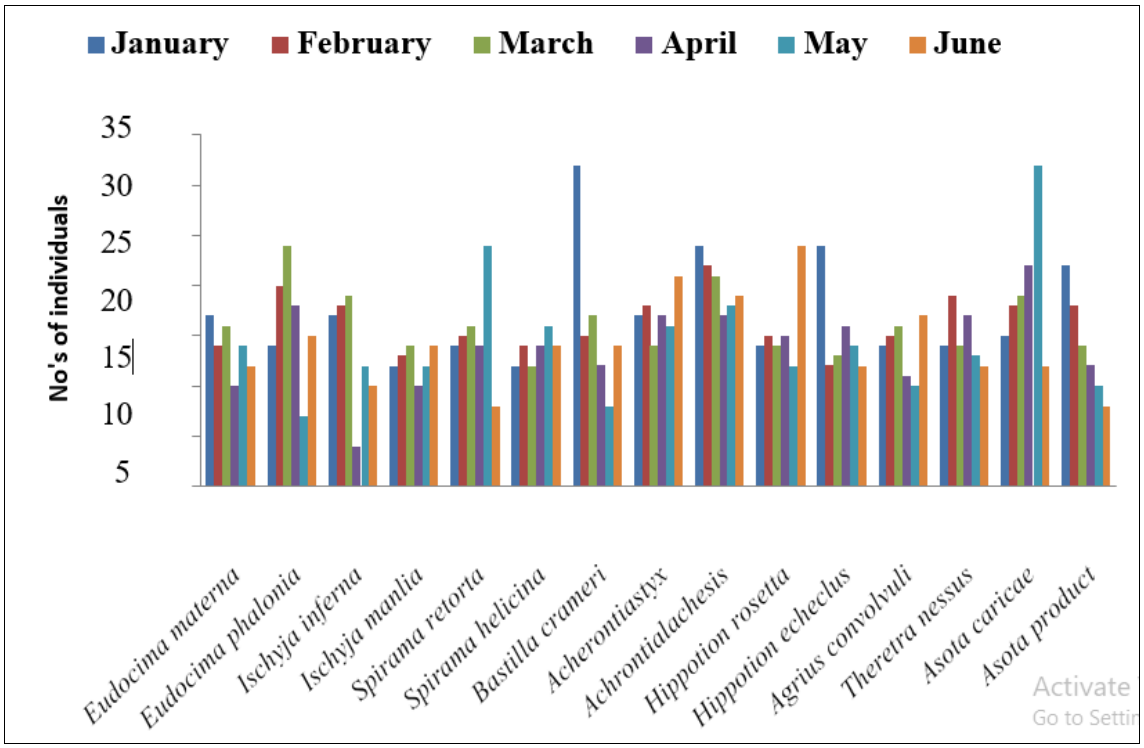

Fig 2: Monthly wise Moths abundance and distribution

The monthly population density of moths varied from 209 to 246 individuals, with the highest density recorded during February 2025, corresponding to the post-monsoon period and the lowest during April 2025, coinciding with summer conditions. This pattern suggests that environmental factors such as temperature and resource availability play a significant role in influencing moth abundance. Species-wise abundance ranged from 4 to 32 individuals, indicating moderate variability among species. The dominant species exhibited temporal variation, with *Bastilla crameri* showing higher abundance during January and *Asota caricae* during May, while *Ischyja inferna* was the least abundant species, particularly during April. The overall species abundance ranged from 75 to 121 individuals, with *Acherontia Lachesis* identified as the most abundant species and *Ischyja manlia* as the least abundant across the study period (Fig.2). The percentage composition of moths varied between 15.03% and 18.85% across months, with the highest contribution observed in January and the lowest in June. At the species level, percentage composition ranged from 5.40% to 8.71%, with *Acherontia lachesis* contributing the highest proportion and *Ischyja manlia* the lowest. Diversity indices indicated a relatively stable community structure, with Shannon–Wiener diversity index values ranging from 2.628 to 2.694 bits per individual, species richness from 0.9213 to 0.9315 and evenness from 0.9704 to 0.9949. The highest diversity was recorded during February, whereas the lowest was observed in May, reflecting seasonal influences on community structure (Fig. 3).

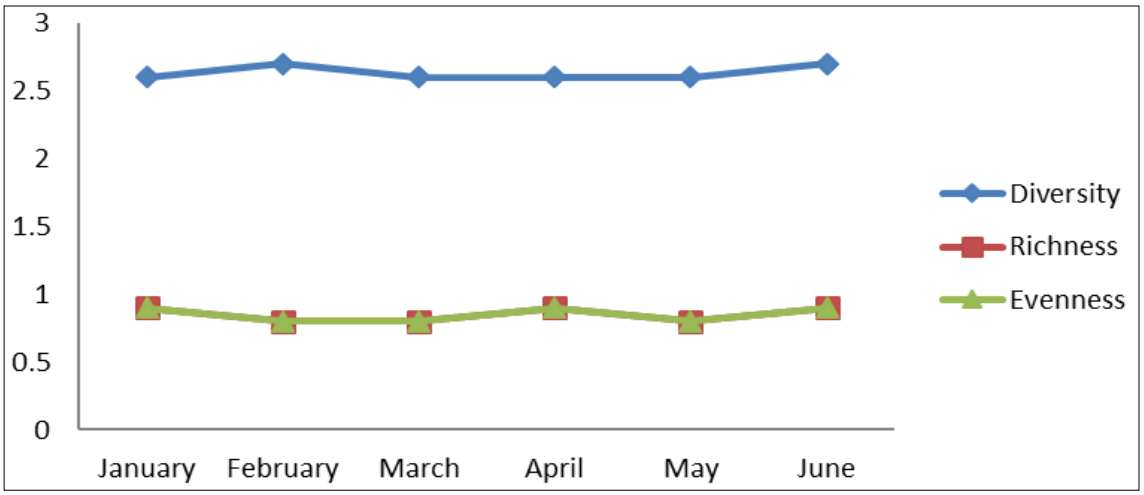

Fig 3: Diversity indices moths from the study period

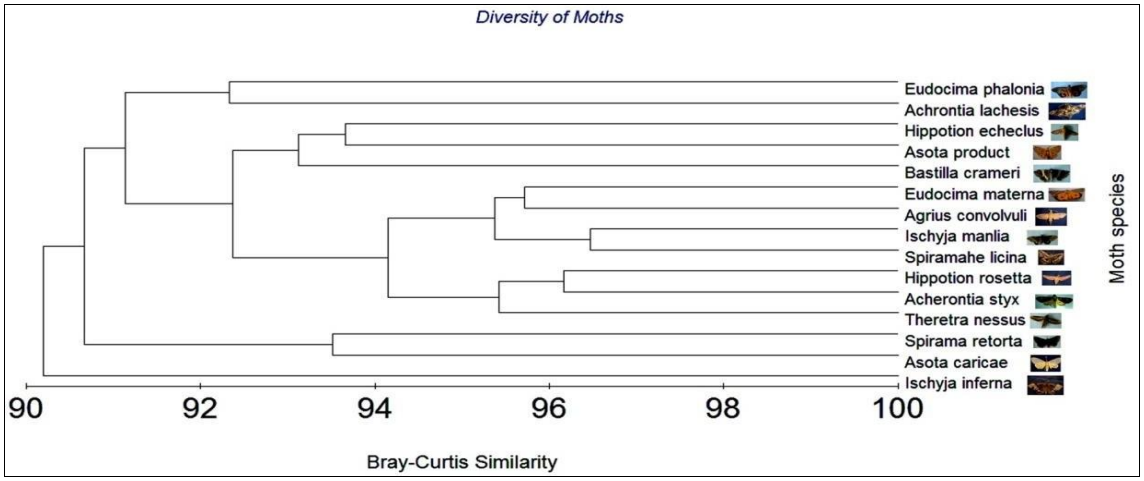

Fig 4: Cluster analysis of *Lepidopteran* moths found in different Species

Cluster analysis based on Bray–Curtis similarity revealed a high degree of similarity (>90%) among months, indicating strong temporal consistency in species composition. The clustering patterns demonstrates that moth assemblages remained structurally stable despite seasonal fluctuations, suggesting ecological resilience and relatively undisturbed habitat conditions in the study area (Fig. 4).

Table 3: *Chic list* of *Lepidopteran* Moths Collected from in and around Cuddalore District

Sl. No.	Species Figure	Family	Genus	Species Name
1.		Erebidae	*Bastilla*	*Bastilla crameri*
2		Erebidae	*Eudocima*	*Eudocima phalonia*
3		Erebidae	*Eudocima*	*Eudocima materna*

4		Erebidae	*Ischyja*	*Ischyja inferna*
5		Erebidae	*Ischyja*	*Ischyja manlia*
6		Erebidae	*Spirama*	*Spirama helicina*
7		Erebidae	*Spirama*	*Spirama retorta*
8		Sphingidae	*Hippotion*	*Hippotion rosetta*
9		Sphingidae	*Hippotion*	*Hippotion echeclus*
10		Sphingidae	*Theretra*	*Theretra nessus*
11		Sphingidae	*Agrius*	*Agrius convolvuli*
12		Sphingidae	*Acherontia*	*Acherontia styx*

13		Sphingidae	*Achrontia*	*Achrontia lachesis*
14		*Noctuidae*	*Asota*	*Asota caricae*
15		*Noctuidae*	*Asota*	*Asota product*

Discussion

The present study provides valuable insights into the diversity, distribution and community structure of *Lepidoptera*n moths in a tropical coastal ecosystem of southern India. A total of 1,390 individuals representing 15 species, 10 genera and3 families were recorded, indicating moderate species richness compared to other regions of India. Previous studies have reported higher diversity, such as 105 species from northeastern India (Kirti *et al*., 2005) [9] and 628 species from Maharashtra (Gadhikar *et al*., 2015) [4], highlighting the influence of habitat complexity and sampling intensity on moth diversity. The comparatively lower diversity observed in the present study may be attributed to limited sampling duration, habitat specificity and regional environmental conditions.

The dominance of the family Erebidae over Sphingidae and *Noctuidae* contrasts with several earlier studies where *Noctuidae* was reported as the most dominant family (Zahoor *et al*., 2003) [22]. This variation suggests that local habitat characteristics and availability of host plants play a critical role in shaping moth community composition, as also supported by Lindenmayer and Hobbs (2004) who emphasized the importance of landscape heterogeneity in enhancing species richness and diversity. The higher representation of Erebidae in the present study may therefore reflect favorable vegetation structure and resource availability in the study area.

Seasonal variation in moth abundance revealed a clear pattern, with maximum population density observed during the post-monsoon period (February) and minimum during summer (April). This pattern is consistent with previous findings that climatic factors such as temperature and rainfall significantly influence moth activity, development and distribution (Yela and Holyoak, 1997; Holloway, 1997) [21]. Increased abundance during post-monsoon months may be associated with enhanced vegetation growth and availability of fresh host plants, while reduced abundance during summer may result from high temperature stress and reduced moisture availability.

The diversity indices obtained in this study indicate a relatively stable community structure, with high evenness values suggesting uniform distribution of individuals among species. The inverse relationship observed between diversity and dominance indices further supports the presence of a balanced community structure, where no single species overwhelmingly dominates the assemblage. Such patterns are characteristic of ecologically stable systems and are influenced by complex interactions among species and environmental variables.

*Lepidoptera*n moths, being primary herbivores, play a significant role in ecosystem functioning and are highly sensitive to environmental disturbances, making them reliable indicators of ecosystem health (Kosenberg *et al*., 1986; Sivasnkaran *et al*., 2011). The observed diversity and distribution patterns in the present study reflect the ecological status of the study area and underline the importance of conserving natural habitats to maintain biodiversity. Anthropogenic pressures, including habitat modification and land-use changes, pose significant threats to tropical ecosystems globally (Sundufu and Dumbuya, 2008) [20] and similar impacts may influence moth diversity in the study region.

The findings of this study also support the concept that species diversity is closely linked to ecological resilience, as proposed by Connell (1978) [3] and further emphasized in ecological theory. Higher species diversity enhances ecosystem stability by strengthening ecological interactions and functional redundancy. Conversely, loss of species may lead to disruption of ecological processes and reduced resilience.

Overall, the present study contributes baseline data on *Lepidoptera*n diversity in the eastern coastal plains of Tamil Nadu, a relatively underexplored region. The results highlight the importance of long-term ecological monitoring and detailed biodiversity assessments to better understand species dynamics and to develop effective conservation strategies. Further studies incorporating seasonal, spatial and environmental variables are essential to fully elucidate the patterns and drivers of moth diversity in tropical ecosystems.

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