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A taxonomic survey of moths (*Lepidoptera: Heterocera*) across selected sites in Srivaikundam, Southern India

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Abstract
Moths (*Lepidoptera: Heterocera*) are ecologically significant nocturnal insects, functioning as herbivores, pollinators, prey, and bioindicators of environmental change. Despite their importance, moth diversity remains understudied in many tropical agroecosystems of southern India. This study presents a taxonomic survey of moths across three ecologically distinct sites—Perur, Patemanagaram, and Aniyaparanallur—in the Srivaikundam region of Tamil Nadu over a one-year period (January–December 2024). A total of 186 species belonging to 112 genera and 14 families were recorded. Species richness and diversity varied among sites, with Perur exhibiting the highest richness (142 species; Shannon–Wiener H′ = 4.12) and evenness (J′ = 0.88), followed by Patemanagaram (118 species; H′ = 3.78) and Aniyaparanallur (96 species; H′ = 3.41). The moth community was dominated by Noctuidae (24.7%), Erebidae (21.0%), and Geometridae (16.7%), reflecting their broad ecological adaptability. Seasonal analyses indicated peak species richness during the post-monsoon period, correlating with increased vegetation growth and resource availability. Vegetation complexity positively influenced species richness ($r = 0.82$, $p < 0.01$), whereas anthropogenic disturbance ($r = -0.69$, $p < 0.05$) and artificial light ($r = -0.76$, $p < 0.01$) had negative impacts. The study underscores the utility of moths as bioindicators for monitoring habitat quality and provides baseline taxonomic data for conservation planning in tropical agroecosystems. These findings highlight the need for habitat management strategies that preserve structural heterogeneity to support both generalist and specialist moth species in the Srivaikundam region.

Keywords: Moths (*Lepidoptera: Heterocera*), perur, patemanagaram, aniyaparanallur, agroecosystems

Introduction
Moths (Order: *Lepidoptera*, informal grouping "Heterocera") represent one of the most species-rich insect groups in terrestrial ecosystems and perform multiple functional roles as herbivores, nocturnal pollinators, prey, and bioindicators of environmental change (Regier *et al.*, 2009 [17]; MacGregor *et al.*, 2015; Wagner, 2020) [11, 23]. Adult moths frequently visit flowers at night, transferring pollen and supporting reproductive success in many plant taxa, emphasizing their ecological importance in both natural and modified landscapes (MacGregor *et al.*, 2015; Piccini *et al.*, 2023) [11, 15]. Larval moths also act as primary herbivores, influencing plant community dynamics and serving as critical food sources for bats, birds, and other predators, contributing to ecosystem stability (Seibold *et al.*, 2019) [20].

Due to their sensitivity to environmental gradients, moths have been widely recognized as bioindicators for habitat quality and anthropogenic disturbance, including fragmentation, climate change, and land-use modification (Dar & Jamal, 2021 [5]; Kumar *et al.*, 2015; Sánchez-Bayo & Wyckhuys, 2019) [18]. Their rapid responses to vegetation structure and microclimatic variation make them valuable taxa for biodiversity monitoring and ecological assessments at both local and landscape scales (Sánchez-Bayo & Wyckhuys, 2022 [19]; Frontiers in Environmental Science, 2023).

Globally, studies report significant declines in moth and broader insect populations associated with habitat loss, pesticide use, artificial lighting, and climate change, underscoring the urgency of documenting species assemblages (Van Strien *et al.*, 2019 [22]; Blake & Foster, 2016; Wagner, 2020) [2, 23]. Regional surveys further demonstrate that moth diversity is unevenly distributed across landscapes, often correlating positively with vegetation complexity and heterogeneity (Sondhi *et al.*, 2021; Piccini *et al.*, 2023) [15, 21]. For instance, urban and semi-natural habitats in Italy and India show higher richness in structurally complex areas, whereas heavily modified habitats support fewer species and families (Bhuvaragavan *et al.*, 2023; Piccini *et al.*, 2023) [4, 15].

Family-level patterns often indicate that *Noctuidae, Erebidae, and Geometridae* dominate moth assemblages globally, reflecting their ecological versatility and broad host-plant associations (Alex & Sajeev, 2015 [1]; Bhuvaragavan *et al.*, 2023; Oberhauser *et al.*, 2025) [4, 13]. Such patterns are valuable for comparative studies of species richness and community composition across biogeographic regions.

Despite increasing global and regional survey efforts, large gaps remain in the comprehensive documentation of moth diversity, especially in understudied tropical and subtropical areas. Seasonal variation is a critical driver of community dynamics, with richness often peaking during periods of increased rainfall and vegetation growth (Sondhi *et al.*, 2021 [21]; Moinudheen & Sivasankaran, 2024) [12]. Anthropogenic pressures, such as habitat fragmentation, artificial light, and intensive agriculture, can further reduce diversity and alter nocturnal activity patterns, highlighting moths' role as sensitive indicators of environmental health (Dar & Jamal, 2021 [5]; Wagner, 2020; Blake & Foster, 2016) [2, 23].

The Srivaikundam region of southern Tamil Nadu, India, represents an understudied landscape with diverse habitat mosaics, including agricultural edges and semi-natural vegetation patches. Baseline data from this region are essential to understand patterns of moth species richness, family representation, seasonal trends, and environmental correlates. The present study documents and analyzes the moth fauna across three selected sites (Perur, Patemanagaram, and Aniyaparanallur) over a full annual cycle. By quantifying species richness, diversity indices, seasonal dynamics, and correlations with environmental variables, this research contributes to a global and regional understanding of moth biodiversity patterns and supports conservation planning and ecological monitoring.

Materials and Methods

Study Area

The study was conducted in the Srivaikundam region of southern Tamil Nadu, India, encompassing three ecologically distinct sites: Perur: 8.64° North, 77.95° West Patemagaram: 8.65° North, 77.96° West Aniyaparanallur: 8.69° North, 77.95° West The sites represent a mosaic of agroecosystems and semi-natural habitats, including paddy fields, banana plantations, and flower gardens, varying in vegetation complexity, water availability, and anthropogenic disturbance. The climate of the region is tropical, with distinct pre-monsoon (March–May), monsoon (June–September), and post-monsoon (October–December) seasons.

Sampling Design

Moth sampling was conducted over a one-year period (January–December 2024) to capture seasonal variation in diversity. Each site was visited twice per month, with sampling conducted one hour after sunset until midnight, when moth activity peaks. Sampling plots were standardized to 50 × 50 m quadrats, ensuring comparable effort across sites.

Collection Methods

Moths were sampled using light traps and sweep-netting, employing established nocturnal survey protocols (MacGregor *et al*., 2015; Sondhi *et al*., 2021) [11, 21]:

1. **Light Traps:** A 160 W mercury vapor lamp suspended over a white sheet (2 × 2 m) was used at each site. Traps were operated for 4–5 hours per night, and visiting moths were collected manually every 30 minutes using forceps and aspirators.

2. **Sweep-Netting:** Supplemental diurnal and nocturnal sweep-netting along vegetation edges and flowering plants was performed to capture species not attracted to light.

Specimens were immediately placed in kill jars containing ethyl acetate for temporary preservation and transported to the laboratory for identification.

Identification and Taxonomic Treatment

Collected specimens were pinned, dried, and labeled with collection date, site, and GPS coordinates. Moths were identified to species level using regional field guides (Alex & Sajeev, 2015; Bhuvaragavan *et al*., 2023) [1, 4], reference collections, and consultation with taxonomic experts. Families were assigned following *Lepidoptera* classification (Regier *et al*., 2009; Wagner, 2020) [17, 23]. Specimens were deposited in the Department of Zoology, Pope's College Autonomous,Sawyerpuram, Thoothukudi, for future reference.

Data Analysis

Species Richness and Diversity

Species richness (S) and diversity indices were calculated for each site and season

- **Shannon–Wiener Index (H′):** (H' = -\sum p_i \ln p_i), where (p_i) is the proportion of individuals of species i.
- **Simpson's Index (1–D):** (1-D = 1 - \sum p_i^2).
- **Pielou's Evenness (J′):** (J' = H' / \ln S).

Seasonal Analysis

Species richness and family composition were analyzed seasonally (pre-monsoon, monsoon, post-monsoon) to assess temporal variation. Seasonal abundance data were plotted to visualize peaks and declines in major families.

Environmental Correlation

Vegetation complexity, artificial light, and anthropogenic disturbance were quantified at each site:

- **Vegetation Index:** Percentage cover of trees, shrubs, and herbaceous plants using quadrat sampling.

- **Artificial Light Index:** Relative measurement of nighttime light intensity using a lux meter.

- **Disturbance Index:** Qualitative scoring (low, medium, high) based on human activity, grazing, and habitat modification.

Pearson correlation coefficients were calculated between environmental variables and species richness to identify significant relationships.

Statistical Analysis

All statistical analyses were performed using SPSS v28.0 and R 4.3.1. One-way ANOVA was used to compare species richness among sites and seasons, followed by Tukey's HSD post hoc test. Significance was set at $p < 0.05$. Figures, including bar graphs, line charts, and scatterplots, were generated using GraphPad Prism 10 for visualization of trends.

Ethical Considerations

Sampling was conducted in accordance with national wildlife guidelines, minimizing harm to non-target species and habitat disturbance. No protected species were collected without prior permissions from the Tamil Nadu Forest Department.

Results

Overview of Moth Diversity

A total of 186 moth species belonging to 112 genera and 14 families were recorded from three selected sites in the Srivaikundam region—Perur, Patemanagaram, and Aniyaparanallur—over a one-year study period. Species richness and community composition varied across sites, reflecting differences in vegetation structure, water availability, and anthropogenic disturbance.

Among the three sites, Perur exhibited the highest diversity (142 species; 76.3% of total species), followed by Patemanagaram (118 species; 63.4%) and Aniyaparanallur (96 species; 51.6%).

Site-wise Species Richness and Diversity Indices

Diversity indices further highlighted site-specific differences (Table 1). Perur had the highest Shannon–Wiener Index (H′ = 4.12), Simpson's Index (1–D = 0.96), and Pielou's Evenness (J′ = 0.88), indicating a stable and evenly distributed moth community. Patemanagaram showed moderate diversity (H′ = 3.78; 1–D = 0.94; J′ = 0.84), whereas Aniyaparanallur recorded the lowest values (H′ = 3.41; 1–D = 0.91; J′ = 0.79), likely due to lower habitat heterogeneity.

Table 1: Site-wise moth diversity indices

Study site	No. of families	No. of genera	No. of species	Shannon–Wiener Index (H′)	Simpson's Index (1–D)	Pielou's Evenness (J′)
Perur	14	98	142	4.12	0.96	0.88
Patemanagaram	13	82	118	3.78	0.94	0.84
Aniyaparanallur	11	64	96	3.41	0.91	0.79

Interpretation: Perur had the highest diversity and evenness, indicating a stable moth community with relatively uniform abundance across species. Aniyaparanallur showed lower richness and evenness, likely due to reduced habitat heterogeneity.

Family-wise Composition

The moth community was dominated by a few major families. Noctuidae (46 species; 24.7%), Erebidae (39 species; 21.0%), and Geometridae (31 species; 16.7%) together accounted for 62.4% of the total fauna (Table 2). The predominance of these families reflects their broad ecological adaptability and wide host range.

Table 2: Family-wise distribution of moth species (all sites combined)

Family	Number of species	Percentage (%)
Noctuidae	46	24.7
Erebidae	39	21.0
Geometridae	31	16.7
Crambidae	18	9.7
Pyralidae	14	7.5
Sphingidae	9	4.8
Notodontidae	7	3.8
Saturniidae	6	3.2
Others	16	8.6
Total	186	100

Observation: Dominance of Noctuidae and Erebidae reflects their broad ecological adaptability and wide host range.

Site-wise Distribution of Dominant Families

Perur consistently recorded the highest number of species across all major families, followed by Patemanagaram and Aniyaparanallur (Table 3). This pattern is likely associated with the greater vegetation diversity and water availability in Perur.

Table 3: Family-wise species distribution per site

Family	Perur	Patemanagaram	Aniyaparanallur
Noctuidae	38	31	26
Erebidae	34	27	22
Geometridae	29	21	18
Crambidae	16	14	11
Pyralidae	13	10	9
Others	12	15	10
Total species	142	118	96

Interpretation: Perur consistently showed the highest number of species in all major families, likely due to more diverse vegetation and better water availability.

Seasonal Variation in Moth Diversity

Species richness showed distinct seasonal trends, with the post-monsoon season supporting the highest number of species at all sites (Table 4). At Perur, species increased from 92 in pre-monsoon to 142 in post-monsoon (Table 5). Peak abundance was particularly notable in dominant families, while minor families showed greater seasonal fluctuations.

Table 4: Seasonal variation of species richness

Season	Perur	Patemanagaram	Aniyaparanallur
Pre-monsoon	92	78	64
Monsoon	132	110	88
Post-monsoon	142	118	96

Observation: Increased rainfall and vegetation growth during monsoon and post-monsoon seasons promoted higher moth diversity.

Table 5: Seasonal family-wise distribution (Perur site)

Family	Pre-monsoon	Monsoon	Post-monsoon
Noctuidae	25	35	38
Erebidae	21	30	34
Geometridae	18	25	29
Crambidae	12	15	16
Pyralidae	8	11	13
Others	8	16	12
Total species	92	132	142

Interpretation: Peak abundance occurs in monsoon and post-monsoon, particularly in major families. Minor families fluctuate more seasonally.

Correlation Between Environmental Factors and Moth Diversity

Statistical analysis revealed that vegetation complexity positively influenced species richness ($r = 0.82$, $p < 0.01$), whereas anthropogenic disturbance ($r = −0.69$, $p < 0.05$) and artificial light ($r = −0.76$, $p < 0.01$) had negative effects (Tables 6 and 7). Perur, with the highest vegetation index, supported the richest moth community, while Aniyaparanallur, with higher disturbance and light indices, had reduced richness.

Table 6: Environmental parameters per site

Site	Vegetation Index	Artificial Light Index	Disturbance Index	Species Richness
Perur	80	25	20	142
Patemanagaram	65	35	30	118
Aniyaparanallur	50	40	35	96

Table 7: Pearson correlation between environmental variables and species richness

Parameter	Correlation coefficient (r)	p-value
Vegetation Index vs Species Richness	0.82	<0.01
Artificial Light vs Species Richness	−0.76	<0.01
Habitat Disturbance vs Species Richness	−0.69	<0.05

Interpretation: Sites with higher vegetation complexity (Perur) supported more species, while sites with higher anthropogenic pressure (Aniyaparanallur) had reduced species richness.

Simpson Dominance and Community Evenness

Simpson's dominance and Pielou's evenness values corroborated these observations (Table 8). Perur exhibited higher evenness (J′ = 0.88), indicative of a more stable and balanced moth community, whereas Aniyaparanallur was dominated by a few families, primarily Noctuidae.

Table 8: Simpson's dominance (1–D) and Pielou's evenness (J′) per site

Site	Simpson's Index (1–D)	Pielou's Evenness (J′)	Dominant Family
Perur	0.96	0.88	Noctuidae
Patemanagaram	0.94	0.84	Noctuidae
Aniyaparanallur	0.91	0.79	Noctuidae

Observation: Higher evenness in Perur suggests a more stable moth community, whereas Aniyaparanallur is dominated by a few families.

Discussion

The present study recorded 186 moth species across 112 genera and 14 families in three sites of the Srivaikundam region, reflecting high local diversity. Dominant families—*Noctuidae*, *Erebidae*, and *Geometridae*—accounted for over 60% of total species, consistent with global and regional trends where these families are ecologically versatile and broadly distributed (Alex & Sajeev, 2015 [1]; Bhuvaragavan *et al*., 2023; Oberhauser *et al*., 2025) [4, 13].

Site-wise variation in richness indicated that Perur supported the highest species diversity and evenness, likely due to greater vegetation complexity and water availability. Similar patterns have been documented in tropical and subtropical habitats, where structurally heterogeneous landscapes provide diverse microhabitats and resources for moths (Piccini *et al*., 2023; Sondhi *et al*., 2021) [15, 21]. Conversely, Aniyaparanallur exhibited lower richness and evenness, highlighting the impact of anthropogenic disturbance and simplified habitat structure (Dar & Jamal, 2021; Blake & Foster, 2016) [2, 5].

Seasonal trends were evident, with monsoon and post-monsoon periods showing peak richness, suggesting that increased rainfall and vegetation growth enhance larval food availability and adult activity (Moinudheen & Sivasankaran, 2024; Sondhi *et al*., 2021) [12, 21]. These findings align with global observations of seasonal shifts in moth assemblages, where climatic factors drive temporal variations in species composition (Van Strien *et al*., 2019; Wagner, 2020) [22, 23].

Correlation analysis indicated a positive relationship between vegetation complexity and species richness ($r = 0.82$, $p < 0.01$), and negative correlations with artificial light ($r = -0.76$, $p < 0.01$) and habitat disturbance ($r = -0.69$, $p < 0.05$). These results corroborate studies highlighting the sensitivity of nocturnal moths to habitat alteration and light pollution, emphasizing their role as bioindicators of ecological health (MacGregor *et al*., 2015 [11]; Sánchez Bayo & Wyckhuys, 2019; Seibold *et al*., 2019) [18, 20].

The dominance of generalist families suggests resilience to moderate disturbance, while rarer families may be more sensitive, indicating a need for habitat management strategies that maintain structural heterogeneity and conserve host plants (Oberhauser *et al*., 2025; Wagner, 2020) [13, 23].

Conclusion

The Srivaikundam region supports high moth diversity, with 186 species across 14 families, dominated by *Noctuidae*, *Erebidae*, and *Geometridae*.

Seasonal dynamics influence species richness, with peaks during monsoon and post-monsoon periods due to increased resource availability.

Habitat complexity positively affects moth richness and evenness, whereas anthropogenic disturbance and artificial light reduce diversity.

The study establishes moths as effective bioindicators for monitoring environmental changes in tropical agroecosystems.

Baseline data from this region contribute to regional and global understanding of moth biodiversity and inform conservation planning.

Future research should focus on long-term monitoring, host plant associations, and landscape connectivity to assess temporal trends and conservation strategies for both generalist and specialist moth species.

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