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Preliminary survey on lepidopteran fauna of U. Nemili, Ulundurpet, Kallakurichi District, Tamil Nadu, India

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Abstract
The order Lepidoptera comprises both butterflies and moths. The preliminary survey was conducted at U. Nemili, Kallakurichi district, Tamil Nadu, India, from July 2023 to January 2024. This district is also known as the city of sugarcane, where agricultural activities are in full swing. The current study identified 27 moth species from six different families, and 33 butterfly species from five different families. Open scrubs and least disturbed areas had the highest species richness, whereas disturbed and urbanized regions had the lowest species richness. High species richness in butterflies was due to the abundance of host and larval plant species. The survey further reveals the dominance of moths in Eribidae and Crambidae with 31%, followed by the Noctuidae family with 15%. The abundance of host plants enhanced the richness of butterflies in the Papilionidae family. This study was focused on understanding the diversity of both moth and butterfly species in this area and on following various measures for the protection and conservation of these Lepidopterans.

Keywords: Butterflies, moth, diversity, lepidopterans, papilionidae, Kallakurichi district

Introduction

Lepidopterans is an order of winged insects comprising both moths and butterflies. The fossil record reveals that the first lepidopteran was observed during the Triassic-Jurassic period, and they have co-evolved with flowering plants. Moths and butterflies play a vital role in the health of the environment, and they are widespread and found in different habitats and are sensitive to changes in the environment. Monitoring their number and range gives us vital clues to observe the changes in the environment. The intrinsic values of these lepidopterans are significant, as they form an important component of rich biodiversity. Butterflies are flagship species for conservation, in particular among invertebrates. The Lepidopterans have fascinating lifecycles; the transformation from egg to caterpillar to chrysalis is one of the amazing wonders of nature. Areas that are abundant in butterflies and moths are also rich in other invertebrates, and they collectively provide environmental benefits, including pollination and natural pest control. Butterflies are widely used by ecologists as model organisms to study the impact of habitat loss, fragmentation, and climate change. In India, an estimated 11,300 moth species exist (Peter Smetacek, 2011) [28]. They act as an integral part of the ecosystem and fulfill important roles as flower pollinators and also as prey for various rodents, birds, and bats (Regier *et al.*, 2009) [29]; (Bates *et al.*, 2014) [2]. Most moths are active at night and primarily feed on plants, closely linked to flowering plants that rely on animals for pollination (Wahlberg *et al.*, 2013) [39]. Most of the world's lepidopterans, which include a wide range of moth species, belong to these unrelated insect groups, and many undiscovered and unnamed moth species, especially from tropical areas, are yet to be found (Heppner, 2008) [11]. Recent reports suggest that moth diversity and abundance have significantly decreased worldwide in the past few decades (Hallmann *et al.*, 2020) [10]. This decline may be due to various factors such as habitat loss, degradation, fragmentation, intensified agriculture, changes in woodland management, urbanization, chemical pollution, artificial light at night, and climate change (Dennis *et al.*, 2019) [4]. Some plant species rely solely on one or a few moth species for pollination, so a decline in moth population and diversity could negatively affect the plant communities in which they pollinate (Young *et al.*, 2017) [40]. India has a remarkably diverse moth population, with almost 10,000 species (Smetacek, 2013) [34]. Kehimker (2008)[14] documented 735 species of butterflies in the Indian subcontinent. Butterflies serve as a proxy for assessing the risk to biodiversity. Some butterfly species are specific to certain seasons and habitats (Kunte,1997) [19], making them effective indicators of human disturbance and habitat quality (Kocher & Williams, 2000) [17]. Unfortunately, their role as indicators has been overlooked by many ecologists despite their strong adaptation to particular habitats (Bibi *et al.*, 2022) [3]. Butterflies are excellent indicators due to their abundance, short lifecycles, good mobility, and high sensitivity to environmental changes (Lee & Kwon, 2012); (Lee and Kwon *et al.*, 2014 [20, 21]. Thus, this survey on butterflies and moths in U. Nemili, Kallakurichi district, enables us to understand the diversity and health of the ecosystem and also to prevent habitat loss and climate change. This survey also prioritizes areas for conservation with effective management and strategies.

Materials and Methods

Study Area

The present study was conducted at U. Nemili village of Kallakurichi district of Tamil Nadu, India (Fig. 1). It comprises an active agricultural area, an urban area, and a barren land area (undisturbed area). Sugarcane cultivation is the predominant agricultural activity, apart from the cultivation of paddy, maize, and other millets and vegetables. The district has moderate temperatures with adequate rainfall and is surrounded by hills.

Moth Survey and Identification

The present study was carried out from July 2023 to January 2024. The observation time was from 6 am to a convenient time at night. The moth survey was conducted using a direct photograph method—moths were photographed both in day and night. The light trap method was also used with 23-watt LED lights hung in front of a white background cloth. The moths were photographed by direct visual methods. The fortnight survey on moth was done with a Canon DSLR 200D. The mobile phone camera MIUI version is Poco M3 Pro 5G. The study aimed to report various species of moths and butterflies observed over a period of six months. Photographic records were documented and identified with standard references (Sondhi & Sondhi, 2016) [35]; (Singh *et al*., 2017) [33] and field guides (Holloway *et al*., 2001) [12]; (Shubhalakshmi, 2018) [32]. The classification was followed as per (Nieukerken *et al.,* 2011) [27].

In addition, several web sources, including www.jpmoths.org, Moths of India https://www.mothsofindia.org/ and iNaturalist, were used for identification. No specimen was captured or killed during the entire study period.

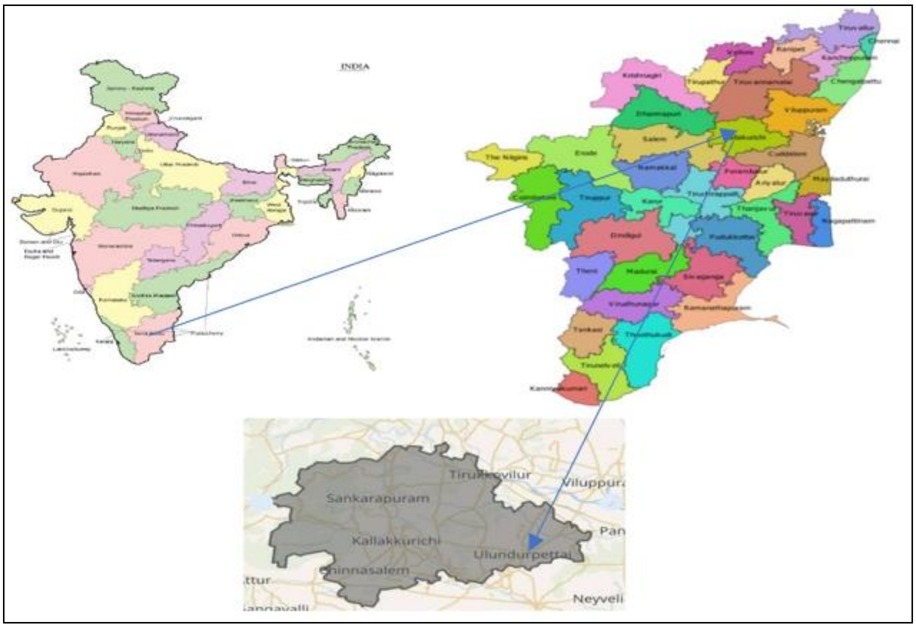


Fig 1: Map of study area

Fig 2: Agricultural area of U. Nemili

Butterfly survey and Identification

Fortnightly surveys on butterflies were carried out in the study area for six months, from July to January 2023-2024. Butterflies were observed in the study area from 12 pm to 2 pm by random observations through walking. Photographs of the butterflies were taken with a DSLR 200-D camera and an MIUI smartphone camera. Butterflies were identified based on the color patterns, size, and shapes from available literature, BNHS field guide—Butterflies of India (kehimker 2016) [15].

Statistical Analysyis

Diversity Indices:

- Simpson index of Dominance
- Shannon – Wiener diversity Index
- Evenness Index

(A) Simpson's Diversity Index (SDI):

$$SDI = \frac{1 - \sum n(n-1)}{N(N-1)}$$

(B) Shannon Wiener Diversity Index (1963): To calculate the diversity of Moth and Butterfly diversity, Shannon index (H') was used as a measure for species richness and abundance. Formula for Shannon Index is

$H = -\sum Pi \times (\ln pi)$

where, Pi = Proportion of the ith species.

ln = Natural logarithm of Pi.

Species evenness was calculated using the formula; $J = H'/\ln(s)$.

where, H' = Value of Shannon–Wiener index.

ln s = The natural log of the species richness (total number of species)

(C) Pielou's Evenness Index (Equitability): The species evenness is the proportion of individuals among the species.

$J = H \div H_{max}$

J= Pielou's evenness index

H= The observed value of Shannon-Wiener index

Hmax: In S (S: Total number of species, In: The natural logarithm)

Table 1: Species diversity, Richness, Evenness and Abundance of families recorded for Moth fauna of U. Nemili

Site	No. of Species	No. of Families	Simpson's diversity index(D)	Shannon- Weiner diversity index(H)	Pielou's Evenness index(J)
U. Nemili, kallakurichi (district), Tamilnadu, India	225	6	0.96	2.62	0.79

Table 2: Species diversity, Richness, Evenness and Abundance of families recorded for Butterfly fauna of U. Nemili

Site	No. of Species	No. of Families	Simpson's diversity index(D)	Shannon- Weiner diversity index(H)	Pielou's Evenness index(J)
U. Nemili, kallakurichi (district), Tamilnadu, India	281	5	0.96	3.5	1.01

Result

Our study recorded 27 different species of moth belonging to six different families, and the total count of moths observed was 225. Of the total, 225 genera consisting of 6 different families, namely Crambidae, Erebidae, Geometridae, Noctuidae, Sphingidae, and Uraniidae, were recorded (Table 3 & Fig. 3). It is of interest to note that from 225 moths, 112 genera were of the Crambidae family, 58 of Erebidae, followed by 38 Noctuidae, 11 Geometridae, and 3 Uraniidae, and the least was observed in Sphingidae (Fig. 5). Based on the number of species, the families Crambidae and Erebidae were the most dominant in the study area, followed by Geometridae, Noctuidae, Uraniidae, and Sphingidae. Similar results of high abundance of the Crambidae family were registered in areas rich in agroecosystems and grassy habitats in the Banaras Hindu University campus (Nayak & Ghosh, 2020) [25]. Gupta & Thakur (1986) [8] reported nine different species of moths from six districts, and Sharma (2011) [30] reported 38 species of moths associated with vegetables in the Aravali range; in 2014, Sharma observed 56 species at the foothills of the Aravalli range, and he also recorded 56 species from the Ajmer district of Rajasthan (2016)[31]. A total of 2,679 moths were recorded in Annamalai Nagar, Tamil Nadu, by Kathirvelu *et al*. (2019) [13]; they have clearly explained that light traps are the best option for moth surveys during the nighttime. Gurule *et al.*, (2013) [9] recorded a different result of Geometridae domination. the highest number was recorded in Erebidae (28) and comparatively lesser numbers in Crambidae (13), Sphingidae (07) and Noctuidae (05) were recorded in Annamalai Nagar (Kathirvelu *et al*., 2019) [13] These reports reveal that this may be due to the least amount of cropping and less rainfall in the study area, which leads to lack of crops. This was found to be contrary to our results because our study area is rich in vegetation with good rainfall.

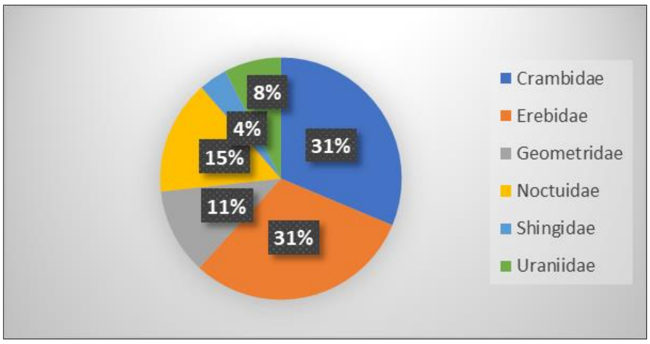


Fig 3: Abundance of moth species at U. Nemili

The diversity indices were measure during Simpson's Diversity Index (D) and it was 0.96, Shannon's Diversity Index (H) was 2.62, and Pielou's Evenness Index (J) was 0.79 (Table 2). From these indices, we can conclude that the moth fauna is highly diverse in the study area. This may be due to the rich vegetation, especially grass and crops, in agricultural area which serve as good feed for the caterpillar of moths.

Table 3: Moth Diversity at Ulundurpet, Nemili

S.no.	Family	Total no of species	Species	Author
1	Crambidae	28	*Cnaphalocrocis medinalis*	Guenee (1854)
2	Crambidae	20	*Diaphania indica*	Saunders (1851)
3	Crambidae	32	*Spoladea recurvalis*	Fabricius (1775)
4	Crambidae	2	*Elophila obliteralis*	Walker (1859)
5	Crambidae	4	*Conogethes punctiferalis*	Guenee (1854)
6	Crambidae	20	*Palpita vitrealis*	Rossi (1794)
7	Crambidae	5	*Patania iopasalis*	Walker (1859)
8	Crambidae	3	*Hellula undalis*	Fabricius (1794)
9	Erebidae	12	*Pericallia ricini*	Fabricius (1775)
10	Erebidae	2	*Anticarsia irrorata*	Fabricius (1781)
11	Erebidae	15	*Chalciope mygdon*	Cramer (1777)
12	Erebidae	4	*Mocis frugalis*	Fabricius (1775)
13	Erebidae	2	*Olepha ricini*	Fabricius (1775)
14	Erebidae	17	*Eublemma anachoresis*	Wallengren (1863)
15	Erebidae	5	*Trigonodes hyppasia*	Cramer (1779)
16	Erebidae	1	*Spirama helicina*	Hubner (1831)
17	Geometridae	1	*Thalassodes immissaria*	Walker (1861)
18	Geometridae	7	*Chiasmia eleonora*	Cramer (1780)
19	Geometridae	1	*Cleora sublunaria*	Guenee (1857)
20	Geometridae	2	*Chrysocraspeda faganaria*	Guenee (1858)
21	Noctuidae	4	*Leucania loreyi*	Duponchel (1827)
22	Noctuidae	8	*spodoptera litura*	Fabricius (1775)
23	Noctuidae	14	*Aegocera venulia*	Cramer (1777)
24	Noctuidae	12	*Ozarba punctigera*	Walker (1865)
25	Sphingidae	1	*Daphnis nerii*	Linnaeus (1758)
26	Uraniidae	2	*Phazaca theclata*	Guenee (1858)
27	Uraniidae	1	*Micrinia aculeata*	Guenee (1857)

Table 4: Lists of Butterfly fauna recorded during the study period.

S-no	Family	Total no of specimens	Scientific name	Author name
1	Papilionidae	15	*Papilio polytes*	Linnaeus (1758)
2	Papilionidae	20	*papilio demoleus*	Linnaeus (1758)
3	Papilionidae	10	*Pachliopta hector*	Linnaeus (1758)
4	Nymphalidae	7	*Mycalesis perseus*	Fabricius (1775)
5	Nymphalidae	12	*Ariadne merione*	Cramer (1777)
6	Nymphalidae	4	*Elymnias hypermnestra*	Linnaeus (1763)
7	Nymphalidae	10	*Byblia ilithyia*	Drury (1773)
8	Nymphalidae	24	*Danus chrysippus*	Linnaeus (1758)
9	Nymphalidae	8	*Danus genutia*	Cramer (1779)
10	Nymphalidae	5	*Tirumala limniace*	Cramer (1775)
11	Nymphalidae	7	*Euploea core*	Cramer (1780)
12	Nymphalidae	20	*Acraea terpsicore*	Linnaeus (1758)
13	Nymphalidae	3	*Neptis hylas*	Linnaeus (1758)
14	Nymphalidae	1	*Hypolimnas bolina*	Linnaeus (1764)
15	Nymphalidae	2	*Hypolimnas mesippus*	Linnaeus (1764)
16	Nymphalidae	7	*Junonia almana*	Linnaeus (1758)
17	Nymphalidae	8	*Junonia iphita*	Cramer (1779)
18	Nymphalidae	17	*Junonia lemonias*	Linnaeus (1779)
19	Nymphalidae	1	*Melanitis leda*	Linnaeus (1758)
20	Pieridae	1	*Pareronia hippia*	Fabricius (1787)
21	Pieridae	8	*Appias albina*	Boisduval (1836)
22	Pieridae	1	*Cepora nerissa*	Fabricius (1775)
23	Pieridae	5	*Colotis amata*	Fabricius ((1775)
24	Pieridae	5	*Colotis danae*	Fabricius (1775)
25	Hesperridae	12	*Borbo cinnara*	Wallace (1866)
26	Hesperridae	8	*Iambrix salsala*	Moore (1866)
27	Hesperridae	5	*Telicota bambusae*	Moore (1878)
28	Lycaenidae	4	*Castalius rosimon*	Fabricius (1775)
29	Lycaenidae	20	*Chilades lajus*	Stoll (1780)
30	Lycaenidae	4	*Zizeeria karsandra*	Moore (1865)
31	Lycaenidae	2	*Jamides celeno*	Cramer (1775)
32	Lycaenidae	18	*Euchrysops cnejus*	Fabricius (1798)
33	Lycaenidae	7	*Catochrysops strabo*	Fabricius (1793)

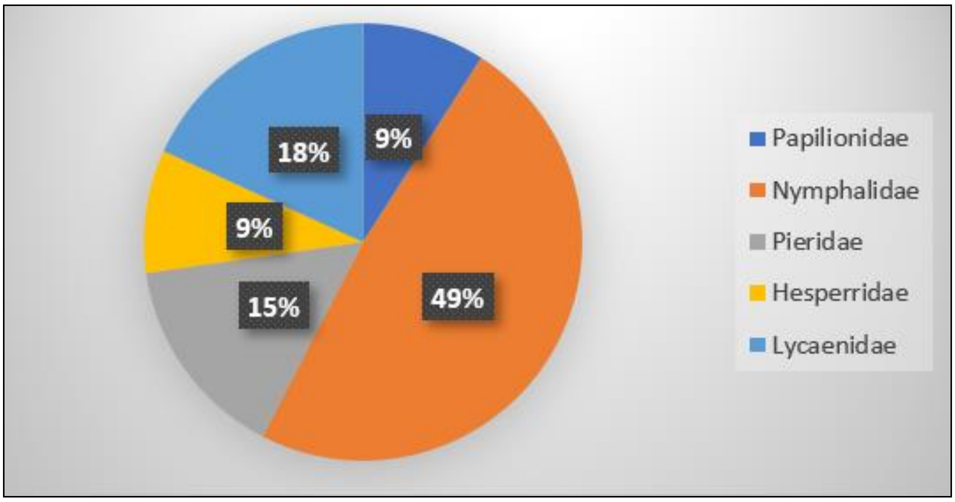
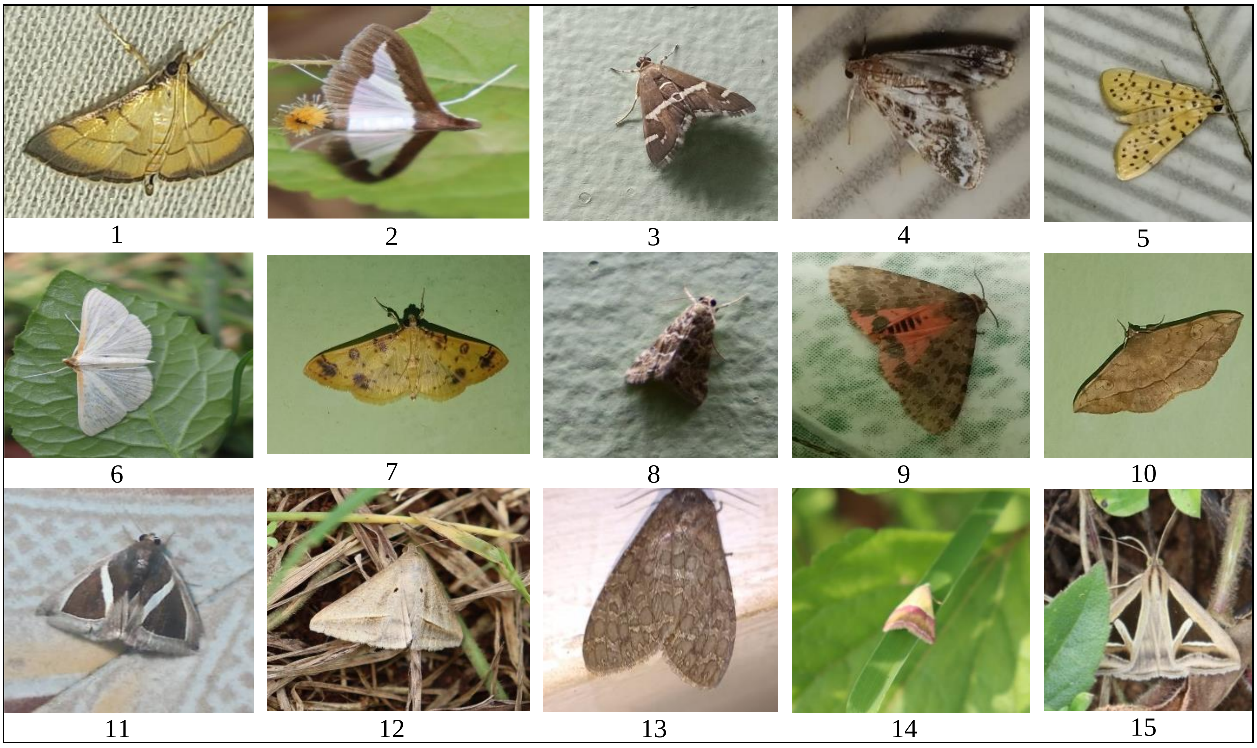


Fig 4: Abundance of butterfly species at U. Nemili

The total butterfly species belonging to different families and their abundance are provided in Table (Table 4, Fig.4). 281 butterflies were recorded from five different families, namely Papilionidae, Nymphalidae, Pieridae, Hesperiidae, and Lycaenidae (Figs. 6 & 7). 136 genera belong to Nymphalidae, 55 belong to Lycaenidae, followed by 45 Papilionidae, 25 Hesperiidae, and the least was from Pieridae (20). Based on the number of species, it is found that Nymphalidae and Lycaenidae were abundant in the study area, followed by Papilionidae, Hesperiidae, and Pieridae. Agricultural sites had significantly more butterflies than non-agricultural sites (Erica Fleishman 1999) [5]. Butterflies have traditionally been viewed as an excellent group of bioindicators, mainly due to the complexity of ecological management required by many species (Thomas 1995) [37], (New *et al.*, 1995) [26]. Butterflies of Madurai city, Tamil Nadu, were studied by Baskaran and Solaiappan (2002) [1]; 33 species were recorded in their study area. Gunasekaran and Balasubramanian (2010) [7] studied butterfly diversity and their conservation on temple premises in Tamil Nadu. Rich vegetation structure is directly associated with greater diversity. The horticultural and agricultural fields provided shelter for suitable foraging in the grounds for some butterflies, and the plantations provided food and nectar resources. Rich environmental factors made the habitat favorable for the survival and reproduction of moths. The host plant provides enough food sources for moth larvae. The abundance of butterfly diversity (Table 2) is observed from Simpson's Diversity Index (D) of 0.96, which indicates that Shannon Diversity Index (H) is 3.5, and Pielou's evenness index (P) is -1.01. These indices indicate highly diverse and rich butterfly fauna in the study area.



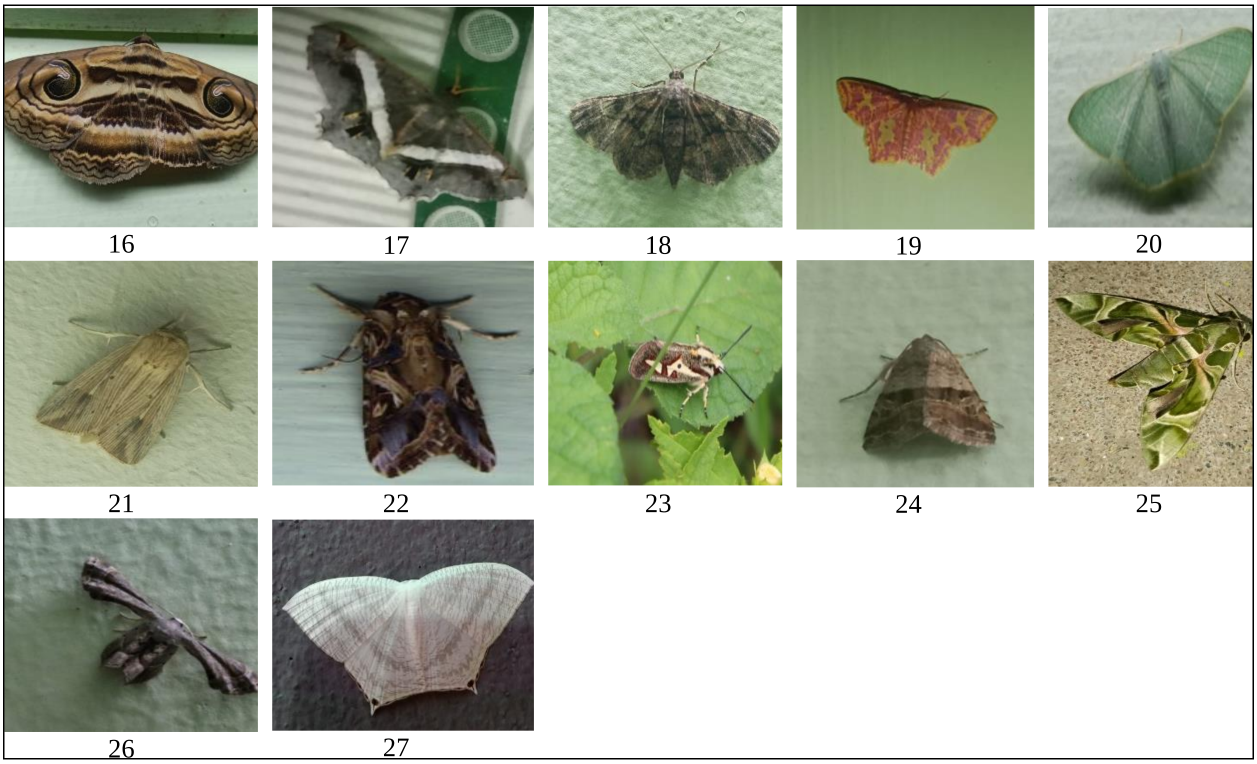


Fig 5: *1-Cnaphalocrocis medinalis (Guenee 1854) ,2-Diaphania indica (Saunders 1851), 3- Spoladea recurvalis (Fabricius 1775), 4- Elophila obliteralis (Walker 1859)., 5- Conogethes punctiferalis (Guenee 1854), 6- Palpita vitrealis (Rossi 1794), 7-Patania iopasalis (Walker 1859), 8-Hellula undalis (Fabricius 1794), 9-Pericallia ricini (Fabricius 1775), 10- Anticarsia irrorate(Fabricius 1781), 11- Chalciope mygdon (Cramer 1777), 12- Mocis frugalis (Fabricius 1775), 13- Olepha ricini (Fabricius 1775), 14- Eublemma anachoresis (Wallengren 1863),15- Trigonodes hyppasia (Cramer 1779), 16- Spirama helicina (Hubner 1831), 17- Chiasmia Eleonora (Walker 1861), 18- Cleora sublunaria (Cramer 1780),19-Thalassodes immissaria (Guenee 1857), 20- Chrysocraspeda faganaria (Guenee 1858), 21- Leucania loreyi (Duponchel 1827), 22- spodoptera litura (Fabricius 1775),23- Aegocera venulia (Cramer 1777), 24- Ozarba punctigera (Walker 1865), 25- Daphnis nerii (Linnaeus 1758), 26- Phazaca theclata (Guenee 1858), 27- Micrinia aculeata (Guenee 1857).*

Fig 6: – *1-Papilio polytes, (Linnaeus 1758) 2-papilio demoleus (Linnaeus 1758), 3-Pachliopta hector (Linnaeus 1758), 4- Mycalesis perseus (Fabricius 1775), 5- Ariadne merione (Cramer 1777),6-Elymnias hypermnestra (Linnaeus 1763), 7-Byblia ilithyia (Drury 1773), 8- Danus chrysippus (Linnaeus 1758), 9- Danus genutia (Cramer 1779), 10-Tirumala septentrionis (Cramer 1775), 11- Euploea core (Cramer 1780), 12- Acraea terpsicore (Linnaeus 1758), 13- Neptis hylas (Linnaeus 1758), 14- Hypolimnas bolina (Linnaeus 1764), 15- Hypolimnas mesippus (Linnaeus 1764), 16-Junonia almanac (Linnaeus 1758), 17- Junonia iphita (Cramer* 1779), *18- Junonia lemonia (Linnaeus 1779), 19- Melanitis leda(Linnaeus 1758), 20-Pareronia hippia (Fabricius 1787)*

Fig 7: *-21- Appias albina (Boisduval 1836), 22-Cepora Nerissa (Fabricius 1775), 23- Colotis amata (Fabricius 1775),24- Colotis danae (Fabricius 1775), 25- Borbo cinnara (Wallace 1866) , 26- Iambrix salsala (Moore 1866), 27-Telicota bambusae (Moore 1878), 28- Castalius rosimon (Fabricius 1775), 29- Chilades lajus (Stoll 1780), 30-Zizeeria karsandra (Moore 1865), 31-Jamides celeno (Cramer 1775), 32- Euchrysops cnejus (Fabricius 1798), 33- Catochrysops Strabo (Fabricius 1793).*

Discussion

Moths constitute an essential component of the biodiversity of an area, and they play a major role in maintaining a healthy environment and ecological balance. Environmental factors make the habitat favorable for survival and reproduction of moths. Host plants provide enough food sources for the moth's larvae. The biodiversity of moth fauna is mostly because of rich vegetation. Vegetation plays a significant role in providing the main food source to insect fauna, and abiotic factors play an important role in habitat structure. Moths depend on vegetation, shrubs, herbs, and trees for food. More moths were seen on the light sheet than in a light trap because the light source used on the light sheet illuminated the large area, increasing the surface area for the settling of moths. In the present study across different habitats of the study area, we found that members of the two moth families Crambidae & Erebidae were very common. The high abundance of the Crambidae family can be attributed to the presence of a large number of agro-ecosystems and grassy habitats throughout the area. Further, their caterpillars had a wide range of adaptations with phytophagous, detritivorous, coprophagous, and parasitic habits, and they also fed on roots, stems, or grasses (Zhu *et al*., 2018) [41]. During the study a total of 281 butterflies belonging to 5 different families were reported, of which the family Nymphalidae was found to be the most dominant, with 16 different species occurring during all seasons. Nymphalidae species were not only abundant in Ulundurpet, Nemili but also in various other parts. The works of (Lodh and Agarwala, 2016) [22] reveal that in Rowa Wildlife Sanctuary, Tripura, 22 Nymphalidae species, accounting for 89 individuals, were recorded. The highest butterfly species was observed during the month of July. This could be due to the effect of temperature, rainfall, and humidity. Butterflies are an important model group in ecology and conservation, as they perform different ecological services such as pollination, nutrient decomposition, and good indicators of the ecosystem's health, etc. (Koh, 2007) [18]; (Kunte, 1997) [19]; (Majumder *et al*., 2012) [23]. The season affects both the diversity and distribution of butterflies. The relationships between butterflies and climate are complex, involving all four stages of the life cycle. Food habits among species (Gilbert & Singer 1975) [6]; (Kitahara *et al*., 2000) [16] also influence the relationships between climate and butterfly diversity and abundance (South wood 1975)[36]. The habitat type also plays a major role in the distribution of species. Seasonal changes play a pivotal role in both the diversity and distribution of butterflies. It is interesting to note there are variations in the number of butterflies during the study period, and in certain months they were more in number (Narmadha *et al*., 2023) [24]. The habitat with open herbs & shrubs, which was least disturbed, has the highest species richness, followed by the habitat in the agricultural field, and the lowest in the urbanized habitat, the most disturbed. The presence of host and larval plant species, whose occurrence influences the dispersal of butterflies, is responsible for this result (Tiple, 2010) [38]. The availability of preferred food plants for larvae and adults is intimately correlated with the habitat selection process in butterflies (Majumdar *et al*., 2012) [23].

Conclusion

The diversity of moth and butterfly fauna in village U. Nemili is significant because of its rich vegetation in this area. Vegetation plays a pivotal role that provides the main food source to insects, and abiotic factors also play an important role in habitat structure. Butterflies play a pivotal role in pollinating various plant species within protected natural ecosystems. Additionally, their seasonal migrations to specific habitats reflect their dependence on particular environmental conditions to ensure their survival. The present study will help to understand the widespread species diversity of moths and butterflies in this area.

Statement and Declaration

The Authors have no relevant financial or non-financial interests to disclose.

Conflict of Interest

The authors declare that there is no conflict of interests for the present study.

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