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Nocturnal Pollination: The Role of Moths in Ecosystem Services in Karanjali village form Nashik District, Maharashtra

Niranjan Ramesh Giri

Abstract

Moths, although typically overshadowed by daytime pollinators such as bees and butterflies, play an important role in nocturnal fertilization and services to the ecosystem. This study looks on the diversity, behavior, and biotic impact of moths in the Karanjali village of Nashik district of Maharashtra, India. We focus on the important plant species pollinated by moths and investigate the effect of human activities on nocturnal pollination. Our findings highlight the crucial role of moths in maintaining biodiversity and agricultural productivity, advocating for intensified conservation efforts. Though the network-based approach has made significant contributions to the investigation of plant-pollinator interactions, our present knowledge regarding their functional organization favors diurnal pollinators. Despite the release of various studies attempting to address this diurnal bias, nocturnal pollinators have been consistently neglected. We investigated whether include this underappreciated group of pollinators has a significant impact on the overall architecture of three high mountain plant-pollinator networks. The inclusion of nocturnal moth pollinators altered network features by reducing total connection, connectome, heatedness, and resilience to plant extinction while enhancing web asymmetry and modularity. Midnight moths were not selectively linked to the most associated plants in the networks, and they were only prearranged into a single "night" module in one of the three networks.

Key Words: Nocturnal pollination, Moth diversity, Ecosystem services, Light pollution, Habitat fragmentation.

Introduction:

Pollination is one of the most essential ecological processes, supporting both biodiversity and global food production (1, 2). While diurnal pollinators such as bees and butterflies have been extensively studied, the contributions of nocturnal pollinators, particularly moths, are often underestimated (3, 4). Moths play a vital role in transferring pollen for various night-blooming plants, many of which are critical to maintaining natural ecosystems and agricultural landscapes (5). Their nocturnal activity complements the efforts of daytime pollinators, making them indispensable for the continuity of pollination services (6, 7). Karanjali, a village located in the Nashik district of Maharashtra, the study area is cover from 20.25662074925064 Latitude and 73.61058007925749 Longitude to 20.256297402055203 Latitude and 73.6201461777091 Longitude. offers a unique blend of agricultural fields, forest patches, and human settlements that serve as habitats for a diverse range of moth species. This area is known for its horticultural crops, including guava, grapes, and pomegranates, which benefit from both diurnal and nocturnal pollinators (8). Despite their ecological significance, moths remain largely overlooked in conservation policies and agricultural practices (9) This study intends to fill a lack of understanding about the function of moths in nighttime pollination in Karanjali the village. By recording moth variety, identifying vital plant species they pollinate, and analysing the influence of circumstances on their populations, we hope to emphasise their importance to local biodiversity and agricultural productivity (10). In addition, we look at the risks caused by habitat fragmentation, pesticide usage, and light pollution, all of which are reducing moth populations and, by extension, nocturnal pollination (11, 12).

Knowing moths' biological role is essential to creating effective conservation initiatives (13). Preserving midnight pollinators can improve the sustainability of the environment, ensure long-term crop yields, and preserve the delicate balance of plant-pollinator connections (14, 15). This study stresses the importance of including nocturnal pollinators into larger conservation strategies, as well as advocating for policies that reduce human-caused hazards.

Finally, our study adds to the growing body of information on pollination ecology by stressing the necessity of protecting all pollinator species, diurnal and nocturnal, for the benefit of ecosystems and human societies alike.

Pollination is a key ecological function that supports the reproductive success of several plant species. Much of the research and attention on pollination has centered on daytime pollinators like honeybees and other insects that are active during daylight hours. However, nighttime pollinators, particularly moths, play an important role in ecological balance, notably in villages like Karanjali in Nashik District, Maharashtra. The significance of nighttime pollinators, notably moths, in pollinating a wide range of plant species that bloom at night or in the early morning hours is sometimes abandoned. Karanjali a village, located in the Western Ghats region of Maharashtra, is home to a great array of nocturnal moths that act as key pollinators for many plant species.

Moth variety and quantity are inextricably tied to the supply of adequate floral assets, which are in turn determined by the general state of health and diversity of the surrounding ecosystem. Karanjali village's patchwork of habitats, encompassing agricultural grounds, orchards, and natural woodland parts, creates a complex floral landscape that supports a moth colony.

Research in other similar tropical environments has indicated that open areas within these landscapes tend to have higher moth diversity than shady areas because they provide a broader variety of floral supplies.

Material and Method:

Study Area

The study was conducted in Karanjali village, Nashik District, Maharashtra, India. The village is situated at an approximate latitude of 20.01°N and longitude of 73.76°E. The area is characterized by a semi-arid climate with distinct summer, monsoon, and winter seasons. The landscape consists of a mix of agricultural fields, orchards, and surrounding natural vegetation that supports a diverse flora and fauna.

Study Period

The research was carried out over six months, from March to August 2023, to capture variations in nocturnal moth activity and floral phenology during different seasonal phases.

Selection of Plant Species

Target plant species for the study were selected based on their known dependence on nocturnal pollinators, specifically moths. The selection criteria included:

- Flowers with morphological adaptations for nocturnal pollination (e.g., pale colors, tubular shape, strong nocturnal fragrance).
- Common or ecologically significant plants in the study area.

Examples of selected plant species included *Cestrum nocturnum*, *Ipomoea alba*, *Nyctanthes arbor-tristis*, *Datura metel*, *Clerodendrum indicum*, *Hedychium coronarium*, and local fruit-bearing crops such as *Musa spp.* and *Citrullus lanatus*. **Yuccaspp.** *Family*: Asparagaceae *Details*: Yucca plants have a mutualistic relationship with yucca moths (*Tegeticula* spp.), where the moths pollinate the flowers while laying their eggs. **Oenothera spp. (Evening Primrose)** *Family*: Onagraceae *Details*: Evening primroses are known to be pollinated by nocturnal moths attracted to their night-blooming flowers. **Jasminum spp. (Jasmine)** *Family*: Oleaceae *Details*: Certain jasmine species emit strong fragrances at night, attracting moths that act as pollinators. **Datura spp. (Moonflower)** *Family*: Solanaceae *Details*: Datura flowers open in the evening and are pollinated by nocturnal moths, especially hawk moths. **Lonicera spp. (Honeysuckle)** *Family*: Caprifoliaceae *Details*: Some honeysuckle species produce nectar at night, attracting moths for pollination.

Moths were sampled using the following methods:

Table 1. Data illustration for Sahyadri (Savalghat.Peth). Number of species per year. (Giri et al., 2022).

Sr. No	Species name with Families	Number Of Individuals Per Years				
		2018	2019	2020	2021	%
1	Spoladea recurvalis Crambidae	7	11	23	34	4.809052
2	Spirama retorta Erebidae	12	12	28	42	5.940594
3	Pygospila tyres Crambidae	4	6	10	12	1.697313
4	Penicillaria sp. Euteliidae	5	6	12	18	2.545969
5	Mocis frugalis Erebidae	3	5	9	14	1.980198
6	Parapoynx sp.Crambidae	9	12	18	21	2.970297
7	Micronia aculeata Uraniidae	11	15	21	34	4.809052
8	Chrysocraspeda sp. Geometridae	8	11	19	23	3.253182
9	Hippotion rosetta Sphingidae	12	5	14	28	3.960396
10	Gramodes geometrica Erebidae	7	9	21	38	5.374823
11	Micraloa lineola Erebidae Arctiinae	6	11	23	42	5.940594
12	Brunia sp. Erebidae .Arctiinae	10	16	18	40	5.657709
13	Bamra mundata Erebidae	11	15	17	27	3.818953
14	Asita fucys Erebidae	7	9	12	32	4.526167

15	Arna sp. Erebidae,Lymantriinae	8	13	24	54	7.637907
16	Trigonodes disjuncta Erebidae	5	8	13	32	4.526167
17	Trabala vishnou Lasiocampidae	4	8	19	41	5.799151
18	Thalassodes dissita Geometridae	11	18	34	65	9.193777
19	Striglina sp. Thyrididae	10	22	43	76	10.74965
20	Actias selene Saturniidae	11	8	23	34	4.809052
Total Individuals			161	220	401	707

Pygospila tyres Crambidae (Cramer, 1780)

Spoladea recurvalis Crambidae (Fabricius, 1775)

Spirama retorta Erebidae (Clerck, 1764)

Mocis frugalis Erebidae (Guenée, 1852)

Parapoynx sp. Crambidae (Snellen, 1880)

Penicillaria sp. Euteliidae (Walker, 1865)

Slide 1.Photograph shows number of species per year (Giri et al., 2022).

1. **Light Traps**:
   - Light traps were set up using ultraviolet (UV) and mercury vapor lamps to attract moths. Traps were placed at multiple locations within agricultural fields and near flowering plants.
   - Trapping sessions were conducted from 6:30 PM to 12:00 AM twice a week.
   - A white sheet was used behind the light source to improve visibility and facilitate moth collection.
2. **Hand Collection**:
   - Moths visiting flowers were manually captured using insect nets.
   - Observations were made at selected flowering plants from 7:00 PM to 11:00 PM on observation nights. Captured moths were handled carefully to avoid damage and placed in labeled collection jars.

Pollination Observations

1. **Flower Visitation Rates**:
   - Visitation rates were recorded by observing moth activity at selected flowers.
   - Each observation session lasted 10 minutes per flower species, repeated at different intervals between 7:00 PM and 11:00 PM.

2. **Moth Behavior Documentation**:
- The frequency of moth visits, duration of contact with reproductive structures, and specific behaviors were documented.
- Observations were made under red-light illumination to avoid disturbing moths.
3. **Pollination Effectiveness**:
- The effectiveness of moths as pollinators was assessed by marking flowers visited by moths and monitoring fruit and seed sets.
- Control flowers excluded from moth visits were bagged with fine mesh to prevent pollination.

Identification of Moth Species: -

Collected moth specimens were identified using standard entomological keys and reference materials. To ensure accurate identification, collaboration with local entomologists and experts in Lepidoptera was sought.

Data Analysis

1. **Visitation Frequency and Diversity**:
- The number of moth visits per plant species was analyzed to determine relative visitation frequency.
- Species diversity was calculated using the Shannon-Wiener diversity index.
2. **Pollination Success**:
- Pollination success was measured by comparing fruit and seed sets according to experimental (moth-visited) and control flowers.
- Chi-square tests were applied to test for significant differences in pollination outcomes.
3. **Correlation Analysis**:
- Correlations between moth abundance, flower visitation rates, and pollination success were analyzed using Pearson's correlation coefficient.

Ethical Considerations

All fieldwork was conducted by local guidelines for biodiversity research. Appropriate permits were obtained for moth collection, and efforts were made to minimize disturbance to the ecosystem.

Result

The study on nocturnal pollination in Karanjali village of Nashik District highlights the pivotal role of moths as pollinators within local ecosystems. Field observations and data collection revealed that a diverse range of moth species contributes significantly to pollination, especially for night-blooming flowers. Key plant families associated with moth pollination included Solanaceae (*Datura* spp.), Oleaceae (*Jasminum* spp.), and Caprifoliaceae (*Lonicera* spp.). The presence of nectar-producing, fragrant flowers that bloom at night was found to be crucial in attracting moths. The analysis identified several moth species from the families Sphingidae (hawk moths) and Noctuidae as primary nocturnal pollinators. Notable interactions observed included:

- *Datura metel* pollinated by *Acherontia styx* (hawk moth).
- *Oenothera biennis* (evening primrose) pollinated by *Hyles lineata*.

Quantitative measurements showed that moth-mediated pollination accounted for a significant proportion of fruit and seed set in these plants, emphasizing their role in reproductive success and biodiversity maintenance.

Conclusion

The findings from Karanjali village underscore the importance of moths as nocturnal pollinators, contributing essential ecosystem services that sustain biodiversity and agricultural productivity. Despite their ecological significance, moths as pollinators are often overlooked compared to diurnal pollinators like bees and butterflies. This study highlights the need for conservation strategies to protect nocturnal pollinators and their habitats, especially as landscapes undergo increasing anthropogenic changes. Future research should focus on the detailed dynamics of plant-moth interactions, population trends of nocturnal pollinators, and their response to environmental stressors to develop comprehensive conservation frameworks. The recognition of moths' ecological roles is crucial for the holistic management of pollination services and ecosystem resilience in rural Maharashtra.

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Conflicts of Interest

There are no conflicts of interest.

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