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Saudi Journal of Biological Sciences



# Original article

# Moth diversity, species composition, and distributional pattern in Aravalli Hill Range of Rajasthan, India

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### ARTICLE INFO

Article history: Received 12 April 2021 Revised 6 June 2021 Accepted 7 June 2021 Available online 15 June 2021

Keywords: Moths Species diversity Composition Abundance Diversity indices Aravalli Hill Range Rajasthan

# ABSTRACT

Moths are phytophagous, cosmopolitan, agricultural pests, night pollinators, chiefly nocturnal and potential bio-indicators. The current study will be the first report on species diversity, species composition, abundance, and distributional pattern of moth fauna in Aravalli Hill Range Rajasthan. During the survey period of 2018–2019, 758 specimens of moths were collected pertaining to 34 species, 26 genera belonging to 05 families, and 13 subfamilies from three different sites of Aravalli Hill Range. Based on the number of genera, family Sphingidae was most dominant with 9 genera, and family Crambidae was least dominant with 2 genera. Based on the number of species, the family Sphingidae was the most dominant, representing 13 species, followed by Erebidae representing 11 species, Saturniidae and Noctuidae with 4 species each, the least dominant was Crambidae with 2 species. The diversity indices for moths have been calculated for the first time from the Aravalli Range of Rajasthan. Across the survey, Simpson's Diversity Index (D'), Shannon Diversity Index (H'), Dominance & Evenness was calculated as 0.95, 3.3, 0.04, and 0.8, respectively, which reflects that moth fauna is diverse in the surveyed areas.

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#### 1. Introduction

Invertebrates' diversity plays a vital role in all ecosystems, e.g., species, population, and individual (Cardinale et al., 2006; Bashir, 2019; Shakeel, 2019). Members of Phylum Arthropoda play a pivotal role in ecological services (Rathore and Jasrai, 2013; Abou-Shaara, 2021; Karar, 2020). Besides most successful Phyllum, they dominate all types of habitats except for the oceanic benthic zone (Jamal, 2021; Abrol, 2019). Lepidoptera is one of the most diverse groups, representing 1,57,424 described species globally (van

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Nieukerken et al., 2011; Sajjad, 2019). According to a recent study, 1, 65,000 moths have been reported globally Khan and Perveen, (2015), among which 12,000 species of moths have been reported from India (Chandra and Nema, 2007).

Moths belong to Order Lepidoptera, characterized by drablycolored scales on the body, epiphysis on the foreleg, phytophagous and predominantly nocturnal nature. They are very sensitive to climate changes and vegetation alterations, making them an important group for monitoring climate and habitat changes (Thomas, 2005). They are also considered vital for ecosystem services because of various roles such as agricultural pests (Sharma and Bisen, 2013), food for mammals (Vaughan, 1997), birds (Wilson et al., 1999), and night pollinators (Macgregor et al., 2015).

The Aravalli Hill Range is the oldest folded mountain range of India, located at 25°00N 73°30E, starting from New Delhi, passes through Haryana, Rajasthan, and ends in Gujarat, covering about 800 km. This range's climate is sub-tropical, dominated by mixed forests such as tropical dry broadleaf forests and Kathiarbar-Gir dry deciduous forests. The variation in topographic conditions

https://doi.org/10.1016/j.sjbs.2021.06.018

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and climatic conditions results in diverse flora and fauna. Gupta and Thakur (1986) have reported 9 species under 9 genera and 5 families from various Aravalli Range of Rajasthan. Sharma (2011) has reported 31 species under 28 genera and 11 families from different regions of the Aravalli ranges of Rajasthan. Sharma (2014) has reported 56 species of moths under 45 genera and 11 families from different areas of Aravalli Hill Ranges of Rajasthan. Sharma and Srivastava (2010) have reported 21 species under 04 families from western Rajasthan. Present work was carried out in order to carry out to explore moth fauna from Aravalli Range.

In this research paper we are determining various factors such as diversity, richness and distributional pattern of moths in Aravalli Hill Ranges of Rajasthan. Species abundance is defined as the number of individuals per species, by virtue of abundance, total number of individuals per species is detected. Species richness represents the count of different species present in a particular community or habitat. More the species richness more will be the diversity of the region. Above mentioned both factors are shown in Table 2.

# 2. Material and methods

# 2.1. Survey area

Raiasthan is globally known for diverse flora and fauna. It's the driest region located in North West of India. The climate of Rajasthan keeps on changing throughout the state. The western part of the Rajasthan is dry and infertile, while as southern part is wet and hilly. Desert areas are included in the western part. Aravalli Hill is one of the oldest mountain ranges covering a distance of about 550 km in Rajasthan The climate of the Aravalli Hill Range of Rajasthan is a sub-tropical type characterized by winter, summer and monsoon seasons. It contains dry deciduous forests with tropical dry broadleaf forests that include teak, Acacia and other trees. The variety in climate and topographic conditions results in diverse flora and fauna. The maximum daytime temperature during the summer varies between 40 and 46 °C. During winter, its ranges between 1.5 and 4 °C. A maximum of 150 mm rainfall is received in the western part during the monsoon. In the eastern part, the temperature is cold due to the maximum of 400–450 mm rainfall received.

Three sampling sites were selected in it for the collection of moths. The three chosen places selected in Aravalli Hill Range are: Sariska Tiger Reserve, Nahargarh Biological Park, and Keoladeo National Park (See Table 1, Fig. 1).

Site A (Sariska Tiger Reserve): It's located in district Alwar of Rajasthan, India. The total area of this tiger reserve is 881 km<sup>2</sup>.

Site B (Nahargarh Biological Park): It is a part of the Nahargarh sanctuary, located 12 km from Jaipur. It comprises an area of 720 ha and is situated under the foothills of the Aravalli range.

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Overview of Sampling sites.

| Sampling sites                     | District  | GPS Coordinates        |
|------------------------------------|-----------|------------------------|
| Sariska Tiger Reserve (Site A)     | Alwar     | 27°23'30"N, 76°22'32"E |
| Nahargarh Biological Park (Site B) | Jaipur    | 27°00'56"N, 75°51'51"E |
| Keoladeo National Park (Site C)    | Bharatpur | 27°09'34"N, 7°21'23"E  |

Site C (Keoladeo National Park): It is located in district Bharatpur of Rajasthan. It is one of the important breeding sites for migratory and non-migratory birds. Approximately, 375 species of birds have been recorded here residing in different habitats inside the National Park

## 2.2. Collection and identification

All legal permits required for the collection of moths were authorized by Rajasthan Forest Department. Moths were collected weekly with the help of a Light trap and Light-sheet system from 9:00 pm to 2: 00 am. Light-sheet  $(7 \times 4 \text{ m})$  was operated by a Mercury Vapour lamp (250 W). A white sheet was hung between two nearby trees, and the light source was placed so that the whole sheet was brightly illuminated. Light-sheet was operated daily from 9:00 pm to 2: 00 am. A simple light trap was used for the collection of moths. It consists of a collecting chamber and a funnel placed above it. The collecting chamber was supplied with pieces of egg trays, so that moths can hide without damaging each other. It was also operated by a Mercury Vapour lamp (250 W). Light trap and light-sheet were operated on the same nights but at different places. Both of the setups were placed far from each other. Light trap resulted in catching of 278 specimens of moths while as light sheet system resulted in catching of 480 specimens of moths. Ethyl acetate fumes killed the collected specimens. Later on, specimens were stretched, pinned, dried, and stored in entomological boxes. The specimens were identified on the basis of morphological characters with the help of modern taxonomic keys. The classification system adapted as per van Nieukerken et al. (2011). The collected specimens were submitted in Departmental Museum of A.M.U, Aligarh. Diversity indices were calculated with the help of PAST 4.04 software.

## 2.3. Diversity indices

#### 2.3.1. Shannon Wiener diversity index (1963)

To calculate the diversity of moth fauna, Shannon index (H') as a measure of species richness and abundance was applied. Shannon index is derived using the following equation:

$$\boldsymbol{H} = -\sum_{i=1}^{s} \boldsymbol{p}_{i} * (\ln \boldsymbol{p}_{i})$$

where:

**H** = Shannon Wiener index for species diversity,

**S** = Number of species,

**P**<sub>i</sub> = Proportion of total sample belonging to the ith species, and **In** = Natural log

In addition, Simpson's index (D) and the Evenness index (E) are evaluated as a measure of species dominance and evenness, respectively (Magurran, 1988).

2.3.2. Simpson's index, Simpson index of dominance

$$SI = \sum pi^*pi$$

SI = Simpson's Index of species diversity,

Table 2

Species diversity, richness, evenness and abundance recorded for moth fauna of the selected sites in Aravalli Hill Range of Rajasthan.

| S. No. | Sites                     | Simpson's diversity index (D') | Shannon Weiner diversity index $(H')$ | Evenness (E) | Species richness | Abundance  |
|--------|---------------------------|--------------------------------|---------------------------------------|--------------|------------------|------------|
| 1      | Sariska Tiger Reserve     | 0.9096                         | 2.584                                 | 0.7795       | 17               | 256        |
| 2<br>3 | Nahargarh Biological Park | 0.9378                         | 2.935                                 | 0.7849       | 24<br>26         | 237<br>265 |



Fig. 1. Map of sampling area.

**S** = No. of species, and

**pi** = proportion of total sample belonging to the i<sup>th</sup> species As biodiversity increases, Simpson's Index decreases. Thus, to find out the clear picture of species dominance D' = 1

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– D or I/D is used.
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2.3.3. Simpson's diversity index

 $D^\prime = 1 - \sum pi \ast pi$ 

$$\mathsf{D}' = 1 - \sum \left( n/\mathsf{N} \right)^2$$

2.3.4. Evenness index (E)

# $E=H/H(max)=-\sum pi^*(ln\ pi)/ln\ S$

where Hmax is the natural logarithm of the total number of species.

# 3. Result

During the present investigation, 758 specimens of moths were collected belonging to 34 species under 26 genera, 5 families, and 13 subfamilies. The number of individuals of different species of moths are presented in Table 3 and 4. Out of 758 specimens of moths, 321 specimens belong to the family Erebidae, followed by 195 specimens belong to Sphingidae, 131 specimens to Noctuidae, 94 specimens to Crambidae, and 17 specimens to Saturniidae (Fig. 3,). Based on the number of species, the family Sphingidae was most dominant with 13 species, followed by Erebidae with 11 species, Saturniidae and Noctuidae with 04 species each Cram-

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Moth fauna recorded from the selected sites of Aravalli Hill Range of Rajasthan.

| S. No | Species                | Total no. of specimens | Subfamily      | Family      | Author and Year               |
|-------|------------------------|------------------------|----------------|-------------|-------------------------------|
| 1     | Creatonotos gangis     | 25                     | Arctiinae      | Erebidae    | Linnaeus, 1763                |
| 2     | Creatonotos interrupta | 22                     | Arctiinae      | Erebidae    | (Linneaus, 1767)              |
| 3     | Spilarctia mona        | 17                     | Arctiinae      | Erebidae    | Swinhoe, 1885                 |
| 4     | Uthesai pulchella      | 52                     | Arctiinae      | Erebidae    | (Linneaus, 1758)              |
| 5     | Eudocima materna       | 46                     | Calpinae       | Erebidae    | Linnaeus, 1767                |
| 6     | Eudocima phalonia      | 28                     | Calpinae       | Erebidae    | Linnaeus, 1763                |
| 7     | Dysgonia stuposa       | 36                     | Erebinae       | Erebidae    | (Fabricius, 1794)             |
| 8     | Erebus macropus        | 12                     | Erebinae       | Erebidae    | Linnaeus, 1768                |
| 9     | Asota ficus            | 23                     | Aganainae      | Erebidae    | Fabricius, 1775               |
| 10    | Asota sericea          | 36                     | Aganainae      | Erebidae    | Moore, 1878                   |
| 11    | Euproctis divisia      | 24                     | Lymantriinae   | Erebidae    | Walker, 1855                  |
| 12    | Acherontia styx        | 11                     | Sphinginae     | Sphingidae  | Westwood, 1847                |
| 13    | Acherontia lachesis    | 23                     | Sphinginae     | Sphingidae  | (Fabricius, 1798)             |
| 14    | Agrius convolvuli      | 15                     | Sphinginae     | Sphingidae  | Linnaeus, 1758                |
| 15    | Psilogramma menephron  | 8                      | Sphinginae     | Sphingidae  | (Cramer, 1780)                |
| 16    | Hippotion rosetta      | 9                      | Sphinginae     | Sphingidae  | (Swinhoe, 1892)               |
| 17    | Hippotion boerhaviae   | 12                     | Sphinginae     | Sphingidae  | (Fabricius, 1775)             |
| 18    | Daphnis nerii          | 38                     | Microglossinae | Sphingidae  | Linnaeus, 1758                |
| 19    | Nephele hespera        | 12                     | Microglossinae | Sphingidae  | Fabricius, 1775               |
| 20    | Hyles nervosa          | 19                     | Microglossinae | Sphingidae  | (Rothschild & Jordan, 1903)   |
| 21    | Theretra silthensis    | 21                     | Microglossinae | Sphingidae  | (Walker, 1856)                |
| 22    | Theretra alecto        | 14                     | Microglossinae | Sphingidae  | Linneaus, 1758                |
| 23    | Leucophlebia emittens  | 6                      | Smerinthinae   | Sphingidae  | Walker, 1866                  |
| 24    | Leucophlebia lineate   | 7                      | Smerinthinae   | Sphingidae  | Westwood, 1847                |
| 25    | Caligula lindia        | 4                      | Saturniinae    | Saturniidae | Moore, 1865                   |
| 26    | Actias selene          | 3                      | Saturniinae    | Saturniidae | Hubner, 1807                  |
| 27    | Anthereaea mylitta     | 4                      | Saturniinae    | Saturniidae | Drury, 1773                   |
| 28    | Anthereaea taprobanis  | 6                      | Saturniinae    | Saturniidae | Walker, 1854                  |
| 29    | Helicoverpa armigera   | 27                     | Heliothinae    | Noctuidae   | (Hubner, 1805)                |
| 30    | Adisura aktinsoni      | 21                     | Heliothinae    | Noctuidae   | Moore, 1881                   |
| 31    | Heliothis peltigera    | 38                     | Heliothinae    | Noctuidae   | Dennis & Schiffermuller, 1775 |
| 32    | Spodoptera litura      | 45                     | Noctuinae      | Noctuidae   | Walker, 1857                  |
| 33    | Diaphania indica       | 45                     | Spilomelinae   | Crambidae   | (Saunders, 1851)              |
| 34    | Spoloadea recurvalis   | 49                     | Pyraustinae    | Crambidae   | (Fabricius, 1775)             |
| Total |                        | 758                    |                |             |                               |

#### Table 4

Distribution of moth fauna in selected sites of Aravalli Hill Range of Rajasthan.

| S. No | Species                | Sariska Tiger Reserve | Keoladeo National park | Nahargarh Biological Park |
|-------|------------------------|-----------------------|------------------------|---------------------------|
| 1     | Creatonotos gangis     | _                     | +                      | +                         |
| 2     | Creatonotos interrupta | +                     | +                      | _                         |
| 3     | Spilarctia mona        | _                     | +                      | +                         |
| 4     | Uthesai pulchella      | +                     | +                      | +                         |
| 5     | Eudocima materna       | +                     | _                      | _                         |
| 6     | Eudocima phalonia      | +                     | _                      | _                         |
| 7     | Dysgonia stuposa       | _                     | +                      | +                         |
| 8     | Erebus macropus        | _                     | +                      | +                         |
| 9     | Asota ficus            | _                     | +                      | +                         |
| 10    | Asota sericea          | +                     | _                      | +                         |
| 11    | Euproctis divisia      | +                     | +                      | +                         |
| 12    | Acherontia styx        | +                     | +                      | +                         |
| 13    | Acherontia lachesis    | _                     | _                      | +                         |
| 14    | Agrius convolvuli      | +                     | _                      | +                         |
| 15    | Psilogramma menephron  | _                     | +                      | +                         |
| 16    | Hippotion rosetta      | +                     | _                      | _                         |
| 17    | Hippotion boerhaviae   | +                     | +                      | +                         |
| 18    | Daphnis nerii          | +                     | +                      | +                         |
| 19    | Nephele hespera        | _                     | _                      | +                         |
| 20    | Hyles nervosa          | _                     | +                      | +                         |
| 21    | Theretra silthensis    | +                     | +                      | _                         |
| 22    | Theretra alecto        | _                     | +                      | +                         |
| 23    | Leucophlebia emittens  | _                     | _                      | +                         |
| 24    | Leucophlebia lineate   | _                     | +                      | +                         |
| 25    | Caligula lindia        | +                     | _                      | _                         |
| 26    | Actias selene          | +                     | +                      | _                         |
| 27    | Anthereaea mylitta     | _                     | +                      | +                         |
| 28    | Anthereaea taprobanis  | _                     | +                      | +                         |

(continued on next page)

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Table 4 (continued)

| S. No | Species              | Sariska Tiger Reserve | Keoladeo National park | Nahargarh Biological Park |
|-------|----------------------|-----------------------|------------------------|---------------------------|
| 29    | Helicoverpa armigera | _                     | +                      | -                         |
| 30    | Adisura aktinsoni    | +                     | +                      | +                         |
| 31    | Heliothis peltigera  | _                     | +                      | +                         |
| 32    | Spodoptera litura    | +                     | +                      | +                         |
| 33    | Diaphania indica     | +                     | +                      | +                         |
| 34    | Spoloadea recurvalis | -                     | -                      | +                         |

(-) indicates absence of species from survey site, while as (+) indicates presence of species in a survey site.



Fig. 2. Species richness of moth fauna with reference to their Families in Aravalli Hill Range of Rajasthan.

bidae with 02 species (Fig. 2). Among subfamilies of Heterocera, subfamily Arctiinae was found to be most abundant with 116 specimens, and Saturniinae was least abundant with 17 individuals. Based on the number of genera, subfamilies Sphinginae and Microglossinae were most dominant with 4 genera each, followed by Arctiinae, Saturniinae, and Heliothinae with 3 genera each, followed by Erebinae with 1 genera subfamilies Aganainae, Lymantriinae, Smerinthinae, Noctuinae, Spilomelinae and Pyraustinae with 1 genus each. Among the subfamilies, subfamily Sphinginae was represented by 6 species; followed by Macroglossinae with 5 species; Arctiinae and Saturniinae each with 4 species; Heliothinae with 3 species; Calpinae, Erebinae, Aganainae and Smerinthinae each with 2 species; Lymantriinae, Noctuinae, Spilomelinae and Pyraustinae and Pyraustinae each with 1 species each (Fig. 4).

Uthesia pulchella was the most dominant species in terms of the number of individuals (52), followed by Spoloadea recurvalis with

321

350

300

250

200

49 individuals. Eudocima materna with 46 individuals, and the least dominant was Actias selene with 03 individuals. Most of the moth species were recorded during the Post-monsoon season followed by the pre-monsoon season. Across the survey, Simpson's Diversity Index (D'), Shannon Diversity Index (H'), Dominance & Evenness (E) was calculated as 0.95, 3.3, 0.04, and 0.8, respectively, which means that moth fauna is diverse. The maximum value of D' was recorded from Keoladeo National Park (0.9378), followed by Nahargarh Biological Park (0.9277), and the least value was recorded from Sariska Tiger Reserve (0.9096). The maximum value of H' was recorded from Keoladeo National Park (2.936), followed by Nahargarh Biological Park (2.935), and the least value was recorded from Sariska Tiger Reserve (2.854). Nahargarh Biological Park showed maximum species richness (26), followed by Keoladeo National Park (24), and the minimum shown by Sariska Tiger Reserve (17). The maximum abundance was recorded from Nahargarh Biological Park (265), followed by Sariska Tiger Reserve (256), and the least abundance was recorded from Keoladeo National Park (237). The Higher value of evenness was calculated from Keoladeo National Park (0.7849), followed by Sariska Tiger Reserve (0.7795), and the lowest value was calculated from Nahargarh Biological Park (0.7236) (Table 2).

## 4. Discussion

The Aravalli Hill Range of Rajasthan has diversified topography, consisting of different types of habitats for animals and plants to flourish and survive. Variations in slopes, wind velocity, angle of sunshine, altitudes and water percolation influence the vegetation of a particular type to grow. It consists of xeric and sparse vegetation having seasonal fluctuations in survival, growth and development. Climate and weather have a direct influence on the abundance and occurrence of moths. If all the climatic factors work in coordination, it will positively affect the abundance of moth species. High species diversity is found in high rainfall areas in India,

150 - 131 100 - 94 50 - 17 0 Erebidae Sphingidae Noctuidae Crambidae Saturniidae

195

Fig. 3. Species abundance of moth fauna with reference to their Families in Aravalli Hill Range of Rajasthan.



Fig. 4. Number of genera and species moth fauna with reference to their subfamilies in Aravalli Hill Range of Rajasthan.

and low species diversity is found in dry areas and low rainfall areas. The high species richness of Nahargarh Biological Park is due to the high rainfall received and thus results in maximum vegetation, followed by Keoladeo National Park, in which medium rainfall is received, and the lowest rainfall is recorded in Sariska Tiger Reserve, which is hot and dry as compared to other places mentioned above. Moreover, forest types in Nahargarh Biological Park and Keoladeo National Park are primarily of are tropical dry deciduous, and dominant plant species are *Anogeissus pendula*, *Boswellia serrata*, *Acacia catechu*, *Dendrocalamus strictus*, *Butea monosperma*, *Capparis* deciduas and Ziziphus *maturittiana* etc., and thus contributes to high species diversity than Sariska Tiger Reserve.

Moreover, among the collection, genus *Creatonotos, Spilarctia, Eudocima, Asota, Acherontia, Hippotion, Theretra, Leucophlebia* and *Anthereaea* dominate the fauna, each represented by 2 species, while as rest of the genus are represented by single species. In terms of species abundance, *Uthesia pulchella* was found to dominate the fauna (52 specimens) and the least abundant was *Actias selene* (3 specimens).

Results depict that Uthesia pulchella is widely distributed and most abundant species, followed by Spoloadea recurvalis, Eudocima materna, Spodoptera litura, Diaphania indica and the least abundant is Actias selene. Similar results are also shown by Hanski et al. (1993) and Gaston (1994) who provided correct explanations of a positive relationship between distribution and abundance of species. Among the selected sites, Keoladeo National Park's species diversity is highest because of the large number of vegetation and water resources. Also, this park serves as a breeding ground for birds, as this place is already colonized by water and vegetation. In contrast, Sariska Tiger Reserve is less diverse, maybe because absence of vegetation and dry forest cover. Variety of vegetation and minimum human interference is directly proportional to the abundance and diversity of moths because moths depend on vegetation, shrubs, herbs, and trees for food. Moths were seen in large number on the light sheet than a light trap because the light source used on the light sheet illuminated the large area, increasing the surface area for settling of moths.

## **Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Acknowledgement

Authors are thankful to Chairperson, Department of Zoology, Aligarh Muslim University, Aligarh for providing necessary facilities to carry out my research work. This work was funded by Taif University Researches Supporting Project number (TURSP-2020/139), Taif University, Taif, Saudi Arabia.

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