Diversity of Geometrid moths (Geometridae: Lepidoptera) in Kashmir valley, India

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ARTICLE INFO

Received : 27 July 2021
Revised   : 12 October 2021
Accepted : 24 October 2021
Available online: 11 February 2022

Key Words:
Diversity
Moth
Geometrid
Lepidoptera

ABSTRACT

A total of 2378 geometrid moth specimens were collected from four districts of Kashmir valley during 2018-2019, which comprised of 39 species belonging to 29 genera, 17 tribes and 4 subfamilies. Five species (Abraxas cashmiria sp. nov., Antiperenia pseudoalbinigrata sp. nov., Aspitates pseudogilvaria sp. nov., Chorodna Baramulia sp. nov. and Xenoplia kashmirensis sp. nov.) are reported for the first time from this area. Diversity indices was highest in Baramulla (H’ = 1.452760) lowest in Srinagar (H’=1.273559). Alcis repandata (Linnaeus) was found to be most dominant species (11.02%), while as Callipia vicinaria (Dognin) was found least dominant (0.25%).

Introduction

Lepidoptera is the largest insect order with approx. 1,57,424 described species worldwide (Van Nieukerken et al., 2011; Sajjad et al., 2019), out of which 100,000 are moths (Khan and Perveen, 2015) and remaining are butterflies. Family Geometridae (Inchworms or loopers), with approximately 23,002 described species (Nieukerken et al., 2011) is the second most diverse family of Lepidoptera, occurring worldwide except in the Polar Regions. Geometridae is a moth family, its species are nocturnal and tend to be more specific to certain habitats particularly at high altitudes (Axmacher and Fiedler, 2008). Geometrid moths (Lepidoptera: Geometridae) are mostly the forest pests of woody plants, agricultural crops, fruit-berry crops and feed mainly on the leaves of wide range of plants particularly trees and shrubs. Geometrids are abundant and diverse component of most forest ecosystems, this along with their weak flight ability and low propensity to migrate (DeWaard et al., 2011) make them excellent indicators of environmental quality (Kitching et al., 2001). The caterpillars are commonly known as loopers or inchworms because of their looping gait resulting from a reduced number of abdominal prolegs. Geometridae are generally secretive and cryptic insects, sometimes moths are green as the leaves on which they rest or have brown, grey and other colours forming mottled bark-like patterns of flecks and wavy lines. Their resting postures enhance camouflage, with the moths spreading their wings flat against the underside of leaves and the caterpillars are often twig-like (Pitkin et al., 2007). Many species are bright coloured, but most are drab. Frequently wavy lines transverse the wings but strong and distinct pattern occur often. The geometrids are characterised by the presence of a basal fork between vein A3 and A3 in the forewing and vein A1 is always absent. Almost 2041 species of geometrid moths are reported from India (Kirti et al., 2019) however, their extensive study has not been carried out from different regions of India as it is diverse country in terms of climate, Topography etc.
Material and Methods
Collection of specimens
For the collection of Geometrid moths from different locations of Kashmir valley various intensive and extensive tours were conducted from April 2018-Nov 2019. Adult geometrid moths were trapped with the help of light traps installed at different places during night time. For collection of specimens portable bucket type light traps fitted with 125 W mercury vapour lamp were used. Moths possess scaly wings which are very delicate and get damaged very easily, so as to avoid the wing damage due to overcrowding in the bucket type light trap, the mercury vapour lamp was hung in front of a white cloth sheet secured to a wall or directly over a plain white wall and moths sitting on the cloth or wall were quickly trapped with the help of wide mouth killing bottle containing benzene for quick killing of moths. Places were electricity was not available rechargeable lamps were used as light source for collection.
Selection of site:
The whole area of Kashmir valley is divided into three regions North Kashmir, south Kashmir and Central Kashmir. The collection was done from four districts of Kashmir namely Anantnag, Baramulla, Budgam and Srinagar, where Anantnag is in south, Baramulla in North, Budgam and Srinagar are in central part of kashmir. From each district two locations were selected, one in Forest ecosystem and other in Agri-Horti ecosystem i.e Verinag (1900 mt) and Achabal (1668 mt) from Anantnag; Drangbal (1650 mt) and Wadoora (1588 mt) from Baramulla; Shalimar (1609 mt) and Bemina (1583 mt) from Srinagar; Dodhpathri (2635 mt) and Ompora (1637 mt) from Budgam (Figure 1).

![Figure 1: Google image of study areas](image_url)

Processing and preservation
Collected moths after being killed with benzene or ethyl acetate vapours in killing bottles were transferred into butter paper envelops (to avoid scrapping off of wing scales which is an important morphological character of moths). In laboratory first specimens were placed over water soaked cotton in airtight petridish for
relaxation of muscles so that they can be stretched easily. Then specimens were properly stretched on wooden stretching board after pinning through the mid of mesothorax. Stretched specimens were then oven dried for 72 hours at 60°C and preserved in fumigated insect collection boxes. Each specimen was labelled properly with name, locality, date of collection, name of collector etc.

**Sorting of collected samples**

Collected adult moths were sorted on the basis of morphological characters like wing pattern, presence of tymphanum on its 1st abdominal segment, wing venation, antennae, thoracic markings, no. of tibial spur etc.

**Identification**

Sorted specimens were identified by comparing with available relevant literature e.g. The Moths of Borneo, Geometrid Moths of the World etc. To confirm the identification of moths, help was also sought from Dr. Jasbir Singh Kirti, PAU Patiala India who is presently working on family Geometridae in India. For identification moth genitalia were dissected and directly photographed by using stereo zoom microscope attached with digital camera (Olympus SZX16), however Adult moths were photographed with Nikon DSLR camera. Identification was confirmed by sending these photographs to above mentioned expert. Specimens were later deposited to museum of bio-systematic laboratory, Division of Entomology, SKUAST-K, Shalimar campus, Srinagar.

**Statistical analysis**

Diversity data of Geometrid moths was analysed for below mentioned indexes:-

1. **Index of species diversity (Shannan and Wiener, 1963).**

   \[
   \text{Index of species diversity (H')} = \sum \pi_i \log_{10} \pi_i
   \]

   Where
   
   - \( \pi_i = \) Important probability of each species (\( N_i/N \))
   - \( N_i = \) No. of individuals of one specie.
   - \( N = \) Total no. of individuals of all species

2. **Evenness index (Pielou, 1966).**

   \[
   \text{Evenness index (J)} = \frac{H'}{\log_{10} S}
   \]

   Where
   
   - \( H' = \) Shannon Wieners index
   - \( S = \) Number of species

**III. Index of dominance (Southwood, 1978)**

\[
\text{Index of dominance (D)} = 1 - J
\]

Where

- \( J = \) Evenness index

**IV. Relative Abundance (R)**

\[
R = \frac{n}{N}
\]

\( n = \) number of individuals in one species
\( N = \) number of individuals in all the species.

**Results and Discussion**

Total of 2378 geometrid moth specimens were captured from different selected locations of Kashmir valley. This total collection comprised of 39 species belonging to 29 genera, 17 tribes and 4 subfamilies which differed in both abundance and distribution (Table 1). Present results indicated that tribe Boarmiini was found most diverse at species level with 14 species followed by Ourapterygini with 6 species, Gonodontini with 3 species and Pseudoterpini with 2 species while as most of the tribes i.e Thinopterygini, Abraxini, Epionini, Aspitatini, Gnophini, Cidarini, Chesiadini, Larentini, Gonodontini, Baptini, Hemitheini, Stammodini and Scopulini were found to be least diverse with one specie each (Table 1).

Present investigation revealed that maximum number of species (35) were recorded from Baramulla followed by Anantnag (33) while as minimum (22) were recorded from Srinagar (Table 2). Further *Alcis repandata* (Linnaeus) was the most dominant species in terms of relative abundance (11.02%) followed by *Ascotis imparata* (Walker) (7.53%), while as *Callipia vicinaria* (Dognin) was found least dominant (0.25%) (Figure 1).

Diversity indices at various localities is framed in Table 2 which indicated that species diversity was found highest in Baramulla (\( H' = 1.452760 \)) followed by Anantnag (\( H' = 1.413907 \)) and lowest in Srinagar (\( H' = 1.273559 \)). Results of present study also revealed that evenness...
## Table 1: Classification of reported species.

| S.no. | Family     | Sub family     | Tribe          | Genus              | Species                                      |
|-------|------------|----------------|----------------|--------------------|----------------------------------------------|
| 1.    |            |                |                | I.                 | Alcis Curtis                                 |
| 2.    |            |                |                | II. Hypomecis      | Hubner                                       |
| 3.    |            |                |                | III. Arichanna     | Moore                                        |
| 4.    |            |                |                | IV. Antiperenia    | Inoue                                        |
| 5.    |            |                |                | V. Ascotis         | Hubner                                       |
| 6.    |            |                |                | VI. Lassaba        | Moore                                        |
| 7.    |            |                |                | VII. Chorodna      | Barlaum sp. nov.                             |
| 8.    |            |                |                | VIII. Psilacis     | Warren                                       |
| 9.    |            |                |                | IX. Aspitates      | Treitschke                                   |
| 10.   |            |                |                | XI. Abraxas        | Leach                                        |
| 11.   |            |                |                | XII. Psyra         | Walker                                       |
| 12.   |            |                |                | XIII. Ourapteryx   | Leach                                        |
| 13.   |            |                |                | XIV. Eutrapela     | Hubner                                       |
| 14.   |            |                |                | XV. Biston         | Leach                                        |
| 15.   |            |                |                | XVI. Thinopteryx   | Butler                                       |
| 16.   |            |                |                | XVII. Baptini      | Hubner                                       |
| 17.   |            |                |                | XVIII. Gonodontini | Stephens                                     |
| 18.   |            |                |                | XIX. Cidarini      | Warren                                       |
| 19.   |            |                |                | XX. Larentia       | Warren                                       |
| 20.   |            |                |                | XXI. Pseudoterpini | Moore                                        |
| 21.   |            |                |                | XXII. Hemitehini   | Stephens                                     |
| 22.   |            |                |                | XXIII. Sterrhinae  | Scopulini                                    |

### Ennominae

- **Boarmiini**
  - 1. *Alcis* Curtis
  - 2. *Hypomecis* Hubner
  - 3. *Arichanna* Moore
  - 4. *Antiperenia* Inoue
  - 5. *Ascotis* Hubner
  - 6. *Lassaba* Moore
  - 7. *Chorodna* Walker
  - 8. *Psilacis* Warren
  - 9. *Aspitates* Treitschke
  - 10. *Abraxas* Leach
  - 11. *Chorodna* baramulia
  - 12. *Medasina* albidaria
  - 13. *Antiperenia* pseudolimigata
  - 14. *Chorodna* selenaria
  - 15. *Ascotis* imparata
  - 16. *Lassaba* contaminata
  - 17. *Chorodna* baramulia
  - 18. *Psilacis* inceptaria
  - 19. *Antiperenia* pseudolimigata
  - 20. *Psilacis* inceptaria
  - 21. *Antiperenia* pseudolimigata
  - 22. *Psilacis* inceptaria
  - 23. *Antiperenia* pseudolimigata
  - 24. *Psilacis* inceptaria
  - 25. *Psilacis* inceptaria
  - 26. *Psilacis* inceptaria
  - 27. *Psilacis* inceptaria
  - 28. *Psilacis* inceptaria
  - 29. *Psilacis* inceptaria
  - 30. *Psilacis* inceptaria
  - 31. *Psilacis* inceptaria
  - 32. *Psilacis* inceptaria
  - 33. *Psilacis* inceptaria
  - 34. *Psilacis* inceptaria
  - 35. *Psilacis* inceptaria
  - 36. *Psilacis* inceptaria
  - 37. *Psilacis* inceptaria
  - 38. *Psilacis* inceptaria
  - 39. *Psilacis* inceptaria

### Geometridae

- **Larentiinae**
  - 1. *Alcis* variegata Moore
  - 2. *Alcis* repandata Linnaeus
  - 3. *Alcis* jubata Thunberg
  - 4. *Alcis* perspicuta Moore
  - 5. *Hypomecis* inscriptaria (Walker)
  - 6. *Arichanna* lapsaria (Walker)
  - 7. *Antiperenia* cordiforma (Inoue)
  - 8. *Antiperenia* pseudoalbinigra (Walker)
  - 9. *Ascotis* selenaria (Dennis and Schiffermuller)
  - 10. *Ascotis* imparata (Walker)
  - 11. *Lassaba* contaminata
  - 12. *Medasina* albidaria
  - 13. *Antiperenia* pseudolimigata
  - 14. *Psilacis* inceptaria
  - 15. *Aspitates* Treitschke
  - 16. *Abraxas* Leach
  - 17. *Chorodna* baramulia
  - 18. *Psila* bluethgeni (Pungeler)
  - 19. *Ourapteryx* pluristrigata
  - 20. *Ourapteryx* multistrigata
  - 21. *Ourapteryx* cashmisirensis
  - 22. *Ourapteryx* sambucaria
  - 23. *Eutrapela* clemataria
  - 24. *Lassaba* Leach
  - 25. *Biston* betularia
  - 26. *Biston* suppressaria
  - 27. *Thinopteryx* Butler
  - 28. *Lomographa* tributaria
  - 29. *Odontopera* Stephens
  - 30. *Tanaocenia* Warren
  - 31. *Xenoplia* Warren
  - 32. *Heterotera* inae
  - 33. *Callipus* Guenee
  - 34. *Photoscotosia* Warren
  - 35. *Aplocera* Stephens
  - 36. *Pingasa* Moore
  - 37. *Pachyodes* Guenee
  - 38. *Chlorissa* Stephens
  - 39. *Problepsis* Leederer
  - 40. *Problepsis* albidor (Warren)
Table 2: Diversity indices of geometrid moths in Kashmir valley during 2017-18.

| S. No. | District  | Total No. of Species | Diversity Index (H) | Evenness Index (J) | Index of Dominance (D) | Species Richness Index (M) |
|--------|-----------|----------------------|---------------------|-------------------|------------------------|---------------------------|
| 1      | Anantnag  | 33                   | 1.413907            | 0.931112          | 0.068887               | 11.028936                 |
| 2      | Srinagar  | 23                   | 1.273559            | 0.948702          | 0.051297               | 8.424395                  |
| 3      | Budgam    | 22                   | 1.284200            | 0.943066          | 0.056933               | 8.660293                  |
| 4      | Baramulla | 35                   | 1.452760            | 0.940865          | 0.059134               | 11.466336                 |

Figure 1: Relative abundance of studied geometrid moth species in Kashmir valley

Index, index of dominance and richness were 0.940865, 0.059134 and 11.466336 in Baramulla, 0.931112, 0.068887 and 11.028936 in Anantnag, 0.948702, 0.051297 and 8.424395 in Srinagar and 0.943066, 0.056933 and 8.660293 in Budgam district, respectively (Table 1). Family Geometridae is known for its major and minor pest species, caterpillars of this group occupy diverse habitats as external foliage feeders on trees, defoliators on forest trees, agricultural crops and fruit plants (Kirti et al., 2008). Not only these species act as plant pest but some were found to affect both domestic and wild animals. During the present course of study, extensive collection cum survey tours were conducted in four different districts viz, Anantnag (South Kashmir), Srinagar and Budgam (Central Kashmir) and
Figure 2: Photo images of Geometrid moths collected from Kashmir valley

1. Alcis variegata Moore
2. Alcis repandata Linnaeus
3. Alcis jubata Thunberg
4. Alcis perspicuata (Moore)
5. Hypomecis infixaria (Walker)
6. Arichanna Lapsariata (Walker)
7. Antipercnia cordiforma (Inoue)
8. Antipercnia pseudoalbinigrata sp. nov.
9. Ascotis selenaria (Denis & Schiffermuller)
10. Ascotis imparata (Walker)
11. Lassaba contaminata Moore
12. Chorodna baramulia sp. nov.
13. Medasina albidaria (Walker)
14. Psilalcis inceptaria (Walker)
15. Opisthograptis moelleri Warren
16. *Aspitates pseudogilvaria* sp. nov.
17. *Abraxas cashmiria* sp. nov
18. *Psyra bluethgeni* (Pungeler)
19. *Ourapteryx pluristrigata* Warren
20. *Ourapteryx multistrigaria* Walker

21. *Ourapteryx caschmirensis* Bastelberger
22. *Ourapteryx sambucaria* Linnaeus
23. *Eutrapela clemataria* (Smith)
24. *Cephis advenaria* Hubner
25. *Biston betularia* (Linnaeus)

26. *Biston Suppressaria* Guenee
27. *Thinopteryx crocoptera* (Kollar)
28. *Lomographa tributaria* (Walker)
29. *Odontopera bidentata* Clerck
30. *Tanaoctenia haliaria* (Walker)
| 31. | Xenoplia kashmirensis sp. nov. |
| 32. | Heterothera Quadrifulta (Prout) |
| 33. | Callipia vicinaria Dognin |
| 34. | Photoscotosia miniosata (Walker) |
| 35. | Aplocera plagiata (Linnaeus) |
| 36. | Pingasa ruginaria (Guenée) |
| 37. | Pachyodes amplificata (Walker) |
| 38. | Chlorissa viridata (Linnaeus) |
| 39. | Problepsis albidor (Warren) |
Baramulla (North Kashmir) of Kashmir valley and the total no of 39 species of adult moths belonging to 29 genera, 17 tribes and four subfamilies i.e. Ennominae, Larentiinae, Geometrinae and Sterrhinae of family Geometridae. All the species were identified with the help of electronic and non-electronic available Literature. Five species (Abraxas cashmiria sp. nov., Antiperenia pseudoalbinigrata sp. nov., Aspitates pseudogilvaria sp. nov., Chorodna Baramulia sp. nov. and Xenoplia kashmirensis sp. nov.) have been reported as new species. Present findings agree with those of Kumar et al. (2018) who conducted the study on biodiversity of geometrid moths in Himachal Pradesh, India to find the status of geometrid moths, during the study he concluded that collected geometrid moths belonged to 27 genera and three subfamilies Ennominae, Geometrinae and Sterrhinae. The subfamily Ennominae was represented with maximum species followed by the subfamily Geometrinae and the subfamily Sterrhinae. Also Walia (2005) published a list of 184 species of family Geometridae from Chandigarh and Himachal Pradesh and out of these, 86 species are under subfamily Ennominae, 46 species under subfamily Sterrhinae, 38 species under subfamily Geometrinae, 13 species belonging to 11 genera of subfamily Larentiinae and a single species under subfamily Desmobathrinae. In present study Alcis repandata (Linnaeus) was found most dominant species in terms of relative abundance (11.02%) followed by Ascotis imparata (Walker) (7.53%) while as Callipia vicinaria (Dognin) was found least dominant (0.25%). Present records further indicated highest species diversity in Baramulla (H’ = 1.452760) followed by Anantnag (H’=1.413907) and lowest in Srinagar (H’=1.273559).

Conclusion
This paper highlighted the diversity of Geometrid moths from the studied areas of Kashmir valley, total of 39 species are reported which belongs to 4 subfamilies. Alcis repandata (Linnaeus) was found most dominant (11.02%) and Callipia vicinaria (Dognin) was least dominant (0.25%). Diversity indices was highest in Baramulla (H’ = 1.452760) and lowest in Srinagar (H’ = 1.273559).

Acknowledgement
The present work was supported by the “Regional Training Centre for Pollination, Pollinators and Pollinizers” SKUAST-K Shalimar, India. We are highly thankful to them for providing us access to their well-equipped laboratory and for their moral support during the course of research.

Conflict of interest
The authors declare that they have no conflict of interest.
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