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# SPECIES DIVERSITY AND ABUNDANCE IN SUBFAMILY CATOCALINAE (NOCTUIDAE: LEPIDOPTERA) FROM KASHMIR HIMALAYA

*by*

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**Abstract**

Twenty-seven species of Catocalinae (Lepidoptera, Noctuidae) were recorded at four study sites during 2010-12. The survey yielded 564 individuals under 18 genera. The highest number of species (25) were recorded at Gulmarg with an altitudinal distribution ranging from 2500-4000m asl (above sea level) followed by 20 species at Pahalgam with an altitudinal range 2500-3500m asl. Eleven species from Yousmarg at 2500m asl and eight species were recorded at Srinagar at an altitudinal range 1400-2000m asl. Most of the species were observed during summer season with July being the peak. The moths were sampled with different types of light traps. The predominant species recorded throughout the investigation was *Drasteria cailino* (14.18%) followed by *Ophiusa triphaenoides* (10.28%) and the least abundant species recorded was *Ophiusa trapezium* (0.21%) of the overall catch respectively. The calculated value showed that the diversity and richness was highest at Gulmarg followed by Pahalgam and lowest at Srinagar. The population abundance of each species recorded was studied.

**Keywords** : Species Diversity, Catocalinae, Kashmir Himalaya

## Introduction

The Catocalinae are a predominantly tropical subfamily and are often traditionally taken to include the subfamily Ophiderinae. Together these two subfamilies account for over half of the species of world Noctuidae (Mathew 2001). It is widely distributed in India. At present the subfamily includes 90 genera and 130 species in India. Catocalinae are medium to large-sized moths, known for their cryptically patterned forewings and their brightly colored hindwings, which are boldly striped with red, yellow, orange, and white. Adults, like most moths, are nocturnal insects, resting by day on tree trunks where their dull colored forewings provide concealment from birds and other predators. *Catocala* moths are worldwide in distribution, mostly in temperate regions, with a few species found in Central America, Southeast Asia, and Formosa (Forbes 1954). Review of literature about *Catocala* species (Goater *et al.* 2003; Jordan and Warren 1909-1914; Kononenko 1990, 2005; Kononenko *et al*. 1998; Sugi and Owada 1982; Yoshimoto 1994) reveals that only a few species (*Catocala uljanae*) having plain hindwings have been known so far (Sinyaev 2007). Proboscis fully developed eyes naked, normal frenulum and retinaculum. Hindwing vein M--$_2$ strong arising close to the lower angle of cell. Mid tibiae spined. Second segment of labial palpi not thickened, Male genitalia with asymmetrical valvae and female genitalia with well developed genital plate. Catocalinae are a predominantly tropical dispersed subfamily and often traditionally taken to include the subfamily Ophiderinae. In Sir George Hampson's exhaustive treatise on the Indian series, moths' volumes (II & III. 1894-1895), he recorded the noctuid moths under ten subfamilies. Lafontaine and Fibiger (2006) divided the Catocalinae into 18 tribes. Kitching (1984) united Catocalinae

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(presence of spines on the mid-tibia) and Ophiderinae (absence of spines on the mid-tibia) into one group Catocalinae. However, Speidel *et al.* (1996) suggested a division of Catocalinae and Ophiderinae complex into two groups. The two subfamilies, Catocalinae (type genus *Catocala* Schrank) and Ophiderinae (type genus *Othreis* Hübner), are unified into one Catocalinae by the possession of a chitinous projection from the inner margin of the tympanal frame (Holloway 2005). Together these two subfamilies account for over half of the species of Noctuidae in the world. Francy and George (2005-2006) studied the genitalia morphology of some species of the subfamily Ophiderinae. He defined the uncus as well developed in all species of the subfamily Ophiderinae. Sivasankaran *et al* (2011; 2012) studied external genitalia morphology of the subfamily Catocalinae and presented new records of Catocalinae from the Tamil Nadu state and whole of India.

Catocalinae contains numerous agricultural pests, which are of considerable economic importance. The larvae feed on certain agricultural crops, a wide variety of trees, shrubs and a majority of them are associated with horticulture (Kenneth 2009). These include both defoliating larvae and fruit-piercing adults, with the occasional occurrence of both within the same genus or species. The defoliators affect both tree and field crops; some can have impacts on forest plantations. Many of the genera included in Catocalinae, particularly those in which the moths have relatively robust bodies, have been noted to feed as adults on fruits. Several species have a modified tongue to facilitate piercing mammalian skin and to suck blood. The larvae of four species, viz. *Achaea janata* (Linnaeus), *Achaea melicerta* (Linnaeus), *Parallelia algira* (Linnaeus), and *Parallelia stuposa* (Linnaeus), behave as semiloopers and damage castor. The bolls of American cotton are known to the seriously attacked by the larvae of *Mocis frugalis* (Fabricius). Besides this, quite a good number of species of this group has association with horticultural vegetation. Apart from this, the species *Lagoptera juno* (Dalman), *Pericyma glaucinans* (Guenée), *Pericyma umbrina* (Guenée) *Ophiusa trapezium* (Guenée) have also been recorded as fruit piercing moths. It may be noted that these moths cause so severe damage that entire orchards are almost or nearly destroyed (Banziger 1982).

The present study demonstrates the species diversity, richness and abundance in Catocalinae from four different location of Kashmir Himalaya.

## Material and Methods

**Study Area:**

**Gulmarg:** It is located at 34.05°N 74.38°E. It has an average elevation of 2,690 m (8,825 ft). With temperatures ranging from 25 to 30 °C, known for its vegetation and wildlife, is spread across an area of 180 sq. km and rests at an altitude of 2400 to 4300 m above sea level. A rich and varied flora and fauna are the main attractions of the Gul Marg Biosphere Reserve of Kashmir. Dominating in the rich green cover of the area are the conifers, accounting for over 90 percent of the vegetation. *Aesculus indica, Pinus griffithii, Cedrus deodara, Abies pindrow* etc consist of the major species. Embracing the ground of the Kashmir, Gulmarg Biosphere Reserve consisting of *Sorbaria tomentosa*, *Viburnum* spp., *Indigofera heterantha*, etc., along with the Dicotyledonus herbs.

**Pahalgam** is located at 34.01°N 75.19°E. It has an average elevation of 2740 metres (8989 feet). This world famous hill station is 95 km from Srinagar and only 45km from the District Head Quarter at Anantnag and located on the banks of river Lidder at an altitude of 7200 ft. from sea level. The area holds a rich cover of vegetation, the dominant forest consisting of conifers. The major shrubs are *Indigofera heterantha, Viburnum* spp., *Sorbaria tomentosa* etc. the ground cover is very rich and dicotyledonus herbs dominate; *Rumex patientia, Primula* spp., *Anemone* spp., etc. Betaab Valley is a very famous tourist spot situated at a distance of 15 kilometers from Pahalgam. The Valley is towards northeast of Pahalgam and falls between Pahalgam and Chandanwadi. The valley surrounded by lush green meadows, snow clad mountains and covered with dense vegetation.

**Yousmarg** is located at 33.83°N 75.30°E. It

has an average elevation of 2,396 m (7,861 ft),

a hill station in the western part of Kashmir Valley. It is situated 47 km south of Srinagar. It is an alpine valley covered with snow clad mountains and the meadows of Pine and Fir, It lies 13 km south of Charari Sharief a town of Budgam district of Jammu and Kashmir. It is situated at the bank of Doodganga River which is a tributary of Jehlum River. A popular tourist destination nestled within the magnificent Pir Panjal peaks, a sub range of Himalaya. It lies at an altitude of 2396 metres above sea level. The town of Yusmarg enjoys a sub tropical climate and the basic seasons in this town are those of summer and winter. The maximum temperature ranges around thirty degrees during and the minimum temperature ranges around eighteen degrees during the summer months. Temperatures start coming down only from September. Winters in the town of Yusmarg are during the months of October, November, December, January, February, and March. These months experience a maximum temperature of fifteen degrees (15°C) to eight degrees (8°C) and a minimum temperature of around minus two degrees (-2°C).

**Srinagar** is located at 34°52 243 N 74°472 243 E, It has an average elevation of 1,585 m (5,200 ft). The city is located on both the sides of the Jhelum River. The river passes through the city and meanders through the valley, moving onward and deepening in the Dal Lake. A wetland is situated near Srinagar (Hokersar). Hokersar is 14 km (8.7 mi) north of Srinagar, a world class wetland spread over 13.75 $km^2$ (5.31 sq mi) including lake and marshy area. Srinagar has a humid subtropical climate with a climate much cooler, due to its moderately high elevation and northerly position. The valley is surrounded by Himalayas on all sides. Winters are cool, with a January daily mean of 2.5 °C (36.5 °F), and temperature remains below freezing at night. Summers are warm with a July daily maximum of 30.1 °C (86.2 °F). The average annual rainfall is around 710 millimetres (28 in). Spring is the wettest season while autumn is the driest.

The study was conducted during 2010-12 at four different agro forestry habitats of Kashmir Himalaya, viz. Gulmarg, Pahalgam, Yousmarg and Srinagar with an altitudinal distribution ranging from 1400-4000m amsl and has resulted a total of 564 individuals of Catocalinae. Moths were collected with the help of six different types of light traps, *viz*. Bucket trap, Mercury trap, Modified Mercury trap, Ordinary light trap, Tube light trap and Mosquito killer trap. The moths coming to rest on the cloth were captured with the help of killing jars containing ethyl acetate and tetrachloroethane, some of the analyzed specimens have also been collected from street lamp lights or on flowers during the night by battery lamp. Photophilous moths were collected during nightfall and by night in both forest and crop areas. After killing the specimens were pinned and stretched properly and preserved in insect cabinets. The specimens were identified with the help of available literature and other electronic and non-electronic sources. The male genitalia of the species were dissected out for confirmation of species identification. For taxonomic study forewing and hindwing of each species were detached from the body of an adult by giving upward jerk followed by dipping into 70% alcohol for 1-2 minutes, then placing in sodium hypochlorite for 10-20 minutes depending upon the size of the insect for descaling, then transferring the wings into glacial acetic acid for 10 minutes, latter on into carbo-xylol for 15 minutes and mounted finally on a glass slides in DPX mountant. The other morphological features like head, legs, genitalia and antennae were dipped overnight or boiled for 20-30 minutes with 10% KOH solution to get the musculature sufficiently relaxed. Later on KOH was removed by washing the different parts in distilled water for 2 or 3 times. The dissection was performed within a cavity block, with the help of fine forceps and needles under an Olympus SZX7 binocular stereoscope microscope. The dissected body parts were transferred to acetic acid glacial in another cavity block for 10-15 minutes and finally transferred to carbo-xylol for 15 minutes. After clearing the body parts of specimen were mounted finally on a slide in DPX mountant and covered with cover slip. The drawing of wings was done on camera lucida attached to binocular

**Table 1 :** List of Catocalinae collected from different habitats of Kashmir Himalaya.

| S. No. | Scientific Name | Site-A Gulmarg | Site-B Yousmarg | Site-C Srinagar | Site-D Pahalgam | Total | % catch |
|---|---|---|---|---|---|---|---|
| 1 | *Achaea janata* (Linnaeus) | 5 | * | * | 3 | 8 | 1.42 |
| 2 | *Anomis guttanivis* (Walker) | 4 | 1 | 2 | 3 | 10 | 1.77 |
| 3 | *Anomis sabulifera* (Guenée) | 3 | * | * | 3 | 6 | 1.06 |
| 4 | *Arcte coerula* (Guenée) | 11 | * | 3 | 7 | 21 | 3.72 |
| 5 | *Artena dotata* (Fabricius) | 3 | 1 | * | 4 | 8 | 1.42 |
| 6 | *Batracharta* sp. | 12 | * | * | * | 12 | 2.13 |
| 7 | *Catocala nymphaea* (Esper) | 4 | 3 | * | 5 | 12 | 2.13 |
| 8 | *Catocala patala* Felder & Rogenhofer | 2 | 3 | 2 | 4 | 11 | 1.95 |
| 9 | *Drasteria cailino* (Lefebvre) | 27 | 16 | 11 | 26 | 80 | **14.18** |
| 10 | *Dysgonia analis* (Guenée) | 13 | 1 | 1 | 27 | 42 | 7.45 |
| 11 | *Dysgonia latifascia* Warren | 24 | 7 | 4 | 8 | 43 | 7.62 |
| 12 | *Eupsilia transversa* (Hufnagel) | * | 3 | * | * | 3 | 0.53 |
| 13 | *Grammodes geometrica* (Fabricius) | 19 | * | * | * | 19 | 3.37 |
| 14 | *Grammodes stolida* (Fabricius) | 4 | * | * | * | 4 | 0.71 |
| 15 | *Lygephila craccae* (Denis & Schiff.) | 14 | * | * | 17 | 31 | 5.49 |
| 16 | *Lygephila lusoria* (Linnaeus) | 2 | 3 | * | 4 | 9 | 1.59 |
| 17 | *Mocis discios* (Kollar) | 15 | 18 | 5 | 11 | 49 | 8.68 |
| 18 | *Mocis frugalis* (Fabricius) | 5 | * | * | 2 | 7 | 1.24 |
| 19 | *Ophiusa tirhaca* (Cramer) | * | * | * | 5 | 5 | 0.88 |
| 20 | *Ophiusa trapezium* (Guenée) | 1 | * | * | * | 1 | **0.18** |
| 21 | *Ophiusa triphaenoides* (Walker) | 9 | 12 | 19 | 18 | 58 | 10.28 |
| 22 | *Pericyma glaucinans* (Guenée) | 23 | * | * | * | 23 | 4.07 |
| 23 | *Pericyma umbrina* (Guenée) | 19 | * | * | * | 19 | 3.37 |
| 24 | *Spirama retorta* (Clerck) | 4 | * | * | 8 | 12 | 2.13 |
| 25 | *Thyas honesta* Hübner | 3 | * | * | 1 | 4 | 0.71 |
| 26 | *Thyas juno* (Dalman) | 5 | * | * | 3 | 8 | 1.42 |
| 27 | *Trigonodes hyppasia* (Cramer) | 26 | * | * | 33 | 59 | 10.46 |
| | ***Total*** | **257** | **68** | **47** | **192** | **564** | |

microscope. The photographs of genitalia and other parts were taken by the help of Olympus digital camera (CAMEDIA C-7070).

After identification of all the specimens the Species diversity index was calculated by using Shanon-Wieners Diversity Index. H = - " Pi (lnPi) and species richness [Ma] was computed by using formula Pielou (1966) Ma= S-1/---- Log--------$_{10}$N. The collected materials have been deposited in the Department of Zoology and Environmental Sciences, Punjabi University Patiala for future reference. The meteorological data for the period of study was taken from the meteorological observatories of the Department of Meteorology Srinagar Kashmir.

## Results and Discussion

The research studies were conducted from March 2010 to October 2012. Specimens of Catocalinae were captured with the help of six different types of light traps and the most effective trap through out the investigation was Modified Mercury trap with 33.9% of overall catch followed by Bucket type light trap i.e. 26.5% and Mosquito killer trap was found least effective with only 4.07% overall catch. A total of 564 specimens of the subfamily Catocalinae were captured representing 27 species from 18 genera inhabiting four different sites of Kashmir Himalaya (Table 1). Diversity and species richness were calculated by Shannon index (1948). The number of species differs in four different sites. The greatest number of species was registered in the forest areas of Gulmarg, Pahalgam and Yousmarg with 91.7% of overall catch (the apparent reason may be the high humidity, high temperature and with dense plantation causing the small scale dispersal of insects in forest area as revealed when sampling was being done in these areas) followed by crop area i.e. Srinagar with only 08.3% of overall catch. There was no significant difference of noctuid population in each month in crop area. According to number of genera, Gulmarg include 17 genera, Yousmarg (nine), Srinagar (seven) and Pahalgam (14) respectively. The results (Table 1.) revealed that Gulmarg (Site 'A') is predominating by 25 species of Catocalinae *viz., Achaea janata* (Linnaeus), *Arcte coerula* (Guenée), *Artena dotata* (Fabricius), *Batracharta* sp., *Catocala patala* Felder & Rogenhofer, *Catocala nymphaea* (Esper), *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Grammodes geometrica* (Fabricius), *Grammodes stolida* (Fabricius), *Lygephila craccae* (Denis & Schiff.), *Lygephila lusoria* (Linnaeus), *Mocis discios* (Kollar), *Ophiusa triphaenoides* (Walker), *Spirama retorta* (Clerck), *Thyas honesta* Hübner, *Thyas juno* (Dalman), *Trigonodes hyppasia* (Cramer), *Anomis sabulifera* (Guenée), *Mocis frugalis* (Fabricius), *Ophiusa trapezium* (Guenée), *Anomis guttanivis* (Walker), *Pericyma glaucinans* (Guenée), *Pericyma umbrina* (Guenée) covering 17 genera representing a total of 45.56% of the overall catch followed by Pahalgam (Site 'D') with 20 species viz., *Achaea janata* (Linnaeus), *Arcte coerula* (Guenée), *Artena dotata* (Fabricius), *Catocala patala* Felder & Rogenhofer, *Catocala nymphaea* (Esper), *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Lygephila craccae* (Denis & Schiff.), *Lygephila lusoria* (Linnaeus), *Mocis discios* (Kollar), *Ophiusa tirhaca* (Cramer), *Ophiusa triphaenoides* (Walker), *Spirama retorta* (Clerck), *Thyas honesta* Hübner, *Thyas juno* (Dalman), *Trigonodes hyppasia* (Cramer), *Anomis sabulifera* (Guenée), *Mocis frugalis* (Fabricius), *Anomis guttanivis* (Walker) under 14 genera with a total catch of 34.04%. Yousmarg (Site 'B') is dominating by eleven species *viz*., *Artena dotata* (Fabricius), *Catocala patala* Felder & Rogenhofer, *Catocala nymphaea* (Esper), *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Lygephila lusoria* (Linnaeus), *Mocis discios* (Kollar), *Ophiusa triphaenoides* (Walker), *Anomis guttanivis* (Walker), *Eupsilia transversa* (Hufnagel) covering nine genera representing 12.06% of the overall catch and Srinagar (Site 'C') is represented by eight species viz., *Arcte coerula* (Guenée), *Catocala patala* Felder & Rogenhofer, *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Mocis discios* (Kollar), *Ophiusa triphaenoides* (Walker), *Anomis guttanivis* (Walker) of Catocalinae under seven genera with a total catch of 8.33% respectively. Overall picture reveals that seven species *viz*., *Catocala*

*patala* Felder & Rogenhofer, *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenee), *Mocis discios* Kollar, *Ophiusa triphaenoides* Walker, *Anomis guttanivis* were common in all the study sites, however ten (10) species *viz*., *Artena dotata* (Fabricius), *Catocala patala* Felder & Rogenhofer, *Catocala nymphaea* (Esper), *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Lygephila lusoria* (Linnaeus), *Mocis discios* (Kollar), *Ophiusa triphaenoides* (Walker), *Anomis guttanivis* (Walker) were found common in Gulmarg (Site 'A') and Yousmarg (Site 'B'), eight species namely *Arcte coerula* (Guenée), *Catocala patala* Felder & Rogenhofer, *Drasteria cailino* (Lefebvre), *Dysgonia latifascia* Warren, *Dysgonia analis* (Guenée), *Mocis discios* (Kollar), *Ophiusa triphaenoides* (Walker), *Anomis guttanivis* (Walker) were common in Gulmarg (Site 'A') and Srinagar (Site 'C'), nineteen (19) in 'A' & 'D'. Seven species were found common in sites 'B' & 'C', ten (10) in 'B' & 'D' and eight species were found common among sites 'C' and 'D'.

The meteorological data were recorded to know the environmental impact on the dispersal and diversity of Catocalinae species. Temperature, humidity and rainfall data were taken for each census day and were averaged for each month. Meteorological data revealed that the moths coming to the light-trap during the months of June when the mean maximum temperature ranged from 27.2$^0$C and mean minimum temperature ranged from 8.3$^0$C. The period of peak activity of these moths was recorded during the month of July comprising a total catch (181) individual, 32.09% of the over all catch. The data also revealed that the maximum population of moths was within the range of one month, i.e. in the month of July and it has been further observed that the occurrence of Catocalinae remains active from June to October with peak emergence during July followed by August with 25.88 of the overall catch and was no more detected from ending October onwards Table 3. It is evident that mean maximum temperature and mean minimum temperature were the most favorable weather parameters during the month of July when the populations of these moths were recorded maximum. When the mean maximum temperature reached 21.3$^0$C and mean minimum temperature reached 3.2$^0$C during the month of October the population declined during the period under studies.

The present findings indicate that the mean maximum temperature 28.1$^0$C and mean minimum temperature 15.3$^0$C and average rainfall 10.1mm proved conducive for the multiplication of the moth species in particular areas. A slight fluctuation in monthly collected population was attributed to the ecological conditions i.e. the monsoon season and the rapid growth of plants and climatic factors caused the dispersal of insects within these agro-forest areas.

The species diversity Index and richness was found highest at site 'A' (1.261 & 24.585) and lowest at site 'C' (0.729 & 7.402) respectively (Table 2). Gray (1989) postulated that in habitats affected by increased disturbance, diversity

**Table 2 :** Species Diversity Index and Richness of Catocalinae collected from different habitats of Kashmir Himalaya.

| S. No. | Name of the Genera | No. of Species | No. of Individuals | Total No. of % catch | | Diversity (H) | Richness ma) |
|---|---|---|---|---|---|---|---|
| 1 | Site - A | 16 | 23 | 257 | 45.56 | 1.261 | 24.585 |
| 2 | Site - B | 9 | 11 | 68 | 12.05 | 0.855 | 10.454 |
| 3 | Site - C | 7 | 8 | 47 | 8.33 | 0.729 | 7.4019 |
| 4 | Site - D | 14 | 20 | 192 | 34.04 | 1.130 | 19.562 |
| | **Total** | 17 | 25 | **564** | | | |

A= Gulmarg; B= Yousmarg: C= Srinagar; D= Pahalgam

Table 3: Meteorological data during the study period.

should decrease; opportunist species should gain dominance and mean size of the dominant species decrease. Our results corroborate this hypothesis to some extent. The actual reason could be the disturbance through cultural practices; spraying, hoeing, pest scouting and monitoring, which cause a decrease in diversity in crop area. At site 'B' the diversity Index was 0.855 with species richness 10.454 and 1.130 & 19.562 at site 'D'. The calculated value showed that species diversity index of Catocalinae was found highest at site 'A' (1.261) followed by site 'D' (1.130) and it was found more sustainable at site 'B' as compared with site 'C'. The species richness was found highest at site 'A' (24.585) followed by site 'B' (10.454), site 'D' was next in the hierarchy of species richness (19.562), and the lowest species richness was observed at site 'C' (7.402) respectively.

*Drasteria cailino* (Lefebvre) was found most dominant species at sites 'A', *Mocis discios* Kollar at site 'B', *Ophiusa triphaenoides* Walker at site 'C' and *Trigonodes hyppasia* (Cramer) at site 'D'. Diversity is the niche time stability dependent i.e., if a large number of niche is present it will support higher diversity. Generally heterogeneous conditions yield higher diversity while as homogenous conditions yield low diversity. The most abundant species recorded throughout the present investigation was *Drasteria cailino* (Lefebvre) representing 80 individuals at all study sites followed by *Trigonodes hyppasia* (Cramer) with 59 individuals and the least abundant species recorded so for viz; *Ophiusa trapezium, Eupsilia transversa and Thyas honesta* representing one, three and four individuals respectively.

## Conclusion

We just shed some light to one part of the diversity and richness of Catocalinae of Kashmir Himalaya. The research is definitely not finished, but has just begun. Our paper shows the current Species Diversity Index of the subfamily Catocalinae (Noctuidae) in four different study sites of Kashmir Himalaya and indicates the need for further explorations and studies. Generally speaking, it can be asserted that the noctuid fauna of Kashmir Himalaya has not been thoroughly studied. The total number of species of these moths in Kashmir Himalaya (27) is smaller. Future investigations should be intensified in different far flung area rich in flora, river valleys and marsh areas etc where additional findings of the species new for the country are expected. We therefore feel that the total number of Catocalinae species in Kashmir Himalaya is in reality considerably greater, something that future extensive and intensive investigations should confirm.

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