Insect pollinator's community structure in different habitats of Shivapuri–Nagarjun National Park, Nepal

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October 6, 2021

Abstract

Insect pollinators are important means for a stable ecosystem. The habitat types play a crucial role in the community composition, abundance, diversity, and species richness of the pollinators. The present study in Shivapuri–Nagarjun National Park explored the species richness and abundances of insect pollinators in four different habitats and different environmental variables in determining the community composition of the pollinators. Data were collected from 1500 m–2700 m using pan traps and hand sweeping methods. Non-metric multidimensional scaling (NMDS) and redundancy analysis (RDA) were conducted to show the association between insect pollinators and environmental variables. The results firmly demonstrated that species richness and abundances were higher in open trails compared to other habitats. The distribution of the pollinator species was more uniform in the open trail followed by the grassland. Similarly, a strong positive correlation between flower resources and pollinator's abundance was found. In conclusion, the open trail harbor rich insect pollinators in lower elevation. The community structure of the pollinators was strongly influenced by the presence of flowers in the trails.

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KEYWORDS Community composition; Open trail; Pollinators; Shivapuri–Nagarjun National Park; Species richness

1. INTRODUCTION

Pollinators are important agents for a stable ecosystem (Kremer, 2008; De Groot et al., 2010). They enhance pollination for both wild and flowering plants and also help humans to increase agricultural production (Kevan et al., 1990; Corbet et al., 1991; Widhiono et al., 2016). These insects also benefit the economic, aesthetic, and cultural aspects of mankind (Gill et al., 2016). In general, social and solitary bees, butterflies and moths, beetle and flies account as dominant pollinators (Vanbergen and Initiative, 2013; Wojcik, 2021).

Most of the cultivated plants around the world are pollinated by bees (56.5%), flies (19%) and, butterflies (4%) (Bashir et al., 2019). Honey bees are well-known insects in comparison to wild pollen bees (Losey and Vaughan, 2006; Potts et al., 2010) while flies and butterflies are less known. (Jennersten, 1984; Larson et al., 2001). Pollinators decline is a globally recorded phenomenon (Carvalho et al., 2013; Dirzo et al., 2016). Especially, bumblebees (Fitzpatrick et al., 2007; Cameron et al., 2011), butterflies (Warren et al., 2001; Van Swaay et al., 2010), and honeybees (Vanengelsdrop et al., 2008) population is shrinking in the world due to natural as well anthropogenic threats. The major drivers of pollinator loss are recognized as habitat loss, landscape modification, intensification in agriculture, and even climate change (Kearns et al., 1998; Potts et al., 2010; Kovács-Hostyánszki et al., 2017). Hence, maintaining pollinator diversity in the given landscape requires an understanding of a clear pattern of pollinator diversity along with the habitat types.

The community composition of pollinators depends upon the local environment (Williams et al., 2010). The activity of pollinators is strongly correlated with air temperature; bees and butterflies prefer warmer temperatures than flies (Kuhse & Bluthgen, 2015), plant species richness (Hudewenz et al., 2012), and elevation; Hymenoptera is dominant pollinators in lowland while Lepidoptera and Diptera dominate at high land (Warren et al., 1988). They require a range of habitats for fulfilling their ecological requirements. However, these ecological demands for insect pollinators are mostly species or guild-specific (Proesmans et al., 2019). Bees prefer to forage the flower plants close to the nesting area (Gathmann and Tschardt, 2002; Greenleaf et al., 2007). Hoverflies and butterflies do not construct the nest and fly away from the egg-laying areas for foraging. Aphidophagous hoverflies such as *Episyrphus*, *Sphaerophoria* depend on agricultural habitat (Jauker et al., 2009; Pinheiro et al., 2015), while saproxylic hoverflies (*Xylota*) are benefitted from the forest (Reemer, 2005), hence, strongly associated with them. Butterflies forage varieties of flower for nectar (Tiple et al., 2005) and can make the flight over greater distances (Herrera, 1987). Such movement may show the selection of varied nutrition of butterflies; pollen (Gilbert, 1972), tree sap, rotting fruit, and dung, decaying flesh, and dissolved minerals in wet sand or dirt. Additionally, oviposition-plant location signifies habitat selection for smaller and less mobile butterflies, such as the "blues," while the larger butterflies like *Erebia epiphodea* and *Colias* probably have fairly large ranges of the search for their widespread ovipositing plants (Sharp et al., 1974). Bee's community structure is also designated by the availability of the nesting substrates. Bee species construct the nest in deadwood (Sydenham et al., 2016) and in the soil of sun-exposed ground (Everaars et al., 2011). So, habitat sharing among the pollinators is obvious. The habitat types play a crucial role in the community composition, abundance, diversity, and species richness of flowering plants and hence the pollinators.

Few studies were found on the study of insect pollinators in different habitats of National Park. We hypothesized that the visit of insect pollinators depends on the floral diversity found in the given habitats. The presence of these plants is strongly influenced by habitat types and elevation. The general understanding is that the natural habitat, if free from pesticides, will probably possess more diversity than the managed habitat. However, the habitat heterogeneity would also affect the pollinator community as the interaction plant–pollinator is specific (Weibull et al., 2000; Rundlof et al., 2008; Oliver et al., 2010).

Similarly, we examined species richness, abundance and, the community composition of insect pollinators in different habitats along the elevation gradient. The pollinator survey was carried at Shivapuri–National Park (SNNP) including managed habitats of buffer zone areas. The research questions were designed to find whether the pollinator composition (richness, abundance, and their association) differs from the defined habitats (grassland, managed area, open trails, and trails of forest) of SNNP. ‘Is pollinator composition influenced by the elevation gradient at the landscape?’

2. MATERIALS AND METHODS

2.1 Study Area

Shivapuri–Nagarjun National Park (SNNP) (Figure 1) is the only protected area in the mid–hill region of Nepal. The Park covers an area of 159 square kilometers with a buffer area of around 118.61 square km. It lies within 27deg45’ to 27deg52’ N latitude and 85deg16’ to 85deg45’ E longitude. It has an altitude ranging from 1360–2732 m ASL. The Park is rich in freshwater resources with abundant biodiversity, and cultural heritage (SNNP, 2017). The park possesses a subtropical to warm temperate with average maximum and minimum temperature of 19.9degC and 11.15deg respectively with the mean annual precipitation of 236.5 mm (Climatic data from 1985 to 2017 AD, Department of Hydrology and Meteorology/ DHM).

The mountainous topography of SNNP with steep slopes of > 30% uses a pattern that constitutes 74.45% forest, 20.45% shrub land, 3.22% grassland, 1.80% cultivated area, and 0.055% other features (SNNP, 2017). Different forest types are present under different altitudes of the Park; Lower Mixed Hardwood, Chir pine Forest, Oak Forest, and Upper Mixed Hardwood Forest (Amatya, 1993). The major tree species are *Schima wallichii*, *Alnus nepalensis*, *Castanopsis* spp., *Myrica esculanata*, *Madhuca indica*, *Pinus roxburghii*, *Pyrus pashia*, *Aesculus* sp., *Acer* sp., *Salix* sp., *Lithocarpus* sp., *Ilex diphyrena*, etc.

2.2 Sampling Sites

We identified five representative study sites across the national park. The sampling blocks were Sundarijal, Shivapuri, Gurjebhanjyang, Nagarjun, and Manichud areas within the SNNP. Each site was sampled in three elevation transects based on forest type; lower transect occurred between 1500 m–1700 m, middle transect at 1800 m–1900 m, and upper transect at 2000 m–2700 m. In each elevation, 25 line transects each of 100 m X 5 m with 100 m inter transect distance was fixed. Four types of habitats; forest trail (FT), grassland (GL), trails of the managed habitat (MH) and the open trail of the forest (OT), that fall under transect were surveyed. Forest habitat is denoted as the forest with canopy coverage of more than 70% with a walking trail of 15 m width. Grassland habitat is an herb–dominated in the transect with sparsely located trees. Open trail habitat of the forest meant the area with no tree coverage within 15 m width on either side of survey transect. The open trail of managed habitat is the transect along walking trail of managed habitat with no canopy tree within 15 m width of the trail. Managed habitat incorporates the buffer zone area of the National Park. The area is a human settlement with cultivated lands. The major crops cultivated during spring are Mustard and coriander while mustard, buckwheat, balsam apple, and squash are in autumn.

2.3 Pollinators’ sampling

Pollinators here mean flower–visiting and nectar–feeding insects. The transect line was fixed in walking trail of forest, open forest, and managed habitat, while in the grassland transects were drawn in the edge and the middle of the grassland with 20 m inter transect distance (Stanley, 2013).

The survey was performed in the spring and autumn seasons for the consecutive years 2018 and 2019. In

each season, the pollinators were sampled for 3 consecutive days in sunny weather between 9 am to 4 pm (Pollard and Yates, 1994). The pollinators were collected by using hand sweeping and color pans. White, Yellow, and blue color pans were used for insect sampling. During each sampling day, a transect walk of 30 minutes was done along the 100 m of the trail in the open trail of the forest, forest trail, and trails of the managed habitat, while in grassland the transect walk was made in the edge and the middle (Stanley, 2013). The transect walk method was used to sample butterflies (Pollard & Yates, 1994), bumblebees (Fussell and Corbet, 1992), hoverflies, and other bees (Proesmans et al., 2019). During the walk, insect pollinators that were feeding on flowers within 2m of the observer were captured, identified, and released (Sutherland, 1996). In the case of the butterfly, they were observed and identified during flight and basking within the line transect. Unidentified insect pollinators were collected in separate vials, transferred in the icebox, and brought to the lab for identifications.

Similarly, pan traps were deployed in each transect. This method aided in simultaneous sampling multiple locations, coverage of a large number of sites, and is the efficient method of bee sampling (Westphal et al., 2008; Neilsen et al., 2011). The pans were plastic bowls of about 15 cm diameter and painted with non-toxic three different colors; white, yellow, and blue (LeBuhn et al., 2003). Each pan was attached to a post using a metal clamp adjusting bowl the rim. The pan was filled with about 400ml of detergent water. Three posts were deployed in 100 m distance and 20m apart from each other. The traps were visited for collecting the fallen insects after 24 hours and were transferred in labelled vials with 70% ethanol.

2.4 Flower Survey

The flower survey was carried out in the spring and autumn season during the pollinator survey in the same transect. We made five quadrates of 10 m X 5 m in each sampling transect. For estimation of flower resource abundance, we scanned insect pollinating herbs and shrubs in each quadrate and identified genus and species levels. The cover of floral resources in each quadrate was ranked between 1– 6 (Szigeti et al., 2016). Rank 1 indicates very scarce, 2 for scarce, 3 for more or less scarce, 4 for more or less abundance, 5 for abundance, and 6 indicates extremely abundance. The flower resource abundance for each sampling transect was calculated as $FLOWER = \sum_{i=1}^n t_i \cdot taxon_i$ (t_i = mean of the rank of flowering plant of each transect).

2.5 Identification of Insect Pollinators

All the insect pollinators were identified to species level in the laboratory using relevant keys from adjacent regions. Bingham, 1897; Tadauchi & Matsumura, 2007; Williams et al., 2010; Imran et al., 2016; Aslam et al., 2017; Ngat et al., 2017, and Kumari et al., 2018 for bee specimens. Brunetti, 1923; Ghorpade, 1994, 2016; Claussen & Weipert, 2003; Subhan, 2016; Sengupta et al., 2017; Hassan et al., 2019, 2020; Sankararaman et al., 2020 for hoverflies and Smith, 2011 for butterflies specimen's identification.

2.6 Statistical analysis

For each habitat type and season, we decided the cumulative species richness and species abundance across all samplings and assembled the community matrix. Pollinator's richness and abundance were compared between different habitats and seasons, using linear mixed-effect models with habitats and seasons as predictor variables and pollinators as response variables. The statistical analysis was performed in R, version 4.0.3. Tukey's test was carried out to find significance.

PAST. Paleontological Statistics (Hammer et al., 2001) Version 3.17 computed the diversity indices. Random matrices with two samples are generated, each with the same row and column totals as in the original data matrix which provided the significance of diversity between groups.

Pollinator's community compositions of different habitats (FT, GL, OT, MH) were analyzed by Non-metric Multidimensional Scaling (NMDS) of the abundance data employing the function meta MDS which is incorporated in the statistical package Vegan (Oksanen et al., 2013) and NMDS result with sample plots of different abundance scores was fitted with different habitats using the package 'ggplot2' (Wickham, 2016).

NMDS was followed by statistical analyses: Adonis (Permutational Multivariate Analysis of variance), ANOSIM (Analysis of similarities), and SIMPER (Similarity Percentage Analysis).

Adonis was carried out following NMDS to analyze statistically if the pollinator community differs between the habitats. It provides the p -value to determine the statistical significance. ANOSIM, on the other hand, was used to determine if the differences of pollinator's community between the habitats are significant. In addition to the significant difference tests, Simper analyses were used to identify those species that contributed most to the observed pollinator's community differences (Clarke & Gorley, 2001).

To find relations between the environmental variables and the species composition, ordinations were performed on insect pollinators. For the pollinator community, a detrended correspondence analysis (DCA) was carried out to decide whether unimodal or linear ordination methods were appropriate (LepVs & VSmilauer, 2003). Based on this data, a redundancy analysis (RDA) was carried. Environmental variables were backward selected ($p < 0.05$) using the 'ANOVA'. A Monte Carlo permutation test with 999 iterations was used to assess the significance of the ordination.

NMDS, RDA, and all of the three procedures (Adonis, ANOSIM, and SIMPER) were carried out in software R 4.0.3 using the "vegan" package (Oksanen et al., 2013).

Venn diagrams showing the species sharing between the habitats were performed in R by using the "Venn Diagram" package employing the function `draw. venn`.

3. RESULTS

3. 1 Insect Pollinators in Shivapuri–Nagarjun National Park

A total of 8720 insect pollinators (Supplementary 1) were identified from both pan (1339) and sweeping net (7381). The butterfly with the most dominant species (48.5%) followed by a bee (29.9%) and hoverfly (21.5%). Over 60 flower herbs and shrubs were recorded from both sampling seasons in both years (Supplementary 2). The abundance of floral resources varied between habitats, elevation, and seasons (Supplementary 3).

3. 2 Abundance and Species richness of insect pollinators in different habitats

Species richness and abundances were higher in open trails than in other habitats (Figure 2). There is a significant difference in species richness and abundance among habitats (Table 1, Tukey's test, $P < 0.05$).

3.3 Analysis of Diversity and Richness of Pollinators Communities

Diversity indices (Species richness, Shannon index) show that the open trail is comparatively more diverse, followed by the managed habitat (Table 2). The distribution of the pollinator species was much even in the open trail followed by Grassland. The species richness and Shannon Index is significant (t -test, $p < 0.05$) in all of the habitats types. Similarly, similar evenness is observed in Forest trails and Grassland.

The highest number of species was found in the open trail (158), followed by the managed habitat (124), forest trail (103), and grassland (92). 61 species were common in all of the habitats, while the number of species exclusively found in one of the habitats was 12 for OT, 6 for FT, and 3 for MH (Figure 3). While comparing two types of habitats, the High number of habitats sharing of species was found between Open trail and Grassland (121) followed by Grassland and Forest trail (97), Managed habitat and Open Trail (82), and Grassland and Open Trail (68).

3.4 Analysis of the Community Composition of Insect Pollinators

The distance matrix of Bray–Curtis dissimilarity was calculated in R to plot non-metric multidimensional scaling (NMDS) to analyze Insect pollinator communities in four studied habitats (forest trail, grassland, managed habitat, and open trial). A stress value of 0.15 cleared convergence of NMDS ordination. Vector fitting of environmental variables showed that elevation, humidity, atmospheric temperature, and flower resource abundance were significant (Table 3; Figure 4). Flower possessed the significantly high NMDS1 score value of 0.615 ($P < 0.001$, $R^2 = 0.63$, Table 3). Elevation and humidity were significantly negative with NMDS1 score values -0.508 ($P = 0.009$, $R^2 = 0.67$) and -1.00 ($P = 0.036$, $R^2 = 0.05$) respectively. The highest compositional abundances of species were found associated with the flower which was at lower elevation

(Positive end of NMDS1). Similarly, high species compositional abundance was seen in the managed habitat and open trail (Positive end of NMDS1) which were again at low elevation.

Pollinators composition in four habitats are significantly different (Adonis, $p < 0.001$) with a significantly strong strength (ANOSIM, $R=0.6164$, $p < 0.001$). Simper analysis showed that *Xylocopa tenuiscapa* (0.7036), *Danaus genutia* (0.6975), and *Pelopidas agna* (0.6851) were three species for different compositions between Forest trail and Managed habitat. Similarly, *Ceratina denticeps* (0.7043), *Xylocopa tenuiscapa* (0.6930), *Graphium sarpedon* (0.6873) were three species for the difference in composition between Forest trail and Open trail. Further, *Syricta orientalis* (0.7019), *Eoseristalis himalayensis* (0.6942), *Lasioglossum albipes* (0.6864) were three species to contribute to the difference in the composition between forest trail and grassland. In managed habitat and open trail *Andrena kathmanduensis* (0.7034), *Neptis hylas* (0.6983), and *Andrena gorkhana* (0.6931) were three species to alter the pollinator's composition while *Elaphropoda impatiens* (0.7048), *Lethe verma* (0.6977) and *Precis iphita* (0.6909) in managed habitat and grassland. In the open trail and grassland *Eristalinus taeniops* (0.7007), *Pieris brassica* (0.6950), and *Graphium sarpedon* (0.6834) were three species indifferent in the composition.

3.5 RDA analysis

The DCA of the insect pollinator community projected a gradient length of 2.4 indicating RDA was the appropriate ordination method. Environmental factors; Elevation and flower resource abundance was found to be the significantly associated environmental factor for the pollinators (ANOVA, $p < 0.05$) (Table 4) The relation of the top 15 most abundant pollinators 9 five from each group) with these significant environmental variables are shown in RDA (Figure 5). Two canonical axes of RDA analysis explained the variance by 12.828 % in the pollinator–environmental interaction where the first axis and second axis accounted for 2.118 % and 10.71% of the variance respectively. Managed habitat types represented the higher abundance of flowers associated with the high number of *Apis cerana* and *Apis mellifera*. On the other hand, *Pieris canidia* was found associated with both open trail and grassland and *Vanessa cardui* in a managed habitat. *Bombus eximius*, *Bombus flavescens*, *Eristalis tenax*, and *Ypthima baldus* were more associated with the forest trail which was relatively humid area. Likewise, *Melanostoma univittatum* and *Episyrphus viridaureus* were associated with the open trail whereas *Episyrphus balteatus* was close to grassland and managed habitat.

4. DISCUSSION

4.1 Species richness and abundance of pollinators in different habitats

Habitat types influence the species richness and abundance of insect pollinators. They are the highest in the open trail of the forest. In our study, species richness and abundance seem to have a direct relation to flower abundance. The abundance of flowers plays an important role in all flower visitors (Sjödin et al., 2008). The open trail of forest harbor, a comparatively thick layer of herbs and shrubs with varieties of wildflowers that suffice pollinators with nectar and pollen source. The quality and quantity of nectar and pollen matter a lot for the pollinators (Hicks et al., 2016). Trails of open forest were densely proliferated and covered by *Ageratin aadenophora* along with other wild herbs providing good resource plate form, especially for hoverflies and bees. Furthermore, weeds like *Ranunculus repens* and *Trifolium repens* were comparatively more abundant in the open trails. These flowers were preferred by bees and butterflies (Hicks et al., 2016; Chaguthi & Dyola, 2019). These plants can provide nectar and pollen to these insects (Erbar & Leins, 2013; Master & Emery, 2015). Adult, hoverflies require high energy for hovering flight that could be obtained from the local landscape with abundant flowers (Haslett, 1989; Meyer et al., 2009; Proesmans et al., 2019). In contrast, scanty flower resources also account for the decline in pollinator species richness and abundance in forest trails with canopy. Canopy cover increases shade in the understory herb and shrub of the forest lowering flower blooms and limiting pollinator's movement (Proesmans et al., 2019). Sampled areas of the managed habitat in SNNP were open and inhabited by humans and disturbed by some human activities. Some previous study also shows that diversity of butterfly is negatively influenced by this factor of human disturbances (Kambach et al., 2013).

4.2 Diversity and habitat sharing between pollinators

Among all pollinators, 61 species (Figure 3) were common in all the studied habitats which show the heterogeneous habitat choice of wild bees and wider temporal range of activities of flies (Willcox et al., 2019). Hoverflies feed on varieties of food resources in different stages of life. For instance, the larva of some hoverfly develops in a close canopy while adults of the same fly hover in open flower-rich biotopes (Gittings et al., 2006). Furthermore, the abundance of hoverflies increases with proximity to the forest (Laura Moquet et al., 2018). Likewise, many bee groups require different habitats for nesting and foraging (Franzén et al., 2009) and also different spatial foraging distances made by bees like *Bombus* spp. and *Xylocopa* spp. (Greenleaf et al., 2007). This could be a probable reason for the presence of some bees group in all habitats. Butterflies too show a different kind of preference of habitats in their life cycles (Janz, 2005). Females dwell in grassland for oviposition while foraging in flower-rich habitats (Evan et al., 2020). In contrast, some pollinators are confined to only one kind of habitat. For an instant, *Vollucella trifasciata* and *Bachha maculata* were recorded from forest habitats only. This result can be linked with the findings of Coe, 1964.

4.3 Analysis of the community composition of Insect pollinators

The measured environmental variables (Elevation, humidity, air temperature, and flower resource abundance) are found to have a significant association with the pollinator's community. Species abundance of pollinators was concentrated in the managed habitat and open trails which were open to the high amount of solar exposer. Activities of the insect pollinators are also highly influenced by such sun exposures (McKinney & Goodell, 2010; Sydenham et al., 2016). Similarly, flower resource abundance was the next positive influencing factor for insect pollinators. The mixture of wildflowers could be a good attraction for all these pollinators as this kind of relation of a different group was also reported in the previous study (Carreck & Williams, 2002).

The complex environmental gradient of high altitude affects the abundance of different taxa of pollinators (Warren et al., 1988). As expected, with the elevation, the abundance of pollinators declined. The reason could be either decreasing of bee and fly attracted flowers or their limited number in higher altitude (Arnold et al., 2009). The plant communities at the high altitude limit the vascular plant and availability of insect pollinators (Mani, 1962). The atmospheric temperature and flower resource abundance have a negative correlation with elevation. Temperature is an important factor for defining the plant composition at higher altitudes (Subedi et al., 2020) and hence alters pollinator abundance. Only a few species of hoverflies that don't have specific food choices (Kearns, 1992) and big size bees, for instance, *Bombus* species that can thermoregulate and forage at low temperature were found in the highest altitude of our study area.

RDA

Among Hymenoptera, *Apis cerana* and *A. mellifera* were mainly determined by the flower abundance of the Buffer zone while *Bombus eximius* and *B. flavescens* were associated with humid forest. The explanation for the *Apis* spp. could be their preference on floral resources near the nesting area like small size bees (Vulliamy et al., 2006; Gathmann & Tschardt, 2002) so that they could gather maximum nectar to support the large bee colony (Potts et al., 2003). Large body-sized bees like *Bombus* spp. could travel away from the nesting area for foraging (Greenleaf et al., 2007) and humid areas to avoid hotter day temperatures (Willmer, 1983). *Aglais caschmirensis* is the most abundant and frequently seen butterfly in all kinds of habitats (Irungbam et al., 2017). This could be the reason for its presence in the forest as well as managed habitat in our study area. Similarly, the association of *Episyrrhus balteatus* in the human habitat indicates the preference for vegetables such as coriander, buckwheat (Pinheiro et al., 2015) as their host plant. The maximum areas of human habitat were cultivated land.

5. CONCLUSIONS

We studied Insect pollinator community structure in different habitats of SNNP Nepal. Habitat and elevation played a significant role in the species abundance, species richness, and community structure. Insect pollinators were strongly associated with flower resource abundance which was highly recorded in an open trial. Shannon Index and evenness were high in open trial and dominance was found similar in managed habitat and grassland. Conservation of plant diversity in the walking trials of SNNP is important to conserve the

community structure of insect pollinators.

ACKNOWLEDGMENTS

This research was funded by University Grants Commission, Nepal (Award No. Ph.D./74_75/S&T-17). We thank Professor Dr. Vasant Kumar Thapa, Professor Dr. Bhaiya Khanal (Natural History Museum, Nepal), and Mr. Muhammad Asghar Hassan (China Agricultural University, Beijing, China) for the identification of pollinators. The first author is grateful to Mr. Bishnu Maharjan for guiding to prepare a map in Arc GIS. The first author also thanks all the students who supported in fieldwork. The first author is also grateful to the Department of National Parks and Wildlife Conservation, Nepal for providing permission for the collection of insects.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

Urmila Dyola: Conceptualization (lead); Data Curation (lead); Investigation (lead); Writing - Original draft (lead); Funding acquisition (Lead); Writing – review and editing (lead); Formal analysis (lead); Investigation (lead), **Chitra Bahadur Baniya:** Conceptualization (Equal); Data Curation (Equal); Investigation (Equal); Writing original- draft (Supporting); Formal analysis (lead); Supervision (Equal), **Puspha Raj Acharya:** Conceptualization (Equal); Writing - original draft (Equal); Writing – review and editing (Equal); Supervision (Equal), **Pradip Subedi:** Data Curation (Supporting); Investigation (Supporting); Formal analysis (Equal), **Anjeela Pandey:** Writing - original draft (Supporting); Investigation (Supporting), **Kumar Sapkota:** Conceptualization (lead); Data Curation (Equal); Writing - original draft (Equal); Writing – review and editing (Equal); Investigation (lead); Supervision (Lead).

Data accessibility statement

The data associated with this manuscript are available at:

DOI <https://doi.org/10.5061/dryad.9zw3r22g1>

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