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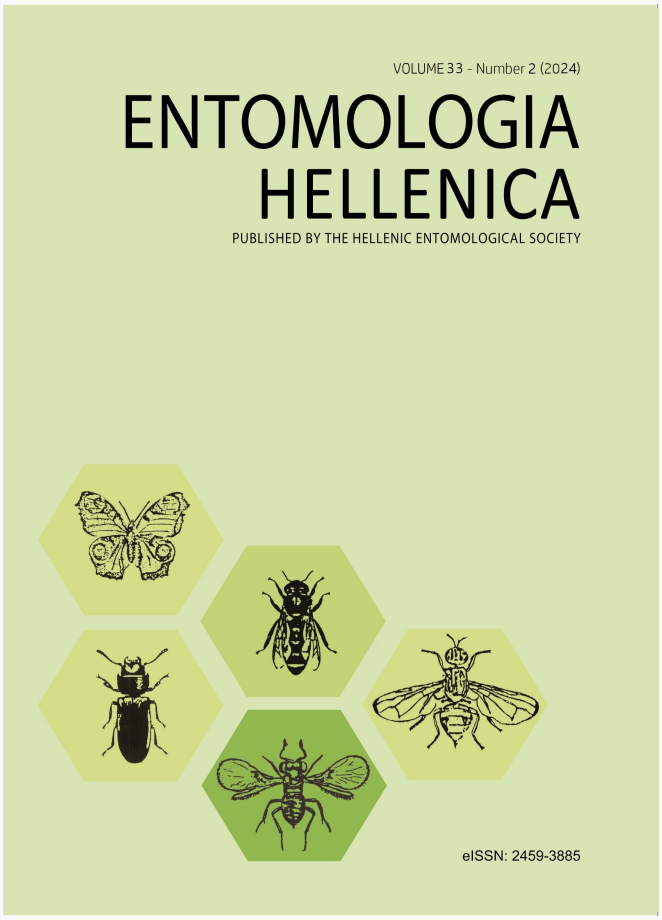

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Ecological Insights into Insect Diversity in Protected Area Networks of Kumaun Region, Western Himalaya

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ABSTRACT

The Uttarakhand region of the Western Himalaya, known for its rich biodiversity, includes several protected areas ranging from tropical to temperate zones. This study explores insect diversity across the six protected areas within the Kumaun Himalayan region. Altogether, a total of 412 insect species from nine taxonomic orders and 70 families were documented. Order Lepidoptera was the most diverse with a maximum of 154 species, followed by Coleoptera (81 species), Hymenoptera (58 species), Orthoptera (33 species), Hemiptera (31 species), Odonata (28 species), Diptera (23 species), Isoptera and Neuroptera as the least dominant with two species each. Shannon's species diversity (Hs) ranged 3.99 to 4.95, with the highest diversity in Nandhaur Wildlife Sanctuary and the lowest in Naina Devi Himalayan Bird Conservation Reserve. Cluster analysis revealed two main diversity patterns, indicating significant beta diversity amongst the study areas. Species-wise occupancy and abundance analysis revealed that *Pieris brassicae*, *P. canidia*, and *Apis dorsata* had the highest relative abundance from all protected areas. Conversely, 91 insect species had a relative abundance of only 0.03% each. Furthermore, seven species demonstrated the highest normalized occupancy of 1.00, indicating their adaptability to diverse environmental conditions within the protected areas. These findings thus emphasize the importance of habitat diversity and targeted conservation strategies to maintain insect populations and ecosystem health in the Kumaun Himalaya.

KEY WORDS: Insects, Distribution, Protected area, Species richness, Kumaun Himalaya.

Introduction

Class Insecta (1,070,781 species) is the most successful group, and it alone accounts for over 80% of all arthropods (Zhang 2013). It is characterized by vast diversity and plays a crucial role in shaping terrestrial ecosystems (Steffan-Dewenter and Tscharntke, 2002; Samways, 2005). Being involved in various ecosystem processes such as pollination, decomposition, predation, serving as prey, bioindicators or influencing nutrient cycling, pest and parasite control (Nichols et al., 2008; Bonebrake et al., 2010; An and Choi, 2021), insects play multifaceted roles in ecosystem dynamics, plant reproduction, and trophic interactions. Even though insects have ecological roles, they are often overlooked in biodiversity research and conservation efforts, overshadowed by larger and more charismatic fauna.

Understanding the diversity and richness of insect assemblages across different protected areas is essential for effective conservation and management strategies. The Protected Area Networks (PANs) with national parks, wildlife sanctuaries and conservation reserves for biodiversity conservation are aimed at preserving the region's ecological integrity and safeguarding its unique biodiversity (Margules and Pressey, 2000). They are essential in the conservation of biodiversity and wildlife against further losses as a result

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of unparalleled anthropogenic impacts (Sharma et al., 2020). In Uttarakhand, there are 18 protected areas where numerous studies have been conducted to understand diversity and richness of various vertebrates and invertebrates, including insects. Published literature on insects from diverse protected areas of Uttarakhand includes Chaturvedi (1981), Baindur (1993), Arora (1994, 1995, 1997), Joshi et al. (1999; 2004), Kumar (2004), Uniyal (2004), Joshi and Arya (2007), Bhardwaj et al. (2008), Joshi et al. (2008), Kumar (2008), Bhargav et al. (2009), Singh (2009), Arya and Joshi (2011), Bhardwaj and Uniyal (2013), Tewari and Rawat (2013), Arya and Joshi (2014), Dayakrishna and Arya (2015), Dey et al. (2015), Singh and Sondhi (2016), Dayakrishna et al. (2016), Uniyal et al. (2016), Sanwal et al. (2017), Arya et al. (2018), Bandyopadhyay et al. (2019), Kumar et al. (2019), Arya and Dayakrishna (2020), Arya and Verma (2020), Arya et al. (2020 a,b), Arya et al. (2021), Chandra et al. (2023). Despite the ecological importance of insects and the pivotal role played by the PANs in biodiversity conservation, our understanding of insect diversity within the protected areas of the Kumaun region remains limited. The present study aims to provide comprehensive baseline data on insect diversity across six protected areas of Uttarakhand and a comprehensive overview of insect occupancy and abundance in these ecologically significant regions. By analyzing spatial heterogeneity, we aim to enhance conservation strategies and deepen our understanding of ecological dynamics in these important habitats.

Materials and Methods

Study area. The state of Uttarakhand lies in the central sector of Himalaya, an area of 53,483 sq. km accounting for 1.63% of India's geographical area within 28°43' and 31°28' North Latitudes and 77°34' and 81°03' East Longitudes. The state's major physiographic zones are the Upper Himalayas, the Shiwaliks and the Terai, which cover a range of diverse landscapes that support many endemic floral and faunal species. About 18.70% of the total area (9,885 sq. km) has been designated for the establishment and management of protected areas in the form of national parks, biosphere reserves and wildlife sanctuaries (Rodgers and Panwar, 1988). The state currently has seven wildlife sanctuaries, six national parks, four conservation reserves and one biosphere reserve. The following six protected area networks (PANs) situated at tropical, temperate and alpine zones from the Kumaun division were chosen for the present study:

Protected Area 1 (PA1) - Binsar Wildlife Sanctuary (BWLS)

Protected Area 2 (PA2) - Corbett Tiger Reserve (CTR)

Protected Area 3 (PA3) - Nandhaur Wildlife Sanctuary (NWLS)

Protected Area 4 (PA4) - Askot Wildlife Sanctuary (AWLS)

Protected Area 5 (PA5) - Nanda Devi Biosphere Reserve (NDBR)

Protected Area 6 (PA6) - Naina Devi Himalayan Bird Conservation Reserve (NDHBCR).

Figure 1 provides the location map of selected study sites within the state.

Data collection and identification of species. The study is a survey-based work conducted in six protected areas of Kumaun from July 2013 to June 2020, where insect sampling occurred on monthly basis along permanent linear transects (each measuring 300 m × 10 m) randomly distributed across each protected area. To ensure consistent sampling and comparison between sites, the study was divided into three distinct periods, each covering two years:

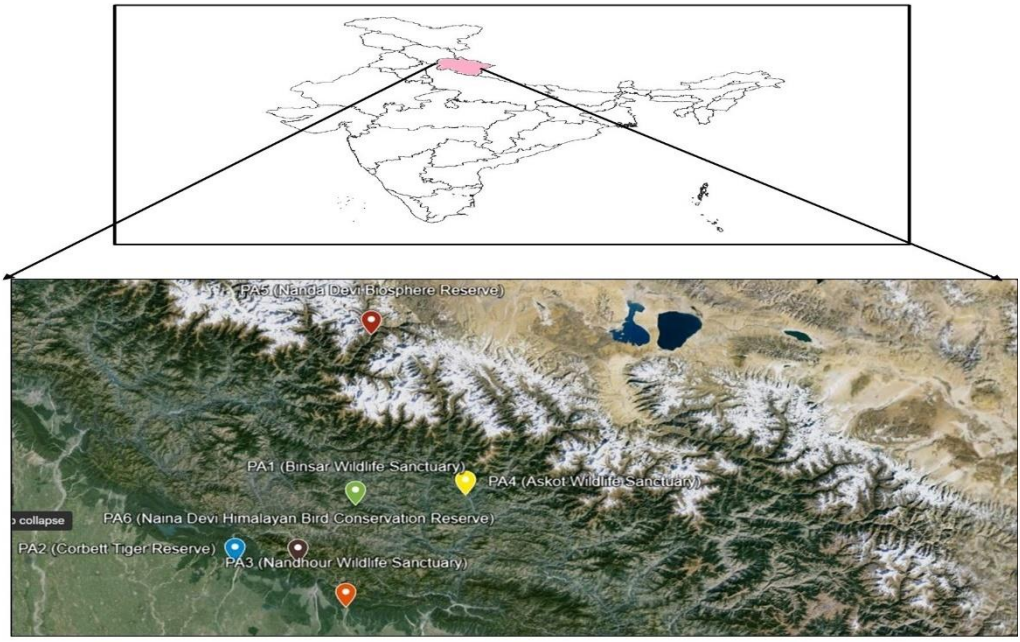

FIG. 1. Location map of selected study sites in study area. (Source: Google Earth)

- **2013-2014 and 2014-2015**: Askot Wildlife Sanctuary (AWLS) and Nanda Devi Biosphere Reserve (NDBR)
- **2015-2016 and 2016-2017**: Corbett Tiger Reserve (CTR) and Binsar Wildlife Sanctuary (BWLS)
- **2018-2019 and 2019-2020**: Nandhaur Wildlife Sanctuary (NWLS) and Naina Devi Himalayan Bird Conservation Reserve (NDHBCR)

Each site was sampled with equal intensity, ensuring consistency in the duration, number of transects and sampling effort across the respective two-year periods. This approach ensured that temporal and spatial biases were minimized, allowing a reliable comparison of insect abundance and diversity across the protected areas. Various techniques, such as modified Pollard walk, net sweeping, beating trays, baited pitfall traps, hand sorting, and light traps, were utilized from 8:00 am to 1:00 pm to estimate different taxonomic groups' abundances (Bhargav et al., 2009). Moth species were sampled between 7:30 pm and 9:30 pm using light traps with an 18 W incandescent lamp placed above a white entomological sheet. Species were identified using morphological descriptions from published literature and cross-checked with reference collections at the Insect Biodiversity Laboratory, Department of Zoology, D.S.B. Campus, Kumaun University, Nainital. Unidentifiable specimens were sent to the Northern Regional Station of the Zoological Survey of India in Dehradun and the Entomological Section at the Forest Research Institute in Dehradun for confirmation. Unknown species were categorized to the morphospecies level and recognized up to the genus level. Most butterfly species were visually identified in the field using published literature (Kehimkar, 2016; Sondhi and Kunte, 2018). Identified insects were then classified into different taxonomic groups to compile an inventory for the study sites.

Data analysis. The assemblage structure of insects was identified, using alpha diversity indices of insects, such as Shannon's Index (Hs) for species diversity, Margalef's Index (Hm) for species richness, and Simpson's Index (Ds) for species dominance using the program PAST 3.04 (Hammer et al., 2001). Bray-Curtis analysis was used to assess beta diversity by measuring the pairwise similarity of insect species abundance between the selected protected areas using the software Biodiversity Pro.

To compare occurrence of insect species in the proportion of protected areas, occupancy-abundance was calculated using Díaz et al. (2020) modified at a threshold of > 5 individuals. To standardize occupancy data, Normalized occupancy was then calculated and adjusted to a scale from 0 to 1. The thresholds were set based on the distribution of normalized occupancy values observed in preliminary analyses of the dataset. This measure helps allow for comparisons across different species (or their distribution patterns) or study areas.

Species Categorization. Species were categorized based on their normalized occupancy into three groups:

a) High Occupancy: Species with normalized occupancy > 0.7
b) Moderate Occupancy: Species with normalized occupancy between 0.5 and 0.7
c) Low Occupancy: Species with normalized occupancy < 0.5.

Results

Insect community structure across protected areas

During the study, a total of 412 insect species belonging to nine taxonomic orders and 70 families were identified throughout the study period. Order Lepidoptera was the richest in terms of relative number of species and individuals (37.37% species; 48.47% individuals), Coleoptera (19.66% species; 18.13% individuals), Hymenoptera (14.07% species; 17.32% individuals), Orthoptera (8% species; 5.36% individuals), Hemiptera (7.52% species; 2.56% individuals), Odonata (6.79% species; 4.8% individuals), Diptera (5.58% species; 2.17% individuals), Isoptera (0.48% species; 0.84% individuals) and Neuroptera (0.48% species; 0.31% individuals). Table 1 shows the distributional pattern of different insect species along six protected areas from the Kumaun division chosen for the study.

Of the reported total species, the maximum dominant were *Pieris brassicae* with a relative abundance of 5.15%, followed by *P. canidia* (4.73%), *Apis dorsata* (4.03%), *A. cerana* (3.33%), *Coccinella septumpunctata* (2.87%), *Aglais caschmirensis* (2.17%), *Apis florae*, *Catopsilia pomona* and *Coccinella septumpunctata vardivericata* (1.47% each), *Orthetrum sabina sabina* (1.36%), *Catopsilia pyranthe* (1.33%) and *Bombus haemorrhoidalis* (1.26%). Similarly, a total of 91 insect species were considered the least dominant with relative abundance of 0.03% each.

Diversity indices across different protected areas

Variations in species composition among different protected areas indicate Shannon's species diversity (Hs) varied from 3.99 to 4.95. PA3 showed the highest species diversity (4.95), followed by PA2, PA1, PA4, PA5 and lowest in PA6 (3.99). Margalef's species richness (Hm) was also found to be the highest in PA3 (27.76), followed by PA2 (21.73), PA4 (16.13), PA1 (14.74), PA6 (13.36) and the lowest in PA5 (12.5). Simpson's dominance was also higher in PA3 (Ds = 0.98) and lower in PA6 (Ds = 0.97). Figure 2 shows the comparison of alpha diversity metrics across different protected areas.

The Bray-Curtis analysis approach for similarity, also revealed significant patterns of beta diversity among the studied sites.

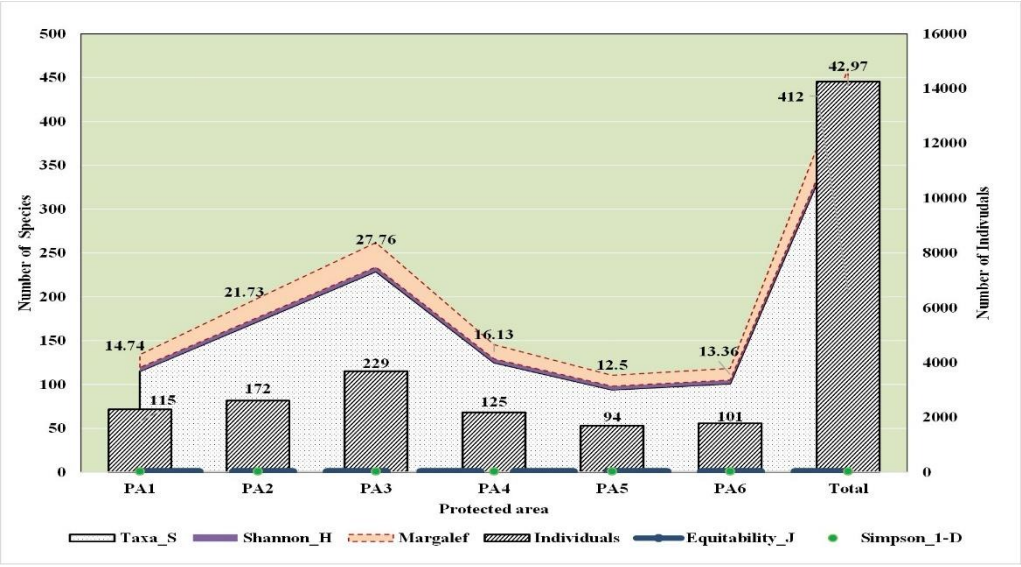

FIG. 2. Alpha diversity of insects in the PANs of Kumaun division of Uttarakhand.

The single linkage Bray- Curtis cluster analysis of species richness showed the % of similarity across the protected areas- showing two major clusters, the first cluster being PA3 and PA2, while the second cluster being PA1, PA4, PA5 and PA6. Single linkage cluster analysis depicted highest the beta diversity between PA5 and PA6 at 68.0% indicating similarities in environmental conditions or dispersal limitations for high compositional similarity of certain species, followed by PA2 and PA3 (58.56%), PA4 and PA5 (54.38%), PA1 and PA4 (50.87%) and PA1 and PA2 (39.11%). Figure 3 shows the Bray-Curtis similarity analysis of Beta diversity across protected areas.

Habitat specificity in species richness and status

PA1 (Binsar Wildlife Sanctuary) - In PA1, the Lepidoptera order was the highest with 43.47% contribution of species, followed by Coleoptera (20.0%), Hymenoptera (11.30%), Orthoptera (7.82%), Odonata (6.95%), Hemiptera and Diptera (5.21% each) orders.

PA2 (Corbett Tiger Reserve) - In the PA2, the Lepidoptera order was the highest with 38.95% contribution of species, followed by Coleoptera (15.11%), Hymenoptera and Orthoptera (11.04% each), Odonata (9.88%), Hemiptera (9.30%), Diptera (3.48%) and Neuroptera and Isoptera (0.58% each) orders.

PA3 (Nandhaur Wildlife Sanctuary) - In the PA3, the Lepidoptera order was the highest with 46.28% of species, followed by Coleoptera (18.34%), Hymenoptera (12.22%), Odonata (9.60%) Orthoptera (8.73%), Hemiptera (2.18%), Diptera (1.74% each) and Isoptera (0.87%).

PA4 (Askot Wildlife Sanctuary) - In the PA4, Lepidoptera was again the highest order with 38.4% contribution of species, followed by Coleoptera (18.4%), Hymenoptera (13.6%), Hemiptera and Diptera (8.0% each), Orthoptera (7.2% each), Odonata (5.6%), and Neuroptera (0.8% each).

PA5 (Nanda Devi Biosphere Reserve) and PA6 (Naina Devi Himalayan Bird Conservation Reserve) - in the PA5, the Lepidoptera order was the highest with

46.80 % contribution of species, followed by Coleoptera and Hymenoptera (17.0% each), Orthoptera and Diptera (5.31% each), Hemiptera and Odonata (4.25% each), whereas in the PA6, Lepidoptera was the highest order with 56.43% contribution of species, followed by Coleoptera (12.87%), Hymenoptera (10.89%), Orthoptera (6.93% each), Odonata and Hemiptera (4.95% each), Diptera (2.97%). The protected areas highlight no particular species confined within their boundaries. A comprehensive list of species recorded in each particular protected area has been listed in Table 2.

Species-wise occupancy and abundance patterns

Considering overall richness of species, common populations such as *Colias fieldii* Menetries, *Neptis sankara* (Kollar), *Coccinella septumpunctata* Linnaeus (Order: Coleoptera), *Crocothemis servilia servilia* (Drury), *Orthetrum glaucum* Brauer (Order: Odonata) were found to be present in all the chosen study sites (Table 1). However, in terms of species occupancy and abundance with >5 individuals, overall analysis of insect species across six protected areas in Uttarakhand revealed significant patterns:

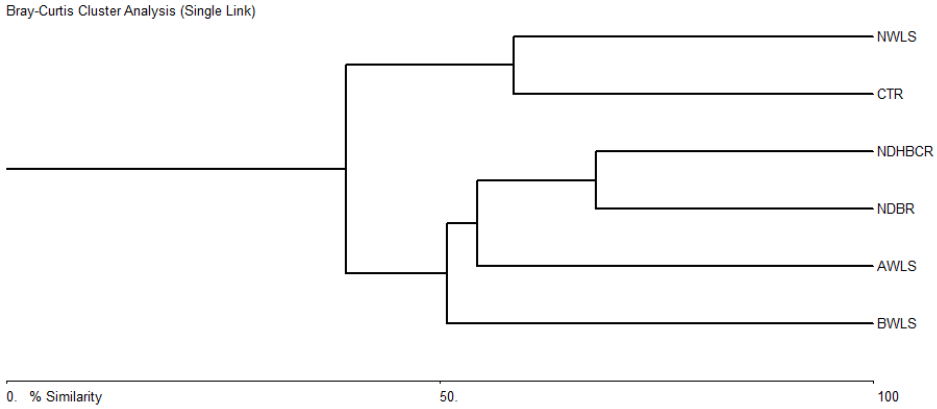

FIG. 3. Bray Curtis analysis for beta diversity between selected protected areas during the study period.

High Occupancy Species (Normalized Occupancy = 0.83)

Species with a normalized occupancy of 0.83 which were found in most, but not all, study sites. They are prevalent across most of the sites, indicating favorable habitat conditions but not universal adaptability. They include:

- Lepidoptera: *Aglais caschmirensis*, *Eurema brigitta*, *Macroglossum necteris*, *Vanessa cardui*
- Hymenoptera: *Apis dorsata*
- Orthoptera: *Paraconophyma scabra*.

Moderate Occupancy Species (Normalized Occupancy = 0.67)

Species with a normalized occupancy of 0.67 exhibited a less consistent distribution, suggesting potential specialization or sensitivity to specific environmental factors. These species include:

- Lepidoptera: *Aporia agathon*, *Dodona durga*, *Eurema hecabe*, *Gonepteryx nepalensis*, *Heliophorus sena*, *Melanitis leda*, *Papilio demoleus*, *P. bianor*, *P. polytes*, *Ypthima huebneri*
- Coleoptera: *Mylabris cichorii*

- Hymenoptera: *Apis cerana*
- Odonata: *Orthetrum sabina sabina*

These species may serve as indicators of specific habitat conditions or altitudinal zones.

Zero Occupancy Species

Certain species were absent from all sites where more than 5 individuals were recorded, indicating a normalized occupancy of 0. These species include:

- Lepidoptera: *Abisara bifasciata*, *A. fylla*, *Aeromachus stigmata*, *Agrius* sp., *Borbo bevani*, *Cepora nerissa*
- Coleoptera: *Adalia* sp., *Adelocera* sp., *Alcides* sp., *Anomala flavipes*, *Ateuchus* sp., among others.
- Hymenoptera: *Amegilla cingulata*, *Myzine dimidiata*, *Vespa* sp.
- Odonata: *Aristocypha quadrimaculata*, *Bayadera indica*, *Ischnura rubilio*
- Orthoptera: *Atractomorpha crenulata*, *Gastrimargus transversus*, *Heteropternis respondence*, and others.
- Hemiptera: *Anoplocnemis phasiana*, *Cletus punctulatus*, *Eurybrachus* sp., and others.
- Diptera: *Anthrrax* sp., *Bombylius* sp., *Lucilia* sp., and others.

Figure 4 illustrates species richness patterns across different study sites with respect to normalized occupancy levels (high, moderate and low). The number of species were higher in areas with low occupancy (L), with 234 species i.e. <0.5 normalized occupancy level, compared to medium (M) and high (H) occupancy levels, which have 40 and 13 species, respectively.

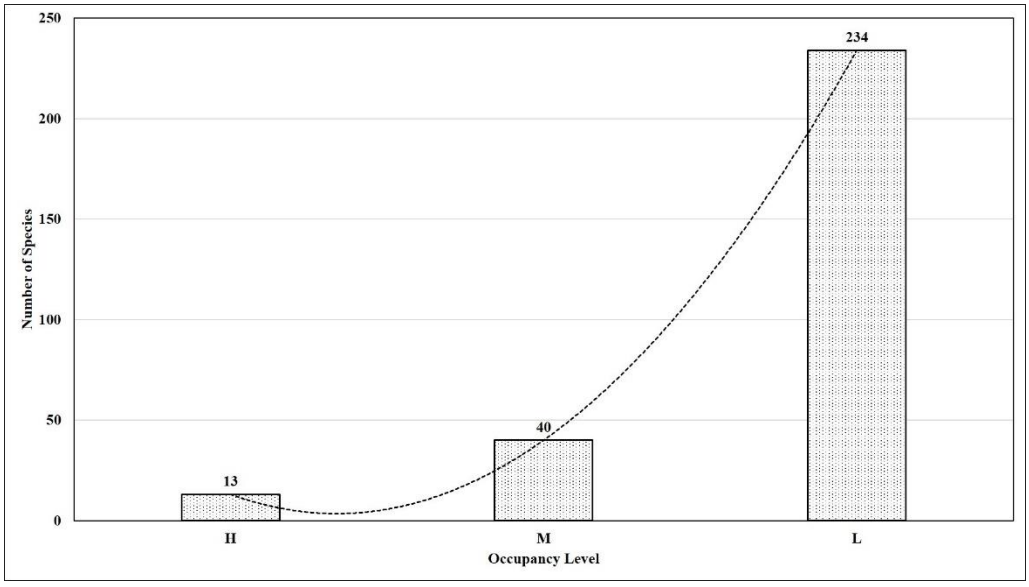

FIG. 4. Species richness across different Occupancy Level (H= High, M= Moderate, L= Low).

Discussion

Protected areas are crucial for understanding ecosystem health and management strategies. The present study contributes to the understanding of insect species richness and diversity within six protected areas. Similar to previous studies, (Joshi et al., 2008; Park et al., 2013; Verma and Arya, 2020), the order Lepidoptera exhibited the highest species richness, followed by the order Coleoptera.

The highest insect species diversity was observed in NWLS, whereas NDHBCR exhibited the lowest diversity. The Bray-Curtis similarity analysis revealed significant beta diversity, with environmental factors such as altitude and vegetation type influencing insect communities. The highest similarity was observed between PA5 and PA6 indicating similar environmental conditions or dispersal limitations. Comparative analysis of the recorded insect species richness of the selected protected areas from Kumaun division with the total insects record in the Indian Himalayan Region, represented about 1.66% of the total insect fauna (24,784 species) and 0.63% of the total insect fauna (65,047 species) in India (Chandra et al., 2018). This indicates that the protected areas studied hereby harbor a unique subset of the region's biodiversity. The observed pattern of species richness suggests a classic inverse relationship between species occupancy and abundance. The significant differences in species occupancy between sites underscore the importance of habitat heterogeneity in maintaining insect diversity. The majority of species are found at the low occupancy level, indicating that they are likely specialists with specific habitat requirements or limited distributions. These species, although numerous, are not widely distributed across the protected areas and may be dependent on particular ecological niches or microhabitats. This pattern is consistent with findings in other ecological studies where many species tend to be rare or have restricted ranges (Gaston, 1994). The moderate occupancy level (with 40 species), represents species that are somewhat more adaptable but still have specific habitat preferences that limit their distribution. These species may thrive in certain conditions that are not as widespread, suggesting a balance between habitat specialization and adaptability. In contrast, the high occupancy level, with only 13 species, includes those that are generalists and can thrive across a broad range of habitats. These species are highly adaptable and resilient to varying environmental conditions, which allows them to occupy multiple sites within the protected areas. Species like *Euploea core* and *Junonia iphita* were universally present, showcasing their adaptability. Conversely, species such as *Abisara bifasciata* and *Aeromachus stigmata* were absent from all sites, highlighting possible habitat or resource limitations. The relatively low number of such species underscores the ecological principle that generalist species are often fewer in number compared to specialists, as the latter have evolved to exploit specific ecological niches (Brown and Freitas, 2000).

These findings underline the need for targeted conservation strategies that address both specialist and generalist species. Protecting and restoring diverse habitats is crucial for sustaining insect populations and their ecological roles, such as pollination and nutrient cycling. The study highlights the importance of certain protected areas, like Nandhaur Wildlife Sanctuary, which show higher species richness, possibly due to better habitat quality, diversity of habitats, or more effective conservation practices. Conversely, areas with lower species richness may require targeted conservation efforts to enhance biodiversity. Long-term monitoring and research are thus essential for developing effective strategies to support insect diversity and ecosystem health.

TABLE 1. Species composition, distribution status and normalised occupancy of insects in the PANs of Kumaun division of Uttarakhand.

S. No.	Order	Family	Species name	PA1	PA2	PA3	PA4	PA5	PA6	R.A.	N.O.
1.	**Lepidoptera**	**Nymphalidae**	*Acraea issoria* (Hubner)	-	-	+	-	+	+	0.18	0.33
2.			*Aglais caschmirensis* (Kollar)	+	-	+	+	+	+	2.17	0.83
3.			*Argynnis childreni* Gray	+	-	-	-	+	-	0.17	0.33
4.			*Argynnis hyperbius* (Linnaeus)	+	-	-	-	-	-	0.07	0.17
5.			*Ariadne merione* (Cramer)	-	+	+	-	-	+	0.38	0.33
6.			*Athyma cama* Moore	-	-	+	+	-	+	0.24	0.33
7.			*Athyma perius* (Linnaeus)	-	-	+	+	-	-	0.14	0.17
8.			*Athyma zeroca* Moore	-	+	+	-	-	-	0.14	0.33
9.			*Aulocera swaha* Kollar	+	-	-	-	+	-	0.28	0.33
10.			*Aulocera padma* Kollar	+	-	-	-	-	+	0.10	0.17
11.			*Callerebia annada* (Moore)	+	-	-	-	+	+	0.17	0.17
12.			*Callerebia scanda* (Kollar)	+	-	-	-	+	+	0.21	0.33
13.			*Charaxes agrarius* Swinhoe	-	+	+	-	-	-	0.10	0.17
14.			*Charaxes bharata* Felder & Felder	-	+	+	-	-	-	0.21	0.33
15.			*Cyrestis thyodamas* Doyere	-	+	+	-	-	-	0.31	0.33
16.			*Danaus chrysippus* (Linnaeus)	+	+	+	+	-	+	0.52	0.33
17.			*Danaus genutia* (Cramer)	-	+	+	+	-	+	0.35	0.5
18.			*Euploea core* (Cramer)	+	+	+	+	+	+	0.77	1
19.			*Euploea midamus* (Linnaeus)	-	-	-	+	-	+	0.07	0
20.			*Euploea mulciber* (Cramer)	-	+	-	-	-	-	0.03	0
21.			*Euthalia aconthea* (Cramer)	-	+	+	-	+	-	0.10	0

22.			*Hestinalis nama* (Doubleday)	-	+	+	-	-	-	0.07	0
23.			*Hypolimnas bolina* (Linnaeus)	-	+	+	-	-	-	0.31	0.33
24.			*Junonia almana* (Linnaeus)	-	+	+	+	-	-	0.49	0.5
25.			*Junonia atlites* (Linnaeus)	-	+	+	-	-	-	0.14	0.33
26.			*Junonia iphita* (Cramer)	+	+	+	+	+	+	0.87	1
27.			*Junonia lemonias* (Linnaeus)	-	+	+	-	-	-	0.28	0.33
28.			*Junonia orithya* (Linnaeus)	-	+	+	+	-	+	0.31	5
29.			*Kallima inachus* (Doyere)	+	-	+	+	-	-	0.14	0.17
30.			*Kaniska canace* (Linnaeus)	+	-	+	-	-	-	0.07	0
31.			*Lasiommata schakra* (Kollar)	+	-	-	+	+	+	0.35	0.5
32.			*Lethe confusa* Aurivillius	-	-	+	+	-	+	0.17	0.17
33.			*Lethe verma* (Kollar)	+	-	-	-	-	-	0.14	0.17
34.			*Libythea lepita* Moore	-	-	+	-	-	-	0.03	0
35.			*Libythea* sp.	-	+	-	-	-	-	0.03	0
36.			*Melanitis leda* (Linnaeus)	-	+	+	+	-	+	0.49	0.67
37.			*Mycalesis* sp.	-	+	+	-	-	-	0.14	0.33
38.			*Neptis hylas* (Linnaeus)	-	+	+	-	+	-	0.10	0
39.			*Neptis sankara* (Kollar)	+	+	+	+	+	+	0.35	0.5
40.			*Neptis zaida* Doubleday	+	-	-	-	-	-	0.03	0
41.			*Parantica aglea* (Stoll)	-	+	+	+	-	+	0.14	0
42.			*Parantica sita* (Kollar)	-	-	-	+	-	-	0.03	0
43.			*Phalanta phalantha* (Drury)	+	+	+	+	+	+	0.87	1
44.			*Pseudergolis wedah* (Kollar)	+	-	-	-	+	+	0.42	5

45.			*Sephisa dichroa* (Kollar)	+	-	-	+	+	-	0.24	0.33
46.			*Symbrenthia lilaea* Hewitson	-	+	+	-	-	+	0.2	0.5
47.			*Tirumala limniace* (Cramer)	-	+	+	-	-	-	0.14	0.33
48.			*Vagrans egista* (Cramer)	-	-	+	-	-	-	0.07	0.17
49.			*Vanessa cardui* (Linnaeus)	+	-	+	+	+	+	0.70	0.83
50.			*Vanessa indica* (Herbst)	+	+	+	+	+	+	1.26	1
51.			*Ypthima huebneri* Kirby	-	+	+	-	+	+	0.28	0.67
52.			*Ypthima nareda nareda* (Kollar)	+	-	+	-	+	-	0.17	0.17
53.		**Lycaenidae**	*Arhopala amantes* (Hewitson)	-	-	+	-	-	-	0.07	0.17
54.			*Castalius rosimon* (Fabricius)	-	+	+	-	-	-	0.28	0.33
55.			*Euchrysops cnejus* (Fabricius)	-	+	-	-	-	-	0.07	0.17
56.			*Flos asoka* (de Niceville)	-	+	+	-	+	+	0.21	0.33
57.			*Freyeria trochylus* (Freyer)	-	+	-	-	-	-	0.10	0.17
58.			*Heliophorus sena* (Kollar)	+	+	+	+	+	+	0.73	0.67
59.			*Jamides celeno* (Cramer)	-	-	+	-	-	-	0.03	0
60.			*Lampides boeticus* (Linnaeus)	-	-	+	-	+	+	0.52	0.5
61.			*Loxura atymnus* (Stoll)	-	-	+	-	-	+	0.28	0.33
62.			*Lycaena pavana* (Westwood)	+	-	-	+	+	+	0.38	0.33
63.			*Lycaena phlaeas* (Linnaeus)	-	-	-	+	-	+	0.07	0
64.			*Megisba malaya* (Horsfield)	-	+	-	-	-	-	0.03	0
65.			*Pseudozizeeria maha* (Kollar)	-	+	+	-	-	-	0.07	0
66.			*Spindasis* sp.	-	+	-	-	-	-	0.03	0
67.			*Talicada nyseus* (Guerin-Meneville)	+	-	+	-	-	-	0.21	0.17
68.			*Tarucus indica* Evans	-	+	-	-	-	-	0.14	0.17

69.			*Tarucus nara* (Kollar)	-	-	+	-	-	-	0.03	0
70.			*Udara dilectus* Moore	+	-	-	-	-	+	0.07	0
71.			*Zizeeria karsandra* (Moore)	-	+	+	-	-	-	0.07	0
72.			*Zizina otis* (Fabricius)	-	+	+	-	-	-	0.07	0
73.			*Zizula hylax* (Fabricius)	-	-	+	-	-	-	0.03	0
74.		**Pieridae**	*Aporia agathon* (Gray)	+	-	-	+	+	+	1.05	0.67
75.			*Belenois aurota* (Fabricius)	+	-	-	-	+	-	0.59	0.5
76.			*Catopsilia pomona* (Fabricius)	+	+	+	-	-	-	1.47	0.33
77.			*Catopsilia pyranthe* (Linnaeus)	-	+	+	-	-	-	1.33	0.67
78.			*Cepora nerissa* (Fabricius)	-	+	+	-	-	-	0.07	0
79.			*Colias erate* (Esper)	-	+	+	-	+	-	0.10	0
80.			*Colias fieldii* Menetries	+	+	+	+	+	+	0.63	0.5
81.			*Delias eucharis* (Drury)	-	+	+	-	-	-	0.70	0.33
82.			*Eurema andersonii* (Moore)	-	+	+	-	+	-	0.21	5
83.			*Eurema blanda* (Boisduval)	-	+	+	-	+	-	0.42	5
84.			*Eurema brigitta* (Stoll)	+	+	+	+	-	+	0.35	0.83
85.			*Eurema hecabe* (Linnaeus)	+	+	+	+	-	+	0.77	0.67
86.			*Eurema laeta* (Boisduval)	+	+	+	-	-	-	0.10	0
87.			*Gonepteryx nepalensis* Doubleday	+	-	+	+	+	-	0.73	0.67
88.			*Leptosia nina* (Fabricius)	-	+	-	-	-	-	0.03	0
89.			*Pareronia hippia* (Fabricius)	-	+	+	-	-	-	0.07	0
90.			*Pieris brassicae* (Linnaeus)	+	+	+	+	+	+	5.15	1
91.			*Pieris canidia* (Linnaeus)	+	+	+	+	+	+	4.73	1
92.			*Pontia daplidice* (Linnaeus)	+	+	-	-	+	+	0.38	0.33

93.		**Hesperiidae**	*Aeromachus stigmata* (Moore)	-	-	+	-	-	-	0.03	0
94.			*Borbo bevani* (Moore)	-	-	+	-	-	-	0.03	0
95.			*Ochlodes brahma* Moore	+	-	-	-	-	-	0.03	0
96.			*Parnara guttatus* (Moore)	-	+	+	-	-	-	0.14	0.33
97.			*Potanthus dara* (Kollar)	-	-	+	-	-	+	0.14	0.33
98.			*Pseudocoladenia fatih* (Kollar)	-	-	+	-	-	-	0.07	0.17
99.			*Sarangesa dasahara* Moore	-	+	-	-	-	-	0.07	0.17
100.			*Sarangesa purendra* Moore	-	+	-	-	-	-	0.07	0.17
101.			*Spilalia galba* (Fabricius)	-	+	-	-	-	-	0.07	0.17
102.			*Tagiades cohaerens cynthia* Evans	+	-	-	-	+	-	0.07	0
103.			*Tagiades litigiosa* Moschler	-	-	+	-	-	+	0.10	0.17
104.			*Telicota bambusae* (Moore)	-	-	+	-	-	+	0.10	0.17
105.			*Telicota* sp.	-	+	-	-	-	+	0.07	0
106.			*Udaspes folus* (Cramer)	-	-	+	-	-	-	0.03	0
107.		**Papilionidae**	*Byasa polyeuctes letincius* (Fruhstorfer)	+	-	-	-	+	+	0.56	0.5
108.			*Graphium cloanthus* (Westwood)	-	-	-	+	-	-	0.31	0.17
109.			*Graphium nomius* (Esper)	-	+	+	-	-	-	0.45	0.33
110.			*Graphium sarpedon* (Linnaeus)	-	+	+	+	-	-	0.66	0.33
111.			*Papilio bianor* Cramer	+	-	+	+	+	+	0.45	0.67
112.			*Papilio clytia* (Linnaeus)	-	+	+	-	-	-	0.07	0
113.			*Papilio demoleus* (Linnaeus)	-	+	+	-	+	+	0.91	0.67
114.			*Papilio machaon* Linnaeus	-	-	-	+	-	+	0.10	0.17
115.			*Papilio polytes* (Linnaeus)	+	+	+	+	+	+	0.66	0.67

116.			*Papilio protenor* Cramer	-	-	+	+	+	-	0.35	0.33
117.		**Riodinidae**	*Abisara bifasciata* Moore	-	-	+	-	-	-	0.03	0
118.			*Abisara echerius* (Stoll)	-	+	-	-	-	+	0.10	0.17
119.			*Abisara fylla* (Westwood)	-	-	-	+	-	-	0.03	0
120.			*Dodona durga* (Kollar)	+	-	+	+	+	+	0.49	0.67
121.			*Dodona eugenes* Bates	+	-	-	-	+	+	0.10	0
122.			*Dodona ouida* Hewitson	+	-	-	-	-	-	0.03	0
123.			*Zemeros flegyas* (Cramer)	-	+	+	-	-	-	0.07	0
124.		**Erebidae**	*Calpe ophideroides* Guenee	+	-	-	-	+	+	0.14	0.17
125.			*Creatonotos transiens* (Walker)	-	-	+	+	-	-	0.10	0.17
126.			*Cyana bellissima* (Kollar)	-	-	+	-	-	+	0.10	0.17
127.			*Cyana detrita* Walker	-	-	+	-	-	+	0.10	0.17
128.			*Episteme adulatrix* (Kollar)	-	-	+	-	-	-	0.07	0.17
129.			*Erebus caprimulgus* (Fabricius)	-	-	+	-	-	-	0.03	0
130.			*Eressa confinis* (Walker)	-	-	+	-	-	-	0.03	0
131.			*Fodina pallula* Guenee	-	-	+	-	-	-	0.03	0
132.			*Lemyra* sp.	-	-	-	+	-	-	0.03	0
133.			*Machrobrochis prasena* (Moore)	-	-	+	-	-	+	0.10	0.17
134.			*Nyctemera adversata* (Schaller)	-	-	+	+	-	+	0.17	0.33
135.			*Nyctemera* sp.	-	-	-	+	-	+	0.10	0.17
136.			*Spirama retorta* Clerck	-	-	+	-	-	-	0.07	0.17
137.			*Syntomoides imaon* Cramer	+	-	+	+	+	-	0.38	0.33
138.			*Trigonodes hyppasia* Cramer	-	-	+	-	-	-	0.03	0
139.			*Vamuna remelana* (Moore)	-	-	+	-	-	-	0.03	0
140.		**Sphingidae**	*Agrius* sp.	-	-	-	+	-	-	0.03	0

141.			*Daphnis nerii* (Linnaeus)	-	-	+	-	-	-	0.03	0
142.			*Hemaris* sp.	-	-	-	+	-	-	0.03	0
143.			*Macroglossum necteris* Kollar	+	-	+	+	+	+	0.52	0.83
144.			*Sphinx* sp.	-	-	-	+	-	-	0.03	0
145.			*Theretra nessus* (Drury)	-	-	+	-	-	-	0.03	0
146.		**Crambidae**	*Bradina diagonalis* (Guenee)	-	-	+	-	-	-	0.07	0.17
147.			*Cnaphalocrocis medinalis* (Guenee)	-	-	+	-	-	-	0.07	0.17
148.			*Paliga damastesalis* (Walker)	+	-	-	-	-	-	0.07	0.17
149.			*Spoladea recurvalis* (Fabricius)	-	-	+	-	-	-	0.07	0.17
150.			*Tyspanodes linealis* (Moore)	-	-	+	-	-	-	0.07	0.17
151.		**Geometridae**	*Dysphania militaris* (Linnaeus)	+	-	-	-	-	-	0.07	0.17
152.			*Ourapteryx clara* (Butler)	-	-	+	-	-	-	0.07	0.17
153.		**Eupterotidae**	*Eupterote* sp.	-	-	+	-	-	-	0.07	0.17
154.		**Saturnidae**	*Actias selene* Hubner	-	-	+	-	-	-	0.07	0.17
155.	**Coleoptera**	**Scarabaeidae**	*Anomala antique* (Gyllental)	-	+	+	-	-	-	0.14	0.33
156.			*Anomala decipiens* (Arrow)	-	+	+	-	-	-	0.21	0.33
157.			*Anomala dimidiata* Hope	-	-	-	+	+	+	0.73	0.5
158.			*Anomala flavipes* Arrow	-	+	-	-	-	-	0.03	0
159.			*Anomala lineatopennis* Blanchard	+	-	-	+	+	-	0.52	0.5
160.			*Anomala* sp.	+	-	-	-	+	+	0.10	0
161.			*Ateuchus* sp.	-	+	-	-	-	-	0.03	0
162.			*Catharsius capucinus* (Fabricius)	-	-	+	-	-	-	0.03	0
163.			*Chiloba acuta* Wied	-	-	-	+	-	-	0.07	0.17

164.			*Clinteria spilota* Hope	-	-	-	+	-	-	0.07	0.17
165.			*Copris sacontala* Redtenbacher	-	+	+	-	-	-	0.14	0.33
166.			*Dsygnathus* sp.	-	-	-	+	-	-	0.07	0.17
167.			*Gymnopleurus subtilis* Walker	+	-	-	-	-	-	0.17	0.17
168.			*Gymnopleurus miliaris* (Fabricius)	-	+	+	-	-	+	0.77	0.5
169.			*Heliocopris bucephalus* (Fabricius)	-	-	+	-	-	-	0.03	0
170.			*Jumnos roylei* Hope	+	-	-	+	+	-	0.24	0.17
171.			*Lachnosterna cavifrons* Brenske	+	-	-	-	-	-	0.03	0
172.			*Lepidiota albistigma* Burmeister	-	+	+	-	-	-	0.14	0.33
173.			*Lytta limbata* Redtenbacher	+	-	-	-	-	-	0.07	0.17
174.			*Melolontha cuprescens* Blanchard	-	-	+	-	-	-	0.17	0.17
175.			*Onthophagus dama* (Fabricius)	-	-	+	+	-	-	0.42	0.33
176.			*Onthophagus gagates* Hope	+	-	-	-	-	-	0.14	0.17
177.			*Onitis falcatus* Wulfen	-	+	+	-	-	-	0.35	0.33
178.			*Oryctes nasicornis* (Linnaeus)	-	-	+	-	-	-	0.03	0
179.			*Oxycertonia versicolor* Fabricius	-	-	-	+	-	-	0.03	0
180.			*Protaetia pretiosa* Nonfried	+	-	+	-	-	-	0.24	0.33
181.			*Protaetia neglacta* Hope	+	-	-	-	+	+	0.24	0.33
182.			*Popilla cupricollis* Hope	-	-	-	+	-	-	0.03	0
183.			*Popillia* sp.	-	-	+	+	+	-	0.42	0.5
184.			*Pseudolucanus cantor* Hope	+	-	-	-	-	-	0.03	0
185.			*Sisyphus hirtus* Wied	-	-	-	+	-	-	0.03	0
186.			*Torynorrhina opalina* Hope	-	-	-	+	-	-	0.03	0
187.		**Chrysomelidae**	*Altica caerulescens* (Baly)	-	-	-	+	-	+	0.63	0.33

188.			*Altica himensis* Shukla	+	-	-	-	+	-	0.59	0.33
189.			*Charidotella* sp.	-	+	+	-	-	-	0.10	0.17
190.			*Colasposoma metallicum* (Clark)	-	+	+	-	-	-	0.10	0.17
191.			*Colasposoma splendidum* Fabricius	-	+	-	-	-	-	0.14	0.17
192.			*Corynodes peregrius* (Fuessly)	-	+	+	-	-	-	0.21	0.33
193.			*Gallerucida rutilans* Hope	+	-	-	-	-	-	0.03	0
194.			*Meristata sexmaculata* (Kollar & Redtenbacher)	+	-	-	-	+	-	0.28	0.33
195.			*Meristata trifasciata* Hope	+	-	+	-	+	+	0.28	0.67
196.			*Mimastra* sp.	+	-	-	+	+	-	0.21	0.5
197.			*Zygogramma bicolorata* Pallister	-	+	+	-	-	-	0.63	0.33
198.		**Coccinelidae**	*Adalia* sp.	-	-	+	-	-	-	0.03	0
199.			*Chilocorus infernalis* (Mulsant)	-	-	+	-	-	-	0.03	0
200.			*Coccinella septumpunctata vardivericata* Olivier	-	-	-	+	+	+	1.47	0.5
201.			*Coccinella septumpunctata* Linnaeus	+	+	+	+	+	+	2.87	1
202.			*Coccinella transversalis* (Fabricius)	-	-	+	-	-	-	0.07	0.17
203.			*Haluzia sanscrieta* Mulsant	+	-	-	-	+	+	0.31	0.5
204.			*Hippodamia varegata* Goeze	-	-	-	+	+	-	0.28	0.33
205.			*Leis dimidiata* (Fabricius)	-	+	+	-	-	-	0.07	0
206.			*Menochilus sexmaculatus* (Fabricius)	-	-	+	+	-	+	0.21	0.5
207.			*Oenopia kirbyi* (Mulsant)	-	-	-	+	-	-	0.03	0
208.			*Psyllora vigintiduopunctata* (Linnaeus)	-	-	+	-	-	-	0.03	0

209.		**Meloidae**	*Epicauta mannerheimi* (Maklin)	-	+	+	-	-	-	0.07	0
210.			*Epicauta* sp.	-	-	+	-	-	-	0.03	0
211.			*Hycleus* sp.	-	-	+	-	-	-	0.03	0
212.			*Mylabris cichorii* (Linnaeus)	+	+	+	+	-	-	0.52	0.67
213.			*Mylabris pustulata* (Thunberg)	-	-	+	-	+	-	0.42	0.33
214.			*Mylabris* sp.	+	-	-	-	-	+	0.28	0.33
215.		**Carabidae**	*Chlaenius* sp.	-	-	+	-	-	-	0.03	0
216.			*Ophonus indicus* Bates	-	+	-	-	-	-	0.03	0
217.			*Ophonus rufibarbis* Fabricius	-	-	+	-	-	-	0.03	0
218.			*Ophonus rubricollis* Hope	+	-	-	+	+	+	0.17	0.17
219.			*Pheropsophus* sp.	-	-	-	+	-	-	0.03	0
220.			*Scarites sulcatus* Olivier	+	-	+	-	-	-	0.07	0
221.			*Scarities* sp.	-	-	-	+	-	-	0.03	0
222.		**Cicindelidae**	*Calomera chloris* Hope	-	+	+	-	-	-	0.14	0.33
223.			*Cicindela flexuosa* (Fabricius)	-	-	+	-	-	-	0.21	0.17
224.			*Cicindela* sp.	-	+	-	-	-	-	0.21	0.17
225.			*Cosmodela intermedia* Chaudoir	-	+	+	-	-	-	0.28	0.33
226.		**Tenebrionidae**	*Cistelomorpha* sp.	+	-	-	-	-	+	0.21	0.33
227.			*Gonocephalum* sp.	-	+	+	-	-	-	0.42	0.33
228.		**Elateridae**	*Adelocera* sp.	-	+	+	-	-	-	0.07	0
229.			*Heteroderes macroderes* Candeze	-	+	+	-	-	-	0.07	0
230.		**Hydrophilidae**	*Hydrophilus* sp.	-	+	-	-	-	-	0.03	0
231.			*Hydrophilus triangularis* Say	-	-	+	-	-	-	0.03	0
232.		**Lagriidae**	*Cerogria nepalensis* Hope	+	-	-	-	-	-	0.03	0

233.		**Curculionidae**	*Alcides* sp.	-	+	-	-	-	-	0.03	0
234.		**Lucanidae**	*Metopodontus biplagiatus* (Westwood)	-	-	+	-	-	-	0.03	0
235.		**Cerambycidae**	*Dorysthenes huegelii* (Redtenbacher)	-	-	+	-	-	-	0.03	0
236.	**Hymenoptera**	**Apidae**	*Amegilla cingulata* (Fabricius)	-	+	+	-	-	-	0.07	0
237.			*Anthophora cofusa* Smith	+	-	-	-	+	-	0.14	0.33
238.			*Anthophora* sp.	-	-	-	+	-	-	0.07	0.17
239.			*Apis cerana* Fabricius	-	-	+	+	+	+	3.33	0.67
240.			*Apis dorsata* Fabricius	-	+	+	+	+	+	4.03	0.83
241.			*Apis florae* Fabricius	-	-	+	+	-	-	1.47	0.33
242.			*Apis laboriosa* Smith	+	-	+	+	+	+	0.35	0.17
243.			*Apis mellifera* Eschscholtz	-	-	+	+	-	-	0.73	0.33
244.			*Bombus haemorrhoidalis* Smith	-	-	+	-	+	+	1.26	0.5
245.			*Bombus* sp.	+	-	-	-	-	-	0.14	0.17
246.			*Bremus* sp.	-	-	-	+	+	-	0.14	0.33
247.			*Coelioxy* sp.	+	-	-	-	+	-	0.10	0.17
248.			*Crocisa ramosa* Lepeletier	+	-	+	-	-	+	0.42	0.5
249.			*Eriades decipiences* Spinola	-	+	-	-	-	-	0.07	0.17
250.		**Scoliidae**	*Campsomeriella collaris* (Fabricius)	-	-	-	+	-	-	0.07	0.17
251.			*Compsomeris asiatica himalaya* Bar.	+	-	-	-	+	-	0.10	0.17
252.			*Compsomeris prismatica* Smith	-	+	-	-	-	-	0.14	0.17
253.			*Myzine dimidiata* Guerin	-	+	-	-	-	-	0.03	0

254.			*Myzine petiolata* Smith	-	+	-	-	-	-	0.03	0
255.			*Phalerimeris* sp.	-	-	+	-	-	-	0.07	0.17
256.			*Scolia affinis* Guerin	-	+	+	-	+	-	0.38	0.5
257.			*Scolia* sp.	-	-	+	-	-	+	0.10	0.17
258.			*Scolia venusta* Smith	+	-	-	-	-	-	0.24	0.17
259.		**Sphecidae**	*Sceliphron caucasium* (Drury)	-	+	+	-	-	-	0.10	0.17
260.			*Sceliphron coromandelicum* Lepeletier	-	+	+	-	-	-	0.10	0.17
261.			*Sceliphron* sp.	-	-	+	-	-	-	0.07	0.17
262.			*Sphex umbrosus* Christ	-	+	-	-	-	-	0.07	0.17
263.			*Sphex* sp.	-	-	+	-	-	-	0.07	0.17
264.		**Vespidae**	*Delta dimidiatipennis* (Saussure)	-	-	-	+	-	-	0.07	0.17
265.			*Eumenes petiolata* (Fabricius)	-	+	-	-	-	-	0.07	0.17
266.			*Labus* sp.	-	+	+	-	-	-	0.10	0.17
267.			*Mandarinia* sp.	-	-	-	+	-	-	0.07	0.17
268.			*Polistes dorsalis* (Fabricius)	-	-	+	-	+	+	0.14	0.17
269.			*Polistes hebraeus* Fabricius	-	-	-	+	-	-	0.07	0.17
270.			*Polistes* sp.	-	-	-	+	-	-	0.07	0.17
271.			*Polistes stigma* (Fabricius)	-	+	+	-	-	-	0.10	0.17
272.			*Vespa cincta* Fabricius	-	+	-	-	-	-	0.07	0.17
273.			*Vespa* sp.	+	-	-	-	-	-	0.03	0
274.			*Vespa velutina* Lepeletier	-	-	+	-	+	-	0.10	0.17
275.			*Vespa velutina auraria* Smith	-	+	-	-	-	+	0.07	0
276.			*Vespula flaviceps* (Smith)	-	-	+	-	-	-	0.07	0.17

277.		**Formicidae**	*Campanotus* sp.	-	-	-	+	-	-	0.07	0.17
278.			*Camponotus compressus* (Fabricius)	-	+	+	-	-	-	0.14	0.33
279.			*Diacomma* sp.	-	-	-	+	-	-	0.07	0.17
280.			*Pachycondyla* sp.	-	-	-	+	-	-	0.07	0.17
281.			*Polyrhachis simplex* Mayr	-	+	+	-	-	-	0.10	0.17
282.			*Polyrhachis* sp.	-	-	-	+	-	-	0.07	0.17
283.		**Xylocopidae**	*Xylocopa auripennis* Lepeletier	-	+	+	-	-	+	0.17	0.33
284.			*Xylocopa fenestrata* Faber.	+	-	-	+	+	-	0.63	0.5
285.		**Halictidae**	*Halictus* sp.	-	-	+	-	-	+	0.10	0.17
286.			*Nomia curvipes* (Fabricius)	-	+	+	-	-	-	0.10	0.17
287.		**Pompilidae**	*Pepsis* sp.	-	-	+	-	-	-	0.07	0.17
288.			*Salius flavus* Fabricius	+	-	-	-	+	-	0.10	0.17
289.		**Ichneumonidae**	*Ichneumon* sp.	+	-	-	-	+	-	0.10	0.17
290.			*Ophion* sp.	+	-	-	-	+	-	0.10	0.17
291.		**Sphecidae**	*Ammophila atripes* Smith	-	-	+	-	-	-	0.07	0.17
292.			*Ammophila punctata* Smith	+	-	-	-	+	+	0.24	0.17
293.		**Andrenidae**	*Andrena cineraria* (Linnaeus)	-	-	+	-	-	-	0.07	0.17
294.	**Odonata**	**Libellullidae**	*Acisoma panorpoides panorpoides* Rambur	-	+	+	-	-	-	0.10	0.17
295.			*Aethriamanta brevipennis* (Rambur)	-	+	+	-	-	-	0.10	0.17
296.			*Brachythemis contaminata* (Fabricius)	-	+	+	-	-	-	0.10	0.17

297.			*Crocothemis servilia servilia* (Drury)	+	+	+	+	+	+	0.28	0.33
298.			*Orthetrum glaucum* Brauer	+	+	+	+	+	+	0.24	0.17
299.			*Orthetrum pruinosum* (Burmeister)	-	-	+	-	-	-	0.07	0.17
300.			*Orthetrum pruinosum neglectum* (Rambur)	+	+	-	+	+	+	0.77	0.5
301.			*Orthetrum taeniolatum* (Schneider)	+	+	+	-	-	-	0.14	0.17
302.			*Orthetrum sabina sabina* (Drury)	+	+	+	+	-	+	1.36	0.67
303.			*Orthetrum triangulare triangulare* (Selys)	-	+	+	-	-	-	0.14	0.33
304.			*Palpopleura sexmaculata sexmaculata* (Fabricius)	-	+	+	+	-	-	0.14	0.17
305.			*Pantala flavescens* (Fabricius)	-	+	+	-	-	-	0.10	0.17
306.			*Rhodothemis rufa* (Rambur)	-	-	+	-	-	-	0.07	0.17
307.			*Symptrum commixtum* Selys	-	-	-	+	-	+	0.07	0
308.			*Tholymis tillarga* (Fabricius)	-	+	-	-	-	-	0.03	0
309.			*Trithemis festiva* (Rambur)	-	+	+	-	-	-	0.10	0.17
310.			*Trithemis pallidinervis* (Kirby)	-	+	+	-	-	-	0.10	0.17
311.		**Coenagrionidae**	*Ceriagrion coromandelianum* (Fabricius)	-	+	+	-	-	-	0.10	0.17
312.			*Ischnura rubilio* Selys	-	-	+	-	-	-	0.03	0
313.			*Pseudagrion australasiae* Selys	-	-	+	-	-	-	0.07	0.17
314.			*Pseudagrion rubriceps rubriceps* Selys	-	+	+	-	-	-	0.10	0.17
315.		**Chlorocyphidae**	*Aristocypha fenestrella* Rambur	-	-	+	-	-	-	0.07	0.17

316.			*Aristocypha quadrimaculata* (Selys)	-	-	+	-	-	-	0.03	0
317.			*Paracypha unimaculata* (Selys)	-	-	+	-	-	-	0.07	0.17
318.		**Aeschnidae**	*Anaximma culiforns* Rambur	+	-	-	+	+	-	0.14	0.17
319.		**Euphaeidae**	*Bayadera indica* (Selys)	+	-	-	-	-	-	0.03	0
320.		**Synlestidae**	*Megalestes major* Selys	+	-	-	-	-	-	0.03	0
321.		**Calopterygidae**	*Neurobasis chinensis* (Linnaeus)	-	+	+	-	-	-	0.14	0.33
322.	**Orthoptera**	**Acrididae**	*Acrida exaltata* (Walker)	-	+	+	-	-	-	0.10	0.17
323.			*Aulacobothrus leutipus* Walker	-	-	+	+	+	+	0.35	0.33
324.			*Ceracris fasciata* (Brunner ven Wattenwyl)	-	+	+	-	-	-	0.10	0.17
325.			*Choroedocus illustris* (Walker)	-	+	+	-	-	-	0.10	0.17
326.			*Chorthippus almoranus* Uvarov	+	-	-	-	-	-	0.45	0.17
327.			*Cyrtacanthacris tatarica* (Linnaeus)	-	+	-	-	-	-	0.07	0.17
328.			*Diobolocantops innotabilis* (Walker)	-	+	+	-	-	-	0.10	0.17
329.			*Gastrimargus africanus africanus* (Saussure)	-	+	+	+	-	+	0.17	0.17
330.			*Gastrimargus transversus* Thunberg	+	-	-	-	-	-	0.03	0
331.			*Heteropternis respondence* (Walker)	+	-	-	-	-	-	0.03	0
332.			*Oedaleus* sp.	-	+	-	+	-	-	0.14	0.17
333.			*Oxya* sp.	-	-	+	-	-	-	0.07	0.17
334.			*Oxyrrheps obusta* (Haan)	-	+	-	-	-	-	0.03	0

335.			*Paraconophyma scabra* Walker	+	+	+	+	+	+	1.12	0.83
336.			*Patanga japonica* (Bolivar)	+	+	-	-	-	+	0.14	0.17
337.			*Phlaeoba antennata* Brunner	-	+	+	-	-	-	0.10	0.17
338.			*Phlaeoba infumata* Brunner	-	+	-	+	-	-	0.17	0.33
339.			*Phlaeoba panteli* Bolivar	-	-	+	-	-	-	0.07	0.17
340.			*Pternoscirta cinctifemur* Walker	+	+	-	-	-	-	0.10	0.17
341.			*Spathosternum prasiniferum prasiniferum* (Walker)	+	+	-	+	+	+	0.63	0.5
342.			*Sphingonotus longipennis* Saussure	-	+	+	-	-	-	0.10	0.17
343.			*Trilophidia annulata* Thunberg	-	+	-	-	-	-	0.03	0
344.			*Tyltropidius varicornis* (Walker)	-	-	+	-	-	-	0.07	0.17
345.			*Xenocatantops humilis humilis* (Serville)	-	-	+	-	-	+	0.10	0.17
346.			*Xenocatantops karnyi* Kirby	+	-	-	+	+	-	0.17	0.33
347.		**Tettigonidae**	*Elimaea* sp.	-	-	-	+	-	-	0.07	0.17
348.			*Letana linearis* (Walker)	+	-	-	-	+	-	0.10	0.17
349.			*Phaneroptera* sp.	-	-	+	-	-	-	0.07	0.17
350.		**Pyrgomorphidae**	*Atractomorpha crenulata* (Fabricius)	-	+	-	-	-	-	0.03	0
351.			*Aularches miliaris miliaris* (Linnaeus)	-	+	+	+	-	-	0.17	0.33
352.			*Chrotogonus trachypterus trachypterus* (Blanchard)	-	+	+	-	-	+	0.14	0.17
353.		**Gryllidae**	*Gryllus* sp.	-	-	+	-	-	-	0.07	0.17

354.			*Teleogryllus testaceus* (Walker)	-	-	+	-	-	-	0.07	0.17
355.	**Hemiptera**	**Coreidae**	*Anaplocne mispasina* Fabricius	-	-	-	+	-	-	0.07	0.17
356.			*Anoplocnemis phasiana* Fabricius	-	+	-	-	-	-	0.03	0
357.			*Cletus* sp.	-	-	-	+	-	-	0.07	0.17
358.			*Leptocorisa varicornis* Fabricius	-	+	-	-	-	-	0.03	0
359.			*Ochrochira albiditarsis* Westwood	+	-	-	-	-	-	0.03	0
360.			*Serinetha augur* (Fabricius)	-	+	+	-	-	-	0.10	0.17
361.		**Pentatomidae**	*Dalpada* sp.	+	+	-	+	+	+	0.31	0.33
362.			*Erthesina fullo* Thunberg	+	+	-	-	+	+	0.17	0.17
363.			*Murgantia histrionic* Hahn	-	-	-	+	-	-	0.03	0
364.			*Nezara viridula* Linnaeus	-	+	-	-	-	-	0.03	0
365.			*Sastragala* sp.	-	-	-	+	-	-	0.07	0.17
366.		**Lygaeidae**	*Lygaeus equestris* Linnaeus	+	-	-	+	-	-	0.10	0.17
367.			*Physopetata schlanbuschi* Brum	-	-	-	+	-	+	0.10	0.17
368.			*Physopetata gutta* Brum	+	-	-	-	+	+	0.35	0.33
369.			*Spilostethus hospes* Fabricius	-	+	-	-	-	-	0.03	0
370.		**Cicadellidae**	*Bothrogonia* sp.	-	-	+	-	-	-	0.07	0.17
371.			*Gaeanam maculata* (Fabricius)	-	-	-	+	-	-	0.07	0.17
372.			*Pycna repanda* Linnaeus	-	-	-	+	-	-	0.07	0.17
373.		**Cercopidae**	*Callitettix versicolor* (Fabricius)	-	+	+	-	-	-	0.10	0.17
374.			*Cosmoscarta septumpunctata* Walker	-	+	-	-	-	-	0.07	0.17

375.			*Cosmoscarta* sp.	-	-	+	-	-	-	0.07	0.17
376.		**Cicadidae**	*Haphsa nicomache* Walker	-	+	-	-	-	-	0.03	0
377.			*Oncotympana* sp.	-	+	-	-	-	-	0.07	0.17
378.			*Pomponia fusca* Olivier	-	+	-	-	-	-	0.03	0
379.		**Reduvidae**	*Euagoras plagiatus* Burmeister	-	+	-	-	-	-	0.03	0
380.			*Harpactor marginatus* Distant	-	+	-	-	-	-	0.03	0
381.			*Harpactor* sp.	-	-	+	-	-	-	0.07	0.17
382.		**Pyrrhocoridae**	*Dysdercus* sp.	-	-	-	+	+	+	0.14	0.17
383.		**Berytidae**	*Cletus punctulatus* Westwood	+	-	-	-	-	-	0.03	0
384.		**Eurybrachinadae**	*Eurybrachys* sp.	-	+	-	-	-	-	0.03	0
385.		**Ricaniidae**	*Ricania speculus* Walker	-	+	-	-	-	-	0.03	0
386.	**Diptera**	**Asilidae**	*Microstylum bicolor* Mcquart	-	-	-	+	-	-	0.07	0.17
387.			*Microstylum* sp.	-	+	-	-	-	-	0.03	0
388.			*Musca domestica* Linnaeus	-	-	-	+	-	-	0.07	0.17
389.			*Neoitamus* sp.	-	-	+	-	-	-	0.07	0.17
390.			*Philodious javanus* Wiedemann	+	-	-	-	-	-	0.03	0
391.			*Stenopagon oldroydi* Josephs and Pauri	+	-	-	+	+	+	0.38	0.33
392.		**Syrphidae**	*Episyrphus balteatus* (De Geer)	-	-	+	-	-	-	0.07	0.17
393.			*Eristalis tenax* (Linnaeus)	-	-	+	-	-	+	0.10	0.17
394.			*Syrphus confracter* Wiedemann	-	+	-	-	+	+	0.10	0
395.			*Syrphus fulvifacies* Brunetti	+	-	-	-	-	-	0.38	0.17
396.		**Tabanidae**	*Philoliche* sp.	+	-	-	+	+	-	0.14	0.17
397.			*Tabanus orientis* Walker	+	+	-	-	-	-	0.07	0
398.			*Tabanus* sp.	-	-	-	+	+	-	0.10	0.17

399.		**Bombyllidae**	*Anthrax georgicus* Macquart	-	-	-	+	-	-	0.07	0.17
400.			*Anthrax* sp.	-	+	-	-	-	-	0.03	0
401.			*Bombylius* sp.	-	-	+	-	-	-	0.03	0
402.		**Calliphoridae**	*Chrysomya* sp.	-	-	-	+	-	-	0.07	0.17
403.			*Lucilia* sp.	-	-	-	+	-	-	0.03	0
404.		**Tipulidae**	*Tipila himalayensis* Brunetti	+	-	-	-	+	-	0.07	0
405.			*Tipula* sp.	-	-	-	+	-	-	0.07	0.17
406.		**Bibionidae**	*Plecia* sp.	-	-	-	+	-	-	0.07	0.17
407.		**Muscidae**	*Ochromyia* sp.	-	+	-	-	-	-	0.03	0
408.		**Sarcophagidae**	*Sarcophaga annandalei* Senior-White	-	+	-	-	-	-	0.03	0
409.	**Neuroptera**	**Myrmeleontidae**	*Myrmeleon inanis* Gerstaecker	-	+	-	-	-	-	0.14	0.17
410.		**Chrysopidae**	*Chrysoperia carnea* (Rambur)	-	-	-	+	-	-	0.17	0.17
411.	**Isoptera**	**Termitidae**	*Microcerotermes championii* Snyder	-	-	+	-	-	-	0.35	0.17
412.			*Odonatatermes obesus* (Rambur)	-	+	+	-	-	-	0.49	0.33

Abbreviations used: PA1 (Protected Area 1): Binsar Wildlife Sanctuary; PA2 (Protected Area 2): Corbett Tiger Reserve; PA3 (Protected Area 3): Nandhaur Wildlife Sanctuary; PA4 (Protected Area 4): Askot Wildlife Sanctuary; PA5 (Protected Area 5): Nanda Devi Biosphere Reserve; PA6 (Protected Area 6): Naina Devi Himalayan Bird Conservation Reserve; RA: Relative abundance; NO: Normalised abundancy; (+): species present in particular protected area; (-): species not present in particular protected area.

TABLE 2. List of species of insects of different orders confined to respective Protective area Kumaun division of Uttarakhand.

PA/ Order	Lepidoptera	Coleoptera	Hymenoptera	Orthoptera	Odonata	Hemiptera	Diptera	Isoptera	Neuroptera
PA1	*Argynnis hyperbius*, *Dodona ouida*, *Dysphania militaris*, *Neptis zaida*, *Ochlodes brahma*, *Paliga damastesalis*	*Cerogria nepalensis*, *Gallerucida rutilans*, *Gymnopleurus subtilis*, *Lachnosterna cavifrons*, *Lytta limbata*, *Onthophagus gagates*, *Pseudolucanus cantor*	*Bombus* sp., *Vespa* sp., *Scolia venusta*	*Chorthippus almoranus*, *Gastrimargus transversus*, *Heteropternis respondence*	*Bayadera indica*, *Megalestes major*	*Cletus punctulatus*, *Ochrochira albiditarsis*	*Philodious javanus*, *Syrphus fulvifacies*	-	-
PA2	*Euchrysops cnejus*, *Euploea mulciber*, *Freyeria trochylus*, *Leptosia nina*, *Libythea* sp., *Megisba malaya*,	*Alcides* sp., *Anomala flavipes*, *Ateuchus* sp., *Cicindela* sp., *Colasposoma splendidum*, *Hydrophilus* sp., *Ophonus indicus*	*Eriades decipiences*, *Compsomeris prismatica*, *Sphex umbrosus*, *Eumenes petiolate*, *Vespa cincta*	*Cyrtacanthacris tatarica*, *Oxyrrheps obusta*, *Trilophidia annulata*, *Atractomorpha crenulata*	*Tholymis tillarg*	*Anoplocnemis phasiana*, *Leptocorisa varicornis*, *Nezara viridula*, *Spilostethus hospes*, *Cosmoscarta septumpunctata*,	*Philodious javanus*, *Syrphus fulvifacies*	-	-

	Sarangesa dasahara, *Sarangesa purendra*, *Spilalia galba*, *Spindasis* sp., *Tarucus indica*					*Haphsa nicomache*, *Oncotympana* sp., *Pomponia fusca*, *Euagoras plagiatus*, *Harpactor marginatus*, *Eurybrachys* sp., *Ricania speculus*			
PA3	*Abisara bifasciata*, *Actias selene*, *Aeromachus stigmata*, *Arhopala amantes*, *Bradina diagonalis*, *Borbo bevani*, *Cnaphalocrocis medinalis*, *Daphnis nerii*,	*Adalia* sp., *Catharsius capucinus*, *Chilocorus infernalis*, *Chlaenius* sp., *Coccinella transversalis*, *Dorysthenes huegelii*, *Epicauta* sp., *Heliocopris bucephalus*, *Hycleus* sp., *Hydrophilus triangularis*	*Ammophila atripes*, *Andrena cineraria*, *Pepsis* sp., *Phalerimeris* sp., *Sceliphron* sp., *Sphex* sp., *Vespula flaviceps*	*Gryllus* sp., *Oxya* sp., *Phaneroptera* sp., *Phlaeoba panteli*, *Teleogryllus testaceus*, *Tyltropidius varicornis*	*Aristocypha fenestrella*, *Aristocypha quadrimaculata*, *Ischnura rubilio*, *Orthetrum pruinosum*, *Paracypha unimaculata*, *Pseudagrion australasiae*		*Bothrogonia* sp., *Cosmoscarta* sp., *Harpactor* sp. (Order: Hemiptera), *Bombylius* sp., *Episyrphus balteatus*, *Neoitamus* sp.	*Microcerotermes championii*	-

	Episteme adulatrix, *Erebus caprimulgus*, *Eressa confinis*, *Eupterote* sp., *Fodina pallula*, *Jamides celeno*, *Libythea* sp., *Ourapteryx clara*, *Pseudocoladenia faith*, *Spirama retorta*, *Spoladea recurvalis*, *Tarucus nara*, *Theretra nessus*, *Trigonodes hyppasia*, *Tyspanodes linealis*, *Udaspes folus*, *Vagrans egista*, *Vamuna remelana*, *Zizula hylax*	*Metopodontus biplagiatus*, *Ophonus rufibarbis*, *Oryctes nasicornis*, *Psyllora vigintiduopunctata*							

PA4	*Abisara fylla*, *Agrius* sp., *Graphium cloanthus*, *Hemaris* sp., *Lemyra* sp., *Parantica sita*, *Sphinx* sp.	*Chiloba acuta*, *Clinteria spilota*, *Dsygnathus* sp., *Oenopia kirbyi*, *Oxycertonia versicolor*, *Pheropsophus* sp., *Popilla cupricollis*, *Scarities* sp., *Sisyphus hirtus*, *Torynorrhina opalina*	*Anthophora* sp., *Campanotus* sp., *Campsomeriella collaris*, *Delta dimidiatipennis*, *Diacomma* sp., *Mandarinia* sp., *Pachycondyla* sp., *Polistes hebraeus*, *Polistes* sp.	*Elimaea* sp.		*Anaplocne mispasina*, *Cletus* sp., *Gaeanam maculata*,, *Murgantia histrionic*, *Pycna repanda*, *Sastragala* sp.	*Anthrax georgicus*, *Chrysomya* sp., *Chrysoperia carnea*, *Microstylum bicolor*, *Musca domestica*, *Plecia* sp., *Tipula* sp.	-	-
PA5	-	-	-	-	-	-	-	-	-
PA6	-	-	-	-	-	-	-	-	-

Abbreviations used: PA1 (Protected Area 1): Binsar Wildlife Sanctuary; PA2 (Protected Area 2): Corbett Tiger Reserve; PA3 (Protected Area 3): Nandhaur Wildlife Sanctuary; PA4 (Protected Area 4): Askot Wildlife Sanctuary; PA5 (Protected Area 5): Nanda Devi Biosphere Reserve; PA6 (Protected Area 6): Naina Devi Himalayan Bird Conservation Reserve; (-): species of no order confined to any protected area.

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Conflict of interests

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Οικολογικά Δεδομένα για την ποικιλομορφία των εντόμων σε δίκτυα προστατευόμενων περιοχών της περιοχής Kumaun, στα Δυτικά Ιμαλάια

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ΠΕΡΙΛΗΨΗ

Η περιοχή Uttarakhand στα Δυτικά Ιμαλάια, γνωστή για την πλούσια βιοποικιλότητά της, περιλαμβάνει πολλές προστατευόμενες περιοχές που περιλαμβάνουν από τροπικές έως εύκρατες ζώνες. Η παρούσα εργασία διερευνά την ποικιλομορφία των εντομολογικών ειδών στις έξι προστατευόμενες περιοχές στην περιοχή Kumaun των Ιμαλαΐων. Συνολικά, τεκμηριώθηκαν συνολικά 412 είδη εντόμων από εννέα τάξεις και 70 οικογένειες. Η τάξη Lepidoptera ήταν η πιο ποικιλόμορφη με μέγιστο 154 είδη, ακολουθούμενη από τα Coleoptera (81 είδη), τα Hymenoptera (58 είδη), τα Orthoptera (33 είδη), τα Hemiptera (31 είδη), τα Odonata (28 είδη), τα Diptera (23 είδη) και Isoptera και Neuroptera ως τα λιγότερο κυρίαρχα με δύο είδη το καθένα. Η ποικιλότητα ειδών κατά Shannon (Hs) κυμάνθηκε από 3,99 έως 4,95, με την υψηλότερη ποικιλότητα να καταγράφεται στο καταφύγιο άγριας ζωής Nandhaur και τη χαμηλότερη στο καταφύγιο προστασίας πουλιών Naina Devi Himalayan. Η ανάλυση cluster αποκάλυψε δύο κύρια μοτίβα ποικιλομορφίας, υποδεικνύοντας σημαντική β-ποικιλομορφία μεταξύ των περιοχών μελέτης. Species-wise occupancy και η abundance analysis αποκάλυψε ότι τα είδη *Pieris brassicae, P. canidia* και *Apis dorsata* είχαν την υψηλότερη σχετική αφθονία από όλες τις προστατευόμενες περιοχές. Αντίθετα, 91 είδη εντόμων είχαν σχετική αφθονία με μόνο 0,03% το καθένα. Επιπλέον, επτά είδη παρουσίασαν την υψηλότερη κανονικοποιημένη πληρότητα 1,00, υποδεικνύοντας την προσαρμοστικότητά τους σε διαφορετικές περιβαλλοντικές συνθήκες εντός των προστατευόμενων περιοχών. Αυτά τα ευρήματα υπογραμμίζουν τη σημασία της ποικιλομορφίας των οικοτόπων και των στοχευμένων στρατηγικών διατήρησης για τη διατήρηση των πληθυσμών των εντόμων και της υγείας των οικοσυστημάτων στο Kumaun Himalaya.

