J. Insect Biodivers. Syst. 09 (3), 483–498

https://jibs.modares.ac.ir

OPEN ACCESS

Tarbiat Modares University Press | Entomological Society of Iran

Resaerch Article | Biodiversity

https://doi.org/10.52547/jibs.9.3.483

ISSN: 2423-8112

https://zoobank.org/urn:lsid:zoobank.org:8AB41BBB-7967-4B8B-83E5-96A03A8562AA

Studies on threat status and food habits of butterflies (Lepidoptera) of Shimla Water Catchment Wildlife Sanctuary, Himachal Pradesh, India

Pawan Kumar
Forest Protection Division, Himalayan Forest Research Institute, Conifer campus, Panthaghati, Shimla-9, India.
kumarp@icfre.org *https://orcid.org/0000-0003-4593-2314*

Anchal Verma
Forest Protection Division, Himalayan Forest Research Institute, Conifer campus, Panthaghati, Shimla-9, India.
anchalverma1401@gmail.com *https://orcid.org/0000-0002-1787-8990*

Ritika Gangotia
Forest Protection Division, Himalayan Forest Research Institute, Conifer campus, Panthaghati, Shimla-9, India.
reetsharmareet@gmail.com *https://orcid.org/0009-0005-5325-7998*

Pawan Kumar Thakur
Forest Ecology and Climate Change Division, Himalayan Forest Research Institute, Conifer campus, Panthaghati, Shimla-9, India.
thakurpawankumar0431@gmail.com *https://orcid.org/0000-0002-0892-9135*

ABSTRACT. The current study gives more information on Lepidoptera (butterfly) diversity and their food plant resources in the conifer woods of Shimla Water Catchment Wildlife Sanctuary, Himachal Pradesh. The study was carried out during the three distinct seasons; summer, monsoon, and autumn from March 2019–April 2022. A total of 1650 butterflies, representing 68 species and 6 families were recorded. The Nymphalidae comprised the greatest number of species (28 species), followed by the Lycaenidae (15), Pieridae (13), Papilionidae (7), Hespiradie (4) and Riodinidae (1). Species abundance and richness were more in mixed forest type which owing water and grass-cover availability supported most unique butterfly assemblages as compared to pure conifers and oak forest. The months from April to November harbor the greatest abundance of species. An overall reduction in species abundance was seen from December through January and until the end of March. This study provides an understanding of butterflies and has inspired additional investigation for the restoration of forest habitats in this protected area. The current study on diversity shows the importance of preserving biodiversity and monitoring climate change. It offers a basic identification, gathers data from a comparative viewpoint, allows synthesis, and develops and stimulates ideas and hypotheses that are applicable to other fields.

Key words: Climate, conservation, diversity, environment, pollinators

Received:
24 January, 2023

Accepted:
30 March, 2023

Published:
30 April, 2023

Subject Editor:
Behzad Miri

Citation: Kumar, P., Verma, A., Gangotia, R. & Kumar Thakur, P. (2023) Studies on threat status and food habits of butterflies (Lepidoptera) of Shimla Water Catchment Wildlife Sanctuary, Himachal Pradesh, India. *Journal of Insect Biodiversity and Systematics*, 9 (3), 483–498.

INTRODUCTION

Insects constitute the majority of species on the globe (May, 1992). An essential component of ecosystem functions is played by insects. They help in maintain soil structure and fertility by cycling nutrients, pollinating plants, dispersing seeds, regulates the populations of other species, and serve as a key food

Corresponding author: Verma, A., E-mail: *anchalverma1401@gmail.com*

source for other taxa (Kaundil & Mattu, 2017). Butterfly species are regarded as charismatic creatures with a variety of useful functions, which a large number are recognized as ecosystem services for human well-being (Kurtz et al., 2001; Nelson, 2007; Guiney & Oberhauser, 2008). Butterflies depend on plants for food and to complete their life cycle, many economically important plants species are pollinated by butterflies. Fruit and seed production reduce as a result of a lack of suitable pollinators (Partap et al., 2001). Rotten fruit, carrion, urine, and animal feces also attract some butterflies (Ehrlich & Raven, 1964). Over 28,000 species of butterflies have been identified worldwide, with tropical areas home to 80% of them. Additionally, the Indian subcontinent is home to 1,504 different species of butterflies which has a varied landscape, climate, and vegetation (Tiple, 2011). A study has been shown that the Indian Himalayan Region (IHR) is a major hotspot area for biological diversity (Myer et al., 2000; Kumar & Mattu, 2014).

The interaction between plants and butterflies is extremely complex and co-evolved (Ehrlich & Raven, 1964). The majority of butterflies are strictly seasonal, and prefer only one kind of habitat, and visit only a small number of flowering plants. The preference of the butterflies is influenced by the colour and shape of the flowers (Hirota et al., 2012; Cepero et al., 2015). Due to their poikilothermic characteristics, insects are highly sensitive to temperature, and because of their high mobility, they quickly adjust to changing thermal circumstances and migrate (Kiritani & Yukawa, 2010). In general, the presence of vegetation in gardens or woodlands, both in semi-natural and natural environments, enhances the conservation of butterflies (van Halder et al., 2008). The range of the plants that serve as hosts for butterflies, as well as the type of vegetation that was assessed and may have an effect on the butterfly community composition, are expected to be included in butterfly distributions, even at small scales (Beccaloni, 1997). Butterflies are strong biological markers of general environmental health and habitat quality (Larsen, 1988). The relative amount of resources for plants and butterflies was a key factor in establishing the pattern of the butterfly community (Yamamoto et al., 2007). The ecosystem structure and functions alter as a result of a decline in the vegetation pattern, which also affects the abundance of the ecosystem's constituent biota. For butterflies, many such events support the decline in species richness and consequently, the quality of the associated habit (Stefanescu et al., 2004). Deforestation, habitat loss due to urbanization, and industrialization are the main factors contributing to the fall of butterfly populations. Since butterflies are exothermic creatures, the surrounding temperature has a significant impact on thir activity. Therefore, changes in the range, phenology, voltinism, and activity patterns will be reflected by equivalent changes in climate. Thus, butterflies are suitable bioindicators, and over the past few decades, there has been a steady buildup of evidence that changes in their distribution and abundance are being driven by the climate. Due to their amazing capacity for environmental adaptation, they are often regarded as the flagship species for conservation (Thomas, 2005). Butterflies offer an excellent subject for studying environmental quality due to their taxonomy, distribution, short lifespan, and day-flying activity. The butterfly was also considered by several researchers and biologists as a useful bio-indicator as its contribution towards the conservation of the forest community (Bhardwaj et al., 2012).

All over the world, habitat loss and fragmentation are two primary threats to biodiversity. Habitat fragmentation is made up of five distinct phenomena: **1.** Decrease in the habitat's overall size, **2.** Reduction in the interior-to-edge ratio, **3.** Disconnection of one habitat fragment from other habitat regions, **4.** Splitting a single habitat patch into multiple smaller ones, and **5.** Reduction in the average size of each habitat patch (Didham, 2010). Population fragmentation and ecological deterioration are both caused by the emergence of discontinuities in an organism's preferred habitat. Geological processes change the topography of the physical environment, which splits habitats. Additionally, human actions like land conversion can change the ecology and result in the eradication of numerous species. The fossil record contains evidence of habitat degradation brought on by natural phenomena like volcanism, fire, and climate change. For example, the destruction of the tropical rainforest habitat in Europe 300 million years ago led to a large loss in the diversity of amphibians, but the drier environment at the same time led to an increase in the diversity of reptiles (Sahney et al., 2010). The fragmentation of habitat is usually the cause of a species near-threatened or threatened status. The ability of a species to survive depends on the environment that is currently accessible. By preserving or establishing native plant corridors, it is possible to connect habitat fragments, which is a solution to the issue of habitat fragmentation. Figure 1 Illustrates a schematic representation of the habitat fragmentation process, This is a process by which a huge habitat area is split up into a number of smaller patches, each with a reduced overall area and being separated from the others by a different matrix of habitats from the original. White patches signify matrix, while green areas signify habitat.

Lots of studies on the diversity of butterflies in different parts of Himachal Pradesh have been conducted by various researchers. The purpose of the current study was to examine the diversity, habitat preferences, food/host plant resources, and to demonstrate how plant species assemblages at study area influence the diversity of butterfly species and their abundance in the coniferous wood of the Water Catchment Wildlife Sanctuary, Shimla, Himachal Pradesh. Understanding the mutualistic interactions between plants and butterflies would help us in better understand the basic principles behind community formation and stability (Wisz et al., 2013). The empirical study provides a significant amount of information that is used in conservation planning and management about the variety and behaviour of butterflies from different terrestrial ecosystems (see Opler, 1995; New, 1999; Barranco-León et al., 2016).

MATERIAL AND METHODS

Study area. Water Catchment Wildlife Sanctuary is located between latitude 31°05'12"N–31°07'11"N and longitudes 77°12'54"E–77°16'04"E in Shimla District of Himachal Pradesh (Fig. 2). The sanctuary covers a total area of 10.25 square Kilometers. The temperature fluctuates from -5.4°C to 32°C, while the altitude ranges from 1,518–2,637 m amsl. The Sanctuary receives about 1600 mm of rain annually, and the majority of that falls as snow during the bitterly cold winter months (Prakash & Pathak, 2019). The sanctuary is divided into four beats (Churat, Chharabra, Seog, Kufri). The region has a wide variety of flora and wildlife. Himalayan Cedar (Deodar) predominates in this area's vegetation, which is also dotted with White Oak, patches of Chir Pine, and Blue Pine at higher elevations. The majority of the ground vegetation, which makes up around 50% of the total, is made up of grasses, while there are also several ferns and vascular herbs (Prakash & Pathak, 2019).

Sampling. The sampling and monitoring of butterflies were carried out in 4 beats of Water Catchment Wildlife Sanctuary Shimla, Himachal Pradesh from March 2019 to April 2022 to assess the butterflies and their host/food plant diversity. The sanctuary experiences four seasons during the year; summer, monsoon, autumn and winter. The survey was done during summer, monsoon, and autumn. Because of low temperature and excessive snowfall within the sanctuary, the sanctuary remains closed during winter. The Pollard walks method (Pollard & Yates, 1994) was used to assess the butterfly fauna. In each of the four study sites, a fixed transect was laid. Transect dimensions were set at 1000 × 20 metres respectively and with the help of an insect net and sweeping technique, the specimens were collected. Additionally, photographic documentation was completed using a zoom lens for the Nikon D5600 Camera that has an EF range of 75 to 300 mm. Butterflies are most active during bright sunlight, so transects were walked mostly from 10:00 AM to 02:00 PM (flight period). During the study period, every location was visited twice a month. All the butterflies at sampling sites were recorded with the number of individuals seen. Also, other parameters such as weather conditions, nectar plants, and geographic characteristics were recorded. Only one or two specimens were brought to the lab for identification. Insect species were identified with the use of relevant literature; Evans (1932), Wynter-Blyth (1957), Kunte (2000), Kehimker (2008) and Singh (2010). Some adult specimens were identified through comparison to a reference collection maintained at national museum at Forest Research Institute (F.R.I.), Dehradun, Uttarakhand, India.

Figure 1. A schematic representation of the habitat fragmentation process, which is the process by which a big habitat area gets divided into a number of smaller patches, each with a smaller total area and being segregated from the others by a matrix of habitats that is different from the original. White patches signify matrix, while green areas signify habitat).

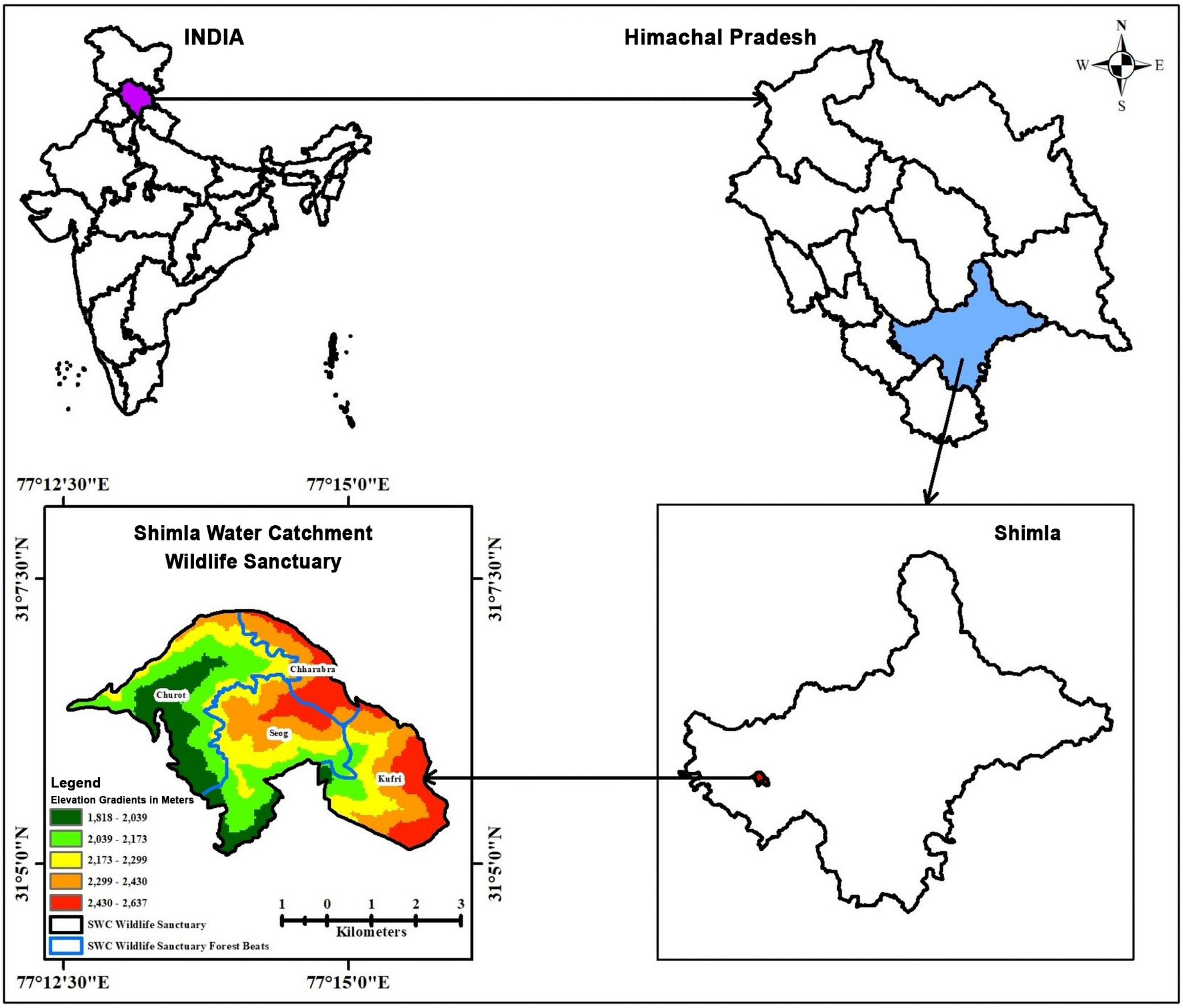

Figure 2. Map of Shimla district, showing Water Catchment Wildlife Sanctuary, Himachal Pradesh, India.

This locality has abundant flowering plants surrounded by trees, shrubs and herbs. Flowers visiting by butterflies were recorded for every plant that adult butterflies visited, although it was not quantified. The butterflies were classified into six categories based on relative abundance estimations Rajasekhar (1991, 1992 and 1995): **1.** *Abundant*: >30%; **2.** *Very Common*: 20–30%; **3.** *Common*: 10–20%; **4.** *Frequent*: 5–10%; **5.** *Occasional*: 1–5%; **6.** *Rare*: < 1%.

Data analysis. Species diversity was calculated using the Shannon Wiener diversity index (*H*) (Shannon-Wiener, 1940). Microsoft excel (ver. 2019) is used to calculate species diversity, evenness, richness.

$$H = -\sum p_i \ln p_i$$

Where *pi* is the proportion of individuals found in the ith species. In a sample the true value of p_i is unknown but is estimated as n_i/N; n_i= number of specimens of *i*-species per sample, *N*= total number of individuals of all the species. The Simpson's index was also used to determine the species diversity measurement; higher values indicate greater diversity. This index is less sensitive to rare species compared to the Shannon-Wiener Index (*H*'). Simpson's index always has a value between 0 and 1 (Simpson, 1949).

$$D = \sum {p_i}^2$$

Where p_i = the proportion of individuals in the ith species. In order to calculate the index the form appropriate to a finite community is used (Magurran, 1998):

$$p_i = \frac{n_i\,(n_i - 1)}{N(N-1)}$$

Where n_i = the number of individuals in the ith species and N = the total number of individuals. As D increases, diversity decreases and Simpson's index is therefore usually expressed as 1-D or l/D. The Berger-Parker index was calculated as a simple measure of the numerical importance of the most abundant species (Magurran, 1998):

$$d = \frac{N_{max}}{N}$$

Where N_{max} is the number of individuals in the most abundant species, and *N* is the total number of individuals in the sample. The Evenness index was calculated utilising (Hill, 1973):

$$E = \frac{H}{\ln S}$$

Where *S* denotes the overall number of species, *E* is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant. As with *H* this evenness measure assurnes that all species in the community are accounted for in the sampie. The Margalef index served as a straightforward indicator of species richness (Margalef, 1958) in which

$$D = \frac{(S-1)}{\ln N}$$

Where *S* = Total number of species, *N* = Total number of individual in sample, *ln* = Natural logarithm.

RESULTS

The current study set out to investigate the diversity, evenness, and habitats preference of butterflies. In the current study, 68 species of butterflies from 52 genera and six families were recorded from various beats of the Water Catchment Wildlife Sanctuary. The family Nymphalidae contributed the most species to the overall number of observed species (28 species), followed by the Lycaenidae (15 species), Pieridae (13 species), the Papilionidae (7 species), the Hesperidae (4 species), and the Riodinidae (1 species) had minor representation. The list of identified butterflies is given in (Appendix 1).

According to the percentage composition of each family (Fig. 3) the Nymphalidae made up roughly (41%) of the overall butterfly fauna, followed by Lycaenidae (22%), Pieridae (19%), Papilionidae (10%), Hesperiidae (6%), and Riodinidae (2%). The Riodinidae had the lowest species diversity (0%), while the Nymphalidae had the highest (2.91). The values of the diversity indices are shown in Table 1. Evenness was highest in family Nymphalidae (0.874) and lowest in Riodinidae (0). The Nymphalidae had the highest species richness (3.90) while the Hesperidae had the lowest (3.60) only one species were represented by the Riodinidae, which made up only 0.36% of all the species in the study area. The most widespread family was Nymphalidae. Simpson's diversity index (SDI) measures community diversity. The range is from 0 to 1, where high scores (close to 1) indicate low diversity. Low scores (close to 0) indicate high diversity. Nymphalidae had the highest diversity (0.06), followed by Lycaenidae (0.09), Pieridae (0.12), Papilionidae (0.20), Hesperiidae (0.32), and Riodinidae (1.00) with lowest diversity. Berger-Parker Dominance Index of Nymphalidae was (0.13), Lycaenidae (0.18), Pieridae (0.15), Papilionidae (0.30), Hesperiidae (0.43), and Riodinidae (0). Among all the sampling sites, it was found that Chharabra beat had the highest number of species followed by Kufri and churat beat having same species richness. The least number of species were found at Seog beat. Based upon sighting frequency, Chharabra beat was found to be the most favorable place for butterfly fauna due to the presence of suitable host /food plants.

Based on the number of sightings throughout the duration of the whole study period, each species was given a relative abundance (Fig. 4). By using the number count method to determine relative abundance, it was found that out of the 68 butterfly species recorded in Water Catchment wildlife sanctuary, 4 species are abundant, 5 species are very common, 11 species are Common, 16 species are Frequent, 19 species are Occasional and 12 species are Rare. The Wildlife Protection Act of 1972's provisions applies to 3 of the 68 butterfly species that were recorded, giving them legal protection in India (Anonymous, 1997).

Out of these, 1 species is protected under Schedule II (*Papilio machon*) and 2 species (*Athyma Jian, Callerabia ananda*) are protected under Schedule IV of the Wildlife Protection Act, 1972 (Anonymous, 1997). Among different vegetation types sampled in study area, butterfly abundance was maximum in scrub habitats, followed by herbs and then trees.

Table 1. The calculated diversity indices for the butterfly communities at Water Catchment Wildlife Sanctuary, Shimla, Himachal Pradesh.

	Shannon-Wiener Index (*H'*)	Species evenness	Species richness (S)	Simpson's Index (λ)	Berger-Parker Dominance Index
Nymphalidae	2.91	0.87	3.76	0.06	0.13
Lycaenidae	2.46	0.90	2.14	0.09	0.18
Pieridae	2.25	0.87	1.74	0.12	0.15
Papilionidae	1.67	0.86	1.33	0.20	0.30
Hesperidae	1.14	0.82	0.97	0.32	0.43
Riodinidae	0.00	0.00	0.36	1.00	0.00

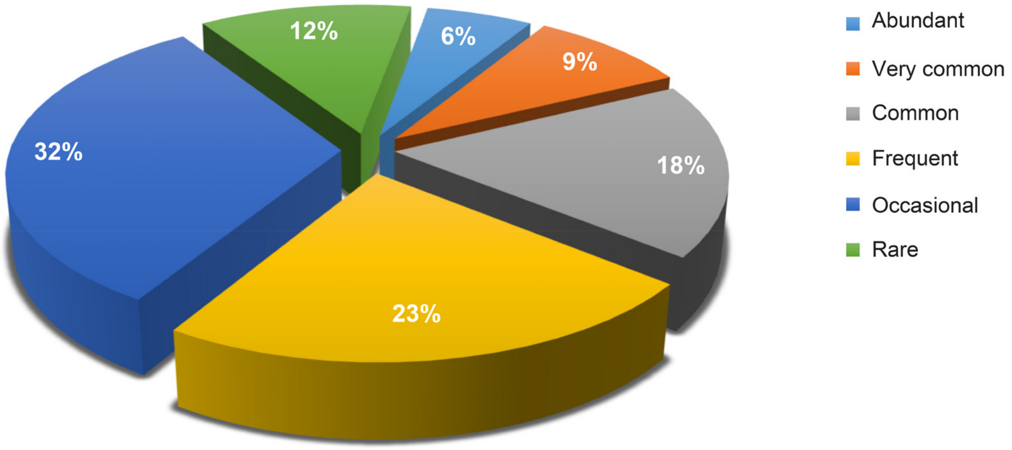

Figure 3. Composition of butterfly species at the Water Catchment Wildlife Sanctuary, Shimla, Himachal Pradesh, during 2019–2021.

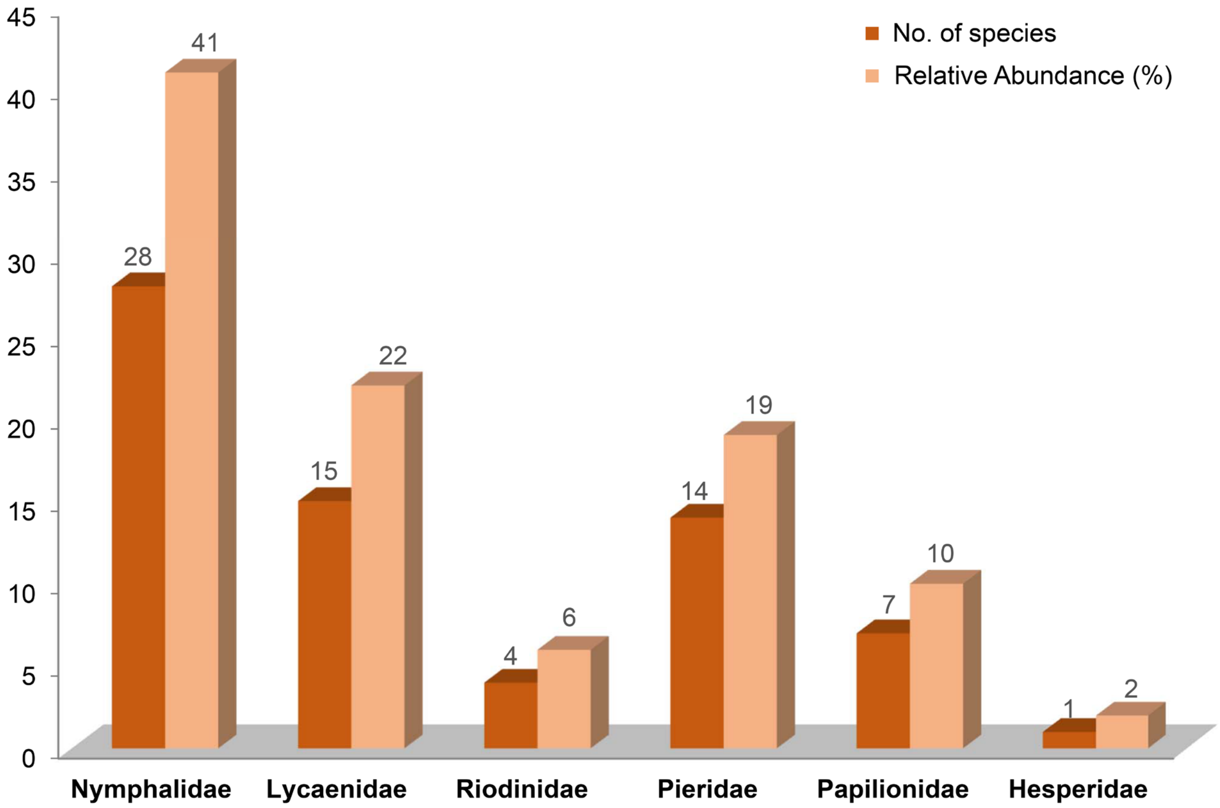

Figure 4. Number of species and relative abundance (%) of each family of butterflies.

Host and nectar plant species. The diversity, abundance, and richness of butterfly species were significantly influenced by the local environment characteristics. Every plant in the study area visited by adult butterflies was also recorded. The most common plants visited by adult butterfly were *Berberis lycium*, *Prinsepia utilis, Bidens pilosa*, *Rosa moschata*. Most butterflies were observed visiting a limited number of plant species; *Kaniska canace* visits only on *Smilax* sp. In addition, some butterflies species were observed on the ground or on rubbish; *Leptotes pliniues* which was found on the ground.

DISCUSSION

Biodiversity is rapidly and drastically changing on a global scale. In addition to the geographic regions and the movement of the species diversity are influenced by its ecological needs (Khan et al., 2011). Only a few species are confined to the Himalayan climate, in the altitude above 4000 m a.s.l. (Khanal et al., 2012). Numerous studies on species diversity and habitat preferences have been conducted all over the world, while addressing the issue of habitat fragmentation. Many institutions began focusing on Rhopaloceran studies at the start of the twenty-first century, which gave India access to a large range of literary materials (Gay et al., 1992). The objective of this study was to better understand the status of butterfly diversity in the Water Catchment WLS as well as how local habitat factors affect the variety, abundance, and richness of butterfly species and the assessment of endangered and protected species of butterflies in this area. Across the range of habitat types, there were very few differences in butterfly diversity and richness. The present butterfly study has much more specimens than earlier publications from this area. In their study (Gangotia & Kumar, 2019) used the same methods to collect butterflies over a period of 1-year from 2017 to 2018. They recorded 31 species of butterflies, which were divided into five groups. These species are nearly two times less common than what was observed in the current study. In 2008 The Zoological Survey of India issued a venerable reference on common butterflies of Uttarakhand (Kumar, 2008). ZSI released a guide on the butterflies of Himachal Pradesh, a year later (Arora et al., 2009). After a short period of time, the Kerala Forest Research Institute produced a thorough report on the Nilgiri Biosphere Reserve's butterflies (Mathew, 2011).

The study area is primarily covered in a variety of plant types with dense vegetation that supports butterfly populations (Rana & Kapoor, 2015) reported 476 different species of Vascular plants. Out of the total number of species, 36 were pteridophytes, 39 were trees, 81 were shrubs, and 320 were herbs. The largest families were Asteraceae (45 species), Lamiaceae (31 species), and Poaceae (32 species) 39 families exhibited monotypy. Temperature fluctuations were found to have an impact on the seasonal distribution of many butterfly species which is the most significant environmental factor determining behaviour, distribution, population size, development, survival, reproduction as well as phenology (Petzoldt & Seaman, 1992).

The temperature within the ideal range increases metabolism, which in turn accelerates the rate of development. The temperature influences each stage of the life cycle because it affects the metabolism (Gullan & Cranston, 2014). According to (Muralirangan et al., 1993), excessive humidity encourages fungal attack whereas high temperatures reduce the number of insects. From June to July, when the monsoon season begins, species abundance climbs and peaks. From August to November and December to February, however, there is a decline in species abundance this decline lasted throughout March. Butterfly populations increased during the monsoon. It might be due to enough host plants and the climate being suitable for the growth and development of butterflies. The least amount of butterflies were gathered in the winter due to inadequate host plants and adverse weather conditions. In windy weather, butterfly variety is generally lower. While many species of Lycaenids and some Papilionids are completely missing from windy areas, other Nymphalids, such as *Vanessa cardui* and *Issoria issaea*, can withstand strong wind pressure. The high abundance observed in our study during specific months was mostly caused by the overlap of seasonal peaks of numerous butterfly species with high abundance. The presence of many abundant species implies the succession of generations, which is only possible if the species can withstand more extreme climate variations and make better use of local resources over longer time periods (Wolda, 1978). Similar data was recorded by various researchers in different districts of Himachal Pradesh as in Balh valley of District Mandi 40 species of butterflies were recorded by (Kumar & Mattu, 2014). 50 species of butterflies were recorded from Pong Lake of District Kangra by (Mehta et al., 2002). According to Singh & Banyal (2014) 49 species are recorded in District Chamba. In 2021 Six rhopaloceran species of the Nymphalidae, Pieridae, Lycaenidae, and Satyridae families were recorded from the Chandertal Wetland by Singh & Thakur (2021).

Due to distinct dry and wet seasons and increased climatic variability, the extremely unequal distribution of butterfly species in the communities raises the possibility that the diversity of butterflies in a sub-tropical region may differ from the tropics. It is well known that richness and abundance increase with relative humidity (Muralirangan et al., 1993). The months of July and August have the greatest average relative humidity measurements, while November has the lowest average readings. Additionally, our results agreed with (Lee et al., 2014, Montero-Munoz et al., 2013, Valtonen et al., 2013, Camero & Calderon, 2007, Clark et al., 2007). They come to the conclusion that environmental gradients either directly or indirectly affect butterfly diversity and abundance. The butterfly assemblage in our study displayed significant seasonal variations in richness and abundance are mentioned in Fig. 2 and in Table 1. A good diversity of butterfly species is supported in the research area. Species of two butterly families, Nymphalidae and Pieridae were found in more numbers than others, which are reflecting the availability of larval food plants of butterflies in this Sanctuary and a similar pattern was observed from the Chanshal valley of district Shimla (Kumar et al., 2016). *Athyma jina*, *Atrophaneura polyeuctes*, *Celastrina lavendularis*, *Junonia iphita*, *Melantis lida*, *Pontia daplidice*, *Vagrans egista* were found to be rare species in the study area. During the transect walk, they just seen occasionally particular with just one or two specimens. Similar result was shown in the watershed's catchment region and the nearby forests yielded a total of 64 species and 45 genera from six butterfly families. Nymphalidae, which included 28 species and 45.84% of all butterflies, was the most prevalent taxonomic group of butterflies.

The Himalayan butterflies, which included rare (17.18% species), habitat-specific (18.75% species), legally protected (7.81% species), and endemic (20.31% species) butterflies, were among the species with the highest conservation priority (Verma & Arya, 2022). Similar result was shown in the study area *Aglais cashmirensis, Athene embolus,* and *Papilio demoleus* was very common in the study area (Verma & Arya, 2022). Habitat preference varies species-wise. It has also been observed that the occurrence and abundance of butterflies was more in grassland and mixed tree forests but their occurrence was very few in pure conifers forests and Oak forests. *Aporia agathion, Kaniska canace* and some *Papilo* sp. were found only in pure conifers forests in the study areas. Butterflies visited flowers with tubular corollas more frequently than those without, as well as those with colours purple, blue, yellow, and red rather than pink and white, and those that were available throughout the year. There is a minimum threshold level determined by each environmental component below which an organism cannot exist. The largest population density is produced by the influencing variables at their best levels, and beyond a certain point again, existence is lost (Mani, 1968). As per the current study, butterflies can find favourable ecological conditions and habitats in the studied locations. It might be because there are enough host plants and the climate is ideal for the growth and development of butterflies.

The current research on biodiversity contributes to the conservation and climate change monitoring requirements. As butterflies are excellent bio-indicators of ecosystem disturbances (Thomas, 2005). They are also recognised as ecological indicators that respond quickly to climatic and ecological changes and the stratification of the vegetation in terms of temperature wind, light, and humidity (Dar et al., 2021) so, studies on their diversity status, etc. Will be very useful in tracking changes in an ecosystem, particularly those caused by habitat loss, deforestation, organic and inorganic pollution which will help in the better management and conservation of butterfly fauna. Our study on diversity shows the importance of preserving biodiversity and monitoring climate change. It offers a basic identification, gathers data from a comparative viewpoint, allows synthesis, and develops and stimulates ideas and hypotheses that are applicable to other fields. Additionally, the planning of programs for eco-restoration and the development of butterfly parks or gardens would be benefited from this information. Recently Ecotourism has been promoted is an effort to enhance awareness of the significance of biodiversity, mainly the variety of butterflies. In developing and planning butterfly parks, the study on plant-butterfly interactions given in the paper gains significance. Furthermore, while suggesting the establishment of new parks and protected areas, conservation efforts must take into account the significant value of beta variety.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: P. Kumar: Conceptualization of the study, Identification of the specimens, review; A. Verma: Collecting the specimens, Identification of the specimens, data analysis and preparation of the manuscript; R. Gangotia: Collecting the specimens; P. Kumar-Thakur: GIS-Mapping. All authors read and approved the final version of the manuscript.

FUNDING

This research was financialy supported by CAMPA, All India Coordinated Research Project (AICRP-31), Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.

AVAILABILITY OF DATA AND MATERIAL

The specimens listed in this study are deposited in reference collection maintained at Himalayan Forest Research Institute (H.F.R.I.), Shimla and are available from the curator, upon request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

ACKNOWLEDGMENTS

Authors are thankful to CAMPA, MoEF & CC, GOI for providing necessary funds to conduct this study. The support and facility provided by Director General ICFRE, Dehradun and Director, Himalayan Forest Research Institute, Shimla H.P. is also acknowledged.

REFERENCES

Anonymous (1997) The Wildlife (Protection) Act, 1972 (as amended up to 1993) with rules uptil 1995. Natraj Publishers, Dehra Dun. 291 p.

Arora, G.S., Mehta, H.S. & Walia, V.K. (2009) *Handbook on Butterflies of Himachal Pradesh*. Zoological Survey of India, Kolkata, 140 p.

Barranco–León, M.N., Luna–Castellanos, F., Vergara, C.H. & Badano, E.I. (2016) Butterfly conservation within cities: a landscape scale approach integrating natural habitats and abandoned fields in central Mexico. *Tropical Conservation Science*, 9 (2), 607–628. https://doi.org/10.1177/194008291600900204

Beccaloni, G.W. (1997) Vertical stratification of ithomiine butterfly (Nymphalidae: Ithomiinae) mimicry complexes: the relationship between adult flight height and larval host-plant height. *Biological journal of the Linnean Society*, 62 (3), 313–341. https://doi.org/10.1111/j.1095-8312.1997.tb01629.x

Bhardwaj, M., Uniyal, V.P., Sanyal, A.K. & Singh, A.P. (2012) Butterfly communities along an elevational gradient in the Tons valley, Western Himalayas: Implications of rapid assessment for insect conservation. *Journal of Asia-Pacific Entomology*, 15 (2), 207–217. https://doi.org/10.1016/j.aspen.2011.12.003

Camero, É., & Calderon, A.M. (2007) Butterflies Community (Lepidoptera: Rhopalocera) Along an altitudinal gradient in Combeima river canyon Tolima, Colombia. *Acta Biológica Colombiana*, 12 (2), 95–110.

Cepero, L.C., Rosenwald, L.C. & Weiss, M.R. (2015) The relative importance of flower color and shape for the foraging monarch butterfly (Lepidoptera: Nymphalidae). *Journal of Insect Behavior*, 28, 499–511. https://doi.org/10.1007/s10905-015-9519-z

Clark, P.J., Reed, J.M., & Chew, F.S. (2007) Effects of urbanization on butterfly species richness, guild structure, and rarity. *Urban Ecosystems*, 10, 321–337. https://doi.org/10.1007/s11252-007-0029-4

Dar, A.A., Jamal, K., Alhazmi, A., El-Sharnouby, M., Salah, M. & Sayed, S. (2021) Moth diversity, species composition, and distributional pattern in Aravalli Hill Range of Rajasthan, India. *Saudi Journal of Biological Sciences*, 28 (9), 4884–4890. https://doi.org/10.1016/j.sjbs.2021.06.018

Didham, R.K. (2010) Ecological consequences of habitat fragmentation. *Encyclopedia of Life Sciences*, 61, 1–11. https://doi.org/10.1002/9780470015902.a0021904

Ehrlich, P.R. & Raven, P.H. (1964) Butterflies and plants: a study in Coevolution. *Evolution*, 18 (4), 586–608. https://doi.org/10.1111/j.1558-5646.1964.tb01674.x

Evans, W.H. (1932) *The Identification of Indian Butterflies*. Bombay Natural History Society, Bombay. 464 p.

Gangotia, R. & Kumar, P. (2019) Habitat preferences of butterflies of conifer forests of water catchment sanctuary Shimla, Himachal Pradesh. *Journal of Entomology and Zoology Studies*, 7 (1), 284–288.

Gay, T., Kehimkar, I.D. & Punetha, J.C. (1992) Common butterflies of India. Oxford University Press, Bombay. 67 p.

Guiney, M.S. & Oberhauser, K.S. (2008) Insects as flagship conservation species. *Terrestrial Arthropod Reviews*, 1, 111–123. https://doi.org/10.1163/187498308X414733

Gullan, P.J. & Cranston, P.S. (2014) *The Insects: An Outline of Entomology*, Fifth Edition. John John Wiley & Sons, Chichester, UK. 584 p.

Hill, M.O. (1973) Diversity and its evenness, a unifying notation and its consequences. *Ecology*, 54, 42–432. https://doi.org/10.2307/1934352

Hirota, S.K., Nitta, K., Kim, Y., Kato, A., Kawakubo, N., Yasumoto, A.A. & Yahara, T. (2012) Relative role of flower color and scent on pollinator attraction: experimental tests using F1 and F2 hybrids of daylily and nightlily. *PLoS One*, 7 (6), e39010.

Kaundil, P. & Mattu, V.K. (2017) A preliminary study on butterfly fauna (Order: Lepidoptera) from Mandi hills of Himachal Pradesh. *Journal of Entomology and Zoology Studies*, 5 (3), 851–854

Kehimker, I. (2008) Book of Indian Butterflies. *Bombay Natural History Society*, Oxford University Press, Mumbai and Delhi. 513 p.

Khan, Z.H., Raina, R.H., Dar, M.A. & Ramamurthy, V.V. (2011) Diversity and distribution of butterflies from Kashmir Himalayas. *Journal of Insect Science,* 24 (1), 45–55.

Khanal, B., Chalise, M.K. & Solanki, G.S. (2012) Diversity of butterflies with respect to altitudinal rise at various pockets of the Langtang National Park, central Nepal. *International Multidisciplinary Research Journal*, 2 (2), 41–48.

Kiritani, K. & Yukawa, J. (2010) *Effects of Global Warming on Insects*. Zenkoku Noson Kyoiku Kyokai Publishing Co Ltd, Tokyo. 347 p. [in Japanese]

Kumar, P. (2008) *Handbook on Common Butterflies of Uttarakhand*. Zoological Survey of India, Kolkata. 124 p.

Kumar, R. & Mattu, V.K. (2014) Diversity of Butterflies (Lepidoptera: Insecta) from Balh Valley (District Mandi in Himachal Pradesh), India. *Asian Journal of Advanced Basic Science*, 2 (3), 66–70.

Kumar, P., Devi, R., Mattu, V.K. (2016) Diversity and abundance of butterfly fauna (Insecta: Lepidoptera) of Subalpine area of Chanshal valley of District Shimla (Himachal Pradesh). *Journal of Entomology and Zoology Studies*, 4 (4), 243–247

Kunte, K. (2000) *Butterflies of Peninsular India.* Universities Press (Hyderabad) and Indian Academy of Sciences, Bangalore. 270 p.

Kurtz, J.C., Jackson, L.E. & Fisher, W.S. (2001) Strategies for evaluating indicators based on guidelines from the Environmental Protection Agency's Office of Research and Development. *Ecological indicators*, 1 (1), 49–60. https://doi.org/10.1016/S1470-160X(01)00004-8

Larsen, T.B. (1988) The butterflies of the Niligiri mountains of the southern India (Lepidoptera: Rhopalocera). *Jourrnal of BNHS,* 85 (1), 26–43.

Lee, C.M., Kwon, T.S., Kim, S.S., Sohn, J.D. & Lee, B.W. (2014) Effects of forest degradation on butterfly communities in the Gwangneung Forest. *Entomological science*, 17 (3), 293–301. https://doi.org/10.1111/ens.12062

Magurran, A.E. (1998) *Ecological diversity and its measurement*. Princeton University Press, Princeton, New Jersey. 179p.

Mani, M.S. (1968) *General Entomology.* National Book Trust, India. 171 p. + 45–48pl.

Margalef, R. (1958) Temporal succession and spatial heterogeneity in phyto-plankton. In: Buzzati-Traverso, A.A. (ed.) *Perspective in Marine Biology*. University of California Press, Berkeley, pp. 323–347. https://doi.org/10.1525/9780520350281-024

Mathew, G. (2011) *A Handbook on the Butterflies of Nilgiri Biosphere Reserve*. Research Report No. 398, Kerala Forest Research Institute, Kerala. 218 p.

May, P.G. (1992) Flower selection and the dynamics of lipid reserves in two nectarivorous butterflies. *Ecology*, 73, 2181–2191. https://doi.org/10.2307/1941466

Mehta, H.S., Thakur, M.S., Sharma, R.M. & Mattu, V.K. (2002) Butterflies of Pong Dam wetland, Himachal Pradesh. *Bionotes*, 5, 37–8.

Montero-Muñoz, J. L., Pozo, C. & Cepeda-González, M.F. (2013) Recambio temporal de especies de lepidópteros nocturnos en función de la temperatura y la humedad en una zona de selva caducifolia en Yucatán, México. *Acta Zoológica Mexicana*, 29 (3), 614–628. https://doi.org/10.21829/azm.2013.2931601

Muralirangan, M.C., Suresh, P.S., Partho, P.D. (1993) Observation on the grasshopper species diversity, density and distributional pattern in peninsular India. *The Entomologist* 112 (3&4), 201–210.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A., Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, 403 (6772), 853–858. https://doi.org/10.1038/35002501

Nelson, S.M. (2007) Butterflies (Papilionoidea and Hesperioidea) as potential ecological indicators of riparian quality in the semi–arid western United States. *Ecological Indicator*, 7, 469–480. https://doi.org/10.1016/j.ecolind.2006.05.004

New, T.R. (1999) Untangling the web: spiders and the challenges of invertebrate conservation. *Journal of Insect Conservation*, 3 (4), 251–256. https://doi.org/10.1023/A:1009697104759

Opler, P.A. (1995) Conservation and management of butterfly diversity in North America. In Pullin, A.S. (ed) *Ecology and conservation of butterflies*. Springer, Dordrecht, pp. 316–324. https://doi.org/10.1007/978-94-011-1282-6_22

Partap, U., Partap, T. & Yonghua, H. (2001) Pollination failure in apple crop and farmers' management strategies. *Acta Horticulture*, 561, 225–230. https://doi.org/10.17660/ActaHortic.2001.561.32

Petzoldt, C. & Seaman, A. (2010) Climate change effects on insects and pathogens. *Factsheet: Climate change and agriculture: promoting practical and profitable responses*, Available from: https://ccsenet.org/journal/index.php/jas/article/download/66504/39269 [Accessed on 23 January 2023]

Pollard, E., Yates, T.J. (1994) *Monitoring Butterflies for Ecology and Conservation: The British Butterfly Monitoring Scheme*. Chapman & Hall, London. 296 p.

Prakash, A. & Pathak, P. (2019) Orchids of Water Catchment Wildlife Sanctuary, Shimla (Himachal Pradesh), North western Himalayas: Their diversity, status, indigenous uses, and conservation status. *Journal of Orchid Society of India*, 33 (1–2), 65–77.

Rajasekhar, B. (1991) Butterflies of Loyola College Campus. *Blackbuck*, 7, 3–4.

Rajasekhar, B. (1992) Observations on the vegetation of Guindy National Park. *Blackbuck*, 8 (2), 38–42.

Rajasekhar, B. (1995) A study on butterfly populations at Guindy national park, Madras. *Journal of Bombay Natural History Society*, 92 (2), 275–278.

Rana, D. & Kapoor, K.S. (2015) Assessment of Floristic Diversity of Shimla water catchment Sanctuary, Himachal Pradesh India. *The Indian Forester*, 141 (12), 1244–1247.

Sahney, S., Benton, M.J. & Falcon-Lang, H.J. (2010) Rainforest collapse triggered Carboniferous tetrapod diversification in Euramerica. *Geology*, 38 (12), 1079–1082. https://doi.org/10.1130/G31182.1

Shannon, C.E. & Weaver, W. (1949) *The Mathematical Theory of Communication*. University of Illinois. Urbana. 117 p.

Simpson, E.H. (1949) Measurement of diversity. *Nature*, 163, 688. https://doi.org/10.1038/163688a0

Singh, A.P. (2010) *Butterflies of India*. Om books International, India. 184 p.

Singh, R. & Thakur, D.R. (2021) Studies on rhopaloceran diversity of high altitude Chandertal Wetland in Lahaul & Spiti district of Himachal Pradesh, India. *Journal of Entomology and Zoology Studies*, 9 (4), 448–452. https://doi.org/10.22271/j.ento.2021.v9.i4f.8818

Singh, V. & Banyal, H.S. (2014) Preliminary ecological studies on the Lepidoptera from Khajjiar lake catchment, Himachal Pradesh, India. *Biodiversity Journal*, 5 (1), 61–68.

Stefanescu, C., Herrando, S. & Páramo, F. (2004) Butterfly species richness in the north- west Mediterranean Basin: the role of natural and human- induced factors. *Journal of Biogeography*, 31 (6), 905–15. https://doi.org/10.1111/j.1365-2699.2004.01088.x

Thomas, J.A. (2005) Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Philosophical Transactions of the Royal Society* B: Biological Sciences, 360 (1454), 339–357. https://doi.org/10.1098/rstb.2004.1585

Tiple, A.D. (2011) Butterflies of Vidarbha region Maharashtra, India; a review with and implication for conservation. *Journal of Threatened Taxa,* 3 (1), 1469–1477. https://doi.org/10.11609/JoTT.o2397.1469-77

Valtonen, A., Molleman, F., Chapman, C.A., Carey, J.R., Ayres, M.P. & Roininen, H. (2013) Tropical phenology: Bi- annual rhythms and interannual variation in an Afrotropical butterfly assemblage. *Ecosphere*, 4 (3), 1–28. https://doi.org/10.1890/ES12-00338.1

van Halder, I., Barbaro, L., Corcket, E. & Jactel, H. (2008) Importance of semi-natural habitats for the conservation of butterfly communities in landscapes dominated by pine plantations. *Biodiversity and Conservation*, 17 (5), 1149–1169. https://doi.org/10.1007/s10531-007-9264-5

Verma, A. & Arya, M.K. (2022) Butterfly diversity and abundance in a sub-tropical wetland environment of Shyamlatal, Western Himalaya. *Asian Journal of Conservation Biology*, 11 (1), 26–40. https://doi.org/10.53562/ajcb.61599

Wisz, M.S., Pottier, J., Kissling, W.D., Pellissier, L., Lenoir, J., Damgaard, C.F. & Svenning, J.C. (2013) The role of biotic interactions in shaping distributions and realised assemblages of species: implications for species distribution modelling. *Biological Reviews*, 88 (1), 15–30. https://doi.org/10.1111/j.1469-185X.2012.00235.x

Wolda, H. (1978) Fluctuations in abundance of tropical insects. *The American Naturalist*, 112 (988), 1017–1045. https://doi.org/10.1086/283344

Wynter-Blyth, M.A. (1957) *Butterflies of the Indian Region*. Today and tomorrow's Printers and Publishers, New Delhi. 523 p.

Yamamoto, N., Yokoyama, J. & Kawata, M. (2007) Relative resource abundance explains butterfly biodiversity in island communities. *Proceedings of the National Academy of Sciences*, 104 (25), 10524–10529. https://doi.org/10.1073/pnas.0701583104

Appendix 1. The list of butterflies (Rhopalocera) species with their relative abundance and Food/host plants specie recorded during study period from Water Catchment Wildlife Sanctuary.

Fauna				Flora	
	Species	Common Name	Families	RV*	Food / host plants specie
1	*Potanthus dara* Kollar, 1842	Himalayan Dart	Hesperidae	A	*Rosa moschata*, Grasses
2	*Celanorhinus aurititvitta* Moore, 1878	Dark yellow banded flat	Hesperidae	R	*Rosa moschata*, Grasses
3	*Pelopedas subochracea* Moore, 1878	Large branded swift	Hesperiidae	A	*Taraxacum officinale, Fragaria nubicola*
4	*Pseudocoladonia dandan* Fabricius, 1787	Fulvous pied flat	Hesperiidae	VC	*Berberis* sp., *Prinsepia utilis*
5	*Neozephirus duma* Hewitson, 1869	Metallic Green Hairstreak	Lycaenidae	F	*Bidens pilosa, Taraxacum officinale*
6	*Lycaena phlaeus* Linnaeus, 1761	Common Copper	Lycaenidae	C	*Taraxacum officinale, Fregaria nubicola*
7	*Heliophorus epicles* Fruhstorfer, 1918	Purple Sapphire	Lycaenidae	O	*Taraxacum officinale, Bidens pilosa*
8	*Athene emolus* Godart, 1823	The Ciliate Blue	Lycaenidae	VC	*Prinsepia utilis, Indigofera* sp.
9	*Zizzeria karsandra* Moore, 1865	Dark Glass Blue	Lycaenidae	C	*Bidens pilosa, Berberis* sp., *Erigeron bellidioides, Potentilla nepalensis*
10	*Polyommatus Icarus* Rottemburg, 1775	Common Blue	Lycaenidae	O	*Prinsepia utilis, Indigofera* sp.
11	*Celastrina lavendularis* Moore, 1877	The Plain Hedge Blue	Lycaenidae	R	*Prinsepia utilis, Berberis* sp.
12	*Aricia astrarche* Denis & Schiffermüller, 1775	Brown Argus	Lycaenidae	O	*Oxalis corniculata*
13	*Leptotes pliniues* Fabricius, 1793	Zebra blue	Lycaenidae	O	Ground, Grasses
14	*Celastrina hueglii* Moore, 1882	Large hedge blue	Lycanidae	F	*Prinsepia utilis, Indigofera* sp.
15	*Celastrina marginata* de Nicéville, 1884	Margined hedge blue	Lycanidae	O	*Prinsepia utilis, Indigofera* sp.
16	*Deudorix epijorbas* Moore, 1857	Hairy line blue	Lycanidae	F	*Prinsepia utilis*
17	*Heliophorus androcle* Westwood, 1851	The green sapphire	Lycanidae	F	*Trifolium repens, Taraxacum officinale*
18	*Lycaena pavanna* Kollar, 1848	White-bordered copper	Lycanidae	C	*Taraxacum officinale*
19	*Prosotus bhutea* de Nicéville, 1884	Bhutya lineblue	Lycanidae	F	*Bidens pilosa, Prinsepia utilis*
20	*Argyreus hyperbius* Linnaeus, 1763	The Indian Fritillary	Nymphalidae	O	*Bidens pilosa, Rubus ellipticus, Viola* sp.
21	*Phalantha phalantha* Drury, 1773	The Common Leopard	Nymphalidae	F	*Taraxacum officinale, Bidens pilosa*
22	*Issoria lathonia* Linnaeus, 1758	Queen of Spain Fritillary	Nymphalidae	O	*Bidens pilosa, Lonicera quinquelocularis*
23	*Callerabia ananda* Moore, 1858	Ringed Argus	Nymphalidae	R	*Cyathula tomentosa*, grasses
24	*Aglais cashmirensis* Kollar, 1848	Small Tortoise Shell	Nymphalidae	VC	*Urtica* sp., *Anaphalis* sp.
25	*Lassiomata schkara* Kollar, 1844	Common Wall	Nymphalidae	O	*Prinsepia utilis, Rubus* sp., *Berberis* sp.
26	*Vanessa carduii* Linnaeus, 1758	Painted Lady	Nymphalidae	R	*Trifolium repens, Taraxacum officinale*
27	*Fabriciana adippe* Denis & Schiffermüller, 1775	High Brown Fritillary	Nymphalidae	O	*Taraxacum officinale, Rumex hastatulus, Viola* sp.
28	*Athyma jina* Moore, 1858	Bhutan Sergeant	Nymphalidae	R	*Prinsepia utilis*, rocks, Grasses
29	*Lethe verma* Kollar, 1844	Straight-banded tree brown	Nymphalidae	C	*Cedrus deodara*, Grasses
30	*Kaniska canace* Linnaeus, 1763	Blue admiral	Nymphalidae	O	*Smilax* sp.
31	*Yathima nareda* Hewitson, 1864	Large three ring	Nymphalidae	F	*Prinsepia utilis, Chaerophyllum reflexum,*
32	*Yathima sacra* Moore, 1857	Himalayan five-ring	Nymphalidae	F	*Prinsepia utilis*
33	*Vanessa indica* Herbst, 1794	Indian red admiral	Nymphalidae	R	*Trifolium repens*
34	*Acraea issoria* Hubner, 1819	Yellow Coster	Nymphalidae	F	*Debregeasia bicolor*
35	*Athyma perius* Linnaeus, 1758	Common sergeant	Nymphalidae	O	*Cedrus deodara, Taraxacum officinale, Trifolium repens*
36	*Junonia iphita* Cramer, 1779	Chocolate pansy	Nymphalidae	R	*Trifolium repens*
37	*Aulocera swaha* Kollar, 1844	Common satyr	Nymphalidae	O	*Bistorta affinis*
38	*Danaus chrysippus* Linnaeus, 1758	Plain tiger	Nymphalidae	C	*Asclepias curassavica, Cynanchum* sp.
39	*Elymnias undularis* Linnaeus, 1763	The palmflies	Nymphalidae	C	*Taraxacum officinale, Rumex hastatulus, Viola* sp.
40	*Hyponephelle pulchella* Grum-Grshimailo, 1890	Tawny Meadow brown	Nymphalidae	F	*Rumex hastatulus, Viola* sp.
41	*Junonia limonias* Linnaeus, 1758	Lemon pansy	Nymphalidae	F	*Barleria* sp., *Hygrophila auriculata*
42	*Lethe naga* Doherty, 1889	Naga tree brown	Nymphalidae	O	*Capillipedium* sp., *Imperata cylindrical*
43	*Lethe rohria* Fabricius, 1787	Common tree brown	Nymphalidae	O	*Apluda* sp.
44	*Melantis lida* Linnaeus, 1758	Common evening brown	Nymphalidae	R	*Bistorta affinis*
45	*Neptis yerburri* Butler, 1886	Yerbury's sailer	Nymphalidae	F	*Prinsepia utilis, Rubus ellipticus*
46	*Sephisa dichroa* Kollar, 1844	Western courtier	Nymphalidae	F	*Prinsepia utilis, Rubus ellipticus, Trifolium repens*
47	*Vagrans egista* Cramer, 1780	Race Sinha	Nymphalidae	R	*Rosa moschata, Cedrus deodara*
48	*Atrophaneura polyeuctes* Doubleday, 1842	Common windmill	Papilionidae	R	*Rosa moschata*
49	*Papilio machon* W.H. Edwards, 1876	Common yellow Swallowtail	Papilionidae	R	*Rosa moschata, Cedrus deodara*
50	*Papilio clytia* Linnaeus, 1758	Common mime	Papilionidae	F	*Alseodaphne semecarpifolia, Cinnamomum verum*
51	*Papilio demoleus* Linnaeus, 1758	Lime butterfly	Papilionidae	VC	*Brassica compestris, Zanthoxylum armatum*
52	*Papilio paris* Linnaeus, 1758	Paris peacock	Papilionidae	C	*Citrus* sp., *Evodia roxburghiana*
53	*Papilio polyctor* Boisduval, 1836	Common peacock	Papilionidae	O	*Prinsepia utilis, Rubus ellipticus, Trifolium repens*
54	*Papilio protenor* Cramer, 1775	The spangle	Papilionidae	A	*Trifolium repens, Taraxacum officinale*

	Fauna				Flora
	Species	**Common Name**	**Families**	**RV***	**Food / host plants specie**
55	*Eurema hecabe* Linnaeus, 1758	Common Grass Yellow	Pieridae	C	*Potentilla nepalensis, Frageria nubicola*
56	*Genopteryx rhamnii* Linnaeus, 1758	Common Brimstone	Pieridae	F	*Prinsepia utilis., Berberis* sp.
57	*Colias fieldii* Menetries, 1855	Darl Clouded Yellow	Pieridae	F	*Trifolium repens, Berberis* sp.
58	*Pieris rapae* Linnaeus, 1758	Cabbage White	Pieridae	C	*Berberis* sp., grass
59	*Pieris brassicae* Linnaeus, 1758	Large Cabbage White	Pieridae	VC	*Berberis* sp., *Arabis amplexicaulis*
60	*Pieris canidia* Linnaeus, 1768	Indian Cabbage White	Pieridae	C	*Berberis* sp.
61	*Belenois aorota* Fabricius, 1793	Pioneer White	Pieridae	O	*Hypericum perforatum, Cedrus deodara*
62	*Aporia agathion* Gray, 1832	Great Black vein	Pieridae	O	*Cedrus deodara, Hypericum perforatum, Berberis* sp.
63	*Aphrissa statira* Cramer, 1777	Statira Sulphur	Pieridae	O	*Hypericum perforatum,* Grasses
64	*Catopsilla Pomona* Fabricius, 1775	Common emigrant	Pieridae	O	*Trifolium repens Bistorta affinis, Impatiens* sp.
65	*Deliasc belladonna* Fabricius, 1793	Plain tiger	Pieridae	C	*Dentrophthoe* sp., *Bistorta affinis*
66	*Pieris napi* Linnaeus, 1758	Green-veined white	Pieridae	O	*Brassica campestris, Brassica oleracea*
67	*Pontia daplidice* Linnaeus, 1758	Bath white	Pieridae	R	*Lepidium virginicum*
68	*Dodona durgae* Kollar & Redtenbacher, 1844	Common punch	Riodinidae	C	*Bidens pilosa*

* Relative Abundance: **A** (Abundant: >30%), **VC** (Very Common: 20–30%), **C** (Common: 10–20%), **F** (Frequent: 5–10%), **O** (Occasional: 1–5%), **R** (Rare: < 1%).

بررسی وضعیت تهدید و عادات غذایی پروانه‌ها (Lepidoptera) در پناهگاه حیات وحش حوضه آبی شیملا، هیماچال پرادش، هند.

پاوان کومار[۱]، آنچال ورما[۱*]، ریتیکا گانگوتیا[۱]، پاوان کومار تاکور[۲]

۱ بخش حفاظت جنگل‌ها، موسسه تحقیقات جنگل‌های هیمالایا، پانتاگاتی، شیملا، هند
۲ بخش اکولوژی و تغییر اقلیم، موسسه تحقیقات جنگل‌های هیمالایا، پانتاگاتی، شیملا، هند

* پست الکترونیک نویسنده مسئول مکـاتبه: *anchalverma1401@gmail.com*

| **تاریخ دریـافت:** ۱۴ بهمن ۱۴۰۱ | **تاریخ پذیرش:** ۱۰ فروردین ۱۴۰۲ | **تاریخ انتشار:** ۱۰ اردیبهشت ۱۴۰۲ |

چکیـــده: این تحقیق اطلاعات جدیدی را در خصوص تنوع پروانه‌ها (Lepidoptera) و منابع غذایی آن‌ها در جنگل درختان سوزی‌برگ پناهگاه حیات وحش در حوضه آبی شیملا، هیماچال پرادش، هند، ارایه می‌دهد. این مطالعه در طول سه فصل مختلف، تابستان، باران‌زا و پاییز، از مارس ۲۰۱۹ تا آوریل ۲۰۲۲ انجام شد. کلیه پروانه‌های ثبت شده ۶۸ گونه و ۶ خانواده با جمعیت ۱۶۵۰ نمونه بودند. خانواده Nymphalidae دارای بیشترین تعداد گونه (۲۸ گونه) ثبت شده بود و پس از آن خانواده‌های Lycaenidae (۱۵)، Pieridae (۱۳)، Papilionidae (۷)، Hespiradie (۴)، و Riodinidae (۱) قرار گرفتند. فراوانی گونه‌ها در جنگل‌های مخلوط با توجه به وجود آب و پوشش گیاهی، بیشتر بود و این منطقه را در مقایسه با جنگل‌های صرفا حاوی سوزنی‌برگان، به عنوان محیطی منحصربه‌فرد برای جمعیت پروانه‌ها مشخص کرد. بیشترین فراوانی گونه در ماه‌های آوریل تا نوامبر دیده شد. کاهش کلی در فراوانی گونه‌ها از دسامبر تا ژانویه و تا پایان مارس مشاهده شد. نتایج این تحقیق شناخت بهتری از پروانه‌ها ارایه داده و می‌تواند الها بخش مطالعات بیشتر برای بازسازی محیط زیست در این منطقه محافظت شده باشد. مطالعه کنونی درباره تنوع زیستی پروانه‌ها، نمایان‌گر اهمیت حفظ تنوع زیستی و پایش تغییرات آب و هوا است. این مطالعه با ارایه اطلاعات شناسایی پایه‌ای و گردآوری داده‌ها از ابعاد مختلف، امکان ترکیب، توسعه و مدل‌سازی ایده‌ها و فرضیات مختلف که در سایر زمینه‌ها نیز کاربرد دارند را فراهم می‌کند.

واژگـان کلیدی: اقلیم، حفاظت، تنوع، محیط زیست، گرده‌افشان‌ها