Asian Journal of Conservation Biology, December 2022. Vol. 11 No. 2, pp. 258–265 AJCB: FP0200/72630
ISSN 2278-7666 ©TCRP Foundation 2022 https://doi.org/10.53562/ajcb.72630

Research Article

Diversity of butterfly along different altitudinal gradient of Munsiyari, Western Himalayan, Uttarakhand, India

Manisha Bisht[1*], Deepika Goswami[1], V.P. Uniyal[2]and Vinay Singh[1]

[1]*Department of Zoology, D.S.B. Campus, Kumaun University, Nainital, Uttarakhand, India*
[2]*Wildlife Institute of India, Dehradun, Uttarakhand, India*

(Received: August 01, 2022; Revised: December 09, 2022; Accepted: December 11, 2022)

ABSTRACT

Bees regarded as global Crop Pollinators, but little known about other Non-Bee Insects for contributing Pollination. Some flower visitors would never enter our mind as potential Pollinators. Present study was conducted from March 2019 to November 2019 in agricultural and wild crops from lower altitude to higher altitude. The study revealed total of 2339 individuals of Butterflies belonging to 51 species and 5 families under Lepidoptera order. In wild crop highest number of species were observed (51 species) as compare to Agricultural crop (48 species). Nymphalidae was most dominant family (23 species, 917 individuals), followed by Pieridae (13 species and 921 individuals), Lycaenidae (7 species and 343 individuals), Papilionidae (6 species and 94 individuals) and Hesperiidae (2 species and 64 individuals). Sweeping net and Direct observation method employed to know about diversity of butterfly. High diversity and wide distribution of Wild crops suggested that Wild crops can be used for Insects Conservation.

Key words: Potential Pollinators, Non- bee insects, Wild crop, Agricultural crop, Diversity, Conservation

INTRODUCTION

Insects are significant keys for successful Agro-Ecosystem. Insects occupy a range of ecosystems and achieve many significant ecological functions (Sodhi *et al.* 2010). Flies are considered to be the second most vital-insect order for both flower visitation and pollination (Larson *et al*., 2001). Pollination by animals plays an important functional role in most worldly ecosystems and provides a key ecosystem service essential to both wild and agricultural plant communities as most angiosperms are pollen-restricted and need animals for sexual reproduction (Potts *et al*., 2010;). A huge percentage of the human diet depends directly or indirectly on Animal Pollination (Klein *et al*., 2007; Garibaldi *et al*., 2013). Butterflies are also efficient pollinators crucial for maintaining the Ecosystem Services and play important biological roles in the food web. Butterflies are virtuous sign of changing climatic, seasonal, and environmental changes, they can also serve in preparing the conservation strategy. Hence butterflies play a vital role in ecosystem and co-evolutionary relationship between them and plants as well as their lives are interlinked (Ghazanfar *et al*., 2016). Butterflies are excellent indicators to assess the ecological state and biotope quality of an environment (Launer and Murphy, 1994; Sharma *et al*., 2020), including the wetland ecosystems (Subedi *et al*., 2020; An and Choi, 2021). Artificial ecosystem like agricultural land use system used to attract various kinds of insects for nesting, resting, hunting available foods, or biological action. Agriculture provides a highly predictable source of food of different kinds i.e., grain, seeds, fruits, and green vegetation of the crop plants, grasses, insects and rodents etc. (O'Connor and Shrubb, 1986; Singh *et al*., 2019). Moreover, monitoring and quantification of butterflies across seasons and habitats have strong implications in their systematic conservation planning (Bonebrake *et al*., 2010; Sharmila *et al*., 2020). Uttarakhand constitute of diverse flora and fauna. Geologically, it share the fraction of both Central and Western Himalayan region and is situated in the central part of Himalaya, thus owing to its vivid and rich biodiversity.Subsequently, several studies have been conducted by various workers to explore the butterfly diversity at different locations in the Kumaun Himalaya (Smetacek, 2002, 2004)and to protected areas (Uniyal, 2004; Joshi and Arya, 2007 and Bhardwaj and Uniyal, 2013). Additionally, Wild Bees are important for the pollination of wild flowers (Forup and Memmott 2005; Biesmeijer *et al.,* 2006; Rollinet *et al.,* 2016) there is evidence that wild flowers might not be adequately pollinated with decreased pollinator abundance.This study is related to diversity, ecology and habitat suitability are extremely necessary for effective and proper conservation of butterflies (Sharma *et al*., 2020). Studies on butterflies are important from the standpoint of understanding their diversity, ecology and multiple functional roles in an ecosystem as well as in exploring the impact of disturbance and land use changes on them (Bhardwaj *et al*., 2012; Sharma *et al*., 2020). Variation in flower diversity can also lead to increase wild pollinator diversity. It is

[*]*Corresponding Author's E-mail: bishtmanisha396@gmail.com*

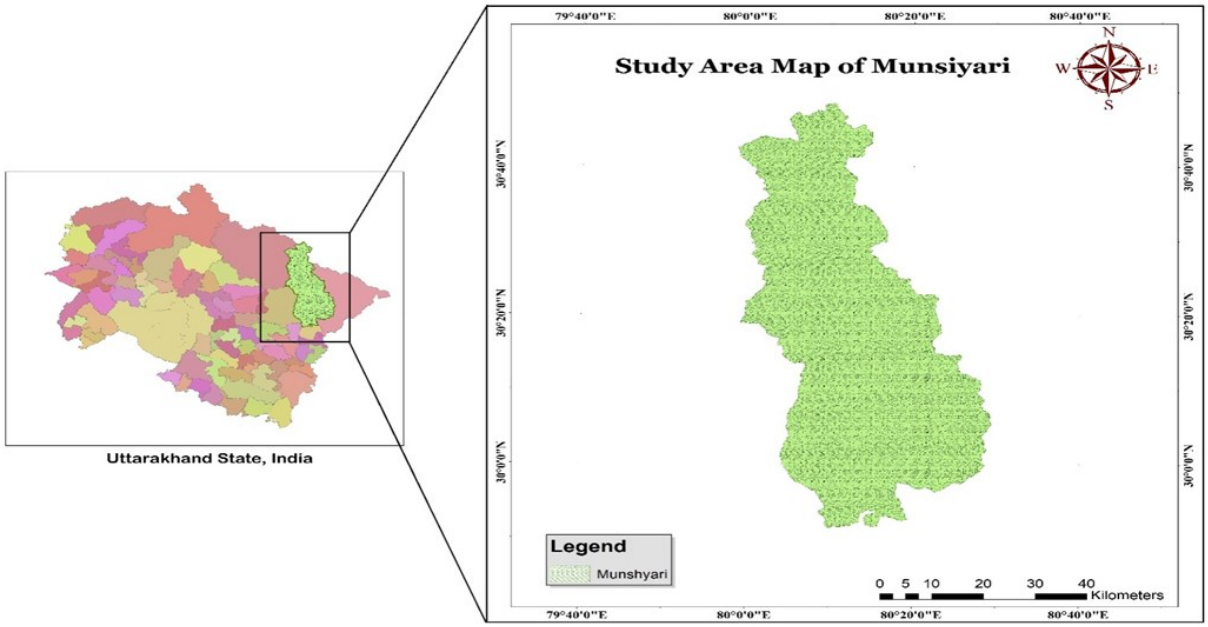


Figure 1. Map of the Study Area

therefore vital we maintain our Wild Insects populations to ensure the continued pollination of our crops and Wild flowers.Habitat and host plant associations render several butterflies to have strong ecological and evolutionary relationships with the environment (Subedi *et al*., 2020).

MATERIALS AND METHOD

STUDY AREA

Munsiyari also known as Little Kashmir has geographical area of about 19.68km sq. It has an elevation of about 2200m above the sea level, covered with dense forest and lies between 30°4'2.69" N'80°1'18.82" E.There is the variation of temperature and vegetation to different altitudinal gradient. The vegetation of Himalayan forest ranges from tropical dry deciduous forest in the foothills to alpine meadow above timberline (Singh and Singh, 1992). Munsiyari has been known for heritage of wild edible plants and have medicinal value also. A highdiversity in compositional pattern of forest is distinctivefeatureof this region Saxena and Singh (1984) (Singh and Singh, 1984).

VEGETATION OF STUDY AREA:

Rubus ellipticus (Hisalu), *Prunus persica* (plum), *Pyracantha crenulate* (Ghigaru), *Ficus auriculata* (Timil), *Drepanostachyum falcatum* (dwarf bamboo), *Urtica dioica* (Bitchu ghas), *Alnas nepalensis* (Utis), *Zanthoxylum armatum* (Timur), *Rumex nepalensis* (Kilmora), Rhododendron species (Buransh), *Lantana camara* (Lantana), *Prunus cornuta* (Mehal), *Cinnamomum tamala* (Tejpatta), *Aesculus indica* (Pangar), *Solanum tuberosum* (Potato), *Lens culinaris* (Masoor), *Pisum sativam* (Pea), *Brassica napus* (Mustard), *Brassica oleracea* (cabbage), *Phaseolus vulgaris* (Rajma), *Coriandrum sativum* (Dhaniya).

SURVEY METHOD

Butterfly was surveyed from March 2019 to November 2019. Butterfly survey was done by direct observation and random walk along side of transect at each site. Observations were taken out regularly on monthly basis between 9:00 am to 2:00 pm when the butterflies were most active. The insects collection made by using sweep sampling method. The collected insects were kept for short time into bottles containing Chloroform-soaked cotton was observed, captured and identified later. Photographic documentation has also been considered to protect the biodiversity loss. The specimens were stretched primarily and then preserved in fumigated insect box Arora (1995).

IDENTIFICATION OF BUTTERFLY

Identification of specimens was done with the help of published articles and standard references books byKunte (2000); Singh (2017) and Sondhi & Kunte (2018)., Kumar (2008), Kehimkar (2016). The unidentified butterflies were taken to the laboratory for further studies. The specimens were stretched, pinned and dried and was set into wooden boxes and labeled.

SPECIES COMPOSITION OF BUTTERFLY

To determine the composition and distribution of identified butterflies, species were arranged according to their families and an inventory was prepared.

ANALYZING DIVERSITY

Population density, Shannon-Wiener (H), Species Richness (Margalef) and Equitability (J) were used to calculate the butterfly diversity in sampling sites.

Table 1. List of Vegetation and Zonal status of Study Area along different Altitudes.

S.No.	Study site	Coordinates	Altitude	Zones	Vegetation
1.	JAULJIBI	29’45”09’78°N 80’22’45’49°E	500-1000m	Subtropical Zone	Shorea robusta, Terminalia chebula, T. bellirica
2.	BARAM	29’51’01’11°N 80’21’27’05’°E	500-1000m	Subtropical Zone	Shorea robusta,Terminalia chebula, T. bellirica
3.	SHER-AGHAT	30’00’44’41°N 80’19’14’30°E	1000m-1500m	Warm temperate Zone	Banz oak(Q. leucotricopora) Pinus roxburghii (chirpine)
4.	JOSHA	30’02’30’74°N 80’7’58’00°E	1500m-2000m	Warm temperate Zone	Banz oak(Q.leucotricopora) Pinus roxburghii (chirpine)
5.	DARKOT	30’05’56’24°N 80’14’51’62°E	1500m-2000m	Warm temperate Zone	Banz oak(Q.leucotricopora) Pinus roxburghii (chirpine)
6.	BOTHI	30’05’00.54°N 80’17’21’51°E	1500-2000m	Warm temperate Zone	Banz oak (Q.leucotricopora) Pinus roxburghii(chirpine)
7.	HARKOT	30’04’42’65°N 80’14’13’90°E	2000m-2500m	Cool temperate Zone	Rubus ellipticus, Alnus nepalensis
8.	KALAMUNI	30’02’16’83°N 80’11’58’97°E	2500m-3000m	Cool temperate Zone	Rubus ellipticus, Alnus nepalensis
9.	KHALIYA	30.0639105°N 80.1880322°E	3000m-3500m	Sub-alpine Zone	Rhododendron barbatum, Pipanthus nepalensis, Angelica emodi, Betula utilis

- Population density: Number of individuals in particular area/total number of individuals × 100
- Shannon-Wiener equation: H’= Σ Pi (lnPi) where, Pi is the proportion of each species in the sample (Shannon and Wiener, 1949). Simpson’s equation: D = Σ n (n-1)/N (N-1). Where, D = Simpson’s index of dominance; N = the total number of individuals of all species; n = number of individuals of specific species per sample.
- Margalef’s formula was used to calculate Species Richness
- SR = (S-1)/ Log N, where S = total number of species and N = total number of individuals present in the sample. (Margalef, 1970)
- Equitability was calculated by formula: Equitability = H/Hmax, where H = sum of Pi (lnPi), Hmax = ln (total number of species).

RESULT AND DISCUSSION

Total of 51 species belonging to 5 families were recorded from study area during the study period (March 2019 to November 2019) (Table 1). The present study was an attempt to compare the diversity of butterflies in two different crops i.e., wild crop and agricultural crop in Munsiyari at different altitudinal gradients. It was observed that the highest numbers of species were observed from wild crops (51 species) as compared to agricultural crops (48 species). Population density, Shannon -Wiener diversity (H), Species richness (SR) and Equitibility(J) was higher in wild crops as compare to agricultural crops due to widely distribution and least effect of climatic change on wild crops (Table 2). In terms of family, the most dominant family was Nymphalidae contain highest number of species and individuals (23, 917 individuals) followed by Pieridae (13, 921 individuals), Lycaenidae (7, 343 individuals), Papilionidae (6, 94 individuals) and Hesperidae (2, 64 individuals) (Figure 2). In the present observation it was observed that the 13 species showing their dominance in the present study area. The most dominant species was Indian Red Admiral (*Vanessa indica*) (63 individuals)showed highest number of individuals followed by Large Cabbage White (*Pieris brassicae)* (58 individuals),Indian Tortoiseshell (*Aglais cashmiriensis*) (58 individuals), Himalayan Brimstone (*Gonepteryx rhamni*)(57 individuals),Sorrel Sapphire (*Heliophorus sena)*(56 individuals),Veined White *(Pieris melete*)(56 individuals), Painted Lady (*Vanessa cardui*) (56 individuals), Mottled Emigrant (*Catopsila pyranthe*) (55 individuals), Dark Clouded Yellow(*Colias fieldii*) (53 individuals),Indian Cabbage White(*Pieriscanidia*) (47 individuals), Common Grass Yellow (*Eurema hecabe*) (42 individuals), Small Grass Yellow (*Eurema brigitta*) (42 individuals),Spotless Grass Yellow (*Eurema laeta*) (40 individuals)(Figure 1). Similar finding has been found by several workers such as Chahar et al., 2021 observed that Plants like Stachytarpheta indica, Lantana camara, Mangifera indica, Citrus limonia and grasses play a significant role in the life cycle of butterfly fauna.Plants like Stachytarpheta indica, Lantana camara, Mangifera indica, Citrus limonia and grasses play a significant role in the life cycle of butterfly fauna. The overall finding in the study area is similar to observation of Choi, S.W. 2015, where wild plants harbored low frequency of insect pollinators but high taxonomic diversity, promoting conservation and enhancement of wild pollinators. We require more thorough studies on the biological connections between plants and pollinators in various ecosystems, as well as the diversity of pollinators themselves.

Table 2. Checklist of butterflies, their Habitat Preference and their Conservation Status in two different crops of study area during study period (March 2019 to November 2019).

S.no	SCIENTIFIC NAME	COMMON NAME	HABITAT
	NYMPHALIDAE		
1.	*Aglais cashmiriensis**(kollar)	Indian tortoiseshell	Agricultural+Wild crops
2.	*Argynnis hyperbius*(Linnaeus)	Indian fritillary	Wild crops
3.	*Ariadne merione*(Cramer)	Common castor	Wild crops
4.	*Athyma opalina**(Linnaeus)	Common sergeant	Wild crops
5.	*Callerebia ananda** (Moore)	Ringed argus	Wild crops
6.	*Danaus chrysippus*(Linnaeus)	Plain tiger	Agricultural crops
7.	*Danaus genutia*(Cramer)	Striped tiger	Wild crops
8.	*Euploea core*(Cramer)**	Common crow	Wild crops
9.	*Euploea mulciber**(Cramer)	Striped blue crow	Wild crops
10.	*Junonia almana*(Linnaeus)	Peacock pansy	Agricultural crops
11.	*Junonia iphita*(Fabricius)	Chocolate pansy	Wild crops
12.	*Junonia lemonias*(Linnaeus)	Lemon pansy	Wild crops
13.	*Lethe confusa*(Aurivillius)	Banded treebrown	Agricultural+Wild crops
14.	*Lethe rohria*(Fabricius)	Common treebrown	Agricultural crops
15.	*Mycalesis perseus*(Fabricius)	Common brushbrown	Wild crops
16.	*Neptis hylas**(Linnaeus)	Common sailor	Wild crops
17.	*Parantica aglea*(stoll)	Glassy Tiger	Agricultural crops
18.	*Phalanta phalantha*(Drury)	Common leopard	Agricultural+Wild crops
19.	*Vanessa cardui*(Linnaeus)	Painted lady	Wild crops
20.	*Vanessa indica*(Herbst)	IndianRed Admiral(LC)	Agricultural+Wild crops
21.	*Ypthima baldus*(Fabricius)	Common Five ring	Wild crops
22.	*Ypthima huebneri*(Kirby)	Common four ring	Wild crops
23.	*Ypthima nareda*(Kollar)	Large Three Ring	Agricultural+Wild crops
	PIERIDAE		
1.	*Catopsilia pomona* (Fabricius)	Common Emigrant	Wild crops
2.	*Catopsilia pyranthe* (Linnaeus)	Mottled Emigrant	Agricultural+Wild crops
3.	*Colias fieldii* (Menetries)	Dark Clouded Yellow	Agricultural+Wild crops
4.	*Eurema brigitta* (Stoll)	Small Grass Yellow	Agricultural crops
5.	*Eurema hecabe* (Linnaeus)	Common Grass Yellow	Agricultural +Wild crops
6.	*Eurema laeta* (Boisduval)	Spotless Grass Yellow	Wild crops
7.	*Gonepteryx nepalensis* (Doubleday)	Himalayan Brimstone	Agricultural crops
8.	*Pieris brassicae* (Linnaeus)	Large Cabbage White	Agricultural+Wild crops
9.	*Pieris canidia* (Linnaeus)	Indian Cabbage White	Wild crops
10.	*Delias belladonna* (Fabricius)	Himalayan Jezebel	Wild crops
11.	*Colias errata* (Fabricius)	Clouded Yellow	Agricultural+Wild crops
12.	*Gonepteryx rhamni* (Linnaeus)	Himalayan Common Brimstone	Agricultural field
13.	*Pieris melete* (Linnaeus)	Veined White	Wild crops
	LYCAENIDAE		
1.	*Acytolepis puspa* (Horsfield)	Common Hedge Blue	Wild crops
2.	*Arhopala atrax* (Hewitson)	Indian oak blue	Wild crops
3.	*Everes lacturnus* (Godart)	Indian cupid	Agricultural crops
4.	*Heliophorus sena** (Kollar)	Sorrel sapphire	Agricultural+Wild crops
5.	*Lampides boeticus** (Linnaeus)	Pea blue	Agricultural+Wild crops
6.	*Lycaena pavana** (Westwood)	White Bordered Copper	Wild crops
7.	*Deudorix epijarbas* (Moore)	Cornelian	Wild crops
	PAPILIONIDAE		
1.	*Pachliopta aristolochiae* (Fabricius)	Common Rose	Agricultural+Wild crops
2.	*Graphium sarpedon* (Linnaeus)	Common bluebottle	Agricultural+Wild crops
3.	*Papilio bianor* (Cramer)	Common Peacock	Agricultural+Wild crops
4.	*Papilio demoleus* (Linnaeus)	Lime Butterfly	Agricultural field
5.	*Papilio paris paris* (Linnaeus)	Paris Peacock	Agricultural+Wild crops
6.	*Papilio polytes* (Linnaeus)	Common Mormon	Wild crops
	HESPERIDAE		
1.	*Parnara guttata* (Bremerv&Grey)	Straight Swift	Wild crops
2.	*Pseudoborbo bevani* (Moore)	Bevan's Swift	Agricultural+Wild crops

Note: - Under Indian Wildlife (Protection) Act (Anonymous, 2006) * (Endemic species),*(Legally protected) and *(Least concern) under Red list of IUCN (2020).

Table 3. Diversity indices of butterflies in two different crops of in Study Area during study period (March 2019 to November 2019)

Sl.No.	Ecosystem	Population Density (%)	No. of Species	Shannon-Weiner's Diversity (H)	Species richness (SR)	Equitability (J)
1.	WILD CROPS	62	51	2.57	6.40	0.65
2.	AGRICULTURAL CROPS	38	48	2.49	6.26	0.64

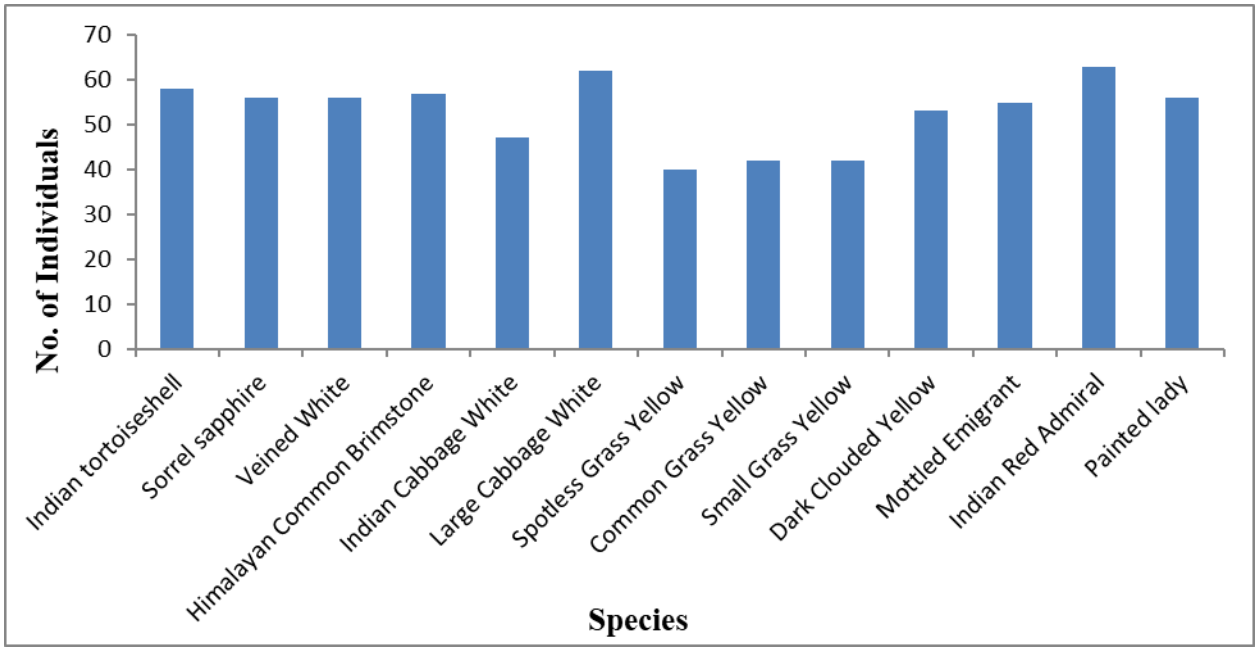


Figure 2. Dominant species of butterflies found in study area during study period (March 2019 to November 2019)

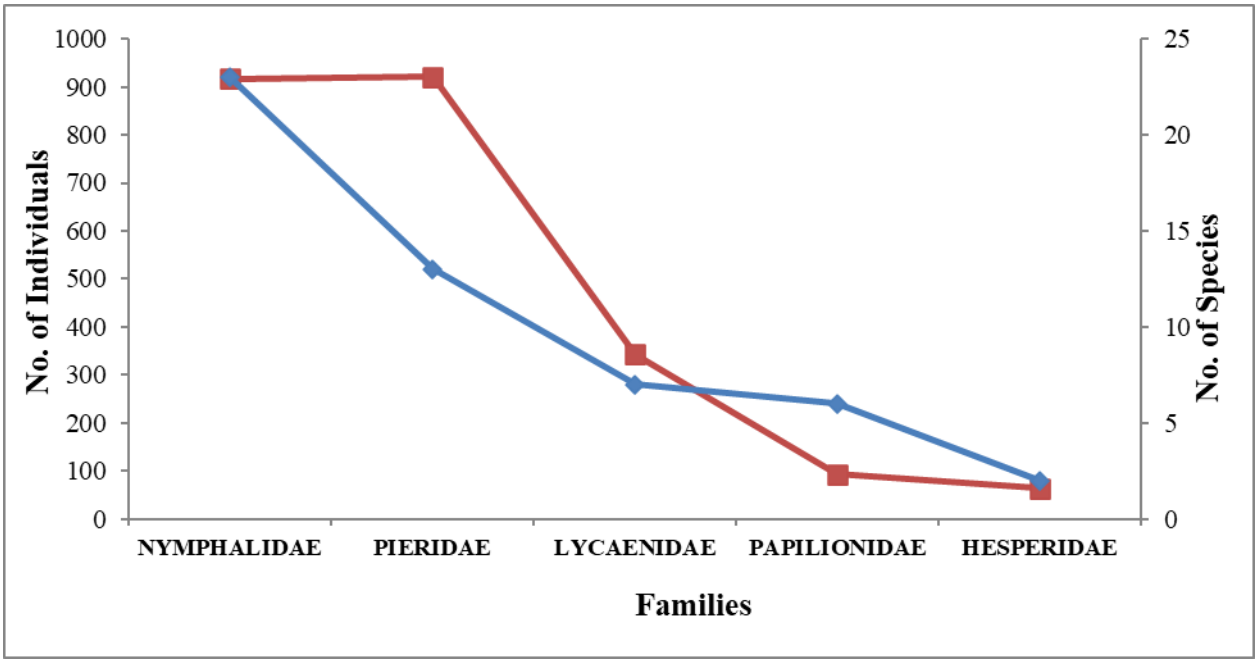


Figure 3. Family wise distribution of Butterflies in study area during Study period (March 2019 to November 2019).

CONCLUSION

The present investigation revealed that Munsiyari region is rich in both floral and faunal wealth including butterflies. Presence of variety of vegetation and different Ecological condition promote the Faunal Diversity More the richness of plant variety, more diverse the species and family in Forest Ecosystem. From the above data we can conclude that with changing climatic condition and damage by some of the wild animals in Himalaya lead to damage of agricultural crops and hence different vegetation types like wild crops can also influence high number of butterfly in that region. The study area also supports enormous varieties of fruit trees that can provide them breeding habitat and nectar as well. Maximum number of species and individuals of butterflies were noticed during summer because as it largely affect the butterfly numbers and species distribution. If the diversity of the wild flowering plants be increased, the diversity of butterflies may also be influence. Presence of Legally protected(3 species),Least concern (1 species),Endemic species (6 species)in the study area is important from conservation point of view and hence it is important to look over the preservation of Butterfly and its habitat .The preservation of biodiversity is an agronomic concern, since it involves the long-term enhancement of agricultural production (Bullock *et al*. 2007).The present study of butterflies cannot be considered conclusive, more field visit will be needed to update the checklist. This area needs to be continuously monitored for sustainable development and conservation of its rich biodiversity that inhabit variety of insects visitors and its floral resources and hence efforts need to be made to document its floral and faunal wealth and there is essential need to have conservation strategy.In this scenario, studies related to diversity, ecology and habitat suitability are extremely necessary for effective and proper conservation of butterflies (Sharma et al., 2020).Moreover, many insect pollinators are threatened by an increasing risk of extinction due to the gradual decrease in nectariferous plants that are food sources for adults, as well as by the decline of the host plants that are essential for oviposition and larval development (e.g., butterflies species) (Kremen *et al*., 2007; Nicholls and Altieri, 2012; Benelli *et al*. 2014).

The studies describe the change in diversity pattern of butterfly visiting crops and hence this can be helpful in giving productive information on population dynamics and will be useful in future for knowing about environment and habitat degradation of Munsiyari region.Pollination from wild insects visitor promote crop production around the world, but are at risk of decline in agricultural landscapes. Plantation of wild flowering plants next to crop fields would increase the diversity of wild pollinators and can promote Pollination and Crop production. Any initiative of habitat restoration and management for butterfly conservation will protect several other floral and faunal species including the ecological functioning of an area (Bonebrake *et al*., 2010; Subedi *et al*., 2020).

ACKNOWLEDGEMENT

Authors are immensely grateful to Head, Department of Zoology, D.S.B Campus, Kumaun University Nainital for continuous support. We are highly thankful to the Director, Wildlife Institute of India to provide financial and Laboratory support to carry Research work. Authors extend their thanks to Forest Department of Munsiyari and local people for continuous help and cooperation throughout the field visit.

REFERENCES

An, J. and Choi, S. 2021. Butterflies as an indicator group of riparian ecosystem assessment. Journal of Asia-Pacific Entomology 24: 195-200. https://doi.org/10.1016/j.aspen.2020.12.017.

Arora, G. S. 1997. Lepidoptera: rhopalocera. Fauna of Nanda Devi Biosphere Reserve (Uttaranchal), zool. Surv. India, Fauna of Conservation Areas Series, 9, 67-88.

Benelli, G., Benvenuti, S., Desneux, N., Canale, A. 2014. Cephalaria transsylyanica- based flower strips as potential food sources for bees during dry periods in European Mediterranean Basin countries. PLoS ONE: e93153. doi: 10.1371/journal.pone.0093153.

Bhardwaj, M., & Uniyal, V. P. 2013. High-altitude butterfly fauna of Gangotri National Park, Uttarakhand: Patterns in species abundance, composition and similarity. ENVIS Bulletin on Wildlife and Protected Areas-Arthropods and their Conservation in India (Insects & Spiders), 38-48.

Bhardwaj, M., Uniyal, V.P., Sanyal, A.K. and Singh, A.P. 2012. Butterflies communities along an elevation gradient in the Tons valley, Western Himalayas: implications of rapid assessment for insect conservation. Journal of Asia–Pacific Entomology 15: 207-217. https://doi.org/10.1016/j.aspen.2011.12.003.

Biesmeijer, J. C., Roberts, S. P., Reemer, M., Ohlemüller, R., Edwards, M., Peters, T., & Kunin, W. E. 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. Science, 313(5785), 351-354.https://doi.org/10.1126/science.1127863.

Bonebrake, T.C., Ponisio, L.C., Boggs, C.L. and Ehrlich, P.R. 2010. More than just indicators: a review of tropical butterfly ecology and conservation. Biological Conservation 143(8): 1831-1841. https://doi.org/10.1016/j.biocon.2010.04.044.

Bullock, J.M., Pywell, R.F., Walker, K.J. 2007. Long-term enhancement of agricultural production by restoration of biodiversity. J Appl Ecol 44:6-12. doi: 10.1111/j.1365-2664.2006.01252.x.

Chahar, S. Dubey, S. and Panchal, N. 2021. Butterfly diversity in Bhandup (west), Mumbai, Maharashtra, India. Journal of Emerging Technologies and Innovative Research, 8(9):346-352.

Choi, S.W. and Jung, C. 2015. Diversity of Insect Pollinators in Different Agricultural Crops and Wild Flowering Plants in Korea: Literature Review. Journal of Apiculture. 30(3): 191-201.

Connor, O. R.J & Shrubb, M. 1986. Farming and Birds.

Forup, M.L., Memmott, J. 2005. The restoration of plant-pollinator inter-actions in Hay Meadows. Restor Ecol 13:265–274. https://doi.org/10.1111/j.1526-100X.2005.00034.x.

Garibaldi, L.A.et al.2013. Wild pollinators enhance fruit set of crops regardless of honeybee abundance. Science 339, 1608-1611. (doi:10.1126/ science.1230200) Crossref, PubMed, ISI, Google Scholar.

Ghazanfar, M., Malik, M. F., Hussain, M., Iqbal, R., & Younas, M. 2016. Butterflies and their contribution in ecosystem: A review. Journal of Entomology and Zoology Studies, 4(2), 115-118.

Joshi, P. C., & Arya, M. 2007. Butterfly communities along altitudinal gradients in a protected forest in the Western Himalayas, India. Tropical Natural History, 7(1), 1-9.

Kehimkar, I. 2016. The Book of Indian Butterflies. Bombay Natural History Society, Oxford University Press, Mumbai.

Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the royal society B: biological sciences, 274 (1608), 303-313.https://doi.org/10.1098/ rspb.2006.3721.

Kremen, C., Williams, N.M., Aizen, M.A. et al. 2007. Pollination and other ecosystem services produced by mobile organisms: a conceptual framework for the effects of land -use change. Ecol Lett 10:299-314. doi: 10.1111/j.1461-0248.2007.01018.x.

Kumar, P. 2008. Handbook on Common Butterflies of Uttarakhand. Zoological Survey of India, Kolkata.

Kunte, K. 2000. India, a Lifescape: butterflies of peninsular India. Universities Press.

Larson, B. M. H., Kevan, P. G., & Inouye, D. W. 2001. Flies and flowers: taxonomic diversity of anthophiles and pollinators. The Canadian Entomologist, 133(4), 439-465.

Launer, A.E. and Murphy, D.D. 1994. Umbrella species and the conservation of habitat fragments: a case of a threatened butterfly and a vanishing grassland ecosystem. Biological Conservation 69: 145-153. https://doi.org/10.1016/0006-3207(94)90054 –X.

Margalef, R. 2020. Temporal succession and spatial heterogeneity in phytoplankton (pp. 323-350). University of California press. https:// doi.org/10.1525/9780520350281-024.

Nicholls, C.I., Altieri, M.A. 2012. Plant biodiversity enhances bees and other insect pollinators in agroecosystems. A review. Agron Sustain Dev 33:257-274. doi: 10.1007/s13593-012-0092-y.

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. 2010. Global pollinator declines: trends, impacts and drivers. Trends in ecology & evolution, 25(6), 345-353.https://doi.org/10.1016/j.tree.2010.01.007.

Rollin, O., Benelli, G., Benvenuti, S., Decourtye, A., Wratten, S. D., Canale, A., & Desneux, N. 2016. Weed-insect pollinator networks as bio-indicators of ecological sustainability in agriculture. A review. Agronomy for sustainable development, 36(1), 8.

Saxena, A. K., & Singh, J. S. 1984. Tree population structure of certain Himalayan forest associations and implications concerning their future composition. Vegetatio, 58(2), 61-69.

Shannon, C. E., & Weaver, W. 1949. The mathematical theory of com-munication. Urbana: University of Illinois Press, 96.

Sharma, K., Acharya, B.K., Sharma, G., Valente, D., Pasimeni, M., Petrosillo, I. and Selvan, T. 2020. Land use effect on butterfly alpha and beta diversity in the Eastern Himalaya, India. Ecological Indicators 110: 105605. https://doi.org/10.1016/ j.ecolind.2019.105605.

Sharmila, E.J., Thatheyus, A.J., Susaritha, S. and Snegapriya, M. 2020. Seasonality of butterflies in Alagar Hills reserve forest, India. Entomon 45 (1): 53-60. https://doi.org/10.33307/ entomon.v45i1.503.

Singh, A.P. 2017. Butterflies of India. Om Books International, Noida, U.P., India.

Singh, J. S. 1992. Forests of Himalaya: Structure, functioning and impact of man. CGyanodaya Prakashan.

Singh, V., Bisht, S. S., Rajwar, N., & Miglani, R. 2019. Avian diversity and its ecological impact on agro -ecosystems as biological pest control agents near Sharda River bank, Uttarakhand, India. Journal of Entomological Research, 43(4), 547-554. DOI: 10.5958/0974-4576.2019.00096.3.

Smetacek, P. 2002. The genus Pontia Fabricius (Lepidoptera: Pieridae) in the Kumaon Himalaya. Journal-Bombay Natural History Society, 99(2), 224-231.

Smetacek, P. 2004. Descriptions of new Lepidoptera from the Kumaon Himalaya. Journal of the Bombay Natural History Society, 101, 269-276.

Sodhi, N. S., Koh, L. P., Clements, R., Wanger, T. C., Hill, J. K., Hamer, K. C.& Lee, T. M. 2010. Conserving Southeast Asian forest biodiversity in human-modified landscapes. Biological Conservation, 143(10), 2375-2384.https:// doi.org/10.1016/j.biocon.2009.12.029.

Sondhi, S. and Kunte, K. 2018. Butterflies of Uttarakhand- A Field Guide. Titli Trust (Dehradun) National Centre for Biological Sciences, Bengaluru.

Subedi, B., Stewart, A., Neupane, B., Ghimire, S. and Adhikari, H. 2020. Butterfly species diversity and their floral preferences in the Rupa wetland of Nepal. Ecology and Evolution 11: 2086-2099. https://doi.org/10.1002/ece3.7177.

Uniyal, V. 2004. Butterflies of Nanda Devi National Park-a world heritage site. Indian Forester, 130 (7), 800-804.

Plate I. Photograph of butterflies recorded from study area during study period (March 2019 to November 2019)

SORREL SAPPHIRE
(*Heliophorus* sena)

INDIAN TORTOISESHELL
(*Aglais caschmirensis*)

STRIPED, BLUE CROW
(*Euploea mulciber*)

STRIPED TIGER
(*Danaus genutia*)

COMMON BRIMSTONE
(*Gonepteryx rhamni*)

HIMALAYAN FRITILLARY
(*Issoria isaea*)

COMMON FIVE RING
(*Ypthima baldus*)

CLOUDED YELLOW
(*Colias fieldii*)

COMMON COPPER
(*Lycaena phlaeas*)

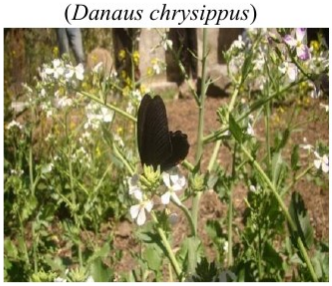
CHOCOLATE PANSY
(*Junonia iphita*)

HIMALAYAN SERGEANT
(*Athyma perius*)

PLAIN TIGER
(*Danaus chrysippus*)

PAINTED LADY
(*Vanessa cardui*)

COMMON LEOPARD
(*Phalanta phalantha*)



SPANGLE
(*Papilio protenor*)