Indian Journal of Ecology (2023) 50(6): 2050-2054
DOI: https://doi.org/10.55362/IJE/2023/4173

Manuscript Number: 4173
NAAS Rating: 5.79

Species Richness and Diversity of Lepidoptera in an Agricultural Ecosystem of Bhabar Region in district Nainital, Uttarakhand

Rekha, D. Goswami, D. Arya and B.R. Kaushal

D.S.B. Campus, Department of Zoology, Kumaun University, Nainital-263 002, India
E-mail: yadavdsb@gmail.com

Abstract: Species richness, abundance, and species diversity of the insect order Lepidoptera was studied in an agricultural ecosystem of Bhabar region in Chhoi, district Nainital, Uttarakhand from March 2018 to February 2020. 838 individuals of Lepidopterans were collected, which belonged to 68 species of 12 families. Family Nymphalidae was the most dominant family with 19 species and 30.9% of total individuals, followed by Pieridae (14 species and 39.7% individuals), Lycaenidae (11 species and 12.7% individuals), Papilionidae (8 species and 9.3% individuals), Erabidae (6 species and 3.5% individuals), Hesperiidae (3 species and 1.6% individuals), Noctuidae (2 species and 3% individuals), Eupterotidae, Zygaenidae, Sphingidae, Crambidae, Geometridae (1 species and 1.5% individuals each). Significant correlation was observed between temperature and species richness, and abundance of individuals collected. The highest diversity of Lepidopterans was (H'=1.857), evenness (E=0.9806; highest value is 1), Margalef's species richness (d=2.457), and Dominance Index (D=0.358). Foraging activity of Lepidopterans as flower pollinators/visitors was also recorded.

Keywords: Lepidoptera, Species richness, Abundance, Diversity Indices, Agricultural ecosystem, Bhabar region

Insects are the most dominating and diverse organisms on the earth, inhabit all habitat types and play major roles in the function and stability of terrestrial and aquatic ecosystems (Godfray 2002). They make up more than 50% of the known global biodiversity. Insects are important because of their diversity, role in ecosystems, human health, influence on agriculture, and natural resources (Losey et al 2006, Premalatha et al 2011). Slightly over one million of insect species have been described, of which five insect orders are the most abundant in their levels of species richness: Coleoptera, Lepidoptera, Hymenoptera, Diptera and the Hemiptera (Jach and Balke 2008). The order Lepidoptera with more than 150,000 species is the second largest and the most diverse order in the Class Insecta (Gullan and Cranston 2010) and are the most diverse group of organisms in most of the ecosystems, serving as important pollinators, environmental bio-indicators, and for making quantitative comparisons among insect fauna (Siregar et al 2016, Subedi and Subedi 2019). Lepidoptera are also known to be very sensitive to any changes in the environment, and are affected both by biotic and abiotic factors (Haber 2006).

Biodiversity studies on Lepidoptera have the advantages because of their high diversity, relatively easy to sample and identify, and are found in many habitats. Species richness provides an extremely useful measure of diversity when complete information of species in the community is available. Insect pollinators and flowering plants have mutual relationships and maintain healthy ecosystem (Atmowidi et al 2007). Many groups of insects belonging to the insect orders Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera, Hemiptera and Neuroptera are of prime significance in the pollination of different agricultural, horticultural, and medicinal herbal crops (Bhowmik et al 2014, Subedi and Subedi 2019). A total of 1504 lepidopteran species have been reported from different habitats in the Indian subcontinent (Tiple 2011). There are reports on species richness, diversity and distribution of Lepidoptera in different habitats (Arya et al 2014, Roy et al 2014, Garia et al 2016, Thiruvengadam et al 2021), but no such reports are available from agricultural ecosystem of Bhabar region in Uttarakhand. The objective of the present study was to estimate the species richness, abundance, species diversity, and foraging activity of Lepidoptera as pollinators in the agricultural ecosystem of Bhabar region in Uttarakhand.

MATERIAL AND METHODS

Geographically, village Chhoi is located in the sub-tropical zone at 29^{0} 58' N latitude and 79^{0} 60' E longitudes at an altitude of 348 m in the Bhabar region of Uttarakhand. The study area has sub-humid tropical climate and is situated in the foothills of central Himalayas. The climatic data indicates hot dry summer and cold winter. The maximum temperature reaches up to 39 °C (May) in summer, and minimum 8.0 °C (January) in winter. The maximum humidity ranged from 23% (May) to 78% (August). The average rainfall was 1734 mm and 75.8% of rainfall occurred in the rainy season. On this

basis, the year can be divided in into three seasons, namely rainy (July to October), winter (November to February) and summer (March to June). Three crops are grown in a year: July to October (Paddy/Soybean), November to April (wheat/mustard) and seasonal vegetables (May-June).The agricultural fields are in the shallow layers of the soil (5 cm). The agro-ecosystems are highly productive, resources rich (water and nitrogen input from irrigation and livestock) and experience a fair amount of disturbance due to anthropogenic activities throughout the growing season.

Sampling of insects was conducted at an interval of 30 days from March, 2018 to February, 2020. The insects were collected by "Sweep Sampling Method" (Gadagkar et al 1990) and hand picking. The net sweeps were used to collect the insects The nets used in sweeping were made of thick cotton cloth with a diameter of 30 cm at mouth and a bag length of 60 cm. A randomly selected area of each study sites was divided into a quadrate of 10x10 m. Hand picking method was used for larger, ground living insects and insects living under the stones. Collected insects were identified with the help of keys and through the available literature. Insects were then separated into different orders and families and to the species level. The representative species were preserved in the laboratory. The species which could not be identified in the laboratory were sent to the Forest Research Institute, Dehradun for identification. The collected insect species were identified and placed into five trophic levels.

Shannon's diversity index or Shannon-Wiener diversity (H') (1963) was calculated as follows:

(A) Species Diversity: $H'(S) = -\sum_{i=1}^{s} pi \log pi$

(B) Seasonal Diversity: $H'(P) = -\sum_{i=1}^{s} qj \log qj$

Where, Pi= ni/N and qj= nj/N, ni = Number of individual of a species at a time I, nj = Number of individual present in a season j. N = Size of whole community, $\sum$ = Number of species/ Number of seasons. S = Total number of species, P = Number of seasons

(C) Evenness (Buzas and Gibson's Evenness) E2:

$$E2 = e^{H/S}$$

Where, S is the number of taxa and H is the Shannon Index

(D) Margalef's Species Richness Index (d):

Species richness was calculated using Margalef's Index (1970)

Margalef's Index (d) = (S-1)/ In N

Where, S = total number of species, N = total number of individuals in sample, In = natural logarithm

(E) Dominance Index (D):

$C = \sum (ni/N)^2$

Where, ni = Importance value for each species, N = Total of Importance values

RESULTS AND DISCUSSION

Species richness and abundance: A total of 838 individuals were collected from the study site. The pooled-up data of two years showed that lepidopteran fauna comprised of 68 species belonging to 12 families (Table 1). Family Nymphalidae was the most abundance with 19 species and a relative abundance of 27.9%, followed by Pieridae, Lycaenidae, Papilionidae, Erabidae, Hesperiidae, Noctuidae and Eupterotidae, Zygaenidae, Sphingidae, Crambidae, Geometridae (Table 2). In terms of number of individuals collected, family Pieridae was the most dominant with 333 individuals with a relative abundance of 39.7%, followed by Nymphalidae, Lycaenidae, Papilionidae, Erabidae, Hesperiidae, Noctuidae, Zygaenidae, Sphingidae, Crambidae and Eupterotidae and Geometridae (Table 2). Families Noctuidae, Zygaenidae, Sphingidae, Crambidae, Geometridae and Eupterotidae were considered as "minor constituents" because of their smaller number of species and abundance of individuals.

Maximum number of species and individuals were collected in the easily spring, summer and rainy seasons. The highest relative abundance (17.9%) was in July followed by October (14.9%), while it was least in February (1.4%). Relatively, *P. lemonias* was the dominant species (6.32%) followed by *P. brassicae* (5.37%) (Table 1). Strong correlation was observed between minimum temperature and species richness (r=0.828), maximum temperature and species richness (r=0.824), but there was a weak correlation between rainfall and species richness (r=0.486). Similarly, strong correlation was observed between minimum temperature and abundance of individuals (r=0.717), maximum temperature and abundance of individuals (r=0.653), but a weak correlation between rainfall and abundance of individuals (r=0.572). Less number of insects was recorded during winter season (November to February) which was due to foggy weather and harsh environmental conditions. The observations are similar to other reported studies (Regniere et al 2012, Nadia et al 2015, Ghani and Maalik 2019). It can thus be concluded that species richness and abundance of individuals is affected by average temperature of the study area.

Diversity indices: Species diversity (H') varied from 1.055 to 1.94 (Table 3). Maximum species diversity (H'=1.94) was recorded in June and minimum (H'=1.055) in November.Buza's Evenness (E) which takes into account the

Table 1. Species richness, number of individuals and relative abundance of Lepidopterans collected in the study site

Taxonomic composition	No. of individual	Relative abundance (%)
Family: Pieridae		
ieris brassicae Linnaeus	45	5.37
P. canidia indica (Sparrman)	25	2.98
Pontia daplidice Linnaeus	20	2.39
Eurema brigitta Cramer	41	4.89
Anapheis aurota Fabricius	19	2.27
Gonepteryx rhamni nepalensis Doubleday	7	0.84
Aporia agathon (Gray)	18	2.15
Pareronia valeria Cramer	25	2.98
Colias electo fieldi Menetries	18	2.15
Catopsilia pyranthe Linnaeus	36	4.30
C. pomona Fabricius	23	2.74
Belenois aurota Fabricius	21	2.51
Cepora nerissa phryne Fabricius	20	2.39
Leptosia nina (Fabricius)	15	1.79
Family: Nymphalidae		
Kallima inachus (Boisduval)	2	0.24
Vanessa indica Herbst	13	1.55
Symbrenthia hippoclus Cramer	18	2.15
Aglais cashmiriensis Kollar	25	2.98
Cynthia cardui Linnaeus	11	1.31
Precis iphita iphita Cramer	14	1.67
Sephisa dichroa (Kollar)	14	1.67
Precis lemonias lemonias Linnaeus	53	6.32
P. almana (Linnaeus)	20	2.39
P. orythia Linnaeus	7	0.84
Neptis sankara Kollar	13	1.55
Euthalia patala Kollar	5	0.60
Symphaedra nais (Forster)	6	0.72
Hypolimnas bolina Linnaeus	3	0.36
Phalanta phalantha (Drury)	11	1.31
Ariadne merione (Cramer)	4	0.48
Ypthima sp.	13	1.55
Danaus chryssippus (Linnaeus)	24	2.86
Euploea core (Cramer)	3	0.36
Family: Lycaenidae		
Heliophorus androcles Doubleday & Hewitson	2	0.24
H. sena Kollar	5	0.60
Talicada nyseus (Guerin-Meneville)	15	1.79
Leptotes plinius (Fabricius)	7	0.84
Neopithecops zalmora Butler	6	0.72
Zemeros flegyas Cramer	6	0.72
Zizeeria sp.	45	5.37
Catochrysops strabo Fabricius	7	0.84
Hypolycaena erylus Godart	6	0.72
Arhopala amantes Hewitson	5	0.60
Acytolepis sp.	2	0.24
Family: Papilionidae		
Atrophaneura aristolochioae Fabricius	12	1.43
Papilio polytes Linnaeus	19	2.27
Graphium doson axionides (Page & Treadway)	1	0.12
Papilio romulus Linnaeus	21	2.51
P. cyrus Linnaeus	9	1.07
P. demoleus Linnaeus	9	1.07
P. stichius Linnaeus	6	0.72
P. clytia clytia Linnaeus	1	0.12
Family: Hesperiidae		
Telicota sp.	2	0.24
Parnara guttata Bremer & Grey	9	1.07
Polytremis eltola Hewitson	2	0.24
Family: Erabidae		
Amata sp.	6	0.72
Eressa confinis (Walker)	1	0.12
Erebus sp.	1	0.12
Lithosiini sp.	2	0.24
Cyana coccinea Moore	8	0.95
Ceryx imaon Cramer	11	1.31
Family: Noctuidae		
Calpe ophideroides Guen.	5	0.60
Episteme adulatrix Kollar	2	0.24
Family: Eupterotidae		
Eupterote sp.	1	0.12
Family: Zygaenidae		
Campylotes histrionicus Westwood	6	0.72
Family: Sphingidae		
Daphnis nerii (Linnaeus)	3	0.36
Family: Crambidae		
Glyphodes orbiferalis Hampson	2	0.24
Family: Geometridae		
Anonychia grisea Warren	1	0.12
Total	838	100.0

Cont...

Table 1 Cont...

distribution of species and their numbers across gradients has returned high values (0.9806; highest value is 1) indicating that no species was dominant in terms of abundance. Margalef's Richness Index was 2.457 indicating high species richness in the study area. Dominance Index (D) varied from 0.1887 to 0.36, and these values are reciprocal to evenness indices and have been observed in the present study also.

Diversity of the order Lepidoptera fluctuates with season. They are abundant for only a few months and are absent or rare during other months of the year. Similar observations have also been in the present as Lepidopterans were recorded less in abundance during winter season because of cold climatic conditions.The results obtained for various Diversity Indices in the present study indicate that values obtained are comparable to other reported values for Lepidoptera in different agro-ecosystems (Arya et al 2014, Usha and John 2015, Garia et al 2016, Rabeih 2018).

Foraging activity of Lepidoptera: The foraging activity of the Lepidopterans showed that the insects were less active in the morning but showed maximum activity during the afternoon. All 68 species of Lepidopterans collected were the most diverse pollinators in the agricultural ecosystem studied. Their large body size helps in sticking pollens to their legs and proboscis when they visit flowers for nectar. This ensures effective transfer of pollens when they visit another

Table 2. Total collected species, individuals of each family and its relative abundance

Family	Species		Individuals		H value
	Number	Relative abundance (%)	Number	Relative abundance (%)	
Nymphalidae	19	27.9	259	30.9	2.651
Pieridae	14	20.6	333	39.7	2.554
Lycaenidae	11	16.2	106	12.7	1.925
Papilionidae	8	11.7	78	9.3	1.793
Erabidae	6	8.8	29	3.5	1.466
Hesperiidae	3	4.4	13	1.6	0.831
Noctuidae	2	3.0	7	0.8	0.598
Eupterotidae	1	1.5	1	0.1	0
Zygaenidae	1	1.5	6	0.7	0
Sphingidae	1	1.5	3	0.4	0
Crambidae	1	1.5	2	0.2	0
Geometridae	1	1.5	1	0.1	0
Total	68	100.0	838	100.0	

Table 3. Diversity indices of Lepidoptera collected in Chhoi during March 2018 to February, 2020

Months	Species richness (S)	Abundance (N)	Relative abundance (%)	Shannon index (H')	Evenness (E)	Margalef's Index (d)	Dominance Index (D)
March	35	75	8.9	1.619	0.7212	1.688	0.2343
April	37	95	11.3	1.857	0.7114	2.216	0.1965
May	37	85	10.1	1.477	0.7296	1.385	0.2754
June	34	65	7.8	1.940	0.6957	2.457	0.1887
July	46	150	17.9	1.716	0.6956	1.828	0.2278
August	37	115	13.7	1.652	0.7451	1.662	0.2316
September	36	65	7.8	1.640	0.7365	1.674	0.2392
October	38	125	14.9	1.799	0.7556	1.924	0.1981
November	10	20	2.4	1.055	0.9572	0.869	0.360
December	9	16	2,0	1.061	0.9629	0.910	0.358
January	7	15	1.8	1.079	0.9806	1.028	0.347
February	6	12	1.4	1.099	1	1.116	0.333
Total		838	100.0				

flower thus making Lepidopterans very effective pollinators of crops. Similar observations are documented for Lepidopterans as pollinators of crops (Duara and Kalita 2013, Rader et al 2016, Das et al 2018).

CONCLUSIONS

A total of 838 individuals belonging to 68 species of 12 families were recorded in the agricultural ecosystem. The suitable ecological conditions and climatic factors such as temperature increase the insect's abundance in early summer and rainy seasons. Biodiversity indices showed relatively diversity values of Lepidoptera. The decline in diversity of pollinators could result in serious threat to crop pollination by reducing the crop yield. Hence, conservation of pollinator species by employing effective crop management techniques is encouraged for higher production of crops.

REFERENCES

Arya MK, Dayakrishna and Chaudhary R 2014. Species richness and diversity of Butterflies in and around Kumaun University, Nainital, Uttarakhand, India. *Journal of Entomology and Zoology Studies* **2(3):** 153-159.

Atmowidi T, Buchori D, Manuwoto S, Suryobroto B and Hidayat P 2007. Diversity of pollinator in relation to seed set of mustard (*Brassica rapa* L. Cruciferae). *Hayata Journal of Bioscience* **14:** 155-161.

Bhowmik B, Mitra B and Bhadra K 2014. Diversity of insect pollinators and their effect on the crop yield *Brassica juncea* L., NPJ-93, from southern West Bengal. *International Journal of Recent Scientific Research* **5**(6): 1207-1213.

Das BJ, Paul K and Basumatary BK 2018. Diversity of insect pollinators of Rabi Crops cultivated in surrounding areas of Barpeta town in Assam, India. *International Journal of Research and Analytical Reviews* **5**(4): 172-177.

Duara P and Kalita J 2013. An investigation on the pollinating insects of medicinally important plants. *International Journal of Life Science, Biotechnology and Pharmacy Research* **2:** 318-324.

Garia A, Goswami D and Kaushal BR 2016. Diversity and abundance of Lepidoptera in a pine forest of Kumaun Himalaya. *Journal of Environment-Bioscience* **30**(2): 477-480.

Ghani A and Maalik S 2019. Assessment of diversity and relative abundance of insect fauna associated with *Triticum aesticum* from district Sialkot, Pakistan. *Journal of King Saud University-Science*. Journal homepage: www.sciencedirect.com

Godfray HC 2002. Challenges for taxonomy. *Nature* **417:** 17-19.

Received 21 April, 2023; Accepted 11 September, 2023

Gullan PJ and Cranston PS 2010. *The Insects: An outline of Entomology*. 4th edition. Wiley-Blackwell Publishers. 565p.

Haber E 2006. Baseline assessment of butterfly biodiversity and community composition of firestone center for restoration ecology. Costa Rica Research Reports of the Firestone Center for Restoration. *Ecology* **2:** 1-22.

Jach M and Balke M 2006. Global diversity of water beetles (Coleoptera) in freshwater. *Hydrobiologia* **595**(1): 419-442.

Losey JE and Vaughan M 2006. The economic value of ecological services provided by insects. *Bioscience* **56**(4): 312-323.

Nadia A, Ashraf I, Hussain T and Ahmad I 2015. Studies on the Diversity and Relative Abundance of Orthoptera and Lepidoptera Species in Urban and Crop Land Areas of Dera Ghazi Khan. *American-Eurasian Journal of Agriculture and Environmental Science* **15**(8): 1693-1699.

Premalatha M, Abbasi T, Abbasi T and Abbasi SA 2011. Energy efficient food production to reduce global warming ecodegradation. The use of edible insects. *Renewable and Sustainable Energy Review* **15**(9): 4357-4360.

Rabieh MM 2018. Biodiversity of noctuid moths (Lepidoptera: Noctuidae) in the agroecosystems of Moshhad County. *Biodiversity International Journal* **2(**2): 147-157.

Rader R, Bartomeus I, Garibaldi LA, Garrat MPD, Howlett BG, Winfree R and Woyciechowski M 2016. Non-bee insects are important contributors to global crop pollination. *Proceedings of the National Academy of Sciences* **113**(1): 146-151.

Regniere J, Powell J, Bentz B and Nealis V 2012. Effects of temperature on development, survival and reproduction of insects: Experimental design, data analysis and modeling. *Journal of Insect Physiology* **58:** 634-647.

Roy S, Gayen AM, Mitra B and Duttagupta A 2014. Diversity, foraging activities of insect visitors of Mustard (*Brassica juncea* L.) and their role in pollination in West Bengal. *The Journal of Zoology Studies* **1**(2): 07-12.

Siregar EH, Atmowidi T and Kahona S 2016. Diversity and abundance of insect pollinators in different agricultural lands in Jambi, Sumatera. *HAYATI Journal of Biosciences* **23:** 13-17.

Subedi N and Subedi IP 2019. Pollinator insects and their impact on crop yield of mustard in Kusuma, Parbat, Nepal. *Journal of Institute of Science and Technology* **24**(2): 68-75.

Tiple AD 2011. Butterflies of Vidharba region, Maharashtra State, Central India. *Journal of Threatened Taxa* **3**(1): 1469-1477.

Thiruvengadam K, Sachin K, Dharini J, Jishnu V, Mathivanan V, Santhiya V and Kumar K 2021. Biodiversity of lepidoptera in agricultural and horticultural ecosystem in Pajancoa & RI, Karaikal-U T of Puducherry. *International Journal of Current Microbiology and Applied Sciences* **10**(1): 2959-2964.

Usha AU and John VK 2015. A study on insect diversity of a selected area in Wadakkancherry (Thrissur, Kerala). *The Journal of Zoology Studies* **2**(3): 38-50.