



# Species Richness and Diversity of Insect Pollinators Associated with Agro-ecosystems in Kumaun Hills of Nainital District, Uttarakhand, India

Deeksha Arya, Deepika Goswami, Rekha and B.R. Kaushal

Department of Zoology, D.S.B. Campus, Kumaun University, Nainital-263 002, India  
E-mail: [deekshu21feb@gmail.com](mailto:deekshu21feb@gmail.com)

**Abstract:** The present study investigates the diversity of pollinating insects in the Kumaun hills of Nainital District, Uttarakhand, India, with a specific focus on the Paharpani region. The study is dedicated to investigating the diversity and abundance of insect pollinators in orchards and agricultural land in the Kumaun Himalaya of Uttarakhand. The study was conducted from March 2019 to February 2021, and total of 77 insects belonging to 7 orders, including Lepidoptera, Hymenoptera, Coleoptera, Diptera, Orthoptera, Hemiptera, and Thysanoptera, were collected from study sites. The maximum number of species belonged to the order Lepidoptera; the lowest number was found in Thysanoptera from the study site. Species richness was highest during the rainy (10.37), summer (8.979) seasons and lower in the winter (5.013).

**Keywords:** Diversity, Pollinators, Diversity indices, Agricultural ecosystems, Kumaun hills

Pollination is a crucial process for the reproduction of most flowering plant species and is ultimately necessary for the production of food (Nunes-Silva et al., 2010). Fruit, vegetable, or seed production from 87 of the leading global food crops depends on animal pollination (Klein et al., 2007). Insects are responsible for over 80 percent of pollination activity. Insects, including bees, are crucial for the pollination of many cultivated and wild plants (Thapa 2006). Different crops have varying pollination needs, which affects their reliance on insect pollinators (Morse and Calderone 2000). The presence of pollinators provides a unique method for monitoring ecosystem health. Various insect species from different orders play crucial roles as pollinators/visitors in the pollination of different crops (Mitra et al., 2008, Divija et al., 2022). Various insect groups that are significantly important for the pollination of agricultural, horticultural, and medicinal herbal crops mainly belong to the Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera, Hemiptera, and Neuroptera (Free 1993, Kearns et al., 1998, Mitra and Parui 2002, Mitra et al., 2008). The current study presents crucial aspects of the diversity, richness, and abundance of insect pollinators.

## MATERIAL AND METHODS

**Study Area:** The present study was conducted in agroecosystems located at Paharpani (2044 masl, 29° 25'38N, 79° 42'41E), in Nainital district of Uttarakhand (Fig. 1, 2) from March 2019 to February 2021. In Paharpani, *Brassica oleracea*, *Brassica sinapis*, *Coriandrum sativum*, *Solanum tuberosum*, *Cucumis sativus*, *Pisum sativum*, *Allium cepa*, *Raphanus sativus*, *Phaseolus vulgaris*, *Capsicum annuum*.

In orchards, *Citrus limon*, *Citrus sinensis*, *Prunus domestica*, *Malus domestica*, *Pyrus persica* and *Pyrus communis* are grown.

**Sampling and collecting of insects:** The site was regularly visited every month between 9:00 am and 2:00 pm when the insects were most active. Insects were sampled at 30-day intervals using sweeping and hand-picking. After collection, the insects were placed in jars with ethyl acetate-soaked cotton and taken to the laboratory for processing and preservation in wooden boxes. The insects were identified using available literature and identification keys, and they were sorted into different orders, families, and species. Representative species were preserved in the laboratory, while unidentified ones were sent to the Zoological Survey of India in Dehradun for further identification. The trophic level in the food chain was assigned to the insects as Phytophagous, predators, polyphagous, nectarivorous, parasitoids, florivorous, saprophagous, polylectic, and detritivorous (Table 1). Shannon's diversity index (Shannon-Wiener diversity 1949), evenness (Hill 1973), and Margalef's species richness index (Margalef's 1970) were calculated.

## RESULTS AND DISCUSSION

The total of 77 species were collected from the study site. The highest number of species belonged to the order Lepidoptera (35), followed by Hymenoptera, Coleoptera, Diptera. Lepidoptera, Hymenoptera, Coleoptera, and Diptera had high abundance and species richness, while Orthoptera, Hemiptera, and Thysanoptera were minor constituents (Table 1). Species richness was highest during the rainy

(10.37), summer (8.979) seasons and lower in the winter (5.013) (Table 3). Insect abundance was significantly correlated with maximum temperature (Fig. 4a), minimum temperature (Fig. 4b), and rainfall (Fig. 4c). Both low and high temperatures, as well as rainfall, impacted the species richness and abundance of insect pollinators (Fig. 5). These findings align with previous studies (Dev et al., 2009, Regniere et al., 2012, Nadia et al., 2015, Abbas et al., 2014, Rekha 2021).

Nine trophic groups were identified: phytophagous,

predators, polyphagous, nectarivorous, parasitoids, florivorous, saprophagous, poyelectic, and detritivorous. Phytophagous insects were predominant, comprising 54.05% of species and 42.28% of individuals. Predators followed at 18.68% of species and 26.93% of individuals, with polyphagous insects at 10.08% of species and 15.36% of individuals. The other groups made up smaller percentages (Fig. 3). Many ecologists have grouped insects into functional trophic guilds to study their ecological interactions (Speight et al., 2008). These findings align with global trends,

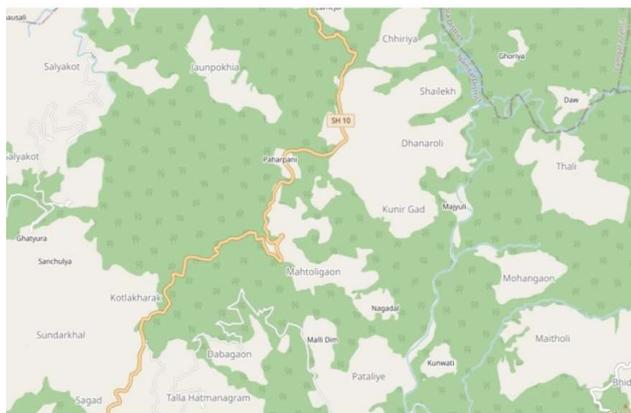


Fig. 1. Map of study area



Fig. 2. General view of study area

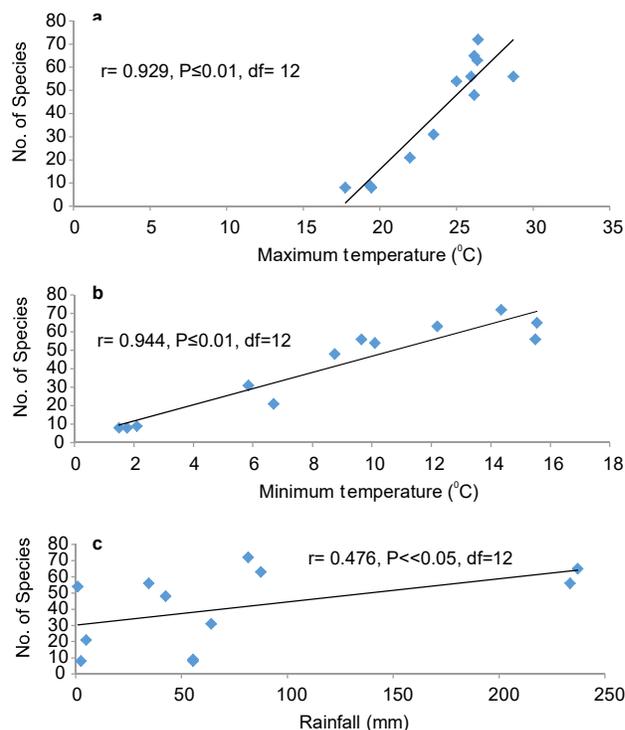


Fig. 4a-c. Correlation between Species richness with minimum temperature, maximum temperature and rainfall during March, 2019 to February, 2021

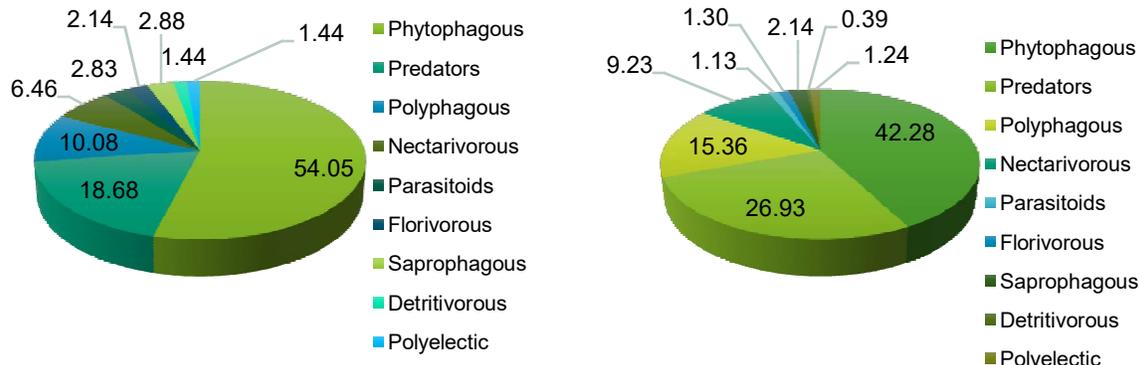


Fig. 3. Guild structure of insects fauna (species individuals)

**Table 1.** Diversity and relative abundance (%) of insect pollinators and trophic components during March, 2019 to February, 2021

Taxonomic composition	Trophic level	2019-2020		2020-2021	
		No. of individuals	Relative abundance (%)	No. of individuals	Relative abundance (%)
ORDER- LEPIDOPTERA					
Family: Pieridae					
<i>Pieris canidia indica</i> (Evans)	Phytophagous	31	1.95	39	2.65
<i>P. brassicae</i> (Linnaeus)	Phytophagous	28	1.76	23	1.56
<i>Pontia daplidice</i> (Linnaeus)	Phytophagous	21	1.32	17	1.16
<i>Gonepteryx rhamni nepalensis</i> (Doubleday)	Phytophagous	19	1.19	15	1.02
<i>Aporia agathon</i> (Gray)	Phytophagous	17	1.07	08	0.54
<i>Colias felidi</i> (Menetries)	Phytophagous	22	1.38	16	1.09
<i>Catopsilia pyranthe</i> (Linnaeus)	Phytophagous	00	0.00	17	1.16
Family: Nymphalidae					
<i>Aglais cashmirensis</i> (Kollar)	Phytophagous	23	1.44	33	2.24
<i>Vanessa cardui</i> (Herbst)	Phytophagous	31	1.95	23	1.56
<i>Danaus chrysippus</i> (Linnaeus)	Phytophagous	00	0.00	16	1.09
<i>Callerebia scanda</i> Kollar	Phytophagous	07	0.44	05	0.34
<i>C. nirmala</i> Moore	Phytophagous	10	0.63	08	0.54
<i>C. annada</i> (Moore)	Phytophagous	13	0.82	10	0.68
<i>C. hybrida</i> Butler	Phytophagous	11	0.69	13	0.88
<i>Ypthima inica</i> Hewiston	Phytophagous	15	0.94	07	0.48
<i>Acraea issoria</i> (Hubner)	Phytophagous	20	1.26	16	1.09
<i>Cyrestis thyodamas</i> Boisduval	Phytophagous	12	0.75	09	0.61
<i>Lasiommata schakra</i> Kollar	Phytophagous	15	0.94	12	0.82
<i>Junonia iphita</i> (Cramer)	Phytophagous	00	0.00	06	0.41
Family: Lycaenidae					
<i>Lycaena pavana</i> Kollar	Phytophagous	29	1.82	36	2.45
<i>L. phlaeas</i> (Linnaeus)	Phytophagous	27	1.70	20	1.36
<i>Zizzeria</i> sp.	Phytophagous	36	2.26	32	2.18
<i>Heliophorus androcles</i> (Hewitson)	Polyphagous	30	1.88	19	1.29
<i>H. sena</i> (Kollar)	Phytophagous	00	0.00	23	1.56
<i>Euchrysops cnejus</i> Fabricius	Polyphagous	26	1.63	19	1.29
<i>Zizina otis</i> Fabricius	Polyphagous	29	1.82	24	1.63
<i>Pseudozizeeria maha</i> Kollar	Polyphagous	24	1.51	32	2.18
<i>Dodona durga</i> (Kollar)	Phytophagous	18	1.13	25	1.70
<i>Aricia agestis</i> (Bergstrasser)	Phytophagous	20	1.26	21	1.43
<i>Acytolepis puspa</i> (Horsfield)	Phytophagous	31	1.95	22	1.50
<i>Telicada nyseus</i> Guerin-Meneville	Phytophagous	18	1.13	17	1.16
Family: Papilionidae					
<i>Papilio polytes</i> Linnaeus	Phytophagous	20	1.26	18	1.22
<i>Atrophanura polyeuctus</i> (Doubleday)	Phytophagous	00	0.00	12	0.82
Family: Hesperidae					
<i>Borbo bevani</i> Moore	Phytophagous	07	0.44	00	0.00
Family: Sphingidae					
<i>Rhopalopsyche nycteris</i> Kollar	Phytophagous	02	0.13	00	0.00

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Taxonomic composition	Trophic level	2019-2020		2020-2021	
		No. of individuals	Relative abundance (%)	No. of individuals	Relative abundance (%)
ORDER- HYMENOPTERA					
Family: Apidae					
<i>Apis cerena indica</i> Fabricius	Nectarivorous	65	4.08	62	4.22
<i>A. mellifera</i> Linnaeus	Nectarivorous	48	3.02	44	2.99
<i>A. dorsata</i> Fabricius	Nectarivorous	29	1.82	21	1.43
<i>Bombus haemarrhoidalis</i> Smith	Phytophagous	08	0.50	05	0.34
<i>B. festivus</i> Smith	Phytophagous	05	0.31	08	0.54
<i>B. hypnorum</i> Linnaeus	Phytophagous	11	0.69	00	0.00
<i>B. ternarius</i> Say	Phytophagous	09	0.57	11	0.75
<i>Ceratina</i> sp.	Nectarivorous	08	0.50	05	0.34
Family: Halictidae					
<i>Nomia</i> sp.	Florivorous	05	0.25	00	0.00
Family: Xylocopidae					
<i>Xylocopa</i> sp.	Phytophagous	16	0.81	10	0.68
Family: Vespidae					
<i>Vespa auraria</i> Smith	Predator	05	0.66	09	0.61
<i>V. basalis</i> Smith	Predator	06	0.56	00	0.00
<i>V. mandrinia</i> Smith	Predator	11	0.46	13	0.88
<i>Polistes</i> sp.	Predator	08	0.91	11	0.75
<i>Allorhynchium argentatum</i> Fabricius	Predator	05	0.35	11	0.75
Family: Scoliidae					
<i>Dielis</i> sp.	Nectarivorous	01	0.06	00	0.00
<i>Campsomeris collaris</i> Guerin-Meneville	Parasitoids	03	0.19	00	0.00
Family: Megachilidae					
<i>Megachile</i> sp.	Florivorous	18	1.13	17	1.16
Family: Andrenidae					
<i>Andrena</i> sp.	Polylectic	22	1.38	16	1.09
Family: Sphecidae					
<i>Sceliphron madraspatanum</i> Fabricius	Predator	03	0.19	06	0.41
Family: Ichneumonidae					
<i>Coelicheumon</i> sp.	Parasitoids	09	0.57	00	0.00
Family: Formicidae					
<i>Camponotus</i> sp.	Predator	32	2.01	18	1.22
ORDER- COLEOPTERA					
Family: Coccinellidae					
<i>Coccinella septempunctata</i> (Linnaeus)	Predator	90	5.65	105	7.14
<i>Oenopia</i> sp.	Predator	26	1.63	18	1.22
<i>Cheilomenes sexmaculata</i> Fabricius	Predator	17	1.07	14	0.95
Family: Meloidae					
<i>Mylabris cichorri</i> Linnaeus	Predator	46	2.89	52	3.54
<i>M. pustulata</i> Thunberg	Predator	52	3.27	47	3.20

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**Table 1.** Diversity and relative abundance (%) of insect pollinators and trophic components during March, 2019 to February, 2021

Taxonomic composition	Trophic level	2019-2020		2020-2021	
		No. of individuals	Relative abundance (%)	No. of individuals	Relative abundance (%)
Family: Scarebaeidae					
<i>Dung beetle sp.</i>	Detritivores	07	0.44	05	0.34
<i>Anomala sp.</i>	Phytophagous	09	0.57	11	0.75
<i>Phyllophaga sp.</i>	Phytophagous	13	0.82	00	0.00
Family: Chrysomelidae					
<i>Aulacophora sp.</i>	Phytophagous	21	1.32	18	1.22
ORDER- DIPTERA					
Family: Muscidae					
<i>Musca sp.</i>	Saprophagous	22	1.38	27	1.84
Family: Syrphidae					
<i>Eristalis sp.</i>	Polyphagous	57	3.58	52	3.54
<i>Episyrphus sp.</i>	Polyphagous	62	3.89	75	5.10
Family: Asilidae					
<i>Philodicus sp.</i>	Predator	23	1.44	15	1.02
Family: Tachinidae					
<i>Archytas sp.</i>	Parasitoids	10	0.63	13	0.88
Family: Sarcophagidae					
<i>Sarcophaga sp.</i>	Saprophagous	17	1.07	00	0.00
ORDER- ORTHOPTERA					
Family: Acrididae					
<i>Xenocatantops sp.</i>	Phytophagous	23	1.44	19	1.29
Family: Tettigoniidae					
<i>Elimaesa sp.</i>	Phytophagous	31	1.95	17	1.16
ORDER- HEMIPTERA					
Family: Pentatomidae					
<i>Nezara viridula</i> Linnaeus	Phytophagous	18	1.13	09	0.61
Family: Lygaeidae					
<i>Lygaeus sp.</i>	Polyphagous	11	0.69	10	0.68
ORDER- THYSANOPTERA					
Family: Thripidae					
<i>Thrips sp.</i>	Predator	98	6.16	83	5.65
Total		1592	100	1470	100

emphasizing the dominance of phytophagous insects (Dev et al., 2009, Chouangthavy et al., 2017, Atencio et al., 2018, Ghani and Maalik 2020). The present study shows similar results, with phytophagous insects being dominant in species richness and abundance.

The Shannon-Wiener Diversity Index ( $H'$ ), Evenness ( $E$ ), and Margalef's Species Richness Index ( $d$ ) were used to calculate the diversity of insect fauna collected (Tables 2 and 4). The maximum Species Diversity Index ( $H'$ ) was 3.981, Evenness ( $E$ ) 0.9514, and Margalef's Richness Index ( $d$ ) 11.33. Lepidopterans had the highest diversity index

( $H'=4.041$ ), the highest species richness ( $d=8.719$ ), and Thysanopterans had the highest evenness ( $E'=0.9966$ ) (Table 4). Previous studies have reported a Shannon Diversity Index for entomofauna ( $H'=2.93$  to 3.57) and Evenness ( $E'=0.721$  to 0.947) in various crops in urban and croplands of Dera Ghazi Khan, Pakistan, indicating high diversity (Amber et al., 2015). Naz et al. (2020) reported a maximum Shannon Diversity Index ( $H'=2.195$ ) and Evenness ( $E'=0.77768$ ) of insect fauna from seven different agro-ecosystems in the Tarai region of Uttarakhand. Similar observations are documented for insect pollinators of

**Table 2.** Species diversity and species richness of insect fauna during March, 2019-2021

Months	2019-2020			2020-2021			2019-2021		
	Shannon Index (H')	Evenness (E')	Margalef (d)	Shannon Index (H')	Evenness (E')	Margalef (d)	Shannon Index (H')	Evenness (E')	Margalef (d)
March	2.945	0.7605	5.146	2.861	0.699	5.212	3.013	0.6562	5.636
April	3.511	0.8165	7.481	3.346	0.6922	7.481	3.52	0.7041	7.781
May	3.647	0.7994	8.556	3.64	0.7621	8.874	3.735	0.748	8.87
June	3.813	0.8231	9.914	3.859	0.8625	10.14	3.924	0.8036	10.19
July	3.78	0.8425	9.79	3.791	0.8522	9.977	3.924	0.7783	10.92
August	3.493	0.8218	8.146	3.572	0.8678	8.415	3.756	0.7637	10.07
September	3.913	0.7946	11.05	3.846	0.7933	10.47	3.981	0.7439	11.33
October	3.543	0.7515	8.911	3.288	0.705	7.784	3.592	0.6723	9.442
November	2.969	0.9273	5.539	2.345	0.8696	3.417	2.868	0.838	4.865
December	1.864	0.9211	2.415	1.735	0.9449	2.276	1.952	0.8805	2.422
January	1.56	0.9514	1.924	1.889	0.9448	2.731	2.119	0.925	2.824
February	1.72	0.9309	2.085	1.735	0.9449	2.276	1.923	0.8551	2.377

**Table 3.** Seasonal species diversity and richness of insect fauna in study area (Paharpani)

Season	2019-2020			2020-2021			2019-2021		
	Shannon Index (H')	Evenness (E')	Margalef (d)	Shannon Index (H')	Evenness (E')	Margalef (d)	Shannon Index (H')	Evenness (E')	Margalef (d)
March-June (Summer)	3.774	0.7024	9.169	3.686	0.6757	8.733	3.77	0.6477	8.979
July-October (Rainy)	3.934	0.7516	10.16	3.901	0.7611	9.876	3.987	0.709	10.37
November-February (Winter)	2.888	0.8549	4.757	2.546	0.797	3.796	2.905	0.7303	5.013

**Table 4.** Relative abundance, Species diversity, evenness and species richness of insect orders (Paharpani)

Orders	Relative abundance (%)	Shannon index (H')	Evenness (E')	Margalef (d)
Lepidoptera	35.76	4.041	0.9025	8.719
Hymenoptera	17.34	3.27	0.6924	5.793
Diptera	21.51	2.195	0.8167	1.689
Coleoptera	16.08	2.455	0.7281	2.446
Hemiptera	1.40	1.346	0.9606	0.775
Orthoptera	2.63	1.359	0.973	0.6667
Thysanoptera	5.28	0.6897	0.9966	0.1924
Total	100			

agricultural land (Duara and Kalita 2013, Das et al., 2018, Rekha et al., 2021, Arya et al., 2023).

### CONCLUSION

The present study indicates that Lepidopteran and Hymenopteran insects are the major pollinators of agroecosystems. Other insect orders, such as Diptera,

Coleoptera, and Thysanoptera, are also considered pollinators but are comparatively less important. Given the importance of these insects, it is necessary to conserve different species of pollinators. Although this was a preliminary attempt to report insect pollinators of Paharpani, Nainital, Uttarakhand, it will undoubtedly serve as baseline data for future researchers studying pollinators in the area.

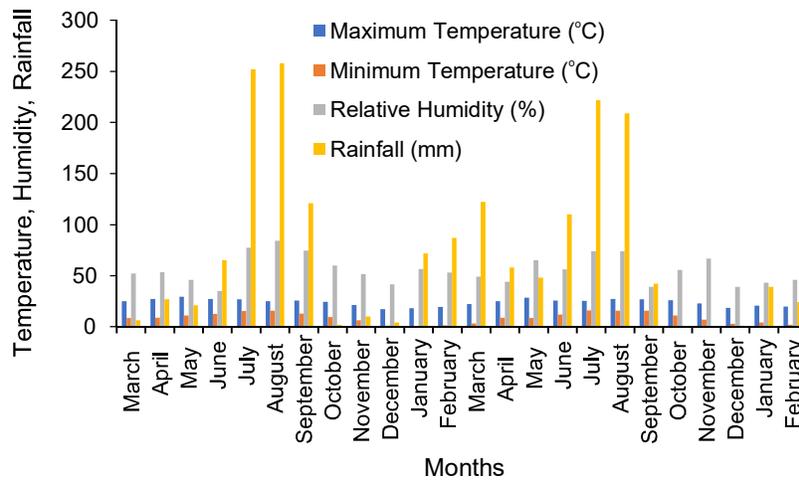


Fig. 5. Climatic data for study site March, 2019 to February, 2021

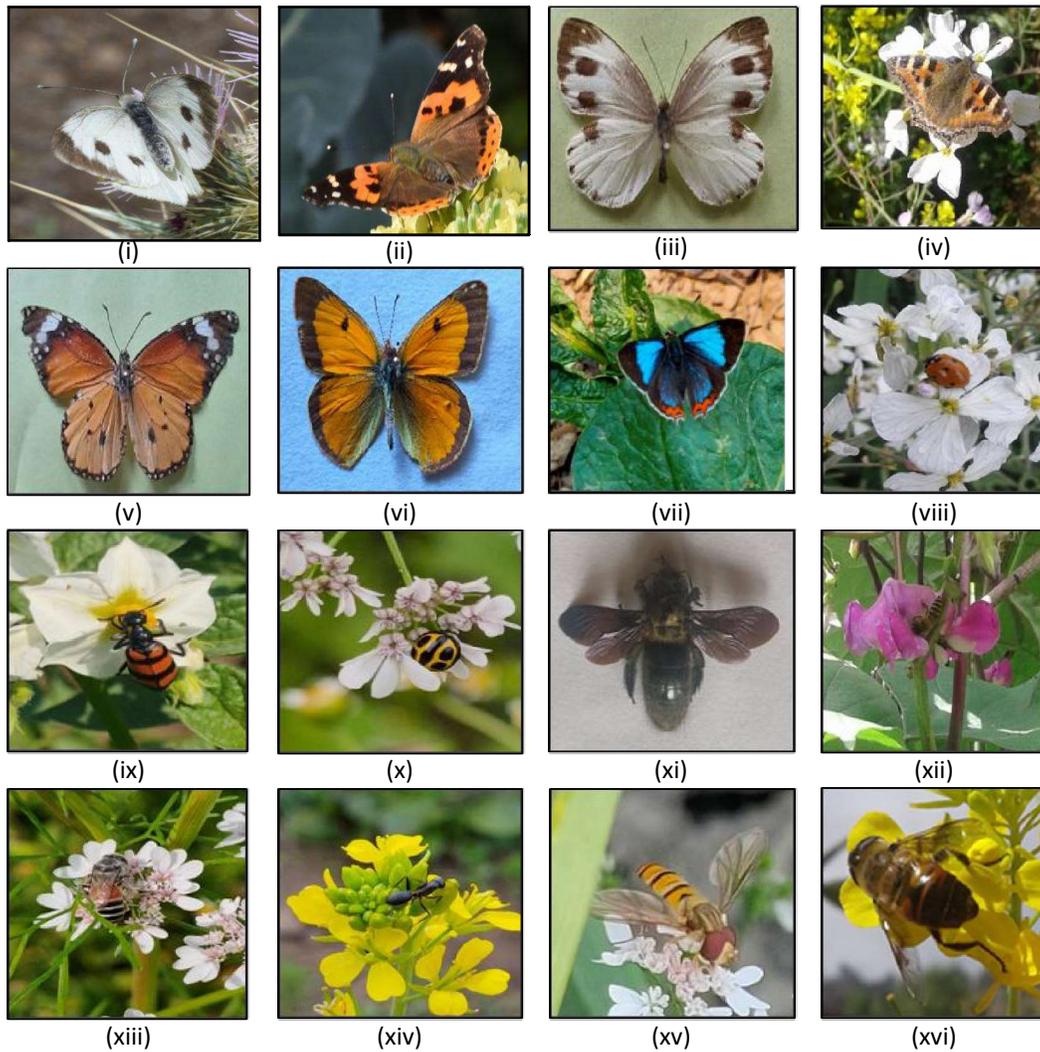


Plate 1. Insect pollinators: (i) *Pieris brassicae*, (ii) *Vanessa cardui*, (iii) *Pieris canidia indica*, (iv) *Aglais caschmirensis*, (v) *Danaus chrysippus*, (vi) *Colias fieldii*, (vii) *Heliophorus androcles*, (viii) *Coccinella septempunctata* (ix) *Mylabris pustulata*, (x) *Oenopia* sp., (xi) *Xylocopa* sp., (xii) *Apis mellifera*, (xiii) *Apis florea*, (xiv) *Camponotus* sp., (xv) *Episyrrhus* sp., (xvi) *Eristalis* sp.

## REFERENCES

- Abbas MN, Rana SA, Mahmood-ul-Hassan M, Rana N, Kausar S and Iqbal M 2014. Biodiversity and dynamics of macro-invertebrate populations in wheat-weeds agro-ecosystem of Punjab (Pakistan). *JAPS: Journal of Animal & Plant Sciences* **24**(4): 1146-1156.
- Amber N, Ashraf I, Hussain T and Ahmad I 2015. Studies on the diversity and relative abundance of orthoptera and lepidoptera species in urban and cropland areas of Dera Ghazi Khan. *American-Eurasian Journal of Agriculture and Environment Science* **15**(8): 1693-1699.
- Arya M and Badoni A 2023. Insect pollinator assemblage on temperate fruit crops in Kumaun Himalaya. *Indian Journal of Entomology* **85**(2): 315-321.
- Atencio R, Goebel FR and Miranda RJ 2018. Entomofauna Associated with Sugarcane in Panama. *Sugar Technology* **21**(4): 605-618.
- Chouangthavy B, Sanguansub S and Kamata N 2017. Species composition, richness and diversity of beetles (Coleoptera) in agricultural ecosystem, Thailand. In: *9th Nakhon Pathom Rajabhat University National Academic Conference*, p 1-7.
- 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* 318-324.
- Dev P, Tewari M and Kaushal BR 2009. Diversity and abundance of insects in a cropland of central Himalayan Bhabar region of Kumaun, Uttarakhand. *Entomon* **34**(1): 11-21.
- Divija SD, Jayanthi PK, Varun YB, Kumar PS, Krishnarao G and Nisarga GS 2022. Diversity, abundance and foraging behaviour of insect pollinators in Radish (*Raphanus raphanistrum* subsp. *sativus* L.). *Journal of Asia-Pacific Entomology* **25**(2): 101909.
- Free JB 1993. *Insect Pollination of Crops* (2nd ed.). Academic Press, London, U.K. pp 684.
- Ghani A and Maalik S 2020. Assessment of diversity and relative abundance of insect fauna associated with *Triticum aestivum* from district Sialkot, Pakistan. *Journal of King Saud University-Science*. **32**(1): 986-995.
- Hill MO 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* **54**(2): 427-432.
- Kearns CA, Inouye DW, and Waser NM 1998. Endangered mutualism: The conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics* **29**: 83-112.
- Klein AM, Vaissiere BE, Cane JH and Tscharntke T 2007. Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B* **274**: 303-313.
- Margalef's R 1970. Temporal succession and spatial heterogeneity in phytoplankton. In: *Perspectives in Marine biology, Buzzati-Traverso* (ed.), University of California Press, Berkeley. Pp 323-347.
- Mitra B and Parui P 2002. New record of entomofauna from Thar Desert. *Insect Environment* **8**: 115-116.
- Mitra B, Banerjee D, Mukherjee M, Bhattacharya K and Parui P 2008. *Flower visiting flies (Diptera: Insecta) of Kolkata and Surroundings, (Pictorial handbook)*. India: Zoological Survey of India (ZSI), Kolkata.
- Morse R and Calderone NW 2000. The value of honey bees as pollinators of U.S. crops in 2000. *Bee Culture* **128**: 1-15.
- 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.
- Naz H, Usmani MK, Ali M, Mobin S and Khan I 2020. Acridoid diversity, species composition and distributional pattern in Tarai region of Uttarakhand, India. *International Journal of Tropical Insect Science* **41**: 547-553.
- Nunes-Silva N, Hrcir M and Imperatriz-Fonseca VL 2010. Pollination by vibration. *Oecologia Australis* **14**(1): 140-151.
- Régnière 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**(5): 634-647.
- Rekha 2021. *Studies on the Diversity and Relative Abundance of Insect Community in Cultivated Land areas at Ramnagar, Uttarakhand*. Ph.D. Thesis submitted to D.S.B. Campus, Kumaun University, Nainital.
- Rekha, Goswami D, Arya D, Arya G, Bisht M, Joshi A and Kaushal BR 2021. Diversity and abundance of insects in cropland of Himalayan Tarai region of Ramnagar, Uttarakhand. *International Journal of Agricultural and Applied Sciences* **2**(2): 151-155.
- Shannon CE and Weiner W 1949. *The Mathematical Theory of Communication*. University Illinois Press, Urbana, IL.
- Speight MR, Hunter MD and Watt AD 2008. *Ecology of Insects: Concepts and Applications*. Wiley-Blackwell, Singapore.
- Thapa RB 2006. Honeybees and other insect pollinators of cultivated plants: A review. *Journal of the Institute of Agriculture and Animal Science* **27**: 1-23.