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ORIGINAL ARTICLE

A Comparative Study on Diversity of Entomofauna in Rural and Urban regions of Aligarh

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ABSTRACT
Insects are largest group of animal kingdom and occur in all habitats. Insect diversity was studied in rural and urban areas of Aligarh district and insects were collected from flowering plants and croplands at AMU Botanical Garden and Nagla Gumani Village with the help of nets and aspirator. Insects were preserved and brought to lab for identification. Insect diversity at both the sites was determined by Simpson's Diversity Index, Shannon's Diversity Index, Effective number of species, Richness, Evenness and Sorenson's Index. Insects collected from the two sites were 380 and 487 respectively. Aphis spiraecola was the most abundant insect at Nagla Gumani Village, while Sarcophaga carnaria was most abundant species at AMU Botanical Garden. Diptera was most diverse and abundant order at AMU Botanical Garden with highest 122 insects of 6 species, making 32% of total number of insects and 24% of total species collected; whereas, Blattoidea was least in terms of insect number (3%), belonging to only 1 species (4%). At Nagla Gumani Village Hemiptera was most abundant order having 110 insects, constituting 23% of total insects recorded, while Hemiptera, Coleoptera and Orthoptera, all three orders were represented by 6 species each, constituting 19% of total species recorded at this site; whereas, only 5 insects (1%) were recorded from Odonata, making it least abundant Order here. In terms of species, the least represented Orders at Nagla Gumani site were Lepidoptera and Odonata (6.5% each). 2 species from each of these two orders were recorded from here. The Simpson's Diversity index for both the sites was calculated 0.955 and 0.963 respectively. The Shannon's Diversity Index (H') was calculated 3.12 and 3.31 at AMU Botanical Garden and Nagla Gumani Village respectively. The Effective Number of Species for both the communities was calculated 23 and 27 respectively. The evenness calculated for both the sites was 0.969 and 0.965 respectively. The average population size of the communities was 15.2 and 15.7 respectively at both the sites. Out of 25 and 31 species recorded from both the sites respectively, both communities share 11 species only. Sorenson's Index was calculated 0.3929.
Keywords: *Insect Biodiversity, Abundance, Lepidoptera, Hemiptera, Coleoptera, Diptera, Orthoptera, Hymenoptera.*

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INTRODUCTION

Biodiversity is one of the most fascinating aspects of biology, which refers to variability among living organisms from all habitats including aerial, terrestrial and aquatic ecosystems. India is one of the world's mega diversity countries. Arthropoda is the largest phylum of Animal Kingdom, of which Class Insecta constitute the highest Number of species. Insects are cosmopolitan, as they live in all available habitats. Insect's biodiversity accounts for a large ratio on the earth. Insects contribute to about 55% of the all recorded species on earth (1). Lepidoptera, Orthoptera, Diptera, Hemiptera, Odonata, Hymenoptera and Thysanoptera are the seven major orders of class Insecta, which comprise 94% of the insects. Insets probably might have the highest biomass. The majority of insects are found on a variety of plants including grasses, weeds, shrubs, trees and flowers. In agro-ecosystems insects serve as pollinators, decomposers of agricultural waste and predators of insect pests. According to different estimates insects pollinate 70% of crop plants worldwide. Soil insects are vital to the ecosystem dynamics, as they participate in biogeochemical processes including decomposition and increase nutrient availability.

Insects have evolved distinct genetic, morphological and functional characteristics in order to adapt to their complex and dynamic ecological conditions that result in significant variety. Among various insects, Coleopterans transform their forewings in to hard shell to defend their hindwings. Lepidopterans possess

colorful wings. Dipterans have only one pair of wings. Hymenopterans are usually found in vast colonies. Hemipterans have a beak or a mouth like drinking straw. Orthopterans feed on plants and jump with their legs. Odonatans are insect predators. The insect biodiversity is also related to variety and abundance of suitable host plant, as host plants not only serve for prospective food source for them as well as acceptable ovipositor site for females to lay eggs. The availability of host plants and insect's ability to locate them are crucial for survival of insects. Insect's diversity is also influenced by temperature of the region. Studies on biodiversity compare the richness of the distinct areas and track changes in a particular area based on the number of species found there.

Insects are the world's most dominant group of animals that can live anywhere because of their small size, high fecundity, areal respiration, food diversity, protective mechanisms and other traits. This served as the primary justification for examining insect diversity in Aligarh region. Aligarh is a district in Northern Indian state, Uttar Pradesh. It stands out as a rich and vibrant hub of insect life, which was explored during the study for their evolutionary adaptations, ecological significance and interaction with local environment. Aligarh is located in the fertile plains of Ganges river basin, having a vast array of habitats ranging from agricultural fields and urban landscapes to wetlands and forests. This varied topography provides a mosaic of environments that support a wide variety of insects, each adapted to thrive in specific ecological niche. From the bustling streets of the city to the tranquil countryside, insects are ubiquitous and are influenced by the surroundings.

MATERIAL AND METHODS

Study Sites: A majority of insects are minute in size, so they can not be identified without observing their minute morphological characters. Therefore, insects were collected, preserved and brought to lab for their identification (2). Insects are found everywhere. However, flowering gardens are most likely place for insect collection. Small insects can also be found in the soil near the roots of plants. Aquatic insects can be collected from pond, lakes and streams. Mosquitoes, flies, fleas and bugs are found in the human dwellings. Dragon flies, Damsel flies and May flies are found near water bodies. Animal dung and debris also act as food source for various insects, so insects had also been recorded from there. In the present study insects were collected from two sites – one was an urban area, Aligarh Muslim University Botanical garden and the other site was a rural area, Nagla Gumani village. The distance of Nagla Gumani village from Aligarh city is 40 Kilometers. The co-ordinates of the village are 27^0 53' N and 78^0 25' E. The village has agricultural fields, orchards, ponds and a canal (Fig. 2). AMU Botanical garden is located on Qila Road, Aligarh. The co-ordinates are 27^0 34' N and 77^0 26' E. The garden has a variety of herbs, shrubs, trees and flowering plants (Fig. 1).

Fig. 1 Map of Site 1 – AMU Botanical Garden

Fig. 2 Map of Site 2 - Nagla Gumani Village

Insect Collection

There are a variety of instruments used for insect collection that include aerial nets, sweep nets, aquatic dip nets, aspirator, beating sheets, pitfall traps, light traps etc. In the present study aerial nets, sweep nets, aspirators and hand pickings were used for insect collection. Aerials nets were used for catching flying insects like wasps, bees, butterflies, moths, dragon flies etc. These nets are light-weighted, having long handle, a hoop frame attached to it and a long bag made of large mesh. Aerial net scoops the insect from the air, its long bag is flipped over the hoop after the insect is trapped. Insects were transferred from aerial net to killing jar. Sweep nets were used for collection of insects from vegetation and cockroaches etc (3). Sweep nets are robust having short handle, heavy inflexible hoop and bag with very small mesh, which provide durability so that these can be assaulted to the substrate with such force that insects become loose and collected in bag of net and then transferred to killing jars. Aspirators were used to catch small insects (4). Vial type aspirators are commonly used, which consist of a plastic vial, a lid penetrated with two tubes. The inner end of one of the tubes, which leads into user's mouth, is covered with a filter that prevents the insect to enter in the user's mouth. Insects are sucked in from second tube and collected in vial. Aphids, mealy bugs, scale insects can be collected by using soft brush or soft cotton cloth soaked in alcohol. Killing jars are normal glass container with lid, having a cotton swab soaked with a killing agent. Normally ethyl acetate, alcohol and chloroform are used as killing agent (5). Insects are transferred from nets to these killing jars to be killed and then preserved. After that insects were brought to laboratory for their identification.

Data Analysis

Most of the insects were identified till species level, however for some of them species was not confirmed, then identification was done up to Genus. Insect diversity was determined by Simpson's Diversity Index, Shannon's Diversity Index, Richness, Evenness, Effective number of species and Sorenson's Index (6).

Simpson's Diversity Indices – These include Simpson's Index (D), Simpson's Index of Diversity (1-D) and Simpson's reciprocal index (1/D). Simpson's Index (D) measures the probability of two randomly selected individuals from a sample belonging to the same species. D is calculated by following formula-

$$D = \sum \frac{n(n-1)}{N(N-1)}$$

Where n = Total number of individuals of a species

N = Total number of individuals of all the species

The value of D ranges between 0 to1. Its higher value indicates lower diversity.

Simpson's index of diversity (1-D) is calculated by subtracting D from 1. It also ranges between 0 to1. Its higher value indicates higher diversity (7).

Simpson's reciprocal index (1/D) is obtained by diving 1 from D. its higher value indicates higher diversity.

Shannon's Diversity Index – It is also called as Shannon-Weiner's Diversity Index. It emphasizes on richness of habitat (number of species in the habitat) and evenness (abundance of species). Its higher value indicates higher species diversity (8). It is denoted by H'. it is calculated by following formula –

$H' = -\sum[(pi)\times\log(pi)]$

$Pi = n/N$

Where pi = Proportion of individuals of i^{th} species in entire community

Log = Natural logarithm

n = Total number of individuals of a species

N = Total number of individuals of all the species

Shannon's Diversity Index typically ranges from 1.5 to 3.5 for mostly ecological studies and it rarely exceeds 4.5. Its higher values (near maximum possible value) show higher diversity.

Effective Number of Species (ENS) – It is the number of equally abundant species that would be needed to achieve same diversity as the observed community. It essentially quantifies the biodiversity by indicating the number of equally abundant species that would be present in a community to produce the same level of diversity as observed in the actual community (9). It is derived from Shannon's Diversity Index. It is calculated by following formula –

Effective Number of Species (ENS) = exp(H')

Evenness – It measures how evenly the individuals of different species are distributed within the community. It ranges between 0 to1. Its high value indicates that individuals of all the species are evenly distributed in the community i.e. all the species have almost equal abundance. It is calculated by following formula –

Evenness = H/ln(k)

Where H = Shannon's Diversity Index

k =Total number of species

Sorenson's Index – It is also known as Sorenson-Dice coefficient. It measures the similarities between two communities for their species composition. It ranges from 0 to1. Its higher value indicates that two communities have similar species (10). It is calculated by following formula –

Sorenson's index (SI) = $2\times N_c \div N_1 + N_2$

Where N_c = Number of common species in both communities

N_1 = Number of species in first community

N_2 = Number of species in second community

RESULTS AND DISCUSSION

Total number of insects collected from AMU Botanical Garden was 380; whereas 487 insects were collected from Nagla Gumani Village (Table 2), which indicates that in rural areas ecosystem is less disturbed so that more insects were recorded from there. *Aphis spiraecola* was the most abundant insect (29 insects) at Nagla Gumani village, which can be due to availability of their host plants; whereas *Sarcophaga carnaria* was most abundant species (28 insects) at AMU Botanical Garden, as it is more common in urban areas. Only 1 insect of *Enallagma* was recorded at Nagla Gumani village and 5 insects of *Ceriagrioin coromandelianum* were caught from AMU Botanical Garden, which were the lowest numbers of insects collected at these sites respectively. The total number of species recorded from AMU Botanical Garden was 25, belonging to 21 Families and 31 species were recorded from Nagla Gumani village, belonging to 24 Families (Table 1), which may account to more undisturbed ecosystem in rural areas. The insects collected from both the sites belong to 8 orders, among which Diptera was most diverse and abundant order at AMU Botanical Garden with highest 122 insects of 6 species, making 32% of total number of insects and 24% of total species collected; whereas, Blattoidea was least in terms of insect number (3%), belonging to only 1 species (4%) (Fig. 3 & 4). At Nagla Gumani Village Hemiptera was most abundant order having 110 insects, constituting 23% of total insects recorded, while Hemiptera, Coleoptera and Orthoptera, all three orders were represented by 6 species each, constituting 19% of total species recorded at this site; whereas, only 5 insects (1%) were recorded from Odonata, making it least abundant Order here. In terms of species, the least represented Orders at Nagla Gumani site were Lepidoptera and Odonata (6.5% each). 2 species from each of these two orders were recorded from here (Fig. 5 & 6). Majority of insects collected from flowering Teak at various sites of Aligarh included Hymenoptera (49%), Lepidoptera (30%) and Diptera (9-15%) (11). Among the insects associated with wheat in Sialkot of Pakistan, Hemiptera (37%) was most abundant, while Coleoptera (30%), Diptera (14%), Lepidoptera (10%) and Hymenoptera (9%) were the other orders of insects collected (12). In croplands at Ramnagar of Uttarakhand Lepidoptera (79%) was the highest contributor to the insect diversity while Coleoptera (7%), Hymenoptera (7%) and Odonata (7%) were the other Orders collected

(13). Most of the insects collected during flowering season in mango orchards in Malaysia belonged to Thysanoptera, Diptera and Coleoptera; whereas during fruiting season Diptera was the major order (80%) (6). At Nainital of Uttarakhand Lepidoptera was most abundant Order followed by Hymenoptera, Coleoptera, Orthoptera and Diptera (14). The variations in the insect diversity and abundance among present study and previous studies by other workers may be due to the fact that previous workers focused on a particular crop for their study, while in the present study insects were collected from general habitat.

Table 1: List of Species collected from AMU Botanical Garden and Nagla Gumani Village

Order	Family	Scientific Name	Common Name	AMU Botanical Garden	Nagla Gumani Village
Hemiptera	Lygaedae	*Spilostethus pandurus*	Seed bug	-	18
	Pentatomidae	*Bagrada hilaris*	Painted bug	-	10
	Scutelleridae	*Chrysocoris stollii*	Jewel bug	22	8
	Aphidae	*Aphis spiraecola*	Green Citrus aphid	25	29
		Myzuspersicae	Green Peach Aphid	-	18
	Pyrrhocoridae	*Dysderus cingulatus*	Red Cotton Bug	10	-
		Dysdercus koenigii	Red Cotton stainer	-	27
	Alydidae	*Leptocorisa acuta*	Rice earhead Bug	8	-
Blattoidea	Blattidae	*Periplanata americana*	American cockroach	9	8
		Blatta orientalis	Oriental cockroach	-	9
	Ectobiidae	*Supella longipalpa*	Brown banded cockroach	-	23
Diptera	Syrphidae	*Episyrphus balteatus*	Marmalade hoverfly	20	
		Eristalinus taeniops	Band eyed drone fly	17	-
		Allograpta	Syrphid fly	12	-
	Muscidae	*Musca domestica*	Housefly	22	20
	Anthomyiidae	*Delia platura*	Bean seed fly	-	15
	Sarcophagidae	*Sarcophaga carnaria*	Flesh fly	28	-
	Calliphoridae	*Chrysomya megacephala*	Oriental Bluefly	-	25
	Bibionidae	*Pleciadispersa*	-	23	-
Coleoptera	Scarabaeidae	*Scarabaeus sanctus*	Dung Beetle	-	9
	Coccinellidae	*Coccinellaseptempuncata*	Seven spot ladybird beetle	20	15
		Coocinella transversalis	Transverse ladybird beetle	-	20
	Staphylinidae	*Paederus fuscipes*	Rove beetle	-	10
	Tenebrinoidae	*Tribolium castaneum*	Red flour beetle	-	12
	Curculionidae	*Sitophilus granarius*	Wheat weevil	-	20
Odonata	Libellulidae	*Bradinopyga geminata*	Granite ghost	10	-
	Aeshnidae	*Anax*	Dragon fly	-	4
	Coenagrionidae	*Ceriagrioin coromandelianum*	Yellow waxtail	5	
		Enallagma	Blue Damsel fly	-	1
Lepidoptera	Lycaenidae	*Celastrina lavendularis*	Plain hedge blue	10	-
	Papilionidae	*Papilio polytes*	Common Mormon	12	-
	Nymphalidae	*Danus chrypsipus*	Plain tiger	15	-
		Tirumala limniace	Blue tiger	12	-
	Pieridae	*Piera rapae*	Cabbagewhite butterfly	15	7
		Pieris brassicae	Cabbage butterfly	-	10
Hymenoptera	Apidae	*Apis dorsata*	Rock bee	10	-
		Apis mellifera	European honey bee	-	25
		Xylocopa violacea	Violet Carpenter bee	25	20
	Formicidae	*Camponotus spp.*	Carpenter Ant	23	28
Orthoptera	Grillidae	*Gryllus bimaculatus*	Two spotted cricket	-	9
		Gryllodes sigillatus	Tropical house cricket	-	17
		Oxya	grasshopper	6	-
	Acrididae	*Anacridium aegyptium*	Egyptian tree locust	-	24
	Tettigonidae	*Conocephalus melaenus*	Black kneed conehead	15	20
	Pyrgomorphidae	*Poekilocerus pictus*	Painted grasshopper	6	14

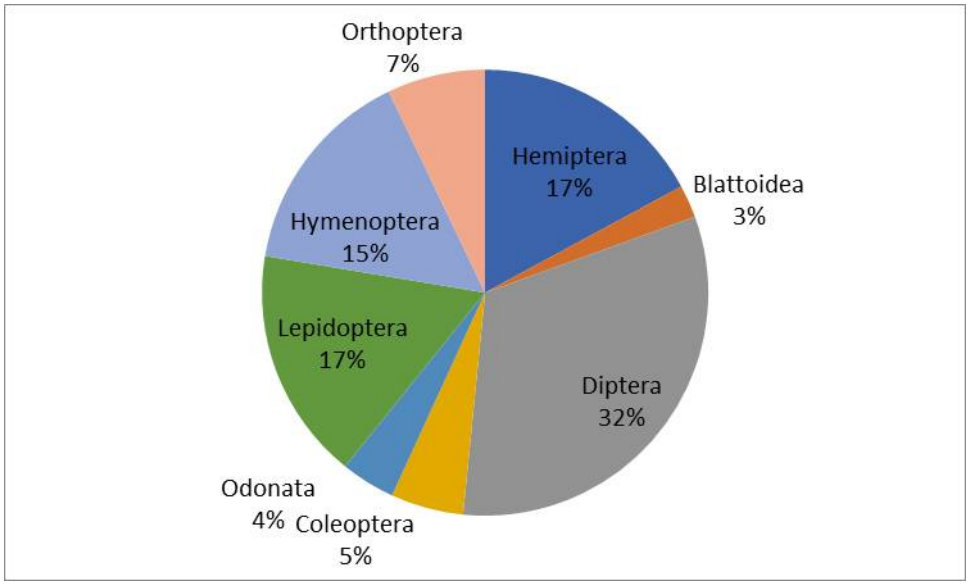

Fig. 3: Percentage of Insects collected according to Orders from AMU Botanical Garden

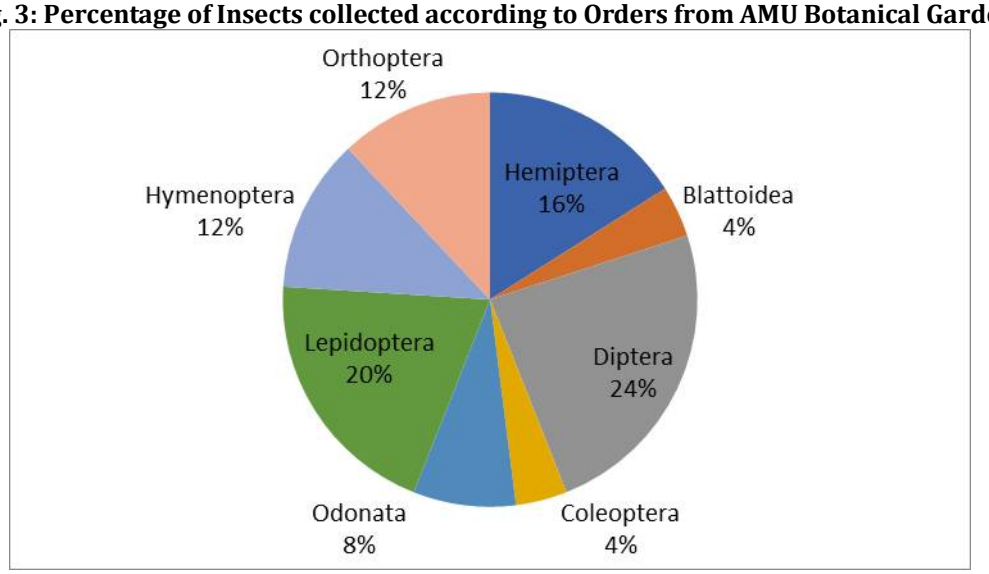

Fig. 4: Percentage of Species collected according to Orders from AMU Botanical Garden

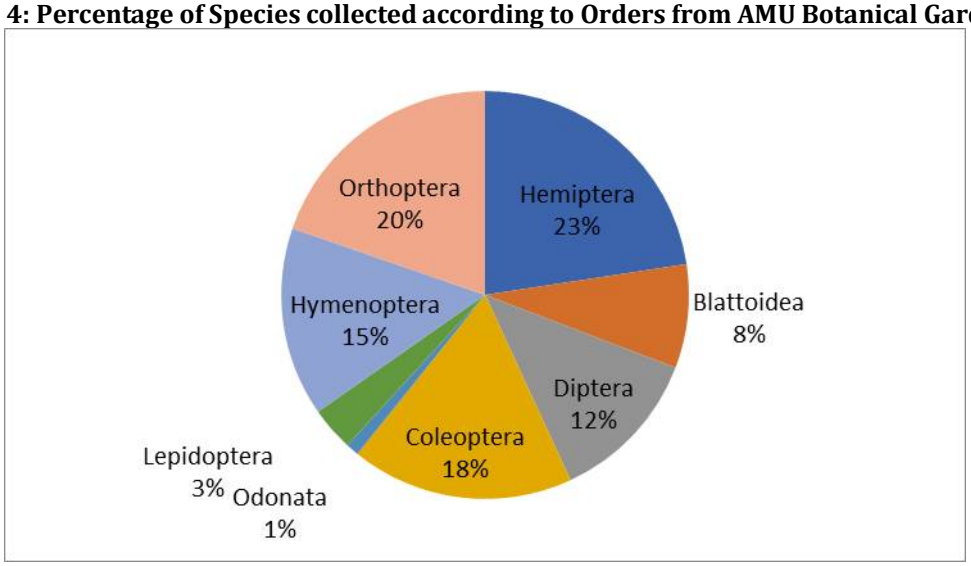

Fig. 5: Percentage of Insects collected according to Orders from Nagla Gumani Village

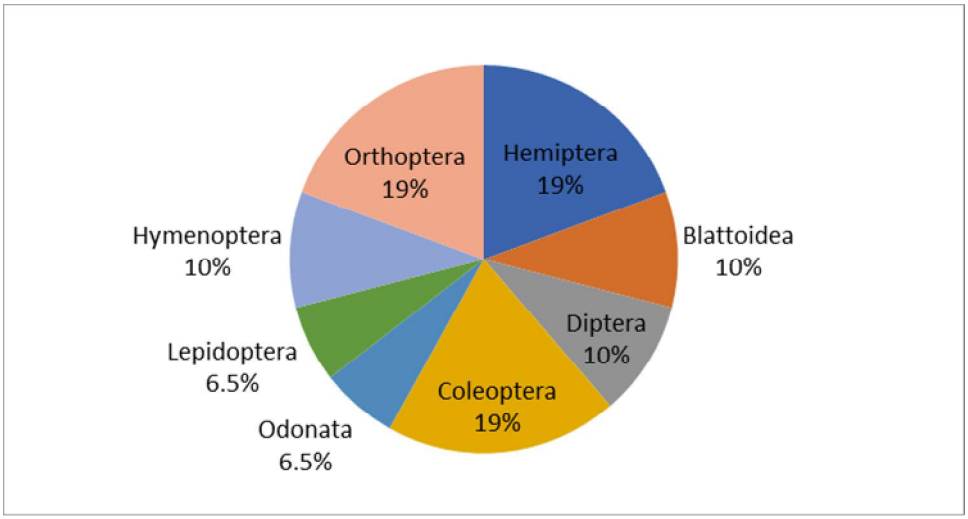

Fig. 6: Percentage of Species collected according to Orders from Nagla Gumani Village

The statistical analysis for various diversity indices of data collected during present study also confirmed that insect diversity was bit higher at Nagla Gumani Village than AMU Botanical Garden. The Simpson's Diversity index (1-D) for both the sites was calculated 0.955 and 0.963 respectively, confirming higher insect diversity at both the sites. Simpson's Index (D) for both the sites was calculated 0.045 and 0.037 respectively and Simpson's Reciprocal Index (1/D) was calculated as 22.222 and 27.027 respectively for both the sites, confirming the higher diversity at Nagla Gumani Village. The value of Shannon's Diversity Index (H) was calculated 3.12 and 3.31 at AMU Botanical Garden and Nagla Gumani Village respectively, confirming higher insect diversity at these sites, Nagla Gumani village to be more diverse than AMU Botanical Garden. The Effective Number of Species for both the communities was calculated 23 and 27 respectively, confirming higher diversity at Nagla Gumani Village. The evenness calculated for both the sites was 0.969 and 0.965 respectively, showing that insects are almost evenly distributed in both the communities, with slightly higher at AMU Botanical Garden. The average population size of the communities was 15.2 and 15.7 respectively at both the sites. Out of 25 and 31 species recorded from both the sites respectively, both communities share 11 species only, that's why the value of Sorenson's Index was calculated 0.3929, which is not very high, indicating mild similarity between the fauna of both the sites.

Table 2: Comparison of Various Diversity Indices at AMU Botanical Garden and Nagla Gumani Village

Diversity Indices	AMU Botanical Garden	Nagla Gumani Village
Simpson's Index (D)	0.045	0.037
Simpson's Diversity Index (1-D)	0.955	0.963
Simpson's Reciprocal Index (1/D)	22.222	27.027
Shannon's Diversity Index (H')	3.12	3.31
Effective Number of Species (ENS)	23	27
Evenness	0.969	0.965
Richness (Number of Species)	25	31
Total number of Individuals	380	487
Average Population Size	15.2	15.7
Sorenson's Index	0.3929	

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