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Insect diversity of Doodhpathri (Budgam), Jammu and Kashmir, India

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Abstract
The study reports the insect diversity of Doodhpathri and a total of fifteen species were recorded belonging to thirteen families and seven orders. Maximum number of species were recorded at site-II (12), followed by site-III (10) and least at site-I (8). Significant variation in density of different species was recorded among the months at site-I ($F_5 = 10.92$, $P < 0.05$), Site-II ($F_5 = 11.45$, $P < 0.05$) and Site-III ($F_5 = 22.69$, $P < 0.05$) and among the species at site-II ($F_{11} = 6.17$, $P < 0.05$) and site-III ($F_9 = 7.61$, $P < 0.05$) with maximum density recorded during the summer at site-II for *Anisopteras sp.* Among different species *Lycosa sp.* was dominant species at site-I and site-III whereas *Anisopetra sp.* at site-III. Diversity indices- Shannon, Simpson's and Margalef index were higher (2.39, 0.90 and 2.39) at site site-II and lowest at lowest (2.04, 0.86 and 1.81) at site-I respectively. Presence of large area with diverse plant species provides a greater diversity of resources for insects and could be the reason for the occurrence of maximum number of species at site-II.

Keywords: Budgam. Diversity. Doodhpathri. Insects. Seasons.

Introduction
Insects are the most abundant form of life on earth. They are a tremendously successful group and can be found in almost all ecological systems. There are 1.4 million specie of insects described in the scientific literature [1] and are indeed an intrinsic part of the Earth's ecosystem. Apart from the open ocean, insects can be found in all habitats of terrestrial and aquatic systems, deserts, even in highly harsh environment such as pools of crude petroleum [2]. Insects play a significant role in functioning of an ecosystem [3]. They have important roles as herbivores, food source for other organisms, scavengers and detritivores, predators and parasites [4]. Insects impress not only by their immense species richness but also by their variety of life forms and their role in energy flow [5]. Among the different insect orders, Coleoptera, Diptera, Lepidoptera, and Hymenoptera, represent major functional groups such as herbivores, pollinators, parasitoids and predators [6, 7]. Insect as decomposers are vital for the breakdown of plant material (both leaf litter and woody material), dead animals and waste materials. Insects are the major herbivores in most terrestrial ecosystems and consumes large proportion of plant biomass [8]. Insects also serve as prey items for a large array of invertebrates and vertebrates. Major group of fishes, amphibians, reptiles, birds and mammals all use insects as the mainstay of their diet. They are valuable pollinators when they fly from plant to plant, gathering nectar and are the one of the important food chain components of the birds, reptiles, spiders and predatory insect [9]. Insect diversity plays significant role in maintaining a sustainable systems [10]. Despite their vital role little is known about the insect communities of Doodhpathri. Therefore, keeping in mind the above fact, present work was conducted to study the diversity and distribution of insects in Doodhpathri, Budgam.

Materials and methods
Study area and study sites
Doodhpathri (Budgam) is known for its lush green pastures and forest. It is at a distance of 42 Km from Srinagar and 15 Km from Khan Sahib, Budgam [11]. It is one of the most beautiful and unexplored area of Budgam, Kashmir, Jammu and Kashmir (fig.1). It is located within the geographical coordinates of 34°42'00″ - 34°50'00″ N latitude and 74°24'00″ -74°54'00″E longitude, with an area of 1291 km². Climate is temperate and receives heavy snowfall during winter [12, 13]. As Sukhnag and Shaliganga flows within the area makes the destination further attractive for local as well as national tourists. Doodhpathri is not just meadow but also a series

of interconnected meadows like Parihas, Sotzalpathri, Doodhpathri, Reshkhal and Sherawali camouflaged in deep forests in the lap of Pir-Panjal mountain range. For the present study, three different sites were selected and details of each site is as:

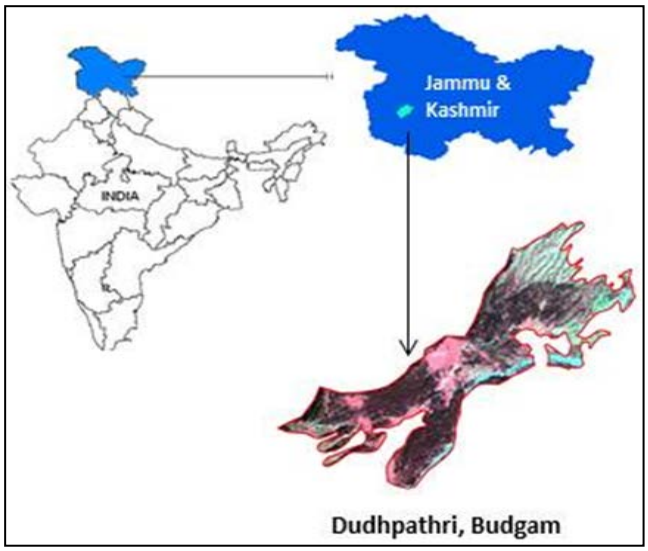

Fig 1: Outline map of study area

Site-I (Tangnar)
It is an agricultural field located at the entrance of Doodhpathri, at a distance of 10 Km from Khan Sahib. It lies at an altitude of 2250 m above the mean sea level within the geographical coordinates as 33º40′30.47″N and 74º44′0.26″E. The area lies in close proximity to forests and is highly degraded. The dominant trees in the area include *Pinus wallichiana* and *Abies pindrow*.

Site-II (Parihas)
It is a lush green meadow surrounded by lofty pine trees and a magnificent view of snowcapped mountains. The site lies at an altitude of 2611m above the mean sea level within geographical coordinates of 33º52′27″N and 74º34′33″E.

Site-III (Doodhpathri)
It is a beautiful place with carpet like meadow. It spreads over 240 km^2 from Palmaidan to Ashtar and is considered to be the largest meadow of Kashmir valley. It is surrounded by Sukhnagnalla and Shaliganga which originates from Tatakati glacier, situated at 4563 m above the mean sea level. The site lies at an altitude of 2543 m above the mean sea level within the geographical coordinates of 33º5′3″N and 74º34′05″E.

Collection of insects
Sampling for insects were carried every month during 2014-2015. Hand picking, sweeping and beating methods were used for the collection of insects from vegetation including grasses, herbs, shrubs, bushes and trees up to a height of 2 m at each site. Aerial nets and Sweep nets were also used for the collection of insects. Insects were then transferred into well labelled collection bottles containing cotton soaked with ethyl acetate and carried to laboratory. All specimens were mounted on entomological boxes with the help of entomological pins and dried to prevent decomposition. The specimens were then send for identification to the Entomology Department of Sher-I-Kashmir Agricultural University of Science and Technology (SKAUST), Kashmir.

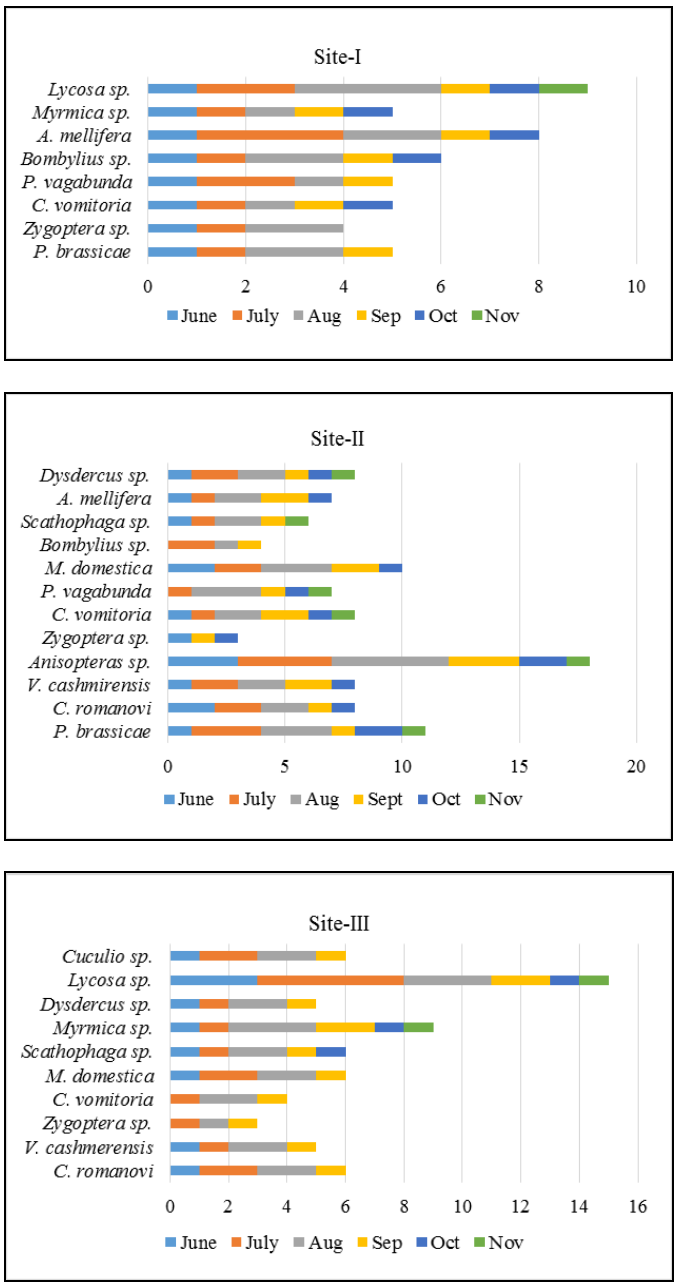

Fig 2: Density of insect species at different sites during different the months.

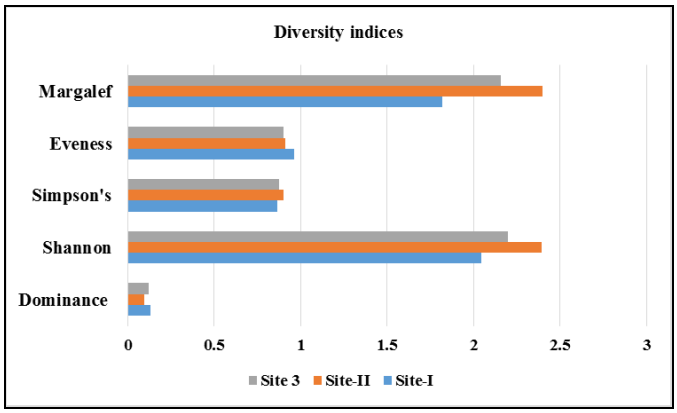

Fig 3: Diversity indices at different sites.

Diversity indices

Diversity indices were calculated by using the formulas as- Margalef species richness DMg (D = S - 1/In N, where S is number of species and N is number of individuals), Shannon diversity index H0 (H0 = -Rpi In pi, where pi the proportional abundance of the ith species = ni/N), Evenness E (E = H0/In S, where H0 is Shannon diversity index and S is number of species) and Simpson's index H = $\sum (Ni/N)^2$ where H is Simpson's index, Where Ni is the number of individuals for all S species and N is the known total number of individuals for all S species in population were calculated for each site [14].

Statistical analysis

With the objective of evaluating significant differences in insect population (within and among the sites) data sets were analyzed by using two-way analysis of variance (ANOVA) at 0.05% level of significance. All statistical analyses were performed using SPSS statistical software.

Results and discussion

During the present study a total of 15 insect species- *Pieris brassicae, Colias romanovi, Vanessa cashmirensis, Anisoptera sp., Zygoptera sp., Musca domestica, Pollenia vagabunda, Bombylius sp., Calliphora vomitoria, Scathophaga sp., Apis mellifera, Myrmica sp., Dysdercus sp., Lycosa sp.* and *Curculio sp.*, from 13 families (Pieridae, Nymphalidae, Gomphidae, Coenagrionidae, Muscidae, Calliphoridae, Bombyliidae, Scathophagidae, Apidae, Formicidae, Pyrrhocoridae, Lycosidae *and* Curculionidae) and 7 orders (Lepidoptera, Odonta, Diptera, Araneae, Hymenoptera, Hemiptera, and Coleoptera) were recorded (Table 1). Pedge and Ahirrao [15] also reported 20 species from Buldhana district of Maharashtra, Arya *et al.* [16] 23 species from Binsar Wildlife Sanctuary (Uttarakhand) whereas Joshi *et al.* [17] recorded 112 species insects belonging to 31 families from Nainital (Uttarakhand).

Table 1: Order and family of insect species recorded at Doodhpathri.

Order	Family	Species
Lepidoptera	Pieridae	*Pieris brassicae*
		Colias romanovi
	Nymphalidae	*Vanessa cashmirensis*
Odonta	Gomphidae	*Anisoptera sp.*
	Coenagrionidae	*Zygoptera sp.*
Diptera	Calliphoridae	*Callophora vomitoria*
		Pollenia vagabunda
	Muscidae	*Musca domestica*
	Bombylidae	*Bombylius sp.*
	Scathophagidae	*Scathophaga sp.*
Hymenoptera	Apidae	*Apis mellifera*
	Formicidae	*Myrmica sp.*
Hemiptera	Pyrrhocoridae	*Dysdercus sp.*
Aranae	Lycosidae	*Lycosa sp.*
Coleoptera	Curculionidae	*Curculio sp.*

The distribution of insect species among different sites is given in Table 2. The insects recorded at Site-I were *P. brassicae, Zygoptera sp., C. vomitoria, P. vagabunda, Bombylius sp., A. mellifera, Myrmica sp.* and *Lycosa sp.*, at Site-II were *P. brassicae, C. romanovi, V. cashmirensis, Anisoptera sp., Zygoptera sp., C. vomitoria, P. vagabunda, M. domestica, Bombylius sp., Scathophaga sp., A. mellifera* and *Dysdercus sp.* and at Site-III were *C. romanovi, V. cashmirensis, Zygoptera sp., C. vomitoria, M. domestica, Scathophaga sp., Myrmica sp., Dysdercus, Lycosa sp.* and *Curculio sp.*

Table 2: Distribution of species among different sites.

S. no.	Name of Species	Site-I	Site-II	Site- III
1	*Pieris brassicae*	+	+	-
2	*Colias romanovi*	-	+	+
3	*Vanessa cashmirensis*	-	+	+
4	*Anisoptera sp.*	-	+	-
5	*Zygoptera sp.*	+	+	+
6	*Musca domestica*	-	+	+
7	*Pollenia vagabunda*	+	+	-
8	*Bombylius sp.*	+	+	-
9	*Callophora vomitoria*	+	+	+
10	*Scathophaga sp.*	-	+	+
11	*Apis mellifera*	+	+	-
12	*Myrmica sp.*	+	-	+
13	*Dysdercus sp.*	-	+	+
14	*Lycosa sp.*	+	-	+
15	*Curculio sp.*	-	-	+

Significant variation in density of different species was recorded among the months at site-I ($F_5 = 10.92$, $P < 0.05$), Site-II ($F_5 = 11.45$, $P < 0.05$) and Site-III ($F_5 = 22.69$, $P < 0.05$) and among the species at site-II ($F_{11} = 6.17$, $P < 0.05$) and Site-III ($F_9 = 7.61$, $P < 0.05$), whereas non-significant at Site-I ($F_7 = 2.07$, $P < 0.05$). Among 8 species at site-I, the dominant species in terms of their number and occurrence during the study was *Lycosa sp.* (9) followed by *A. mellifera* (8) and *Zygopetra sp.* (4) with least occurrence (fig.2). Dominant species at site-II among 12 species were *Anisopetra sp.* (18), *P. brassicae* (11) and *M. domestica* (10), however at site-III *Lycosa sp.* (15) and *Myrmica sp.* (9) were dominant among 10 species. Different sites within an area, even in close proximity, may have highly variable insect populations due to subtle differences in environmental factors or plant composition and numbers may fluctuate greatly within the sites [18]. The various environmental factors such as temperature, humidity, rainfall, vegetation and food sources directly affecting the diversity and distribution of insect populations [19-21]. According to Uniyal and Mathur [22] that diverse topography, vegetative features and climatic setting provide wide availability of food resting and breeding sites in a forest area. Site II with larger area than other sites may also be the reason for holding more insect species as larger area harbors more number of plant and plant diversity. According to Khadijah *et al.* [3] large areas support more species of insects as compare to smaller areas as the plant diversity and richness affect insect diversity and abundance. The structure of vegetation between different zones affects the insect diversity [23] Presence of wooden logs in addition to normal vegetation at Site III supported the growth and survival of many insect species. It has also been reported that physical and chemical changes occurring during the course of wood decomposition provide a varied resource for different insects within the log habitat [24]. Temperature, rainfall and vegetation cover have been reported to influence the population density of insects [25, 26]. Both the Sites II and III were rich in plant diversity, which may be the other reason for holding more insect species. Insect species richness increases with increasing plant species richness because a greater diversity of plants provides a greater diversity of resources for insects. Thus the diversity of insects is related to the diversity of their

food resources [27, 28]. The presence of lesser number of insect species at site-I might be attributed to human interferences. The interference in the form of upcoming construction results in lack of resting sites and food availability.

The maximum number of insects were recorded in the months of July and August. The temperature showed an increasing trend from July and August which may be in favor of certain insect species to flourish. According to Arya *et al.* [16] increase in temperature (optimum) favors the insect community and leads to an increase in their population which seems to be the reason for the peak value in population density during summer months. The seasonal effects of weather and ongoing changes in climatic conditions directly lead to modifications in dispersal and development of insect species. Seasonal variations in community composition are related to changes in temperature and humidity that affect activity and development [29]. It has also been found that seasonal variations of dung insect population also probably reflect seasonal variability in availability and quality of food resources [30]. Thus it has been observed that the increased population of insects during summer months may be attributed to the increase in optimum temperature. During the summer months productivity of plants also increases which results in the increase of insect diversity and richness. It has been found that higher plant diversity may increase the availability of alternate resources, including alternate hosts within a functional group for herbivores as well as vegetative and floral resources of species that require both [3]. According to Southwood [31] productivity increases insect diversity and species richness.

Biological diversity is the variation of lifeforms within a given species, ecosystem or biome. Diversity indices provide important information about the rarity and commonness of species in a community. The two main components taken into account when measuring the diversity are richness and evenness [32]. Richness is a measure of the number of different kinds of organisms present in a particular area whereas evenness is the measure of relative abundance of the different species within a community. Simpson's index is used to measure the dominance but it fails to measure the species richness. Shannon index is expected to measure both diversity characteristics evenness and richness. This implies that diversity cannot be estimated by using single index and thus it is necessary to quantify the diversity by using various diversity indices [33, 34, 35].

Diversity indices are given in fig. 3. The dominance was maximum for Site I (0.134) and minimum for site II (0.099). In ecology, the dominance gives more weight to common or dominant species, with values between 0 (all taxa are equally present) to 1.0 (one taxon dominates the community completely) and the present values indicates that almost all species are equally present at all site. Shannon-Wiener index was maximum for Site II (2.393) and minimum for Site I (2.044). In ecology, Shannon-wiener index (H) is the most preferred index among the other diversity indices. Joshi *et al.* [17] reported Shannon index of 1.092-1.319 from fruit orchards whereas Arya *et al.* [16] between 2.65-2.72 from Binsar Wildlife Sanctuary. Presence of higher number of species at site-II contributes to higher Shannon-Wiener index. Simpson's diversity index varied from (0.865) at Site I to (0.900) at Site II. Joshi *et al.* [17] reported Simpson value of 0.716 to 0.879 from fruit orchards. Simpson's index values (D) are between 0 to 1. The values (0.6 to 0.9) indicates the mature and stable communities have high diversity while the values close to zero indicates the communities under stress [36]. Evenness varies between (0.90) at Site III to (0.965) at Site I. The values of evenness are between 0 to 1 when the value is getting closer to 1, it means that the individuals are distributed equally. Arya *et al.* [16] also reported evenness value between 0.693 to 0.712 from Binsar Wildlife Sanctuary. Margalef diversity index are between (1.818) at Site I to (2.399) at Site II. Margalef index has no limit and it shows a variation depending upon the number of species, thus site-II exhibited higher diversity as compared to site-I and site-III.

Conclusions

Among the fifteen insect species recorded in the study, the *Anisopteras sp.* and *Lycosa sp. were* dominant species in terms of their density and occurrence. Higher value of Shannon-Wiener index and Margalef index at site-II is attributed to higher number of species recorded at the site. The presence of large area with greater plant diversity provides diverse resources that contributed to insect diversity. Occurrence of maximum number of insect during summer is contributed to favorable condition but the human interference in the form of upcoming construction results in lack of resting sites and food availability which is effecting adversely the overall insect diversity.

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