Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(6): 575-582

Received: 19-08-2020
Accepted: 29-09-2020

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Foraging behaviour, abundance and rank abundance of insect pollinators on plum crop (*Prunus domestica*) in Himalayan regions

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Abstract
Plum (*Prunus domestica*) is self-unfruitful, requires cross-pollination by insects to produce fruit. The demand for plum exceeds the supply due to low product yields that have resulted from a decrease in pollination services. Although plum is grown in Kashmir valley, but little is known about the correspondence between pollinator abundance and pollinator services for this plant genus. In this study, daily activity patterns, hourly abundance, ranks abundance and pollination effectiveness of insects visiting *Prunus domestica* were investigated. Highest of 41 species, belonging to 5 orders, 19 families and 28 genera visiting insects were identified to interact with plum flowers. Conducting χ^2-test, the order Hymenoptera (*Mann-Whitney U test*), family Halictidae and genus *Lasioglossum* were found dominant among all pollinators observed. Refraction curve were made and species wise sample count were plotted. The daily activity peaks of the five visiting insects were between 10:00 and 14:00, which may have been related to the pattern of floral resource production (particularly nectar availability). Therefore, the wild flower visitors that pollinate wild and cultivated plum plants should be protected in Kashmir valley to enhance the crop production.

Keywords: Plum, pollinators, hymenoptera, Himalayan, foraging behaviour, abundance

Introduction
Insect pollinators interact with flowering plants to underpin wider biodiversity, ecosystem function and resource conservation services to agricultural crops (Dar *et al*. 2017a) [17] and ultimately contributes to human nutrition. The non-availability of continuous floral resources, anthropogenic factors (Dar *et al*. 2017b) [18], diseases (Ullah *et al.* 2020) [36] and nest sites are two factors that are thought to limit bee populations in farmland. For sufficient pollination of the flowering plants, the habitat requirement (Dar *et al*. 2017c) [16] and the conservation of insect pollinators is most essential for overall diversity (Dar *et al.* 2016a) [19] and ecosystem sustainability (Dar *et al.* 2017d) [21]. Therefore, insect mediated pollination is only the suitable option for pollination in plum fruit crops in general. In New Zealand field trials were conducted and it was recorded that honey bees are important pollinators of Japanese plums (Hopping and Jerram, 1980) [23]. Langridge and Goodman (1985) [25] examined the pollination diversity of Japanese plums (*Prunus salicina* Lindl. cv. Satsuma) in orchards of Victoria, and honey bees were main pollinators and comprised of 88.5 per cent of all flower visitors. Whileas, *Trigona* species were not seen to visit the plum flowers. Further, Langridge and Goodman (1985) [25] also reported that pollen-collecting bees seem to be the main pollinators of plum species because of their activity early in the flowering period. The honey bee has been recognized as a primary pollinating agent of plums and other Prunus species (Waugh, 1900) [38] and importance of bees as pollinators of plums were stressed. Serini (1985) [34] summarized the observations on the species composition of the pollinating insect of Plum (Prunus species) in different localities in Italy. Wild and domesticated bees predominated; while as, Syrphids, Calliphorids, Nymphalids, Sphingids and Pierids were present in small numbers, especially if the orchards were surrounded by uncultivated areas having wild flowering plants (Dar *et al*. 2018b) [20]. Correia *et al*. (1991) [9] surveyed the abundance, diversity and seasonality of wild bees in Portuguese on plum, and showed that wild bees were very promising fruit pollinators accounted about 3, 2 and 3 species of Bumble bees (Bombus), leaf-cutter bees (Megachilidae)

and Osmia spp., respectively. In an observation on flower visitors by *Apis* and *Trigona* species on *Pyrus communis* and *P. domestica* in northern Thailand at an altitude of 1300 m, and a strong and significant correlation were found between relative abundance, floral visitation, flight activity (*Trigona* spp.) and distance to the forest areas (Boonithee *et al*. 1991) [8]. Abrol *et al*. (1990) [2] showed that insect pollination is very essential for almond, cherry, peach and plum; and the similar observations were also recorded earlier (Abrol, 1989a; 1989b; 1989c; 1990; 1992) [4, 1, 7, 5, 3], Abrol and Bhat (1989) [4]. In Jammu and Kashmir two species of honey bees, several species of wild bees and flies visiting the several fruit crops were observed by many authors. Most abundant and widely distributed pollinators were from orders Hymenoptera followed by Lepidoptera and Diptera. The species *viz*., *Lasioglossum, Colletes, Anthophora, Xylocopa, Episyrphus balteatus, Eristalis tenax, M. domestica, Megachile* were observed as efficient pollinators of genus prunus (Abrol, 1992) [3] and cherry (Dar *et al*. 2018a) [14]. The fruit crop production increases significantly after cross-pollination by insects (Wei *et al*., 2019) [39], e.g. production rates increased 2 to 4.5 times after cross-pollination by bees (Sara *et al*., 2002; Zhao *et al*., 1985) [31, 41]. However, little is known about the correspondence between pollinator abundance and pollinator services for *P. domestica*. Information about pollinator abundance, visitation and their habitat would be helpful for improving yield and protecting their pollinating insects in present scenarios of climate change. The objectives of present study were to investigate the daily activity patterns and pollination effectiveness of the insects visiting plum crop at 3 experimental locations and 81 sub-location in Himalayan region.

Material and methods

The present investigation on "foraging behaviour, abundance and rank abundance of insect pollinators on plum crop (*Prunus domestica*) in Himalayan region" were carried out during the cropping season 2013 and 2014 following the methodology given under:

Study area and sites

The experimental area were geographically stretched between 32º 17" to 37º 60" N latitude and 73º 26" to 80º 30" E longitudes. The mountain range in the Himalayas region varies in altitude between 5,550m on North-east dip down to about 2,770m on South. The research were conducted in three locations of each Budgam, Pulwama and Srinagar districts situated at the height of 1610, 1630 and 1550 meters respectively, from mean sea level (MSL). The research were conducted during March and July in 2013 and 2014. The average altitude of three districts is around 2350 meter above mean sea level. The habitat types selected were having the patches dominated by tree species of plum plants.

Field survey and sampling

Each study site selected was visited three times during the study period. Data were recorded throughout the blooming period from April to June between 800h to 1200h on each week by transect walk using plot samplings and a minimum distance of 50m were left from the forest edge to avoid any edge effect. Plots were circular with a radius of 10m or 200m separated from each other (Owiunji *et al*. 2004) [29], to cover the distance of 200 m which is the flight range of the most wild bees. Selected plants were grown in similar environment with uniform exposure to abiotic factors like sunshine hours, growing degree days (Dar *et al*. 2018c) [10], moisture regimes, evapotranspiration (Dar *et al*. 2017e) [12], crop geometry and nitrogen application (Dar *et al*. 2014) [11]. Before the observations were recorded about the wild pollinators' activity in each selected plot, GPS point's altitude, temperature, and the weather status were recorded. During the 10 min observation time in each plot, all encountered flower-pollinator interactions were recorded (TIEE, 2004) [35]. The open flowers were monitored by moving slowly through plots to avoid disturbance of pollinators visiting flowers, so as to determine the total number of observed individuals of pollinators interacting with the plant species (plum fruits) when ≥ 10 per cent of the plants had started to bloom upto 80 per cent of the anthesis. Further, the stopwatches, marking tape, "eyeball ID", hand lenses, thermometer, data sheets and help from a junior entomologist were also taken to record visitation and keep eyes on flowers. All this was implemented at the fields of different locations for accurate data collection. Agriculture Field Experiment that suits to present study were given by Dar *et al*. (2016b) [13] and used.

Selection of trees

Three trees of each plant species per three locations were used for the study from each experimental location growing at least 12 m x 12 m of spacing, otherwise about 200 m away from one another in similar environments. Hourly foraging behaviour was calculated by using formula as given below:

Total visits

$$\frac{\text{Number of visits}}{\text{Flower bout of one meter square length } (m^2)}$$

Visitation rate

$$\frac{\text{Total number of visits}}{\text{Insects}/m^2/10 \text{ minutes}}$$

Visitation per cent

$$\frac{\text{Total Number of visits}}{\text{Bout of one meter square length } (m^2)} \times 100$$

Time periods

Between the time scales from 900-1700, we took 10 min of focal observations during each hour, totaling 100 min day^{-1}, and in 7 days totaling 700 min of week. In plum flowering period is very short, and flowering disappears quickly. In vicinity of flowering plants other competitive flowering vegetations compete for foragers during course of study, so we took very keen and intensely study to get accurate informations possible about foraging characteristics.

Insect collection and preservation

All canopy insects were collected at the stages coinciding with the most receptive period of the flowers using hand net. The collected insects were killed in the glass container containing the cotton saturated with ethyl acetate. All collected specimens were mounted and preserved following dry preservation method given by Schauff (1986) [32]. All the samples were labeled and deposited in the laboratory of RTCPPPM-SKUAST-K, Srinagar.

Identification of samples

From the each plum tree insects were collected and sorted into broad categories then identified by comparison with the preserved specimens. RTCPPPM SKUAST-K, Srinagar assists in identification of the pollinators. Further, the *Lasioglossum* specimens were identified by Dr. Alian Pauly from Belgium, Europe, Dr. Vickrim Singh Thakur from Patailla, Punjab and Syrphid flies were identified from Department of Zoological Survey of Bangalore, India.

Data collection and Analysis

Recordings were made from the onset of the main blooming period with temperature ≥ 15ºC, low rain ad dry vegetation (Westpahl *et al.* 2008) [40]. Depending on the height of the tree, the uses of a telescopic net and smaller ladder in the field were used to sample the foragers in all parts of the trees. In order to study the proportion of each species within the local community, species diversity were recorded (will be discussed in next paper). ANOVA (one way), Chi square test (χ2-test), T-test, *Kruskal Wallis test* and Pearson's correlation were performed to the raw data. Whittaker plot is drawn to display the relative species abundance, a component of biodiversity.

Result and Discussion

In all of three experimental locations selected, a significant variation existed between the pollinators/visitors of plum in their total visits, visitation rate and per cent visitation. The species *Lasioglossum marginatum* recorded the highest total visits, visitation rate and visitation percentage of 6.50 (No. visits/flower bout m^2), 1.094 (Total visits/insects/m^2/10min.) and 13.96 visits/bout (m^2) ×100) (Total 1), respectively. The analysis of variance test (ANOVA) showed significant differences in total visits (CD= 0.77, P≤ 5%; t-test≤0.001), visitation rate (CD= 0.06, t. test≤0.05; P≤ 5%) and per cent visitation (CD= 0.091, t. test<0.05; P≤ 5%) of various plum pollinators across the three districts. Dar *et al.* (2017d) [21] observed that *L.marginatum* is pollinators of wild shrubs and fruit crops (Dar *et al*. 2018b) [20] too. Research further suggested that if proper conservation practices (Dar *et al*. 2017e) [12] would be followed at farmer's level *L. marginatum* would be so high in population and very effective in foraging that it would replace honey bees in near future. This variation is almost entirely accounted for by differences in flower handling time. Although most Helictids *viz*., *L. marginatum*, *L. nursi*, *L. himalayanse* and some Syrphid flies gather pollen, but nectar is the main reward sought by pollinators in plum flowers. Among Helictid species visiting to plum flowers, the highest foraging were made by *L. marginatum* and lowest of 0.98 (No. visits/flower bout m^2), 0.403 (Total visits/insects/m^2/10min.) and 2.048 (Total visits/bout (m^2)×100) were performed by *Sphecodes tantalus*, however as mentioned in earlier article that *S. tantalus* is cleptoparasitic on *L.marginatum* (Dar and Wani 2018) [15]. Highest visitation rate were found during 2013 (P-value≤0.005) and lowest were found during 2014 (P-value≤0.001). Overall the pollinators of order Hymenoptera showed higher total visits, visitation rate and per cent visitation to plum flowers during the both years of study. Among the species of family *Andrenidae*, the total visits, visitation rate and per cent visitation of 2.00 (No. visits/flower bout m^2), 0.763 (Total visits/insects/m^2/10min.) and 4.293 (Total visits/bout (m^2)×100) were exhibited by *Andrena patella*. While as *Xylocopa valga* and *X. violaceae* showed the total visits (No. visits/flower bout m^2), visitation rate (Total visits/insects/m^2/10min.) and per cent visitation (Total visits/bout (m^2)×100) of 2.81, 0.631, 5.503 and 2.10, 0.470, 4.022, respectively. Among the Dipteran pollinators/visitors of plum flowers, species *Sphaerophoria bengalensis* exhibited good foraging behaviour followed by *Sarcophaga nodosa* and Tachinid flies. The mean time spend by pollinators on plum flowers varies among different species (N=41, Pearson's correlation=0.96, p-value≤0.001). In family Helictidae the maximum mean time of 36±0.03 s were spend by species *L. sublaterale*; while as, minimum of 16±0.93s were spend by *L. marginatum*.

Hourly activity duration of insect pollinators has a direct bearing on the intensity of pollination. Insect pollinators will pollinate more flowers if they remain active for a longer duration. Foraging activity duration of a pollinator vary from species to species and plant to plant (Free, 1993) [22]. During the present investigation the hourly abundance of insect pollinators of plum were found maximum in after-noon. This is in confirmation with the results of Wadhwa and Sihag (2015) [37] who reported that irrespective of insect species, the abundance on stone fruit flowers were 0.24 insects/m² at 700 h, 1.68 insects/m² at 900 h, 2.97 insects/m² at 1100 h and reached at peak level 4.17 insects/m² at after noon,1300 h. Averaged over daytime, the insect pollinator abundance (Helictid family, χ2=0.044) start raising from early in the morning (900-1000 hrs) and become peak maximum in late afternoon (1300-1400 hrs). However, the abundance at the dusk hours (1600-1700 hrs) were less compared to noon hours, this is again in agreement with the findings of Wadhwa and Sihag (2015) [37] that there was a bit decline in abundance to 3.72 insects/m² at 1500 h and 1.96 insects/m² at 1700 h in the evening; unlike the results of Roy *et al* (2014) [30] who reported that average abundance of all visitor insects was maximum at the middle of the day i.e. 12 noon and 2 P.M.

Generally, most of the dipteran insects are pests on crops (Mir *et al*. 2014; Mir *et al.* 2017) [26, 27]; however foraging for the nectar is a requirement for flight maintenance as food for gaining energy. It is clear, that dipteran insects don't have specialized organs for transferring pollen and if pollen get shifted across flowers, that would be generally through their morphological behaviour or by their flight in between flowers drafting the pollen load in air. Activity of Dipteran pollinators start at 900-1000hrs confirmed by results of Wadhwa and Sihag (2015) [37] that Dipteran activity started at 1100hrs; further Roy *et al*. (2014) [30] also support the current findings that Dipteran pollinator activity start in morning at 8.0 AM (800h). Hymenopteran species activities on plum were high at 1300-1400hrs, and then decreased supported by Nderitu *et al*. (2008) [28] that relative abundance peak of Apis bees was at 12:00 pm. Schinohara (1987) [33] concluded his studies that *A. mellifera* were the most frequent visitors mainly during afternoon timings. Kasina (2007) recorded the peaked density of Apis on sunflower between 10:00 am and 02:00 pm; unlike our observations Kumar *et al*. (1994) recorded peak activity periods of *Apis mellifera* between 09:00 am and 11:00 am. Since, peak activity of insect pollinators on stone fruit flowers were high at noon hours which corresponds to peak foraging activity of the pollinators, this is in agreement with Kumar *et al*. (2005) [24] that maximum foraging activity is around 11:00 am. The possible reason for the recorded differences may be the floral density, floral fragrance, observation months (January-February), whileas current observations were done in period commencing from April to May, 2013-14. Irrespective of the species collected during the present investigation, the abundance of pollinators was lowest (1.75 bees/m^2/10 min.) at 900-1000 and highest (6.75 bees/m^2/10 min.) at 1300-1400hrs. The species abundance revealed that *L. marginatum* dominated the total insect visitors in recording the highest mean abundance and hourly abundance activity. *Conducting Mann Whitney-2 tailed U* test comparing families abundance of hymenopteran order with the abundance of Dipteran families at d.f .7 the minimum value obtained is U_1=22 (p<0.005; we rejected null hypothesis) and maximum U_2= 27, indicating that hymenopteran families were significantly more abundant and good pollinators of plum under Kashmir conditions $U_{1\ state}<U_{critical\ value}$ (therefore P<0.001).

Table 1: Foraging behaviour of Insect pollinators/visitors on plum during 2012-2015

S. No.	Pollinator Species	Pollination efficiency			
		Time spent (Seconds)	Total Visits (No. of visits/ flower bout one sq. meter (m^2) length)	Visitation rate (Total No. visits/ abundance (insects/ m^2/ 10min.)	Per cent visitation (Total No. visits/bout (m^2)×100)
1	*Lasioglossum marginatum*	16±0.93	6.50	1.094	13.96
2	*L. regolatum*	31±0.03	3.45	0.880	7.411
3	*L himalayen*	30±0.06	4.00	0.959	8.592
4	*L sublaterale*	36±0.03	3.40	0.899	7.303
5	*L leucozoni*	29±0.04	2.90	0.763	6.229
6	*L nursei*	30±0.04	4.00	0.900	8.592
7	*L. polyctor*	28±0.04	1.33	0.419	2.857
8	*Halictus constructus*	20±0.21	1.20	0.463	2.577
9	*Sphecodes tantalus*	19±0.44	0.98	0.403	2.048
10	*Andrena patella*	18±0.03	2.00	0.763	4.296
11	*Andrena flordula*	30±0.03	1.60	0.720	3.437
12	*Andrena cineraria*	28±0.31	0.19	0.575	0.408
13	*Amegilla cingulata*	27±0.03	0.09	0.132	0.193
14	*Megachile rotundata*	20±0.83	0.32	0.410	0.687
15	*Anthedium consolatum*	26±0.03	0.20	0.256	0.429
16	*Xylocopa valga*	9.0±0.01	2.81	0.631	5.503
17	*X. violacea*	11±0.04	2.10	0.470	4.022
18	*Camponotus longus*	112±3.01	0.30	0.112	0.644
19	*Formica rufa*	96±4.41	0.63	0.226	0.353
20	*Vespa auraria*	90±1.34	0.1	0.047	0.214
21	*Erisyrphus balteatus*	38±0.03	0.47	0.652	1.009
22	*Eristalis tenax*	40±0.03	0.89	0.760	1.912
23	*Sphaerophoria bengalensis*	37±0.22	1.05	0.789	2.255
24	*Didea fasciata*	57±0.03	0.5	0.316	1.074
25	*Eristalis cerealis*	18±0.03	0.9	0.676	1.933
26	*Sarcophaga nodosa*	14±0.53	1.24	0.620	2.663
27	*Scathophaga stercoraria*	20±0.03	0.96	0.448	2.062
28	*Scathophaga inquinata*	24±0.04	0.86	0.427	1.847
29	*Chrysomya megacephala*	12±0.14	1.22	0.628	2.620
30	*Bibio johannis*	18±0.34	0.84	0.631	1.804
31	*Plecia* sp.	16±0.34	0.6	0.600	1.288
32	*Musca domestica*	35±0.21	0.9	0.625	1.933
33	*Musca* sp.	24±0.04	0.3	0.638	0.644
34	*Ophyra* sp.	13±0.04	0.43	0.430	0.923
35	Empididae *sp.*	19±0.34	0.24	0.363	0.515
36	*Tachinid fly*	18±0.03	0.78	0.644	1.675
37	*Neomyia cornicina*	12±0.04	0.22	0.220	0.472
38	*Pieries brassicae*	12±0.21	0.01	0.045	0.021
39	*Vanessa cashmeriensis*	13±0.11	0.01	0.045	0.021
40	*Ischnura verticalis*	68±2.24	0.001	0.002	0.002
41	*Oncopeltus fasciatus*	50±2.01	0.004	0.004	0.008
Statistics N=41		CD=8.73, P≤ 5%; t-test<0.001	CD= 0.77, P≤ 5%; t-test<0.001	CD= 0.06, t. test<0.05; P≤ 5%	CD= 0.091, t. test<0.05; P≤ 5%

(Conductingχ2- test the value obtained were 631.2, N=41, and were found significant at P< 0.05 level). However, the genus *Lasioglossum* were found highly significant at P<.001 level)

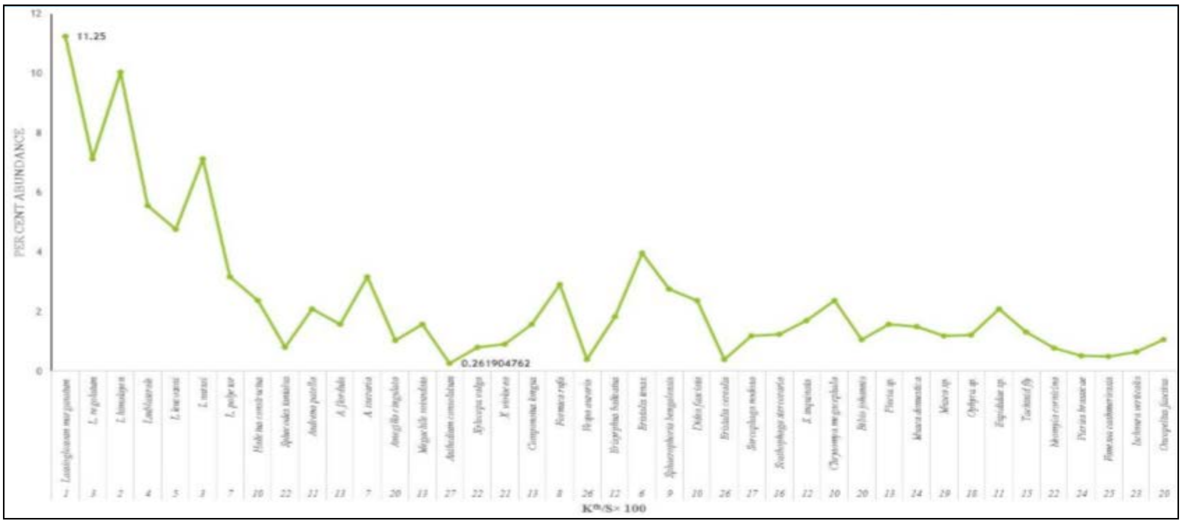

Fig 1: K-Dominance value ($K^{th}/S\times 100$ vs % species abundance) of insect pollinator abundance of plum (*Prunus domestica*)

Table 2: Hourly abundance (Number of insect pollinators/m^2/10min.) of insect pollinators on Plum (*Prunus domestica*) during the 2013-2014

S. No.	Species	Hourly abundance							
		900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700
1	*Lasioglossum marginatum*	3.0±0.54	5.6±0.11	6.0±0.76	6.33±0.27	7.0±0.15	7.75±0.76	8.9±0.32	4.0±0.11
2	*L. regolatum*	2.0±0.12	3.0±0.23	4.01±0.10	4.67±0.12	4.8±0.45	5.01±0.20	6.0±0.22	3.0±0.12
3	*L. himalayense*	3.0±0.10	5.33±0.2	6.33±0.23	6.67±0.32	7.0±0.65	7.71±0.30	8.0±0.30	3.0±0.01
4	*L. sublaterale*	2.0±0.10	3.0±0.40	3.67±0.50	4.0±0.450	4.3±0.32	5.67±0.24	5.0±0.40	3.0±0.01
5	*L. leucozonium*	2.0±0.23	3.3±0.56	3.71±0.60	4.0±0.901	4.6±0.43	5.71±0.30	5.3±0.56	3.3±0.43
6	*L. nursei*	2.0±0.30	3.0±0.70	4.1±0.780	5.0±0.802	5.6±0.54	6.0±0.560	7.0±0.50	3.3±0.60
7	*L. polyctor*	1.0±0.40	2.0±0.80	3.1±0.110	3.3±0.763	3.7±0.65	5.01±0.70	5.6±0.70	2.1±0.50
8	*Helictus constructus*	0.0±0.0	2.0±0.90	2.55±0.33	2.7±0.540	3.0±0.76	4.00±0.80	5.45±0.6	2.2±0.80
9	*Sphecodes tanatus*	0.0±0.0	0.87±0.11	1.69±0.22	2.47±0.30	2.7±0.87	2.9±0.120	2.69±0.8	1.71±0.7
10	*Andrena patella*	0.0±0.0	1.67±0.22	2.33±0.11	3.3±0.230	4.0±0.90	5.00±0.30	6.0±0.70	2.0±0.01
11	*A. floribunda*	0.0±0.0	1.01±0.01	1.95±0.89	2.79±0.10	3.06±0.8	4.00±0.20	4.67±0.9	2.1±0.10
12	*A. cineraria*	0.0±0.0	0.0±0.0	0.67±0.34	1.0±0.431	1.33±0.0	1.5±0.430	0.33±0.0	0.0±0.00
13	*Megachile rotunda*	0.0±0.0	0.85±0.32	1.61±0.60	1.8±0.451	2.6±0.11	2.7±0.501	3.1±0.12	1.0±0.30
14	*Anthedium consolatum*	0.0±0.0	0.0±0.0	0.67±0.45	0.8±0.601	1.1±0.12	1.33±0.40	1.67±0.1	0.33±0.1
15	*Xylocopa valga*	0.0±0.0	0.33±0.10	0.671±0.3	0.7±0.110	0.9±0.11	1.67±0.01	2.1±0.30	0.67±0.4
16	*X. violacea*	0.0±0.0	0.0±0.0	0.33±0.12	0.5±0.210	0.8±0.11	1.0±0.120	2.1±0.13	0.33±0.3
17	*Amegilla cingulata*	0.0±0.0	0.33±0.14	0.33±0.11	0.67±0.61	1.3±0.11	2.33±0.10	2.67±0.2	0.0±0.00
18	*Vespa aurantalis*	0.0±0.0	0.0±0.0	0.4±0.890	0.65±0.51	0.84±0.23	0.96±0.30	0.66±0.1	0.0±0.00
19	*Formica sp.*	0.98±0.6	1.45±0.40	1.75±0.87	2.08±0.31	2.35±0.43	2.94±0.13	3.4±0.43	2.15±0.1
20	*Camponotus longus*	0.95±0.0	1.01±0.90	1.25±0.77	1.33±0.21	1.67±0.87	1.80±0.14	2.0±0.50	1.2±0.50
21	*Erisyrphus balteatus*	1.67±0.2	2.01±0.11	2.35±0.60	2.89±0.10	3.16±0.98	3.9±0.150	4.0±0.40	2.04±0.8
22	*Eristalis tenax*	1.11±0.4	1.64 ±0.11	2.195±0.3	2.72±0.23	2.95±0.11	3.12±0.16	3.44±0.6	2.09±0.1
23	*Sphaerophoria bengalensis*	1.34±0.5	1.62±0.20	2.63±0.22	2.87±0.40	3.09±0.21	3.17±0.10	3.16±0.4	1.97±0.9
24	*Eoseristalis cerealis*	1.06±0.6	1.29±0.01	1.78±0.01	2.54±0.50	2.9±0.340	3.21±0.20	2.89±0.7	1.87±0.7
25	*Didea fasciata*	0.33±0.5	0.67±0.45	1.11±0.20	1.33±0.65	2.11±0.01	2.33±0.32	3.0±0.68	0.67±0.1
26	*Scathophaga stercoraria*	0.94±0.1	1.03±0.01	2.01±0.88	2.15±0.76	2.52±0.54	2.77±0.20	2.83±0.7	1.72±0.7
27	*S. inquinata*	0.67±0.3	0.8±0.660	1.33±0.77	1.67±0.80	2.00±0.60	2.3±0.501	2.75±0.9	1.0±0.01
28	*Chrysomya megacephala*	0.67±0.2	0.91±0.70	2.17±0.44	2.64±0.70	2.70±0.50	2.84±0.20	2.85±0.7	1.89±0.2
29	*Bibio johannis*	1.28±0.4	1.9±0.811	2.22±0.20	2.51±0.01	2.78±0.70	2.98±0.60	2.79±0.1	1.45±0.4
30	*Plecia* sp.	1.31±0.3	1.92±0.01	2.51±0.30	2.87±0.03	2.93±0.60	2.99±0.36	2.9±0.12	1.43±0.2
31	*Musca domestica*	0.76±0.5	1.23±0.22	1.94±0.12	2.29±0.02	2.55±0.80	2.76±0.47	2.02±0.0	1.56±0.4
32	*Muscadae* sp.	0.5±0.10	0.71±0.01	1±0.78890	1.33±0.02	1.60±0.70	2.0±0.750	2.3±0.30	0.8±0.20
33	Empididae sp.	0.58±0.2	0.85±0.12	1.18±0.70	1.83±0.02	2.37±0.90	2.68±0.86	2.09±0.0	1.53±0.5
34	*Tachinid fly*	0.68±0.3	0.99±0.34	1.99±0.66	2.24±0.02	2.77±0.80	2.96±0.80	3.48±0.2	1.95±0.3
35	*Neomyia cornicina*	0.0±0.0	0.0±0.0	0.78±0.45	0.96±0.02	1.46±0.10	1.87±0.10	2.35±0.2	1.57±0.5
36	*Oncopeltus fasciatus*	0.0±0.0	0.98±0.77	1.35±0.11	1.58±0.09	2.69±0.10	2.71±0.11	2.98±0.2	1.71±0.0
Statistics		N=37, t-test=0.031; p.value<0.05%; Study commencing from 1st week of March to 1st week of April							

S. No.	Species	Mean abundance (No. of insect pollinators/m²/ 10 minutes)	Species (%)	Genus (%)	Family (%)	Order (%)	Rank (on order basis)
1	*Lasioglossum marginatum*	4.73	11.03	48.06	51.18 (Halictidae)	67.20 (Hymenoptera)	1
2	*L. regolatum*	3.00	6.99				
3	*L himalayense*	4.22	9.84				
4	*L sublaterale*	2.33	5.43				
5	*L leucozonium*	2.00	4.66				
6	*L nursei*	3.00	6.99				
7	*L. polyctor*	1.33	3.10				
8	*Halictus constructus*	1.00	2.33	2.33			
9	*Sphecodes tantalus*	0.34	0.79	0.79			
10	*Andrena patella*	0.88	2.05	6.68	6.68 (Andrena)		
11	*A. flordula*	0.66	1.53				
12	*A. cineraria*	1.33	3.10				
13	*Amegilla cingulata*	0.44	1.02	1.02	1.02 (Anthophoridae)		
14	*Megachile rotundata*	0.67	1.56	1.56	1.81 (Megachilidae)		
15	*Anthedium consolatum*	0.11	0.25	0.25			
16	*Xylocopa valga*	0.34	0.79	1.70	1.70 (Apidae)		
17	*X. violacea*	0.39	0.91				
18	*Camponotus longus*	0.67	1.56	1.56	4.42 (Formicidae)		
19	*Formica rufa*	1.23	2.86	2.86			
20	*Vespa auraria*	0.17	0.39	0.39	0.39 (Vespidae)		
21	*Erisyrphus balteatus*	0.78	1.81	6.09	11.14 (Syrphidae)	29.93 (Diptera)	2
22	*Eristalis tenax*	1.67	3.89				
23	*Eristalis cerealis*	0.17	0.39				
24	*Sphaerophoria bengalensis*	1.17	2.72	2.72			
25	*Didea fasciata*	1.00	2.33	2.33			
26	*Sarcophaga nodosa*	1.00	2.33	2.33	2.33 (Sarcophagidae)		
27	*Scathophaga stercoraria*	0.52	1.21	2.93	2.93 (Scathophagidae)		
28	*S. inquinata*	0.74	1.72				
29	*Chrysomya megacephala*	0.06	0.13	0.13	0.13 (Calliphoridae)		
30	*Bibio johannis*	0.45	1.04	1.03	2.59 (Bibionidae)		
31	*Plecia* sp.	0.67	1.56	1.56			
32	*Musca domestica*	0.63	1.46	3.79	6.88 (Muscidae)		
33	*Musca* sp.	1.00	2.33				
34	*Ophyra* sp.	1.00	2.33	2.33			
35	*Neomyia cornicina*	0.33	0.76	0.76			
36	Empididae sp.	0.88	2.05	2.05	2.05 (Empididae)		
37	*Tachinid fly*	0.81	1.88	1.88	1.88 (Tachinidae)		
38	*Pieries brassicae*	0.22	0.51	0.51	0.51 (Pieridae)	0.99 (Lepidoptera)	3
39	*Vanesa cashmieriensis*	0.21	0.48	0.48	0.48 (Nymphilidae)		
40	*Ischnura verticalis*	0.27	0.62	0.62	0.62 (Coenagrionidae)	0.62 (Odonata)	4
41	*Oncopeltus fasciatus*	0.44	1.02	1.02	1.02 (Lygaeidae)	1.02 (Hemiptera)	5
Total mean abundance (No. of insect pollinators/m²/10 minutes)		-	-	-	-	-	Σ(x) = 15

Conducting χ2- test at genus level, higher significance with P=0.0048 were recorded with respect to abundance of genus *Lasioglossum* (N=27, χ2- value=27.41). Whileas, at family and order level, Halictidae and Hymenoptera were found significant compared to other visitors groups.

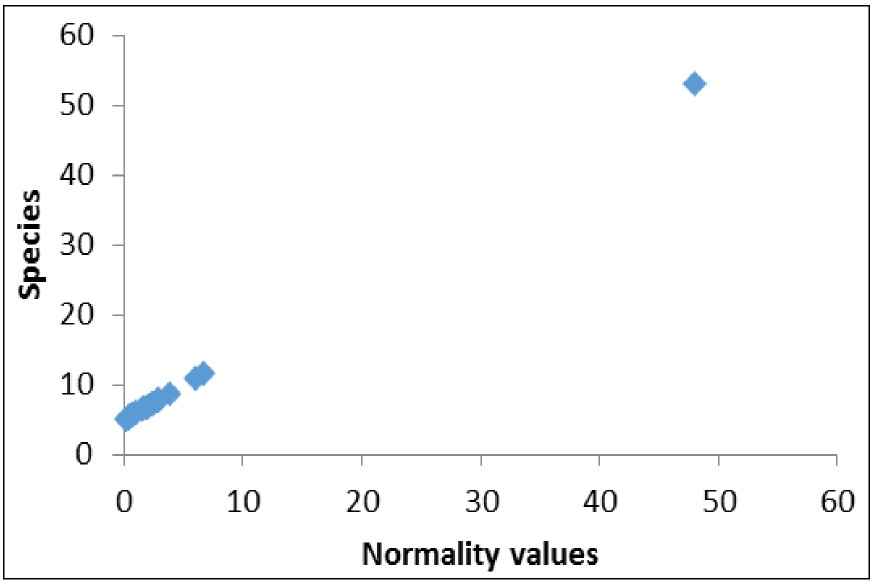

Fig 2: Normality distribution (Z-test) of the abundance at genus level.

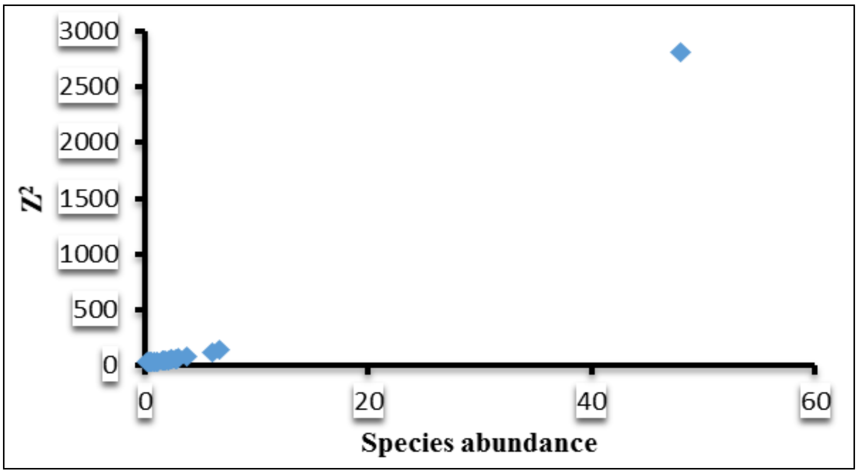

Fig 3: χ2- Distribution at genus level.

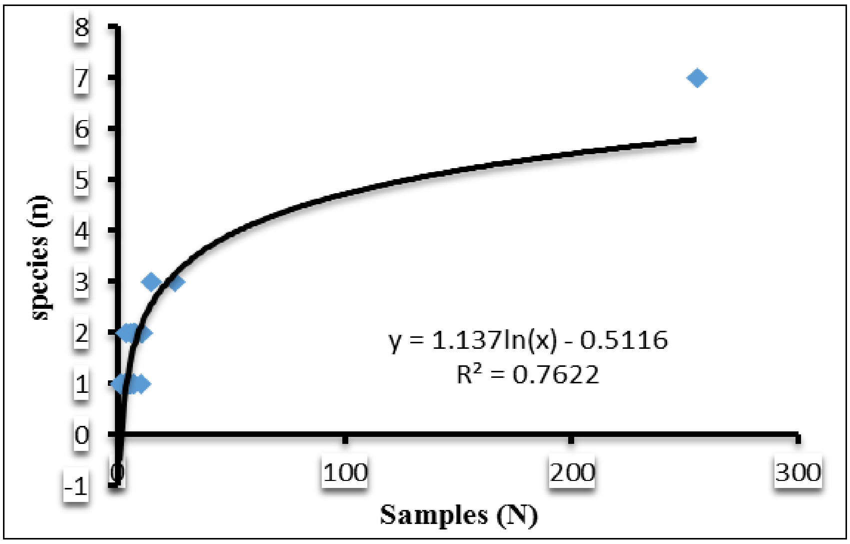

Fig 4: Refraction curve total samples collected during survey N *vs* total species (n) identified.

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