RESEARCH ARTICLE
doi: 10.2306/scienceasia1513-1874.2018.44.319

ScienceAsia 44 (2018): **319–324**

Species richness and diversity of Vespidae (Insecta: Hymenoptera) of Swat Khyber Pakhtunkhwa Pakistan

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Received 20 Mar 2018
Accepted 21 Sep 2018

ABSTRACT: Keeping in view the agricultural importance, Vespidae is an important family of the order Hymenoptera (Insecta). The objective of the study was to find out the number of species of the family and to mark the distribution of the species of the family Vespidae in various locations of the study area. The wasps were collected with the help of hand net through active search, killed with insecticide and preserved in insect boxes having naphthalene balls as preservatives. Species richness were calculated using Margalef and Menhinick indices while species diversity was calculated using Simpson diversity index. The most abundant subfamily was Polistinae with 65% abundance while the least abundant was the Eumeninae with 2% abundance. However, the most diverse and species rich subfamily is Eumeninae with a Simpson (1-D) value of 0.803, Menhinick and Margalef indices values of 1.540 and 2.543, respectively. Among the seven tehsils, Kabal is the most species rich and diverse having Margalef value 2.408, Menhinick Value 0.514 and Simpson (1-D) value 0.777 while Bahrain is the least species rich and having no diversity. The Margalef, Menhinick and Simpson (1-D) values for tehsil Bahrain are 0, 0.333, and 0, respectively. The Polistinae is the dominant subfamily in the area and can be used as biocontrol agent for various pests of agricultural importance.

KEYWORDS: Polistinae, Vespinae, Eumeninae, diversity indices, solitary wasps

INTRODUCTION

The Vespidae is a large and diverse family of the order Hymenoptera (Arthropoda: Insecta) including nearly 5000 species of wasps[1]. It is a cosmopolitan and predominantly tropical family[2]. Adult wasps are predominantly black or brown in colour but often may have yellow or white markings on the body. The subfamilies Polistinae and Vespinae contain the highly eusocial species while solitary species are included in the subfamilies Eumeninae, Eupragiinae and Masarinae[3]. The subfamily Eumeninae, also known as mason or potter wasp, is the most diverse and species rich with approximately 205 genera and 3743 species[4]. The second largest subfamily is the Polistinae having 1100 species in total, and is the second most diverse subfamily. The subfamily Vespinae contains 67 known species under four genera[5]. Wasps perform valuable services in the ecosystem, though most people think of them as pests, they prey on various arthropods pests like caterpillars, spiders, bugs and flies and hence control their populations[6]. The wasps also help in cross pollination during their visits to flower and to obtain nectar. In some countries like Japan, the larvae and pupae are used as food and considered as a good source of protein. Hitherto, a stinging at their ovipositor poses a great threat to humans. Stinging is an excellent defence in wasp colonies against predators and other possible dangers[7]. The stings are dangerous, painful and even fatal if it causes an anaphylactic allergic reactions[8].

The members of the family Vespidae like other insects needs to be identified and grouped in accordance with their environment, predator, prey, and climate[9]. This will help obtain information about the habitat and niche of the species[10] and its use as a predator, scavenger or pollinator[11]. The use of various statistical methods in ecology is to find out the asymptotic number of species not detected in the area[11]. The species richness estimates are based on assumptions that the observed species number is less than the actual number of species present

in the area[12]. The main purpose of the study was to find out species richness, distribution, diversity and species evenness of Vespidae. Based on the information obtained from the study, various species of the family Vespidae can be used as pollinators of agriculturally important crops or predators of important crop pests.

MATERIALS AND METHODS

Study area

The valley of Swat is situated in the north of Khyber Pakhtunkhwa, 35° North latitude and 72° and 30° East longitude, enclosed by the sky-high mountains[13]. Chitral and Gilgit are situated in the north, Dir in the west, and Mardan in the south, while Indus separates it from Hazara in the east. On the basis of Physical Features, Swat is divided into two physical regions: Mountainous Ranges and Plains. Swat is divided into seven tehsils: Babuzai, Barikot, Kabal, Matta, Charbagh, Khwazakhela and Bahrain. Each tehsil is divided into certain number of union council[14].

Collection

The seven locations (Tehsils) were visited once a month from April 2014 to November 2016 for the collection of wasps. The wasps were captured by active searching with the help of hand net. After catching, the wasps specimens were killed with the help of insecticide spray (Mortein) in the net. The specimens were then stretched on setting boards and labelled with full data such as date and locality of the specimen with altitude, latitude and longitude and pinned in the insect box. Phenolphthalein balls were placed in the boxes as preservative.

Identification

The specimens were examined with the help of Stereoscope (Labomet CZM4-4X, Japan) and identified up to species level by running them through latest available literature, Vespine wasps of the world[5]; new records of vespid wasps from Yemen with synonymy in Belonogaster (Hymenoptera: Vespidae: Polistinae and Eumeninae)[15]; a catalogue of the Eumeninae (Hymenoptera: Vespidae) of the Ethiopian region[16]; catalogue of the vespid wasps of Iran[17].

Statistical Analysis

The relative abundance (R_A) of the species was calculated by using the formula[12], $R_A = n_i/N$, where n_i is the number of individuals in the ith species and N is the total number of individuals in the sample or sampling area.

The specie richness R was calculated by using Margalef's index[18] and Menhinick's index[19]. The forms of Margalef's and Menhenick's are $R = (S-1)/\ln(N)$ and $R = S/\sqrt{N}$, repesctively, where S is the number of species.

The diversity D was calculated by Simpson diversity index[20], $D = \sum n_i(n_i-1)/N(N-1)$, as D measures dominance, so the higher value of D lesser value of the diversity. In this index, 0 means infinite diversity and 1 represents no diversity, therefore, Simpson index of diversity $1-D$ was used. In this case, increase in value of Simpson (1-D) means increase in diversity.

RESULTS

The area wise collection representing the total number of individuals collected is summarized in Table 1. This included 11 species of the subfamily Eumeninae, 8 of Polistinae and 5 of Vespinae. At taxonomic level, Polistinae was the most abundant with a relative abundance of 65% followed by Vespinae 33% while the least abundant subfamily observed (2%) was Eumeninae (Table 2). At the species level *P. stigma* had a relative abundance of 28% in the family followed by *Vespula flaviceps* (20%) and *P. olivaceous* (14%).

Polistinae was the dominant subfamily in six locations represented by eight species and two genera in a set of 1548 specimens from the area. The genus *Polistes* is widely distributed while *Ropalidia* was present only in Kabal and Barikot. Out of the *Polistes* species, *P. olivaceous*, *P. wattii* and *P. flavus* were collected from all the locations except Bahrain. *P. rothneyi* was collected from five locations and *P. stigma* from two locations, i.e., Kabal and Khwaza Khela. Of the two species of *Ropalidia*, *R. cyathiformis* was collected in Kabal while *R. brevata* from Barikot. Vespinae were widely distributed in the study area and 798 specimens of the subfamily were collected from all the seven locations. The subfamily is represented in the area by five species; four in the genus *Vespa* and one in the genus *Vespula*. *Vespa velutina* was found to be the most common hornet of the study area and was collected from all the locations. According to the bee keepers of the area, this hornet is a voracious predator of the bee and hence poses great threat to the apiculture. The second common hornet was the *Vespa tropica* which was collected from six locations, *Vespa orientalis* was collected from Babozai and Barikot while *Vespa mandarinia* was only collected from Matta. In the area, only one species of the yellow jacket, *Vespula flaviceps*, is present and it was only collected from Kabal. A total

Table 1 Location wise collection of wasps.

Species	Kabal	Babozai	Matta	Barikot	Charbagh	Khwaza Khela	Bahrain	Total
Vespa velutina	139	60	31	25	13	14	9	291
Vespa tropica	15	5	1	4	1	1	–	27
Vespa orientalis	–	5	–	4	–	–	–	9
Vespa mandarinia	–	–	1	–	–	–	–	1
Vespula flaviceps	470	–	–	–	–	–	–	470
Polistes rothneyi	47	12	2	1	–	3	–	65
P. stigma	625	–	–	–	–	66	–	691
P. olivaceous	176	69	14	62	3	10	–	334
P. flavus	142	42	10	37	2	9	–	242
P. wattii	80	29	14	26	2	8	–	159
P. indicus	29	9	–	7	–	–	–	45
Ropalidia cyathiformis	10	–	–	–	–	–	–	10
Ropalidia brevata	–	–	–	2	–	–	–	2
Antepipona deflenda	1	–	–	–	–	–	–	1
Antepipona sibilans	1	–	–	–	–	–	–	1
Rhynchium spp 1	1	–	–	1	–	–	–	2
Rhynchium spp 2	1	–	–	–	–	–	–	1
Rhynchium spp 3	1	–	–	–	–	–	–	1
Rhynchium bruneum	5	4	–	–	–	–	–	9
Rhynchium quinquecinctum	11	6	–	–	–	–	–	17
Rhynchium carnaticum	–	1	–	–	–	–	–	1
Antodynerus flavescens	5	–	2	2	–	–	–	9
Delta dimidiatepenne	4	1	–	2	–	–	–	7
D. esuriens	–	–	–	2	–	–	–	2
Total	1763	243	75	175	21	111	9	2397

of 51 individuals representing 11 species under four genera of the subfamily Eumeninae were collected. Although the least abundant but most species rich, the Eumeninae is not evenly distributed among the seven locations. The members of the Eumeninae were only collected from Kabal, Babozai, Matta, and Barikot. Four species, *Antepipona deflenda*, *A. sibilans* and two unidentified species of the genus *Rhynchium* were only collected from Kabal, one species *Rhynchium carnaticum* from Babozai, one species *D. esuriens* from Barikot while the rest were shared by Kabal, Barikot and Matta or Babozai.

The Simpson index of diversity (1-D) value for the Eumeninae is 0.803 while those for Vespinae and Polistinae are 0.519 and 0.717, respectively. The values of Menhinick and Margalef indices are also highest for the Eumeninae as compared to Vespinae and Polistinae. The comparison in terms of richness and diversity is shown in Fig. 1.

From Tehsil Kabal, a total of 1763 specimens were collected representing 19 species under 8 genera of the 3 subfamilies and hence is the most diverse among the 7 tehsils. Of the total 19 species collected from Kabal, 13 are shared with other

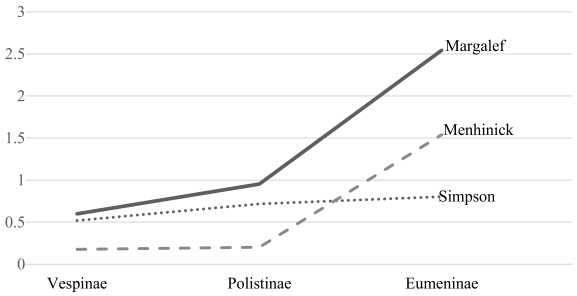

Fig. 1 Margalef, Simpson (1-D) and Menhinick indices for the 3 subfamilies of Vespidae.

locations and 6 are collected only from Kabal. From Babozai, 12 species were collected, in which *R. carnaticum* was only collected from this location. From Matta 8 species, Barikot 13 species, Charbagh 5 species, Khwaza Kheka 7 species and Bahrain, one species was collected (Table 1).

The data show that Kabal is the most diverse locality with a Simpson (1-D) value of 0.77 showing 77% diversity. Kabal was also found to be the most species rich, the value of Margalef index for the whole study area, i.e., Swat is 2.956, while the

Table 2 Relative abundance R_A of the species with in their own subfamilies and within the family.

Subfamily	Species	n_i	R_A	
			Subfamily	Family
Polistinae	*P. olivaceous*	334	0.216	0.139
($N = 1548$)	*P. wattii*	159	0.103	0.066
	P. flavus	242	0.156	0.102
	P. indicus	45	0.029	0.018
	P. rothneyi	65	0.042	0.027
	P. stigma	691	0.446	0.288
	R. brevata	2	0.002	0.001
	R. cyathiformis	10	0.006	0.004
Vespinae	*V. velutina*	291	0.365	0.121
($N = 798$)	*V. tropica*	27	0.034	0.011
	V. orientalis	9	0.011	0.004
	V. mandarinia	1	0.001	0.0004
	V. flaviceps	470	0.589	0.196
Eumeninae	*A. deflenda*	1	0.019	0.0004
($N = 51$)	*A. sibilans*	1	0.019	0.0004
	A. flavescens	9	0.176	0.004
	D. dimidiatepenne	7	0.137	0.003
	D. esuriens	2	0.039	0.001
	R. bruneum	9	0.176	0.004
	R. carnaticum	1	0.019	0.0004
	R. unidentified	2	0.039	0.001
	R. quinquecinctum	17	0.333	0.007
	R. unknown	2	0.039	0.001

Table 3 Diversity of the district Swat and its seven tehsils using Margalef, Simpson (1-D), and Menhinick diversity indices.

Location	*N*	Margalef	Simpson	Menhinick
Swat	2397	2.956	0.828	0.490
Kabal	1763	2.408	0.777	0.514
Babozai	243	2.003	0.744	0.770
Matta	75	1.621	0.739	0.924
Barikot	175	2.147	0.767	0.983
Charbagh	21	1.314	0.576	1.091
Khwaza K.	111	1.274	0.610	0.664
Bahrain	9	0	0	0.333

highest value is 2.408, among the 7 tehsils of Kabal. The Margalef, Simpson (1-D) and Menhinick values for Babozai were 2.00, 0.74, and 0.77, respectively. From Bahrain only nine specimens of one species, *Vespa velutina*, were collected representing zero diversity. Margalef, Simpson (1-D) and Menhinick values for Bahrain are 0, 0, and 0.33, respectively (Table 3).

DISCUSSION

This study was the first attempt to find out the diversity of Vespidae in the area. Various faunistic works on the Vespidae of Pakistan are available[21] but the present study explores the diversity among species of Vespidae with application of various diversity indices. A total of 24 species were identified from a sample size of 2397 individuals. It is necessary to identify and count the individuals properly up to species level for ecological purposes[22]. However, species quantification is difficult[23] but can be estimated using statistical tools such as species abundance distributions[11]. It was observed that the subfamily Eumeninae was the most diverse and species rich subfamily while the least diverse was the Vespinae. On the other hand, Polistinae was found to be the most abundant and dominant subfamily. The species diversity uses mathematical indices called diversity indices using information on evenness and richness[24]. It is useful to identify insects and to group them in accordance with their environment, climate, host, prey, and predators[9]. According to the feeding behaviour, it was observed that majority of the members of the Vespidae were carnivorous, though some also feed on plants or nectar. It is observed globally that herbivorous insects are more common than carnivorous[25]. Keeping in view the agricultural importance, the Vespidae plays a key role in pollination by visiting various flowers for nectar and insects and biological control by feeding the insects and their larvae[26]. Results reveal that numerically, Polistinae was the dominant and agronomically most important, as it was widely distributed in the area. According to Ref. 27, members of the Hymenoptera form major portion of the insect community and play vital role of agricultural importance.

The climate, landscape and agriculture of the area had a great effect on species richness and diversity[27]. The diversity and species richness observed in seven locations were different from each other. The most species rich and diverse locality was Kabal while the least diverse locality was Bahrain. District Swat falls in Sino Japanese region with characteristic vegetation including coniferous forests, open woodlands and rarely scrubs[28]. All the seven locations differ from each other in climate, physical features and vegetation. The study reveals that species richness variations are affected more by border effects than climatic factors. Of course no one community has the same biodiversity as the other even if both are having the same characters like

topography, vegetation and weather[29]. Although Kabal was the most species rich as calculated by Simpson and Menhinick indices but low evenness. A community with the low evenness is that where a few species dominate[30]. In all the sites except Bahrain, the wasps were dominated by Polistinae.

CONCLUSIONS

The study shows that the subfamily Eumeninae was the least abundant but most diverse and species rich. Only 51 specimens out of a total of 2397 belonged to this subfamily represented by 4 genera and 11 species. The most dominant subfamily was the Polistinae, second in terms of diversity and species richness. About 1548 specimens representing 2 genera and 8 species belong to the subfamily Polistinae. Second in terms of dominance and third in terms of species richness and diversity was the Vespinae having 798 specimens represented by 2 genera and 5 species. The study reflects that the area has a great potential and needs further exploration.

Acknowledgements: The Authors are thankful to the following staff of Govt: Degree College Kabal Swat, Prof. Fazli Rahman, Statistics Department, Mr Shamsher Ali and Mr Izhar Ali of Zoology Department for their help in the collection of wasps and statistical Analysis.

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