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Distribution of Family Vespidae (Insecta: Hymenoptera) in Sindh

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Abstract
Collection of different species of family Vespidae was carried out in different regions of Sindh. Sampling was sorted out into 35 species and sub-species under 17 genera below 03 sub-families viz. Eumeninae, Polistinae and Vespinae. Out of these species and subspecies found, 24 are part of the Oriental fauna, 10 are part of the Palearctic fauna, 12 are part of Afrotropical fauna and 03 are Palaeo-Oriental/ Palaeo-tropical fauna. This reconfirms the transitional bio-geographical position of the Pakistani fauna. However, 6 more species of family Vesidae are expected to be present in Sindh. About species diversity, the Shanon-Wiener's and Simpson's indices reveal comparatively lower diversity at zone AII: Piedmont Soil Region (0.6123 and 0.3236 respectively) and higher at C: Main Kotri Command Area (1.708 and 0.7406 respectively). Concerning richness, Margalef's and Menhinck's indices show lower diversity in zone AII: Piedmont Soil Region (0.3669 and 0.1965 respectively) and higher diversity in zone C: Main Kotri Command Area (1.431 and 0.5498 respectively). Regarding evenness, although both Shannon's equitability and Evennesse^H/S indices disclose lower diversity at zone BI: Non-Perennial Guddu Command Area (0.4661 and 0.3295 respectively) while Shannon's equitability index shows higher diversity at zone C: Main Kotri Command Area (0.7772) and Evennesse^H/S index shows higher diversity at zone AII: Piedmont Soil Region (0.6149) among all the seven agro-ecological zones of Sindh province.

Keywords: Vespidae, diversity, zones, evenness, species, Sindh

1. Introduction
It has been evidence from literature that Vespidae, is presumed to have evolved independently in ancient times within the insects' order Hymenoptera (Michener, 1969) [15]. Family Vespidae is one of the few groups that exhibit transitional status, social evolution, solitary status, pre-social arrangement, eusocial conduct (Crespi and Yanega, 1995) [6], and eusocial taxa (Hunt, 1999; Hunt, 2007) [11, 12]. This family includes some of the most common and prominent wasps such as yellow jackets, paper wasps, mason wasps and potter wasps etc. it is second most well studied family among the vespoid aculeates (Hunt *et al.*, 1991, Persson, 2015) [13, 16]. The family Vespidae has been chosen for this study due to reasons that it might provide a great opportunity to comprehend all aspects of insect life exhibited by this family. Moreover, this group is less explored and overlooked despite immense significance. Much work on this important family is conducted in different regions of the world. Some studies on exploration of fauna and systematics of subfamilies of family vespidae have also been conducted in Punjab and northern areas of Pakistan (Chaudhary *et al.*, 1966; Das and Gupta, 1989; Aziz, 2008; Gusenleitner, 2006, 2007, 2008; Mahmood *et al.*, 2012; Siddiqui *et al.*, 2015; and Bodlah *et al.*, 2015) [5, 7, 10, 11, 12, 13, 18]. All aforesaid literature showed that major share of vaspid fauna prevailing in Pakistan are belonging to subfamilies Eumeninae, Polistinae and Vespinae. The vaspid fauna of Sindh is largely unexplored. The essence of this study is taxonomic in nature with some new morphological discoveries related to the region, country or new to science as well as diversity, distribution and bio-geographical affiliation with specific bio-geographical region which has not carried out, despite the fact as mentioned above that biogeography of Pakistan represents major elements of Palaeractic biogeography followed with Oriental as well as Afro-tropical elements. Yet the Vaspidae fauna of Sindh is untouched therefore, present study is designed with prime object of its occurrence and distribution in this area.

2. Material and Methods
2.1 Selection of Localities
The basis of selection of localities for surveys was based on agro-ecological variations. The localities for surveys were selected out of three major agro-ecological zones of Sindh Province explicitly (A) Wheat-Rice zone of right-bank of Indus River in upper Sindh province, (B) Wheat-Cotton zone of left-bank of Indus River, and (C) Sugarcane-Wheat-Rice zone in lower Sindh province. Detail surveys were

conducted in seven localities representing the seven sub agro-ecological zones viz. (A-I) Main area of rice-wheat in Sindh–District Larkana,(A-II) Piedmont soil region–Dadu Zone, (B-I) Non-perennial Guddu command area – Ghotki Zone, (B-II) Perennial Sukkur command area – Sukkur Zone, (C) Main area of Kotri command – Jamshoro Zone, (D) Thar and Nara deserts–Tharparkar Zone, and (E) Kohistan/ hilly area – Karachi Zone.

2.2 Collection and Preservation
The wasp specimens were collected from each locality randomly from fields, gardens and other vegetation after a 20 days interval during the study. At each locality, collection of wasps were done from 8:00 AM to 12:00 PM. Arial net of proper bag size,comprising of soft fabric to curtail the chances of harm to wings of wasps, was used for collection. Spot catching of the wasps sitting on the walls or any other objects, their nests and bait collection in markets was also opted. After collection, the wasps were taken out of the nets and put into the killing bottles containing ethyl acetate or freezer for attaining their mortality. The collected wasp specimens were mounted on pins, labeled, and conserved in wooden-boxes with naphthalene as preservative. Field data of each locality such as date, location and coordinates were recorded. Besides this, description of localities in terms of flora and water resources etc. was also be made.

2.3 Identification
The wasp specimens were recognized in detail up to level of species and sub-species based on their morphological traits with the help of key given by Archer (1989) & Carpenter and Nguyen (2003) [4].

2.4 Species Diversity
Species diversity was measured by calculating its various parameters viz. species abundance, richness and evenness. For estimation of diversity indices, Rank Lists were created for every locality based on maximum abundance of species. Likewise, collective rank lists of localities containing list of taxa were also prepared. And the diversity was computed by applying Shannon-Weiner's diversity index (Shannon and Weiner, 1963) [17] and Simpson's index (Simpson, 1949) [19].

3. Results & Discussion
During present study, detail surveys and research work on Vespid wasps of Sindh province was conducted. The basis of selection of localities for surveys was based on agro-ecological variations. The wasp specimens were collected from 49 localities randomly from fields, gardens, vegetation and urban premises after a 20 days interval. This study provides the first annotated checklist of the vespid wasps of Sindh Province. The findings are based on recent collection and previously reported species/ subspecies of wasps from Sindh. A total of 35 species/ subspecies under 17 genera (Table 2-4) categorized under three subfamilies namely Eumeninae, Vespinae and Polistinae are documented (Table-1). Out of these species and subspecies found, 24 are part of the Oriental fauna, 10 are part of the Palearctic fauna, 12 are part of Afrotropical fauna and three are Palaeo-Oriental/ Palaeo-tropical fauna. This reconfirms the transitional bio-geographical position of the Pakistani fauna. However six more species of family Vesidae are expected to be present in Sindh. Regarding species diversity, the Shanon-Wiener's diversity index reveals comparatively lower diversity at AII: Piedmont Soil Region (0.6123) and higher C: Main Kotri Command Area (1.708) among all seven agro-ecological zones. While Simpson's Index shows lowest value (0.3236) of diversity at AII: Piedmont Soil Region and highest value (0.7406) at C: Main Kotri Command Area out of calculated values for all seven zones. Concerning richness, the Margalef's Index shows comparatively lower diversity in AII: Piedmont Soil Region (0.3669) and higher diversity in C: Main Kotri Command Area (1.431) among all seven zones. While Menhinck's Index shows lower diversity at zone AII: Piedmont Soil Region (0.1965) and higher diversity at C: Main Kotri Command Area (0.5498) as compare to other agro-ecological zones. Regarding evenness, the Shannon's equitability Index discloses lower diversity at zone BI: Non-Perennial Guddu Command Area (0.4661) and higher diversity at C: Main Kotri Command Area (0.7772). While the Evennesse^H/S shows reasonably lower diversity at BI: Non-Perennial Guddu Command Area (0.3295) and higher diversity at zone AII: Piedmont Soil Region (0.6149) among all the seven agro-ecological zones.

Table 1: Key for various sub-families of Vespidae

1	Parategula present on mesoscutum; Tarsal claws always cleft.	**Eumeninae**
--	Parategula absent on mesoscutum; Tarsal claws always simple…..	2
2	Hind wing lacking of jugal lobe; from dorsal view metasoma sessile in first tergum and laterally rapid declivity; dorsal carina present on metacoxa.	Vespinae
--	Hind wing having jugal lobe; from dorsal view metasoma subsessile or petiolate and laterally smooth declivity; dorsal carina not present on metacoxa.	Polistinae

Table 2: Vespid Fauna Collected from Sindh Province

Family Vespidae								
Genus	**Species**	**AI: Main Area**	**AII: Piedmont Soil Region**	**BI: Non-Perennial Guddu Command Area**	**BII: Perennial Sukkur Command Area**	**C: Main Kotri Command Area**	**D: Thar and Nara Deserts**	**E: Kohistan and Coastal Area**
Subfamily Eumeninae								
Allorhynchium	*Argentatum*	-	-	-	-	+	+	+
	Metallicum	-	-	-	-	+	-	+
Antepipona	*Sibilans*	+	-	+	+	-	-	-
	Ceylonica	-	-	+	-	-	-	-
Antodynerus	*flavescensflavescens*	+	-	-	+	-	-	-
	Limbatus	+	-	-	+	-	-	-
Delta	*dimidiatipenne*	+	+	-	+	+	+	+
	campaniformecampaniforme	-	-	+	-	-	-	-

	Esuriens	+	-	+	+	-	-	+
Knemodynerus	*Excellens*	+	-	+	+	-	-	-
Subfamily Polistinae								
Polistes	(*Polistes*) *indicus*	-	-	+	+	+	-	-
	(*Polistella*) *stigma tumula*	-	-	-	-	+	-	+
	(Gyrostoma) wattii	+	+	+	+	+	+	+
Ropalidia	*Bravita*	-	-	-	-	+	+	-
	variegate variegate	+	-	-	-	+	+	+
Subfamily Vespinae								
Vespa	*Orientalis*	+	+	+	+	+	+	+

Table 3: Specimens of Vespid Fauna Collected from Sindh Province

Species Name	Rank	Zones of Sindh							Total
		AI: Main Area	AII: Piedmont Soil Region	BI: Non-Perennial Guddu Command	BII: Perennial Sukkur Command Area	C: Main Kotri Command Area	D: Thar and Nara Deserts	E: Kohistan and Coastal Area	
Allorhynchiumargentatum	1	0	0	0	0	9	6	7	22
Allorhynchiummetallicum	2	0	0	0	0	6	0	9	15
Antepiponasibilans	3	23	0	19	34	0	0	0	76
Antepiponaceylonica	4	0	0	6	0	0	0	0	6
Antodynerusflavescensflavescens	5	13	0	0	27	0	0	0	40
Antodyneruslimbatus	6	18	0	0	17	0	0	0	35
Delta dimidiatipenne	7	27	18	0	23	15	29	12	124
Delta campaniformecampaniforme	8	0	0	9	0	0	0	0	9
Delta esuriens	9	7	0	12	16	0	7	13	55
Knemodynerusexcellens	10	3	0	7	9	0	0	0	19
Polistes (Polistes) indicus	11	0	0	9	11	18	0	0	38
Polistes (Polistella) stigma tumula	12	0	0	0	0	13	0	21	34
Polistes (Gyrostoma) wattii	13	239	189	264	193	118	203	384	1590
Ropalidiabravita	14	0	0	0	0	19	26	0	45
Ropalidiavariegatavariegata	15	16	0	0	0	12	23	17	68
Vespa orientalis	16	47	26	17	37	58	62	79	326
Total									2502

Table 4: Diversity Indices of Vespid Fauna in Agro-Ecological Zones of Sindh

Diversity Indices	Zones of Sindh						
	AI: Main Area	AII: Piedmont Soil Region	BI: Non-Perennial Guddu Command	BII: Perennial Sukkur Command Area	C: Main Kotri Command Area	D: Thar and Nara Deserts	E: Kohistan and Coastal Area
Taxa_S	9	3	8	9	9	7	8
Individuals	393	233	343	367	268	356	542
Simpson_1-D	0.6025	0.3236	0.3987	0.6898	0.7406	0.6277	0.4728
Shannon_H	1.4	0.6123	0.9692	1.63	1.708	1.343	1.057
Evenness_e^H/S	0.4505	0.6149	0.3295	0.5672	0.6129	0.5473	0.3599
Menhinick	0.454	0.1965	0.432	0.4698	0.5498	0.371	0.3436
Margalef	1.339	0.3669	1.199	1.355	1.431	1.021	1.112
Equitability_J	0.6371	0.5573	0.4661	0.7419	0.7772	0.6902	0.5085

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