SPECIES DIVERSITY, ABUNDANCE AND SPATIAL DISTRIBUTION OF WASPS (HYMENOPTERA: VESPIDAE) IN DISTRICT BAJAUR, PAKISTAN

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Abstract

Wasps (Hymenoptera: Vespidae) play a vital ecological role as predators and natural biological control agents in diverse ecosystems. This study investigated the species composition, abundance and spatial distribution of wasps in District Bajaur, Khyber Pakhtunkhwa, Pakistan. Field surveys were conducted across five tehsils (Salarzai, Utman Khel, Khar, Barang and Mamund) from August to September 2024, using aerial nets and insecticide immobilization to collect adult specimens. Collected individuals were preserved, pinned and identified to the species level using standard taxonomic keys. Data were organized and statistically analyzed to evaluate species composition, distribution patterns and biodiversity indices. A total of 934 adult wasp specimens representing seven species, two subfamilies (Polistinae and Vespinae) and one family (Vespidae) were recorded. Among the species, Polistes olivaceus was the most abundant (24.84%), followed by Polistes herbaceus (19.70%) and Vespa orientalis (19.27%), while Vespula germanica was the least abundant (0.32%). The subfamily Polistinae accounted for 60% of the total population, whereas Vespinae contributed 40%. Tehsil-wise, Salarzai (231 specimens) and Mamund (216 specimens) showed the highest abundance, while Utman Khel (152 specimens) recorded the lowest. Locality-wise analysis revealed hotspots of abundance in Bartrass, Kamal Dara and Damadola, suggesting that habitat characteristics, nesting opportunities, and resource availability strongly influence species distribution. Biodiversity indices indicated moderate species diversity (Shannon H' = 1.75, Simpson D = 0.82) and high evenness (Pielou J = 0.90), reflecting a relatively balanced wasp community. These findings demonstrate that District Bajaur supports a diverse and widely distributed wasp community, with Polistinae species being dominant. The study provides baseline data for entomological research, biodiversity monitoring and potential application of wasps as biological control agents. Further investigations considering seasonal dynamics and additional habitats are recommended to better understand the ecological roles and conservation status of wasp populations in the region.

INTRODUCTION

Wasps belonging to the family Vespidae (Order: Hymenoptera) represent one of the most diverse and ecologically significant groups of insects. They are widely distributed across the globe and inhabit a variety of ecosystems ranging from forests and grasslands to agricultural and urban environments. Wasps play an important ecological role as predators and natural biological control agents because they feed on larvae and adults of many harmful insect species that damage crops and vegetation. Through this predatory behavior, they contribute significantly to maintaining ecological balance and regulating pest populations (Mahmood *et al.,* 2012; Ross & Matthews, 1991). Due to their ecological importance and behavioral diversity, wasps have become a subject of increasing interest in biodiversity and entomological studies.

The diversity and distribution of insect species are strongly influenced by ecological factors such as habitat availability, vegetation structure and geographic area. One of the key ecological concepts explaining species diversity is the species–area relationship, which suggests that larger areas generally support a greater number of species due to habitat heterogeneity and resource availability (Connor & McCoy, 1979). Environmental variation and ecological adaptation also influence the abundance and distribution of insect populations over time (Schoener, 1976). Wasps, in particular, exhibit considerable adaptability to different environmental conditions, which allows them to occupy a wide range of habitats and climatic regions.

Globally, wasps are distributed across several major biogeographical regions, including the Ethiopian, Oriental and Neotropical regions, where their diversity is relatively high. In contrast, comparatively fewer species are found in the Palearctic, Nearctic, and Australian regions (Dvořák, 2007). Pakistan occupies a unique zoogeographical position at the intersection of the Oriental and Palearctic regions, which makes it an important area for biodiversity research.

Approximately 21 species of social wasps have been reported from different parts of Pakistan, including twelve species belonging to the subfamily Polistinae and nine species belonging to Vespinae (Dvořák, 2007). Previous studies conducted in northern Pakistan, such as in the Swat region, have also documented several species of the genera *Vespa* and *Vespula*, highlighting the region's potential for further taxonomic and ecological investigations (Rasool, 2017).

Climatic and environmental factors such as temperature, humidity, rainfall and vegetation patterns play a significant role in shaping the distribution and abundance of wasp populations. Temperature, in particular, strongly influences insect metabolism, activity levels and reproductive cycles. Wasps are generally more abundant in warm and temperate environments where ecological conditions support their survival and colony development (Alkhalaf *et al.,* 2015). Despite their ecological importance, studies on the diversity and spatial distribution of wasps in Pakistan remain limited, especially in remote and mountainous regions such as District Bajaur, Khyber Pakhtunkhwa. Therefore, the present study aims to investigate the species composition and spatial distribution of wasps in District Bajaur to contribute to the understanding of regional biodiversity and ecological dynamics.

MATERIALS AND METHODS

Study Area

The study was conducted in District Bajaur, Khyber Pakhtunkhwa, Pakistan, a mountainous region along the Pakistan-Afghanistan border. The area comprises diverse habitats including agricultural fields, forests, grasslands and human settlements. The climate is generally semi-arid to temperate, with hot summers and relatively cold winters (Shah *et al.,* 2025a, 2025b, 2026). Field surveys were carried out in five tehsils (Salarzai, Utman Khel, Khar, Barang and Mamund) to document the species composition, abundance, and distribution of wasps (Hymenoptera: Vespidae) across different habitats.
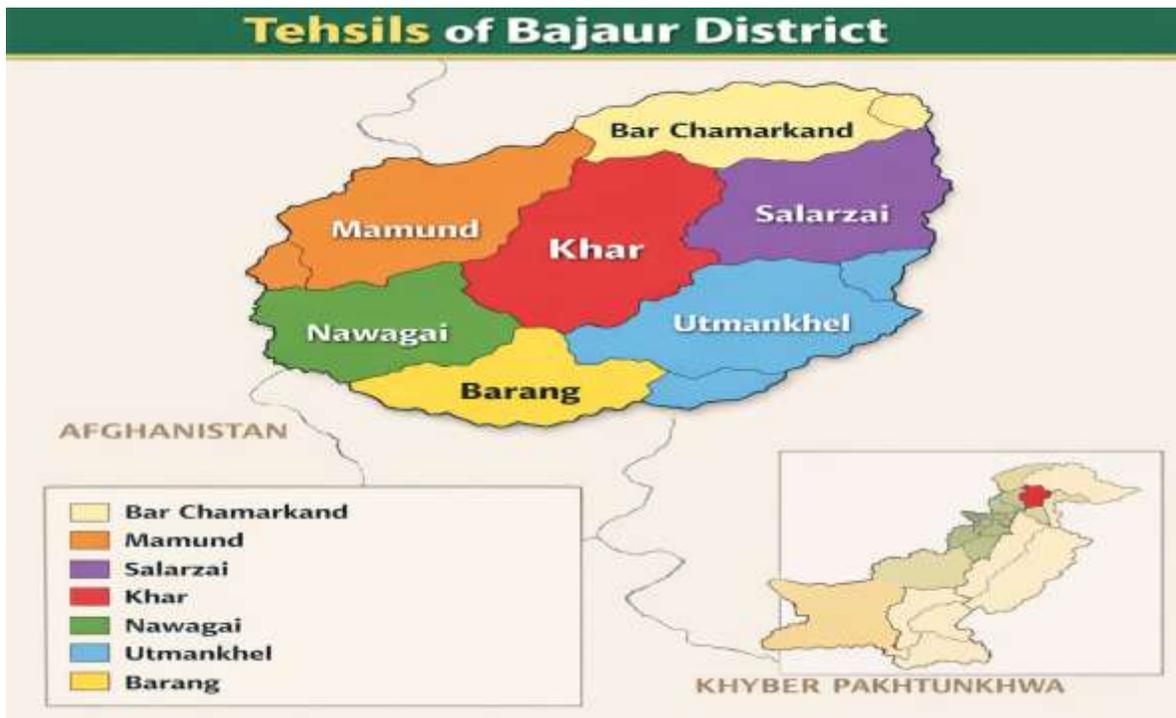
Map of study area

Sampling and Collection of Specimens
Field sampling was performed from August to September 2024. Adult wasps were collected using an aerial insect net from diverse habitats including agricultural fields, vegetation and residential areas. Specimens were immobilized using insecticide spray (Cobra) for safe handling. Collected individuals were carefully pinned with entomological pins and preserved in insect collection boxes to maintain their morphological characteristics. All specimens were kept in the Entomology Laboratory, Department of Zoology, Abdul Wali Khan University Mardan for identification and further analysis.

Identification of Specimens
In the laboratory, the collected specimens were examined and identified to the species level using standard taxonomic keys and relevant literature. Diagnostic morphological features such as body size, coloration, wing venation, antennae and other species-specific traits were observed to ensure accurate identification.
Data Organization and Analysis

Data on species composition, abundance, and collection sites were recorded and organized using Microsoft Excel and data were analyzed by biodiversity indices.

Biodiversity Indices
To evaluate the diversity and distribution pattern of wasp species in District Bajaur, different biodiversity indices including the Shannon–Wiener diversity index (H′), Simpson diversity index (1 − D), and Pielou's Evenness index (J) were calculated based on the relative abundance of each species.

Shannon–Wiener diversity index (H′)
The Shannon–Wiener diversity index (H′) was used to measure species diversity in the study area and was calculated using the following formula:
$$H' = -\sum (pi. \ln pi)$$
Where pi is the proportion of individuals of species i relative to the total number of individuals in the sample.
Simpson diversity index

The Simpson diversity index was calculated to determine the probability that two individuals randomly selected from the sample belong to different species. First, Simpson's dominance index (D) was calculated as:

$$D = \sum p_i^2$$

The Simpson diversity value was then calculated using:

$$1 - D$$

Higher values of $(1 - D)$ indicate greater species diversity within the community.

Pielou's Evenness index (J)
Pielou's Evenness index (J) was used to determine how evenly individuals are distributed among the recorded species and was calculated using the formula:

$$J = \frac{H'}{\ln(S)}$$

Where H′ is the Shannon diversity index and S represents the total number of species recorded in the study area.

These biodiversity indices were calculated using the relative abundance data of the recorded wasp species to assess the diversity and distribution patterns in District Bajaur.

RESULTS
Species Composition of Wasps in District Bajaur
A total of 934 wasp specimens belonging to seven species, two subfamilies (Polistinae and Vespinae), and one family (Vespidae) were collected from different tehsils of District Bajaur during the study period. Among the recorded species, three species belonged to the subfamily Polistinae (*Polistes indica*, *Polistes olivaceus* and *Polistes herbaceous*) and four species belonged to the subfamily Vespinae (*Vespa orientalis*, *Vespa velutina*, *Vespa tropica* and *Vespula germanica*).

Among all recorded species, *Polistes olivaceus* was the most abundant species with 232 individuals (24.84%), followed by *Polistes herbaceous* with 184 individuals (19.70%) and *Vespa orientalis* with 180 individuals (19.27%). *Polistes indica* represented 144 individuals (15.42%), while *Vespa tropica* accounted for 111 individuals (11.88%) of the total collected specimens. *Vespa velutina* was comparatively less abundant with 80 individuals (8.57%), whereas *Vespula germanica* was the least recorded species with only 3 individuals (0.32%) during the entire study period.

Overall, the subfamily Polistinae contributed 560 individuals (approximately 60%), whereas the subfamily Vespinae contributed 374 individuals (approximately 40%) of the total collected wasp population, indicating that Polistinae species were relatively more abundant in the study area.

Table: 1. Distribution of species in different tehsils of district Bajaur.

Family	Sub family	Species	Salarzai	Utman Khel	Khar	Barang	Mamund	Total	%age
Vespidae	Polistinae	*Polistes indica*	34	29	18	25	38	144	15.42%
Vespidae	Polistinae	*Polistes olivaceus*	62	32	42	51	45	232	24.84%
Vespidae	Polistinae	*Polistes herbaceus*	30	40	25	37	52	184	19.70%
Vespidae	Vespinae	*Vespa orientalis*	65	27	19	26	43	180	19.27%

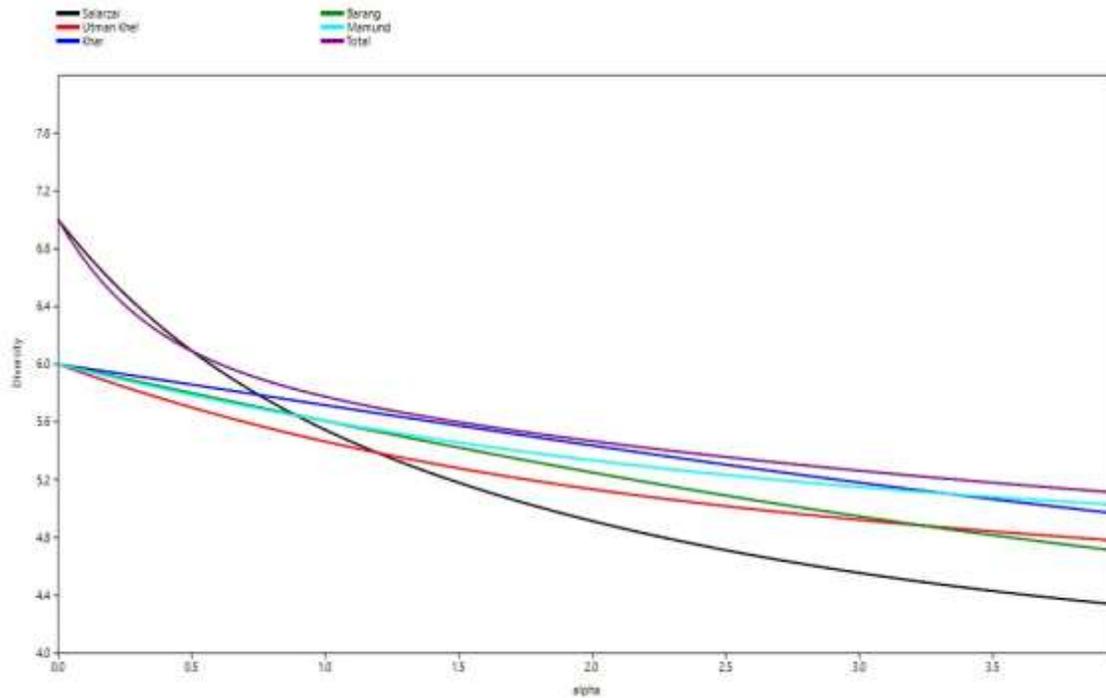| Vespidae	Vespinae	*Vespa velutina*	14	09	21	16	20	80	8.57%
Vespidae	Vespinae	*Vespa tropica*	23	15	31	24	18	111	11.88%
Vespidae	Vespinae	*Vespula germanica*	3	00	00	00	00	03	0.32%
Total			231	152	156	179	216	934	100%

Figure: 1. Diversity profile of species in different tehsils of Bajaur.

Spatial Distribution of Wasps in Different Tehsils

The distribution of wasp species varied among the five surveyed tehsils of District Bajaur. The highest number of specimens was recorded from Salarzai Tehsil, with 231 individuals, representing the highest species abundance in the study area. This was followed by Mamund Tehsil, where 216 individuals were collected. Barang Tehsil contributed 179 specimens, while Khar Tehsil accounted for 156 individuals. The lowest number of wasp specimens was recorded from Utman Khel Tehsil, where 152 individuals were collected.

The results indicate that wasps are widely distributed across all surveyed tehsils of District Bajaur, although their abundance varied among locations. The relatively higher abundance in Salarzai and Mamund may be associated with the presence of suitable habitats, vegetation cover and availability of food resources that support wasp populations.

Table: 2. Overall collected species in different tehsils

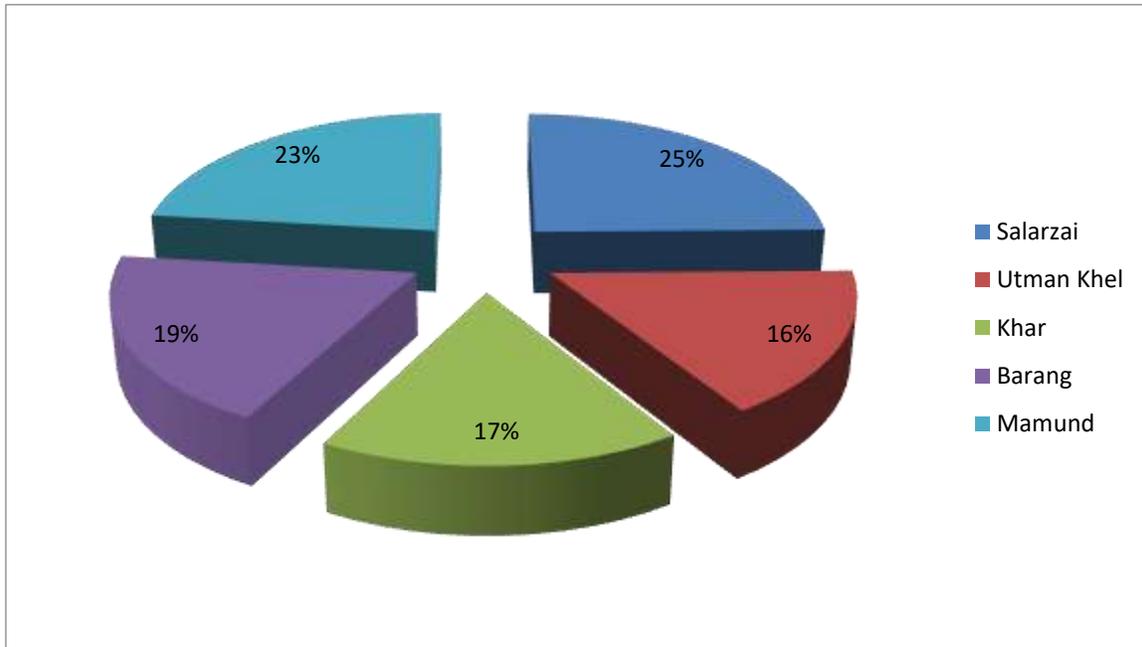| S.NO	Tehsils	Collected Species
1	Salarzai	231
2	Utman Khel	152
3	Khar	156
4	Barang	179
5	Mamund	216

Figure: 2. Number of collected species in different tehsils

Locality-wise Distribution of Wasps in District Bajaur

The distribution of wasp specimens was further analyzed at the locality level within each tehsil of District Bajaur. A total of 934 specimens were collected from 16 different localities across the five tehsils. The results indicate noticeable variation in species abundance among different sampling sites, suggesting that local environmental conditions and habitat characteristics may influence wasp distribution.

In Salarzai Tehsil, three localities were surveyed including Bartrass, Pashat and Batwar. Among these sites, Bartrass recorded the highest number of specimens (90 individuals), followed by Batwar with 75 individuals, while Pashat contributed 66

individuals. The geographical coordinates for these sites ranged between 34.50–34.95° latitude and 71.17–71.52° longitude, indicating their distribution across different ecological locations within the tehsil.

In Utman Khel Tehsil, wasp specimens were collected from Hayati, Arang and Seri Sar. The highest number of specimens was recorded from Arang (78 individuals), followed by Hayati (54 individuals), while Seri Sar showed comparatively lower abundance with 20 individuals. These sites were located between 34.30–34.76° latitude and 71.11–71.76° longitude, reflecting variation in local environmental conditions within the tehsil.

Similarly, in Khar Tehsil, four localities were surveyed including Jar, Raghagan, Tangkhata and

Loi Sam. Among these sites, Jar recorded the highest number of specimens (46 individuals), followed by Loi Sam (43 individuals), Tangkhata (35 individuals), and Raghagan (32 individuals). In Barang Tehsil, specimens were collected from Kohi Sar, Memolo, and Kamal Dara, where Kamal Dara showed the highest abundance with 83 individuals, followed by Kohi Sar (55 individuals) and Memolo (41 individuals). In Mamund Tehsil, four localities were surveyed including Bar Khalozo, Shago, Lagharai and Damadola. Among these, Damadola recorded the highest number of specimens (70 individuals),

followed by Bar Khalozo (62 individuals), Shago (49 individuals), and Lagharai (35 individuals).

Overall, the results demonstrate that wasps were widely distributed across different tehsils and localities of District Bajaur, although their abundance varied considerably among sampling sites. These variations may be influenced by factors such as habitat type, vegetation cover, availability of food resources, and climatic conditions, which play an important role in determining the distribution patterns of wasp species.

Table: 3. Distribution of wasp species in different localities of district Bajaur

| Tehsil	Locality	No of Specimen collected	Co-ordinates	
			Latitude	Longititude
Salarzai	Bartrass	90	34.50	71.17
	Pashat	66	34.86	71.52
	Batwar	75	34.95	71.51
Utman khel	Hayati	54	34.30	71.11
	Arang	78	34.76	71.76
	Seri Sar	20	34.68	71.70
Khar	Jar	46	34.41	71.30
	Raghagan	32	34.79	71.75
	Tangkhata	35	34.72	71.49
	Loi sam	43	34.66	71.29
Barang	Kohi sar	55	34.78	71.58
	Memolo	41	34.61	71.64
	Kamal Dara	83	34.63	71.59
Mamund	Bar khalozo	62	34.75	71.45
	Shago	49	34.73	71.44
	Lagharai	35	34.81	71.35
	Damadola	70	34.80	71.47
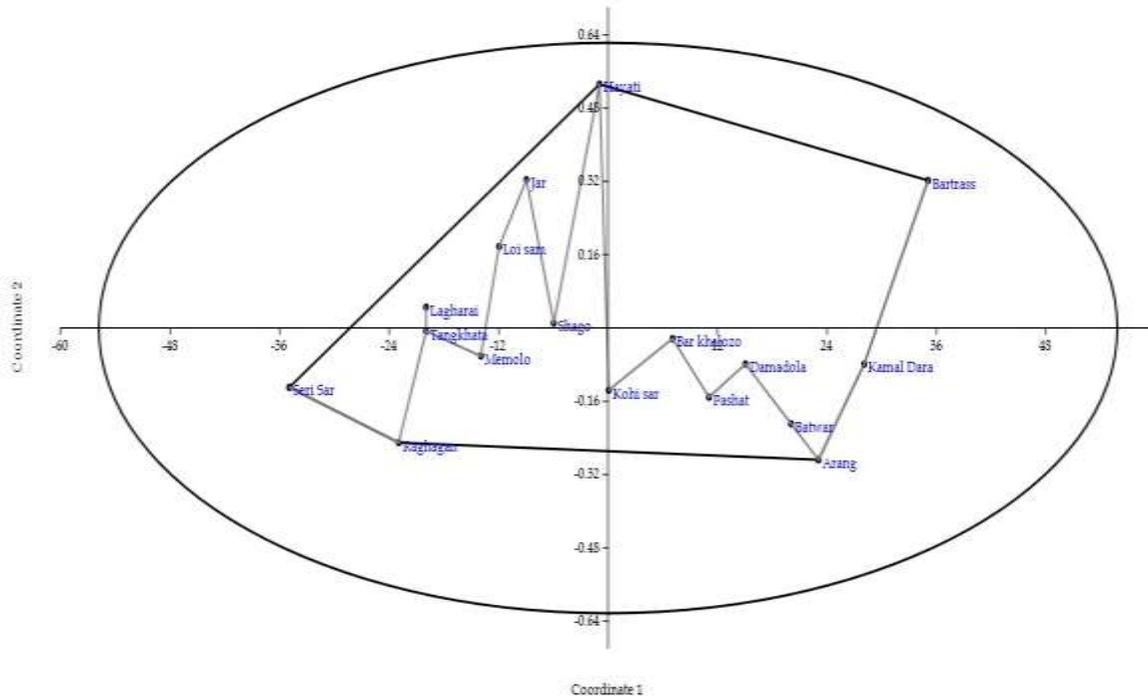
Figure: 3. Principal coordinates analysis of species distribution

Biodiversity Indices of Wasps in District Bajaur

To evaluate the diversity and distribution pattern of wasp species in District Bajaur, different biodiversity indices including Shannon-Wiener diversity index (H′), Simpson diversity index (D), and Pielou's Evenness index (J) were calculated based on the relative abundance of the recorded species.

The Shannon-Wiener diversity index (H′) was calculated to measure species diversity within the study area. The calculated value of H′ = 1.75, indicating a moderate level of species diversity of wasps in District Bajaur. This suggests that the study area supports a relatively diverse wasp community.

The Simpson diversity index $(1 - D)$ was also calculated to determine the probability that two randomly selected individuals belong to different species. The calculated value of Simpson's diversity index was 0.82, indicating a high probability of species diversity and suggesting that no single species completely dominates the wasp community.

In addition, Pielou's Evenness index (J = 0.90) was calculated to evaluate how evenly individuals are distributed among the recorded species. The value close to 1 indicates that individuals are fairly evenly distributed among the different species, although some species such as *Polistes olivaceus* were comparatively more abundant.

Table: 4. Different diversity indices

Index	Value
Shannon Diversity (H′)	1.75
Simpson Diversity (1−D)	0.82
Pielou Evenness (J)	0.90

Overall, the calculated biodiversity indices indicate that District Bajaur supports a moderately diverse and relatively balanced wasp community, with variation in species abundance influenced by habitat characteristics and environmental conditions.

DISCUSSION

The present study documented the species composition and distribution of wasps (Hymenoptera: Vespidae) in District Bajaur, Khyber Pakhtunkhwa, Pakistan. A total of 934 specimens belonging to seven species and two subfamilies (Polistinae and Vespinae) were recorded during the study period. Among the identified species, the subfamily Polistinae was more abundant than Vespinae, indicating that paper wasps are more common in the study area. Similar patterns of dominance of Polistinae species have been reported in previous studies conducted in different regions, where paper wasps showed higher abundance due to their adaptability to diverse habitats and nesting behavior (Ross & Matthews, 1991).

Among the recorded species, *Polistes olivaceus* was the most abundant species, followed by *Polistes herbaceus* and *Vespa orientalis*. The dominance of *Polistes* species may be attributed to their ability to utilize a wide range of nesting sites such as trees, buildings, and vegetation, which increases their chances of survival in different environments. Previous studies conducted in Pakistan and neighboring regions have also reported *Polistes olivaceus* as one of the most common and widely distributed social wasp species (Mahmood et al., 2012; Dvořák, 2007). The relatively low abundance of Vespula germanica observed in the present study may be due to its limited habitat preference and ecological requirements compared to other species.

The spatial distribution of wasps across different tehsils of District Bajaur revealed noticeable variation in species abundance. The highest number of specimens was recorded from Salarzai and Mamund tehsils, while Utman Khel showed comparatively lower abundance. These variations may be associated with differences in vegetation cover, habitat diversity and availability of food resources in different localities. Areas with rich vegetation and suitable nesting substrates provide favorable conditions for wasp colonies to establish and grow. Similar findings have been reported by other researchers who observed that habitat structure and environmental conditions strongly influence the distribution and abundance of social wasps (Oliveira et al., 2017). Locality-wise analysis further showed that certain sites such as Bartrass, Kamal Dara, and Damadola recorded relatively higher numbers of specimens compared to other localities. These areas likely provide suitable environmental conditions including availability of prey insects, flowering plants for nectar, and appropriate nesting sites. Climatic factors such as temperature and humidity also play an important role in regulating insect populations and their distribution patterns (Alkhalaf *et al.*, 2015). Wasps generally thrive in warm environments where metabolic and reproductive activities are optimal.

The calculated biodiversity indices also indicated a moderate level of species diversity and relatively even distribution of species in the study area. This suggests that District Bajaur provides favorable ecological conditions for the survival of multiple wasp species. However, the presence of some dominant species alongside rare species indicates ecological variation among habitats.

Overall, the present study contributes valuable information regarding the diversity and distribution of wasps in District Bajaur, an area where entomological studies are still limited. The findings highlight the ecological importance of wasps as predators and natural biological control agents in local ecosystems. Further studies covering longer sampling periods and additional habitats are recommended to better understand the seasonal diversity and ecological roles of wasps in the region.

CONCLUSION

The present study assessed the species composition, abundance and distribution of wasps (Hymenoptera: Vespidae) in District Bajaur, Khyber Pakhtunkhwa, Pakistan. A total of 934 specimens representing seven species from

two subfamilies (Polistinae and Vespinae) were recorded across five tehsils. *Polistes olivaceus* was the most abundant species, followed by *Polistes herbaceus* and *Vespa orientalis*, while *Vespula germanica* was least abundant. Polistinae dominated over Vespinae, indicating better adaptation to local environmental conditions. Spatial variation showed higher abundance in Salarzai and Mamund compared to Utman Khel, likely due to differences in vegetation, habitat, and climate. Biodiversity indices revealed moderate diversity with high evenness, suggesting a balanced community. This study provides baseline data on wasp diversity and distribution, emphasizing their ecological role as natural biological control agents and highlighting the need for further long-term and seasonal investigations.

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