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Original Article

Spider diversity in different habitats at District Mardan, Khyber Pakhtunkhwa Pakistan

Diversidade de aranhas em diferentes habitats no Distrito de Mardan, Khyber Pakhtunkhwa, Paquistão

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Abstract

Spider species are important for maintaining ecological balance, controlling insect populations, and providing potential sources of medicinal compounds. Highlighting the importance of spider species, the present study was aimed at exploring the diversity of spider fauna and species richness in various habitats in District Mardan, Khyber Pakhtunkhwa, Pakistan, from March 2021 to December 2021. Spiders were collected through different methods: pitfall traps, cryptic searching, ground hand collection, aerial hand collection, and vegetation beating. Then, the captured spiders were washed in alcohol and preserved in a combination of 80% alcohol and 20% glycerol for further observation. Identification was carried out with the help of available spider identification keys and literature. A total of 578 specimens representing 29 species from 17 families and 26 genera were collected and identified. Family Lycosidae was the most dominant family (13.49%), followed by Salticidae (10.2%), Araneidae (8.47%), Tetragnathidae (7.61%), Pholicidae (6.4%), Oxyopidae (5.88%), Thomisidae (5.7%), Clubionidae (5.53%), Sicariidae (5.19%), Scytodidae (5.01%), Corinnidae (4.67%), Agelenidae (4.32%), Cheiracanthiidae and Sparassidae (4.15%), Oecobiidae and Hersiliidae (3.97%) and Theridiidae was the rarest among all (1.21%). The most commonly identified species are *Hippasa partita*, *Lycosa poonaesis*, *Lycosa terrestris*, *Draposa oakleyi*, *Plexippus paykulli*, *Menemerus nigli*, *Thyene imperialis*, *Thyene bivittate* and *Hasarius adansoni*. *Argiope versicolor*, *Neoscona theisi*, *Tetragnatha extensa*, *Crossopriza lyoni*, and *Oxyopes Javanus*. During the present study, it was observed that spider species were abundantly found in warm areas from May to August, which demonstrates that the spider fauna of the study area is very rich but has yet to be explored.

Keywords: spider species, District Mardan, Khyber Pakhtunkhwa, Pakistan.

Resumo

As espécies de aranhas são importantes para manter o equilíbrio ecológico, controlar populações de insetos e fornecer fontes potenciais de compostos medicinais. Destacando a importância das espécies de aranhas, o presente estudo teve como objetivo explorar a diversidade da fauna de aranhas e a riqueza de espécies em vários habitats no Distrito de Mardan, Khyber Pakhtunkhwa, Paquistão, de março de 2021 a dezembro de 2021. As aranhas foram coletadas por meio de diferentes métodos: armadilhas de queda, busca críptica, coleta manual no solo, coleta manual aérea e batida na vegetação. Em seguida, as aranhas capturadas foram lavadas em álcool e preservadas em uma combinação de 80% de álcool e 20% de glicerol, para observação posterior. A identificação foi realizada com a ajuda de chaves de identificação de aranhas disponíveis e da literatura. Um total de 578 espécimes representando 29 espécies, de 17 famílias e 26 gêneros, foram coletados e identificados. A família Lycosidae foi a família mais dominante (13,49%), seguida por Salticidae (10,2%), Araneidae (8,47%), Tetragnathidae (7,61%), Pholicidae (6,4%), Oxyopidae (5,88%), Thomisidae (5,7%), Clubionidae (5,53%), Sicariidae (5,19%), Scytodidae (5,01%), Corinnidae (4,67%), Agelenidae (4,32%), Cheiracanthiidae e Sparassidae (4,15%), Oecobiidae e Hersiliidae (3,97%) e Theridiidae, que foi a mais rara entre todas (1,21%). As espécies mais comumente identificadas são *Hippasa partita*, *Lycosa poonaesis*, *Lycosa terrestris*, *Draposa oakleyi*, *Plexippus paykulli*, *Menemerus nigli*, *Thyene imperialis*, *Thyene bivittate* e *Hasarius adansoni*, *Argiope versicolor*, *Neoscona theisi*, *Tetragnatha extensa*, *Crossopriza lyoni* e *Oxyopes Javanus*. Durante o estudo atual/presente, observou-se que espécies de aranhas foram encontradas abundantemente em áreas quentes de maio a agosto, o que demonstra que a fauna de aranhas da área de estudo é muito rica, mas ainda pouco explorada.

Palavras-chave: espécies de aranhas, Distrito Mardan, Khyber Pakhtunkhwa, Paquistão.

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1. Introduction

Spiders are ancient invertebrates that belong to the phylum Arthropoda, subphylum Chelicerate, class Arachnida, and order Araneae (Escuer et al., 2022). The early spiders were larger and had segmented bodies, but today's spiders almost all have non-segmented abdomens. Only the suborder Mesothelae has been described as having a segmented abdomen, and they are generally regarded as the oldest spider species (Nooreen et al., 2017). They are distinguished from insects by the absence of antennae and wings and the presence of eight rather than six legs. Also, they have two body components (cephalothorax and abdomen), eight legs with seven segments, and pedipalps (Ghazanfar et al., 2016). The cephalothorax on the dorsal side is covered by the carapace, a stiff sclerotic shield, and on the ventral side by the sternum (Dippenaar, 2014). Spider's species are different from one another by their size, shape, and length. Based on their size, shape, length, and eye shape.

Spider comes in various shapes, sizes and lengths. They range in size from the tiny Samoan moss spider *Patu marplesi*, *with a leg span of 0.5 mm*, *to the giant bird-eating goliath tarantula (Theraphosa blondi)*, which has a body length of 75 mm with leg length up to 255 mm (Perveen et al., 2012). Female spiders are larger than male spiders (Perveen and Khan, 2015).

They live in various habitats, including houses, ground, meadows, woods, croplands, woodlands, and flower petals, where they catch prey, and they also have adopted an aquatic lifestyle (Abbas et al., 2018). Physical conditions such as temperature, humidity, wind, and light intensity and biological factors such as vegetation density, height, competitors, enemies, and prey availability are the essential factors that play a significant role in spider community structure. Thus, these abilities give them the strength to be stable in various ecological habitats and different environmental conditions (Spears and MacMahon, 2012).

Spiders are one of the most important predators in controlling pests in various crops (Mishra et al., 2012). Adult spiders are all predaceous, which means they can help control pest populations. However, individual spider species, on the other hand, lack many of the qualities that have been proposed as essential for a successful biological control agent (Pearce et al., 2004). Their diversity, distribution, and feeding habits are all important aspects of nature's balance (Perveen and Khan, 2015). Their venom is less harmful as compared to pesticides used in agroecosystems and is also used as testing for the treatment of heart disease. Spiders also control the population of arachnids and spiders of the same species by killing. They are also an important food source for a variety of birds, lizards, wasps, and, particularly, desert animals (Novak, 2001; Perveen et al., 2012).

Spiders are the most widespread and diverse predators. There are 129 families, 4218 genera, and 49513 species globally (WSC, 2021). Many species, particularly in the Tropics, have yet to be identified and described (Sebastian and Peter, 2009). Several authors document the diversity of spiders in Pakistan well. For example, they reported 504 species of spiders from Pakistan, while Ali et al. (2018) documented 62 species from Cholistan and vicinities (Pakistan). Parveen et al. (2007) recorded 157 species of spiders from Punjab, Pakistan; however, 56 species from Sargodha, Punjab, Pakistan. Kazim et al. (2014) reported 80 species of spiders from Karachi, Sindh, Pakistan. Similarly, a few researchers in the province of Khyber Pakhtunkhwa are also studying the diversity and distribution of spiders peculiar to individual sites. Eight species of spiders were recorded by Sajid et al. (2021) from District Dir Lower in the Malakand Division; 44 species were documented by Nooreen et al.. (2017) from Charsadda, Khyber Pakhtunkhwa; twelve species were reported by Khan and Zaman (2015) from Pir Baba District Buner; sixteen species were recorded from Mitha Khel and its territories, Karak; and twenty-three species were recorded by Perveen et al. (2012) from the Frontier region of Peshawar, Khyber Pakhtunkhwa.

However, land cover and use have changed recently as a result of developmental activities. This results in extensive devastation and an invasion of the forest ecosystem. As a result of urbanisation, the number of spiders is decreasing continuously. Therefore, it is crucial to conduct a site-specific analysis of the diversity of spiders in order to develop a comprehensive plan for the restoration of habitats and future species protection. Thus, a study was carried out in the Khyber Pakhtunkhwa region of Mardan to figure out the distribution of spiders in various settings.

2. Materials and Methods

2.1. Study area

This study was conducted in the district of Mardan, Khyber Pakhtunkhwa (KP) province of Pakistan. District Mardan is the second largest city in the Khyber Pakhtunkhwa province, with a total covered area of 1632 square kilometres (Figure 1). District Mardan is surrounded by districts Swabi and Buner on the east and the north by district Malakand. On the western side, district Mardan is surrounded by district Charsadda, while on the southern side by district Nowshera (Gul et al., 2022). The region has distinct summer and winter seasons, with an average temperature of 22 °C and an annual rainfall of 559 mm. Topographically, the area has plains in the south and west and mountainous terrain in the northeast (Gul et al., 2022). According to the 2017 population census, the total population of the district Mardan is 2,373,061 individuals (Pakistan Bureau of Statistics, 2017). Administratively, there are three tehsils of district Mardan: Takht Bhai, Katlang, and Mardan itself (Khyber Pakhunkhwa, 2024).

2.2. Study duration

The present study was conducted from March 2021 to December 2021 in various habitats of District Mardan of Khyber Pakhtunkhwa Province (Figure 1) to determine the spiders' fauna of different tehsils in the district, namely Katlang, Takht Bhai, and Mardan. Daytime was selected for the collection of spiders because they are more active during this period of the day. Under optimal weather

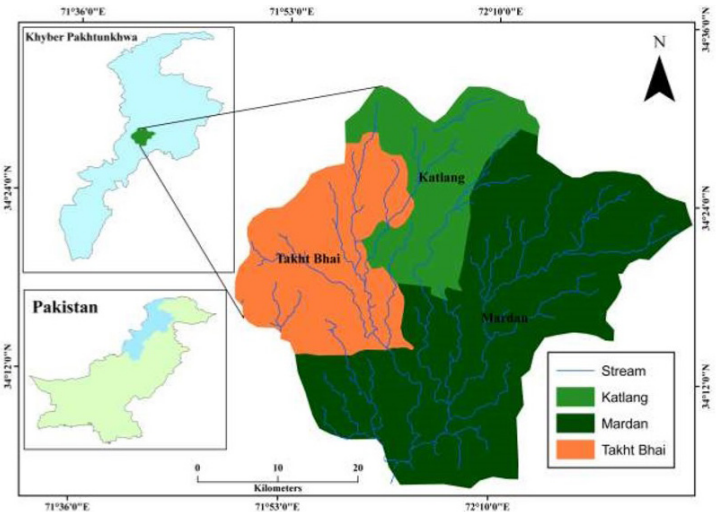

Figure 1. Study area map of District Mardan of Khyber Pakhtunkhwa (KP) province of Pakistan.

conditions, sampling took place in the morning from 7 a.m. to 11 a.m. and in the afternoon from 1 p.m. to 5 p.m. both in summer and winter.

2.3. Sampling sites

Spiders were gathered from both indoor and outdoor environments. Most of the spiders were found in warm parts of the house, like kitchens, bathrooms, store rooms, ceilings, and walls, as well as warm rooms and cow quarters. Outdoor places that were sampled included fields, open spaces, riverbanks, streams, marshy areas, hills, mountains, rocks, under-stones, crops, ground, underground, dried wood, loose plant bark, leaf litter, plant stems, shrubs, and grasses.

2.4. Samples collection methods

Spiders can be found in a variety of environments. Thus, it was sufficient to use a single sampling technique. The procedures for gathering samples are listed below.

2.5. Handpicking

This strategy is useful for spiders inhibited by the ground, such as leaf litter, logs, forest floor trash, stones, and plants below knee level. The hand-picking method for ground layer spiders is used by looking down, kneeling, and crawling. Small spiders were collected using an alcohol-soaked brush. At the same time, the spiders on the webs and leaf blades were trapped in the vials by keeping them open beneath them and tapping the spiders into them with the lid. This procedure was followed for an hour in each location (Sajid et al., 2021).

2.5.1. Arial collection

Forceps, a brush, and a vial are used in this hand-collection procedure. This approach was used to capture web-building spiders and free-living foliage dwellers. They were carefully gathered without harm and placed in alcohol-filled plastic vials (Sajid et al., 2021).

2.5.2. Foliage dwelling spiders

Sweep netting was employed to gather foliage-dwelling spiders (for middle-layer spiders up to 1 m) (Nooreen et al., 2017).

2.5.3. Pitfall trap

This pitfall trap was used to gather ground-active, surface-active, and leaf litter-inhibiting spiders. This procedure utilised a circular plastic cup with a diameter of 10 cm and a depth of 11 cm filled with ethylene glycerol as a pitfall trap. These traps were placed in the field to keep the spider specimens safe until they could be processed and identified in the lab. A total of 50 traps were set up in a specific region for 3 to 15 nights and monitored every 24 hours. After two days, the specimens were taken from the traps.

2.5.4. Beat sheet method

The vegetation beating method is also known as the beat sheet method. Spiders living in shrubs, bushes, high herb growth, tiny trees, and branches were identified using this method. This approach involves stretching a bright-coloured cloth beneath a tree or other low vegetation and shaking the branch vigorously. Spiders resting or nesting in this vegetation fell onto the fabric on disturbance, were captured, and transported to the sample vials. This procedure searched each area of vegetation for 30 minutes (Singh et al., 2012).

2.5.5. Cryptological exploration

Spiders that reside in mysterious places like litter, holes in trees or fallen logs, bark cracks beneath logs, stones, moss, and within rotting trees were found using cryptic searching. The litter was either directly sampled or moved on sheets (Sajid et al., 2021).

2.5.6. Sweep netting

Sweep netting was done with a round sweep net diameter of 28 cm (aluminium ring) and a 1m long handle.

This strategy is mostly utilised in areas with long grasses, shrubs, and low-growing shrubby and herbaceous plants. Each location was sampled with 30-40 sweeps spread at a distance of 2 meters. An hour was set aside for sampling. The net was emptied at regular intervals after three to five sweeps to minimise specimen loss and damage (Sajid et al., 2021).

2.5.7. Leaf litter method

This approach was also used to capture ground-based spiders. This procedure involved collecting leaf litter from a one-square-meter area in a polythene bag and depositing it on a white surface. The spiders were caught in the leaf litter with a paintbrush dipped in alcohol and immediately placed in 80 percent alcohol. It was repeated 10-15 times in each habitat from different locations (Singh et al., 2012).

2.6. Preservation

Spiders were captured and washed in alcohol from various locations and preserved in a combination of 80% alcohol and 20% glycerol. The collection number, date, habitat, location, altitude, longitude, latitude, temperature, and collection technique were all accurately labelled on the samples.

2.7. Identification

The collected spiders were classified based on external morphological characters, such as different families identified based on the arrangement of eyes. The available keys and literature used to identify families were the World Spider Catalogue (WSC, 2021) and Jocqué and Dippenaar-Schoeman (2006). Female epigynum and male palp were dissected with forceps and needles for genus and species identification. In immature spiders, epigyne and pedipalps were not well developed and thus could not be identified up to species level. The epigyne was cleaned in 10% KOH and studied under a stereomicroscope.

After identification, the dissected epigyne was preserved in 1-inch-long glass micro-vials blocked with cotton and placed in the respective spider species vial. Similarly, the palp of the left hand of mature male spiders was dissected and analysed using a charge-coupled device (CCD) microscope. Its structure was also compared to that of the available literature. All of the collected spiders were identified in the laboratory of the Department of Zoology, Islamia College Peshawar, and the College of Veterinary Sciences, Faculty of Animal Husbandry and Veterinary Sciences, Agriculture University Peshawar.

2.8. Statistical analysis

The relative abundance (RA) of the species was calculated using the formula $RA = 1 / L \; x \; 100$

The number of specimens of each spider species is represented by the '1'. The total number of specimens gathered is denoted by the letter 'L.'

The species distribution was computed using the formula $(C) = n / N \times 100$.

The number of collecting sites is n, and the total number of collecting spots is N.

The following Formulas 1-4 calculated diversity indexes, richness, as (Luqman et al., 2022).

Species richness (D):

$$D = S - 1 / \ln N \quad (1)$$

where: D = species richness; S = number of species; N = number of individuals.

Shannon Diversity Index (H'):

$$(H') = -\sum (Pi \; In \; Pi) \quad (2)$$

where: H'= Shannon Diversity Index; Pi = Proportional frequency of the species.

Evenness Index (E):

$$E = H' / In(S) \quad (3)$$

where: H' = Shannon Diversity Index; S = number of species.

Simpsons Diversity Index:

$$SDI = 1 - \sum n \; (n-1) / N \; (N-1) \quad (4)$$

where: SDI = Simpsons Diversity Index; n = no. of each species; N = total no. of individuals in a sample.

3. Results and Discussion

A total of 578 specimens representing 29 species from 17 families and 26 genera were collected and identified. Among these families, Lycosidae was the most dominant (13.49%), whereas Theridiidae was the rarest (1.21%) (Tables 1 and 2). Other families found during this study were Salticidae (10.20%), Araneidae (8.47%), Tetragnathidae (7.61%), Pholicidae (6.40%), Oxyopidae (5.88%), Thomisidae (5.70%), Clubionidae (5.53%), Sicariidae (5.19%), Scytodidae (5.01%), Corinnidae (4.67%), Agelenidae (4.32%), Cheiracanthiidae (4.15%), Sparassidae (4.15%), Oecobiidae (3.97%) and Hersiliidae (3.97%).

The results of this study are in agreement with the study of Perveen et al. (2012), while the difference is that of the family Gnaphosidae, which is not found here in the present study. Mukhtar (2004) studied the spider fauna of Punjab's foliage and reported 124 species belonging to 51 genera and 17 families, with the Araneidae family having the most species and the Corinnidae family having the least. However, 17 families were identified during the current study, with Lycosidae having the most species and Theridiidae having the smallest. Ursani and Soomro (2010) revised the spider fauna checklist for 16 districts in Sindh, Pakistan. There were 132 species found, divided into 24 families and 73 genera. The majority of these species had previously been identified, but only the Zodariidae family was discovered in Pakistan for the first time. In comparison to this study, we found a smaller number of families (up to 17), and the Zodariidae family was not found.

Similar results were also found in a study conducted by Sajid et al. (2021). Many of its species are currently reported from other countries like India, China, and Afghanistan. A study from India by Caleb in 2019 also

Table 1. Percentage Distribution of Spiders on the Basis of Their Families.

Family	Natural History	Percentage Abundance
Lycosidae	Wolf spiders	13.49%
Salticidae	Jumping spiders	10.20%
Araneidae	Orb weavers	8.47%
Tetragnathidae	Long jawed orb weavers	7.61%
Pholicidae	Cellar/ Daddy long leg spiders	6.40%
Oxyopidae	Lynx spiders	5.88%
Thomisidae	Crab spiders	5.70%
Clubionidae	Sac spiders	5.53%
Sicariidae	Six-eyed sand spiders	5.19%
Scytodidae	Spitting spiders	5.01%
Corinnidae	Ant mimic ground spiders	4.67%
Agelenidae	Funnel web spiders	4.32%
Cheiracanthiidae	Yellow sac spiders	4.15%
Sparassidae	Huntsman spiders	4.15%
Oecobiidae	Star legged spiders	3.97%
Hersiliidae	Two-tailed spiders	3.97%
Theridiidae	Red back widow spiders	1.21%

Table 2. Distribution of Spider Families Identified During the Study.

Families (n=17)	No. of Specimens (n=578)	No. of Genera (n=26)	No. of Species (n=29)
Lycosidae	78	3	4
Salticidae	59	4	5
Araneidae	49	4	8
Tetragnathidae	44	1	2
Pholicidae	37	1	1
Oxyopidae	34	1	1
Thomisidae	33	1	1
Clubionidae	32	1	Unidentified
Sicariidae	30	1	1
Scytodidae	29	1	1
Corinnidae	27	1	Unidentified
Agelenidae	25	1	1
Cheiracanthiidae	24	1	1
Sparassidae	24	2	1
Oecobiidae	23	1	Unidentified
Hersiliidae	23	1	1
Theridiidae	7	1	1
Total	578	26	29

revealed the same results, and this family was also found in Madras, India. Noreen and a co-worker collected a total of 2005 specimens, Representing 44 species under 29 genera and 15 families from the district of Charsadda. The most dominant family observed during the study was the Salticidae (Nooreen et al., 2017).

Another study from India conducted by Shirbhate and Shirbhate (2017) reported different species and genera of this family, but the genus Bijoaraneus was not found in that family. A study conducted by Luqman et al. (2022) from Pakistan revealed the same genus and species of this family also found in their study sites, i.e., the Buner area of Pakistan. Another study from Dir Lower also showed the same results as the present study (Sajid et al., 2021).

The distribution of spider families regarding their presence in different areas is given in Table 3. The spot location for their presence was divided into two main sections, named indoor and outdoor collection points. Indoor collection points include the kitchen, cattle rooms, store rooms, washrooms, ceiling, walls, and flowers or plants. Outdoor collection includes ground, river banks, streams, marshy places, hills, rocks or undertones, fields or crops, underground, dry wood or leaf litter and bushes or grasses. Table 3 showed that more collections (80) were isolated from rocks or under stones, followed by 79 isolates from ground areas and 60 from hilly regions.

Details of the complete isolation of spider families are presented in Table 3. Another important part of the current study is the habitat of the spider. In the present study, both indoor and outdoor collections were carried out. The results showed that the family Lycosidae was mostly found outdoors on the ground and at home in the winter. Salticidae was found everywhere except moist and marshy places but was abundantly found in store rooms and home walls. Araneidae and Tetragnathidae were both found in riverbanks, streams and marshy areas. Pholicidae are only found indoors. Oxyopidae in grasses and shrubs on hills were found—the species of Thomisidae, i.e., *Thomisus zaheeri*, found mostly in flowers. The family Clubionidae was mostly abundant on the ground and under stones. Sicariidae was found in storerooms and under rocks and hills. Scytodidae were mostly found in washrooms, cervices, and storerooms, as well as under stones in hills. Like the Lycosidae family, Corinnidae were abundantly found on the ground. Agelenidae was found under stones and in old trees. The family Cheiracanthiidae was active during the night and was mostly found in small shrubs and plants. Sparassidae were found mostly in bathrooms and storerooms, with a few in kitchens and underground. The family Oecobiidae was only found outdoors under stones and hills. Cytodidae were mostly found in washrooms, cervices, and storerooms, as well as under stones in hills. Like the Lycosidae family, Corinnidae were abundantly found on the ground. Agelenidae was found under stones and in old trees. The family Cheiracanthiidae

Table 3. Distribution of Spider Families with Respect to their Location.

Families	Indoor collection (148)					Outdoor Collection (430)										
	Kitchen	Cattle rooms	Store room	Wash room	Ceiling & walls	Plants	Ground	River banks	Streams	Marshy places	Hills	Rocks	Fields	Underground	Dry woods	Bushes/Grasses
Lycosidae	1	2	3	0	0	0	43	0	0	0	9	6	0	7	4	3
Salticidae	4	5	9	7	9	0	7	0	0	0	3	6	3	4	2	0
Araneidae	0	0	0	0	0	0	0	17	11	8	0	0	7	0	0	6
Tetragnathidae	0	0	0	0	0	0	0	25	11	8	0	0	0	0	0	0
Pholicidae	8	9	9	5	6	0	0	0	0	0	0	0	0	0	0	0
Oxyopidae	0	0	0	0	0	0	0	0	0	0	10	0	7	0	0	17
Thomisidae	0	0	0	0	0	23	0	0	0	0	0	0	0	0	4	6
Clubionidae	0	0	0	0	0	0	12	0	0	0	10	10	0	0	0	0
Sicariidae	0	0	6	0	0	0	0	0	0	0	9	12	0	3	0	0
Scytodidae	3	2	5	6	4	0	1	0	0	0	3	4	0	1	0	0
Corinnidae	0	0	0	0	0	0	14	0	0	0	0	4	3	6	0	0
Agelenidae	0	0	0	0	0	0	0	0	0	0	0	13	0	5	7	0
Cheiracanthiidae	0	0	0	0	0	3	0	0	0	0	0	0	5	0	2	14
Sparassidae	2	3	5	4	3	0	2	0	0	0	2	2	0	1	0	0
Oecobiidae	0	0	0	0	0	0	0	0	0	0	11	7	0	5	0	0
Hersiliidae	0	0	0	0	0	0	0	0	0	0	0	14	0	0	9	0
Theridiidae	0	0	2	0	0	0	0	0	0	0	3	2	0	0	0	0
Total	18	21	39	22	22	26	79	42	22	16	60	80	25	32	28	46

was active during the night and was mostly found in small shrubs and plants. Sparassidae were found mostly in bathrooms and storerooms, with a few in kitchens and underground. The family Oecobiidae was only found outdoors under stones and hills.

Hersiliidae was found on the stems of large trees and under stones, while the scare family Theridiidae was found indoors in storerooms and outdoors in hills and under stones. According to Singh et al. (2012), the spider fauna varies greatly depending on location. The majority of the spider families and species studied in this study have been recorded from other areas of the world, with varying levels of relative abundance. Sugumaran et al. (2007) reported 38 species belonging to 13 families in horticulture crops at Yercaud Hills in the Selem district of Tamil Nadu, India. They found 28 species belonging to 12 families in coffee plantations, followed by 13 species (7 families) in fruit trees, 12 species (7 families) in grasses and shrubs, 10 species (7 families) in pepper crops, and 9 species (5 families) in flowering crops (Sugumaran et al., 2007). However, Kazim et al. (2014) recorded 80 species belonging to 21 families in the agriculture field. On the other hand, much more studies were conducted at the forest habitat. Oyewole and Oyelade (2014) found that the high number of spider families found in cultivated and open field habitats indicates the complexity of the plants that spiders rely on for their life cycle, whether for food, shelter, or web building. Our study shows consistency with the above reports because we observed the diversification of spiders in warmer points as compared to cold regions in the same district. Therefore, our study suggests that warmer areas are enriched with spider fauna as compared to moderate and cold areas of the region. The difference is because the climate and habitat of the areas mentioned in their studies are different from the present research area.

The distribution of different species, genera, and families throughout different communities is displayed in Table 4. Compared to Tehsil Mardan, a city with unfavourable conditions for their growth, most of the species were detected in Tehsil Katlang because of the favourable environmental conditions there. In comparison to the other two tehsils, this one had a smaller population because there weren't as many habitats accessible.

The diversity index of all three communities was also discussed during this study. Simpson's diversity index formula was used for this finding. The diversity index may range from 0 to 1, which means from a minimum diverse community to a maximum diverse community. The result of Simpson's diversity index formula showed that Tehsil

Table 4. Family, Genera, and Species Distribution According to Study Area.

S.No	Family	Genus	Species	Katlang	Takht bhai	Mardan	Total
1	Lycosidae	Lycosa	*Lycosa poonaensis*	7	6	4	17
			Lycosa terrestris	6	5	3	14
		Draposa	*Draposa oakleyi*	11	6	4	21
		Hippasa	*Hippasa partita*	10	11	5	26
2	Salticidae	Plexippus	*Plexippus paykulli*	9	8	4	21
		Thyene	*Thyene imperialis*	5	4	3	12
			Thyene bivittata	2	2	1	5
		Menemerus	*Menemerus nigli*	4	4	3	11
		Hasarius	*Hasarius adansoni*	5	3	2	10
3	Araneidae	Neoscona	*Neoscona theisi*	3	1	1	5
			Neoscona adianta	5	3	0	8
			Neoscona oaxacensis	2	3	2	7
		Argiope	*Argiope versicolor*	2	1	1	4
			Argiope pulchella	3	2	1	6
			Argiope aemula	2	2	3	7
		Bijoaraneus	*Bijoaraneus mitificus*	4	1	2	7
		Eriovixia	*Eriovixia excelsa*	2	2	1	5
4	Tetragnathidae	Tetragnatha	*Tetragnatha extensa*	9	9	8	26
			Tetragnatha montana	0	6	12	18
5	Pholicidae	Crossopriza	*Crossopriza lyoni*	16	13	8	37
6	Oxyopidae	Oxyopes	*Oxyopes javanus*	17	11	6	34
7	Thomisidae	Thomisus	*Thomisus zaheeri*	13	13	7	33
8	Clubionidae	Clubiona	Unidentified	14	10	8	32
9	Sicariidae	Loxosceles	Loxosceles rufescens	9	15	6	30
10	Scytodidae	Scytodes	*Scytodes thoracica*	12	10	7	29
11	Corrinnidae	Castianeira	Unidentified	12	5	10	27
12	Agelenidae	Tegenaria	*Tegenaria domestica*	8	10	7	25
13	Cheiracanthiidae	Cheiracanthium	*Cheiracanthium saccharanalis*	8	9	7	24
14	Sparassidae	Heteropoda	*Heteropoda afghana*	6	4	3	13
		Olios	Unidentified	5	3	3	11
15	Oecobiidae	Oecobius	Unidentified	9	12	2	23
16	Hersiliidae	Hersilia	*Hersilia savignyi*	9	9	5	23
17	Theridiidae	Latrodectus	*Latrodectus hasselti*	5	2	0	7
			Total	234	205	139	578

Katlang had high diversity as compared to Takht bhai and Mardan (Table 5).

The different traits of the multiple communities that were observed throughout the research are displayed in Table 5. The Katlang section of the research areas exhibited higher variety than the other two communities, with a spider family richness of 50.3, a Simpson index (1-D) of 0.96, and a Shannon index (H) of 3.2. Takhtbhai's values were as follows: richness of 44.2, evenness of 0.92, Shannon index of 3.1, and Simpson diversity index of 0.95. On the other hand, Mardan's richness was 27.8, evenness was 0.91, Shannon's index was 3.0, and Simpson's diversity index was 0.950 (Table 5). Two more important factors that affect the spider fauna are evenness and richness.

To calculate the Simpsons' evenness, richness, and variety index, the Shannon index (H) and the Diversity Index (1-D) were applied. Katlang had a richness of 50.3, an evenness of 0.96, a Shannon Index (H) of 3.2, and a

Table 5. Diversity, Evenness, and Richness of Different Communities.

Study Sites	No. of Specimens	No of Species	Simpsons Index (1-D)	Shannon index (H)	Evenness	Richness
Katlang	194	28	0.96	3.2	0.96	50.3
Takht Bhai	175	29	0.953	3.1	0.92	44.2
Mardan	116	27	0.950	3.0	0.91	27.8

Simpsons Diversity Index (1-D) of 0.96. Takht Bhai has an evenness of 0.92, a richness of 44.2, a Shannon index (H) of 3.1, and a Simpsons Diversity Index (1-D) of 0.953. Comparing these two habitats (H), Mardan discovered a 3.0 Shannon index and a 0.950 Simpsons Diversity Index (1-D). Mardan's richness was 27.8, and its evenness was 0.91. Comparable investigations have been conducted around the globe to ascertain the evenness and richness of such locations. Henderson (2010) found that Lick Creek Park, Texas, had low diversity and evenness, with scores of 0.966 and 0.264, respectively, on the Simpson diversity and evenness indices. However, Rain et al. (2016) found that the evenness was 0.91 and the Shannon-Wiener diversity score was 2.18 at the Jahangir Nagar University campus in Bangladesh. Deshmukh and Raut (2014) found Shannon, Simpson, and richness indices of 1.06, 0.103, and 8.4 in the Salbardi forest (Satpura range) in Maharastra (Anindita et al., 2017). It follows that these sites demonstrated variations in the faunal diversity of spiders. Variables such as climate, location, temperature, and food accessibility are what produce a variety of variations in the locations under study.

This research project also investigated the relative abundance status and distribution status of different species. *Crossopriza lyoni* was the most abundant species, with 7.62% relative abundance, followed by *Oxyopes javanus* with 7.01%, *Thomisus zaheeri* with 6.80 percent, and *Loxosceles rufescens* with 5.97 percent. *Tetragnatha extensa* and *Hippasa partita* had a relative abundance of 5.36%, while *Tegenaria domestica* had 5.15%. *Cheiracanthium saccharanalis* had the lowest RA of 4.94 percent, followed by *Hersilia savignyi* at 4.74 percent, and *Draposa oakleyi* and *Plexippus paykulli* at 4.32 percent.

Different species were also divided into groups with relative abundances ranging from 3 to 4%. *Tetragnatha Montana* had 3.71%, and *Lycosa poonaensis* had 3.50% in this group. *Lycosa terrestris* (2.88%), *Heteropoda afghana* (2.68%), *Menemerus nigli* (2.2%), and *Hasarius adansoni* (2.06%) were among the species with RA between 2% and 3%. *Thyene bivittata* and *Neoscona adianta* species showed a relative abundance of 1.03% each, whereas *Latrodectus hasselti*, *Neoscona oaxacensis*, *Argiope aemula*, and *Bijoaraneus mitificus* species showed a relative abundance of 1.44% each. *Argiope pulchella* was the species with the lowest RA, with a relative abundance of 0.82%. During this study, species were also divided on the basis of relative abundance status. Relative abundance status was divided into dominant, sub-dominant, and satellite species. Dominant species included *Tetragnatha extensa*, *Hippasa partita*, *Crossopriza lyoni*, *Oxyopes javanus*, *Thomisus zaheeri*, *Loxosceles rufescens*, *Scytodes thoracica*, *Tegenaria domestica*, and *Cheiracanthium saccharanalis*. Subdominant species included *Tetragnatha Montana*, *Lycosa poonaensis*, *Lycosa terrestris*, *Draposa oakleyi*, *Plexippus paykulli*, *Thyene imperialis*, *Thyene bivittata*, *Menemerus nigli*, *Hasarius adansoni*, *Neoscona theisi*, *Neoscona adianta*, *Neoscona oaxacensis*, *Argiope pulchella*, *Argiope aemula*, *Bijoaraneus mitificus*, *Eriovixia excelsa*, *Heteropoda afghana*, *Hersilia savignyi*, and *Latrodectus hasselti*, whereas only one species included in the satellite is *Argiope versicolor*.

Similarly, the distribution status of various species was also investigated. The different distribution statuses used were sporadic, moderate, frequent, and infrequent. Sporadic included *Tetragnatha extensa*, *Tetragnatha montana*, *Thyene bivittata*, *Argiope versicolor*, *Eriovixia excelsa*, Oxyopes *javanus*, *Thomisus zaheeri*, *Tegenaria domestica*, *Hersilia savignyi*, and *Latrodectus hasselti*. *In contrast*, *Lycosa terrestris*, *Lycosa poonaensis*, *Draposa oakleyi*, *Hippasa partita*, *Thyene imperialis*, *Scytodes thoracica*, and *Heteropoda afghana were* included in moderate distribution status. Those species that were included in the infrequent distribution status were *Menemerus nigli*, *Hasarius adansoni*, *Neoscona oaxacensis*, *Argiope pulchella*, *Argiope aemula*, *Crossopriza lyoni*, *Loxosceles rufescens*, and *Cheiracanthium saccharanalis*. *Plexippus paykulli* was the only species with a frequent distribution status. This clearly indicates that the distribution of spiders varied with the geographical region.

4. Conclusion

This study, titled "Morphological Identification of Spider Fauna of District Mardan," identified a total of 578 spider specimens. The identified families are Lycosidae, Salticidae, Araneidae, Tetragnathidae, Pholcidae, Oxyopidae, Thomisidae, Clubionidae, Sicariidae, Scytodidae, Corinnidae, Agelenidae, Cheiracanthiidae, Sparassidae, Oecobiidae, Hersiliidae, and Theridiidae. Among them, the most dominant family observed was Lycosidae, and the scarcest family was Theridiidae. The current study concluded that there is a great variety among the spider fauna found in different locations of the study area due to diverse habitats. Most of the species were of the family Araneidae, Salticidae, and Lycosidae, while the remaining families were represented by just one and two species each. Some immature specimens were left unidentified until the species level, and we hope they will be new to science. The current study area is very rich in spider fauna. Still, no work has been done on the diversity of spiders to date, and people also have less knowledge about the diversity of spiders in district Mardan.

References

ABBAS, A., ARSALAN, M., GUL, S.U., REHMAN, H.U., JAWAD, S.M., SHAH, W. and MEHMOOD, A., 2018. Exploring spider fauna in Mitha Khel, Tarkhakoi, Sangathri, Sarekhawa, Shawal Ada and Niazi Chowk district Karak KP, Pakistan. *Journal of Entomology and Zoology Studies*, vol. 6, no. 1, pp. 1412-1415.

ALI, P.A., MADDISON, W.P., ZAHID, M. and BUTT, A., 2018. New chrysilline and aelurilline jumping spiders from Pakistan (Araneae, Salticidae). *ZooKeys*, vol. 783, no. 783, pp. 1-15. http://doi.org/10.3897/zookeys.783.21985. PMid:30275723.

ANINDITA, B., MAHADEV, C. and PRABAL, S., 2017. Spider diversity in different habitats at Jaintia Hills of Meghalaya. *International Journal of Life Sciences*, vol. 217, no. 5, pp. 4.

DIPPENAAR, A.S., 2014. *A revision of some genera of the subfamily Misumeninae (Thomisidae: Araneae) of Southern Africa*. Johannesburg: University of Johannesburg.

DESHMUKH, U.S., and RAUT, N.M., 2014. Seasonal diversity and status of spiders (Arachnida: Araneae) in Salbardi forest (Satpura Range), Maharashtra, India. *Journal of Entomology and Zoology Studies*, vol. 2, no. 6, pp. 278-281.

ESCUER, P., PISARENCO, V.A., FERNÁNDEZ-RUIZ, A.A., VIZUETA, J., SÁNCHEZ-HERRERO, J.F., ARNEDO, M.A., SÁNCHEZ-GRACIA, A. and ROZAS, J., 2022. The chromosome-scale assembly of the Canary Islands endemic spider *Dysdera silvatica* (Arachnida, Araneae) sheds light on the origin and genome structure of chemoreceptor gene families in chelicerates. *Molecular Ecology Resources*, vol. 22, no. 1, pp. 375-390. http://doi.org/10.1111/1755-0998.13471. PMid:34268885.

GHAZANFAR, M., HUSSAIN, M., HASHIM, M. and FAHID, A., 2016. Checklist of spider (Araneae) fauna of Pakistan: a review. *Journal of Entomology and Zoology Studies*, vol. 4, pp. 245-256.

GUL, S., KHAN, K., SAJJAD, M., JAMAL, M., ULLAH, M., REHMAN, G. and ALI, A., 2022. Spatial distribution, seasonal abundance and physio-chemical assessment of mosquito larval breeding sites in Mardan District, Khyber Pakhtunkhwa, Pakistan. *Journal of Arthropod-Borne Diseases*, vol. 16, no. 1, pp. 34-44. http://doi.org/10.18502/jad.v16i1.11190. PMid:36636243.

HENDERSON, T. Y., 2010. Diversity, distribution, and abundance of ground dwelling spiders at Lick Creek Park, College Station, Texas. Texas: A & M University. Doctoral dissertation.

JOCQUÉ, R. and DIPPENAAR-SCHOEMAN, A.S., 2006. *Spider families of the world*. Tervuren: Musée Royal de l'Afrique Centrale.

KAZIM, M., PERVEEN, R., HUSSAIN, R. and FATIMA, N., 2014. Biodiversity of spiders (Arachnida: Araneae) of Karachi (Urbon) Sindh Province, Pakistan. *Journal of Entomology and Zoology Studies*, vol. 2, no. 6, pp. 308-313.

KHAN, J. and ZAMAN, A., 2015. Biodiversity of spider fauna in Pir Baba, district Buner, Khyber Pakhtunkhwa, Pakistan. *Journal of Entomology and Zoology Studies*, vol. 3, no. 1, pp. 69-74.

KHYBER PAKHUNKHWA, 2024 [viewed 26 February 2024]. *Mardan District demographics* [online]. Available from: http://kp.gov.pk/page/mardandistrictdemographics

LUQMAN, L., SAEED, K., MUHAMMAD, K., AHMAD, M., AKBAR, F., RASOOL, A., ISRAR, M., JABEEN, H., MEHMOOD, S.A., AHMED, S., ALAM, A., ULLAH, S., SAEED, N., USMAN, K., HUSSAIN, I., EL HALIM, H.M.A., KHAN, W. and SHAH, M., 2022. Biodiversity of orb-web spiders (family: araneidae) of buner valley, Pakistan. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 82, e238339. http://doi.org/10.1590/1519-6984.238339. PMid:34161423.

MISHRA, R., AHMAD, G. and CHAUBEY, S., 2012. Study on the morphology, feeding capcity and prey preference of neoscona crucifera and *N. adianta* (Orb-weaving spiders). *Indian Journal of Life Sciences*, vol. 1, no. 2, pp. 29.

MUKHTAR, M.K., 2004. *Taxonomic studies on the foliage spider fauna of Punjab*. Faisalabad: University of Agriculture.

NOOREEN, N., ZAHID, M. and RASOOL, M., 2017. Spider (Araneae: Arachnida) fauna of district Charsadda Khyber Pakhtunkhwa Pakistan. *Journal of Entomology and Zoology Studies*, vol. 5, no. 2, pp. 1077-1082.

NOVAK, K., 2001. Spider venom helps hearts keep their rhythm. *Nature Medicine*, vol. 7, no. 2, pp. 155-155. http://doi.org/10.1038/84588. PMid:11175840.

OYEWOLE, O.A. and OYELADE, O.J., 2014. Diversity and distribution of spiders in southwestern Nigeria. *Natural Resources*, vol. 5, no. 15, pp. 926-935. http://doi.org/10.4236/nr.2014.515079.

PARVEEN, R., KHAN, A.A., MUSHTAQ, S. and RANA, S., 2007. A checklist of the spiders of the Punjab. *Pakistan Journal of Agricultural Sciences*, vol. 44, pp. 625-626.

PEARCE, S., HEBRON, W.M., RAVEN, R.J., ZALUCKI, M.P. and HASSAN, E., 2004. Spider fauna of soybean crops in south-east Queensland and their potential as predators of *Helicoverpa* spp. (Lepidoptera: noctuidae). *Australian Journal of Entomology*, vol. 43, no. 1, pp. 57-65. http://doi.org/10.1111/j.1440-6055.2003.00378.x.

PERVEEN, F. and KHAN, N., 2015. Checklist of the first recorded spider fauna in Sheringal, Khyber Pakhtunkhwa, Pakistan. *Advances in Entomology*, vol. 3, no. 3, pp. 94-100. http://doi.org/10.4236/ae.2015.33011.

PERVEEN, F., JAMAL, A., YASMIN, S. and KHATAK, K.U., 2012. Biodiversity of spiders fauna in the Frontier Region, Peshawar, Pakistan. *Journal of Entomology and Nematology*, vol. 4, no. 3, pp. 22-33.

RAIN, F.F., HOWLADER, A.J. and BASHAR, K., 2016. Diversity and abundance of spider fauna at different habitats of Jahangirnagar University Campus, Bangladesh. *Journal Of Entamology And Zoology Studies*, vol. 4, no. 5, pp. 87-93.

SAJID, M., ZAHID, M., BUTT, A., RASOOL, M., SHAH, M., AHMAD, R. and ULLAH, I., 2021. Faunal diversity of order Araneae species from District Dir Lower of Malakand division, Pakistan. *Pure and Applied Biology*, vol. 10, no. 3, pp. 902-912. http://doi.org/10.19045/bspab.2021.100093.

SEBASTIAN, P. and PETER, K., 2009. *Spiders of India*. Hyderabad: Universities Press.

SHIRBHATE, M.V. and SHIRBHATE, A.M., 2017. Diversity and distribution of spider fauna (family-Araneidae) in and around Katepurna Sanctuary, Akola, India. *Environment Conservation Journal*, vol. 18, no. 3, pp. 45-52. http://doi.org/10.36953/ECJ.2017.18306.

SINGH, S., BORKOTOKI, A. and SARMAH, C., 2012. Species distribution of spiders in barpeta district of Assam: a diversity measure. *E-International Scientific Research Journal*, vol. 4, no. 1, pp. 47-57.

SPEARS, L.R. and MACMAHON, J.A., 2012. An experimental study of spiders in a shrub-steppe ecosystem: the effects of prey availability and shrub architecture. *The Journal of Arachnology*, vol. 40, no. 2, pp. 218-227. http://doi.org/10.1636/P11-87.1.

SUGUMARAN, M., SOUNDARARAJAN, R. and LAKSHMANAN, V., 2007. Spider fauna in the horticultural crops of Yercaud hills. *Zoos' Print Journal*, vol. 22, no. 6, pp. 2721-2722. http://doi.org/10.11609/JoTT.ZPJ.1598.2721-2.

URSANI, T.J. and SOOMRO, N.M., 2010. Check-list of spider fauna of Sindh Province, Pakistan. *Pakistan Entomologist*, vol. 32, no. 1, pp. 18-23.

WORLD SPIDER CATALOGUE – WSC [online], 2021 [viewed 26 February 2024]. Available from: https://wsc.nmbe.ch/

PAKISTAN BUREAU OF STATISTICS, 2017. *Pakistan Tehsil Wise Census*. Islamabad: Pakistan Bureau of Statistics. Available from: https://www.pbs.gov.pk/census-2017-district-wise.