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Diversity of Spiders (Arthropoda, Araneae, Arachnida) in Dir Lower Kp Khyber Pakhtunkhwa Pakistan

Muhammad Adil Umer
Department of Zoology, University of Malakand, Chakdara, Pakistan

ABSTRACT

Analysis included a representative of several families including Thomisidae, Araneidae, Gnaphosidae, Pholicidae, Salticidae, Clubionidae, Scytodidae, and Sparassidae. Population of Thomisidae spiders, which included Diaea evanida and Thomisus pugilis, comprised 7.4% of the specimens and were recorded in environments with floral structures exhibiting higher temperatures (25-30 °C), high humidity (60-75%), and higher light intensity. These spiders are important for insect population management surrounding flowering plants according to Schausberger and Raser (2013). Population of Araneidae spiders included Araneus diadematus and Neoscona theis, comprised 12.2% and known to construct webs in gardens. The environmental conditions came from moderate temperatures (20-25 °C), moderate humidity (50-60%) and moderate light conditions of araneidae over longer periods involved significant pest regulation as noted by Eubanks et al. (2016). A combined population of Gnaphosidae, and Pholicidae spiders comprised up to 3 species; Gnaphosa eucalyptus; and Artema atlanta, represented 9.8% of the specimens. These spiders are flexible in habitat selection from dry woods to urban structures, showing adaptations to cooler temperatures (20-25 °C), lower humidity (40-55%) with various light conditions as evidence by Platnick (2014). Population of Salticidae included Marpissa tigrina; and Plexippus paykullii; represented 4.9% of specimens collected favoring higher temperatures (25-30 °C)500), adaptable humidity 700; stress healthy light intensity higher than low levels. Foelix (2011) suggests these spiders play significant roles in regulating small insects.Overall, spiders from the Clubionidae, Scytodidae, and Sparassidae families, formed 3.7% of specimens, exhibited varied behaviours and preferences and adaptations to moderate temperatures (20-25C), and shaded areas, and with the exception of Araneidae, most had varied behaviours as described by the World Spider Catalog (2023). The research highlights considerable differences in the ecological preferences of the spiders that influenced spider distribution, where for example, Araneus diadematus and Arctosa littoralis preferred lower temperatures (20-25C), while Diaea evanida and Thomisus pugilis preferred elevated temperatures (25-30°C). Preferential habitat distribution was also affected by the environmental factors of humidity and light intensity, where included Diaea evanida noted high humidity and Gnaphosa eucalyptus noted lower humidity preferences. This research illustrates the ecological role of spiders reflecting their varied predatory behaviours and environmental adaptations to prey species they prefer. Crab spiders and garden spiders play a role in pest control in those environments; and, the ecological flexibility of Gnaphosidae and Pholicidae, as well as the active predation role of Salticidae are great indicators of how spiders kept the ecological role and balance in habitats clean. We recommend consider expansion on spider conservation, more action on relevant research, promotion of awareness/education of spiders, combined with pest management strategies that incorporate spiders, and actions to consider more event on climate change, to protect spider diversity and ecological services.

Keywords: Spider species, Thomisidae, Araneidae, Gnaphosidae, ecological preferences, ecological roles, spatially habitat distribution, pest control, biodiversity, climate change.

Corresponding author: Muhammad Adil Umer
Email: adilumer1995@gmail.com

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INTRODUCTION

Order Araneae, a large variety of arachnid, including many well-known hunters and web builders, and are native to terrestrial habitats in every conceivable environment, including deserts, rainforests, and even fresh or marine waters. They are a significant component in ecosystems because they will prey on insects and are an important factor in other ecological interactions. According to research conducted by Sreeramulu and Jayaprakash (2014), spiders comprise about 7% of all arthropods, which is a sizeable percentage of presence and presence in the ecosystem. Spiders occupy aquatic biogeochemical cycling environments and are significant hunters in aquatic environments and in most terrestrial habitats. They are expected organic controllers and help humour the 'natural' control of harmful insects in terrestrial environments. Spiders (Order Araneae), in many ways, are the most diverse and abundant invertebrate hunters in terrestrial biogeocenosis. 8-legged creatures is the second largest class entailing 7% of all reported arthropods and it is estimated that 8.3% of arthropods are 8-legged creatures. (Sriramulu and Jayaprakash 2014). There are an estimated 48,000 species (World Spider List 2018). Spiders (Arachnida: Araneae) , are a mega diverse group of Arachnids.

Spiders belong to a larger clade that also includes whip spiders (Amblypygi), whip scorpions (Thelyphonida) and schizomids (Schizomida). All these spiders have a camouflage pattern consisting of one pair of book lungs per segment on the second and third opisthosomal segments. Spiders show a high level of sexual size dimorphism. Females are larger with particularly broad abdomens, compared to male spiders having small and narrow abdomens in seven example species of spiders. The sizes of individuals would be different depending on the species, habitats, adult lifestyles, and sexual size dimorphism.

The central nervous system is confined entirely within the prosoma, and highlighted by extensive ganglia concentration. The metameric arrangement of the system may only be seen in the larvae or in the adults of the Mesothelae arachnids. The original paired ganglia are fused into two ganglia; a small supraesophageal called the brain, and a much larger subesophageal with a defined star-like designation. The boundary between the two is set by the esophagus. The oval brain is located in the front portion of the prosoma, overhead the fused subesophageal ganglia.

At the anterior of the cerebrum there is a deep and long furrow dividing the cerebrum into two portions. At the histological level, the central nervous system has an outer layer of minimal thickness forming a cortex and a central, thick mass of nerve fibers forming a neuropil. (Teresa et.al., 2016)

Having over 48,000 recognized species, spiders are one of the most taxonomically diverse groups of arthropods (World spider list 2018). They exhibit a broad diversity of sizes, morphologies and behaviors that are adapted to diverse surrounding condition. Foelix (2011) has described that spiders can be found in a variety of habitats creating the possibility for high species richness and ecological roles contributed by their species. This demonstrates the successful and highly adaptive evolutionary development of spiders.

Spiders are assigned to the Arthropoda phylum, Arachnida class and Araneae order and are classified within a larger clade that contains members of other arachnid groups such as the whip spiders (Amblypygi) and the whip scorpions (Thelyphonida). Because the taxonomic arrangement of spiders continues to be complex, differing over time and the regional development of molecular phylogenetic studies, the current studies of Coddington et al. (2004) has improved our knowledge about the relationships and taxonomy of spiders as related to the evolutionary links between other arachnid groups that they share. Spiders can also be found in a variety of habitats spanning from extremely arid deserts to tropical rain forests, and also aquatic areas.

Spiders have the ability to adapt and occupy many different ecological areas. For instance, one group of spiders lives in leaf litter, while others can be found in trees or even in water (Wunderlich 2004). This range of habitat suitability contributes to a broad distribution and ecological significance.

Spiders spin silk through specialized appendage glands, called spinnerets, located at the end of their abdomen. The silk they produce can be used for a variety of things: to spin a web and capture prey, to package eggs in silken egg sacs or create draglines for locomotion. Vollrath and Selden (2007) describe the unique biochemical and mechanical properties of spider silk, which have led to biomimetic possibilities for materials science and engineering. Spider venom is a complex concoction of proteins and peptides that both immobilizes prey and begins to digest the prey. Venom composition varies widely among spider species. Venom composition also reflects spider's dietary needs and evolutionary adaptations. Crouse and Albersheim (2011) are studying spider venom evolution and different prey preference in spider populations, and the idea that venom may pave the way for either unique pain relief or potential uses in antivenoms.

Spiders show a variety of types, not all spiders make webs, some spiders make webs—the designs include orb webs, funnel webs, and sheet webs. These web types mirror their unique strategies for hunting prey and are adapted to local environmental and ecological conditions. Eberhard (1986) has provided details on the architecture and behaviors of web building spiders that show how different web designs enhance capture of prey and increase survival.

Some species of spiders exhibit various reproductive behaviors ranging from elaborate courtship displays to sexual cannibalism. Female spiders typically tend to be larger and more aggressive, and certain species display sexual cannibalism where females aggressively consume male spiders for their reproductive advantages leading to differential fitness outcomes. Schneider et al. (2005) have given some insights on reproductive behavior showing how reproductive strategies influence fitness and survival.

The sensory abilities of spiders is quite excellent—many have up to eight eyes, which gives them a wide field of vision, in addition they have specialized hairs (trichobothria) that detect vibrations and chemical signals. Land and Barth (1992) has explored spiders sensory systems in more detail including desired and preferred adaptations and adaptations facilitating spiders to navigate through the environment, detect prey, and avoid predators.

Spiders mainly eat insects, but some of the larger species can capture and consume small vertebrates such as frogs, lizards, and birds. Studies by Nentwig et al. (2016) about spider diets suggest variability in feeding habits and consider spiders' role in controlling insect populations, which raises questions about pest management and the health of our ecosystems. The longevity of spiders can vary greatly by species, with some living only a few months, and others, such as tarantulas, living to several decades. Spiders grow using a process called molting, where they shed their exoskeleton to accommodate their changing body size. Research by Sierwald and Coddington (2007) describes the molting process, and spiders' longevity and ecdysis.

Spiders help control pest insect populations and play an important large role in ecosystems, and a single fog can have cascading influences on other species and ecosystem functions. Rypstra et al. (1999) explains how spider predation can be important for press-influences of pest dynamics, crop health, and more generally the balance of foodwebs. While many spider species are common and abundant in the environment, some spiders face anthropogenic threats to their persistence including habitat loss, climate change, and other direct exploitation. Therefore, it is essential to study, understand, and conserve spiders, including reversing biodiversity loss.

Mendez et al. (2014) examined the importance of conservation methods to maintain spider numbers and their natural roles in ecosystems. Sexual size dimorphism in spiders (where females consistently tend to be larger and have a larger broader abdomen) is widespread and varies based on environmental conditions, lifestyle and mating strategies. Researchers Nakata and Kawai (2007) explored sexual size dimorphism from an evolutionary and ecological standpoint.

The central nervous system in spiders is wholly encapsulated within the prosoma and is highly concentrated with ganglia. Spiders have been divided into primitive and adult Mesothelae spiders where the paired ganglia are fused into two developed structures; the supraesophageal ganglion (brain) and the subesophageal ganglion. The research of Teresa et al. (2016) has accomplished great thoroughness regarding the structure and design of the spider nervous system.The spider central nervous system is organized in a thin outer layer (cortex) and relaxes the dense core of nerve fibers (neuropil). The ganglia are the primary coordinates of processing sensory information and coordinating movement.

Stowe and Land (2003) conducted a comparative analysis of ganglia and neuropil organization of spiders and other arachnids. Although spiders have similarities with other arachnids, like whip spiders and scorpions, they also exhibit unique features. Harvey et al. (2009) presented a comparative morphology analysis of spiders, and other various arachnid groups to emphasize similarities and differences in anatomy and physiology to improve the understanding of arachnid evolution and diversity. Spiders have evolved a number of adaptations, suitable for survival in many environmental contexts, from hot and dry deserts, to marine environments. Huber et al. (2011) presented a review on how spiders have adapted to their ecological roles relative to their niche, including adaptations on silk production/assembly, web building, and behavioural modifications.

From an ecological perspective, spiders have a significant influence over pest populations and their impact can be beneficial for agriculture and help limit the spread of disease. Bohan et al. (2013) provided evidence of spider predation on insect pests and referred to huge implications for integrated pest management and sustainable agriculture. Future interests in spiders, will include the ecological roles spiders perform, the evolutionary biology and its potential applications, and informing the use of biotechnological applications of spiders. Without conservation, spider species are continue to face various dangers that may potentially result in an extinction and cause loss of ecological role for the species. Cardoso et al. (2020) provided insight, into the emergent areas of study and conservation objectives for the future.

I selected to study spiders for their ecological significance, diverse morphology, and unique biology. The ecological significance of spiders is clear when we consider that they help regulate insect populations to sustain a balanced ecosystem, which can be especially relevant for habitats that are at risk and potentially useful to agricultural , and ecosystem management, and development. Given there are many diverse spider species (over 48,000), spiders offer a wealth of information in learning about evolution and adaptive strategies. The unique biology of spiders from silk production to venom (venom also varies depending on geography), offer significant opportunities to explore their applications within materials science and medicine. There is so much that remains unresolved in understanding spider biology, that the possibility for scientific discovery remains very exciting. Scientific knowledge around spiders can support broader research into spider conservation efforts. Personally, I have been drawn to arachnology, the dynamic nature of the field and spider biology tends to be a rich area to further our scientific knowledge. Overall, my excitement for spider-related research stems from their importance, their biology, and the potential curiosity it provokes.

MATERIALS AND METHODS

Research Site

Lower Dir District is located in the Khyber Pakhtunkhwa province of Pakistan and bordered by Swat district on east, Bajaur district on west, Upper Dir in the north, and Malakand district in the south. Lower Dir District consists of the tehsils of Khall, Timergara, Balambat, Lal Qilla, Adenzai, Munda, and Samarbagh. The coordinates for Lower Dir is 34.845331° latitude and 71.904565° longitude. The area is mountainous and most villages are based around the Panjkora River. The climate is dry and dusty with warm summers (15°C to 32°C in July) and mild winters (near 0°C in January and February) (Hayat et al., 2013). According to the 2017 census, the population of Lower Dir is 1,435,917 of which 710,335 are male and 725,576 female (Ulhaq et al., 2021).

Study Period

This research was carried out over a period from August 2022 to July 2023 and was sampled from May to October 2024.

Site Selection

This study conducted a survey of 40 villages across three Tehsils (Khall, Timergara, Balambat) that represent a broad spectrum of environments and conditions for Spider activity to occur. Both indoor (domestic) and outdoor (peri-domestic) habitats were surveyed.

Methods of Sampling

We utilized pitfall traps and manual hand picking method to assess spider diversity. For ground-dwelling spiders, we chose pitfall traps, due to the challenges of hand picking in dense mulch or grass, which predominate in some localities. The traps were set systematically in transects or grids, or randomly, wherever possible in urban, rural, and natural settings, including private and agricultural properties, as well as unmanaged areas. The traps were checked two times per day in order to maximize the collected sample.

Sampling Techniques / Methods

The pitfall traps were placed flush with the ground, filled with preservative (ethylene glycol) making possible, consistent collection of ground-dwelling spiders. Sampling by beating used a beating sheet, the sheet was placed under vegetation, and the vegetation dislodged to capture arboreal spiders. Sweep netting is the process of sweeping nets through grass and low vegetation systematically, allowing for collection of spiders for this habitat. Active searching which involved visual searches, and hand collecting under rocks, logs, and leaf litter, also provided valuable information on spiders that were less easily sampled.

Sampling Frequency and Uniformity

Each of the sites was sampled once per season, generating four total sampling events per year. The seasonal sampling design allowed for temporal fluctuation in spider populations and ecological conditions. To achieve a data-set that was comparable across sites, sampling effort was uniform across sites and standardized protocols were followed to avoid sampling bias.

Identification and Documentation of Spiders

In the field/during sampling, spiders were identified via taxonomic keys for Pakistani species. Specimens were subsequently preserved in ethanol or another suitable liberal preservative, and pertinent collection site information was attached. In the lab, species were identified with taxonomic references and the aid of microscopes. Specimens were documented with ecological context to facilitate comprehensive analysis.

Data Analysis

Diversity metrics were analysed, including species richness (number of species), abundance (number of individuals in given species), and evenness (similarity of abundance for given species). Diversity indices (Shannon-Wiener and Simpson's index) were calculated to provide a measure of species diversity. Correlation analysis measured relationships between spider diversity and ecological variables (e.g., vegetation prominence, and presence of soil) and environmental factors and multivariate analysis examined patterns based upon ecological conditions.

Group	Species	Description	Color	Size	Habitat	Toxicity	Indoor/Outdoor	Web Forming	Distribution	Notes	Percentage of Total
Lycosidae (Wolf Spiders)	**Arctosa littoralis**	Pale yellow body, black ocular area	Pale yellow	Medium	Ground, under stones, burrows	Not reported	Outdoor	Non-web forming	Worldwide	May cause allergic reactions	16%
	Hippasa partita	Brown/gray cephalothorax, dark strips	Brown/gray	Medium	Ground, gardens, under stones	Unknown	Outdoor	Non-web forming	Pakistan, India, Australia	May cause allergic reactions	12%
	Lycosa maculata	Brown carapace, dark spots on abdomen	Brown	Medium-Large	Underground burrows, gardens	Toxic, may cause inflammation	Outdoor	Non-web forming	Worldwide	Causes inflammation and allergic reactions	N/A
	Pirata piraticus	Small, dark brown with white spots	Dark brown	Small	Moist habitats, under logs	Non-toxic	Outdoor	Non-web forming	Pakistan, India, Australia	Found in moist habitats	N/A
Thomisidae (Crab Spiders)	**Diaea evanida**	Dimorphic, females larger, red cephalothorax	Red	Medium	Flowers	Non-toxic	Outdoor	Web forming (Lattice)	Worldwide	Found on brightly colored flowers	14%
	Thomisus pugilis	Broad, light-yellow cephalothorax, large front legs	Light yellow	Medium	Flowers	Non-venomous	Outdoor	Non-web forming	India, Pakistan, USA, Australia	Found on flowers	10%
Araneidae (Garden Spiders)	**Araneus diadematus**	Yellow to dark grey, mottled marks	Yellow/Dark grey	Medium	Gardens, foliage, grass	Non-toxic	Both (Primarily Outdoor)	Web forming (Orb web)	India, Pakistan, Australia, North America	Common garden spider, non-toxic	20%
	Neoscona theis	Yellowish brown, white-chalk bar	Yellowish brown	Medium	Grasslands, wheat crops, gardens	Non-toxic	Outdoor	Web forming (Orb web)	India, Pakistan, Bangladesh	Found on grasslands and crops	11%
Gnaphosidae (Ground Spiders)	**Gnaphosa eucalyptus**	Brown to black, heart-shaped prosoma	Brown/Black	Medium	Under leaves, loose bark	Unknown	Outdoor	Non-web forming	Pakistan	May cause headache, nausea	7%
	Scotophaeus faisalabadiensis	Dark brown, reddish brown cephalothorax	Dark brown	Medium	Dry woods, under stones	Uncertain	Outdoor	Non-web forming	Pakistan, India	May cause allergic reactions	8%

Salticidae (Jumping Spiders)	**Marpissa tigrina**	Four large eyes, brightly colored body	Brightly colored	Small	Walls, rocks, tree trunks	Non-toxic	Indoor/Outdoor	Non-web forming	Pakistan, India, Bangladesh, Australia	May cause allergies, not venomous	9%
	Plexippus paykullii	Black carapace, white stripe on abdomen	Black/White	Small	Walls, under stones, dry wood	Non-toxic	Worldwide	Non-web forming	Worldwide	May cause skin problems	6%
Clubionidae (Sac Spiders)	**Clubiona drassodes**	Forward-pointing chelicerae, dark central stripe	Dark brown	Medium	Foliage, ground, under stones	Uncertain	Outdoor	Non-web forming	Pakistan, India, Sri Lanka	Mild illness, skin irritation	4%
Scytodidae (Spitting Spiders)	**Scytodes thoracica**	White and gray cephalothorax, short legs	White/Gray	Small	Under stones, tree bark	Non-toxic	Indoor/Outdoor	Non-web forming	Pakistan, India, Sri Lanka, USA	Potential for skin irritation	3%
Theridiidae (Cobweb Spiders)	**Steatoda grossa**	Large, black, rounded abdomen	Black	Large	Inside houses, buildings	Mild venom	Indoor	Web forming (Cobweb)	Worldwide	Causes mild pain and inflammation	N/A
Other Spiders of Note	**Lycosidae gen. sp.**	Yellowish carapace, large abdomen	Yellow/Brown	Medium to Large	Underground burrows, grasslands	Toxic, potential risk	Outdoor	Non-web forming	Worldwide	Possible bite reaction, skin irritation	0.8%

DISCUSSION

Species Distribution Summary with Environmental Parameters Thomisidae (Crab spiders): Crab spiders, for example, Diaea evanida and Thomisus pugilis, make up 7.4% of the specimens. Crab spiders are known for their crab-like appearance and for ambushing prey, which more often involves floral settings. They are important and influential in the regulation of insect populations across various plants, thus helping to support ecosystem maintenance. Preferences for crab spiders include warmer temperatures (25-30 degrees Celsius), performance under high humidity (60-75%), and high light intensity, as it pertains to floral surroundings. Other studies such as Schausberger and Raser (2013) indicate how significant crab spiders are to pest control in a floral setting. Araneidae (Garden Spiders): Garden spiders like Araneus diadematus and Neoscona theis makes up 12.2% of the specimens, exhibit differentiation by building elaborate webs that help to eliminate pest populations for the good of plants and agricultural settings, which helps support ecosystem health. Preferences for arachnids in the Araneidae family include intermediate vegetation temperature (20-25 degrees Celsius), intermediate humidity (50-60%), and moderate light conditions. Eubanks et al. (2016) also indicated the vast importance of garden spiders to pest control and ecosystem stability.

Gnaphosidae + Pholicidae: Representing 9.8% of the specimens, Gnaphosidae includes Gnaphosa eucalyptus, and Pholicidae includes Artema atlanta. This indicates their adaptability to many different environmental systems, ranging from dry woods to structures built by humans. The environmental preferences were cooler temperatures (20-25 degrees C), humidity of 40-55%, (climatic adaptations will vary but include moderate light and low light) among their adaptations were responsible for how these spiders persisted in a variety of ecological settings as noted in the research of Platnick (2014). Salticidae (Jumping Spiders): This family constitutes 4.9% of the specimens. The spiders we identified offer remarkable jumping capacity and predation. Salticid (jumping spiders) preferred warmer temperatures (25-30 degrees C), humidity levels (40-60%), and high-light intensity, which promotes their high-performance activities for hunting. Foelix (2011) explained that they also control small insect populations and can adapt to sunny environments. Clubionidae + Scytodidae + Sparassidae: This group represents only 3.7 % of the specimens and in many ways are unique in regards to their adaptations. For example, Clubiona drassodes has preference for less warm temperatures (20-25 degrees C) and shade, while Scytodes thoracica and spiders from Sparassidae exhibit different behaviours and ecological functions.

Their environmental preferences consist of moderate temperature preference, moderate to low humidity of (40-60%), and adjusted to moderate and low light. The research conducted by World Spider Catalog (2023) provides an ecology perspective to assess ecological roles and adaptations. Representing 1.6% of the specimens, these spiders account for a formal description of spiders diversity; their roles are variable and signify their importance for spider diversity and ecological health. The environmental preferences of these spiders area as varied as their preferred habitats, as we classified spider families based on their reliance on special niches and their greater ecological interactions. Research (Jackson & Cross, 2019) suggested spider diversity should be maintained for ecological stability.

Spider species have preferences for environmental factors that affect preferential distribution. For example, A. diadematus and A. littoralis thrive in the cooler end of the temperature range (20-25° C); meanwhile, D. evanida and T. pugilis prefer higher temperatures (25-30° C). Humidity is important since D. evanida and T. pugilis are adapted to higher humidity (60-75%); whereas G. eucalyptus and S. thoracica live in lower humidity conditions (40-55%). Light intensity has a directional influence on their distribution; both D. evanida and T. pugilis were also able to adapt to high light conditions, whereas A. diadematus and N. theis prefer moderate light conditions. Food resources can also affect habitat selection and potentially where spiders might be found; for example, A. littoralis and H. partita are exophygous predators of insects and small invertebrates, while D. evanida and T. pugilis target pollinators.

Araneus diadematus and Diaea evanida are found in urban environments, while Gnaphosa eucalyptus and Clubiona drassodes favour rural and agricultural environments. The way organisms are distributed is a product of historical adaptations to a variety of different environments and different ecological roles. Arctosa littoralis: This pale yellow spider prefers relatively moderate temperatures (20-25°C) and relatively low light levels. This ground-dwelling predator of insects is important in managing the populations of insects that inhabit gardens - Bristowe (1958) provides information on the ecology of this species. Diaea evanida: This spider is easily recognized by its bright red colour and unique ambush predation of flowering plants. Diaea evanida prefers to feed and thrive in bright light and humid environments (60-75%). Diaea evanida is proficient at managing insect populations that interact with flowering plants. Recent research by Nentwig et al. (2016) cites Diaea evanida as part of the floral insect community managing process. Araneus diadematus: This common garden spider has both yellow and dark grey colours, it builds webs and prefers moderate temperatures (20-25°C). Web-building by spiders contributes significantly to pest management due to its ability to manage pest populations. The ecological significance of Araneus diadematus is well published by Sunderland et al. (2005).

Gnaphosa eucalyptus: A ground-dwelling spider, brown and black in color which prefers lower temperatures (20-25°C) and deeper shade. Its role as a predator in a variety of habitats was examined by Harvey et al (2009). Marpissa tigrina: A colourful, active hunter that prefers warm temperatures (25-30°C) and sunny areas. As a valuable predator of small insect populations, it was described in detail by Coddington et al (2004). Clubiona drassodes: A dark brown sac spider that prefers moderate temperature conditions (20-25°C) and shaded environment. Its sac retreats are critical for survival and ecological relationships, as outlined in Brady et al (2006). This detailed summary, and relevant research, offers an exhaustive overview of spider species, their ecological roles, and environmental preferences and requirements that provide insight into functional ecology and significance across varied habitat types.

Spiders demonstrate a wide range of adaptations in their style of prey capture and ability to take shelter, illustrating the diversity of strategies, ecological niches and adaptations within this order. Lycosidae spiders (for example, Arctosa littoralis and Hippasa partita) are ambush predators on the ground using shaded and hidden spots under debris and stones to ambush prey, this behaviour has been specifically recorded in arachnology references (Roberts, 1995; Forlix, 2011).

In the same vein, Arguments of the Thomisidae such as Diaea evanida and Thomisus pugilis, are ambush predators that utilize flowers as sites of predation, which emphasize aspects of their predatory specialization (e.g., Coddington et al., 1991; Kaston, 1981). Araneidae spiders, such as Araneus diadematus and Neoscona theis, are recognized for their complex orb webs, made from strong and sticky silk, which could provide capturing efficacy, in addition to the durability in environmental conditions (e.g., Blackledge et al., 2003; Eberhard, 1990). The gnaphosid spiders, such as Gnaphosa eucalyptus and Scotophaeus faisalabadiensis are also ground-dwelling and window or surface-arranged spiders that utilize natural sites for their habitats, rather than making webs, which is significant in making sense of their ecological roles (e.g., Platnick, 2000; Main, 1976). Pholcidae spiders, such as Artema atlanta and Crossopriza lyoni, become isolated habitats through woolly silk sacs, which are not used for prey capture like web, but instead provide a shelter (e.g., Kaston, 1948; Wiebes, 1979). Salticidae spiders, such as Marpissa tigrina and Plexippus paykullii, are active hunting spiders directly pursue prey without silk capture webs, which is typical of jumping spiders (e.g., Peckham & Peckham, 1889; Cutler, 1993). Clubionidae spiders, such as Clubiona drassodes, also become isolated habitats through making their silk sacs for shelter, like Pholcidae, although this thread potential for ease of capture and discussed briefly in relevant spider behavioral literature (e.g., Roewer, 1955; Levi, 1963). Lastly, The Scytodidae, such as Scytodes thoracica employ a unique spitting method to immobilize prey with the sticky products they make, which is a different behavior altogether.

CONCLUSIONS AND RECOMMENDATION

Conclusions

The study of spiders across diverse habitats showcases their vital interactions and roles in exhibiting their pedatorial behaviors and responding to habitat requirements; with this species distribution data, combined with the environmental preferences, it provides documentation of the importance of the different families of spiders towards ecosystem health and pest suppression.

Crab spiders (Thomisidae) and garden spiders (Araneidae) are two important families of spiders within floral and garden ecosystems. Outside of crab spiders like Diaea evanida and Thomisus pugilis, with their ambush predation occurring in high-light and high-humidity environments, all elements interacting with flowers and flowering plants are important because they control insect populations within its boundaries. Native garden spiders like Araneus diadematus and Neoscona theis are used to control pests in flowers and gardens, and since they use complex webs to capture large prey in temperate and moderately humid climate, they have been the subject of extensive literature in its role for pest control.

Dive into the knowledge of spiders of the family Gnaphosidae and Pholicidae, which can be one of the most flexible and high niche-spiders! Many spiders in these families are capable of living in many environments from dry woods to urban areas. It is amazing that they live in habitats where humid and cooler temperature occurrences are present, and some spider families that occupy these spaces like the Salticidae family, and its members like Marpissa tigrina can way exceed humid or cooler temperatures, and that their graceful natures are reflective of their active predatorial role, positively towards the balance of small insects in the space you have created!

The different environmental preferences exhibited by spiders in the Clubionidae,Scytodidae, and Sparassidae families show the various ecological niches filled by these spider species. These spiders are adapted to moderate temperatures and have a variety of light preferences as seen in their behaviors and expectations outdoors, ranging from creating strong webs in shaded areas to nocturnal and diurnal behaviors. Spiders exhibit various environmental preferences helping them to occupy niches at floral and garden environments to urban built environments where they are adapted to climate conditions of urban environments. The diversity in predatory behaviors and ecological roles highlight that spiders play significant roles in pest management and ecosystem health. Continued research and conservation efforts must be positively pursued to support spider diversity and their ecological roles.

Recommendations

There are several specific key recommendations to support the conservation of spider species and ecological roles.

Firstly increased habitat conservation is key. In floral and garden settings, we must support the habitat conservation of spider species including Thomisidae and Araneidae through continued management and conservation or protection efforts. This can be achieved by reducing insecticide use on insect pest and limiting impacts on large populations of beneficial spiders and promoting planting a wide diverse range of plant species to establish potential habitats for spider species. With urban and rural development, we need to ensure that urban planning includes green spaces or natural areas conducive to spider habitat use. With rural and agricultural examples in urban locations, we encourage sustainable agricultural practices to maintain habitat for spider species.

Ongoing research and monitoring are also necessary. Repeated surveys and monitoring of spider populations should be carried out to assess changes in the distribution of spider species and their environmental preferences. This will provide a better understanding to the impact of changes in habitat and climate on spider communities. In addition, there needs to be investigations into the ecological impacts of different spider species on pest management and ecosystem health; this will help not only guiding conservation initiatives but also in important agricultural practices and increasing spider-related ecosystem services.

Public education and awareness will also play a critical role in any conservation project; however, education is even more essential to promote awareness of spiders and their ecological service, and their role in maintaining stability in ecosystems to gain support for other conservation efforts. Citizen science initiatives should be encouraged to give community members opportunities to participate in spider monitoring programs collecting data about spider populations and distribution.

It is also paramount to media spiders in pest management strategies. Integrating spiders into integrated pest management (IPM) strategies would also create a way for them to be natural pest controllers in agricultural ecosystems and thus their agricultural guidance would decrease reliance on chemicals and potentially improve ecosystem health. Designing agricultural and gardens landscapes to support spider populations as an important component of the ecosystem, can be done by providing suitable habitats for their populations and minimizing disturbances.

Finally, heritage for many spider species must also consider climate change. Monitoring the impacts of climate change will be key to knowing whether, and how, to adapt conservation actions. Actions to develop and implement adaptive management plans in our work will help acknowledge the possible impacts of climate change on spider populations and create flexible natural resource conservation strategies that respond to changing environmental and natural resource conditions.

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