



Ecological Role of Spiders in Terrestrial Ecosystem and Their Conservation Priorities

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.9734/ajriz/2024/v7i4171>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/122869>

Review Article

Received: 30/08/2024

Accepted: 01/11/2024

Published: 16/11/2024

ABSTRACT

Spiders are members of the phylum Arthropoda, the largest phylum of animal groups in the world under the class Arachnida. Spiders are ubiquitous in distribution, invade almost every type of habitat, and are the most abundant invertebrate predators in terrestrial ecosystems. Nearly 47,617 species of spiders under 4,092 genera in 114 families were recorded in the world. Spiders are a key component of terrestrial ecosystems, occupying a unique position in food webs. As predators, they are important in the regulation of invertebrate populations, which include pest species, and as prey, they provide food for other invertebrates and birds. They are important components of the food chain. This is not withstanding the contribution they make to ecosystems in their own right. Spider silk has unique properties that have potential applications in medicine and technology. Many species of spiders have been used as medicines. As bee populations plummet, spiders might be the next solution to the pollination process. Spiders are among the most

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Cite as: Khan, Nazneen Akther, and Manoj Singh. 2024. "Ecological Role of Spiders in Terrestrial Ecosystem and Their Conservation Priorities". *Asian Journal of Research in Zoology* 7 (4):71-76. <https://doi.org/10.9734/ajriz/2024/v7i4171>.

fascinating creatures on earth, and their importance in scientific research cannot be overstated. Spiders play a critical role in maintaining ecological balance, and studying their behavior and biology can greatly advance our understanding of the natural world. The witnessing role of spiders in terrestrial ecosystems has made them ecologically important. In the past few years, spiders have faced several threats that have affected their populations and diversity. Prior conservation programs are required to protect this species from being more vulnerable and endangered.

Keywords: Spiders; terrestrial ecosystem; ecosystem services; conservation.

1. INTRODUCTION

Spiders are members of the class Arachnida, and order Araneae. The biggest order of arachnids, spiders are ranked seventh among all other groupings of organisms in terms of overall species diversity [1]. Spiders are amazing animals; the fossil record shows that they first appeared as living things 380 million years ago, during the Devonian period [2]. Their body is divided into two segments cephalothorax and abdomen; the former has four pairs of segmented appendages, is wingless, and lacks chewing mouth parts. Spiders were recognized by their distinctive ability to produce silk thread. Although many spiders are incapable of spinning webs, all spiders are capable of producing silk thread, which they employ to form sacs to hold eggs, build nests, and, most often, wrap prey.

They make up a substantial percentage of the terrestrial arthropod diversity. Spider diversity can be beneficial for biological control since different species have different hunting tactics, preferred habitats, and activity cycles [3]. In reaction to concentrations of prey, spiders show both functional and numerical responses. Spiders are ubiquitous in distribution invade almost every type of habitat, and are the most abundant invertebrate predators in terrestrial ecosystems. Nearly 47,617 species of spiders under 4,092 genera in 114 families were recorded in the world [4]. There are 1520 known species of spider's in India, categorized into 377 genera and 60 families [5]. One of the most diverse and widespread orders of arthropods in the world is the spider. Among the Arthropoda, arachnids are a significant yet understudied category. Spiders are found as predators in nearly every type of terrestrial ecosystem, except Antarctica, such as caverns, tundra, high elevations, and intertidal zones [6]. The range of their abundance per square meter is 0.64 to 842 [7]. They occupy a vast range of niches and, thanks to their amazing diversity of predation techniques, they also serve as important predators that control the majority of

the insect population. These characteristics give them a perfect model for community assessments as extra terrestrial predators. For this ecosystem functioning the spiders, also can provide various other protective, regulative, and cultural ecosystem services. These ecosystem services provided by the spiders must be properly documented. Previous studies have focused on the predator functioning of spiders, which has been documented in different ecosystems [8]. But it's essential to report the other ecosystem functions of the spiders. Keeping in view the above discussion in the present study we have provided a brief description about the role of spiders in terrestrial ecosystem. From past few years spiders have witnessed the drastic climatic changes and other natural climates, which have threatened spider diversity.

Thus in this context, the conservation of the spiders is necessary. In the present study we have highlighted the prior conservation strategies for the spiders.

2. RESEARCH METHODOLOGY

The present study is a descriptive study, which uses secondary data to frame out the basic ecosystem services provided by the spiders. The secondary data were collected from different published research papers, review papers, short communications, reports, published PhD thesis, news papers, journals, magazines, blogs, websites, different publishers like Springer, Elsevier, etc. The data was collected and the literature related to the present study was screened and the results were formulated.

3. RESULTS AND DISCUSSION

Spiders are obligate predators, meaning they must obtain the energy needed to sustain life by eating other animals [9]. Spiders can prey on a variety of organisms, including other spiders, vertebrates (rarely), and their most common prey type, insects. It is estimated that one spider can

eat as many as 2000 insects in one year [10]. As generalist consumers, many spiders play an important role in each of the communities they are found in by regulating the density of organisms across multiple trophic levels (herbivores and predators). When you combine their variety of food types and their sheer abundance, spiders are one of the most important invertebrate predators in many ecosystems.

Spiders can maintain a dynamic interaction of the ecological units in a micro-level food web [11]. In integrated crop pest management it can serve as an essential element [12]. They are the efficient natural controller of many insect-mediated diseases like malaria, dengue, etc [13]. Spiders being ecologically important are economically beneficial also. In pharmaceutical industries spider silk and venom are now very important industrial inputs [14]. Spider silk being proteinaceous and antibacterial with very high tensile strength is not only helpful in spinning webs, wrapping the prey, egg sac covering, medium of transportation or movement from one place to another but also for making surgical threads, bulletproof jackets and threads of musical instruments, while its venom is useful as an antidote in many ailments [15]. Abundance as well as diversity of spiders is a good indicator of the health of a particular ecosystem [16].

Spiders have important ecological roles in maintaining a healthy and stable community. Spiders also directly benefit humans by consuming prey items that are pests to humans thus reducing their abundance. Many of the insects that spiders eat directly affect humans, including mosquitoes, a pest that transmits deadly diseases like West Nile virus, malaria, dengue, and yellow fever. While many spiders eat mosquitoes that fly into their web, two species of jumping spiders, *Evarcha culicivora* and *Paracyrbawanlessi*, are known as “mosquito terminators.” Both of these species are specialist predators, each preferring to eat mosquitoes from different life stages (adult & nymph respectively; Jackson et al. [17]). Regardless of how mosquitoes are consumed, spiders that have this pest as a part of their diet directly reduce the numbers of these pests and have the potential to reduce the spread of disease.

There is an ancient proverb: “The enemy of my enemy is my friend.” Agricultural pests directly reduce crop yields by feeding on the plants, robbing the fruit/seed output that we harvest for

food. Spiders directly benefit humans by eating a variety of pests, including aphids, grasshoppers, leafhoppers, beetles, and caterpillars [18]. Reductions in pest abundance have led to decreased crop damage (Reichert and Bishop, 1984), which could help increase yields. Sadly, farmers spend billions of dollars on non-natural pesticides designed to reduce weeds and insect pests that have been shown to reduce the abundance of spiders in fields, a natural and thus environmentally friendly form of pest control [18,19,20], and could end up resulting in a pest resurgence [21].

Spiders are seen to be kind animals that bring wealth, happiness, and/or good fortune in many cultures around the world [22]. Because they come from heaven above, Chinese people hold great esteem for spiders and refer to them as “happiness spiders” or “good luck spiders.” It's reported in India that at weddings, spiders are scattered like confetti! The spider was regarded by the Egyptian goddess Neith as the “spinner” and “weaver” of fate. Spiders are the subject of several mythology and folktales across the globe [23]. These are a few convictions:

- You will meet a friend that day if you step into a spider web.
- You will bring rain if you step on a spider.
- Even if a spider manages to get into your pocket, money will always be there.
- A bride will be happy if she discovers a spider on her wedding gown.
- Anticipate company if a spider weaves a web over your door.
- Sunny weather is on the way as spiders begin weaving their webs before midday.

In the view of scientists and researchers, spiders have already established themselves as model organisms for research and education because of their ability as bio-indicators, biological control agents, having high medicinal value, and architects [24]. In the current era, we find that many researchers are involved in proving various biological theories. Thus from this perspective, we can highlight that the spiders play a pivotal educational role.

The above discussion has cleared up how spiders play an important regulatory, protective, and cultural role in a terrestrial ecosystem. In the past few years, it has been reported that the spider population across the globe, is under threat [25]. Many species of spiders are extinct,

are facing vulnerability, and many species are endangered due to various factors. The major reasons for spider threats are given asunder;

- Climate change
- Habitat destruction
- Use of pesticides in agricultural ecosystems
- Environmental pollution
- Introduction of invasive species
- Habitat shifts and ecoslips
- Negative people perception
- Lack of people awareness
- Overgrazing and deforestation

Recent data raises the possibility that local and global spider populations are falling, endangering the viability of the ecological services that spiders offer. Since the Neotropics are home to some of the world's hotspots for spider diversity and endemism, losses in the species are especially concerning. One strategy to stop and lessen spider reductions is through conservation legislation, however, they are typically skewed in favor of vertebrate species. Here, we address the possible benefits and drawbacks of many important policy tools for the protection of spider biodiversity. These include sectoral policies, biodiversity off setting, market-based mechanisms, protected areas and Indigenous and Community Conserved Areas (ICCA), species specific action programs, and the international policy instruments that support these initiatives. While these policies may indirectly increase the variety of spider species, there are ways to better address the unique requirements of spiders in policy to slow down the reductions. Assessing the possibility of extinction for additional spider species would enable policymakers to more effectively target at-risk species and protect their habitats through area-based actions. Different approaches to pest management and improved spider monitoring across several land-based production sectors. Incorporating into international agreements and conventions quantifiable and attainable goals for spider conservation. Lastly, the critical roles that increased public knowledge and community involvement in accomplishing these advancements in spider conservation laws.

4. SIGNIFICANCE AND FUTURE SCOPE

Spiders represent a significant proportion of global animal biodiversity. The role of spiders in

the ecosystem has been discussed in above section. The study provides a comprehensive overview of the role of spiders in ecosystem functioning. It highlights the significance of spiders as bioindicators and their potential for sustainable pest management. Underscores the need for further research on spiders in different types of ecosystems like; agro-ecosystem, forest ecosystem, grassland ecosystem, orchards, man-made gardens etc. There is a need to conduct researches on how spiders regulate the populations of other terrestrial organisms. Analytical studies need to be conducted to determine the species specific role of spiders, so that they can be used for specific purposes. In this review the major threats to the populations have been documented. The researchers need to conduct studies on the conservation status of different spider species. Lastly the threats at local level to the spider populations need to be documented.

5. CONCLUSION

Spiders have been regarded as an important species from an ecological point of view. It has been reported that the spiders provide different ecological services to the terrestrial ecosystem. Some of these services include; acting as obligate predators, occupying a specific position in trophic levels of the food web, having high medicinal values, bearing a wide gene pool, seed dispersal, pollination, integrated pest management, educational value and cultural value. These ecological services have made this species an important one. The spiders are facing serious threats from different factors. This has resulted from the decrease in the spider population. Keeping in view the threats to the spider population, prior conservation programs are required to save this precious species on the earth.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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