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Spider Fauna of Navdanya
Biodiversity Farm, Uttarakhand, India

Spiders are abundant in most terrestrial ecosystems forming one of the dominant macro-invertebrate predator groups. They are sensitive to a wide range of environmental factors including topography, season and other microhabitat factors. Considering their role in the ecosystem, in the present study, we attempted to investigate the diversity and composition of the spiders in Navdanya Biodiversity Farm, Uttarakhand, India. The habitat types that were selected for sampling are mango farm, herbal garden and other crop fields such as brinjal, tomato etc. Sampling was carried out in the month of June 2016. Spider specimens were collected randomly by using five semi quantitative techniques viz., ground hand collection, aerial hand collection, sweep netting, litter sampling and beating method. A total of 112 spider specimens representing 52 species coming under 33 genera belonging to 14 families were collected from Navdanya farm. Salticidae was the dominant family. High generic diversity was found in Salticidae reporting 9 genera. Oxyopes species were active in controlling insects that could be potential pests. A total of 7 feeding guilds were identified by the analysis of feeding behaviour of collected spiders. This study is also the first documentation of the spider fauna in Navdanya Biodiversity Farm, Uttarakhand, India.

Key words: Spider, Diversity, Navdanya, Farm, Guild.

Spiders are important pest control agents managing the harmful insects and other invertebrates' population in our farms and fields naturally.

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Introduction

Spiders, which include 47876 described species under 4116 genera belonging to 118 families, comprise a significant portion of the terrestrial arthropod diversity (World spider catalogue, 2018). Spiders (Order: Araneae) are belonging to the largest order of arachnids and rank seventh in total species diversity among all other orders of organisms and occupy most of the terrestrial habitats. They are generalist predator, which can act against a broader range of insect pests (Sunderland and Samu, 2000). Spiders form one of the ubiquitous groups of predaceous organisms in the animal kingdom. Generally, the spider distribution depends on the zone, location and floral diversity. The great success of these animals is probably due to their innovation in the use of silk, which resulted in a big capability of adaptation, culminating in a high diversity in this group. Spiders are ancient animals with a history going back many millions of years. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their physiological tolerances, which in turn makes them ideal candidates for land conservation studies (Noss, 1990). Landscape diversity is an important factor to spider communities, who depend on the surrounding habitat, vegetation, shrubs and herbaceous layer, since these structures can act as refugee areas (Alderwireldt, 1989). Habitat diversity around the fields enhances migration from the orchard's surroundings, allowing re-colonisation of the agro-ecosystem (Bishop and Riechert, 1990). India is one of the 12 mega biodiversity countries in the world with about 1,25,000 described and about 4,00,000 as yet undescribed

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species of living organisms (Nagendra and Gadgil, 1998). Uttarakhand lies on the southern slope of the Himalaya range, and the climate and vegetation vary greatly with elevation, from glaciers at the highest elevations to subtropical forests at the lower elevations.

Navdanya is an Indian-based non-governmental organization which promotes biodiversity conservation, organic farming, and the rights of farmers and the process of seed saving. Navdanya meaning 'nine crops' began in 1984 as a program of the Research Foundation for science, Technology and Ecology (RFSTE), a participatory research initiative founded by the scientist and environmentalist Vandana Shiva, to provide direction and support to environmental activism. It represent India's collective source of food security. The Navdanya Biodiversity Conservation Farm, spread across 47 acres, is situated between the Yamuna and the Ganga, the Himalayas and the Shivalik range. The farm is a sanctuary of biodiversity where saving more than 1500 varieties of seeds, which attracts life of all forms such as bees, birds, insects and microorganisms. The soil has been regenerated as 690 (and increasing) varieties of rice, 200 varieties of wheat, 60 types of millets, lentils, vegetables, oilseeds, spices and more. The farm has grown from its original seed bank and office to include cattle sheds, a storage warehouse, a vermicomposting unit, a medicinal plant garden, a soil laboratory and a large orchard with 9 varieties of mango. There is no checklist available for spiders in this chosen study area. Therefore, this study is the first attempt to enumerate a preliminary status of the spiders of Navdanya Biodiversity Farm.

Material and Methods

Study area

The site identified for the study is the Navdanya Biodiversity Conservation Farm, spread across 47 acres, is situated between the Yamuna and the Ganga, the Himalayas and the Shivalik range. It is situated at 30.3408°N altitude and 78.0441° E longitude in Dehradun, Uttarakhand. The mean maximum and minimum temperature are 35^0 and 23^0 respectively. The mean relative humidity is 59%. The area is carefully maintained and diversity of vegetation presents a number of ecosystems that can be a heaven for a diverse array of spider fauna. The study carried is an exploratory survey of spiders from, vegetables, oilseeds, spices, a medicinal plant garden, and a large orchard with nine varieties of mango.

Sampling

The study was conducted in June 2016. Spiders were collected between 6.00 am and 12.00pm and evening 4.00pm till 7.00pm. An all-out search method was used for collecting spiders. Sampling was carried out from the habitats such as vegetables, edges, a medicinal plant garden, and a large mango orchard. Commonly used collection techniques were ground hand collection, aerial hand collection, sweep netting, litter sampling and beating method (Coddington and Levi, 1991). The collected specimens were preserved in 70% ethyl alcohol with proper labeling of locality, date and other notes of importance for further studies.

They were examined under a Stereomicroscope (MOTIC™). All the adult samples were identified up to species level. Epigyne were dissected and cleaned using Lactic acid. The specimens were deposited at the Wildlife Institute of India, Dehradun. Diversity analysis determined the species richness and the species involved in prey predation mostly.

Guild structure studies

Ecological characteristics relating to foraging manner, nature of web, prey species, microhabitat use and daily activity pattern at family level were subjected to guild classification. Output of the analysis was organized into graphical form. The spider guild classification was done according to the families collected during the study. Designation of spider guild was based on ecological characteristics known for the family (Young and Edward, 1990).

Results

Spider fauna of Navdanya biodiversity farm

The study was conducted in June 2016. A total of 112 individuals of spiders representing 52 species belonging to 33 genera of 14 families were collected during the study period (Table 1). Guild structure of the collected spider fauna is also analyzed and the observation is represented graphically (Table 2).

Out of the 14 families collected during the study, Salticidae was the dominant family with 11 species belonging to 9 genera. Oxyopidae was the second dominant family with 9 species. The third dominant family was Araneidae which reported 7 species. Other families such as Lycosidae reported 6 species, Theridiidae consisted of 5 species, Thomisidae with 3 species, Uloboridae, Linyphiidae, Hersiliidae and Eutichuridae with 2 species each, Pisauridae, Gnaphosidae, Sparassidae and Tetragnathidae with 1 species each.

Species diversity

A total of 53 species were recorded from an extensive survey of spiders in an area of 47 hecters.

Generic diversity

Out of the 252 genera recorded from the Indian region, 33 genera were discovered in Navdanya biodiversity farm. Accounting for 13% of genera reported from India. Maximum generic diversity was found in Salticidae (9) followed by Araneidae (5) Theridiidae (4), Lycosidae (2), Oxyopidae (2), Thomisidae (2), Uloboridae (2), Linyphiidae (1), Eutichuridae (1), Gnaphosidae (1), Hersiliidae (1), Tetragnathidae (1), Pisauridae (1) and Sparassidae (1).

Family diversity

Out of the 59 families recorded in the Indian region, 14

Table 1: List of spiders collected from Navdanya biodiversity farm.

Family	Species
Araniedae Clerck, 1757	*Araneus* indet. *Plebs himalayaensis* (Tikader, 1975) *Eriovixia laglaizei* (Simon, 1877) *Neoscona mukerjei* Tikader, 1980 *Neoscona theisi* (Walckenaer, 1841) *Neoscona* indet. *Gea* indet.
Cheiracanthiidae Wagner,1887	*Cheiracanthium melanostomum* (Thorell, 1895) *Cheiracanthium* indet.
Gnaphosidae	*Herpyllus* indet.
Hersiliidae Thorell, 1870	*Hersilia savignyi* Lucas, 1836 *Hersilia* indet.
Linyphiidae Blackwall, 1859	*Neriene birmanica* (Thorell, 1887)
Lycosidae Sundevall, 1833	*Lycosa* indet. *Pardosa* indet. *Pardosa* indet. *Pardosa* indet. *Pardosa songosa* Tikader and Malhotra, 1976 *Pardosa shyamae* (Tikader, 1970)
Oxyopidae Thorell, 1870	*Oxyopes javanus* Thorell, 1887 *Oxyopes kusumae* Gajbe, 1999 *Oxyopes shweta* Tikader, 1970 *Hamataliwa* indet. *Oxyopes* indet. *Oxyopes* indet. *Oxyopes* indet. *Oxyopes* indet. *Oxyopes* indet.
Pisauridae Simon,1890	*Nilus albocinctus* (Doleschall, 1859)
Salticidae Blackwall, 1841	*Bianor inciatus Thorell, 1890* *Brettus anchorum* Wanless, 1979 *Evarcha* indet. *Myrmaplata plataleoides* (O. Pickard-Cambridge, 1869) *Plexippus paykulli* (Audouin, 1826) *Plexippus* indet. *Phintella vittata* (C. L. Koch, 1846) *Hyllus semicupreus* (Simon, 1885) *Rhene* indet. *Rhene flavigera* (C. L. Koch, 1846) *Telamonia dimidiata* (Simon, 1899)
Sparassidae Bertkau, 1872	*Olios sanguinifrons* (Simon, 1906)
Tetragnathidae Menge, 1866	*Leucauge decorata* (Blackwall, 1864)
Theridiidae Sundevall, 1833	*Argyrodes* indet. *Euryopis* indet. *Nihonhimea mundula* (L. Koch, 1872) *Nihonhimea* indet. *Theridion* indet.
Thomisidae Sundevall, 1833	*Mastira menoka* (Tikader, 1963) *Thomisus lobosus* Tikader, 1965 *Thomisus* indet.
Uloboridae Thorell, 1869	*Uloborus krishnae* Tikader, 1970 *Zosis geniculata* (Olivier, 1789)

families were discovered in this area representing 24% of the total families recorded from India. Salticidae was the dominant family and composed of 11 species of 9 genera.

Guild Structure

Out of 52 species of spiders, collected from Navdanya biodiversity farm, majority of species (40%) belong to "Stalkers" category. The second dominant guild constituted the orb web weavers (21%). Other guilds are ground runners (15%), foliage runners (12%), ambushers (8%), tangle weavers (2%), space web builders (2%).

Orb Web Weavers

Spiders of this guild construct perfect Orb webs for

Table 2. Number of spider fauna belonging to different families and functional guild.

Sl. No.	Spider Families	Total No.	Guild
1	Araneidae	15	Orb web weavers
2	Cheiracanthiidae	3	Foliage runners
3	Gnaphosidae	1	Ground runners
4	Hersiliidae	2	Foliage runners
5	Linyphiidae	2	Tangle weavers
6	Lycosidae	17	Ground runners
7	Oxyopidae	29	Stalkers
8	Pisauridae	1	Ambushers
9	Salticidae	22	Stalkers
10	Sparassidae	1	Foliage runners
11	Tetragnathidae	1	Orb web weavers
12	Theridiidae	13	Space web builders
13	Thomisidae	3	Ambushers
14	Uloboridae	2	Orb web weavers

prey capture. Spiders of the family Araneidae, Tetragnathidae and Uloboridae come under this category.

Stalkers

Spiders coming under this category actively jump over the prey for feeding. Spiders of the family Oxyopidae and Saliticidae show this type of feeding behavior. A total of nine species of two genera were collected from the family Oxyopidae. Family Salticidae constituted eleven species under nine genera.

Space Web Builders

These spiders construct space like web for prey capture. This guild is formed of Family Theridiidae and was represented by five species under four genera.

Ambushers

These spiders show a “sit-and-wait” type of behavior for prey capture. Spiders of the families Pisauridae and Thomisidae belong to this category.

Tangle Weavers

These spiders construct sheet webs for prey capture. Spiders of the family Linyphiidae belongs to this category.

Ground Runners

Spiders of this guild mainly feed on ground layer of the field and rarely come to the foliage or canopy of the plant for prey capture. The family coming under this guild is Gnaphosidae and Lycosidae.

Foliage Runners

Spiders of this guild mainly run along the leaves, bark, sometimes makes folds in between leaves for prey capturing. The families coming under this guild are Hersiliidae and Cheiracanthiidae.

Discussion

Agro-ecosystems harbour a variety of natural enemies that are involved in regulating several types of insect pests. The site identified for the study is the Navdanya Biodiversity Conservation Farm, spread across 47 acres. The habitat types that were selected for sampling were Mango farm, Herbal garden and other crops such as Brinjal, Tomato etc. The study was conducted only for 3 days between 6.00 am until 12.00 pm and evening 4.00 pm until 7.00 pm. A total 112 individuals representing 53 species of spiders coming under 33 genera belonging to 14 families were collected from Navdanya farm. Salticidae was the dominant family. High generic diversity was found in Salticidae reporting 9 genera. A total of 7 guilds were identified based on feeding habits of collected spiders. Because of their high abundance and predominantly insectivorous feeding habits, spiders are suspected to play an important predatory role in agro-ecosystems, woodlands, and other terrestrial ecosystems (Nyffeler and Benz, 1987; Nyffeler, 2000). They are one of the major groups of generalist predators that are needed in the development of efficient, sustainable, low-input agricultural systems (Ekschmitt *et al.,* 1997).

Dominant species present in the study area where *Telamonia dimidiate* (Simon, 1899)*, Oxyopes javanus* Thorell, 1887*, Nihonhimea mundula*, *Rhene flavigera, Neoscona* indet., ***Bianor inciatus*** Thorell, 1890., Pardosa indet. Members of Oxyopes species were actively involved in prey predation. They were seen associated mostly with crops like brinjal, tomato and along crop edges. Members of the family Oxopidae hunt actively on vegetation and do not use webs for predation (Nyffeler *et al.,* 1992). ***T***heir presence was highly seen on herbs and medicinal plants also. *Telamonia dimidiata* was also involved in prey predation and was seen mostly in mango orchard. Lycosids were the dominant ground dwelling spiders in the study area. Lycosids hunt on the ground and do not make webs (Ford, 1978). In this area hunting spiders were actively present than the ground runners and are considered to be of particular importance as predators of the various stages of crop pests (Muniappan and Chada, 1970; Horner, 1972; Young

and Lockley, 1985; Lockley and Young, 1987; Young, 1989). They are mobile foragers that actively patrol the plant surface in search of larvae and adults of lepidopterans and heteropterans (Whitcomb, 1974).

Hersilia indet. were seen on the barks of Mango habitat. *Cheiracanthium melanostomum* was seen in the folds of mango leaves. *Nihonhimea mundula* was seen only in mango orchard in between a messy web of folded dead leaves and was the dominant species present in mango orchard, found in the low branches of mango tree. Majority of spiders living on ground and vegetation exhibiting protective colouration for camouflage; *Hersilia savignyi* Lucas, 1836 that resembled the bark of the tree, *Nihonhimea mundula* exhibited the colour of dried leaves, ground running spider such as lycosids, had a dirty textured appearance that camouflaged well with the colour of soil the colour of soil.

Spiders are considered to be of economic value to farmers as they play valuable role in insect pest management by consuming large number of insects in the agriculture fields without any damage to crops (Rajeshwaran *et al.*, 2005). According to the 'habitat heterogeneity hypothesis' (Simpson, 1949; Lack, 1969), structurally complex habitats may provide more niches and diverse ways of exploiting the environmental resources and thus increase species diversity (Bazzaz, 1975).

The study in Navdanya farm reported 53 species of spiders, which is quite high number of species as compared to some studies where the duration of collection was more *viz.*, five major agro ecosystems of Jambughoda Village, Panchmahal District, Gujarat (Solanki and Kumar, 2015), which revealed only 67 species of spiders from Gibbon Wildlife Sanctuary (Chetia and Kalita, 2012) Assam, reported 95 species of spider faunal diversity in Perumalmalai forest area, Kodaikanal hills, Dindigul district, Tamil Nadu (Sudhikumar *et al.*, 2005) reported only 25 species of spiders.

Hawksworth and Kalin Arryo (1995) proved that diversity generally increases when a great variety of habitat types are present. Highly varied habitats provide a greater array of microhabitats, microclimatic features, alternative food sources, retreat sites and web attachment sites, all of which encourage colonization and establishment of spiders. Many other studies also have demonstrated an existing correlation between the structural complexity of habitat and species diversity (Andow, 1991). In 1991, Uetz reported that structurally a more complex shrub can support a more diverse spider community. They limit insect pests due to their entomophagous nature. In spite of their beneficial role, most farmers are unaware of the spider's role in agro-ecosystems. The traditional farming practices were helpful in maintaining the population of bio-control agents like spiders. Thus, spiders are important bio-control agents.

Conclusion

Spiders are natural ecological indicators, which determine the quality of habitat and good biological pest control agents. Species richness and generic diversity of spiders depend upon was due to different habitats and organic practices used for farming. Results of present study again highlighted the pure essence of traditional methods of farming practiced in Navdanya biodiversity conservation farm and ecological value of spiders in agro ecosystems. This work intends to create a benchmark data on the spiders of this region.

नवदान्य जैवविविधता फार्म, उत्तराखण्ड, भारत के मकड़ी प्राणिजात

पूजा ए. अनिल कुमार, शाजिया क्वेसिन, श्री लक्ष्मी एवं विरेन्द्र प्रसाद उनियाल

सारांश

प्रधान वृहद-अपृष्ठवंशी परभक्षी समूहों में से एक का निर्माण करते हुए सबसे स्थलीय पारितंत्रों में मकड़िया प्रचुर हैं। ये स्थलाकृति, मौसम तथा अन्य सूक्ष्म आवास कारकों सहित पर्यावरणीय कारकों की व्यापक रेंज के प्रति संवेदी हैं। पारितंत्र में इनकी भूमिका पर विचार करते हुए वर्तमान अध्ययन में, हमने नवदान्य जैवविविधता फार्म, उत्तराखण्ड, भारत में मकड़ियों की विविधता और संयोजन की जाँच करने का प्रयास किया। प्रतिचयन के लिए चयनित आवास किस्में आम फार्म, शाकीय उद्यान और अन्य फसल क्षेत्र, यथा-बैंगन, टमाटर आदि, हैं। प्रतिचयन जून, 2016 में किया गया। पाँच अर्ध मात्रात्मक तकनीकों, यथा- धरातल हस्त संग्रहण, वायवीय हस्त संग्रहण, स्वीप नैटिंग, खरपतवार प्रतिचयन और बीटिंग विधि, का उपयोग करके बेतरतीब रूप से मकड़ी के नमूने एकत्र किए गए। नवदान्य फार्म से 14 कुलों से संबंधित 33 वंश के अन्तर्गत आने वाली 52 प्रजातियों का प्रतिनिधित्व करने वाले कुल 112 मकड़ी नमूने एकत्र किए गए। सेल्टिसिडा प्रधान कुल था। 9 वंश सूचित करते हुए सेल्टिसिडा में उच्च जातिगत विविधता पाई गई। ऑक्सीओप्स प्रजाति कीटां को नियंत्रित करने में सक्रिय थी, जो सक्षम नाशीजीव हो सकती है। एकत्रित मकड़ियों के संभरण व्यवहार का विश्लेषण करके कुल 7 संभरण की पहचान की गई। यह अध्ययन नवदान्य जैवविविधता फार्मउत्तराखण्ड, भारत में मकड़ी प्राणिजात का पहल प्रलेख-पोषण भी है।

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