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# FUNCTIONAL CAPABILITIES OF SPIDERS IN SUPPORT OF SUSTAINABLE AGRICULTURE

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**ABSTRACT**

**Modern agricultural techniques have a detrimental effect on ecosystems, and hence ecofriendly agriculture is required for sustainable agriculture with biodiversity conservation. Spiders play a vital role in keeping pest populations under control as an alternative to chemical pesticides. This study assessed the functional diversity of spiders to control pest populations by estimating their diversity in diurnal and seasonal appearance, preferred microhabitats, and hunting strategies. From August 2020 to November 2021, random quadrate sampling was undertaken in cultivated and wild plant communities. A metaanalysis of the ecology and diversity found that spiders have the capability to provide biological pest control against a wide variety of pests in Odisha's coastal environment.**

**Key words:** Diversity, spiders, agricultural pests, sustainable development, organic farming

Agricultural output is the basis of a nation's economy, providing humankind with the ingredients it needs for survival and raw materials for industrialisation (Praburaj et al., 2018). After independence, widespread and intensive farming practices have brought a green revolution in India (Parayil, 1992). On the other hand, the continuous conversion of forestland to farmland and the application of artificial chemical fertilisers and pesticides raises issues about soil health, pollution, pesticide toxicity, and agricultural production sustainability (Yadav et al., 2013). So, to have sustainable agriculture, organic farming could be an appropriate option where we reduce the application of harmful chemicals while enhancing the use of organic compost to retain natural nutrient recycling (Mahdi et al., 2010; Pindi and Satyanarayana, 2012) and augment the effectiveness of natural enemies to control pests (Letourneau and Bothwell, 2008; Garratt et al., 2011; Xu et al., 2011; Puech et al., 2014). The principal loss of agricultural productivity is caused by various insect pests and mites that cause damage to different parts of the crop plants (Bellotti and Schoonhoven, 1978; Dhaliwal et al., 2015; Rathee and Dalal, 2018). To control those pests, it is, therefore, necessary to have a sufficient diversity of natural enemies with different microhabitats, activity periods, population dynamics, and hunting strategies with high fecundity and dispersal capabilities. All these characteristics are fulfilled by spiders (Sunderland, 1999). Again, ecofriendly agriculture must enable existing natural enemies to resist pests while also boosting agricultural production via locally accessible conventional approaches that cause little disruption to the natural environment (Pierce and Nowak, 1999). Naturally, spiders occupy all kinds of microhabitats and ecological niches to enhance agricultural productivity. Integrating biodiversity conservation by conserving the spider fauna, which is considered the king of microhabitats, with agriculture is the most contemporary and environmentally beneficial strategy for achieving sustainable agriculture, effective use of natural resources, low management effort, and the development of ecotourism (Dumanski et al., 2006; García-Frapolli et al., 2007; Norris, 2008). This research aimed to determine if naturally occurring diverse fauna of spiders could manage agricultural pests by studying their diversity in terms of diversity indices, occupied microhabitat, feeding behaviour, and diurnal and seasonal appearance in the coastal belt of Odisha.

## MATERIALS AND METHODS

From August 2020 to November 2021, random quadrate sampling was conducted in cultivated and wild plant communities. Cultivated plant communities include rice, pulses, vegetables, cashew and mango plants. For low height herbs and shrubs, $1\times1m^2$ quadrate and for high foliage shrubs and trees $5\times5m^2$ quadrate (as plants were distributed sparsely) with a maximum sampling height of 6ft were used to collect spiders from various microhabitats at four time periods (early morning, midday, afternoon and dusk hours) of the day and four seasons (premonsoon, monsoon, postmonsoon and winter) of the year. From each time period of a season, at least 5 quadrates were taken from each plant community. The study was carried out in the coastal areas of Gopalpur and its surrounding area in Odisha, India (19° 15.149'N, 84° 53.554'E). Only mature individuals were considered for estimating diversity. Field observation, calculation and sampling of specimens were done using sweep nets, beating and shaking branches, leaf litter collection, pitfall traps, and handpicking. Following the collection of predaceous arthropods, photographs were taken in the laboratory once again, and specimens were preserved in a separate container with proper abelling for further identification. The identification was done using key characters in Jocque and Dippenaar-Schoeman (2007) and Tikader (1987), Tikader and Malhotra (1980), World Spider Catalogue (2022). Statistical analysis was done using PAST (Paleontological Statistics), version 4.08. The functional diversity of predaceous arthropods to control agricultural pests was estimated by calculating the number of species and individuals sampled from different microhabitats, bearing different feeding habits and appearances in different periods of the day and seasons.

## RESULTS AND DISCUSSION

The taxonomic diversity of spider fauna depicted in Table 1 reveal 37 species belonging to 10 families and 30 genera (Fig.1). The maximum samples belonged to *Scytodes thoracica*, followed by *Anepsion maritatum*, *Myrmarachne* sp., *Peucetia viridana*, *Cyclosa insulana*, *Hyllus semicupreus*, *Telomonia dimidiata*, *Olios melliti*, *Myrmaplata platleoides*, *Phintella vittate, Oxyopes javanus* etc. In wild vegetation, *Anepsion maritatum*, *Cyclosa insulana*, *Gastracantha geminatum*, while in cultivated vegetation, *Scytodes thoracica*, *Phintella vittate* and *Hyllus semicupreus* were dominant species. The species richness and total abundance of predaceous arthropods in the wild plant communities were 37 and 707 whereas in cultivated plant communities that was 29 and 304, respectively (Table 1). The computed diversity indices (Simpson's diversity indices (D, 1-D), Shannon's diversity index (H), Evenness (e^H/S), Brillouin index, Margalef index, Equitability (J), Berger-Parker index, Fisher's index), revealed that although the total abundance of predaceous arthropods in cultivated lands was less than half of that of wild vegetation, still the whole diversity is not greatly different between them. This result indicates that chemical fertilisers and pesticides and even burning action in the field after harvesting cause a severe decline in the spiders (Pekar, 2012). Diversity of spiders increased due to the quicker migration of a wide number of species (agrobiont spiders) from wild plant communities to cultivated plant communities (Samu and Szinetar, 2002).

Table 2 shows the diverse functional capability of the spider to control agricultural pests. The number of

Fig. 1. Spider diversity (Gopalpur, Odisha)

Table 1. Diversity of spider fauna (wild and cultivated plant communities)

| Families | Species name | No. of individuals sampled from wild habitat | No. of individuals sampled from cultivated habitat | Total No. of individuals sampled |
|---|---|---|---|---|
| Araneidae (Orb web or tent web spiders) | *Anepsion maritatum* (O. Pickard-Cambridge, 1877) | 48 | 11 | 59 |
| | *Araneus* sp. | 17 | 2 | 19 |
| | *Araneus viridisomus* Gravely, 1921 | 8 | 0 | 8 |
| | *Argiope anasuja* Thorell, 1887 | 17 | 11 | 28 |
| | *Argiope pulchella* Thorell, 1881 | 22 | 17 | 39 |
| | *Cyclosa insulana* (Costa, 1834) | 38 | 13 | 51 |
| | *Gasteracantha geminata* (Fabricius, 1798) | 37 | 7 | 44 |
| | *Neoscona* sp. | 8 | 1 | 9 |
| | *Neoscona* odites (Simon, 1906) | 1 | 0 | 1 |
| Agelenidae (Funnel web spiders) | *Agelena* sp. | 12 | 9 | 21 |
| Clubionidae (Sac spiders) | *Clubiona sp.* | 14 | 11 | 25 |
| Lycosidae (Wolf spiders) | *Evippa* sp. | 12 | 6 | 18 |
| | *Pardosa* sp. | 16 | 9 | 25 |
| Oxyopidae (Lynx spiders) | *Hamataliwa* sp. | 5 | 0 | 5 |
| | *Oxyopes bharatae* Gajbe, 1999 | 18 | 13 | 31 |
| | *Oxyopes birmanicus* Thorell, 1887 | 13 | 11 | 24 |
| | *Oxyopes javanus* Thorell, 1887 | 35 | 9 | 44 |
| | *Peucetia viridana* (Stoliczka, 1869) | 36 | 19 | 55 |
| Salticidae (Jumping spiders) | *Hyllus semicupreus* (Simon, 1885) | 29 | 21 | 50 |
| | *Myrmaplata plataleoides* (O. Pickard-Cambridge, 1869) | 29 | 17 | 46 |
| | *Myrmarachne* sp. | 35 | 23 | 58 |
| | *Phintella vittata* (C.L. Koch, 1846) | 26 | 18 | 44 |
| | *Plexippus paykulli* (Audouin, 1826) | 12 | 2 | 14 |
| | *Portia fimbriata* (Doleschall, 1859) | 9 | 1 | 10 |
| | *Rhene* sp. | 3 | 0 | 3 |
| | *Siler semiglaucus* Simon, 1901 | 3 | 1 | 4 |
| | *Telamonia dimidiata* (Simon, 1899) | 36 | 14 | 50 |
| Sparassidae (Giant crab spider) | *Heteropoda venatoria* (Linnaeus, 1767) | 5 | 3 | 8 |
| | *Micrommata* sp. | 9 | 0 | 9 |
| | *Olios milleti* (Pocock, 1901) | 31 | 19 | 50 |
| | *Olios* sp. | 10 | 2 | 12 |
| Scytodidae (Spitting spiders) | *Scytodes thoracica* (Latreille, 1802) | 36 | 29 | 65 |
| Tetragnathidae (Long jawed spiders) | *Leucauge decorata* (Blackwall, 1864) | 26 | 3 | 29 |
| | *Tetragnatha javana* (Thorell, 1890) | 11 | 0 | 11 |
| Thomisidae | *Thomisus* sp. | 13 | 2 | 15 |
| | *Xysticus* sp.1 | 19 | 0 | 19 |
| | *Xysticus* sp.2 | 8 | 0 | 8 |

Table 2. Functional capabilities of spiders and their variation

| Name of the ecological characters | Types | No. of Species | No. of individuals |
|---|---|---|---|
| Occupied microhabitats | Leaves and branches of tree canopy or high shrubs | 13 | 359 |
| | Bark of trees | 2 | 15 |
| | Inside leaf litter | 2 | 43 |
| | Inside low shrubs and herbs | 21 | 801 |
| | Inside small herbs and grasses on the ground | 3 | 50 |
| | On barren or rocky land | 3 | 42 |
| Feeding behaviour | Passive hunter by making webs | 13 | 446 |
| | Ambush hunter | 16 | 510 |
| | Active hunter | 8 | 354 |
| Activity period in a day | Early morning (Sunrise-10am) | 25 | 489 |
| | Midday hours (10am-2pm) | 22 | 434 |
| | Afternoon hours (2pm-6pm) | 9 | 136 |
| | Dusk hours (After Sunset) | 12 | 251 |
| Seasonal appearance | Premonsoon (March-May) | 27 | 511 |
| | Monsoon (Jun to Aug) | 19 | 286 |
| | Postmonsoon (Sep-Nov) | 25 | 392 |
| | Winter (Dec-Feb) | 11 | 121 |

species and individuals of spiders was highest inside low shrubs and herbs, which can provide the best biological protection from pests to the annual crop plants having low foliages like rice, pulses, vegetables, etc. The reason for having the highest species diversity inside low shrubs and herbs was due to frequent storms in that coastal area which cause the wild vegetation community to possess mostly herbs, shrubs, and saplings of some trees with sparsely distributed low height trees. Most of the species used ambush hunting strategies to get their prey. Again the diversity of web-building spiders is the potential to control a wide variety of flying adult insect pests, as webs can be traped and kill pests which might be or might not be their prey. Active hunting also killed several active pests but is not significant strategies in cultivated communities as most of the agricultural insect pests were slow-moving. Most of the species were active during morning hours (Sunrise to noon). After that, their number declined, and again towards the sunset, both the number of species and individuals increased. Most of the species sampled were diurnal. Some species collected from tree bark, under the leaves, leaf litter and stones were collected during their resting condition as they were nocturnal in their behaviour. As different species were active during different hours of the day including nocturnal species, the spider community can able to control all sorts of agricultural pests. The number of species and individuals was highest during the premonsoon season followed by monsoon, postmonsoon and winter seasons. Wide varieties of pulses and vegetables were usually harvested during the premonsoon season (Singh, 2013) and that is the appropriate season to control the diverse pest population in crop fields. During the early and late winter season, we sampled 11 species to be active and breed during that time. In the winter season, spiderlings were distributed through ballooning ways to reach the cultivated land easily. During the winter season, the number was poor because most of the sampled species were juveniles and were not considered to estimate the diversity.

It is suggested that having wild vegetation around the cultivated land is essential to preserve spider diversity even after disturbances in cultivated areas due to the harvesting and application of chemical pesticides. In integrated pest control strategies, when required low dose of chemical pesticides can be applied to the core area of the cultivated plants, after which the spider species can quickly eat the resistant pests to control their destructive activities. Moreover, switching from conventional agriculture to ecofriendly organic farming is crucial for sustainable development in the agricultural sector.

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## AUTHOR CONTRIBUTIONS

S Sahoo conducted the sampling, collected, took the photographs and identified the specimens. S Sahoo, G Mishra, J K Seth, L K Murmu and S Goud made an analysis and prepared the manuscript. All authors read and approved the manuscript.

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