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Diversity of Spider Fauna *(*Arachnida*:* Araneae*)* in Rice Agro Ecosystem

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ABSTRACT: Spiders can be found all over the world, and with the irregularity of air and sea colonization, they have established themselves in virtually every habitat. They are effective crop pest predators due to their prey-finding ability and polyphagy. Spiders are obligate carnivores and are the only arthropod group that is entirely predatory. Predation helps to keep insect populations in check. Consequently, during *Kharif* 2018-2019 and *Kharif* 2019-20, the diversity of spider fauna (Arachnida: Araneae) in the rice agro-ecosystem was investigated at the Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar. Using various sampling methods, 622 spider specimens from 9 species, 7 genera, and 4 families were collected from the rice ecosystem in Bhubaneswar. Species richness (S), Shannon diversity index (H'), Evenness index (E), Simpson index (D), and effective number of species were used to assess spider species diversity at different growth stages in rice (ENS). The spider species richness increased gradually with the crop's growth stages, peaking at the ripening stage (6.8). At the reproductive and ripening phases, higher values of diversity indices, such as Shannon diversity index (H') (1.76) and evenness index (E) (0.92), revealed a more homogeneous distribution pattern of species, resulting in a higher diversity of spider species. Further, lower values of the Simpson index (D) (0.11) at ripening stage gave an indication that the ecosystem was well protected from any disturbances, along with the presence of some rare spider species.

Keywords: Rice**,** spider, diversity, species richness, Shannon diversity index, Simpson index, Evenness index, Odisha.

INTRODUCTION

The phylum Arthropoda, class Arachnida, and order Araneae include spiders, which are a major component of global biodiversity. They are the largest Araneae order and have the seventh highest species diversity of any other predatory group of organisms. Spiders are an example of a “megadiverse” group that has been widely accepted as an indicator of environmental quality in ecological studies (Churchill, 1993). Taxonomists have identified more than 45,700 spider species worldwide, divided into 114 families (World Spider Catalogue, 2015). Their ability to hunt in a variety of habitats in a generalist foraging mode, combined with high abundance positions, makes them potential biocontrol agents for terrestrial arthropod populations (Riechert and Lockley 1984). The rice crop, in conjunction with terrestrial and aquatic ecosystems, creates a diverse mosaic of habitats that helps to preserve biological diversity. Wetland rice ecosystems have greater biodiversity than many natural ecosystems. Spiders are the only obligate carnivore arthropods in the rice ecosystem, accounting for about 80% of the predatory fauna (Wang, 1989). In the rice ecosystems of South and Southeast Asia, nearly 350 species of spiders have been identified (Barrion and Litsinger 1995). They can eat large numbers of prey caught in their webs or on the plant or soil surface. Knowledge of spider diversity in agro ecosystems is essential for observing the effects of spiders on herbivorous pests and comprehending how significant changes in the environment can affect spiders. Such research is required in order to design crop pest management tactics that do not disrupt the vast range of natural control provided by these key predators. Pathak and Saha (1999) and Bhattacharya (2000) conducted basic research on the spider fauna of

Indian rice fields. Sebastian *et al.* (2005); Vinothkumar (2012); Rajna *et al.* (2016); Anitha *et al.* (2019) reported on the abundance and diversity of major spider predators in rice ecosystems in India. In comparison to other parts of the country, Odisha has very little information on spider diversity and distribution in the rice ecosystem. Hence, the diversity of spider fauna in rice was assessed under the coastal agroclimatic conditions of Bhubaneswar.

MATERIALS AND METHODS

The present investigation was carried out at the Central Research Station, Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar during *Kharif* 2018 and *Kharif* 2019. The study area was located at an altitude of 45.9 M (45°52′E /20°15′N) with an average rainfall of 1505 mm. Documentation of spiders in the rice ecosystem was carried out from the observational strip of rice crop (var: Swarna), which was raised under unprotected conditions following the standard agronomic package of practices. Three methods *viz.,* direct counting method, sweep net method and pit fall trap method were followed to gather information regarding the aerial and ground species composition of spiders at weekly intervals during the morning hours starting from the 7th day after transplanting.

Collected spiders were killed using chloroform and the specimens were preserved separately in 70 per cent ethyl alcohol (70 parts of 100 per cent alcohol +30 parts of distilled water) or formaldehyde for identification purpose. Representative preserved spider specimens (both immature and adult stages) were critically examined under a zoom, stereoscopic, trinocular microscope having 10 × eyepieces and a 0.7 to 4.5× objective lens for their proper identification. Identification up to genus level was done based on the keys given by Barrion and Listenger (1995). Some spider species which could not be identified at our level were sent for identification to Dr. M. Sampath Kumar, Scientist (Entomology), Division of Germplasm collection and characterization, ICAR-National Bureau of Agricultural Insect Resources, Ministry of Agriculture and Farmers Welfare, GOI, P. Bag no. 2491, H.A. farm post Bellary road, Bengalure-504 026, Karnataka, India. The species diversity of spider was assessed at different growth stages in rice during both the seasons using various indices, *viz*., species richness (S), Shannon diversity index (H'), Evenness index (E), Simpson index (D) and effective number of species (ENS) by using the formulae given below.

- **Shannon - wiener index (H')**: H' $=\sum_{i=1}^{n}$ (Pi(Lnpi))

Where, Pi = proportion of individuals found in this species, Ln = Natural logarithm

- **Species evenness (Evenness Index)(E):** The evenness index (E) was used to understand species evenness. This was calculated by using the formula (Pielou, 1966).

E= H'/Ln S

Where, H' = Shannon –wiener diversity index, Ln = Natural logarithm

S = Total number of species in the sample.

- **Simpson index (D):** D = $\sum_{i=1}^{n} \frac{(ni(ni-1)}{(N(N-1)}$

ni = No. of individuals with species, N= Total no of individuals

- **Effective number of species (ENS):** this was calculated by the following formula (Shannon and Wiener, 1949).

ENS = Exponential (H')**,** Where H' = Shannon- wiener index

RESULTS AND DISCUSSION

During the course of the study, 622 spider specimens from 9 species, 7 genera, and 4 families were gathered from the rice ecosystem in Bhubaneswar using various sampling methods. *Tetragnatha mandibulata* (Walckenaer) (Tetragnathidae), long jaw spider, *Tetragnatha maxillosa* (Thorell) (Tetragnathidae), Wolf Spider, *Pardosa pseudoannulata* (Boes and Strand) (Lycosidae), Lynx spider, *Oxyopesbharatae* (Gajbe) (Oxyopidae), Grass cross spider, *Argiope catenulate* (Doleschall)(Araneidae) and Spotted Orb Weaver, *Neoscona elliptical* (Tikader and Bal)(Araneidae) were reported at various growth stages of rice during *kharif* 2018- 2019. While during *kharif* 2019-20, about eight species of spider from four families *viz.*, *T. mandibulata*, *T. maxillosa*, Tailed Spider, *Tetragnatha javana* (Thorell) (Tetragnathidae), *P. pseudoannulata* (Lycosidae), *O. bharatae* (Oxyopidae), *A. catenulate*, Orb weaving spider, *Araneus* sp. and Larinia Orb Weaver, *Larinia* sp (Araneidae) were observed.

Spider diversity: The mean value of various diversity indices compiled over the two seasons at various growth stages of rice is presented in Table 1.

(a) Species richness: Species richness, the most widely adopted diversity measure, examines the number of species occurring in a habitat. Various environmental factors like seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability, and productivity affect the species diversity in a particular habitat. The different growth stages of rice crop observed in the field along with different arthropod populations were observed in rice crop (Heong *et al*., 1991). In the present studies, the number of spider species recorded from rice fields was six during *kharif* 2018-19 and eight during *kharif* 2019-20. The mean value of species richness over the two seasons increased gradually from 4.2 in vegetative stage to 6.8 at the ripening stage (Table 1). Similar results were also obtained by Barrion and Litsinger (1995) in Phillipines, Anbalagan and Narayanasamy (1999) from Tamil Nadu, Khan and Mishra (2003) from Uttar Pradesh and Patil (2004) in Karnataka, where they studied that the spider population was directly related to the growth stages of the rice plants.

Table 1: Diversity of spider species at different growth stages in rice at Bhubaneswar (Mean of *kharif* 2018-19 and *kharif* 2019-20).

Growth stages of rice	Species richness (S)	Shannon Index (H')	Evenness (E)	Simpson Index (D)	Effective number of species (ENS)
A. Vegetative phase	4.2	1.47	0.75	0.16	3.51
B. Reproductive phase	6.5	1.72	0.92	0.15	4.69
C. Ripening phase	6.8	1.76	0.92	0.11	4.80

(b) Shannon index (H'): The next diversity index used here was the Shannon index (H'), which is sensitive to changes in the abundance of rare species in a community. The mean Shannon index (H') value computed over the two seasons progressively increased along with crop growth (1.47 to 1.76) and was highest (1.76) during the ripening stage, showing higher diversity (Table 1). In the present study, the value of H' increased as crop growth advanced which indicated the presence of some rare species in the spider community and indicated a moderately stable diversity of spider species. According to Goswami *et al.* (2015), the Shannon index (H) diversity in rice from three districts in Bihar ranged from 1.73 to 2.17 at various growth stages. During the *kharif* and rabi seasons, respectively the Shannon Index (H') or species diversity, ranged between 1.53 and 1.81. (Anitha and Vijay 2016). Rice has a higher Shannon index (H) diversity value of 2.18, according to Faria *et al.* (2016). The variability in Shannon index (H') values was due to differences in species richness between locations. The current findings corroborate those of previous researchers.

(c) Evenness index (E): In general, species richness and species evenness are two independent characteristics of biological communities that contribute to their diversity (Heip and Engel 1974). Ecologists' most commonly used evenness index is E, which should be independent of the number of species in the sample. Several studies have shown that adding a rare species to a sample containing only a few species significantly changes the value of E. When all of the species in a sample are equally abundant, the evenness index reaches its maximum, and then decreases to zero as the relative abundance of the species diverges from evenness.

In the present study, a gradual increase in mean evenness (E) value over the two seasons (0.75 in the vegetative phase to 0.92 in the ripening phase) was observed (Table 1). A high evenness value (0.92) was recorded at the reproductive and ripening phases, displaying the distribution of more homogenous species that leads to a higher diversity of spider species. As Pianka (1966) hypothesized, crop development improves prey availability, allowing more spider species to exist. In two years of research, the evenness value (E) in the rice ecosystem at Gujranwala, Pakistan (Ghafoor and Mahmood 2011), 0.69 to 0.72 at different growth stages in rice from three districts in Bihar (Goswami *et al*., 2015), and 0.59-0.72 in rice at Hyderabad were found in published literature (Anitha *et al*., 2019). The current observations are completely consistent with the findings of the previous authors.

(d) Simpson index (D): The Simpson index (D) is a dominance index because it gives more weight to common or dominant species and is sensitive to changes in the most abundant species in a community. The value of D ranges between 0 (infinite diversity) and 1 (no diversity). Mean Simpson index (D) value computed over the two seasons ranged between 0.11 and 0.16 for all the studied growth stages (Table 1). The Simpson index was highest (0.16) at vegetative phase and lowest during the ripening stage (0.11). A declining trend of Simpson index (D) values along with the growth stages in the present study indicated the dominance of some spiders like tetragnathids and lycosids in the initial period of crop growth. Higher D values give an indication that a particular habitat has undergone immediate disturbances, while the lower values suggest protection from disturbances and indicate the presence of less rare spider species. In early and late season rice crops in China's Guangdong province, Zhang *et al.* (2013) found Simpson index (D) values ranging from 0.26 to 0.15. At different growth phases of rice from three districts in Bihar, the Simpson index (D) value ranged from 0.13 to 0.18 (Goswami *et al*., 2015). In the rice ecosystem at Hyderabad, Anitha and Vijay (2016) calculated Simpson index (D) values of 0.29 during the *kharif* season and 0.19 during the rabi season. The observed findings are consistent with prior workers' reports.

(e) Effective number of species (ENS): The effective number of species (ENS) is another measure of diversity which depicts the number of equally common species required to give a particular value of an index. ENS is the reciprocal of D which gives information on the effective number of species in the study area. ENS has been increasingly used for biodiversity monitoring, assessment, and conservation planning. Like Shannon Index (H') and Evenness (E) index, an increasing trend of values of the effective number of species was also observed during the vegetative, reproductive, and ripening phases of growth in rice (Table 1). At ripening, the effective number of species was maximum (4.80) at ripening phase while it was minimum (3.51) at vegetative phase of growth. As the values of ENS are smaller than the S (species richness), which indicates the presence of an uneven spider community. The current finding was found to be highly supported by Anitha and Vijay (2016), who investigated the effective number of species of 4.62 during the rabi season and 6.11 during the rice ecosystem at Hyderabad.

CONCLUSION

From the above-mentioned discussion with respect to implications of various diversity indices of spiders it is inferred that no single measure or index could reflect the diversity of the spiders in rice under Bhubaneswar conditions. Spider diversity and abundance increased with the growth of rice crop. The spider diversity was moderately stable with even species distribution due to low species richness and is well protected from any disturbances.

FUTURE SCOPE

Spiders play an important role in ecology since they are solely predatory and thus regulate insect populations. Because spiders are good biocontrol agents in the rice ecosystem, future research should focus on mass production and field release of spiders in rice.

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Conflict of Interest. None.

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