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Ecological Guild and Predatory Behavior of Spider Fauna (Arachnida : Araneae) in Rice Agro Ecosystem

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ABSTRACT

Studies on ecological guild and predatory behavior of spider fauna (Arachnida: Araneae) in rice agro ecosystem was carried out at Central Research Station, Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar during *kharif* 2018-2019. Results revealed that the spider species collected from the rice field at various growth stages belonged to two different major ecological guilds viz., web building and hunting spider. Under web building spider the orb web weavers was the only one observed ecological guild. Ground runners and stalkers were the other two ecological guild observed under the hunting spiders. Among the members of four spider families collected various guild were orb weavers (69%), ground runners (16 %) and stalker (15%). Major preys of web building spiders consisted of mostly the insects belonging to order Hemiptera (60.09 %), Lepidoptera (36.04%) and Diptera (3.87%).The big jawed spider *Tetragnatha mandibulata* (Walckenaer), the dominant species of spider in the present study preyed on an average 3.4±0.5 adults of white backed plant hopper (WBPH) *Sogatella furcifera* (Horvath) per day and 2.3±0.7 adults of brown plant hopper *Nilaparvatha lugens* (Stal) per day under laboratory conditions showing a greater preference for *S. furcifera.*

Keywords Ecological guild, Prey spectrum of spider, Predatory behavior, Spider, Rice agro ecosystem.

INTRODUCTION

Spiders (Arachnida: Araneae) occupy a wide array of spatial and temporal niches which employ a remarkable diversity of predation strategies. They are characterized by high within-habitat taxonomic diversity exhibiting taxon and guild-specific responses to environmental change. They are also useful indicators of the overall species richness and health of biotic communities (Norris 1999). The spider guild composition is complex and it depicts the differences in the structure of spider communities from a variety of habitats. Spider guilds are grouped according to the ecological characteristics of species like their distinct

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strategies in foraging, web type, hunting methods and circadian activity (Cardoso *et al.* 2011). Determining ecological guild in rice field is useful in examining assemblage response to change in climate, habitat disturbance and management. Spiders play a major role in controlling insect pests in the agricultural ecosystem because they can consume large numbers of insects, either trapped in their webs or on the plant or soil surface. Very limited information is available on the predatory efficiency of spiders and their predatory roles in pest control; therefore, they seldom have been treated as an important biological control agent (Riechert and Lockley 1984). Nearly 350 species of spiders are reported to occur in the rice ecosystem in South and South East Asia (Barrion and Litsinger 1995).The spiders have higher host finding capacity and can consume larger numbers of preys than other rice field inhabiting predators. The importance of spiders as suppressant of the rice pests like *Nilaparvta lugens* (Stal), *Sogatella furcifera* (Horvath), *Nephotettix virescens* (Distant) (Rajendran 1987 and Nirmala 1990), *Scirpophaga incertulas* (Walker) (Bastistas *et al.* 1993) have been well recognized. Information on ecological guild of spiders and their predatory behavior in the coastal rice ecosystem of Odisha is rather scarce. Hence, the present studies were conducted to assess the guild classification of rice spiders, prey spectrum of the web spider and the predatory potential of *Tetragnatha mandibulata* (Walckenaer) under the coastal agro climatic conditions of Odisha.

MATERIALS AND METHODS

Field experiments were carried out at the Central Research Station, Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar during *kharif* 2018 -2019. The study area was located at an altitude of 45.9 M ($45^0$52'E /20 ^{0} 15' N) and receives 1505mm rainfall annually. Documentation of spider in rice ecosystem was carried out from the observational strip. The rice crop (var swarna) was raised under the 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 interval during morning hours starting from 7th day after transplanting. Activity of spiders irrespective of species was monitored at weekly intervals in rice (var Swarna) from 33rd std week (Aug12-18) to 50th std week (Dec 9-15) during both the years for which its population per each quadrant of one square meter canopy area was recorded.

Ecological characteristics of identified spider species relating to distinct strategies in foraging, nature of web, prey species, hunting methods and circadian activity were subjected to guild classification. Output of the analysis was organized into tabular form. The spider guild classification was composed according to the families collected during the study. Guild composition for both the seasons was worked out. Designation of spider guild was based on the ecological characteristic known for the family (Young and Edwards 1990 and Uetz *et al.* 1999). To know about the prey spectrum of the web spider, the number of prey caught in each web was recorded at weekly intervals from 20 quadrants at the time of observation on seasonal activity of spiders during *kharif* 2018-19 and 2019-20. The preys were collected and identified in the laboratory. Data collected over standard weeks were pooled and the percentages of each item were worked out.

Predatory potential of major rice spider under laboratory conditions : Predatory potential of adult stage of *Tetragnatha mandibulata* (Walckenaer), the dominant species of spider in the present study was evaluated under laboratory conditions (mean temperature 25.15^{0}C and mean relative humidity 90.15%) in the Bio-control Laboratory of Department of Entomology, College of Agriculture, Bhubaneswar during September - November 2019. Species of prey for this study was adults of white backed plant hopper *Sogatella furcifera* (Horvath) and adult of brown plant hopper *Nilaparvatha lugens* (Stal). The methodology described by Kamal *et al*. (1990) was followed in this study.

For mass culture of the prey insects viz., brown plant hopper (BPH) and white backed plant hoppers (WBPH) under net house conditions respectively, the insects were collected from infested rice crop initially. Ten days old seedlings of rice (var swarna) were planted in clay pots (40 cm × 15 cm) in the net house.

To maintain a standing water condition, pots were then placed in trays full of water. All recommended cultural practices including fertilizer application were followed for raising rice crop in pot. Two weeks after transplanting, the plants in each pot were placed in a circular mylar film cage (50 cm × 40 cm) to exclude other rice pests and natural enemies. The top of the cage was covered with fine- mesh nylon cloth. Ten such pots were maintained for each prey insects separately. Adult stages of BPH were collected with the help of aspirator from the basal region of infested rice fields of the research farm. Immediately after collection, the insects were placed in test tube of medium size (15 cm in length). The mouth of the test tubes were then closed with pieces of fine nets and fastened with rubber bands. The collected insects were then brought to the net house and 10 number of adults were released into circular mylar cages with 30 days old rice plants. All the cages were examined periodically for the presence of any predators and prompt removal of these were necessary for maintaining the population. Twenty-five days later, sufficient numbers of insects became available at the time for the feeding potential study of spider. Similar method was followed for mass culture of WBPH under net house conditions.

Adults of *T. mandibulata* caught from unsprayed rice field were kept in a glass jar (20 cm x 15 cm) without food for 24 hrs for starvation. Twenty five adults each of white backed plant hopper (WBPH) and brown plant hopper (BPH) were collected from the rice plant raised under net house conditions with the help of aspirator. Then these adults were released separately into the glass jar to maintain the food supply for the spider. Fresh leaves of rice plant were kept in the glass jar as food for the WBPH and BPH. The glass jar was covered with muslin cloth and kept in wooden cage for 24 hrs without any disturbance. The numbers of insects preyed upon were recorded 24 h after their release and continued for 7 days. After each recording time, the population of WBPH and BPH were replaced with fresh prey numbers to maintain live food for the spiders. Ten such sets were maintained each for BPH and WBPH. The daily per cent predation of WBPH and BPH by *T. mandibulata* was worked out separately and averaged for seven days.

RESULTS AND DISCUSSION

Composition of different feeding guild of spiders in rice : The spider species collected from the rice field at various growth stages during *kharif* 2018-19 and 2019-20 were classified based on the foraging mode into two different major ecological guilds viz., web building and hunting spider (Young and Edwards, 1990).Under web building spider the orb web weavers was the only one observed ecological guild. Ground runners and stalkers were the other two ecological guild observed under the hunting spiders (Tables 1-2).

Orb web weavers : Among the members of four spider families collected, majority (64.93% in *kharif* 2018-19 and 72.17% in *kharif* 2019-20) belong to orb weavers category. Spiders of orb web weavers guild constructed perfect orb webs for capturing the

Table 1. Composition of different feeding guilds of spiders in rice ecosystem during *kharif* 2018-19.

Sl. No.	Feeding guilds with families	Total number of specimens	Relative abundance (%)	Total number of genera	Total number of species
A.Web building spiders					
a) Orb web weaver					
1	Araneidae	51	19.03	2	2
2	Tetragnathidae	123	45.90	1	2
B.Hunting spiders					
a) Ground runner					
3	Lycosidae	48	17.91	1	1
b) Stalker					
4	Oxyopidae	46	17.16	1	1
	Total	268	100	5	6

Table 2. Composition of different feeding guilds of spiders in rice ecosystem during *kharif* 2019-20.

Sl. No.	Feeding guilds with families	Total number of specimens	Relative abundance (%)	Total number of genera	Total number of species
A.Web building spiders					
a) Orb web weaver					
1	Araneidae	67	18.93	3	3
2	Tetragnathidae	192	54.24	1	3
B.Hunting spiders					
a) Ground runner					
3	Lycosidae	50	14.12	1	1
b) Stalker					
4	Oxyopidae	45	12.71	1	1
	Total	354	100	6	8

preys. Two families viz., Araneidae (4 species) and Tetragnathidae (3 species) constituted this category.

Ground runners: The second dominant guild constituted the ground runners (17.91% in *kharif* 2018-19 and 14.12% in *kharif* 2019-20). Spiders under this category chiefly feed on ground layer of the field and rarely come to the foliage or canopy for capturing their preys. The family Lycosidae (one species) was included under this ecological guild.

Stalkers: Stalker (17.16% in *kharif* 2018-19 and 12.71% *kharif* 2019-20) was the other ecological guild of these spiders. This category of ecological guild actively jump over preys for feeding .The family Oxyopidae (one species) was included under this ecological guild.

Table 3. Prey composition in webs of web building spiders in rice ecosystem during *kharif* 2018-19.

Prey (Order and species)	Prey caught/20 webs No	%	Total prey from an order (%)
1. Diptera			
Unidentified flies	10	4.73	
2. Hemiptera			4.73
BPH	60	28.43	
GLH	20	9.48	58.30
WBPH	30	14.22	
Gundhi bug	5	2.37	
Unidentified species	8	3.80	
3.. Lepidoptera			
YSB	15	7.10	
Leaf roller	12	5.68	
Horned caterpillar	18	8.54	36.97
Leaf folder	25	11.85	
Unidentified species	8	3.80	
Total	211		

About seven ecological guilds in rice were reported from Kerala (Joseph and Premila 2016). Faria *et al*. (2016) identified nine different guilds of spiders rice at Jahangir Nagar University campus, Bangladesh. Eight feeding guilds viz., orb weavers, ground hunters, ambushers, ground runners, stalkers, space web builders, branch dwellers and foliage hunters were recorded from rice field (Al Faruki and Ahmed 2018). Jose *et al*. (2018) found seven feeding guilds of spiders viz., stalkers, orb weavers, ambushers, foliage runners, hunters, space web builders, ground runners and wandering sheet weavers from rice field at Kavvayi river basin, Kerala. In the present study only three feeding guilds were registered which might be due to lower species richness. Spiders may constitute more than one assemblage guild as their predatory potential in agro ecosystem is dependent upon the microhabitat, seasons, time of day and foraging strategy.

The present findings of dominance of web building spiders in rice ecosystem are in full conformity with reports of Patel *et al.* (2013), Anitha and Vijay (2016) and Sharma and Singh (2018).The abundance of orb weavers is influenced by the physical structure of the vegetation and the availability of web sites. According to many previous studies, the availability of attachment substrates for the webs of web-building spiders was determined by vegetation complexity.

Further, orbicular web builders need open spaces to construct their webs and capture flying insects and thus were expected to be more abundant in rice than in grassland (Blackledge *et al.* 2003).

Prey composition in webs of spiders: Prey composition in webs of web building spiders during the ripening stage of rice was studied during *kharif* 2018-2019 and *kharif* 2019-20 (Table 3 and Table 4). Potential preys of web building spiders consisted of mostly the insects during both the years belonging to order Hemiptera (58.30% in *kharif* 2018-2019 and 61.89% in *kharif* 2019-20), Lepidoptera (36.97% in *kharif* 2018-2019 and 35.10% in *kharif* 2019-20) and Diptera (4.73% in *kharif* 2018-2019 and 3.01%in *kharif* 2019-20). The major insect prey species under order Hemiptera were BPH (28.43% in *kharif* 2018-2019 and 28.30% in *kharif* 2019-20), GLH (9.48 % in *kharif* 2018-2019 and 11.32% in *kharif* 2019-20),WBPH (14.22% in *kharif* 2018-2019 and 17.000% in *kharif* 2019-20), Gundi bug (2.37%in *kharif* 2018-2019 and 2.26% in *kharif* 2019-20) and unidentified species (3.80% in *kharif* 2018-2019 and 3.01% in *harif* 2019-20).

The web builder spiders comprising of three guilds viz., orb web weavers, scattered line weavers and sheet web builders spin various types of aerial webs for trapping walking, jumping and flying insects as their prey. Most of the prey species found trapped in the spider webs of *Tetragnatha* mainly included leafhoppers (*Nephotettix* spp.), leaf bugs (*Eysarcoris* sp,), other cicadellids and plant hopper species, some species of Diptera and larvae of Lepidoptera (Baldissera *et al.*2004). Butt and Tahir (2010) found that the main prey of *T. javana* were Lepidoptera, Diptera, and Hemiptera. In the ripening stage, the main captured prey was *Delphacidae* (Hemiptera), the common rice insect pests in southern Thailand (Rattanapun 2012). The main groups in the prey spectrum of Tetragnatha spiders were detritus feeding, plankton feeding, and sap-sucking insects (insect pests), which were trapped in webs in different proportions along the rice growing season (Saksongmuang *et al*. 2020).All these findings of previous researchers are in line with the results of present study.

Predatory potential of major rice spider under laboratory conditions: The big jawed spider,*T.mandibulata* was identified as the most abundant spider species at vegetative, reproductive and ripening stage of rice in the present study. *Tetragnatha* species make horizontal orb webs with an open hub, and adapt to capture small prey flying weakly. The webs made of silk thread were strong and sticky. Results evinced that the mean number of adults of *S.furcifera* consumed by the *T.mandibulata* ranged from 3.2±0.4/day to 3.7±0.6/day at different days of caging (Table 5). Similarly, the mean number of adults of *N.lugens* predated by *T.mandibulata* per day varied from 2.1±0.8 to 2.5±0.8 at various days of caging. On an average *T.mandibulata* preyed 3.4 adults of *S.furcifera* per day and 2.3 adults of *N. lugens* per day showing a greater preference for WBPH.

Table 4. Prey composition in webs of web building spiders in rice ecosystem during

Prey (Order and species	Prey caught/20 webs No	%	Total prey from an order (%)
1. Diptera			
Unidentified flies	8	3.01	3.01
2. Hemiptera			
BPH	75	28.30	
GLH	30	11.32	
WBPH	45	17.00	61.89
Gundhi bug	6	2.26	
Unidentified species	8	3.01	
3. Lepidoptera			
YSB	20	7.54	
Leaf roller	12	4.53	
Horned caterpillar	25	9.43	35.1
Leaf folder	30	11.33	
Unidentified species	6	2.27	
Total	265		

Table 5. Feeding potential of T.mandibulata on different insect pests of rice. *Mean of 10 observations.

Days after caging	Mean no of adult stage of insect pest of rice consumed by *T. mandibulata* per day*	
	Sogatella furcifera	*Nilaparvata lugens*
1	3.7±0.6	2.2±0.8
2	3.2±0.4	2.2±0.7
3	3.3±0.4	2.1±0.8
4	3.7±0.6	2.5±0.8
5	3.7±0.6	2.2±0.7
6	3.2±0.4	2.20±0.7
7	3.20±0.4	2.20±0.7
Mean	3.4±0.5	2.3±0.7

Several studies carried out in Philippine showed that spiders were important predators of rice hoppers (Barrion and Litsinger 1980). Samiayyan and Chandrasekharan (1988) reported that *Tetragnatha* and *Oxyopes* sp. consumed more of GLH and their potential against WBPH and BPH was almost equal. Wipadavungsilabutr (1988) found that the males of *T. mandibulata, T. javana, T. virescens* and *T. maxillosa* consumed on an average 1.40, 1.08, 1.33 and 1.14 adults of *S. furcifera* per day, respectively, whereas females consumed on an average 1.50, 1.42, 1.33 and 1.47 adults of *S. furcifera* per day, respectively. *Nirmala* (1990) reported that *T. javana* consumed 1.30 WBPH per day. All these work of previous researchers are in accordance to the present findings.

CONCLUSION

It was concluded from the present investigation that the spider species collected from the rice field at various growth stages were classified as two different major ecological guilds viz., web building and hunting spider based on their foraging mode. Orb web weavers were the only one observed ecological guild under web building spider. Ground runners and stalkers were the other two ecological guild recorded under the hunting spiders. The insects belonging to order Hemiptera constituted the major share of preys of web building spiders followed by Lepidoptera and Diptera. The big jawed spider, *Tetragnatha mandibulata* Walckenaer showed greater prey preference to *S.furcifera* than *N. lugens*.

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