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Research Article

Vertical stratification of spiders in Kuttanad rice agroecosystem, Kerala

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ABSTRACT: Investigations were carried out during the period from July 2010 to January 2011 on the vertical stratification of spiders in the rice agroecosystem of Kuttanad, Kerala. For the present study, five main functional groups were recognized based on the activity and foraging behaviour related to average height of the rice plant, namely <20cm from water/soil surface, 20-40cm, 40-60cm, 60-80cm and >80cm. The final growth stage of each plant was thoroughly examined from top to bottom, on leaf blades, flowers, dry leaves and ground stratum. Spiders were then identified with the help of available literature. A total of 1632 individuals from 69 species, 49 genera and 17 families were collected during the study period. The most species rich family was Salticidae (15 species) followed by Tetragnathidae (12 species) and Araneidae (7 species). The spiders collected were classified into 7 ecological guilds based on the foraging mode of the spiders. Among the 69 species of spiders collected, 54% belongs to stalkers (28%) and orb weavers (26%) categories. The second dominant guilds are the ground runners (13%) and space web builders (11%). Ambushers (10%), foliage runners (7%), sheet web builders (5%) and sheet web builders are the other ecological guilds to which these spiders belong.

KEY WORDS: Araneae, rice, stratification, guild, microhabitat, spiders

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INTRODUCTION

During the recent years, there has been an interest in the employment of natural enemies, notably predators, for the regulation of insect pests. Spiders are abundant and ubiquitous, employ a remarkable diversity of predation strategies, occupy a wide array of spatial and temporal niches, are characterized by high within-habitat taxonomic diversity, exhibit taxon- and guild-specific responses to environmental change, and are relatively easy to sample and identify. They are important regulators of insect populations (Wise, 1993) and may prove to be useful indicators of the overall species richness and health of biotic communities (Norris, 1999).

The population densities and species abundance of spider communities in agricultural fields can be as high as in natural ecosystem (Tanaka, 1989). In spite of this, they have not usually been treated as an important biological control agent because very little is known of the ecological role of spiders in pest control (Riechert and Lockley, 1984). The present study was conducted to document the diversity of spiders in rice ecosystem in Kuttanad, Kerala along with the vertical stratification of the spiders.

MATERIALS AND METHODS

The study was conducted in Kuttanad region extends from 9° 17' N to 9° 40' N and 76° 19' E to 76° 33' E, covering 874 km^2 of which 290 km^2 comprise garden lands rising 1-2 m above mean sea level. The remaining area is 0.6 - 2.2 m below MSL. In Kuttanad, rice is cultivated in 53,639 hectares.

The investigation was carried out from July 2010 to January 2011. Sampling was conducted during Kharif 1 (Monsoon crop: July 2010 to September 2010) and Rabi 1 (Winter crop: November 2010 to January 2011). The Kharif season is characterized by heavy rain (South-West Monsoon) and high humidity. More than 80% of the total annual rainfall is received during this season. The Rabi season is characterized by low rainfall and dry weather (Menon *et al.*, 2000). The following eight sites were selected for the study:

Chambakulam, Edathua, Krishnapuram, Moncompu, Nedumudy, Pallathuruthy, Pallikoottuma and Vellisrakka.

Sampling

The sampling was done fortnightly. Each crop season included seven stages of sampling according to the growth of the plant. Spiders were collected by handpicking method.

Handpicking

The areas around each plant were thoroughly examined from the top to bottom -on leaf blades, flowers and dry leafs for spiders and insect pests. The ground area near the plants was also searched. According to the collection, the location where the spiders was found was also noted. Spiders were easily collected by leading them into glass vials (5.2 cm x 2.0 cm) from the ground stratum and from the terminals of the plants. All the collected specimens were preserved in 70% ethyl alcohol with proper labelling of locality, date, crop stage and other notes. Field record was maintained throughout the study period.

Vertical stratification

Spiders collected from the field were classified into five main functional groups based on their distribution in the different strata. These strata are based on the relative distance in the crop itself that exhibit limitations on spiders set by both physical conditions and biological factors. Describing the spider diversity in terms of these groups allows greater insights into how habitat differences may be reflected in the foraging strategies. In the present study, 5 main functional groups were recognized, namely <20cm from water /soil surface, 20 – 40 cm, 40 – 60 cm, 60 – 80 cm and >80 cm.

Guild structure

Ecological characteristics relating to foraging manner, nature of web, prey species, microhabitat use, site tenacity and daily 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. Designation of spider guild was based on the ecological characteristic known for the family (Young and Edwards, 1990).

RESULTS AND DISCUSSION

Diversity

A total of 1632 individuals from 69 species, 49 genera and 17 families were sampled in Kuttanad during the study period (Table 1). The spiders collected from the various sites were identified with the help of literature.

Table 1. Checklist of spiders collected

SL. No.	FAMILY/GENUS/SPECIES	No. of. Specimens collected
I	FAMILY ARANEIDAE Simon,	
1	*Araneus ellipticus* Tikader & Bal	31
2	*A. inustus* Koch	24
3	*Argiope aemula* Walckenaer	13
4	*A. catenulata* Doleschsall	13
5	*A. pulchella* Thorell	30
6	*Cyclosa confraga* Thorell	22
7	*Cyrtophora cicatrosa* Forskal	24
II	FAMILY CLUBIONIDAE Wagner	
8	*Clubiona drassodes* Cambridge	55
III	FAMILY LINYPHIIDAE Blackwall	
9	*Atypena adelinae* Barrion & Litsinger	31
10	*Atypena* sp.	18
11	*Ergione bifurca* Locket	34
IV	FAMILY LYCOSIDAE Sundevall	
12	*Arctosa khudiensis* Sinha	12
13	*Lycosa mackenziei* Gravely	32
14	*L. tista* Tikader	23
15	*Pardosa pseudoannulata* Bosenberg & Strand	54
16	*P. sumatrana* Thorell	29
17	*Trochosa punctipes* Gravely	9
V	FAMILY MITURGIDAE Simon	
18	*Cheiracanthium melanostomum* Thorell	59
VI	FAMILY OXYOPIDAE Thorell	
19	*Oxyopes ashae* Gajbe	29
20	*O. javanus* Thorell	46
21	*O. shweta* Tikader	48
22	*O. sunandae* Tikader	44
23	*Peucetia viridana* Stoliczka	21
IX	FAMILY PHILODROMIDAE Thorell	
24	*Philodromus* sp.	42
X	FAMILY PHOLCIDAE Koch	
25	*Crossopriza* sp.	12
26	*Pholcus* sp.	18
XI	FAMILY PISAURIDAE Simon	

27	*Dendrolycosa gitae* Tikader	61
XII	FAMILY SALTICIDAE Blackwall	
28	*Asemonea* sp.	16
29	*Bavia* sp.	30
30	*Bianor* sp.	36
31	*Brettus* sp.	28
32	*Carrhotus viduus* Koch	33
33	*Hasarius adansoni* Audouin	12
34	*Hyllus semicupreus* Simon	16
35	*Menemerus* sp.	12
36	*Myrmarachne orientales* Tikader	8
37	*M. plataleoides* Cambridge	13
38	*Plexippus paykulli* Audouin	18
39	*P. petersi* Karsch	21
40	*Rhene danieli* Tikader	9
41	*Siler* sp.	7
42	*Telamonia dimidiata* Simon	9
XIII	FAMILY SCYTODIDAE Blackwall	
43	*Scytodes fusca* Walckenaer	27
44	*S. thoracica* Latreille	26
XIV	FAMILY TETRAGNATHIDAE Menge	
45	*Dyschiriognatha dentata* Zhu & Wen	24
46	*Leucauge decorata* Blackwall	24
47	*L. pondae* Tikader	25
48	*Orsinome* sp.	11
49	*Tetragnatha andamanensis* Tikader	13
50	*T. javana* Thorell	39
51	*T. cochinensis* Gravely	26
52	*T. fletcheri* Gravely	9
53	*T. mandibulata* Walckenaer	26
54	*T. maxillosa* Thorell	13
55	*T. viridorufa* Gravely	19
56	*Tylorida* sp.	14
XV	FAMILY THERIDIIDAE Sundevall	
57	*Achaearanea* sp.	22
58	*Argyrodes andamanensis* Tikader	28
59	*Chrysso argyrodiformis* Yaginuma	29
60	*Phycosoma martinae* Roberts	31
61	*Theridion lumabani* Barrion & Litsinger	13
62	*Theridion* sp.	27
XVI	FAMILY THOMISIDAE Sundevall	
63	*Misumenops maygitgitus* Barrion & Litsinger	11
64	*Oxytate virens* Thorell	20
65	*Thomisus pugilis* Stoliczka	10
66	*Runcinia* sp.	8
67	*Xysticus* sp.	11
XVII	FAMILY ULOBORIDAE Thorell	
68	*Uloborus krishnae* Tikader	16
69	*Zosis* sp.	9
	TOTAL	1632

Vertical stratification

Spiders were divided into five strata based on the activity and foraging behaviour related to average height of the rice plant. The spiders which build perfect orb-web were mainly present at the canopy level of the crop. Hence Araneidae and Tetragnathidae were mainly foraging at the top layer of the rice plants. There is very little chance to locate ground dwelling spiders at the canopy level of the plant. Ground dwellers such as lycosids were mainly present at the bottom level of the field, although there is possibility of these spiders coming up for pursuing the insect prey. The spiders which build irregular cobwebs also were present at near to bottom of the field or below the half level of the average plant height. Thus, the growth of the individual plant influences species composition of spiders at different stages of the growth of the plant community in the field (Table 2).

Guild structure

The spiders collected during the study were classified into 7 ecological guilds based on the foraging mode of the spiders. Among the members of 17 families of spiders collected, majority (28%) belong to "stalkers" category. The second dominant guild constituted the orb weavers (26%). Ground runners (13%), space web builders (11%), ambushers (10%), foliage runners (7%) and sheet web builders (5%) are the other ecological guilds of these spiders.

1. Stalkers

Spiders under this category actively jump over the prey for feeding. Spiders of the families Salticidae and Oxyopidae show this type of feeding behaviour. Oxyopidae was represented by 5 species belonging to 2 genera and Salticidae consisted of 15 species coming under 13 genera.

Table 2. Vertical distribution of 10 dominant species

Sl. No	Species (% of total collection)	Vertical strata (above water/soil surface)				
		<20cm	20-40cm	40-60cm	60-80cm	>80cm
1	*Dendrolycosa gitae* (3.73)	R	R	++	+++	+
2	*Cheiracanthium melanostomum* (3.61)	R	+	++	+++	++
3	*Clubiona drassodes* (3.37)	R	+	++	+++	++
4	*Pardosa pseudoannulata* (3.3)	+++	+	+	R	R
5	*Oxyopes shweta* (2.94)	R	++	+++	+++	++
6	*O. javanus* (2.81)	R	++	+++	+++	++
7	*O. sunandae* (2.69)	R	++	+++	+++	++
8	*Philodromus* sp. (2.57)	R	R	++	+++	+++
9	*Tetragnatha javana* (2.39)	R	R	+	+++	+++
10	*Bianor* sp.(2.2)	+++	++	+	+	R

R Very rare; + Usually present; ++ Fairly common; +++ Abundant

2. Orb weavers

Spiders of the "orb weavers" guild construct perfect orb webs for prey capture. Families Araneidae (7 species), Tetragnathidae (12 species) and Uloboridae (2 species) constitute this category.

3. Ground runners

Ground running spiders mainly feed on ground layer of the field and rarely come to the foliage or canopy of the plant for prey capture. The families Lycosidae (6 species) and Scytodidae (2 species) come under this guild.

4. Space web builders

Spiders of this guild construct irregularly spaced webs for prey capture. Belonging to this category are the families Pholcidae (2 species) and Theridiidae (6 species).

5. Ambushers

Ambushers show a "sit-and-wait" type of behaviour for prey capture. Spiders of the families Philodromidae (1 species), Pisauridae (1 species) and Thomisidae (5 species) are members of this guild.

6. Foliage runners

These spiders hunt on foliage for phytophagous insect pests. This guild is formed of 2 families *viz.,* Clubionidae and Miturgidae with one species each.

7. Sheet web builders

Spiders of the guild sheet web builders construct sheet like web for capture. Only one family of paddy field spiders belong to this category namely, Linyphiidae, with 3 species. Linyphiids were abundant in the final stages of crop development.

A preliminary survey for a period of six months in the Kuttanad rice agro ecosystem indicates that the study area is foraged by 69 species of spiders belonging to 49 genera distributed in 17 families. This study, covering an area of 874 km^2 reveals that the spider fauna in the paddy fields is very rich both qualitatively and quantitatively. The number of species found here is higher than the number recorded for other agro ecosystems surveyed in India (Jose *et al*., 2007). The number of taxa recorded is generally higher than those reported for other surveys of rice ecosystems.

Spiders can be grouped into specific functional groups based on the relative distribution and predatory methods (Bultman *et al*., 1982). Describing the spider diversity in terms of these groups allows greater insights into how habitat differences may be reflected in life history strategies (Lee and Kim, 2003).

According to the guild classification, 8 among the 17 families come under the wandering category. They lead a nomadic life in the agro ecosystem and may migrate to other ecosystems or immigrate from other systems. In the seven web-building families, Araneidae, Tetragnathidae and Uloboridae build orb-webs for trapping prey. Pholcidae and Theridiidae weave scattered lines or irregular webs for prey capture. The linyphiids make sheet webs for food gathering.

Spiders colonizing agricultural fields are mostly generalist predators of arthropods, and they may have evolved their particular niche exploitation patterns under different ecological circumstances, that exploit same class of resources. Since the predatory potential of spiders in agro ecosystem may vary with microhabitat, season, time of day and foraging strategy, spiders may constitute more than one "assemblage guild." Changes in the vegetation structure of the habitat influence species composition. The final stage of the crop growth appears to be more complex and has high diversity.

The difference in the spider species found at the base of the plant and collected from the canopy of the plant was of course due to the difference in position of their habitation on the paddy field. Structural complexity may determine the guild composition of a crop spider fauna and indirectly influence the level of herbivore damage (Young and Edwards, 1990). Structurally complex crops providing a wider assortment of resources would be predicted to support a more diverse spider assemblage, thus increasing the chances of the "best" match between spiders and insect pests. Araneidae and Tetragnathidae were mainly foraging at the top layer of the rice plants. This provides sufficient area for the construction of the web and increases the chance of prey entanglement in the webs. The web building and plant wandering spiders rely on vegetation for some part of their lives, either for finding food, building retreats or for web building. The structure of the vegetation is therefore expected to influence the diversity of spiders found in the habitat. There were many more plant wanderers and web builders sampled than ground dwellers. This again indicates that structural diversity of the vegetation may, in some way, influence the spider diversity. Thus, the physical structure of the environments significantly influences the habitat preferences of spider species especially web-building species.

Vegetation structure is an essential factor for spiders. Dense and compact vegetation provides shade and humidity which are appropriate conditions, especially for small spiders of the families Linyphiidae and Theridiidae. These spiders, exposed to loss of water more than larger ones, find hiding places in numerous, tiny spaces of such habitats (Duffey, 1962). Linyphiids were most abundant in the final stages, in which the vegetation provided good support for sheet webs. The findings support the suggestions of Baur *et al*. (1996) that communities of spiders or other invertebrates are mainly organized as a function of the structural complexity of the environments. Variations in species composition can be explained by habitat preferences resulting from behavioural and morphological characteristics of the spiders (Johnson, 1995). It can be concluded that structural complexity is an important factor for the organization of spider communities on these plants, a factor that can affect richness and, even more strongly, composition of the spider species associated with them. Although it is reasonable to expect a significant influence of crop characteristics on structuring the resident spider community, the importance of adjacent habitats must also be considered (Duelli *et al*., 1990). Selective forces of the crop environment can act only on "what is available" i.e., sets of species colonizing in the fields from the neighbouring habitats. Neighbouring habitats may also influence the composition of crop spider fauna indirectly by modifying the dispersal of potential spider prey and predators in the patchy agricultural landscapes (Polis *et al*., 1998).

REFERENCES

Baur B, Joshi J, Schmid B, Hanggi A, Borcard D, Stary J, Pedroli-Christen A, Thommen GH, Luka H, Rusterholz H, Oggier P, Ledergerber S, Erhardt A. 1996. Variation in species richness of plants and diverse groups of invertebrates in three calcareous grasslands of the Swiss Jura Mountains. *Revue Suisse Zoologie* **103**: 801-833.

Bultman TL, Uetz GW, Brady AR. 1982. A comparison of cursorial spider communities along a successional gradient. *J Arachnol*. **10**: 23-33.

Duelli P, Studer M, Marchand I, Jakob S. 1990. Population movements of arthropods between natural and cultivated areas. *Biol Conser*. **54**: 193-207.

Duffey E. 1962. A population study of spiders in limestone grass land: The field layer fauna. *Oikos* **13**: 15-34.

Johnson SR. 1995. Spider communities in the canopies of annually burned and long-term unburned Spartina pectinata wetlands. *Environ Entomol*. **24**: 832-834.

Jose SK, Sudhikumar AV, Samson Davis, Sebastian PA. 2007. Preliminary studies on the spider fauna (Arachnida: Araneae) in Parambikulam wildlife sanctuary in Western Ghats, Kerala, India. *J Bomb Nat Hist Soc*. **104**: 216-232.

Lee JH, Kim ST. 2003. *Use of spiders as natural enemies to control rice pests in Korea*. Food and Fertilizer Technology centre, Taiwan. 12pp.

Menon NN, Balchand AN, Menon NR. 2000. Hydrobiology of the Cochin backwater system – a review. *Hydrobiologia* **430**: 149-183.

Norris KC. 1999. Quantifying change through time in spider assemblages: sampling methods, indices and sources of error. *J Insect Conser*. **3**: 309-325.

Polis GA, Hurd SD, Jackson CT, Sanchez-Pinero F. 1998. Multifactor population limitation: variable spatial and temporal control of spiders on Gulf of California islands. *Ecol*. **79**: 490-502.

Riechert SE, Lockley T. 1984. Spiders as biological control agents. *Ann Rev Entomol.* **29**: 299-320.

Tanaka K. 1989. Seasonal food supply for the house spider, *Achaearanea tepidariorum* (Araneae: Theridiidae) in northern Japan. *Jpn J Entomol.* **57**: 843-852.

Wise DH. 1993. *Spiders in ecological webs*. Cambridge University Press.

Young OP, Edwards GB. 1990. Spiders in United States field crops and their potential effect on crop pests. *J Arachnol*. **18**: 1-27.