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DIVERSITY OF SPIDERS AS INFLUENCED BY CULTIVATION TECHNIQUES IN RICE

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ABSTRACT

Field studies were carried out in wet seasons of 2014 and 2015 in rice fields of College Farm, Rajendranagar, Hyderabad to understand the abundance and biodiversity of spiders in varied rice systems. Design of the experiment was split plot with three main modules, viz., transplanted, broadcasted and drumsown rice and sub treatments under each main module included three plant protection methods viz., organic protection, farmers' practices and 'no protection' practices. Results showed that predator numbers in 'no protection' and organic protection plots of all main treatments were higher than in farmers' practices indicating the impact of the chemical pesticides. A total of 22 genera of spiders belonging to 12 families were recorded in rice ecosystem in the present study which comprised of 7 guilds based on their hunting strategies and microhabitats. Shannon diversity index ranged between 1.83 and 2.26 and Pielou's evenness index of 0.59-0.72 in two years of study indicating a stable ecosystem and even species distribution in rice crop at Rajendranagar. Study of the guild assemblage indicated that orb-weavers constituted 28.1% of the population, ground runners 23.51%, space web builders 18.38%, sheet-web builders 13.12%, stalkers 8.04% and Ambushers made upto 0.38% of the spider population. Understanding the vertical stratification of various spider genera on the plant gave further insight into the prey preferences of these valuable predators.

Key words: Spiders, biodiversity, rice, cultivation systems, abundance, organic, farmers' practice, no protection, guilds, assemblages, diversity indices

Rice is the staple food of India and pests on the crop are a major impeding factor. Natural biological control in irrigated rice at the early crop stages can mainly be attributed to spiders (Sigsgaard, 2000). Abundant detritivores early in the season help to colonise predators in the rice fields (Settle et al., 1996). Spiders being polyphagous- can predate on alternative prey such as Collembola during fallow periods, thereby maintaining high population levels. Abundance of alternative prey in turn depend on decaying organic material available in the field (Sigsgaard, 2000). There are many environmental factors that affect species diversity. Some of these include seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity (Rosenzweig, 1995). Literature suggests that spider populations are generally affected by factors like vegetation type and structure, which in rice depended on the cultivation practices like transplantation, drum sowing and broadcasting methods and also on the plant protection measures adopted. This study assesses the impact of cultivation systems and plant protection practices and their interaction in determining spider abundance in rice crop.

MATERIALS AND METHODS

The experiment was laid out in a split plot design in 1500 m^2 at the College farm, Rajendranagar for two years, *kharif* 2014 and 2015 with rice variety BPT 5204. There were three main modules, each with different establishment technique *viz*., transplanted rice, broadcasted rice and drumsown rice. The size of each module was 36 x 12 m. Under each module, three types of plant protection measures viz., organic protection, farmers' practice and 'no protection' were taken up. Recommended dosages of fertilizers were applied to all the modules and Transplantation, broadcasting and drum sowing were done in the last week of July. Under organic protection, *Trichogramma japonicum* cards were pinned to the underside of the leaves @ 50,000/ha/release and six such releases were carried out starting at 35 days after transplantation. *T. chilonis* cards were also pinned to the leaves @ 50,000/ha/release and six such releases were carried out starting at 37 standard week (SMW) when leaf folder adults were noticed in the field. Pheromone traps with *Scirpophaga incertulas* lures were installed in the organic protection plots @

8 traps/acre at 30 DAT and the lure was changed once every 22 days till 70 DAT. Two sprays of Neem oil 1.0% were taken up in the organic protection plots when the stem borer crossed economic threshold level once at 36 SMW and again at 69 SMW.

In farmers' practice, carbofuran 3G granules were applied to the crop one week before pulling of nursery at the rate of 200 g/cent of nursery in the transplantation module plots. In the broadcasted and drumsown rice, carbofuran granules were applied at 30 days after sowing at the rate of 10 kg/ acre. In addition, foliar sprays of chlorpyriphos @ 2.50 ml/L water were given when the pests crossed the Economic Threshold Level (ETL) once at 36 SMW and again at 69 SMW. No protection measures were taken up in the untreated control. Weekly observations on the populations of spiders were recorded in each of the treatment plots in the morning hours between 7.00 a.m. and 9.00 a.m. in five quadrats (1m x 1m)/ each treatment plot from 34 to 47 standard weeks coinciding with 30 days after transplantation (DAT) to 120 DAT . In each plot, a metal quadrat was placed in the four corners and in the centre to get a un1iform count of the insects in that plot.

Diversity parameters of spiders were worked for the pooled data using the Biodiversity Pro 2.0 Software to find out the species richness, species diversity and Pielou's Evenness Index or equitability (Pielou, 1966) with standard formulae. Total predator density, guild composition (based on their predation habits and preying techniques- Uetz et al, 1999). Vertical stratification was computed with vertical height of the rice plant divided into five strata viz., 0-20 cm (bottom 20cm if the stem), 20-40 cm, 40-60 cm, 60-80 cm and > 80cm (crop canopy) based on the activity and foraging behaviour.

RESULTS AND DISCUSSION

Abundance

In the present study a total of 45,071 spiders were collected both the years belonging to twelve families and comprising 22 genera and 29 species (Table 1.). Among the three major modules, abundance of spiders was found to be more in the broadcasted method of cultivation followed by the drum sown method and

Table 1. List of spiders and the families

S.No	Family	Genus	Species name
1	Araneidae Clerck,1757	Genus *Neoscona*	*Neoscona mukerjei,* Tikader*, 1980*
			Neoscona molemensis Tikader & Bal, 1981
		Genus *Araneus*	*Araneus inustus* (L. Koch, 1871)
			Araneus mitificus (Simon, 1886)
		Genus *Argiope*	*Argiope catenulata* Doleschall, 1859
			Argiope anasuja Thorell, 1887
			Argiope aemula (Walckenaer, 1841)
2	Tetragnathidae Menge, 1866	Genus *Tetragnatha*	*Tetragnatha maxillosa* Thorell, 1895
			Tetragnatha versicolor Walckenaer, 1841
		Genus *Pachygnatha*	*Pachygnatha degeeri* Sundevall, 1830
		Genus *Leucauge*	*Leucauge decorata* (Blackwall, 1864)
3	Salticidae Blackwall, 1841	Genus *Bianor*	*Bianor* sp.
		Genus *Chalcotropis*	*Chalcotropis* sp.
		Genus *Mymarachne*	*Myrmarachne* sp.
		Genus *Telamonia*	*Telamonia* sp.
4	Lycosidae Sundevall, 1833	Genus *Lycosa*	*Lycosa mackenziei* Gravely, 1924
			Lycosa pseudoannulata
		Genus *Pardosa*	*Pardosa sumatrana* (Thorell, 1890)
		Genus *Arctosa*	*Arctosa* sp.
5	Oxyopidae Thorell, 1870	Genus *Hamataliwa*	*Hamataliwa incompta* (Thorell, 1895)
		Genus *Oxyopes*	*Oxyopes shweta* Tikader, 1970
6	Theridiidae Sundevall, 1833	Genus *Chrysso*	Chrysso urbasae (Tikader, 1970)
7	Thomisidae Sundevall, 1833	Genus *Runcinia*	*Runcinia roonwali* Tikader, 1965
8	Eutichuridae Lehtinen, 1967	Genus *Cheiracanthium*	*Cheiracanthium danieli* Tikader, 1975
			Cheiracanthium melanostomum (Thorell, 1895)
9	Sparassidae Bertkau, 1872	Genus *Heteropoda*	*Heteropoda* sp.
10	PholcidaeC. L. Koch, 1850	Genus *Pholcus*	*Pholcus* sp.
11.	Clubionidae Wagner, 1887	Genus *Clubiona*	*Clubiona* sp.
12.	Linyphiidae Blackwall, 1859	Genus Atypena	*Atypena formosana* (Oi)

the transplanted method. A total of 22 genera were recorded but only 12 genera were considered as the others were in negligible numbers. Genera *Tetragnatha, Pachygnatha, Telamonia, Lycosa* and *Pardosa* were significantly abundant in the drumsown plots (36.26, 9.57, 7.09, 19.63 and 31.52 respectively), compared to the broadcasted plots (29.38, 7.73,6.28, 16.89 and 27.32 spiders/quadrat respectively) and transplanted plots (28.86, 9.11, 4.46, 14.02 and 25.10 spiders/quadrat respectively) (Table 2).

Neoscona, Bianor, Oxyopes and Clubiona were more in numbers (3.62, 9.01, 3.62 and 3.59 spiders/ quadrat respectively) in the broadcasted plots compared to the drumsown module (3.34, 8.69,3.34 and 3.16 spiders/quadrat respectively) and transplanted module (1.99,8.06,1.99 and 2.82 spiders/quadrat respectively) (Table 1). *Chrysso, Cheiracanthium* and *Atypena* were in higher numbers in transplanted plots (42.17, 4.94 and 30.16 spiders/quadrat respectively compared to drumsown plots (41.66, 2.89 and 28.53 spiders/ quadrat respectively and broadcasted plots with 40.82, 3.95 and 27.97 spiders/quadrat respectively. *Cheiracanthium, Lycosa, Bianor and Clubiona* genera were in significantly higher in broadcasted organic plots (6.13, 5.10, 10.38 and 5.10 spiders/quadrat respectively), while *Pachygnatha, Chrysso and Atypena* were in significantly higher in transplanted 'No protection' plots (10.79, 48.26, 33.97 spiders/quadrat respectively).

Plant protection practices influenced spider numbers greatly. 'No protection' plots registered maximum numbers of *Neoscona, Tetragnatha, Pachygnatha, Lycosa, Pardosa, Chrysso* and *Atypena* (1.27, 42.03, 10.44, 19.61, 29.99, 46.32 and 29.94 spiders/ quadrat respectively, while organic protection plots registered lesser numbers of these genera (1.11, 30.48, 9.31, 16.11, 28.50, 40.86 and 28.85 spiders/quadrat respectively and farmers' practices registered the lowest numbers indicating the vulnerability of the spiders to even neem oil and the insecticides. However, *Bianor*, *Oxyopes*, *Cheiracanthium* and *Clubiona* were found to be significantly more abundant in organic protection plots (9.64, 3.67, 4.67 and 3.64 spiders/quadrat respectively), than in the 'no protection' plots (8.75, 3.34, 3.98 and 3.14 spiders/quadrat respectively). The farmers' protection plots registered significantly lower numbers

Table 2. Abundance and diversity of spiders in different establishment systems of rice

Family	Genus	Guild	Contribution to the Guild (%)	Population of spiders (no./quadrat)			CD (0.05)	SEm±
				Transplanted rice	Broadcasted rice	Drum sown rice		
Araneidae	Genus *Neoscona*	Orb weavers	28.17	1.99 (3.38)^{c}	3.62 (3.05)^{a}	3.34 (3.19)^{b}	0.03	0.009
Tetragnathidae	Genus *Tetragnatha*			28.86 (15.84)^{c}	29.38 (15.99)^{b}	36.26 (17.92)^{a}	0.57	0.16
	Genus *Pachygnatha*			9.11 (9.03)^{b}	7.73 (8.31)^{c}	9.57 (9.19)^{a}	0.11	0.03
Salticidae	Genus *Bianor*	Stalkers	8.04	8.06 (8.49)^{c}	9.01 (8.98)^{a}	8.69 (8.81)^{b}	0.11	0.03
	Genus *Telamonia*			4.46 (6.29)^{c}	6.28 (7.51)^{b}	7.09 (8.08)^{a}	0.15	0.04
	Genus *Oxyopes*			1.99 (4.06)^{c}	3.62 (5.74)^{a}	3.34 (5.53)^{b}	0.13	0.04
Lycosidae	Genus *Lycosa*	Groundrunners	23.51	14.02 (11.17)^{c}	16.89 (12.31)^{b}	19.63 (13.28)^{a}	0.11	0.003
	Genus *Pardosa*			25.10 (16.47)^{c}	27.32 (17.25)^{b}	31.52 (18.36)^{a}	0.10	0.03
Theridiidae	Genus *Chrysso*	Space web builders	18.38	42.17 (19.45)^{a}	40.82 (19.15)^{c}	41.66 (19.34)^{b}	0.02	0.005
Eutichuridae	Genus *Cheiracanthium*	Foliage runners	8.40	4.94 (6.65)^{a}	3.95 (5.87)^{b}	2.89 (5.09)^{c}	0.19	0.06
Clubionidae	Genus *Clubiona*			2.82 (5.02)^{c}	3.59 (5.62)^{a}	3.16 (5.3)^{b}	0.19	0.06
Linyphiidae	Genus *Atypena*	Sheet web Builders	13.12	30.16 (16.44)^{a}	27.97 (15.85)^{c}	28.53 (16.01)^{b}	0.37	0.06

of all the spider genera establishing the toxicity of insecticides to the spiders (Table 3).

A study of the interaction effects of the establishment systems and plant protection measures revealed that Transplanted 'No protection', Broadcasted organic protection, Drumsown organic protection and Drumsown 'no protection' recorded higher abundance levels of most of the genera of spiders. Transplanted 'no protection' plots recorded maximum population of a few genera like *Pachygnatha* (10.79 spiders/quadrat), *Pardosa* (26.52 spiders/quadrat), *Chrysso* (48.26 spiders/quadrat) and *Atypena* (33.97 spiders/quadrat). Broadcasted organic protection recorded highest numbers of *Bianor* (10.38 spiders/quadrat), *Lycosa* (5.10 spiders/quadrat), *Pardosa* (28.74 spiders/quadrat), *Chrysso* (40.90 spiders/quadrat), *Cheiracanthium* (6.13 spiders/quadrat) and *Clubiona* (5.10 spiders/quadrat). Drumsown organic protection plots registered highest numbers of *Oxyopes* (4.38 spiders/quadrat), *Lycosa* (3.31 spiders/quadrat) and *Pardosa* 29.88 spiders/quadrat), while drumsown no protection plots recorded increased numbers of *Neoscona* (1.43 spiders/quadrat), *Tetragnatha* (85.76 spiders/quadrat), *Pachygnatha* (10.73 spiders/quadrat) and *Pardosa* (35.90 spiders/quadrat) (Table 4).

Tetragnathids, Lycosids and Salticids are active spiders and the extra space between the rows in the drumsown and broadcasted plots could have helped Tetragnathids and Araneids to build webs in the top canopy. According to Turnbull (1973), most webs have specific attachment and space requirements. Cherrett (1964) found that adult orb weavers in a grass land habitat needed a vertical space of at least 25-30 cm^2 for web placements, a factor which strongly limited those spiders to certain habitats, maybe like the broadcasted and drumsown plots. Other workers have also found the availability of specific structural features to limit the habitats occupied by various web-builders (Duffey, 1962). Moreover, drum sown and broadcasted plots had higher diversity of weeds because of the structured gaps in drumsown plots and haphazard gaps in broadcasted crop, which contributed to their growth with lesser competition from the rice crop. Other workers also reported that greater habitat complexity resulted in higher abundance and diversity of spiders because structurally more diverse habitats allow a greater niche diversification and coexistence of more spider species (Langellotto and Denno,2004; Stokmane and Spungis, 2016).

Microclimate is the main factor that accounts for

Table 3. Abundance and diversity of spiders in different plant protection methods in rice

Family	Genus	Guild	Contribution to the Guild (%)	Population of spiders (no./quadrat)			CD (0.05)	SEm±
				Organic Protection	Farmers' Practices	No Protection		
Araneidae	Genus *Neoscona*	Orb weavers	28.17	1.11 (3.32)[b]	0.94 (2.91)[c]	1.27 (3.4)[a]	0.05	0.01
Tetragnathidae	Genus *Tetragnatha*			30.48 (16.55)[b]	21.99 (13.78)[c]	42.03 (19.41)[a]	0.46	0.12
	Genus *Pachygnatha*			9.31 (9.17)[b]	6.68 (7.67)[c]	10.44 (9.69)[a]	0.1	0.009
Salticidae	Genus *Bianor*	Stalkers	8.04	9.64 (9.3)[a]	7.38 (8.12)[c]	8.75 (8.86)[b]	0.17	0.04
	Genus *Oxyopes*			3.67 (5.71)[a]	1.95 (4.04)[c]	3.34 (5.60)[b]	0.07	0.02
Lycosidae	Genus *Lycosa*	Groundrunners	23.51	16.11 (11.98)[b]	14.82 (11.51)[c]	19.61 (13.27)[a]	0.08	0.003
	Genus *Pardosa*			28.50 (17.21)[b]	25.46 (17.38)[c]	29.99 (17.50)[a]	0.17	0.06
Theridiidae	Genus *Chrysso*	Space web builders	18.38	40.86 (19.18)[b]	37.47 (18.36)[c]	46.32 (20.41)[a]	0.03	0.009
Eutichuridae	Genus *Cheiracanthium*	Foliage runners	8.40	4.67 (6.4)[a]	3.14 (5.30)[c]	3.98 (5.91)[b]	0.13	0.004
Clubionidae	Genus *Clubiona*			3.64 (5.66)[a]	2.79 (4.99)[c]	3.14 (5.30)[b]	0.14	0.04
Linyphiidae	Genus Atypena	Sheet web Builders	13.12	28.85 (16.09)[b]	27.88 (15.82)[c]	29.94 (16.38)[a]	0.28	0.07

Table 4. Interaction effects of various cultivation systems and plant protection methods on spider abundance in rice

Genus	Transplanted Organic protection	Transplanted farmers' protection	Transplanted 'no protection'	Broadcasted organic protection	Broadcasted farmers' protection	Broadcasted 'no protection'	Drumsown organic protection	Drumsown farmers' practices	Drumsown 'no protection'	CD (0.05)	SEm±
Genus *Neoscona*	1.25 (1.15)^{b}	1.14 (1.07)^{b}	1.28 (1.16)^{b}	1.03 (1.12)^{c}	0.80 (0.94)^{c}	0.93 (0.99)^{d}	0.93 (0.99)^{d}	0.76 (0.91)^{c}	1.43 (1.24)^{a}	0.09	0.003
Genus *Tetragnatha*	28.88 (5.37)^{g}	15.29 (3.88)^{i}	42.42 (6.59)^{c}	30.69 (5.50)^{f}	25.90 (4.49)^{h}	37.09 (5.99)^{d}	31.88 (5.67)^{c}	47.78 (5.42)^{b}	85.76 (6.82)^{a}	0.79	0.15
Genus *Pachygnatha*	9.53 (3.11)^{b}	6.98 (2.64)^{f}	10.79 (3.28)^{a}	7.80 (2.93)^{e}	5.41 (2.41)^{h}	8.33 (2.97)^{d}	9.24 (3.13)^{c}	6.70 (2.64)^{g}	10.73 (3.44)^{a}	0.17	0.04
Genus *Bianor*	9.07 (3.01)^{c}	6.74 (2.59)^{g}	8.37 (2.89)^{d}	10.38 (3.22)^{a}	7.46 (2.73)^{f}	9.21 (3.03)^{bc}	9.48 (3.07)^{b}	7.93 (2.80)^{e}	8.66 (2.94)^{d}	0.3	0.006
Genus *Oxyopes*	2.36 (1.55)^{f}	0.43 (0.67)^{h}	3.18 (1.85)^{d}	3.65 (1.99)^{b}	3.06 (1.82)^{de}	3.38 (1.93)^{c}	4.38 (2.17)^{a}	1.96 (156)^{g}	2.98 (1.81)^{e}	0.13	0.04
Genus *Lycosa*	2.51 (1.59)^{f}	3.09 (1.75)^{cd}	2.85 (1.68)^{de}	5.10 (2.26)^{a}	2.71 (1.64)^{ef}	2.98 (1.72)^{d}	3.31 (1.82)^{c}	2.56 (1.60)^{f}	3.60 (1.89)^{b}	0.19	0.06
Genus *Pardosa*	26.88 (5.54)^{c}	21.92 (5.15)^{d}	26.52 (5.79)^{abc}	28.74 (5.85)^{ab}	25.67 (5.66)^{bc}	27.55 (5.73)^{abc}	29.88 (5.82)^{ab}	28.78 (5.57)^{bc}	35.90 (5.97)^{a}	0.29	0.47
Genus *Chrysso*	40.88 (6.39)^{d}	37.38 (6.11)^{h}	48.26 (6.95)^{a}	40.90 (6.39)^{a}	37.56 (6.13)^{f}	43.99 (6.63)^{c}	40.81 (6.39)^{e}	37.48 (6.12)^{g}	46.70 (6.83)^{h}	0.06	0.004
Genus *Cheiracanthium*	0.39 (0.62)^{b}	4.13 (2.03)^{d}	5.64 (2.37)^{b}	6.13 (2.47)^{a}	2.80 (1.69)^{f}	2.94 (1.71)^{f}	2.83 (1.68)^{f}	2.49 (1.58)^{g}	3.25 (1.83)^{e}	0.22	0.05
Genus *Clubiona*	2.51 (1.59)^{f}	3.09 (1.75)^{cd}	2.85 (1.68)^{de}	5.10 (2.26)^{a}	2.71 (1.64)^{ef}	2.98 (1.72)^{d}	3.31 (1.82)^{c}	2.56 (1.60)^{f}	3.60 (1.89)^{b}	0.24	0.08
Genus *Atypena*	27.81 (5.26)^{e}	28.72 (5.35)^{d}	33.97 (5.83)^{a}	29.09 (5.39)^{cd}	25.63 (5.06)^{g}	29.10 (5.44)^{b}	29.64 (5.44)^{b}	29.30 (5.41)^{bc}	26.65 (5.16)^{f}	0.49	0.08

unprotected drumsown rice plots, respectively. Evenness and number of species influence the Shannon-Wiener index in any ecosystem.

Guild structure

Spider genera collected during the two years period were classified into seven categories on the basis of mode of predation or attack on the prey (Uetz et al., 1999). Contribution of each type of guild to the total spider population in the rice ecosystem was worked out and the results are presented in **Fig** 1.

Many workers worked on the guild of rice spiders in various parts of the country. Mathew et al., (2014) reported 17 families of spiders on rice crop in Kuttanad rice ecosystem and 28% of them belonged to stalkers category, 26% to orb weavers, 13% were ground runners, 11% were spaceweb builders, 10% ambushers, 7% foliage runners and 5% were sheet web builders. Chapke (2012) made a study on spider diversity in agroecosystem of Vidharbha region, Maharashtra collecting spiders representing 11 families, 30 genera and 65 species and reported that Salticidae constituted 37% and Araneidae, Thombicidae 14% each respectively while Lycosidae and Clubionidae constituted 10% and 7% of the total collection.

Spiders can be grouped into specific functional groups based on the relative distribution and predatory methods (Bultman et al., 1982). Describing spider diversity in terms of these groups allows greater insight into how habitat differences may be reflected in life history strategies (Lee and Kim, 2001). Spiders are mostly generalists and their diversity and abundance in a crop depends on many factors like spacing, microclimate and macroclimate, season and time of the day and their foraging strategy. Changes in the vegetation structure of the habitat influence species composition (Mathew et al., 2014) dense and compact canopy as in the case of rice crop. Structural complexity may determine the guild composition of a crop spider fauna and indirectly influence the level of herbivore damage (Young and Edwards, 1990).

Vertical stratification

Most of the Tetragnathidae and Araneidae build webs in the top canopy of the crop and wait for prey like adults of stem borer, leaf folder adults, green leaf hopper, Diptera, dragonflies, damsel flies flying at heights of the rice canopy (**Table** 6). Eutichuridae and Sparassidae were found in the 60-80 cm of the plant height preying upon Lepidopteran adults or grasshoppers, adult flies, wasps while Clubionidae, Philodromidae and Thomisidae were found to thrive on the 40-60 cm stratum of the rice plant. They preferred to feed on leafhoppers and brown plant hoppers and other small insects or Coccinellids. Oxyopids were observed to be moving actively in the 20-60 cm stratum, stalking their prey which mainly consisted of Hymenopterans, small Dipterans and small adult moths. Thomisids especially are ambushers and adept at pouncing upon quick moving leaf hoppers and Coccinellids like *Scymnus* sp. They waited behind the flowers and leapt upon honey bees or butterflies which alight on the panicle to suck the nectar from flowers.

Sheetweb spiders of Linyphiidae and jumping spiders of Salticidae were seen at the penultimate stratum 20-40 cm where the former built small webs to trap prey but the latter were stalkers and could jump upon a wide range of insects like hoppers, wasps, flies, moths and butterflies. Theridiids and Lycosids (*Pardosa* sp.) were observed in the 0-20cm stratum chasing their prey which consisted of water dwelling insects also

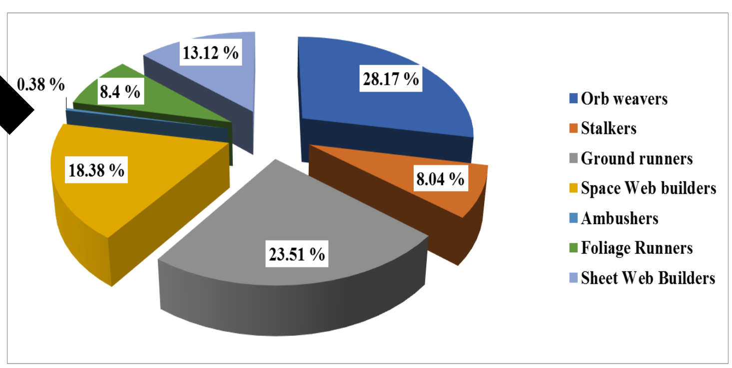

Fig. 1. Guild composition of spiders in rice ecosystem

Table 6. Vertical Stratification of spiders in rice fields

S. No	Family	Genus	Stratum observed (height in cm of crop canopy from the base)
1.	Araneidae	Genus *Neoscona*	20 cm
		Genus *Araneus*	>80 cm
		Genus *Argiope*	80 cm
2.	Tetragnathidae	Genus *Tetragnatha*	80 cm
4.		Genus *Pachygnatha*	>20 cm
		Genus *Leucauge*	>80 cm
3.	Salticidae	Genus *Bianor*	20-40 cm
		Genus *Chalcotropis*	20-40 cm
		Genus *Mymarachne*	20-40 cm
		Genus *Telamonia*	20-40 cm
4.	Lycosidae	Genus *Lycosa*	<20 cm
		Genus *Pardosa*	<20 cm
		Genus *Arctosa*	<20 cm
5.	Oxyopidae	Genus *Hamataliwa*	<20 cm
		Genus *Oxyopes*	40-60 cm
6.	Theridiidae	Genus *Chrysso*	<20 cm
7.	Thomisidae	Genus *Runcinia*	40-60 cm
8.	Eutichuridae	Genus *Cheiracanthium*	60-80 cm
9.	Sparassidae	Genus *Heteropoda*	60-80 cm
10.	Pholcidae	Genus *Pholcus*	40-60 cm
11.	Clubionidae	Genus *Clubiona*	40-60 cm
12.	Linyphiidae	Genus Atypena	20-40 cm

at times as they lived close to the ground. Genera of these families Linyphiidae and Theridiidae (*Atypena* and *Chrysso*) were found in higher abundance in the present study.

In the present study, the spider community displayed good evenness and stability. Communities that exhibit more even numbers of individuals within the total number of species present may be closer to a state of equilibrium than those in which the numbers of individuals is not that even. Because the energy flow within ecological systems is constantly changing, consistent patterns of evenness within a given community can be equated with community stability.

Most of the Tetragnathidae and Araneidae build webs in the top canopy of the crop and wait for prey like adults of stem borer, leaf folder adults, green leaf hopper, Diptera, dragonflies, damsel flies flying at heights of the rice canopy. Sebastian et al. (2005) attributed the dominance of Tetragnathid spiders in the rice ecosystem of central Kerala to the wet habitat which is congenial for this family. Eutichuridae and Sparassidae were found in the 60-80 cm of the plant height preying upon Lepidopteran adults or grasshoppers, adult flies, wasps while Clubionidae, Pholcidae and Thomisidae were found to thrive on the 40-60 cm stratum of the rice plant. They preferred to feed on leafhoppers and brown plant hoppers and other small insects or Coccinellids. Oxyopids were observed to be moving actively in the 20-60 cm stratum, stalking their prey which mainly consisted of Hymenopterans, small Dipterans and small adult moths. Thomisids especially are ambushers and adept at pouncing upon quick moving leaf hoppers and Coccinellids like *Scymnus* sp. They wait behind the flowers and leap upon honey bees or butterflies which alight on the panicle to suck the nectar from flowers. Sheet web spiders of Linyphiidae and jumping spiders of Salticidae were seen at the penultimate stratum 20-40 cm where the former built small webs to trap prey but the latter were stalkers and could jump upon a wide range of insects like hoppers, wasps, flies, moths and butterflies. Theridiids and Lycosids (*Pardosa* sp.) were observed in the 0-20cm stratum chasing their prey which consisted of water dwelling insects also at times as they lived close to the ground.

Deviation in the spider species found at the base of the plant and collected from the canopy of the plant was due to the difference in position of their habitation in the paddy field. (Mathew et al., 2014). This indicated that the position of spider genera depended on the placement of the prey, possibility of finding it and structure of the vegetation. 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 (Mathew et al., 2014). These also reported more web building and plant dwelling spiders like the present study than ground dwellers. Hence, the diversity of spiders depends on the structural complexity of the vegetation to a large extent.

Complexity of the structure of vegetation again depended on the method of establishment of the crop; plants in the transplanted plots were more uniformly spaced compared to the plots where rice was sown by drumsown and broadcasted methods. The drumsown and broadcasted plots had wider spacing and this could have led to better aeration between the hills which supported lower pest levels and subsequently lesser populations of spiders were recorded in those plots. Dense and compact vegetation provides shade and humidity which are appropriate conditions, especially for small spiders of Linyphiidae and Theridiidae (Mathew et al., 2014) and genera of these families (*Atypena* and *Chrysso*) were found in higher abundance in the present study. These spiders, exposed to loss of water more than larger ones, find hiding places in numerous, tiny spaces of such habitats (Duffey, 1962). Baur et al. (1966) opined that community of spiders or other invertebrates are mainly organized as a function of the structural complexity of the environments.

The present study focused on the diversity of spiders in rice ecosystem that showed enormous scope for natural control in rice in the absence of impeding forces like the indiscriminate use of agricultural chemicals, which have long term effects on the biology, fecundity and behavior of these valuable predators. Our results demonstrated that there is a strong relationship between cultivation systems, plant protection measures and the abundance and diversity of spiders in rice crop. A huge diversity of twelve families, 22 genera and 29 species were observed in the study area, which if conserved would help suppress pests in a natural way with no ill-effects to the environment.

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