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Species diversity and vertical stratification of spiders of the family Tetragnathidae Menge, 1866 (Araneae) in different paddy farming practices at Kuttanad, Kerala, India

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ABSTRACT: The study aims to understand the species composition and habitat preferences of the spiders of the family Tetragnathidae in rice agroecosystem of Kuttanad. Surveys were carried out for a period of five months from July to November 2020. A total of thirteen tetragnathid species were collected from paddy fields and their nearby areas following organic way (do not use any pesticide) and a total of nine species collected from rice fields with its surroundings which use chemical pesticides. It was observed that the ecological guild structure of these spiders was based on foraging behaviour in relation to the height of the rice plant. © 2022 Association for Advancement of Entomology

KEY WORDS: Rice ecosystem, foraging behaviour, chemicals, ecological guilds

In the current scenario of using integrated pest management techniques in agroecosystems, the importance of spiders as a biological agent due to their inherent predatory nature is gaining more attention. The abundance and richness of these spiders in agricultural fields made them essential regulators of insect populations (Wise,1993). Also, studies describe spiders as one of the most potential predators in the paddy fields (Tanaka, 1989; Sudhikumar *et al*., 2005). And it has been noted that Tetragnathidae spiders are the most prevalent in cultivated fields (Vungsilabutr, 1988). Various studies examining qualitative analysis of spiders in the rice ecosystem revealed that spiders belonging to the genus Tetragnatha were found more in number (Okuma, 1979; Chatterjee and Datta, 1979, Kamal *et al*., 1990; Thakur *et al*., 1995). Sebastian *et al*. (2005) and Sudhikumar *et al*. (2005) reported Tetragnthathidae as the most dominant family, contributing up to 90 per cent of the spiders in the rice agroecosystems. *Tetragnatha mandibulata* is the most common species among tetragnathids (Bhardwaj and Pawar, 1987). The present study estimates the species composition in paddy fields and adjacent areas along with the vertical stratification of these spiders belonging to the family Tetragnathidae.

Study Area: Kuttanad is a low-lying agricultural area that spread over the Pathanamthitta, Alappuzha, and Kottayam districts of Kerala contributing nearly 20 per cent of Kerala's total rice production and is known as the "Rice Bowl of Kerala." This wetland rice agroecosystem is a

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warm, humid region with a seasonal variation in temperature ranging from 21–38 °C. The plots selected for the present study were Champakulam, Edthuva, Veeyapuram, and Kainakary situated at 9.41°N, 76.4 °E; 9.36°N, 76.45°E; 9.30°N, 76.46°E and 9.48°N, 76.37°E respectively. The experimental plots were decided on the basis of farming techniques adopted there. Champakulam and Edthuva are organic agroecosystems which do not use any pesticide, while Kainakary and Veeyapuram use chemical pesticides for pest control. The study was carried out for a period of five months, from July to November 2020.

Sampling: The sampling was done around every 30 days for a period of five months. The plots were selected and divided into ten quadrants (1m x 1m). The specimens were collected between 6 am to 9 am. Visual search and sweep net method was used for a sample collection from each quadrant. A sweep net with a handle length of 30 cm, rim diameter 10 cm, and mesh size 1 mm was used for collecting spiders. Collected specimens were preserved in 70 percent alcohol for further analyses.

Identification: Detailed examination of each spider was done using a stereo zoom microscope (Magnus, MS 24). The epigynum of female adult spider was dissected, cleared in 10% KOH, mounted on a temporary slide and observed under a compound microscope (Leica DM1000 LED) at both 10X and 20X magnifications to study the internal structures. Adult male spiders were identified by the morphology of the chelicerae and the pedipalps. Spiders were identified using World Spider Catalog (2020) and Platnick (2014) at family, genus and species level. All available published taxonomic papers and distributional records enlisted in Aranea of India (Caleb and Sankaran, 2022) were also used for identification. All the collected specimens are deposited in the Zoological Museum of the Department of Zoology, University of Kerala, Kariavattom.

Vertical stratification: Spiders belonging to family Tetragnathidae were observed to be distributed in different strata of the paddy. The specimens were observed, photographed and collected. The strata are based on habitat preferences of the spider species related to the average height of the rice plant. The height is measured in centimetres from ground level: 15-20 cm, 20-50 cm, 50-80 cm, >80 cm and at the tip of the leaf during the reproductive stage of the rice crop. The ecological stratification of these spiders in terms of constructing orb webs at different levels may reflect foraging strategies and dominance of different species.

A total of 3435 tetragnathid specimens were collected from the study areas during the surveys. Thirteen species of tetragnathid spiders were recorded during the survey. *Tetragnatha mandibulata*, *T. javana*, *Glenognatha dentata* and *Tylorida striata* were recorded in all the paddy fields and its proximate areas of Edthua, Champakulam, Kainakary and Veeyapuram in Kuttanad. All the other tetragnathid species varied in their occurrence (Table 1, Plate 1, 2). The vertical stratification of seven tetragnathid species observed during the study (Table 2).

It was observed that tetragnatha spiders sustain on a diverse range of pests which may explain their potential occurrence during the growing season of rice crops (Saksongmuang *et al*., 2020). In the present study, the most abundant spiders recorded in the rice fields of Edthuva and Champakulam using organic fertilizers included *Tetragnatha mandibulata*, *T. javana*, *T. keyserlingi*, *Tylorida striata, Glenognatha dentata* followed by *Leucauge* sp. and *L. granulata*. Few other species were also recorded from the nearby areas of these fields like *Tetragnatha ceylonica*, *T. viridorufa*, *Tetragnatha* sp., *Leucauge decorata*, *Tylorida ventralis* and *Guizygiella* sp. Whereas in rice fields of Veeyapuram and Kainakary which employ chemical fertilizers, the species found in more numbers are *T. mandibulata*, *T. javana*, *G. dentata* and *Ty. striata*. Tetragnathids collected from the proximate areas of pesticide affected farm lands were *T. viridorufa*, *L. decorata*, *Ty. ventralis* and *Guizygiella* sp. *Tetragnatha mandibulata*, *T. javana* and *T. keyserlingi* occupied the topmost part of the leaf, according to the vertical stratification of tetragnathid spiders in rice fields that was determined from soil level, while

Table 1. Tetragnathids collected from paddy fields and its proximate areas in Kuttanad

Species	Edthua		Champakulam		Kainakary		Veeyapuram	
	PA	PR	PA	PR	PA	PR	PA	PR
Tetragnatha mandibulata Walckenaer, 1841	+	+	+	+	+	+	+	+
T. javana (Thorell, 1890)	+	+	+	+	+	+	+	+
T. keyserlingi Simon, 1890	+	+	+	+	+	-	-	-
T. ceylonica O. Pickard-Cambridge, 1869	-	+	-	+	-	-	-	-
Tetragnatha sp.	-	+	-	+	-	-	-	-
T. viridorufa Gravely, 1921	-	+	-	+	-	+	-	+
Glenognatha dentate (Zhu & Wen, 1978)	+	+	+	+	+	+	+	+
Leucauge granulate (Walckenaer, 1841)	+	+	+	+	-	-	-	-
Leucauge sp.	+	+	+	+	-	-	-	-
L. decorata (Blackwall, 1864)	-	+	-	+	-	+	-	+
Tylorida striata (Thorell, 1874)	+	+	+	+	+	+	+	+
Ty. ventralis (Thorell, 1874)	-	+	-	+	-	+	-	-
Guizygiella sp.	-	+	-	+	-	-	-	+

Plate 1- Tetragnathids of Kuttanad. ©Nishi Babu. Fig. 1 *Glenognatha dentata;* Fig. 2 *Tetragnatha ceylonica;* Fig. 3 *Leucauge granulata;* Fig. 4 *T. javana;* Fig. 5. *Tetragnatha viridorufa*; Fig. 6 *Tylorida striata;* Fig. 7 *Tylorida ventralis;* Fig. 8 *T. mandibulata;* Fig. 9 *Guizygiella* sp.

Table 2. Vertical stratification of tetragnathid spiders in rice fields from soil level

No.	15-20 cm	20-50 cm	50-80 cm	>80 cm	Tip of the leaf
1.	*Glenognatha dentata*	*G. dentata*	*Leucauge* sp.	*Tylorida striata*	*Tetragnatha mandibulata*
2.		*Leucauge* sp.	*L. gegranulata*	*G. dentata*	*T. javana*
3.					*T. keyserlingi*

Plate 2 - Tetragnathids feeding on pests of paddy. ©BinishRoopas. Fig. 1 *Tetragnatha javana* feeding on brown plant hopper; Fig. 2 *T. mandibulata* feeding on green; plant hopper; Fig. 3 *Glenognatha dentata* feeding on rice pest; Fig. 4 Juvenile *Tetragnatha* sp. feeding on rice aphids

Glenognatha dentata predominated in the basal section. Other areas of the plant were colonised by *Tylorida striata*, *Leucauge granulata* and *Leucauge* sp. In the entire paddy field, the spider species that were taken from various parts of the plant were found to be identical. Spiders have been seen to create multiple guilds based on pest abundance, microhabitat, crop season and foraging technique. However, vegetation structure may also affect spiders' choices for habitat as reported by Mathew *et al*. (2014).

Tetragnthids make up a significant portion of the spider community in rice agroecosystems, hence the variety and abundance of these spiders in rice fields must be positively correlated with pest eradication and biological management (Joseph and Premila, 2016). The findings presented here show the variations in the species makeup of the Tetragnathidae family in four rice ecosystems utilizing various agricultural practices and chemical and organic fertilizers in Kuttanad. The presence of a wide variety of pests as prey species in the area due to the lack of pesticide use may explain the considerable number of tetragnathids and differences in species composition in farms using organic fertilizer. Additional research is being done to examine the importance of its predatory behaviour and the tactics employed to control the pest population in paddy fields.

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