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Spider richness in Kuttanad, a major low-lying rice agroecosystem in Central Kerala, India

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Abstract

This study focused on the spider fauna of the rice agroecosystem around Kuttanad's paddy fields and proximate areas. The spider richness, abundance, and species composition between the rice agroecosystem and nearby surroundings were assessed from July 2021 to April 2022. Pitfall trap and sweeping net were used to conduct monthly collection in six sites: Edthuva, Champakulam, Veeyapuram, Kainakary, Moncompu, and Karuvatta. We collected only adult spiders for identification. Edthuva represented the highest number of specimens, followed by Champakulam, Moncompu, Karuvatta, Kainakary, and Veeyapuram. Representatives from 16 families were obtained, with Salticidae, Araneidae, and Tetragnathidae being the most prevalent. Also, it was noted that the spider species in rice fields were typical, and statistical analysis revealed a substantial variation in species composition between paddy fields and their nearby areas. In addition to the species diversity, a closer look at the vertical distribution pattern of orb-web weavers belonging to Tetragnathidae and Araneidae in paddy fields were also observed. The diversity indices indicate that the Edthuva and Champakulam rice agroecosystem spider communities are more diversified than those in other locations.

Keywords: Spider fauna, Paddy fields, Kuttanad, Biocontrol, Paddy pest

Introduction

Scientists have recently focused on studying biological diversity in agroecosystems to create sustainable ecosystems. Additionally, monitoring a few ecologically significant species is an intuitively appealing way to assess the sustainability of that ecosystem. One such agroecosystem is the cultivation of rice, which is the most ancient form of intensive agriculture in Kuttanad, a low-lying fragile wetland ecosystem in the south Indian state of Kerala, which consists of approximately eight agroecosystem zones. Paddy cultivation has been the primary livelihood in Kuttanad. According to Roger (1996), the rice crop and associated ecosystems constitute a rich mosaic of habitats that preserve high biological diversity. Therefore, increasing the yield and protecting it from pest attacks are necessary.

Moreover, the use of pesticides may reduce not only pest species but also their natural enemies. Other than the use of chemicals, the most effective pest management strategy is the promotion of biological control. As biocontrol provides self-perpetuating control at little to no ongoing expense, it is both economically and environmentally favourable since it reduces the non-target effects and environmental damage caused by many synthetic inputs (Bale *et al.*, 2008). Since spiders are one of the natural enemies that help to reduce the pest populations, their diversity and density are crucial in any attempt to use them as biocontrol agents. Also, they exhibit high diversity and are dominant insectivores in many terrestrial ecosystems. Research has shown that spiders can be effective predators in reducing the numbers of planthoppers and leafhoppers in rice fields (Hamamura 1969; Gavarra and Raros 1973; Samal and Misra 1975;

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Kobayashi 1977; Chiu 1979; Holt *et al.*, 1987; Tanaka 1989). Dispersal by running and ballooning allows spiders to quickly establish colonies in agricultural fields following disturbance from agricultural techniques. Lee *et al.* (1997) showed that spiders represent more than 90% of the natural enemies of brown planthoppers living in paddy fields. Because of this, most studies on the biological control of planthoppers have focused on spiders. As a result, studies on the diversity of spiders in agroecosystems are important to monitor how these predators affect herbivorous pests (Maloney *et al.*, 2003) and to understand how environmental changes affect spider colonization. (Oberg, 2007).

Spiders utilize various techniques to capture their food, and it has been noted that orb-web spiders may trap more insects than they consume (Tahir *et al.*, 2009). In the present study, Tetragnathidae and Araneidae are the two orb-web weavers most frequently found in the paddy fields of Kuttanad. This work aims to assess the species composition and vertical stratification of these Tetragnathidae and Araneidae spiders in paddy fields and adjacent areas. Also, this study intends to propagate the knowledge that spiders are a common and influential group of natural predators that are thought to be effective in the biocontrol of significant paddy pests in agroecosystems.

Materials and Methods

Study Area

Kuttanad Wetland is a low-lying area located between 9°15' N to 9°33' N latitudes and 76°19' E to 76°34' E longitudes, with backwaters, canals and stream networks located in the southern end of India's largest Ramsar site, the Vembanad-Kole wetlands. This wetland is a deltaic trough-like formation shaped by the confluence of four major rivers of the state, the Meenachil, the Manimala, the Pampa, and the Achenkovil, flowing towards the north-western direction and debouching into the Vembanad Backwater. Kuttanad has an area of approximately 874 km^2 and covers three districts of Kerala: Pathanamthitta, Alappuzha, and Kottayam, each contributing nearly 20 percent of Kerala's total rice production. It is therefore acknowledged as the "Rice Bowl of Kerala." The Food and Agriculture Organization of the United Nations recognises the Kuttanad wetland farming system as "unique", saying it is the "only system in India that favours rice cultivation below sea level". The sites selected for the present study were in Champakulam, Edathua, Veeyapuram, Kainakary, Karuvatta, and Moncompu, situated at 9.41°N, 76.4 °E; 9.36°N, 76.45°E; 9.30°N, 76.46°E, 9.48°N, 76.37°E, 9.311 °E;76.43°N and 9.44°E; 76.42°N respectively. Edathua and Champakulam are organic farms that do not employ chemical fertilizers. Farmers in Karuvatta and Moncompu use weedicides to control insect attacks, while those in Veeyapuram and Kainakary use pesticides.

Study Period

The study was conducted from July 2021 to April 2022, in paddy fields and their proximate areas at six stations located at Edathua, Champakulam, Kainakary, Veeyapuram, Moncompu, and Karuvatta. The period of each paddy's cultivation is four months, with two seasons, Rabi and Kharif. Sampling was conducted in these two seasons: Rabi, which is characterised by heavy rain (South-West Monsoon) and high humidity, and Kharif, which is characterized by low rainfall and dry weather (Menon *et al.*, 2000).

Sampling

The sampling was done for each season once in a month. The paddy fields were selected and divided into 10 quadrants of 1m x 1 m. The specimens were collected from each quadrant using a visual search and sweeping method between 6am to 9am. The collected specimen were preserved in 70% alcohol and transported to the laboratory.

Sample identification

A detailed examination of each spider was done using a stereo zoom microscope (Magnus, MS 24). The epigynum of female adult spider was cleared in 10% KOH, and mounted on a temporary slide, and observed under a compound microscope (Leica DM1000 LED) to study the internal structures. Adult male spiders are identified by observing their palp. Measurements of the legs and pedipalps are taken using the Leica S8APO version 4.2. The specimens were identified using literature. All the collected specimens were preserved and deposited in the Zoological Museum of the Department of Zoology, University of Kerala, Kariavattom.

Vertical stratification

We conducted field observations on the spiders belonging to the families Tetragnathidae and Araneidae based on their distribution in different strata of the paddy crop. The vertical stratification of the spider species is related to the height of the rice plant (Babu and Prasad, 2022).

Data Analysis

Spider diversity of paddy fields and proximate regions of each station was analysed using R Core Team (2022). Other indices such as the Shannon-Weiner index (H'), Simpson's Dominance index, Margalef's species richness, and Evenness were analysed using the *vegan* package in R. To estimate the possible reach of spider fauna in both paddy and proximate regions of each station, a species accumulation curve was done using *vegan* package in R. To observe the patterns of community structure in the study area, a

Non-metric Multidimensional Scaling (NMDS) ordination was performed using the *vegan* package in R.

Results and Discussion

Sampling yielded a total of 3569 individuals of 80 species representing 16 families and 57 genera (Table 1). The dominant group of families has 24 species of Salticidae, 14 species of Araneidae, and nine species of Tetragnathidae. The analysis of diversity patterns of the spider community in both paddy and proximate areas of each study area is represented in Tables 2 and 3. The rice agroecosystem of Champakulam has the highest species diversity, with H' of paddy fields is 2.88 and proximate is 3.86, and also having lowest dominance and highest evenness. Followed by Edthuva with H' of paddy fields is 2.81 and its adjacent area is 3.95. The lowest diversity of spiders was observed in Veeyapuram *i.e.,* in paddy fields it is 2.37 and in proximate areas the value is 3.09. In Kainakary also the same H' value has been reported for paddy fields but in the proximate area the value is 3.48, a higher value than that of Veeyapuram. The highest evenness index was observed in the paddy fields of Champakulam and proximate regions of the Karuvatta rice agroecosystem with values of 0.85 and 0.69 respectively. Species richness measured using Margalef's index had maximum value in rice fields and proximate region Champakulam, whereas minimum value was observed in Veeyapuram. The species accumulation curve of each site is also given in Figure 1 (paddy fields) and Figure 2 (proximate areas), indicating that sampling was almost complete. The species accumulation curve was computed as a qualitative measure of species richness, with Shannon-Weiner and Simpson's diversity being higher in Edathua and Champakulam due to higher species richness. And, the curves may indicate stabilization in the estimated number of species.

The NMDS scatter plot indicates significant values of spider assemblage of the sampling sites (Figure 3). Higher spider diversity in Champakulam and Edathua suggested a favourable habitat for spiders. The vertical stratification of spiders *Tetragnatha mandibulata*, *T. javana*, *T. keyserlingi*, *Tylorida striata*, *Leucauge granulata,* and *Glenognatha dendata* belonging to the families Tetragnathidae and *Neoscona theisi*, *N. nautica*, *Argiope catenulata* and *Araneus ellipticus* representing the family Araneidae observed during the study is presented in Table 4. Most of the tetragnathids and araneids were reported from the upper layer of the rice plant. The present study documented species diversity and assemblage in selected rice fields and their adjacent areas of Kuttanad. According to the findings, more species are reported in paddy fields of Edathua and Champakulam (organic farms) than in other farms in Kuttanad. Overall, species richness is the most widely adopted diversity measure, which examines the number of species occurring in a habitat (Sudhikumar *et al.*, 2005). The organic farms obtained the highest species richness value in the present study. The highest evenness index obtained resulted in the conclusion that all species in that site are equally abundant. It is possible that the excessive usage of chemical fertilizers is responsible for the lower diversity in the fields of Veeyapuram and Kainakary. The rice agroecosystems in Karuvatta and Moncompu, which used weedicides, displayed greater diversity than pesticide-affected fields but had a different species composition from organic farms. As a result, it can be assumed that spiders can serve as indicators of an ecosystem's health.

According to Tahir *et al.* (2012), orb-weaving spiders utilize the vertical stratification method of niche portioning and do not actively compete with one another. Orb-web weavers can efficiently reduce niche overlap by capturing different prey at different heights due to differences in the web structure. Araneids and some tetragnathids were seen foraging at the upper layer of the rice plants in the current investigation. *Glenognatha dentata* dominated the plant's basal region. Therefore, spiders can form several guilds based on the prevalence of pests, the microhabitat, and feeding strategies and coexist depending on the plant structure for their preferred habitat.

Table 1. Checklist of spiders recorded in the study

I.	**Family Araneidae** Clerck, 1757
1.	Anepsion maritatum (O. Pickard-Cambridge, 1877)
2.	Araneus ellipticus (Tikader & Bal, 1981)
3.	Argiope catenulata (Doleschall, 1859)
4.	Argiope anasuja Thorell, 1887
5.	Chorizopes khanjanes Tikader, 1965
6.	*Cyclosa confraga* (Thorell, 1892)
7.	Cyclosa neilensis Tikader, 1977
8.	Cyrtophora citricola (Forsskål, 1775)
9.	Eriovixia laglaizei (Simon, 1877)
10.	Gasteracantha geminata (Fabricius, 1798)
11.	*Guizygiella* sp.
12.	Herennia multipuncta (Doleschall, 1859)
13.	Neoscona nautica (L. Koch, 1875)
14.	Neoscona theisi (Walckenaer, 1841)
II.	**Family Clubionidae** Wagner, 1887
15.	Clubiona drassodes O. Pickard-Cambridge, 1874
16.	Clubiona filicata O. Pickard-Cambridge, 1874
17.	Clubiona tridentata Dhali, Roy, Saha & Raychaudhuri, 2016
III.	**Family Corrinidae** Karsch, 1880
18.	Castianeira zetes Simon, 1897
19.	Corinnomma severum (Thorell, 1877)
IV.	**Family Eresidae** C. L. Koch, 1845
20.	Stegodyphus sarasinorum Karsch, 1892
V.	**Family Hersiliidae** Thorell, 1869
21.	Hersilia savignyi Lucas, 1836
22.	Hersilia tibialis Baehr & Baehr, 1993
VI.	**Family Lycosidae** Sundevall, 1833
23.	Pardosa pseudoannulata (Bösenberg & Strand, 1906)
24.	Pardosa sumatrana (Thorell, 1890)
VII.	**Family Oxyopidae** Thorell, 1869
25.	Oxyopes javanus Thorell, 1887
26.	Oxyopes birmanicus Thorell, 1887
27.	Oxyopes shweta Tikader, 1970
28.	Peucetia viridana (Stoliczka, 1869)
VIII.	**Family Philodromidae** Thorell, 1869
29.	Psellonus planus Simon, 1897
IX.	**Family Pholcidae** C. L. Koch, 1850
30.	Pholcus sp.
X.	**Family Pisauridae** Simon, 1890
31.	Dendrolycosa gitae (Tikader, 1970)
XI.	**Family Salticidae** Blackwall, 1841
32.	Asemonea tenuipes (O. Pickard-Cambridge, 1869)
33.	Bianor angulosus (Karsch, 1879)
34.	Brettus cingulatus Thorell, 1895
35.	Carrhotus viduus (C. L. Koch, 1846)
36.	Curubis tetrica Simon, 1902
37.	Epocilla aurantiaca (Simon, 1885)
38.	Hyllus semicupreus (Simon, 1885)
39.	Icius vikrambatrai Prajapati, Malamel, Sudhikumar & Sebastian, 2018
40.	Indomarengo chavarapater Malamel, Prajapati, Sudhikumar & Sebastian, 2019
41.	Indopadilla insularis (Malamel, Sankaran & Sebastian, 2015)
42.	Marengo Sachintendulkar Malamel, Prajapati, Sudhikumar & Sebastian, 2019
43.	Menemerus bivittatus (Dufour, 1831)
44.	Myrmaplata plataleoides (O.P.-Cambridge, 1869)
45.	Phintelloides undulatus (Caleb & Karthikeyani, 2015)
46.	Phintella vittata (C. L. Koch, 1846)
47.	Plexippus petersi (Karsch, 1878)
48.	Plexippus paykulli (Audouin, 1826)
49.	Rhene flavicomans Simon, 1902
50.	Rhene flavigera (C.L. Koch, 1846)
51.	Rhene rubrigera (Thorell, 1887)

52. Siler semiglaucus (Simon, 1901)	
53. Telamonia dimidiata (Simon, 1899)	
54. Thiania bhamoensis Thorell, 1887	
55. Thyene bivittata Xie & Peng, 1995	
XII. Family Sparassidae Bertkau, 1872	
56. Heteropoda venatoria (Linnaeus, 1767)	
57. *Olios* sp.	
58. Olios milleti (Pocock, 1901)	
59. Thelcticopis moolampilliensis Jose & Sebastian, 2007	
XIII. Family Tetragnathidae Menge, 1866	
60. *Glenognatha dentata* (Zhu & Wen, 1978)	
61. *Leucauge granulata* (Walckenaer, 1841)	
62. *Tetragnatha javana* (Thorell, 1890)	
63. *Tetragntha keyserlingi* Simon, 1890	
64. *Tetragnatha mandibulata* Walckenaer, 1841	
65. *Tetragnatha* sp.	
66. *Tetragnatha viridorufa* Gravely, 1921	
67. *Tylorida striata* (Thorell, 1874)	
68. *Tylorida ventralis* (Thorell, 1874)	
XIV. Family Theridiidae Sundevall, 1833	
69. Meotipa argyrodiformis (Yaginuma, 1952)	
70. Meotipa picturata Simon, 1895	
71. Nihonhimea indica (Tikader, 1977)	
72. *Theridion* sp.	
73. Theridion manjithar Tikader, 1970	
XV. Family Thomisidae Sundevall, 1833	
74. Camaricus formosus Thorell, 1887	
75. Indoxysticus minutus (Tikader, 1960)	
76. Thomisus projectus Tikader, 1960	
77. Thomisus pugilis Stoliczka, 1869	
XVI. Family Uloboridae **Thorell, 1869**	
78. Philoponella feroka (Bradoo, 1979)	
79. *Philoponella* sp.	
80. Zosis geniculata (Olivier, 1789)	

Table 2: Diversity indices of spiders from the selected paddy fields of Kuttanad

	Karuvatta	Moncompu	Edathua	Champakulam	Veeyapuram	Kainakary
Dominance_D	0.08214	0.07772	0.06192	0.06045	0.09801	0.09861
Simpson_1-D	0.9179	0.9223	0.9381	0.9336	0.902	0.9014
Shannon_H	2.583	2.62	2.879	2.816	2.374	2.374
Evenness_e^H/S	0.8277	0.8581	0.8086	0.8597	0.8259	0.8265
Margalef	1.917	1.94	2.598	2.631	1.549	1.569

Table 3: Diversity indices of spiders from the **proximate areas of the selected paddy fields of Kuttanad.**

	Karuvatta	Moncompu	Edathua	Champakulam	Veeyapuram	Kainakary
Dominance_D	0.02531	0.0303	0.03097	0.0237	0.05351	0.03898
Simpson_1-D	0.9747	0.9697	0.969	0.9763	0.9465	0.961
Shannon_H	3.847	3.699	3.861	3.948	3.091	3.481
Evenness_e^H/S	0.6994	0.652	0.6015	0.656	0.647	0.5804
Margalef	7.477	7.128	8.701	8.865	4.071	6.661

Table 4. Vertical stratification of tetragnathid and araneid spiders in rice fields from soil level

Sl. No.	15-20cm	20-50cm	50-80cm	>80cm	Tip of the leaf
1.	*Glenognatha dentata*	*Glenognatha dentata*	Araneus ellipticus	*Tylorida striata*	*Tetragnatha mandibulata*
2.			*Leucauge granulata*	*Glenognatha dentata*	*Tetragnatha javana*
3.			*Argiope catenulata*	*Araneus ellipticus*	*Tetragnatha keyserlingi*
				Neoscona theisi	
				N. nautica	
				Argiope catenulata	

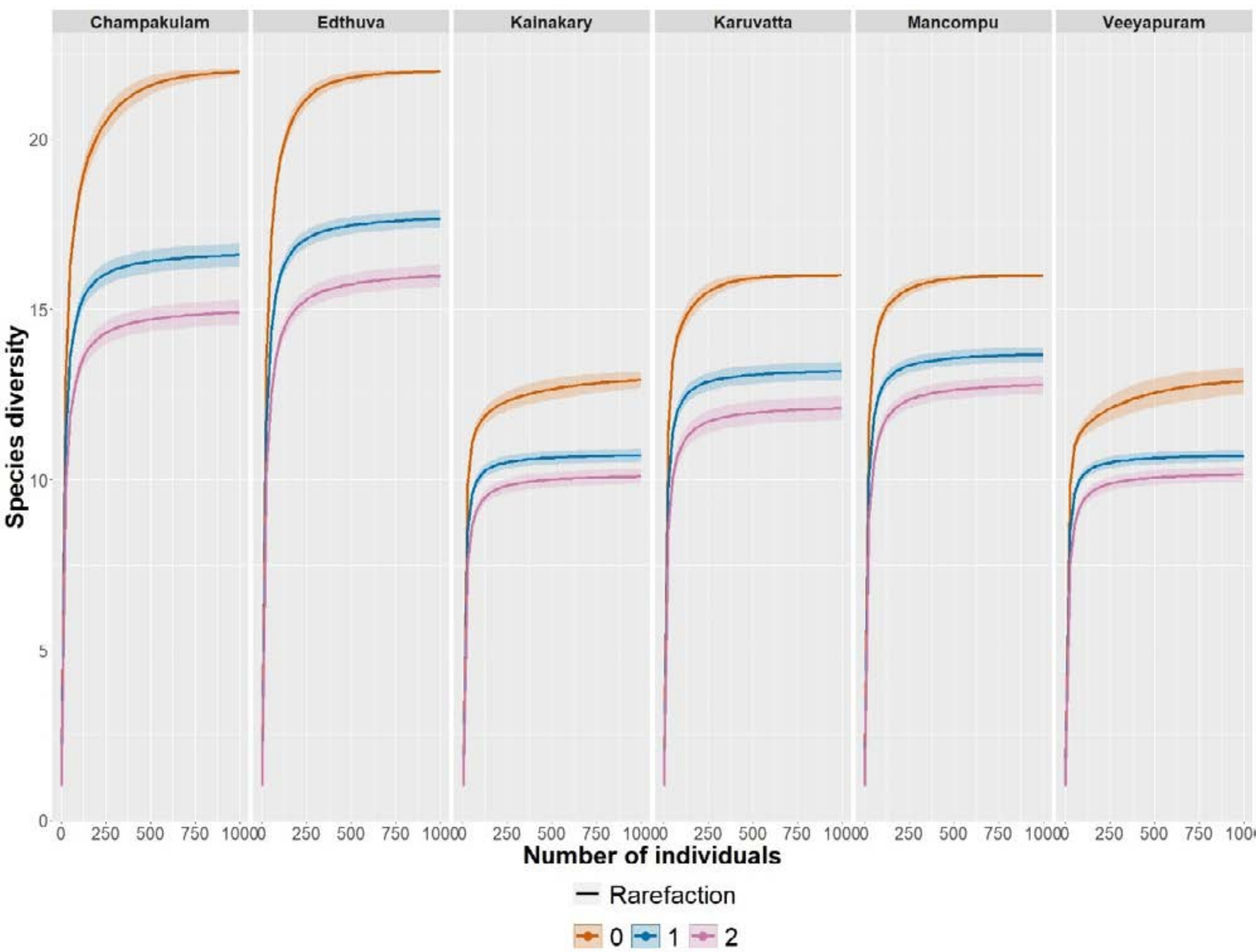

Figure1. Species accumulation curve of selected paddy fields of Kuttanad. 0-Richness, 1-Shannon diversity, and 2-Simpson diversity.

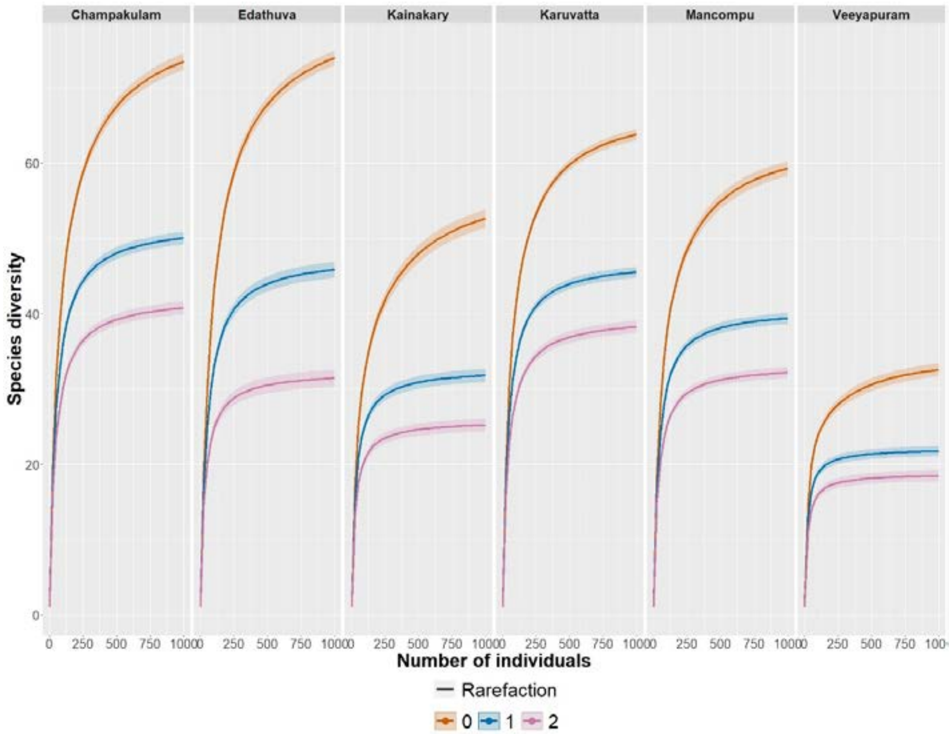

Figure2. Species accumulation curve of proximate regions of selected paddy fields of Kuttanad. 0-Richness, 1- Shannon diversity and 2- Simpson

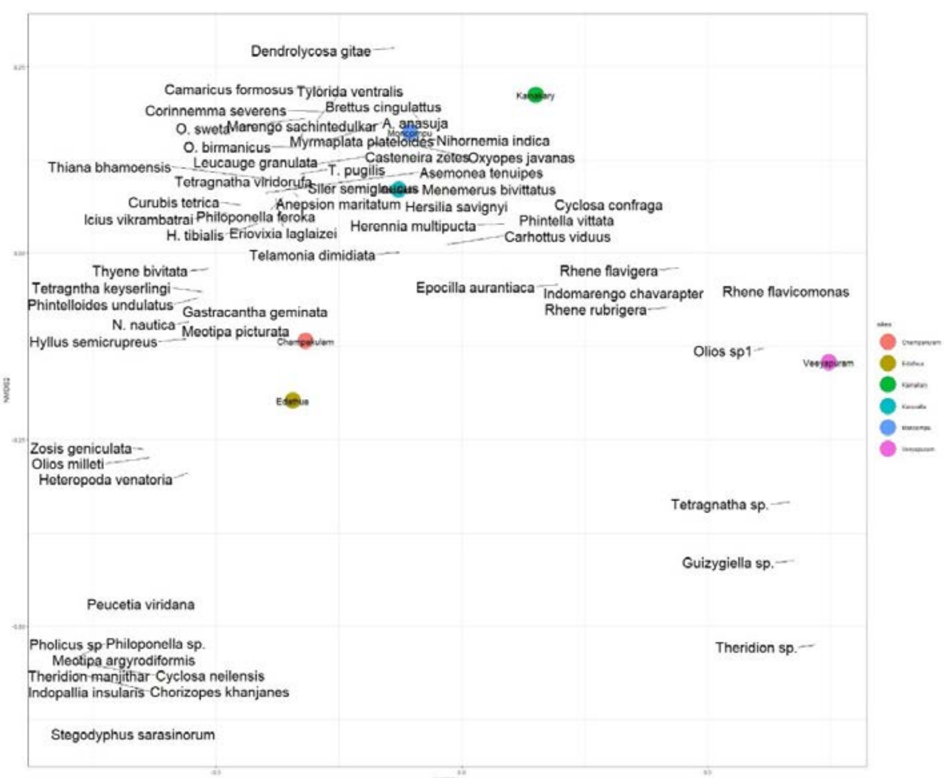

Figure3. NMDS: Distribution of species in different sites.

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References

Babu, N. and Prasad, G. 2022. Species diversity and vertical stratification of spiders of the family Tetragnathidae Menge, 1866 (Araneae) in different paddy farming practises at Kuttanad, Kerala, India. *Entomon*, 47(3): 323-328.

Bale, J.S., van Lenteren, J.C. and Bigler, F. 2008. Biological control and sustainable food production. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 363: 761– 776.

Chiu, S.C. 1979. Biological control of the brown planthopper. In: Brown Planthopper, Threat to Rice Production in Asia. International Rice Research Institute, Los Baños, Laguna, Philippines, 335-355 pp.

Gavarra, M. and Raros, R.S. 1973. Studies on the biology of the predator wolf spider, *Lycosa pseudoannulata* Bös. st Str. (Araneae: Lycosidae). *Philippine Entomologist,* 2, 6: 427.

Hamamura, T. 1969. Seasonal fluctuation of spider populations in paddy fields. *Acta Arachnologica*, 22(2): 40-50.

Holt, J.Cook., , A.J. Perfect, T.J. and Norton, G.A. 1987. Simulation analysis of brown planthopper (Nilaparvata Lugens) population dynamics on rice in the Philippines. *Journal of Applied Ecology,* 24: 87-102.

Kobayashi, S. 1977. Changes in population density of spiders in paddy field during winter. *Acta Arachnologica*, 27: 247-251.

Lee, J.H., Kim, K.H. and Lim, U.T. 1997. Arthropod community in small rice fields associated with different planting methods in Suwon and Icheon. *Korean Journal of Applied Entomology*, 36(1): 55-66.

Tahir, M.H., Butt, A. and Sherawat, S.M. 2009. Foraging strategies and diet composition of two orb web spiders in rice ecosystems. *Journal of Arachnology*, 37(3): 357-362

Maloney, D., Drummond, F.A. and Alford, R. 2003. Spider predation in agroecosystems: Can spiders effectively control pest populations. (Published by Maine Agricultural and Forest Experiment Station Technical Bulletin 190). Menon N.N., Balchand, A.N. and Menon, N.R. 2000. Hydrobiology of the Cochin backwater system – a review. *Hydrobiologia*, 430: 149-183.

Öberg, B. Ekbom, R. Bommarco. 2007. Influence of habitat type and surrounding landscape on spider diversity in Swedish agroecosystems. *Agriculture, Ecosystems and Environment*, 122: 211-219

Oksanen, J., Kindt, R., Legendre, P., O'Hara. B., Simpson, G.L., Solymons, P., Stevens, M.H.H. and Wagner, H. (2008). Vegan: community Ecology Package (R package version 1.15-1)

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Roger P.A. 1996. Biology and management of the floodwater ecosystem in rice fields. IRRI, P. O. Box 933, Manila 1099, 250 pp.

Samal, P. and B.C. Misra. 1975. Spiders: The most effective natural enemies of the brown planthoppers in rice. *Rice Entomology. Newsletter,* 3: 31.. Sudhikumar A.V., Mathew M.J., Sunish E. and Sebastian P.A. 2005. Seasonal variation in spider abundance in Kuttanad rice agroecosystem, Kerala, India (Araneae). *European Arachnology,* 1: 181-190.

Tahir, H., M. Butt, A. Mukhtar, M., K. Bilal, M and Khan S.Y. 2012. Coexistence of four orb weaving spiders in the rice ecosystem. *Pakistan Journal of Zoology*,44: 1521–1528.

Tanaka, K. 1989. Movement of the spiders in arable land. *Plant Protection,* 43(1): 34-39.