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Research Article

SPECIES COMPOSITION, ABUNDANCE AND DIVERSITY OF SPIDERS (ARACHNIDA; ARANEAE) FROM COTTON AND PADDY AGRO-ECOSYSTEMS OF MANAMADURAI TALUK, SIVAGANGAI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

The purpose of the present study was to document the various species of predatory spiders present in cotton and paddy agro-ecosystems of Manamadurai Taluk, Sivagangai district, Tamilnadu, India. The research was carried out from February 2020 to September 2021.The Main aim of this study was to determine the species richness and relative abundance of spiders in cotton and paddy fields. Pitfall traps, hand picking, visual counting and sweep net methods were used to collect spider samples on a bimonthly basis. A total of 7,553spiders comprising 55 species, 29 genera and 9 families were recorded. Araneidae family contributed a major share to the overall count of spiders, accounting for 42.12 % of the total. The most dominant species was *Argiope anasuja*(4.47) followed by *Neoscona rumpfi, Neoscona theisi and Oxyopes javanus* in cotton field, while in paddy field the most dominant species was *Argiope pulchella* followed by *Tetragnatha extensa and Tetragnatha elongata.* The highest species richness was found in the cotton plantation with 37 species belonging to 25 genera and paddy field recorded 29 species belonging to 16 genera under 9 families. Diversity indexes were higher at paddy (H' =1.49; 1-D = 0.71) and lower at cotton (H' = 1.40; 1-D = 0.70). Similarity index revealed high resemblance in species composition between cotton and paddy. The findings of the present study will help in the pest management techniques that can be implemented in cotton and paddy growing areas throughout the world.

Keywords: Agro-ecosystem, Biodiversity, Cotton, Guild structure, Rice, Spiders.

INTRODUCTION

Spiders are the most diverse and omnipresent invertebrate predators in terrestrial agro-ecosystems (Fatima *et al.*, 2021).In the world, spiders are the one of the most diverse and captivating invertebrate animals. Throughout the world 48,643 species of spiders belonging to 4173 genera and 128 families have been reported of which, 1700 spider species under 450 genera and 64 different families have been reported in India (World Spider Catalog, 2019).Spiders are good indicators of the climate condition and changes of their diversity help to assess the condition of habitats (Raiz Tabasum *et al*., 2018). Spiders play a significant role in controlling the insect pest populations in the agricultural crop fields (Reshma *et al*., 2020). Spiders are more sensitive to habitat loss, climatic change, environmental disruptions (Thirukonda *et al*., 2022). Paddy (*Oryza sativa* L.) is one of the most important staple food crops in the world. Rice is a major cash crop plays a vital role in the agro based economy of India. Spiders are the most important group of predatory arthropods in paddy fields which play a significant role in suppression of insect pests (Umesh *et al*., 2018).Warm and humid atmosphere make suitable condition for proliferation of various species of insect pests in paddy field (Anjali *et al*., 2019).Spiders have a vital role in ecology by maintaining ecological equilibrium (Ambily and Anju, 2016). Cotton (*Gossypium hirsutum* L.) plays a significant role in India, agro-based economy which is major source of foreign export earnings. Spider fauna and abundance are rich in cotton, rice, sugarcane fields and terrestrial land. Insect pests act as a serious threat to economy as it is estimated that they are

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responsible for 20-40 % loss of agricultural crops globally (Nadeem *e t al.,* 2023).Spiders are one of the most important arthropods and are extremely important in maintaining insect pest densities in agro-ecosystems (Mahalakshmi and Jeyaparvathi, 2014).

The study of biodiversity associated with agro-ecosystems has very important in the fields of ecology and conservation. In agriculture, the maintenance of biodiversity is essential for ecologically sustainable productivity (Leila *et al*., 2008). Spiders are able to capture the prey that differs in body size and developmental stages, because of magnetic variation in spider size and prey capture strategies (Henaut *et al*., 2001). Spiders cause to reduce the pest density by trapping the prey in the webs and they promote the diversity and stability of the natural enemy density and they act as a drastic basis of pest control (Sunderland, 1999).The main goal of the growers is to maintaining population of these insect pests below their economic threshold levels (ETL) without disturbing the food web of many other depending insect species which are essential for the maintenance of a balanced and sustainable agro-ecosystem (Hallmann *et al*., 2020).

The spider diversity was influenced by climatic factors such as temperature, humidity and precipitation (Raiz *et al*., 2018). However, a very little documentation has been done on spider diversity in southern part of Tamilnadu. There is no hitherto report on spider diversity in Sivagangai district. Therefore, the present study was carried out with the aims were as follows: (1) to describe and compare the composition and structure of spider assemblages in Cotton and Paddy crop fields in Manamadurai, Sivagangai district in Tamilnadu, India; (2) to explore diversity and seasonal variation on diversity of spiders. The outcome of this present study will help devise for pest management strategies in cotton and paddy growing areas present throughout the world.

MATERIALS AND METHODS

Study Area

The present study was conducted during 2020 and 2021 in Thiruppachethi (9.77^0 N; 78.34^0 E) Mangulam (9.49^0 N; 78.150 E), cotton and paddy growing areas of Manamadurai Taluk, Sivaganga district, Tamilnadu, India. Manamadurai belongs to Sivaganga District of Tamil Nadu State of India, with the total area of 635 Sq. km including 43 villages. This is a warm humid area and with the seasonal rainfall of 275.8 mm from South west monsoon and 382.5 mm from North east monsoon. Humidity is showing the seasonal fluctuations. To observe various spiders in the cotton and paddy fields, different sampling methods were used in all selected sites during two consecutive cotton and paddy cropping seasons. During the period of study, the data regarding physiological parameters (temperature, humidity and rainfall) was obtained from Indian Metrological Department.

Figure 1. Map showing the study area (Blue star).

Sampling procedure

Spiders were collected by sweeping, beating, hand picking and visual searching methods in the cotton and paddy crop fields. Sampling was done every month by quadrate method. Spiders were collected from one quadrate (1sq. m x 1sq. m) placed at 4 corners and one center of 10 sq. m x 10 sq. m size were laid down with threads inside rice and cotton fields separately. The spiders found inside the quadrates were collected by using sweeping net (25 cm in diameter) and visual search method between 8.00 am to 10.00 am. A sufficient core area was left to reduce edge effects. All sampled specimens were preserved in plastic bottles containing 75% alcohol in the field and counted and identified under the microscope in the laboratory.

Species identification

The collected spider specimens were identified under sterio-zoom microscope following standard taxonomic key provided by Tikader (1987), Barrion (1995) and Keswani (2012).The latest nomenclature of the identified spider species is based on World Spider catalog (2017) and' Checklist of Indian spiders (2023).

Data analysis

Different statistical tools were used to determine the spider diversity indices, richness, and evenness using the biodiversity software, PAST version 4.03.

RESULTS AND DISCUSSION

A total of 55 species belonging to 28 genera under 9 families were recorded from the cotton and paddy crop fields (Table 1). In the present study, Araneidae was the dominant family constituting 18 species under 4 genera, followed by Salticidae (14 species), Tetragnathidae (7 species), Oxyopidae (5 species), Thomisidae (5 species), Sparassidae (3 species), Cheiracanthiidae (1 species), Clubionidae (1 species) and Lycosidae (1 species) (Table 1, Figure 2 &3).

Table 1. The relative abundance (R. A) Of spiders associated with the cotton and paddy ecosystems of ManamaduraiTaluk, Sivagangai, Tamilnadu.

S.No.	Family / Species	Cotton	Paddy	Total	R.A
1.	**Araneidae**	0	144	144	1.90
	Araneus diadematus				
2.	*Araneius gemmoides*	119	0	119	1.57
3.	*Argiopeana suja*	338	0	338	4.47
4.	*Argiope amoena*	0	122	122	1.61
5.	*Argiope pulchella* (Thorell, 1881)	42	319	361	4.77
6.	*Argiope aurantia*	0	143	143	1.89
7.	*Argiope sp.*	0	127	127	1.68
8.	*Argiope keyserlingi*	0	89	89	1.17
9.	*Cyclosa ginnaga*	132	0	132	1.74
10.	*Cyclosa sp.* (Menge, 1866)	0	146	146	1.93
11.	*Cyclosasp*	0	94	94	1.24
12.	*Neoscona theisi* (Walckenaer, 1841)	187	82	269	3.56
13.	*Neoscona punctigera*	135	76	211	2.79
14.	*Neoscona crucifera*	179	0	179	2.36
15.	*Neoscona sp.*	183	0	183	2.42
16.	*Neoscona rumpfi*	210	0	210	2.78
17.	*Neoscona moreli*	145	0	145	1.91
18.	*Neoscona adianta*	0	176	176	2.33
19.	***Cheiracanthiidae***	74	53	127	1.68
	Cheiracanthium inclusum				
20.	**Clubionidae**	12	96	108	1.42
	Clubiona caerulescens(Latreille, 1804)				
21.	***Lycosidae***	7	78	85	1.12
	Pirata piraticus				
22.	***Oxyopidae* (**Thorell,1869)	169	158	327	4.32
	Peucetia viridans				
23.	*Oxyopes sunandae* (Tikader, 1970)	123	119	242	3.20
24.	*Oxyopes shweta*(Tikader, 1970)	175	145	320	4.23
25.	*Oxyopes salticus*(Hentz, 1845)	138	0	138	1.82

26.	*Oxyopes javanus*(Thorell, 1887)	184	0	184	2.43
27.	***Salticidae*** **(**Blackwall,1841) *Arachnura angura*	146	0	146	1.93
28.	*Camponotus cericeus*	0	135	135	1.78
29.	*Marpissa muscona*	152	0	152	2.01
30.	*Myrmarachne spissa*	94	0	94	1.24
31.	*Menemerus bivittatus*	76	0	76	1.00
32.	*Phidipus clarus*	149	0	149	1.97
33.	*Pellenes sp.*	0	64	64	0.84
34.	*Platycryptus undatus*	47	0	47	0.62
35.	*Plexippus paykulli*(Audouin, 1826)	32	0	32	0.42
36.	*Pristobaeus sp.*	168	0	168	2.22
37.	*Salticus senicus*	137	0	137	1.81
38.	*Salticus sp.*	74	0	74	0.97
39.	*Metacyrba taeniola*	0	82	82	1.08
40.	*Telamonia dimidiata*	61	0	61	0.80
41.	***Sparassidae*** *Heteropoda venatoria* (Linnaeus, 1767)	0	35	35	0.46
42.	*Micrommata virescens*	96	0	96	1.27
43.	*Olios giganteus*	48	0	48	0.63
44.	***Tetragnathiidae*** **(**Menge,1866) *Leucauge decorataa* (Blackwall, 1864)	0	174	174	2.30
45.	*Tetragnatha elongata*	32	211	243	3.21
46.	*Tetragnatha mandibulata* (Walckenaer,1842)	21	196	217	2.87
47.	*Tetragnatha extensa* (Linnaeus, 1758)	0	223	223	2.95
48.	*Tetragnatha montana* (Simon, 1874)	0	172	172	2.27
49.	*Tetragnatha keyserlingi* (Simon, 1890)	0	92	92	1.21
50.	*Tetragnatha virescens*	0	71	71	0.94
51.	***Thomisidae*** *Misumena vatia*	6	0	6	0.07
52.	*Thomisus callidus*	2	0	2	0.02
53.	*Thomisus lobosus*	25	0	25	0.33
54.	*Thomisus sp.*	0	5	5	0.06
55.	*Thomisus spectabilis*	8	0	8	0.10
	Total	**3926**	**3627**	**7553**	**100**

The family Araneidae was most abundant (1670 individuals collected) in both cotton and paddy fields. A total of 55 species were collected from cotton and paddy fields, of which 37 were found in the cotton field. Interestingly, the diversity of Lycosidae in the relatively well-studied cotton field is significantly lower in comparison to the paddy field (Figure 2). The largest number of species is represented by Araneidae (11 species) followed by Tetragnathiidae (7 species) and lowest number of species is represented by family Thomisidae(1 species), with 1518, 1139 and5 individuals collected respectively from paddy field (Figure 3).Taxonomically, the most diverse spider species *Argiopeana suja* and *Neoscona rumpfi* were represented as dominant and *Thomisus callidus* represented in lowest number in the cotton field. The most numerous individuals of *Tetragnatha elongata* represented as dominant and a smaller representative of *Thomisus* species was recorded from paddy field. The wolf spider, *Oxyopes shweta* was common in both cotton and paddy agro-ecosystems (Table 1, Plate 1& 2). According to first axis, all the spider assemblages are distributed in the main from the summer beginning to its end except in early September in the cotton field. In paddy field the spider assemblages in late June early July are more widely distributed along the second axis (Figure 4). The spiders were grouped into five different functional guilds based on their foraging mode. Orb-web builders were the dominant feeding guilds with 57.87% followed by stalkers 34.69%, foliage runners 3.1%, ambushers 2.94% and ground runners 1.12%. The dominant orb-web builders constituted 25 species. Stalkers composed of a total of 19 species belonging to the families, Salticidae and Oxyopidae (Figure 5).

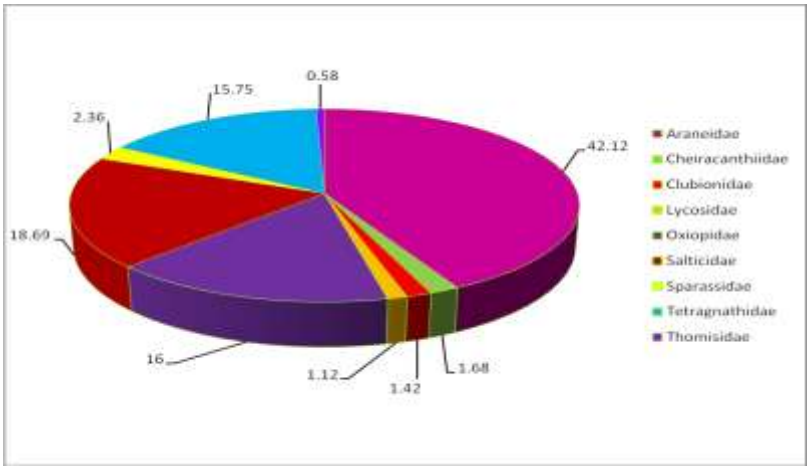
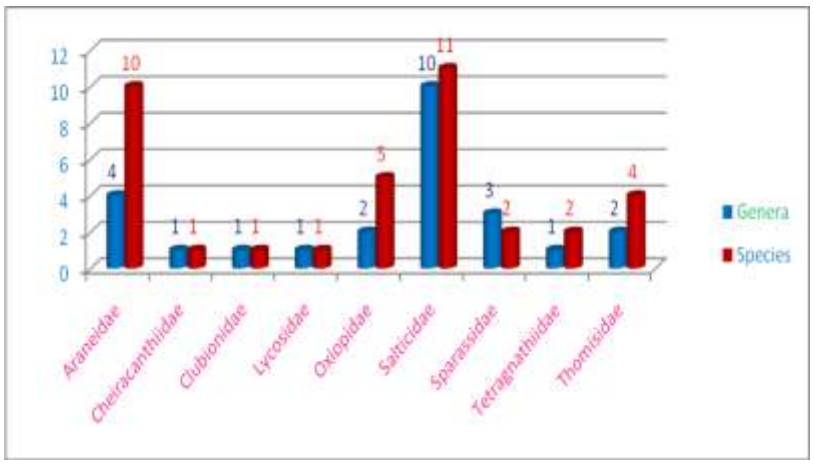


Figure 2. Family composition of spiders recorded from the cotton and paddy agroecosystems of ManamaduraiTaluk, Sivagangai district, Tamilnadu, India.

A) Spiders of cotton



B) Spiders of paddy

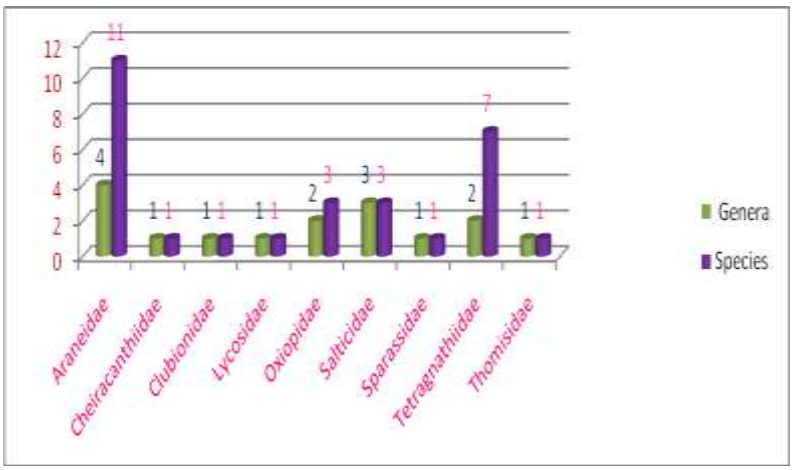


Figure 3.Species and Genera accumulation of the spiders collected from (A) Cotton (B) Paddy agroecosystems of Manamadurai Taluk, Sivagangai district, Tamilnadu, India.

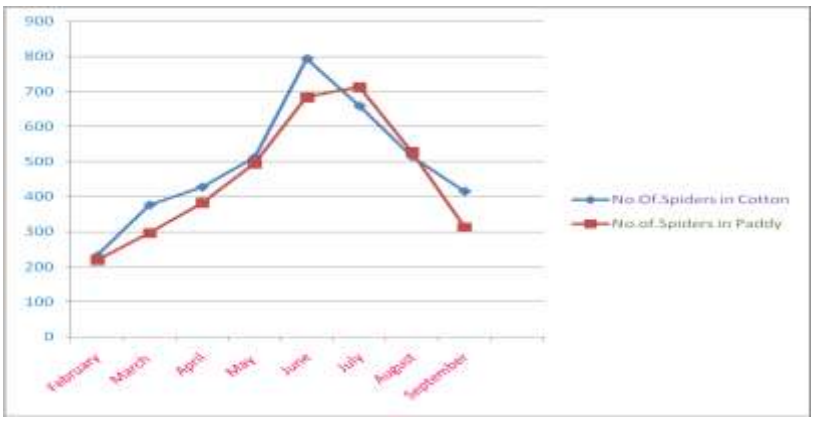


Figure 4. Seasonal abundance of spiders recorded from the cotton and paddy agro-ecosystems of Manamadurai, Taluk, Sivagangai district, Tamilnadu, India**.**

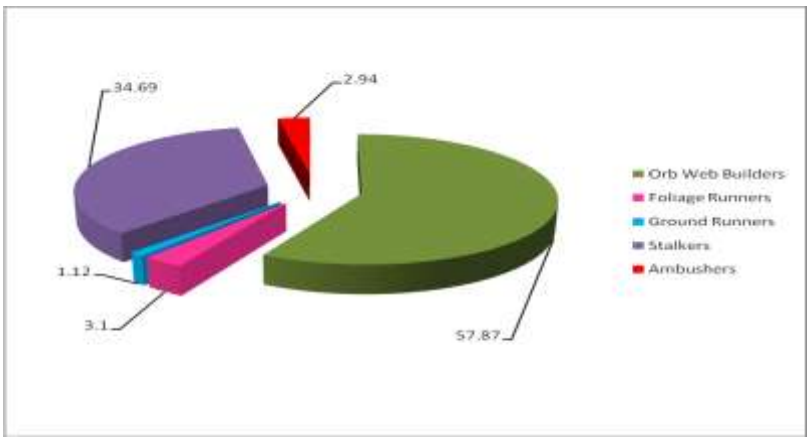


Figure 5. Guild structure of spiders collected from the cotton and paddy agro-ecosystems of Manamadurai Taluk, Sivagangai district, Tamilnadu, India

Table 2. The evenness, diversity, richness, and total abundance of the spiders collected from Cotton and Paddy ecosystems of Manamadurai, Taluk, Sivagangai district, Tamil Nadu, India.

Parameters	**Cotton**	**Paddy**
Total abundance	3926	3627
Richness Index		
Dominance_D	0.3149	0.304
Menhinick Index	0.1436	0.1494
Margalef Index	0.9667	0.9761
Diversity indices		
Simpson's Index_1-D	0.7004	0.7141
Shannon-Wiener Index_H	1.402	1.499
Evenness index		
Evenness_e^H/S	0.4514	0.4976

The Simpson index for the spider assemblages of the cotton (0.70) and paddy (0.71) are most similar. The differences in the Shannon index and evenness between the cotton and paddy crop fields were significant as well (Table 2).The available data in present study permit us to comment on the reliability of the different species of spider composition in cotton and paddy agro-ecosystems.

In the current study, a total of 55 spider species belonging to 29 genera under 9 families were recorded from the cotton and paddy agro-ecosystems of Manamadurai, Taluk, Sivagangai District, Tamil Nadu, India (Table 1). Sebastian *et al*., (2005) reported 92 spider species from the paddy agro-ecosystem in central Kerala, India, while Tahir, (2009) documented 44 spider species from rice fields in Punjab, Pakistan. Bao *et al*., (2018) recorded 61 spider species from rice crop fields and Yang *et al*., (2018) collected 375 spider species from fields. Nadeem, (2022) reported 39 spider species in cotton fields of Southern Punjab, Pakistan.

In the present study, Araneidae and Saltisidae spider families were dominated in cotton field and Araneidae and Tetragnathiidae dominanated in paddy field. (Table 1, Figure 2 & 3). Spiders of these families feed on different stages of insect pests of the cotton and paddy crop fields. The dominance of these spider families have been reported by some researchers from different crop fields in Pakistan (Nadeem *et al*., 2023).Tetragnathidae was the second most dominant in rice field (Figure 3), they uses webs to capture prays and the web is typically somewhere between vertical and horizontal (Siddhu *et al*., 2021).Members of the spider families Oxyopidae and Thomisidae were found during mid-July (Figure 4). These families are important predators of different bollworm species in cotton field and other insect pests of paddy fields. The presence of these spider families indicates that the availability of cotton bollworms in the fields (CCRI, 2020). Oxyopes species are considered as active predators among spider species in both cotton and paddy agro-ecosystems. Whitcomb, (1967) reported that spider family Oxyopidae are more active predators when compared to other arthropod predators, they preyed on more larvae of cotton bollworms also destroyed on other insect pests like leaf hoppers and plant bugs in cotton field. Van den Berg,(1989) reported that Thomisidae spider species were collected from different parts of cotton and paddy plants such as leaves, stems and under the dry leaves. Spider families such as Araneidae, Salticidae and Thomisidae were abundant and also broadly distributed in the various plantations in the Western Ghats, Wayanad(Jose *et al*., 2018; Fathima *et al*., 2021). Spider of family Salticidae are known as stalkers, they found on foliage and the ground in cotton and rice fields. Nyffeler *et al*., (1994) stated that they are act as polyphagous but can become selective numbers when prey is available in more density. Lycosidae spider species are good cursorial runners, present on various parts of plant such as leaves, flowers of cotton and rice plants, they hide under dry leaves and in crevices of the soil (Van den Berg, 1989).

Spider species were observed as the maximum numbers during the end of July in both crop fields (Figure 3). At that time, diversity and abundance of different insect pest species of cotton and paddy agro-ecosystems were maximum. The results of the present study indicate that the cotton plantations showed the highest species richness with 37 species belonging to 9 families while in paddy field 29 species and 9 families were recorded (Table 1). The statistical values of different indices about spider diversity, abundances and richness showed higher in cotton than paddy crop field (Table 2), which might result from the different set of biota and environment in the cotton and rice crop fields. Species richness and their abundance recorded in the current study indicate that the habitat structure and complexity of vegetation influenced the presence of different species of spider and also observed by Valcerde and Lobo, (2007). The habitat structure supports both the web builders and non-web builders. The two habitat crops in the observation can be classified into two habitat groups: (1) plant with many (complex) branches in cotton and less (complex) branches in paddy. The diversity of spider species was probably significantly different between cotton and paddy due to habitat complexity in the present study. The physical structure and complexity of crop plants provide good conditions for spiders to construct webs, availability of prey, shelter, microclimatic conditions such as temperature and humidity, mating and predatory activity (Warghat *et al*.,2010; Siddhu *et al*.,2021).

CONCLUSION

Spiders, being invertebrate predators are found as the predominant predators that colonies the cotton and paddy crop fields. In cotton and rice agro-ecosystem, they were found on the various parts of the plant and in ground surfaces. The spider density is high at the beginning of the summer is determined by the life cycle of the members of this group. The habitat structure and complexity differences between the study plots, along with seasonal changes, significantly affect the structure of spider composition, with the microclimatic factor having a stronger effect on their differentiation. Spiders have a wide range of prey, and they destroy different stages of the life cycle of various insect pests, such as eggs, larvae, pupae, and moth. Hence, they are considered as one of the most important biological control agents against different insect pests of the cotton and paddy agro-ecosystems. It is believed that the results of the present study may help the researchers working on predator communities in crop fields, with similar environmental conditions in different areas of the world.

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REFERENCES

Ambily, C.B., & Anju, A. (2016).Diversity and distribution of spiders in agro ecosystem of Ernakulam, District, Kerala. *The Journal of Zoology Studies*, 3(5), 73-77.

Anjali, G., Bandana, R., Rameshwor, P., & Namuna, A. (2019). Diversity and abundance of insect pest of low land rice field in Lamahi, Dang district of Nepal. *Journal of Agriculture and Natural Resources*, 2(1), 238-243.

Bao, L., Ginella, J., Cadenazzi, M., Castiglioni, E.A., Martínez, S., Casales, L., Caraballo, M.P., Laborda, Á., & Simo, M. (2018). Spider assemblages associated with different crop stages of irrigated rice agro-ecosystems from eastern Uruguay. *Biodiversity Data Journal*, 6, 1-17. https://doi.org/10.3897/BDJ.6.e24974

Barrion, A.T., & Litsinger, J.A. (1995).Riceland Spiders of South and Southeast Asia.*CAB International, Wallingford*, 1- 736.

CCRI, (2020).Central Cotton Research Institute Multan, Pakistan. http://www. ccri.gov.pk/ento.html (accessed 10.7.2021).

Fathima, P.S., Smija, M.K, Sruthi, R., Puthanpurayil, K.P., &Ambalaparambil, V.S. (2021). Spider diversity (arachnida; araneae) in different plantations of western ghats, wayanad region, india. *European Journal of Ecology*, 7(1), 80-94.

Fritz, L.L., Heinrichs, E.A, Machado, V., Andreis, T.F., Pandolfo, M., Salles, S.M., Oliveira, J.V., & Fiuza, L.M. (2011). Diversity and abundance of arthropods in subtropical rice growing areas in the Brazilian south. *Biodiversity and Conservation*, 19.DOI 10.1007/s10531-011-0083-3.

Hallmann, C.A., Zeegers, T., van Klink, R., Vermeulen, R., vanWielink, P., Spijkers, H., van Deijk, J., van Steenis, W., & Jongejans, E. (2020). Declining abundance of beetles, mothsand caddisflies in the Netherlands. *Insect Conservation Diversity*, 13 (2), 127-139.

Henaut, Y., Pablo, J., IbarraNunez, G., &Williams, T. (2001). Retention, capture and consumption of experimental prey by orb-web weaving spiders in coffee plantations of Southern Mexico. *Entomologia Experimentalis et Applicata*, 98, 1-8. https://doi.org/10.1046/j.1570- 7458.2001.00750.x.

Jose, A.C., Sudhin, P.P., Prasad, P.M., &Sreejith, K.A. (2018). Spider Diversity in Kavvayi River Basin, Kerala, Southern India. *Current World Environment*, 13,100-112. DOI:10.12944/CWE.13.1.10.

Keswani, S., Hadole, P., &Rajoria, A. (2012). Checklist of Spiders (Arachnida: Araneae) from India-2012. *Indian Journal of Arachnology*, 1(1), 129.

Mahalakshmi, R.,&Jeyaparvathi, S. (2014). Diversity of spider fauna in the cotton field of Thailakkulam, Virudhunagar district, Tamilnadu, India. *The Journal of Zoology Studies*, 1(1), 12-18.

Nadeem, A., Tahir, H.M., Khan, A.A., Hassan, Z., & Khan, A.M. (2023). Species composition and population dynamics of some arthropod pests in cotton fields of irrigated and semi-arid regions of Punjab, Pakistan. *Saudi Journal of Biological Sciences*, 30, 103521.

Nyffeler, M., Sterling, W.L, &Dean, D.A. (1994). How spiders make a living. *Environmental Entomology*, 23,1357-1367. https://doi.org/10.1093/ee/23.6.1357.

Raiz, T.N., Nagaraj, B., Shubha, S., Sreenivasa, V., &SaiSandeep, Y.(2018). Assessment of spider diversity and composition along the Tungabhadra irrigation channel at ballari, Karnataka. *International Journal on Biological Sciences*,9 (1), 36-44.

Reshma, S., & Manju, S. (2020). A preliminary checklist of spiders (Araneae: Arachnida) in Jambughoda Wildlife Sanctuary, Panchmahal District, Gujarat, India**.** *Journal of Threatened Taxa*, 12(11), 16576-16596 .

Sebastian, P.A., Mathew, M.J., Pathummal Beevi, S., Joseph, J., & Biju, C.R. (2005).The spider fauna of the irrigated rice ecosystem in central Kerala, India across different elevational ranges. *Journal of Arachnology*, 33,247–255. https://doi.org/10.1636/05-08.1.

Siddhu, J.,Lohani, H.P., Pathak, G., & Kaushal, B.R. (2021).Spider diversity in different agricultural crops in Mangoli, Nainital District, Uttarakhand, India. *Journal of Mountain Research*, 16(1), 151-159.DOI: https://doi.org/10.51220/jmr.v16i1.15

Sunderland, K. (1999). Mechanisms underlying the effects of spiders on pest populations. *Journal of Arachnology*, 27,308-316. http://www.jstor.com/stable/3706002.

Tahir, H.M. (2009). Biodiversity and predatory efficacy of spiders inhabiting the rice fields of central Punjab, Pakistan. University of the Punjab, Lahore, Pakistan.Ph.D. dissertation.

Thirukonda, R.G.,Thangavel, R., & Ponnirul, P. (2022). Diversity and abundance of spider population (Arachnida: Araneae) in some selected localities in and around Madurai city, India. *Ecology, Environment and Conservation*, 28, S231-S236.

Tikader, B.K. (1987). Handbook of spiders (Anon, Ed).*Zoological Survey of India*, Calcutta, 251.

Umesh, C., Singh, I.B., & Singh, H.M. (2018).Survey of spiders and hoppers in paddy crop under different ecosystem. *International Journal of Current Microbiology and Applied Sciences*, (7), 959-967. http://www.ijcmas.com

Valcerde, A.J., &Lobo, J.M. (2007). Threshold criteria for conversion of probability of species presence to either or presence-absence. *Acta Oecologia*, 31(3), 361-369.

Van den Berg, A.M. (1989). An investigation into the effects of two commonly used pesticides on spider mite predator populations in cotton with special reference to spiders. University of Johannesburg (South Africa). M.Sc. dissertation.

Warghat, N.E., Sarma, N.R., Chirde, S.G., & Chandrasekar, M.R. (2010).Distribution of spiders from foot hill

agricultural fields of Satpura mountain range of Amravati district, Maharashtra, India. *Bioscience Biotechnology Research Communications*, 3(2), 150-153.

Whitcomb, W.H. (1967). Field studies on predators of the second-instar bollworm, *Heliothiszea* (Boddie) (Lepidoptera: Noctuidae). *Journal of Georgia Entomological Society*, 2,113-118.

World Spider Catalog.*Natural History Museum Bern*, online at http://wsc.nmbe.ch, version 18.0.accessed on 13 July, 2017.

World Spider Catalog. *Natural History Museum Bern, online at http://wsc.nmbe.ch version 19.5 accessed on 1 May 2019.*

Yang, H., Peng, Y., Tian, J., Wang, J., Wei, B., Xie, C., &Wang, Z. (2018). Rice field spiders in China: a review of the literature. *Journal of Economic Entomology*, 111,53-64.https://doi.org/10.1093/jee/tox319.