J. Sci. Trans. Environ. Technov. 2022, 16 (1) : 33 - 39

Distribution and Diversity of Spiders in a Paddy field and in adjacent barren land in response to application of Insecticides

A. Sankari*., K. Thiyagesan and S. Pughazhendhi

Article History
Received: 12.07.2022
Revised and Accepted: 14.08.2022
Published: 10.09.2022

https://doi.org/10.56343/STET.116.016.001.007
www.stetjournals.com

Abstract

The effect of insecticide application in paddy crop (*Oryza sativa*) on spider population was evaluated by monitoring their abundance and density in a paddy field and its adjacent barren land, in Nallathukudi village located in Nagapattinam District, Tamil Nadu, from May 2014 to September 2014. Overall, 26 species of spiders belonging to nine families were recorded from both the habitats. The paddy field harbored lower number of species (n = 17) than nearby barren field (25 species). After the application of insecticide *viz.,* Profenofos (organophosphate insecticide EC. 40%) the spider density in the paddy field declined significantly while the barren field experienced significantly higher density. However, a few days after the application of insecticide, the spider density increased gradually in paddy field, indicating the in and out-word movements of spiders from crop field to barren land and back to avoid the effect of insecticide. Thus, the unmanaged barren lands in agro-ecosystem have a significant role of acting as temporary refuge for the spiders.

Keywords: Barren land, insecticide, *Oryza sativa*, paddy field,spider density.

INTRODUCTION

Spiders are geologically an old group of predators belonging to order Araneae and recognized as an effective bio-control agent of insect pests with diverse life styles and foraging. They are cosmopolitan in distribution, found in crop field, forest floor, human habitations etc. Spiders have been reported to be abundant in crop fields such as rice (Fagan *et al.,* 1998; Ghavami, 2004; Sankari and Thiyagesan, 2012a), Wheat (Sunderland, 1987; Greenstone, 2001 and Danisman *et al.,* 2007), Cotton (Ghavami, 2017; Ghavami *et al.,* 2008), Groundnut (Munyuli *et al.,* 2008) and Sunflower (Pekar, 2005). Spiders were also recorded in the surrounding landscape of agricultural fields by many research, such as a fragmented semi-desert habitat nearer to the agroecosystem (Galle and Feher, 2006; Rodrigues, *et.al*., 2009; Muff, *et.al.,* 2009; Opatovsky *et.al*., 2010), forest and grassland patches adjacent to cultivable crops (Baba *et.al.,* 2018; Saqib *et. al.,* 2020) and in the surrounding barren lands to agricultural land (Young and Lockley, 1994; Miliczky and Horton, 2005; Oberg *et al.,* 2007; Anjali and Prakash, 2012) as well. Horvath *et.al* (2002) reported that higher web building spider richness in the edge zone. Galle and Feher (2006) recorded higher ground dwelling lycosid spiders in the edge of forest.

Spider populations in crop field is known to vary with various farming practices like application of insecticide, fertilizers and weeding. Cardenas *et al.* (2006) reported that spider abundance proved significantly higher in organic regime than in conventional regime in olive trees. Indeed agricultural fields that were frequently sprayed with pesticides often had lower spider populations (Bogya and Marko, 1999; Holland *et al.,* 2000; Amalin *et al.,* 2000; 2001). According to Rodrigues *et al.* (2009) adjacent area of cultured land, having more complex vegetation structure and usually less managed, could work as refuges in the time of disturbance, forcing to disperse. Even the smallest non-crop habitat islands could be beneficial for

A. Sankari
P.G and Research Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal – 609 305, Mayiladuthurai.
email: sankarizoology@gmail.com

P-ISSN 0973-9157
E-ISSN 2393-9249

distribution of spiders in agricultural landscape (Knapp and Rezac, 2015). The present study attempts to evaluate the effect of insecticides applications on the spider population parameters in the a selected paddy field and adjacent barren land of the present study area.

MATERIALS AND METHODS

A survey was carried out to document the various species of spiders, their density and the effect of insecticide on them in a paddy field and adjacent barren land situated in the village Nallathukudi, Mayiladuthurai Taluk of Nagapattinum District, Tamil Nadu, India between May 2014 and September 2014. The sampling was carried out on 0.3 acre area for both paddy field and adjacent barren land using ten random plots, measuring 1 X 1m for each. The populations of different species of spiders were estimated by direct count method (Sebastian *et al.,* 2005). The density assessment of spider was reported as number / m^2. The effect of insecticides was assessed by comparing the density of ten selected plots, before and after the applications of insecticides *viz.,* Profenofos (organophosphate insecticide EC 40%) in both paddy field and barren land up to eight days with 24 hours interval. The same procedure was repeated thrice during the study period. Basic statistics *viz.,* arithmetic mean, and standard error were calculated for all the replicate variables and are given as $\bar{x}$ ± 1SE. Mainly parametric tests *viz.,*'t' test and One way ANOVA were used to test the hypothesis for insecticidal effects.

RESULTS AND DISCUSSION

Composition of Spiders

Twenty six species of spiders belonging to nine families were recorded. The composition of spiders in both habitats clearly differed; spiders belonging to 17 species and eight families were recorded in paddy field while 25 species and eight families were recorded in adjacent barren land (Table 1). This result was similar with the findings of Muff *et al.* (2009). They compared the distribution and diversity of spiders in five different habitats across an alpine timberline in Switzerland and they recorded spiders in different composition among the habitat studied. This result also indicated that barren land had more species than the paddy field. This finding was similar to Knapp and Rezac (2015). They reported that non-crop habitat islands situated inside arable land hosted many unique ground-dwelling spider species that were not present within the surrounding arable land. Saqib et.al., (2020) recorded the assemblage patterns of spiders in vegetable fields. The correlation results demonstrated that assemblage patterns of most spider families positively responded to the interplay between local factors and forest patches in the landscape. The spider abundance was greatest in cauliflower crops surrounded with forest and grassland patches in landscape. Baba *et.al.,* (2018) reported that the size of the forest adjacent to Japanese rice fields is an important determinant of spider guild composition and pest abundance. They recorded the abundances of ground spiders and horizontal web weavers increased with increasing forest area. Increasing forested area within 200 m had a positive effect on both Tetragnatha and lycosid had a negative influence on the abundance of brown planthopper nymphs, suggesting that the surrounding landscape indirectly influenced the pest control service mediated by spiders. The barren land of this study had a variety of grasses, weeds, *Acacia* etc., and there was no management practice during the study period. This might be due to its less disturbed nature and more heterogeneous environment it might have had higher spider richness than the paddy field.

Insecticide application and spider population variations

Among the 26 species observed only 16 species were commonly found in both habitats studied. Out of these 16 species, ten of the most predominant spider species of both habitats were taken for studying effect of Profenofos insecticide. The population densities of all the ten predominant spider species declined significantly after the application of Profenofos in the paddy field. Consecutively, the barren field experienced significantly higher density of spiders. Among the ten species of spiders, *O. javanus* and *H. agelenoides* had marked increases in the barren land (Table 2; 't' test; $p<0.05$). This result is similar to the result of Amalin *et al*. (2001).

They recorded reduced population of spiders in lime orchard in south Florida after the insecticide application. They also argued that the conventional management practices such as insecticide and herbicide application have numerous indirect effects on the spider population, which result in lesser availability of prey for spider. Rhoads and Stoddard (2021) reported that a broad-spectrum insecticide used to control mosquitoes had affected the behaviour of orb-weaving spiders. Eventhough the application did not kill the spiders, it reduced their prey capture behaviour.

Higher densities of lycosids were reported at the field's margins in other agro ecosystems as well (Alderweireldt, 1989; Holland *et al.,* 1999; Baba *et.al.,* 2018). Permanent grassy and weedy borders at field's margins were found to provide shelters and alternate food source for spiders in frequently disturbed habitats such as conventional agricultural fields by Oberg (2007). Thus the higher density of spider in barren land after the application of insecticide in the paddy field suggests that the barren land is an important alternative habitat for spiders at the time of unfavorable conditions in the paddy field.

The diversity of selected spider species in paddy field declined significantly within the second day after application of insecticides and a concurrent increase on the adjacent barren land (Table 3; ANOVA; $p < 0.05$). In barren land, the population of spiders increased significantly after the second to third day of the insecticide application in the paddy field (Table 4; ANOVA; $p < 0.05$). Whitmore *et al.* (2002) stated that increasing disturbance level leads to decreasing spider richness and density. According to Clausen (1990) disturbance created by herbicides can decrease the population size for more than a month after application. Another interesting result was that the spider density increased gradually after fourth day of spray of insecticide in the paddy field. This result was similar to the earlier report of Sankari and Thiyagesan (2012b), where the population of spiders regained after 72 hours of spray of insecticide and reached the level of pre-treatment counts in a brinjal field. Oberg *et al.* (2007) stated that nearby perennial habitats, such as boundaries, are structurally and vegetationally more diverse, which can lead to more spider species in crop fields. Other studies also found that species richness of spiders increased with proportion of non-crop in the surrounding landscape (Schmidt *et.al.*, 2005). Ostman *et al.* (2001) showed that a high proportion of non-crop habitats were positively related to the strength of predator impact on aphid. The present study has also clearly shown that the in and out-word movements of spiders from crop field to barren land and back to avoid the effect of insecticide after the post treatment period. Thus, the unmanaged barren lands in agro-ecosystem are acting as temporary refuge for the spiders and play a significant role in spider is viable population densityand diversity.

Table 1. Occurrence of Spider species in Paddy Field and adjacent Barren Land of the present study area during the Study Period

S. No	Family	Name of the spider	Paddy field	Barren land
1	*Araneidae*	*Argiope catenulate*	✓	✓
		Araneus inustus	✓	✓
		Argiope anasuja	x	✓
		Larinia phthisica	✓	✓
		Neoscona theisi	✓	✓
		Cyclosa turbinate	x	✓
		Cyrtophora cicatrosa	x	✓
		Gasteracntha germinata	x	✓
2	*Tetragnathidae*	*Tetragnatha javana*	✓	✓
		Tetragnatha cochinensis	✓	✓
		Tetragnatha mandibulata	✓	✓
3	*Oxyopidae*	*Oxyopes javanus*	✓	✓
		oxyopes lineatipes	✓	✓
		Oxyopes birmanicus	✓	✓
4	*Lycosidae*	*Pardosa pseudoannulata*	✓	✓
		Pardosa sumatrana	✓	✓
		Hippasa agelenoides	✓	✓
5	*Salticidae*	*Plexippus paykulli*	x	✓
		Hyllus semicupreus	x	✓
		Rhene flavigera	x	✓
		Hyllus maskaranus	x	✓
6	*Clubionidae*	*Clubiona drassodes*	✓	✓
7	*Tomisidae*	*Thomisus pugilis*	x	✓
		Thomisus sp	✓	✓
8	*Philodromidae*	*Thanatus parangvulgaris*	✓	✓
9	*Pisauridae*	*Thalassius albocinctus*	✓	X

✓- indicates the presence of spiders; x- indicates absence of spiders

Table 2. Densities of Selected Spider species in before and after application of Insecticide in the paddy field and adjacent barren land (Mean ± S.E; 't' test)

Species	Paddy field (n=3)				Barren land (n=3)			
	Before Insecticide	After Insecticide	t	P	Before Insecticide	After Insecticide	t	p
A.catenulata	0.93 ± 0.14	0.69 ± 0.08	1.460	0.002*	0.31±0.04	0.39±0.06	0.999	0.023*
A.inustus	0.68 ± 0.07	0.55 ± 0.07	1.150	0.000***	0.12±0.02	0.36±0.06	3.683	0.000***
T. javana	1.20 ± 0.08	0.69 ± 0.07	4.543	0.000***	0.21±0.03	0.34±0.06	1.668	0.000***
T.cochinensis	0.92 ± 0.06	0.51 ± 0.07	4.241	0.019*	0.13±0.03	0.41±0.06	3.765	0.000***
T.mandibulata	0.66 ± 0.06	0.29 ± 0.05	4.430	0.000***	0.14±0.03	0.36±0.06	3.202	0.000***
O. javanus	0.97 ± 0.09	0.56 ± 0.08	3.265	0.000***	0.32±0.04	1.06±0.09	6.927	0.000***
O. lineatipes	0.47 ± 0.05	0.40 ± 0.05	0.920	0.004*	0.23±0.04	0.80±0.08	5.891	0.000***
P.pseudoannulata	1.44 ± 0.11	1.20 ± 0.11	1.426	0.061*	0.76±0.65	0.92±0.09	1.454	0.013**
P.sumatrana	0.62 ± 0.06	0.46 ± 0.05	1.873	0.000***	0.34±0.05	0.97±0.08	6.044	0.000***
H.agelenoides	0.45 ± 0.06	0.05 ± 0.01	6.280	0.000***	0.55±0.06	1.25±0.11	5.469	0.000***

***-p < 0.05; **-p <0.01; ***-p<0.001**

Table: 3 Densities of Selected Spider species during different days after application of insecticide in the paddy field (Mean ± S.E; ANOVA)

Spider species	Before application of Insecticide (n=3)	Days After application of Insecticide								ANOVA	
		Day-1 (n=3)	Day-2 (n=3)	Day- 3 (n=3)	Day-4 (n=3)	Day-5 (n=3)	Day-6 (n=3)	Day-7 (n=3)	Day-8 (n=3)	F	p
A.catenulata	0.93±0.14	0.20±0.11	0.10±0.06	0.20±0.09	0.00±0.00	1.40±0.30	1.80±0.20	2.00±0.00	2.10±0.27	4.169	0.000***
A.inustus	0.68±0.07	0.05±0.05	0.00±0.00	0.50±0.11	0.70±0.10	0.80±0.24	0.50±0.26	0.60±0.26	2.30±0.39	6.423	0.000***
T. javana	1.20±0.08	0.45±0.15	0.20±0.09	0.45±0.13	0.90±0.12	1.10±0.31	1.20±0.41	1.10±0.10	0.90±0.27	3.782	0.000***
T.cochinensis	0.92±0.06	0.25±0.09	0.10±0.06	0.10±0.06	0.70±0.20	1.60±0.30	1.00±0.25	0.90±0.27	0.40±0.22	7.034	0.000***
T.mandibulata	0.66±0.06	0.10±0.06	0.05±0.05	0.20±0.09	1.15±0.19	0.00±0.00	0.10±0.10	1.10±0.10	0.30±0.15	6.146	0.000***
O. javanus	0.97±0.09	0.00±0.00	0.00±0.00	0.35±0.13	1.65±0.34	0.60±0.16	0.70±0.15	1.00±0.00	0.50±0.16	5.228	0.000***
O.lineatipes	0.47±0.05	0.00±0.00	0.10±0.06	0.45±0.11	0.65±0.10	0.00±0.00	0.70±0.15	0.70±0.21	1.10±0.34	4.270	0.000***
P.pseudoannulata	1.44±0.11	0.70±0.23	0.70±0.17	0.65±0.15	0.95±0.15	1.10±0.31	3.00±0.44	1.20±0.44	3.20±0.24	6.466	0.000***
P.sumatrana	0.62±0.06	0.45±0.16	0.35±0.13	0.25±0.12	0.50±0.68	0.40±0.16	0.90±0.10	0.50±0.16	0.70±0.15	1.104	0.360
H.agelenoides	0.45±0.06	0.15±0.08	0.10±0.06	0.05±0.05	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	3.337	0.001***

***-p < 0.05; **-p <0.01; ***-p<0.001**

Table.4. Densities of Selected Spider species in the barren land during different days after application of insecticide in the adjacent paddy field (Mean ± S.E; ANOVA)

Spider species	Before application of Insecticide (n=3)	Days after application of Insecticide								ANOVA	
		Day-1 (n=3)	Day-2 (n=3)	Day- 3 (n=3)	Day-4 (n=3)	Day-5 (n=3)	Day-6 (n=3)	Day-7 (n=3)	Day-8 (n=3)	F	p
A.catenulata	0.31±0.04	0.60±0.21	0.45±0.18	0.20±0.13	0.45±0.18	0.20±0.20	0.10±0.10	0.40±0.22	0.60±0.16	1.073	0.382
A.inustus	0.12±0.02	0.25±0.09	0.65±0.19	0.80±0.20	0.25±0.14	0.20±0.13	0.00±0.00	0.00±0.00	0.30±0.15	7.264	0.000***
T. javana	0.21±0.03	0.65±0.19	0.55±0.19	0.30±0.14	0.30±0.16	0.20±0.13	0.00±0.00	0.00±0.00	0.30±0.21	2.248	0.024*
T.cochinensis	0.13±0.03	0.50±0.13	0.80±0.20	0.70±0.20	0.50±0.19	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	7.507	0.000***
T.mandibulata	0.14±0.03	0.50±0.18	0.80±0.20	0.70±0.16	0.20±0.09	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	7.263	0.000***
O. javanus	0.32±0.04	1.45±0.19	1.80±0.21	1.70±0.24	0.95±0.22	0.30±0.15	0.30±0.21	0.10±0.10	0.30±0.15	20.134	0.000***
O.lineatipes	0.23±0.04	0.85±0.22	1.45±0.18	1.20±0.21	0.65±0.20	0.80±0.32	0.30±0.21	0.10±0.10	0.10±0.10	12.049	0.000***
P.pseudoannulata	0.76±0.06	1.50±0.21	1.35±0.20	1.00±0.24	0.55±0.15	0.60±0.40	0.60±0.26	0.30±0.21	0.80±0.29	3.207	0.002*
P.sumatrana	0.34±0.05	1.45±0.184	1.60±0.18	1.35±0.23	1.05±0.22	0.40±0.16	0.00±0.00	0.20±0.20	0.20±0.20	14.566	0.000***
H.agelenoides	0.55±0.06	1.00±0.21	1.10±0.27	1.65±0.31	0.90±0.26	2.40±0.22	1.70±0.39	1.40±0.30	0.20±0.20	9.171	0.000***

***-p < 0.05; **-p <0.01; ***-p<0.001**

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