

Seasonal Diversity and Status of Spiders (Arachnida: Araneae) in Cashew Ecosystem

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Abstract: Spiders are recorded as indigenous natural enemies of tea mosquito bug (*Helopeltis* spp.), which is one of the major economically important pests of cashew. Consecutive survey for three years revealed occurrence of 117 species of spiders belonging to 18 families viz., Araneidae, Clubionidae, Corinnidae, Gnaphosidae, Hersiliidae, Linyphiidae, Lycosidae, Miturgidae, Nephilidae, Oxyopidae, Pholcidae, Pisauridae, Salticidae, Sparassidae, Tetragnathidae, Theridiidae, Thomisidae and Uloboridae. Of these, 30 species were classified as very common, 26 species common, 34 species rare and 27 species very rare. Salticids were predominant (30 %) and Araneidae contributed 22 % of the spider fauna. Shannon index, Simpson index, Evenness index and Margalef Richness index evaluated were 4.20, 0.04, 0.50 and 14.73, respectively. Spiders belonged to 7 feeding guilds and population was higher during winter and monsoon season. The present investigation will form baseline for the new approaches in IPM strategies of cashew.

Key words: Cashew • Spiders • Diversity • Seasonality • Biological Control

INTRODUCTION

Several insect pests have been recorded on cashew (*Anacardium occidentale* L.) in India prominent among which is the tea mosquito bug (TMB), *Helopeltis* spp. (Hemiptera: Miridae). Spiders are recorded as the most promising potential predators of this pest [1].

At present, chemical control measures are recommended for management of *Helopeltis* spp. on cashew [2]. Since, there is potential restriction in USA and EEC countries in importation of cashew kernels containing pesticides residues, developing integrated pest management with main emphasis on non- insecticidal control methods viz., biological control is required [3]. A better understanding of spider guilds, their composition and factors influencing spider community structure is very much essential for Integrated Pest Management (IPM) strategy [4].

Currently 39,882 valid described species of spiders in 3676 genera and 108 families have been described globally [5]. The spider fauna of India is represented by 1520 spider species belonging to 377 genera and 60 families [6].

The spider fauna of the rice fields in India has been studied by many authors [7, 8, 9]. However, the study on diversity of spiders in plantation crops like cashew is

meager. Earlier, 6 species [1] and 35 species [10] of spiders were reported on cashew. There is no comprehensive study on the seasonal variation and distribution of spiders.

Considering the importance of spiders, for development of future IPM strategy, the present study aimed to improve the understanding of spider diversity their status and seasonal variations in the cashew ecosystem.

MATERIALS AND METHODS

The present study was carried out at cashew plantations of Directorate of Cashew Research, Puttur and Experimental Station, Shanthigodu, consisting of 148 ha (12.45°N latitude, 75.4°E longitude) in the Karnataka state of Southern India. The altitude is 90 m above Mean Sea level. The temperature in the area varied from 16.0°C to 38.0°C. The region receives an annual rainfall of 429.6 mm to 1827.9 mm during the southwest monsoon between June and September. The relative humidity varied from 43 to 98%.

Field observations were made for consecutive three years from November 2009 to October 2012. Spiders were collected by hand-picking method. Collections were made

from foliage and tree-trunk of cashew trees. The collected spiders were preserved in 70 % alcohol solution in glass vials labeled with date of collection in the field and counted under a zoom stereomicroscope (Leica) in the laboratory. The collected spiders were grouped into four categories *i.e.* very common (spiders found in ≥ 35 collections), common ($15 \leq 35$ collections), rare ($5 \leq 15$ collections) and very rare (≤ 5 collections). The seasonality in occurrence of spiders and their predatory behavior on *Helopeltis* spp. were also recorded.

Voucher specimens were preserved in 70 % alcohol were identified and deposited in a reference collection housed with the Arachnology Division, Department of Zoology, Sacred Heart College, Cochin, Kerala, India.

The diversity of spiders were analyzed by widely used indices *viz.*, the Shannon-Wiener index (H'), which is sensitive to changes in the abundance of rare species in a community and the Simpson index (λ), which is sensitive to changes in the most abundant species in a community, Margalef Richness index (R) and Evenness index (E) of spider communities were calculated using the SPDIVERS.BAS program [11].

Shannon-Wiener index is defined as:

$$H' = -\sum_i \log p_i$$

where:

p_i = The observed relative abundance of a particular species [12]

Simpson index is defined as:

$$\lambda = \sum n_i (n_i - 1) / [N(N-1)]$$

where:

n_i = The number of individuals of species i and $N = \sum n_i$

Margalef richness index is defined as:

$$R = S-1/\ln(n)$$

where:

S = Total number of species in a community and

n = Total number of individuals observed.

Evenness index is defined as:

$$E = \ln(NI)/\ln(N0)$$

where:

NI = Number of abundant species in the sample and

$N0$ = Number of all species in the sample.

Feeding guild classification was done following [13].

RESULTS

A total of 2629 individuals belonging to 117 species 63 genera and 18 families were collected during the study (Table 1). The families: Araneidae (26 species), Clubionidae (2 species), Corinnidae (1 species), Gnaphosidae (4 species), Herisilidae (1 species), Linyphiidae (1 species), Lycosidae (1 species), Miturgidae (1 species), Nephilidae (4 species), Oxyopidae (6 species), Pholcidae (2 species), Pisauridae (2 species), Salticidae (35 species), Sparassidae (2 species), Tetragnathidae (6 species), Theridiidae (11 species), Thomisidae (10 species) and Uloboridae (1 species) were recorded. Of these, 30 species were classified as very common, 26 species common, 34 species rare and 27 species very rare (Table 2).

Salticidae was the most predominant spider family, forming 29.91% of the whole collection. It was followed by Araneidae (22.22%), Theridiidae (9.40%), Thomisidae (8.55%), Oxyopidae (5.13%) and Tetragnathidae (5.13%), Gnaphosidae (3.42%) and Nephilidae (3.42%) and Sparassidae (2.56%). Families *viz.*, Clubionidae, Corinnidae, Herisilidae, Lycosidae, Linyphiidae, Miturgidae, Pholcidae, Pisauridae, Uloboridae contributed below 2 % (Fig. 1).

The spiders sampled belonged to 7 functional groups (guilds) based on their foraging behaviour in the field. Stalkers (35 %) and orb weavers (32%) were the dominant groups, subsequently space builders (11%), ambushers (10%), foliage runners (6%), ground runners (5%) and sheet webs (1%) (Fig. 2).

Spiders exhibited seasonal variation in their occurrence. A total of 95 species were recorded during Monsoon season (June, July, August, September and October); 46 species during winter (November, December, January, February); 34 species during summer (March, April, May) and 12 species were recorded throughout the year (Table 3).

Field observation revealed *Telamonia dimidiata* and *Oxyopes shweta* were the major predators of *Helopeltis* spp. The spiders *viz.*, *Argiope pulchella*, *Cyclosa fissa*, *Eriovixia laglazei*, *Neoscona mukerjeri*, *Nephila pilipes*, *Oxyopes sunandae*, *Bavia kairali*,

Table 1: List of spiders collected from cashew ecosystem with common name, occurrence and status

Sl.No.	FamilyScientific name	Common name	No. of individuals	Season	General abundance
Suborder: Araenomorphae					
I	Araneidae (Orb- Web spiders)				
1	<i>Arachnura</i> sp.		3	M	VR
2	<i>Arachnura</i> sp.		2	M	R
3	<i>Arachnura angura</i> Tikader*	Scorpion - tailed spider	7	S	R
4	<i>Araneus bilunifer</i> Pocock*	Orb-weaver	2	S,M	VR
5	<i>Araneus bituberculatus</i> Simon	Orb-weaver	17	M	C
6	<i>Araneus mitificus</i> Simon	Kidney garden	6	M	R
7	<i>Araneus nympha</i> Simon	#	2	M	VR
8	<i>Argiope pulchella</i> Thorell	Garden cross spider	38	W,S,M	VC
9	<i>Argiope</i> sp.	Garden cross spider	6	S,M	R
10	<i>Cyclosa fissicauda</i> Simon	#	62	M	VC
11	<i>Cyrtarachne keralaensis</i> Thorell*	Grass jewel spider	50	S,M	VC
12	<i>Cyrtarachne raniceps</i> Pocock	Grass jewel spider	8	S,M	R
13	<i>Cyrtarachne</i> sp.	Grass jewel spider	41	M	VC
14	<i>Cyrtarachne</i> sp.	Grass jewel spider	8	S	R
15	<i>Cyrtophora citricola</i> Forsskal	Jungle tent web spider	6	W,M	R
16	<i>Cyrtophora</i> sp.		7	M	R
17	<i>Cyrtophora unicolor</i> Doleschall	Garden tent web spider	29	W,M	C
18	<i>Eriovixia laglazei</i> Simon	Grey bird dropping spider	64	M	VC
19	<i>Gasteracantha geminate</i> Fabricius	Garden spiny spider	32	M,W	C
20	<i>Neoscona mukerjeri</i> Tikader*	Common garden spider	74	W,S	VC
21	<i>Neoscona poonaensis</i> Tikader	#	71	W	VC
22	<i>Neoscona pavidia</i> Simon	#	7	W,M	R
23	<i>Neoscona</i> sp.		17	W,M	C
24	<i>Neoscona</i> sp.		6	S	R
25	<i>Parawixia dehani</i> Doleschall	Abandoned web spider	16	M	C
26	<i>Thelecantha brevispina</i> Doleschall	False gasteracantha	2	W	VR
II	Clubionidae (Sac spiders)				
27	<i>Clubiona</i> sp.	Patchy sac spider	1	W	VR
28	<i>Matidia</i> sp.		2	W	VR
III	Corinnidae (Ant mimicking sac spiders)				
29	<i>Castianeira zetes</i> Simon	Black-ant mimicking spider	4	M	VR
IV	Gnaphosidae (Mouse spiders)				
30	<i>Drassodes</i> sp.		1	M	VR
31	<i>Poecilochroa barmani</i> Tikader*		3	M	VR
32	<i>Poecilochroa</i> sp.		6	M	R
33	<i>Scotophaeus</i> sp.		6	S	R
V	Hersiliidae (Two- tailed spiders or bark spiders)				
34	<i>Hersilia savignyi</i> Lucas	Two tailed spider	15	S,W	C
VI	Linyphiidae (Sheet web spiders)				
35	<i>Lynyphia striata</i> sp.nov.	Stripped linyphid spider	42	M,W	VC
VII	Lycosidae (Wolf spiders)				
36	<i>Hippasa</i> sp.		45	W	VC
VIII	Miturgidae (Dark- sac spiders)				
37	<i>Cheiracanthium melanostomum</i> Thorell	Yellow sac spider	15	M,W	C
IX	Nephilidae (Long legged-orb weavers)				
38	<i>Nephila</i> sp.		16	M	C
39	<i>Nephila pilipes</i> Simon	Giant wood spider	29	M,W	C
40	<i>Herennia multipuncta</i> Doleschall	Ornamental tree trunk spider	1	M,W	VR
41	<i>Herennia</i> sp.	Ornamental tree trunk spider	1	M	VR
X	Oxyopidae (Lynx spiders)				
42	<i>Oxyopes birmanicus</i> Thorell*	Crossed lynx spider	6	W,S	R
43	<i>Oxyopes shweta</i> Tikader	White lynx spider	68	W,S,M	VC
44	<i>Oxyopes</i> sp.		39	W	VC

Table 1: Continued

45	<i>Oxyopes</i> sp.		37	M,W	VC
46	<i>Oxyopes sunandae</i> Tikader*	Orange lynx spider	35	W,S,M	VC
47	<i>Peucetia viridana</i> Stoliczka	Green lynx spider	6	S	R
XI	Pholcidae (Daddy-long-leg spiders)				
48	<i>Pholcus</i> sp.	Long- bodied cellar spider	2	M	VR
49	<i>Uthinia atrigularis</i> Simon	Leaf-dwelling pholcid	9	M,W	R
XII	Pisauridae (Nursery web spiders)				
50	<i>Pisaura gitae</i> Tikader*	Common nursery web spider	16	S, M	C
51	<i>Perenethis venusta</i> L. Koch	Single stripped grass spider	1	W	VR
XIII	Salticidae (Jumping spiders)				
52	<i>Asemonea tenuipes</i> O. P Cambridge	Tailed jumper	36	M,S	VC
53	<i>Bavia kairali</i> sp.nov	Scorpion jumper	13	W,M	R
54	<i>Brettus albolimbatus</i> Simon	Crescented jumper	7	M	R
55	<i>Brettus</i> sp.		6	M	R
56	<i>Carrhotus</i> sp.		22	M	C
57	<i>Carrhotus viduus</i> CL Koch	Black and white jumper	29	M	C
58	<i>Epeus</i> sp.		38	W,S,M	VC
59	<i>Epeus indicus</i> Proszynski*	White spotted green jumper	37	W,S,M	VC
60	<i>Epeus tender</i> Simon	Orange crested jumper	2	M	VR
61	<i>Epocilla aurantiaca</i> Simon	Jolly epocilla	7	S,M	R
62	<i>Hasarius adansoni</i> Audouin	Adanson's house jumper	36	S	VC
63	<i>Hasarius</i> sp.		35	S	VC
64	<i>Hyllus semicupreus</i> Simon	Heavy-bodied jumper	64	W,S,M	VC
65	<i>Menemerus</i> sp.	Common wall jumper	16	M	C
66	<i>Myrmarachne orientalis</i> O. P Cambridge	Brown ant-mimic	34	M	C
67	<i>Myrmarachne plataleoides</i> Tikader	Red ant-mimic	63	S,M	VC
68	<i>Myrmarachne ramunni</i> Narayan*	#	11	M	R
69	<i>Myrmarachne</i> sp.		8	M	R
70	<i>Myrmarachne</i> sp.		6	M	R
71	<i>Myrmarachne</i> sp.		17	M	C
72	<i>Myrmarachne</i> sp.		16	M	C
73	<i>Myrmarachne</i> sp.		8	M	R
74	<i>Myrmarachne</i> sp.		3	M	VR
75	<i>Myrmarachne</i> sp.		19	M,W	C
76	<i>Myrmarachne</i> sp.		6	M	R
77	<i>Myrmarachne</i> sp.		3	M,W	VR
78	<i>Myrmarachne</i> sp.		2	M	VR
79	<i>Phintella vittata</i> C. L. Koch	Banded phintella	196	W,S,M	VC
80	<i>Plexippus paykulli</i> Audouin	Small zebra jumper	53	W,S,M	VC
81	<i>Plexippus petersi</i> Karsch	Small zebra jumper	55	W,S,M	VC
82	<i>Plexippus</i> sp.		43	S,M	VC
83	<i>Rhene rubigera</i> Thorell	#	2	M	VR
84	<i>Siler semiglaucus</i> Simon	Metallic jumper	11	M	R
85	<i>Telamonia dimidiata</i> Simon	Two-stripped jumper	117	W,S,M	VC
86	<i>Thiania bhamoensis</i> Thorell	Metallic blue jumper	2	M	VR
XIV	Sparassidae (Giant crab spiders)				
87	<i>Heteropoda</i> sp.	Common house spider	43	W,S,M	VC
88	<i>Olios</i> sp.	Green crab spider	21	M	C
89	<i>Olios</i> sp.		35	M	VC
XV	Tetragnathidae (Long - jawed spiders)				
90	<i>Leucauge decorate</i> Blackwall	Three-humped leucauge spider	7	W	R
91	<i>Leucauge</i> sp.		2	M	VR
92	<i>Leucauge pondae</i> Tikader*	Pond leucauge spider	2	M	VR
93	<i>Opadometa fastigata</i> Simon	Humped silver spider	1	W,S,M	VR
94	<i>Tetragnatha fletcheri</i> Gravely*	#	33	M	C
95	<i>Tetragnatha viridorufa</i> Gravely*	Green tetragnathid spider	37	M	VC

Table 1: Continued

XVI	Theridiidae (Comb-footed spiders)				
96	<i>Achaearanea tepidariorum</i> C.L. Koch	Wall corner spider	37	W,M	VC
97	<i>Achaearanea mundula</i> L. Koch	Rolled leaf spider	53	M	VC
98	<i>Argyrodes ambalikai</i> Tikader*	#	1	W,M	VR
99	<i>Argyrodes argentatus</i> OP Cambridge	Quick-silver spider	16	M	C
100	<i>Argyrodes gazedes</i> Tikader*	Parasitic comb-footed spider	2	W,M	VR
101	<i>Argyrodes</i> sp.		6	W,M	R
102	<i>Ariamnes flagellum</i> Doleschall	Whip spider	2	M	VR
103	<i>Chrysso argyrodiformis</i> Yaginuma	Brush- legged spider	27	M	C
104	<i>Chrysso nigra</i> OP Cambridge	Black pearl spider	5	M	R
105	<i>Chrysso</i> sp.		5	M	R
106	<i>Theridion</i> sp.		15	M,W	C
XVII	Thomisidae (Crab spiders)				
107	<i>Amyciaea forticeps</i> O P Cambridge	Red ant spider	5	W,M	R
108	<i>Camariacus formosus</i> Thorell	Brown flower spider	58	S,M	VC
109	<i>Camariacus</i> sp.		16	S,M	C
110	<i>Loxobates</i> sp.		5		R
111	<i>Oxytate virens</i> Thorell	Green crab spider	35	S,M	VC
112	<i>Strigoplus netravati</i> Tikader*	Grass crab spider	41	W	VC
113	<i>Thomisus lobosus</i> Tikader*	White crab spider	79	W,S,M	VC
114	<i>Thomisus pugilis</i> Stoliczka*	Common rose spider	2	W	VR
115	<i>Xysticus minutes</i> Tikader*	Brown crab spider	21	S,M	C
116	<i>Xysticus</i> sp.		4	M	VR
XVIII	Uloboridae (Hackled web spiders)				
117	<i>Miagrammopes extensus</i> Simon	Twig spider	1	M	VR

VC-Very common, C-Common, R-Rare, VR-Very rare.

W-Winter (November, December, January, February) S-Summer (March, April, May),

M-Monsoon (June, July, August, September, October).

*Indicates endemic to India

Common name not available

Table 2: Genera and species distribution of spiders in cashew ecosystem

Family	Guild	Genera	Species	No. of individuals	Status			
					VC	C	R	VR
Araneidae	Orb weavers	11	26	583	7	5	10	4
Clubionidae	Foliage runners	2	2	3	0	0	0	2
Corinnidae	Ground runners	1	1	4	0	0	0	1
Gnaphosidae	Ground runners	3	4	16	0	0	2	2
Herilidae	Foliage runners	1	1	15	0	1	0	0
Linyphiidae	Sheet webs	1	1	42	1	0	0	0
Lycosidae	Ground runners	1	1	45	0	1	0	0
Miturgidae	Foliage runners	1	1	15	0	1	0	0
Nephilidae	Orb weavers	2	4	47	0	2	0	2
Oxyopidae	Stalkers	2	6	191	4	0	2	0
Pholcidae	Space builders	2	2	11	0	0	1	1
Pisauridae	Ambushers	2	2	17	0	1	0	1
Salticidae	Stalkers	16	35	1023	12	7	10	6
Sparassidae	Foliage runners	2	3	99	2	1	0	0
Tetragnathidae	Orb weavers	3	6	82	1	1	1	3
Theridiidae	Space builders	5	11	169	2	3	3	3
Thomisidae	Ambushers	7	10	266	4	2	2	2
Uloboridae	Orb weavers	1	1	1	0	0	0	1
Total		63	117	2629	30	26	34	27

Table 3: Seasonal occurrence of spiders in cashew ecosystem

Season	No. of spider species
Winter (November, December, January, February)	46
Summer (March, April, May),	34
Monsoon (June, July, August, September, October).	95
Throughout the year	12

Table 4: Diversity indices of spiders in cashew ecosystem

Diversity indices	Cashew
Shannon index H	4.20
Simpson index λ	0.04
Evenness index E	0.50
Margalef Richness Index R	14.73

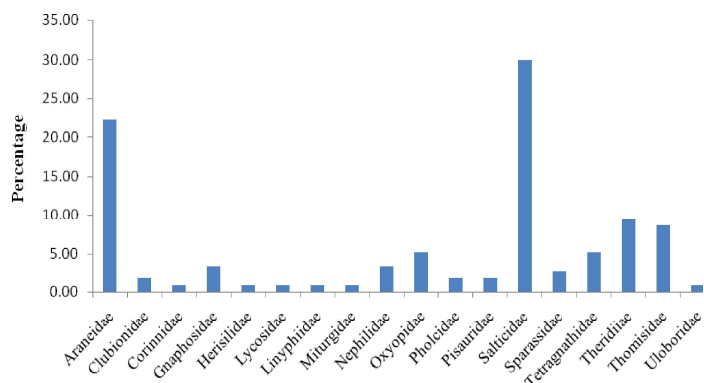


Fig. 1: Per cent distribution of spider families in cashew ecosystem

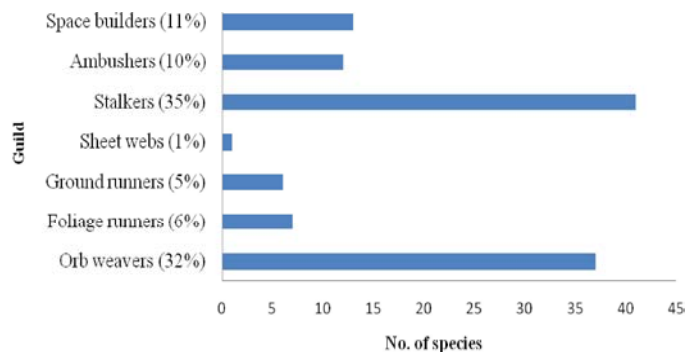


Fig. 2: Guild wise distribution of species of spiders in cashew ecosystem

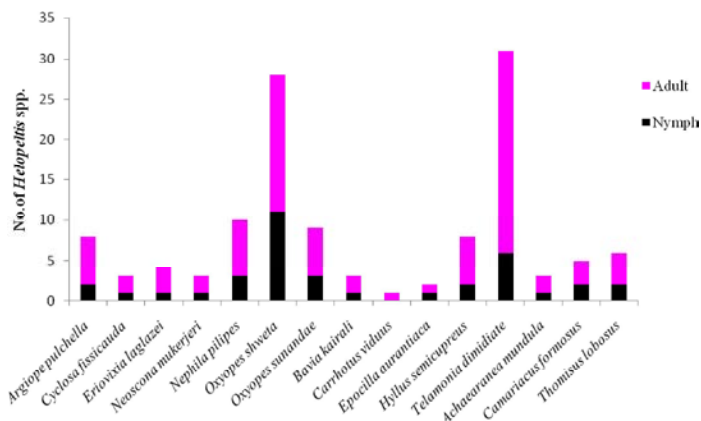


Fig. 3: Spiders recorded predating on *Helopeltis* spp.

Carrhotus viduus, *Epocilla aurantiaca*, *Hyllus semicupreus*, *Achaearanea mundula*, *Camariacus formosus* and *Thomisus lobosus* were also recorded as superior predators of *Helopeltis* spp. (Fig. 3).

The Shannon index, Simpson index Evenness index and Margalef Richness index evaluated were 4.20, 0.04, 0.50 and 14.73, respectively (Table 4).

DISCUSSION

Thirty five species of spiders were recorded in cashew agro-ecosystem [10]. However, during the present spider survey, it is found that 117 species spiders exist in cashew with 63 genera and 18 families. Seasonality study revealed maximum spider population during winter and monsoon period indicating their life cycle coinciding with that of prey population. The peak population density of spiders coincides with an increase of insect pests [14]. Hsieh and Dyck [15] noted the reduction of green leafhoppers population in paddy fields during the predation by spiders. An increase in the spider population depends on prey availability and, if the density of prey becomes higher, spiders are expected to increase proportionally to some extent.

A total of 1053 endemic species of spiders are reported from India so far [16]. Among the collection, 19 species are found to be endemic to India (Table 1).

A diversity index incorporates both species richness and evenness in a single value [17]. The diversity indices used here are Shannon-Wiener index (H'), which is sensitive to changes in the abundance of rare species in a community and Simpson index (λ), which is sensitive to changes in the most abundant species in a community. Species richness (R) examines the number of species occurring in a habitat and when all species in a sample are equally abundant an evenness index (E) will be at its maximum.

Present research has paid more attention to incorporate the requirements of the vast fauna of spiders, into cashew management strategies. This rich diversity of spiders is also indicative of the overall biodiversity of cashew plantations since spiders are considered to be useful indicators of the species richness and health of terrestrial ecosystems and amply emphasizes the need for preserving cashew patch intact from a biodiversity conservation perspective [18]. With an inventory of three years, 117 spider species could be recorded, which is comparatively high. This indicates that the spider diversity in cashew needs further long term detailed studies using additional methodologies. As spiders are

the major group of natural enemies, the present work will form the baseline for the new approaches of Integrated Pest Management strategies of cashew.

ACKNOWLEDGEMENTS

Our thanks are due to Dr.P.A.Sebastian, Sacred Heart College, Thevara, Cochin, for identification of spiders. Financial support received for the Out Reach Programme on Management of Sucking Pests of Horticultural Crops, from the Indian Council for Agricultural Research (ICAR), New Delhi is gratefully acknowledged. We are also indebted to the Director, Directorate of Cashew Research, Puttur for providing necessary facilities.

REFERENCES

1. Sundararaju, D., 2003. Record and cumulative effect of recommended insecticidal spray schedule on arthropod predatory fauna occurring on cashew. *The Cashew*, 17(1): 30-33.
2. Sundararaju, D., N. Bakthavatsalam and P.S. Bhat, 1993. Ovicidal activity and residual toxicity of certain insecticides of tea mosquito bug *Helopeltis antonii* Sign. (Heteroptera: Miridae) infesting cashew. *Pestology*, 17: 14-17.
3. Stonedahl, G.M., 1991. The Oriental species of *Helopeltis* (Heteroptera: Miridae): a review of economic literature and guide to identification. *Bull. Entomol. Res.*, 81: 465-490.
4. Riechert, S.E. and T. Lockley, 1984. Spiders as biological control agents. *Annu. Rev. Entomol.*, 29: 299-320.
5. Platnick, N.I., 2011. The World Spider Catalog, Version 12.0. American Museum of Natural History. <http://research.amnh.org/entomology/spiders/catalog/index.html>.
6. Sebastian, P.A. and K.V. Peter, 2009. Spiders of India, First edition, Universities Press, Hyderabad, India, pp: 615.
7. Pathak S. and N.N. Saha, 1999. Spider fauna of rice ecosystem in Barak valley zone of Assam, India. *Indian J. Entomol.*, 2: 211-212.
8. Bhattacharyya, S., 2000. Biodiversity of spiders in the rice fields of Kalyani, West Bengal, India. *Res. J. Chemistry and Environment*, 4: 75-76.
9. Sudhikumar, A.V., M.J. Mathew, E. Sunish and P.A. Sebastian, 2005. Seasonal variation in spider abundance in Kuttanad rice agroecosystem, Kerala, India (Araneae). *Acta zool. Bulg.*, 1: 181-190.

10. Beevi, P.S. and G.K.Mahapatro, 2008. Species-spectrum and inter-relationship between ant and spider fauna in cashew agro-ecosystem. J. Plant. Crops, 36(3): 375-381.
11. Ludwig, J.A. and J.F. Reynolds, 1988. Statistical Ecology: A primer on methods in computing. New York, John Wiley and Sons, pp: 337.
12. Solow, A.R., 1993. A simple test for change in community structure. J. Anim. Ecol., 62: 191-193.
13. Uetz, G.W., J. Halaj and A.B. Cady, 1999. Guild Structure of Spiders in Major Crops, 27: 270-280.
14. Kiritani, K., S. Kawahara, T. Sasaba and F. Nakasuji, 1972. Quantitative evaluation of predation by spiders on the green rice leaf hopper, *Nephotettix cincticeps* Uhler, by a sight count method. Res. Popul. Ecology, 13: 187-200.
15. Hsieh, C.Y. and V.A. Dyck, 1975. Influence of predators on the population density of the rice green leafhopper. Plant. Prot. Bull., 17: 316-352.
16. Siliwal, M. and S. Molur, 2007. Checklist of Spiders (Arachnida: Araneae) of South Asian including the 2006 update of Indian spider checklist. Zoo Print J., 22(2): 2551-2597.
17. Magurran, A.E., 1988. Ecological diversity and its measurement. New Jersey, Princeton University Press, pp: 255.
18. Noss R.F., 1990. Indicators of monitoring biodiversity: a hierarchical approach. Conserv. Biol., 4: 355-364.