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Research Article

Diversity of predatory spider fauna in maize ecosystem

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ABSTRACT: Investigations conducted on the identification of predatory spider fauna in maize ecosystem throughout the crop growth, in Tamil Nadu Agricultural University, Coimbatore during 2013-2014 yielded around 2821 spiders, belonging to 16 species under 10 genera of 6 families from seedling to maturity stage. Majority of the spiders collected belonged to the families Lycosidae (1671 individuals), Salticidae (459 individuals), Oxyopidae (352 individuals), Gnaphosidae (178 individuals), Corinnidae (96 individuals) and Clubionidae (65 individuals). The predatory spider species dominating in the maize ecosystem included the species *Lycosa barnesi, L. pseudoannulata, Pardosa birmanica, Salticus* sp. and *Hippasa lycosina.* Dendrogram analysis of spiders revealed that the families, Clubionidae and Gnaphosidae were closely related when compared to other predatory spider families. Correlation analysis with the weather parameters showed that the predatory spider population had non-significant positive correlation with relative humidity at 14:22 hrs and negative correlation with all other weather parameters *viz.,* maximum temperature, minimum temperature, relative humidity at 07:22 hrs, rainfall, sunshine hours and rainy days.

KEY WORDS: Diversity. maize crop ecosystem, spiders, predator.

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INTRODUCTION:

Spiders are among the most abundant predators of insects of terrestrial ecosystems (Darlene *et al.,* 2003). They are ubiquitous, generalist super predators as well as specialized predators under different ecological niches (Marc and Canard, 1997). Because of their high abundance and predominantly insectivorous feeding habits, spiders are suspected to play an important predatory role in agro-ecosystems by lowering the insect densities, as well as stabilizing pest populations. The recent trends of chemical less agriculture i.e. reduced pesticide use and ecological sustainability have also led to increased interest in promoting the natural bio-control by conservation of the parasites and predators. In this context the spiders which are already present in all agro-ecosystems may have profound influence on the pests of crops. Considering the potential of these spiders as predators, their species distribution and diversity has been studied under the maize agro-ecosystem throughout the crop growth, in Eastern Block, Tamil Nadu Agricultural University, Coimbatore during 2013-2014.

MATERIALS AND METHODS

Collection of spiders

Sampling techniques employed for the collection of spiders included pitfall trapping, visual searching and hand picking methods. For placing the pitfall traps, plots were chosen at random in the field and a single trap was placed in each such plot. Around 20 traps were placed one each in 20 randomly selected plots in a field of nearly one acre area. The traps were set out using a plastic container (15x10 cm) dug into the soil to the depth of 20 cm. The traps were placed in the early morning. Teepol was used in the traps as a trapping fluid and it was changed weekly once. Observations were recorded at weekly intervals on the number and type of spiders trapped in each trap. Hand picking was done by walking diagonally in the field and care was taken to capture them without injuring. They were collected in polythene bags for further studies.

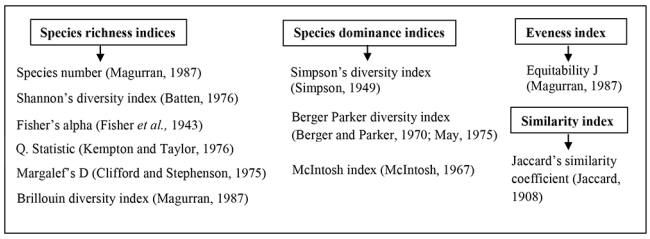
Preservation and identification of spiders

The method described by Tikader and Bal (1981) was followed for the preservation of the field collected

spiders. Spiders collected from the pitfall traps were preserved in 70 per cent ethyl alcohol in glass vials of size 10 cm x 2.5 cm and labeled. Spiders were relaxed and the body parts viz., legs, pedipalps, etc were adjusted as in the living form with the help of the needles and forceps. Spiders were then observed and photographed with a phase contrast microscope (LEICA DM 750) with a close up lens attachment to the camera with artificial illumination. The spiders were identified based on published literature and keys by comparing the morphological and taxonomical features (Tikader, 1987; Samiayyan, 2014).

Diversity analysis of spiders in maize crop ecosystem

Diversity indices are mathematical expressions that combine species richness and evenness as a measure of diversity and are frequently seen as indicators of a good ecosystem. Hence, different alpha diversity indices as well as similarity index were estimated to assess and compare the diversity and distribution of predatory spider fauna (at family, genus and species level) in maize crop ecosystem at different stages of the crop growth. The indices estimated are as follows:



Similarity index

The binary data obtained by scoring the presence and absence of individual species and families in each of the crop stages of the maize ecosystem were subjected to cluster analysis. Cluster analysis starts with a matrix giving the similarity between each pair of families. The two most similar sites in this matrix are combined to form a single cluster. The analysis proceeds by successfully clustering similar sites until all are combined in a single dendrogram. However, these measures do not give any direct measure of beta diversity but might be used to infer the number of different communities present. It is also possible to identify the characteristic species in each community. Similarity matrix was constructed using Jaccard's similarity coefficient (Jaccard, 1908). The similarity values were used for cluster analysis. Sequential agglomerative hierarchical non-overlapping (SAHN) clustering was done using Unweighed Pair Group Method with Arithmetic Averages (UPGMA) method. Data analysis was done using NTSYSpc version 2.02 (Rolff, 1998).

Influence of weather parameters on seasonal abundance of spiders

Correlation between the weekly collection of spiders from the maize crop ecosystem and the weather parameters like maximum and minimum temperatures, relative humidity (morning and evening), rainfall and sunshine hours was also estimated to observe the influence of weather parameters on the seasonal incidence of spiders.

RESULTS AND DISCUSSION

Collection and identification

Studies on spider diversity in maize ecosystem yielded 16 species, 10 genera and 6 families of spiders. The vegetation architecture, intercultural operations and the weather conditions greatly influenced the collection of spiders in the maize ecosystem. In the overall collection of spiders (2821 individuals) throughout the crop growth period i.e. vegetative, flowering, grain filling and maturity stages, the highest number of spiders were recorded under the family Lycosidae (1671 individuals) followed by Salticidae (459 individuals), Oxyopidae (352 individuals), Gnaphosidae (178 individuals), Corinnidae (96 individuals) and Clubionidae (65 individuals) (Fig. 2). The spider collection included *Clubiona* sp., *Oedignatha* sp., *Drassodes* sp., *Hippasa* sp., *Lycosa* sp.**,** *Pardosa* sp., *Phidippus* sp., *Plexippus* sp. and *Salticus* sp. Lycosidae was represented by *Hippasa, Lycosa* and *Pardosa* genera with majority of individuals from *Lycosa* and *Pardosa* genera. Among these *Lycosa barnesi* was the predominant species. Salticidae was represented by the genera *Salticus, Plexippus* and *Phidippus*, with majority of individuals from *Salticus* and *Plexippus* genera. Oxyopidae was represented by the species *Oxyopes rufisternum* and *O. javanus.* Gnaphosidae was represented by the genera *Drassodes,* Corinnidae by the genera *Oedignatha* and Clubionidae by the genera *Clubiona* (Fig.1).

The spider collection of the present study are in line with earlier reports of many workers (Singh and Sandhu, 1977; Jalali and Singh, 2002; Singh *et al.,* 1975) who recorded several spider species of Araneidae, Lycosidae, Oxyopidae, Salticidae, Tetragnathidae and Clubionidae families from maize fields. Similarly, Andrea *et al.* (1999) reported that the wolf spiders (Lycosidae) are among the dominant epigeal predators of maize ecosystem. In a study by Patra *et al.* (2013) it was reported that about 13 spider species were recorded in maize ecosystems of Meghalaya and among the spider species recorded, Araneidae and Salticidae were found to be the most prominent species which is almost on par with the present findings.

***Oedignatha* sp.**

***Clubiona* sp.**

Oxypes rufisternum

Oxypes javanus

***Drassodes* sp.**

***Drassodes* sp.**

Hippasa lycosina

Lycosa barnesi

***Pardosa* sp. 2**

Pardosa birmanica

***Pardosa* sp. 3**

Lycosa pseudoannulata

***Salticus* sp. (Female)**

***Salticus* sp. (Male)**

***Plexippus* sp. 1**

***Phidippus* sp.**

***Plexippus* sp. 2**

Fig 1. Spiders collected from maize ecosystem

Diversity indices

Alpha diversity indices

a. **Species richness indices:** In the present study, the highest species number (16.00) was observed in flowering (i.e. tasseling and silking stages) and grain filling stage, which coincide with the pest population. With reference to Fisher's Alpha, analysis at familial, generic and species level followed an identical pattern with the maximum diversity recorded during the maturity stage (5.7054) at species level. Analysis of species diversity using this index recorded a clearer picture of within habitat species diversity. Margalef's D index presented a similar picture at species level (3.0675) during the maturity stage. Brillouin index revealed that the spider diversity at species level was highest during the grain filling stage (2.5140). Shannon – Weiner (H') index, the most widely used index by various ecologists revealed similar data, both at familial level and species level, with the highest value of index being recorded at the grain filling stage of the crop (2.5924) at the species level (Table 3).

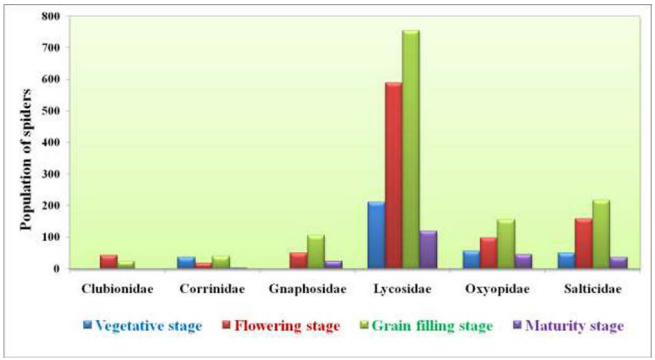


Fig 2. Abundance of predatory spider families at different stages of maize crop.

Hughes (1978) concluded in his work that the taxonomic level of identification is one of the most important factors influencing the value of the Shannon-Weiner index. In the current study, in most of the cases, estimating species richness or abundance based on family level was closer to species. Samways (2005) stated through his study that, while species surrogate measures are useful, there are risks involved with it, as the regional diversity might be overlooked. While the family richness

Table 1. Weather data recorded during the period of observation

Crop growth period (weeks)	Spiders	Max. Temp.	Min. Temp.	RH (07:22)	RH (14:22)	Rainfall	Sunshine hours	Rainy days
1st	46	30.1	18.3	87	37	0.0	8.8	0
2nd	95	30.0	20.5	83	45	0.0	6.3	0
3rd	118	30.8	20.9	81	46	0.0	7.3	0
4th	91	29.9	19.9	84	41	0.0	7.9	0
5th	308	30.8	19.1	82	39	0.0	9.2	0
6th	299	33.2	16.9	71	26	0.0	10.2	0
7th	321	33	21.5	81	44	0.0	8.2	0
8th	356	31.8	22.4	81	47	0.2	5.0	0
9th	330	32.8	22.8	81	47	0.0	6.7	0
10th	329	32.6	23.2	80	46	0.0	6.3	0
11th	277	34.2	20.5	73	26	0.0	9.9	0
12th	83	36.3	23.3	72	30	0.0	10.1	0
13th	54	36.2	21.4	70	26	0.0	9.9	0
14th	50	36.7	25.1	76	37	0.0	9.3	0
15th	28	35.9	24.2	83	41	17.4	6.8	1
16th	9	35.9	24.2	84	38	0.0	8.6	0

might be a good predictor of species richness, this approach has the inherent disadvantage of overlooking rare and threatened endemic species. Hoback et al. (1999) reported that ideally an estimate of diversity should examine organisms at species level, as any estimate of diversity at taxonomically higher level will be unable to explain the relationship between the species or population size. However, in the absence of taxonomic keys or expertise, the examination of the community for the purpose of estimating the diversity could be accomplished by use of family level identification.

b. Species dominance indices: Dominance measures are weighed towards the abundance of the commonest species rather than providing the measure of species richness. In the current study, only Simpson's index and Berger Parker index discriminated the variation at all the three levels i.e. familial, generic and species with the discrimination being more pronounced at the species level. Of the three indices, Simpson's index is commonly used for estimating diversity based on dominance with moderate discriminate ability according to Magurran (1987). McIntosh index recorded contradictory results as far as the three levels are considered, with similar trend being observed at all the levels (Table 3).

c. Evenness index: Equilitability J was used for the measure of evenness index in maize ecosystem in the present study. The index was similar in familial, generic and species level with a maximum value of index at grain filling stage of the crop (0.9493) and minimum value recorded at vegetative (0.5974) and maturity stages (0.5147) at the species level (Table 3).

Similarity index: Dendrogram analysis of predatory spider families in maize crop, constructed based on the Jaccard's coefficient depicted the similarity coefficient values ranging from 0.00 to 0.25. The dendrogram separated the 6 families into 1 cluster based on 25 per cent similarity. The major cluster included the families, Clubionidae and Gnaphosidae with higher similarity coefficient (Fig. 3). Similarly, dendrogram of predatory spider species in maize crop was constructed. The similarity coefficient values ranged from 0.00 to 0.56. The dendrogram separated the 16 species into 3 clusters based on 25 per cent similarity. The major clusters included the species *Clubiona* sp., *Pardosa* sp., *Drassodes* sp.1, *Drassodes* sp.2, *Plexippus* sp.1, *Plexippus* sp.2, *Phidippus* sp. *and Hippasa lycosina* with higher similarity coefficient when compared to the other species (Fig. 3).

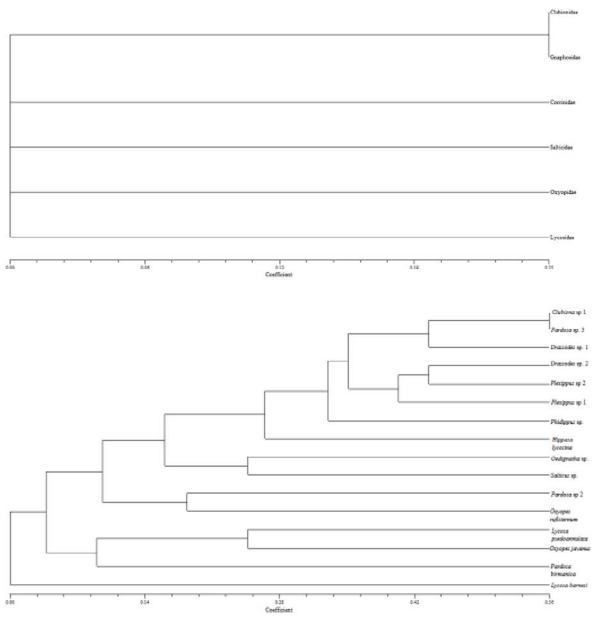


Fig. 3. Dendrograms showing the similarity of predatory spider families and species collected from maize ecosystem respectively based on Jaccard's similarity coefficient.

Table 2. Influence of weather parameters on seasonal abundance of spiders in maize ecosystem (Correlation analysis)

Correlation analysis of spiders								
Variables	Spiders	Max temp	Min temp	RH at 07:22 hrs	RH at 14:22 hrs	Rainfall	Sunshine	Rainy days
Spiders	1							
Max temp	-0.30746	1						
Min temp	-0.25236	0.64257	1					
RH at 07:22 hrs	-0.12264	-0.57604	0.02591	1				
RH at 14:22 hrs	0.21379	-0.49453	0.28830	0.75376	1			
Rainfall	-0.28936	0.29737	0.31517	0.18934	0.09010	1		
Sunshine	-0.24227	0.42090	-0.28800	-0.60313	-0.88217	-0.23147	1	
Rainy days	-0.29333	0.29883	0.31376	0.18821	0.08665	0.99993	-0.22528	1

Table 3. Spider diversity in maize ecosystem during 2013-2014 (Alpha diversity indices and Similarity index at species level)

Crop growth stages and Weeks		Species number	Shannon –Weiner index)	Fisher's alpha index	Margalef's D index	Q. statistic	Brillouin index	Simpson's index	McIntosh index	Berger Parker index	Equitability J
Vegetative stage	1st	7.00	1.6565	2.2982	1.5671	2.3270	1.4560	4.6833	0.6096	0.3695	0.5974
	2nd	8.00	1.9049	2.0844	1.5372	3.7210	1.7632	6.0338	0.6488	0.2736	0.6870
	3rd	8.00	1.8325	1.9417	1.4673	3.1059	1.7156	5.4786	0.6219	0.2881	0.6609
	4th	8.00	1.8735	2.1156	1.5518	2.9070	1.7298	5.9348	0.6462	0.2747	0.6757
Flowering stage	5th	16.00	2.3795	3.5869	2.6178	5.2423	2.2779	8.2915	0.6878	0.2532	0.8582
	6th	16.00	2.5240	3.6174	2.6314	7.9934	2.4160	10.448	0.7278	0.2107	0.9103
	7th	16.00	2.5090	3.5452	2.5990	4.5591	2.4086	11.163	0.7371	0.1308	0.9049
Grain filling stage	8th	16.00	2.5924	3.4456	2.5532	6.7475	2.4967	12.147	0.7482	0.1348	0.9350
	9th	16.00	2.5194	3.5180	2.5866	6.0642	2.4193	10.625	0.7289	0.1666	0.9086
	10th	16.00	2.5789	3.5209	2.5880	13.9150	2.4770	11.504	0.7413	0.1641	0.9301
	11th	16.00	2.6320	3.6989	2.6671	9.0611	2.5140	12.892	0.7613	0.1407	0.9493
Maturity stage	12th	13.00	2.3410	4.3251	2.7156	5.6075	2.1082	10.009	0.7494	0.2048	0.8443
	13th	11.00	2.2483	4.1760	2.5069	8.8093	1.9634	9.540	0.7542	0.2037	0.8108
	14th	13.00	2.3030	5.7054	3.0675	5.4568	1.9725	9.5703	0.7572	0.2200	0.8306
	15th	9.00	2.1072	4.5922	2.4008	6.4921	1.7277	10.216	0.7882	0.1785	0.7600
	16th	5.00	1.4271	4.6325	1.8205	2.8854	0.9922	5.1429	0.7006	0.4444	0.5147

Influence of weather parameters on seasonal abundance of spiders in maize ecosystem

In order to find out the effect of different abiotic factors on the occurrence of spiders, correlation was worked out and the results revealed that the occurrence of spiders in maize crop ecosystem was positively correlated with relative humidity at 14:22 hrs and negatively correlated with all the other weather parameters viz. maximum temperature, minimum temperature, relative humidity at 07:22 hrs, rainfall, sunshine hours and rainy days (Table 1 and 2). Extreme temperatures, both hot and cold, are the most extensively documented abiotic mortality factors for spiders. High temperatures have been shown to negatively affect spiders as thermal stress prevents the spiders from being active. Thus, the thermal environment limits foraging activities to certain periods of the day. However, the temperature influences different species in different ways and some spiders actually select warmer areas in order to enhance egg development e.g. some Lycosid species (Wise, 1993). According to a study conducted in Warangal, Telangana, the abundance of spider population showed positive correlation with relative humidity (morning and evening) and negative correlation with temperature and rainfall (Laxman *et al.,* 2016). According to another study, the spider population showed positive correlation with temperature and relative humidity and negative correlation with rainfall, wind velocity and sunshine hours (Yogesh, 2017).

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