Journal of Biological Control, 35(3): 161-170, 2021, DOI: 10.18311/jbc/2021/28638

Research Article

Diversity and population dynamics of insect predatory fauna in the brinjal ecosystem under IPM and non-IPM situations

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ABSTRACT: The study was conducted to assess and document the diversity, abundance of insect predators and its relationship with weather parameters in brinjal ecosystem at Horticultural farm, Horticultural College and Research Institute, Thiruchirapalli. The study has shown that the Lynx spider, *Peucetia viridana* was the dominant species with relative abundance of 19.04% and 20.39%, respectively in IPM and non-IPM plots. Among the coccinellid predators, *Brumoides sutularis* was recorded as the predominant species with relative abundance of 13.82% and 20.42% in respective IPM and non - IPM plots. Simpson and Shannon Weiner index of the present study showed that the natural enemies' population was abundant in intercropped (IPM) plot than in the non - IPM plot. Spider population fluctuated throughout the cropping period and exhibited positive correlation with maximum temperature (r = 0.097 to 0.465), morning relative humidity and negative correlation with rainfall (r = - 0.078 to - 0.395) exhibiting that the population buildup was good at high temperature. Similarly, correlation coefficient obtained for coccinellids also exhibited that the maximum temperature (r = 0.057 to 0.443), minimum temperature and morning relative humidity had positive effect on the population. Whilst, wind velocity and rainfall (r = - 0.020 to - 0.990) implicated negative effect on the population of coccinellid predators. The neuropteran and heteropteran predators showed negative correlation with maximum temperature, evening relative humidity and positive correlation with minimum temperature, morning relative humidity and rainfall.

KEY WORDS: Brinjal, coccinellids, diversity indices, relative abundance, spiders

(Article chronicle: 15-08-2021; Revised: 27-09-2021; Accepted: 29-09-2021)

INTRODUCTION

Brinjal is usually called as *"King of Vegetables"* and grown around the globe as it is well adapted to varied climatic conditions (Tripura *et al*., 2017). Globally about 5.51 million tonnes of brinjal are produced from an area of 1.84 mha. India is the second leading brinjal producer with 1.268 million tonnes of production under harvested area of 0.072 mha (FAOSTAT, 2019). Brinjal crop is infested by insect pests starting from nursery to harvest stage (Regupathy *et al*., 1997; Kumar 2017; Ajabe *et al.,* 2019). More than 16 insect species infesting brinjal crop were recorded, of which leaf hopper *Amrasca biguttula biguttula*, Ishida), whitefly (*Bemisia tabaci*, Gennadius), shoot and fruit borer (*Leucinodes orbonalis*, Guenee), *Epilachna* beetle (*Epilachna vigintioctopunctata*, Fabricius) and the non-insect pest red spider mite (*Tetranychus urticae*, Koch) are the predominant species that squanders the crop from attaining its optimum yield (Jarwar *et al.*, 2014; Dar *et al*., 2015). Besides harmful insects, beneficial arthropods are also occurred in an ecosystem that keeps the herbivory at bay. An ecosystem maintains its goodness by creating a balance between harmful and beneficial organisms. Natural enemies being eco-friendly enhances the production and reduces the cost of cultivation by lowering the utilization of pesticides. In brinjal ecosystem, the insect predator species belonging to families Coccinellidae, Carabidae, Staphylinidae, Chrysopidae are found to occur. The non-insect predators like spiders belonging to the class Arachnida also limits the uptick of brinjal insect pest population (Sankari and Thiyagesan, 2010). Border crops and intercrops serve as a healthy habitat for the multiplication and perpetuation of natural enemies in any ecosystem. The present study was carried out to explore the diversity of predatory fauna in brinjal intercropping system and to observe the influence of weather parameters on the dynamics of predatory population.

MATERIALS AND METHODS

Field experiment was carried out to study the diversity of insect pests and natural enemies in brinjal ecosystem in two different plots separately for IPM and farmer's practice with an area of 400 m^2 during the period of March to August, 2020 - 21. In IPM plot, the various components were evaluated in 6x4 m^2 plot area with four replications. Brinjal is planted along with intercrops *viz.,* thulasi, cowpea, marigold, coriander and border crops such as maize, sorghum, sunflower and cumbu napier. Scheduled spray includes the botanicals, biocontrol agents and chemical pesticides. None of the border crops and intercrops were raised in non-IPM plot. Regular application of pesticides includes Imidacloprid 17.8 SL, Flubendamide 48% EC, Emamectin benzoate 5% SG and Thiamethoxam 25 WG. These experiments were laid out in the farm of Horticultural college and Research Institute for Women, Thiruchirapalli located at 10°45'22.5"N latitude and 78°36'03.7"E longitude at 85 m from Mean Sea Level. Soil and climatic conditions of Thiruchirapalli region is well suited for good yielding of the local variety Manapparai brinjal. In favour to the farmers, the present study was performed with Manapparai brinjal variety. The seedlings were raised and transplanted at 35 DAS at 60 X 60 cm spacing. For taking observations field was divided into four and from each quarter data was recorded. About 5 quadrats of size 1m^2 were placed randomly chosen from each quarter and the population of natural enemies were recorded from the plants found within quadrats (4 plants per quadrat). Observations of insect pests and natural enemies was undertaken at morning hours before 9 am by an absolute visual searching method at weekly intervals commenced from 30 DAT and continued up to 150 DAT. The number of predators belonging to different families occurring in an individual plants for each quarter were counted and then mean was calculated and represented as number of individuals per 5 m^2.

Diversity indices

Diversity indices provides the basic knowledge on composition of insect diversity in an ecosystem. Number of species present in the brinjal ecosystem can be obtained through relative abundance. Relative abundance was calculated to know the dominant species in brinjal ecosystem. After pooling all of the data, relative abundance was calculated using the procedure below and presented as a percentage.

$$Relative\ abundance = \frac{Number\ of\ species}{Total\ number\ of\ species} \text{ X } 100$$

The following indices were derived on the population dynamics of various predators by using the formulae given below.

Correlation studies

Weekly weather data was obtained from meteorological observatory of Anbil Dharmalingam Agricultural College and Research Institute, Thiruchirapalli, to assess the influence of abiotic factors on the variation of predatory population. The observations on the mean population of predators were statistically analysed, and the correlation coefficient was derived using IBM SPSS Statistics 23 software.

RESULTS AND DISCUSSION

Relative abundance and diversity of predators in brinjal ecosystem under IPM and non-IPM plots

In the present study about fourteen species of plant dwelling predators were observed in IPM plot and thirteen species were noticed in non - IPM plot belonging to families *viz.*, Oxyopidae, Salticidae, Thomisidae, Araenidae, Coccinellidae, Chrysopidae and Geocoridae (Table 1, Fig.

Indices	Formula	Parameters
Margalef Species Richness Index (Margalef, 1968)	R = S - 1 / log N	R = Margalef Species Richness Index S = Total number of species N = Total number of individuals
Shannon Weiner Index (Shannon Weiner, 1948)	$H = -\sum_{i=1}^{s}\left(\frac{ni}{n} X\ ln\ \frac{ni}{n}\right)$	H = Shannon Weiner Index ni = Number of individuals belonging to the i^{th} species n = Total number of individuals in the sample ln = Natural logarithm
Simpson Index (Simpson, 1949)	$\lambda = \sum_{i=1}^{s}\left(\frac{ni\ (ni-1)}{n(n-1)}\right)$	ni = Number of individuals belonging to the i^{th} species n = Total number of individuals in the sample

1&2). Among the predators observed, *Peucetia viridana* was the most dominant species with relative abundance of 20.04 % in IPM plot and 21.39% in non - IPM plot. Following *Peucetia viridana*, *Oxyopes javanus* was the second abundant spider species escorted by 18.16% in IPM and 20.66 % in non - IPM plot. The observations registered in the current findings were in line with Murali *et al*. (2017a) in which it has been recorded as *Peucetia viridana* as the most abundant spider species of brinjal ecosystem both in sprayed (12.29%) and the other unsprayed (12.38%) sites followed by *Oxyopes* sp. in all year-round. About 86.5% of predatory spider population was constituted by Oxyopidae which includes *Peucetia viridana* and *Oxyopes birmanicus* in brinjal ecosystem (Mallick *et al.*, 2017). In Coccinellidae, *Brumoides sutularis* was recorded as the most abundant predatory arthropod in either of the plots with 13.82% and 13.19% respectively. In IPM plot, the minimum abundance was recorded by *Micraspis discolor* (2.26%) and *Pseudaspidimerus* sp. (1.06%), whereas in non IPM plot also the least abundance was noticed as *Pseudaspidimerus* sp. (0.71%) and *Scymnus* sp. (1.33%). The present findings have been in accordance with Latif *et al*. (2009) found that among the predators, spiders and coccinellids accounted for nearly 42.44 and 30.23 per cent respectively. Murali *et al*. (2017b) also recorded the abundance of coccinellids in brinjal under both the sprayed and unsprayed ecosystems. The above finding stated that in both sprayed and unsprayed fields, *Cheilomenes sexmaculatus* was the dominant coccinellid species of 15.48 per cent and 21.09 per cent respectively, in all three seasons raised throughout the year.

The diversity indices were calculated to identify the species richness and evenness between IPM and non - IPM plot. Simpson index measures the number of species and number of individuals in each species. Simpson index lies between 0 and 1. As the numeric value increases, diversity increases. Shannon Weiner index includes the couple of abundance and evenness of species. The species richness can be assessed in the Margalef index of diversity. However, sample size is a limiting factor in this index. In Table 2 Simpson index measured as 0.12 in IPM plot and in non - IPM plot measured as 0.09, indicates that the diversity was excess in IPM plot than non - IPM plot. Similarly, IPM plot and non - IPM has Shannon Wiener index of 2.47 and 1.98 respectively. The results shows that higher predatory population was seen in IPM plot than the non - IPM plot. Margalef species richness index in non- IPM plot (1.94) was less than IPM plot (2.24). Simpson and Shannon Weiner index of the present study showed that the natural enemy population was copious in intercropped plot than in the non - IPM plot. The results are in accordance with Anbalagan *et al.* (2016) in which it has been described about the natural enemy biodiversity in vegetable crop, the Shannon Weiner index was reported above 3.5 in all vegetable fields throughout the study period. Meanwhile, Species richness index was lower in intercrop when compared to the monocrop. Amala and Shivalingasamy (2018) reported the value of all the three indices were higher in intercropped/border cropped guava ecosystem than the monoculture. Intercrops and border crops serve as a source of nectar, pollen, and refuge for resident parasitoids and predators during flowering. They also safeguard the natural enemies by sheltering local parasitoids and predators during pesticide application in the main crop.

Population dynamics of spiders, coccinellids and others in brinjal ecosystem

The number of spiders, coccinellids, heteropteran and neuropteran predators varied throughout the study period but the population in non - IPM plot was relatively lower than the IPM plot. Repeated exposure of pesticides in non - IPM plot resulted in the poor population buildup. Akhtar Ali Khan (2012) stated that the pesticide use had a significant impact on the population of web builders and tactile hunters (Thomisidae) in apple ecosystem. Gajendra Singh *et al*. (2020) also confirmed the drastic reduction of spider population in pesticide treated plots.

I. Spiders

Among the spiders observed, *Peucetia viridana* was the dominant species in both IPM and non-IPM situation. In IPM plot, the mean spider population *viz*., lynx spider, jumping spider, crab spider and orb weavers were ranged between 47.25 and 348.25 nos./5m^2 (Table 3) whereas, in non - IPM plot as a result of repeated exposure to pesticides, there was a decline in density and the mean population varied from 13.50 to 107.50 nos./5m^2(Table 4). Islam and Das (2017) reported that the population of lynx spiders was dramatically reduced due to application of Libsen 45 SC (Spinosad) with 15.32 per cent mortality in brinjal ecosystem. Rahman *et al*. (2019) also reported that the application of flubendamide has suppressed the density of lynx spider and ladybird beetles around 50 - 60 % sprayed for the management of *Leucinodes orbonalis.* Ghananand *et al*., (2011) supported the present findings that the exposure of spiders to imidacloprid causes mortality ranged from 41 - 47 % in brinjal crop.

It was found that all the spider species excluding *Thyene* sp. was positively correlated with maximum temperature (r = 0.176 - 0.465), morning relative humidity (RH) (r = 0.060 - 0.499) and negatively correlated with rainfall (r = -0.169 to -0.610) (Table 3 & 4). *Thyene* population buildup showed significant and negative correlation with maximum temperature (r = -0.541) and positively correlated with rainfall (r = 0.495). The population of *Thyene* sp. in non - IPM plot was absent during the period of study. The value

Table 1. Relative abundance of predatory fauna in brinjal ecosystem

S. No	Common name	Scientific name	Family	Relative abundance (%)	
				IPM plot	Non-IPM plot
A.	**SPIDERS**				
1.	Green lynx spider	*Peucetia viridana* (Stolickza)	Oxyopidae; Araneae	20.04	21.39
2.	Striped lynx spider	*Oxyopes javanus* (Thorell)		18.16	20.66
3.	Striped lynx spider	*Oxyopes birmanicus* (Thorell)		3.81	1.44
4.	Jumping spider	*Thyene* sp.	Salticidae; Araneae	5.65	0
5.	Crab spider	*Thomisus* spp.	Thomisidae; Araneae	5.31	4.77
6.	Orb weaver spider	*Araneus* sp.	Araneidae; Araneae	3.87	2.19
B.	**COCCINELLIDS**				
7.	Ladybird beetle	*Cheilomenes sexmaculatus* (Fabricius)	Coccinellidae; Coleoptera	8.61	7.82
8.		*Micraspis discolour* (Fabricius)		2.26	4.58
9.		*Brumoides sutularis* (Fabricius)		13.82	13.19
10.		*Pseudaspidimerus* sp.		1.06	0.71
11.		*Coccinella transversalis* (Fabricius)		5.30	4.58
12.		*Scymnus* sp.		2.94	1.33
C.	**NEUROPTERA**				
13.	Green lacewing bug	*Chrysoperla zastrowii sillemi* (Esben-Peterson)	Chrysopidae; Neuroptera	8.58	7.06
D.	**HEMIPTERA**				
14.	Big eyed bug	*Geocoris* sp.	Geocoridae; Hemiptera	5.53	5.06

Table 2. Diversity indices of natural enemies in brinjal ecosystem in IPM and non - IPM plots

Components	Margalef species Richness Index (R)	Shannon Weiner Index (H)	Simpson Index (λ)
IPM plot	2.24	2.47	0.12
Non-IPM plot	1.94	1.98	0.09

R^2 (0.495 - 0.850) indicated that the weather parameters influenced 49 - 85 % on the population buildup of spiders. The present findings in tune with the result of Ramzan *et al*., 2019 stated that the temperature was positively correlated and rainfall was negatively correlated with the spiders and coccinellids population in cotton.

II. Coccinellids

The activity of coccinellid predators in IPM plot was fluctuated throughout the cropping season ranged from 53.00 to 253.00 nos./5m^2 (Table 3) . Whilst, in non - IPM plot, the mean population extending from 10.50 to 115.75 nos./5m^2 (Table 4) and *Pseudaspidemerus* sp. population was seen occassionally in negligible numbers. The correlation coefficient data had shown that coccinellids were positively correlated with maximum temperature (r = 0.056 - 0.443), morning relative humidity (r = 0.02 - 0.545). Wind velocity and rainfall (r = -0.020 to -0.445) was negatively correlated with ladybird predators. The present findings are in accordance with Gurung *et al*. (2018) found that the *Cheilomenes sexmaculatus* was positively related with maximum temperature (r = 0.152) and negatively related with rainfall

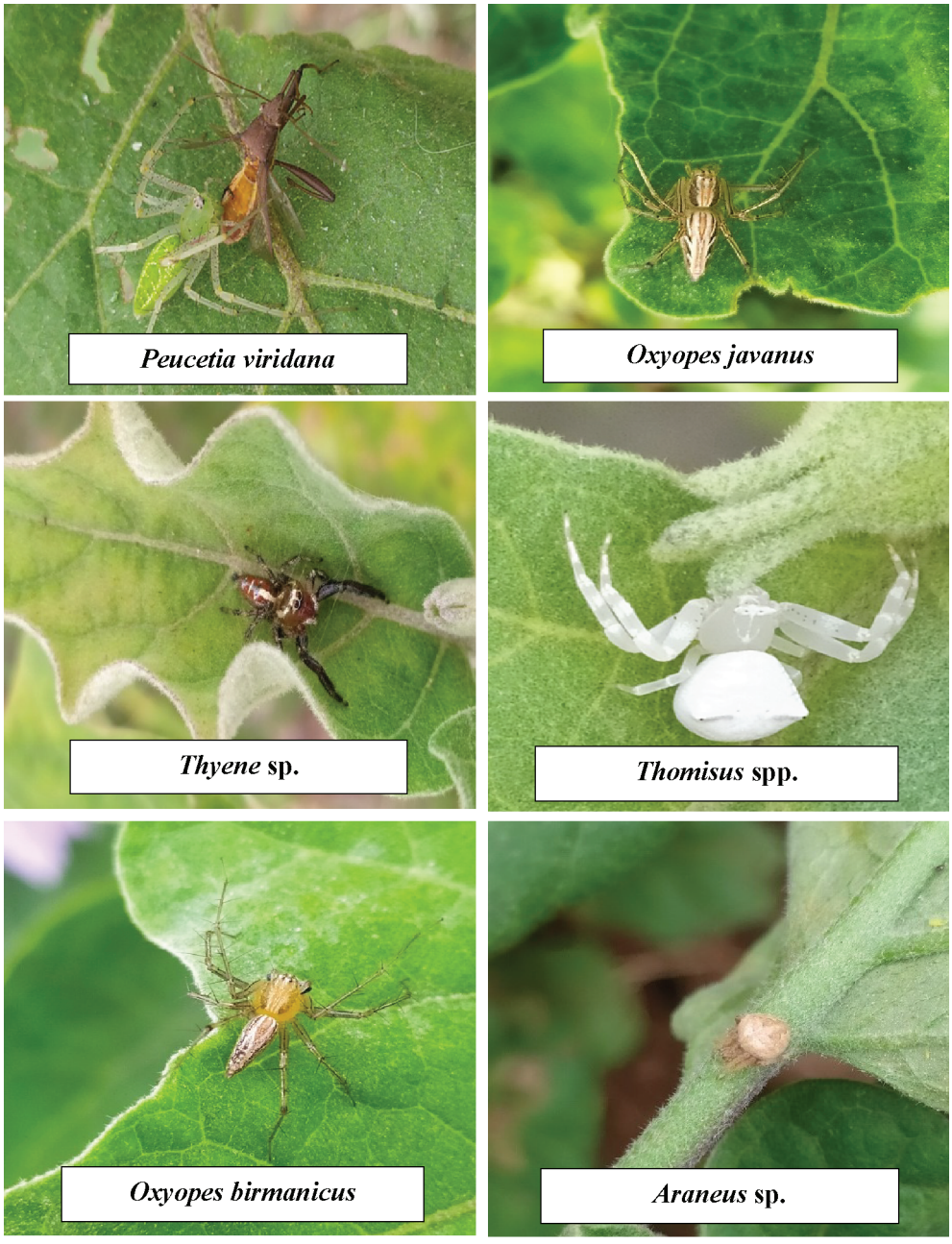
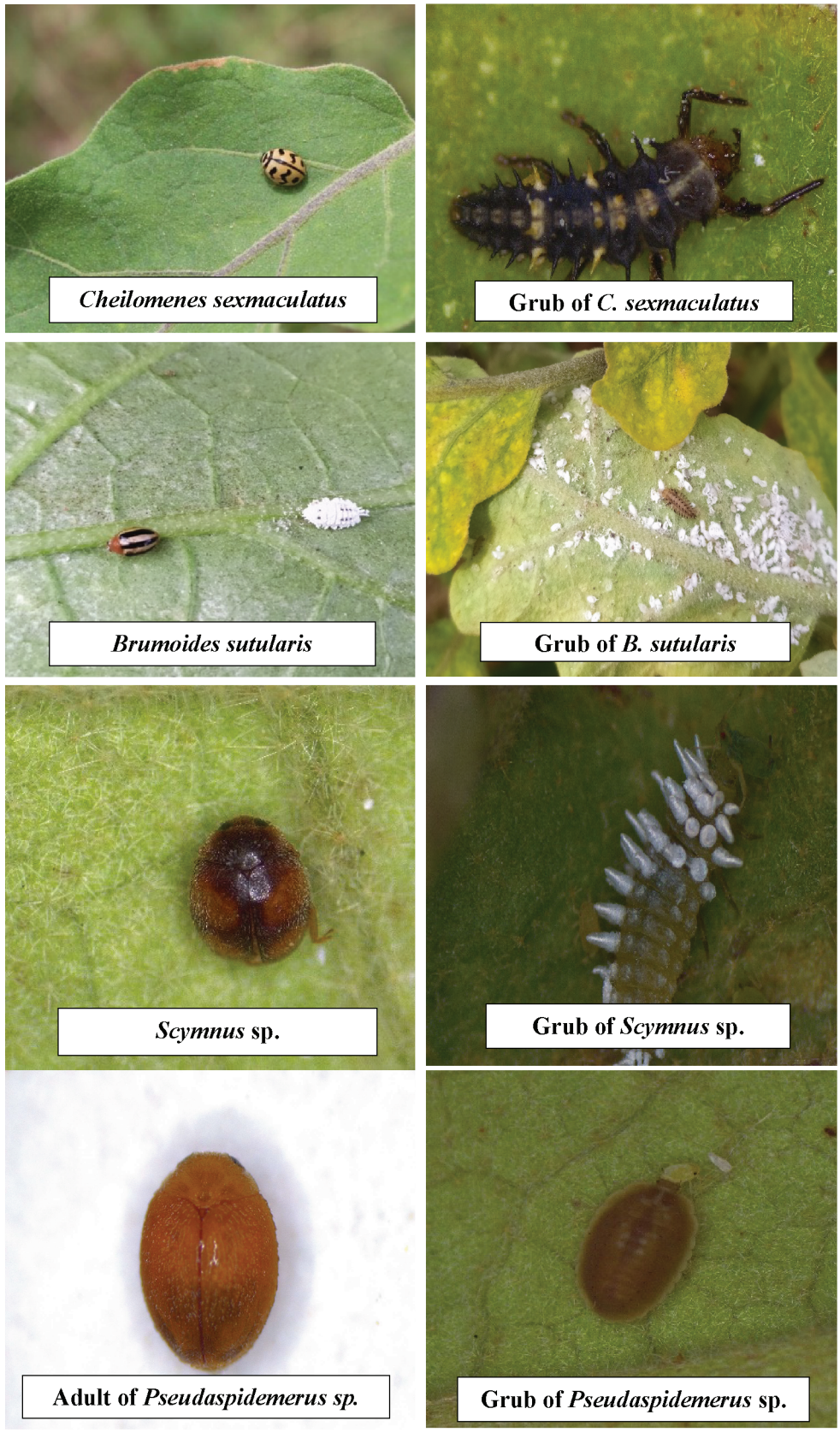


Fig. 1. Different species of spiders in brinjal ecosystem.

(r = -0.078). According to Saha *et al*. (2018), *Coccinella* in cucumber was positively correlated with temperature and negatively correlated with humidity in Bihar. Dwivedi *et al*. (2018) also reported that the population of *Coccinella* spp. in mustard showed non-significant positive correlation with maximum temperature and negative correlation with rainfall in Kanpur.

III. Big eyed bug

The observations recorded has indicated that the mean population of big eyed bug was 128.50 nos./5m^2 (Table 3) in IPM plot and in non - IPM plot it was about 32.50 nos./5m^2 (Table 4). Population was positively correlated with temperature (r = 0.306 & 0.428), morning RH (r = 0.412 & 0.250) and rainfall had negative correlation (r = -0.116). The value R^2 indicated about 53 - 57 per cent influence of weather parameters on its density (Table 4). Shyed *et al*. (2021) evinced that the population of *Geocoris* was positively correlated with temperature (r = 0.56) and relative humidity (r = 0.21) which supported the present findings. Additionally, the present findings were contrary to Ali *et al*., 2020 marked that the *Geocoris* had shown negative correlation with temperature and positive correlation with relative humidity and wind speed on sucking pests of cotton.


Cheilomenes sexmaculatus
Grub of *C. sexmaculatus*
Brumoides sutularis
Grub of *B. sutularis*
Scymnus sp.
Grub of *Scymnus* sp.
Adult of *Pseudaspidemerus sp.*
Grub of *Pseudaspidemerus* sp.

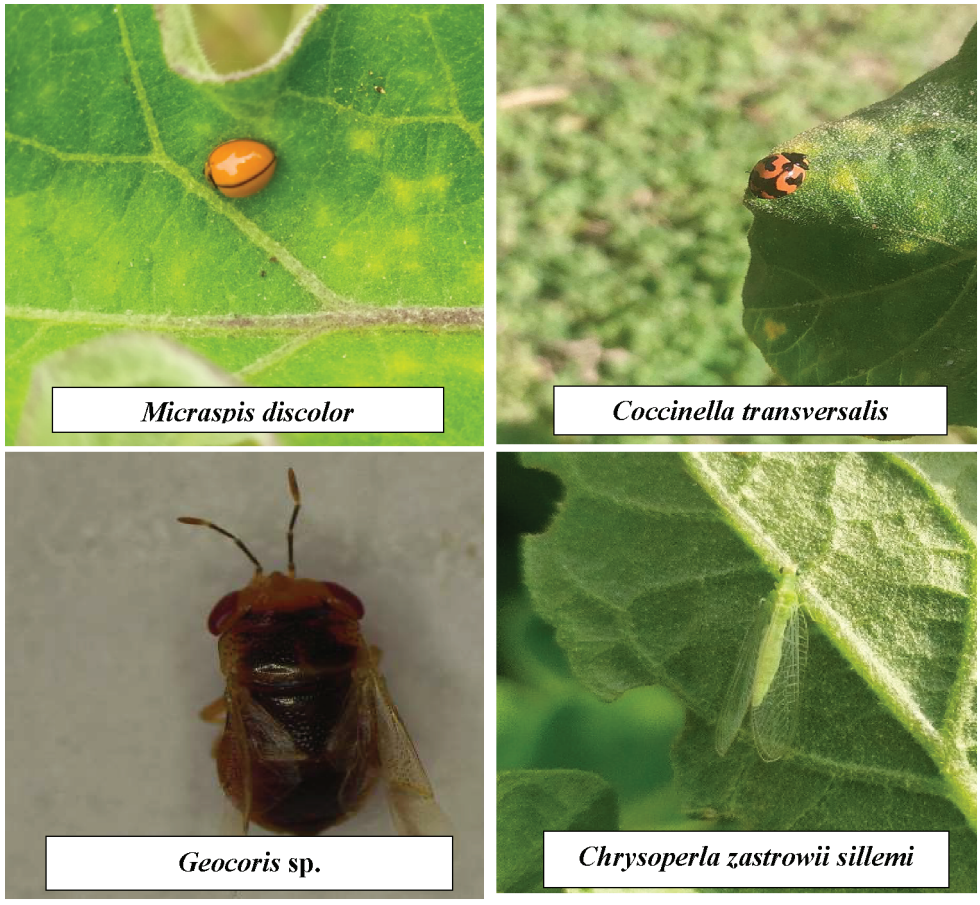


Fig. 2. Coccinellids and other predators in brinjal ecosystem.

IV. Green lacewing bug

Chrysoperla zastrowii sillemi was active during the entire growing season of brinjal. The mean population recorded was 87.25 nos./5m^2 in IPM and 32.50 nos./5m^2 in non- IPM plot (Table 3&4). The results of statistically analyzed data shown that the population was negatively correlated with maximum temperature (r = -0.165 & -0.241), evening relative humidity (r = -0.002 & -0.083) and positively correlated with rainfall (r = 0.467 & 0.326). Overall weather factors contributed 40 - 57 per cent to the population dynamics of *Chrysoperla*. Dhaka and Pareek (2007) found that C*hrysoperla* population was negatively correlated with maximum and minimum temperature and also reported that the relative humidity and rainfall had no impact on chrysopid population.

CONCLUSION

Spiders are considered as a generalist predator and have an ability to disperse in a diverse habitat for searching its prey. In the present study, numerous spiders were found along with the other coccinellid and chrysopid predators. Conservation of predators and parasitoids could be encouraged through raising of border and intercrops that nurtures the beneficial insects and promotes its activity in an ecosystem. This study clearly depicts that the integration of ecofreindly of management strategies for the management of insect pests in brinjal ecosystem encourages the predatory fauna as compared to the experimental site imposed with insecticides.

ACKNOWLEDGEMENTS

The corresponding author is highly thankful to the Dean, Horticultural College and Research Institute for Women, Thiruchirapalli for granting permission to take-up the field trial in the HCRIW campus. The support rendered by the Professor and Head, Department of Plant Protection and the Dean, Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Thiruchirapalli by providing laboratory and other facilities for the conduct of study is duly acknowledged.

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Table 3. Correlation coefficient of natural enemies with weather parameters in IPM plot

Predators	Mean population	T_{max} (°C)	T_{min} (°C)	Morning RH (%)	Evening RH (%)	Wind velocity (km/hr)	Sunshine (hrs)	Evapora-tion (mm)	Rainfall (mm)	R^2
A. SPIDERS										
Peucetia viridana	348.25	0.135	0.150	0.440	- 0.248	0.559*	0.068	- 0.088	- 0.610	0.691
Oxyopes javanus	209.25	0.322	0.206	0.400	- 0.288	- 0.564	0.190	0.050	-0.169	0.626
Oxyopes birmanicus	47.25	0.176	- 0.384	- 0.349	0.136	0.310	-0.523	-0.230	-0.395	0.706
Thomisus spp.	102.75	0.097	0.234	0.490*	- 1.56	- 0.670**	0.246	- 0.580	- 0.340	0.616
Thyene sp.	107.75	- 0.541*	-0.056	0.060	0.169	0.161	- 0.332	-0.135	0.236	0.495
Araneus sp.	85.25	0.465	0.208	0.499	-0.281	-0.711	0.239	0.009	-0.216	0.85
B. COCCINELLIDS AND OTHER PREDATORS										
Brumoides sutularis	253.00	0.298	0.006	0.242	- 0.158	- 0.654**	0.060	-0.610	- 0.425	0.738
Cheilomenes sexmaculatus	129.00	0.132	0.231	0.407	0.322	- 0.336	0.136	0.296	-0.020	0.371
Coccinella transversalis	89.25	0.263	0.084	0.120	-0.246	- 0.113	-0.160	- 0.840	- 0.283	0.482
Micraspis discolor	48.00	0.056	0.142	0.430	0.583*	- 0.077	0.073	0.271	- 0.064	0.614
Scymnus sp.	84.50	0.443	0.239	0.545*	0.006	- 0.680**	0.275	0.860	- 0.328	0.782
Pseudaspide-merus sp	53.00	0.078	0.215	0.332	0.276	- 0.078	0.171	0.400	-0.119	0.532
Geocoris sp.	128.50	0.306	0.307	0.412	- 0.158	- 0.511*	0.181	0.195	- 0.116	0.575
Chrysop-erla zastrowii silemii	87.25	- 0.165	0.200	0.444	- 0.083	-0.534	0.50 *	- 0.168	0.326	0.572

* Significant at 0.05%
** Significant at 0.01%

Table 4. Correlation coefficient of natural enemies with weather parameters in non - IPM plot

Predators	Mean population	T_{max} (°C)	T_{min} (°C)	Morning RH (%)	Evening RH (%)	Wind velocity (km/hr)	Sunshine (hrs)	Evaporation (mm)	Rainfall (mm)	R^2
A. SPIDERS										
Peucetia viridana	107.50	0.346	0.042	0.491	- 0.018	- 0.671*	0.007	-0.021	- 0.39	0.790
Oxyopes javanus	66.00	0.352	0.199	0.445	- 0.137	- 0.488	0.143	0.211	- 0.048	0.632
Oxyopes birmanicus	10.50	0.291	-0.048	0.130	- 0.138	0.042	- 0.066	0.194	- 0.078	0.669
Thomisus spp.	31.75	0.365	0.427	0.013	- 0.220	0.139	0.490	0.206	- 0.018	0.510
Araneus sp.	13.50	0.296	-0.007	0.142	- 0.070	- 0.300	0.080	0.028	- 0.262	0.21
B. COCCINELLIDS AND OTHER PREDATORS										
Brumoides sutularis	115.75	0.196	0.194	0.428	- 0.150	- 0.528*	0.106	0.014	- 0.048	0.461
Cheilomenes sexmaculatus	24.50	0.119	0.143	0.166	0.265	- 0.039	-0.065	0.462	- 0.990	0.624
Coccinella transversalis	10.50	0.057	0.038	- 0.02	- 0.179	- 0.0619	0.051	0.132	- 0.173	0.120
Micraspis discolor	22.50	0.130	-0.048	-0.124	- 0.017	0.023	-0.092	0.168	- 0.351	0.201
Scymnus sp.	31.25	0.433	0.177	0.415	- 0.145	- 0.683	0.238	0.138	- 0.33	0.75
Geocoris sp.	32.50	0.428	0.304	0.250	- 0.235	- 0.196	0.161	0.259	- 0.116	0.539
Chrysoperla zastrowii silemii	32.50	-0.241	0.340	0.282	- 0.002	- 0.156	0.256	0.098	0.467	0.406

* Significant at 0.05%
** Significant at 0.01%

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