

Natural enemy (Arthropoda-Insecta) biodiversity in vegetable crops in Northeastern Tamil Nadu, India.

Veeramuthu Anbalagan ^{*a,b}, Michael Gabriel Paulraj^a,
Savarimuthu Ignacimuthu^a, Kathirvelu Baskar^{a,c} and Jonas Gunasekaran^b

^aEntomology Research Institute, Loyola College, Chennai, 600 034, India.

^bPG Research Department of Zoology, TBML College, Porayar, Tamilnadu, India.

^cDepartment of Entomology and Ecotoxicology, Bioscience Research Foundation, Porur -600 116, Chennai, India.

* E-mail: anbueri@gmail.com

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ABSTRACT. Natural enemies of insect pests in vegetable crops (brinjal, okra and tomato) were recorded and their diversity was studied in Kancheepuram and Tiruvallur Districts, Tamil Nadu. Natural enemies were collected by pitfall traps, sweeping nets and by hand picking from January 2011 to December 2013 twice in a month. Totally 129 species of predatory and parasitic insects were recorded. All the natural enemies were grouped into 50 families under eight different orders. Order hymenoptera contained the highest number of families and species. Among the predators, Coccinellidae (ladybird beetles) was found to be the dominant group with high number of species. It was clear that Coccinellidae, Staphylinidae, Carabidae and Pentatomidae were the predominant natural enemies throughout the study period. In 2013, formicidae formed the major family of occurrence from July to December in the vegetable fields; in this period the total number of individuals collected from all families was the highest. The maximum Shannon-Wiener diversity index was 3.70 during the second season in 2013. Maximum richness (5.99) was recorded in the second season of 2012. The variations in the diversity, species richness and evenness between two cropping systems are discussed in this paper.

1. INTRODUCTION

Insects are the most dominant organisms in the earth in terms of number of species and biomass. Insects play various roles in our society. Some are beneficial and some are harmful. The role of insects in agriculture is very important to man, because agriculture is the basic job of more than 50% of our population. Many insects cause serious damage to agricultural crops and reduce the yield. On the other hand some insects are acting as natural enemies of these pests. In nature, there is a balance between the pest and natural enemy populations. These natural enemies help the farmers by keeping the harmful pests under check. Many agriculture scientists have emphasized that the presence of a variety of natural enemies in agro ecosystems would reduce the cost of cultivation by cutting down on the pesticide usage. Natural enemies build up their population by consuming their prey/hosts (pests) and regulate them [1]. This natural event is called Biological control and the natural enemies are called biological control agents. If biological control is used extensively, then there is no need of pesticides and the environment will be free from chemicals [2]. Conservation biological control is one important approach, in which the agro ecosystem is modified in such a way to support the natural enemy populations. Mixed cropping and intercropping methods are said to be favourable to natural enemies. The presence of weeds in an agricultural field could influence the abundance and distribution of natural enemies [3]. Intercrops or border crops provide breeding grounds, pollen and nectar to adult natural enemies. The present study was undertaken to record the natural enemies in vegetable fields (brinjal, okra and tomato) and also to analyze the effect of intercrop on natural enemy diversity in the vegetable fields.

2. MATERIALS AND METHODS

Study period and study area

This study was undertaken during January 2011-December 2013 in brinjal, okra and tomato fields in Kanchipuram and Tiruvallur Districts in Tamil Nadu, India. Insect sampling was done in Mangadu, Kakilipettai, Paraniyuthur, Setthupattu, Padappai, and Manimangalam villages in Kanchipuram District. In Tiruvallur districts, five villages namely Parivakkam, Vayalanallur, Pallavakkam, Tamaraipakkam and Thandurai were selected for the insect collection. Natural enemies were collected from monoculture vegetable crops (brinjal, okra and tomato) and from vegetable fields where castor, roselle, cowpea and agathi were grown as intercrops or border crops. In each village, one acre field was sampled for both monocrop and intercropped fields.

Collection of natural enemies

Specimens were collected by different devices such as light trap, pitfall tarp and sweeping net. They were also collected by hand picking method. The collected insects were killed by ethyl acetate vapor, sorted out into different orders and families and mounted in insect boxes. Small and soft body insects were preserved in 70% ethanol. Most insects were identified up to genus and species level with the help of experts. Insects were collected during early morning or evening hours.

Diversity indices

Insects collected from different villages in a district were pooled together and the natural enemies were sorted out into different orders and families. Total number of individuals collected under each family of natural enemy was recorded. The biodiversity indices namely richness, Hill's number (N0), Margalef index (R1), Menhinick index (R2), Simpson's index (λ), Shannon's index (H'), Hill's diversity N0. 1 (N1), Hill's diversity No.2 (N2) and evenness indices (E1 to E5) were calculated using the software 'PAST (version 3.11).

3. RESULTS

Natural enemy composition

Totally 129 species of predatory and parasitic insects were recorded from the study areas. All the natural enemies were grouped into eight different orders namely Odonata, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Mantodea and Neuroptera. Among the different orders, hymenoptera contained the highest number of families and species. Among the predators, Coccinellidae recorded the highest number of species. The parasitic insects included egg parasitoids, larval parasitoids and pupal parasitoids of Hymenoptera and pupal parasitoids of Diptera. Coccinellidae, Staphylinidae, Carabidae and Pentatomidae were the predominant natural enemies throughout the study period. In 2013, Formicidae formed the major family of occurrence from July to December in the vegetable fields; in this period the total number of individuals collected from all families was the highest.

Predatory insects

The predatory insects comprised of dragonflies and damselflies (Odonata), assassin bugs, mirid bugs, anthocorid bugs (Hemiptera), ground beetle, rover beetle and lady bird beetles (Coleoptera), ant and wasp (Hymenoptera), predatory syrphid fly (Diptera) and ant lion and owl fly (Neuroptera). Some common predatory insects in the vegetable fields are given below:

The dragonflies and damselflies (Odonata) recorded were: *Ceragrion coromandelianum* (Fabricius), *Ischnura senegalensis* (Rambur), *Ischnura aurora* (Brauer), *Ischnura inarmata* (Galvert) (Coenagrionidae) and *Calopteryx syriaca* (Rambur) (Calopterygidae), *Heliogomphus selysi* (Fraser), *Ictinogomphus distinctus* (Rambur), *Ictinogomphus rapax* (Rambur), *Anax immaculifrons* (Rambur), *Rhyothemis variegata* (Linn), *Brachythemis chalybea* (Brauer), *Brachythemis contaminata* (Fab), *Tramea limbata* (Desjardins), *Pantala falvenscens* (Fab), *Trithemis pallidinervis* (Kirby), *Trithemis festiva* (Rambur), *Trithemis aurora*, *Tramea basilaris* (Palisot

debeauvois), *Crocothemis servilia* (Drury), *Diplocodes trivialis* (Rambur), *Orthetrum sabina* (Drury), *Orthetrum testaceum* (Burmeister), *Neurothemis tullia* (Drury), *Sympetrum vulgatum flavum* (Bartenef), *Calopteryx syrica* (Rambur), *Lestes viridis*, *Lestes viridulus* (Rambur), *Copera marginipes* (Rambur), *Platynemis dealbata* and *Epallage fatime*.

The predatory hemipteran insects included *Plinychus rusticus* (Fab), *Geocoris tricolor* (Fab) (Lygaeidae), *Arilus cristatus* (Linn), *Evagoras plagiatus*, *Zelus* sp, *Rhynocoris fuscipes* (Fab), *Polididus armatissimus* (Stal) and *Pygolampis unicolor* (Walker) (Reduviidae). The most common coleopteran predatory beetles were: *Carabus granulates*, *Carabus caschmirensis*, *Chlaenius besucheti* (Sengupta), *Trepanes articulatus*, *Notaphus varius*, *Notaphilus orientalis*, *Eudema angulatum*, (Carabidae). *Cheilomenos sexmaculata*, *Coccinella transversalis*, *Scymnus coccivora*, *Serangium serratum* (Poorani), *Propylea dissecta* (Mulsant), *Micraspis discolor*, *Oenopia billieti* (Mulsant), *Brumoides suturalis* (Fab) and *Illeis indica* (Timberlake).

Hymenopteran parasitoids from different families namely Braconidae, Cynipidae, Evaniidae, Encyrtidae, Eupelmidae, Halictidae, Ichneumonidae and Pteromalidae were recorded.

Diversity indices in the year 2011

The diversity indices of natural enemies in vegetable fields showed great variations between two seasons (Jan to June and July to December) and between cropping patterns. There was a clear difference observed in the diversity indices of natural enemies between monocrop and intercrop vegetable fields. During the first season, the evenness indices (E1 to E5), Shannon's index (H'), Simpson's index, N1 and N2 were lower in intercrop vegetable field compared to monocrop. Margalef and Menhinick indices were also low in intercrop field compared to monocrop during the first season (Table 1). During the second season, the evenness of natural enemy species was higher in intercrop field than monocrop. Simpson's index and Shannon's index were also higher in the intercrop field during the second season (Table 1).

Natural enemy Diversity in 2012

During the year 2012, the Margalef index and Menhinick index were low in intercrop field compared to monocrop during both seasons (Table 2). All other diversity indices such as Simpson's index, Shannon's index, N1, N2 and evenness indices were also found to be lower in intercrop field during both seasons of the study.

Diversity indices in 2013

The data clearly showed that natural enemy diversity in intercropped vegetable fields was very high compared to monocrop. Both Simpson's and Shannon's indices were high in intercropped vegetable fields in both seasons (Table 3).

4. DISCUSSION

Diversified agroecosystems can support different types of natural enemies and thereby reduce pest population naturally [4]. Growing intercrops or border crops along with main crop will provide alternative food sources like nectar, pollen and honeydew to natural enemies. Moreover it will provide shelter, favourable microclimate and breeding grounds to natural enemies. The impact of intercropping on beneficial insects can be assessed by biodiversity studies. Biological diversity studies use diversity indices as indicators. Species richness is the number of species present in the community. In the present study, natural enemy diversity was assessed in both in monoculture and intercropped vegetable fields separately.

From the results it was evident that natural enemy diversity was influenced by cropping pattern. Previously many investigators have reported that crop diversification will increase the natural enemy populations in agroecosystems [5]. In the present study the number of individuals under each species and families increased in intercropped fields compared to monocrop fields. However there was no concrete difference in diversity indices except in the year 2013. Any difference in the

natural enemy diversity in the present study might be due to both intercrops and seasonal variations. In Kancheepuram and Tiruvallur Districts, farmers use Cowpea (*Vigna unguiculata*), castor (*Ricinus communis* Linn.) and Roselle (*Hybiscus sabdariffa* (Linn)) as intercrops and agathi (*Sesbania grandiflora* L) as bordercrop in brinjal and okra fields. Evenness is an important indicator to assess whether an ecosystem is in good condition or not. A evenness of 1 will indicate that all species are evenly distributed and the ecosystem is in good condition. In the present study the evenness in intercropped field was almost above 0.9 (nearly 1) during July to December period every year. However evenness was low during January to June period from 2011 to 2012. In the year 2013 intercropped field recorded higher evenness during January to June and July to December.

Different diversity indices were used in the present study. Each index has its own merit and demerit. So, all possible indices should be analyzed. Simpson's Index of Diversity (1-D) represents the probability that two individuals randomly selected from a sample will belong to different species. The values range between 0 and 1, the greater the value, the greater the sample diversity. Simpson's index is heavily weighed towards the most abundant species in the sample while being less sensitive to species richness [6]. Shannon's index accounts for both abundance and evenness of the species present in the community. Shannon diversity is the most widely used index for comparing diversity between various habitats [7]. In the present study Shannon diversity index values were above 3.5 in all study periods and indicated that the natural enemy diversity was rich in both monoculture and intercrop vegetable fields. Margalef's and Menhinick's indices have one advantage that they can be easily calculated. Margalef index of diversity is weighed towards species richness. The higher the Margalef index the greater the diversity. Margalef index has a very good discriminating ability. But it is sensitive to sample size.

Overall results showed that natural enemy fauna was abundant during the second half of each year, i.e. from July to December. This might be due to the monsoon climate and low temperatures during these months. Tonhasca [8] studied the effect of intercrops on natural enemy fauna in soybean ecosystem. He found out that many natural enemies were significantly more abundant in intercropped fields than in monocropped fields. Based on his findings, he has proposed the theory of greater abundance of natural enemies in more complex agroecosystems. Elancheyan *et al.*, [9] reported thirteen crops as intercrops in brinjal crops maximum number of natural enemies populations found like Coccinellidae predator, syrphids, highly abundant in intercropped with clustsesr bean in compared to brijal pure crop. Maximum number of Hymenoptera parasites and parasitoid insects found in the vegetable ecoytesm [10]. Edmund [11] has reviewed the 'enemies hypothesis', which states that predatory insects and parasitoids are more effective at controlling populations of herbivores in diverse systems of vegetation than in simple ones. The natural enemy fauna in the present report comprises of 50 families, which were recorded throughout the study period. Among the natural enemies Carabidae, Coccinellidae, Formicidae, Staphylinidae and Braconidae were found to be the most abundant families since maximum number of individuals were collected from these families. Coccinellid predators are entirely depending upon aphids and mealy bugs [12]. Brinjal and okra plants harbor such prey insects and this attracts different genera of Coccinellids.

CONCLUSION

Natural enemy diversity was largely influenced by seasons and also by cropping pattern. Intercrops and border crops supported different species of natural enemies and the total number of individuals under different families of natural enemies was higher in mixed cropping than monoculture vegetable crops.

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Table 1. BIODIVERSITY INDICES OF NATURAL ENEMY FAMILIES IN MONOCROP AND INTERCROPPED VEGETABLE FIELDS IN KANCHEEPURAM AND TIRUVALLUR DISTRICTS DURING 2011

Biodiversity indices	Year 2011			
	Monocrop		Intercrop	
	Jan. to June	July to Dec.	Jan. to June	July to Dec.
Richness				
Margalef's (R1)	5.94	5.82	4.86	4.72
Menhinick (R2)	1.25	1.17	0.57	0.50
Diversity				
Simpson's (1-D)	0.97	0.96	0.96	0.97
Shannon's (H')	3.69	3.61	3.62	3.69
Hill's Div.No.1 (N1)	40.17	36.97	37.53	40.16
Hill's Div.No.2 (N2)	39.40	31.94	33.28	38.02
Evenness				
E1	0.98	0.95	0.96	0.98
E2	0.93	0.85	0.87	0.93
E3	0.95	0.88	0.89	0.95
E4	0.98	0.86	0.88	0.94
E5	0.97	0.85	0.88	0.94

Table 2. BIODIVERSITY INDICES OF NATURAL ENEMY FAMILIES IN MONOCROP AND INTERCROPPED VEGETABLE FIELDS IN KANCHEEPURAM AND TIRUVALLUR DISTRICTS DURING 2012

Biodiversity indices	Year 2012			
	Monocrop		Intercrop	
	Jan to Jun	Jul to Dec	Jan to Jun	Jul to Dec
Richness				
Margalef's (R1)	5.80	5.99	4.94	4.71
Menhinick (R2)	1.15	1.29	0.61	0.49
Diversity				
Simpson's (1-D)	0.97	0.96	0.96	0.96
Shannon's (H')	3.64	3.63	3.53	3.56
Hill's Div.No.1 (N1)	38.44	37.81	34.41	35.34
Hill's Div.No.2 (N2)	35.79	1.29	27.94	29.19
Evenness				
E1	0.97	0.96	0.94	0.94
E2	0.89	0.87	0.80	0.82
E3	0.91	0.90	0.81	0.84
E4	0.93	0.84	0.81	0.82
E5	0.92	0.09	0.80	0.82

Table 3. BIODIVERSITY INDICES OF NATURAL ENEMY FAMILIES IN MONOCROP AND INTERCROPPED VEGETABLE FIELDS IN KANCHEEPURAM AND TIRUVALLUR DISTRICTS DURING 2013

Biodiversity indices	Year 2013			
	Monocrop		Intercrop	
	Jan to Jun	Jul to Dec	Jan to Jun	Jul to Dec
Richness				
Margalef's (R1)	5.72	5.55	4.21	4.79
Menhinick (R2)	1.09	0.98	0.29	0.54
Diversity				
Simpson's (1-D)	0.96	0.97	0.97	0.97
Shannon's (H')	3.55	3.69	3.66	3.70
Hill's Div.No.1 (N1)	35.00	40.31	39.10	40.48
Hill's Div.No.2 (N2)	30.76	38.31	35.79	38.05
Evenness				
E1	0.94	0.97	0.97	0.98
E2	0.81	0.98	0.90	0.94
E3	0.80	0.93	0.93	0.93
E4	0.87	0.95	0.91	0.93
E5	0.87	0.94	0.91	0.93

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