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COMPUTATION OF INSECTS BIODIVERSITY IN BHENDI (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) ECOSYSTEM

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ABSTRACT
Field experiments were conducted to inventorize the insect's species in bhendi ecosystem. It was observed those hemipteran herbivores and hymenopteran and coleopteran predators were relatively abundant in *kharif*, 2012 and *rabi*, 2012-13 respectively. It was found that the herbivores (77.23 and 74.83 per cent) were relatively abundant followed by predators (22.77 and 25.17 per cent). The species richness (R) of predators (3.08 and 2.95) was more than herbivores (2.62 and 2.67) and a decreasing trend of evenness (J) was observed in predators. The Shannon and Wiener diversity index (H') and Simpson index (λ) values of herbivores (2.286 and 2.294) (0.155 and 0.154) and predators (2.882 and 2.757) (0.063 and 0.076) were more or less same. The species diversity indices and species evenness indices of predators and herbivores were more or less equal and exhibited a similar diversification in *kharif* and *rabi* season. The biodiversity indices in bhendi was not reported earlier and henceforth the present findings stand as a base for further research in the biodiversity of arthropods in bhendi ecosystem.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is commonly known as 'bhendi' or lady's finger in India. It is the choicest vegetable grown extensively in the tropical, subtropical and warm area of the temperate zones of the world. It is a native of tropical Africa and widely cultivated in India. In India, Uttar Pradesh, Assam, Bihar, Orissa, Maharashtra, West Bengal and Karnataka are important bhendi producing states. In India, it is grown in an area of 0.49 million hectares with an annual production of 5.80 million tonnes and productivity of 11.6 tonnes per hectare (Anon., 2011). Bhendi is valued for its delicious tender fruits. It is the best source of iodine and calcium. Bhendi accounts for 60 per cent of export of fresh vegetables excluding potato, onion and garlic (Sharma and Arora, 1993). Many insect pests incidence were recorded from sowing upto harvest on bhendi plants in India and listed the most destructive insect pests as leafhopper, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* (Glover), whiteflies, *Bemisia tabaci* (Gennadius), fruit borer, *Helicoverpa armigera* (Hubn.), spotted bollworm, *Earias vittella* (Fabricius) and *Earias insulana* (Boisd.) (Kale *et al.,* 2005; Kumar and Pathania, 2006 and Mane *et al.,* 2010)

Arthropods are important components of ecosystems occupying vital positions in food webs, dynamics of populations and communities. They play various roles in ecosystems acting as herbivores, predators, decomposers, parasitoids and pollinators. Population ecologists discussed diversity of arthropods in two aspects, species richness *i.e.,* the number of species in a set of sample and equitability *e.g.,* the number of individuals of each species in a sample (Disney, 1999). There are evidences that species rich ecosystems are more stable than species-poor ecosystems. It is now established that arthropod predators suppress the pest populations (Chang and Kareiva, 1999 and Synmondson *et al.,* 2002).

Although, several researchers published reports on pests of bhendi elsewhere. The information about the major insects community and their importance in the bhendi agroecosystem is limited. Keeping this in view the present investigation was carried out to calculate the biodiversity of insects in bhendi ecosystem.

MATERIALS AND METHODS

Two field experiments were conducted in 20 X 30 m^2 plots to inventorize the arthropod fauna in bhendi during *kharif,* 2012 and *rabi,* 2012-13 at East farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal, U. T. of Puducherry. The variety MH 10 was

used. The agronomic practices were carried out as per the crop production guide of TNAU, Coimbatore. The surveillance of bhendi crop was initiated at the seedling emergence of the crop and continued until the last picking. Insect fauna were collected in the early hours of the day (6-8 hours) at weekly intervals by using different methods of collection *viz., insitu* and net sweeping (Hassan *et al.,* 1995). The arthropod fauna were recorded by *Insitu* counts from 24 plants per week of middle rows, leaving the border row plants and a total of 288 plants from 12 weeks of crop duration were evaluated to formulate an inventory of arthropod fauna in bhendi ecosystem. The above ground arthropod insect pests and predator species were trapped in sweep nets (32 cm dia and 70 cm long) and were monitored. Five sweeps was done and weekly data on the number of individual of each species obtained by net sweeping was used to formulate the inventory of arthropod fauna. The population of sucking pests were visually recorded on 3 leaves (top, middle and bottom leaves). The insects collected by various methods were brought to the laboratory and killed by placing a small cotton swab dipped in ethyl acetate or chloroform inside the polythene bags. The killed insects were stretched, pinned, labelled, preserved in the wooden collection boxes and identified from different institutes by renowned scientists (Devarassou, 2002). The scientific names were updated by consulting Nair (1984) and Lepindex of Natural History Museum, London.

Estimation of relative abundance

It measures the percentage of individuals over all the species. It was measured by the formula,

$$R = \frac{\alpha}{N} \times 100$$ .....(Singh and Rai, 2000)

Where,

R = Relative abundance

a = Total population of a particular species/taxon

N = Total population of all the species/taxon

Note: It measures the percentage of individuals over all the species

Estimation of biodiversity indices

Complete counts of organisms is not practicable and hence indirect solution was adopted for practical purpose to measure biodiversity of a community.

Simpson index

It is an index that focuses on the dominance aspect of a community, for example communities where only one or few species are dominant and most are very rare (Simpson, 1949).

$$\lambda = \sum_{i=1}^{s} \frac{n_i(n_i - 1)}{n(n-1)}$$

Where,

nb" = Number of individual of the i^{th} species

n = Total number of individuals in the sample

Note

If the value of 'λ decreases, diversity will increase

Shannon-Wiener

In order to study the proportion of each species within the local community, species diversity was computed based on Shannon-Wiener formula, also been called the Shannon index or Shannon Wiener index (Humphries *et al.*, 1996). It is, also, a nonparametric measure of heterogeneity. It is the most popular measures of species diversity and it is based on information theory. The main objective of information theory is to try to measure the amount of order (or disorder) contained in a system.

$$H' = -\sum_{i=1}^{s} \left[\left[\frac{n_i}{n} \right] \times \ln \left[\frac{n_i}{n} \right] \right]$$

Where,

n_i = Number of individuals belonging to the i^{th} species

n = Total number of individuals in the sample

ln = Natural logarithm

Species evenness *(J)*

How equally abundant the species are. There are many measures of evenness proposed. One of the most common approaches has been to scale one of the heterogeneity measures such as the Shannon-Wiener Diversity measure above, relative to its maximum theoretical value when each species in the sample is represented by the same number of individuals.

$$J = \frac{H}{\log \lambda S}$$ .....(Pielou, 1969).

Where, H is the Shannon-Wiener biodiversity index; and S is the number of species in the community.

Species richness *(R)*

In order to assess how the diversity of the population is distributed or organised among the particular species, this index was calculated.

$$R = \frac{S-1}{\log \lambda N}$$ .....(Margalef, 1958)

Where, S is the total number of species collected and N is the total number of individuals in all the species.

RESULTS AND DISCUSSION

Arthropods collected at weekly intervals during *kharif,* 2012 (Field experiment I) and *rabi,* 2012-13 (Field experiment II) seasons from the bhendi ecosystem were identified to the extent of possible taxons (order, family, genus and species levels) and are presented in Table 1 and Table 2 respectively.

A total of 26 herbivory and 23 predatory insect species were recorded in the bhendi ecosystem. Among the herbivory insect species, a total of 24 genera, 20 families and 5 orders and among the predatory insect species, a total of 21 genera, 11 families and 7 orders were observed in the bhendi ecosystem. Amongst the herbivores, the order hemiptera was the most diversed with 9 species followed by coleoptera (7 species), lepidoptera (6 species), orthoptera (3 species) and thysanoptera (1 species). Amongst the insect families, the order hemiptera consists of maximum 9 families followed by followed by coleoptera (7 families), lepidoptera (6 families), orthoptera (3 families) and thysanoptera (1 family).

Amongst the predators, the order coleoptera was the most

Table 1: Inventory of herbivory insect fauna in bhendi ecosystem

Order	Family	Species
Coleoptera	Cetonidae	*Oxycetonia versicolor* Fabricius
	Chrysomelidae	*Aulacophora foveicollis* Lucas
	Chrysomelidae	*Aulacophora intermedia* Jacoby
	Curculionidae	*Alcidodes affaber* Aurivillius
	Meloidae	*Hycleus balteata* Pallas
	Meloidae	*Hycleus thunbergi* Billberg
	Meloidae	*Mylabris pustulata* Thunberg
Hemiptera	Aleyrodidae	*Bemisia tabaci* Gennadius
	Aphididae	*Aphis gossypii* Glover
	Cicadellidae	*Amrasca biguttula biguttula* Ishida
	Coreidae	*Cletus punctiger* Dallas
	Lygaeidae	*Oxycaraenus hyalipennis* Kirby
	Membracidae	*Tricentrus bicolor* Distant
	Pentatomidae	*Nezara viridula* Linnaeus
	Pseudococcidae	*Ferrisia virgata* Cockerell
	Pyrrhocoridae	*Dysdercus cingulatus* Fabricius
Lepidoptera	Crambidae	*Sylepta derogata* Fabricius
	Gelechiidae	*Pectinophora gossypiella* Saund.
	Noctuidae	*Anomis flava* Fabricius
	Noctuidae	*Helicoverpa armigera* Hubner
	Noctuidae	*Spodoptera litura* Fabricius
	Nolidae	*Earias vittella* Fabricius
Orthoptera	Acrididae	*Acrida exaltata exaltata* Walker
	Acrididae	*Atractomorpha crenulata* Fabricius
	Tettigoniidae	*Phaneroptera gracilis* Burmeister
Thysanoptera	Thripidae	*Thrips tabaci* Linderman

Table 2: Inventory of predatory insect fauna in bhendi ecosystem

Order	Family	Species
Coleoptera	Coccinellidae	*Brumoides suturalis* Fabricius
	Coccinellidae	*Cheilomenes sexmaculata* Fabricius
	Coccinellidae	*Coccinella transversalis* Fabricius
	Coccinellidae	*Harmonia octomaculata* Fabricius
	Coccinellidae	*Illeis cincta* Fabricius
	Coccinellidae	*Micraspis discolor* Fabricius
	Coccinellidae	*Propylea dissecta* Mulsant
	Carabidae	*Ophionea nigrofasciata* Schimdt Goebel
	Staphylinidae	*Paederus fuscipes* Curtis
Hemiptera	Reduviidae	*Rhynocoris* sp.
Hymenoptera	Formicidae	*Camponotus sericeus* Fabricius
	Formicidae	*Camponotus compressus* Fabricius
	Formicidae	*Crematogaster* sp.
	Formicidae	*Paratrechinica longicornis* Latreille
Mantodea	Mantidae	*Mantis* sp.
Neuroptera	Chrysopidae	*Chrysoperla carnea* Stephens
Odonata	Coenagrionidae	*Ischnura aurora* Brauer
	Libullelidae	*Crocothemis servillia* Drury
	Libullelidae	*Diplocodes trivialis* Fabricius
	Libullelidae	*Orthetrum sabina* Drury
Orthoptera	Gryllidae	*Metioche* sp.
	Tettigoniidae	*Conocephalus longipennis* de Haan
	Tettigoniidae	*Conocephalus maculatus* Le Gulliou

diversed with 9 species followed by hymenoptera and odonata (4 species in each), orthoptera (3 species), hemiptera, mantodea and neuropteran (1 species in each). Amongst the insect families, the order coleoptera consists of maximum 9 families followed by followed by hymenoptera and odonata (4 families in each), orthoptera (3 families), hemiptera, mantodea and neuropteran (1 family in each).

Relative abundance

A total number of 3940 individuals were recorded from the survey comprising 22 taxons and 5 orders of herbivore and 22 taxons and 7 orders predators respectively from 288 plants during 12 weeks of crop period, during kharif, 2012 (Table 4).

It was recorded that, the relative abundance (herbivores) of hemiptera, lepidoptera, thysanoptera, coleoptera and orthoptera were 79.27, 9.02, 6.44, 3.64 and 1.63 per cent respectively and the relative abundance (predators) of hymenoptera, coleoptera, odonata, orthoptera, neuroptera, mantodea and hemiptera were 32.43, 28.52, 20.38, 13.7, 3.01, 1.22 and 0.67 per cent respectively. It was observed that the herbivory order hemiptera and the predatory order hymenoptera were relatively abundant followed by other orders.

In rabi, 2012-13, a total number of 3473 individuals were recorded from the survey comprising 22 taxons and 5 orders of herbivore and 21 taxons and 7 orders of predator respectively from 288 plants during 12 weeks of crop period, during kharif, 2012 (Table 4).

It was recorded that, the relative abundance (herbivores) of hemiptera, thysanoptera, lepidoptera, coleoptera and orthoptera were 73.12, 10.50, 8.84, 5.31 and 2.23 per cent respectively and the relative abundance (predators) of coleopteran, hymenoptera, orthoptera, odonata, neuroptera and mantodea were 37.28, 24.13, 19.67, 13.83, 4.80 and 0.22 per cent respectively. It was observed that the herbivory order hemiptera and the predatory order coleoptera were relatively abundant followed by other orders. It was found that the herbivores (77.23 and 74.83%) were relatively abundant followed by predators (22.77 and 25.17%) during *kharif* and *rabi* respectively.

Biodiversity indices

Based on the primary arthropod data, four different indices namely Simpson index (ë), Shannon-Wiener (H), Species evenness (J), Species richness (R) had been calculated for herbivores and predators during *kharif,* 2012 and rabi, 2012-13 and are presented in Table 4.

Species richness index R (Margalef) included total number of individuals apart from number of species. According to this index, species richness of herbivores and predators were 2.62 and 3.08 and 2.67 and 2.95 during *kharif* and *rabi* respectively. It was found that, the species richness of predators were more

Table 3: Relative abundance of major herbivory and predatory insect orders

Order	Relative abundance of herbivores (%)		Relative abundance of predators (%)	
	Kharif	Rabi	Kharif	Rabi
Coleoptera	3.64	5.31	28.52	37.28
Hemiptera	79.27	73.12	0.67	0
Lepidoptera	9.02	8.84	0	0
Orthoptera	1.63	2.23	13.7	19.67
Thysanoptera	6.44	10.50	0	0
Hymenoptera	0	0	32.43	24.13
Mantodea	0	0	1.22	0.22
Neuroptera	0	0	3.01	4.80
Odonata	0	0	20.38	13.83

Table 4: Comparison of diversity, evenness and richness of major insects in bhendi

Season	Taxon	S	N	RA (%)	J	R	H	λ
Kharif	Herbivores	22	3043	77.23	0.74	2.62	2.286	0.155
	Predators	22	897	22.77	0.93	3.08	2.882	0.063
Rabi	Herbivores	22	2599	74.83	0.74	2.67	2.294	0.154
	Predators	21	874	25.17	0.90	2.95	2.757	0.076

S- No. of species, N- Total no. of individuals in all species, RA- Relative abundance, J- Species Evennes, R- Species Richness, H- Shannon-Wiener index, ë - Simpson's Index

than herbivore during both the seasons.

The evenness index (J) of herbivore (0.74 and 0.74) and predators (0.93 and 0.90) during *kharif* and *rabi* respectively indicating the decreasing trend of evenness in predators.

Shannon and Wiener diversity index (H') is the most popular and widely used index in community ecology. It is the average degree of 'uncertainity' and if this average 'uncertainity' increases as the number of species increase and distribution of individuals among the species also become even. It was observed that the Shannon and Wiener diversity index (H') of herbivores and predators was 2.286 and 2.882 and 2.294 and 2.757 respectively, indicating the more or less similar diversification of both categories in both the seasons.

Simpson index (ë) measures the strength of dominance, because it weighs towards the abundance of the most common species and varies inversely with species diversity (Whittaker, 1972). A value of this index ranges from 0 to 1; zero represents no dominance and 1 for maximum dominance *viz*., only one species in the sample (Berger and Parker, 1970). The diversity values (ë) of herbivores and predators were (0.155 and 0.063) and (0.154 and 0.076) respectively, indicated that the diversity was more or less equal.

Mishra and Mishra (2002), Ravikumar *et al*. (2003) and Rajpal and Joshi (2003) reported that, the spiders and beetles were the main defenders in bhendi ecosystem. It was also reported that, 6 species and 4 genera of coccinellids occurred in bhendi ecosystem (Vasconcelos *et al*., 2008). Coccinellids have great importance, since they have proved their value in checking pest populations *viz*; mealybugs, scales, aphids, coccids, etc (Siddhapara *et al*., 2013).

Mandal *et al*. (2006) and Loknath *et al*. (2011) reported that, the jassids, *A. biguttula biguttula* was found to be relatively abundant in occurrence in bhendi. The whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is currently recognized as a species complex with 28 genetic groups or morphologically indistinguishable species (Asha Thomas and Asha Gaur, 2014). Latif *et al*. (2009) reported that, the relative abundance of jassids, *A. biguttula biguttula* (58.37%) was ranked first in respect to the frequency followed by white flies *B. tabaci* and aphids *A. gossypii* in brinjal. It was also stated that coleopteran was the most important predatory insects (42.44%) followed by spiders (30.23%), hymenoptera, hemiptera, neuroptera, diptera, dictyoptera which was about 27.33 per cent of the total arthropods. The present findings are in corroborate with the above findings.

It was concluded that species richness of predators were found to be abundant compared to the herbivores during *kharif,* 2012 and *rabi,* 2012-13. Considering the species diversity indices and species evenness indices, it was found that the predators and herbivores were more or less equal and exhibited a similar diversification in both the seasons.

The biodiversity indices in bhendi was not reported earlier and henceforth the present findings stand as a base for further research in the biodiversity of arthropods in bhendi ecosystem.

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APPLICATION FORM

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