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Diversity of natural enemies on sorghum ecosystem

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Abstract
The intensive study was carried out during karif 2018 at the Tamil Nadu Agricultural University, Coimbatore, to explore the natural enemy diversity in sorghum agro ecosystem. the richness and diversity of natural enemies was measured through the popular standard diversity indices such as Simpson's diversity index, Shannon-Wiener diversity index, Margalef richness index and Pielou's evenness index from seedling to maturity stage. About of 45 species of natural enemy have been documented and identified upto the minimum level of insect families in the taxonomic hierarchy. Insect species belonging to the orders Coleoptera (13), Hemiptera (3), Hymenoptera (23), Diptera (2), Neuroptera (1), Thysanoptera (2) and Dermaptera (1) were recorded and identified. The natural enemy diversity and uniformity in distribution were increasing trend from seedling (H′=0.86, J'=0.27) to the maturity stages (H′=1.73, J'=0.59). The stage specific variation in diversity of natural enemies was observed.

Keywords: Sorghum, natural enemy, diversity indices, Coimbatore

Introduction
The sorghum *Sorghum bicolor* (L.) is a globally important crop due to rich diversity, adaptability to wide range of environmental conditions, unfavorable situations and minimum level of input requirement, etc., Sorghum grains have been a nutritional food source for above 500 million people who lived in food insecurity in more than 30 countries of subtropical and semi-arid area of Africa and Asia (Kumar *et al*. 2011) [1]. More than 150 insect pest were associated with sorghum among them 29 insects were reported as economically important pests (Sharma 1993; Sharma *et al*., 2007) [9] throughout the world. The pest status may vary with geographical region by the influence of various biotic and abiotic factors within the same crop. Natural enemies accountable for around 33 per cent of the pest control in agroecosystems (Getanjaly *et al.*, 2015) [3]. The sorghum shoot fly was elaborately studied for their natural enemy diversity because of their economic importance (Singh and Sharma, 2002) [7].
Biodiversity study made by Daniel and Ramaraju, (2017) [2] in rice ecosystem paved the way to conserve the natural enemy for pest management and who observed the variation in diversity due to geographical region. The season and area under cultivation (Wilby *et al.*, 2006) [12] may influence on diversity. Sherlin *et al.*, (2019) [10] explored the entomofauna diversity of sorghum and found variation across the crop stages. With the above background of information, the present natural enemy diversity was undertaken.

Materials and methods
The exploration of natural enemy diversity in sorghum was conducted at the Millet Breeding Station, New area, Tamil Nadu Agricultural University, Coimbatore during Karif 2018 with the geographical plane of 76° 57' E, 11° 0' N and 420 MSL. The crop was cultivated with standard package of practices given in the crop production guide 2018 excluding the pest management practices. The natural enemy diversity was recorded at weekly intervals during different succession of crop growth from seedling to maturity stages. The individual plant was observed by walking across the crop raised in 100 (4m) ridges and furrows, either in morning hours or late evening by avoiding the hot sun. The insect natural enemy samples were collected and preserved for identification through appropriate dry (stored in freezer) and wet preservation methods (stored in 70% ethanol).
The natural enemies were identified using standard key characters, web based databases and with the help of taxonomists.

The minute insect taxonomic characters were studied by imaging through Leica M205 stereozoom microscope at the Insect Museum, Dept of Agrl. Entomology, TNAU, Coimbatore. As following the standard and popular alpha diversity indices (Whittaker, 1972) were used to measure natural enemy biodiversity in sorghum ecosystem (Table. 1.)

Table 1: Alpha diversity indices used for measuring the crop stage specific diversity of natural enemies

S. No.	Biodiversity indices	Formula	Parameters measured	Reference
1.	**Shannon-Wiener**	$H' = -\Sigma\ Pi \ln (Pi)$	**Species diversity**	**Shannon, 1947**
	Where Pi = the proportion of individuals in the total sample belonging to species i(S/N) S = the total number of individuals of a single species in the sample, N = the total number of individuals in the sample, ln = natural logarithm to the base e.			
2.	**Simpson index**	$D = \Sigma n\ (n-1)\ /\ N\ (N-1)$	**Species dominance**	**Simpson, 1949**
	Where n = the total number of individuals of a particular species N = the total number of individuals of all species.			
3.	**Margaleff's index**	$\alpha = (S-1)\ /\ ln\ (N)$	**Species richness**	**Margalef, 1958**
	Where, S = the total number of species in sample N = the total number of individuals in sample			
4.	**Pielou's index**	$(J) = H'/\ ln\ (S);$	**Species evenness**	**(Pielou, 1966)**
	Where H' = the maximum value of Shannon-Wiener diversity index S = total number of species in the sample			

Results and discussion

Total of 45 species of natural enemies belonging to 25 families under 9 insect orders were documented during this study (Table 2). The parasitoids and predators diversity by Shannon-Weaver diversity index is indicator of richness and uniformity, was increasing from seedling (H′ = 0.86), flowering (H′ = 1.22), vegetative stage (H′ = 1.57) and maturity stage (H′ = 1.73), which ranged between 0 and 5 indicating the rich in diversity and evenness as the value increase (Table. 3).

Therefore, it indicates the increasing uniformity in distribution of species during the growth stages. This uniformity in species distribution identified by Shannon-Weaver diversity index is reconfirmed with Pielou's evenness index, expressing maximum at maturity stage (EI = 0.59) of sorghum.

The dominance was measured by the Simpson's dominance index, fell in line with the results of Shannon-Weaver diversity index and pielou's evenness index ranging from 0.38 to 0.78. Simpson's dominance index shows the species dominance and diversity ranging from 0-1 and increase in this value indicates the increase in the dominance and diversity, reconfirming the Shannon-Weaver diversity index.

The species richness was measured using Margaleff's richness index. It differed in all the four stages, maximum during vegetative (α =4.21) followed by flowering (α =2.84) and seedling (α =2.44) stages, while the least in the maturity stage (α =2.2).

The natural enemy diversity, dominance and evenness were found to increase from the seedling to maturity stage in accordance with the development of pest population during karif 2018. Due to the adequate pest availability as a food sources for predators and parasitoids in addition to the sequential presence of pollen and nectar for the adult natural enemy. The increase in higher diversity of natural enemy may also attributed to the pesticide free environmental zone and also prevailed conducive climatic conditions, supported by dense crop growth may lead to successful eco-friendly pest management by assessing the pest population build up and diversity of natural enemies as influenced by various biotic and abiotic factors.

Table 2: List of insects observed in sorghum agro eco system (kharif 2018)

S. No.	Order	Family	Insect
1	Coleoptera	Carabidae	*Bradycellus* spp.
2		Coccinellidae	*Cheilomenes sexmaculata* (Fabricius)
3			*Chilocorus melas* Weise
4			*Coccinella transversalis* (Fabricius)
5			*Cryptogonus quadriguttatus* (Weise)
6			*Cryptolaemus montrouzieri* Mulsant
7			*Illeis* spp.
8			*Jauravia dorsalis* (Weise)
9			*Micraspis* spp.
10			*Propylea dissecta* (Mulsant)
11			*Scymnus nubilus* Mulsant
12			*Stethorus pauperculus* (Weise)
13		Staphylinidae	*Paederus fuscipes* Curtis
14	Hymenoptera	Bethylidae	*Goniozus indicus* Muese
15		Braconidae	*Cotesia* sp.
16			*Myosoma chinensis* (Szepligeti)
17			*Stenobracon nicevielli* (Bingham)
18		Chalcididae	*Antrocephalus nasutus* (Holmgren)
19			*Antrocephalus* sp. 1
20			*Antrocephalus* sp. 2
21			*Dirhinus anthracia* Walker
22		Eulophidae	*Aprostocetus* spp.

23			*Aprostocetus* spp.
24			*Neotrichoporoides* sp.
25			*Neotrichoporoides nyemitawus* Rohwer
26			Unidentified
27		Figitidae	Unidentified
28		Formicidae	*Camponotus compressus* (Fabricius)
29			*Solenopsis* spp.
30		Ichneumonidae	*Isotima* sp.
31		Mutillidae	*Zavitilla* spp.
32		Pristocerinae	Unidentified
33		Sphecidae	*Sceliphron* spp.
34		Pteromalidae	*Spalangia endius* Walker
35		Trichogramatidae	*Trichogramma* spp.
36		Vespidae	*Ropalidia marginata* lepeletier
37	Hemiptera	Geocoridae	*Geocoris* spp.
38		Miridae	*Orius* spp.
39		Pentatomidae	*Eocanthecona furcellata*
40	Diptera	Dolichopodidae	Long legged fly
41		Hybotidae	Unidentified
42	Thysanoptera	Haplothripinae	*Thrips* sp. 1
43		Phlaethripidae	*Thrips* sp. 2
44	Neuroptera	Mantispidae	Mantispid fly
45	Dermaptera		Unidentified

Table 3: Diversity index of natural enemies in irrigated sorghum ecosystem (karif 2018)

Crop stage	Diversity index			
	H′	1-D	α	E1
Seedling	0.86	0.38	2.44	0.27
Vegetative	1.22	0.45	4.21	0.35
Flowering	1.57	0.72	2.84	0.50
Maturity	1.73	0.78	2.2	0.59

H′- Shannon-Weaver diversity index, 1-D - Simpson's index of diversity, α - Margaleff's richness index, E1- Pielou's evenness index

Conclusion

Of the natural enemy observed the parasitoid group was dominated by hymenoptera 23 out of 45 species, while the predators by coleoptera 10 out of 45 species. The incidence and distribution of natural enemy in accordance with the developing crop stages indicating a general increasing trend recommending the necessity for assessment of bio-diversity for economical eco-friendly pest management.

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