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DIVERSITY OF ENCYRTID PARASITOIDS FROM THREE ECOSYSTEMS

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ABSTRACT

Encyrtid parasitoids play an important role in the biological control of many agricultural as well as horticultural pests. The present study determines and compares the faunal and temporal diversities of Encyrtidae in finger millet, rice and sugarcane ecosystems at the College of Agriculture, V C Farm, Mandya, Karnataka. The study was conducted at fortnightly intervals over a period of 12 months from March, 2016 to February, 2017 at the G and C-blocks of the farm. As a result, 2647 encyrtids were collected- 1019 specimens (20 genera) were from finger millet; 604 (22 genera) and 1024 (29 genera) were from rice and sugarcane ecosystems, respectively. The abundance, Shannon-Wiener index, Simpson index and richness (Margalef's index) were computed and it was concluded that maximum diversity occurred in sugarcane and rice ecosystems (H′=3.00) and the least was with the finger millet ecosystem (H′=.2.78). Bray-Curtis cluster analysis and Metric Multidimensional scaling analysis were made to study the similarity and encyrtid diversity in different seasons.

Key words: Encyrtidae, Mandya, abundance, rice, finger millet, sugarcane, Shannon-Wiener index, Simpson index, richness (Margalef's index), Bray-Curtis analysis

Encyrtidae is one of the largest families of superfamily Chalcidoidea of parasitic Hymenoptera group and they are highly diverse micro-hymenopterans with 3710 described species under 455 genera (Noyes and Valentine, 1989). At present, 742 species of Encyrtidae are known from India (Noyes, 2020). Hymenopterans act as useful biodiversity indicators as their abundance and richness reflect the diversity of other arthropods (Anderson et al., 2011). Encyrtids play an important role in communities, as they are endoparasitoids or hyperparasitoids of other arthropod pests and have the greatest impact on maintaining the diversity. These can be used as efficient biological control agents against key insect pests, and are important primary parasitoids of mealybug, scales, aphids and also other insects like Lepidoptera, Neuroptera and the eggs of ticks and spiders (Hayat, 2006). Three important crops viz., finger millet, rice and sugarcane of Karnataka were selected for the present study. Their cultivation practices differ significantly with finger millet being a rainfed crop, sugarcane an irrigated crop and rice, a crop that is submerged in water throughout its growth period. In addition, sugarcane is an annual crop; rice and finger millet are seasonal in nature. Plant architecture too varies between these crops. The interplay of these factors can be expected to impact the diversity as well as faunal composition of encyrtid parasitoids.

MATERIALS AND METHOD

This study was conducted to determine and compare the faunal and temporal diversities of encyrtids in finger millet, rice and sugarcane ecosystems at the College of Agriculture, V C Farm, Mandya, Karnataka under southern dry zone of Karnataka (12°34.3'N, 76°49.8'E, 697 masl). The study was conducted over a period of 12 months from March, 2016 to February, 2017 at the G and C-blocks of the farm. Rice was cultivated in C block of an area of 2 ha and G block where the finger millet and sugarcane crops were grown in an area of 1 and 4 ha, respectively. A distance between the finger millet and sugarcane crops in G block is half a km. The varieties of finger millet grown in the first cropping season were MR-1 and MR-6 and in the 2nd season were INDOF-9 and INDOF-7. Hybrid lines of rice were grown in both cropping seasons, while VCF-0517 variety of sugarcane was grown in both seasons of study period. Yellow pan traps (YPT) work on the principle of yellow colour being attractive to insects (Hollingworth et al., 1970). Twenty yellow pan traps (21cm dia., 2cm deep) were laid on the ground, randomly at fortnightly intervals from March (79th Julian day), 2016 to February

(49th Julian days), 2017 in each of the three ecosystems of experiment site to collect encyrtid parasitoids. Twenty-four hours after the installation of the traps, the contents (water plus the trapped insects) were sieved and collected in 70% ethanol for further sorting. The samples collected contained Hymenoptera, Diptera, Coleoptera, Lepidoptera, Collembolans, Diplurans, etc., Encyrtidae were sorted under a stereozoom microscope, and were identified up to generic level through the keys provided by Hayat (2006) and Noyes and Hayat (1994).

Generic abundance data were tabulated and analysed across time to ascertain the temporal changes in the diversity of Encyrtidae in finger millet, rice and sugarcane ecosystems. Generic richness (Margalef's diversity index D_{mg} = S-1 / ln N, Where, S is the number of genera recorded and N is the number of individuals combined of all S genera), Shannon-Wiener index ($H' = - \sum Pi \ln Pi$ …………… Eq. 1, Where, Pi = Proportion of individuals of genera i) and Simpson index ($D = 1-\sum Pi^2$ ……………… Eq. 2, Pi = Proportion of individuals of genera i) were estimated. Multivariate analyses such as Bray Curtis Cluster analysis and Metric Multidimensional scaling (M-MDS) analysis were done using PRIMER version 7.0.5 (Clarke and Gorley, 2015). Abbreviations used: ACE – *Acerophagus*; ADE – *Adelencyrtus*; AGA – *Agarwalencyrtus*; ALO – *Aloencyrtus*; ALA – *Alamella*; ANA – *Anagyrus*; ANI – *Anicetus*; ANO – *Anomalicornia*; APO – *Apoleptomastix*; BLE – *Blepyrus*; CAL – *Callipteroma*; CHE - *Cheiloneurus*; COP - *Copidosoma*; DIV - *Diversinervus*; ENC - *Encyrtus*; GEN - *Gentakola*; HOM - *Homalotylus*; LEP - *Leptomastix*; MET - *Metaphaenodiscus*; MEP - *Metaphycus*; MIC - *Microterys*; NEO - *Neodusmetia*; OOE - *Ooencyrtus*; PEN - *Pentelicus*; PRO - *Prochiloneurus*; PRT - *Protyndarichoides*; RHO - *Rhopus*; SAK - *Sakencyrtus*; TAS- *Tassonia*; ZAP - *Zaplatycerus*.

RESULTS AND DISCUSSION

Abundance: A total of 2647 encyrtids were collected from finger millet, rice and sugarcane ecosystem. Among these, 1019 individuals belonging to 20 genera were from finger millet ecosystem, 604 individuals of 22 genera and 1024 individuals of 29 genera in rice and sugarcane ecosystems, respectively. Crop architecture too is similar in all these crops. Increasing complexity in canopy density is also noticed with abundance increasing progressively from finger millet to rice to sugarcane. Waschke et al. (2014) stated that the increasing parasitoid diversity and abundance is direct proportional to the plant diversity and foliage. As results of one year survey, 30 genera of Encyrtidae were collected from finger millet, rice and sugarcane ecosystems. *Encyrtus, Homalotylus* and *Sakencyrtus* were only collected from finger millet and sugarcane ecosystems. *Anicetus, Protyndarichoides, Metaphaenodiscus* and *Procheiloneurus* were only recorded in the rice and sugarcane ecosystems. *Zaplatycerus* were found exclusively in the rice ecosystem. *Microterys, Gentakola, Pentelicus, Agarwalencyrtus* and *Alamella* were collected from the sugarcane ecosystem (Table 1). These findings are supported by Randhawa et al. (2006) where, *Copidosoma* sp. and *Copidosomopsis nacoleiae* on rice leaf folder *Cnaphalocrocis medinalis* from India was reported and Dung (2006) reported *Copidosomopsis coni* from Vietnam. Similarly, Sallam (2006) reviewed and listed the major parasitoid families viz., Encyrtidae, Bethylidae, Braconidae,

Table 1. Richness and abundance of encyrtid parasitoids (March-2016 to February-2017)

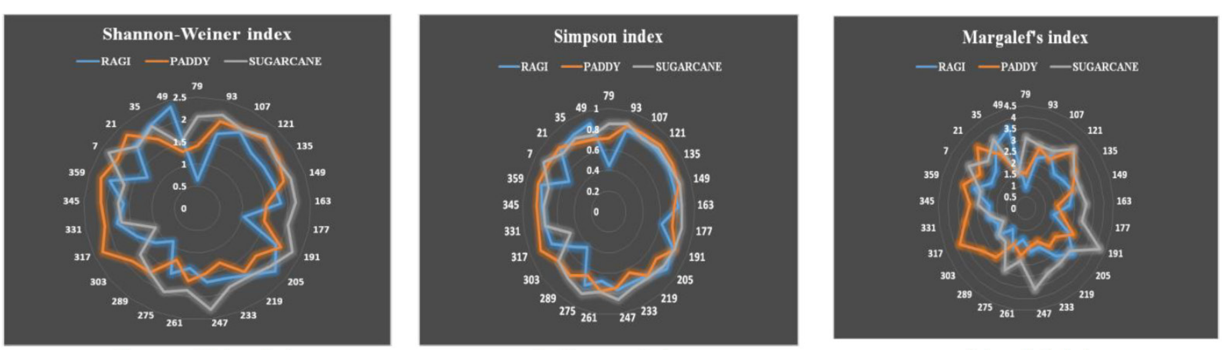
Sl. No.	Generic richness	Abundance		
		Finger millet	Rice	Sugarcane
1	*Acerophagus*	46	13	101
2	*Adelencyrtus*	9	12	11
3	*Agarwalencyrtus*	0	0	10
4	*Alamella*	0	0	8
5	*Aloencyrtus*	56	6	14
6	*Anagyrus*	32	22	44
7	*Anicetus*	0	14	13
8	*Anomalicornia*	73	12	9
9	*Apoleptomastix*	13	8	35
10	*Blepyrus*	4	6	4
11	*Callipteroma*	10	14	18
12	*Cheiloneurus*	53	32	17
13	*Copidosoma*	438	113	277
14	*Diversinervus*	3	18	11
15	*Encyrtus*	1	0	8
16	*Gentakola*	0	0	9
17	*Homalotylus*	15	0	24
18	*Leptomastix*	6	7	21
19	*Metaphaenodiscus*	0	14	17
20	*Metaphycus*	119	47	92
21	*Microterys*	0	0	6
22	*Neodusmetia*	42	164	107
23	*Ooencyrtus*	26	19	103
24	*Pentelicus*	0	0	5
25	*Procheiloneurus*	0	9	10
26	*Protyndarichoides*	0	12	9
27	*Rhopus*	48	35	25
28	*Sakencyrtus*	4	0	5
29	*Tassonia*	21	14	11
30	*Zaplatycerus*	0	13	0
	Total	1019	604	1024

Chalcididae, Elasmidae, Eucoilidae, Eulophidae, Ichneumonidae, Eupelmidae, Pteromalidae, Scelionidae and Trichogrammatidae on sugarcane pests. The genus *Copidosoma* (438 individuals), *Neodusmetia* (164 individuals), *Copidosoma* (277 individuals) were the most abundant in finger millet, rice and sugarcane ecosystems, respectively, whereas, the least abundant genus was *Encyrtus* (1 individual) in finger millet; *Blepyrus* and *Aloencyrtus* (6 individuals) in rice and *Blepyrus* (4 individuals) in sugarcane ecosystem (Table 1). *Copidosoma* is most abundant in three ecosystems because these individuals are major egg larval parasitoids of many lepidopteran pests. *Cheiloneurus* sp. had been recorded as a hyperparasitoid of dryinids on *N. lugens* in Vietnam (Lam, 2002).

Diversity: The Shannon-Wiener index diversity values for the three ecosystems revealed that it was more or less similar, with maximum diversity accounted for the sugarcane and rice ecosystems (H′=3.00) and the least diversity in the finger millet ecosystem (H′=.2.78). The Simpson's index values were near to one for all the three ecosystems, even though there was a difference in the assemblages of the parasitoids. The sugarcane (0.94) and rice (0.94) ecosystems showed maximum Simpson's index, followed by finger millet (0.92) ecosystem. From the values of the Margalef index (α), it was observed that the sugarcane ecosystem was very rich in genera with a richness value of 3.53, followed by finger millet (3.35) and rice (3.25) with closely similar values. Thus, it is clear that species diversity and richness did not vary greatly between the ecosystems. Crop architecture too is similar in all these crops. Increasing complexity in canopy density can however be noticed with diversity increasing progressively from finger millet to rice to sugarcane. The majority of the studies reviewed by Waschke et al. (2014) revealed an increasing parasitoid diversity and abundance as a result of increased plant diversity and foliage.

Temporal variation and generic richness: The highest Shannon-Wiener index, Simpson index and Margalef's index, 2.36, 0.88, 3.60, respectively were observed during monsoon whereas the least of Shannon-Wiener (0.63), Simpson (0.44) and Margalef's indices (0.91) were observed during early summer (Fig. 1a-c). Encyrtid parasitoids were the most abundant during the monsoon, because of the lush growth of the crops as well as weeds and also a large number of plants resources. The availability of hosts and plentiness of nectar enabled the increase in parasitoids. Though the number of individuals varied significantly, very little variation was noticed in the number and composition of the families of parasitoids. Daniel et al. (2020) also compared the diversity of parasitic Aculeata in high rainfall zone and dry zone (Cauvery delta zone) and results revealed that, the high rainfall zone was the most diverse and the dry zone (Cauvery delta zone) become the least diverse. The population of encyrtid parasitoids were the least during summer and post monsoon months due to high temperature, less rainfall and availability of host as well as plant resources. Similarly, Anbalagan et al. (2015) stated that the parasitoid abundance and diversity were maximum during the monsoon and winter seasons. In Mandya, the diversity and abundance of parasitoids was more in monsoon followed by summer.

Bray Curtis cluster Analysis and M-MDS analysis: In rice, the data showed that there were three clusters formed between the seasons- 1. post monsoon (75% similarity); 2. a mixed cluster between post monsoon and winter (December-16 and February 17); 3. again, a mixed cluster between summer and monsoon season (April 16 and July 16) (Fig. 2a). The collected raw data from rice ecosystem are highly validated through M-MDS. The analysis revealed the high diversity status of Encyrtidae parasitoids observed between the seasons of post monsoon and winter (December 16- February 17). The contribution of CHE,



a. Shannon-Weiner index b. Simpson index c. Margale index

Fig. 1. Temporal variation in diversity of Encyrtidae in finger millet, rice and sugarcane ecosystems

TAS, PRT, ADE, ANO and OOE were observed more towards the seasons between summer and monsoon (April 16- July 16) (Fig. 3a). In finger millet, there were three clusters- 1. that formed between summer and early monsoon period (April 16- June 16); 2. that formed between 3 different seasons (July 16, December 16 and February 17); and the third also between 3 seasons (August 16- November 16 and January 17) (Fig. 2b). The collected raw data from finger millet ecosystem are highly validated through M-MDS. The analysis showed that there was maximum diversity of encyrtid parasitoids observed in two seasons such as monsoon (August 16) and winter (January 17- February 17). The contribution of DIV, ADE, CHE, CAL, MEP, ALO, COP, HOM, ANO, NEO and ACE were observed to be more towards the seasons such as monsoon (August 16), post monsoon (October- November 16) and winter (January 17) (Fig. 3b). About sugarcane, again there were 3 clusters formed with post monsoon, monsoon and summer (Fig. 2c); the raw data are highly validated through M-MDS. The analysis showed that there was maximum diversity of Encyrtidae parasitoids observed between the seasons summer and monsoon (April- September 16). The most influencing variable during the seasons were ALO, ANO, NEO, LEP, CAL, COP, OOE, PRT, APO, SAK, and ALA (Fig. 3c).

Univariate as well as multivariate analyses shows that the diversity of encyrtid parasitoids were rich in sugarcane followed by rice and finger millet ecosystems. The genus *Copidosoma* is the most abundant in finger millet and sugarcane ecosystems because of it is polyembryony and on of larvae of moths in the subfamily Plusiinae (Noctuidae). The lepidopteran (Noctuidae) pest incidence is usually more in finger millet and sugarcane as compared to rice ecosystem, hence the abundance of *Copidosoma* was more. The genus *Neodusmetia* is more abundant in rice ecosystem because these are parasitoids of Rhodes grass scale, *Antonina graminis* (Green). These scales feed on grasses like *Cynodon dactylon*, *Rhodes* grass, *Eragrastes ciliaris* (Dean et al., 1979). In general, the growth of the above listed grasses more in rice ecosystem as compared to other two ecosystems. The diversity and generic richness of Encyrtidae were more in monsoon season compare to winter and summer. In the entire crop ecosystems, March 16 got outliered due to the less diversity of encyrtid parasitoids.

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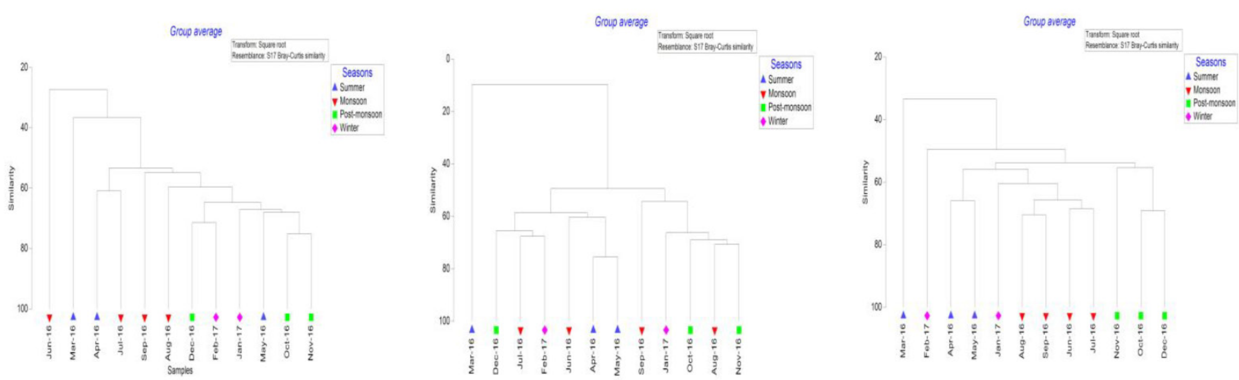
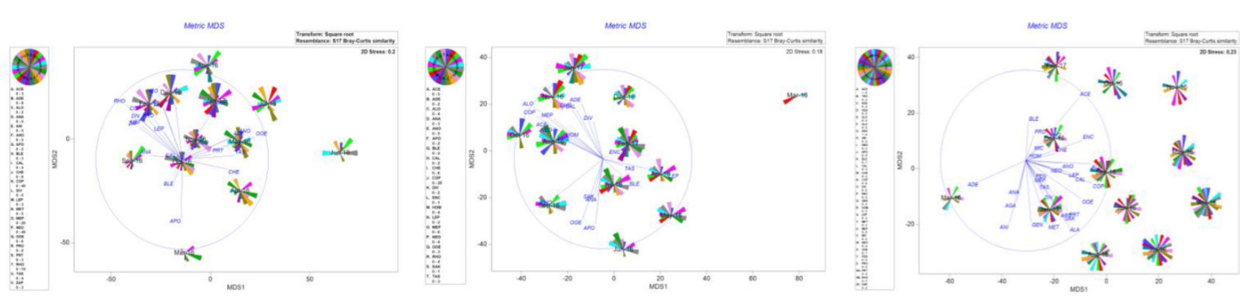


a. Rice ecosystem b. Finger millet ecosystem c. Sugarcane ecosystem

Fig. 2. Brays-Curtis cluster analysis- formation of cluster between the seasons



a. Rice ecosystem b. Finger millet c. Sugarcane

Fig. 3. M-MDS analysis- diversity status of encyrtid parasitoids among seasons

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