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Influence of rice crop stage on the distribution of hymenopteran parasitoids of insect pests

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ABSTRACT: A total of 43 insect parasitoid species belonging to fourteen families (Aphelinidae, Braconidae, Ceraphronidae, Diapriidae, Encyrtidae, Eulophidae, Eurytomidae, Ichneumonidae, Megaspilidae, Mymaridae, Platygasteridae, Proctotrupidae, Pteromalidae, Trichogrammatidae) has been documented in the rice ecosystem using yellow pan trap. The observations were made at four important stages of rice crop like early tillering, active tillering, booting and panicle development. The parasitoids were also compared with the occurrence of sixteen insect pests that were recorded simultaneously in each stage of the crop. The result revealed that, there is a significant difference in the occurrence of parasitoids according to the stage of the crop and insect host availability. This understanding help in the introduction of specific parasitoids at respective stages for effective biocontrol.

KEY WORDS: Stages of rice, parasitoids, yellow pan trap, insect pests

INTRODUCTION

Rice is an important food crop and India plays a significant role in its production. India has approximately 44 million hectares of land under rice cultivation. But the increasing human population in the country like India have created more demand for food crops. With demand on food crop increase on one hand, the population of insects also are likely to increase due to global warming. This can cause serious loss to the agricultural ecosystem. Global yield losses of these grains due to pests and pathogens are projected to be around 24.6 to 40.9 per cent (Savary *et al.,* 2019). In order to effectively and sustainably control the insect pests, biological control by the use of natural enemies is highly demanded. However good understanding on the diversity of natural enemies in each stage of crop development is lacking. Among the natural enemies, hymenopteran parasitoids are highly significant as it can be used as efficient biocontrol agents due to its host specificity (Dey *et al.*, 1999).

In order to monitor the activity of these parasitoids in rice ecosystem, yellow pan trap proves to be highly efficient (Daniel *et al.*, 2018). This trap

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works on the principle of insect's attractive response towards yellow colour (Kennedy *et al*., 1961; Hollingsworth *et al*., 1970). The current study uses this trap to effectively monitor the variation in the occurrence of the parasitoid species at four important stages of rice crop like early tillering, active tillering, booting and panicle development. These stages were also monitored for the prevalence of insect pests so as to understand the relationship of pest and parasitoid populations at specific host plant stages. This understanding will help in better implementation of biocontrol in integrated pest management programs.

MATERIALS AND METHODS

A paddy field of 400 square meters was taken for the study. The field was located at the wetland, Tamil Nadu Agricultural University, Coimbatore. GPS coordinates of the location is 11.0031° N, 76.9249° E. Inside the field, 16 locations were selected for sampling. Samples were drawn at the four important stages of rice crop like early tillering (2-3 leaf stage), active tillering, booting and panicle development.

Yellow pan traps were used for the collection of parasitoids. The trap pans are bright yellow in colour with a size of 133mm x 195mm and a depth of 48 mm. The traps were filled to 3/4th with soap solution mixture. The mixture consists of water, drops of liquid detergent (to break the surface tension) and a pinch of salt (to reduce the rate of evaporation and prevent rotting of trapped insects). At each stage of the crop the traps were placed randomly in 16 places in the field. The traps were placed in between the plants over a flat heap made of clay soil in order to prevent its floating in the field water. After a day, the traps containing the insects were collected in a polythene cover and taken to the laboratory for further washing and preservation. The specimens were preserved in 70% ethanol and refrigerated. Sorting and Identification of the specimens were done under the Leica stereo zoom microscope (Model: M205 C) and also with the help of Stemi (Zeiss) 2000C stereo zoom compound microscope. Taxonomic literature and keys of authors like Narendran (1994), Jonathan (2006), Rajmohana (2006) and Sureshan (2008) were used for initial identification. In addition, help was also taken by referring to the already identified collection of parasitoids at Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore. The identified parasitoid species were also verified from the list of parasitoids in rice ecosystem published by Daniel and Ramaraju, (2019) and Noyes, (2017). Identified collections are deposited at Insect Biosystematics laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Some of the major and minor insect pests of the rice were also recorded during these four stages of the plant. At each stage of the crop, 16 plots were selected and in each plot 15 plants were observed *insitu* for the occurrence of hopper pests and thrips. Sweep net collection was made randomly at sixteen places in the field for remaining pests. Return sweeping were done twice in each place at each stage of the crop.

Shapiro-Wilk normality test was applied to the data using R to check for normality distribution of the data. Since the data was not normally distributed (P value < 0.05), non-parametric Kruskal wallis test was used for analysis. Both the P and H value to the test were noted. These statistical analyses were performed using SPSS.

RESULTS AND DISCUSSION

A total of 43 hymenopteran parasitoids were observed in the yellow pan trap collection. There belonged to families like Aphelinidae, Braconidae, Ceraphronidae, Diapriidae, Encyrtidae, Eulophidae, Eurytomidae, Ichneumonidae, Megaspilidae, Mymaridae, Platygasteridae, Platygasteroidea, Proctotrupidae, Pteromalidae and Trichogrammatidae.

Significant differences in the occurrence of parasitoids at each stage of rice were observed using the non-parametric Kruskal wallis test in fourteen parasitoid species. They include *Apanteles* sp. (P value = 0.026), *Opius* sp. (P = 0.000), Undetermined diaprid (P = 0.001), *Tetrastichus* sp. (P = 0.001), two undetermined eulophid species

(P = 0.001), *Anagyrus* sp. (P = 0.000), *Dicopus* sp. (P = 0.000), *Lymaenon* sp. (P = 0.000), *Mymar* sp. (P = 0.028), *Baeus* sp. (P = 0.000), undetermined species of platygasteroidea (P = 0.006), *Telenomus* sp. (P = 0.047) and *Trichogramma* sp. (P = 0.002) (Table 1). Similar to the parasitoids, insect pests (except flea beetle) were also found to differ significantly according to the age of the crop (Table 2).

The variation in the occurrence of parasitoids according to the stage of the crop can be compared with the pest infestation in the field. Pests like thrips, yellow stem borer, leaf folder, green leaf hopper, brown plant hopper, white backed plant hopper, white hopper, hispa, green horned caterpillar, skipper, flea beetle, grass hopper, black bug, ear head bug, hairy caterpillar and stink bug were recorded during the four stages of rice plant. Higher occurrence of rice yellow stem borer *Scirpophaga incertulas*, Walker were found on booting stage followed by panicle development stage during which its egg parasitoids like *Tetrastichus, Trichogramma* and *Telenomus* were very minimum. However, the larval parasitoids like Ichneumonids were very active during booting stage. This implies that the parasitoids of stem borers are found to occur according to the developmental stage of the crop and insect host availability. *Anagyrus* sp., an egg parasitoid of plant and leaf hoppers was higher in the early tillering stage keeping the population of the hoppers in control. Other mymarids were found to be prevalent throughout the stages of the rice plant according to the availability of the hopper. Like the parasitoids of yellow stem borer, mymarids (parasitoids of hoppers) were also observed to show preferences according to the stage of the crop in relation to pest occurrence. Larval parasitoids *viz.*

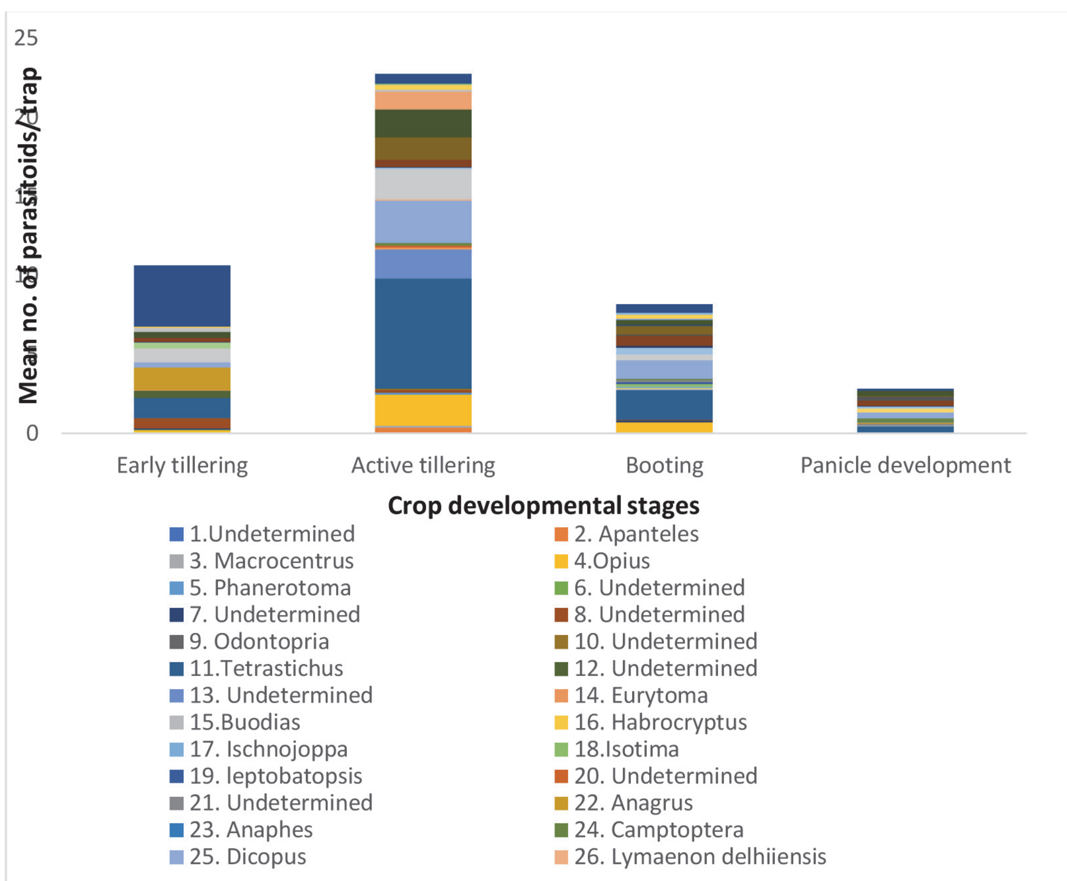

Fig. 1. Hymenopteran parasitoids occurrence in each stage of rice crop

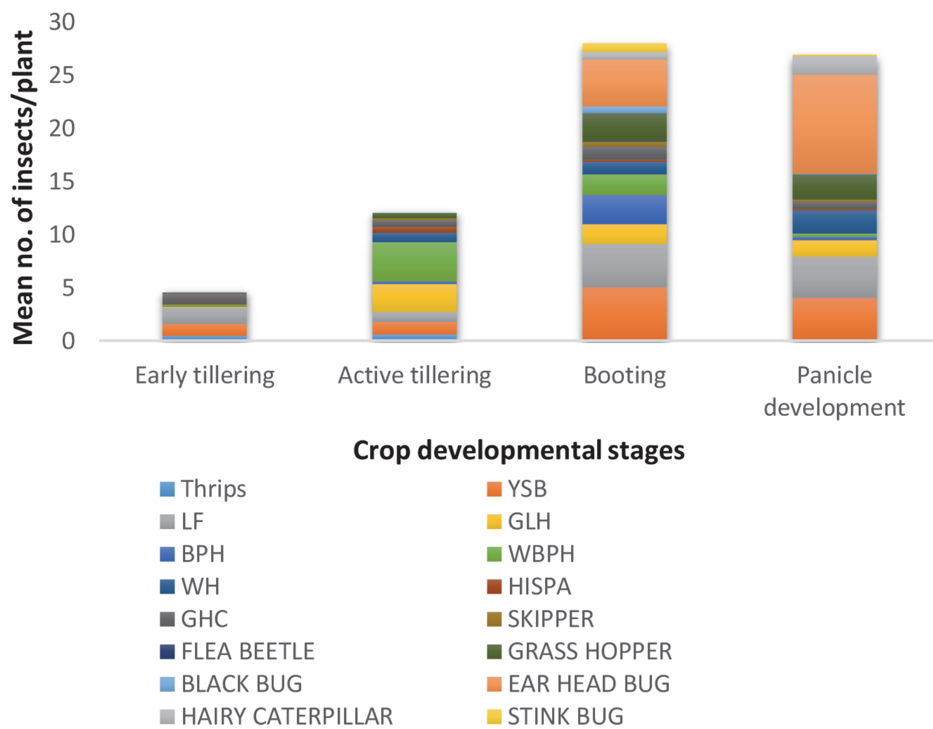

Fig. 2. Distribution of rice insect pests in each stage of rice crop

braconids (*Apanteles* sp.) and ichneumonids were observed to be active in each stages of the rice plant and managed the population of other minor pests like rice horned caterpillar and rice skipper (Devi and Varatharajan, 2013; Hendawy *et al*., 2016). Certain parasitoid species like *Tetrastichus, Trichogramma, Duta indica*, *Calliscelio indicus*, *Dicopus* sp. and certain unidentified platygastroidea were found throughout the stages of rice plant. These results imply that the parasitoids are distributed throughout the period of host availability however, their occurrence is also dependent on the stage of the crop development. Their significant difference according to the stage of the crop was also confirmed with the statistical analysis.

Host specific occurrence of the parasitoids were also observed in case of egg parasitoids of rice ear head bug. The *Gryon orestes* was observed only in the rice booting and panicle development stage according to the period of their host occurrence. The egg parasitoid of grasshopper *Duta indica* and *Calliscelio indicus* were observed throughout the stages of the plant though the grasshoppers were not observed in the early tillering stage of the crop. The presence of *Duta* during the early tillering stage of the crop might be due to the attraction of the parastioid from the neighbouring field with matured rice crop. Relationship between the insect host and parasitoids was also reported by Daniel *et al.* (2019).

From the results of the present study, it is interesting to observe the fluctuation in the occurrence of parasitoid species according to the developmental stage of the crop irrespective of the host availability. Similar trend was observed among the parasitoids of *Spodoptera frugiperda* in maize (Durocher-Granger *et al.*, 2020). Overall, among the four stages of rice observed, the presence of parasitoids were higher during the active tillering stage followed by early tillering of the crop (Fig. 1). While a greater number of pests occurred in the booting stage followed by panicle

Table 1. Distribution of parasitoids in each stage of the rice crop

No.	Parasitoids	Family	Mean no. of parasitoids/trap				Kruskal wallis test	
			Early tillering stage	Active tillering stage	Booting stage	Panicle stage	H value	P value
1.	Undetermined species	Aphelinidae	0.00	0.00	0.12	0.00	3.000	0.392
2.	*Apanteles* sp.	Braconidae	0.00	0.71	0.00	0.00	9.289	0.026*
3.	*Macrocentrus* sp.	Braconidae	0.00	0.24	0.00	0.00	6.097	0.107
4.	*Opius* sp.	Bracondiae	0.35	3.65	1.18	0.00	17.939	0.000*
5.	*Phanerotoma* sp.	Braconidae	0.00	0.24	0.00	0.00	6.097	0.107
6.	Undetermined species	Braconidae	0.12	0.00	0.00	0.00	3.000	0.392
7.	Undetermined species	Ceraphronidae	0.12	0.00	0.24	0.00	3.787	0.285
8.	Undetermined species	Diapriidae	1.18	0.35	0.12	0.00	16.371	0.001*
9.	*Odontopria* sp.	Diapriidae	0.12	0.00	0.00	0.00	3.000	0.392
10.	Undetermined species	Encyrtidae	0.00	0.12	0.00	0.00	3.000	0.392
11.	*Tetrastichus* sp.	Eulophidae	2.35	13.18	3.53	0.82	15.535	0.001*
12.	Undetermined species	Eulophidae	0.82	0.00	0.00	0.00	19.525	0.000*
13.	Undetermined species	Eulophidae	0.00	3.41	0.00	0.00	23.113	0.000*
14.	*Eurytoma* sp.	Eurytomidae	0.12	0.24	0.00	0.00	2.033	0.566
15.	*Buodias* sp.	Ichneumonidae	0.00	0.00	0.12	0.12	2.032	0.566
16.	*Habrocryptus* sp.	Ichneumonidae	0.00	0.00	0.12	0.00	3.000	0.392
17.	*Ischnojoppa luteator*	Ichneumonidae	0.00	0.00	0.12	0.00	3.000	0.392
18.	*Isotima* sp.	Ichneumonidae	0.00	0.00	0.35	0.00	6.095	0.107
19.	*Leptobatopsis indica*	Ichneumonidae	0.00	0.00	0.24	0.00	3.000	0.392
20.	Undetermined species	Ichneumonidae	0.00	0.24	0.00	0.00	3.000	0.392
21.	Undetermined species	Megaspilidae	0.00	0.00	0.24	0.24	3.702	0.296
22.	*Anagrus* sp.	Mymaridae	2.71	0.00	0.00	0.12	27.072	0.000*
23.	*Anaphes* sp.	Mymaridae	0.00	0.00	0.00	0.12	3.000	0.392
24.	*Camptoptera* sp.	Mymaridae	0.00	0.35	0.12	0.35	3.575	0.311
25.	*Dicopus* sp.	Mymaridae	0.59	5.06	2.24	0.71	20.728	0.000*
26.	*Lymaenon delhiensis*	Mymaridae	0.00	0.12	0.00	0.00	3.0000	0.392
27.	*Lymaenon* sp.	Mymaridae	1.65	3.65	0.71	0.00	20.352	0.000*
28.	*Mymar pulchellum*	Mymaridae	0.00	0.00	0.00	0.47	6.095	0.107
29.	*Mymar* sp.	Mymaridae	0.00	0.12	0.82	0.24	3.000	0.028*
30.	Undetermined species	Mymaridae	0.71	0.00	0.00	0.00	9.136	0.392
31.	*Calliscelio indicus*	Platygastridae	0.12	0.12	0.24	0.12	0.641	0.887
32.	*Duta indica.*	Platygastridae	0.47	0.82	1.18	0.59	6.670	0.083
33.	*Gryon orestes*	Platygastridae	0.00	0.00	0.12	0.47	9.183	0.027
34.	*Baeus* sp.	Platygastroidea	0.00	2.71	1.06	0.12	19.758	0.000*
35.	*Macroteleia* sp.	Platygastroidea	0.00	0.00	0.12	0.00	3.000	0.392
36.	Undetermined species	Platygastroidea	0.71	3.29	0.59	0.59	1.731	0.630
37.	Undetermined species	Platygastroidea	0.00	0.00	0.12	0.00	3.000	0.392
38.	Undetermined species	Platygastroidea	0.00	2.12	0.00	0.00	12.584	0.006*
39.	*Telenomus* sp.	Platygastroidea	0.47	0.24	0.00	0.00	7.966	0.047*
40.	Undetermined species	Proctotrupidae	0.12	0.59	0.47	0.00	5.677	0.128
41.	Undetermined species	Pteromalidae	0.00	0.00	0.24	0.00	6.097	0.107
42.	*Trichogramma* sp.	Trichogrammatidae	0.00	0.12	0.00	0.00	3.000	0.392
43.	*Trichogramma* sp.	Trichogrammatidae	7.29	1.18	1.06	0.24	15.325	0.002*

*Indicates significant value ($p < 0.05$) of non-parametric Kruskal wallis test.

Table 2. Distribution of rice insect pests according to the stage of crop development

No.	Pests	Mean no. of pests/plant or sweep				Kruskal wallis test	
		Early tillering stage	Active tillering stage	Booting stage	Panicle development stage	Chi square value	P value
1.	Thrips	0.8	1	0	0	8.853	0.031*
2.	Yellow stem borer	1.8	1.9	8.1	6.5	26.140	0.000*
3.	Leaf folder	2.4	1.5	6.5	6.2	18.101	0.000*
4.	Green leaf hopper	0.2	4.2	3	2.5	24.391	0.000*
5.	Brown plant hopper	0.1	0.4	4.4	0.5	25.430	0.000*
6.	White backed plant hopper	0.2	5.9	3.1	0.5	24.618	0.000*
7.	White hopper	0	1.4	1.9	3.5	27.125	0.000*
8.	Hispa	0.1	0.9	0.3	0.2	7.299	0.063*
9.	Green horned caterpillar	1.5	1	2	1.1	10.139	0.017*
10.	Skipper	0.1	0.3	0.7	0.3	5.035	0.017*
11.	Flea beetle	0.1	0	0.1	0	2.032	0.566
12.	Grass hopper	0	0.8	4.2	3.8	37.552	0.000*
13.	Black bug	0	0	1	0.1	12.551	0.006*
14.	Ear head bug	0	0	7.1	14.9	55.954	0.000*
15.	Hairy caterpillar	0	0	1.1	2.8	37.684	0.000*
16.	Stink bug	0	0	1.3	0.2	20.631	0.000*

*Indicates significant value ($p < 0.05$) of non-parametric Kruskal wallis test.

development stage of the crop (Fig. 2). The occurrence of pests was increased when the population of parasitoids in the field is reduced. So, the conservation of insect natural enemies for effective pest management is a criterion to be taken care in IPM. Moreover, the understanding of the role of parasitoids throughout the stages of crop development is critical to assess timely and effective conservation practises.

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