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ECOLOGICAL INTERACTION BETWEEN INSECT PESTS, CLIMATIC FACTORS AND PLANT TRAITS ON ABUNDANCE OF BENEFICIAL INSECTS IN PADDY FIELD

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Abstract

The presences of beneficial insects in the paddy field are very important for the ecological systems of paddy field as those insects could help managing the population of the pests. Hence, it will reduce the dependence on pesticides usage to combat the population of insect pests. This study was aimed to study on ecological interaction between environmental factors such as insect pests, plant height, rainfall, temperature and humidity with abundance of beneficial insects in paddy field of Sungai Burong, Tanjung Karang, Selangor for two seasons of paddy planting. Low number of insects composition were recorded in paddy field at Sungai Burong during the vegetative phase and highest during the reproductive and maturity phases for two seasons of paddy planting. The trend of mean composition of insects were gradually increasing from vegetative to maturity phases while, the ecological interaction between insect pests, climatic factors and plant traits were acceptable as good predictor for all beneficial insects collected in this study namely Zygoptera, Gerridae, Coccinellidae and Staphylinidae except for Anisoptera. Therefore, consideration on several stated factors by maintaining or conserving ecology and controlling practices in good manner in paddy field has high potential and more reliable to control insect pests effectively using beneficial insects.

Keywords: Ecological, beneficial, insect pests, climatic factors, plant traits

1. INTRODUCTION

The presences of beneficial insects in the paddy field are very important for the ecological systems of paddy field as those insects could help managing the population of the pests. Following, less usage of chemicals that can harm the physical and chemical properties of the soil, water and paddy plants. Moreover, in the paddy field with minimize pesticides application, crop production commonly depends on the natural control by biological agents (Ueno, 2012). Therefore, the present of beneficial insects is one of the key resources to improve both productivity and sustainability in the paddy field. Study on ecological interaction between environmental factors such as insect pests, plant height, rainfall, temperature and humidity with abundance of beneficial insects in paddy fields are important. Those environmental factors have significance influences on the abundance of beneficial insects in the paddy fields. Once the survival factors of beneficial insects in the paddy

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field were determined, thus the population of the those insects could be increased. As consequences, the population of insect pests that had been major problems in paddy field can be solved. Furthermore, the information gathered from this study can be used by the farmers as a guideline for an augmentation population of beneficial insects in the paddy field.

2. MATERIAL AND METHODS

2.1. Study area

This study was conducted in paddy fields at Sungai Burong (3.4167°N, 101.1833°E). This area had been chosen due to it is one of primary paddy field in Malaysia. In this area, the paddy plants are cultivated twice a year and the rice is commercially selling for local markets. A total of six paddy plots and drainages respectively in Sungai Burong were identified as selected study areas (Table 1).

Table 1: Coordinates of sampling areas

Localities	Sampling areas	Coordinate
Paddy plots and drainages	A	3.304 °N, 101.102 °E
	B	3.300 °N, 101.938 °E
	C	3.293 °N, 101.908 °E
	D	3.290 °N, 101.834 °E
	E	3.284 °N, 101.764 °E
	F	3.279 °N, 101.726 °E

2.2. Sampling and samples analysis

Samplings were carried for two seasons consisted of all phenological phases of paddy growth namely vegetative, reproductive and maturity phases. The samples were collected as earlier as 0700. There were three replications of insects sampling at each sampling areas. A sweeping hand net was (0.5mm) was used to collect the insect. The insect was killed in the killing jar containing 90% of chloroform. The sorting, classifying and counting of insects were done in the Entomology Laboratory, Faculty of Plantation and Agro technology, Universiti Teknologi MARA. The climatic data namely rainfall, temperature and humidity for both seasons were obtained from Malaysian Meteorology Department. The height of the plant was proximately measured in the selected paddy plant in the sampling areas.

2.3. Data analysis

The composition of insects were calculated based on phenological phases of paddy growth while, the diversity of insects were calculate using Ecological Indices of Shannon's (H') index and Simpson's (d) index. For the species richness of insects, both Margalef's (R_1) index and Menhinick's (R_2) index were used while, the evenness values of insects estimate using Pielou's index (J'). The Shannon's diversity index determined the species relative abundance while, the Simpson's diversity index determined the abundance of the most common species. The richness index is measured the number of species presence from the overall insects which had successfully collected. The evenness index (Pielou's) was used to quantify the distribution of individual species present in the paddy field (Carlo *et al.*, 1998; Balachandran *et al.*, 2012). The multiple regression from Statistical Package for Social Science (SPSS) version 9 was apply to predict the ecological interaction that exist between insect pests, climatic factors and plant traits on abundance of beneficial insects. The stepwise regression was done prior the multiple regression in order to select the variables that contributed to the abundance of beneficial insects.

3. RESULTS

There were 1,257 of individuals insects consisted both beneficial and insect pests were successfully counted and classified. As for beneficial, the insects were known as rove beetles (Coleoptera; Staphylinidae), ladybird (Coleoptera; Coccinellidae), water strider (Hemiptera; Gerridae), dragonflies (Odonata; Anisoptera) and damselflies (Odonata; Zygoptera) while, the insect pests collected were green leafhoppers (Hemiptera; Cicadellidae), moth (Lepidoptera; Pyralidae) and midge (Diptera; Chironomidae).

The mean of insect composition according to the phases of paddy growth was shown in Figure 1. The trend of mean compositions for Gerridae, Coccinellidae, Staphylinidae and Pyralidae were gradually increasing from the vegetative to the maturity stages. Family Gerridae recorded highest mean composition during the maturity phases with the value of 12.83 followed by Coccinellidae with 1.29 and Pyralidae with 0.83. The mean composition of Staphylinidae was 0.33. As for Zygoptera (damselflies), Cicadellidae (green leafhoppers) and Chironomidae (midges), the means of composition were highest during the reproductive phase of the paddy plant growth. The mean composition for Zygoptera was 3.53, while the mean composition for Cicadellidae was 0.31. The Chironomidae had mean composition of 5.94.

None of orders showed high composition during the vegetative phase except for Odonata (sub-order Anisoptera). The mean composition of Anisoptera during the vegetative phase was 0.25. After vegetative phase, the mean of composition for Anisoptera was decreased during the reproductive phase (0.03) and increased again at the maturity phase of paddy growth (0.08). In overall, most of beneficial and insect pests have a high composition after the vegetative phases which are reproductive and maturity stages.

The ecological indices were summarized in Table 2. The Shannon's index was ranging between 0.13 and 1.49 for three phases of paddy growth in all sampling areas. The paddy plots showed higher value of Shannon's (H') index compared to paddy drainages throughout two seasons of paddy planting. The highest Shannon's (H') index value was recorded at the paddy plot in the first season during the vegetative phase and the lowest value of Simpson's (d) index was recorded at the paddy plot in the first season during the vegetative phase. The values of Shannon's (H') and Simpson's (d) indices were 1.49 and 0.28 respectively. The lowest Shannon's (H') index value was detected in the second season of paddy planting at the paddy drainages during the maturity phases of paddy growth. Nevertheless, the value of Simpson's (d) index was higher at the paddy drainages during the maturity phases of second season. The values were 0.13 and 0.96 for Shannon's (H) and Simpson's (d) indices respectively.

The highest and the lowest values of species richness were recorded particularly during the first season of paddy planting. The highest value for Margalef's (R1) and Menhinick's (R2) indices were 4.15 and 3.29 respectively during the vegetative phase of paddy plant at the paddy plots. The lowest values for Margalef's (R1) and Menhinick's (R2) indices were the same 0.57 during the reproductive phases of paddy plants at the drainage.

Seasons	Area	Phases of paddy growth	Diversity Index		Richness Index		Evenness
			Shannon's	Simpson's	Margalef's	Menhinick's	Pielou's
1	Plot	Vegetative	1.49	0.28	4.15	3.29	0.83
		Reproductive	0.86	0.41	2.20	2.01	0.53
		Matured	0.80	0.45	1.78	1.62	0.50
	Drainage	Vegetative	0.73	0.53	1.10	1.10	0.15
		Reproductive	0.34	0.81	0.57	0.57	0.49
		Matured	0.16	0.94	0.65	0.65	0.15
2	Plot	Vegetative	0.50	0.78	1.31	1.31	4.70
		Reproductive	1.13	0.45	1.50	1.50	0.54
		Matured	1.39	0.29	1.32	1.32	0.86
	Drainage	Vegetative	0.64	0.65	1.28	1.28	0.22
		Reproductive	0.57	0.68	0.95	0.95	0.52
		Matured	0.13	0.96	0.72	0.72	0.09

There were good interaction between insect pests (Cicadellidae, Chironomidae and Pyralidae), climatic factors (rainfall, temperature and humidity) and plant traits on abundance of beneficial insects (Anisoptera, Zygoptera, Gerridae, Coccinellidae and Staphylinidae) in paddy field of Sungai Burong, Selangor (Table 3) for two seasons of paddy planting. However, the insect pests, climatic factors and plant traits are incompetent to shows any ecological interaction with the Anisoptera throughout two seasons of paddy planting.

The significance values (p-values) recorded for Zygoptera were 0.000. This indicated that the sets variables were able to predict the abundance of Zygoptera in the paddy field with R^2 values of 63.6%. Furthermore, there were significance interaction between the plant height and rainfall on abundance of Zygoptera ($p<0.01$). The plant height, temperature and humidity were good predictors ($p < 0.05$) for Gerridae. The overall significance values for ecological interaction between the insect pests, climatic factors and plant traits on abundance of Gerridae was 0.004 ($p<0.05$). However, the R^2 values for these interactions were very low as much as 27%. Therefore, there were others factors could contribute to the abundance of the Gerridae in the paddy field such as the physical and chemical properties of water since the Gerridae is an aquatic insect. Consequently, the ecological interaction for Gerridae was possibility highly affected by the quality of water in the paddy field instead of insect pests, climatic factors and plant traits.

The plant height, temperature and rainfall were good predictors ($p<0.05$) for abundance of Coccinellidae in the paddy field. In addition, the overall significance values for ecological interaction between insect pests, climatic factors and plant traits were 0.00. However, the R^2 value is low (42.3%). Therefore, it will be others factors could interact and affect the abundance of Coccinellidae in the paddy field.

As for the Staphylinidae, the results shows that two of insect pests namely Pyralidae and Chironomidae can be a good predictors ($p<0.05$). Besides, plant height also can be good predictor to the abundance of Staphylinidae in the paddy field ($p<0.05$). However, the R^2 values is low (27.5%) indicating a low ecological interaction between those set variables (insect pests, climatic factors and plant height) with abundance of Staphylinidae in paddy field.
Overall, the ecological interaction between insect pests, climatic factors and plant traits were acceptable for all beneficial insects collected in this study except for Anisoptera. Further, the plant height shows good ecological interaction for Zygoptera, Gerridae, Coccinellidae and Staphylinidae. The insect pests namely Pyralidae and Chironomidae have good ecological interaction with Staphylinidae.

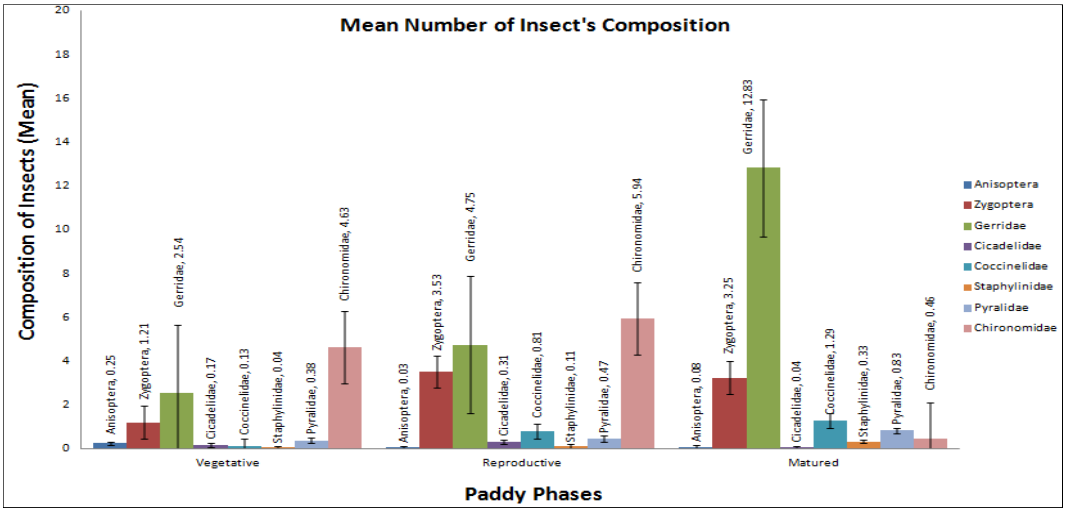

Figure 1: Insect compositions (mean number) based on phases of paddy growth

Table 3: Multiple regression analysis between beneficial insects and insect pests, plant height, temperature, rainfall and humidity on both season of paddy planting

Beneficial insects		Predictors							
		Constant[a]	Pyralidae	Cicadellidae	Chironomidae	Plant height	Temperature	Humidity	Rainfall
Anisoptera	Coefficient		-0.104	-0.078	-0.016	0.113	0.811	0.689	-0.011
	T	2.258	-0.693	-0.497	-0.102	0.748	-0.630	0.521	-0.055
	P	0.884	0.491	0.621	0.919	0.457	0.531	0.604	0.956
	R^2	0.044							
Zygoptera	Coefficient		0.056	-0.132	0.030	0.341	1.408	-1.457	0.745
	T	2.706	0.605	-1.365	0.307	3.669	1.772	-1.787	6.335
	P	0.000(s)	0.548	0.177	0.760	0.000(s)	0.081	0.79	0.000(s)
	R^2	0.636							
Gerridae	Coefficient		-0.0.77	-0.0.16	-0.036	-0.403	2.719	-2.653	0.093
	T	4.763	-0.592	-0.117	-0.260	-3.055	2.416	-2.297	0.557
	P	0.004(s)	0.556	0.907	0.796	0.003(s)	0.019(s)	0.025(s)	0.580
	R^2	0.270							
Coccinelidae	Coefficient		0.219	0.034	0.056	0.289	2.004	-1.964	0.347
	T	0.048	1.886	0.282	0.460	2.465	2.002	-1.912	2.341
	P	0.000(s)	0.064	0.779	0.647	0.016(s)	0.049(s)	0.060	0.022(s)
	R^2	0.423							
Staphylinidae	Coefficient		-0.291	-0.218	0.278	0.329	1.762	-1.667	0.212
	T	0.268	-2.234	-1.603	2.037	2.507	1.571	-1.448	1.280
	P	0.003(s)	0.029(s)	0.114	0.046(s)	0.015(s)	0.121	0.153	0.205
	R^2	0.275							

Note: (s) is significance at $p < 0.05$

4. DISCUSSIONS

The mean composition of insects in paddy field at Sungai Burong was found to be the lowest during the vegetative phase and highest during the reproductive and maturity phases for two seasons of paddy planting. The vegetative phase is the phase of paddy plants begins to develop the panicles and there are no grains or flowers developed in the paddy plants. Not as a vegetative phase, the biology traits of paddy plants during the reproductive and maturity phases have a lot of grains and flowers. Following that, a lot of insects especially the insect pests were attracted to the paddy plants as food sources, resulting in high mean composition of the insects. Due to high abundance of insect pests, the numbers of beneficial insects would be highest. Abundance of food was known as one of the important factors for the presence of insects in particular areas as in studies of Basset (1999), Erb *et al.* (2008) and Bambaradeniya and Edirisinghe (2008).

The ecological indices of insects (Table 2) shows that diversity of insects calculated from Shanon's (H') and Simpson's (d) were varied throughout the sampling periods. Consequently, these results noted that the composition and diversity of insects were changing over the time with the phenological phases of paddy growth. Each phenological phases of paddy growth have different level of paddy water, fertilizer usage and pesticides application. Moreover, although the mean composition of insects was slightly different within the phases of paddy growth, the diversity of insects were varied throughout two seasons of paddy planting. The changes of biological traits of the paddy plants from the vegetative to the maturity phases may attract different insects to the paddy plants (Koji *et al.*, 2012).

In addition, the values for species richness by Margalef's (R_1) and Menhinick's (R_2) indices and species evenness by Pielou's (J') index were found to be the highest in the paddy plots. However, the lowest values for species richness by Margalef's (R_1) and Menhinick's (R_2) indices and species evenness by Pielou's (J') index were recorded in the paddy drainages. The findings suggest that localities of sampling areas have significance influences toward the richness and evenness of the insects. Paddy plots provided more foods for the insects compared to the paddy drainages. This is because paddy plots have many paddy plants but low water level, while the paddy drainages have no paddy plants and have a depth water level. Availability of foods influenced the diversity and abundance of insects compared to the areas which have fewer amounts of food sources.

Result of multiple regression (Table 3) shows that insect pests (Cicadellidae, Pyralidae and Chironomidae), climatic factors (rainfall, temperature and humidity) and plant traits are unable to shows any ecological interaction with the Anisoptera. Therefore, the abundance of Anisoptera in paddy field would be influenced by others factors. According to Norazliza *et al.* (2014), the abundance of Anisoptera in the paddy field was highly influenced by the water parameters namely water pH, dissolved oxygen, ammonia and total suspended solid. Anisoptera is recognized as an aquatic insect and sensitized to water parameters for the breeding site (Fox and Cham, 1994). Hence, the abundance of Anisoptera in paddy field is highly interrelated with water parameters instead of abundance of insect pests, climatic factors and plant traits.

The plant height shows good ecological interaction with Zygoptera, Gerridae, Coccinellidae and Staphylinidae. According to Kandibe *et al*. (2005), Fox and Cham (1994), Kadoya *et al.* (2009) and Harabis *et al.* (2013) agreed that growth of paddy plants have important influences on the successful survivors of Zygoptera from the predators and weather. In addition, the plant height was also important for survival of Coccinellidae especially during the reproductive phase. Snyder (2009) noted that the Coccinellidae (ladybirds) used chemical cues of the plant to inhibit eggs and oviposition. Gerridae are known as aquatic insect but the result shows that Gerridae have significant ecological interaction with the plant traits indicating that there were indirect interaction between Gerridae and plant height. The Gerridae was fed on insects that belong to Order Diptera, Homoptera and Hymenoptera which recognized as terrestrial insects (Izabella *et al.*, 2007). In addition, results (Table 3) shows that ecological interaction between insect pests, climatic factors and plant traits was very low (27%). Study by Norazliza *et al*. (2014) found that abundance of Gerridae in paddy field was highly influenced by physical and chemical properties of water.

As for Staphylinidae, it shows abundance of Staphylinidae are influenced by plant height. According to Caroline (2013), Staphylinidae are favour to high dense vegetation canopy for survival. In addition, the Staphylinidae move to the weed plants during the harvesting time for a shelter. Besides that, the presence of Pyralidae and Chironomidae shows good interaction with Staphylinidae. A study done by Ghahari *et al.* (2009) noted that the Staphylinidae was also a good predator for the egg of Pyralidae.

To conclude, insect pests such Pyralidae (moth) and Chironomidae (midge), plant height, temperature, rainfall and humidity can be a predictors to abundance of beneficial insects such as Zygoptera (damselfy), Gerridae (water strider), Coccinellidae (ladybird) and Staphylinidae (rove beetles) in the paddy field of Sungai Burong, Selangor.

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