A PRELIMINARY STUDY OF INSECT DIVERSITY ASSOCIATED WITH GLUTINOUS PADDY PLANT AT TELOK CHENGAI, ALOR SETAR, KEDAH, MALAYSIA

Nurul Farisa Reward*, Muhammad Muzzammil Mohd Nizar, Zulidzham Mohd Sani & Mohd. Fahimee Jaapar
Agrobiodiversity and Environmental Research Centre,
Malaysian Agricultural Research & Development Institute (MARDI) Headquarters,
43400 Serdang Selangor.
*Corresponding author: *nurulfarisareward12@gmail.com*

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ABSTRACT

A preliminary study of insect diversity associated with glutinous paddy plant was conducted from July to September 2019 in Telok Chengai, Alor Setar, Kedah, Malaysia. Six samplings of insects were carried out during the growing phase at six plot paddy fields with an area of 5.53ha starting from the active tillering stage until the flowering stage. Sweep net and insects scoring sampling methods were used for insect collections, and identification process at the laboratory. The data were determined by using a descriptive statistic, diversity index, and statistical test for mean comparisons. A total of 791 individuals comprising 44 species representing 36 families and seven orders of insects were recorded. From the total of the insects collected, the insects can be categorized into ecological guilds. The pest was dominant with 459 individuals (58.03%) followed by the predators (261 individuals, 33.0%), the parasitoids (12 individuals, 1.5%), and other groups of insects (59 individuals, 7.46%). For index diversity analysis of the total growing phase, the maximum tillering stage had the highest insect's diversity with Shannon-Wiener diversity index (H') of 2.40 and Margalef Richness index (R) of 5.82, whereas the flowering stage had the lowest H' of 1.68 and R of 2.52. However, there was no significant differences ($P>0.05$) of insect abundance between the stages of growing paddy fields. Results for this preliminary study indicated that the population of pest in the glutinous paddy field population was dominant compared to the beneficial insects and other insect communities during various phases of glutinous paddy development that may cause a loss in yield. Therefore, this database can be used for future insect pest management of the glutinous paddy ecosystem in Malaysia.

Keywords Ecological guild, glutinous paddy, Hemiptera, insect diversity, pest

ABSTRAK

Satu kajian awal kepelbagaian serangga yang berkaitan dengan pokok padi pulut telah dijalankan dari Julai hingga September 2019 di Telok Chengai, Alor Setar, Kedah, Malaysia. Enam persampelan serangga telah dijalankan semasa fasa pertumbuhan di enam petak sawah padi dengan keluasan 5.53ha bermula dari peringkat membaja aktif sehingga peringkat berbunga. Kaedah jaring sauk dan kaedah persampelan penskoran serangga digunakan untuk proses pengumpulan dan pengenalpastian specimen di makmal. Data ditentukan dengan menggunakan statistik deskriptif, indeks kepelbagaian, dan ujian statistik untuk perbandingan min. Sebanyak 791 individu terdiri daripada 44 spesies mewakili 36 famili dan tujuh order serangga direkodkan. Daripada jumlah keseluruhan individu yang dikumpul dapat dikategorikan kepada kumpulan ekologi. Perosak merupakan serangga dominan dengan 459 individu (58.03%) diikuti oleh pemangsa (261 individu, 33.0%), parasitoid (12 individu, 1.5%), dan kumpulan serangga lain (59 individu, 7.46%). Untuk analisis kepelbagaian indeks bagi fasa pertumbuhan keseluruhan, peringkat membaja maksimum mempunyai kepelbagaian serangga yang paling tinggi dengan indeks kepelbagaian Shannon-Wiener (H') sebanyak 2.40 dan indeks Kekayaan Margelef (R) sebanyak 5.82, manakala peringkat berbunga mempunyai H' terendah iaitu 1.68 dan R' sebanyak 2.52. Walau bagaimanapun tiada perbezaan yang signifikan ($P > 0.05$) bagi kelimpahan serangga antara peringkat penanaman padi. Keputusan kajian awal ini menunjukkan bahawa populasi perosak dalam populasi sawah padi pulut adalah dominan berbanding dengan komuniti serangga berfaedah dan serangga lain semasa pelbagai fasa pembangunan padi pulut yang boleh menyebabkan kerugian dalam hasil. Maka, pangkalan data ini boleh digunakan untuk pengurusan serangga perosak di ekosistem padi pulut Malaysia pada masa hadapan.

Kata kunci: Guild ekologi, padi pulut, Hemiptera, kepelbagaian serangga, perosak

INTRODUCTION

Rice is an essential food to most nations worldwide and rice production in Malaysia is very important for supplying primary food to people and economically important especially to farmers (Harun et al. 2021). Rice is the main food source and staple food for daily consumption in Malaysia. The self-sufficiency level (SSL) production in Malaysia is about 75% and the government has a target to achieve 100% SSL for the population's demand (Rahim et al. 2017). Generally, rice diversity in Malaysia consists of more than 120,000 varieties with various unique characteristics (Roy et al. 2016). One of the most famous varieties is sticky rice, also known as glutinous rice. Glutinous rice or also known as White Rice and Black Rice, is mainly used as an ingredient in Malay traditional dishes (Noor et al. 2013). The main property of rice is starch that consists of amylose and amylopectin (Cruz & Khush 2000). However, glutinous rice contains more than 98% of amylopectin (Eakkanaluksamee & Anuntagool 2000) in their endosperm (Sharma 2010).

To date, rice industries in Malaysia face problems such as pests and diseases. Most pests consist of brown planthopper (BPH), white-backed planthopper (WBPH), and small brown planthopper (SBPH) (Norton et al. 2010). Over 800 insect pests have been recorded on rice crops and some contribute to serious pest problem (Adhikari et al. 2018). There are several natural predators in the rice fields that if conserved, can play an effective role in decreasing the pest population density. On the other hand, several pests such as *Leptocorisa* sp. cause damage and yield loss to this crop. Both adult and nymph of this genus feed on the grain during the milking stage of paddy (Bisen et al. 2019).

There are several techniques to control pests and diseases in rice fields, such as biological control, chemical control, non-chemical control, and eco-engineering practices (Vasudevan et al. 2002). Most past studies have shown data about the macroscopic groups of insect pests in rice paddy field ecosystems such as earthworms, springtails, mites, nematodes, ants and other arthropods. The same goes for the glutinous rice field ecosystem with common insect pests. Even though the study of insects in the rice paddy ecosystem in Malaysia is common, further research is essential to gain sustainable pest management in the paddy field. Therefore, this study aimed to identify the insect associated with irrigated glutinous rice paddy fields and to determine their ecological guild in the paddy field ecosystem.

MATERIALS AND METHODS

Study Site

The insect samplings were conducted from July to September 2019 (3 months) at six plots of glutinous paddy variety Pulut Susu (TR), with an area of 5.53ha located in the State Department of Agriculture Telok Chengai, Alor Setar, Kedah, Malaysia (coordinate 6°05'43.5"N 100°19'53.1"E). Six insect samplings were carried out and the insects occurred between 9 to 11 am were collected. Samplings were done on the growing phase of the paddy, starting from the active tillering stage, maximum tillering stage (vegetative phase) until the flowering stage (reproductive phase). Sweep net sampling method and scoring were applied. The plot was randomly swept by a sweeping net in a zig-zag manner for a total of 40 sweeps per plot (Figure 1). For the scoring insect method, the insects at the paddy leaf were counted as additional data insects for each plot.

Insect Collection and Identification

In the sampling site at a glutinous paddy field, specimens were collected, sorted from litters or debris, and put into Beatson bottle containing 70% alcohol and labelled for each plot study. After that, the procedure was proceeded with the identification of specimens under microscope Leica MS5 at the Insect Museum laboratory of MARDI, Serdang. Most of the specimens were identified to the order and family, then up to the species level by cross-references with the sample in Insect Museum and reference books (Borror et al. 2005). However, some specimens identification were identified up to genus level only due to some damaged specimens and other factors that occurred during identification.

Statistical Analysis

Paleontological Statistics software 4.03 (PAST) software was used to analyze the Shannon-Wiener index (H’), Simpson diversity index (D’), Evenness index (E’), and Margalef richness index (R) of insect diversity. One-way ANOVA analysis was analyzed to find the significant differences of the insect population in the paddy plot value using Minitab 17 statistical software.

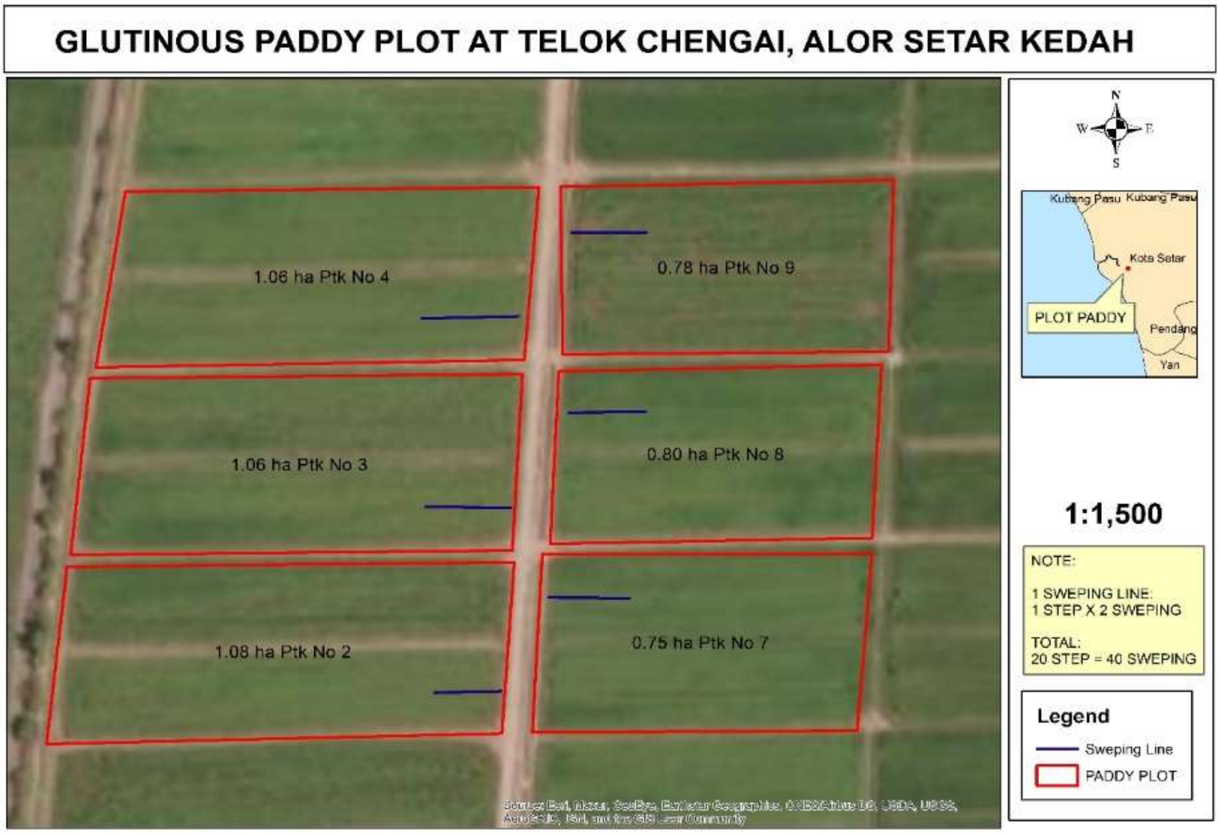

Figure 1. Location of sampling site of insect at paddy plot

RESULTS

A total of 791 individuals comprising 44 species of insects representing 36 families and seven orders of insects were recorded in the study area (Table 1). The most order of insects found in glutinous rice was Hemiptera with 392 individuals (50%), followed by Coleoptera with 183 individuals (23%), Diptera with 86 individuals (11%), Odonata with 78 individuals (10%), Orthoptera with 32 individuals (4%), Hymenoptera with 12 individuals (1%), and the lowest was Lepidoptera with eight individuals (1%) (Figure 2). Based on Figure 3, the order of Hemiptera showed the highest number of individuals with 316 individuals recorded during the maximum tillering phase. Apparently, the lowest number of individuals was from the Hymenoptera order for all three growing phases (Figure 3). In terms of insect pest recorded, *Leptocorisa* sp. was the most abundant pest found with 257 individuals (25.79%) in the sampling area followed by, *Nephotettix virescens* with 83 individuals (10.15%) and *Nilaparvata lugens* with 82 individuals (10.02%) and the lowest insects pest were *Pelopidas mathias* and *Rivula atimeta* with only one individual (0.12%). In addition, the highest species beneficial insects found was *Micrapis discolor* with 157 individuals (19.19%) while the lowest with only one individual (0.12%) included parasitoid as shown in Table 1.

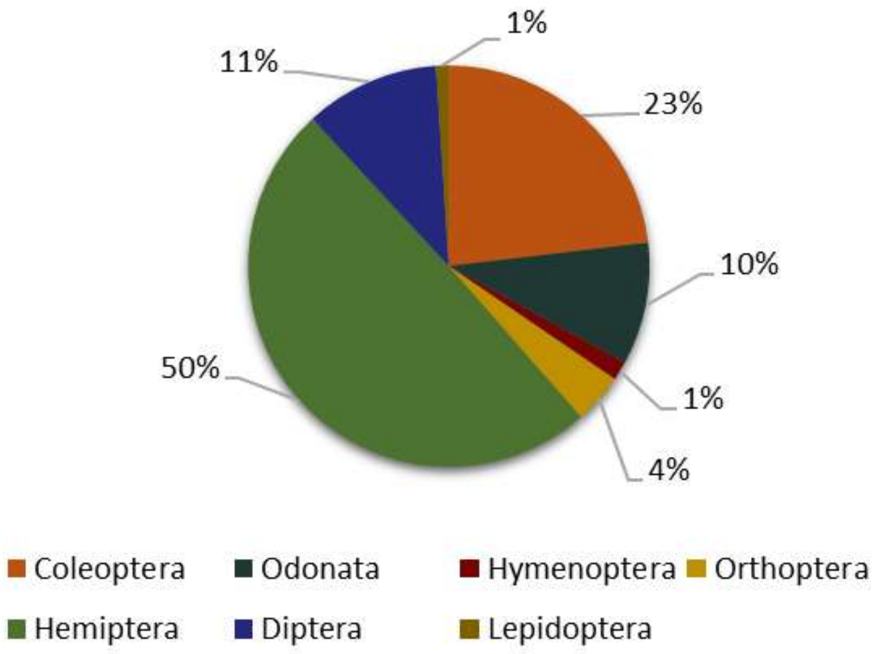

Figure 2. Percentage of insect composition in the study area

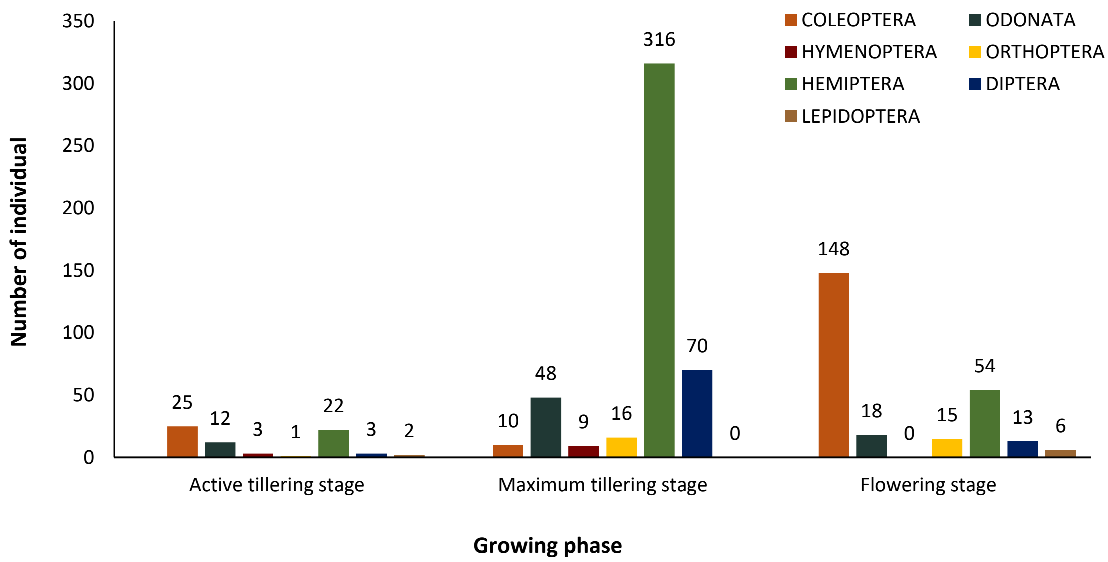

Figure 3. Insect abundance at different stages

Table 1. List of species collected during the vegetative stage until the flowering stage of glutinous paddy

ORDER	FAMILY	SPECIES	FUNCTION	TOTAL	% SPECIES
COLEOPTERA	Coccinellidae	*C. transversalis*	Predator	1	0.13%
		Harmonia octomaculata	Predator	1	0.13%
		Micracpis discolor	Predator	157	19.85%
	Carabidae	*O. nigrofasciata*	Predator	17	2.15%
		Stenolophus sp.	Predator	1	0.13%
	Chrysomelidae	*Altica* sp.	Predator	4	0.51%
	Staphylinidae	*Paederus fuscipes*	Predator	2	0.25%
ODONATA	Agrionidae	*Agriocnemis pygmaea*	Predator	36	4.55%
		Ischnura senegalensis	Predator	33	4.17%
	Libellulidae	*Crocothemis servilia*	Predator	4	0.51%
		Diplacodes sp.	Predator	5	0.63%
HYMENOPTERA	Braconidae	*Apanteles galleriae*	Parasitoid	3	0.38%
		Opius sp.	Parasitoid	4	0.51%
		Aleiodes sp.	Parasitoid	1	0.13%
	Chalcididae	*Brachymeria* sp.	Parasitoid	1	0.13%
	Evaniidae	*Hyptia* sp.	Parasitoid	3	0.38%
ORTHOPTERA	Acrididae	*Acrida turricata*	Pest	2	0.25%
	Tettigoniidae	*Oxya chinensis*	Pest	4	0.51%
		Conocephalus longipennis	Pest	26	3.29%
HEMIPTERA	Alydidae	*Leptocorisa* sp.	Pest	211	26.68%
	Cicadellidae	*Nephotettix nigropictus*	Pest	6	0.76%
		Nephotettix virescens	Pest	83	10.49%
		Recilia dorsalis	Pest	3	0.38%
		Idioscopus nitidulus	Pest	3	0.38%
	Delphacidae	*Nilaparvata lugens*	Pest	82	10.37%
		Sogatella furcifera	Pest	1	0.13%
LEPIDOPTERA	Miridae	*Euscyrtus* sp.	Pest	3	0.38%
	Hesperiidae	*Pelopidas mathias*	Pest	1	0.13%
	Noctuidae	*Rivula atimeta*	Pest	1	0.13%
DIPTERA	Pyralidae	*Nympula depunctalis*	Pest	6	0.76%
	Agromyzidae	*Phytobia* sp.	Pest	10	1.26%
	Ephydridae	*Hydrellia philippina Ferino*	Pest	17	2.15%
	Asteiidae	*Leiomyza* sp.	Others	1	0.13%
		Asteia sp.	Others	1	0.13%
	Asilidae	*Ommatius* sp.	Others	4	0.51%
	Calliporidae	*Chrysomya megacephala*	Others	2	0.25%
	Ceratopogonidae	*Culicoide* sp.	Others	1	0.13%
		Forcipomyia sp.	Others	2	0.25%
	Chironomidae	*Chironomus* sp.	Others	2	0.25%
	Chloropidae	*Rhopalaopterum* sp.	Others	15	1.90%
	Dolichopodidae	*Dolichopus* sp.	Others	5	0.63%
	Pipunculidae	*Chalarus* sp.	Others	22	2.78%
	Tipullidae	*Tipula paludosa*	Others	1	0.13%
	Syrphidae	*Erictalinus megacephalus*	Others	3	0.38%

From the total of individual insects that has been collected, it can be categorized into ecological guilds such as pests, predators, and parasitoids. The abundance of the pest was dominant at 459 individuals (58.03%) followed by the predators at 261 individuals (33.0%), the parasitoids at 12 individuals (1.52%), and the rest were from other groups of insects with 59 individuals (7.46%). The highest number of individuals was from the Hemiptera order with 389 individuals and mostly were insect pests, and the lowest insect pest was from the Lepidoptera order with only 5 individuals recorded (Figure 4).

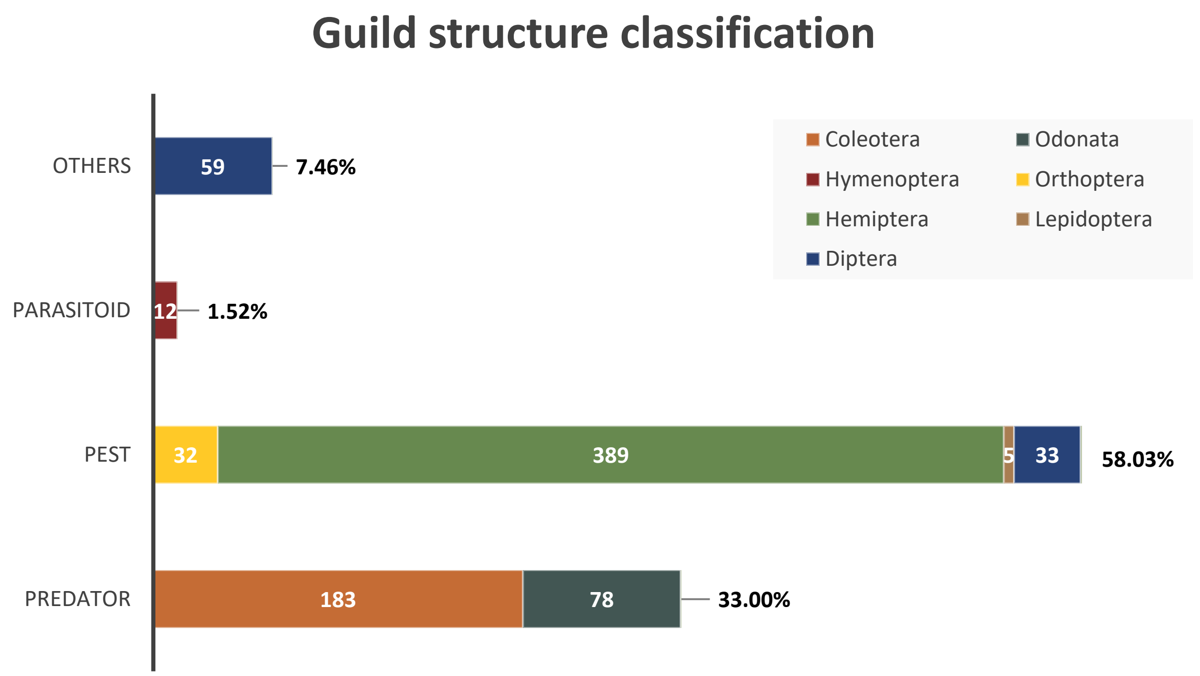

Figure 4. Number of individual insects according to order and ecological guilds with a percentage

Species Diversity Between Planting Stages

The Shannon-Wiener species diversity index (H') indicated that the maximum tillering stage had the highest diversity with 2.30 while the lowest diversity (H') was recorded at 1.63 during the flowering stage. A different trend was shown in the Evenness index (E') and Margalef index (R'). For example, the active tillering stage and the maximum tillering stage had higher R' values with 4.27 and 5.20, respectively. However, the flowering stage showed higher E' (0.39) compared to the maximum tillering stage (0.30) but lower than the active tillering stage (0.48). The value of the Simpson diversity index (D') seemed to follow the R' value where the highest was during the maximum tillering stage while the flowering stage had the lowest index with D' of 0.83 and 0.69, respectively. The result showed that all stages had higher D' value compared to the Evenness index (E') and Margalef index (R') (Table 2). However, the One-way ANOVA did not show any significant difference (*P<0.05*) in insect abundance between the stages of growth phases paddy plot (Table 3).

Table 2. Ecological indices of insect abundance of growing phases paddy plot

Growing phases of paddy	**Ecological indices**				
	Species collected (S)	**Shannon-Wiener diversity index (H')**	**Evenness index (E')**	**Margalef index (R')**	**Simpson diversity index (D')**
Active tillering stage	19	2.211	0.4805	4.266	0.8257
Maximum tillering stage	33	2.302	0.3029	5.201	0.8280
Flowering stage	13	1.631	0.3931	2.167	0.6927

Table 3. Analysis of variance of insect abundance between the stages growing phases paddy plot

Growing phases of paddy	Sum of Squares	df	Mean Square	F	Sig. (*p*)
Between Groups	1966	2	982.9	1.44	0.243
Within Groups	47638	70	680.5		
Total	**49604**	**72**			

DISCUSSION

To date, study on the diversity of insects in glutinous rice in Malaysia is still scarce as compared to the study on the diversity of insects in the rice field. Our findings showed that Hemiptera was the dominant order in the study site. Hemiptera directly damages plants by sucking the cell sap from the stem or leaves causing the drying of leaf tips and the flipping orange with curls (Alves et al. 2016). They also injure the plant tissues and cause the deformation of leaves. Some Hemipteran is controlled by insecticide or biological control such as weed (Teramoto 2003). Hemipteran were also recorded abundant in all. Hemipteran during the maximum tillering stage was the highest because sapsuckers, leaf-feeding, and grain sucker insects such as Cicadellidae, Delphacidae, and Alydidae flourish during the vegetative phase (tillering stage) of rice growth (Gangurde 2008). Meanwhile, the most dominant pest species was *Leptocorisa* sp. (Family: Alydidae). According to Elanchezhyan (2015), *Leptocorisa* sp. is the major sap-sucking insect of rice that causes the grain of paddy to become chaffy under severe infestation. Moreover, the damaged grain caused by both adult and nymph *Leptocorisa* sp. has decreased 30% of yield production (Bisen et al. 2019).

Furthermore, new studies on an insect from Family Cicadellidae showed the viral diseases outbreaks which the virus may consequently harm the crop infested by the insect and cause yield loss (Yang et al. 2017). *Nephotettix* spp. (green leafhoppers) of Cicadellida is a serious rice pest that causes direct damage by sucking sap, injecting toxic chemicals, and indirectly transmitting rice dwarf virus diseases and phytoplasma diseases such as rice dwarf disease, waika disease, and yellow dwarf disease (Hirae et al. 2007). According to Shimizu et al. (2009), the rice dwarf virus leads to the appearance of white chlorotic spots on leaves and the stunting of plant growth that may decrease grain yield.

Another common serious insect pest is *Nilaparvata lugens* (brown planthoppers), a phloem-feeding insect by removal of translocating nutrient from the plant sap, reduces the rate of photosynthetic available for the plant, hence reducing chlorophyll contents and stem nitrogen concentration. Brown planthoppers (BPH) also transmit virus vectors which are rice ragged stunt virus (RRSV) and rice grassy stunt virus (RGSV) (Bao et al. 2013). Research done by Zheng et al. (2014) found that *N. lugens* transmit (RGSV) in a persistent-propagative manner where the virus initially infected the epithelium and then replicates in its insect vector.

The distribution of serious insect pests can be controlled by a group of natural enemies. Entomophagous insects are insectivorous insects that act as natural enemies of pests in a glutinous rice field ecosystem. Natural enemies are always present in a paddy field as their population is dependent on the availability of suitable prey (Sigsgaard 2000). Although the current study found the predators were less than the pests, their presence and natural role would be important to control the outbreaks of serious insect pests that present in the glutinous rice ecosystem.

Among the predators, the Odonata and Coleoptera orders were the most important natural enemies. Thus, from our findings, the important groups for predator-prey interactions were Coleoptera and Odonata recorded as general predators of glutinous rice pests. The symbiosis of entomophagous with pests can further be highlighted with the role of predatory insects. For example, Family Coccinellidae (Coleoptera), the ladybird (*Micraspis discolor*) are very effective control agents that are mainly used against aphids and coccids as well can kill small caterpillar. As a biological control agent, among the Odonata, the damselflies population was more compared to the dragonflies, and both can be the predators to insect pests *Nephotettix* spp. (Giuliano & Bogliani 2019). Other important natural enemies on the insect pests of rice are recorded as parasitoid belonging to Hymenoptera orders. Parasitoids are insects whose larvae live as parasites that eventually kill their hosts and act as biological controller for pests in rice fields. For example, *Trichogramma* sp. are easily mass-produced and used to control insect pests by killing the lepidopteran pest during the egg stage (Masry et al. 2020). Although this study did not record any *Trichogramma* sp., other parasitoids recorded also play the same role. The recorded Hymenopterans were identified parasitoids such as family Braconidae, *Opius* sp., *Aleiodes* sp., and *Apanteles* sp.

CONCLUSIONS

This preliminary study recorded the pest insects associated with the glutinous paddy field was dominant compared to other guild components such as predator and parasitoid. Consequently, these pest have the potential to cause damage the glutinous paddy production as well as the yield production. However, natural enemies that present in the growing phase of the glutinous field can minimize the pest population if other measures are taken such as by controlling the usage of pesticides and insecticides. Additionally, further research is needed to identify biological control agents among predators and parasitoids to gain effective pest management as well as to increase the crop production of glutinous rice in Malaysia.

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