Diversity of Insect Based on Growth Stages of Rice (*Oryza sativa* L. 'IR 64') at High Altitude in Kepurun Village, Manisrenggo Sub-district, Klaten District, Central Java

Aryo Seto Pandu Wiranto[1] Nindita Sabila Ningtyas[1] Regina Diah Rachmawati[1]
Rahmatullah Rahmatullah[1] Sukirno Sukirno[2,*]

[1] *Master Student at Department of Biology, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sekip Utara, Bulaksumur, Yogyakarta 55281, Indonesia.*
[2] *Entomology Laboratory, Faculty of Biology, Universitas Gadjah Mada.*
Jl. Teknika Selatan, Sekip Utara, Bulaksumur, Yogyakarta 55281, Indonesia.
[*]*Corresponding author. Email: sukirnobiougm@ugm.ac.id*

ABSTRACT
Rice (*Oryza sativa* L.) is one of the biggest commodities in Indonesia. Rice is cultivated in monoculture, so it affects the diversity of insects present in rice fields. The purpose of this research is to study the diversity of insect present at different 'IR 64' rice growth stages including seedling (21 DAP), vegetative (60 DAP), reproductive (92 DAP), ripening (115 DAP). The observation and sampling method was carried out by visual counting, using five repetitions at each rice growth stage. The specimen was identified using morphological characteristics. Total individuals of species obtained at each location were analyzed using diversity index and ANOVA. The correlation regression used to analyze the relationship between total of species and the developmental stage of rice. The results showed that at seedling, vegetative, reproductive, and ripening stages there were found 2, 11, 12, 7, and 12 insect families, respectively. The insect diversity index values at these stages were 0.96, 2.48, 1.81, and 2.28, respectively. Similarity index analysis showed that at vegetative and ripening stages tend to have high similarity. The correlation test results show the P-value of total individuals (N), total species (S), Shannon-Wiener diversity index (H'), and evenness index (E') are 0.96, 0.732, 0.672, and -0.631. It means the number of individuals has a very strong correlation with the rice growth stage. The correlation between the total species and the diversity index with the age of rice indicate a moderate correlation. These results implied the more mature rice growth stage the more insect species diversity.

Keywords: *Monoculture cultivation, Paddy growth stage, Rice pest, Rice variety IR64.*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is categorized as grain crops which contains complex carbohydrates.. It is known as the second major agricultural product in the world 0. Rice needs a lot of water and heat to grow. It grows well in a tropical climate like Indonesia. Since 1980, Indonesia is being the highest country that producing rice among the other countries in tropical climate areas of Asia. Rice mostly cultivated under irrigation and intercropping systems. The number of rice increase in irrigated and rainfed lowland area for a year. About 85% of the lowland areas today are IR64 with growth duration for 110 days 0.

IR64 is the combination of productive plant and resistance from insect and disease. More than 40% of total area in Indonesia was a major producer of IR64 and was still popular in 2009 0. IR64 being new advance in combining excellent palatability of rice which is most growing areas and spread quickly in new site. IR64 has contributed significantly to agriculturist livelihoods not only as it were through higher yields, but also through made strides quality that outcome in higher costs and earlier maturity. It has too been utilized broadly as a parent in breeding programs 0.

IR64 has moderately long-lasting resistance to brown planthopper (BPH) and it is known to carry the main gene *Bph1*. However, it is superior safe than other varieties carrying *Bph1* and has great field resistance to the pest showing antibiosis, antixenosis and resistance 0. IR64 is resistible from *Xanthomonas oryzae* pv. *oryzae* because of Bacterial Blight (BB) disease. The main gene *Xa4* for resistance 00. The quality of gene *Xa4* considered to agronomic benefits in expansion to BB resistance 0. Several *quantitative trait loci* (QTLs) for resistance were identified 0. IR64 can be abiotic stress resistance such as considered sensitive to heat. It has shallow and unoccupied root 00. IR64 has generally low water uptake rate in condition of water stress 0. However, it was demonstrated that IR64 is really tolerant of high heat at generative phase 0.

The sustainable production of rice constraints and issues are pest, such as brown planthopper (BPH), stem borers, gall gnats and rats. Another kind of insect predators found on rice are dragon flies, spiders, wasps, pond skaters and many others 0. Rice disease can be caused by Brown planthopper (*Nilaparvata lugens* Stal), because it sucks the sap of rice tissues so the rice wilt and dies. Three viral diseases are also transmitted by the pest. They detain rice growth and prevent grain formation. *Homorocoryphus nitidulus* Scopoli is a long-horned grasshopper from the family Tettigoniidae. It is also known as *Ruspolia differens* Serville. It is edible and formally known as Hatchlings. It grown-ups by eating the anthers of grasses or grains, such as rice, millet, sorghum and maize [14]. White-backed leafhopper (WBPH) *Sogatella frucifera* (Horvath) (Homoptera: Delphacidae), rice green leafhopper *Nephotettix virescens* Distand (Homoptera: Euscelidae) may be a monophagous species of rice. The most related to rice cultivating in Asia, *Scirpophaga incertulas* Walker, *Leptocarisa acuta* Thunberg, *Cnaphalocrocis medinalis* (Guenee) and *Nympula depunctalis* (Guenee) 00.

The natural enemies, predators and parasitoid of pest intercept the pest density under economic threshold levels. It can be used as biological control agent for harmful species. Beneficial insects such as *Cyrtorhinus lividipennis* Reuter, *Anagrus nilaparvatae* Pang & Wang as predator for eggs of the rice brown planthopper (BPH) and their relation to the rice volatiles. There were 500 beneficial insect species and 130 pest species recorded 00. And 150 insect species were "neutral" since they do not causing rice diseases although they can be survive from predators when the rice was lacking.

Insects have responsibility in ecosystem functions, including as biological agent for pest control. It can decompose organic material in soil or being as natural food for their predators [18][19][20]. Intensive agricultural management system (e.g., monoculture plantations) could decrease arthropod biodiversity, natural enemies, predator and parasitoids significantly [21][22]. Monoculture is a farming system which produce a single crop variety in field at the same time.

Data on insects found in rice and their role in the Kepurun Village has not carried out. The insect on the highlands area which altitude is 350 masl has not been studied before. This research aimed to study insect diversity at different growth stages of rice (seedling, vegetative, reproductive, and ripening) in Kepurun Village, Manisrenggo Sub-district, Klaten District, Central Java.

2. METHODS

2.1. Study Area

This research was carried out from April to June 2021, located in Kepurun Village, Klaten, Central Java (7040'28.4"S 110028'39.8"E) at 350 meters above sea level. The sampling of the research focused on four different fields based on the rice growth stage (IR64 variety), namely the seedling, vegetative, reproductive, and ripening rice stages (Figure 1).

Based on (Table 1), there were four different

Table 1. Description of the sampling locations for the study of insect diversity in Kepurun Village, Manisrenggo, Klaten, Central Java

Location	Altitude (masl)	Growth stage	Day after Planting (DAP)	Irrigation Type
1	320	Seedling	21	River
2	320	Vegetative	60	River
3	315	Reproductive	92	River
4	315	Ripening	115	River

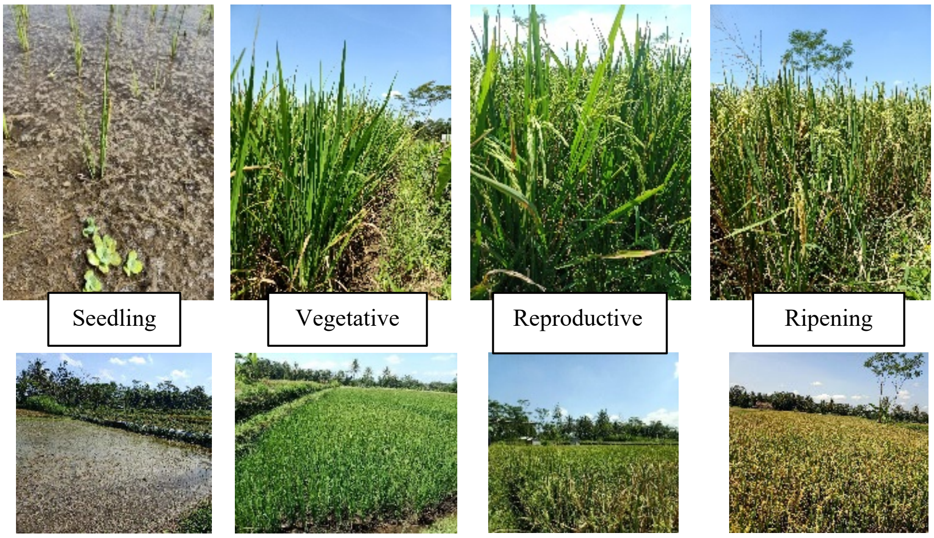

Figure 1. Sampling locations of insects in various stages of rice growth in the rice fields of Kepurun Village, Manisrenggo, Klaten, Central Java.

observation locations with different altitudes and rice growth stages using river as main irrigation system.

2.2. Insect Collection and Identification

The observation and sampling method was carried out by visual counting on each observation location with 5 replications and collection of several specimens with purposive sampling on April 29, 2021, at 10:05 AM - 12:43 PM. Five person was at a different point at the same observation location and at the same time visual counts and collect insects using a sweeping net for 30-45 minutes. The process of identifying insects based on morphology was carried out in the laboratory using the book: An Introduction to The Study of Insect (Borror et al. 1989) and Pest Crops in Indonesia (Kalshoven et al. 1981), as well as the website Catalog of Life (https://www.catalogueoflife.org) as a reference.

The preservation process began with killing the insect specimens were killed in a killing bottle using chloroform and continued with the pinning and mounting process. After the pinning and mounting process was completed, the samples were dried in a dry

wooden box (34 cm x 23 cm x 22 cm) using a five-watt Phillips lamp for 24 hours and tagged with a label on the surface of the box.

2.3. Data Analysis

After the identification process was carried out, it was continued with data analysis by tabulating and calculating the total individuals on each location and then the diversity index, evenness index and similarity index was calculated with the Shannon-Wiener index of species diversity (H') is shown in Equation (1) 0, where *pi* is proportion of each species found. Shannon evenness index (E') is shown in Equation (2) 0, where *S* is total species found. Jaccard Similarity Index (SI) is shown in Equation (3) 0, where *A* total insect species found only at growth stage a, *B* is total insect species

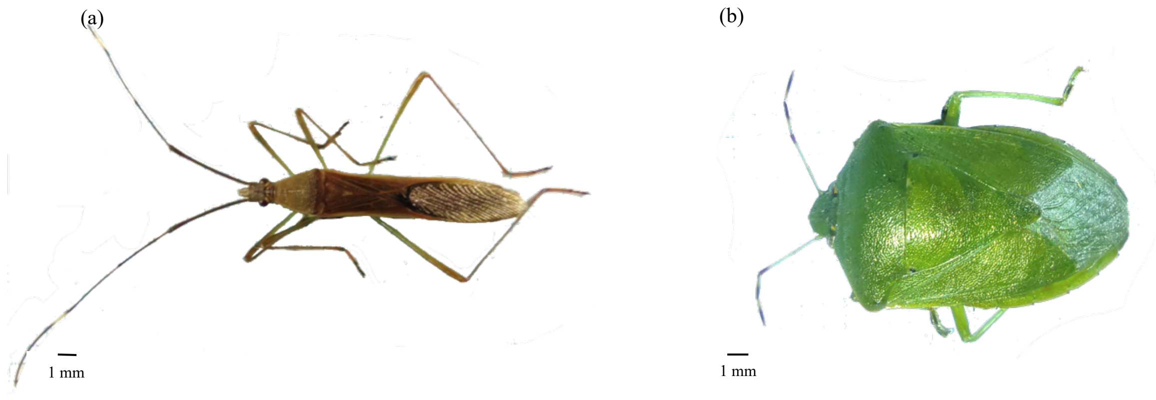

Figure 2. The most common types of insects found in the rice fields of Kepurun Village, Manisrenggo, Klaten, Central Java. *Leptocorisa acuta* (a) and *Nezara viridula* (b). (Scale bar: 1 mm).

found only at growth stage b, and *C* is total insect species found at both locations.

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad (1)$$

$$E' = \frac{H'}{\ln(s)} \quad (2)$$

$$SI = \frac{C}{A+B-C} \quad (3)$$

The correlation between rice age (DAP) and the number of individuals (N), total species (S), diversity index (H'), and evenness index (E') were analysed with SPSS 23.

3. RESULTS AND DISCUSSION

The number of insects found in 4 locations based on the growth and development stage of rice were 157 individuals. Insects were caught manually with a sweep net, but insects under the shade or on the ground are difficult to catch 0. The following Table 2. is the number of orders and species in each stage of growth and development. In the seedling stage, there were two orders, namely Diptera and Orthoptera. Insects found in the vegetative stage consisted of 5 orders, namely Coleoptera, Diptera, Hemiptera, Lepidoptera, and Orthoptera. Whereas, at reproductive stage there were 12 species found and consisted 4 orders, namely Coleoptera, Hemiptera, Lepidoptera, and Orthoptera. For the ripening stage, there were 16 species of 7 orders found, namely Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera.

The highest number of insects was found in the reproductive and ripening rice fields. Various factors contribute to differences in the number of individuals and the diversity of insects in rice fields. One of these is due to land management practices such as the application of chemical pesticides 0, various management methods and strategies 0. In addition, differences in data collection time will result in differences in insect diversity. Arthropod communities taken between the beginning and the end of rice cultivation showed significant differences 0 and would later affect the evenness and dominance of insects found. Based on literature and observations, the different types of insects are classified into their respective roles in the ecosystem 0.

Species name of insects were found out using the morphological features. The most common types of insects found in IR 64 rice fields at Kepurun Village, Manisrenggo, Klaten, Central Java are *Leptocorisa acuta* (Thunberg, 1783) with 39 individuals and *Nezara viridula* (Linnaeus, 1758) 23 individuals (**Figure 2**). Each role of the taxon was categorized into pests, predators, natural enemies and as vectors of diseases in plants according to the literature. The insects found in rice plants is dominated by insect pests.

According to the data in Table 3, the diversity index (H') that has the highest value compared to the others is in the vegetative stage, while the seedling stage has the lowest value (Table 3). This shows that insects in the vegetative stage have a wide range of species and are dominated by phytophagous insects from the Order Orthoptera. At this stage, the rice leaves are in large numbers and are very suitable for the consumption of leaf-eating phytophagous insects such as grasshoppers 0. The evenness index value of each growth stage is at a fairly high level and represents a good evenness of species in each growth stage. However, even though the evenness index value is quite high, the types of insect pests are still relatively more than the types of insects that act as natural enemies.

Table 2. Insect diversity found in IR64 rice fields at Kepurun Village, Manisrenggo, Klaten, Central Java

Rice field stages	Order	Family	Species	Roles in Ecosystem
Seedling	Diptera	Muscidae	*Coenosia* sp.	Natural enemy
		Muscidae	Sp 9	
	Orthoptera	Gryllidiae	Sp 10	Pest
Vegetative	Coleoptera	Carabidae	*Colliuris* sp.	Natural enemy
		Chrysomelidae	*Dicladispa* sp.	Pest
		Carabidae	*Ophionea* sp.	Natural enemy
	Diptera	Muscidae	*Coenosia* sp.	Natural enemy

		Sciomyzidae	*Sepedon* sp.	Pest
	Hemiptera	Coreidae	*Leptocorisa acuta*	Pest
	Lepidoptera	Larval stage	Sp 7	Pest
		Hesperiidae	*Carterocephalus* sp.	Pest
		Lymantriidae	*Orgyia* sp.	Pest
		Arctiidae	*Amata* sp.	Pest
	Orthoptera	Acrididae	*Oxya chinensis*	Pest
		Acrididae	*Xenocatantops humilis*	Pest
		Tettigoniidae	*Conocephalus* sp.	Pest
		Tettigoniidae	Sp 8	
		Tettigoniidae	*Tettigonia viridissima*	Pest
		Acrididae	*Oxya japonica*	Pest
		Pyrgomorphidae	*Atractomorpha* sp.	Pest
Reproductive	Coleoptera	Coccinellidae	*Micraspis kiotoensis*	Natural enemy
	Hemiptera	Pentatomidae	*Nezara viridula*	Natural enemy
		Coreidae	*Leptocorisa acuta*	Pest
		Coreidae	*Acanthocephala* sp.	Pest
	Lepidoptera	Lymantriidae	*Orgyia* sp.	Pest
	Orthoptera	Acrididae	*Oxya chinensis*	Pest
		Acrididae	Sp 6	
		Tettigoniidae	*Conocephalus* sp.	Pest
		Acrididae	*Xenocatantops humilis*	Pest
		Acrididae	*Oxya japonica*	Pest
		Pyrgomorphidae	*Atractomorpha* sp.	Pest
Ripening	Coleoptera	Chrysomelidae	*Cerotoma trifurcata*	Pest
		Coccinellidae	*Curinus coeruleus*	Natural enemy
		Coccinellidae	*Micraspis kiotoensis*	Natural enemy

	Diptera	Dolichopodidae	Sp 1	
	Hemiptera	Coreidae	*Leptocorisa acuta*	Pest
		Pentatomidae	*Nezara viridula*	Natural enemy
	Hymenoptera	Formicidae	*Lasius niger*	Natural enemy
		Halictidae	Sp 2	
	Yellow winged fly	Sp 3		
	Leaf rolling larvae	Sp 4		
	Lepidoptera	Nymphalidae	*Junonia almana*	Pest
	Odonata	Coenagrionidae (SF: Zygoptera)	*Ischnura senegalensis*	Natural enemy
	Orthoptera	Tettigoniidae	*Conocephalus cognatus*	Natural enemy

Table 4. Similarity index of insects present between rice growth stages at Kepurun Village, Manisrenggo, Klaten, Central Java

Growth stage (a) & Growth stage (b)	Jaccard similarity index (*SI)*
Ripening & reproductive	0.417
Ripening & vegetative	0.125
Ripening & seedling	0
Reproductive & vegetative	1
Reproductive & seedling	0
Vegetative & seedling	0.059

*0-1 with a tendency of the level of similarity (IS) to be higher if the value is closer/equal to 1

		Acrididae	*Caryanda* sp.	Natural enemy
	Orthoptera	Acrididae	*Xenocatantops humilis*	Pest
	Hymenoptera	Formicidae	Sp 5	

Similarity between each growth stage of rice (Table 4) shows that the vegetative and reproductive stages had very similar kinds of insects manifesting them. Two successive stages tend to have high similarity and this is possibly because the transition from one stage to the next may still be able to support the existence of the same type of insect.

Table 3. Correlation of rice growth stages with total individuals (N), total species (S), diversity index (H'), and evenness index (E') of insects at Kepurun Village, Manisrenggo, Klaten, Central Java

Parameters	Age of Rice (day)				Pearson Correlation Test Value
	21	60	92	115	
Total Individuals (N)	7	38	56	56	0.960*
Total Species (S)	3	17	11	16	0.732
***Diversity Index* (H')**	0.96	2.48	1.81	2.28	0.672
***Evenness Index* (E')**	0.87	0.87	0.75	0.82	-0.631

*significant at 0.05 level of confidence

Based on the regression analysis (Table 3), rice age was positively correlated with total individuals (N), total species (S), and Diversity Index (H') of insects found in rice fields, but negatively correlated with Evenness Index (E'). The correlation between the age of rice and the number of individuals showed a P value of 0.96, which means that the second variable has a very strong correlation. The longer the age of rice, the more insects found in the fields. Meanwhile, the correlation between the total species and the Diversity Index with the age of rice showed P values of 0.732 and 0.672, respectively. These results indicate a moderate correlation, the longer the age of rice, the total insect species, and the diversity index tend to increase. Rice in the reproductive stage experienced a decrease in the number of species, diversity index, and evenness index compared to the vegetative stage due to the application of insecticides on the land by farmers to repel pests but indirectly, insecticides also reduce the diversity of non-target insects 0.

The number of individuals has a very strong correlation with the age of rice. The total species and the diversity index with the age of rice indicate a moderate correlation. So, the longer the age of rice affects the total insect species and the diversity index tends to increase. The results obtained from this study may be utilized for further management of rice agriculture. Utilization of proper methods for each growth stage according to each kind of insect found.

AUTHORS' CONTRIBUTIONS

Aryo Seto Pandu Wiranto lead in writing the manuscript, data analysis, and designed the figures. Nindita Sabila Ningtyas, Regina Diah Rachmawati, and Rahmatullah Rahmatullah collected and identify the sample, analyzed the data, arranged the data presentation, composed the manuscript draft and commented on the manuscript. Sukirno Sukirno devised the project, supervised, and gave inputs on the writing of the manuscript.

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