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Population Dynamics of Rice Bugs (*Leptocorisa oratorius* Fabricius, (Hemiptera: Alydidae) and Natural Enemies in the Reproductive Phase of Rice

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A B S T R A C T

The pest of rice bugs (*Leptocorisa oratorius* Fabricius) is very dangerous for rice plants, especially when the rice plants begin to have grain bodies, therefore monitoring is necessary at all times in the field. The population dynamics of the pest of stink bugs was highest during the third week of 2.78 and the lowest at the second and fifth weeks of 0.21 respectively. The intensity of the pest attack was the smallest during the third observation, which was 9% and the highest at the sixth observation reached 73%. The development of natural enemy populations in each observation seemed to dominate the ladybugs, the highest was achieved in week VIII as many as 35, with a total population of 74 individuals. Followed by 13 spiders, the highest at week V as many as 3 tails, then 6 butterflies and wasps each. The last dragonfly with a population of 4 tails. The correlation between insect pests (stink bugs), and natural enemies with temperature and humidity did not have a significant relationship. Only the intensity of pest attack with temperature had a significantly negative relationship, with the regression equation Y = 1.52 - 0.046 X1 (Y = intensity of pest attack of stink bugs, and X1 = temperature).

Introduction

The pest can be a significant pest on rice crops, as it feeds on the developing grain (milk stage): reducing crop quality and sometimes yield. Since the attacks occur before harvest, if farmers spray insecticides in an effort to control the outbreak, they risk leaving harmful pesticide residues on crops. Rice bugs (*Leptocorisa acuta* Thunberg) is a major pest of rice plants. The broad-headed insect belonging to the family Alydidae, is a well-known but relatively small plant-eating insect. These insects are usually seen feeding on the leaves and flowers of leguminous and graminaceous plants. *Leptocorisa acuta* (Thunberg) can be found on many food crops in the family Poaceae (grasses), especially rice, and is reported to be an economically important pest in rice-producing countries such as India, Australia, and China (Schaefer and Panizzi, 2001). *Leptocorisa acuta* is usually found at the flowering stage of rice plants, which coincides with rainfall and high humidity at the beginning of the rainy season (Reji and Chander, 2007).

Nymphs and adults have piercing-sucking mouthparts to feed on developing rice grains. These insects prefer to eat the host plant when the host plant is young, when the starch in the grain is not fully formed. *Leptocorisa acuta* is crepuscular, active in the morning and evening. During the midday heat, they leave the rice fields in search of wild grass areas (Pathack and Khan, 1994).

These insects also seek refuge during the dry months (Corbett, 1930). *Leptocorisa acuta* is known to transmit *Sarocladium oryzae* and *Sarocladium attenuatum* (fungus), which cause midrib rot disease. Midrib rot disease damages the panicle (branched flower arrangement) of rice plants, causing the plant to produce underdeveloped or damaged grains. In severe cases, infected plants may not produce rice grains.

Materials and Methods

Place and time of research

The research was carried out in two places: 1) sample collection of the pest and natural enemies was carried out in the field in Penatih Dangin Puri Village, East Denpasar District, and 2) the Plant Pest Laboratory, Faculty of Agriculture, Udayana University. The research was conducted from March to June 2022.

Population Dynamics

Pests that appeared in each experimental plot were counted for their population and type and quantitatively the number was recorded from week to week during the period of plant growth. The exponential growth dynamics of each pest population is then calculated by the Malthus (1798) formula:

Nt = Noer or dN/dt = rN

Where:

No = Total initial population, at time t = 0 Nt = Total population at time t

e = Natural logarithmic base = 2.71828

r = Constant/intrinsic rate of natural growth

dN = Speed of changing population/time at a certain time dt = time interval

Attack Intensity

The intensity of the pest attack can be calculated using the formula:

I = n/N x 100% (n = number of affected panicles, and N = total number of panicles observed). Samples were taken from each plot with a size of 10 m2, then repeated 3 times. Observations were made 9 times, which were repeated once a week, until the rice plants were close to harvest. Observations are made every morning at 7.30 pm, when the sun begins to rise.

Determining Diversity and Dominance Index

Diversity and dominance of contaminant fungi can be determined by calculating the Shannon-Wiener diversity index (Odum, 1971) and microbial dominance is calculated by calculating the Simpson index (Pirzan and Pong-Masak, 2008).

Relative abundance

The relative abundance according to Odum (1971) is the percentage of the number of individuals of a species to the total number of individuals present in a certain area in a community and is formulated as follows:

RA = ni/N x 100%

Where:

RA = relative abundance

Ni = number of individuals of each i-th species N = total number of individuals

Microbial diversity index

The microbial diversity index in pineapple was determined by the Shannon-Wiener diversity index, namely by the formula (Odum, 1971):

$$H' = - \sum_{i=1}^{s} Pi \ln Pi.$$

Where:

H' = Shannon-Wiener diversity index S = Number of genera
Pi = ni/N as the proportion of the ith species (ni = the total number of individuals of the total microbial species i, N = the total number of individuals in the total n)

Evenness uniformity index (E)

To determine the balance of the community, the uniformity index is used, which is a measure of the similarity of the number of individuals between species in a community. The more similar the number of individuals between species (the more evenly distributed), the greater the degree of balance. The uniformity index formula (e) is obtained from (Insafitri, 2010):

$$e = H'/\ln S$$

Where:

H' = diversity index

S = Number of species

e = Evennes uniformity index

The smaller the value of the diversity index (H') then the uniformity index (e) will also be smaller, which indicates the dominance of one species over another.

Here's the range:

$e < 0.4$: small population uniformity

$0.4 < e < 0.6$: moderate population uniformity $e > 0.6$: high population uniformity

Dominance index

The soil microbial dominance index was calculated by calculating the Simpson index (Pirzan and Pong-Masak, 2008), with the following formula:

$$C = \sum_{i=1}^{s} Pi^2$$

Where:

C = Simpson's index S = Number of genera

Pi = ni/N = the proportion of individuals of type i and all individuals (ni = total number of individuals of species i, N = number of all individuals in total n).

Furthermore, the species dominance index (D) can be calculated using the 1-C formulation (Rad *et al.,* 2009). The criteria used to interpret the dominance of soil microbial species are: close to 0 = low index or lower dominance by one microbial species or there is no species that extremely dominates other species, close to 1 = large index or tends to be dominated by several microbial species (Pirzan and Pong-Cook, 2008).

Temperature and Humidity Observation

Observations of temperature and humidity were carried out by placing a Thermohygrometer under the rice fields, then recorded every time the pest was observed. So that temperature and humidity can be related to the pest population and natural enemies by correlation and regression. Correlation and regression analysis were searched by using excel program analysis.

Relationship Between Pest Population with Temperature and Humidity

Analysis to determine the relationship between the population of pests and natural enemies with temperature and humidity used a regression analysis approach, and the interrelationships of the two variables were calculated by correlation analysis (Gomes and Gomes, 2007).

Results and Discussion

Pest Population of Stink Bugs

The results of observations of the stink bugs population fluctuated from an average of 16.67 per 10 m2 then increased with increasing age of rice plants before harvest to 50 at the VIII observation and 44 per 10 m2 at the IX observation (Table 1; Figure 1).

Rice bugs does not like light, tends to hide in a shady place, and avoids sunlight. The cropping pattern greatly determines the pest population, the cropping pattern at the observation site is rice-paddy-rice, so the pest population remains high, and according to Wijaya *et al.,* (2011) if a severe attack of stink bugs can reduce rice production by up to 60%.

The number of tillers is in line with the number of panicles, the more the number of tillers/panicles, the better the microclimate conditions of the plant and the more preferred by organisms, especially the pest of rice bugs, as well as the colour of the plant also determines whether pests like it or not (Paputungan *et al.,* 2019).

It is often observed that the pest stink bugs is having a marriage (Figure 2), after holding a marriage it will lay eggs and hatch into larvae, pupae and imago. Imago of *L. oratorius* showed that the imago was brown, winged, 14-17 mm long and 3-4 mm wide with long legs and antennae. This description of the rice bugs imago belongs to the species *L. oratorius*.

Nymphs show bright green nymphs, wings not fully developed, then slender. The morphology of male and female stink bugs is different where the end of the tail (abdomen) of male stink bugs looks slightly rounded or looks like the "head of a caterpillar" while the female stink bugs is pointed and more bigger than male bugs. They actively fly from clumps to clumps in the morning and evening, located at the base of the plant at during the day because stink bugs does not do much activity during the day. Adult stink bugs are very strong at flying and in large numbers can fly together towards other crops quickly. Rice bugs can move (migrate) from grasses, weeds, or from areas of existing woody plants. around rice plantations (Paputungan *et al.,* 2019).

Intensity of Attack of Rice Bugs

The intensity of the pest attack was the smallest during the third observation, which was 9% and the highest at the sixth observation reached 73%. Based on samples taken from the planted area, fluctuating data were obtained (Table 2; Figure 3). Symptoms of pest infestation appear to be brown and empty panicles, because the contents are sucked in by the bugs (Figure 4). Stink bugs actively flies from clump to clumps in the morning and evening, are at the base of the plant during the day because the stink bugs does not do much activity during the day.

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Natural Enemy Population

The development of natural enemy populations in each observation seemed to dominate the ladybugs, the highest was achieved in week VIII as many as 35, with a total population of 74 individuals. Followed by 13 spiders, the highest at week V as many as 3 tails, then 6 butterflies and wasps each. The last dragonfly with a population of 4 individuals (Table 3; Figure 5).

An ecological approach by considering biodiversity is the basis for thinking and implementing biological control. Thus, natural enemies become an important component of the ecosystem in every biological control activity. The existence of natural enemies in the ecosystem can be seen from their role in natural control and biological control and their status as "biological agents". This is partly due to climatic deviations such as very heavy rain, drought or a sudden decrease and increase in temperature. Due to the nature of the dependence of the natural enemy on the host or prey, the existence of the host required for the growth and reproduction of the natural enemy is absolute. In other words, for the continuity of natural enemies, the availability of the intruder's body is always needed. This means, for the preservation of natural enemies, the population of nuisance bodies should not reach zero, or there should be no nuisance bodies remaining. In other words, we must not destroy a disturbing body, so that the biological and natural balance can be preserved (Sopialena, 2018).

Population Dynamics of Rice Bugs

The dynamics of the rice bugs population was obtained the highest at the third week of 2.78 and the lowest at the second and fifth weeks of 0.21 respectively. The size of the population dynamics indicates that there are a certain number of stink bugs born and there is a certain number of stink bugs migrating to other places. At the time of the third week the population dynamics was reached at 2.05, this is a sign that the development of the stink bugs population at that time was quite rapid, as much as 2 times the previous population, while the population dynamics at the second and fifth weeks were 0.21 respectively. It means that from a hundred population of stink bugs increases by 21% every week (Table 4).

The factors that determine the high and low population of an organism consist of internal, external, and food factors. Insect internal factors include life cycle, sex ratio, and personality. The life cycle is the length of time an insect develops from egg to the insect lays its first egg. The shorter the life cycle, the faster the insect population will grow. Sex ratio is the ratio of male and female insects where the more females produced, the faster the insect population will develop, and personality, namely the number of eggs produced by a female, of course, the higher the personality level of an insect, the faster the insect population will develop (Dadang, 2006).

Furthermore, Dadang (2006) said that external factors consist of abiotic and biotic environments. The abiotic environment includes rainfall, temperature, humidity, and other factors that will limit or encourage insect populations to develop. High rainfall can affect the development of insect populations directly, namely by physical effects due to rain, especially for small insects and indirectly by creating good conditions for the development of diseases that can make insects sick to death. Various biotic environmental factors include predators, parasitoids, pathogens, competitors, and others. The presence of predators and parasitoids in a crop will suppress the development of the insect pest population. The food factor is another factor that will determine the development of the insect population. Food quality and quantity factors will have an influence on the high and low population development.

Table.1 Population of the pest in each observation

Variable	Replication	Observation time (weeks)								
		I	II	III	IV	V	VI	VII	VIII	IX
Rice bugs	I	15	24	9	68	39	52	64	56	52
	II	21	13	31	53	51	57	51	68	37
	III	14	23	13	37	49	28	19	26	43
Total		50	60	53	158	139	137	134	150	132
Average		16.67	20	17.67	52.67	46.33	45.67	44.67	50	44

Fig.1 The graph of the development of the Stink bugs population in each observation

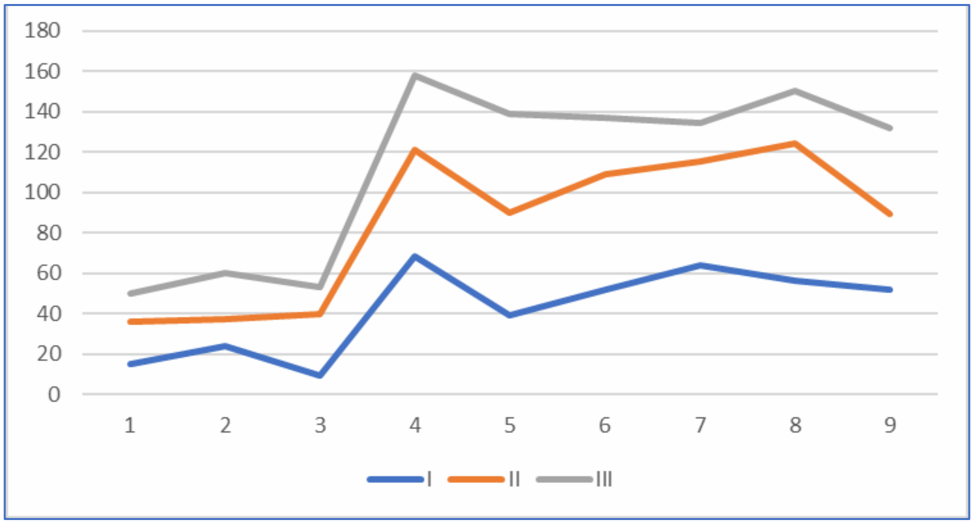


Table.2 Intensity attack of rice bugs

Variable	Replcation	Observation time (week) (%)								
		I	II	III	IV	V	VI	VII	VIII	IX
Rice bugs	I	20	20	11	13	49	88	40	20	35
	II	24	29	8	20	20	60	11	39	26
	III	27	13	8	14	41	71	20	63	34
Total		71	62	27	47	110	219	71	122	95
Average		24	21	9	16	37	73	24	41	32

Fig.2 Rice bugs during marriage (left) and nymph (right), morning observation at 7.30 am (personal document)

Table.3 Natural enemy population for each observation

Variable	Observation time (week)									
	I	II	III	IV	V	VI	VII	VIII	IX	Jumlah
Butterfly (Papilionidae)	3	-	-	-	1	1	-	1	-	6
Ledybug (Pentatomidae)	4	1	1	4	3	6	4	35	4	74
Spiders (*Oxyopes salticus*)	-	1	2	2	2	3	1	1	1	13
Wasp (*Amata huebneri*)	1	1	1	-	2	-	1	-	-	6
Dragon fly (*Choristhemis flavoterminata*)	-	-	1	-	-	2	1	-	-	4

Table.4 Population dynamics od stink bugs each observation

Pest	Replication	Observation time (week)							
		I	II	III	IV	V	VI	VII	VIII
Rice bugs	I	0.59	0.14	2.78	0.21	0.49	0.45	0.32	0.34
	II	0.23	0.88	0.63	0.35	0.41	0.33	0.49	0.20
	III	0.60	0.21	1.05	0.49	0.21	0.25	0.50	0.61

Fig.3 The intensity of the pest attack at each observation

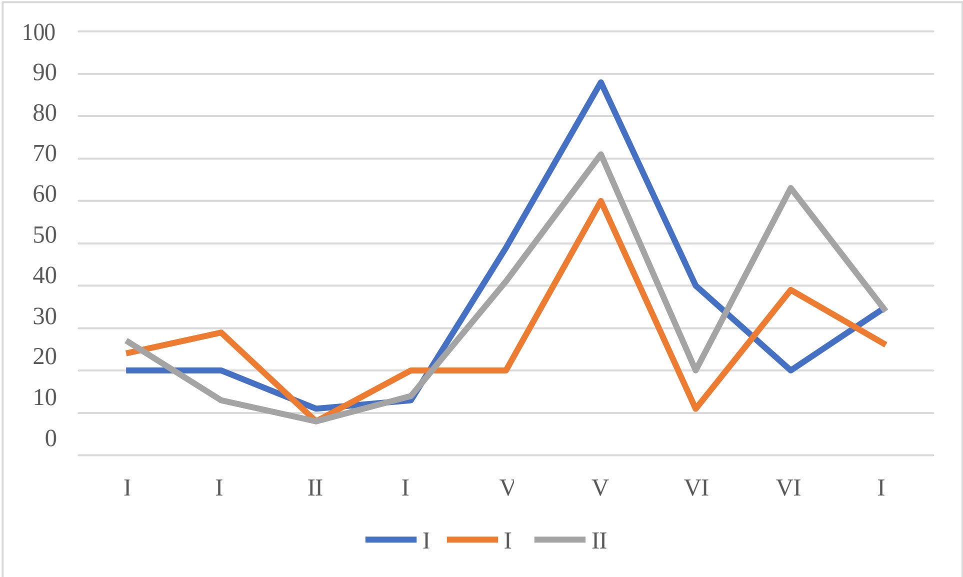


Fig.4 Natural enemy population development for each observation

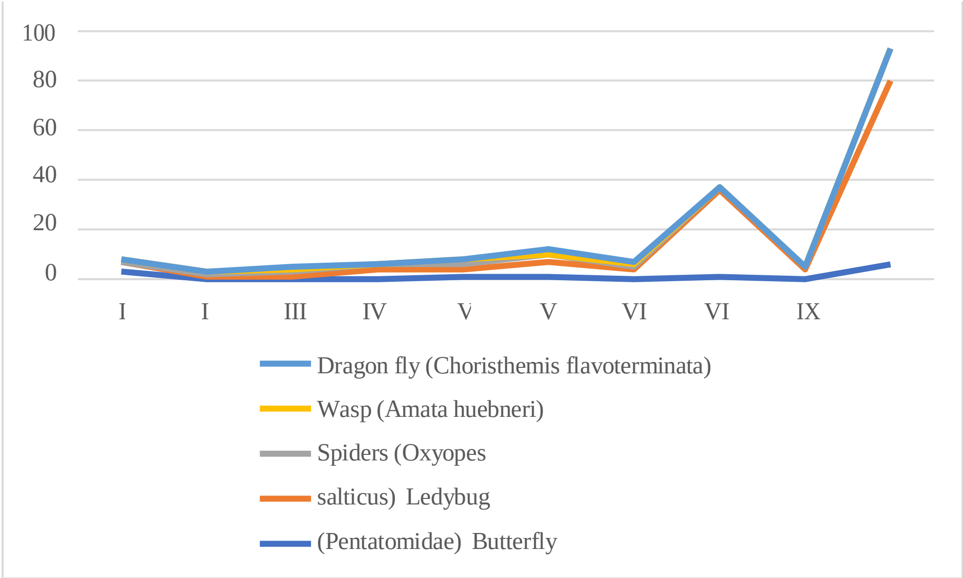


Table.5 Enemy diversity and dominance index

Enemies	pi	pi/P	Ln (pi)	pi/P x Ln (pi)	(pi/P)2
Butterfly (Papilionidae)	6	0.058252	1.79175947	0.1043743	0.0033933
Ledybug (Pentatomidae)	74	0.718447	4.30406509	3.0922409	0.5161655
Spiders (*Oxyopes salticus*)	13	0.126214	2.56494936	0.3237315	0.0159299
Wasp (*Amata huebneri*)	6	0.058252	1.79175947	0.1043743	0.0033933
Dragon fly (*Choristhemis flavoterminata*)	4	0.038835	1.38629436	0.0538367	0.0015082
Total	103			3.6785578	0.5403902
H' (diversity index)	3.6786				
D (dominance index)	1 - C	1-0.5404	0.4596		

Table.6 Criteria for weighting environmental quality (Tauruslina *et al.*, 2015)

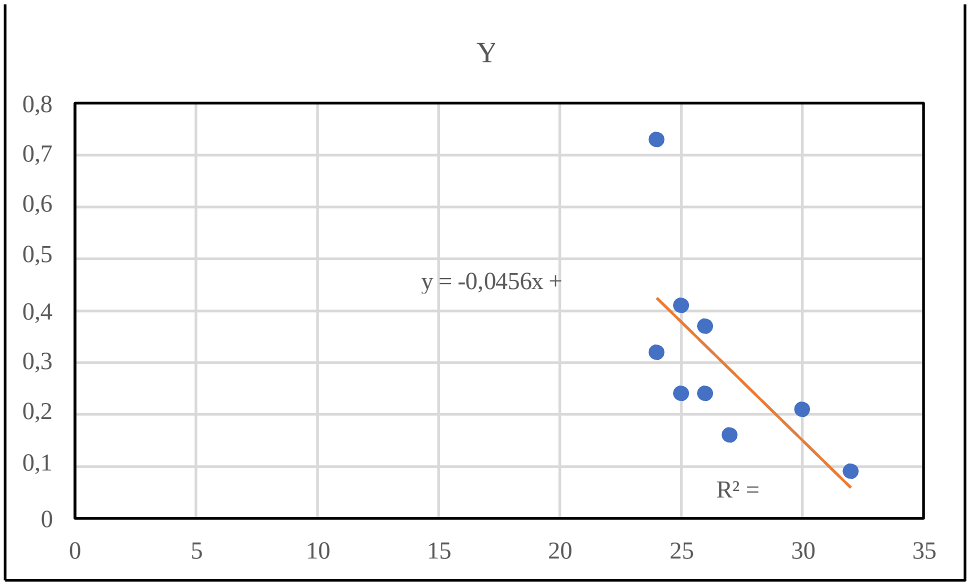
Diversity index	Community structure conditions	Category	Scale
>2.41	Very stable	Very good	5
-2.4	More stable	good	4
1.21 – 1.8	Stable enough	Currently	3
0.61 – 1.2	Less stable	Bad	2
<0.6	Unstable	Very bad	1

Table.7 Correlation and regression relationship between insect pest population, intensity of pest attack and natural enemies with temperature and humidity

Variable	Temperature		Relative humidity	
	Correlation coefficient	Regession	Correlation coefficient	Regession
Musuh alami = Anemies	-0.48	-	0.09	-
Walang sangit = Rice bugs	-0.60	-	-0.21	-
Intensitas serangan hama = Attack intensity	-0.67*	Y* = 1.52 – 0.046 X_1	-0.46	-

*significantly relationship, X1 = temperature

Fig5 Regression relationship between attack intensity and temperature



Natural Enemy Diversity and Dominance Index

The results of the analysis of the diversity index and dominance of natural enemies showed that the diversity index was 3.6786 and the dominance index was 0.4596 (Table 3). According to Tauruslina *et al.*, (2015) with a diversity index of 3.6786, it means that the condition of the community structure is very stable with a very good category and a scale of 5 (Table 4). While the dominance index is still below 0.5, it means that the species is considered evenly distributed.

Based on the analysis of relative abundance (Table 3), the highest was achieved by ladybugs at 72%, followed by spiders at 13%, then butterflies and wasps each at 5.8% and the smallest was dragonflies at 3.9%. While the Evennes uniformity index (e) was obtained at 0.7937 meaning $0.4 < e < 0.6$ which means moderate population uniformity.

Correlation and Regression Relationship between Insect Pest, Intensity of Attack and Natural Enemies with Temperature and Humidity

The correlation between insect pests (rice bugs), and natural enemies with temperature and humidity did not have a significant relationship. Only the intensity of pest attack with temperature had a significantly negative relationship, with the regression equation $Y = 1.52 - 0.046\ X1$ (Y = intensity of pest attack by pests and diseases, and X1 = temperature) (Table 6).

The higher the temperature to a certain extent the smaller the intensity of the pest attack. This is due to the fact that stink bugs does not like light, even during the day, it tends to take shelter on the lower leaves (avoiding sunlight) (Figure 6). The correlation between natural enemies and the pest population showed an unsignificant relationship, as well as the intensity of attacks with the pest population which was not significantly related.

Pests and plant diseases are dynamic and their development is influenced by the biotic environment (plant growth phase, population of other organisms, etc.) and abiotic (climate, season, agroecosystem, etc.) environment.

Basically all organisms are in balance (under control) if the ecological balance is not disturbed. In certain locations, certain pests and diseases have existed before or come (migrate) from other places because they are attracted to the newly growing rice plants. Climate change, crop stadia, cultivation, cropping patterns, presence of natural enemies, and control methods affect dynamics development of pests and diseases.

Important things that need to be known in controlling pests and diseases are: the type, when it is in the location, and what disturbs its balance so that its development can be anticipated in accordance with the stages of plant growth (Makarim *et al*., 2003).

Based on the discussion above, it can be concluded as follows: Population dynamics of the pest of the pest stink bugs was highest at week III of 2.78 and the lowest at week II and V of 0.21 respectively. The intensity of the pest attack was the smallest during the third observation, which was 9% and the highest at the sixth observation reached 73%. The development of natural enemy populations in each observation seemed to dominate the ladybugs, the highest was achieved in week VIII as many as 35, with a total population of 74 individuals.

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Only the intensity of pest attack with temperature had a significantly negative relationship, with the regression equation $Y = 1.52 - 0.046\ X1$ (Y = intensity of pest attack of stink bugs, and $X1$ = temperature).

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