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The Roles of Predators Suppress Brown Planthopper, *Nilaparvata lugens* Stal in the Ricefields

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Original Research Article

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Abstract: Research the roles of predators as natural enemies suppress brown planthopper (BPH) were conducted in two season, two varieties, and 3 locations that were at Ciasem, SHS Seed Center and Ciberes of Subang district of West Java. The results showed that the relationship of BPH and predators was influenced by differences of season, place, varieties, initial population of BPH and increased population of BPH during rice plant growth. The multiple regression equation between BPH and predators were a remarkable equation with a high coefficient of determination, although in the simple linear regression didn't show a real relationship. The development of BPH population increased with increasing age of rice and the fastest BPH development on Pandanwangi variety in Ciberes exceeding the economic injury level. The development of predators *L. pseudoannulata*, Spiders, *P. fuscipes*, *O. nigrofasciata*, *Coccinella*, and *C. lividipennis* were stable in all locations, on all varieties, and at all seasons, although BPH as food were abundance. The coefficient of determination adjusted (Adj. R^2) of multiple regressions between BPH with predators decrease at the BPH population increasing rapidly. On BPH development was around the economic threshold will be followed by development of predators with the coefficient of determination was the highest reaches Adj.R^2 =0.7046. On BPH development exceeds of economic threshold will still be followed by development of predators, but the coefficient of determination decreased to Adj.R^2 =0.6365. On the other hand of BPH development was in economic injury level or more didn't be followed by development of predators with the coefficient of determination was the lowest up to Adj.R^2 = 0.1530.
Keywords: Natural enemies, predators, BPH, rice, regression

INTRODUCTION

The rice planthoppers Delphacidae of Hemiptera widespread throughout Asia, especially in Indonesia existed two rice planthoppers namely brown planthopper (BPH), *Nilaparvata lugens* Stal. and whitebacked planthopper (WBPH), *Sogatella furcifera* Horvath. In the others country as China and Vietnam, besides the two planthoppers mentioned there was small brown planthopper (SBPH), *Laodelphax striatellus*. Baehaki *et al.*, [1] reported BPH is one of the most economically important insects and the most famous planthoppers which caused a major problem to increase rice production. Both nymphs and adults of the BPH damage rice directly by removing nutrients and indirectly by transmitting rice grassy stunt virus (RGSV) and rice ragged stunt virus (RRSV).

Naturally the BPH in the normal population has been successfully controlled by natural enemies of both predators and parasitoids. The richness of natural enemies as an asset of agroecosystem uncountable in the field. On the other hand understood that function of natural enemies is very adequate to control pests in rice crops, so that the biological balance of pest-natural enemies are very rarely towards near under the economic threshold. Failure of natural enemies suppress to rice pests within reasonable limits, actually do not automatically have to be controlled using insecticides, but the farmers opinion in a hurry use insecticides in order steady in the slight yield losses. Therefore control to the rice brown planthopper, *Nilaparvata lugens* Stal. (Hemiptera: Delphacidae) is still base on to insecticides, since they rapidly reduce pest populations to below the economic threshold [2]. In the other hand that chemical applications have negative impacts on the populations of natural enemies are needed some restrictions both in application and type of insecticides.

Predators found in the ricefields consuming nymphs and adults of hoppers was spiders (*Pardosa* (*Lycosa*) *pseudoannulata*, *Tetragnatha maxillosa*, *Clubiona javonicola*, *Araneus inustus*, *Calitrichia formosana*, *Oxyopes javanus*, and *Argiope catenulate*), *Ophionea nigrofasciata* and *Paederus fuscipes* [3]. Similarly found many predators of coccinelid and libellulid.

The rice pests are the prey of predators and also Chironomid a neutral insects was useful as supplements food of predators, moreover Garcıa-Berthou [4] reported that Chironomid provide an important link between different trophic levels, and play a key role in recycling organic matter. Baehaki *et al.*[5] reported that organic matter be able to enriches the populations of neutral insect as food for spiders and dragonflies that both groups natural enemies are useful for suppressing rice pests.

In the ricefield sometimes populations of natural enemies decreasingly not only a directly suppressed by insecticides, but also indirectly the natural enemies drastically decrease caused lack of pests-foods. Pests be killed by used carelessly insecticides. The consequently of the main food decreased to urge may natural enemies died. Insecticides are commonly used to control rice insect pests, however, these insecticides also affect to beneficial organisms [6].

To understanding of pest-natural enemy-insecticide interaction is needed to formulate more effective integrated pest management strategies [7]. It is important to understand how the relationship pests and natural enemies that are a strategy in ecological engineering to improve the performance of natural enemies suppress rice pests. Therefore, the objective of this research is to explore information about the role of natural enemy especially predators in rice cultivation, in relation to brown planthopper.

MATERIALS AND METHODS

Research the roles of predators as natural enemies suppress brown planthopper (BPH) were conducted in 3 locations at Subang District of West Java in the DS 2012 at Ciasem and in WS 2013 at SHS Seed Center and Ciberes. The varieties used were Ciherng for Ciasem and Pandanwangi for SHS Seed Center and Ciberes.

Twenty one days seedling old of Ciherang and Pandanwangi varieties was planted on 5 x 8 m plot size (three plots as replication) with spacing 25 x 25 cm. Nutrient SP36 (125 kg/ha) and KCl (50 kg/ha) were given before transplanting. The nitrogen fertilizer from urea were given three times namely before transplanting, 25 day after transplanting (dat), and at 45 dat each for 1/3 part of nitrogen dose (50kg/ha Urea). All of the plot didn’t apply by pesticides for weeds, pests, or for diseases. In the other hand the rice plants around the experimental plots are controlled by insecticides, so as not to disrupt the development of BPH populations and natural enemies in the treatment plots and do not affect the population due to pest movements.

Observations started at 4 weeks after planting with every 1 week interval up to 2 weeks before harvest on 30 hills cross diagonal. At each diagonal were observed 15 hills. At each observation was recorded BPH population and predators *Lycosa* (*Pardosa*) *pseudoannulata*, other spiders, *Ophionea nigrofasciata, Paederus fuscipes, Coccinella,* and *Cyrtorhinus lividipennis*. Spiders of many kinds such as *Lycosa pseudoannulata* (Boesenberg and Strand), *Oxyopes javanus* Thorell, *Oxyopes lineatipes* (CL Koch), *Phidippus* sp, *Atypena* (= *Callitrichia*) *formosana* (Oi), *Agriope catenulata* (Doleschall), *Araneus inustus* (CLKoch), and *Tetragnatha maxillosa* Thorell. Therefore in observation only distinguished into *Lycosa pseudoannulata* and other spiders to facilitate visual observation in the field.

The data was analyzed of relationship between BPH with predators using simple regression equation: y = a + bx. The dependent variable (y) as BPH and the independent variables (x) as each predator. The value b is the estimated slope of a regression of y on x and a is the intercept. In the other hand from simple linear regression equation followed by multiple regression equation with equation: $BPH = a + b_1lyc + b_2spd + b_3pae + b_4oph + b_5coc + b_6cyt$. On the multiple regression the values of b_1, b_2 .....b_6 are the partial regression coefficients and the intercept (a), notation of lyc, spd, pae, oph, coc, and cyt are *L. pseudoannulata*, spiders, *P. fuscipes*, *O. nigrofasciata*, *Coccinella*, and *C. lividipennis* respectively.

RESULTS AND DISCUSSIONS

Abundance of BPH and Predators in Various Locations

At DS 2012 in Ciasem ricefield were found BPH and predators. The kinds of predators were *L. pseudoannulata*, other spiders, *P. fuscipes*, *C. lividipennis*, *O. nigrofasciata, Coccinella,* and *C. lividipennis*. The average of BPH population in one season was 6.42 BPH/hill, the initial population was 2 BPH/hill, and the highest population was 13 BPH/hill. The peak BPH population occurred at 6 weeks after transplanting (WAT) (= 3 weeks from start of observation) in samples 7, 8, and 9 were 11.83, 12.57 and 12.17 BPH/hill respectively. The average natural enemies were 0.071, 3.244, 0.609, 0.049, 1.18, and 0.291 tails/hill for *L. pseudoannulata*, other spiders, *P. fuscipes, O.nigrofasciata, Coccinella,* and *C. lividipennis* respectively.

The development of BPH every week at DS 2012 was around at the economic threshold (ET), although in the field quite a lot of natural enemies. The population of BPH in samples 1, 2, and 3 (4 WAT) was very low and began to increase at 5 WAT (samples 4.5, and 6).

Baehaki [8] reported that BPH economic threshold on the vegetative and generative phase was 9 and 18 BPH/hill respectively if the price of rice grains was US $0.1/kg (900 IDR/kg). If the price of rice at harvested will be >3,150 IDR/kg, then the value of ET = 3 BPH/hill under the rice crop age below 40 days after transplanting (DAT) or the value of ET = 5 BPH/hill on the rice crop stage more than 40 DAT. At 8 WAT (samples 13, 14, 15) the BPH population declined lower than the predator's population of spiders, *Coccinella*, and *P. fuscipes* were quite high exceeds of the BPH population (Fig.1).

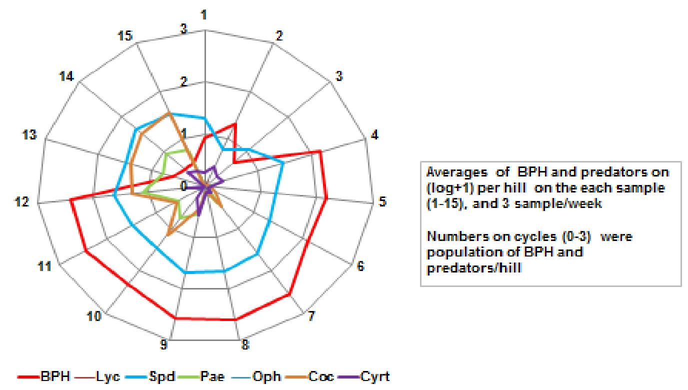

Fig. 1. Development of BPH population (log+1) and predators (log+1) per hill on the each week up to 2 weeks before harvest at Ciasem. DS 2012

In samples 4-12 (5-7 WAT) there were a closed system between BPH and predators, ie the highest of BPH population covered a population of predators. In the samples 13-15 (8 WAT) there were an open system between BPH and predators, the BPH population lower than predator's population and give an opportunity for predators to control the BPH. Actually, in a closed system can be occurred in biological balance if the BPH population under economic threshold. Such a situation can be accepted as logically of biology, because at that time the population of BPH didn't cause to economicaly damage.

In WS 2013, the rice cultivation at SHS Seed Center obtained BPH and predators. The kinds of predators found were *L. pseudoannulata*, other spiders, *P. fuscipes, C. lividipennis, O. nigrofasciata, Coccinella* and *C. lividipennis.* The development of BPH continues to exceed the ET value, although in the field quite a lot of natural enemies.

The average BPH population in one season was 21.18 BPH/hill, the initial population was 5 BPH/hill, and the highest population was 50 BPH/hill. The peak BPH population occurred at 8 WAT in samples 13, 14, and 15 were 43.83, 42.07 and 50.07 BPH/hill respectively. The average natural enemies were 0.063, 1.746, 0.372, 0.017, 0.03, and 0.869 tails/hill for *L. pseudoannulata*, other spiders, *P. fuscipes, O. nigrofasciata, Coccinella,* and *C. lividipennis*.

The BPH population of samples 1, 2, and 3 (4 WST) and samples 5, 6, and 7 (5 WAT) were very low around the ET, but BPH increased at 6 WST (4.5, 6 and 6) up to 8 WST (samples 13, 14, and 15). At 9 WAT (sample 16, 17, 18) the BPH population declined greatly, but remained higher than the predators population (Fig. 2). Research in the SHS Seed Center from sample 1-18 (4-9 WAT) there was a closed system between brown planthopper and predators, BPH population more higher and covered population of predators.

In WS 2013, the rice cultivated at Ciberes were found BPH and predators. The kinds of predators were the same with that found on the crop of SHS Seed Center. The development of BPH has been high since the beginning exceeds the ET and continues to increase and exceed the value of economic injuries level (EIL) more than 100 BPH/hill, this was due to the predators population was in stable development as the predators development in Ciasem and SHS Seed Center.

The average BPH population in one season was 411.2 BPH/hill, the initial population was 38 BPH/hill, and the highest population was 901 BPH/hill. The peak BPH population occurred at 7 WAT in samples 10, 11, and 12 were 829.6, 891.4 and 687.4 BPH/hill respectively. The average natural enemies were 0.041, 1.578, 0.152, 0.041, 0.089, and 11.55 tails/hill for *L. pseudoannulata*, other spiders, *P. fuscipes, O. nigrofasciata, Coccinella*, and *C. lividipennis*. In the study at Ciberes the same as in SHS Seed Center starting from sample 1-18 (4-9 WAT) there were a closed system between BPH and predators, ie is higher BPH population covered the population of predators (Fig.3).

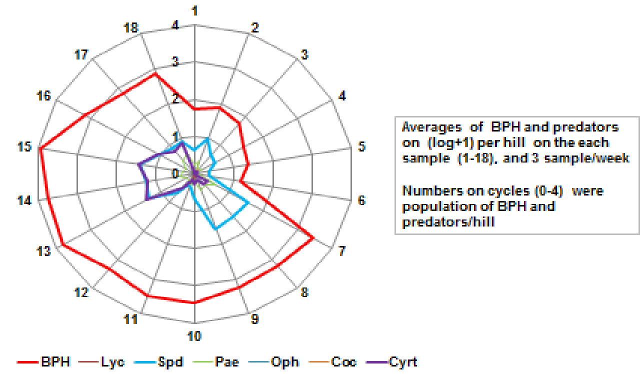

Fig. 2. Development of BPH population (log+1) and predators (log+1) per hill on the each week up to 2 weeks before harvest at SHS Seed Center. WS 2013

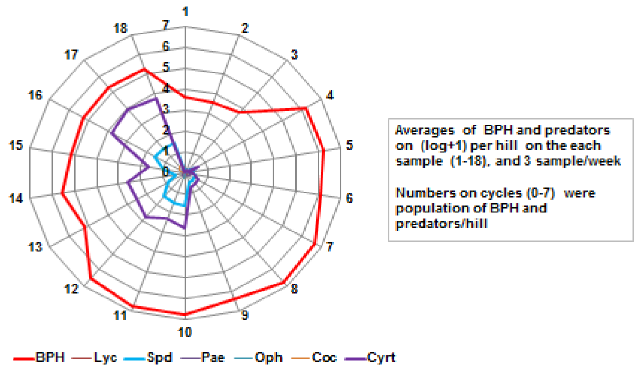

Fig. 3. Development of BPH population (log+1) and predators (log+1) per hill on the each week up to 2 weeks before harvest at Ciberes. WS 2013

The Relationship of BPH and Predators in Simple and Multiple regression

Research at Ciasem, after analyzing the relationship between BPH developments and predators showed that the predator ability was very low overcome BPH growth. The relationship of BPH development with the *L. pseudoannulata* showed very low coefficient of determination with R^2 value of 0.0099, while Adj.R^2 only reached -0.0663. The relationship of BPH with *L. Pseudoannulata* was insignificant with the correlation coefficient $r_{calculate}$ = 0,099 <$r_{tabel05\ (df\ =\ 13)}$ = 0.514, likewise the slope value of equation 4,50220 was insignificant because $t_{calculate}$ = 0.36 <$t_{tabel05\ (df\ 13)}$ = 2.160. This showed that *L. pseudoannulata* was less of role to suppress the BPH development. Although some researcher reported that *L. pseudoannulata* was a good predator. Both spider species *Araneus inustus* and *Pardosa pseudoannulata* have the same killing ability in dense prey populations, but predation is higher for *Pardosa* at low prey density [9]. In the other hand in unsprayed rice, BPH numbers normally remain low, while *P. pseudoannulata* is known to be a key natural enemy of BPH, the contribution to BPH reduction by the smaller *Atypena formosana* is less well known [10].

The relationship of BPH with other predators Spiders, *P. fuscipes, O. nigrofasciata, Coccinella,* and *C. lividipennis* was insignificant with $r_{calculate}$ <$r_{tabel05\ (df\ =\ 13)}$ = 0.514, although there was a coefficient of determination of spiders and *Coccinella* little bite higher. On the other hand the slope value of the equation was insignificant because $t_{calculate}$ <$t_{tabel05\ (df\ 13)}$ = 2.160 (Table 1).

Table-1: The simple regression equations between BPH and predators on Ciherang variety, Ciasem, DS 2012

Equation	R^2	Adj.R^2	$r_{calculate}$	$t_{calculate}$
BPH =6.10005 + 4.50220lyc	0.0099	-0.0663	0.099	0.36
BPH = -1.28685 + 2.37533spd	0.2160	0.1557	0.465	1.89
BPH = 6.62176 -0.33134 pae	0.0022	-0.0746	0.047	-0.17
BPH = 5.58141 + 17.16083oph	0.0811	0.0104	0.285	1.07
BPH = 7.80348 -1.17257coc	0.1282	0.0612	0.358	-1.38
BPH = 7.04729 -2.15513cyt	0.0091	-0.0671	0.095	0.35

Remarks: BPH= brown planthopper, *L. pseudoannulata* =lyc, Spider =spd, *P. fuscipes* =pae, *O. nigrofasciata* =oph, *Coccinella* =coc, *C. lividipennis* =cyt, $r_{table05(df=13)}$ =0.514, $t_{table05\ (df\ 13)}$ =2.160

From the simple regression equations between BPH and each predators, although insignificant was followed by multiple equations using the SAS program. The purpose of a multiple regression is to find an equation that best predicts the y variable as a linear function of the x variables. One use of multiple regression is the prediction or estimation of an unknown y value corresponding to a set of x values [11]. The multiple regression equation in Ciasem between BPH and all predators (*L. pseudoannulata* = lyc, Spiders = spd, *P. fuscipes* = pae, *O.nigrofasciata* = oph, *Coccinella* = coc, *C. lividipennis* = cyt), which resulted the following equation:

BPH_{Ciasem}= -1.11568 + 12.13210lyc+ 3.08706spd+ 8.77580pae -11.78304oph -5.63455coc -5.02509cyt
R^2 =0.8312, Adj R^2 =0.7046, P=0.0091

Analysis of multiple regression was significant with P = 0.0091 <P 0.05 with coefficient of determination R^2 = 0.8312, and value of adj. R^2 = 0.7046 showing the number of BPH was 70.46% were explained by abundance of *L. pseudoannulata*, Spiders, *P. fuscipes*, *O.nigrofasciata*, *Coccinella*, and *C. lividipennis.*

The R^2 as coefficient of determination is measured to determine how well the regression line approximates the real data points. The coefficient of determination adjusted (Adj. R^2) is a calibration or alignment of R^2. Differences of R^2 and adjusted R^2 value lies on correction factor (degrees of freedom). R^2 does not have a correction factor so that if the independent variables continue to be added, will cause the value of R^2 continue to grow. Adjusted R^2 have a correction factor, so the addition of independent variables does not necessarily increase value of R^2, therefore adjusted R^2 much more useful measure of how well a multiple regression equation fits to the sample data than R^2 [12, 13]. Research at SHS Seed Center after analyzed the relationship between the development of BPH and some predators showed that the ability of predators was very low to overcome the growth of BPH with correlation as in Table 2.

The relationship of BPH development with *L. pseudoannulata* showed very low coefficient of determination with R^2 value of 0.0953, whereas Adj R^2 only reached 0.0387. The relationship of BPH with *L. pseudoannulata* was insignificant with the correlation coefficient $r_{calculate}$ = 0.309 <$r_{tabel05\ (df\ =\ 16)}$ = 0.468, an then the slope value -0.29915 was not real because $t_{calculate}$ = -1.30 <$t_{tabel05\ (df\ 16)}$ = 2.120. This showed that *L. pseudoannulata* was less of role to suppress the BPH development.

The relationship of BPH development with spiders shows a significant correlation coefficient with R^2 value was 0.3215, while Adj R^2 reaches 0.2791. The relationship of BPH with spiders was significant with the correlation coefficient $r_{calculate}$ = 0.568> $r_{tabel05\ (df\ =\ 16)}$ = 0.468, likewise the slope value of the 7.32944 was significant because $t_{calculate}$ = 2.75> $t_{tabel05\ (df\ 16)}$ = 2.120. This showed that the spiders significantly suppress the development of BPH.

The relationship of BPH development with *C. lividipennis* showed a significant correlation coefficient with R^2 value was 0.5631, whereas Adj R^2 was 0.5358. The relationship of BPH with spiders was significant with the correlation coefficient $r_{calculate}$ = 0.750> $r_{tabel05\ (df\ =\ 16)}$ = 0.468, as well as the slope value of the equation =10.67715 was significant because $t_{calculate}$ = 4.54> $t_{tabel05\ (df\ 16)}$ = 2.120. This showed that the *C. lividipennis* significantly suppress the development of BPH. The relationship of BPH with *P. fuscipes*, *O. nigrofasciata*, and *Coccinella*, was insignificant with the correlation coefficient of $r_{calculate}$ <$r_{tabel05\ (df\ =\ 16)}$ = 0.468 (Table 2).

Table-2: The simple regression equations between BPH and predators on Pandanwangi, SHS Seed Center, WS 2013

Equation	R^2	Adj.R^2	$r_{calculate}$	$t_{calculate}$
BPH = 22.31220 -0.29915lyc	0.0953	0.0387	0.309	-1.30
BPH = 8.38257 + 7.32944spd	0.3215	0.2791	0.568	2.75
BPH = 13.62686 + 20.28866pae	0.0854	0.0282	0.292	1.22
BPH = 20.12241 + 63.94177oph	0.0119	-0.0498	0.109	0.44
BPH = 24.52681 -112.78016coc	0.1064	0.0506	0.327	-1.38
BPH = 11.90849 + 10.67715cyt	0.5631	0.5358	0.750	4.54

Remarks: BPH= brown planthopper, *L. pseudoannulata* =lyc, Spider =spd, *P. fuscipes* =pae, *O. nigrofasciata* =oph, *Coccinella* =coc, *C. lividipennis* =cyt, $r_{table05(df=16)}$ =0.468, $t_{table05\ (df\ 16)}$=2.120

The multiple regression equation in SHS Seed Center between BPH and all predators (*L. pseudoannulata* = lyc, Spiders = spd, *P. fuscipes* = pae, *O.nigrofasciata* = oph, *Coccinella* = coc, C. *lividipennis* = cyt) as follows:

BPH_{SHS} = 10.45876 -0.11297 lyc+ 3.87505spd-13.32161pae+ 236.37351oph -87.83360coc + 9.25271cyt

R^2 = 0.7648, Adj R^2 = 0.6365, P=0.0055

Analysis of multiple regression equation with P = 0.0055 <P 0.05 with coefficient of determination R_2 = 0.7648, and Adj. R^2 = 0.6365 indicates the number of BPH was 63.65% were explained by abundance of *L. pseudoannulata*, Spiders, P. *fuscipes, O.nigrofasciata, Coccinella,* and *C. lividipennis.*

Research at Ciberes, after analyzed the relationship between BPH and predators developments indicates that very low predation ability overcomes BPH growth with correlation as in Table 3. The relationship of BPH development with *L. pseudoannulata* showed very low correlation coefficient with R^2 = 0.0037, whereas Adj R^2 only -0.0585. The relationship of BPH with *L. pseudoannulata* was insignificant with the correlation coefficient $r_{calculate}$ = 0.0037 <$r_{tabel05\ (df\ =\ 16)}$ = 0.468, as well the slope value of the equation was -345.99226 insignificant because $t_{calculate}$ = -0.25 <$t_{tabel05\ (df\ 16)}$ = 2.120. This showed that *L. pseudoannulata* was less of role to suppress the BPH development. In the other hand the relationship of BPH with other predators spiders, *P. fuscipes, O. nigrofasciata, Coccinella, and C. lividipennis* insignificant with the correlation coefficient $r_{calculate}$ <$r_{tabel05\ (df\ =\ 16)}$ = 0.468 (Table 3).

Table-3: The simple regression equations between BPH and predators on Pandanwangi, Ciberes, WS 2013

Equation	R^2	Adj.R^2	$r_{calculate}$	$t_{calculate}$
BPH =425.27935 -345.99226lyc	0.0037	-0.0585	0.0037	-0.25
BPH =339.45883 + 45.45269spd	0.0484	-0.0111	0.0484	0.90
BPH =424.73126 -1.80009pae	0.0336	-0.0268	0.0336	-0.75
BPH =397.95062 -590.04753oph	0.0088	-0.0572	0.0088	-0.37
BPH =456.09355 -505.69977coc	0.0906	0.0338	0.0906	-1.26
BPH =461.48349 -4.35664cyt	0.0572	-0.0017	0.0572	-0.99

Remarks: BPH= brown planthopper, *L. pseudoannulata* =lyc, Spider =spd, *P. fuscipes* =pae, *O. nigrofasciata* =oph, *Coccinella* =coc, *C. lividipennis* =cyt, $r_{table05(df=16)}$ =0.468, $t_{table05\ (df\ 16)}$=2.120

The multiple regression equation in Ciberes between BPH and all predators (*L. pseudoannulata* = lyc, Spiders = spd, *P. fuscipes* = pae, *O.nigrofasciata* = oph, *Coccinella* = coc, C. *lividipennis* = cyt) as follows:

$BPH_{Ciberes}$ = 209.01275+ 2411.68371lyc+ 162.47779 spd -1.19821pae+ 2305.45361oph -1585.71111coc -6.07415cyt

R^2 = 0.4706, Adj R^2 = 0.1530, P=0.2776

Multiple regression analysis was insignificant with P = 0.2776> P 0.05 with coefficient of determination R^2 = 0.4706 and Adj. R^2 = 0.1530 shows the number of BPH very lowest about 15.30% were explained by abundance of *L. pseudoannulata*, Spiders, *P. fuscipes, O. nigrofasciata, Coccinella,* and *C. lividipennis*. Another meaning of this multiple regression equation was inability of all predators to overcome BPH development.

Results of the research at three locations indicate that different places, varieties, season, initial of BPH population, and BPH development along plant growth give different influences to the relationship of BPH and predators. The multiple regression equation between BPH and predators in Ciasem on DS 2012 and in SHS in WS 2013 was an amazing equation with a high coefficient of determination, although in the simple linear regression didn't showed any real relationship, except in SHS on WS 2013 that the BPH relationship with Spiders and *C. lividipennis* showed a significantly of equation. High positive correlation or numerical response to hopper density indicate that densities of three groups of predator were directly related to hopper densities. *C. lividipennis* had strong numerical response to hoppers in Bayombong and Kiangan, but were negligible in IRRI, Cabanatuan, and Banaue, because *C. lividipennis* is a predator to hopper eggs, in the other hand spider response were high in Kiangan, IRRI, and Bayombong, but significantly lower in Cabanatuan and Banaue [14].

The performance of predators as together can follows the development of BPH, it can be understood that in an ecosystem between horizontal factors (in one level tropic) and vertical factors (inter level tropic) supporting of each to other, especially the performance of natural enemies is very useful and play a role in technology of ecological engineering. Therefore, when seeing the performance of predators should not be viewed from the performance of each, but must be viewed of the holistic the performance natural enemies both major and minor.

The development of BPH population increased with increasing age of rice in three places (Ciasem, SHS Seed Center, and Ciberes), but the fastest development was in Ciberes on Pandanwangi variety in the WS 2013 exceed out of the EIL. The development of BPH at SHS Seed Center on Pandanwangi variety in the WS 2013 showed that the population growth of BPH slightly increased compared to BPH at Ciasem on Ciherang variety in the DS 2012. On the other hand the natural enemies of *L. pseudoannulata*, Spiders, *P. fuscipes*, *O. nigrofasciata*, *Coccinella*, and *C. Lividipennis* was not fast growing despite abundant food such as the BPH population in Ciberes that passes through to the EIL. This showed that natural enemy's developments were stable at all sites, on all varieties, and in all seasons (Table 4).

Table-4:Summary of BPH and predators development in three locations

Location	Population of BPH/hill			Population of predators/hill						$Adj.R^2$
	Initial	Peak	Average	Lyc	Spd	Pae	Oph	Coc	Cyt	
Ciasem	2	13	6.42	0.071	3.244	0.609	0.049	1.18	0.291	0.7046
SHS	5	50	21.18	0.063	1.746	0.372	0.017	0.03	0.869	0.6365
Ciberes	38	901	411.2	0.041	1.578	0.152	0.041	0.089	11,55	0.1530

Remarks: BPH= brown planthopper, *L. pseudoannulata* =Lyc, Spider =Spd, *P. fuscipes* =Pae, *O. nigrofasciata* =Oph, *Coccinella* =Coc, *C. lividipennis* =cyt

The most abundant of natural enemies found in Subang District-West Java-Indonesia in the ricefield are spiders, although wolf spider *L. pseudoannulata* was low. In the other hand *C. lividipennis* was higher on Pandanwangi in SHS Seed Center and Ciberes compared to Ciherang in Ciasem, this is due to differences in genotype varieties. Pandanwangi variety was not resistant to BPH, but Ciherang variety was moderate resistance to BPH biotype 1, 2, and 3 [15]. The functional response of a single mirid *C. lividipennis* prey 3.33 and 2.66 BPH nymphs and 2.66 and 3.0 WBPH nymphs per day on TN1 and ADT36 rice varieties, respectively [16]. The predation rates of the predator on various varieties and plants treated with different levels of nitrogen were consistent with that of its olfactory response in 5 of the 6 cases evaluated, which showed that rice volatiles played an important role in the foraging behaviour of *C. lividipennis* [17]. Volatile organic compounds emitted from *Xoo* rice were significantly higher than those from healthy rice plants, *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) infection on BPH fed plants caused rice plants to emit more the herbivore-induced plant volatiles, while all of these changes correlated to the temporal dimension. These results demonstrated that *Xoo* infection significantly influenced the interactions of rice plants with two non-vectors, BPH and its predator, although these effects exhibited in a temporal pattern after infection [18].

Development of BPH around the economic threshold will be followed by the development of predators, so that the coefficient of determination of the multiple regression equation was the highest reaches $Adj.R^2 = 0.7046$ and the relationship BPH-predators were significant. Development of BPH above the economic threshold will still be followed by the development of predators, but the coefficient of determination of the multiple regression equation decreasing to $Adj.R^2 = 0.6365$ and the relationship BPH-predators was still significant. On the development of BPH above economic injury level or more didn't be followed by predator's development, so the coefficient of determination from the multiple regression equation was the lowest reaches $Adj.R^2 = 0.1530$ and the relationship BPH-predators were insignificant.

Natural enemies in their development face up to BPH have limitations because of their long life cycle compared to BPH. Baehaki *et al*. [19] reported the life cycle one generation of BPH at 2012 were 25,70 and 25,1 days on Inpari 13 and Pelita I/1 respectively, whereas life cycle one generation of BPH at 1984 on Pelita I/1 was 31,15 days. A lady beetle Coccinellidae takes 1-2 weeks to develop from egg to adult, but produces150-200 offspring in 6-10 weeks [20]. In the

Palearctic region reported that the duration of development aphidophagous coccinellid from oviposition to emergence of adults, varied from 2 months in April and May to 3 weeks in August [21]. Coccinellids lay extra infertile eggs with the fertile eggs. These appear to provide a backup food source for the larvae when they hatch. The ratio of infertile to fertile eggs increases with scarcity of food at the time of egg laying [22]. The mean generation time of *P. fuscipes* from Malaysia between 43.08 -48.57 days [23].

The life cycle plant bug *Cyrtorhinus lividipennis* develop to adults in 2-3 weeks but produce 10-20 young, in the other hand the wolf spider *Lycosa pseudoannulata*, lynx spiders *Oxyopes* sp, and long-Jawed spider *Tetragnatha* sp produced 200-400 eggs, 200-350 and 100-200 eggs respectively, but have long the life cycles namely 3-4 months, 3-5 months, 1-3 for wolf spider *Lycosa pseudoannulata*, lynx spiders *Oxyopes* sp, and long-Jawed spider *Tetragnatha* sp respectively [20].

The decisions control in IPM implementation based on natural enemies is required weekly monitoring to determine ET and movement of development of BPH population. The failure of rice production is usually caused by the negligence of the production actors, where as too late pests control which is often done during EIL. Therefore, decisions control must be made when natural enemies are naturally unable to controlling BPH, at least on a slightly above the ET.

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CONCLUSIONS

Research at three locations (Ciasem, SHS Seed Center, and Ciberes) indicate that relationship of BPH and predators will give different influences depend on different places, varieties, season, initial of BPH population, and BPH development along plant growth. The multiple regression equation between BPH and predators in Ciasem on DS 2012 and in SHS in WS 2013 was an amazing equation with a high coefficient of determination, although in the simple linear regression didn't showed any real relationship, except in SHS on WS2013 that the BPH relationship with Spiders and *C. lividipennis* showed a significantly of equation

The development of BPH population increased with increasing age of rice in three places, but the fastest development was in Ciberes on Pandanwangi exceeding the economic injury level. The development of BPH at SHS Seed Center on Pandanwangi variety showed that the population growth of BPH slightly increased compared to BPH at Ciasem on Ciherang variety. The development of natural enemies *L. pseudoannulata*, Spiders, *P. fuscipes, O.nigrofasciata, Coccinella*, and *C. lividipennis* were stable in all locations, in all varieties, and in all seasons, although BPH as food were abundance

The coefficient of determination adjusted (Adj. R^2) of multiple regressions between BPH with predators decrease at the BPH population increasing rapidly. On BPH development was around the economic threshold will be followed by development of predators with the coefficient of determination was the highest reaches Adj.R^2 =0.7046. On BPH development exceeds of economic threshold will still be followed by development of predators, but the coefficient of determination decreased to Adj.R^2 =0.6365. On the other hand of BPH development was in economic injury level or more didn't be followed by development of predators with the coefficient of determination was the lowest up to Adj.R^2 = 0.1530.

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