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Population's preference of rhinoceros beetle (*Oryctes rhinoceros*) between oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera l.*): Contributing to pest's controlling strategy

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ABSTRACT
The rhinoceros beetle (Oryctes rhinoceros) began to establish itself in Malaysia with the emergence of coconut cultivation. Rhinoceros beetles were well adapted to survive on oil palm (Elaeis guineensis) and coconut (Cocos nucifera L.) trees. Different host plants could have different interactions and food preferences with the Rhinoceros beetle against their host plant, even within the same family. Additionally, climatic change, particularly rainfall, could also influence the population dynamics of O. rhinoceros especially in terms of the biological aspect of the pest. This study was carried out to evaluate the difference in population of rhinoceros beetles between oil palm and coconut palm as a preference host comparison in relation to the climatic factors on the plantation scale. The population of rhinoceros beetles was found to be higher in oil palm as compared to coconut palm. It can be concluded that rhinoceros beetles highly prefer oil palms when compared to coconut palms. This study highlighted the importance of planting similar families in order to reduce the risk of pest attacks. This study also found that climate is one of the factors influences the population dynamics of rhinoceros beetles and puts pressure on plants, subsequently making it a favorable condition for rhinoceros beetles in the field. Interestingly, female rhinoceros beetle in an oil palm field was significantly correlated with the rainfall. Therefore, preventive measures need to be taken during the rainy season, considering the high risk of planting nearby and/or similar plants.

Contribution/Originality: This study was carried out on the preference of the major pest (*Oryctes rhinoceros*) on both host plants, namely oil palm and coconut palm, at the plantation scale, considering gender variables. The findings and outcomes of this study could contribute to the fundamental body of knowledge about good agronomic practices when planting both palmae families in the same area or nearby. The growers could use this information as a basis for decision, particularly when planting oil palms near coconut palm areas, which had a higher risk of being infested by *Oryctes rhinoceros* due to their preference. The same family should not be planted in the same area or nearby to lower the risk of *Oryctes rhinoceros* attacks.

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1.INTRODUCTION

Rhinoceros beetle is one of the insect pests that could cause very serious problems on oil palm and coconut palm plantations. *Oryctes rhinoceros*is naturally and usually destroys young palms in fields (Pradipta, Wagiman, & Witjaksono, 2020). *Oryctes rhinoceros* attacking young palm plants will delay the maturing process of young palm plants. Chung, Sim, and Balasubramaniam (1999) estimated that the average crop loss in oil palm caused by *O. rhinoceros*can reached up to 53.16%. Census palm for monitoring and evaluating young palm at early replanting is one of the important practices in plantations (source: Malaysian Palm Oil Board (MPOB) (2012)). It is a common practice and is included in standard operating procedures in estates. The main purpose of the census at the early stage after replanting is to estimate the pest damage during the immature stage and the yield at the mature stage. Data are recorded purposely for further action based on the condition of the estate (source: Pertubuhan Peladang Negeri Johor (PPNJ) (2015)). The serious damage done by pest damage should be controlled by using chemical or biological control. It is the common practice in estates to control the population of *O. rhinoceros*is using pheromone traps or chemicals such as Cypermethrin at 0.05% (source: Pertubuhan Peladang Negeri Johor (PPNJ) (2015)). Cypermethrin is usually applied every two weeks using a mist blower or knapsack sprayer. A pheromone trap was installed at the boundaries to prevent *O.Rhinoceros*from entering the field. The populations of*O.Rhinoceros*are are monitored, and data from the census on palm damage is also recorded (source: Pertubuhan Peladang Negeri Johor (PPNJ) (2015)).

*Oryctes rhinoceros*highly preferred and attacked at the vegetative as the reproductive part of palm (Norman, Mohd Basri, & Ramle, 2005). The reproductive part of the palm, namely the leaves, petiole, and spindle. *O.Rhinoceros*more is more likely to attack the petiole part and permanently make a hole in the spindles and leaves (Ahmad, 2006). *O.Rhinoceros* feeding activities on the leaves of the plants will result in a "V' shape with a cutting mark, and the fronds will easily break with light winds because of the chewing marks on the spindle (Manjeri, Muhammad, & Tan, 2014).

Different host plants could have different interactions between pests and their hosts. Climatic change could also influence the population dynamic, especially in terms of biological aspects of pests such as life cycle, fecundity, and longevity (Karuppaiah & Sujayanad, 2012). Nowadays, climate change is reported as one of the major issues, such as global warming, that contributes to inconsistencies in temperature and rainfall distribution.

The population and abundance of *O.Rhinocerosexhibited temporal fluctuations and variations.* This scenario happened mainly due to several factors, such as a biotic and abiotic factors, specifically host plants, and climatic factors. Norman and Mohd Basri (2014) reported that the population of *O.Rhinoceros*fluctuated with time in the replanting area, and largely due to the living organism factor. In terms of agronomic practices, zero burning is one of the standard procedures used in many oil palm plantations (Mohd Rizuan, Abu Hassan, Hasber, & Noor Hisham, 2014). This technique was found to significantly influence the population of *O. rhinoceros*. The remaining trunks and stems in the field provide a good breeding site as favorable conditions for *O. rhinoceros*to increase their population (Mohd Rizuan et al., 2014). This technique could encourage and attract the population of *O.Rhinoceros* (Norman et al., 2005).

Liew and Sulaiman (1993) found that the breeding site of*O.Rhinoceros*can be reduced by planting cover crops. Cover crops acted as a physical barrier to the breeding site of *O. rhinoceros*. When Norman et al. (2005) studied the relationship between the physical characteristics of the habitat and *O. rhinoceros*, it was found that the cover crop height and moisture content in the chip trunk were equally important in affecting the number of*O. rhinoceros*. A negative correlation was shown between cover crop heights and the population of *O. rhinoceros*. Adult *O.Rhinoceros*have a positive influence on the moisture content in chip trunks (Norman et al., 2005). More rapid decomposition of the chip trunk could also influence the population of larvae in oil palm. Additionally, if similar families of plants were planted nearby or in the same area, direct effect on the pest population could be achieved. For instance, integrating oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) together in the same area.

In the aspect of abiotic effect on the *O. rhinoceros*in palm area, Allee, Park, Emerson, Park, and Schmidt (1949) stated that both biotic and abiotic factors exist in the environment. Smith (1935) stated that ecologists defined abiotic as the non-living factors and biotic as the living organism. Basically, insect populations fluctuated based on the seasonal basis. The survival of an organism, particularly *O.Rhinoceros*, was highly influenced by the environment (Norman et al., 2005). In general, rainfall, temperature, and humidity are several environmental factors that commonly influence the organism. Diniz and Pinheiro (2000) found that after rain, Coleoptera, Diptera, Homoptera, Hymenoptera, Lepidoptera, and Orthoptera were found to be the most abundant in the field.

The population dynamics of *O.Rhinoceros*may be influencedby climatic factors. In this study, rainfall distribution was recorded at Ladang Penyelidikan, Bukit Bujang, and Segamat to evaluate the relationship between climate and the population abundance of *O.Rhinoceros*in oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) as well. Additionally, rainfall could directly affect the breeding site of *O.Rhinoceros*as reported by Norman et al. (2005). Rhinoceros beetle (*Oryctes rhinoceros*) was found to be more attracted to aromatic coconut palm (*Cocos nucifera* L.) compared to oil palm (*Elaeis guineensis*) and prefers to attack young coconut palms (*Cocos nucifera* L.) due to its much lower height (Zhong et al., 2013). Therefore, this study was carried out to evaluate the difference in population of

O.Rhinoceros between oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) as a preference host in Ladang Penyelidikan, Bukit Bujang, Segamat, Johor and the relationship with the climatic factor.

2. MATERIAL AND METHODS

Preparations of experimental plots and explanations on oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.). The study was carried out in the field at Bukit Bujang, Segamat, Johor. The oil palm and coconut palm research plots were planted in 2013. The palm planting distance for oil palm and coconut palms was designed at 29m x 29m between palms. The planting distance of palm was following the recommended agronomic practices and the standard operation procedures of plantations and the Ministry of Agriculture. The total number of coconut plants involved was 2500 palms. Meanwhile, the total number of plants involved in oil palm was 2760.

This study monitored the populations of rhinoceros beetleson oil palm and coconut palm. Monitoring was also conducted on rainfall and temperature to study the relationship of the population of rhinoceros beetleswith climatic factors for 40 weeks (March 2015-February 2016). Data on rainfall distribution was recorded biweekly for each treatment for both crop oil palm and coconut palm. A rain gauge meter was used to collect and record data on rainfall. Data on temperature were supplied by the Malaysian Meteorological Department for year's sampling period, referring to the nearest location of the experimental plot.

2.1. Trapping System

The population and abundance of *Oryctes rhinoceros* were observed and caught using traps. Pheromone trap was used in this study to catch *O. rhinoceros* to evaluate the population and abundance of *O. rhinoceros* for a one-year sampling period in both host plants, such as oil palm and coconut palm, and correlate with climatic factors. The number of *O. rhinoceros* beetles for both male and females was counted and recorded.

2.2. Pheromone Trap (Oryctes Rhinoceros)

Pheromone traps were used in oil palm plantations to control the *O. rhinoceros* population. Pheromone traps have become an important component in IPM for controlling and monitoring *O. rhinoceros* in oil palm plantations. This trapping can also be used to study the ecology of *O. rhinoceros*. In this study, pheromone trap was used to collect adult males of *O. rhinoceros*. Ethyl 4-methyloctanote is a pheromone aggregation that is produced for commercial use (Hallet, 1995). Chung (1997) claimed that the double vane type of pheromone trap was found to be the most effective and economical. In this study, double vanes trapping was used and placed at 3 meters above ground, and for young oil palm, it was 1-2 meters above the canopy. The pheromone was hung in the center of metal vanes. The metal vanes, like a zinc plate, were placed on top of the pails. One unit of pheromone trap was installed for every 2 hectares and replaced with a new hormone set for every two months. The female and male numbers of *Oryctes rhinoceros* were recorded in this study. The number of *O. rhinoceros* was collected and counted from the pheromone trap that hangs at the boundaries of the oil palm experimental plot. The height of the trap and the distance between the pheromone traps were following the standard of procedure in Ladang Penyelidikan Bukit Bujang. The Federal Land Development Authority (FELDA) and other plantations also used the same technique. High consideration for the elevation of traps on the top of the pole is crucial before hanging the pheromone trap. It is because *O. rhinoceros* is proven to be significantly attracted to the pheromone trap. Therefore, by setting up the optimum elevation of the pheromone trap's pole and the distance interval between pheromone traps, which was 125 meters from one to another, the maximum number of rhinoceros can be caught. The number of rhinoceros was observed by using a pheromone trap for each plot with coconut palm and oil palm as host plants. The total acreage was 18 hectares for both host plants, coconut palm and oil palm,respectively. The observation of the rhinoceros's population was designed by placing the pheromone traps in the particular plots, as is common practice done by FELDA.

2.3. Preparation of Trapping System

Pheromone traps were installed at each block's boundaries of the experimental plot according to the standard practice. For pheromone traps, the height of the traps is one foot higher than the oil palm tree. Height of the trapping was 7-8 feet from the ground. Pheromone trap was hung at the top of pole and replaced every 2 months with a new one. The pail was hung below the vane, and the pheromone was placed at the center of the pail purposely to trap and collect the *Oryctes rhinoceros*.

2.4. Parameters of Study

Number of *Oryctes rhinoceros*, male and female, was collected, monitored, and recorded biweekly. The pheromones were replaced every two months to ensure the accuracy and reliability of the data.

2.5. Data Collection

The trapped *Oryctes rhinoceros* were taken and recorded every two weeks after pheromone trap installation. In oil palm and coconut palm field studies, there were five plots, and each plot consisted of five replications for pheromone traps. For each replication, number of male and female *O. rhinoceros* was counted. The numbers of *O. rhinoceros* were collected, including male and female. The data was collected to determine the population dynamics of *O. rhinoceros* and its relationship with climatic factors. The number of *O. rhinoceros* was recorded and sorted in order to determine the abundance of the population and also to differentiate the population between host plants, oil palm and coconut palm. The *O. rhinoceros* were attracted to the pheromones and entered and were trapped in the trap. Male and female

O. rhinoceros were trapped because the pheromones used in this study were not specifically sexual. In this study, pheromone traps were placed randomly in each block. The maintenance and agronomy practices in this research plot were done as planned and followed the standard of procedure.

2.6. Data Analysis

To compare data on the rhinoceros beetle population (*Oryctes rhinoceros*) between oil palm and coconut palm, a t-test was used in this study to differentiate the pest population between these two Palmae families. Data population dynamics male, female, and total of *O. rhinoceros*) in oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) were used. Pearson's correlation test and linear regression analysis were used to study the relationship of the *O. rhinoceros*in oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) with the climatic factors (rainfall and temperature).

3. RESULTS

3.1. Comparison Population Abundances of Rhinoceros Beetle (Oryctes Rhinoceros) between Oil Palm (Elaeis Guineensis) and Coconut Palm (Cocos Nucifera L.)

In this study, abundance and population dynamic of rhinoceros beetle (*Oryctes rhinoceros*) in oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) were observed. Rhinoceros beetle was found to be more attracted to oil palm plots than coconut palm plots. Population of rhinoceros beetlesin oil palm was significantly greater ($t = 3.861$, $P < 0.01$) than population of rhinoceros beetlesin coconut palm in this study. Figure 1 shows the mean number of male and female of *O.Rhinoceros*in both host plants, oil palm and coconut palm for 40 sampling weeks. The trend population of *O. rhinoceros* males and females, for both oil palm and coconut palm plots exhibited similar trend that fluctuated for the entire sampling period. The population of *O.Rhinoceros*in oil palm and coconut palm fluctuated from week 2 until week 40. At the beginning of the week after installing pheromone trap (week 2), interestingly, the mean number of *O.Rhinoceros* was 8.67 and 10.44 in oil palm and coconut palm, respectively. The highest populations of *O.Rhinoceros*were recorded in coconut palm as compared to oil palm plot Figure 2.

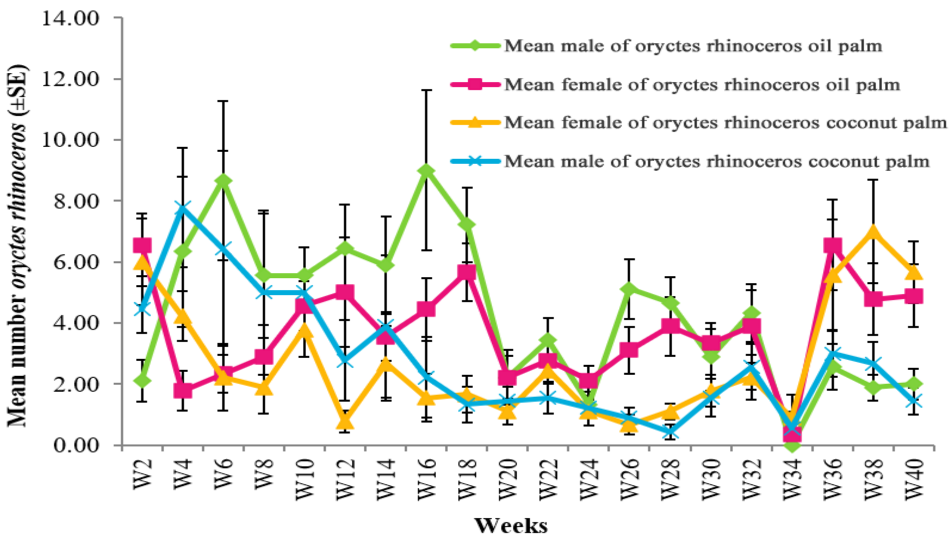

Figure 1. Mean number of *O. rhinoceros*in oil palm and coconut palm plantation for 40 weeks sampling periods.

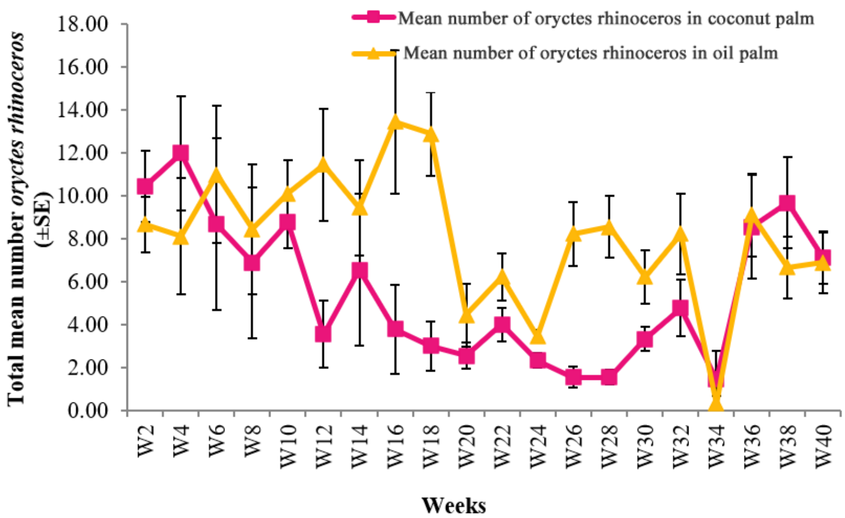

Figure 2. Total mean number of *O. rhinoceros* (Male and Female) in oil palm and coconut palm plantation for 40 weeks sampling periods.

Overall, the total female and male populations of *O. rhinoceros*in oil palm (*Elaeis guineensis*) ranged from 0.33/sampling week to 13.44/sampling week. The total female and male population of *O. rhinoceros*in coconut palm (*Cocos nucifera* L.) ranges from 1.44 per sampling week to 12.00 per sampling week Figure 2. Interestingly, from week 6 until week 32, the population of *O.Rhinoceros*in both oil palmand coconut palmplots fluctuated with similar trends. Mean number of *O. Rhinoceros*was constantly recorded lower in the coconut palm compared to mean number of *O. rhinoceros*in oil palm for the entire sampling period.

3.2. Relationship Between Rhinoceros Beetle (Oryctes Rhinoceros)in Oil Palm (Elaeis Guineensis) and Coconut Palm (Cocos Nucifera L.) and Rainfall and Temperature

3.2.1. Oil Palm

Table 1 shows the correlation of therhinoceros beetle (*Oryctes rhinoceros*) (total male and female, male, and female) with the rainfall distribution and temperature in oil palm (*Elaeis guineensis*). The male ($P > 0.05$; $r = 0.016$) and total (male and female) ($P > 0.05$; $r = 0.081$) of *O.Rhinoceros* were found to not be significantly correlated to rainfall distribution in oil palm experimental plots. This study indicated that the rainfall did not influence the male and total numbers (male and female) of rhinoceros beetle *O. rhinoceros*. However, the *O. Rhinoceros* female was observed to be significantly influenced with low correlation ($r=0.140$, $P<0.05$) by rainfall in an oil palm experimental plot. Meanwhile, female and total (male and female) *O.Rhinoceros* was observed to be significantly influenced ($P<0.05$) by temperature in oil palm) experimental plots, and the temperature did not influence the number of male*O. rhinoceros*.

Table 1. Correlation analysis between male, female and total (Male and female) of *Oryctes rhinoceros* and rainfall and temperature in oil palm.

Oryctes rhinoceros (Sex)	Plant variety	Rainfall		Temperature		N
		Pearson correlation	Sig.2-tailed	Pearson correlation	Sig.2-tailed	
Male	Oil palm	0.016	P>0.05	-0.109	P>0.05	200
Female		0.140	P<0.05	-0.185	P<0.05	200
Total (Male and female)		0.081	P>0.05	-0.168	P<0.05	200

The study observed that there was a parallel pattern and variability in the distribution of rainfall and temperature during the duration of sampling period. Average temperature during the entire sampling period was 26.55°C. Result showed that in week 24, the mean rainfall was 8.57mm and the mean number of the total *O.Rhinoceros* was 7.00. In general, it can be explained from the graph Figure 3 that higher mean number of rainfall and lesser number of *O.Rhinoceros* total (male and female) were in week 24. The lowest mean of the rainfall was recorded in week 40 (0.00), with a temperature of 26.96°C and the lowest mean of the total number of male and female of *O.Rhinoceros* was observed in week 34 (0.00), at a temperature 27.41°C.

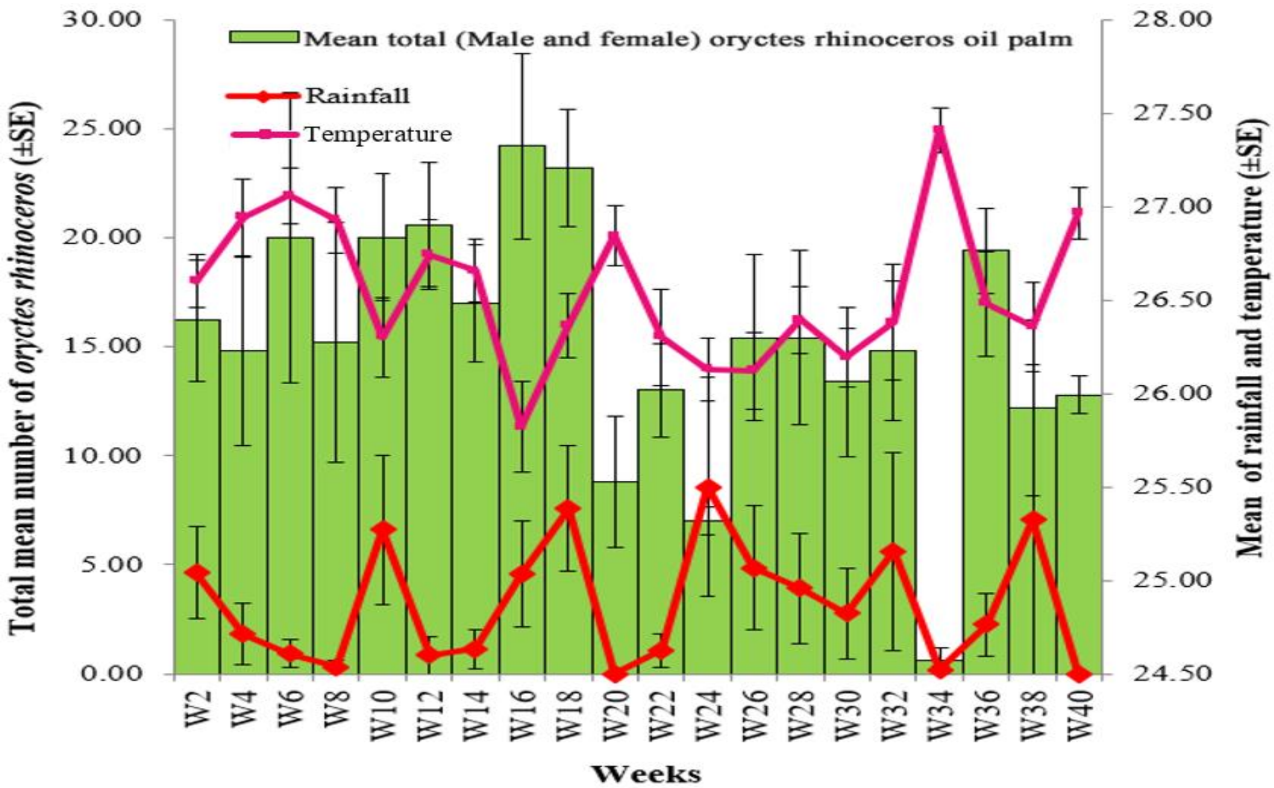

Figure 3. Total mean number of *O. rhinoceros* (Male and female) correlated with rainfall distribution and temperature in oil palm plantation for 40 weeks sampling periods.

The highest mean number of rhinoceros beetles (*Oryctes rhinoceros*) was recorded in week 16 at temperature (25.82°C) and rainfall (24.20mm). The graph also explained that the populations of *O.Rhinoceros*, with the rainfall distribution, and the temperature are fluctuating throughout the weeks. In correlation analysis, the population of *O.Rhinoceros* was observed not significantly (P>0.05) influenced by rainfall distribution.

Bedford (2014) found that during wet weather traps, the captured rhinoceros beetle showed an increasing trend in flight activities and exhibited a higher number of males during the full moon. In another study, Yusof, Tuck, and Chong (2013) found that the survival rate of other herbivores attacked in oil palm ranged between 25°C and 35°C.

Figure 4 shows that the population dynamics of rhinoceros beetle male throughout the sampling period from week 2 until week 40 correlated with the rainfall distribution and temperature. The lowest number of mean for rainfall was recorded in week 40 (0.00) at temperature 26.96°C and the highest volume of rainfall distribution was recorded in week 24 (8.57mm) at temperature 26.13°C. Meanwhile, in week 34 (0.00) the lowest population male of *O. rhinoceros* was observed at temperature 27.41°C and the highest number of *O. rhinoceros*recorded in week 16 (16.20) at temperature 25.82°C. However, in correlation analysis, *O. rhinoceros's*male was not significantly correlated (P>0.05; r=0.016) with rainfall distribution and also not significantly correlated with temperature (P > 0.05; r =-0.109) in oil palm test plot.

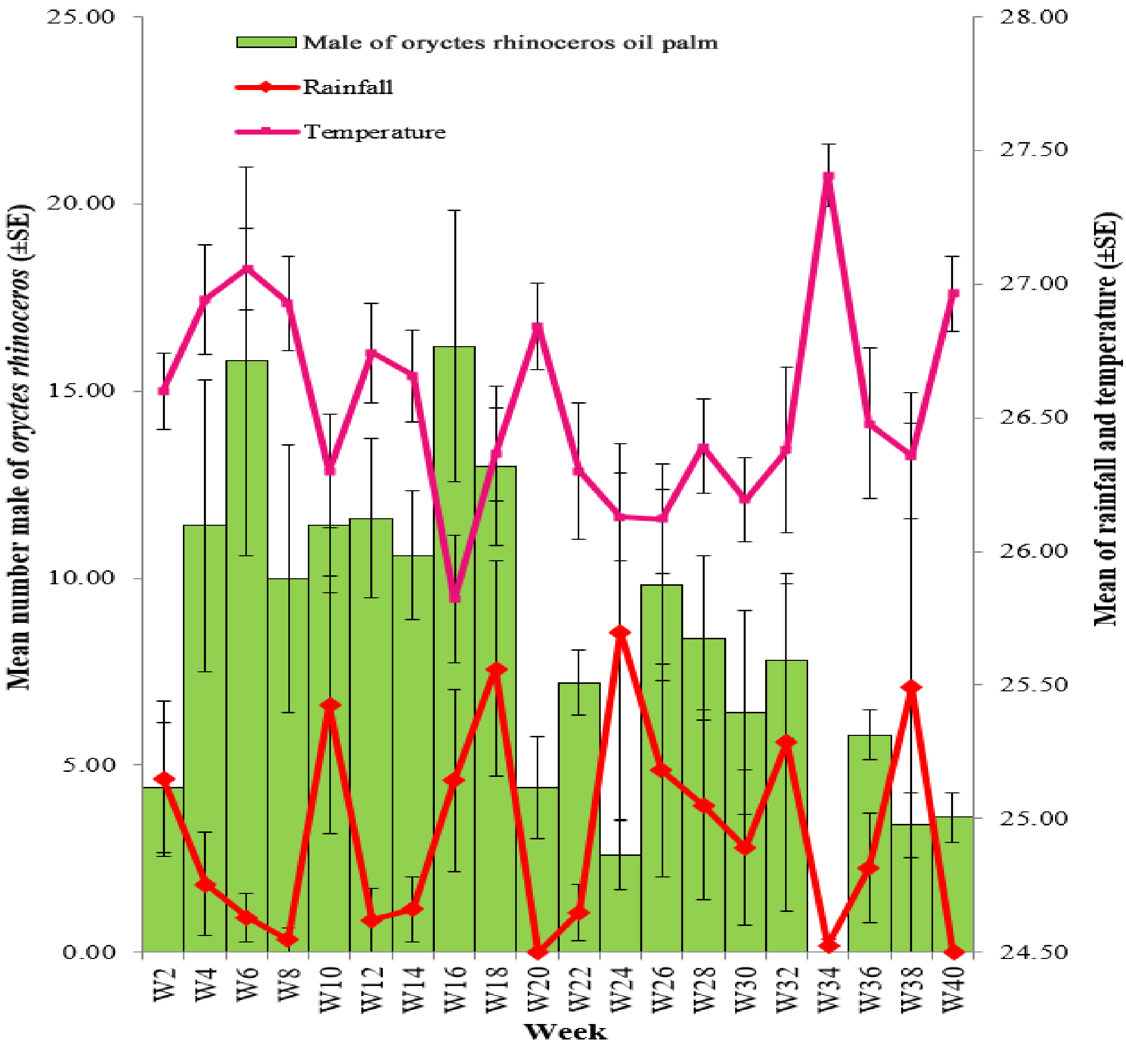

Figure 4. Mean number of *O. rhinoceros* Male correlated with rainfall distribution and temperature in oil palm plantation for 40 weeks sampling periods.

The female of rhinoceros beetle (*Oryctes rhinoceros*) was positively and significantly correlated with rainfall (r = 0.140; P < 0.05) and female was negatively and significantly correlated with the temperature (r =- 0.0185; P < 0.05). The highest volume of rainfall was recorded in week 24 (8.57mm) at temperature 26.13°C and the highest number of females was observed in week 36 (13.60) at temperature 26.48°C. Meanwhile, the lowest rainfall was in week 40 (0.00mm) at temperature 26.96°C and the lowest number of females was in week 34 (0.60) at temperature 27.4°C. From the graph Figure 5, it was observed that from week 2 until week 22 the graph showed that the populations of the female had a positive relationship with the rainfall distribution and negative relationship with temperature. In week 34, a similar trend clearly can be observed whereby when the rainfall and temperature dropped or increased, the population of female *O. Rhinoceros* followed the similar trend.

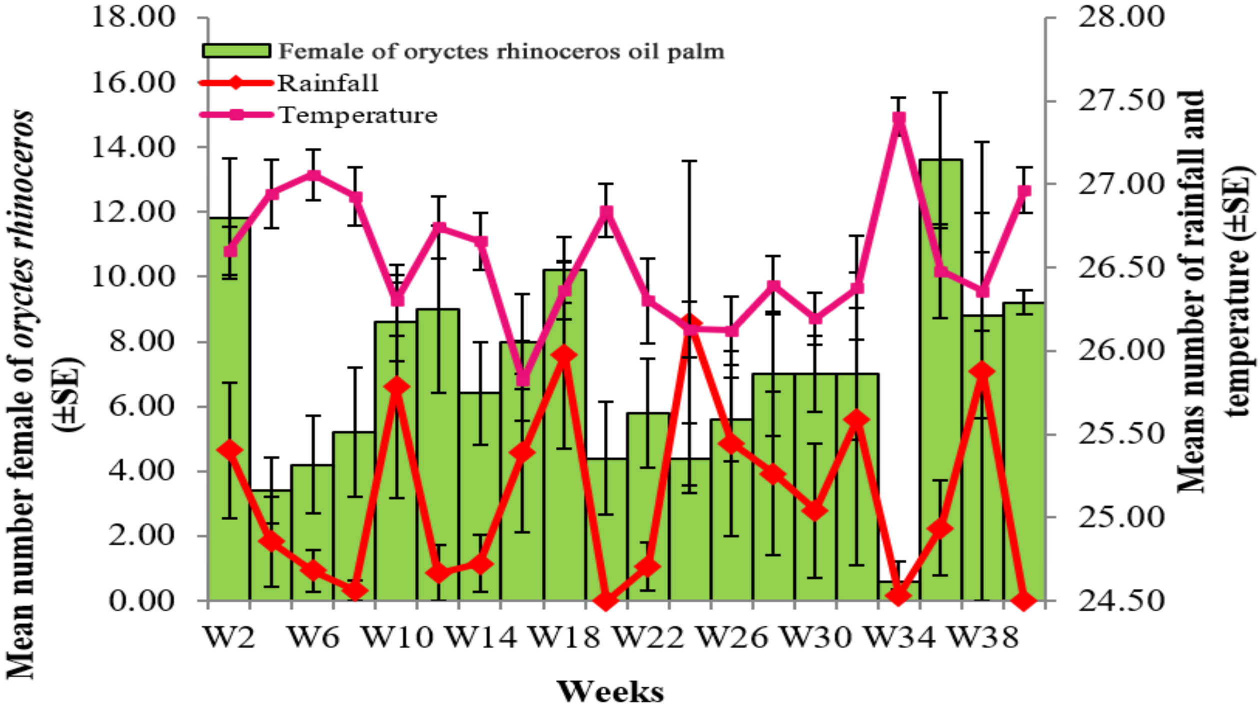

Figure 5. Mean number of *O. rhinoceros* female correlated with rainfall distribution and temperature in oil palm plantation duration for 40 weeks of sampling periods.

However, a finding of this study was parallel with a study done by Ahmad (2006) in FELDA plantation in Lepar, Pahang. He found that the number of *O. Rhinoceros* captured was dropped in drought season (February, 2005 – April, 2005) which using pheromone traps. They found that the highest mean numbers of rhinoceros beetle were caught in the end of the September 2005 (14 month after planting) and the lowest means numbers of rhinoceros beetle were caught in the first week of February 2005 (7 months after replanting). 15 months after planting, they found that the damaged related to higher population caused by rhinoceros beetle was very severe.

The significant deterioration observed in the oil palm can likely be attributed to the pronounced preference of the immature palm for the rhinoceros beetle. Planting material DXP palms seedlings in Ladang Penyelidikan Segamat was planted in 2013 and the tested plot was in the middle of the plantation. The border was planted with mature palms about 25 to 30 years old palms. Therefore, the migration of the *O.Rhinoceros* was observed due to alternate host plant from old oil palm at the border, which differed in palm age significantly. The beetle migrated from old mature palms to nearby sites to search new breeding sites and food. Therefore, the field was abundantly higher with *O. Rhinoceros* and may cause higher damage level on the palms.

3.2.2. Coconut Palm

Table 2 shows male, female and total (male and female) population of *O. Rhinoceros* were not correlated ($P > 0.05$) significantly by rainfall distribution but, male of rhinoceros beetle was significantly influenced ($P < 0.05$) by temperature in coconut palm plot. Interestingly, both female and total (male and female) of rhinoceros beetle was not significantly correlated ($r = 0.056, P > 0.05$) to the rainfall distribution.

Table 2. Correlation analysis between (Male, female and Total (Male and female) of *Oryctes rhinoceros* and rainfall and temperature in coconut palm.

Oryctes rhinoceros (Sex)	Plant variety	Rainfall		Temperature		N
		Pearson correlation	Sig.2-tailed	Pearson correlation	Sig.2-tailed	
Male	Coconut palm	-0.074	P>0.05	0.150	P<0.05	180
Female		0.056	P>0.05	0.043	P>0.05	180
Total (Male and female)		-0.020	P>0.05	0.120	P>0.05	180

Total male and female of rhinoceros beetle are plotted into the graph Figure 6. Week 24 was recorded as the highest (8.57) rainfall distribution at temperature 26.13°C and the highest population total male and female of *O. rhinoceros*was recorded in week 4 (36) at temperature 26.94°C. But the lowest number of the total (male and female) of*O.Rhinoceros* was recorded in week 34 (4.33) at temperature 27.41°C and the lowest rainfall amount (0.00) was in week 40 at temperature 26.96°C. Population of the total male and female of *O. Rhinoceros* was seemed not to be influenced by the rainfall distribution.

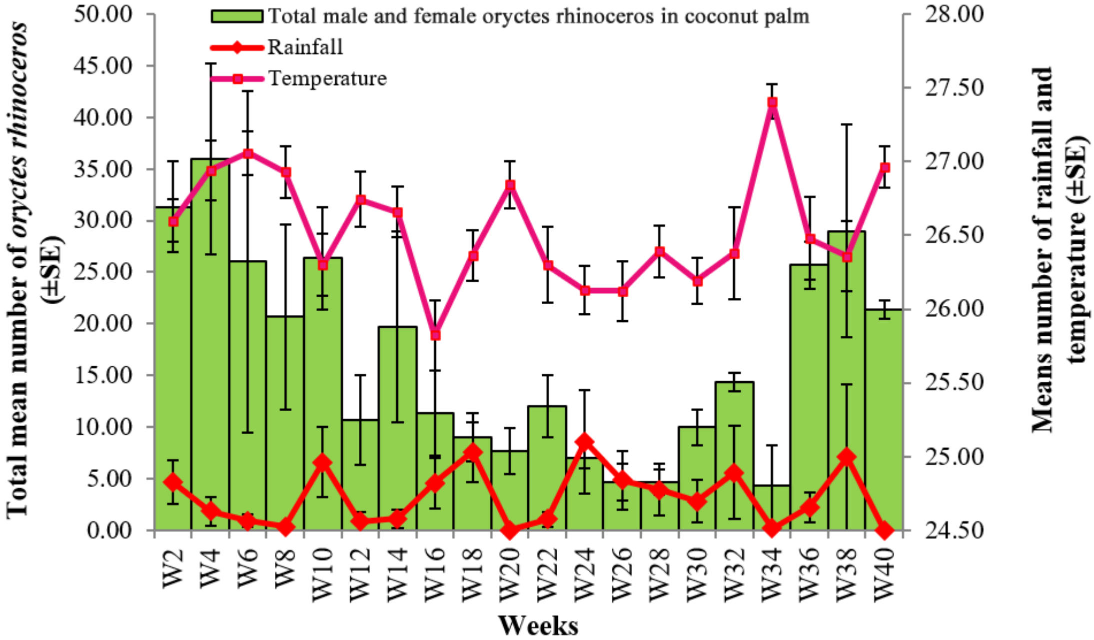

Figure 6. Total mean number of *O. rhinoceros* (Male and female) correlated with rainfall distribution and temperature in coconut palm plantation for 40 weeks of sampling periods.

Interestingly, in week 30 until week 40, Figure 7 shows that male and rainfall line seemed to have a positive relationship, but statistically there was no correlation (P > 0.05; r=-0.074) with rainfall in coconut palm. Meanwhile, male of *O. rhinoceros*was significantly influenced (P < 0.05; r=0.150) by temperature in coconut palm. The highest number of males was captured in week 4 (23.33) at temperature 26.94°C but the lowest number of males was in week 28 (1.33) at temperature 26.39°C.

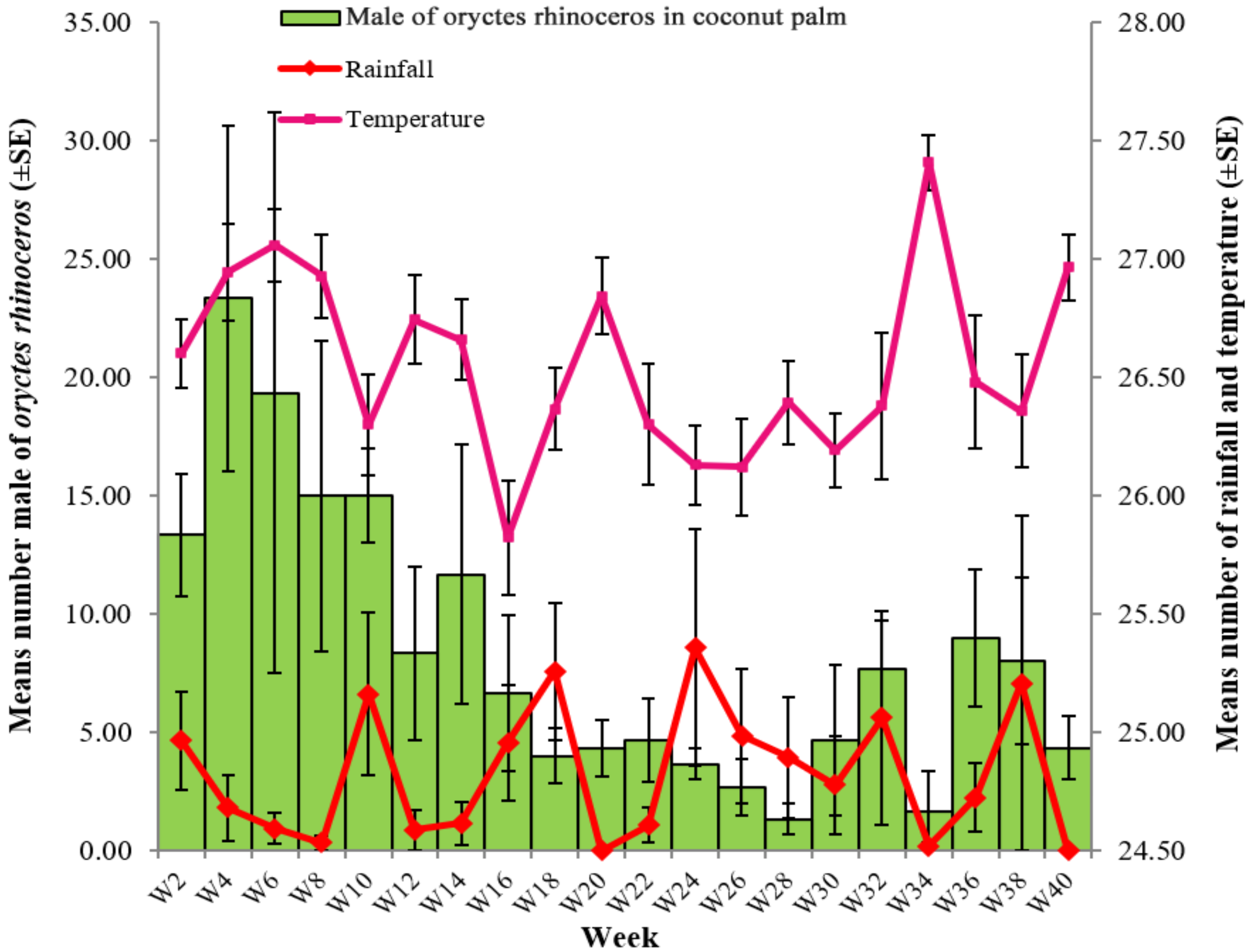

Figure 7. Mean number of *oryctes rhinoceros* male correlated with rainfall distribution and temperature in coconut palm plantation for 40 weeks of sampling periods.

Based on statistical analysis, no significant link was observed between the female population of the rhincervos beetle species and the distribution of rainfall as well as temperature. The highest number of female (21.00) was recorded in week 38 at temperature 26.36°C when the mean rainfall at 7.07mm. The lowest number female of *O.Rhinoceros* was in week 12 (2.33) at temperature 26.74°C while the rainfall was 0.86mm Figure 8. Overall, both male and female did not correlate with rainfall. Data was analyzed and found that female and total (male and female) of *O. Rhinoceros* also did not correlate with the temperature, but male of *O. rhinoceros* was significantly influenced by temperature in coconut palm plot. Basically, rhinoceros beetle's reproduction process continues under favorable condition. *O. Rhinoceros* active and reproduce when food and breeding site available but not directly affected by rainfall. Coconut palm was found to be a good host plant with minimal dry season may give favorable condition for *O. Rhinoceros* and active for activity of food searching.

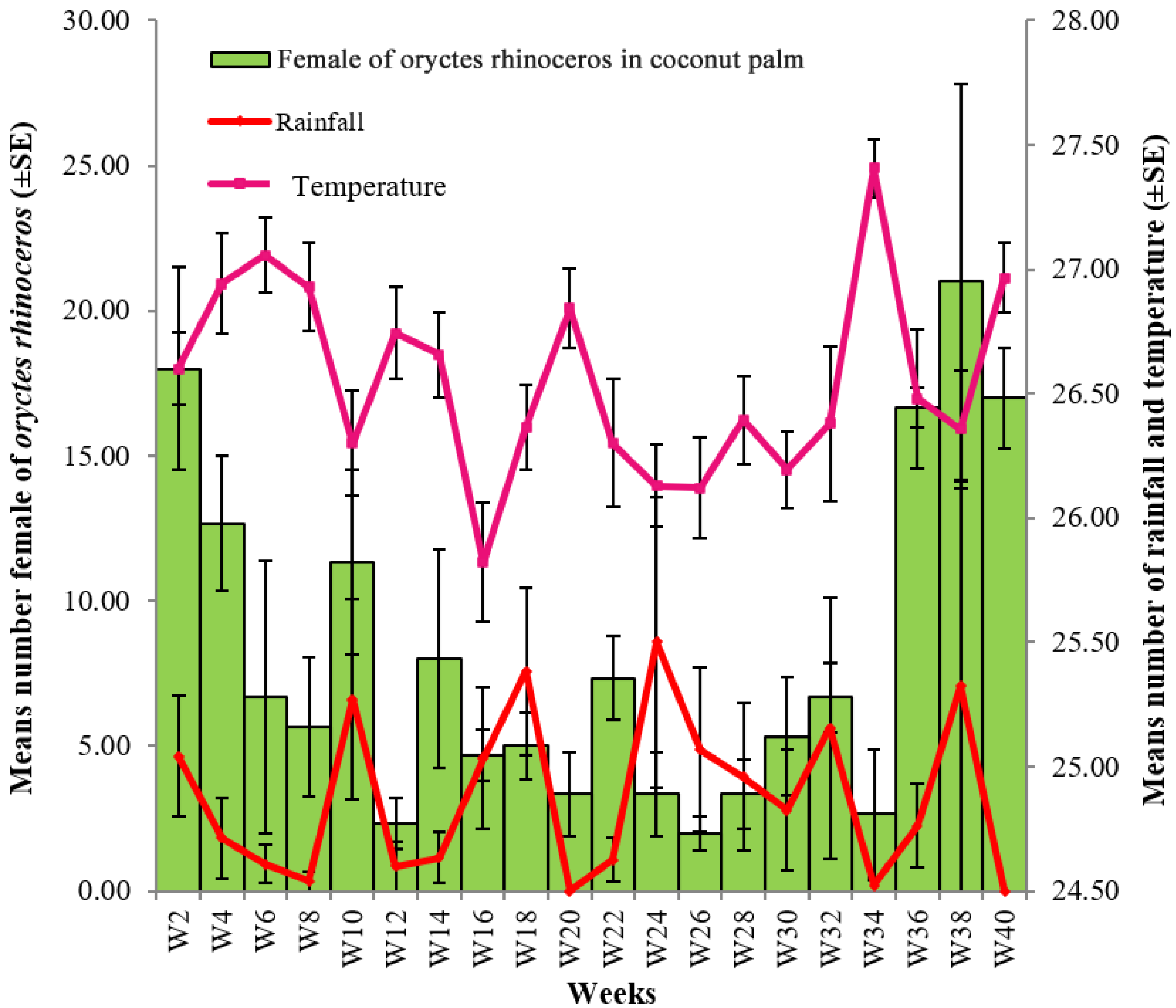

Figure 8. Mean number of *oryctes rhinoceros* female correlated with rainfall distribution and temperature in coconut palm plantation for 40 weeks of sampling periods.

4. DISCUSSION

In this study, different varieties of oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera* L.) were evaluated to determine the reaction of rhinoceros beetle (*Oryctes rhinoceros*) population. Data male and female of rhinoceros beetle were collected and recorded for 40 weeks in both oil palm and coconut palm that were collected from the pheromone trap in each experimental plot. Rhinoceros beetle is one of the major pests in Palmae Family. The Image of the rhinoceros beetle is serious stage, which is called as a destructive stage. Rhinoceros beetle has a record of causing severe damage. Yusof et al. (2013) found that rhinoceros beetle population of male pupae has five instars and survives at 25°C with the optimum survival at 30°C.

In this study, generally, the mean number of rhinoceros beetles in oil palm was higher than the mean number of rhinoceros beetleson coconut palm in many occasions during the sampling period. Interestingly, only at the early stage, especially weeks 2 and 4 and at the end of the sampling week, such as weeks 38 and 40, the population of rhinoceros beetles in coconut palm was higher than the population of rhinoceros beetles in oil palm plots. The population of rhinoceros beetles is probably lower in oil palm due to the agronomic practices that have been carried out by management, such as fertilizer application and physiological changes in plant performance. As a result, the rhinoceros beetle population shifted, and the cocunt palm was discovered to be a suitable alternative host. Additionally, population number of rhinoceros beetles was found to be higher in some varieties of coconut palm because of different varieties with different physical appearances. The physical appearance of coconut palm differed between plant varieties and it was more attractive compared to oil palm. Based on the previous study by Mohammed and Hassan (2004), indicated that beetle highly preferred the yellow color. Chemical composition and nutrient content differed based on the different plant varieties Zhang, Li, and Li (2016) may also affect the abundance of the population of rhinoceros beetle. Allou et al. (2012) found that rhinoceros beetle's mating process and laying egg require an affordable host.

The lowest population of rhinoceros beetles for both oil palm and coconut palm plots was detected in week 34. In week 34, rainfall distribution was recorded as the lowest compared to another week. Parallel with other studies done by Karuppaiah and Sujayanad (2012), low rainfall, the survival rate of insect pest brown plant hopper, and rice leaf folder were declined. However, the multitude of species will decrease in growth rate, fecundity, and mortality rate. Allou et al. (2012) also found that larvalrhinoceros beetles aremore preferred host, which can provide them food to survive.

The temperature, rainfall and weather condition are one of the most important factors in population dynamic of insect pest. Climatic factors are important for rhinoceros beetle survival particularly for searching their food and breeding site. The highest number of rhinoceros beetle was observed in week 16 (13.44) in oil palm plot. The population of rhinoceros beetle generally fluctuated for both oil palm and coconut palm plot Figure 1.

Climatic condition is one of the factors that may influence population dynamic of the rhinoceros beetle (*Oryctes rhinoceros*) in the oil palm (*Elaeis guineensis*) and coconut palm field. Rhinoceros beetle need favorable condition for breeding process. However, in oil palm, male and female populations were not influenced by rainfall distribution. Male of rhinoceros beetle in oil palm was also not influenced by the rainfall. However, interestingly, in this study, the female of rhinoceros beetle in oil palm had significant relationship with the rainfall. It is because female need the favorable condition for the breeding sites to lay their egg and rainfall could interrupt the breeding or reproduction process. Previous study reported that imago rhinoceros beetle was active during raining season Permadi (2012) which indicated that laying eggs process was occurred before raining season. This explained that rainfall much contributes to the development and growth of immature of rhinoceros beetle. At early stage in this study, average temperature in week 2, week 4 and at end of the sampling period in week 38 and week 40 were 26.72°C. This range of temperature is suitable for survival rate of the insect pest population and Yusof et al. (2013) also find that 79% male of pupae are survived at 25°C to 30°C.

In coconut palm, the population of rhinoceros beetlewas not influenced by rainfall distribution. Statistically, there was no relationship between population rhinoceros beetlewith the rainfall in coconut palm plots. These plant traits will give different effect towards pest's preference (Fathul, Mohd Rasdi, & Nur, 2018; Mohammed & Hassan, 2004) and whereas rainfall did not give effect to rhinoceros beetle population.

From the beginning of June 2015 until September 2015 (weeks 2-18), female population male and female population of rhinoceros beetlesdecreased gradually and increased from October 2015 till February 2016 (weeks 20-40). During this season, particularly in June 2015 (weeks 2-4), the climate was drought-prone. During the drought-prone, temperature increase and rhinoceros beetles migrate to search for favorable conditions for breeding sites. More larvae of rhinoceros beetles need a high level of moisture content 80% - 100% to survive (Norman et al., 2005); low moisture content was unfavorable for larvae; and a dry microclimate retarded the developmental process of rhinoceros beetles.

Interestingly, this study found that when the rainfall decreased, the populations of the rhinoceros beetle in coconut palmalso decreased gradually (week 2-week 8), and when the rainfall distribution increased, the population of the rhinoceros beetle also increased (week 10) Figure 5. Norman et al. (2005) found that rainfall was highly significant and positively correlated with population of first and second instar larvae of rhinoceros beetles. Rainfall had affected the population dynamics of the rhinoceros beetle due to wet season, which was favorable for breeding activities. Adult rhinoceros beetle was found actively flying in wet season and searching for new breeding sites reported by Norman et al. (2005).

This study revealed that there was no relationship between rhinoceros beetle and the rainfall Table 2. This finding explained that the population of rhinoceros beetles (*Oryctes rhinoceros*) in coconut palm did not have a clear relationship with rainfall distribution. The result was against the finding from Karuppaiah and Sujayanad (2012) which states that rainfall and weather affect the mortality rate, survival rate, fecundity, developmental rate, and dispersal of the pest population. However, climate change may alter the nutritional value of plants, alter insect abundance, and increase the consumption rate of herbivores.

Physical characteristic of the plant host or habitat may affect the population of rhinoceros beetle. In this study, plant variety for both crops were studied. Norman et al. (2005) found that nutrient value of K in trunk chips and moisture content increased the population of the rhinoceros beetle. Rhinoceros beetle also needed Nitrogen element which nutrient for protein to form its hard cuticular structure. From the finding, planters can properly plan pest and disease control during planting both crops (Fathul et al., 2018). Planters also can manipulate the microclimates within the habitat of the rhinoceros beetle to be less favorable for the breeding site. Avoid replanting at the wet season condition that may attract the rhinoceros beetle for breeding site. Another way to avoid the increased number of breeding site for adult rhinoceros beetle, planters can plant the legume cover crops to hinder the for aging of the adult. Further study on chemical and nutritional in each variety for both crops was needed to be carried out.

Overall, again female and total of male and female of rhinoceros beetle in the coconut palm had no correlation with the temperature. Meanwhile, female and total of male and female of rhinoceros beetle in oil palm was negatively correlated with the temperature. For male of rhinoceros beetle in coconut palm, there was positively correlated with the temperature compare to male of rhinoceros beetle n oil palm because rhinoceros beetle can be active and reproductive throughout the year occur in no cold season and a minimal dry season (Pradipta et al., 2020). Rainfall will provide moisture to organic materials and this will help the developmental of the insect pest population. Insect pest population survives for food searching and helps in food consuming. Manjeri et al. (2014) found that adult females of rhinoceros beetle will deposited its eggs inside the dead palms, decaying plant material, soil with high organic matter, and wooden structure (Allou et al., 2012). Adults will be flying to a new tree to search for new habitat for feed, and mate. Adults of rhinoceros beetle feed on fresh leaves (Zhong et al., 2013).

The changes of climate in the environment affects the pest population dynamics in two ways either directly or indirectly by altering the host physiology. Insect pest population and plant exposed to complex of the interactions among the changes in temperature, precipitation and increased level of CO_2 and variations in nutrient availability (Karuppaiah & Sujayanad, 2012).

5. CONCLUSIONS AND RECOMMENDATIONS

Overall, the population of rhinoceros beetles (*Oryctes rhinoceros*) was found higher in oil palm (*Elaeis guineensis*) as compared to coconut palm (*Cocos nucifera* L.). It can be concluded that rhinoceros beetles highly prefer oil palms when compared to coconut palms.

Climate is one of the factors that might influence the population dynamics of rhinoceros beetles in field. Rainfall distribution and temperature seemed to not influence the total number of males and the total number of males and females of rhinoceros beetles, beetles in oil palm and coconut palm in this study. Rhinoceros beetles need moisture and favorable conditions for breeding process. Interestingly, it was found that female rhinoceros beetles in oil palm field was correlated with the rainfall. This might be probably that the female rhinoceros beetles need favorable condition for breeding sites to lay their eggs. High rainfall, high of moisture, and temperature will decrease, and rhinoceros beetles will search for the favorable condition for the mating process and also for sources of food for the larva. Rhinoceros beetles prefer shelter for their breeding site. This scenario is probably due to types of canopies, both oil palm and coconut palm. Oil palm plants have a longer and wider rachis compared to coconut palm. It gives more shaded area in oil palm compared to coconut palm. The shaded area has a more favorable condition during high temperatures and it will influence the availablity of hosts for pest rhinoceros beetles. Preventive measures need to be taken with high consideration for climatic factors such as rainfall and temperature. Climatic factors affect and exert pressure on plants, making them favorable conditions for pests and diseases. Further study should be carried out in terms of chemical compounds in the both palmae varieties to determine the main reason why the rhinoceros beetle (*Oryctes rhinoceros*) is more attracted to the variety of the oil palm.

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