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DENSITY AND COMPOSITION OF *Oryctes Rhinoceros* (COLEOPTERA: SCARABAEIDAE) STADIA IN FIELD

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ABSTRACT

O. rhinoceros is a major pest of coconut palm in Indonesia. The research aims to study the ecology of the density and composition of the stadia *Oryctes rhinoceros* in field. The study location was determined by purposive sampling method. The observed locations were the goat and cattle manure piles, garbage piles, rotten coconut trunks, and sawmills. The insects in these sites were recorded on its number and stadia (egg-larva (grub) -pupa-imago). Then, the population density and the stadia composition were calculated. To caoture adult of *O. Rhinoceros* beetle observed by using pheromone, called ferotrap. The larval breeding sites were found in 26 locations. The densities of O. rhinoceros in the breeding site were 0.2-3.7 head/ind/m2. Total of *O. rhinoceros* were 460, consisting of eggs (5.43%), 1st instar (4.78%), 2nd instar (14.13%), 3rd instar (72.39%), and pupae (1.73%) and imago (1.52%). The most abundant composition found in the habitat was the larval stage of *O. rhinoceros* especially the instar 3 larvae. There were 217 O. rhinoceros and 59 *Rhynchophorus*sp captured for 12 weeks. The benefit of this research is to predict the exact time when the insects will turn into imago and attack the coconut plantations. Therefore, it can be useful for proper control strategies.

Keywords: ecology study, population density, stadia composition, *O. rhinoceros* in nature.

INTRODUCTION

Oryctesrhinoceros (Coleoptera: Scarabaeidae) is one of the highly destructive pests in coconut plants in Jepara, Indonesia (Indriyanti *et al.*, 2017a). Jepara is located on the waterfront where most residents plant the coconut trees (*Cocosnucifera*) in their backyard or garden. However, the productivity of coconut crop in Jepara has decreased in recent years. This phenomenon occurs because of the *Oryctes rhinoceros* beetle pests attack. This pest is difficult to control because of its imago broach the top of coconut shoots where it is hard to reach (Indriyanti *et al.*, 2017b). According to Moore *et al.* (2015), *O. rhinoceros* is a major pest of the coconut palm. Adult beetles bore into crowns to feed on sap. The adults will be in the top of coconut trees to mate and eat. Female beetle will fall from a coconut tree to lay its eggs on the ground which content by the organic material until the end of the pupal stage (Moore, 2012).

The existence of the pest will be difficult to detect because the larvae live in the soil together with the rest of the rotten coconut plant stems (Indriyanti *et al.*, 2015). *O. rhinoceros* larvae or grub will hide in substrates that contain lots of organic material to supply its development into adults (Bedford, 2013). *O. rhinoceros* larvae feed on decaying vegetation and do no economic damage. They usually are found in dead standing coconut palms, fallen coconut logs, and rotting coconut stumps. They also are found commonly in piles of sawdust and manure. Grubs feed only on decaying vegetation and usually are found in dead standing coconut trees and decaying coconut debris on the ground (Moore *et al.*, 2015).

An ecological study on insect larvae life is limited and has not been widely investigated, in particular on the information on the density and composition of the *O. rhinoceros* stadia that occupy the nest (breeding sites) in nature. Therefore, this paper aims to give the information on the density and composition of the O. rhinoceros stadia in nature, particularly in Jepara. The benefit of this research is to predict the exact time when the insects will turn into imago and attack the coconut plantations. Therefore, it can be useful for proper control strategies.

MATERIALS AND METHODS

Density and composition of *O. rhinoceros*

The study was conducted in Jerukwangi village, Jepara, Indonesia in April-June 2016. The research location was determined using the purposive sampling method. The research sites are the place that *O. rhinoceros* larva often found in it such as cattle and goat manure piles, garbage piles, rotten coconut trunks, and sawmills. At the location of the research, the observation plots in size of 1×1 m were made. The size of plot observation was expanded when larvae were found in the location. At the larva position, the soil was excavated at 0.5 m in depth. The number and stadia of insects from egg, larva, pupa, and imago were recorded. Data of *O. rhinoceros*density (Pi) was calculated using the following formula:

$$Pi = \frac{\sum O.rhinoceros}{\text{Width of area}} \text{ individuals/m}^2 \quad (1)$$

Data recorded were the abiotic factors, i.e.: temperature, humidity, soil pH, soil moisture, and light intensity. 100 g soil samples were collected for further determination on the moisture level.

Monitoring *O. rhinoceros* beetles

The amount of *O. rhinoceros* beetle observed by using pheromone, called "ferotrap" to attract beetles come.

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Pheromones were hung in black bucket, 50 cm diameter, 60 cm height. Bucket hangs on a wooden pole, 3 m above from the ground. There were 10 ferotrap installed at 10 locations, the distance were approximately 500 m each other. The amount of beetles trapped were observed each week, for 12 weeks.

RESULTS AND DISCUSSIONS

A. O. Rhinoceros population density

The results of observation showed 26 plots or locations where *O. rhinoceros* lived. *O. rhinoceros* population densities are presented in Table-1.

Table-1. Density, *O. rhinoceros* biomass, and moisture level of soil in each observation Location.

Plot	Number of insects	Density (Individual/m^2)	Total mass (g)	Moisture level of soil (%)
1	10	0.8	144	51.0
2	43	3.3	383	42.6
3	21	1.6	93	64.6
4	12	0.9	132	48.2
5	48	3.7	580	63.6
6	6	0.5	85	67.2
7	23	1.8	211	47.0
8	10	0.8	153	53.0
9	26	2.0	241	64.6
10	13	1.0	44	48.2
11	4	0.3	35	57.6
12	4	0.3	19	58.4
13	25	1.9	262	42.6
14	5	0.4	85	48.2
15	35	2.7	112	64.0
16	11	0.8	128	56.8
17	28	2.2	271	51.0
18	7	0.5	68	48.2
19	27	2.1	210	74.6
20	3	0.2	116	54.8
21	16	1.2	134	48.2
22	30	2.3	298	64.0
23	8	0.6	98	51.0
24	13	1.0	103	39.0
25	7	0.5	60	34.6
26	25	1.9	92	36.0

Table-1 reveals that each plot showed the different density of *O. rhinoceros*. There are 3-48 individuals/m^2 inhabited each plot. The total of *O. rhinoceros* in 26 plots was 460 showing the high population in the field. The highest density was found in plot 5 (the number of larvae was 48; density was 3.7 heads/ind/m^2). *O. rhinoceros* lowest density was in plot 20, where 3 larvae with a density 0.2 heads/ind/m^2 were found.

The density of *O. rhinoceros* that was found in the of Jepara was quite high, due to there were a lot of of growing palm, that plant is suitable for host plant. In addition, most of the village residents have cattle, where dung of cattle and goats were the most strategic place for the female beetles lay eggs (Figure-1). According Suin (2004) when the density of an animal or plant in a region is very high, it indicates that the environmental conditions in these areas is very supportive for the life of the animal.

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There is a close relationship between the compositions of the media with the density of *O. rhinoceros* in soil habitat. *O. rhinoceros* highest density was found on the ground composed of media from manure and straw or trash. According to Marlina *et al*. (2015), there some microorganisms play the role on the decomposition of waste. The organic compound on the waste is transformed into simple molecules which is beneficial for the availability of nutrients for animals that live in the soil. The nutritive complex serves as a source of nutrients for the development of the larval stage of *O. rhinoceros*. Rotten organic materials pose a distinctive odor as a result of the volatile chemical compounds. The smell of these chemical compounds attracts the female insects as a sign of feeding stock availability; therefore, the insects will immediately lay eggs there.

Figure-1. Location of where *O. rhinoceros* larvae were found in nature, i.e. cow and goat manure piles, straw and trash wastes.

The availability of organic materials as food and an abundance of nutrients strongly support the existence of *O. rhinoceros*. It is supported by several references stating that a pile of rotting wastes, rotting palm plant are suitable to place for insects breeding (Yustina *et al*., 2012). According to More (2013), manure or compost, rotten-palm wood, and sawdust is best breeding ground for *O. rhinoceros* larvae. Also, female *O. rhinoceros* lays her eggs in garbage piles, decayed leaves, dry leaves, and wood debris (Bedford, 2013; Wan *et al*., 2009). According to Sanders *et al.* (2015), *O. rhinoceros* female beetle will lay its eggs in a hidden place rich in organic materials. In Jepara, most of the larvae live in the trash, rotting crop residues and dung of cattle and goats. Therefore, it is easy to find *O. rhinoceros* larvae in the field; those places are the primary objectives.

Environmental factors mainly light intensity and temperature also affect the number of insect larvae. In general, the location where *O. rhinoceros* found is in a shady place for many plants which led to lower light intensity. The low light intensity affects the temperature and humidity in the microenvironment. Therefore, it will provide the low-temperature environment. The insects which live in the shady places grow with larger numbers comparing with the insects live in open area. According to El-Shafie (2014), the *O. rhinoceros* larvae will avoid an unfavorable environment and avoid environment with temperatures above 37 °C. In this study, the temperature at the research site was ranged from 30-33 °C, air humidity in between 68-87%, 49-70% soil moisture, soil pH ranged from 6.8 -7 and 39-82 lux of light intensity. Jepara has plenty of lush plants which provide the shady environments to support the growth of larvae insects.

The soil pH (6.8-7) on each plot observation results was almost the same. The difference in soil pH is indirectly affecting the presence of *O. rhinoceros* in its habitat. According to Kamarudin (2005), there is no significant difference in the number of *O. rhinoceros* if the soil pH is less than 4.2 comparing with less acidic areas. Insects grow and develop properly in the supporting environment. According to Moore (2014), the life cycle of *O. rhinoceros* depends on the favorable environmental conditions. In a proper environment, the female insect can have three generations per year.

The highest soil moisture level (74.6%) was found on plot 19, while the lowest was in plot 25 (34.6 %) as shown in Table-1. High level of soil moisture on plot 19 was due to the shady area. Plot 25 condition was in an open land surface which is exposed to direct sunlight. It led to high soil water evaporation; therefore, the moisture content was low. The maximum moisture level was at plot 19 inhabited by 26 larvae with 210 g biomass; whereas the lowest soil water level was in plot 25 where 8 larvae were found with biomass at 60 g. *O. rhinoceros* prefer to live in the field with an average moisture content between 60-70%. The study period in this research was in April to June, where the transition between wet and dry season occurs. In this season, larvae can be found easily in the garden, whereas in the dry season, larvae are beginning to difficult to find. This condition is because the larvae are moving into the deeper soil to avoid the heat on the surface of the ground. According Pujiastuti (2010) larvae of *O. rhinoceros* were at a depth of 10-30 cm.

According to Table-2, the number of *O. Rhinoceros* found in all plot were 460. There were 25 eggs (5.43%), 1st instar larvae (L-1) were 22 (4.78%), 2nd instar larvae (L-2) were 65 (14.13%), 3rd instar larvae (L-3) were 333 (72.39%), or total larvae stadia (91.30%), 8 pupae (1.74%) and 7 beetles (1.52%). In its habitat, the composition of *O. rhinoceros* larva stadiumwas the highest, which has the longest lifetime comparing the other stadia.

The composition of most stadia *O. rhinoceros* found in nests is a larval stage, especially the three instar larvae. Larval stage has a period of living longer than at other stadia. The larvae consume the soil organic compounds. It is often found the high body weight-big-fat larvae in the soil containing animal manure mixed with the rotten died plants. Pujiastuti (2010) suggested that larvae can move into deeper soil layer because of the soil texture which has the abundant amount of debris that has already broken down into organic matter. According USDA (2015), the larvae are usually found in 5-30 cm below the soil surface layer. Moreover, some early instar larvae often die in a dry substrate, but some late instar larvae can dig and move deeper into the moist soil to avoid dehydration. The late instars larvae are not active when heading into the pupae stage. Also, the larval development depends on the season and the presence of substrates that support its growth (Zhong *et al*. 2013).

The population density is determined from the number of eggs laid by female insects. A female beetle can produce 35-70 eggs during its lifetime (Pracaya, 2009). The eggs hatch into larvae and then the larvae will eat the soil organic material. One *O. rhinoceros* life cycle from egg to adult takes about 6-9 months (Riostone, 2010). A female beetle lays about 35-70 eggs (Pracaya 2009) or 70-100 eggs (Manjeri *et al.,* 2014). *O. rhinoceros* eggs are round-shaped, white with a length of approximately 2.5 mm and a width of 2 mm. After 12 days, the eggs will hatch into larvae (Pracaya, 2009; USDA, 2015). The larval stage lasts for 4-5 months, and some even reach 2-4 months. The larval stage consists of three instars, i.e. first instar for 11-12 days (Pracaya, 2009), 16 days (USDA, 2015), second instar 12-21 days (Pracaya, 2009), 18 days (USDA, 2015) and third instar 60-165 days (Pracaya, 2009), 99 days (USDA, 2015). Pre pupa 10 days and pupa for 24 days (USDA, 2015).*O. rhinoceros* emerges from the pupa will remain in place for 5-20 days, and then, it will fly out (Prawirosukarto *et al*., 2003). *O. rhinoceros* beetle that appears will begin to fly at dusk or night towards the coconut tree leaves and the stem end (Pracaya, 2009). Beetle can life for 113 days (USDA, 2015).

According to data in Table-2, it can be linked to the life cycle of *O. rhinoceros* based on USDA (2015) (Figure-2), so we can predict when the female insects lay its eggs and when it will develop to attack coconut palm trees. It can be analyzed as follows.

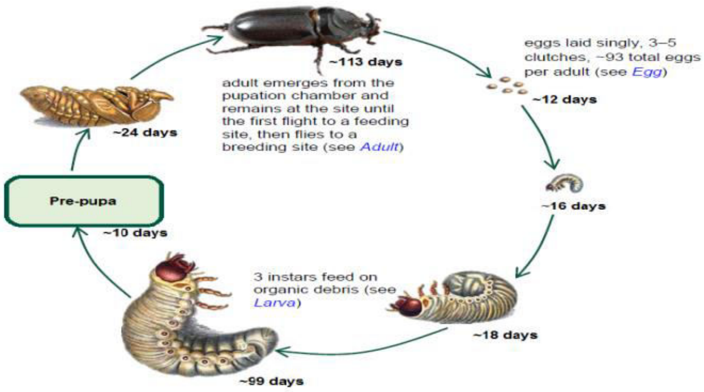

Figure-2. The life cycle of *O. rhinoceros* (USDA, 2015).

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Table-2. Composition of *O. rhinoceros* stadia in 26 locations breeding site.

Plot	Egg	L-1	L-2	L-3	Pupae	Image (beet)	Total
1.	-	-	-	10	-	-	10
2.	-	-	6	28	5	4	43
3.	-	4	3	14	-	-	21
4.	-	-	2	10	-	-	12
5.	-	-	2	45	-	1	48
6.	-	-	-	6	-	-	6
7.	-	1	2	20	-	-	23
8.	-	-	2	8	-	-	10
9.	-	-	6	20	-	-	26
10.	-	7	3	3	-	-	13
11.	-	1	-	3	-	-	4
12.	-	2	2	-	-	-	4
13.	-	-	2	22	-	1	25
14.	-	1	-	4	-	-	5
15.	25	-	-	8	2	-	35
16.	-	-	2	8	1	-	11
17.	-	6	-	22	-	-	28
18.	-	-	-	7	-	-	7
19.	-	-	2	24	-	1	27
20.	-	-	1	2	-	-	3
21.	-	-	15	1	-	-	16
22.	-	-	1	29	-	-	30
23.	-	-	-	8	-	-	8
24.	-	-	-	13	-	-	13
25.	-	-	7	-	-	-	7
26.	-	-	7	18	-	-	25
Total	25	22	65	333	8	7	460

If the research conducted in June, so the female imago is estimated to start laying eggs within 157 days or five months in January (rainy season). The third instar larvae will soon transform to pupae within 10 days (pre-pupa) and 24 days (pupa). Therefore, imago is predicted to begin to appear within 34 days in July or August (when the dry season comes). Therefore, the attack of insects will start on that month, so we have to be alert. Based on data, the presence of insects in all stadia (egg-larva-pupa-imago) is all year long.

B. *O. rhinoceros* beetle caught by ferotrap

The observation of *O. rhinoceros* beetles trapped by ferotrap for 12 weeks (Figure-3).

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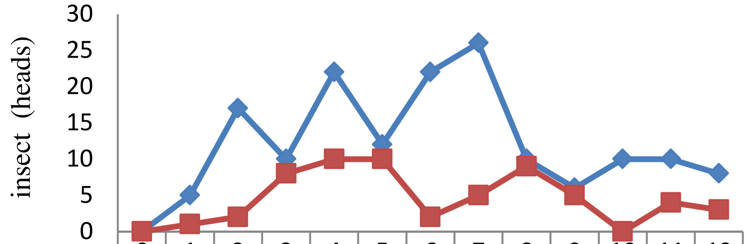

	0	1	2	3	4	5	6	7	8	9	10	11	12
O. rhinoceros	0	5	17	10	22	12	22	26	10	6	10	10	8
Rhynchophorus	0	1	2	8	10	10	2	5	9	5	0	4	3

Figure-3. Number of *O. rhinoceros* beetles and other insects were caught by ferotrap for 12 weeks of observation.

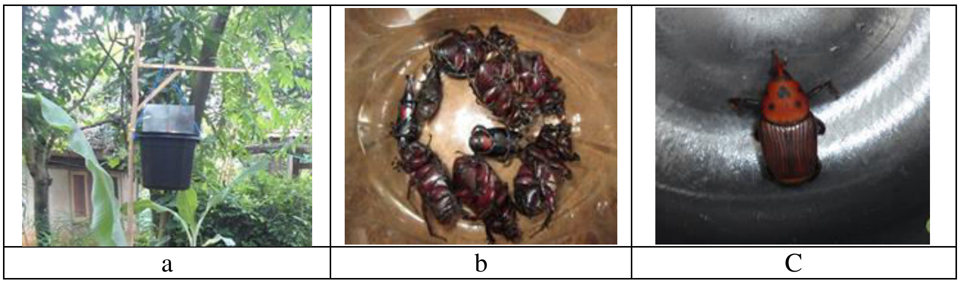

Figure-4. Ferotrap (a),*O. rhinoceros* (b), *Rhynchophorus*sp (c).

The number of *O. rhinoceros* beetles were captured during 12 weeks was 158 and other insect pests *Rhynchophorus*sp were 59. The number beetle started decrease after 8th week, due to the attractant compound was running out so it is no longer interesting. The data also showed that *O. rhinoceros* beetle population in the field is very high. In addition *O.rhinoceros* beetles are caught there are other insects that was *Rhynchophorus* sp. (Figure-4) known as a snout beetle. Snout beetle is a pest of coconut attack after attack *O.rhinoceros*. These insects are actually aggravate the damage to crops, cause plants die. Therefore need to alert for attacks more severe in the coming months.

O. rhinoceros high population density is caused due to: 1) Jepara is located on the waterfront, where coconut palm trees and *O. rhinoceros* grow throughout the year; 2) There is a power plant in the area where at the time of its construction, many coconut trees were felled, and it was utilized as a bridge construction material. The debris of coconut trunk was rotten to the organic materials and became the nest of *O. rhinoceros*; 3) Almost 50% of residents in Jerukwangi have the animal husbandries in their backyard. The animal manure piled up in the garden attracts insects to come and lay their eggs; 4) many coconut palm trees are abandoned with less treatment; and also there are piles of garbage or other organic material left in the area. This fact is in agreement with the opinion of Mawikere (2007), *O. rhinoceros* mostly attack the abandoned coconut palm trees and causing severe damage. These factors are allegedly causing the high *O. rhinoceros* population in Jerukwangi, Jepara.

The effort on *O. rhinoceros* control management is mainly conducted by taking larvae from the field and then destroys it. Unfortunately, this effort can be made when there are grants from the government. This condition causes the high population of *O. rhinoceros* throughout the year. According to Moore *et al*. (2015), the control of insects can be performed by relied on pheromone trapping, using ethyl 4-methyloctanoate to capture adults, and sanitation to remove rotting vegetation used as breeding sites. However, these control strategies are effective if it suits the time of insects' life cycle. Control using insecticides is not recommended; according to Tarwotjo & Rahadian (2017) excessive use of insecticide can pollute the environment and cause resistance. By the present study, the pest controller can predict the proper time of *O. rhinoceros* attack. Therefore, the prevention and anticipation can be performed before the attack occurs.

CONCLUSIONS

Based on the survey, there are 26 locations of *O. rhinoceros* larvae habitat in Jerukwangi village, Jepara, Indonesia. The population density between 0.2- 3.7 individuals/m^2.*O. rhinoceros* stadia composition found in the field were larvae (91.30%), eggs (5.43%), pupae (1.74%) and imago (1.52%). The sufficient number was larvae which live in cow and goat manure piles as well as in straw and waste piles. Monitoring the presence of *O. rhinoceros* beetle by using pheromone in the field, show that the population was high (217), and other insect *Rhynchophorus*sp (59). It seem that the beetle population was high. This study is useful for pest management system which can be applied to predict the life cycle time of *O.*

rhinoceros. Also, it can be used as a reference to set the plan when is the proper time for a control system to prevent the severe damage of coconut palm trees caused by the insects.

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