POPULATION DYNAMICS OF *Oryctes rhinoceros* IN DECOMPOSING OIL PALM TRUNKS IN AREAS PRACTISING ZERO BURNING AND PARTIAL BURNING

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ABSTRACT

Zero burning concepts during oil palm - to - oil palm replanting has provided ample breeding and foraging sites for the Oryctes rhinoceros *beetles. This study investigated the impact of the different techniques of residue management in oil palm replanting to the abundance of* O. rhinoceros. *Two types of breeding sites, zero and partial burning were selected and the beetle populations were determined between three to 18 months after felling and chipping (MAF). At the sixth MAF, different stages of* O. rhinoceros *were collected from chipped trunks. The results showed that a high population of* O. rhinoceros *was detected at the 13th MAF; no beetles were detected at the third, fourth and fifth MAF from both types of breeding sites. The third instar larvae were recorded as the dominant stage detected during the study. The females were found to be more abundant than the males, indicating better food quality and a potential for higher infestation for the coming months. There was no significant differences on the population of* O. rhinoceros *in both sites. The beetles population tended to increase with MAF. The results of this study suggested that the partial burning of chipped trunks did not decrease the population of* O. rhinoceros *apart from polluting the environment.*

Keywords: *Oryctes rhinoceros,* zero and partial burning, month after felling and chipping (MAF).

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INTRODUCTION

The rhinoceros beetle (RB), *Oryctes rhinoceros* is endemic to the lowland areas of South-east Asia. The beetle attacks and destroys the developing fronds and spears of oil palms, and it is the most important insect pest on palms of less than four years, especially in areas practicing the zero burning technique during replanting. Prolonged and severe damage can result in delayed palm maturity (Chung *et al.*, 1991). Adult feeding produces galleries which can be several centimetres long at the base of the unopened spears (Jacquemard *et al,*. 2002).

In younger palms, the damage can be more severe because the feeding galleries can retard the development or even kill the palms (Turner, 1981; Mariau, 2000). In mature palms, attacks by adult beetles may reduce the yield by 20% to 25%, and in immature palms the attack may be lethal. Furthermore, the damage caused by RB may provide entry points for secondary attacks by the palm weevil or by pathogens.

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In the field, the felled oil palm trunk residue takes three to four years to rot completely. Within this period, the young oil palm replant are exposed to pests, especially the RB. The nutrients released from the biodegradation of the palm residues partly supply the total nutrients required by the young palms in subsequent years (Basri and Norman, 2000; Khalid *et al.,* 2002). In special cases, where open burning is still practised, the palm biomass is left to dry before burning in order to reduce pest and disease problems. Illegal burning of oil palm trunks is prohibited to avoid excessive release of smoke, which has a major effect on the air quality and the visibility of the area undergoing replanting (Ho, 1996; Basri and Norman, 2000; Khalid *et al.,* 2002). The law has provision for open burning but requires prior permission from the Department of Environment (DOE) before controlled burning is allowed (Khalid *et al.,* 2002).

The existence of large oil palm estates profoundly modifies the environment, resulting in one of the most dynamic features in oil palm cultivation, *i.e.* changes in the importance of individual pest species. Pest problem can become acute without any control regarding to the infestation of pest (Chung *et al.,* 1995; Ho, 2002; Turner and Gilbank, 2003; Chung, 2004). The population of RB increases tremendously (Norman, 2001) in zero burning replanting fields. *In situ* breeding sites (chipped trunk heap) provide suitable sites for the beetle's growth and multiplication. The RB takes only five to six months to develop into adult beetles (Norman, 2001) when feeding on young palms. Natural controls, such as infection by pathogens or predations by predators, may reduce the pest numbers in many situations. Integrated Pest Management (IPM), utilising the full use of biological control measures would be the best option to achieve environmentally sustainable oil palm production in facing the RB threat (Jackson *et al.,* 2003; Ramle *et al.,* 2011).

Palms in the replanting areas are especially at risk because the decaying logs of the former stand provide the breeding ground for the larvae, which feed on the rotting organic material (Wood, 1968). When feeding is completed, the larvae pupate and later emerge as adult beetles. Adult RB feed on the growing palms leaf tissues causing damage as discussed earlier. Within the oil palm replanting ecosystem, study on the population and infestation levels of *O. rhinoceros* is fundamentally important to understand the relationship between environmental factors and natural enemies (Norman, 2001). This study aims to investigate the population dynamics of *O. rhinoceros* in different stages of decomposition of oil palm trunks in zero burning and partial burning replanting techniques.

METHODOLOGY

Study Site

This study was carried out in an area of approximately 45 ha out of 544.86 ha oil palm replanting at FELDA Global Ventures Plantation (Malaysia) Sdn Bhd [FGVP (M) SB] Lepar Utara 05 Estate, Pahang. The study which took 16 months covers all types of land topography as sampling sites: hilltops, hillsides, roadsides, borders to mature palms, swamps and valleys. The oil palm biomass was stacked to form a single heap of about 0.5 m high and 2.0 m wide in between rows or at the terracing lips. The trial commenced about three months after the completion of the chipping and stacking phase. The estate practiced one round random partial burning of oil palm residue in this replanting area.

Sampling Procedures

Two types of study sites, namely zero burning and partial burning were sampled every fortnightly. In every sampling occasion, nine 1 m^2 of decomposed trunks (1 m^2 per sampling x 9 samples x 2 sites) were randomly selected and examined for RB population. A hoe and manual hand pick were used to collect the different stages of RB from the decomposing heaps of chipped trunk. The RB were classified to the seven stages of development: eggs, 1st instar larvae, 2nd instar larvae, 3rd instar larvae, prepupae, pupae and adults. Their numbers were recorded *in situ* and the RB at different stages of development were then destroyed.

The sexual differentiation can be determined at the pupal stage by examining the dorsal part of the head. The head of the female pupa has a short horn while the male pupa has a longer horn. But for adult stage, the sex of a sexually matured adult is determined using the tip of the abdomen. The female adult has a tuff of velvet bristle while the male does not.

For a normal data, a paired t-test and one-way ANOVA were carried out with the number of RB in zero burning and partial burning trunks as dependent variables and the duration in months after felling and chipping (MAF) as the independent variables. Analyses were performed on the log $x + 1$ transformation for the number of beetles at different stages of development collected in the decomposing trunks.

RESULTS AND DISCUSSION

Table 1 shows the seven stages of development of the RB collected during the 16th month sampling

TABLE 1. NUMBER OF *O. rhinoceros* IN ZERO BURNING AND PARTIAL BURNING SITES

Stages of beetles	Zero burning		Partial burning		t value	p value	Sex ratio
	N	Mean ±SE	N	Mean ±SE			
Eggs	25	0.1736 ± 0.121	25	0.1736±0.211	t = 0.260 df = 143	p = 0.795	-
1st instar	48	0.3542±0.041	195	1.347±0.122	t = 2.139 df =143	p = 0.035*	-
2nd instar	364	2.500±0.025	341	2.299±0.032	t = 0.162 df = 143	p = 0.873	-
3rd instar	433	2.965±0.074	566	4.056±0.055	t = 0.373 df = 143	p = 0.710	-
Prepupae	12	0.0764±0.033	33	0.1667±0.014	t = 1.026 df = 143	p = 0.306	-
Pupae	30	0.1875±0.028	63	0.4375±0.025	t = 1.568 df = 143	p = 0.119	-
Adults	27	0.1875±0.017	41	0.2431±0.028	t = 0.917 df = 143	p = 0.361	(1:2) 21♂,47♀

Note: * Significant, $p < 0.05$.

period in zero burning and partial burning study sites. The results showed that the number of eggs found were equal in both sites. The number of eggs found in the palm residues was much higher (within one to 24 eggs m^{-2} per sampling) as compared to the mean fecundity of females captured by trap [16 eggs per female, Norman *et al.* (1999)] but lower than the female mass-reared in the laboratory, between 49 -60 eggs per female (Hurpin and Fresneau, 1973).

The number of females collected in the chipped trunk was double that of males. A significant difference exists only between the number of first instar larvae in zero burnt and partial burnt trunk chips ($t = 2.143$, $df = 143$, $p \leq 0.05$) (*Table 1*). The low sex ratio of RB adults suggests that environment, habitat and abiotic factor strongly affect the population (Norman, 2011). *Figures 1* and 2 show the numbers of different stages of RB in relation to MAF (all stages). Starting from the sixth MAF, *O. rhinoceros* beetles could be found in the decomposing trunks. The highest beetle population was detected at 13th MAF followed by 16th and 10th MAF. No beetles were found during the third, fourth and fifth MAF. At sixth MAF, the immature stages of RB started to appear in the decomposing trunks.

A total of three third instar larvae, one prepupal, one pupal, and five adults were observed at sixth MAF. This was probably due to the immigration of adults, especially the gravid beetles from adjacent areas (either from mature area or other nearest replanting area). The first, second and third instar larvae were observed to be present continuously after six MAF. The third instars of *O. rhinoceros* started to appear between 3.2 - 6 months after eggs were laid (Catley, 1969; Chung, 2004; Hinckley, 1973; Bedford, 1976a; b). Altogether, about 23.9 and 35.7 beetles were found in zero burning and partial burning area, respectively at 13th MAF which usually represented the maximum samples found. One-way ANOVA test indicated a significant difference between the stages of beetle and duration of MAF ($F = 25.313$: $df = 6, 15$; $p < 0.05$).

Wood (2004) stated that sometimes ground vegetation, for example *Mucuna bracteata* failed to act as a barrier to cover the heaps to make them unsuitable as breeding sites for the RB in the replanting area. Irrespective of MAF, our results tend to agree with that of Wood (2004). The study sites has 80%-90% ground cover provided by *Asystasia intrusa* sp. and *Mucuna bracteata* at 12th MAF, but the beetle population remained high (*Figure 1*).

High numbers of second and third instar larvae were regularly found, while the pupae and prepupae were easily observed in all parts of the heaps especially in the decomposing fronds and deep beneath the soil (0.46 m) during the 16th MAF. This is probably due to the fact that decomposing oil palm trunks attracted a high number of beetles to breed during the 6 to 24 months after replanting (Norman, 2001).

Decomposing crown and frond of the palms provide suitable habitats for the prepupal and pupal stages. In fact, Norman (2001) found that the *O. rhinoceros* was detected in the decomposed trunk heaps up to 26th MAF. This may be due to the attraction of the beetles to the volatile compounds produced by the decaying biomasses as well as the aggregation pheromone, ethyl – 4 – methyloctanoate (produced by beetles) which was used to trap beetles of both sexes (Jackson *et al.*, 2003).

The presence of the immature stages was easily detected by the shape of the faeces in the decompos-

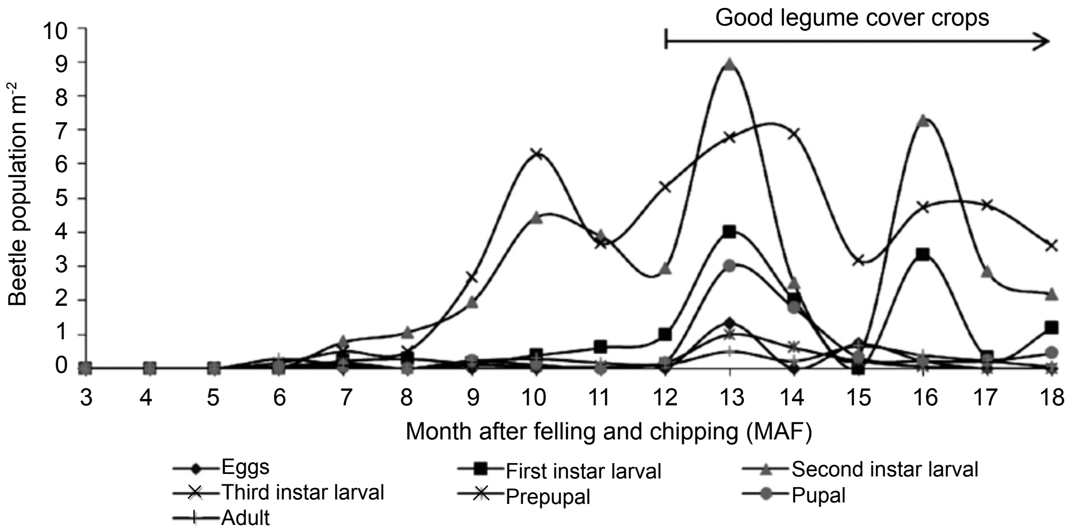

Figure 1. Different stages of O. rhinoceros *in relation to months after felling and chipping (MAF) with legume cover crop covered 80% to 90% of the trunk chips at 12th MAF at FGVP (M) SB Lepar Utara 05 oil palm plantation in both sites.*

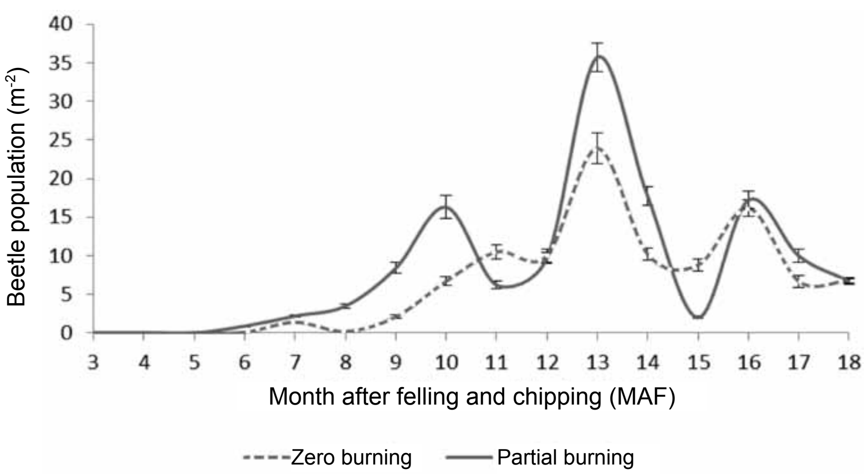

Figure 2. Total number of O. rhinoceros *in decomposing trunks up to 18 months after felling and chipping (MAF) at FGVP(M)SB Lepar Utara 05 oil palm plantation in partially burned and zero burned sites. Bars indicate the standard error of the mean (±SEM).*

ing trunk. The moist condition of the rotting trunks was preferred by the second and third instar larvae. Unidentified mites (Archridae) were found on the external surfaces of the various stages of the RB, except the eggs. Moreover, they were observed living inside the cases of prepupae or pupae. These mites could probably be the ectoparasites of the beetle. Most arachnids are carnivorous, vegetarian and parasitic (Wood, 1968).

During the immature stages, the RB are exposed to several mortality factors. Immature beetles are preyed upon by several ground animals such as rats (*Rattus tiomanicus*), wild boars and reptiles. These different stages of the RB are preyed upon because of their large size and long life cycle of about 160 days (Norman, 2001). However, they would burrow deep into the soil to avoid sunlight and predators such as wild animals and other insects. The 3rd instar larvae may need suitably low temperature or humidity to become prepupae, pupae and finally adults (Bedford, 1980; Norman, 2001).

The trunk heaps need to be burned four to five times to achieve complete burning. However, the DOE limits the activities of open burning to only the outer layer of the chipped trunks. Partially burnt chips still serve as suitable breeding habitats for *O. rhinoceros* to lay their eggs. However, biological agents such as *Metarhizium anisopliae* and *Oryctes* virus can help to manage immature and adult beetles in oil palm biomass at the early stage of replanting (Ramle *et al.*, 2004; 2007; Noor Hisham, *et al.*, 2005).

The application of the fungus of *M. anisopliae* in the decomposing trunks of oil palm could infect all stages of *O. rhinoceros* (except egg) with the highest infection observed on the third instar larvae (Ramle *et al.*, 2000; Noor Hisham *et al.*, 2011). This biocontrol agent can provide between 33% to 80% control in the field using different delivery techniques (Ramle *et al.*, 2013).

CONCLUSION

This study demonstrates that the RB population increased in abundance at the sixth MAF of matured oil palm. All life stages such as egg, first, second and third instar larvae, prepupae, pupae and adults were observed in the field in zero burning areas. In the partial burning areas, the third instar larvae first appeared at the sixth MAF. The presence of different stages of RB in the decomposing trunk continued up to 18^{th} MAF and the majority of the beetle stages found in the decomposing trunks were the second and third instar larvae. Some of the eggs had already hatched before they were sampled. The high abundance of the first generation RB in the oil palm decomposing trunks occurred between ninth to 18^{th} MAF. It is therefore concluded that the palm chips provided the optimum habitat for the breeding of RB in replanting areas. However, no difference was detected in the number of RB found in zero burnt and partially burnt habitats. The abundances of RB in both areas started to appear from the sixth MAF. Therefore, for the management of RB, residue burning should be stopped and the implementation of zero burning should be encouraged. Our finding shows that late introduction of the legume cover crops failed to control the RB population. Perhaps the legume covers should be established earlier to fully cover the trunk chips within six MAF as to prevent the female beetles from laying their eggs in the decomposing palm residues. The burning of chipped trunks not only cost more, but also caused environmental pollution. This practice too had failed to reduce the RB population.

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