FINAL REPORT ON CONTROL OF RHINOCEROS BEETLES (*Oryctes rhinoceros*) (SCARABAEIDAE:COLEOPTERA) IN A ZERO BURNING REPLANTED OIL PALM AREA, FELDA PLANTATION, LEPAR UTARA, PAHANG (2003-2006).

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Executive Summary

The research was carried in FELDA Plantations in LEPAR UTARA 5, 9 and 14 under FELDA Plantation Sdn. Bhd. Central Pahang between September 2003 and January 2006. This is the first kind of research on replanted oil palms (0-4 years old) on the effect of zero burning on the bionomics of rhinoceros beetles (*O. rhinoceros*) (RB) and its attack on the young palms. The decomposing felled trunks provided ample breeding sites for RB immatures. The damages caused by RB on Tissue Culture (TC) palms were higher than on the DXP palms. The mean percentage of damages was high as up to 67.4% in 1-2 years old TC. Damages on different topographies were similar.

Based from the pheromone trapping technique, some fresh information was revealed. There was a distinct demarcation of direction that the beetles migrated from old mature palms to nearby sites where felling and chipping of trunks were carried out. As the migration is almost simultaneous with replanting, it would be essential to place the traps alongside the fringes bordering mature palm before placing the traps within the replanting area.

Pheromone traps can be installed within the replanting area after about 6 to 7 months after Felling and Chipping (MAF), to coincide with the new emergence of adults. Adult trapping can be stopped when first harvesting starts. At the same time, good trapping can reduce the numbers of gravid female in field and decrease the probability of reproductive female to lay eggs into the habitats.

Field efficacy of Marshal, Furadan and naphthalene balls showed some effect of the RB. Overall, a Marshal 5G 12 gram is the most effective than the other treatments but it had the highest number of palms scorched. However it has the highest numbers of dead

beetles found followed by Marshal 5G 6 grams, Furadan 3G 30 grams and Marshal 5G 3 grams. 12 grams, 6 grams, and 3 grams Marshal 5G showed the best reduction of damages. The damage levels were below 10% damages after 10 Week of applications. This indeed demonstrated the reduction of damage percentages caused by rhinoceros beetles at the end of the treatments due to the efficacy of Marshal 5G.

The immature of Rhinoceros beetle were sampled in decomposing trunks from 3 month after felling and chipping (MAF) until the 18th months. Overall, in the 3, 4 and 5 MAF **no beetles of any stages** were found. However, at 6 MAF RB immature started to appear in the rotting trunk chips with a total 3 larvae from third instar, 1 prepupae, 1 pupae, and 5 adults, respectively. Started from **6 MAF**, a significant of immature beetle population in the rotting trunks, started to appear. Almost every month after 6 MAF, the first ,second and third instars larvae were continuously observed in the samples until the end of sampling, the 18th MAF. The highest density of RB immatures and adults were found in 13 MAF.

GENERAL OBJECTIVES:

1) To evaluate the damage cause by rhinoceros beetles (*O. rhinoceros*) in replanted oil palm in zero burning area at FELDA Plantation Lepar Utara, Pahang of different planting materials, ages of palms, and topographies.

2) To investigate population dynamic of *Oryctes rhinoceros* adults in immature oil palms for 1 year using pheromone traps in 40-hectare plot each at FELDA Plantations: Lepar Utara 05, 09, and 14.

3) To evaluate the effectiveness of several insecticides against *Oryctes rhinoceros* in 1-2 years oil palm and its phytotoxicity to palms. Their efficacy based on palm damages and the dead beetle counts.

4) To investigate the rotting of palm chip ages/times in relation to the abundance and the life stages of *Oryctes rhinoceros* matures in a new replanted area. Comparisons were made in zero burning (A) and partial burning (B) sites.

CHAPTER 1

DAMAGE CENSUS CAUSE BY RHINOCEROS BEETLES IN REPLANTED OIL PALMS.

Objective: To evaluate the damages cause by rhinoceros beetles (*Oryctes rhinoceros*) in replanted oil palm in zero burning area at FELDA Plantation Lepar Utara, Pahang according to planting materials, ages of palms and different topographies.

1.1 Introduction

Natural instinct has lead the rhinoceros beetles destroying developing young palms in fields. Prolonged and severe damage can result in delayed palm maturity. In 1999 (Chung et al., 1999) combined the average crop loss for 569 palms plot caused by rhinoceros beetles had been estimated to be 53.16%. The result is more than the 40% value given by Liau and Ahmad (1993), and less than the 79% given by PPKS (1996) (Chung et. al., 1999).

That is why the census is needed to estimate effect of pest damage during immature phase on the early yields of oil palm. This procedure should be carried out in estates to determine the condition of estates. Infestation of RB continuous should be controlled by chemicals during serious attack is the best way and may reduce the yield loss by RB attack. The infestation is usually brought down by selective control in estates carrying out regular spraying of Cypermethrin at 0.05% every two weeks. Monitoring the population dynamic by using pheromone trap is important in order to know the economic injured level (EIL) of rhinoceros beetle in immature estates. This section will be discussed later in Chapter 2.

The pests cause infestation by attacking the vegetative as well as the reproductive parts of the palm namely the spindle, leaf, and petiole. The pest attack is more on the petiole region with permanently marked holes than on the spindles and leaves. On the leaves RB causes inverted "V" shaped cutting mark, which is due of the pest eating the leaf in the crown stage before emerging out. On the spindle the pest causes the chewing marks, which may lead to the breaking and drooping and also causes a conspicuous permanent hole on the leaf petiole making the fond to break or snap with light winds (Kalidas, 2002) (Table 1.0). Furthermore, it can leads to the invasion of secondary pests like red palm weevil, earwig (Dermaptera), stag bug, and bud rot causing fungi.

1.1.1 Recognition of damages symptoms

Several symptoms of damage caused by RB on the canopy of oil palm are recognized and summarized in the table 1.0 below:

Table 1.0 Damage symptoms caused by RB on the canopy of oil palm

PLANT PARTS	*DAMAGES SYMPTOMS*
Spear	Section of unopened spear cut off with distinct chewing marks on remaining portion.
Spear	Unopened spear dieback (dead spear are easily pulled out) or snapping with chewing marks on basal end.
Fronds	Snapping of newly opened fronds.
Fronds	Fan shaped cut fronds.
Fronds	Little leaf complex from palms recovering from severe attack.
Rachis/petiole	Oval shaped bore holes on the rachis and /or petiole of fronds.
Petiole/Frond bases	Cluster of chewed materials closed to frond bases.
'Palm Death'	Complete absence of many upper fronds, and rotting in the growing point (cabbage).

1.2 Materials and Methods

1.2.1 Evaluation of damages on palms in the 20 hectares plots.

Location of Sampling

The study was conducted for three times in different location from May 2004 to January 2005 located at Ladang Lepar Utara 14 and 09, FELDA Plantation, Jerantut, Pahang.

Sampling Procedures

The evaluations of damage palms caused by *O. rhinoceros* were initiated from a subplot in a 20 hectares area. Census was taken by systematic sampling for 1300 palms, at every even line. From visual assessment on the severity of damage, of 1300 palms each the following categories were selected: **severely damaged**; more two injured/dead unopened spears (easily pulled out, fan shaped cut frond) or more than two fronds were bored or snapped, **slightly damaged**; Less than two unopened spear or 1-2 fronds were injured, dead/bored/snapped, and **Nil/negligible**; palms with no RB attack (Table 1.1 and Figure 1). Damage assessments on the number of damaged fronds and spears were evaluated. Each census was taken three times (May, September 2004 and January 2005) for various location and type of planting materials for eight months (Table 1.2 and 1.3). The result showed the varying incidence level of damage in the wide area (20-hectares), different severity of damage on different ages of plantings and types of planting materials.

Table 1.1: Damage classifications by RB on the palms during the sampling activities.

Damage severity level	*Symbol*	*Damage symptoms*
Nil/Negligible	0	Palms with no RB damage/incidence.
Light	x	Less than 2 unopened spear or less 3 fronds were injured, dead or bored/snapped.
Severe	xx	More two injured/dead-unopened spears found (easily pulled out, fan shaped cut fronds) or more 2 fronds were bored or snapped.

Table 1.2: Type of planting materials and location of plot for damage census

Palm Ages	**Materials of planting**	**Location**
0-1	Tissue culture	Lepar Utara 14 PM 80A
0-1	D X P	Lepar Utara 09 PM 83A
1-2	Tissue culture	Lepar Utara 09 PM 84B
1-2	D X P	Lepar Utara 09 PM 01F
2-3	D X P	Lepar Utara 09 PM 01E

1.2.2 Evaluation damages in different topographies.

Location of Census sites

Severe incidence of rhinoceros beetles was encountered in 6 – 14 months old palms in November 2003 among planting (DxP) materials in an oil palm estate Block 32 and 33 of PM 80A in Felda Plantation, Lepar Utara 14, Pahang

Census Procedures

From visual assessment on the severity of damage (severely damaged palms, slightly damaged palms and palms with no damage), 120 immature palms (1 ha) were selected randomly from more than 1 hectare of various topographies. Damage assessment evaluations were done on the number of damaged fronds and spears (Figure 1) and were conducted in June 2004, September 2004 and January 2005. The description of the varying topographies such as roadside, hillside, hilltop, swamp and valley, and border of mature palm were detailed (Table 1.3). The result showed the varying incidences level of damages in the different topographies in 1 hectare on palms.

Table 1.3: The schedule of sampling program of palms census on different topographies.

Topographies	Date	No. of palms evaluated
Roadside	June, Sept. 2004 and Jan. 2005	120 palms x 3 times (Random)
Hillside	June, Sept. 2004 and Jan. 2005	120 palms x 3 times (Random)
Hilltop	June, Sept. 2004 and Jan. 2005	120 palms x 3 times (Random)
Swamps and Valleys	June, Sept. 2004 and Jan. 2005	120 palms x 3 times (Random)
Border of mature palm	June, Sept. 2004 and Jan. 2005	120 palms x 3 times (Random)

Figure 1: Different symptoms of damages.

1.3 Results

Table 1.4 shows the percentages of palm damage caused by RB in 20 hectares after three times census on different planting materials, location and age. Although the samplings were carried in different estates, location and time but the results showed the significant of damages, respectively. All damages detection was taken based on Table 1.3. and a total of 3900 palms were sampled for DxP 0-1 year, DxP 1-2 years, DxP 2-3 years, Tissue culture 0-1 year and Tissue culture 1-2 years.

Mean damages of *Oryctes rhinoceros* on DxP palms and Tissue culture palms were 21.1%, 28.4%, 10.1%, 67.4% and 49.7% after three times of census in the 20- hectare plot (Table 1.4 and Figure 2). The census found that tissue culture seedlings 0-1 year have the highest damages caused by RB followed by 1-2 years Tissue culture palms, 1-2 years DxP palms, 0-1 year DxP palms and 2-3 years DxP palms ($P<0.05$, Figure2, Appendix 1).

Meanwhile, census on damages based on different topographies in 1-hectare plot showed that percentages of damage for all topographies were similar (Table 1.5, $P>0.05$) but the percentages of severe damages on palm bordering mature palms was 10.23% which is slightly higher than other topographies (Figure 3, $P>0.05$, Appendix 2).

Table 1.4 Percentages of palm damage caused by RB in 20 hectares for three times census and mean percentages.

Plantings Material and palm ages	Palm damages (Damages %)			
	1st Census	2 nd Census	3 rd Census	Mean ± SEM
D x P (0-1 year)	22.2	23.6	17.6	21.1 ± 1.81 ac
D x P (1-2 years)	34.5	28.5	22.3	28.4 ± 3.52 ac
D x P (2-3 years)	11.5	10.2	8.6	10.1 ± 0.84 a
Tissue culture (0-1 years)	53.3	68.5	80.5	67.4 ± 7.87 b
Tissue culture (1-2 years)	67.5	27.0	54.7	49.7 ± 11.95 bc

* Tukey HSD test for significant differences between means i.e. means followed by the same letters in same column are not significantly different at 5% level according to the Tukey HSD after arcsine transformation.

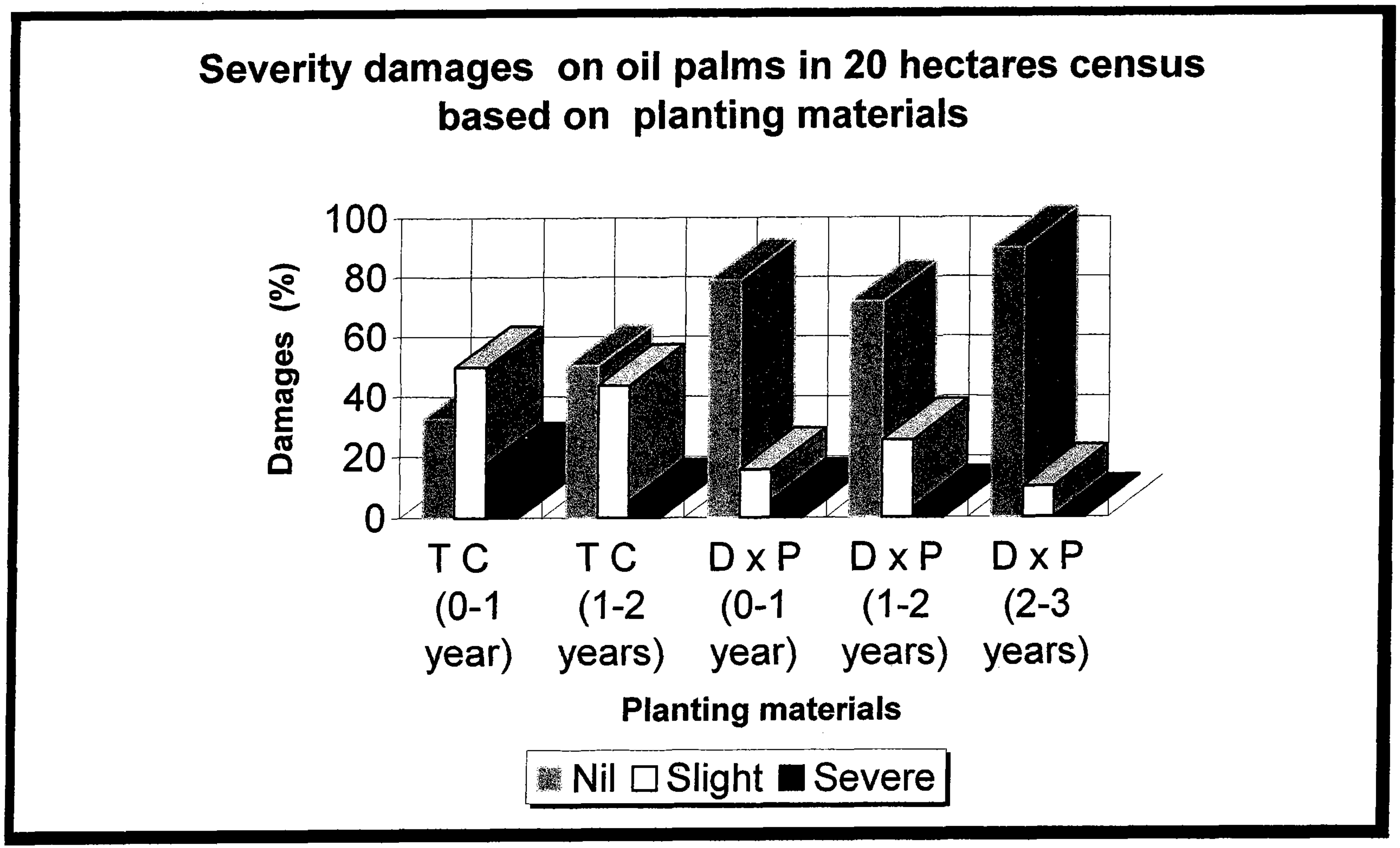


Figure 2: The percentages of damage caused by RB in 20 hectares census on different planting materials.

Table 1.5: Percentages of palm damage caused by RB at different topographies for three times census and mean percentage.

	Palm damages (Damages %)			
Topographies	1st Census	2 nd Census	3 rd Census	Mean ± SEM
Roadside	28.5	56.9	33.0	39.5 ± 8.81a
Border Mature Palms	44.6	42.3	56.9	47.9 ± 4.52 a
Hillside	19.2	30.8	59.2	36.4 ± 11.88 a
Hilltop	50.8	36.9	27.4	38.4 ± 6.79 a
Swamps and Valleys	55.4	41.5	37.6	44.8 ± 7.04 a

* Tukey HSD test for significant differences between means i.e. means followed by the same letters in same column are not significantly different at 5% level according to the Tukey HSD after arcsine transformation.

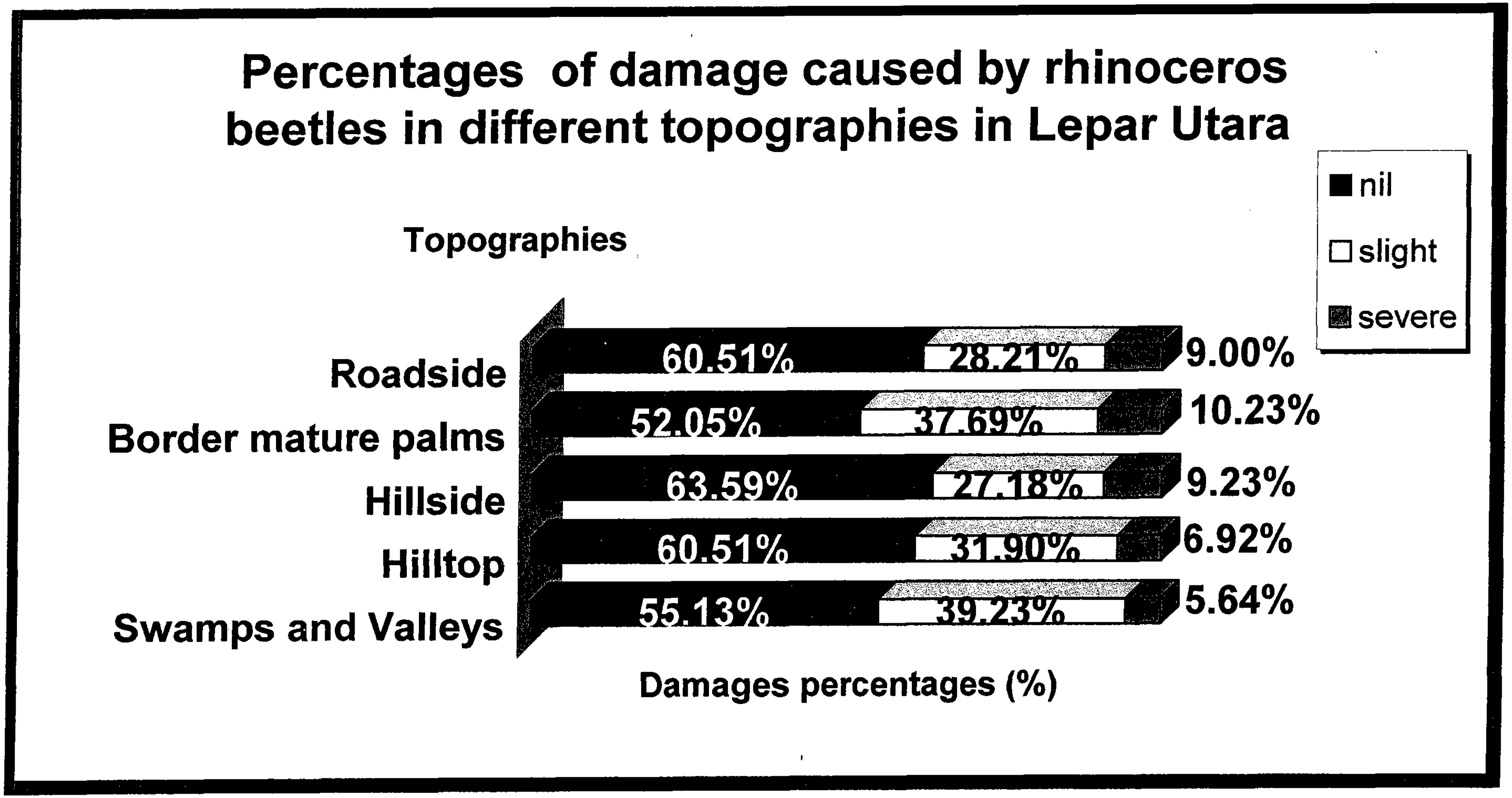


Figure 3: The percentages of damage caused by RB in different topographies in Lepar Utara 14.

1.4 Discussion

Palms in replanting areas are at risk because of the decaying logs of the former stand of oil palm providing breeding ground for RB larvae. The larvae of RB develop in rotting organic material (Wood, 1968). Besides the zero burning, the eggs and larvae of RB are abundance in the rotting palms. Nowadays, FELDA introduced two types of planting material in plantations; Dura X Pisifera (DxP) and Tissue culture (DxP). Lepar Utara 14 was planted with more than 40 hectares with tissue culture varieties in Block 31 PM 80A. From the visual damage assessment, we found that tissue culture suffered more RB damages due to the beetle foraging. Tissue culture (TC) 0-1 year at LU 14 (PM80A) showed 67.4% palm damages and TC 1-2 years at LU 09 (PM84B) had 49.7% palm damages. This showed that *O. rhinoceros* preferred on tissue culture plantings than the DXP seedling planting materials. However, the incidences of RB damage will de reduced when palms is more three years old in all planting materials.

Evaluation of damages was carried in 5 different topographies (hilltop, hillside, roadside, bordering to mature palms and swamps and valleys). Plantations of immature plants bordering mature palms faced high risk to RB damage with a mean of 47.92% of palm damages. This is because we believed that mature palms were providing second breeding or foraging home to *Oryctes*(see Chapter 2). Similarly, the result had showed or proved that different topographies did not contribute and related to the level of damages by *Oryctes* to young oil palm. We can conlude i) Damages on palm caused by *Oryctes* did not influence by topographies, and or ii) Damages level of palms on various topographies were almost similarly.

Appendix 1. Damages in 20 hectares for different planting material (One-way ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between Planting materials	2559.831	4	639.958	13.167	.001
error	486.047	10	48.605		
Total	3045.877	14			

Appendix 2. Damages in different topographies (One- way ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between topography	.009	4	.002	.450	.771
error	.049	10	.005		
Total	.058	14			

CHAPTER 2

BIONOMIC OF *ORYCTES RHINOCEROS* ADULTS IN IMMATURE PALM CAUGHT BY PHEROMONE TRAPS

Objective: To investigate dynamic of *Oryctes rhinoceros* adults in immature oil palms for 14 months using pheromone traps in 40-hectare plots at Lepar Utara 05, 14 and 09, FELDA Plantations.

2.1 Introduction

Rhinoceros beetle is one of the important pests of palms (family palmaeceae). Use of aggregation pheromone ethyl 4 – methyloctanoate was observed to be a potential tool for controlling the beetles (Ho, 1996). The aggregating pheromone (AP), oryctalure (Produced by Chemtica International, Costa Rica) is responsible for effective trapping of beetles and it has been used as another additional tool for control approach. Traps are used at a rate of two to five/ha where there is good interrow legume cover. Pheromone trapping is one of safe chemical control components; it is ecologically safe and environmentally friendly tool in IPM. The AP has been used for mass trapping, monitoring and integrated with biocontrol and chemical control agents. Nevertheless, it can decrease the population of adult in estates if rightly established. However the reduction remains insufficient especially in plantations with high incidence of beetles.

Noor Hisham *et. al.*, (2001), recommended the rhinoceros aggregation pheromone, ethyl 4 - methyloctanoate to lure the beetle adults by keeping on ratio 1: 5 or 1:10 hectare for situation in non-serious incidence or average caught is below 10 adults per trap per week. But if the population increases or high incidence, it is recommended that one trap for every 2 ha of planted area. The recommendation was also stated by Norman *et. al.*, (1999). Research carried by Pusat Pertanian Tun Razak (PPTR) Sungai Tekam, found that 56% - 70% beetles caught were female. Indirectly, it will reduce the populations of female adult especially gravid females and the next generations.

This lure has been found to be highly effective in Malaysia for mass trapping, by using traps at the rate of one trap/2 ha, during low pest population, *i.e.* < 10 to 15 beetles/trap/week (Turner *et. al.*, 2003). Sime RB pheromone was designed to dispense the pheromone aggregation for about one and half month to two months and varied considerably in different weather conditions and how it was applied in the field. This study also will show how the sachet of Sime RB and trap is best manipulated in the fields. Three sites were selected (i) Lepar Utara 05 planted in July 2004; ii) Lepar Utara 14 planted in planted in June 2003 and (iii) Lepar Utara 09 planted in June 2001.

2.2 Materials and Methods

Traps Location

A total 60 traps were evaluated in replanted area for 13 months in 3 estates with design line transit 20 traps per site (Table 1). Traps were installed at Lepar Utara 09 in May 2004, LU14 in July 2004 and LU 05 in October 2004.

Location	Evaluation	Total of Traps
PM 01F; Lepar Utara 09 (40.0 ha)	20 traps / 2 ha for months	60 Traps
PM 80A; Lepar Utara 14 (40.0 ha)	20 traps / 2 ha for months	
PM 04I ; Lepar Utara 05 (40.0 ha)	20 traps / 2 ha for 13 months	

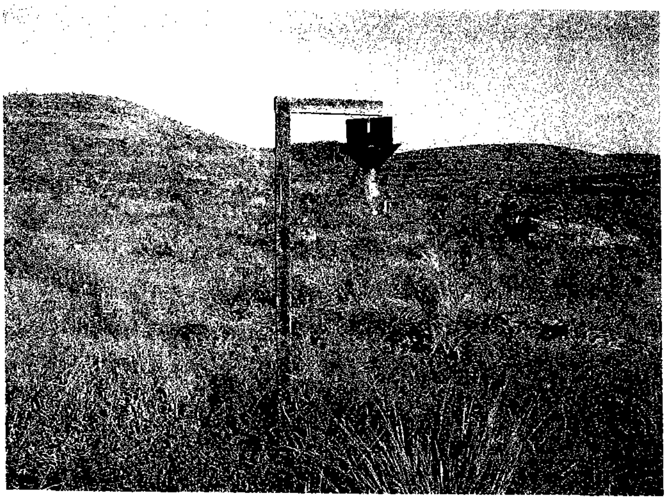
Table 1: Traps evaluation based on three different location

Traps evaluation

The study was focused on the determination of population trends and infestation levels of *Oryctes rhinoceros* in the oil palm replanted areas. The traps were evaluated vary considerably on the height and age of young palm canopy. The bioefficacy of aggregation pheromone (AP) into an 18-L bucket/bottle hung at the height of palm on a wooden support with a black-painted vane to guide the beetles at a density of one trap per two hectares for twenty hectares per location. Small drainage holes at the bottom of each bucket and bottle were made to remove rainwater. Lepar Utara 09 (3-4 years old palm) used an 18-L bucket added water (to avoid beetle crawling out of bucket) on a stand of 2.8 meter wooden support, while Lepar Utara 14 (1-2 years) and Lepar Utara 05 (0-1 year old) used bottle traps (FASSB design) on a stand of 2.0 meter wooden support (Figure 2.1). The traps were serviced weekly. The beetles caught were sexed, and counted. The trapping was carried out for thirteen months. The AP sachets were established with cover and were replaced when either beetle catch decreased to zero or very low number or the lure odorless, approximately every two months.

The economic- injury level (EIL) is defined as the lowest number of *Oryctes* that will cause economic damage, or the minimum number of insects that would delay the growth/yield equal to the gain threshold. While, General Equilibrium Position (GEP) is a population long-term average density.

i)



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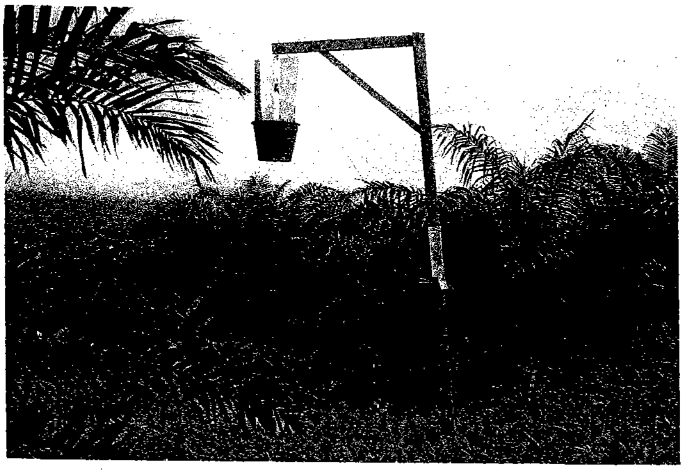

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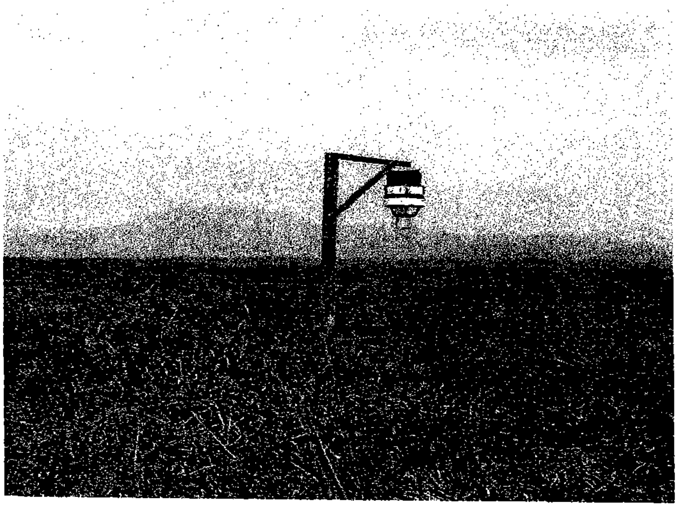


Figure 2.1 The established of pheromone traps at; i) LU 05, ii) LU 09, and iii) LU 14

2.3 Results

The trap was effective in trappings adult beetles (Figure 2.1) and the oryctalure was covered to prevent evaporation. In term of strategies, some ethyl 4 – methyloctanoate was manipulated by covering the sachet in order to minimize excessive evaporation process. It is important to use the pheromone optimally (up to two months). However, the longevity of the lure may vary considerably according to the prevailing weather conditions. Drop in beetle number captures was observed during drought season (February, 2005 – April, 2005).

The traps were laid in the second weeks of October 2004 (i.e 3 Month After Replanting - MAR) at Lepar Utara 05 (PM01B). Mean numbers of beetles (MNB) caught by the traps for 3 months after replanting (MAR) was below 10 individuals' ha^{-2} $week^{-1}$ $trap^{-1}$ (IPHsWT) in first five weeks (Figure 2.2). Starting from weeks two in December 2004, the GEP and EIL were lying on similarly level but suddenly increased above EIL after 10 MAR. The highest mean numbers beetles (MNB) were caught in the end of September, 2005 (i.e 14 MAR), with 39.6 MNB and the lowest MNB (7.0 MNB) was in first week in February 2005 (i.e 7 MAR).

After 10 MAR, the number of beetles increased suddenly and continued to increase above the economy injured level (EIL). The increase was very fast and two months later (i.e 12 MAR) the number of beetles caught was above from the general equilibrium position (GEP). The situation was very serious in 15 MAR.

Traps at LU 14 were installed one year after planting (i. e 12 MAR). A total 42.41 ha were planted by tissue culture material in block 31 PM 80A. The mean number of beetles (MNB) was 29.8 in first week of 12 MAR (Figure 2.3). The highest MNB was shown in second week of November 2004 (16 MAR) with 68.2 MNB and the lowest numbers of beetles was found in first week of May, 2005 (i.e. 22 MAR) with 6.1 MNB. General Equilibrium Level was around GEP when the MNB were between 30 to 40. At last, it suddenly decreased in first week of 18 MAR but still above of the EIL. Mean number of beetles were below 10 individuals' ha^{-2} $week^{-1}$ $trap^{-1}$ (IPHsWT) after 8 month of installing the trap or 21 MAR. But the beetle population increased again after 24 MAR. The numbers of beetles after first week of June 2005 (i.e. 24 MAR) were increasing from 11.2 to 18.3 until the evaluation of traps were ceased.

Meanwhile, the traps were laid in third weeks of May 2004 (i.e. 34 MAR) in LU9. Mean numbers of beetles caught by the pheromone traps at LU 09 showed the highest record in September 2004 (i.e. 38 MAR) with 35.0 MNB and the lowest was in 39 MAR with mean numbers of beetles is 1.2 (Figure 2.4). Only after 39 MAR, the MNB was below EIL. It is believed that the infestation levels of *Oryctes rhinoceros* were maintained below 10 individuals' ha^{-2} $trap^{-1}$ (IPHsWT) after 38 MAR. General equilibrium position of *Oryctes* populations was always above 15 IPHsWT before 39 months after replanting (MAR).

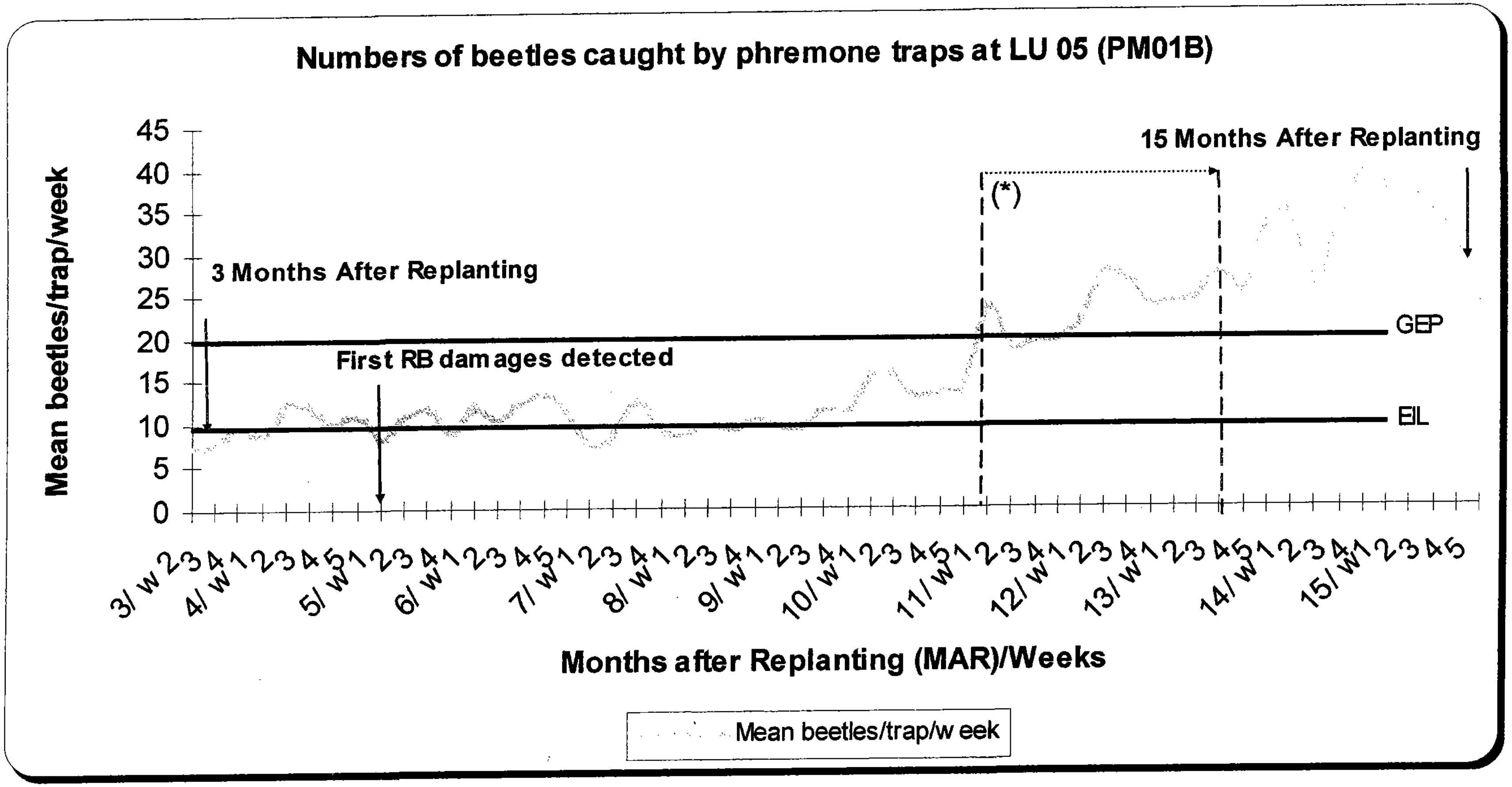


Figure 2.2: The numbers of beetles caught by pheromone traps at Lepar Utara 05 (PM01B) for 15 months after replanting. EIL= Economic injured level; GEP= General equilibrium position. (*) is duration of new felling and chipping division on boundary around the border of study site.

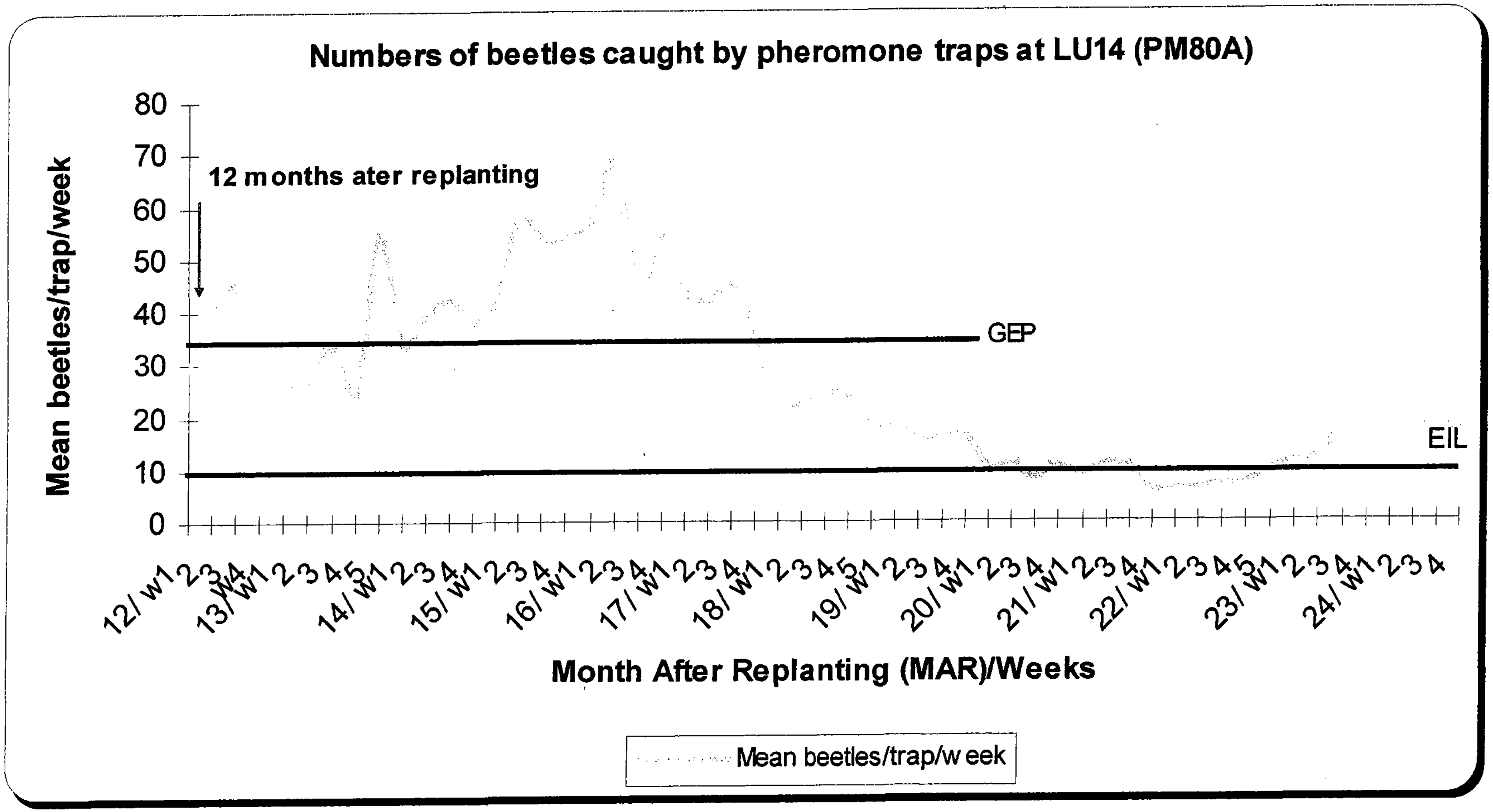


Figure 2.3: The numbers of beetles caught by pheromone traps at Lepar Utara 14 (PM80A) for 24 months after replanting.

EIL = Economic injured level; GEP = General equilibrium position.

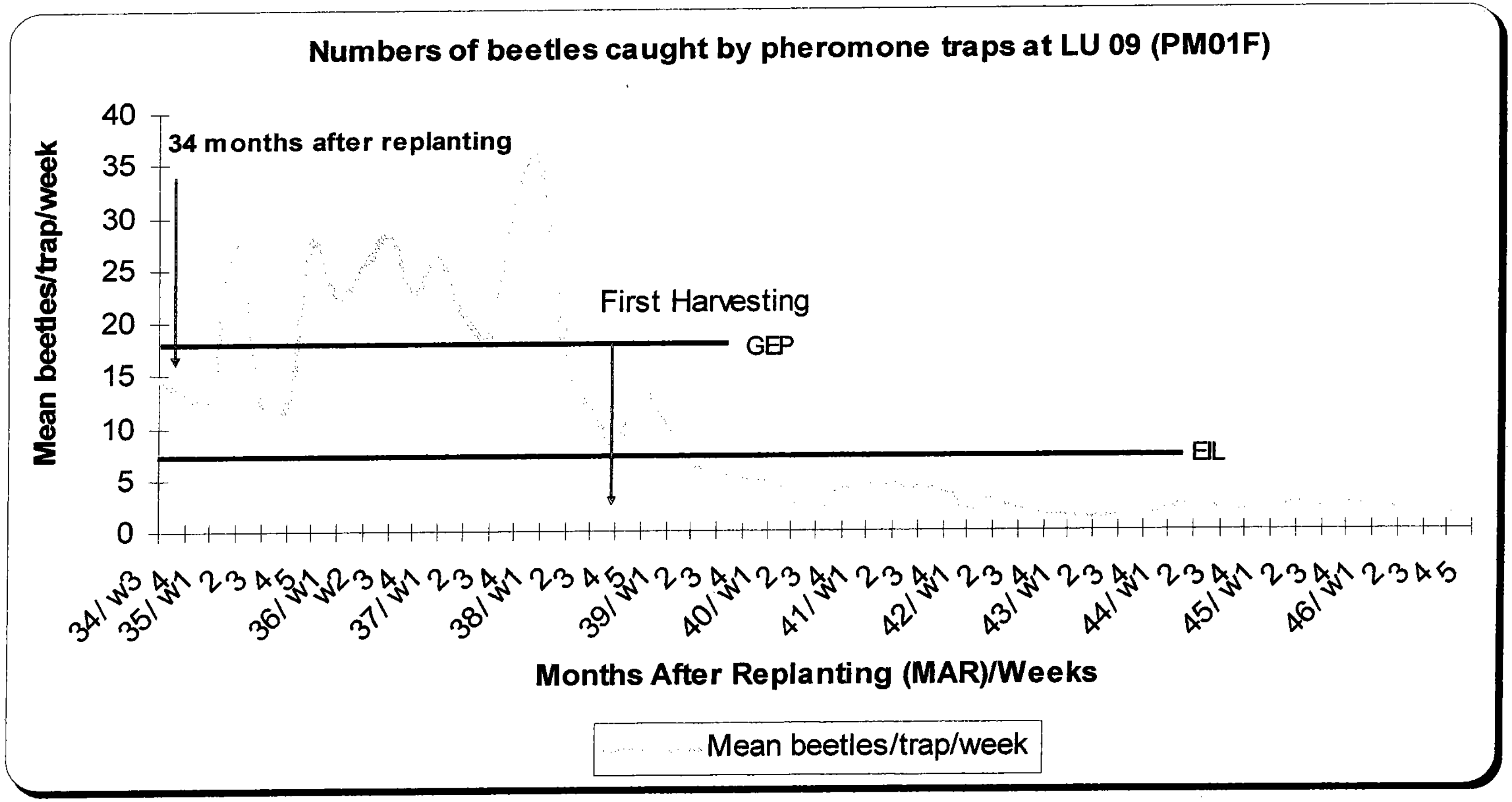


Figure 2.4: The numbers of beetles caught by pheromone traps at Lepar Utara 09 (PM01F) for 45 months after replanting.

EIL = Economic injured level; GEP = General equilibrium position.

2.4 Discussion

Pheromones are biochemicals used for communication between two or more animals of a single species. The most conspicuous use of pheromone by insects is causing other members of the same species to aggregate in a particular area (Chung, 1997). In term of strategies, utilization of pherotraps in replantations or a large scale covering a year of planting completely, instead of individual blocks where heavy attack occur would possible maintain the *Orytes* population under EIL. Norman *et al.*,(2001) documented with high-density trapping, infestations levels were maintained below 10 individuals m^2 (IPMS) and were not detect in the heaps after a period of 16 months of replanting. In the normal trapping density, the populations were also maintained below 10 individuals m^2 (IPMS) were found present in the heaps for up to 24 months.

Study on bionomic of adult beetles was conducted for 13 months. It provided new experiences and data with weather and some inferences. When the numbers of beetles reached the Economy Injured Level (EIL) that would put the estates in the ready state to manage the pest attack. Where General equilibrium position (GEP) provides the population long-term average density. When GEP is above the EIL then the combination of crop, environment, time and lack of parasitoid or predator was probably caused the population abundance of *Oryctes* in plantation. The GEP must be below the EIL for achieving good profit.

Three trap designs were evaluated and were found highly effective in mass trapping. A new design was introduced as a modification from FASSB model. It is easy to handle in the field. Costing and time saving were the factors considered with low maintenance (Figure 2.1.iii). Using the trap will directly monitor the population level or reduce the population of RB. From the three graphs above (Figure 2.2, Figure 2.3 and Figure 2.4) it is predicted the Figure 2.5 will be a pattern of RB in estates started from palm planting until up to 46 months after replanting (MAR). The high level is caused by the intraspecies-competition and lack of breeding sites or food. The beetle populations were decreasing slowly until palms become 4 years old (48 MAR) (Norman, 2001) but **RB** will not be eliminated in oil palm estate monoculture.

The mean numbers of beetles (MNB) at Lepar Utara 14 and 09 were always below the EIL although number of adults bounce back in June 2005 at Lepar Utara 14 but for LU 05 MNB it is predicted to increase as the situation of MNB caught at LU 09 and LU14. At least, this is an indicator that the trap catches were insufficient to bring down the population to below economic injury level (EIL).

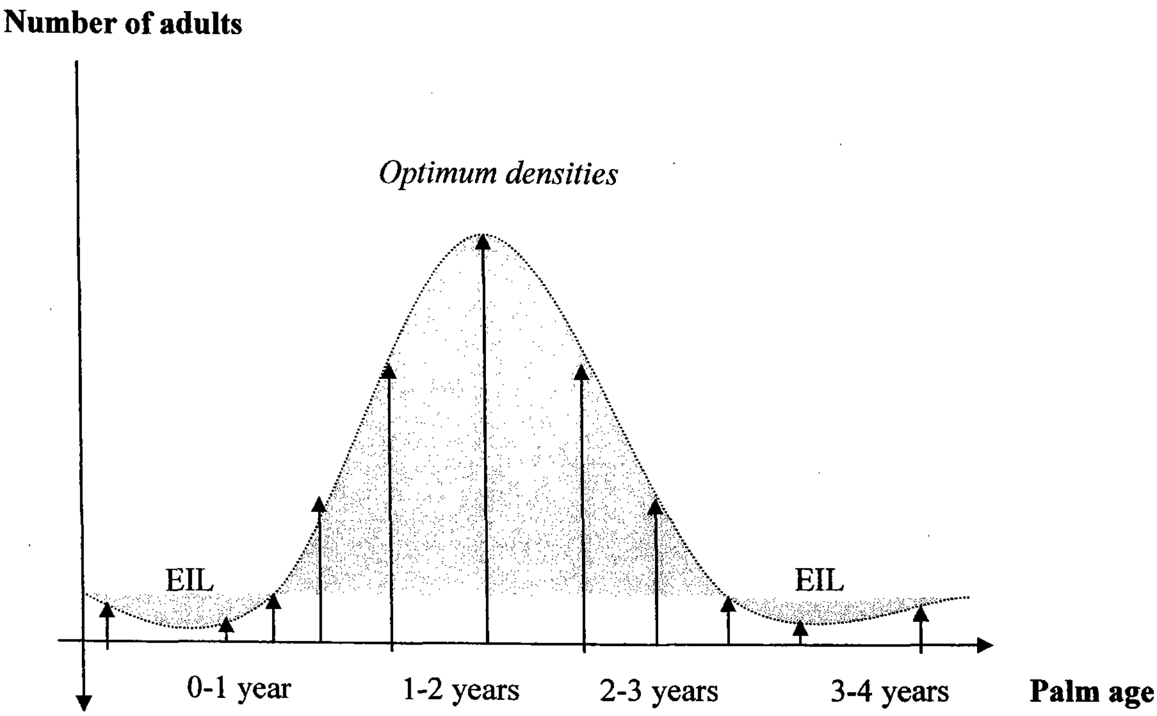


Figure 2.5: Prediction on pattern of abundance of rhino beetles caught by traps from replanted oil palms of 0-4 years old.

In mid of June 2005, Lepar Utara 05 was carrying out felling and chipping which started from June 15 to August 20, 2005 for 487.57 ha bounder by mature palm, block PM 01B. This situation has related with the phenomena called "*Desperate immigrations*" by adults RB and is shown by traps on PM 01B (see also Figure 2.2) where the adult beetles caught on traps suddenly increased especially in border areas. A more recent study has suggested that in certain areas, *O. rhinoceros* can readily migrate to infest an area as soon as replanting is conducted, i.e. when there is an abundance of oil palm trunk chips (Noman *et al.,* 1999). From the inspection, we observed that traps bordering on the mature palm were showing continuously high density of RB catches.

The cause of the increasing in numbers of beetles caught by pheromone trap at LU 14 on the 24 months after replanting (MAR) was probably due to the installation of "Sponge pit" application in field. The empty fruits bunches (EFB) were dumped in 5" x 16' x 4" sponge pit for soil moisturizing and nutrient which became the breeding site for *Oryctes*.

2.5 Conclusion

Based from the trapping technique, some fresh information was revealed. From the figure 2.2, there was a distinct demarcation of direction that the beetles migrated from old mature palms to a nearby site where felling and chipping of trunks were carried out. Thus field was abundant with RB coming to our traps and may cause the increase in damages on the palms. As the migration is almost simultaneous with replanting, it would be essential to place the traps alongside the fringes bordering mature palm before placing the traps within the replanting area.

With such suggestion, pheromone traps can be installed within the replanting area after about 6 to 7 months after Felling and chipping (MAF), to coincide with the new emergence of adults. For best result, adult trapping can be stopped when first harvesting starts. At the same time, good trapping can reduce the numbers of gravid female in field and decrease the probability of reproductive female to lay eggs into the habitats. This is observed as the adult population was high in July until end of October.

Predation by the rats *Rattus tiomanicus and R. argiventus*, black cobra, fox species and iguana on the RB caught were the interference the trap catches. The interferences were common among traps in border to forest area. The predators decreased the accuracies of data.

CHAPTER 3

FIELD EFFICACY STUDY OF SEVERAL INSECTICIDES AGAINTS ADULT OF *Oryctes rhinoceros* (L.)

Objective:

To evaluate the effectiveness of several insecticides against *Oryctes rhinoceros* in immature sensitive oil palms.

3.1 Introduction

Several methods of controlling the rhinoceros beetles in oil palm plantations have used employed. These methods include culture practice such as destruction of breeding sites, ground cover crop, manual hand picking and application of chemical like Furadan (Carbofuran), Cypermethrin and pheromone trap. Adult beetles emerge from the breeding sites and need to feed in order to gain energy before becoming mature sexually (3-4 weeks). Commonly, the adult attacks the palms nearest to the breeding site. Thus, palms nearby chipping trunks have the high-risk of being attacked. Hence, such incidences may have been the results of specific agronomic and land preparation practice during replanting, such as chipping of oil palm trunks, underplanting and the use/disposal of empty fruit bunches (EFB), which increase the risks of associating numerous suitable breeding sites with vulnerable palms (Chung *et. al.,* 1991). Wood *et al.,* (1973) considered that the yield losses in the first 18 months of harvest from badly damaged palms were relatively small. Previous studies had reported that the efficacy of the three dosages of insecticide Marshal 5G (12 grams, 6 g, and 3 g) over 1-2 years oil palms. The results of the studies showed the insecticides were significantly different with the Naphthalene balls, manual handpicking and untreated (Christa *et al.,* 1997). Ho (1988) stated that controlled release formulation of Carbosulfan (at 20 g/palm) was most cost-effective treatment, with one application provided six months control in young oil palms.

Toh and Brown (1978) found that Carbofuran granules in the base of the spears would both protect palms and reduce the beetles population in the locality. This measure has been widely used for prophylactic control in young oil palms. Application rates of 14-28 g (0.5 – 1 oz) Furadan 3G per palm, applied at 4-6 weeks interval, appear to bring about a marked decline in the incidence of damage (Chung *et. al.,* 1991). Gurmit, (1987) reported the significant control Naphthalene balls in controlling *Oryctes* in heavily infested coconut and oil palm replants. Applications were most effective, giving more than 95 per cent control, followed by dust or granular formulations of BHC and Carbofuran. Such informations were expected to enhance leads towards more detailed studies on application insecticides as safer alternatives for the control of rhinoceros beetles. Some researchers stated the effectiveness of some insecticides to n control rhinoceros beetles in fields (Toh and Brown, 1978; Ho, 1988; Chung *et. al.,* 199; Christa *et al.,* 1997; Gurmit, 1997). The objective was to evaluate the efficacy of insecticides and their phytotoxicity to immature palms.

3.2 Materials and Methods

The study was conducted in FELDA Plantation, Lepar Utara 14, Pahang, Malaysia. The trial was carried in immature oil palms (1-2 years) (Tissue culture seedlings). The treatment is shown in table 3.1. Each replicate of a treatment has 20 palms. The study was conducted in randomized complete block design (RCBD) (Tables 3.1, 3.2).

First applications of insecticides were done after the pre-treatments count of palm damages (Table 3.3) and continued at 1, 2, 3, 4, and 5 months after application (MAA) except Naphthalene balls were applied every 2 weeks interval for 5 months. All Insecticides were applied by using the ice-cream plastic (0.04 x 1½" x 14") around to the crown of the leaves and fronds. Observations on new leaf/frond damages on the palm were carried out every two weeks up to 20 weeks. Short and long-term phytotoxicity and beetles dead/live count were observed and noted. Statistical analysis was carried out on new leaf/frond damaged, dead count beetles, and phytotoxicity to evaluate the efficacy of all the treated. Further analysis by used Tukey HSD test was carried out ($P < 0.05$).

Table 3.1: Layout of the experiment: Randomized Complete Block Design (RCBD)

		Treatments					
Blocks (Replicates)	1	Naphthalene Balls ±30 gm	Marshall 12 gm	Marshall 6 gm	Untreated (Control)	Marshall 3 gm	Furadan 30 gm
	2	Furadan 30 gm	Untreated (Control)	Marshall 3 gm	Marshall 6 gm	Marshall 12 gm	Naphthalene Balls ±30 gm
	3	Marshall 6 gm	Marshall 3 gm	Naphthalene Balls ±30 gm	Furadan 30 gm	Untreated (Control)	Marshall 12 gm
	4	Furadan 30 gm	Naphthalene Balls ±30 gm	Untreated (Control)	Marshall 3 gm	Marshall 6 gm	Marshall 12 gm

Table 3.2: The details information on the insecticides.

Treatment	Active Ingredient %(w/w)	Dosage (gm/palm)
Marshal 5G	Carbosulfan 5%	12 grams/palm
Marshal 5G	Carbosulfan 5%	6 grams/palm
Marshal 5G	Carbosulfan 5%	3 grams/palm
Furadan 3G	Carbofuran 3%	30 grams/palm
Mothballs (6 balls)	Naphthalene	±30 grams/palm
Untreated Control	—	—

Table 3.3: A scale of damage assessment.

Damage severity level	Symbol	Damage symptoms
Nil/Negligible	0	Palms with no Rhinoceros beetle damage/incidence.
Slight	X	2 unopened spear and/or less than 3 fronds were injured, dead or bored/snapped.
Severe	XX	More 2 injured/dead-unopened spears found (easily pulled out, fan shaped cut fronds) and more than one frond were bored or snapped.

3.3 RESULTS

(i) Efficacy in 20 weeks of treatment.

Table 3.4 showed the efficacy of several insecticides against *Oryctes rhinoceros* in immature oil palm (Tissue culture-planting materials). Palms treated by 12 grams, 6 grams, and 3 grams Marshal 5G, 30 grams Furadan 3G and Mothballs showed some reduction on damages by RB in the later part of treatment (Week 4, 10, 12 and 20) and significantly different from untreated (control). On Week 2 and Week 6 treated palms by 12 grams Marshal 5G and 30 grams Furadan 3G were significantly different from untreated (control). On week 18 after application, 12 grams Marshal 5G has showed the 0% damage for all blocks or replicates.

Overall, a Marshal 5G 12 gram is the most effective than the other treatments but it had the highest number of palms scorched (Figure 1) (Table 3.5). However it has the highest numbers of dead beetles found followed by Marshal 5G 6 grams, Furadan 3G 30 grams and Marshal 5G 3 grams (Table 3.6). 12 grams, 6 grams, and 3 grams Marshal 5G showed the best reduction of damages by (Figure 1). The damage levels were below 10% damages after 10 Week of applications. This indeed demonstrated the reduction of damage percentages caused by rhinoceros beetles at the end of the treatments due to the efficacy of Marshal 5G.

Table 3.4: Efficacy of several insecticides against *Oryctes rhinoceros* in immature oil palms.

Treatment	Palms damage (% damages)									
	*Week 2	Week 4	*Week 6	Week 8	*Week 10	Week 12	*Week 14	Week 16	*Week 18	Week 20
Marshal 5G (12g/palm)	30.00 a	26.00 a	25.00 a	15.00 a	11.00 a	9.00 a	5.00 a	4.00 a	0.00 a	1.00 a
Marshal 5G (6g/palm)	41.00 b	30.00 b	25.00 b	18.00 b	9.00 b	9.00 b	8.00 b	4.00 b	3.00 b	1.00 b
Marshal 5G (3g/palm)	40.00 b	26.00 a	26.00 c	19.00 c	9.00 c	9.00 c	6.00 c	3.00 c	3.00 c	3.00 c
Furadan 3G (30g/palm)	29.00 a	21.00 a	30.00 d	21.00 d	11.00 d	4.00 d	4.00 de	2.00 de	2.00 d	4.00 d
*Mothballs (6bls/palm)	46.00 b	58.00 a	50.00 e	30.00 a	16.00 e	11.00 d	13.00 e	12.00 e	10.00 a	10.00 a
Untreated control	68.00 a	61.00 ab	61.00 ab	51.00 abc	35.00 abcde	23.00 abcd	20.00 abcd	14.00 abd	14.00 acd	11.00 abcd

- Tukey HSD test for significant differences between means i.e. means followed by the same letters in same column are significantly different at 5% level according to the Tukey HSD after arcsine transformations.
- *Week applied for chemical except mothballs every two weeks

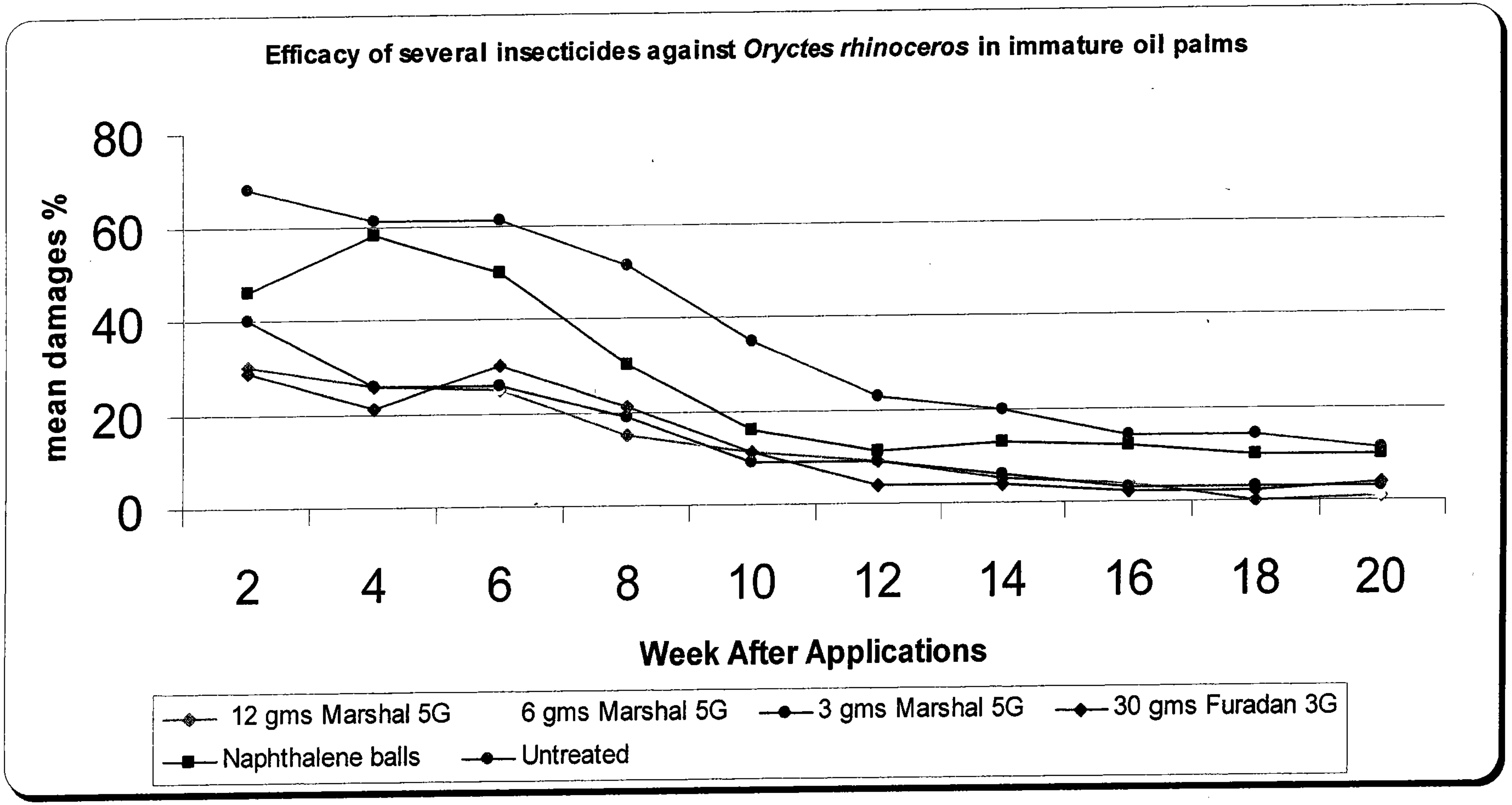


Figure 1: The percentages of damages caused by rhinoceros beetles after 20 weeks of several insecticides applications.

(ii) Phytotoxicity on oil palm treated.

The results are summarized in Table 3.5. Palms that received granular treatment of Marshal 5G 12 grams and 6 grams (Carbosulfan) were scorched at the treated portion after the first round of treatment. Fifty-eight palms were scorched by Marshal 5G 12 grams and 21 palms by Marshal 5G 6 grams. After second application, 12 palms for Marshal 5G 12 grams and 10 palms for Marshal 5G 6 grams were scorched. The symptom of scorching disappeared after the 6th week application. Marshal 5G (3 grams), Furadan 3G (30 grams) and Mothballs (6 balls) granular treatments did not cause any visible symptom of scorching.

(iii) Effect of 5 chemical treatments for control of rhinoceros beetles (RB) in immature oil palms.

More dead beetles were detected in plots with the more effective treatments. However, these numbers do not correlate closely to occurrence of damage, but indicating the relative effectiveness of treatments in actual killing of the beetles. Table 3.6 showed that 12 grams Marshal 5G (M5G) treated palms from week 2 until week 20 have killed 122 rhinoceros beetles adults. Numbers of dead beetles on palm were reduced at the end of applications. Meanwhile, Naphthalene balls acted as a repellent for insects and did not cause mortality to RB.

Table 3.5: The phytotoxicity of 5 chemicals treatments in immature oil palms (Tissue Clone plantings), Lepar Utara 14 (September 2004 - February 2005).

Chemical	Trade name	Formulation	Rate	Total of palms scorched after treated 480 palms/4 replicates)								
				Week 2	*Week 4	Week 6	*Week 8	Week 10	* Week 12	Week 14	* Week 16	Week 18/20
Carbosulfan	Marshal 5G	5% w/w	12g/palm	58	12	7	0	0	0	0	0	0
Carbosulfan	Marshal 5G	5% w/w	6g/palm	21	10	3	0	0	0	0	0	0
Carbosulfan	Marshal 5G	5% w/w	3g/palm	0	0	0	0	0	0	0	0	0
Carbofuran	Furadan 3G	3% w/w	30g/palm	0	0	0	0	0	0	0	0	0
Naphthalene	Mothballs	5. 3 g each	6bls/palm	0	0	0	0	0	0	0	0	0
Untreated control	-	-	-	0	0	0	0	0	0	0	0	0

* Week applied for chemical except naphthalene every two weeks.

Table 3.6: Effect of 5 chemical treatments for control of rhinoceros beetles in immature oil palms, Lepar Utara 14 .

Trade name	Rate	Total of dead beetles on palm (400 palms/ 4 replicates)									
		Week 2	*Week 4	Week 6	*Week 8	Week 10	* Week 12	Week 14	*Week 16	Week 18	Week 20
Marshal 5G	12g/palm	11	15	17	12	12	21	14	14	4	2
Marshal 5G	6g/palm	15	13	13	15	11	14	9	7	2	1
Marshal 5G	3g/palm	9	18	13	13	6	9	9	9	3	1
Furadan 3G	30g/palm	13	10	11	13	9	9	9	6	3	0
* Mothballs	6 b/palm	0	0	0	0	0	0	0	0	0	0
Untreated Control	-	-	-	-	-	-	-	-	-	-	-

*Week applied for chemicals except mothballs every two weeks.

3.4 DISCUSSIONS

This study was conducted in 4 hectares tissue culture seedlings planted. At present, the age palm was more than 2 years. Some of the palms werebreeding sites already producing fruit bunches, male and female inflorescences. This plot have encountered serious damaged by rhinoceros beetles. The usual Lepar utara 14 estate practice in controlling RB is the cyclic treatments to the palms by Cypermethrin and Furadan 3G in rotation for one-month interval. Pre-assessment was done on the day before the first applications. The pre-assessment has showed the critical damaged (Slight and Severe) were more than 50% in each replicate (Block 1= 50%; Block 2 = 100%; Block 3 = 75% and Block 4 = 75%). Applications of the granular insecticides was easy to handle, safer to the applicator and accurate applications.

Beetles activities in field showed by Figure 1. The up and down damage percentages showed that the beetles populations in field were attacking the palms. The beetle population suddenly reduced in the end of experiment including control plots. That is the population of beetles in area was decreasing. Thus we can reduce beetle population and damage percentages (Table 3.6) if the treatments are continued for a long term. Meanwhile, numbers of dead beetles on palm were reduced at the end of applications showing the affect of chemical to the feeding activities of rhinoceros beetles. Dead beetles were found either on top spear or based of palms. Sometime 3-5 dead beetles were observed in the same palm in the interval two weeks (Table 3.6).

CHAPTER 4

STUDY ON *ORYCTES RHINOCEROS* IN THE DECOMPOSING TRUNKS IN A NEW REPLANTING AREA

Objectives: To investigate the rotting of palm chip ages/times in relation to the abundance and to find the life duration of *Oryctes rhinoceros in* a new replanted area. Two types of study sites were identified; A= Zero burning and B= Partial burning. Sampling was done by random in 40 hectares where each sampling has 9/m²/sampling samples to run in for each type.

4.1 Introduction

With the new directive from the Department of Environment (DOE) on the environment, open burning activities are prohibited in order to avoid excessive release of smoke, which has a major effect on the air quality and visibility in the area undergoing replanting (Khalid *et. al.,* 2002*)*. The policy of zero burning for replanting oil palm is currently considered desirable since it minimizes air and water pollution and may also enable the development of more economically sustainable practices based on nutrient supply from organic matter management (Mohd Hashim *et. al.,* 1993). Replanting of oil palm is normally carried out after about 20-25 years due to the harvesting problem and other economic considerations. Heong (1981) observed that the pest infestation of RB was often related with the availability of the breeding sites. In Malaysia, the zero burning bans encouraged the explosion abundance of rhinoceros beetles due to the existing of oil palms residues that were left to rot *in situ* thus chipping the crop residues into small pieces (±10 cm) and avoiding a thick pile formation of the residues is recommended to reduce the breeding sites and outbreaks of RB.

Oil palm residues take 3-4 years to rot completely. Within these periods, young oil palms were exposed to many pests especially by *Oryctes rhinocreros*. The nutrients released from the biodegradation of the palm residue, partly supply the total nutrients required by the young palms in subsequent years. In special cases, where open burning is still practiced because of pest and disease problems, the palm biomass is left to dry before burning. However, law requires prior permission from the DOE before burning allowed (Khalid *et. al.,* 2002).

Larvae of RB, like many others of the subfamily Dynastinae, feed on heaps of decaying organic matter. When feeding is completed, the larvae pupate and later emerge as adult beetles. Adult of rhinoceros beetles feed on the growing leaf tissue of young palms. The incursion will lead the disaster to the oil palm cultivation and if it becomes severe palms can be stunted or die. Outbreak of RB infestation in oil palm from rhinoceros beetles resulted after the implementation of a zero burning technique environmental policy in the 1990's (Ho, 1996; Wahid *et. al.,* 2000). Palms in replanting areas are especially at risk because the decaying logs of the former stand of oil palm provide breeding ground of the larvae, which develop in rotting organic material (Wood, 1968). Beetles are attracted to organic matter in the early stages of trunk decomposition, where gravid female beetles lay eggs, in which the larvae to feed in the decomposed trunk.

Besides decaying oil palm trunks, the beetle also breeds in other decomposing materials, such as coconut trunks, woods, sawdust, *Pandanus trunks,* cocoa pod shells, cattle dung, paddy straw, rubber stumps, failed oil palm female inflorescence, leaf axils filled with humid organic wastes and empty oil palm fruit bunch (EFB) heaps (Cumber, 1957; Burlow and Chew, 1970; Bedford, 1976c; Dhileepan, 1988).

The Lepar Utara 05 estate started the partial burning at random in 496 hectares replanting area. This contributed different environmental conditions to rhinoceros beetles. Beside to investigate the rotting age of palm chip for optimum life cycle and the abundances of *Oryctes rhinoceros* in a new replanted area, the study will also discuss the situation on decomposing trunks in two environmental conditions i) Zero burning, and ii) Partial burning.

4.2 Materials and Methods

4.2.1 Location of Samplings

The study was carried out on 40 hectares of heaps of chipping trunks to investigate the abundances and the rotting ages of palm chip for optimum life cycle of *Oryctes* at Lepar Utara 05 for 16 Months (June 2004 – September 2005). Study sites include all types of topographies which consists of hilltop, hillside, and roadside, border to mature palms, and swamps and valleys.

4.2.2 Sampling Procedures

The evaluations of the optimum life cycle of *Oryctes rhinoceros* in a new replanted area were initiated from a subplot measuring 40 hectares for 16 months. Two type of study sites were identified; A= Zero burning and B= Partial burning (Appendix 1). Sampling was done at random in 40 hectares, in which each sampling has 9 /1m²/sampling samples to run at fortnightly interval per month.

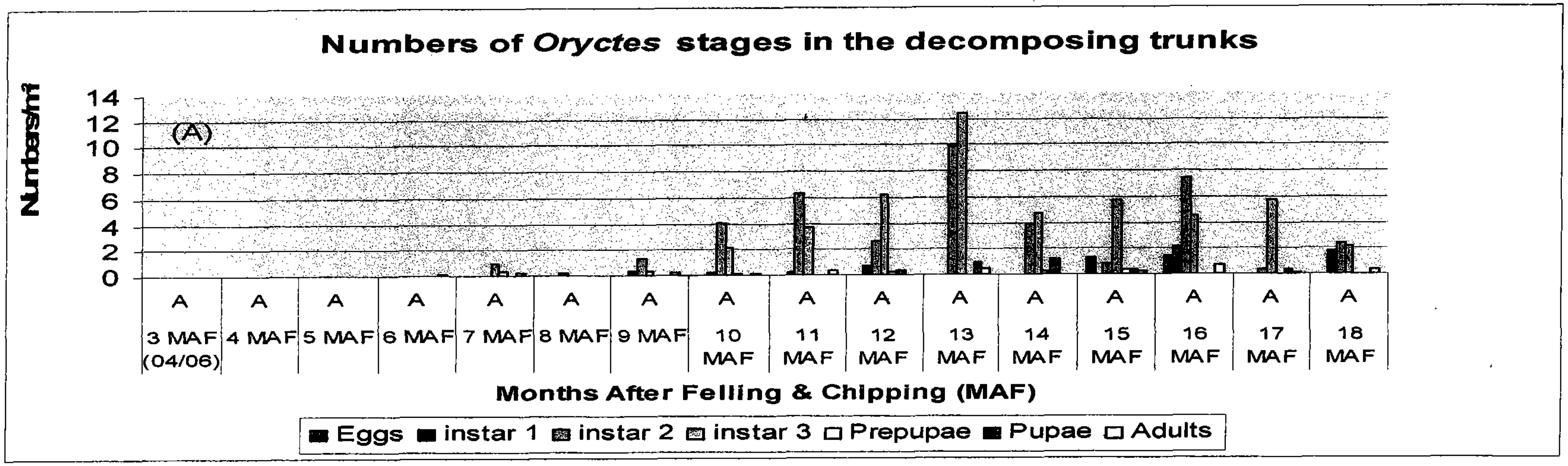
Mechanical method by a hoe and manually handpicking were used to collect stages of rhinoceros beetles. Total of number of different stages of beetle in decomposing heaps were recorded *in-situ* (Appendix 2) and were identified immediately by researchers before eradicated. Some specimens were taken to the laboratory for future study. Two-way ANOVA (without replication) was carried out with number of *Oryctes* of different stages in zero burning trunks sampling, and partial burning trunks and month after felling & chipping (MAF). Analyses were performed on the log transformation for numbers of *Oryctes* stage in the decomposing trunks.

4.3 Results

For the period of 16 months sampling of rhinoceros beetle immature in the decomposing trunks; the trunks and stem roots contained the high numbers of abundances of *O. rhinoceros*. The highest number of beetle stage that was regularly found in trunk chipping was the third and second instar larvae. While the pupal and prepupal was easily observed in all parts especially in decomposing fronds and deep in the ground (one foot). This phenomenon was clearly depicted in the numbers of the *Oryctes* in the decomposing trunks (Figure 4.1.A & 4.1.B). Based on the observation, we can easily detect the immature stage by the feces in the chip and the condition of trunks especially for larvae of second and third instar (Appendix 5).

The study was carried out in the area which was almost entirely chipped completely and felled for three months ago before samplings was carried out. In the 3 months after felling and chipping (MAF), 4 MAF and 5 MAF showed no *Oryctes* stages were found both on sites. But, on the **6 MAF** in the zero burning (Figure 4.1.A), the numbers of newly emerged adult were 0.1 adult/m²/sampling (MSS^{-1}) and partial burning (Figure 4.1.B) showed 0.3 larvae of third instar, 0.1 prepupae, 0.1 pupae and 0.1 adults m²/sampling (MSS^{-1}) were observed. Started from 6 MAF, the numbers of *Oryctes* immature were increasing especially for second instars and third instars larvae. Peak numbers recorded were 13.5 of third instars larvae in the sample of the partial burning area in April 2005, **13 months** after felling and chipping (**MAF**) (Figure 4.1.B). Figure 4.2 shows the density of the third and second instars larva where both instars were highest in numbers during 13 MAF with 12.5 individual per m2 of third instars and 9.9 individual per m2 of second instars. Abundance of *Oryctes* were more significant **after 9 MAF** with 0.3 larvae first instar, 1.3 larvae second instar, 0.3 larvae third instar, 0 for prepupae and pupae, and 0.2 adults per m2.

During **8 MAF**, we only found larvae from second instars with 0.2/m2. Meanwhile, **eggs** were only found with 1.3 and 1.4 per m2 in **15 MAF and 16 MAF**, respectively. The dominations of immature stages in decomposing trunks continued until 18 MAF during the fortnightly sampling. At least, on two occasions the beetle egg were observed during 15 MAF and 16 MAF with the high numbers was 13 eggs/m^2/sampling (MSS^{-1}) in 16 MAF. As mentioned earlier, the first detection of *Oryctes* immatures started in 6 MAF with 0.3 larvae from third instar, 0.1 prepupae, 0.1 pupae and 0.4 adults, respectively (Figure 4.1.B). While, eggs were detected in 13 MAF and it was the only month that all stages of *Oryctes* were present with mean numbers of 2.7 eggs, 8.0 larvae first instar, 8.0 larvae second instar, 13.5 larvae from third instar, 1.0 prepupae, 2.1 pupae and 0.4 adults, respectively. The highest number of eggs was observed in 13 MAF which was 24 eggs/m^2/sampling (MSS^{-1}). Eggs were also observed in 15 MAF with mean number 0.1.



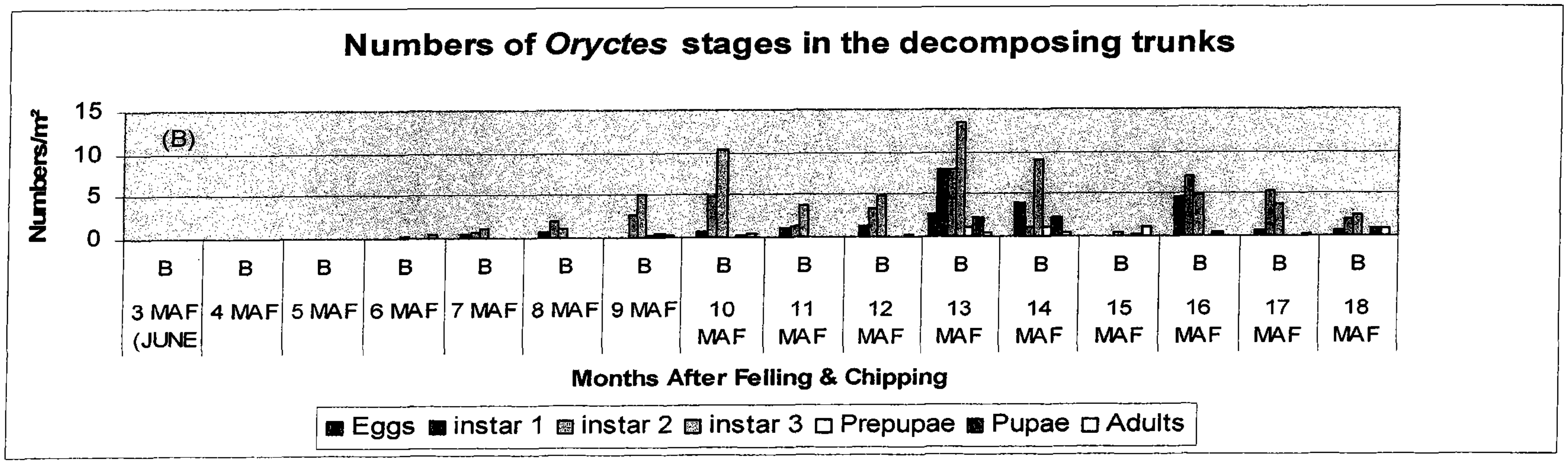


Figure 4.1 Mean numbers of *Oryctes* in the decomposing trunks on Months after felling & chipping (MAF) starts from 3 MAF (June 2004) until 18 MAF (September 2005) and (A) Zero burning: (B) Partial burning in Lepar Utara 05.

Figure 4.2 shows the analysis of total beetles found in decomposing trunks during the study of 18 months after felling and chipping. Overall, in the **3, 4 and 5 MAF no beetles** were found. However, at **6 MAF** RB immature started to appear in the rotting trunk chips with a total 3 larvae from third instar, 1 prepupae, 1 pupae, and 5 adults, respectively (Appendix 3). Started from **6 MAF**, a significant of immature beetle population in the rotting trunks appeared. It was indicating that a big immigration of adults especially gravid beetles occurred. Almost every month the first instar and the numbers of second and third instars were continuously observed in the samples. About 161 second instar larvae and 235 third instars were found in 13 MAF where the number is high.

While, Wood, (2001) stated that sometimes ground vegetation e.g.: *Mucuna bracteata* prevent the breeding of RB. During 12 MAF we sampled the RB immatures in the rotting heaps covered by *Assytasia sp.* (weed) and *Mucuna bracteata* (cover crop) (see Figures 4.2 and 4.3). A trunk if is totally covered by cover crops caused difficulty in the sampling and hinderer the RB adults to lay eggs in the decomposing trunks.

There was a significant difference in numbers of RB immatures between months after felling and chipping (MAF) ($F_{15,1994} = 11.931$, $P < 0.05$) and of RB immatures beetle stages ($F_{6,1994} = 25.313$, $P < 0.05$)(Appendix 4.i). While zero burning and partial burning definitely show a significant difference between beetles numbers evaluated ($F_{1,1999} = 3.967$, $P < 0.05$)(Appendix 4. ii).

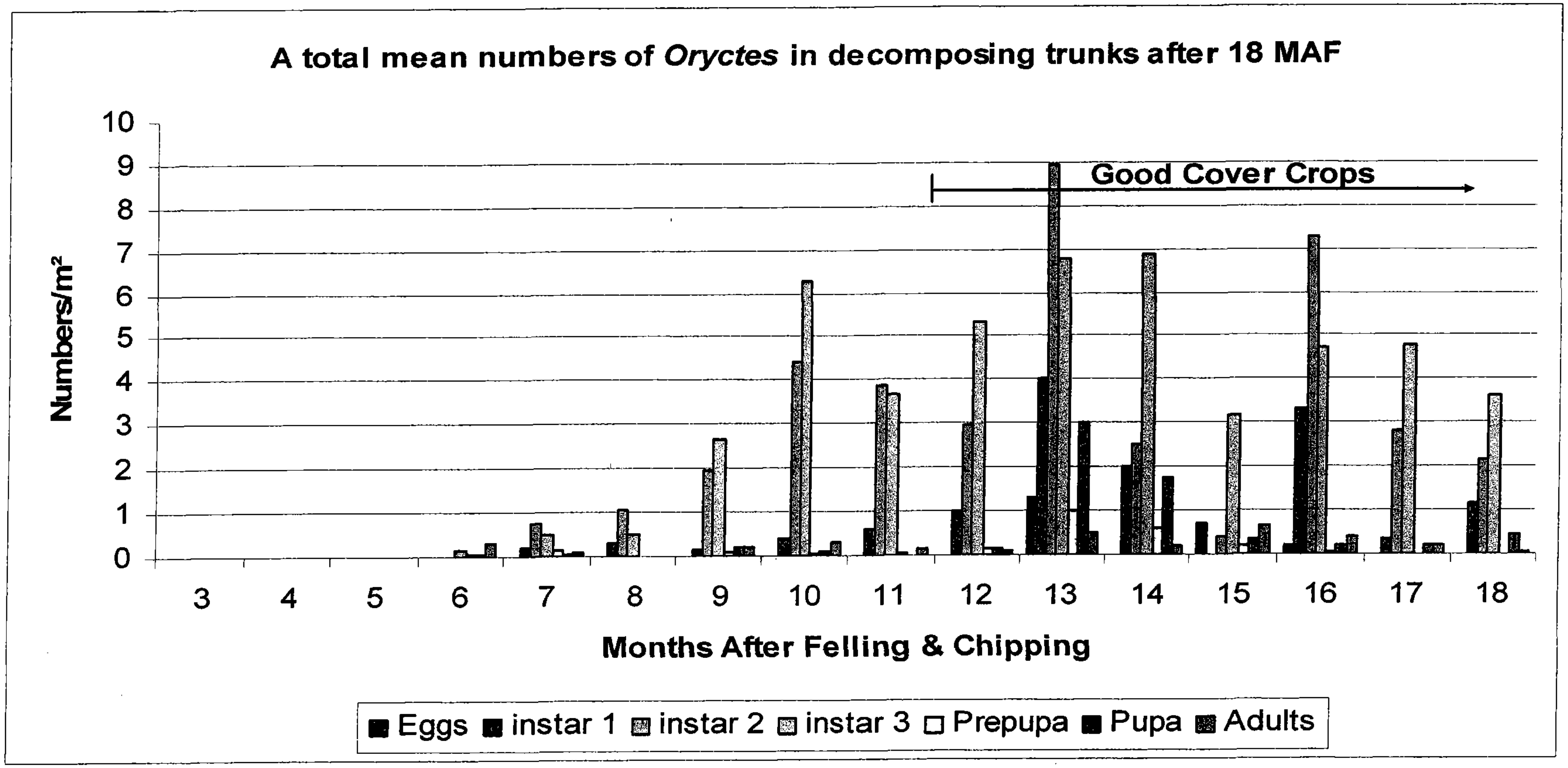
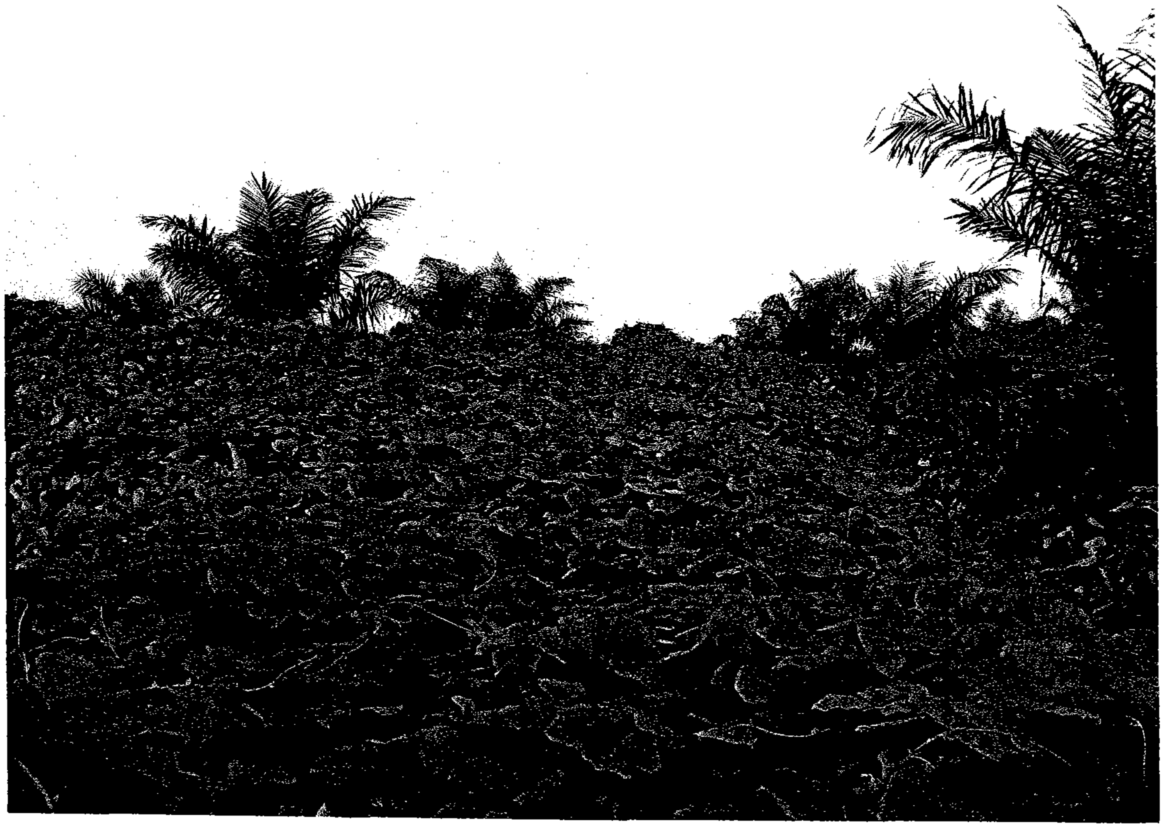


Figure 4.2: A total mean numbers of *Oryctes* in decomposing trunks during 18 months after felling and chipping (MAF). Cover crops established well 12 months after felling and chipping.

Figure 4.3: A well established cover crop (*Mucuna bracteata*) in Ladang Lepar Utara 9 helps to reduce the breeding of RB.



4.4 Discussion

Norman (2001) found that the *Oryctes rhinoceros* immatures were still detected in the heaps up to more than two years (at 26 months after replanting). Beetles were attracted by the volatile compounds produced through the decay of the organic matter, and also the beetles produce an aggregation pheromone, ethyl-4 methyloctanoate which can be used to trap beetles of both sexes (Jackson *et al.,* 2003).

Immature stages were most in danger in the beetle life cycle based on its habitats. Besides other insect predator, immature beetles are preyed upon by the ground animals such mammals *Rattus tiomanicus, R. argiventus,* and pig and reptile for examples snakes, and iguana. Larvae of third instar are most vulnerable to predators because it's big size and has a long life cycle (161.1 days; based on Norman, 2001).

Trunks heap need to be burn 4 -5 times for complete burning and that is why DOE limited the activities on burning of the heaps (Turner, *et. al.,* 2001). In this study of partial burning of heap was carried on the out layer only. This did not help to prevent the *Oryctes* to lay the eggs or reduced the breeding sites. But the immatures increased after 6 MAF and showed positive for eggs, larvae of first instar, larvae of second instar, larvae of third instar, prepupae, pupae and adults, respectively. The immatures of RB were present in the decomposing trunks in the 6 MAF with 0.1 adult/m^2/sampling (MSS^{-1}) (First generation) in the zero burning area. Meanwhile, in partial burning areas, the larvae of third instar started to appear in the rotting trunks in the 6 MAF. Based on Catley (1969), Chung (2003), Hinckley (1973) and Bedford (1976a, b) stated the third instar larvae of *Oryctes rhinoceros* can be observed between 3.2 - 6 months after eggs being laid. The present of RB immature stages continued up to 17 MAF and majority *Oryctes* stages found in the decomposing trunks were the second and third instar larvae were in high numbers. From the observation, third instar larvae can be found up to two feet deep in the ground. Basal stem and upper stem have been found to provide more immature stages especially third instar larvae and pupae. Crown or frond of palm only provide breeding sites for the prepupal and pupal stage.

Some immature stages were brought to laboratory for further study. Externally, *Oryctes* can be sexed on pupae stage by examined the dorsal head. The head of the female pupae has a short horn, while the male pupae has a long horn but it not that accurate if compared in sexually matured beetles where the tip of the female abdomen has a tuff of velvet shiny bristles. Young pupae contained white liquid before the adult develops from the pupal cell. Unidentified ectoparasites were found on external surfaces of all stages beetles except eggs. These insects maybe parasitizing the *Oryctes* but their status are not known. Many of them were observed on the cocoon of prepupae or pupae.

Nevertheless, there is not different between the abundances or numbers of *Oryctes* found between (A) zero burning and (B) partial burning. Both of types (A and B) showed that the rotting palm chips have high population of *Oryctes rhinoceros* in replanting area started from 6 months after felling and chipping (Appendix 4). Ten to thirty MAF were the ages of palm chip optimum for breeding of *Oryctes rhinoceros* in replanted area. Thus, partial burning should be stopped. Zero burning should be practiced 100%. Some how, partial burning is wasting of time and money as it is shown from our research.

Appendix 1:

(i)

(ii)

An evaluation of *Oryctes* in (i) Partial burning; and (ii) Zero burning among trunk heaps of 5 MAF by digging with a hoe.

Appendix 2: *Oryctes* in decomposing trunks evaluation form.

Locality:................................ Date of Sampling:.....................

Type of Heap:....................... MAF:...........................

Sample no. 1		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 2		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 3		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 4		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 5		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 6		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 7		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 8		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								
Sample no. 9		Egg	Larvae 1	Larvae 2	Larvae 3	Prepupae	Pupae	Female	Male
	Oryctes rhinoceros								

Appendix 3: The numbers of *Oryctes* in decomposing trunks by the months after felling and chipping (MAF).

3 MAF – June 2004

Beetle Stages	**A**	**B**	**Total**	**Mean A**	**Mean B**	**Total Mean**
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	0	0	0.00	0.00	0.00
Instar 2	0	0	0	0.00	0.00	0.00
Instar 3	0	0	0	0.00	0.00	0.00
Prepupae	0	0	0	0.00	0.00	0.00
Pupae	0	0	0	0.00	0.00	0.00
Adults	0	0	0	0.00	0.00	0.00

4 MAF – July 2004

Beetle Stages	**A**	**B**	**Total**	**Mean A**	**Mean B**	**Total Mean**
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	0	0	0.00	0.00	0.00
Instar 2	0	0	0	0.00	0.00	0.00
Instar 3	0	0	0	0.00	0.00	0.00
Prepupae	0	0	0	0.00	0.00	0.00
Pupae	0	0	0	0.00	0.00	0.00
Adults	0	0	0	0.00	0.00	0.00

5 MAF – August 2004

Beetle Stages	**A**	**B**	**Total**	**Mean A**	**Mean B**	**Total Mean**
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	0	0	0.00	0.00	0.00
Instar 2	0	0	0	0.00	0.00	0.00
Instar 3	0	0	0	0.00	0.00	0.00
Prepupae	0	0	0	0.00	0.00	0.00
Pupae	0	0	0	0.00	0.00	0.00
Adults	0	0	0	0.00	0.00	0.00

* A = Zero Burning; B = Partial Burned

6 MAF – September 2004

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	0	0	0.00	0.00	0.00
Instar 2	0	0	0	0.00	0.00	0.00
Instar 3	0	3	3	0.00	0.33	0.17
Prepupae	0	1	1	0.00	0.11	0.06
Pupae	0	1	1	0.00	0.11	0.06
Adults	1	4	5	0.11	0.44	0.28

7 MAF – October 2004

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	4	4	0.00	0.44	0.22
Instar 2	8	6	14	0.90	0.67	0.77
Instar 3	0	9	9	0.00	1.00	0.50
Prepupae	3	0	3	0.30	0.00	0.17
Pupae	0	1	1	0.30	0.11	0.06
Adults	2	0	2	0.22	0.00	0.11

8 MAF – November 2004

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	0	5	5	0.00	0.56	0.28
Instar 2	2	17	19	0.22	1.87	1.06
Instar 3	0	9	9	0.00	1.00	0.50
Prepupae	0	0	0	0.00	0.00	0.00
Pupae	0	0	0	0.00	0.00	0.00
Adults	0	0	0	0.00	0.00	0.00

* A = Zero Burning; B = Partial Burned

9 MAF – December 2004

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0.00	0.00	0.00
Instar 1	3	0	3	0.33	0.00	0.17
Instar 2	12	23	35	1.3	2.56	1.94
Instar 3	3	45	48	0.33	5.00	2.68
Prepupae	0	2	2	0.00	0.22	0.11
Pupae	0	4	4	0.00	0.44	0.22
Adults	2	2	4	0.22	0.22	0.22

10 MAF – January 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	2	5	7	0.22	0.63	0.39
Instar 2	37	43	80	4.10	4.78	4.44
Instar 3	20	93	113	2.20	10.33	6.28
Prepupae	1	0	1	0.11	0	0.06
Pupae	0	2	2	0	0.20	0.11
Adults	1	4	5	0.11	0.44	0.28

11 MAF – February 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	2	9	11	0.22	1	0.61
Instar 2	57	13	70	6.33	1.44	3.89
Instar 3	33	33	66	3.67	3.67	3.67
Prepupae	0	1	1	0	0.11	0.05
Pupae	0	0	0	0	0	0.00
Adults	3	0	3	0.33	0	0.17

* A = Zero Burning; B = Partial Burned

12 MAF – March 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	6	12	18	0.7	1.3	1.00
Instar 2	23	30	53	2.6	3.3	2.94
Instar 3	56	43	96	6.2	4.8	5.33
Prepupae	2	1	3	0.2	0.1	0.17
Pupae	3	0	3	0.3	0	0.17
Adults	0	2	2	0	0.2	0.11

13 MAF – April 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	24	24	0	2.7	1.33
Instar 1	0	72	72	0	8	4.00
Instar 2	89	72	161	9.9	8	8.94
Instar 3	113	122	235	12.5	13.5	6.78
Prepupae	0	18	18	0	1	1.00
Pupae	9	19	27	1	2.1	3.00
Adults	5	4	9	0.5	0.4	0.5

14 MAF – May 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	0	36	36	0	4	2
Instar 2	36	9	45	4	1	2.5
Instar 3	43	81	124	4.8	9	6.89
Prepupae	2	9	11	0.2	1.2	0.61
Pupae	11	21	32	1.2	2.6	1.78
Adults	0	4	4	0	0.4	0.22

* A = Zero Burning; B = Partial Burned

15 MAF – June 2005

The Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	12	1	13	1.3	0.1	0.72
Instar 1	0	0	0	0	0	0.00
Instar 2	7	0	7	0.8	0	0.39
Instar 3	52	5	57	5.8	0.5	3.17
Prepupae	4	0	4	0.4	0	0.22
Pupae	3	3	6	0.3	0.3	0.33
Adults	2	10	12	0.2	1.1	0.66

16 MAF – July 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	13	0	13	1.4	0	0.22
Instar 1	19	41	60	2.1	4.6	3.33
Instar 2	67	64	131	7.4	7.1	7.28
Instar 3	41	44	85	4.6	4.9	4.72
Prepupae	0	1	1	0	0.1	0.06
Pupae	0	4	4	0	0.4	0.22
Adults	6	1	7	0.7	0.1	0.39

17 MAF – August 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	0	6	6	0	0.7	0.33
Instar 2	4	47	51	0.4	5.2	2.83
Instar 3	52	34	86	5.8	3.8	4.78
Prepupae	0	0	0	0	0	0.00
Pupae	4	0	4	0.4	0	0.22
Adults	1	3	4	0.1	0.3	0.22

* A = Zero Burned; B = Partial Burned

18 MAF – September 2005

Beetle Stages	A	B	Total	Mean A	Mean B	Total Mean
Eggs	0	0	0	0	0	0.00
Instar 1	16	5	21	1.77	0.55	1.17
Instar 2	22	17	39	2.44	1.89	2.17
Instar 3	20	45	65	2.22	2.5	3.61
Prepupae	0	0	0	0	0	0.00
Pupae	0	8	8	0	0.9	0.44
Adults	4	7	11	0.44	0.78	0.05

* A = Zero Burned; B = Partial Burned

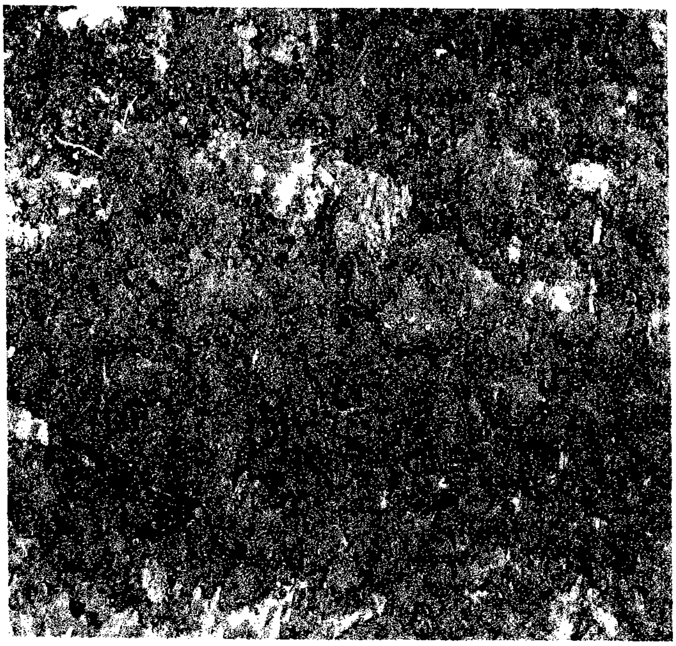
Appendix 4: Results of the Two – way ANOVA is presented in the table below.

i) Dependent Variable: Beetles numbers

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
MAF	16.387	15	1.092	11.931	.000
Stages	13.906	6	2.318	25.313	.000
Error	182.572	1994	.092		

ii) Dependent Variable: Beetles numbers

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
MAF	16.387	15	1.092	11.137	.000
Trunk Condition	.389	1	.389	3.967	.047
Error	196.089	1999	.098		



Appendix 5: Feces of third instar of *Oryctes rhinoceros* in heaps of 6 months after felling and chipping (MAF).

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TRAINING AND POST GRADUATE STUDENT AS OUTPUT OF THE PROJECT

A. EMPLOYMENT

1. The research assistant En Hasber bin Salim has been employed as Plant Protection Officer of FASSB stationed at Sg Tekam.
2. The research assistant En Cik Mohd Ridzuan Zainal Abidin has been employed as Assistant Manager by FELDA Plantation Sdn. Bhd.

B. GRADUATE STUDIES

1. MSc thesis. Bionomics of rhinoceros beetle (*Oryctes rhinoceros*) in zero burning replanted oil palms. By Cik Mohd Ridzuan Zainal Abidin. Will be submitting to The School of Biological Sciences, USM, Penang, in December 2006.
2. MSc thesis. Entofauna in zero burning replanted oil palms in relation control of rhinoceros beetle (*Oryctes rhinoceros*) by some insecticides. By Wan Zaki Bin Wan Mamat. Will be submitting to The School of Biological Sciences, USM, Penang, in December 2006.

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