CONTROL MEASURES AND INTEGRATED APPROACH FOR MAJOR PESTS OF OIL PALM IN FELDA

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ABSTRACT

The practice of Integrated Pest Management (IPM) has been implemented in FELDA against several pests and diseases (P&D) of oil palm. Holistic approaches have been designed for P&D control programme to reduce pest populations below the threshold level with minimal environmental impact. In the Oryctes *control programme, reducing the pest population before oil palm replanting is a much needed action to prevent outbreak. Therefore, pheromone trapping is advocated towards the beginning of replanting, that is, immediately after felling of the old palms. Continuous replanting every 1-2 years within the same region greatly increases the risk of severe beetle damage. Knowledge of the pest's life cycle is important in its control. In most cases of replanting in FELDA, critical damage occurred during two periods viz. 14 to 18 months after felling and 24 to 28 months after felling. Proper legume cover establishment and the use of the biological agent,* Metarhizium anisopliae *against the grubs at the breeding site have been successfully implemented in some of the replanting areas. In the case of leaf-eaters, most of the FELDA estates have difficulty in controlling the infestations effectively. Apparently, the lack of understanding of the behaviour of these pests and their control contributes to the ineffectiveness of the control measures. Failures to coordinate and plan control actions amongst the neighbouring estates have also aggravated the problem. As a result, leaf-eating caterpillars are still serious pests of these affected estates. As an effective long term solution, FASSB have established a Pest Monitoring System (PMS) to assist these estates to manage the problem. Study of the rat population trend in replanting schemes had generated useful information for rat control. Rat population was found to increase and peak at more than 400 rats per ha at 4 to 7 months after felling. Furthermore, controlling rat through baiting during this high population level was insufficient to reduce its population to a low level. Therefore, the estate must initiate a control programme prior to felling off old palms followed by several rounds of baiting before replanting. The role of the barn owl,* Tyto alba*, in controlling rats in mature oil palm was investigated through census of the barn owl population, damage on FFB and baiting requirements in several FELDA estates. About 50 to 68% of the baiting cost could be saved by putting out barn owl nest boxes and maintaining rat baiting after the critical damage level had been breached. Preliminary results suggested that combination of baiting and predation by barn owl markedly controlled rat damage in oil palm plantation.*

INTRODUCTION

Attempts have been made by researchers to obtain quantitative estimates of yield loss due to pest damage in oil palm. Several pests have been identified to have caused significant losses to oil palm yield. Rhinoceros beetle frequently cause serious damage during immature phase of the crop, inflicting an average of 25% yield loss in the first two years of production (Liau and Ahmad, 1991). Yield loss from defoliation by pests was estimated to be as high as 30-40% over a two year period after a single defoliation of 50% (Wood *et al.* 1973). Later, Liau (1987) gleaned from actual outbreaks of *Mahasena corbetti,* that the yield depression in mature palms, especially after serious defoliation, to be sizeable at about 30% in two years, which reflects the above estimates. *Rattus tiomanicus* is a rodent pest of considerable economic importance in oil palm plantations in Peninsular Malaysia, whereas other species notably *Rattus rattus diardii* prevail in Sabah. Rats cause significant oil losses in excess of 5% of normal crop yields where no proper control measures are taken. The economic loss due to these pest thus needs to be addressed in order that control measures are implemented before the critical level of the pest is reached to affect yield.

Integrated Pest Management (IPM) is an approach towards pest control whereby a number of practices are implemented in the long term without relying on any one method. In its absence, pest population may build up to become a threat to the main crop. An effective IPM programme should involve cultural, biological, mechanical and physical practices as well as implementation of a proper Monitoring and Surveillance System (MSS). The latter should provide information on the pests' presence, activity and severity of infestation. The real needs of the crop, reduction in pesticide use and assurance that pesticides are applied at the correct life-cycle stage should be addressed through this MMS programme. As a result, chemical usage would be minimised to reduce risks to human health and the environment.

Drawing on Felda Agricultural Services Sdn Bhd's (FASSB) experiences, this paper discusses the pest and disease control measures and their economic impact on oil palm plantations. Major disease of oil palm caused by *Ganoderma* and its threat to FELDA is also discussed.

ORYCTES RHINOCEROS

Oryctes rhinoceros is a major pest of immature palms during replanting. Almost 80% of the replanting areas in FELDA have experienced pest incidences of more than 5% caused by not following proper control program. This is further aggravated by zero burning of the oil palm tree biomass adopted as the standard practice. The "chipped and windrow" practice by FELDA and "under-planting" methods by non-participant smallholders resulted in intense breeding of *O. rhinoceros*, which has become the most serious pest in immature and young mature palms. Empty fruit bunch heaps that were not properly managed in the mature palm plantations also created breeding sites for beetles that eventually resulted in damage of the mature palms.

a) Reproductive potential & economic importance

Oryctes rhinoceros usually attacks young palms during their immature period (before fruiting). Severity of damage is much dependent on the continuity of replanting in that particular region every one to two years. Normally, the first replanting phase suffers less damage compared to the second phase of replanting. This is because of the multiplying beetle population from the first replanting to another phase of replanting in that particular region. In the same phase of the replanting programme, there are two peaks of damages where the second peak is higher than the first (*Figure 1).* From FASSB's observation in the replanting programme, the average number of fertile eggs was about 14 eggs per female (*Table 1*). At an estimation of 80% hatching success, the potential population increase from a single female is about 10 beetles or a multiplying factor of ten. At a threshold level of 5% frond fresh damage (monitor at monthly interval), severe damage could be expected in the second generation of the beetle.

The lifespan of an adult beetle is 6 to 9 months for male and female, respectively. During this period, there are successive periods of feeding of 4 to 6 days before the adult moves to another palm. Consequently, the damage by rhinoceros beetle is felt even in a small population (Desmier & Kang, 2001).

Young palms damaged by beetle are reported to have a delayed immaturity period (Liau and Ahmad, 1991). An average of 25% yield loss over the first two years of production can be expected after a serious attack by rhinoceros beetle (Liau and Ahmad, 1991). After three consecutive attacks, the affected palms generally need replacements. Those that suffer only one attack on the spear, a loss of growth of 30 cm or 1 m in height with reduction in yield in the first year of production of up to 59% was recorded (Desmier & Kang, 2001). Almost 80% of the replanting programmes in FELDA were reported to suffer serious rhinoceros beetle damage (>5%). Economic losses within an eight year period in the FELDA replanting programme (1996-2003) amounted to more than RM900,000.00 or RM7.70/ha/yr.

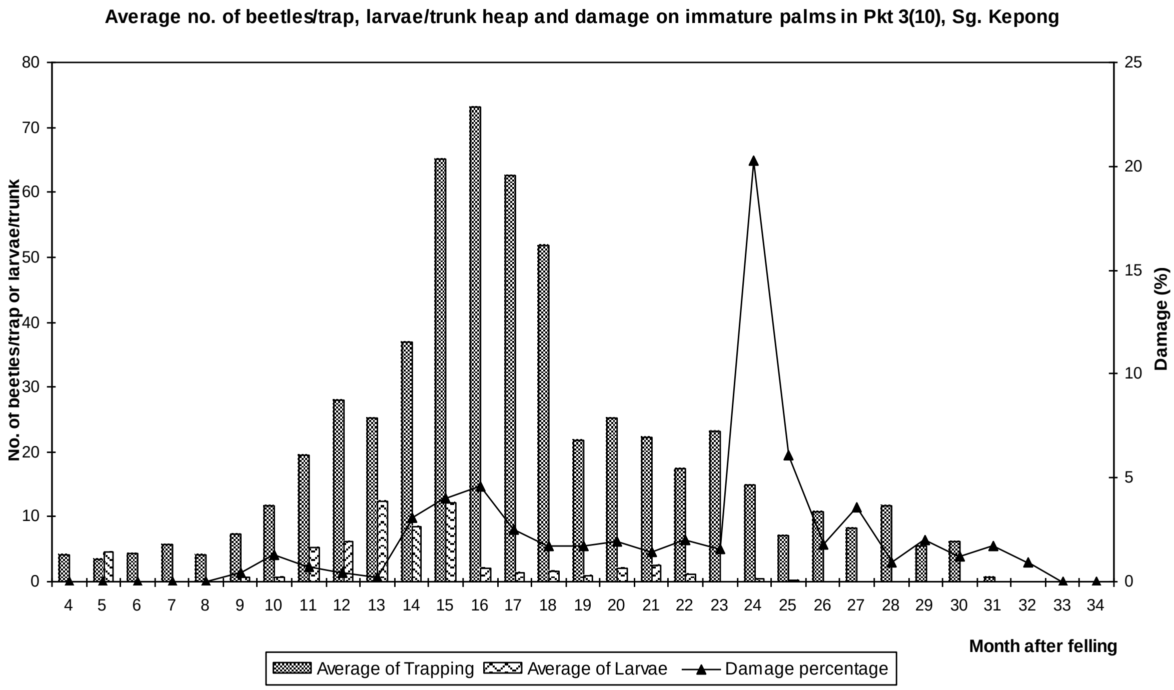

Figure 1: Population and damage trend of Oryctes during 34 months of the replanting programme

TABLE 1. AVERAGE NUMBER OF EGGS COLLECTED FROM ADULT FEMALES CAUGHT IN OIL PALM REPLANTS

Number of female trapped with eggs	Total number of eggs dissected from ovary	Average number of eggs per female
2,157	29,671	13.756

b) Period of peak damage on immature palms

Understanding of the life cycle and population trend of the rhinoceros beetle is important to formulate strategies on how to overcome it in the replanting areas. Integrated pest management with different methods has been recommended. In most of the replanted areas in FELDA, critical damage were observed during two periods viz. 14 to 18 months after felling and 24 to 28 months after felling with damage in the latter period was much higher than the first. This means that beetles could complete two generations in the trunk heaps during the replanting programme (*Figures 1 and 2*). The estates have been informed to monitor the damage level and initiate control measures if damage exceeds the critical level (5%) at these two periods.

The cost effectiveness of control by using the monitoring and census system is given in *Appendix 1*. By using this approach, chemical treatment is only applied during the peak critical period i.e. 4 months period between 14-18 months after chipping and 4 month period between 24 – 28 months after chipping. The second beetle generation could complete its life cycle earlier due to availability of decomposed organic matter from the first phase of replanting programme.

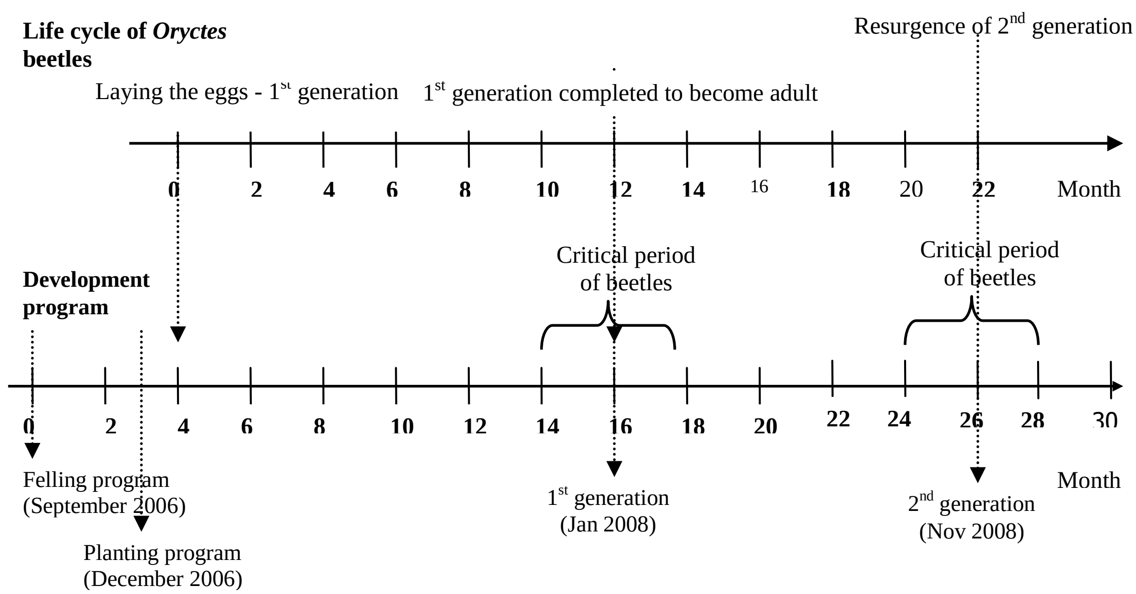

Figure 2 : *General schedule of* Oryctes *development in a replanting programme*

c) Pheromone trapping

In FELDA replanting programmes pheromone traps are normally set up after palm damage exceeds the critical level. Most of pest population during this time are newly emerged adults which are very active in search of food for development of reproductive maturity. The current *modus operandi* is to set up pheromone traps immediately at the rate of 1 trap in 5 hectares. It was noted by Norman *et al.* (1999) that captures were mostly higher at the borders of the replanting block, indicating immigration of beetles from the surrounding breeding sources. There was also evidence that beetles readily migrated into the block as soon as there were trunk chips during replanting (Norman et al. 1999).

Study of the male and female ratio during replanting showed that the female population was higher in the first month after felling at 7 females : 3 males. From then on until seven months after felling, the population of female decreased and the male's population matched the female (1 female : 1 male) (*Figure 3*). Thus, capturing female beetles soon after felling would reduce the breeding females. Desmier *et al.* (2001) found that *Oryctes* could complete its life cycle at the petiolar bases remaining on the stem. When such trunks are highly available in the area, adult beetles could breed even before the trunks decay.

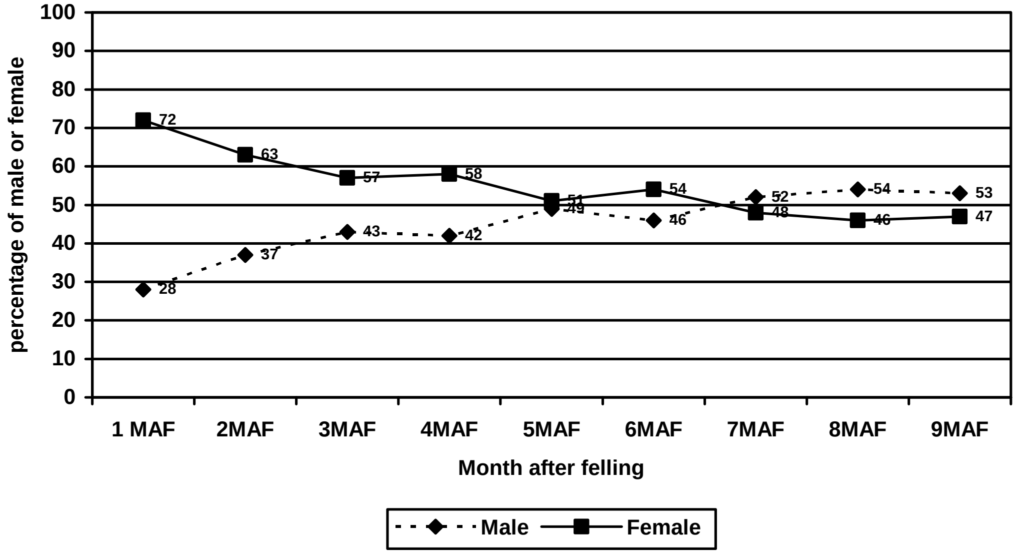

Figure 3: *Percentage of different sexes of adult* Oryctes *captured during replanting*

d) Legume covers to suppress breeding of pest and increase the level of Metarhizium infection

Ground cover established to a height of 0.6 – 0.9m hinders breeding of the *Oryctes* beetle (Liew, 1993). Early and fast establishment of legume covers prevent the female beetles from laying eggs. However, uncertain climatic conditions which affect the growth of the legume or difficulty to plant the legume in unsuitable land area (unfavourable topography), or the presence of larvae in the trunks before the establishment of the cover crops limit the effectiveness of this control measure. In one of FASSB's study in an undulating area (replanted estate) planted with *Mucuna bracteata*, the total number of larvae collected in poorly established legume cover plots was 247 larvae per ha, 62% higher than plots with good legume cover (93 larvae/ha) (*Figure 4*).

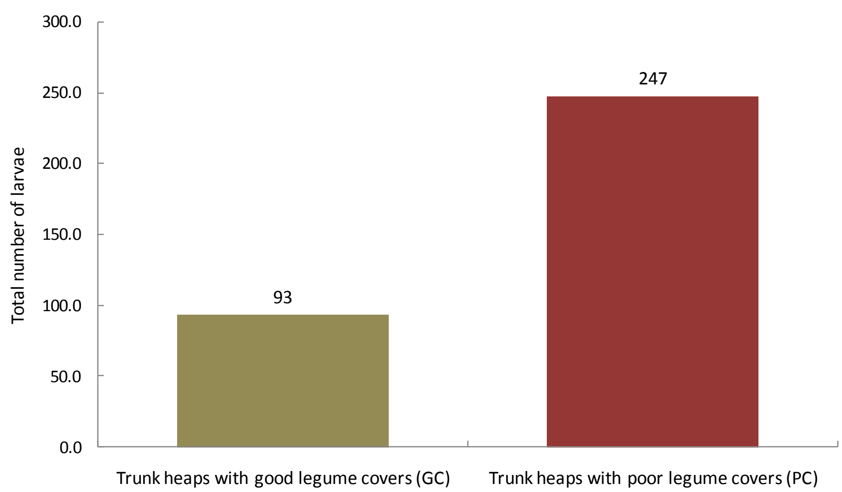

Figure 4: Total number of larvae collected from the palm residues in plots with good legume cover and plots poorly covered by legumes cover crop. Data for 4 months period collected randomly at 20 points per sampling (1 point per 5 ha).

e) Metarhizium anisopliae as a biological control agent

The entomopathogenic fungus, *Metarhizium anisopliae,* is one of the most promising microbial control agents against insect pests, especially soil-inhabiting insects such as scarab grubs. Many efforts have been devoted to improve their infectivity or method of application against these pests. However, the control by entomopathogenic fungi is not always consistent as they are easily affected by temperature, humidity and antagonistic microorganisms or their interactions. However, the use of entomopathogenic fungi to suppress scarab grubs in soil requires large amounts of inocula (Villani *et al*., 1994).

M. anisopliae was used by Tey and Ho (1995) and Ramle *et al.* (1999) to control *Oryctes* beetle in oil palm plantation. They applied sporulated substrates and spore suspensions of the fungus to the breeding sites of the pest. Both formulations were equally effective and significantly reducing the larval population three months after application. Further improvement of *Metarhizium* as a biocontrol agent against *Oryctes* was undertaken by the Malaysian Palm Oil Board (MPOB).Several aspects of *M. anisopliae;* pathogenicity, characterisation and formulation were studied. A joint project of MPOB and FASSB was carried out to mass produce the fungus and to test its efficacy in large field trials. The pilot project aimed to produce 300 kg per month or 3.5 tonnes per year of *Metarhizium* powder in 2006. However, this production is currently very low because every year approximately 10,000 to 15,000 hectares of oil palm estates are replanted and required treatment. At the recommended rate of 0.84 kg/ha, this production barely furnishes 30%-50% of the plantations.

Preliminary laboratory and small scale field trials have shown the effectiveness of the powder formulation of *M. anisopliae* on *Oryctes* beetles. Application by either a mist blower or a power sprayer was efficient, causing 100% mortality at 10 weeks after treatment (Noor Hisham *et al.,* 2005a). A single application of the product on decomposed oil palm debris using high volume spraying significantly reduced the population of *Oryctes*.

TABLE 2. PERCENTAGE OF CUMULATIVE MORTALITY OF ORYCTES LARVAE TREATED AT DIFFERENT RATES OF METARHIZIUM POWDER FORMULATION USING A MIST BLOWER AND A POWER SPRAYER

Type of sprayer	Treatment (rates, amount of spore /m^2)	Cumulative mortality (%) over time after treatment (Weeks)				
		2	3	4	5	6
MIST BLOWER	T1 (Ctr)	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
	T2 (0.5 g)	90.8 a	100.0 a	100.0 a	100.0 a	100.0 a
	T3 (1.0 g)	83.8 a	94.6 a	99.3 a	100.0 a	100.0 a
	T4 (1.5 g)	72.2 a	91.1 a	97.3 a	100.0 a	100.0 a
	T5 (2.0 g)	94.3 a	100.0 a	100.0 a	100.0 a	100.0 a
	T6 (2.5 g)	86.5 a	95.4 a	99.3 a	100.0 a	100.0 a
POWER SPRAYER	T1 (Control)	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
	T2 (0.5 g)	92.3 a	98.6 a	99.3 a	100.0 a	100.0 a
	T3 (1.0 g)	88.7 a	97.0 a	98.5 a	100.0 a	100.0 a
	T4 (1.5 g)	93.7 a	97.9 a	99.3 a	100.0 a	100.0 a
	T5 (2.0 g)	95.5 a	96.2 a	98.5 a	100.0 a	100.0 a
	T6 (2.5 g)	97.2 a	98.5 a	98.5 a	100.0 a	100.0 a

Means in columns with the same letter are not significantly different by Duncan's Multiple Range Test (P>0.05)

The above study shows that treatment by both application methods caused significantly higher (P<0.05) mortality than the control (Table 2). The lowest treatment rate (0.05 g/m^2) was sufficient to bring about satisfactory control of the larval population after 5 weeks. At this dose (0.5mg/m2), the amount of product required is equivalent to 12 g of powder per liter of water or 0.84 kg of powder in 700 liters of water sprayed onto 1 ha of 5 month old trunk chips. Application of *M. anisopliae* is more effective during the rainy season. This recommendation is currently adopted by FELDA replanting program to reduce the population of beetles and damage on the immature palms.

The effectiveness of *M. anisopliae* was investigated in plots with varying growth of cover crops over 4 months period. The result showed that 32.44% of L3 larvae were infected with *Metarhizium* after application in the good legume covered plots as compared to only 3.98% in poor legume cover plots (*Figure 5*). This finding has shown that legume cover has enhanced the efficacy of *Metarhizium* spores to infect the *Oryctes* grubs at the breeding sites.

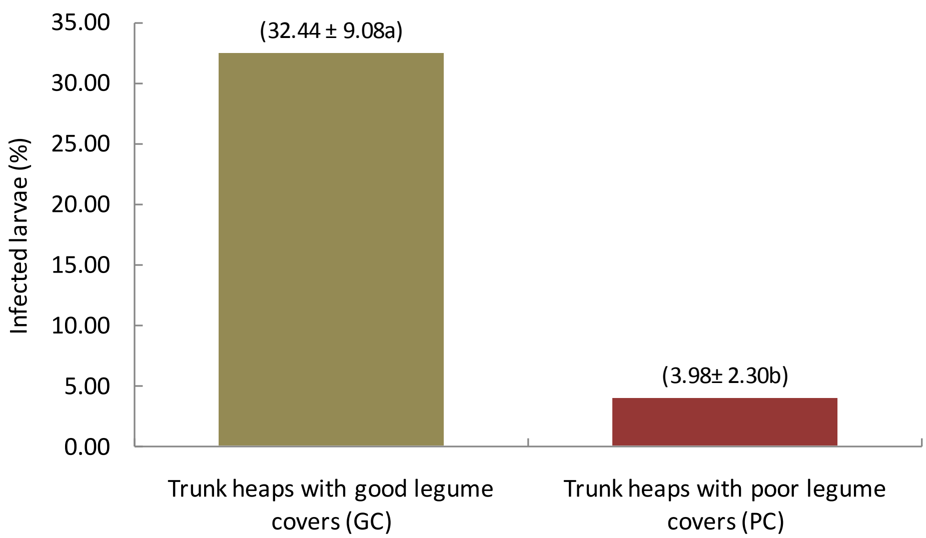

Figure 5. Percentage of larvae infected with M. anisopliae *under two legume cover conditions. Means ± SE followed by different letters within bars are significantly different at P<0.05).*

LEAF EATING CATERPILLARS

The oil palm occasionally experiences serious outbreaks of leaf-eating caterpillars. In nature, biological enemies and pathogens keep caterpillar numbers low but sometimes, this delicate balance of nature between caterpillars and their natural enemies breaks down (Noor Hisham *et al*., 2004). Unusual weather changes usually tigers the pest outbreak due to imbalance of ecosystem components.. In such condition, the caterpillar population multiplies swiftly to very high numbers and their voracious feeding habit leads to severe skeletonization of the palm fronds. It is imperative to initiate control at the early stage of infestation to prevent full blown outbreaks. Controlling the pests at the early stage of infestation is more effective and will reduce the cost of control.

Most estates however, have difficulty in controlling infestations effectively. This includes the estates and schemes in the FELDA Besout, Trolak and Sahabat complexes. For many years, estates in these complexes have failed or neglected to quickly control early infestations, allowing severe outbreaks to follow. One reason is the lack of understanding of the nature of these pests and their control. Failure to coordinate and plan control actions together with among neighbouring estates have also contributed to this problem. Despite of all actions taken, leaf-eating caterpillars are still serious pests in these complexes. Consequently, a lot of money have been spent on insecticides and their applications. The plantations suffered additional loss due to physiological damage on the palm trees that leads to low production of FFB.

As an effective long term solution, FASSB have established a **Pest Monitoring System (PMS)** to assist the complexes in managing and controlling these leaf-eating caterpillars.

a) Pest Monitoring Systems

For many years, there was a lack of coordination in control efforts among the FPSB, FTPSB and FELDA. This has allowed reinfestation from untreated fields into those already treated, causing repetitive pest resurgences. The PMS was established to coordinate FPSB, FTPSB and FELDA in the planning and execution of control programmes.

Research has shown that a 50% defoliation of palms will cause 30% loss in yield over a period of 2 years. If one hectare of palms can produce 25 tonnes of FFB a year, this would mean a loss of 3.75 tonnes. At the current FFB price of RM260.00 per tonne, monetary loss will amount to RM975.00 per hectare annually. Various systems to control leaf-eating caterpillars have been practised by the plantation industry. Some of these are briefly described below:-

According to Chung & Sim (1993), the implementation of IPM control of leaf eating pests relies heavily on the development of a good **Monitoring and Surveillance System** (MSS). Pest monitoring and surveillance systems have been practised by a number of plantation agencies, with slight modification and variation amongst them. Basically, these systems are divided into 3 stages i. Alert and Detection ii. Census and Assessment and iii. Action and Follow-up.

The Alert stage is to detect the presence of the pests. Once a pest is detected, estate management is informed and the Census stage is activated. Census is carried out in each block of the outbreak areas. One of the middle fronds is cut down and the pests on it are counted and recorded. From the Census stage, information on the pest status is obtained. This information allows the estate management to decide on the next course of Action. Chung & Sim (1993) recommended that application of control measures was initiated when infestation is spreading in the area and no natural control took place. The pests have to be at young larval stage and live cocoons are few or absent in the area. The action threshold value for the smaller species is 5 larvae per frond (eg. *Metisa plana* and *Pteroma pendula*) while that of the larger ones is 2 larvae per frond (eg. *Mahasena corbetti*, *Setothosea asigna* and *Setora nitens*).

Objective of a Pest Monitoring System

Successful management of leaf-eating caterpillars requires a sound and effective monitoring system. Usually control actions are taken only after pocket infestations have become a full-blown outbreak. One factor contributing to this problem is the inability of estate management to accurately assessment the situation and failure to track on developmental progress of the pest. Clearly, there is a lack of an effective monitoring programme.

In responding to the need of a good monitoring system, FASSB has established a Pest Monitoring System for all oil palm pests. Its objective is to detect potential pest problems at an early stage and help estate management to make accurate decision to control the pest and keep track of its development. The PMS involves all of FPSB, FTPSB and FELDA estates in the complex as the pests have the ability to spread and infest a wide area over a very short space of time.

The FASSB PMS is a mobile team of FASSB crop protection staff. This team visits all estates in the complex to assess the pest infestation status on oil palm at least three times a year. The team conducts census by cutting one frond from the middle canopy and make a physical count of the larvae found on the frond. As recommended by various researchers, 1% of palm should be consistently sampled in each block. Based on our experiences this procedure takes a long time to complete large numbers of palm trees. The team has gained a skill through their experiences to locate outbreak areas by focusing on fresh damage of middle or upper fronds. The pest census is only carried out along the fringe of the respective blocks because the palms at the edge of planting block usually suffer heavier infestation than those in the inner rows. A report detailing the pest status together with recommended measures is forwarded to the estate for its action.

The periodic visits by the PMS team alone however, do not completely accomplish the pest surveillance program without the involvement of the respective estate staff. All estate staff have to be on alert for signs of early infestation to ensure an efficient detection mechanism. The PMS team of FASSB assists the estate management by providing the training in pest detection to its staff. The PMS team is always on stand-by to respond to any infestation alert from the estates.

Once a pest has been detected, the estate must inform the PMS team immediately. The team then runs a census on the pest status. The duration of the census depends on the nature of the pest. When there is a rapid defoliation caused by nettle caterpillars or bagworm, the survey of the infested area would be carried out immediately for assessment of the damage and recommendation of appropriate control measures. Pest outbreaks are recorded in a logbook or in a computerised database and the census teams will make periodic follow up assessments for any resurgence. Until 2012, a total of 68 FELDA estates with 127,000 ha have been monitored by the PMS.

Regular monitoring of pest infestations by FASSB's MS had provided useful information on the distribution of the various pest species, their biology and their potential threat to the oil palm estates (*Table 5*).

TABLE 5. LEAF-EATING CATERPILLAR SPECIES DISTRIBUTION IN SEVERAL OUTBREAK REGIONS (2012)

Species / Location	*Metisa plana*	*Pteroma pendula*	*Mahasena corbetti*	*Setora nitens*	*Setothosea asigna*	*Darna trima*	*Dasychira sp.*	*Calliteara horsefieldii*
Kalabakan						Y		
Besout	A	T			Y			
Trolak	A	Y						
Merchong/Keratong	A							
Bera Selatan	A							
Komplek Maokil	A							
Paloh*	A							
Kerteh	A							
Serting Hilir/Tembangau*	A							
Palong Timur/Palong	A							
Mengkarak*	A		A					
Nitar *	A							
Tenggaroh*	A					Y		
Kota Gelanggi*								T
Kechau*		T						
Lok Heng*	A							
Triang Selatan	A							
Sg Mas	A							
Selendang	A							

A : Pest population is at critical level.
T : Non-critical population level.
Y : The population is critical.
X : Non-major species attack palm in respective area at a Non-critical population level.
* : New *Metisa palana* attack was detected in respective year and complexes.

b) Establishment of beneficial plants

The natural balance between pests and their natural enemies (predators or parasitoids) plays an important role in preventing the outbreak of leaf-eating caterpillars. Therefore, establishment of beneficial plants as food provision for the natural enemies and avoidance of blanket herbicide spraying are standard recommendations to all estates.

Studies showed that several families of parasitoids and predators lived on three common species of beneficial plants in oil palm plantations, *Turnera longifolia*, *Cassia cobanensis* and *Antigonon leptopus* (Yusdayati *et al.* 2012).

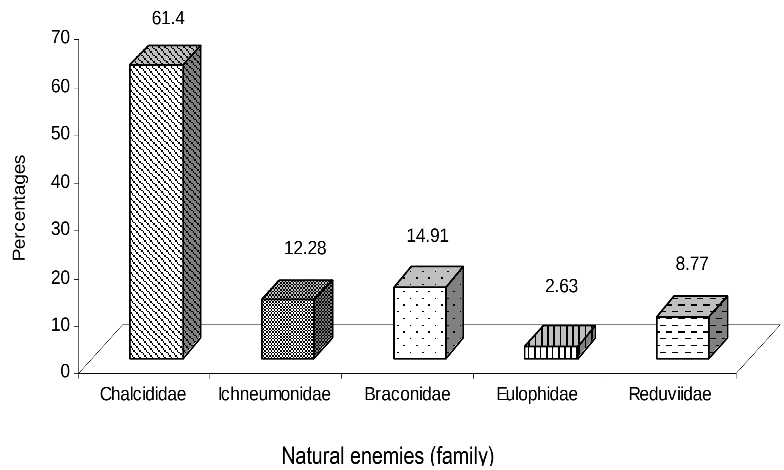

Figure 6 : Composition of different families of natural enemies collected from three main major beneficial plants planted in FPSB Besout, Perak (Yusdayati et al. 2012).

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All oil palm plantation blocks in FELDA Sahabat in Sabah were planted with these three major plant species since 2003 to 2006. Significant decline of leaf eating caterpillar infestation was observed each year since the establishment of these plants (*Figure 5*). Currently, almost hundred percent of estates in Sabah have been planted with *Turnera latifolia*, *Cassia cobanensis* and *Antigonon leptopus*. However, establishment of these beneficial plants need to be continuously maintained to keep a long term balance between pest and natural enemies in all outbreak areas.

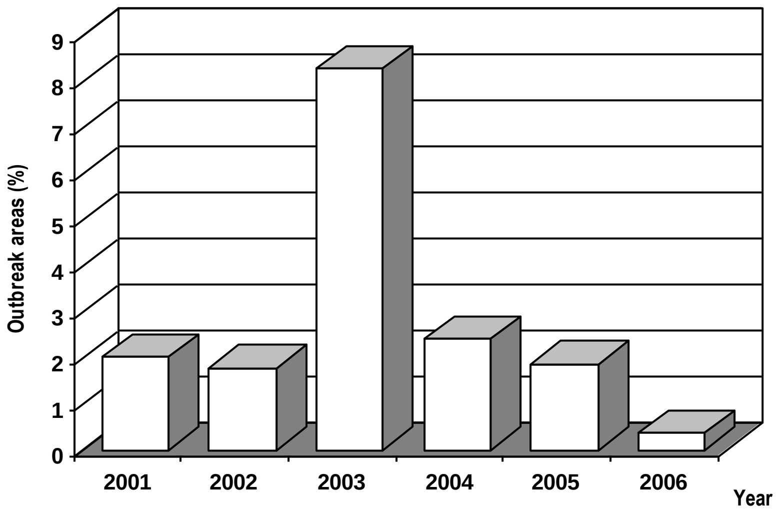


Figure 7 : Percentage of outbreak areas in FELDA Sahabat, Sabah from 2001 to 2006

c) Aerial spraying in FELDA Gunung Besout Complex

The bagworm, *Metisa plana,* is a major leaf defoliator of oil palm in the FELDA Gunung Besout complex since 1980's. The moth larvae are normally control through trunk injection with methamidophos or monocrotophos. An average of RM80.00/ha each year between 2000 and 2003 with a total of RM 1.8 million was spent for the insecticide control (trunk injection) in this plantation complex. Nevertheless, due to the short lifecycle of *M. plana*, the moth has dispersed to large areas and a large scale outbreak occurred in FELDA Gunung Besout complex during the period. The failure of the control was mainly related to poor coordination amongst the estates which led to difficulty and less effective control measures.

In view of the serious outbreak of *M. plana* over large hectarage of oil palm in this complex as well as the lack of effective ground control, an aerial spraying was resorted. Prior to the treatment, two weekly censuses were carried out to determine the correct time of treatment (young caterpillar stage immediately after hatching and low live cocoon counts). The insecticides were aerially sprayed within the critical period of the bagworm life cycle approximately two weeks after hatching.

Large scale aerial spraying of trichlorphon (1.75 kg ai/ha) on 10,600 ha plantation in the complex, had effectively controlled the bagworm outbreak in 2004. Census at 16 weeks after spraying showed that 96% of the infestation areas recovered and 94% of the larvae died two weeks after spraying (*Table 6*). Total cost of this exercise was about RM1.25 million or at RM117.00/ha. Although the cost was high, the impact of this control method was much more efficient than the trunk injection technique.

Pest census before insecticide application was very important to determine the correct timing of the control. Follow-up treatments against surviving population were carried out using conventional trunk injection to further reduce the pest population.

TABLE 6. EFFICACY OF AERIAL SPRAYING USING TRICLORPHON IN FELDA GUNUNG BESOUT COMPLEX

	Census on infestation outbreak of *M. plana*		
	Before aerial spraying	2 weeks after aerial spraying	16 weeks after aerial spraying
Size of infestation area (ha)	2800 ha	376 ha	110 ha
% Infected area	25.8	3.5	1.0
% Recovery	0	86.6	96.1

Source : Noor Hisham *et al*., 2005b

RATS

a) Rat baiting

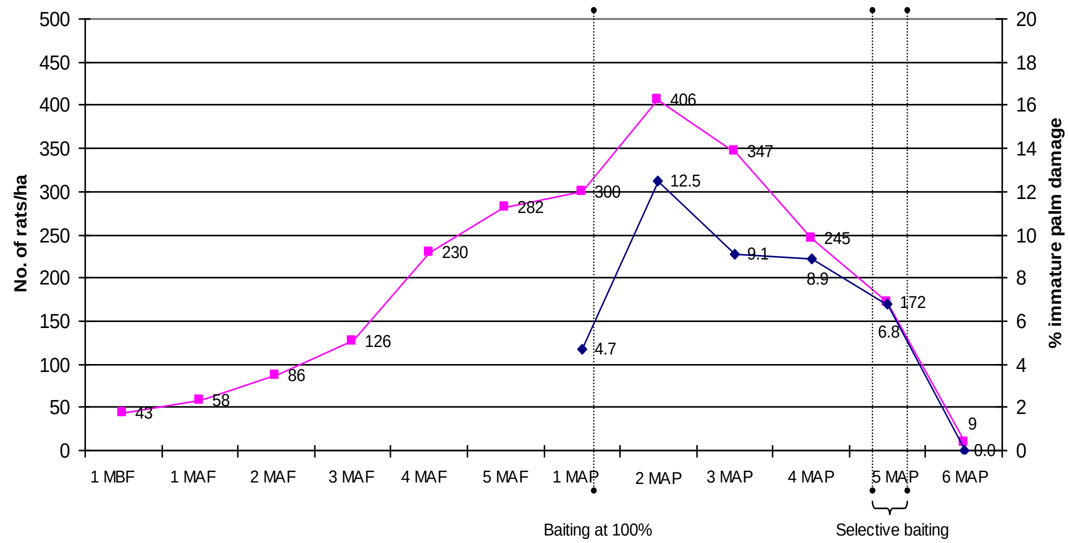
Rat problem in oil palm plantation has to be taken seriously because rats eat on oil palm fruits (FFB) soon before harvest. Palm oil production can be subjected to substantial losses by rat damage. Traditionally, rat is controlled by using first generation anticoagulant baits such as warfarin and chlorophacinone. In FELDA plantations, the first generation anticoagulant poison, chlorophacinone has been used since 1980's replacing warfarin which was previously the main bait for rats.

b) Rat control in oil palm schemes

There are several ways of controlling rats in the oil palm plantations. The most popular method is baiting using poisoned bait. Ready-made baits available in the market are by far the most effective. Other practices include fixing up wire netting collar as a protectant. Natural control of rat population is not sufficient to keep attack at a significantly low level. In this paper, the methods of control are discussed in both young and mature plantings.

i. Control of rats in young oil palms

High rat population levels in replanting areas pose very serious problems to newly planted palms. A field newly cleared from old oil palms for planting is exposed to invasion by rats from previously uncontrolled areas. The rat population was found to increase at peak from 4 to 7 months after felling. Studies have shown that rats potentially improve their survival rate to more than 400 rats per ha after palm felling (*Figure 6*). Normally, the breeding potential correspond closely with the reproductive and availability of nutritional food sources in the oil palm field. Thus, the availability of *in situ* food sources from the rotting fruit bunches (i.e palm kernel) and other ready protein sources (i.e insects and its larvae) increased the survival and reproduction rate of rats (Turner & Gillbanks, 2003). Baiting during the high population levels was not sufficient to reduce the population to a low level.



Notes : MBF (Month before felling); MAF (Month after felling); MAP (Month after planting)
Source : Noor Hisham *et al.* (2004a)

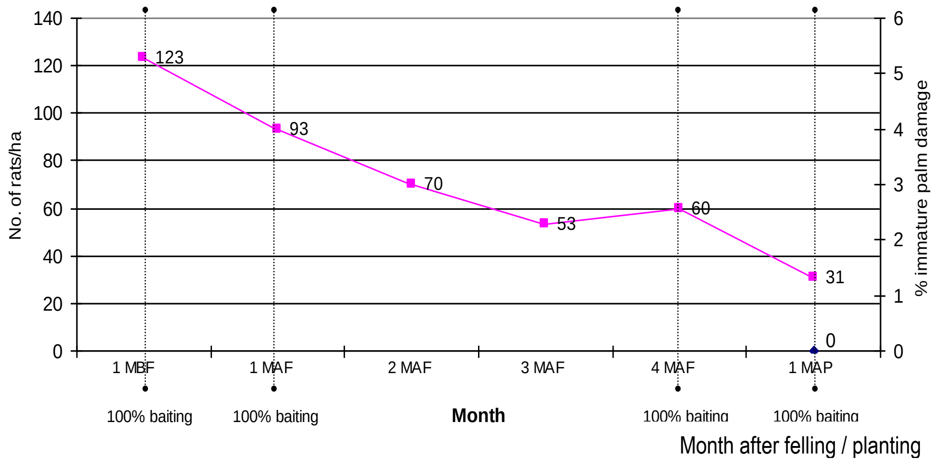
Figure 6: Rat population trend during replanting of a FELDA scheme

The use of poisoned baits is absolutely necessary during the early stage of replanting. In most estates, rat baiting rounds are carried out right from the beginning of replanting as a preventive measure. Otherwise, intensive baiting rounds have to be done when the estates are heavily infested (*Figure 6*). Satisfactory result was obtained in FELDA replanting areas which were baited before the felling of the old palms (*Figure 7*).

Hundred percent baiting refers to baiting of the whole area by placing one cube of bait on the ground close to the collar of the palm. At least for three rounds of 100% baiting is required before planting. Single application after planting is sufficient to reduce the rat population to a low level with minimal damage. Failure to implement this recommendation would lead to severe damage of the palms that requires 2-3 rounds of baiting.

Unlike baiting in mature plantings, subsequent baiting rounds after previously successful control can only be determined by the occurrence of fresh attack. Baiting, either hundred percent or selective (baiting in only certain areas where attack is observed), has to continue as long as there is new attack. Following a proper (recommended) baiting program would very much reduce the cost of control or replacements of dead seedlings.

Some of the replanting schemes have been using wire netting collars to protect the seedlings, but this method is expensive and can only prevent rats from attacking the protected seedlings but not killing them. Baiting is still necessary to eliminate the rats.



Notes : MBF (Month before felling); MAF; (Month after felling), MAP (Month after planting)
Source : Noor Hisham and Suhaidi (2004)

Figure 7: Rat population trend during replanting in a FELDA scheme with a complete (100%) rat baiting programme.

Economic loss due to rat damage in immature palms

Rats also kill seedlings in the nursery as well as immature palms in the field. They first attack the lower fronds of immature palms, subsequently the rats burrow into the palm base to feed on succulent growing tissues. A 20% crop loss has been reported in heavily damaged palm areas during the first 12 months of harvesting (Chung *et al*., 1999).

Table 6 shows an estimated economic loss due to rat damage in a replanting program. The estimate includes potentially 3% damage of fronds and the cost of 2% seedling replacements in a hectare plot. Total economic loss due to 5% damage was about RM97.00/ha for a 12 month period over the first year yield. If the average first year yield is about 12 t/ha and FFB price at RM255.00/t, then 5% damage would reduce the revenue by 3% within the one year period.

Between 1996 and 2003, some RM2.2 million (average RM18.00/ha/year) had been lost through infestation of rat in the oil palm replanted areas at FTPSB. This amount is second largest after wild boar damage at RM35.00/ha/yr.

TABLE 6: ESTIMATED LOSS OF REVENUE IN THE OIL PALM (FIRST YEAR) PER HECTARE DUE TO RAT ATTACK ON IMMATURE TREES

Economic loss	Seedling replacement	Severe Frond Damage
% damage	2.0 %	3.0%
Cost /ha	RM 17.00	-
% Yield loss	100%	20%*
FFB yield loss (t/ha)	0.24 t/ha	0.072 t/ha
Revenue loss / ha	RM61.20/ha	RM18.40/ha
Total	**RM78.20/ha**	**RM18.40/ha**
Total	**RM96.60/ha**	

Notes :
- Supplying cost:
  1. Labour – RM1.30/palm 2. Seedling – RM5.00/palm. For land size of 1 ha (135 palms), estimated supplying cost is RM17.00/ha.
- OER: 17% with CPO price at RM1,500/month
- Estimated 1st year yield: 12 tonnes/ha
- * Ref: Chung *et al*., 1999

Cost effectiveness of baiting campaign

Presently a recommended baiting program is a minimum of three rounds of baiting before planting and another round after planting of the young palms.

ii. Rat control in mature oil palms

Rats are known to feed on loose fruits lying on the ground long before significant damage is noticed on the intact fruits. During such time, they multiply to a sizeable population that makes baiting costly. In such situations, it is difficult to make a good assessment of the damage to determine the need to control them. Baits placed amongst the loose fruits are less easily found by the rats. As such, loose fruits should not be left on the ground.

Rats are known to multiply in a very short time and they can cause considerable damage about 5-6 months after the previous successful control. A six monthly baiting would be a fair practice. However, bimonthly census is necessary for assessment of rat damage.

In Peninsular Malaysia, only 100% baiting is recommended in mature plantings for yearly monitoring or rat damage. When the damage persists, selective baiting to respective area is recommended. In some of the estates especially in Sabah, single application of BUTIK S as normally practiced is not sufficient to bring the rat population below the threshold level. Therefore, two baiting campaigns are recommended annually.

Economic loss due to rat damage in mature palms

Rats feed on unripe and ripe fruits of oil palm. Crop losses due to *R. tiomanicus* feeding on the mesocarp of fruits have been estimated to be about 5% of the oil yield (Wood, 1976). Liau (1990) has updated the estimate taking into account removal of detached fruits leading to increased losses of about 7 to 10% of oil palm production. According to Wan Ibrahim (1995), rats can consume about 700kg of oil palm mesocarp per ha per year in an uncontrolled area. Fruit mesocarp contains fifty percent oil. For a 2000 ha planting, there would be a loss of 700 tonnes of oil, and at an oil price of RM1500 per tonne, this loss would be more than RM 1 million per year. For a settler with a 4 ha estate, the loss would be RM2100 per year or RM525/ha/year. This loss can easily be reduced by rat baiting at a mere cost of about RM 20 per ha per year.

c) Barn owl as a biological agent to control rat population

The role of barn owl, *Tyto alba,* in controlling rats in oil palm plantation was investigated based on census of the barn owl population, damage on FFB and baiting requirements in several FELDA estates. The studies showed that FFB damage remained below the critical level (5.0%) and at a very low cost of control. About 50 to 68% of the baiting cost could be saved by putting out barn owl nest boxes and maintaining rat baiting when the population is above the critical level had been breached (Noor Hisham & Samsudin, 2004). Preliminary results suggested that both chlorophacinone baiting and predation by barn owl markedly control rat damage.

Occupancy of nest boxes have been monitored in two FPSB estates. Generally, the barn owl population has established well in all the estates observed. FFB damage assessed in all the estates was generally below the critical level, and only supplementary baiting rounds are required in some areas (*Table 8*).

TABLE 8. OCCUPANCY OF NEST BOXES AND FFB DAMAGE

Estate	Year Established	No. of Boxes	Rate Per Box (ha)	Occupancy and FFB damage (%)	
				1st Year	2nd Year
FPSB Lepar Utara 11	Nov 1999	76	20	60.5 (0.5)	77.6 (0.3)
FPSB Bera Selatan 6	NOV 2000	88	20	80.7 (2.1)	92.0 (2.2)

Table 9 and *Table 10* show the cost effectiveness of keeping barn owl as a biological control agent in FPSB Lepar Utara 11 and FPSB Bera Selatan 6. In these two areas 50% to 68% cost of oil palm production were reduced through the practice. However, in high rat populated areas, rat baiting needs to be supplemented because barn owl alone is unable to reduce the rat population to below the critical level.

TABLE 9. BARN OWL COST EFFECTIVENESS STUDY IN FPSB LEPAR UTARA 11

	Control Progam (RM)			
	Only with rat baits*	Barn Owl		
		Year 1 (2000)	Year 2 (2001)	Year 3 (2002)
1. Rat bait	20 300	348	-	5 568
2. Manpower	2 100	36	-	576
3. Nest box:‡	-	2 300	2 300	2 300
4. Monitoring cost	-	3 176	3 176	1 588
Total cost	22 400	5 860	5 476	10 032
Cost per hectare	14.00	3.70	3.40	6.30
% cost saving	-	74	76	55
Average cost saving	-	68 %		

Notes
Hectarage : 1,587.88 ha
* : Cost allocated by estate for rat control using baits before establishment of barn owl boxes
‡Durability : 10 years.

Source : Noor Hisham and Samsudin (2004)

TABLE 10. BARN OWL'S COST EFFECTIVENESS STUDY IN FPSB BERA SELATAN 6

	Control program (RM)		
	Only with rat baiting*	Barn owl	
		Year 1 (2001)	Year 2 (2002)
1. Rat bait	22 700	-	-
2. Manpower	2 400	-	-
3. Nest box:‡	-	3 520	3 520
4. Monitoring cost	-	11 968	5 984
Total cost	25 100	15 488	9 504
Cost per hectare	14.00	8.70	5.40
% cost saving	-	38	62
Average cost saving	-	50 %	

Notes
Hectarag : 1,777.13 ha
*: Cost allocated by estate for rat control using rat baits before establishment of barn owl boxes
‡Durability : 10 years

Source : Noor Hisham and Samsudin (2004)

CONCLUSION

Rhinoceros beetle is a major pest of oil palm replants. Rapid establishment of good ground cover such as *Mucuna bracteata* and *Pueraria javanica* would prevent beetles from breeding in the field. Pheromone trapping is carried out to reduce the rhinoceros beetle population as well as to monitor their population level. However, the use of pheromone trap alone isinsufficient to control severe beetle infestations and timely applications of insecticide are necessary to protect the young palms when severity of beetle damage exceeds the critical level. A further approach by using microorganisms such as *Metarhizium* is being introduced.

Leaf-eating pests, primarily the nettle caterpillars and bagworms are naturally controlled by various insect predators and parasitoids. Several host plants such as *Cassia cobanensis, Turnera sp.* and *Antigonon leptosus* have been established in the field to provide food source, shelter and breeding sites for these beneficial insects. Information on the location of pest outbreak, size of infested area and the developmental stage of the pest is vital for effective control measures. For this purpose, census as a surveillance tool is important in providing such information. Pest Monitoring Teams have been established in the FELDA estates to monitor the infestation levels in endemic areas. The monitoring system would consist of Alert, Census and Action stages. A systematic census involving 1% of the palms in each block would provide adequate time for plantation management staff to prepare and implement control measures and thus prevent the spread of the pests before it reaches epidemic proportions. Control measures would be taken once the pest population exceeds the threshold level of 5-10 larvae/frond. Spraying using synthetic pyrethroids is recommended for young palms.

Rats are the most important amongst vertebrate pests. Baiting with first generation anticoagulant poisons such as warfarin and chlorophacinone is very effective with no apparent ill effects on barn owl (*Tyto alba*) via secondary ingestion. The barn owl as a biological control agent, greatly assists in rat control. However, the owls cannot completely replace rat baiting. In young and newly planted fields where legume covers provide ample shelter for the rats, the employment of barn owl is inadequate. Areas with low owl populations will usually take a few years before their contribution becomes significant. During this period, rat baiting is still needed. The barn owl that feeds mainly on rat, appears to tolerate the first generation anticoagulants used in rat baiting programmes. Establishment of barn owl nest boxes at the rate of 1 box to 20 ha is being practised to minimize baiting with poison.

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Appendix 1

COST EFFECTIVENESS OF SEVERAL CONTROL MEASURES WITHIN A 2 YEAR PERIOD FOR RHINOCEROS BEETLE CONTROL

1. With routine chemical application techniques

A. Using carbofuran 3G (4 weekly interval)

i. Cost of product : 30g x 135 palms x RM 2.80/kg	= RM11.30/round/ha
ii. Labour cost	= RM5.00/round/ha
Total per month	= RM 16.30/ha
Total per year (12 rounds)	= RM195.60/ha/year
2 year period	= RM391.20/ha

B. Using cypermethrin (4.7%) (2 weekly interval)

i. Cost of product : 0.289liter/ha x RM25.00/liter x 2 rnds/month	= RM14.45/month/ha
ii. Labour cost : RM5.00 x 2 rounds/month	= RM 10.00/month/ha
Total per month	= RM24.45/ha
Total per year	= RM293.40/ha/year
2 year period	= RM586.80/ha

2. With monitoring and chemical (applied when damage above critical level @ 5%)

C. Pheromone trapping (1 sachet/2 ha and replace every 2 months up to 12 months)

i. Pheromone : RM20.00/sachet/2 ha x 6 times replacement/year	= RM60.00/ha/year
ii. Trapping set and labour cost	= RM25.00/ha/year
Total cost per year	= RM85.00/ha/year

D. Chemical treatment (2 major periods : 14-18 months and 24-26 months after chipping)

i. Cost of cypermethrin : 8 months x RM14.45/month/ha	= RM115.60
ii. Cost of carbofuran: 8 months x RM16.30	= RM130.40
Total cost (2 year period)	= RM 246.00

Note : Application cost of items C and D was RM331.00 which is lower than the blanket application of chemical throughout a 2 year period.