Oil Palm Bulletin 74 (May 2017) p. 17-24

The Red Palm Weevil, *Rhynchophorus ferrugineus*: Current Issues and Challenges in Malaysia

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ABSTRACT

The red palm weevil (RPW), Rhynchophorus ferrugineus *is an economically important pest of palms in many parts of the world. The weevil was first reported in the east coast of Peninsular Malaysia in the early 2007, where it is now causing severe damage to coconut palms. However, in 2016, the RPW has been reported in five states – Perlis, Kedah, Pulau Pinang, Terengganu and Kelantan, with the latter being the worst-hit. The weevil has also been found in oil palm plantations of FELDA and FELCRA by using pheromone trapping, but so far there is no evidence of the oil palm trees being affected. Current method to manage the RPW in Malaysia is largely based on pheromone mass trapping. However, it is still not an effective way to reduce the infestation of the RPW as the weevil population keeps increasing drastically. Thus, urgent action with special management considerations should be taken in order to reduce the problem. Here we report the identification, life cycle, symptoms of infestation, current management tactics for the RPW, and the potential threat of RPW to oil palm industry.*

ABSTRAK

Kumbang merah palma (RPW), Rhynchophorus ferrugineus *adalah merupakan perosak penting pokok palma di banyak kawasan di dunia. Kehadiran kumbang ini pertama kali dilaporkan di pantai timur Semenanjung Malaysia pada awal tahun 2007, di mana kini ianya menyebabkan kerosakan yang teruk kepada pokok kelapa. Walau bagaimanapun, pada 2016, RPW telah dilaporkan melanda lima negeri - Perlis, Kedah, Pulau Pinang, Terengganu dan Kelantan, negeri terakhir yang paling teruk terkesan. Kumbang ini juga telah ditemui di ladang sawit FELDA dan FELCRA dengan menggunakan perangkap feromon, tetapi setakat ini tiada bukti menunjukkan serangan telah berlaku ke atas pokok sawit. Kaedah semasa untuk menguruskan RPW di Malaysia adalah sebahagian besarnya menggunakan perangkap feromon. Walau bagaimanapun, kaedah ini bukanlah satu kaedah yang efektif untuk mengurangkan infestasi RPW kerana populasi kumbang didapati telah bertambah secara drastik. Oleh itu, tindakan segera perlu dilakukan untuk mengurangkan masalah ini dengan mengambilkira pengurusan yang khusus. Penulisan berkaitan RPW ini merangkumi keterangan identiti, kitaran hidup, simptom serangan, taktik pengurusan semasa dan juga potensi ancamannya terhadap industri sawit.*

Keywords: red palm weevil, *Rhynchophorus ferrugineus*, control management, coconut palm, oil palm.

INTRODUCTION

Rhynchophorus ferrugineus (Coleoptera: Dryophthoridae) or commonly known as the red palm weevil (RPW) is a destructive insect pest of a wide range of palm trees (Abbas, 2010). The attack of the RPW in Malaysia was first detected in 2007 by the Department of Agriculture (DOA) Terengganu and had spread to 58 localities in all the seven districts of the state of Terengganu. In 2011, the number of infestation sites has increased significantly to 858 localities (DOA, 2011). Recently in 2016, the weevil has been found in Perlis, Kedah, Pulau Pinang, Terengganu and Kelantan which indicated a drastic increase and rapid spread of RPW population in Malaysia (DOA, 2016). The weevil is believed to be introduced by date palm trees which were brought in across the border either for the date palm plantation or landscaping purposes without proper quarantine several years back (Wahizatul *et al*., 2013). One of the severe signs of infested coconut palms is the drooping of dried leaves giving the umbrella-like shaped, but the sign is considered too late and eventually inflicts the death of the palms between six to eight months. Other symptoms are the presence of holes in petioles and chewed up plant fibres with a very foul fermented odour.

This weevil is a concealed tissue borer that attacks more than 26 palm species worldwide belonging to 16 genera, including coconut, oil palm and sago

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palm (EPPO, 2007) (*Table 1*). However, there is no evidence of breeding preference by the RPW for any specific palm species or genera, although the RPW attacks a broad range of palm species. RPW is widely distributed in many geographical areas, as it had spread from its native Southeast Asia, to Asia (including China and India), Northern Africa, the Middle East, Europe, Oceania (Australia, Papua New Guinea, *etc*.) and the Caribbean (Aruba and Curacao) (EPPO, 2007).

The RPW is most destructive on date palms especially in the Middle East (*i.e*. Saudi Arabia, United Arab Emirates, Sultanate of Oman and Egypt) (Bokhari and Abuzuhira, 1992). It has also been reported that *R. ferrugineus* is a major pest of sago palm in Sarawak, besides *R. vulneratus* (Flach, 1983) and *R. schach* (Bong *et al*., 2008). In India and Sri Lanka, RPW is reported to be a serious pest of coconut (Nirula, 1956; Faleiro and Kumar, 2008) and oil palm (Misra, 1998) and it can completely destroy the plants. In 1994, RPW was found in southern Spain and other European countries (Barranco *et al*., 1996). In 2010, it was first reported attacking the landscape palms in Laguna Beach, California but it has been successfully eradicated from California (EPPO, 2014). Due to that, RPW is listed on the A2 list of EPPO (European and Mediterranean Plant Protection Organization) as a significant serious pest (EPPO, 2008).

Current strategies for management of the RPW are mostly based on insecticide applications which might cause long-term damage to the environment and human health. Now, there is a strong emphasis on the development of integrated pest management (IPM) which integrates different techniques to suppress the pest populations based on pheromone traps and biological control rather than insecticides applications (Faleiro, 2006). Pheromone traps had been incorporated into RPW-IPM programs and used successfully to monitor and mass trap this pest in several countries (Oehlschlager *et al*., 1993; Hallett *et al*., 1999; Al-Saoud *et al*., 2010). Recently, in Malaysia, the Department of Agriculture (DOA) has conducted many approaches to control its spread, including spraying with the cypermethrin and soil drenching in the highly infested areas. Besides, the DOA is also conducting pheromone trapping using the aggregation pheromone imported from Costa Rica (ferrolure, 4-methyl-5-nonanol) throughout Malaysia to control the RPW infestation. However, the effectiveness of the control strategies is still unknown as the infestations keep increasing in recent years.

Malaysia houses a broad range of palm species. These include the coconut (*Cocos nucifera*), oil palm (*Elaeis guineensis*), sago palm (*Metroxylon sagu*) and several other ornamental palm trees including

TABLE 1. LIST OF HOST PLANTS FOR THE RED PALM WEEVIL, *Rhynchophorus ferrugineus* IN SOUTH EAST ASIA (Murphy and Briscoe, 1999; DoA, 2016)

Host species	Common name	Location of records
Areca catechu	Betel nut palm	Philippines
Arenga pinnata	Sugar palm	Indonesia, Philippines
Borassus flabellifer	Toddy palm	India, Indonesia
Caryota cumingii	Fishtail palm	Philippines
Caryota maxima	Pugahan	Philippines
Cocos nucifera	Coconut palm	Malaysia, Indonesia, Thailand, Philippines, India, Sri Lanka
Corypha elata	Buri palm	Philippines
Corypha gebanga	Gebong	Indonesia
Elaeis guineensis	Oil palm	India, Indonesia, Philippines
Livistona decora	Ribbon fan palm	Malaysia
Livistona chinensis	Chinese fan palm	Malaysia
Metroxylon sagu	Sago palm	Malaysia, Indonesia
Oncosperma horridum	Nibong palm	Indonesia
Oncosperma tigillarium	Nibong palm	Indonesia, Philippines
Roystonea regia	Royal palm	Malaysia, Philippines
Phoenix canariensis	Date palm	Malaysia, India, Indonesia

Source: Muhd Syazlie Che Ibrahim.

the canary date palm (*Phoenix canariensis)*. As this invasive weevil has the potential to become an aggressive pest that will threaten the oil palm industry in Malaysia, effective control measures must be considered seriously. Thus, this paper highlights some of the important aspects of RPW which includes the taxonomy and biology of RPW, signs and symptoms of infestation, management of RPW and its potential threat to oil palm.

IDENTIFICATION OF RPW

Rhynchophorus ferrugineus belongs to the family Dryophthoridae, Superfamily Curculionoidea from the Order Coleoptera. The *Rhynchophorus* palm weevil is a large insect (> 25 mm long), polyphagous and attacks a broad range of palm species. Seven of the ten known species of genus *Rhynchophorus* attack palms, causing devastating effect to the crop. The Asian species include: *R. ferrugineus* (Olivier), *R. vulneratus* (Panzer), *R. distinctus* Wattanapongsiri, *R. lobatus* (Ritsema) and *R. bilineatus* (Montrouzier). The taxonomic status of the Asian *Rhynchophorus* species is clearly uncertain where there is some confusion about the RPW identification between *R. ferrugineus* and *R. vulneratus.*

According to the morphological assessment, Wattanapongsiri (1966) concluded that *R. ferrugineus* and *R. vulneratus* were valid species, whereas *R. schach* as a synonym of *R. vulneratus.* He proposed that both *R. ferrugineus* and *R. vulneratus* could be differentiated by the pronotum shape or pronotal marking and the colour of the body. However, more recently, Hallet *et al.* (2004) concluded that *R. ferrugineus* and *R. vulneratus* should be considered as colour morphs of the same species and be synonymized under the name *R. ferrugineus* based on the morphological, molecular-genetic and breeding study. Hallet *et al.* (2004) found that *R. ferrugineus* and *R. vulneratus* were similar in random amplified polymorphic DNA (RAPD) banding pattern, mitochondrial DNA sequencing, preference of the host plants and the production of the same pheromone. In addition, *R. ferrugineus* was reported of having three morphologically and genetically different forms (Salama and Abdel-Razek, 2002). Interestingly, a very recent study by Rugman-Jones *et al.* (2013) revealed that there were high levels of genetic variation in the mitochondrial cytochrome oxidase subunit I (COI) gene sequences across 600 *R. ferruginieus* specimens. They suggested that *R. ferrugineus* and *R. vulneratus* are distinct species and the true *R. ferrugineus* is native to the western and northern parts of Southeast Asia. They also suggested that RPW from its native Southeast Asia is the one responsible for almost all invasive populations worldwide.

In early 2007, RPW was first reported in some small coconut land holdings in Rhu Tapai, Setiu, Terengganu, Malaysia (Wahizatul *et al.,* 2013). Its orgins are unknown but the theory surrounding its appearance is that the weevil could have been transported accidentally from date palms from the Middle East. It was observed that more than 30 variations in adult sizes, colours, numbers and shapes of pronotal markings found in Terengganu (*Figure 1*). Preliminary morphological assesments were unable to confirm the identity of the RPW although it bears remarkable similarities to *R. ferrugineus*. Hitherto, all RPW species associated with major damage to sago palm in Sarawak (Bong *et al.,* 2008) and coconut in Hilir Perak (Sivapragasm *et al.,* 1990) is regarded as *R. schach*, then known as *R. vulneratus* or commonly as the Red Stripe Weevil.

A current study by Yong (2016) revealed that the DNA sequences of the mitochondrial COI from the two *Rhynchophorus* morphospecies populations in Terengganu showed high percentage variation of nucleotide bases (55.99%), which further suggests that *R. ferrugineus* is probably distinct from *R. vulneratus.* By comparing the phylogeographic evidence by Rugman-Jones *et al.* (2013), hence, *R. vulneratus* can now be confirmed as "different species" of the same genus. Based on a study by

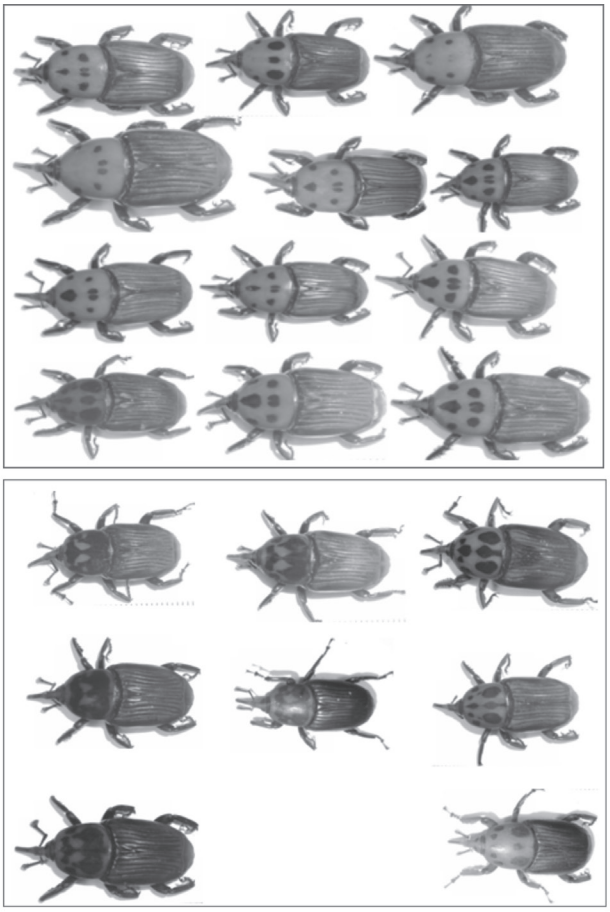

Figure 1. Some variations in adult sizes, colours, number, shape and distribution of pronotal markings on the reddish-brown of R. ferrugineus *collected in Terengganu*.

El-Mergawy *et al.* (2011) on the genetic variation of RPW in the Middle East and Mediterranean Basin, the RPW population in Terengganu are similar with haplotype 8 (H8) which might have originated from the Mediterranean Area (*i.e*. Spain, Italy, Turkey and Cyprus). Thus, it could be suggested that RPW population from Terengganu is probably the original source of RPW populations from the Mediterranean Basin. Therefore, the phylogenetic of this species is urgently required in order to determine and find evidence on how the RPW invaded Terengganu and other states of Peninsular Malaysia.

LIFE CYCLE

Previous studies conducted on the biological aspects of *R. ferrugineus* have been inconclusive and contradictory. Some studies reported overlapping generations which comprised of the different stages of the weevils. For example, RPW could lay up to 531 eggs (Wattanapongsiri, 1966), 55-412 eggs (Aldhafer *et al.,* 1998) and 250 eggs (Murphy and Briscoe, 1999). Larval development has been reported as between 25-105 days (Abraham *et al.,* 1998; Avand Faghih 1996), depending on feeding substrates and temperature. In Malaysia, a study done by Yong *et al.* (2015) found that a female RPW could deposit 342.3±0.97 eggs on average (ranged from 270 to 396). These eggs are light-yellow, oval in shape and approximately 2.5 mm long. The eggs are usually laid close to the surface of the incision along the trunk or petioles, and also in wounds made by the *Oryctes rhinoceros*. *Figure 2* shows the pictures of egg, larvae and pupae of RPW.

On hatching, the apodal whitish-yellow larvae bore into the interior of the palm and feed on the soft succulent tissues of the palm. The larvae feed and grow for another 25–105 days (Avand Faghih, 1996; Abraham *et al.,* 2002), before entering a nonfeeding prepupal stage (between 11-45 days). The prepupal larvae construct an oval-shaped cocoon made of fibre and pupate inside the cocoon, developing into adults. Adults remain inactive inside the cocoon between 4–7 days to reach sexual maturity (Menon and Pandalai, 1960). The life cycle may vary from 82 days (Menon and Pandalai, 1960) to 139 days (Esteban-Duran *et al.,* 1998) depending on different geographical region of the world. The number of generation per year ranges between 3 to 4 generations (Rahalker *et al.,* 1972; El Azaby, 1997). In Egypt, El Azaby (1997) recorded that the weevil has three generations per year, and another study done by Salama and Abdel-Razek (2002) estimated that the weevil had more than four generations annually.

Generally, a complete life cycle of RPW from eggs to adults takes around 6-8 months (Murphy and Briscoe, 1999). Usually, several generations of the RPW can develop within the same host tree before the tree collapses (Rajamanickam *et al.,* 1995; Faghih, 1996). The adult only moves out in search for another host for food when the infested tree is completely destroyed (Faleiro *et al.,* 1999). However, until now there is very limited study on biology and life history of *R. ferrugineus* recorded in Malaysia. In Malaysia, a study by Yong (2016) showed that the eggs took 4-5 days to hatch, larvae duration took about 120 days, pupal duration took 21-25 days and the complete life cycle of *R. ferrugineus* took approximately four to five months.

SYMPTOMS OF INFESTATION

The signs and symptoms of RPW infestation in this paper is mainly based on a report by Wahizatul *et al*. (2013). The RPW is reported to usually attack young palms, mostly below the age of 20 years as the young palm stem is soft, succulent and easily penetrated. Various stages of RPW may co-exist in the same infested coconut palm, until the total death of the palm, where the adults will move to another host plant. The larvae can be found starting from the cabbage of the palm, tunneling and making large cavities inside the palm stem, and even at the base of the trunk. When the palm is destroyed, the adult flies to the next healthy palm within the radius of 9 to 20 m of the dead palm (Abraham *et al.,* 1989). It is very difficult to detect the presence of RPW at the early stages of infestation. By the time the presence of the weevil is realized, it is already too late to save the palm. Thus, visual examination for early detection of symptoms is very hard and

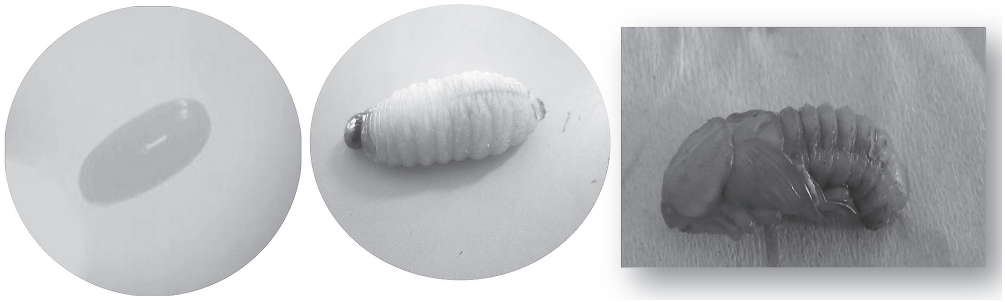

Figure 2. Egg, larvae and pupae of R. ferrugineus.

cannot really determine whether there are larvae and adults present inside the coconuts palms, and making the control efforts ineffective (Murphy and Briscoe, 1999).

According to Wahizatul *et al.* (2013), RPW attacked the coconut palms in three ways. The first way is through the shoot and straight to the cabbage of the coconut. The second way is through trunk, where adults of RPW made holes on the trunk or used the holes that already made by other insects. Usually the holes are made by *O. rhinoceros* (Coconut rhinoceros beetle). The third way is through the root system, where adults of RPW dug the soil and tunnelled into the coconut palm root system.

One of the symptoms that are frequently observed is the cracks and holes in petioles of infected coconut palms. Damaged petioles are dark in colour, and thick brownish fluid oozed out from the wounds; the appearance of chewed up plant tissue and larvae are the major stage that caused damage in petioles. The soft tissues inside the trunk eaten by the larvae turned to brownish and dark colour. At the end stage of infestation, the trunk becomes hollow with only minimal hard tissues left. Empty pupal cases (cocoons) are mostly attached in the inner side of the infected trunk.

In the cabbage part, the soft tissue of the cabbage become dark, sticky, full of RPW larvae with presence of holes and chewed up fibres which give out a very foul smell. This usually happens to infected coconut palms at the critical stage of infestation. *O. rhinoceros* adult is suspected of causing damage to the palms by boring into the center of the crown of the palm. As they bore into the crown and injure the young, growing tissues, the RPW will use the same hole or crack to deposit the eggs. Once the eggs hatch, the larvae will tunnel in and eat out galleries through the soft and juicy tissue, and finally destroy the heart of the palm cabbage.

When the coconut trees are infected, the shoots turn brown and later become dried. Usually, the apical shoot are destroyed, broken and showed signs of wilting and drooping of dried leaves (umbrella-shaped or skirting-shaped) which indicate the critical stage of infestation (*Figure 3*). As such, the damage is devastating, and caused the break off the crown or stem of the tree, and immediate death of the palm. Generally, the adults will only move to another host tree when the one infested is completely destroyed.

CURRENT MANAGEMENT AND CONTROL OF RPW

So far, the effective methods for the control strategy of the RPW is very difficult to develop due to the concealed nature of the larvae. The methods of RPW control such as sanitation, baits and pheromone trappings of RPW have been well studied in many countries (*i.e*. India, Saudi Arabia, Spain), and when used in combination with chemicals or food baits, have been proven effective in field trials.

Figure 3. The umbrella-shaped or skirting-shaped, which indicated the critical stage of RPW infestation.

Current practices for RPW management involve monitoring and mass trapping of RPW adults with pheromones, cultural control and insecticide applications (Abraham *et al.*, 2002; Soroker *et al.*, 2005). Pheromone traps have been the effective way in controlling RPW, but high cost and require intensive labour. In addition, chemical treatments lead to the development of resistance and potential for negative effects to the environment, and therefore, alternative methods should be considered. The increasing concerns over environmental pollution, human-health risks, and insect resistance as well as effects on non-target organisms have stimulated research on alternative control strategies and their use within IPM programmes.

Another way that should be considered to control the RPW infestation is the biological control as mechanical and chemical controls are insufficient (El-Mergawy and Al-Ajlan, 2011). Some of the biocontrol agents are entomopathogenic fungi (EPF), entomopathogenic nematode (EPN) and cytoplasmic polyhedrosis virus (CPV). EPF may play a significant role in the regulation of many insect pests. These fungi are able to infect and parasitize the susceptible hosts by direct contact, penetrating the insect cuticle. In general, the host can be infected by the EPF both by direct transmission of inoculums from infected insects to

uninfected insects, or to subsequent developmental stages through new generation of spores. These unique characters make the EPF particularly important for the control of concealed insects, such as the RPW. To date, EPF are a part of the biological control agents in the Integrated Pest Management (IPM) programs of RPW control management as the fungi are important regulators of insect populations under natural conditions (Faleiro, 2006). Apart from that, the genetic control method which is known as Male Sterile Technique (MST) is also used to control this weevil (El-Mergawy and Al-Ajlan, 2011). X-rays and gamma rays radiation have been used in order to induce sterility in the male adult and the F2 male generations of this pest, respectively. However, this method seems less effective since the female can mate with multiple partners and a fertile offspring can still be produced (Bertone *et al.*, 2010).

However, all these methods are still under experimentation and the effectiveness of the biocontrol agents are unclear and inconclusive. Therefore, one of the effective controls of its ongoing expansion is dependent on a legal framework that effectively regulates the imports of palm trees across the border. The Biosecurity Division of Department of Agriculture is crucially needed to improve the quarantine procedures by establishing demarcated infested areas and regulating import requirements and conditions for movement of palms arriving in Malaysia.

POTENTIAL THREAT OF RPW TO OIL PALM INDUSTRY

RPW is considered as a rare and local insect in natural and uncultivated areas within southern India (Nirula, 1956). However, with rapid commercialisation of coconut and oil palm, it has caused a drastic increase and rapid spread of RPW in southern India. Presumably, the development of monocultures plantation has facilitated or created the ideal conditions for the wider expansion of this pest. A study done by Mohd Haris H. (Personal communication) from 2014 to 2016 on pheromone trappings of RPW showed that the weevils are highly abundant and distributed in some oil palm plantations in Terengganu. He found that the number of captured RPW was higher at palms between 6 to 10 years old, where the yield of the oil palms at their maximum. However, to date, there has been no report of dead oil palm due to RPW infestation. Therefore, the questions remain unsolved: Do RPW feeds on oil palm cabbage but have not yet damaged the palms?

In addition, a study on the developmental growth of RPW reared on different food diets under laboratory conditions was conducted by Ainatun (2016) in order to determine whether different food diets would affect the duration of larval period. She found that there were significant differences in the duration of developmental growth of the larval period among the three diets ($p<0.05$). Through this study, a new finding has revealed that the oil palm diet showed the highest growth rate in which the RPW larval stage duration could be shortened. The growth of RPW larvae reared on oil palm was significantly shorter compared to the other food diets, where the RPW only need one month and nine days to complete the larval duration.

As such, this weevil is presumed to be one of the aggressive pests that will threaten the survival of oil palm, which represents the backbone of Malaysia's commodity. Malaysia has more than five million hectares of oil palm, which provides a stable source of income to many smallholders and the Federal Land Development (FELDA) settlers of the country. Therefore, urgent action is crucially required to avoid significant economic yield losses before it is too late.

CONCLUSION

For the sustainability of the RPW management, more comprehensive and effective control measures of the RPW must be considered seriously due to its impact on major cultivated palms all over the world. However, in order to implement an effective integrated pest management (IPM) of the weevil, early detection and monitoring of the pest is essential. Thus, further study is required to focus on a new technology or innovation in device development for the early detection of this pest. Besides, more emphasis on the improvement of the trapping systems and effective methods for delivery of chemicals should be further studied. As several bio-control agents have been evaluated in the past, a reliable indigenous strain of bio-control agents should be developed for future effective formulation of the IPM to control this coconut pest weevil in Malaysia. However, a proper quarantine protocol at the national level is most needed as there is still a lack of national level enforcement to control the ongoing expansion of this weevil.

ACKNOWLEDGEMENT

We would like to thank Hj Zazali Chik and his supportive team from the Department of Agriculture, State of Terengganu, for assistance rendered during the field work; Dr Norman Kamarudin and Dr Ramle Moslim from Malaysia Palm Oil Board (MPOB) for the continued support and advice; the Universiti Malaysia Terengganu for the laboratory facilities; and the Ministry of Higher Education of Malaysia for providing the Research Grant Schemes.

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