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THE EFFICACY OF SYNTHETIC FOOD BAITS IN CAPTURING RED PALM WEEVIL, *Rhynchophorus ferrugineus* (COLEOPTERA: CURCULIONIDAE) IN CAMPUS AREA OF UNIVERSITI MALAYSIA TERENGGANU

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ABSTRACT

Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* is known as one of the most destructive pest of major cultivated palm industries such as coconut palm (*Cocos nucifera*), date palm (*Phoenix dactylifera*) and oil palm (*Elaeis guineensis*). In early 2007, RPW was first recorded in some small coconut plantations in Setiu, Terengganu by Department of Agriculture (DOA). One of the current methods to control the RPW is the use of the pheromone traps instead of chemical pesticides. In this current study, a 60 days experiment of pheromone mass trapping using synthetic food baits was conducted around Universiti Malaysia Terengganu (UMT) campus to evaluate the effectiveness of synthetic food baits in capturing RPW. A total

number of 164 individuals of RPW were captured in this study. E2 treatment (ethylene glycol) recorded the highest number of trapped RPW with 52 individuals (10.4 individuals/trap), followed by E1 treatment (ethyl acetate), E3 treatment (ethanol) and control which were 48 individuals (9.6 individuals/trap), 44 individuals (8.8 individuals/trap) and 20 individuals (4 individuals/trap) respectively. However, there was no significant difference between total numbers of trapped RPW with the types of treatment (F=1.174, df=3, p=4.449). Interestingly, the sex ratio of trapped adults was clearly female biased (4 female: 1 male) as there was significant difference between the sexes (t=4.699, df=19, p= 0.000). This study has showed that palm esters could be used as potential synthetic food bait in pheromone trapping system of RPW which is suitable to be applied in dry or wet monsoon seasons.

Keywords: *Rhynchophorus ferrugineus*, synthetic food baits, pheromone trap, palm esters.

ABSTRAK

Kumbang Palma Merah (RPW), *Rhynchophorus ferrugineus* dikenali sebagai salah satu daripada serangga perosak bagi industri tanaman utama pokok palma seperti pokok kelapa (*Cocos nucifera*), pokok kurma (*Phoenix dactylifera*) dan pokok kelapa sawit (*Elaeis guineensis*). Pada awal tahun 2007, RPW telah direkodkan buat pertama kali di kawasan ladang kelapa kecil di Setiu, Terengganu oleh pihak Jabatan Pertanian (DOA). Salah satu langkah untuk mengawal RPW tersebut adalah dengan menggunakan perangkap feromon yang mana lebih baik daripada penggunaan racun perosak kimia. Di dalam kajian ini, 60 hari eksperimen pemasangan perangkap feromon menggunakan umpan makanan sintetik telah dijalankan di sekitar kampus Universiti Malaysia Terengganu (UMT) untuk menilai keberkesanan umpan makanan sintetik dalam menangkap RPW. Sejumlah 164 individu RPW telah berjaya ditangkap di dalam kajian ini. Rawatan E2 (etilena glikol) telah merekodkan jumlah tangkapan tertinggi RPW dengan 52 individu (10.4 individu/perangkap), diikuti oleh rawatan E1 (etil asetat), rawatan E3 (etanol) dan rawatan kawalan iaitu masing-masing adalah 48 individu (9.6 individu/

perangkap), 44 individu (8.8 individu/perangkap) dan 20 individu (4 individu/ perangkap). Walaubagaimanapun, tidak ada perbezaan yang signifikan antara jumlah RPW yang terperangkap dengan jenis-jenis rawatan (F=1.174, df=3, *p*=4.449). Menariknya, nisbah jantina bagi tangkapan kumbang dewasa tersebut adalah jelas lebih kepada betina (4 betina: 1 jantan) sebagaimana terdapat perbezaan yang signifikan antara jantina (t=4.699, df=19, *p*=0.000). Kajian ini telah menunjukkan bahawa ester palma boleh digunakan sebagai umpan makanan sintetik yang berpotensi bagi sistem perangkap feromon RPW yang mana sesuai untuk diaplikasikan di dalam musim kering atau musim basah.

Kata kunci: *Rhynchophorus ferrugineus*, umpan makanan sintetik, perangkap feromon, ester palma.

INTRODUCTION

The Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae), is known as a serious pest for the date palm (*Phoenix dactylifera*) (Malumphy and Moran, 2009). Other than that, RPW also have been recorded to damage coconut, sago and oil palms. This invasive pest usually attracted to dying or damaged parts, however, it also has possibility to attack undamaged palms (Murphy and Briscoe, 1999). In Terengganu, the onslaught of an invasive pest known as *Rynchophorus* sp. was first recorded in 2007 and was reported to attack the coconut (*Cocos nucifera*) plantation especially in coastal region of Terengganu (DOA, 2011). The coconut plantation in seven districts of Terengganu had been detected attacked by RPW in 58 localities. In 2011, the numbers of locality attacked by RPW has increased to 858 locations (Wahizatul *et al.,* 2013).

Currently, many methods have been used in controlling RPW including the use of chemicals insecticides, biological control, soil treatment and aggregation of pheromone (Abbas, 2010). Aggregation pheromones have been reported as successful tools in controlling RPW in the field. Trapping of RPW can be synergized by adding together of food besides male-produced aggregation pheromone (Oehlschlager, 2007). A study done by Giblin-Davis *et al.,* (1996) found that the trapping of *Rhynchophorus* spp. can be enhanced by the use of synthetic aggregation pheromones with a variety of sources

plant volatiles. The relationship between plant kairomones and sensory organs of insect shows that kairomones can be used in controlling of insects in form of baits or traps (Metcalf & Metcalf, 1992). Usually, trapping of RPW by using natural food bait are not long-lasting, less effective during wet season, need to be changed every two weeks and expensive. The most obvious problem when use natural food baits in RPW pheromone traps is it needs frequent replacements for maximum trapping efficacy (Hallet *et al.,* 1999, Fiaboe *et al.,* 2011). Therefore, the use of pheromone trapping with synthetic food baits could be an alternative method in controlling RPW (Guarino *et al.,* 2010). It is hoped that replacement from natural food baits to synthetics food baits could be an alternative method in controlling the RPW.

The trap that baited with chemical lures such as pheromones and food can be applied in semiochemical based mass trapping (El-Sayed *et al.,* 2006). In fact, the host plant volatiles (kairomone) have been proven to attract RPW in trapping method (Giblin-Davis *et al.,* 1996). Ethyl acetate has been used in attracting of RPW in mass trapping (Guarino *et al.,* 2010). In fact, ethyl acetate, ethyl propionate, ethyl butyrate, ethyl isobutyrate and ethyle lactate that known as palm esters are found to be produced from the fermentation of the palm tissues of the host plant. Interestingly, RPW are able to detect the lower dose of ethyl acetate at a long distance as shown by Electro antennographic (EAG) (Guarino *et al.,* 2010). Fermentation of coconut sap has been believed to produce volatiles that can attract RPW (Gunawardena and Gunatilake, 1993). The compounds found in coconut sap comprised of mainly a short chain alcohols (Samarajeewa and Adama, 1985). In short range distance, ethyl alcohol and isopropyl alcohol are found to attract weevil.

The coconut palms and pineapple had been proven by chemical analysis comprised of ethanol and ethyl acetate that can attract insect whereas pentane, hexanal and isopentanol only can be found in coconut palms. The effectiveness to attract the insect usually can be done by mixing these compounds in same amount as in the natural coconut tissue (Jaffe *et al.,* 1993). Besides that, ethanol has been known can catch the attention of the palm weevil (Hagley, 1965) and can be found in also in sugar cane and bananas (Macku and Jennings, 1987). Besides the ethanol, the humidity, stress situation, damaged or dying host tissues also can become an attractiveness of weevils into the

traps because of high sugar content (Giblin-Davis *et al.,* 1996). The combinations of aggregation pheromone and host kairomones are strongly attract the RPW into the trap (Hallett *et al.,* 1993).

Therefore the objective of this study was to evaluate the effectiveness of synthetic food baits (ethyl acetate, ethylene glycol and ethanol) in capturing RPW. Finding from this study will be used to develop a new formulation of pheromone trapping which is more effective and long-lasting in capturing RPW.

MATERIALS AND METHODS

Study Site:

The study was conducted around Universiti Malaysia Terengganu (UMT) campus which is located in Terengganu. UMT was chosen as the sampling site because the surrounding area is considered as one of the highly infested areas in Terengganu. Previous study done by Shahrol Nizam (2012) showed that there were present of RPW around UMT area but the trapping method used was synthetics pheromone with natural food baits (sago, pineapple and sugarcane). In this study, pheromone traps with synthetic pheromones along synthetics food baits (palm esters and alcohol) were used. The study period was from 17 October 2012 until 21 December 2012 (60 days).

Five sites were chosen and the coordinates of each location was taken using Global Positioning System (GPS) device (Model: Garmin). The five locations were Tok Jembal Beach (N05º24.383', E103º05.912'), UMT hostel (N05º24.308', E103º05.662'), Biawak Road in UMT (N05º24.660', E103º05.509'), UMT back gate (N05º24.949', E103º05.301') and Sultanah Nur Zahirah Library of UMT (N05º24.541', E103º05.347'). Each site contained four treatments. The ecological parameters (humidity and temperature) of surrounding locations were taken using multi-hydrometer.

Pheromone trap design

The traps used in this study were 7L dark blue polypropylene buckets. The buckets were covered with a lid and had four openings to allow the RPW entrance. The dark blue buckets were chosen because in Abu Dhabi, UAE, results indicated that dark-coloured traps were more preferred by RPW adult (Al-Saoud *et al.,* 2009). The outer

surface of the buckets was brushed by metal brush to make it rough thus enabling the entering and climbing of RPW into traps easily. The lid of buckets has a hook to hang the synthetic aggregation pheromone dispenser (ChemTica Int., Costa Rica). The glass bottles were used to put the palm esters and alcohol which acted as synthetic food baits and glued inside the buckets. The glass bottles were used because they can withstand the chemical reaction by the palm esters. Then, 600 mL water was put in the buckets. Water was always been added if there was decreased in volume and to avoid escape of RPW. The detergent was mixed with water in the buckets to break the surface tension of water and killed the RPW instantly.

Experimental Design and Trap Installation

Several synthetic food baits were chosen as treatments in this study. The synthetic food baits were consisted of ethyl acetate, ethylene glycol and ethanol. The synthetic food baits act as a palm tissues and sugar fermentation that can attract the RPW into the traps.

The experimental design was a Completely Randomized Design (CRD) with four treatments and five replicates (locations). A total of 20 traps were placed for a trapping of RPW. Each site has all of the treatment to compare which treatments were more preferred by the RPW. The distance between the traps was about 20m with other traps in same site. Traps were tied to tree trunks with bendable wire. Captured weevils were collected and recorded daily (number of males, females and total weevils) in each trap and sites during study period. The volume of the synthetic food baits were refilled every month which was similar to initial level. The final volume of the synthetic food baits were recorded weekly to compare the reduction volume among the treatments tested for each month. Besides that, the buckets were located under the shady area to reduce the evaporation rate of the treatment and water.

Statistical Analysis

Analysis of variance (ANOVA) using the SPSS program was used to compare the interaction between types of synthetic food baits on the total numbers of captured RPW in order to determine which treatment was the most effective in capturing RPW**.** Besides that, t-test was used to evaluate the differences between the number of

captured of RPW for male and female in each treatment. Correlation analysis was used to determine the influence of the temperature and rainfall on the total number of RPW captured.

RESULTS AND DISCUSSION

Effectiveness of food baits

After 60 days of sampling periods, a total of 164 RPW were captured on different types of synthetic food baits (Figure 1). Ethylene glycol captured the highest numbers of RPW with 52 individuals (10.4 individuals/trap), followed by ethyl acetate (E1 treatment), ethanol (E3 treatment) which was 48 (9.6 individuals/trap) and 44 (8.8 individuals/trap) individuals respectively. The lowest captured was by control treatment which was only 20 individuals (4.0 individuals/trap) (Figure 1). However, there was no significant difference between synthetic food baits used ($F=1.174$, $df=3$, $p=4.449$; $p>0.05$).

Recently, pheromone-baited traps have been used as one of the method in controlling the spreading of RPW as it is ecologically safe and environmental friendly. Trapping of RPW can be synergized by adding the food beside the male-produced aggregation pheromone (Oehlschlager, 2007). It is suggested that the use of synthetic food baits in pheromone-based mass trapping system is better than using the natural food baits from the aspect of long-lasting usage to lure

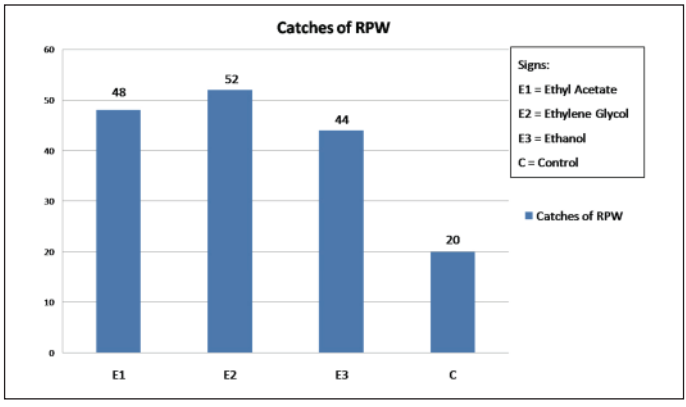

Figure 1. Comparison of total captured RPW and mean of individuals/trap/treatment on four different type synthetic food baits.

RPW entering the pheromone trap. In this study, the palms esters and alcohol were tested to determine the most effective and long-lasting synthetic food baits that can be used in capturing RPW. Aggregations of sex pheromone give intraspecifically transitory signals while kairomones such as plant-volatiles act interspecifically with the pest (Dusenbery, 1992).

From the experiment, ethylene glycol (E2 treatment) captured the highest total of RPW trapped compared with ethyl acetate (E1 treatment) and ethanol (E3 treatment). Findings from previous study found that ethylene glycol is produced from ethylene via ethylene oxide. The gas of ethylene can be produced in pineapple during vegetative maturity which enhances the pineapple to undergo flowering and fruiting cycle (National Organic Standards Board, 2007). Previous study done by Shahrol Nizam (2012) found that the pineapple was the most preferred food baits compared to sugarcane and sago in pheromone trapping of RPW. From that, it is suggested that there is special compounds found in pineapple that attracts most RPW. In addition, ester including ethylene glycol and ethyl acetate can be found in coconut palm (host plant) in proportion 60-90% of overall volatiles that can attract RPW (Guarino *et al.,* 2010). The same odour produced from synthetic food bait and coconut palm can be a reason why the RPW attracted to the coconut palm. There are few studies used ethyl acetate as the synergist or 'magnet weevil' to capture more RPW (e.g. Hoddle and Hoddle, 2011; Soroker *et al.,* 2005). However, in this study, ethylene glycol attracted more RPW compared with ethyl acetate. Thus, it shows that instead of using ethyl acetate as the 'magnet weevil', ethylene glycol seems to be a better choice in attracting the weevil based on the result from this experiment.

Comparisons of total volume of synthetic food baits by weekly

Figure 2 compares the volume in the synthetic food baits for month November and December. Overall, the volume of all three types of synthetic food baits was slowly declined over the time. At the beginning, all the volume of synthetic food baits were 310 ml. Gradual reductions were found for each of the synthetic food bait until week 4. Interestingly, in both months, the volume of ethylene glycol (E2) was the highest volume left after week 4, followed by ethyl acetate (E3) and ethanol (E2).

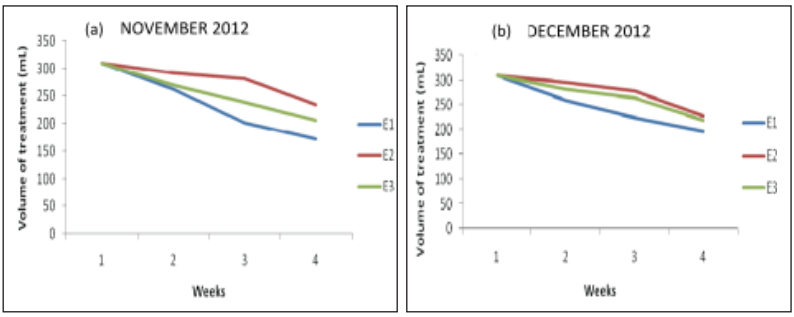

Figure 2. Comparison between trends of volumes for different treatments by weekly in (a) November 2012 and (b) December 2012. (Note: E1=Ethyl acetate, E2=Ethylene glycol, E3=Ethanol)

In November, the volume of ethylene glycol (E2) left was 234 ml whereas in December, the volume of ethylene glycol (E2) left was 228 ml.

Based on the Figure 2, it was found that the volume of synthetic food baits decreased slowly over time. In this study, it was found that ethylene glycol was less evaporated compared to other synthetic food baits. This is due to the structure of ethylene glycol which has higher viscosity because it contains two hydroxyl groups (ChemPaths, 2009) which cause it to evaporate more slowly compared to the chemical that contain no hydroxyl group (ethyl acetate). Besides that, MEGlobal (2008) stated that ethylene glycol has low-volatility liquid that makes the chemical able to evaporate slowly compared to the ethyl acetate that has medium to high volatility (Rhodia, 2012). It is suggested that ethylene glycol was the most long-lasting synthetic food bait used due to the highest retained volume that depends on their properties.

The effect of rainfall and temperature to the numbers of RPW captured

In this study, the amounts of rainfall and average daily temperatures were found influenced the total RPW captured. Generally, low number of RPW (1 individual/trap) was captured when high rainfall (>31mm) and the numbers of RPW increased (14 individual/trap) during no rainfall. Similar trend was observed for average daily temperature, where higher RPW (14 individuals/trap) were collected when high

temperature (>27p C) compared with low temperature (<25pC) with 1 individual/trap. However, based on regression analysis (Figures 3a and 3b), amount of rainfall and average daily temperature showed a weak correlation with the total captured RPW with R=0.004 and R=3.988 respectively.

In this study, ecological factors play an essential role in determining the activity of RPW which influence the trapping of this pest (Faleiro, 2006). The ecological factor is important for the performance of RPW pheromone trap as it is directly associated with RPW mobility, pheromone dispersal and very useful for the prediction of RPW population activities. A study conducted by Vidyasagar *et al.* (2000) at Al-Qateef, Saudi Arabia found that the weevil activity was high during April to May (summer) and low during October-November (winter). Similarly, another study done at Al-Hassa, Saudi Arabia also found that the activity of this lethal pest is higher during the summer that causes higher infestation (Anon., 1998). Other than that, a study done by Al-Saoud *et al.* (2010) at Al-Rahba, Abu Dhabi (UEA) found that the numbers of RPW trapped could depend on temperature and other weather parameters. In this study, it was found that the temperature and rainfall influenced the numbers of RPW captured even though the correlation was considered low. It was clearly that high numbers of RPW were collected during no rainfall and high temperature (range 32-35ºC). Thus, the amount of rainfall and temperature might affect the efficacy of pheromone mass trapping

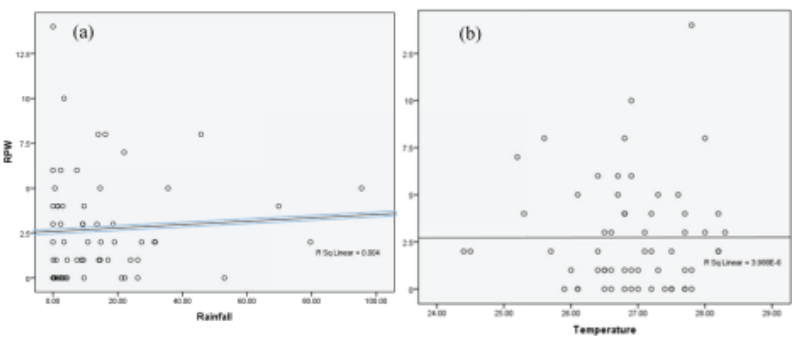

Figure 3. The relationship between the amount of (a) rainfall (mm) and (b) average daily temperature (ºC) on number of RPW captured.

system. Other than that, weather also might affect the mobility, mating season and efficacy in searching food sources of RPW. Therefore, it is suggested that the seasonal weather conditions should be considered as part of the forecasting in prediction of RPW population and strategy of trapping system.

Sex ratio of RPW captured in different types of treatments

Overall, out of 164 individuals, higher numbers of females were captured which was 76% compared with males which were 24% (Figure 4). The overall ratio of male and female captured was 1 is to 4 (Figure 4). The number of females captured was significantly higher than the number of males in all treatments (Table 1). Based on the paired samples t-test analysis, there was significant difference between the number of female and male captured weevil ($t= 4.699$, $df= 19$, $p= 0.000$).

From the ratio of RPW captured in each treatment (Table 1), all the treatments captured higher total numbers of female RPW compared to male RPW. This finding is supported by Kaakeh *et al.,* (2000) who found that higher number of females was captured in the traps compared to male weevils at Al-Ain (UAE). Other than that, Shahrol Nizam (2012) and Haris (2012) also reported higher numbers of female weevil were captured than males in Terengganu. According

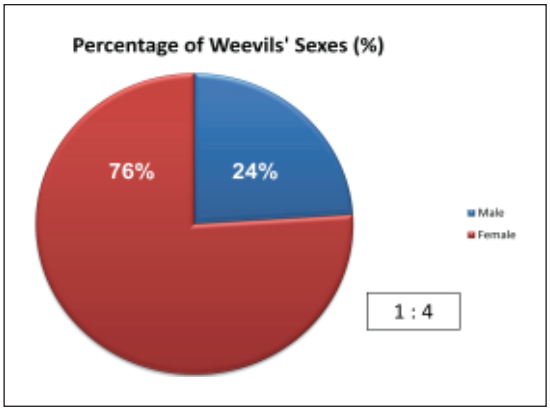

Figure 4. The overall ratio and percentage of weevil's sexes of RPW captured in the study period.

Table 1. The ratio of male and female RPW captured in each treatment used.

Number	Synthetic food baits	Code	Male	Female
1	Control	C	0.29	0.71
2	Ethyl acetate	E1	0.29	0.71
3	Ethylene glycol	E2	0.19	0.81
4	Ethanol	E3	0.08	0.92

to Kaakeh *et al.,* (2000), the numbers of female captured higher might be due to female needs to find food source for their young. This finding might helps in reducing the spreading of RPW as the females lay hundreds of eggs at one time that contributed to higher infestations.

CONCLUSION

From the study, ethylene glycol is the most effective synthetic food bait treatment to be used. Therefore, it is suggested to use ethylene glycol as the 'magnet weevil' rather than ethyl acetate, based on the RPW catches, higher viscosity, low-volatility liquid and less evaporated factor. The experiment also shows that the synthetic food bait is more long-lasting in approximately for two months in field compared to the natural food bait which need frequent replacements (current in seven days) for trapping efficacy.

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