Factors affecting the efficacy of ethyl acetate in the red palm weevil aggregation pheromone traps

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ABSTRACT

The aggregation pheromone trap is the cornerstone in any Integrated Pest Management Program for the red palm weevil, Rhynchophorus ferrugineus Olivier. Ethyl acetate is one of the important components of this technique; the effectiveness of the ethyl acetate is affected by many factors, such as trap color and date fruit quantity. The results of field trials conducted on date plantations in Al-Rahba (UAE) during May 2005- April 2006, showed that the number of RPW captures in yellow traps were,7.1, 8.4, 8.7 and 9.8 weevils / trap / month when added 150, 250, 300 and 350 g of date palm fruits as a food baits compared by 11.6, 13.8, 14.9 and 15.9 weevils / trap / months for these four treatment with ethyl acetate respectively. The other results showed highly significant differences between the treatments with and without ethyl acetate. Capture rates were 11.8, 20.0, 20.6 and 22.7 weevils / trap / month for white, red, brown and black traps without ethyl acetate respectively compared by 22.3, 34.6, 36.0 and 39.7 weevils / trap / month for these four trap colors with ethyl acetate respectively during January2010-May 2011. It is recommended to use black bucket colored traps containing aggregation pheromone, 350g of date fruits, ethyl acetate and water. The traps should be served, allows and distributed in all date palm plantations all over the year.

Keywords: date fruit quantity, date palm, ethyl acetate, *Rhynchophorus ferrugineus*, pheromone traps, traps color.

INTRODUCTION

The Red Palm Weevil (RPW) *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) is one of the most destructive pests of date palm trees (*Phoenix dactylifera* L.) all over the Gulf Countries (Bokhari and Abuzuhairah, 1992; Gush 1997; Abraham *et al.,*1998; Al-Saoud and Ajlan 2013). Red palm weevil has caused severe damage to date palm trees, in several Middle Eastern countries (Abozuhairah *et al.,* 1996).The insect has caused up to 20% loss of these plantations in Asia and Middle East (Hussein *et al,* 2010). The pest found all over the year (Abraham *et al.,* 1998; Vidyasagar *et al.,* 2000a; Al-Saoud 2007) and the number of female superior numbers on the numbers of male (Abraham *et al.,* 1999; Faleiro and Rangnekar, 2000; Al-Saoud 2009a).

The pest is difficult to control in the early stage of attack because it is an internal tissue borer (Abraham *et al.,* 1998). Initial attempts to control red palm weevil in the Kingdom of Saudi Arabia with insecticides were not successful (Bokhari and Abozuhairah,1992). The Integrated Pest Management (IPM) strategy, modeled on the lines of tackling the pest on coconut in India was implemented in the kingdom of Saudi Arabia, and has successfully suppressed the pest in the date plantations (Abraham *et al.,* 1998). The aggregation pheromone traps has been used successfully monitoring and mass trapping the pest, and is considers the corner stone in any Integrated Pest Programme (Abozuhairah *et al.,* 1996; Perez *et al.,* 1996; Faleiro *et al.,* 1998; Vidyasagar *et al.,* 2000b; Abraham *et al.,* 2000; Al-Saoud, 2011a, Al-Saoud, 2013). The pheromone attracts both male and female weevils (Oehlschlager, 1998; Faleiro, 2000; Abraham *et al.,* 2001; Faleiro *et al.,* 2002; Oehlschlager *et al.,* 2002; Al-Saoud *et al.,* 2010; Al-Saoud and Ajlan, 2013).

The trap effectiveness is affected with many factors, colors (Hallett *et al.,* 1999; Al-Saoud *et al.,* 2010; Al-Saoud, 2013)

trap contents(Al-Saoud, 2009a), food bait, (Nair *et al.,* 2000; Al-Saoud, 2011a) and trap sites (Faleiro, 2005; Al-Saoud, 2011b). The addition of Ethyl acetate (EA) to the aggregation pheromone traps significantly affects on the number of cached weevils and increases the effectiveness of the traps, (Al-Saoud, 2009b; Al-Saoud, 2010; Tigila *et al.,* 1998). The ethyl acetate effectiveness is affected with many factors, trap colors (Al-Saoud, 2013), food bait quantity (Al-Saoud, 2009b) The aim of the study was to evaluate the effect of date fruit quantities and trap colors on the effectiveness of ethyl acetate on red palm weevil aggregation pheromone traps

MATERIALS AND METHODS

1. Study sites

The experiments were conducted in RPW infested date plantations at Al-Rahba, Abu Dhabi (Lat. 24º 28´ N; Long. 54º 22´ E), UAE.

2. Traps and treatments

Pheromone traps were fabricated by using a10-Litre polypropylene bucket with four rectangular (3 x 7cm) windows cut equidistantly below the upper rim of the bucket. The bucket was covered with a lid that had four windows similar to the ones on its sides. The outer surface of the bucket was rough with small projection (1-2 mm) to help the weevils climb to the trap and enter.The upper surface of the lid had a small handle to ease opening the trap and the lower side had a small knob to which a wire was fixed to hold the pheromone and ethyl acetate (EA) dispensers. Each trap contained the following materials: (i) dispenser of the RPW male aggregation pheromone (Ferrolure ™) (4-Methyl-5-Nonanol 90% + 4-Methyl-5-Nonanone 10%) at 95% purity. (ii) 4- 5 Liter of water, with a water level inside the bucket of 2-3 cm below the windows. Water in the traps was replenished so as to keep sufficient moisture. The perforated ladle was used to collect the trapped weevils and to shaken well the traps contents, to prevent growth of any fungi/mould, collection and recorded the weevils captured (male, female), weekly Every trap was shifted to next location after taking weekly results, to avoid location effect on collected insects as recommended by (Faleiro *et al.,* 2002; Al-Saoud, 2006; Al-Saoud, 2010). Water in the traps was replenished so as to keep sufficient moisture.

3. Experimental design and statistical analysis

The experimental design was a randomized complete block design. A distance of 50m was maintained between two treatments (Traps).The data were subjected to analysis of variance (ANOVA) and the means were separated using Least Significant Difference LSD 5% test.

The experimental period, treatments and other trap contents differ according the aim of the each study and were as following:

1-Effect of date frit quantities on the ethyl acetate effectiveens in red palm weevil pheromone traps.

The experiment was done during May 2005 to April 2006, using yellow traps which common used in UAE. The experimental design was a randomized complete block design with four replicates (4 date palm farms) and nine treatments (I- Ethyl acetate +150 g date fruits, ii- Ethyl acetate +250 g date fruits, iii- Ethyl acetate +300 g date fruits, iv- Ethyl acetate + 350 g date fruits, v- 150 g date fruits, vi- 250 g date fruits, vii- 300 g date fruits, viii- 350 g date fruits, ix- Ethyl acetate). The trap were 3-4 m distance from palm trees, they were fixed in hole of 12-15 cm depth in the sand, part of the trap was covered by sand to fix it in safe place, and to avoid trap turning upside-down by wind, animals or any other external factors. Each treatment had dispenser of the RPW male aggregation pheromone (Ferrolure ™) contains 400 mg of active ingredients.

Food bait (dates) was changed once, and the each 20 days. The new pheromone lure was added every 3 weeks, while the new ethyl acetate desponser (Weeil Magent™) containing 40 ml of the active ingredent of EA was added every 45 days during the warmmer months(May – September) and every tow months during the cold period(October- April) to susain the trapping efficiency.

2-Effect of red palm weevil aggregation pheromone trap colors on the effectiveens of ethyl acetate.

The experiment was done during January 2010 to May 2011, with five replicates (5 date palm farms) and eight treatments: (i)-Red colour trap+ Ethyl acetate, (ii)-White colour trap+ Ethyl acetate.(iii)-Black colour trap+ Ethyl acetate.(iv)-Brown colour trap + Ethyl acetate.(v)-Red colour trap without ethyl acetate.(vi)-White colour trap without ethyl acetate. (vii)-Black colour without ethyl acetate.(viii)-Brown colour trap without ethyl acetate, and five replicates (5 date palm farms), where each farm constituted a single replication. All the experimental sites had the above eight treatments and serial numbers were assigned to all traps (1 to 8) at each of the five test farms. Traps were set at ground level, beside the trunk. Each trap contains, (i)- dispenser of the RPW male aggregation pheromone (Ferrolure ™) contains 700 mg of active ingredients. (ii)-350 g date fruits as recommended by (Al-Saoud 2009a) and (iii)-4-5 Liter waters.

Food bait (dates) was changed once a month while the new pheromone lure was added every 45 days during the cold period (October -April) and every month during warmer months (May-September), while the new ethyl acetate desponser (Weeil Magent™) containing 40 ml of the active ingredent of EA was added every month

during the warmmer months(May – September) and every 45 days during the cold period(October- April).

The choice of trap colors in this trial was based on our previous experience where it was seen that superior captures were recorded in red color traps as compared to traps with lighter color shades (Al-Saoud *et al.,* 2010). Hence, we selected red, black and brown colored traps for this study along with the commonly used white (control) color RPW pheromone traps in UAE.

RESULTS

1-Results of study during May 2005 to April 2006:

The weevils were found all over the months of the study in the date palm plantation area in Al-Rahba, Fig. (1). Tthe number of catch weevils/trap/month was differing from month to month. The rate of catches were (5.6, 5.1, 5.4, 5.6, 4.7, 5.3, 13.8, 6.4, 6.7, 14.6, 27.6 and 23.8, weevils/ trap / month), during the period May 2005 to April 2006 respectively. The highest catch (27.6 and 23.8 weevils/ trap) were recorded in March and April, 2006 respectively, and the lowest catch (5.1, 5.4, 4.7 and 5.3, weevils/ trap) were recorded in June, July, September and October 2005 respectively. The numbers of female weevils dominated in the captures in the traps at all months of the study, Fig (1). The sex ratio (Males: Females) ranged between 1: 1.21 in June 2005 to 1: 2.39 in April 2006 with overall mean of 1: 1.95.

The results in Table (1) indicate that there were significant difference between the date fruit quantities in the RPW traps ($F=5.3$, $df=9$, $p<0.005$). The numbers of catches were, 897, 1066, 1130 and 1231 weevils with cached rates of 9.3, 11.1, 11.5 and 12.8 weevils/trap/ month for the traps baited with, 150g, 250 g, 300g and 350 g of date fruits respectively. The mean of RPW captures in the traps baited with 350 g of date fruits dominated over the mean of RPW captures in the traps baited with 150 g date fruits. The percentage increase in weevil captures by the 250, 300 and 350 g date fruit quantities over the 150 g date fruits in the trap were 18.8, 25.9 and 37.2% for these three date fruit quantities respectively, Table(1).

The results in Table (2) show that there were significant differences between the mean of RPW captured in the traps charged with EA and the traps without EA ($F=28$, $df=24$, $p<0.005$). The rate of captures were 7.1, 8.4, 8.7 and 9.8 weevils/ trap/ month, in the traps bitted with 150, 250, 300 and 350 g of date fruits compared by 11.6, 13.8, 14.9 and 15.9 weevils / trap / month for these four treatments charged with ethyl acetate respectively. The percentage increase in weevil captures by the traps charged with EA over the mean of captured weevils in the traps without EA were, 63.4, 64.3, 71.3 and 62.2%, for the traps baited with 150g, 250 g, 300 g and 350 g of date fruit quantities respectively, Table(2).There were no significant difference between the means of captured weevils with the treatments charged with ethyl acetate and, 350 g, 300g and 250 g of food baits, and these three treatments dominated on the traps without ethyl acetate. All treatments dominated on the traps without date fruits (Pheromone and ethyl acetate) which recorded the lowest rate of captures (3.5 weevils / trap / month).

The results in Fig.(2) Show that the RPW pheromone traps charged with EA recorded the highest rates of captured weevils during all the months of the study. The traps charged with EA captured 4324 RPW, with capture rate of 14.1 weevils / trap / month compared by traps without EA, which captured 2693 RPW, with capture rate of 8.5 weevils / trap / month. The percentage of RPW captured were 62.3% and 37.6% for the traps with EA and the traps without EA respectively.

2-Results of study during January 2010 to May 2011:

The results in Fig (3) show that the red palm weevils were found all over the months of the study in the date palm area in Al-Rahba (UAE) during January 2010 to May 2011. The number of catch was differing from month to month. The rate of catches were (11.2, 20.8, 44.6, 47.5, 28.0, 23.2, 21.8, 11.0, 7.2, 8.9, 8.5, 8.7, 19.5, 31.5, 67.9, 57. and 24.4, weevils/ trap / month), during the period January 2010 to May 2011 respectively. The highest catch (67.9 and 57.2 weevils/ trap) were recorded in the months of March and April, 2011 respectively, and the lowest catch (7.2, 8.9, 8.5 and 8.7, weevils/ trap) were recorded in the months of September, October, November and December 2010 respectively. The numbers of female weevils dominated in the captured weevils in the traps at all months of the study, Fig (3).The sex ratio (Males: Females) ranged between 1: 1.8 in June 2010 to 1: 4.6 in October 2010 with overall mean of 1: 2.1.

The results in Table (3) show that there were differences between the mean of catch weevils in different trap colors ($F=87.6$, $df=12$, $p<0.005$). The numbers of cached weevils were 30.8, 28.6, 27.4 and 17.1 weevils/trap/ month for black, brown, red and white traps respectively. The analysis results showed that the all three colors superior as white (control) and the black traps superior on the brown and red traps, no significant differences were found between the mean of cached in brown and red trap. The percentage of collection weevils were 29.6%, 27.6%, 26.4% and 16.4% for black, brown, red and white traps respectively.

The results in (Table 4) show that there were significant differences between the mean of RPW captured in traps charged with EA and the traps without EA, ($F=102$, $df=28$,

p<0.005) . The captures rate were 22.7, 20.6, 20.0 and 11.8 weevils / trap / month for black, brown, red and white traps without EA compared with 38.9, 36.6, 34.8 and 22.3 weevils / trap / month for these 4 trap colors without EA. The black traps charged with EA recorded the highest weevil captures of 38.9 weevils / trap / month, while the white trap without EA recorded the lowest captures of 11.8 weevils / trap / month. The captured rates were 18.8 and 33.2 weevils / trap / month for the traps without EA and the traps with EA respectively.

The results revealed that the total number of catch weevils were 17672 where as male is 5707 and female is 11965 with sex ratio: 1:2.1.

DISCUSSION

The results show that red palm weevil is presented all over the year in date palm plantations in UAE during all years of study, reproduce and increase the infestation severity. Similar results were found by (Abraham *et al.,* 1999; Vidhyasagar *et al.,* 2000b; Al-Saoud and Ajlan, 2013). The peak of activity was in March and April, during all years of study, it may be due to favorable environmental conditions and smell of date palm trees flowers. The lowest activity was in September, October 2005, Fig. (1) and during September, October, November and December 2010,Fig. (3), while in Saudi Arabia, (Abraham *et al.,* 1999) found high weevil's activity in April to November, 1995, but in 1996 he got two peaks of activity, one in May to June and the other in October. But in 1997, the two peaks were found in May and September. The overall sex ratio (Males: Females) of the red palm weevil caught in the pheromone traps was 1:1.95 during May 2005 to April 2006 and 1: 1.2 during January 2010 to May 2011, which differs from the results of Abraham *et al*.(1999), who reported a sex ratio 1: 2.68 in favor of females. Al-Saoud (2007), Al-Saoud (2009b) found that the sex ratio of RPW ranged was 1: 1.33 to 1: 2.28. During May 2005to April 2006, and January 2010 to May 2011 periods, the highest red palm weevils were captured during the March and April which is moderate and date palm trees flowering period, in United Arab emirates. The lowest captures occurred during the wormer and colder months, Fig (1 and 3). The EA and date fruits quantity play an important role in the RPW baited pheromone traps, and the captured weevils increase when are the important components (Red palm weevil aggregation pheromone, date fruits, ethyl acetate and water) are combined together.

The results show that the traps charged with EA captured more RPW all over the months of the study, (Fig. 2 and 4). Similar results were found by (Sebay, 2003; Oehlschlager, 2005; Abdullah and Al-Khatr, 2005; Abdullah *et al.,* 2008; Al-Saoud, 2009b; Al-Saoud, 2013). The date fruit quantities and trap colors affect on the effectiveness of EA (Table, 2 and Table 4).The same result was obtained by Abdallah1 and Al-Khatri (2005) in Sultanate of Oman. (Al-Saoud *et al.,* 2010), in the UAE., found that red trap color is more effective than white color to catch the weevil, which recorded the lowest captures, and it was commonly used in UAE. While Kalleshwaraswamy and Jagadish, (2006) results revealed that there were no significant differences in capture rates between red, blue, green, yellow and white traps in India.

Therefore this study reveals that the red palm weevil pheromone traps are those black- colored baited with, red palm weevil aggregation pheromone (contains 700 mg active ingredients), 350 g of fermented date fruits, ethyl acetate and 4-5 L of water captured more weevils during January 2010 to May 2011. These results are similar with Hallett *et al.,* (1999) who recorded the higher weevil captures in black traps compared with the white traps. Furthermore, trap color is known to influence the efficacy of red palm weevil pheromone traps (Kirk, 1984; Hallett *et al.,* 1999; Ajlan and Abdulsalam, 2000; Sansano *et al.,* 2008; Anonymous, 2009; Al-Saoud *et al.,* 2010; Al-Saoud 2013). Ajlan and Abdulsalm (2000) found that the green traps captured more RPW compared with white and yellow traps. Abdallah and Al-Khatri (2005) recorded that the red trap color captures more RPW compared by other trap colors. Sansano *et al.,* (2008) reported that the brown-reddish colored traps recorded the height red palm weevil captures in Spain. Al-Saoud *et al.,* (2010) found that dark- colored traps, in general and red colored ones, recorded more captured weevils compared with white, yellow, pink, orange and blue colored traps in UAE. Al-Saoud (2013) reported that the black traps capture more RPW compared by the brown, red and white traps. These results lead us to use the dark RPW traps colors in particular, black colors contains, 350g of date fruits, 4-5 liter of water, EA and RPW aggregation pheromone in all the highly infested areas in date palm plantation all over the year. Using these traps during the active periods (March to June) in UAE, and use the RPW baited pheromone traps without EA in other areas because the EA is highly volatile, it would increase the cost of the trapping programme. The maintenance of traps is very necessary and replenished the water, change the bait and water monthly and adds new pheromone and EA according the environmental conditions.

Literature Cited

Abdallah s., Al-Abbad A. H., Munhim D. A., Abdallah Ben A. and Faleiro J. R. 2008. Enhancing trapping efficiency of red palm weevil pheromone traps with ethyl acetate. *Indian Journal of Plant Protection* 36, 310-311.

Abdallah, F.F. and S.A. Al-Khatri. 2005. The effect of pheromone, kairomone and food bait on Attracting males and females of red palm weevil. *Egyptian Journal of Agricultural Research* 83, 169- 177.

Abraham,V. A., Al Shuaibi, M. A., Faleiro, J. R., Abozuhairah, R.A. and Vidyasagar, P. S. P. V. 1998. An integrated management approach for red palm weevil, *Rhynchophorus ferrugineus* Oliv. A key pest of date palm in the Middle East. *Agricultural Sci*. 3: 77-83.

Abraham, V.A., Faliero, J. R., Prem- Kumar. T. and M. A. A. Shuaibi. 1999. Sex ratio of weevil *Rhynchophorus ferrugineus* Oliv. captured from date plantations of Saudi Arabia using pheromone (Ferrolure)traps . *Indian. J. Entomol*.(India) . June 1999.Vol. 61(2): 201-204.

Abraham, V. A., Faleiro, J.R., Al-Shuaibi, M.A. and Prem Kumar, T. 2000. A strategy to manage red palm weevil *Rhynchophorus ferruginous* Oliv. In date palm *Phoenix dactylifera*. Its successful implementation in Al- Hassa, Kingdom of Saudi Arabia. *Pestology*, 24(12): 23-30.

Abraham, V. A., Faleiro, J.R., Al-Shuaibi, M.A. and Abdan, S. 2001. Status of pheromone trap captured female red palm weevil from date gardens of Saudi Arabia. *Journal of Tropical Agriculture*, 39: 197-199.

Abuzuhairah, R.A., Vidayasagar, P.S.P.V., Abraham, V.A., 1996. Integrated pest management of red palm weevil *Rhynchophorus ferrugineus* Olivier. In date palm plantations of the Kingdom of Saudi Arabia. Proceedings, XX International Congress of Entomology, 1996. August 25-31; Firenze, Itality, 541 P.

Ajlan,A.M. and Abdulsalam,K.S. 2000. Efficiency of pheromone traps for controlling the red palm weevil *Rhynchophorus ferruginous* Olivier(Coleoptera: Curculionidae), under Saudi Arabia conditions. *Bull.Ent.Soc.Egypt.Econ.ser*.,27(109).

Al-Saoud, A.H. 2004. The role of aggregation pheromone in integrated control of red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) Pages 107-112 in Proceedings of the Date Palm Regional workshop on Ecosystem based IPM for Date Palm in the Gulf Countries UAE University, Al-Ain, UAE; 28-30 March,2004 (A. Zaid, Ed.).

Al-Saoud, A.H. 2006. Control of the red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera : Curculionidae) using aggregation pheromone. *Damascus University Journal for the Agricultural Sciences*. 22(1):147-164

Al- Saoud, A.H. 2007. Importance of date fruit in red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) aggregation pheromone traps. Pages 405- 413 in Proceedings of the Third International Date Palm Conference. Abu Dhabi, UAE. February 190-21.A.Zaid. V. Hegarty and H.H.S. AL Kaabi Ed.)

Al-Saoud, 2009a. Effect of red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera : Curculionidae) aggregation pheromone traps contains on the number of captures weevils. *Damascus University Journal for the Agricultural Sciences*. 25(1):151-175.

Al-Saoud, A.H. 2009b. The role of kairomone in red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) aggregation pheromone traps Contains on The Number of Capture Weevils. *Damascus University Journal of Agricultural Sciences*.2009. 25 (2):121- 134

Al-Saoud, A.H. 2010. Investment optimization of (RPW) *Rhynchophorus ferrugineus* Oliv. (Coleoptera: Curculionidae) aggregation pheromone traps in United Arab Emirates. Red Palm Weevil. The Challenge, 30-31 March 2010. Saudi Basic Industries Corporation (SABIC) Riyadh, Kingdom of Saudi Arabia.

Al-Saoud, A.H. 2011a. Comparative effectiveness of four baits in aggregation pheromone traps on red palm weevil l *Rhynchophorus ferrugineus* Olivier. *Arab Journal of Plant Protection*, 29: 83-89.

Al-Saoud.A.H.2011b. Effect of aggregation pheromone traps sites of red palm weevil *Rhynchophorous ferrugineus* Olivier (Coleoptera: Curculionidae) on the number of captured weevils. *Damascus University Journal of Agricultural Sciences* .27(2): 77-95.

Al-Saoud, A.H. 2013. Effect of ethyl acetate and trap colour on weevil captures in red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) pheromone traps. *International Journal of Tropical Insect Science* 33(3): 202-206.

Al-Saoud, A.H. and Aziz Ajlan. 2013. Effect of date fruits quantity on the numbers of red weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) captured in aggregation pheromone traps. *Agriculture and Biology Journal of North America* 4(4): 496-503.

Al-Saoud, A.H., M.A. Al-Deeb and A.K. Murchie. 2010. Effect of color on the trapping effectiveness of red palm weevil pheromone traps. *Journal of Entomology*, 7(1): 54-59.

Bokhari, U. G. and Abozuhairah, R. A. 1992. Diagnostic tests for red palm weevil. *Rhynchophorus ferrugineus* infestd date palm trees. *Arab Gulf J. Sci. Res*. 10(3): 93-104.

Faleiro, J. R., 2000. Investigation of the role of pheromone trapping in the suppression of red palm weevil *Rhynchophourus ferrugineus* Oliv. Population in Coconut plantations, International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century, New Delhi, India Feb. 14-18, 2000, pp 1338-1339.

Faleiro, J.R. 2004. Pheromone passed strategy for the management of red palm weevil in date palm and coconut agro-ecosystems: Implications, protocols and impact. Pages 45-57 in Proceedings of the Date Palm Regional workshop on Ecosystem Based IPM for Date Palm in the Gulf Countries UAE University, Al-Ain, UAE; 28-30 March,2004. (A. Zaid., Ed.).

Faleiro, J. R., Abraham, V. A. and Al- Shuaibi, M. A. 1998. Role of pheromone trapping in the management of Red Palm Weevil. *Indi*. *Coc*. *J*. 29(5): 1-3.

Faleiro, J. R. and Rangnekar, P.A. 2000. Sex ratio of pheromone trap captured red palm weevil *Rhynchophorus ferrugineus* Olivier in coconut gardens of Goa. Presented at the International Conference on Plantation Crops (PLACROSYM XIV) Hyderabad, India, 12-15, December, 2000. Session I Abstract 83.

Faleiro, J. R., Ashok Kumar J and Rangnekar, P.A. 2002. Spatial distribution of red palm weevil *Rhynchophorus ferrugineus* Olivier in coconut plantations. *Crop Protection* 21, 171-176.

Gush, H. 1997. Date with disaster. The Gulf Today. September 29.pp.16.

Hallett, R.H., Oehlschlager, A.C. and Borden, J.H. 1999. Pheromone trapping protocols for the Asian palm weevil, *Rhynchophorus ferrugineus* Oliv.(Coleoptera: Curculionidae). *International Journal of Pest Management* 45: 231-237.

Hallett R. H., Oehlschlager A. C. and borden J. H. 1999. Pheromone trapping protocols for the Asian palm weevil, *Rhynchophorus ferrugineus* Oliv.(Coleoptera: Curculionidae). *Internbational journal of Pest Management* 45, 231-237.

Hussein W. B.,Hussein M. A., Becker T. 2010 Detection of the red palm weevil, *Rhynchophorus ferrugineus* using its bioacoustics features. *Bioacoustics* 19, 177-194.

Kalleshwaraswamy, C. M. and Jagadish P. S. 2006. Standardization of food bait, height and color of the trap for attracting red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) using synthetic aggregation pheromone Lure. *Annals of Plant Protection Sciences*. 3: 7-9.

Kirk W. D. J. 1984.Ecologically selective colored traps. *Ecological Entomology* 9, 35-41.

Nair, S.S., Abraham, V.A. and Radhakrishnan Nair, C.P. 2000. Efficiency of different food baits in combination with pheromone lures in trapping adults of red weevil, *Rhynchophorus ferrugineus* Oliv. (Coleoptera: Curculionidae). *Pestology*, 24(6): 3-5.

Oehlschlacher, A.C. 1998. Trapping of the date palm weevil, FAO Workshop on date palm weevil (*Rhynchophoru ferrugineus)* and its control. Cairo, Egypt, December 15-17.

Oehlschlacher, A.C. 2005. Current status of trapping palm weevil and beetles. *Planter* 81, 123-143

Oehlschlager, A.C., Chinchilla, C., Castillo, G. and Gonzalez, L.M. 2002. Control of Red Ring Disease by Mass Trapping of *Rhynchophorus palmarum* (Coleoptera: Curculionidae), *Fla. Entom*. 85: 507-513.

Sansano Javaloyes M. P., Gomez Vives S., Ferry M. and Diaz Espejo G. 2008. Ensayos de campo para la mejora de la efecacia de las trampas de catura de *Rhynchophorus palmarum* Olivier. (Coleoptera: Dryophthoridae), picudo rojo de la palmera (Field trials for the improvement of the effectiveness of the trapping system of the red palm weevil, *Rhynchophorus palmarum* Olivier. (Coleoptera: Dryophthoridae). *Boletin de Sandad Vegetal-Plagas* 34, 135-145.

Sebay Y. 2003. Ecological studies on the red palm weevil, *Rhynchophorus palmarum* Oliv. (Coleoptera: Curculionidae) in Egypt. *Egyptian Journal of Agricultural Research* 81, 523-529.

Tiglia, E.A., Vilela, E.F., Moura, J.I.L. and Anjos, N. 1998. Efficacy of traps with aggregation pheromone and sugarcane to capture *Rhynchophourus palmarum* (L). *Anis da sociedade Entomologica do Brazil*. 27(2): 177-183.

Vidhyasagar, P. S. P. V., AL- Saihati, A.A., Al- Mohanna, O.E., Subbei,A.I. and Abdul Mohsin, A.M. 2000a. Management of Red Palm Weevil *Rhynchophorus ferrugineus* Olivier. A serious Pest of Date Palm in Al- Qatif, Kingdom of Saudi Arabia, *Journal of Plantation Crops*, 28(1): 35-43.

Vidhyasagar, P. S. P. V., Mohammed Hagi; Abozuhairah, R.A.; Omar E Al Mohanna and Ali A Al Saihati. 2000b. Impact of mass pheromone trapping on Red Palm Weevil: Adult population and infestation level in date palm gardens of Saudi Arabia. *The Planter, Kuala Lumpur*, 76(891): 347-355.

Tables:

Table.1. Effect of date fruit quantities on the number of red palm weevil captures / trap/ month at Al-Rahba(UAE) during May 2005 to April 2006.

Date fruit quantities in RPW trap	No. RPW Captured / 8 traps	Mean ±SE of red palm weevil Captures/trap/ month[1]	Percentage of increase [2]
150 g date fruits	897	9.3±1.3 [b]	---
250 g date fruits	1066	11.1±1.1 [ab]	(18.8)
300 g date fruits	1130	11.5±1.6 [a]	(25.9)
350 g date fruits	1231	12.8±0.9	(37.2)
Mean	1081	11.2±1.1	
LSD 5%		2.0	
F		5.6	

[1]Means with similar letters are not significant different at LSD 5% level.(ANOVA analysis)
[2]Values in parentheses are percentage increase in weevil captures in the traps baited with more than 150 g date fruits over the traps baited with 150 g date fruits.

Table.2. Effect of ethyl acetate and date quantities on the number of red palm weevil captures / trap/ month at Al-Rahba (UAE) during May 2005 to April 2006.

Date fruits quantity in RPW trap	Mean ±SE of red palm weevil captures/ trap[1]		% EA added increase 2
	With EA	Without EA	
150 g date fruits	11.6±1.1[bc]	07.1±1.6[e]	(63.4)
250 g date fruits	13.8±1.4[ab]	08.4.±0.8[de]	(64.3)
300 g date fruits	14.9±2.1[a]	08.7±1.0[de]	(71.3)
350 g date fruits	15.9±1.1[a]	09.8±0.7[ed]	(62.2)
Mean	14.1	08.5	
LSD 5%	2.3		
F	28**		

EA: Ethyl acetate
[1]Means with similar letters are not significant different at LSD 5% level.(ANOVA analysis)
[2]Values in parentheses are percentage increase in weevil captures in the traps charged with EA over the same treatment without EA.

Table 3. Effect of trap colors on the number of red palm weevil captures / trap/ month at Al-Rahba (UAE) during January 2010 to May 2011

RPW trap colors	No. RPW Captured / 10 traps	Mean ±SE of red palm weevil captures /trap[1]	% of increase [2]
Black traps	5286	30.8±3.0 [a]	(82.0)
Brown traps	4832	28.6±2.9 [b]	(66.4)
Red traps	4650	27.4±2.7 [b]	(60.1)

RPW trap colors	No. RPW Captured / 10 traps	Mean ±SE of red palm weevil captures /trap[1]	% of increase [2]
White traps	2904	17.1±2.3 [c]	-------
Mean	4418	26.0±2.7	
LSD 5%		2.0	
F		88.8**	

[1]Means with similar letters are not significant different at LSD 5% level.(ANOVA analysis)
[2]Values in parentheses are percentage increase in weevil captures over white traps.

Table4. Effect of trap colors and ethyl acetate on the number of red palm weevil captures / trap/ month at Al-Rahba(UAE) during January 2010 to May 2011

Trap color	Mean ±SE of red palm weevil captures/ trap[1]		% EA added increase 2
	With EA	Without EA	
Black traps	38.9±3.5 [a]	22.7±2.6 [c]	(74.9)
Brown traps	36.6±3.6 [ab]	20.6±2.1 [c]	(74.8)
Red traps	34.8±3.0 [b]	20.0±2.4 [c]	(73.0)
White traps	22.3±2.7 [c]	11.8±2.1[d]	(89.0)
Mean	33.2	18.8	
LSD 5%	2.7		
F	102**		

EA: Ethyl acetate
[1]Means with similar letters are not significant different at LSD 5% level. (ANOVA analysis)
[2]Values in parentheses are percentage increase in weevil captures in the traps charged with EA over the same traps without EA.

Figures

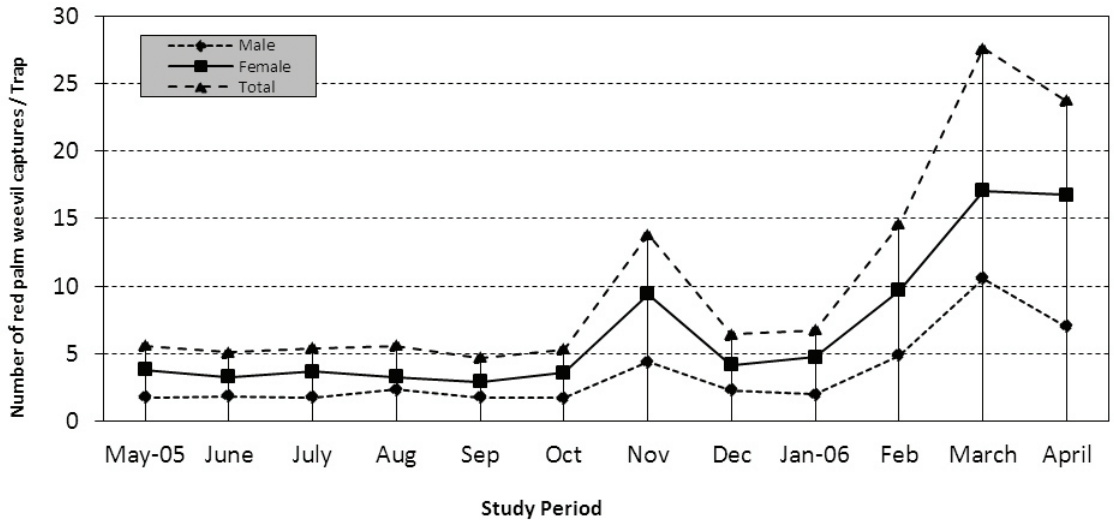

Fig.(1) Activity of red palm weevil, *Rhynchophorus ferrugineus* at Al-Rahba during May 2005 to April 2006

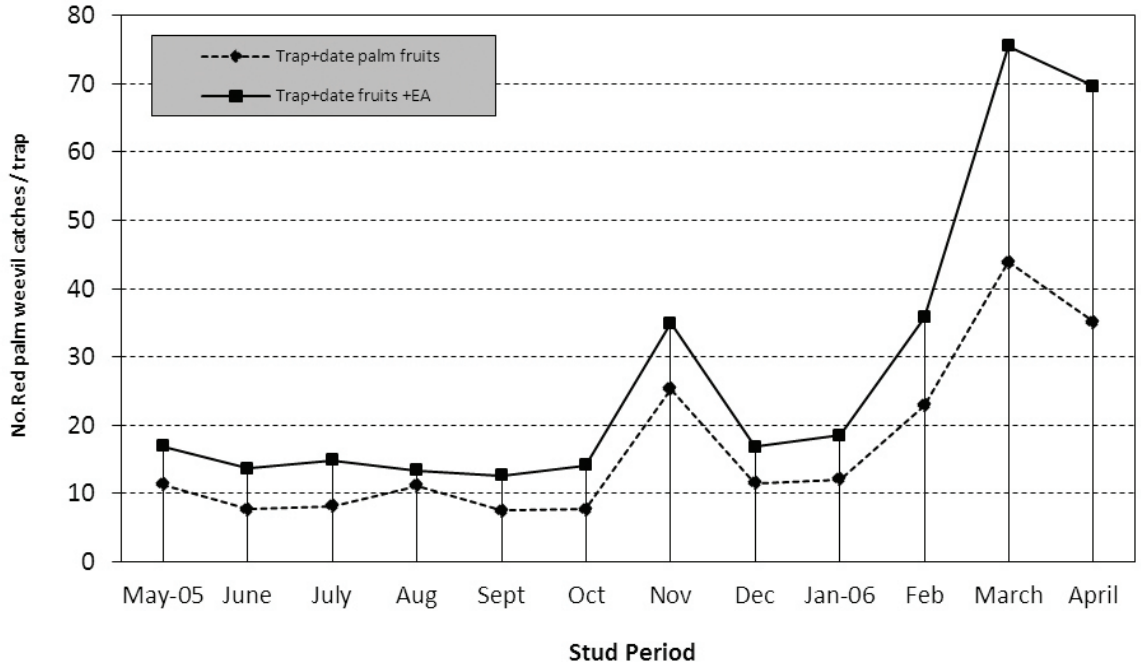

Fig. (2) Effect of ethyl acetate on the number of red palm weevil, *Rhynchophorus ferrugineus* captured in pheromone traps at Al-Rahba during May 2005 to April 2006

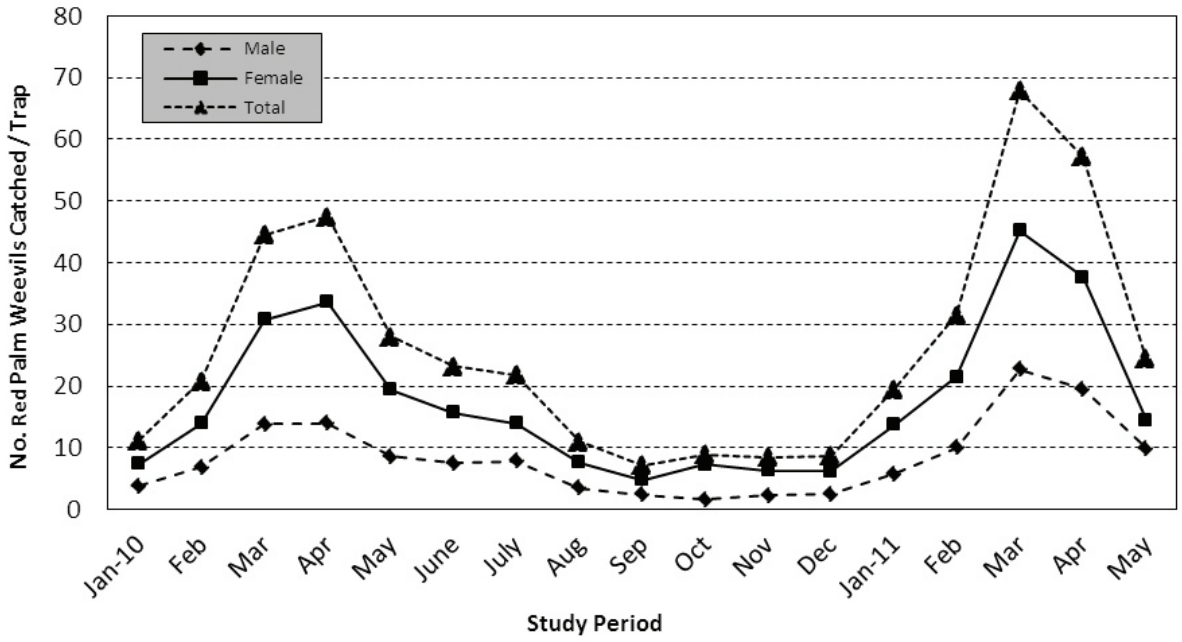

Fig. (3) Activity of red palm weevil, *Rhynchophorus ferrugineus* at Al-Rahba during January 2010 to May 2011.

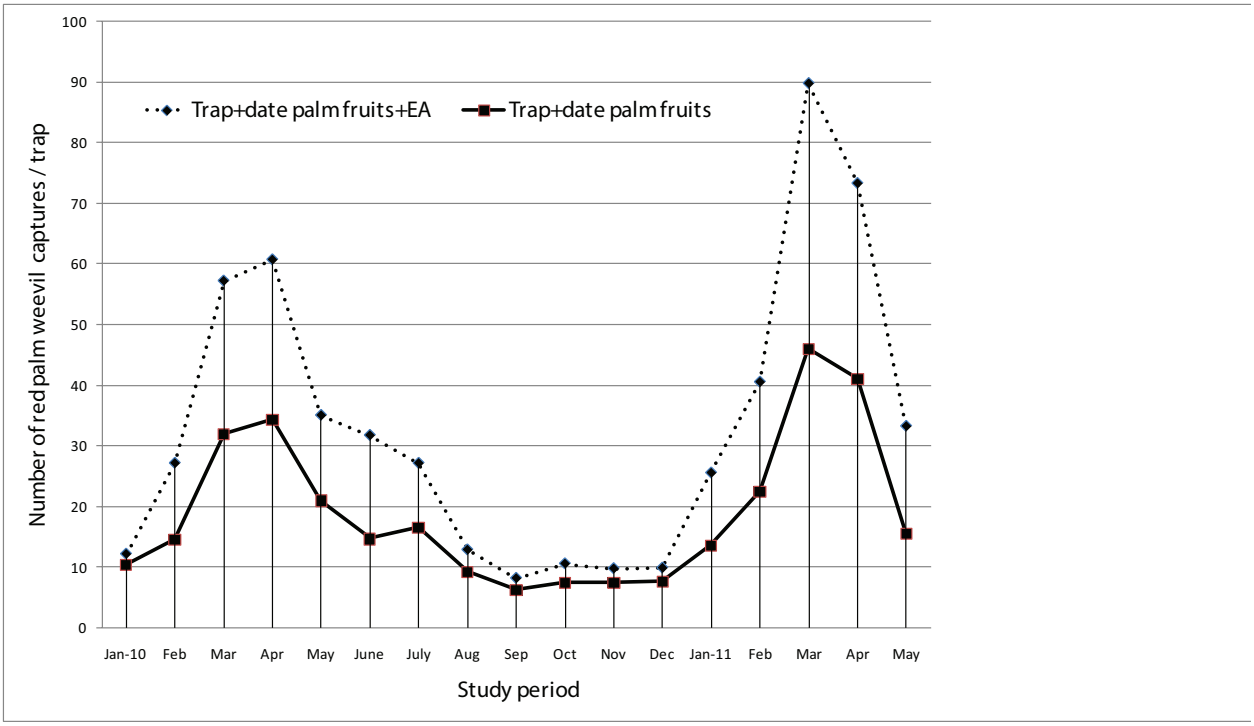

Fig. (4) Effect of ethyl acetate on the number of red palm weevil, *Rhynchophorus ferrugineus* captured in pheromone traps at Al-Rahba during January 2010 to May 2011