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MANAGEMENT OF THE RED PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUES* OLIV., BY A PHEROMONE/FOOD-BASED TRAPPING SYSTEM

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ABSTRACT

Tests were conducted to determine the feasibility and the effect of using pheromone/food-baited traps in a trapping system within a commercial date palm plantation on the spatial dynamics of the red palm weevil (*Rhynchophorus ferrugineus* Oliv.) (RPW). One registered pheromone lure (Ferrolure+ or called pheromone 7 in the test) and four experimental aggregation pheromone lures (called pheromone 5, 6, 8, and 9) were evaluated in ten farms from 1998 to 2000. The effect of trapping on the spatial patterns was based on the number of weevils caught per trap per specific period. Efficacy of various pheromones used was determined based on the number of weevils caught per trap per time period and the percentage of tree infestations. There was a variation in trap catches of the pheromone lures used during the growing seasons. Two major population peaks were noticed: the first peak started early-March and ended mid-May; the second peak started mid-September and ended late-December. The total number of infested trees was significantly decreased compared with the previous years where chemicals were used for the control of the weevil. The percentage reduction of infestation was 90.4, 90.9, and 100% for the treatments of pheromone lures 5, 8, and 7, respectively. The ability of the tested pheromones to capture more females than males in the traps makes trapping a potential tool for managing this economic insect. The release rate of the pheromone lures influenced the efficacy of the pheromone in attracting the adults. The results presented here are promising in utilizing pheromones-food baited traps for reducing RPW populations and protecting palm trees from RPW infestations within the field. If large-scale tests are desired, pheromones lures 5, 7, and 8 could be selected for further evaluation and/or commercial use.

Additional Index Words: *Rhynchophorus ferrugineus*, pheromone, trapping, date palm trees

INTRODUCTION

The red palm weevil (RPW), *Rhynchophorus ferrugineus* Oliv., (RPW) (Curculionidae: Coleoptera), is an economically important, tissue-boring pest of date palm in many parts of the world. The insect was first described in India as a serious pest of coconut palm (Lefroy, 1906) and later on date palm (Madan Mohan Lal, 1917; Buxton, 1918). The weevil was recorder later in Seri Lanka, Indonesia, Burma, Punjab, and Pakistan (Laskshmanan, 1972). Currently, the insect is a major pest of date palm in some of the Arabian Gulf States including Saudi Arabia, United Arab Emirates, Sultanate of Oman, and Egypt (Cox, 1993; Abraham et al. 1998). The agroclimatic conditions prevalent in this region and the unique morphology of the crop, coupled with intensive modern date palm farming, have offered the pest an ideal ecological habitat (Abraham et al., 1998).

Current strategies for management of *R. ferrugineus* infestations involve monthly surveys of all palms in infested regions. Infested palms are removed and infected parts are sectioned and buried. As a preventative measure all palms in infested areas are sprayed to run off with a variety of insecticides. Because of the environmental pollution and economic costs of continuous insecticide spraying, more environmentally and economically acceptable alternatives are being sought to aid in the management of this pest.

The recent discovery of the male-produced aggregation pheromone [ferrugineol, 4-methyl-5-nonanol] for *R. ferrugineus* (Hallett et al. 1993a, b) made the implementation of pheromone-based monitoring and trapping of this weevil possible for the management of this pest. Gunawardena and Bandarage (1995a) found that at a release rate of 0.38 mg synthetic ferrugineol/day from capillaries suspended in bucket traps filled with soap water, significantly caught more weevils compared to a control trap in the field They also found (1995b) that a combination of ferrugineol with 5 alcohols (n-propanol, n-butanol, n-pentanol, n-hexanol, and n-nonanol) were field-tested as baits. A significantly higher catch of 0.85 weevils/day/trap, was obtained with ferrugineol and n-pentanol. In a recent study, El-Garhy (1996) reported that catch rates were highest during the period from April to June (50-65 weevils), which corresponds to the warmer weather in Egypt. El-Ezaby *et al.* (1998) reported maximum catches in March and April.

Aggregation pheromones have been reported as effective tools for monitoring and trapping RPW in the field (Gunnawardena and Badarage, 1995a, b; El-Ezaby *et al*., 1998; El-Garhy, 1996). The objective of this study was to determine the feasibility and the effect of using pheromone-food baited traps in a pheromone trapping system within a commercial date palm plantation, in the United Arab Emirates, on the spatial dynamics of *R. ferrugineus*. Specific objectives were to (1) determine the seasonal variations of abundance of adults RPW and the effectiveness of pheromone-food baited traps for monitoring and controlling populations, (2) determine the effect of trapping on the level of infestation by RPW to date palm trees, and (3) determine the release rates of the tested pheromone lures.

MATERIALS AND METHODS

Pheromone Lures

Five aggregation pheromone lures were evaluated for RPW catch in the field (Figure 1). Lures were different in their components and thickness of their walls that affect the release rate, also differences in the % purity of the active ingredient. One registered commercially available pheromone lure was used under the trade name ferrolure+ or pheromone lures *Rhynchophorus ferrugineus* (ChemTica International Co., Costa Rica). The components of this pheromone lure are 4-methyl 1-5-nonanol (9 parts) + 4-methyl nonanone (1 part) - purity 99.9% + 0.1% colorant and 0.1% antioxidant. Ferrolure+ was compared with four other pheromone lures contained 4-methyl-5-nonanol (96.5% purity) with isomers (4S, 5S- = 30%, 4R, 5R- = 30%, 4R, 5S- = 20%, 4S, 5R- = 20%) (SciTech, Czech Republic and IPM Technologies, USA). In our study, ferrolure+ called pheromone 7 or pheromone control; the other four pheromone lures called pheromone 5, 6, 8, and 9. Pheromones 7 and 8 contained an attractant.

Figure 1. Various types of pheromone lures used for monitoring *R. ferrugineus*.

Components of the Pheromone-Food Baited Trap

The standard pheromone-food baited trap (figures 2 and 3) used in UAE farms consisted of (a) a 10 liter plastic bucket covered from the outside by a rough cloth to allow the adult weevils to crawl up easily on the trap to reach the inside through the openings, rather than falling down from the smooth surface of the bucket; the bucket had a four 2.5 x 6 openings for the entrance of the attracted adults, (b) Soft date fruits placed at the lower part of the bucket as baits, (c) a granular insecticide diazinon placed on the top of the date fruit to kill adults upon arrival, (d) a pheromone lure to be hanged from underneath of the bucket cover, and (e) a water to wet the insecticide, treated date fruits.

Figure 2. Components of the pheromone-food baited traps: (a) a plastic bucket covered with a rough cloth, (b) date fruit, (c) an insecticide, (d) pheromone lure, and (5) water.

a

b

Figure 3. Preparation of the pheromone-food baited traps. (a) adding an insecticide to the date fruit at the lower part of the plastic buckets, and (b) hanging the pheromone lure to the underneath of the bucket lid.

Trap maintenance was required during the experimental period. Traps were inspected weekly, during the experimental period, to replace the insecticide-treated dry date fruits and add water as needed.

Pheromone-food baited traps were placed on the ground with the lower half of the trap inserted in the ground between the date palm trees. Traps located at ground level captured significantly more weevils than those located at 1.7 m, and the latter captured significantly more weevils than traps located on poles at 3.1 m (Oehlschlager et al. 1993).

Figure 4. Placement of the pheromone-food baited trap between the date palm trees.

Field Study Sites

Experiments to evaluate five aggregation pheromone lures were carried out between March 1998 and May 1999. Ten commercial farms, in Al-Ain (UAE), were selected for the tests in which two farms were used to evaluate each of the five pheromone lures. Farms contained trees 7-15 year old. The distance between trees ranged from 4 to 6 m. Table 1 shows the total number of pheromone-food baited traps and the number of date palm trees for each pheromone treatment.

Table 1. Total number of traps for each pheromone lure, and the total number of date palm trees in the two farms used for each pheromone lure.

Pheromone Lure No.	Total No. of Farms	Total No. of Traps	Total No. of Trees
5	2	6	1148
6	2	6	1014
7 (control)	2	7	1187
8	2	8	1558
9	2	6	900

Effect of Trapping on Population Patterns and Level of Infestation

The effect of trapping on population spatial patterns was based on (1) the number of weevils caught per trap per specific period, and (2) the level of infestation that occurred during the experimental period. Traps were inspected weekly during the experimental period and the number of adults RPW were counted and collected. Trapped adults were identified as males or females and the ratio of female/male was determined. Date palm trees were inspected during the experimental period to determine if new infestations occurred. Pheromone lures in all traps were replaced monthly with new ones.

Pheromone release Rates

Because the release rate of a lure is considered one of the factors influencing the efficacy of the pheromone in attracting the adults, the lures of all pheromones evaluated in the tests were monitored for their release rates. Lures were placed in the traps (similar to the traps placed in the field) (n = 6). The weights of all lures were recorded before placing them in the traps, and every few days thereafter. The net weight of the pheromones in each lure type varied (pheromone 5 = 297 mg, pheromone 6 = 331 mg, pheromone 7 = 752 mg, pheromone 8 = 605 mg, and pheromone 9 = 328 mg). The percent loss of the pheromone in the dispenser was calculated.

Figure 5. Weekly inspection of the pheromone-food baited traps for counting the number of adults RPW.

RESULTS AND DISCUSSION

Seasonal Variations of Abundance of RPW

Figure 6 shows a fluctuation of RPW population, during the growing season, as indicated by trap catches of five pheromone lures used. This fluctuation can also be noted between each week of each month. There were two population peaks during 1998 tests (March to December 1998): the first major peak started from early-March and ended mid-May (with a small peak from mid-May to mid-July). The highest trap catch during this period was 8 adults per trap for pheromone 7 on 31 March, 6.3 adults per trap for pheromone 5 on 14 April, and 3.6 adults per trap for pheromone 6 on 24 March. The second major peak (which was smaller than the first major peak) started from mid-September and ended late-December, 1998. The highest trap catch during this period was on 10 October, where 5 adults were caught per trap for pheromone 7, 3.5 adults per trap for pheromone 5, 3 adults per trap for pheromone 6, and 2 adults per trap for pheromones 8 and 9. Results for the high capture rates during the first peak agree with those reported by El-Garhy (1996) and El-Ezaby (1998). El-Garhy (1996) reported that the high catch rates during the period from April to June probably due to the emergence of broods whose development was slowed by the cooler winter months.

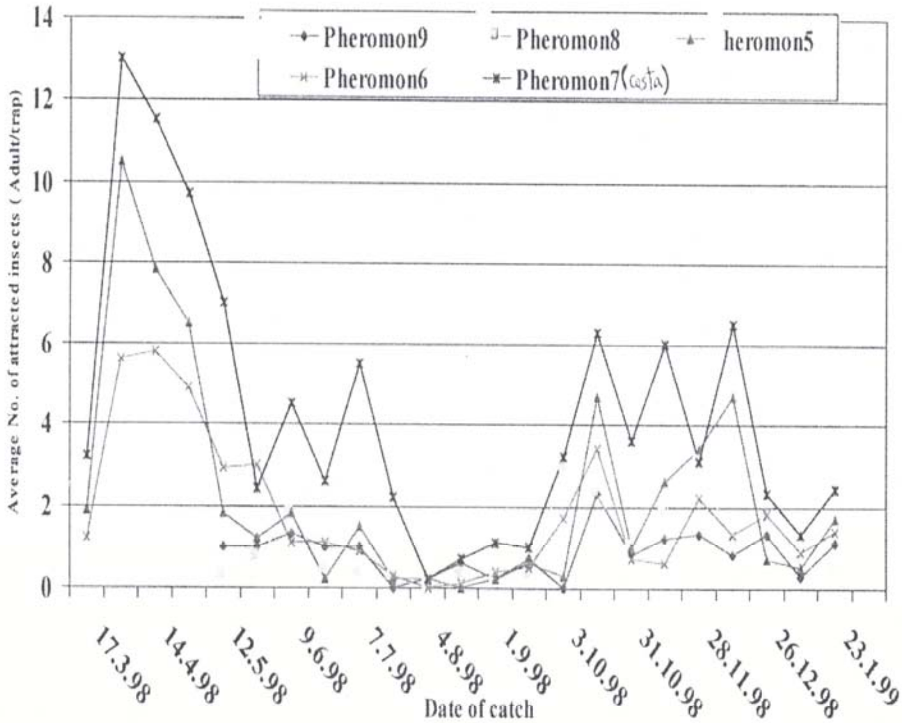

Figure 6. Average number of adults of *R. ferrugineus* caught per pheromone traps

Fluctuations in the average minimum and maximum temperature and percent humidity during the tests were recorded. Trap catch during March, April, and early-May was higher than those recorded during June and July; the temperature at the first period was lower. The very low numbers of weevils were caught during July, August, and September where very high temperatures were recorded. Trap catch increased from mid-September where average maximum temperature was less than 40C.

Effect of Trapping on the Level of Infestation

The level of infestation prior to the initiation of the tests and during the pheromone trials is reported in Figures 7 and 8. The total number of infested date palm trees in the ten farms used for our pheromone trials was significantly decreased compared with the previous years where chemicals were used for RPW control. Figure 7 shows a comparison of the pheromones 5, 6, and 7 (evaluation from March 1998 to March 1999). The number of infested trees reported for 1987 season (i.e., one year before stating the pheromone trials) was 21, 13, and 7 trees for treatments of pheromone 5, 6, and 7, respectively. The number of infested trees during pheromone trial period was 2, 10, and 0 trees for treatments of pheromone 5, 6, and 7, respectively. This corresponds to a percentage reduction of infestation equal to 90.4, 23.1, and 100%, respectively. The average number of adult weevils per trap per month was 65.2, 48.5, and 112.0 adults for the treatments of pheromone 5, 6, and 7, respectively.

Figure 8 shows a comparison of the pheromones 8, 9, and 7 (evaluation started June 1998). The number of infested trees reported for 1987 season (i.e., one year before stating the pheromone trials) was 11, 2, and 5 trees for treatments of pheromone 8, 9, and 7, respectively. The number of infested trees during pheromone trial period was 1, 2, and 0 trees for treatments of pheromone 8, 9, and 7, respectively. This corresponds to a percentage reduction of infestation equal to 90.9, 0, and 100%, respectively. The average number of adult weevils per trap per month was 23.6, 18.7, and 65.2 adults for the treatments of pheromone 8, 9, and 7, respectively.

The overall performance of pheromone dispensers was very good (especially if we correlate the trap catch with the level of new infestations occurred in the farms during the pheromone trial period). The performance of the RPW dispensers (in order), based on trap catch data after one year of

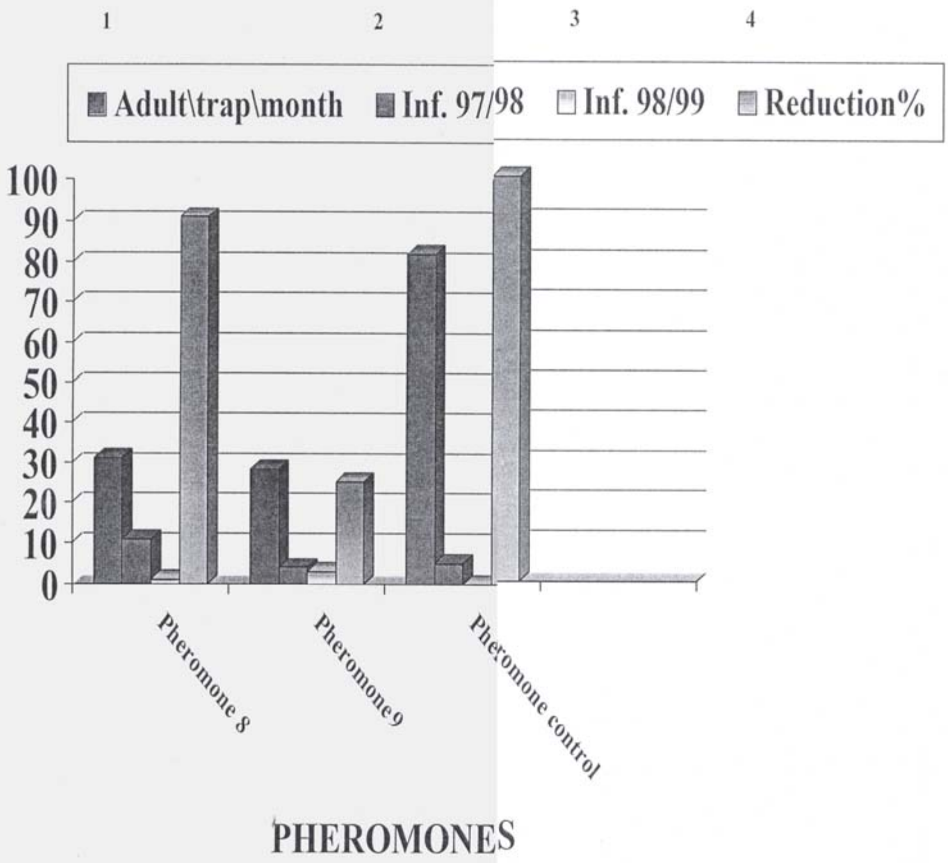

Figure 8. Relationship between No. of insects (DPW) attracted to different aggregation pheromone traps (lures numbered 7 [or control], 8, and 9) and % of infestation from June 1998 to September 1999 .

1 2 3 4

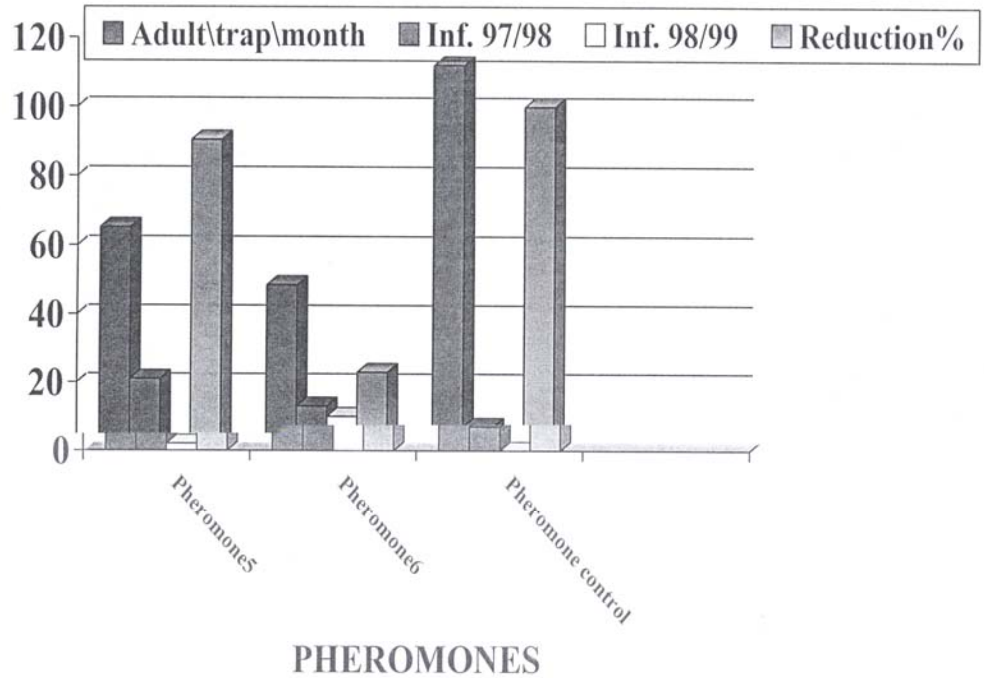

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Figure 7: Relationship between the number of RPW attracted to different aggregation pheromone traps (lures numbered 5, 6, and 7 [or control]) and percentage of infestation from March 1998 to March 1999.

trapping, was pheromone 7, 8=5, 6, and then 9. In addition, pheromones 7, 5, and 8 protected palm trees from infestations during the pheromone trials period, with one or two infestations reported for treatments of pheromones 5 and 8.

Sex differences in trap catch were noticed. Both sexes were attracted to traps, but the number of females captured in the traps was higher than male weevils (Table 2). Female: Male ratios were 1.5 for the pheromone lures 5, 6, and 7 evaluated during the first population peak. The sex ratio during the second population peak was 2.8 for pheromone 5 and pheromone 6.0, 1.9 for pheromone 7, and 2.2 for both pheromones 8 and 9. El-Garhy (1996) reported that twice as many female as male weevils were captured. The higher number of females than males in the traps may be due to that females may disperse more than males in order to find a suitable food source for their progeny. Also, the aggregation pheromone released from males may have attracted females more than males. The ability of the tested pheromones to capture more females than males in the traps makes trapping a potential tool for managing this economic insect.

Table 2. Total trap catches of females and males during the two population peaks (first peak period: from March 3 to May 19; second peak period: from September 19 to December 19).

First Peak Pheromone Lure No.	Female	Males	Ratio (F/M)	Second Peak Females	Males	Ratio (F/M)
5106	70	1.51	75	27	2.8	
6	108	71	1.52	61	22	2.8
7	163	109	1.50	122	64	1.9
8	-	-	-	62	28	2.2
9	-	-	-	31	14	2.2

F/M = females/males ratio

Pheromone Release Rates

The release rates of the five pheromone lures (regardless of initial weight of each pheromone in the lures) during the 32 days of hot weather, from May 23 to June 24 of 1998, are shown in Figure 9. The average minimum temperature during this period was 27.3ºC, average maximum temperature was 43.5ºC, the average minimum humidity was 15.8% and the average maximum humidity was 52.1%. A complete release (100%) of the pheromone from the lures was noted after 7 days for pheromone 5 (42.5 mg/day; too fast) and 7 days for pheromone 6 (47.0 mg/day), 22 days for pheromone 7 (34.0 mg/day) and 22 days for pheromone 8 (27.5 mg/day), and 32 days for pheromone 9 (10.2 mg/day). The time period needed for a complete release of pheromone 8 was similar to that of pheromone 7, the amount of pheromone released per day was higher for pheromone 7 (34.0 mg/day) compared with those of pheromone 8 (27.5 mg/day). The best lures used, based on the release rate was pheromone 9 with 10.2 mg released per day.

Figure 10 shows the release rates of the five pheromone lures during 73 days of cool weather, from November 25 of 1998 to February 6 of 1999. Release rates slowed during the cooler days. During this period, the average minimum temperature was 17.3ºC, average maximum temperature was 30.0ºC, the average minimum humidity was 18.5% and the average maximum humidity was 88.0%. Pheromones from all lures were not released completely after 73 days. Only 9% of the pheromones was released from pheromone 9 (0.44 mg/day; too slow during this cool weather), 40% from pheromone 7 (4.0 mg/day), 60% from pheromone 6 (2.8 mg/day), 75% from pheromone 5 (4.4 mg/day), and 85% from pheromone 8 (7.0 mg/day).

The use of pheromones in monitoring and controlling RPW populations has become an important tool for managing this pest (Kaakeh *et al.*, 2001). The factors that influence the ability of pheromone-food baited traps to monitor populations of RPW include the following: dose, ratio, and release rate of the pheromone blend from the lure (Jansson *et al.*, 1990; Sanders, 1992; Pfeiffer *et al.*, 1993a, b), effectiveness of the blend at a variety of population densities (Sanders 1992), lure type (Sanders and Meighen 1987), species specificity of the pheromone blend (McLaughlin and Heath, 1989), longevity of the lure over the trapping period (Jansson *et al*. 1990), trap position or location (Howell et al., 1990; Oehlschlager *et al.*, 1993), trap color (Oehlschlager *et al*., 1993), trap density (Houseweart *et al*. 1981, Oehlschlager *et al*., 1993), repellency of killing agents or dead insects within the trap (Sanders 1986), the effect of weather on trap catch (Pitcarin *et al*., 1990) and ease of management and cost of monitoring (Sanders 1992).

Av. Min. Temp. = 27.3 C Av. Max. Temp. = 43.5 C
Av. Min. Hum. = 15.8% Av. Max. Hum. = 52.1%

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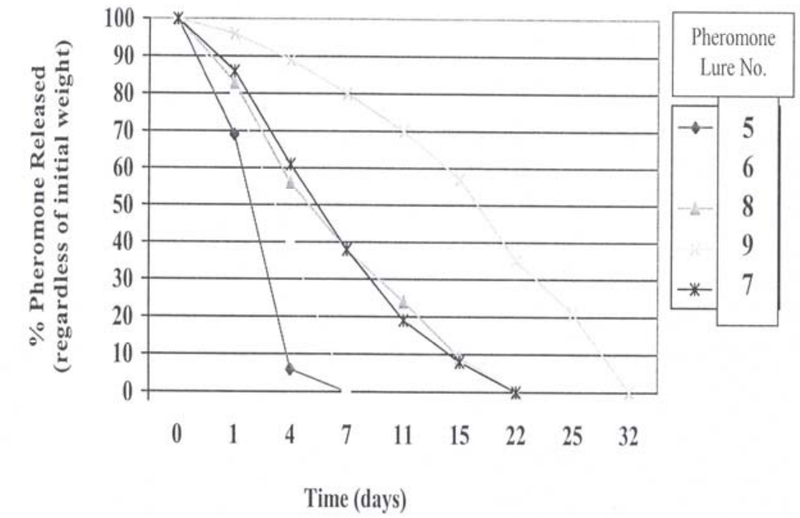

Figure 9 . Release rates of the pheromone lures from 23 May to 24 June, 1988

Av. Min. Temp = 17.3 C Av. Max. Temp = 30.0 C
Av. Min. Hum. = 18.5% Av. Max. Hum. = 88.0%

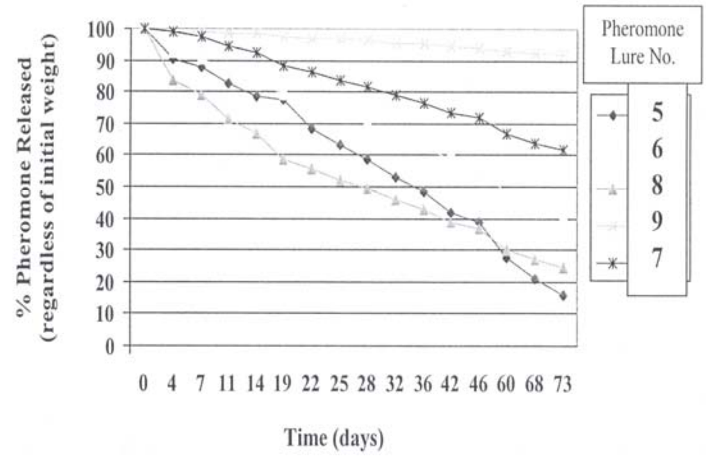

Figure 10. Release rates of pheromone lures from 25 November, 1988 to 6 February, 1999.

There are several benefits for using the pheromone-food trapping system (Kaakeh 2000): (1) monitoring traps indicate where RPW populations are highest, (2) mass trapping can intercept invading weevils from abandoned farms and, in turn, can lower the risk of new infestation from these weevil hot spots, and (3) efficient trapping can be a substitute for insecticide control during fruit maturation and harvesting. Farmers in UAE should be aware of the seriousness of the RPW problem. This can be achieved by encouraging and training farmers to conduct trapping system for RPW monitoring and/or control, and obtain some experience with trapping. There is a need to initiate mass trapping in heavily infested and abandoned farms. Trapping might remove sufficient proportions of emerging weevils that mechanical destruction of these farms might not be necessary. In addition, national integrated management program for the RPW should be implemented using a pheromone trapping system in all agricultural and urban areas. The government should have the coordinating and regulatory authority.

The results presented here are promising in utilizing pheromones for significantly reducing RPW populations and for protecting date palm trees from RPW infestations within the field. Further studies should be conducted to understand the RPW-date palm tree interaction and the factors affecting their behavior in the laboratory and the field (Kaakeh, 1998). These include the study of the effect of environmental and physiological factors on mating frequency of RPW, weevil activities in the presence or absence of host odor or frequency of RPW activities in the presence or absence of host odor or food, and time of day in which mating occurs. Knowledge on the function of aggregation pheromones in the mating behavior of RPW is also important for the development of pheromone application in controlling the destructive pest.

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