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ORIGINAL ARTICLE

M. S. T. Abbas · S. B. Hanounik
A. S. Shahdad · S. A. AI-Bagham

Aggregation pheromone traps, a major component of IPM strategy for the red palm weevil, *Rhynchophorus ferrugineus* in date palms (Coleoptera: Curculionidae)

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Abstract The population fluctuation of the red palm weevil, *Rhynchophorus ferrugineus* was studied, using the aggregation pheromone traps, during 2000 and 2001 in the United Arab Emirates. The insect population increased gradually from January to reach its peak in March, April, or May. The populations in three date palm plantations were much less in 2001 compared to 2000 with reductions of 29.7–51.7%. An evaluation of the performance of the pheromone traps showed that they could capture 4.4 to 20.7% of the resident populations of *R. ferrugineus* in the three different date palm plantations. No significant differences could be found in rates of capture between males and females. Individuals of marked weevils released in date palm plantations migrated 1–7 km from the plantations in which they were released. The released marked weevils were recaptured, mostly, within 3–5 days post release.

Introduction

The red palm weevil, *R. ferrugineus*, is the major destructive insect pest of palm trees. It was widely found in southern Asia and Melanesia where it attacked a broad range of palms including date, coconut, sago and oil palms causing severe damage (Oehschlager 1996). It was detected in the Gulf area in mid-1980s; United Arab Emirates (UAE) in 1986 and in Saudi Arabia in 1987, before invading the Islamic Republic of Iran in 1992 (Murphy and Briscoe 1999). The insect was able to cross the Red Sea as it was found in Egypt in 1992 (Cox 1993) and Israel and Jordon in 1999 (Bitton and Nakache 2000). All developmental stages of *R. ferrugineus* remain right inside the trunk feeding on the central tissue and thus killing the tree. This cryptic habit makes it difficult to apply chemical insecticides for controlling the insect. Consequently, the recent strategy has focused on integrated pest management programmes including sanitation, cultural, trapping, and chemical and biological control (Peter 1989; Gobinadhan et al. 1990; Rajan and Nair 1997; Murphy and Briscoe 1999; Hanounik 1998; Hanounik et al. 2000; Abbas et al. 2000, 2001). Hallett et al. (1993) reported that males of *R. ferrugineus* and *R. vulneratus* were found to produce the aggregation pheromones 4-methyl-5-nonanol and 4-methyl-5-nonanone, respectively. Both pheromones enhanced attraction of male and female. Abraham et al. (1999) found that effective weevil trapping was possible only if the pheromone was used along with the food-bait. Also, the sugar cane molasses and toddy (alcohol extracted from coconut) attracted larger numbers of *R. ferrugineus* (Rajamanickam et al. 1995). Griffith (1987), Chinchilla (1988) and Chinchilla et al.(1993) reported that the most common strategy to lower the incidence of red ring disease in oil palm, transmitted by *R. palmarum*, was the reduction of weevil population through eliminating of breeding sites and trapping the weevils.

The present investigation deals with using pheromone traps to estimate the population fluctuations of *R. ferrugineus* in date palms and the rate of capturing this insect from the resident populations.

Material and methods

The study was carried out at AI-Hamranyia Research Station, Ras AI-Khaima, UAE.

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M. S. T. Abbas (✉)
Plant Protection Res. lnstitute, Nady El-Seid Street,
Dokki, Giza, Egypt
E-mail: mstabbas@hotmail.com

S. B. Hanounik · A. S. Shahdad · S. A. AI-Bagham
Ministry of Agriculture, Ras Al-Khaima, P.O. Box 60,
Dubai, United Arab Emirates

Pheromone trap

Terrestrial pheromone trap reported by Hanounik et al. (2000) was used. It consists of a 10 L plastic bucket with three holes, 3 cm diameter, in the bucket's lid and six lateral similar holes just below the lid around the side walls. A pack of 400 mg of aggregation pheromone mixture; 4-methyl-5-nonanol + 4-methyl-5-nonanone (9:1), Chern Tica International. S.A. Costa Rica, and a 20 ml dark-brown bottle, with 1 mm hole in its lid, filled with kairomone extracted from dates were attatched to the inner surface of the trap's lid. The trap was provided with food substrate (to keep the captured weevils alive) consisting of about 500 gm of dates, a teaspoonful of yeast and 5 L of water. The pheromone pack was replaced by a new one almost monthly, the kairomone bottle was refilled when needed and the food substrate changed weekly. The trap was buried in the soil up to the lateral holes.

Population fluctuation of the red palm weevil (RPW)

Population fluctuation of *R. ferrugineus* was studied, using pheromone traps, in three date palm plantations (1, 2 and 3) in Ras Al-Khaima in 2000 and 2001. Pheromone traps were installed at a rate of one trap per hectare. The captured weevils were collected weekly and transferred to the laboratory where they were counted.

Percentages of RPW captured by pheromone traps

Percentages of weevils captured by pheromone traps from the resident populations of the insect were estimated by releasing marked weevils in date palm plantations and recapturing by pheromone traps. The weevils were released out at 1–2-week intervals at 10 to 40 individuals per release. Adult *R. ferrugineus* were marked using small pieces of thin coloured plastic glued onto the thorax. Different colours and different shapes were used representing different date palm plantations and different dates of release. The study was carried out in 2000 and 2001. In 2000, males of RPW were marked, released and recaptured from April to December. The study was carried out in three date palm plantations (3, 4 and 5) representing three locations at Ras Al-Khaima. Twelve pheromone traps were installed in each plantation at a rate of one trap per hectare. The weevils were collected from the traps weekly (3–4 days post release) and transferred to the laboratory where they were checked, and the marked males were counted. In 2001, both males and females were marked, released and recaptured from January until December in only two plantations (3 and 4). In addition, groups of marked males and females were released, occasionally, in other four date palm plantations. Such four plantations were among more than 130 date palm plantations in the above mentioned three localities provided with pheromone traps at a rate of one trap per hectare. This trapping procedure was carried out by Ministry of Agriculture in UAE to distribute pheromone traps in all date palm plantations as a method for controlling *R. ferrugineus*. All captured weevils were collected and transferred to our laboratory weekly. Thus, we could estimate the dispersion of released weevils from the plantations in which they were released. It should be noted that the percentages of marked weevils captured by the pheromone traps did not include those weevils which captured in the successive weeks after the first capture (3–4 days post release). Also, they did not include the marked weevils captured in the plantations other than in those where they were released.

Results

Population fluctuation of the RPW

Figures 1 and 2 show that the monthly number of *R. ferrugineus* captured by pheromone traps increased gradually from January to reach the peak in March (in plantation 2) or April (in plantation 1). In plantation 3, however, the population reached its peak in May

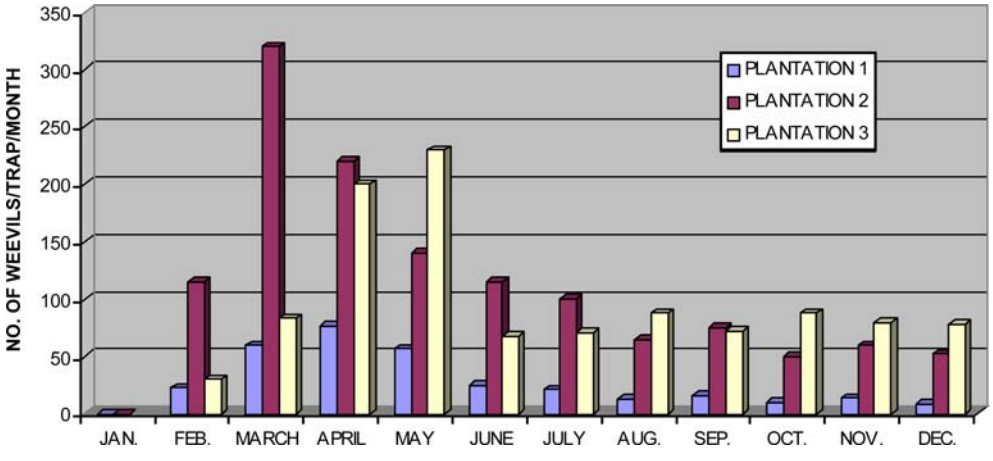

Fig. 1 Population fluctuation of RPW plantations 1, 2, & 3 in 2000

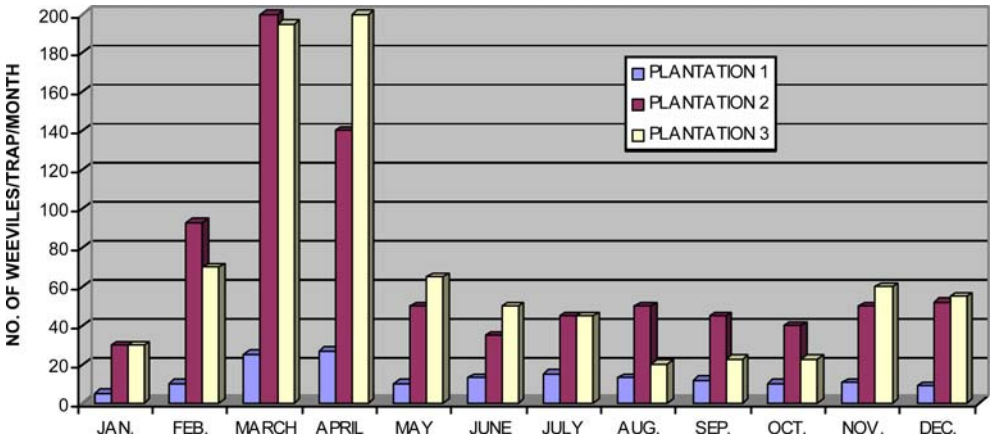

Fig. 2 Population fluctuation of RPW plantations 1, 2 & 3 in 2001

(in 2000) or in April (in 2001). The populations of the insect decreased gradually in the three plantations with no distinct trend. Such populations were much less in 2001 compared to those in 2000 in the three plantations; the total number of weevils captured in 2000 were 3,268, 1,244 and 1,110 in plantations 1, 2 and 3, respectively, compared to the corresponding numbers of 1,611,767 and 780 in 2001. The reduction of the populations ranged from 29.7 (in plantation 3) to 51.7% (in plantation 1). Sex ratio in *R. ferrugineus* was found to be 1 male: 1.5 females in both years.

Percentages of RPW captured by pheromone traps

Monthly percentages of marked *R. ferrugineus* captured by pheromone traps, 3–4 days post release, from April to December 2000 averaged 4.4% (0.0–7.7%) in plantation 4, 12.6% (6.0–27.5%) in plantation 3 and 20.7% (12.0–33.3%) in plantation 5 (Fig. 3). The respective averages in 2001 were 5.9% (0.0 –12.5%) in plantation 4 and 11.0% (3.6–31.7%) in plantation 3 (Fig. 4). Capture of marked released weevils did not happen in all the releases as no marked weevils could be captured from 15 releases in plantation 4, 10 releases in plantation 3 and three releases in plantation 5 out of the 32 releases in each plantation in 2000. The respective numbers (of no capture) in 2001 were 19 in plantation 4 and 11 in plantation 3 out of the 41 releases. However, the rate of capture reached 80% when 16 marked males were captured out of the 20 released in plantation 3 in the last week of December 2001. The maximum weekly capture in plantation 4 was 33.3% (in the second week of January 2001). The percentage of capture of marked females did not differ, significantly, from that of marked males in the six plantations in 2001. An average of 12.2% of marked males were captured compared to 11.9% marked females (Fig. 5).

Migration of released weevils

Individuals of the released marked weevils (males and females) were captured from date palm plantations 1–7 km away from the plantations in which they were released. These marked weevils were captured within 3–18 days post release but the vast majority was captured within 3–5 days. However, one male was captured 40 days post release. Migration of the released weevils was observed in 10 releases out of 41 in plantation 3 during 2001. An average of 9.8% (2.5–20%) of weevils in these 10 releases were captured from other eight

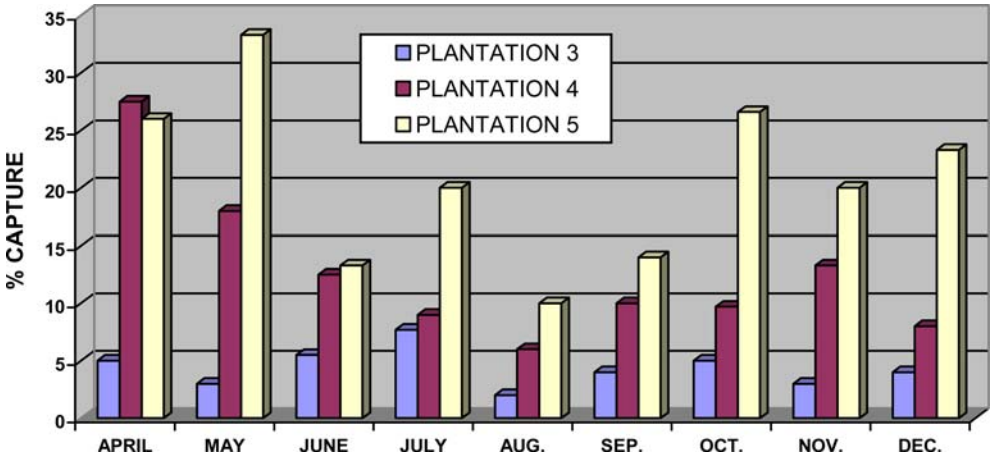

Fig. 3 The percentage of capture of marked RPW *Ferrugineus* adults released in 3 date palm plantations in 2000

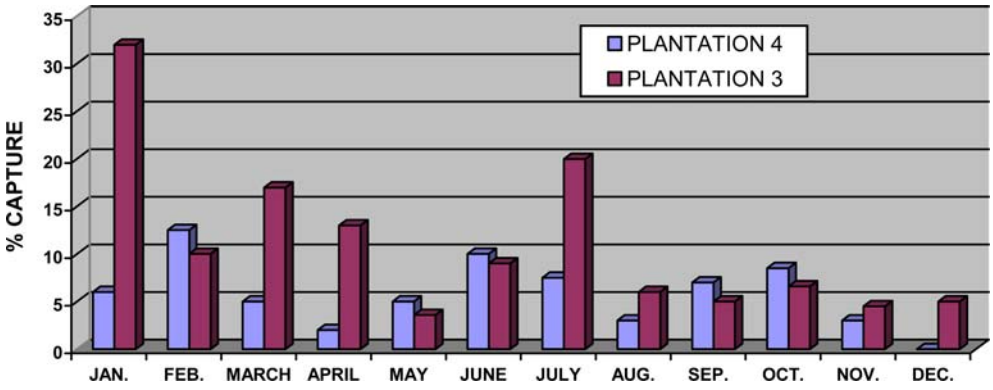

Fig. 4 % Capture of released RPW in 2 date palm plantations in 2001

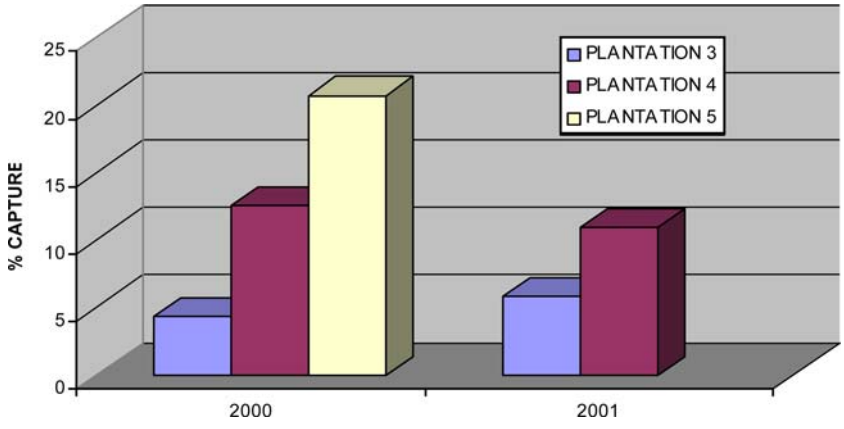

Fig. 5 Average % capture of marked RPW released in plantations 3, 4 & 5 in 2000 and 2001

plantations. Migration of marked weevils from plantation 4, however, was noticed in only two out of the 41 releases in 2001 with 3 and 5.5%, respectively of the released weevils being recuptured.

Discussion

Population of the red palm weevil, *R. ferrugineus* was found to increase from January to reach its peak in March, April or May when it becomes warmer. The insect was noticed to overwinter in January and February, as late instar larvae, pupae and inactive newly formed adults in the cocoons inside the infested palms (unpublished). In summer (June–September), as the temperature reaches an average of 42.8°C (39–48) during day, the population of RPW decreases. During this period the weevils may dwell in the infested date palms or inhabit the soil seeking shade and shelter (Abbas et al. 2000). El-Garhy (1996) found that more adults of *R. ferrugineus* were captured during the summer months than during the winter months in Egypt.

The monthly numbers of *R. ferrugineus* adults captured in 2001 were much lower than those in 2000. This may indicate that the pheromone traps have a potential role in suppressing the population of the insect in date palm plantations. What supports this claim is that a total of 65,000 weevils were captured within 18 months by pheromone traps installed in more than 130 date palm plantations in Ras AI-Khaima starting from July 2000. A reduction of 22–93% in the numbers of weevils captured in the peak months (March and April) in 2001 compared to 2000 was noticed in all such plantations. Muralidharn et al. (1999) obtained similar results and reported that the capture rate of *R. ferrugineus* was reduced by trapping by 75.17% within 3 years. In addition, Rajan and Nair (1997) claimed that employing integrated pest control strategy, including trapping system, against *R.ferrugineus* reduced infestation in oil palms from 7% to zero. Sex ratio in red palm weevil captured in the three date palm plantations was almost 1 male: 1.5 females. El-Garhy (1996) found this ratio to be 1:2 in Egypt. It should be noted that no significant difference was observed between response patterns of female and male *R. ferrugineus* to the aggregation pheromone (Hallett et al. 1993).

When marked males were released in three date palm plantations during April–December, 2000 the average percent of captured marked males was 4.4% in plantation 4, 12.6% in plantation 3 and 20.7% in plantation 5. Corresponding averages in 2001(January–December) were 5.9% in plantation 4 and 11.0% in plantation 3. The low capture rate in plantation 4 could be attributed to the high rate of infestation by RPW as well as the high incidence of weeds in this plantation. The high rate of infestation by RPW led to the production of high rate of

natural aggregation pheromone (secreted by males) and kairomones (volatilized from infested palms), which were much more attractive to released males than the synthetic pheromone and kairomone in the traps. Kalshoven (1981) reported that volatiles from infested palms and from fermenting palm sap (as a result of infestation) were well known to attract palm weevils. The high incidence of weeds, in turn, attracted the weevils as a habitat providing shade and shelter. In contrast, the high rate of capture in plantation 5 could be attributed to the very low rate of infestation by RPW as well as to the great age of the palm trees (more than 15 years old). Thus, the pheromone and kairomone in the traps were more attractive to the released marked weevils. Our field studies (unpublished) revealed that the rate of infestation by *R. ferrugineus* was higher in palm trees 6–10 years old than in trees 1–5 years old. This rate in palms more than 15 years old, however, was very low.

The present study demonstrated also that the marked released weevils were capable of migrating up to 7 km from the plantations in which they were released within 3–5 days. In this regard, Chinchilla et al. (1993) reported that out of 535 released marked *R. palmarum*, 53 were recaptured in traps 500 m away from the release point and 13 each in traps 1 km and 2 km from this point 2 days post release. They proposed that the average flight of *R. palmarum* was 500 m per day and a small portion (16%) migrated up to 1 km per day.

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