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Development of a semiochemical-based trapping method for the New Guinea sugarcane weevil, *Rhabdoscelus obscurus* in Guam

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Abstract: Aggregation pheromone of the Australian population of New Guinea sugarcane weevil, *Rhabdoscelus obscurus* (Boisduval), in conjunction with other semiochemicals, was used to develop an efficient trapping method for the weevil population in Guam. In a field experiment at Yigo, plastic bucket traps baited with the lure of the Australian *R. obscurus* population in combination with ethyl acetate and cut sugarcane captured significantly more weevils than traps baited with pheromone + ethyl acetate, pheromone + sugarcane or individual lure components alone. Traps baited with various semiochemical-based lures and treated with insecticide captured significantly greater numbers of weevils than those not treated with insecticide. Traps baited with cut sugarcane caught significantly more weevils than those without sugarcane. Semiochemical-based trapping in weevil management has potential either in mass trapping or as part of an integrated pest management (IPM) programme. Based on the present findings, a future line of work for the control of this weevil is proposed.

Key words: *Rhabdoscelus obscurus*, Coleoptera, Curculionidae, ethyl acetate, (*E*2)-6-methyl-2-hepten-4-ol (rhynchophoral), 2-methyl-4-heptanol, sugarcane, trap

1 Introduction

The New Guinea sugarcane weevil, *Rhabdoscelus obscurus* (Boisduval) (Col., Curculionidae) is a native of New Guinea and the adjoining islands (Muir and Swezey, 1916; Timberlake, 1927). It was originally described from specimens collected in New Ireland and Papua New Guinea (Boisduval, 1835) and has since spread to many islands in the Pacific, including Australia and Indonesia. Dispersal of the weevil was almost certainly associated with inter-island trading of sugarcane in earlier years, but more recently palms introduced for the ornamental horticultural industry have become the most favoured hosts of this weevil (Halfpapp and Storey, 1991). In Guam, *R. obscurus* is a major pest of ornamental and other palms such as coconut palm (*Cocos nucifera* L.), betel nut (*Areca catechu* L.), champagne palm [*Hyophorbe lagenicaulis* (Bailey)], pritchardia palm (*Pritchardia martii* (Gaud) H. Wendl.), pygmy date palm (*Phoenix roebelenii* O'Brien), Alexander palm [*Archontophoenix alexandrae* (F. Muell.) H. Wendl. & Drude], royal palm [*Roystonea regia* (Kunth) O.F. Cook] and date palm (*Phoenix canariensis* Hort. ex Chabaud) as well as sugarcane (*Saccharum officinarum* L.).

Adult female *R. obscurus* chew a 3-mm-deep cavity into the sugarcane stalk, usually in existing adult feeding scars or cracks and occasionally at internodes or near the base of leaf sheaths (Napompeth et al., 1972; Dharmaraju et al., 1979; Halfpapp and Storey, 1991). On palms, weevils lay their eggs in the petiole and on the stem. Larvae bore into the living tissue, producing frass-filled tunnels that weaken affected parts of the host plant and permit invasion of fungal and bacterial pathogens. Mature larvae pupate in cocoons made of plant fibres close to the exit holes (Halfpapp and Storey, 1991). Currently, this weevil poses a serious threat to ornamental palms in the nurseries and to betel nut production in Guam. The recent withdrawal of the ban on entry of betel nut into the US mainland from Guam by the Food and Drug Administration has encouraged commercial cultivation of betel nut on Guam. Therefore, an effective management programme for this weevil is urgently required.

Chang and Curtis (1972) reported that both male and female *R. obscurus* produced a pheromone only when fed on sugarcane. Virgin males, 4–6 days old, fed on sugarcane produced a pheromone which attracted only females. However, 12–16-day-old males attracted both the sexes. Giblin-Davis et al. (2000) identified the pheromone of Hawaiian *R. obscurus* as 2-methyl-4-octanol and the corresponding pheromone compounds for Australian *R. obscurus* population are 2-methyl-4-octanol (*E*2)-6-methyl-2-hepten-4-ol (rhynchophorol) and 2-methyl-4-heptanol. However, authors could not find any behavioral effect of

2-methyl-4-heptanol and did not include it as one of the optimized pheromones for *R. obscurus*.

According to Giblin-Davis et al. (1996a), approximately 3 mg/day of synthetic pheromone in combination with insecticide-treated plant tissue constituted highly attractive baits for palm weevils, including *R. obscurus*. In a previous study, traps baited with the Australian geographical population caught significantly more weevils than those baited with the Hawaiian population of *R. obscurus*, suggesting that the Guam population is similar to the Australian population (Muniappan et al., 2004). Furthermore, it was also observed from our previous study that addition of ethyl acetate to the pheromone lures significantly increased the trap catches of *R. obscurus*.

The purpose of this study was to develop a semiochemical-based trapping method and a suitable sampling method to complement other methods of control to manage *R. obscurus* in Guam.

2 Materials and Methods

2.1 Traps

Plastic bucket traps were used in field experiments to compare the potency of the pheromone, ethyl acetate (EA), and cut sugarcane in attracting *R. obscurus*. Each trap (fig. 1) consisted of 19.0-l white plastic-tapered containers (37.0 cm height × 30.0 cm inner diameter base). Two holes (17.5 cm long and 7.5 cm wide) were cut on the opposite sides of the container to allow weevil entry into the trap. Twenty drainage holes, each 3 mm in diameter, were made in the base. Each assembled trap was placed at the base of a mature coconut tree in the field and strapped securely against it. Such a set-up helped the weevils to walk into the trap (A.C. Oehlschlager, ChemTica International, Costa Rica, pers. comm.). At each location, inter-trap distance was set at 100 m.

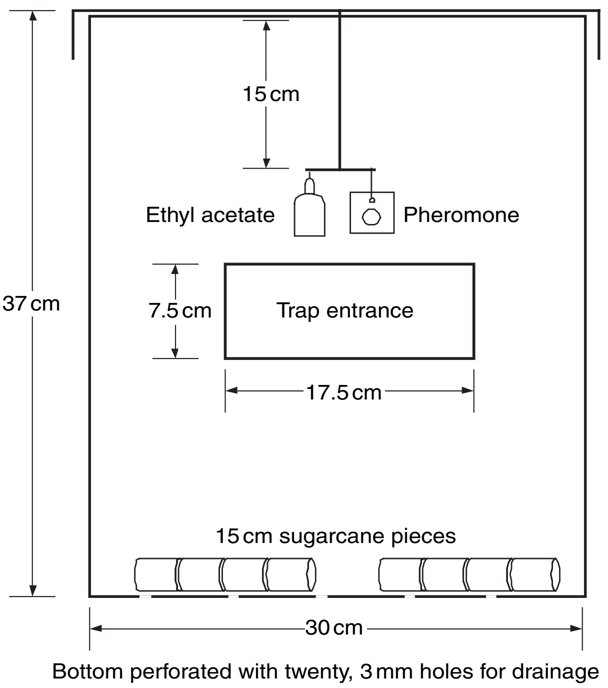

Fig. 1. *Diagram of the trap showing the various holes and bait placement*

2.2 Chemicals

The pheromone and ethyl acetate lures (ChemTica International S.A., San Jose, Costa Rica) were stored in a refrigerator until use. Pheromone lure was sealed in a polymer membrane release device optimized for the Australian population of *R. obscurus* [(*E*2)-6-methyl-2-hepten-4-ol and 2-methyl-4-octanol] and was suspended halfway inside the trap with a wire. Release devices for ethyl acetate lures consisting of ethyl acetate (minimum 40 ml of attractant, 95% min. purity, release rate of 200–400 mg/day; Weevil Magnet® (ChemTica International S.A., San Jose, Costa Rica) 40 ml lure) were stored in plastic bottles. Before use, the white cap was removed from the device and hung in the trap. The diffusion rate of pheromone and ethyl acetate directly depends on the outside temperature which fluctuates during the day (A.C. Oehlschlager, per comm.). Fresh sugarcane sections 15 cm long and split in the middle along half their length were used alone and in combination with both pheromone and ethyl acetate, with pheromone alone and ethyl acetate alone to test the trapping efficiency. The cut sugarcane was placed directly in the bucket trap and replaced with fresh canes weekly. Pheromone and ethyl acetate lures were changed at 4-month intervals, while freshly cut sugarcane sections were replaced in the trap weekly.

2.3 Field experiments

All experiments were carried out at the Agricultural Experiment Station located at Yigo, Guam between 15 January 2003 and 15 January 2004. The following treatments were employed; and each replicated four times in a randomized block design.

1. Pheromone lure of the Australian population of *R. obscurus* (PH) + ethyl acetate (EA) + fresh-cut sugarcane (SC).
2. PH + EA.
3. PH + SC.
4. EA + SC.
5. PH.
6. EA.
7. SC.
8. Control (no lures).

Each trap was baited with one of the above treatments. Identical treatments were set up at the same site with a 5-ml spray of permethrin (0.75 ml/l) in the traps as it was observed in our previous studies that the weevils appear to visit and leave the trap in between observation periods. The chemical was sprayed with an atomizer directly on the cut sugarcane in the traps. Permethrin was selected as it has a knockdown effect on weevils and has less repellent properties (Reddy, G.V.P., unpubl. data). Weevils in the traps were removed weekly, counted and the weevils from the traps without insecticide were used for laboratory culture. Overall, there were 64 traps and the trap positions re-randomized each month.

2.4 Statistical analysis

Data on the mean monthly trap catches and for insecticide or cut sugarcane comparisons were analysed using analysis of variance in SPSS. As the variance was strongly correlated with the mean, the data were transformed to √(catch + 1) before ANOVA was applied. Tukey's tests were performed for mean separation, where significant ($P < 0.05$) statistical differences were detected by ANOVA.

3 Results

In the field experiment, traps baited with PH combined with EA and SC caught significantly ($P < 0.05$; $F = 32.69$; d.f. = 7; ANOVA; fig. 2) more weevils than traps baited with other semiochemical-based lures both with and without insecticide. In insecticide-treated traps, the number of weevils caught in traps baited with PH + EA + SC was twice that of PH + EA and PH + SC and four times that of EA + SC and PH (fig. 1).

Pooled data from with and without insecticide indicated that traps baited with PH + EA + SC caught significantly more weevils than other treatments ($P < 0.05$; $F = 28.15$; d.f. = 7; ANOVA). Weevils caught in PH + EA + SC were twice that of PH + SC and four times that of PH + EA, PH and EA + SC. Traps baited with various semiochemical-based lures with insecticide captured significantly more weevils than those without insecticide ($P < 0.05$; $F = 31.28$; d.f. = 1; ANOVA). Except in PH + EA + SC and PH + SC, the traps with insecticide caught significantly more weevils than the ones without insecticide. Baited traps with cut sugarcane caught significantly ($P < 0.05$; $F = 34.22$; d.f. = 1; ANOVA) more weevils than those without sugarcane. The difference in number of weevils caught with sugarcane in each treatment was almost four times that of the treatments without sugarcane.

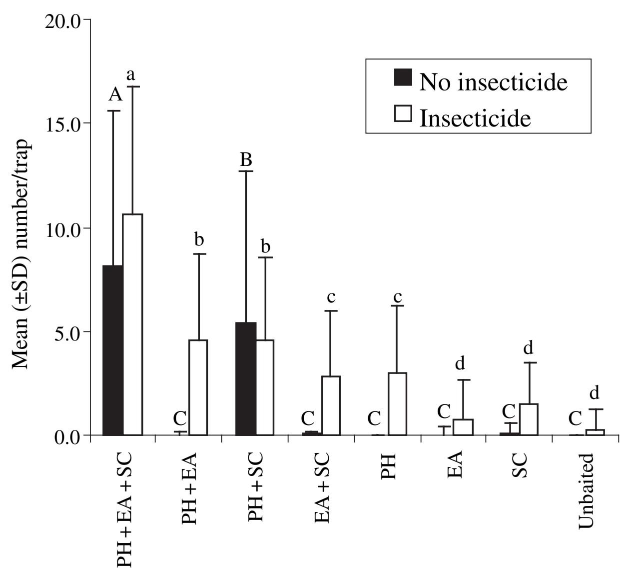

Fig. 2. Mean numbers (±SD) of R. obscurus *captured in traps baited with different semiochemical based lures with or without insecticide. Mean values with the same letter are not significantly different ($P > 0.05$; Tukey's test; ANOVA); PH, pheromone; EA, ethyl acetate; SC, cut sugarcane*

4 Discussion

In the present study, traps baited with lures containing pheromone of *R. obscurus* in combination with EA and SC trapped significantly greater numbers of weevils than those baited with either EA or PH alone or in combination or unbaited traps. Our results corroborate those of Giblin-Davis et al. (2000) who found that lures containing the aggregation pheromone and SC captured more male and female *R. obscurus* than did lures containing pheromone or SC alone. The addition of EA to the aggregation pheromone in our field research is in agreement with the other studies. Host odour enhancement of attraction responses to pheromones occurs in several insect species (Reddy and Guerrero, 2004). For example, Jaffe et al. (1993) reported that rhynchophorol [(*E*2)-6-methyl-2-hepten-4-ol], the active component of the aggregation pheromone of the American palm weevil, *Rhynchophorus palmarum* (L.) (Col., Curculionidae), attracted weevils in olfactometer tests, whereas in the field the traps attracted only if plant volatile, ethyl acetate was added to the aggregation pheromone. Giblin-Davis et al. (1994) achieved good chemically mediated field trapping of *Rhynchophorus cruentatus* Fabricius (Col., Curculionidae) with its aggregation pheromone (5-methyl-4-octanol) plus ethyl acetate (852 mg/day) and to a lesser degree with each of those compounds. Rochat et al. (2000) reported that a blend of ethanol–ethyl acetate in combination with an aggregation pheromone (rhynchophorol) in various ratios showed moderate synergy in the field to *R. palmarum*. The attraction of *Metamasius hemipterus* (Olivier) (Col., Curculionidae) to gallon and bamboo traps baited with insecticide-treated SC and the male-produced pheromones 4-methyl-5-nonanol and 2-methyl-4-heptanol are more efficient if ethyl acetate is added (Perez et al., 1997; Oehlschlager et al., 2002).

Traps baited with EA + SC did not capture as many weevils as those baited with the pheromone in combination with EA and SC or alone. However, our results differ with the findings of Giblin-Davis et al. (1996b), wherein ethyl acetate alone (123–174 mg/day) was as attractive as 250 g of fermenting sugarcane or the racemic blend of the male aggregation pheromone (5-methylnonan-4-ol and 2-methylheptan-4-ol) at 8 : 1 ratio at 3 mg/day for *M. hemipterus sericeus*. A similar report on another species indicated that 1-kg of 1- to 3-day-old oil palm (*Elaeis guineensis* Jacq.) tissue was significantly more effective than synergistic kairomone (ethyl propionate) in enhancing pheromone attraction of *Rhynchophorus phoenicis* (F.) (Col., Curculionidae) (Gries et al., 1994). Ethyl acetate alone is known to attract a variety of insects such as dipteran flies (Lee et al., 1997; Casana-Giner et al., 1999), sap beetles (Nout and Bartelt, 1998; Bartelt and Wicklow, 1999), and melolonthid scarab beetles (Camino-Lavin et al., 1996). However, there is a contrasting report by Jaffe et al. (1993), who noticed that the chemical compound, ethyl acetate alone or as a mixture with ethanol, pentane, hexanol and isopentanol were attractive to the palm weevil, *R. palmarum*, in the laboratory but did not attract weevils in the field. The authors found that host-based volatile compounds were attractive to weevils in the field only when an aggregation pheromone was added.

Cut sugarcane is known to attract *R. obscurus* in the field (Van Zwaluwenburg, 1938). We observed that traps baited with SC alone did not attract as many weevils as those baited with EA in combination with SC. Our results agree with those of Giblin-Davis et al. (2000) who reported that SC, in combination with 2-methyl-4-octanol, attracted more weevils than did pheromone alone or sugarcane alone. This indicates that aggregation pheromone components are required for enhancing the trapping efficiency of cut sugarcane. Regarding the no-insecticide traps in the present study, they did well when both pheromone and sugarcane was present. Behaviorally, the pheromone was the key attractant, but the weevils stayed in the trap when there was something to eat when they arrived. Traps with insecticide trapped more weevils than the unsprayed ones; possibly some of the attracted weevils were leaving the traps in between the monitoring period in the traps without insecticide.

In summary, our results indicate the potential of using lures containing the pheromone components in combination with EA, SC and insecticide for mass-trapping the weevil borers in Guam. However, further studies are required to investigate whether mass trapping alone can reduce the *R. obscurus* population below the economic threshold level and whether this trapping technique can be used as part of an integrated pest management (IPM) programme in Guam. Our findings mostly corroborate the findings of Sallam et al. (2001), who used lures containing rhynchophorol/octanol and ethyl acetate in combination with several 5-cm lengths of split cane for pheromone mass trapping of *R. obscurus* in far-north Queensland during February–June 1999. The authors observed that the treated plots trapped higher numbers of weevils, and had more infested stalks and more damaged internodes than the control plots. However, during the following season (January–August 2000), pheromone trapping in combination with application of the insecticide Regent (Bayer Crop Science Pty Ltd., East Hawthorn, Victoria 3123, Australia) (200 g/l fipronil at 75 g active ingredient per ha) resulted in some level of weevil control.

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