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Field Response of Guam Populations of the New Guinea Sugarcane Weevil, *Rhabdoscelus obscurus* (Boisduval) (Coleoptera: Curculionidae), to Aggregation Pheromones and Food Volatiles

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Abstract—Lures of aggregation pheromones of the Australian and Hawaiian populations of New Guinea sugarcane weevil, *Rhabdoscelus obscurus* (Boisduval), with other semiochemicals were used to clarify the identity of the weevil population in Guam. In a field experiment at eight different locations (Dededo, Tumon, Yigo, Hagåtña, Mangilao, Yona, Agat and Malesso), plastic bucket traps baited with the lure of the Australian *R. obscurus* population in combination with a food volatile compound (ethyl acetate) and cut sugarcane captured significantly more weevils (total of 348) than traps baited with pheromone lure of the Hawaiian *R. obscurus* population in combination with food volatile and cut sugarcane which caught a total of 128 weevils. Traps baited with lure containing only the food volatile and cut sugarcane or only cut sugarcane captured significantly fewer weevils (total of 36 and 30, respectively) than those baited with pheromone compounds. Data from trap catches indicate that the Guam population of *R. obscurus* responded significantly more to the pheromone lure of the Australian population than to pheromone lure of the Hawaiian population indicating that the Guam *R. obscurus* population is related more closely to the Australian population. Trap catches at the Tumon and Dededo locations were greater than those in Yigo, Yona, Mangilao, Hagåtña, Agat, and Malesso. Rainfall had a low correlation with trap catches at all locations except at Yigo where it positively correlated to the Australian population lure treatment. Semiochemical based trapping in weevil management has potential either in mass trapping or as part of an IPM program. A future line of work is also proposed for the control of weevil borers based on these initial results.

Introduction

The New Guinea sugarcane weevil, *Rhabdoscelus obscurus* (Boisduval) (Arthropoda: Insecta: Coleoptera: Curculionidae) originated in New Ireland,

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Papua New Guinea (Boiduval 1835). Muir & Swezey (1916) and Timberlake (1927) reported that the original habitat of this weevil was New Guinea and the adjoining islands. It has since spread to most 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 in recent years palms introduced for the ornamental horticultural industry have become the most favored host for this weevil (Halfpapp & Storey 1991). On Guam, *R. obscurus* is a major pest of ornamental palms, betel nut palm (*Areca catechu* L.), coconut palm (*Cocos nucifera* L.) and sugarcane (*Saccharum officinarum* L). The most affected plants are coconut, betel nut, champagne palm (*Hyophorbe lagenicaulis* (Bailey), pritchardia palm (*Pritchardia pacifica* Seem. & 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 plam (*Phoenix canariensis* Hort. ex Chabaud).

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 (Halfpapp & Storey 1991). Females oviposit in cracks and crevices, or in the holes they have chewed with their mandibles (Napompeth et al. 1972; Dharmaraju et al. 1979). On palms, weevils lay their eggs in the petiole and on the trunk. Larvae bore within the living tissue, producing frass filled tunnels that weaken affected parts of the host and permit fungal pathogen invasion. Mature larvae pupate in cocoons made of plant fibers (Halfpapp & Storey 1991). Recent withdrawal of the ban on entry of betel nut into the U.S. mainland from Guam by the Food and Drug Administration has resulted in an increase in the area of betel nut cultivation on Guam. Currently this weevil poses a serious threat to ornamental palms in the nursery industry and to betel nut production in Guam.

Chang & Curtis (1972) reported that male *R. obscurus* to produce an aggregation pheromone that is attractive to both male and female weevils. Furthermore, the authors found that split-cane traps baited with mated or virgin male *R. obscurus* were more attractive than traps with or without female weevils. 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* populations are 2-methyl-4-octanol, (*E*2)-6-methyl-2-hepten-4-ol (rhynchophorol) and 2-methyl-4-heptanol.

The purpose of this study was to identify the Guam population of *R. obscurus* either with Australian or Hawaiian populations. A second purpose was to develop a suitable semiochemical-based trapping method to control this weevil.

Materials and Methods

Trap

Plastic bucket traps were used in field experiments comparing the attraction of the pheromones, food volatile (ethyl acetate) (FV), and cut sugarcane (SC) in trapping *R. obscurus*. Each trap consisted of 18.925 L white plastic tapered containers (36.83 cm height × 29.84 cm ID). Two holes (17.78 cm long and 7.62 cm wide) on the opposite sides of the container were cut to allow entrance of the weevils 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 helps to allow the weevils to walk into the trap (A.C. Oehlschlager, ChemTica International, Costa Rica, personal communication). Because our aim was to recover live weevils, no insecticide was used in the trap.

The distances between selected locations varied from 3 to 5 km. At each location, inter-trap distance was set at 100 m.

Chemicals

The lures were sealed in a polymer membrane release device optimized for the Hawaiian (2-methyl-4-octanol) and Australian *R. obscurus* ((*E*2)-6-methyl-2-hepten-4-ol and 2-methyl-4-octanol) and were suspended halfway inside the trap with a wire. The lures were obtained from ChemTica International S.A., San Jose, Costa Rica. Release devices for food volatile consisting of ethyl acetate (minimum 40 mL of attractant, 95% min. purity, release rate of 200-400 mg/day, weevil magnet 40 ML lure) were also obtained from ChemTica International and were refrigerated until use. Before use, a white cap was removed from the device and hung in the trap with or without sugarcane. The lures emitted pheromone at a constant rate until the pheromone was exhausted. Fresh, matured sugarcane sections 15 cm long were used in combination with pheromones or food volatile, both or alone to test the trapping efficiency. Pheromone and ethyl acetate lures were changed at 4-month intervals while freshly cut sugarcane sections were placed in the trap once every week. Dried canes were removed after two weeks.

Field Experiments

Experiments with different lures of pheromones of Hawaiian and Australian populations, food volatile blends and cut sugarcane were carried out from January through August, 2002 at Yigo, Dededo, Hagåtña, Agat, Malesso, Yona, Mangilao and Tumon in Guam.

The following treatment combinations were employed:

(1) lures of pheromone of the Australian population of *R. obscurus* (AU) plus food volatile (FV) plus fresh cut sugarcane (SC).
(2) lures of pheromone of the Hawaiian population of *R. obscurus* (HI) plus FV plus SC.
(3) FV plus SC.
(4) SC

Each trap was baited with one of the above treatment combinations and set up at each of the eight locations on January 11, 2002. Weevils in the traps were removed every week, counted, and cultured in the laboratory for further laboratory studies. Daily temperature, relative humidity, wind velocity and rainfall

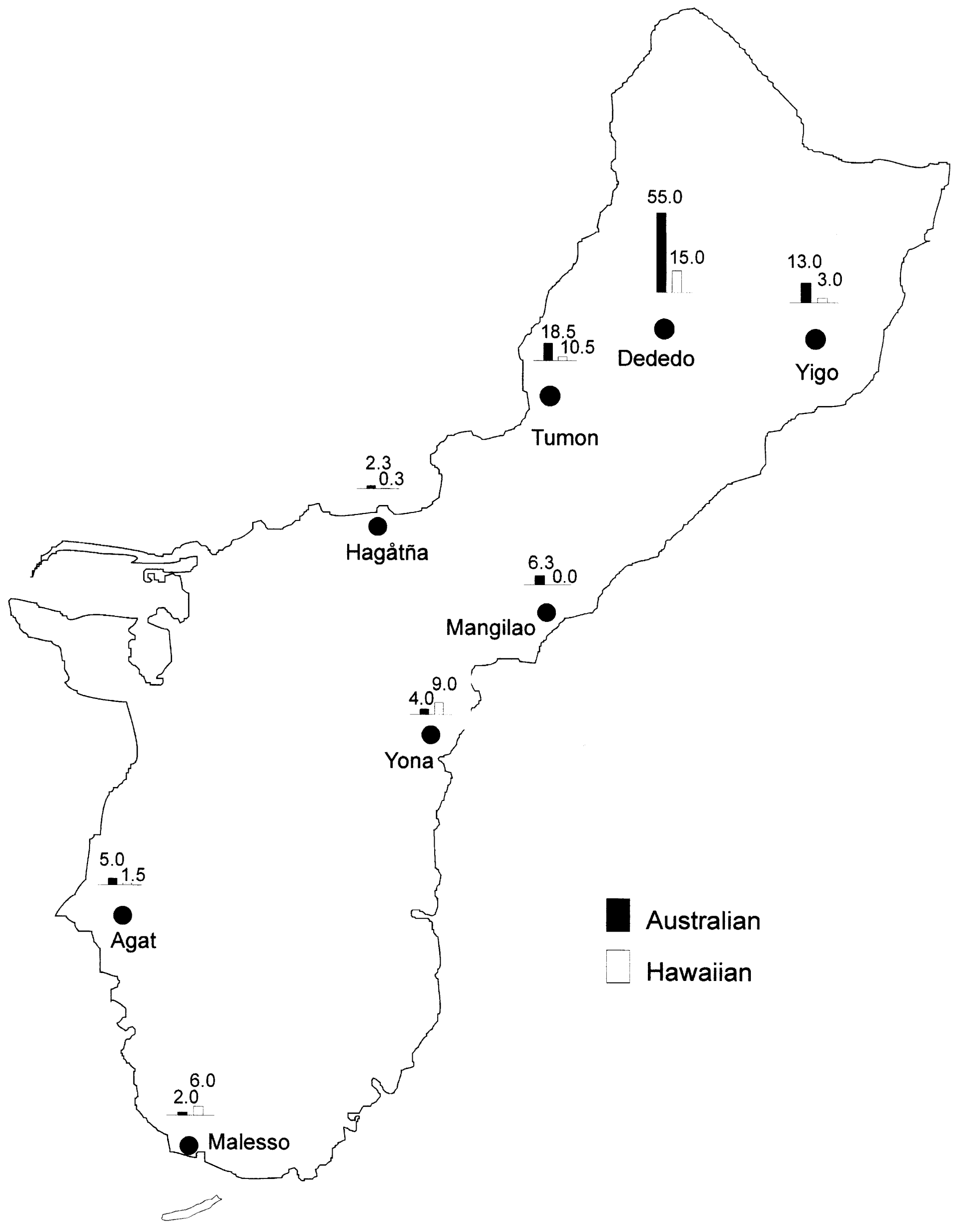

Figure 1. Distribution of the New Guinea sugarcane weevil, *Rhabdoscelus obscurus* in Guam. Bars with gray indicate the average number of adult catches in traps baited with pheromone lure of the Australian *R. obscurus* population in combination with a Food volatile (FV) and Sugarcane (SC) while white bars indicate the average number of catches by the traps baited with pheromone lure of the Hawaiian *R. obscurus* population in combination with a FV and SC.

during the experiment were recorded at the Yigo Agricultural Experimental Farm for analysis.

Statistical Analysis

Data on the mean monthly trap catches were analyzed using a T test, ($P \leq 0.05$) and the impact of rainfall on trap catches was analyzed using linear regression (Sokal & Rohlf 1995).

Results

The semiochemical-based lures indicated a widespread occurrence of *R. obscurus* populations at eight different locations in Guam (Fig. 1). In Guam, overall cumulative average trap catch data indicated significantly ($P < 0.05$; t-test; Fig. 1) more weevils were attracted to the pheromone lure of the Australian *R. obscurus* population than to the lure of the Hawaiian population. Trap catches at the Tumon and Dededo locations were significantly greater ($P < 0.05$; paired samples t-test; Fig. 2) than in other locations. However, there were no significant differences between the trap catches at Yigo, Yona, Mangilao, Hagåtña, Agat and Malleso.

At the Dededo location, mean monthly trap catches ranged from 9.1 to 14.5 during the summer months of May to June (Fig. 3). The next highest trap catches were found in Tumon from June to August (4.0 to 7.0), followed by Yigo from April to June (2.5 to 3.3), Agat from February to April (1.6 to 2.5), Hagåtña from February to March (1.3 in both months), and Yona from April to June (2 to 3.5).

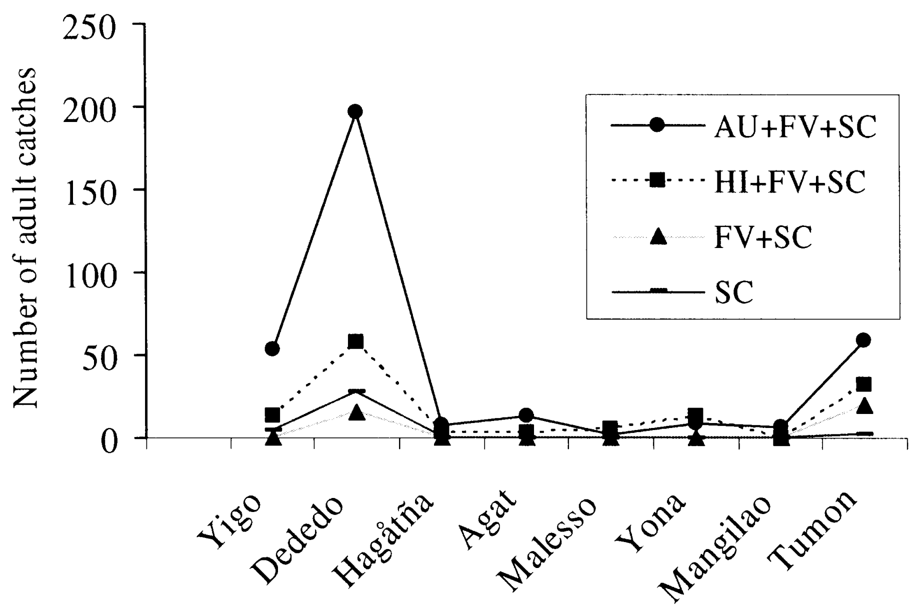

Figure 2. Total number of adult *R. obscurus* captured in plastic bucket traps baited with four different lures.

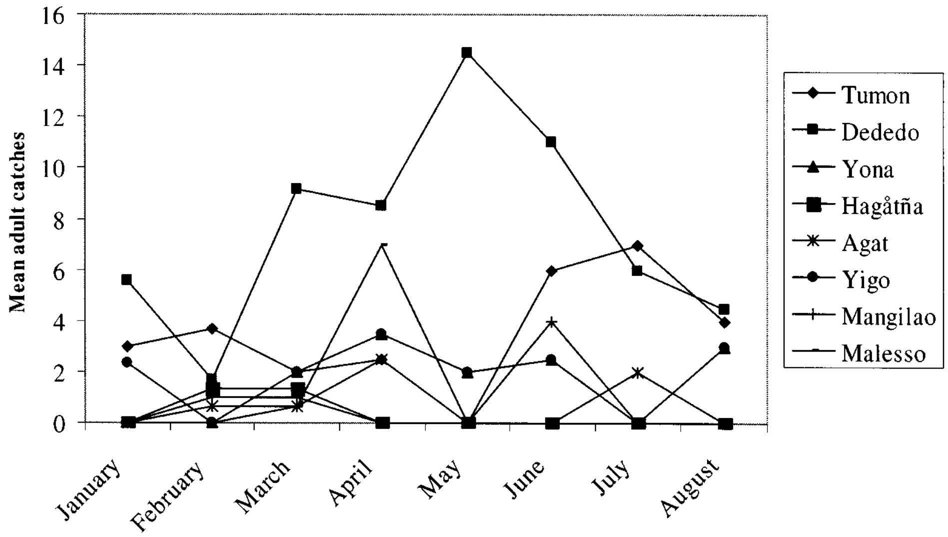

Figure 3. Mean monthly trap catches at eight locations of adult *R. obscurus*. Traps baited with pheromone lures of the Australian and Hawaiian *R. obscurus* populations.

The trap catches were very low for most months at Mangilao and Malesso, with the exception of June in Mangilao when a trap caught 4 weevils.

Rainfall had little effect on trap catches at the three locations where maximum numbers of *R. obscurus* were captured (Table 1). At Yigo, trap catches to pheromone lure of Australian populations were positively correlated ($r > 0.78$, df=1, p=0.020) with the rainfall. Similarly, when the total trap catches to the pheromone lures of the two populations were correlated with the rainfall, a significant difference ($r > 0.88$, df=1, p=0.003) was observed only at the Yigo location. However, there was a negative correlation between the numbers of trapped *R. obscurus* in other locations, suggesting that rainfall did not affect the pheromone

Table 1. Results of linear regression with ANOVA conducted on rainfall (independent variable) vs. average trap catches (dependent variable) to lures of two geographical isolates (HI and AU) at three different locations in northern Guam.

Location	HI		AU		Total	
	r	*P*	*r*	*P*	*r*	*P*
Tumon	0.31692	0.4444	0.69758	0.0544	0.64729	0.0827
Dededo	0.55060	0.1573	0.33374	0.4192	0.53410	0.1727
Yigo	0.67022	0.0690	0.78881**	0.0200	0.88914**	0.003

Asterisks indicate a significant difference ($p \leq 0.05$). Average monthly rainfall (January to August, 2002) was compared with average number of adult *R. obscurus* captured in plastic bucket traps baited with pheromone lures of Australian (AU) (6-methyl-2-heptene-4-ol and 2-methyl-4-octanol) and Hawaiian (HI) (2-methyl-4-octanol).

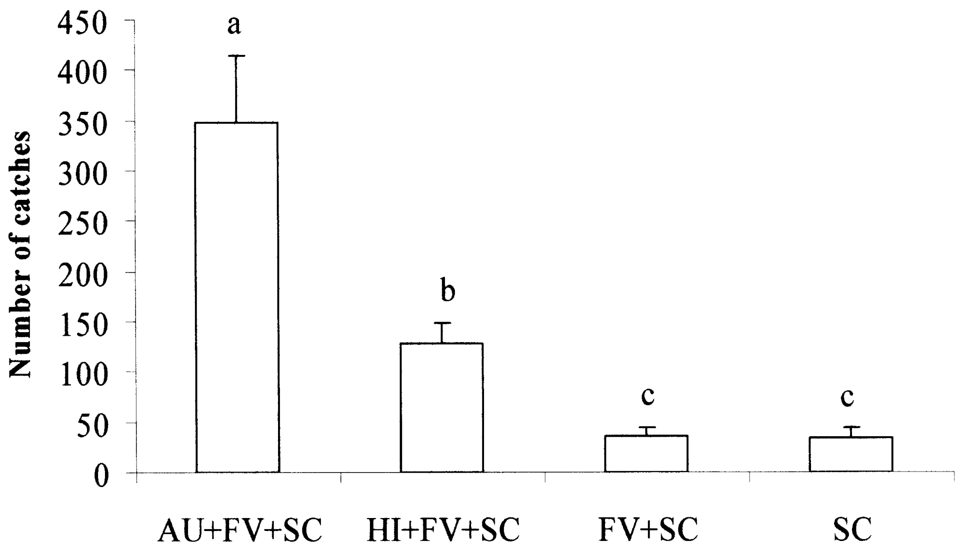

Figure 4. Number of adult *R. obscurus* captured in plastic bucket traps baited with pheromone lures of the Australian (AU) and Hawaiian (HI) isolates and in combination with Food volatile (FV) + Sugarcane (SC). Bars with different letters are significantly different from each other ($p \leq 0.05$; t-test)

trapping. Through the trapping period, the average rainfall, temperature, relative humidity and wind velocity at Yigo were 6.9 mm, 25.4ºC, 85.8% and 2.29 m/s.

In the field experiment at eight different locations, traps baited with pheromone lure of AU combined with FV and SC caught significantly ($P < 0.05$; t-test; Figure 4) more weevils (total of 348) than traps baited with pheromone lure of the HI combined with the FV and SC which caught a total of 128 weevils. Each trap baited with lure containing only FV plus SC, or SC alone, captured significantly ($P > 0.05$; t-test) fewer weevils (totals of 36, 30 respectively) than traps containing the pheromone lures of AU or HI in combination with FV and SC.

Discussion

According to Giblin-Davis et al. (1996), approximately 3 mg per day of synthetic pheromone in combination with insecticide-treated plant tissue constituted highly attractive baits for palm weevils, including *R. obscurus.* Traps baited with lure of the Australian geographical population caught significantly more weevils than traps baited with lure of Hawaiian population *R. obscurus,* suggesting that the Guam population is reacting similarly to the Australian population. Trap catches in the northern region (Dededo, Tumon and Yigo) were higher than in the central and southern regions of Guam. We believe that recent increases in commercial nurseries and ornamentals plants in this region have provided more preferred hosts for the weevil. Giblin-Davis et al. (2000) found that the New Guinea sugarcane weevil in Hawaii and Australia are different. In this context we decided to determine the relationship of Guam population either to Austrlian or Hawaiian populations of *R. obscurus.* In the Hawaiian population, synthetic 2-methyl-4-octanol alone enhanced the attractiveness, while in the Australian population, synthetic 2-methyl-4-octanol needed to be combined with (*E*2)-6-methyl-2-hepten-4-ol to enhance attractiveness to *R. obscurus.*

In the present study, traps baited with lures containing pheromone of the AU or HI populations of *R. obscurus* in combination with FV and SC trapped significantly greater numbers of weevils than traps baited with no pheromone or unbaited traps. Our results corroborate with 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 FV (ethyl acetate) to the aggregation pheromone in our field research is in agreement with the other studies. Lin et al. (1992) reported that addition of aggregation pheromone to bread dough or the synthetic bread dough odor significantly increased attraction of *Carpophilus lugubris* Murray (Coleoptera: Nitidulidae) in the field to a level 4.8- and 3.1-fold greater, respectively than the aggregation pheromone alone, which elicited little beetle response. Jaffe et al. (1993) reported that rhynchophorol, 2 (*E*)-6-methyl-2-hepten-4-ol, the active component of the aggregation pheromone of the American palm weevil, *Rhynchophorus palmarum* (L.) (Coleoptera: Curculionidae), attracted weevils in the olfactometer whereas in the field the traps attracted only if plant volatile, ethyl acetate is added to the aggregation pheromone. Giblin-Davis et al. (1994) achieved good chemically mediated field trapping of *R. cruentatus* Fabricius (Coleoptera: 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) (Coleoptera: 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 is more efficient if ethyl acetate is added (Perez et al. 1997, Oehlschlager et al. 2002).

Traps baited with FV + SC did not capture as many weevils as traps baited with the pheromone in combination with FV and SC. However, our results do not agree with the results of Giblin-Davis et al. (1996) wherein ethyl acetate released alone (123-174 mg/day) was as attractive as 250 g of fermenting sugarcane or the racemic blend of the male aggregation pheromone (5-methyl-nonan-4-ol and 2-methyl-heptan-4-ol) at 8:1 ratio at 3 mg/day for *Metamasius hemipterus sericeus.* A similar report on another species indicated that one-kilogram of one- to three-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.) (Coleoptera: Curculionidae) (Gries et al. 1994). It is unwise to generalize the attractiveness of ethyl acetate on insects. For example, Smilanick et al. (1978) reported that traps baited with a mixture of ethyl acetate, acetaldehyde and ethyl alcohol, volatile compounds present in figs, caught more adult *C. hemipterus* (Linnaeus) (Coleoptera: Nitidulidae) in the field than those baited with single compounds, other mixtures, or fig paste. Liu & Hwang (2000a) screened 21 constituents from guava (*Psidium guajava* L.), mango (*Mangifera indica* L.), citrus (*Citrus grandis* L.) and carambola (*Averrhoa carambola* L.) to determine the most attractive compounds for luring oriental fruit flies, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). Their results showed that ethyl acetate and a few other related compounds were the most attractive to both female and male flies. Further, they reported that 50% molasses mixed with ethyl acetate and ethyl butyrate at a 1:1 ratio had higher attraction to adult *B. dorsalis* (Liu & Hwang 2000b). Ethyl acetate is also known to attract a variety of insects such as dipteran flies (Lee et al. 1997, Casana-Giner et al. 1999), sap beetles (Nout & Bartelt 1998, Bartelt & 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 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 as weevils traps baited with FV 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 caught 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.

In summary, our results show that the Guam *R. obscurus* population is closer to the Australian population in its response to attractants. Additionally this work focused on the potential of using lures containing the pheromone components of the Australian population in combination with FV and SC 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) program 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 borers, 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 (200 g/L fipronil at 75 g active ingredient per ha) resulted in some level of weevil borer control.

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