LETHAL PITFALL TRAP FOR EVALUATION OF SEMIOCHEMICAL-MEDIATED ATTRACTION OF *METAMASIUS HEMIPTERUS SERICEUS* (COLEOPTERA: CURCULIONIDAE)

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ABSTRACT

A lethal pitfall trap was developed for evaluating field response of adults of the West Indian sugarcane borer, *Metamasius hemipterus sericeus* (Olivier), to semiochemical attractants. Using this trap, we determined that early (≤ 5 days) volatile fermentation products from 250 g of chopped fresh stem tissue from the cabbage palmetto (*Sabal palmetto* [Walter]), sugarcane (*Saccharum officinarum* L.), pineapple (*Anana comosus* [L.]), or pseudostem from banana (*Musa* sp.) (fermented under water for 5-7 days) were attractive to *M. h. sericeus* adults in the field. Weevils were not trapped with fresh banana pseudostem and chopped unfurled leaves of *S. palmetto*. The addition of 20 males or 20 females to 250 g of chopped *S. palmetto* stem tissue increased capture of *M. h. sericeus* over tissue alone. Surveys with the lethal pitfall trap baited with sugarcane tissue demonstrated that *M. h. sericeus* is established in Dade, Broward, and Palm Beach Counties, Florida. This weevil poses a potential threat to sugarcane and field plantings of certain ornamental palm species, including *Hyophorbe verschaffeltii* Wendland, *Phoenix canariensis* Hortorum ex Chabaud, *Ptychosperma macarthurii* (Wendland), *Ravenea rivularis*, *Roystonea regia* (Humbolt, Bonpland & Kunth), and *Washingtonia robusta* Wendland.

RESUMEN

Se evaluó en el campo la atracción de adultos del picudo de la caña podrida, *Metamasius hemipterus sericeus* (Oliver) a atrayentes químicos colocados en una trampa letal. Los primeros productos volátiles (< 5 días) emanados de la fermentación de 250 g de tejido fresco picado de palmeto de col (*Sabal palmetto* [Walter]), caña de azúcar (*Saccharum officinarum* L.), piña (*Anana comosus* [L.]) o pseudotallo de banano (*Musa* sp.) (fermentado en agua por 5-7 días), fueron atractivos a los adultos de *M. h.*

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sericeus en el campo. El pseudotallo de banano y las hojas picadas del cogollo de *S. palmetto* no atrayeron adultos del picudo. La captura de *M. h. sericeus* aumentó al adicionar 20 machos o 20 hembras a una trampa con 250 g de tallo picado de *S. palmeto* en comparación con el tallo picado solo. El uso de la trampa letal demostró que *M. h. sericeus* está establecido en Florida en los condados de Dade, Broward y Palm Beach, Florida y presenta una amenaza potencial a la caña de azúcar y a ciertas especies de palmas ornamentales, tales como *Hyophorbe verschaffeltii* Wendland, *Phoenix canariensis* Hortorum ex Chabaud, *Ptychosperma macarthurii* (Wendland), *Ravenia rivularis, Roystonia regia* (Humboldt, Bonpland & Kunth), y *Washingtonia robusta* Wendland.

The West Indian sugarcane borer, *Metamasius hemipterus* (L.) is an economically important pest of sugarcane and other tropical plants in the Neotropics (Raigosa 1974, Vaurie 1966). There are three recognized subspecies of this weevil; *M. h. hemipterus* (L.) is distributed southwards from Puerto Rico through the Lesser Antilles and into most of South America; *M. h. sericeus* (Olivier) is found in the Greater Antilles and Central America south from Nicaragua to western Colombia and Ecuador; while *M. h. carbonarius* (Chevrolat) occurs from Mexico south to El Salvador and Honduras (Vaurie 1966). *Metamasius hemipterus sericeus* first became established in Dade Co., Florida in about 1984 (Woodruff & Baranowski 1985).

The biology of all three subspecies is very similar. Adult weevils are attracted to, and oviposit in, damaged or stressed sugarcane stalks, banana pseudostems, ripe fruit (i.e. pineapple, mango, papaya), or palm sheaths or stems (Vaurie 1966) where the larvae develop to adults in less than 2 months (Woodruff & Baranowski 1985). Wolcott (1955) reported that the female weevil oviposits in damaged sugarcane stem but that the larvae tunnel into healthy tissue causing it to ferment.

Fermenting sugarcane tissue has been used to attract *M. hemipterus* (Raigosa 1974) and *M. anceps* (Gyllenhal) (Teran 1968) in the field. Also, a yeast, water, and molasses mixture applied to sugarcane bagasse in single open-ended bamboo cylinder traps was used to attract *M. hemipterus* in Colombia (Arango & Rizo 1977). In all of these cases, the bait was poisoned with an insecticide to kill the weevils. Six times more *M. hemipterus* were attracted to sugarcane soaked for 12-24 hrs in water than to sugarcane soaked in 0.1% parathion and placed in traps made of 30-40 cm long cylinders of bamboo with a single open end (Raigosa 1974). The use of a lethal trap is critical for evaluation of semiochemicals, especially when pheromones are suspected. The use of insecticides can be very effective for field trapping and study of the chemical ecology of weevils (Oehlschlager et al. 1992). However, the attractancy or repellency of the insecticide to the target organism must be evaluated and safety precautions must be followed in trap set-up, placement, and maintenance. A safe and effective trap for evaluating semiochemical attractants for the subspecies of *M. hemipterus* is needed.

Males of many species of weevils produce aggregation pheromones which can be useful for monitoring the movement of pests, mass trapping, or for timing applications of pesticides or biologicals (Weissling et al. 1994). Increasing our knowledge of semiochemical attractants for *M. h. sericeus* is important because they would be extremely useful for monitoring weevil movement into the southeastern U.S.A. and for developing biorational approaches for their management in Florida.

The purpose of this study was twofold: (1) to develop a safe, lethal trap to field-evaluate the attraction of semiochemicals to *M. h. sericeus* adults and (2) to use this trap to evaluate the attraction of different fermenting plant tissues alone, and with or without conspecifics, to *M. h. sericeus* adults in the field. During this study we also demonstrated that this weevil is newly established in two counties in southeastern Florida. Symptoms of *M. h. sericeus* infestations in field-grown palm plantings were observed and are described herein.

Materials and Methods

Lethal Trap Design

The lethal pitfall trap that was developed consisted of two translucent white, high density polyethylene (HDPE) plastic tapered containers (Fisher Scientific Co., Pittsburgh, PA), one 4.9 liters and the other 0.946 liters in size (Fig. 1). Soapy water in the bottom of the larger container acted as the lethal agent. Four 3-mm diam drainage holes were drilled at 90° from each other in the sides of the 4.9-liter bucket, 6 cm from the bottom. The 0.946 liter container, which was used to hold the attractant, had 2 rows of 9 ventilation holes drilled in its sides near the bottom (Fig. 1b). An 8.5-cm diam hole was cut in the lid of this container and a 9.5-cm diam piece of aluminum screening (1.5-mm square openings) was glued to the inside of the lid to cover this hole. The lid was needed to retain the attractant (250 g of chopped test tissue and/or adult weevils) within the container when it was inverted inside the larger container (Fig. 1b). It was suspended in this container on a vinyl clad steel wire (32 cm in length) which was threaded through 3-mm holes at 180° from each other 1 cm below the top opening in the 4.9-liter bucket and through the bottom (now top) of the inverted bait container. It was suspended concentrically in the mouth of the bucket (Fig. 1a,b). Each assembled trap was buried to within about 2.5 cm of the trap top in the shade of a mature banana plant and filled with about 600 ml of soapy water (10 g Alconox soap [Alconox, Inc., New York, NY] per liter water).

In a preliminary study, this trap design was baited with 250 g of banana (*Musa* sp.) pseudostem (fermented under water for 5-7 days) and compared with the following six designs: 1) the above design set on the soil surface, 2) a fermented banana pseudostem sandwich trap (Mitchell 1978) with two slices of pseudostem (total about

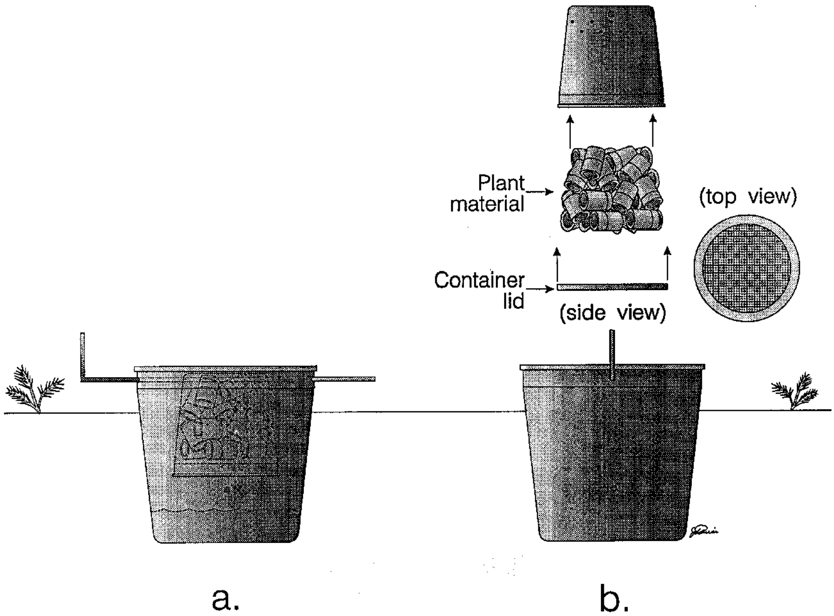

Fig. 1. Lethal pitfall trap used to capture and kill adults of *Metamasius hemipterus sericeus* attracted to different fermenting plant tissues and/or conspecifics: (a) assembled, (b) unassembled.

550 g of tissue) bound together with a rubber band and placed on the ground, 3) a live *Rhynchophorus cruentatus* (F.) trap (Weissling et al. 1992) placed on the ground with 1.3 kg of fermented banana pseudostem, 4) a lethal *R. cruentatus* trap (Weissling et al. 1993) set on the ground, with and without a polyvinyl chloride composite lid, baited with 1.3 kg of fermented banana pseudostem, and 5) a 19-liter black plastic bucket set on the ground and baited with 1.3 kg of fermented banana pseudostem. There were two replicates for each of the seven designs and traps were set out in a 15.5 ha, 2 year-old banana plantation, located near Homestead, Dade County, FL. Traps were spaced ≥ 20 m apart in rows of banana plants.

Field Response of Weevils to Fermenting Plant Tissues

Experiment No. 1 was conducted 6-11 January 1993 using the lethal pitfall trap described previously. The plant tissue attractants were 250 g of chopped tissue from the following sources: 1) fresh unfurled leaves of *Sabal palmetto* (Walter), 2) fresh stems of sugarcane, *Saccharum officinarum* L., 3) fresh pineapple, *Anana comosus* (L.), 4) fresh pseudostem of banana, *Musa* sp., 5) 7-10 cm-thick cross-sections of banana pseudostem fermented for 5-7 days under water, and 6) no tissue.

Experiment No. 2 was conducted 20-25 January 1993. The treatments were the same as for experiment No. 1 except that both banana pseudostem treatments were dropped and fresh *S. palmetto* stem tissue was added as the fifth treatment.

Traps for both experiments were arranged in a randomized complete block design in the previously described banana plantation. Treatments were spaced about 20 m apart in a row of banana plants (block) and blocks were separated by about 20 m (2 or more rows of banana plants). There were seven blocks for experiment No. 1 and eight for experiment No. 2. Total numbers of adult male and female *M. h. sericeus* collected per trap for each 5-day trapping period were used for analysis. Data were transformed $(x + 0.5)^{0.5}$ and a Statistical Analysis System general linear models procedure (SAS Institute 1985) for unbalanced ANOVA was used. Untransformed means are presented. A Waller-Duncan k-ratio t-test ($k = 100$, $P \leq 0.05$) was used for means separation.

Field Response of Weevils to Fermenting Plant Tissues and/or Conspecifics

The lethal pitfall trap (Fig. 1) was used in the field to test the attraction of weevils to live conspecifics in contact with and without *S. palmetto* tissue. All traps contained two water-moistened cellulose sponges. Treatments were traps baited with the following: 1) moistened sponges (unbaited control), 2) 20 males of *M. h. sericeus*, 3) 20 females of *M. h. sericeus*, 4) 250 g of chopped fresh *S. palmetto* stem tissue, 5) 250 g of chopped tissue plus 20 male weevils, 6) 250 g of chopped tissue plus 20 female weevils, and 7) 250 g of banana pseudostem fermented as previously described. The experiment was conducted 2-7 December 1992 (4 replicates) and 9-14 December 1992 (4 replicates) after re-randomization of treatments in a different field location. Experimental design and analysis were as previously described.

Survey of Dade, Broward, and Palm Beach Counties in Florida for *M. h. sericeus* and Symptoms

Lethal traps baited with 250 g of chopped sugarcane were used to survey plantings of sugarcane, banana, or ornamental palms in Broward (3 sites), Dade (10 sites), and Palm Beach (8 sites) counties during March-September 1993. Two to seven survey traps were used in each location. Broward, Dade, and Palm Beach county extension units, personnel of the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and cooperative growers collaborated with us in locating active *M. h. sericeus* infestations and candidate sites for survey and observation of symptoms in host plants.

RESULTS AND DISCUSSION

Lethal Trap Design

In the preliminary study, the lethal pitfall trap (Fig. 1) was 2-17 times more effective for trapping of *M. h. sericeus* than any of the other designs tested. The mean counts from the traps tested were; lethal pitfall trap depicted in Fig. 1 (17 weevils), trap design 1 (2 weevils), trap design 2 (5 weevils), trap design 3 (1 weevil), trap design 4 with pvc lid (9 weevils), trap design 4 without pvc lid (9 weevils), and trap design 5 (1 weevil). The lethal trap is safe, simple, effective, and kills incoming weevils, thus preventing contact with test attractants or pheromone(s).

This design was used for all of our other experiments. The trap design, color, and placement will be optimized in future studies when other semiochemical attractants for *M. h. sericeus* have been identified.

Field Response of Weevils to Fermenting Plant Tissues

Our study showed that semiochemicals produced by early fermentation (≤ 5 days) of a variety of plant tissues were equally attractive to *M. h. sericeus*. In experiment No. 1, sugarcane tissue was significantly more attractive to females of *M. h. sericeus* (Table 1) than pineapple and fermented banana pseudostem, which were equally attractive. Unfurled leaves of *S. palmetto*, fresh banana pseudostem, and the check were equally unattractive (Table 1). Sugarcane and pineapple were equally attractive to males of *M. h. sericeus*. The other tissues were not significantly different from the check (Table 1). The combined sex ratio for all treatments was about 5.5 females to 1.0 male.

In experiment No. 2, *S. palmetto* stem tissue, sugarcane, and pineapple were all equally attractive to males and females of *M. h. sericeus*. Unfurled leaves of *S. palmetto* and the check were not attractive (Table 1). The sex ratio in experiment No. 2

TABLE 1. ATTRACTION OF *METAMASIUS HEMIPTERUS SERICEUS* ADULTS TO LETHAL FIELD TRAPS BAITED WITH DIFFERENT PLANT TISSUES (250 G) IN A BANANA PLANTATION IN DADE CO., FLORIDA, FOR 5 DAYS.

Treatments	No. of Replicates	No. Weevils per Trap (Mean ± S.E.)[1] Females	Males
Experiment No. 1 (6-11 January 1993)			
Fresh sugarcane stem (chopped)	7	69.6 ± 23.6a	11.4 ± 3.6a
Fresh pineapple (chopped)	6	25.0 ± 15.3b	7.3 ± 4.9ab
Fermented banana pseudostem[2] (chopped)	7	16.3 ± 6.0b	1.3 ± 0.7bc
Unpresented *Sabal palmetto* leaves (chopped)	7	1.3 ± 0.5c	0.4 ± 0.3bc
Fresh banana pseudostem (chopped)	7	0.7 ± 0.3c	0.0 ± 0.0c
Empty	7	0.0 ± 0.0c	0.0 ± 0.0c

TABLE 1. (CONTINUED) ATTRACTION OF *METAMASIUS HEMIPTERUS SERICEUS* ADULTS TO LETHAL FIELD TRAPS BAITED WITH DIFFERENT PLANT TISSUES (250 G) IN A BANANA PLANTATION IN DADE CO., FLORIDA, FOR 5 DAYS.

		No. Weevils per Trap (Mean ± S.E.)[1]	
Treatments	No. of Replicates	Females	Males
Experiment No. 2 (20-25 January 1993)			
Fresh *Sabal palmetto* stem (chopped)	8	3.8 ± 1.5a	25.4 ± 12.2a
Fresh sugarcane stem (chopped)	8	2.9 ± 2.3ab	18.9 ± 6.4a
Fresh pineapple (chopped)	8	1.3 ± 0.5ab	15.8 ± 7.7a
Unpresented *Sabal palmetto* leaves (chopped)	8	0.0 ± 0.0b	0.3 ± 0.2b
Empty	8	0.0 ± 0.0b	0.0 ± 0.0b

[1]Means followed by the same letter are not significantly different according to a Waller-Duncan *k*-ratio *t*-test on $(x + 0.5)^{0.5}$ transformed data ($k = 100$, $P \leq 0.05$). Untransformed means are presented.

[2]Fermented as 7-10 cm thick cross-sections under water for 5-7 days.

was reversed from that in experiment No. 1 with about 7.5 males to 1.0 female. The lack of attractancy of fresh banana pseudostem and unfurled leaves of *S. palmetto* may have been caused by a lack of moisture in these tissues. This would have affected the quality of fermentation and the quantity of attractive volatiles released. Surprisingly, *S. palmetto* stem tissue was an excellent source of attractive volatiles even though this palm has not been observed as a host for *M. h. sericeus*. These data are consistent with observations that *M. h. sericeus* is attracted to wounded or fermenting tissue of palms, sugarcane, banana, and certain fruits (Vaurie 1966). Currently, we are using gas chromatograph-electroantennograph detection (GC-EAD) procedures to identify semiochemicals attractive to *M. h. sericeus* which have been collected from air perfusions of fermenting *S. palmetto*, sugarcane, pineapple, and fermented banana pseudostem. Active chemicals are being evaluated in the field using the lethal pitfall trap.

Field Response of Weevils to Fermenting Plant Tissues and/or Conspecifics

Sabal palmetto tissue plus 20 males and *S. palmetto* tissue plus 20 females were equally attractive to females and males of *M. h. sericeus* and more attractive than *S. palmetto* tissue alone (Table 2). Twenty females or 20 males alone, fermented banana pseudostem alone, and the empty check were all equally not attractive to males and females (Table 2). Although not statistically significant, male *M. h. sericeus* increased the attractiveness of palm tissue more than females (Table 2).

Our data show that semiochemicals emanating from fermenting tissue of *S. palmetto* are attractive by themselves (Table 2). The feeding activity of males or females on fermenting tissue possibly enhances the release of these volatiles (Table 2). This has been observed when the pine weevil *Hylobius abietis* (L.) feeds on pine (Tilles et al. 1986). These results differ from what has been observed for the palmetto weevil, *Rhynchophorus cruentatus* (F.). With this species the combination of caged males and *S. palmetto* tissue was much more attractive than females and tissue, tissue alone, males alone, females alone, and the empty check, all of which were about equally unattractive (Weissling et al. 1993). A male-produced pheromone, 5-methyl-4-octanol (cruentol), has been identified from *R. cruentatus*. It has been shown to be ineffective in field traps when released alone but strongly synergizes the weak attraction of volatiles from fermenting plant tissue (Giblin-Davis et al. 1994, Weissling et al. 1994).

TABLE 2. ATTRACTION OF *METAMASIUS HEMIPTERUS SERICEUS* ADULTS TO LETHAL FIELD TRAPS BAITED WITH FRESH *SABAL PALMETTO* OR FERMENTED BANANA PSEUDOSTEM TISSUES (250 G) AND/OR LIVE CONSPECIFIC WEEVILS, OR LEFT UNBAITED IN A BANANA PLANTATION IN DADE CO., FLORIDA FOR 5 DAYS (2-7 AND 9-14 DECEMBER 1992).

		No. Weevils per Trap (Mean ± S.E.)[1]	
Treatments	No. of Replicates	Females	Males
Fresh *S. palmetto* stem + 20 ♂♂ *M. hemipterus*	8	36.1 ± 8.6a	24.6 ± 5.8a
Fresh *S. palmetto* stem + 20 ♀♀ *M. hemipterus*	8	30.8 ± 5.4a	17.6 ± 3.9a
Fresh *S. palmetto* stem	8	18.1 ± 4.9b	6.0 ± 2.3b
Fermented banana pseudostem[2]	7	3.7 ± 1.2c	1.0 ± 0.8c
20 ♂♂ *M. hemipterus*	8	0.4 ± 0.2c	0.0 ± 0.0c
Empty	8	0.0 ± 0.0c	0.3 ± 0.3c
20 ♀♀ *M. hemipterus*	8	0.0 ± 0.0c	0.1 ± 0.1c

[1]Means followed by the same letter are not significantly different according to a Waller-Duncan *k*-ratio *t*-test on $(x + 0.5)^{0.5}$ transformed data ($k = 100$, $P \leq 0.05$). Untransformed means are presented.

[2] Fermented as 7-10 cm thick cross sections under water for 5-7 days.

Recently, we collected volatiles from males and females of *M. h. sericeus* and recovered eight male-produced chemicals (four GC-EAD-active alcohols and four GC-EAD-active ketones) (Perez et al. 1994). Using the lethal pitfall trap described herein (Fig. 1), the four alcohols combined (3-pentanol, 2-methyl-4-heptanol, 2-methyl-4-octanol, and 4-methyl-5-nonanol), each released at 3 mg/day, were as attractive as 250 g of sugarcane. When combined, these two treatments showed additive, not synergistic, attraction (Perez et al. 1994). The four GC-EAD-active ketones of *M. h. sericeus* males reduced weevil attraction in the field when released with the GC-EAD-active alcohols plus sugarcane suggesting a role as “spacing” pheromones (Perez et al. 1994). The lack of a significant difference in attraction between treatments of males plus palm tissue and females plus palm tissue in the present study is not clear. Densities of 20 males of *M. h. sericeus* may have been too high resulting in a release of the four GC-EAD-active ketones negating any response to attractive male-produced semiochemicals.

Survey of Dade, Broward, and Palm Beach Counties in Florida for *M. h. sericeus* and Symptoms

Metamasius hemipterus sericeus were trapped near and in banana plantings, sugarcane fields, and fields of ornamental palms in southern Dade County, and Pahokee and Belle Glade, Palm Beach County. We also observed larval infestations for the first time in damaged sugarcane at the Everglades Research and Education Center in Belle Glade (1 February 1994). In central and western Broward County, *M. h. sericeus* adults were trapped near and in small banana plantings and fields of ornamental palms.

Larval infestations of *M. h. sericeus* were noted in palms during 1991-1993 in Florida as follows: 1) forty healthy (Dade Co.) and about 20 wounded (Dade and Broward Co.) 3 to 4-year-old, field grown spindle palms, *Hyophorbe verschaffeltii* Wendland; 2) four 3 to 4-year-old healthy Canary Island date palms, *Phoenix canariensis* Hortorum ex Chabaud in Dade Co.; 3) three healthy MacArthur palms, *Ptychosperma macarthurii* (Wendland) in Dade Co.; 4) more than one hundred 3 to

4-year-old healthy field grown Majesty palms, *Ravenea rivularis* in Palm Beach Co.; 5) six 3 to 4-year-old healthy field grown royal palms, *Roystonea regia* (Humbolt, Bonpland & Kunth) in Broward and Palm Beach Co.; and 6) two 3 to 4-year-old healthy Washington fan palms, *Washingtonia robusta* Wendland in Dade Co.

Metamasius hemipterus sericeus larval tunneling appeared to start in petioles or wounds in the petioles, crown, or stem and then extends into healthy stem tissue. Observed symptoms included: 1) the appearance of a dark amber-colored gummy exudate which issued from openings to the surface from larval galleries in the stem and petioles of the crown region or sometimes in the stem near or amongst exposed roots (*R. regia*); and 2) open 1.0-1.5 cm diam larval galleries in the leaves, petioles, and stem. Signs included abandoned cocoons made of stem or petiole fibers, and/or adult, larval, and pupal weevils at the base of petioles and in galleries in the stem. Overall symptoms were a lethal wilt with general chlorosis and premature leaf death which was noticed in all of the *P. macarthurii*, and in several *H. verschaffeltii* and *R. rivularis* that were examined. Eventually, the crown was completely destroyed and collapsed because of larval tunneling. These symptoms are very similar to those caused in a number of palm species by the cane weevil borer, *Rhabdoscelus obscurus* (Boisduval) in Australia (Halfpapp and Storey 1991).

Because the smooth, columnar trunks of *H. verschaffeltii*, *R. rivularis*, and *R. regia* are an important part of their aesthetic appeal, even slight damage by *M. h. sericeus* is of economic importance. The *W. robusta* that we examined were booted (with old petioles attached) and asymptomatic for *M. h. sericeus* damage until the boots were removed near the crown revealing typical larval weevil damage. Booted species of palms would have a higher threshold for aesthetic trunk damage but high densities of undetected *M. h. sericeus* might cause stress or kill the tree or provide access for pathogenic organisms. Palms that are asymptomatic for early *M. h. sericeus* damage could escape early visual detection and not be exposed to insecticide treatments in palm field nurseries. In such cases, a chemically-mediated lethal trap for *M. h. sericeus* would be extremely useful for monitoring, mass-trapping, or pathogen delivery.

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