Evaluation of an Entomopathogenic Nematode and Chemical Insecticides for Control of *Metamasius hemipterus sericeus* (Coleoptera: Curculionidae)[1,2]

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ABSTRACT Several chemical insecticides and the entomopathogenic nematode, *Steinernema carpocapsae* (Weiser) (All strain), were evaluated for efficacy against the West Indian sugarcane weevil, *Metamasius hemipterus sericeus* (Olivier), in laboratory and field tests. Three different bioassays and a field study with sugarcane demonstrated that *S. carpocapsae* were efficacious against larvae but not adults of the weevil. These bioassays also demonstrated that adults of *M. h. sericeus* were killed by labelled rates of commercial formulations of acephate 75WP, carbofuran 2F, chlorpyrifos 4 EC, cyfluthrin 2 EC, disulfoton 15G, imidacloprid 2F, isofenphos 2I, lindane 25WP, and Vydate L. In a field test with weevil-infested Canary Island date palms, *Phoenix canariensis* Hortorum ex Chabaud, lindane (25 WP, 1.5 g AI/palm), and imidacloprid (75 WP, 1.2 g AI/palm) had the greatest effect on the percentage mortality of total weevils present per palm (> 60%) followed by *S. carpocapsae* (8×10^6 infective juveniles [IJs]/palm) (51%) and acephate (2.9 g AI/palm) (39%) which were statistically equal to the controls (14%). Control palms harbored over 200 *M. h. sericeus* per tree in the petioles and stem periphery. Because of the potential for high weevil production per palm and the cryptic habitat of the boring stages of this weevil, chemical insecticides and/or entomopathogenic nematodes will need to be applied frequently and over a long period of time for effective management.

KEY WORDS Banana, chemical insecticides, Coleoptera, Curculionidae, entomopathogenic nematode, *Metamasius hemipterus sericeus*, ornamental palms, *Phoenix canariensis, Steinernema carpocapsae*, sugarcane, West Indian sugarcane weevil

The West Indian sugarcane weevil, *Metamasius hemipterus sericeus* (Olivier), is an important pest that affects palm nurseries, banana, and sugarcane plantings in southern Florida and threatens to invade other areas within the state and the southeastern United States (Giblin-Davis et al. 1994, Peña et al. 1995). This weevil, which is distributed in the West Indies, Central, and South America (Vaurie 1966), was first reported in Dade Co., FL in 1984 (Woodruff

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and Baranowski 1985). Larvae of *M. h. sericeus* are borers which can seriously damage palms such as *Hyophorbe verschafeltii* Wendland (spindle palm), *Phoenix canariensis* Hortorum ex Chabaud (Canary Island date palm), *Ptychosperma macarthurii* (Wendland) (solitaire palm), *Ravenia rivularis* Jumelle and Perrier (majesty palm), and *Roystonea regia* (Humboldt, Bonpland & Kunth) (royal palm) (Giblin-Davis et al. 1994). These weevils also attack and destroy wounded banana, *Musa* spp. pseudostems (Peña et al. 1995), and sugarcane, interspecific hybrids of *Saccharum* (Vaurie 1966). Adults are attracted to and oviposit in palm sheaths and stems where the larvae develop to adults in less than 2 months (Woodruff and Baranowski 1985). Larval tunneling starts in petioles, wounds in the petioles, crown, or stem and then extends into healthy leaf or stem tissue. Affected palms are often characterized by the production of an amber-colored and gummy exudate in the stem, crown shaft or petioles, and galleries in the leaves, petioles, and stems (Giblin-Davis et al. 1994). Infestations can become quite damaging and extensive in palm field nurseries because weevil damage can escape early detection (R. G.-D. and J. P. unpubl. obs.).

Currently, Florida Department of Plant Industry regulations require that palm nurseries with infestations of *M. h. sericeus* be quarantined and sprayed with insecticides until weevils are not detectable in plants for sale or distribution to prevent further spread of the pest. We are aware of no published research on the efficacy of current insecticides or entomopathogenic nematodes for control of this weevil.

We report the results of laboratory and field trials comparing the efficacy of the entomopathogenic nematode, *Steinernema carpocapsae* (Weiser) (All strain) and selected contact and/or systemic chemical insecticides against *M. h. sericeus* on palms, banana, and sugarcane in Florida.

Materials and Methods

Insects. A laboratory colony of *M. h. sericeus* was reared on 3 kg of sugarcane stem pieces/can (approximately 200 g or 30 cm per cane stem) in 125-liter green plastic garbage cans with screened lids. Adult males and females of *M. h. sericeus* (100 ± 21; 1:1 sex ratio) were introduced into each cage and maintained for 9 ± 2 days at 25 ± 2°C and 75-85% RH with a 12-h photoperiod and then removed. No additional food was added. Sixty days later, 63 ± 10 adults per cage were harvested and placed in 800-ml plastic containers for experimental use. Several cages were also set-up for larval production and larvae were collected about 30 days after cane infestation.

Petri Dish Bioassays of *S. carpocapsae*. Adult *M. h. sericeus* (n = 60/treatment) were individually transferred to 14.5-cm diam Petri dishes lined with a single layer of Whatman no. 1 filter paper (Whatman Laboratory Division, Kent, England). About 20 g of fresh banana pseudostem was added as a food source. Six concentrations of *S. carpocapsae* (All strain) (0, 1.7, 2.1, 4.5, 6.8, and 14.0 $\times 10^3$ infective third-stage juveniles [IJs/ml]) were prepared in deionized water. One ml of each suspension was individually pipetted onto the filter paper in the dishes. *Steinernema carpocapsae* was supplied by biosys (Palo Alto, CA). Nematode densities were estimated by counting the number of

IJs in ten 1-ml aliquots. Adult mortality was assessed 1, 2, and 3 wks after treatment. Moribund individuals were considered alive. Dead adults were dissected and the presence or absence of nematodes recorded. Mortality was analyzed by POLO, a computer program for probit analysis (Russell et al. 1977). Nematode densities that killed 50 and 90% of the adult weevil population (LC_{50} and LC_{90}, respectively) were determined and reported as IJs per insect.

The same experimental design also was used for assessing mortality of last-instar larvae of *M. h. sericeus* exposed to different concentrations of *S. carpocapsae,* except that 10 larvae were used for each concentration. Five concentrations of *S. carpocapsae* (0, 1.9, 3.7, 5.6, and 9.3 $\times$ 10^3 IJs/ml) were prepared and dispensed into individual Petri dishes as described above. Mortality was assessed 5 days after treatment. Dead larvae were kept individually for 1 to 3 wks in Petri dishes on moist filter paper until dissection to confirm cause of death. Nematodes were counted in measured aliquots of suspension.

Laboratory Bioassays Using Banana Pseudostem. Formulated chemical insecticide products and Vector TL (biosys, Palo Alto, CA) (AI = *S. carpocapsae* [All strain]) were evaluated against *M. h. sericeus* adults in a bioassay using banana pseudostem. Formulated insecticidal products were applied to 100 g of fresh banana pseudostem tissue at the recommended field rates as follows: Experiment 1 - carbofuran 2 F (1.2 g AI/L), *S. carpocapsae* (2.6 $\times$ 10^3 IJs/L), Vydate L (1.2 g AI/L), and disulfoton 15G (2.4 g AI/L); Experiment 2 - chlorpyrifos 4EC (1.2 g AI/L), cyfluthrin 2 EC (0.15 g AI/L), imidacloprid 2 F (0.45 g AI/L), isofenphos 2I (2.4 g AI/L), acephate 75WP (2.4 g AI/L), and lindane 25WP (0.6 g AI/L). The controls in both experiments were treated with deionized water. Pseudostems were dipped in the appropriate solution for 2 min and air dried for 30 min. Each pseudostem was placed into a 12-cm diam Petri dish lined with Whatman no. 1 filter paper. Two *M. h. sericeus* adults were placed on top of each pseudostem. Petri dishes were covered and adult mortality was checked 24 h after treatment (except for weevils treated with *S. carpocapsae* which were checked daily for 3 days). Petri dishes were kept at 25 ± 2 °C. Relative humidity in the Petri dish was approximately 90-100%. Experimental design was a randomized complete block with 20 replicates per treatment. Count data were transformed to $(X + 0.5)^{0.5}$ values before analysis; untransformed means are presented. Data were analyzed by ANOVA and the means separated by the least-square-difference test ($P < 0.05$) (SAS Institute 1985).

Impact of Control Agents on Adults and Progeny in Potted Palm. A bioassay was used to measure the relative effect of *S. carpocapsae* and chemical insecticides on the mortality of *M. h. sericeus* adults and progeny on 5-liter container-grown *R. rivularis* (majesty palm). Each 2-year-old palm was infested with three adult males and 11 females of *M. h. sericeus* on 1 November 1993 and placed in a 125-liter garbage can cage as previously described. Twenty-one days after infestation, the palms were removed from the cage, treated with insecticides which were sprayed to runoff with a 7.56-liter hand sprayer under approximately 0.7 kg/cm^2 pressure. The treatments were chlorpyrifos 4 EC (1.2 g AI/L), *S. carpocapsae* (2.6 $\times$ 10^3 IJs/L), imidacloprid 2 F (0.45 g AI/L), isofenphos 2 I (2.4 g/L), and lindane 25% WP (0.6 g AI/L). At least 15 min after treatment, the palms were returned to their cages. The experimental design was a randomized complete block with 6 replicates. Damage to the palms and larval and adult infestation levels were recorded by destructive sampling at 8 days after treatment. Count data were transformed to $(X + 0.5)^{0.5}$ values, and percentage data were transformed by arcsin prior to analysis; untransformed means are presented. Data were analyzed by ANOVA and the means separated by the least-square-difference test ($P < 0.05$) (SAS Institute 1985).

Trials in Sugarcane. During the spring of 1994, a 0.05-ha field of first ratoon sugarcane located at the Tropical Research and Education Center, Homestead, FL was used to compare the efficacy of selected systemic insecticides and *S. carpocapsae* for control of larvae of *M. h. sericeus*. Each clump of sugarcane had at least three, 3-cm diam stalks. A 1.1-cm diam hole was drilled 2.5 cm into the base of a cane (2.5 cm above ground), and a third, fourth, or fifth-instar larva was placed inside the opening which was then sealed with a 1.5-cm long × 1.2-cm diam sugarcane plug. To insure that the hole remained plugged and to prevent red imported fire ant (*Solenopsis invicta* Buren) predation, a 3-cm wide band of Parafilm® (American National Can, CT) was wrapped twice around the stalk. Insecticides were applied to the soil as a drench or granular application depending upon the formulation. The treatments were carbofuran 2 F (1.12 kg AI/ha or 1.2 g AI/L), *S. carpocapsae* (2.5×10^8 IJs/ha or 2.6×10^3 IJs/L), Vydate L (0.33 kg/ha or 1.2 g AI/L), and disulfoton 15 G (2.25 kg AI/ha or 2.4 g AI/L). Insect mortality was determined by dissecting the marked stem at 1 wk after treatment. To assess the persistence of the treatments, the two remaining stalks were infested at 2 and 4 wks after treatment. Mortality was assessed 1 wk following each infestation. The experimental design was a randomized complete block with 5 replications with analysis as previously described.

Field Trials in Canary Island Date Palms. A field test was conducted in a 1-ha field nursery of 6-year-old Canary Island date palms, *P. canariensis*, interplanted with 6-year-old sabal palms, *Sabal palmetto* (Walter), in Broward Co., FL. The date palms were infested with all stages of *M. h. sericeus*. There were 5 treatments with 4 replicates each. Treatments were applied to palms exhibiting severe petiolar and some stem damage. The experimental design was a randomized complete block with blocks assigned by location in the grove. All treatments were applied as a crown drench to each tree as follows: (1) no treatment, (2) 2.5 liters of lindane 25WP (0.6 g AI/L) sprayed to run-off, (3) 2.5 liters of imidacloprid 75WP (1.2 g AI/L) applied with a watering can, (4) 2.5 liters of acephate (Ortho, Orthene Systemic Insect Control, Monsanto Co., San Ramon, CA) (1.1 g AI/L) applied with a watering can, and (5) 8×10^6 IJs of *S. carpocapsae* (Vector TL) dispersed in 2.5 liters of water and applied with a watering can. All treatments were applied on 4 April 1995, except lindane which was applied the following morning by a commercial applicator. Palms were harvested 21 days later with a chain saw and temporarily placed in labelled 125-liter garbage can cages before being destructively sampled by block. Each palm was measured for stem diameter, rated for weevil damage, and then quartered longitudinally with a chain saw to facilitate sampling. For most palms, the entire plant was carefully dissected with pruning sheers and/or a knife and all stages of weevils counted (including empty cocoons). In several trees, where counts were very high, two random quarter samples were taken to estimate the weevil counts. Count data were transformed to $(x + 0.5)^{0.5}$ values and the percentage mortality data for each stage were transformed by arcsin and analyzed by the general linear models procedure for unbalanced analysis of variance (SAS Institute 1985). Untransformed means are presented. Significant differences ($P < 0.05$) among treatment means were separated using the least-square-difference method.

Results and Discussion

Petri Dish Bioassays of *S. carpocapsae*. *Steinernema carpocapsae* does not appear to have good potential for killing adults of *M. h. sericeus*. The LC_{50} and LC_{90} values for *S. carpocapsae* were 1.14×10^4 and 2.63×10^7, respectively, with a slope of 0.38. The 95% fiducial limits were not estimable because the probit analysis provided a poor fit of the data. In fact, the calculated LC_{90} value was more than one order of magnitude higher than the highest concentration we tested, suggesting that much higher concentrations should have been used for more accurately estimating the LC values. However, it is clear from this experiment that *S. carpocapsae* (All strain) would not be cost effective for treatment of adult weevils. Recent work on other species of entomopathogenic nematodes (*Steinernema feltiae* (Filipjev) (N-27 strain) and *Heterorhabditis bacteriophora* Poinar (HP-88 strain) show similar results (J. P., unpubl. data).

This preliminary experiment, however, showed that *S. carpocapsae* was effective against larvae of *M. h. sericeus* and caused 90% mortality at 1.9×10^3 and 100% mortality at concentrations of 3.7 to 9.3×10^3 IJs/larva. Control mortality was 40%. No *S. carpocapsae* were recovered from control larvae. *Steinernema carpocapsae* IJs were recovered from each of the dead larvae receiving nematode treatments. The average number of IJs per cadaver per treatment ranged from 5,000 to 35,000.

Laboratory Bioassays Using Banana Pseudostem. In the first banana pseudostem experiment, carbofuran, Vydate, and disulfoton were more effective than *S. carpocapsae* which was more effective than the control against adult *M. h. sericeus* (Fig. 1). This supports the results from the previous experiment that suggested poor efficacy of *S. carpocapsae* against adult weevils. In the second experiment, all of the insecticides tested were more effective against adults of *M. h. sericeus* than the control (Fig. 1). Imidacloprid at the rate tested was less effective or slower acting than the other insecticides (Fig. 1).

Impact of Control Agents on Adults and Progeny in Potted Palm. In this experiment, chlorpyrifos, imidacloprid, isofenphos, and lindane were more effective against adults of *M. h. sericeus* than *S. carpocapsae* or the control which were equal (Fig. 2A). Contrastingly, *S. carpocapsae* was the only treatment that was more effective than the control for the mortality of larvae + pupae (Fig. 2A). The average number of total adults recovered was equal for all treatments (Fig. 2B), whereas the numbers of larvae + pupae were lowest for the *S. carpocapsae* and lindane treatments (Fig. 2B). The low numbers and high mortality for larvae + pupae of *M. h. sericeus* after treatment with *S. carpocapsae* relative to the control are consistent with the Petri dish bioassay results.

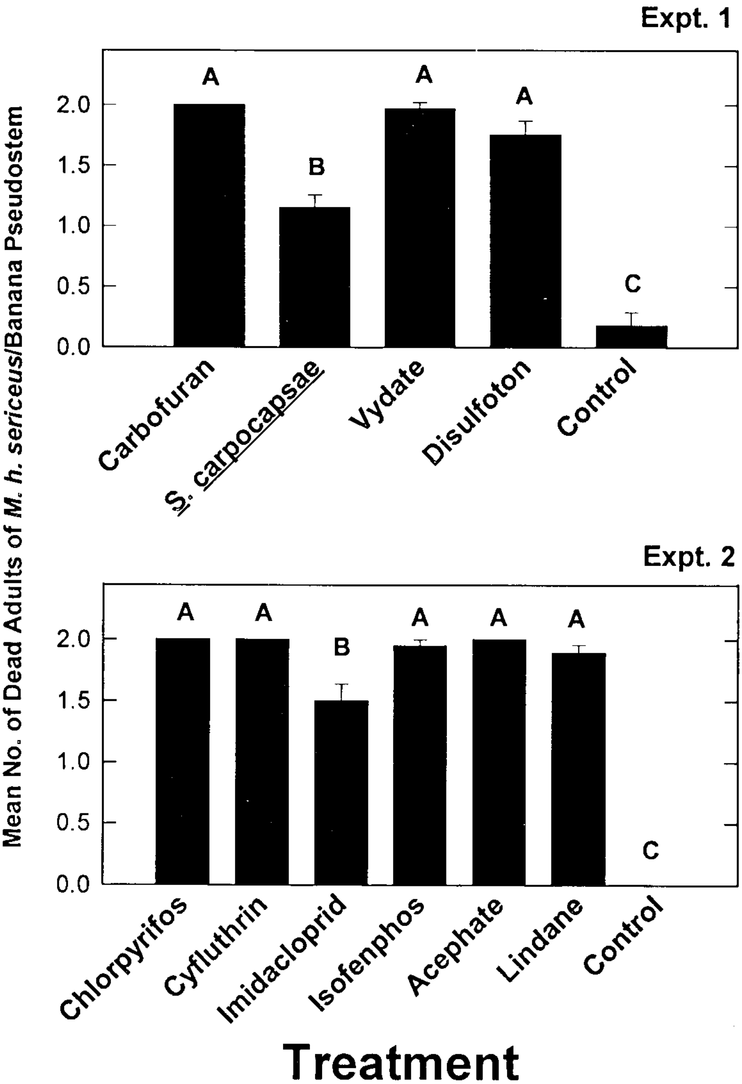

Fig. 1. Plot of the mean number of dead adults of *Metamasius hemipterus sericeus* per Petri dish (n = 2 weevils per Petri dish) on 100 g of banana pseudostem that was treated with different formulated chemical insecticides or the entomopathogenic nematode, *Steinernema carpocapsae* (see Materials and Methods for rates of application). Means (± standard error) followed by the same upper case letter are not significantly different (least-square-difference, $P > 0.05$). Count data were $(X + 0.5)^{0.5}$ transformed prior to analysis; untransformed means are presented.

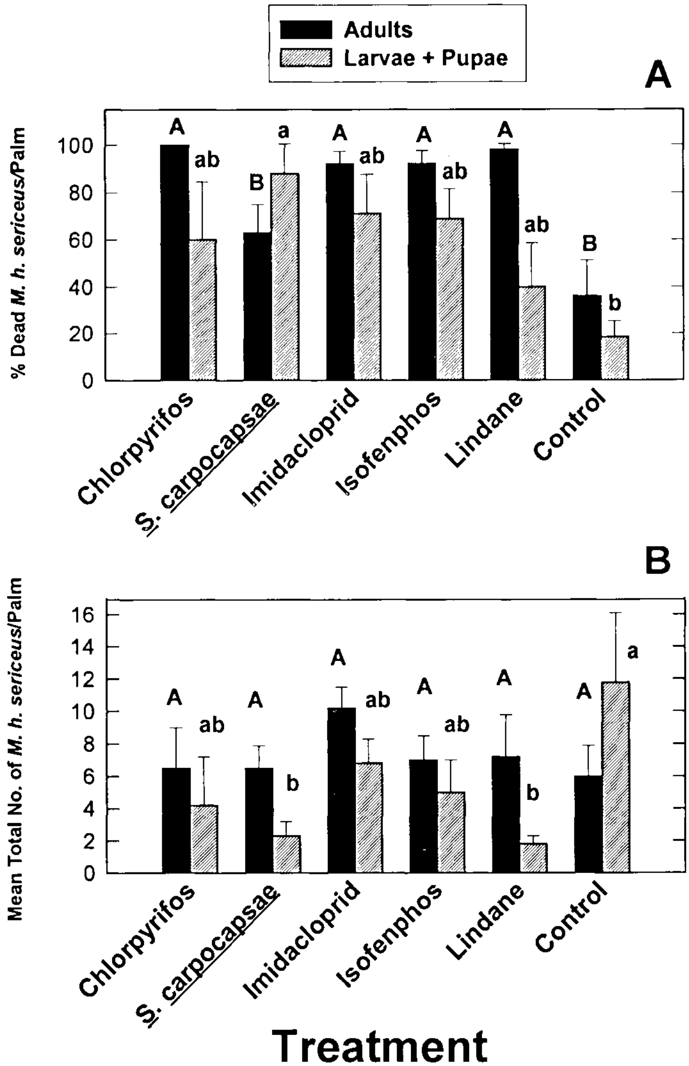

Fig. 2. A. Plot of the mean percentage of dead adults and progeny of *Metamasius hemipterus sericeus* per potted *Ravenia rivularis* palm that were treated with different formulated chemical insecticides or the entomopathogenic nematode, *Steinernema carpocapsae* (see Materials and Methods for rates of application). B. Plot of the mean total number of adults or progeny of *M. h. sericeus* per potted palm for the different treatments. Means (± standard error) followed by the same upper or lower case letter are not significantly different (least-square-difference, $P > 0.05$). Count data were $(X + 0.5)^{0.5}$ transformed and percentage data were arcsin transformed prior to analysis; untransformed means are presented.

Field Trials in Sugarcane. Carbofuran was more effective than the other two systemic insecticides tested or *S. carpocapsae* for causing mortality to larvae of *M. h. sericeus* in sugarcane (Fig. 3). The effect of carbofuran persisted for at least 14 to 21 days (Fig. 3). Results from 28 to 35 days after treatment showed no difference in larval mortality between the carbofuran treatment and control (data not shown). Unfortunately, carbofuran is a restricted-use insecticide which is not labelled for field-grown palms, and it appears that the manufacturer is not interested in expanding the label. Therefore, we discontinued any further evaluations of the chemical. *Steinernema carpocapsae* was more effective than the control at both 0 to 7 and 14 to 21 days after treatment and more effective than disyston at 0 to 7 days (Fig. 3). Vydate was more effective for larval mortality than the control at 0 to 7 days after treatment only (Fig. 3). These data reflect the searching capabilities of *S. carpocapsae* for finding and killing the cryptic larval stage of *M. h. sericeus* in the host.

Field Trials in Canary Island Date Palms. The average stem diameter for *P. canariensis* was equal for all treatments at 26.2 cm (data not shown). Symptoms were the same or similar for all treatments suggesting that any effects on weevil mortality were not immediately manifested in improved plant performance. There were no differences in the total numbers of empty cocoons present for each treatment (Table 1) which averaged 260/palm for the experiment. Also, there was no difference in the total number of weevils per palm (total weevils + empty cocoons) for any of the treatments (Table 1). Because we do not know the history of weevil occupation for an empty cocoon, the counts of empty cocoons and total weevils + cocoons can only be used as a rough estimate of the potential for weevil production for a 6-year-old field-grown *P. canariensis*. Control trees were infested with 215 weevils of all stages and had about the same number of empty cocoons (Table 1).

Infestations of *M. h. sericeus* usually involved the petioles and the periphery of the stem where the petioles attached. Stages associated with pupation (last instar larvae, prepupae, pupae, and newly-emerged adults) were usually found in the petioles (sometimes as many as 25 cocoons per petiole). Only in heavily-infested palms were deeper stem infestations found. This situation was exacerbated by raccoon (*Procyon* sp.) foraging damage and often resulted in death of the palm. Raccoons prey upon *M. h. sericeus* (Giblin-Davis et al. 1996). Three of the palms also were infested with the palmetto weevil, *Rhynchophorus cruentatus* (F.). When *R. cruentatus* co-occurred with *M. h. sericeus* in *P. canariensis,* damage to the palm was much more severe and often resulted in palm death. This is because *R. cruentatus* larvae burrow through the crown area and damage the apical meristem. Thus, chronic damage by *M. h. sericeus* appears to lead to very high densities of weevils per tree and attracts even more damaging pests such as *R. cruentatus* and raccoons. We even noticed a large number of palms with what appeared to be secondary infestations of the banana moth, *Opogona sacchari* Bojer (Peña et al. 1990).

Lindane and imidacloprid had the greatest effect on mortality of total weevils present per palm (>60%) followed by *S. carpocapsae* (51%) and acephate (39%) which were statistically equal to the controls (14%) (Table 1). Palms treated with lindane had higher mortality of pupae, free adults, and adults in

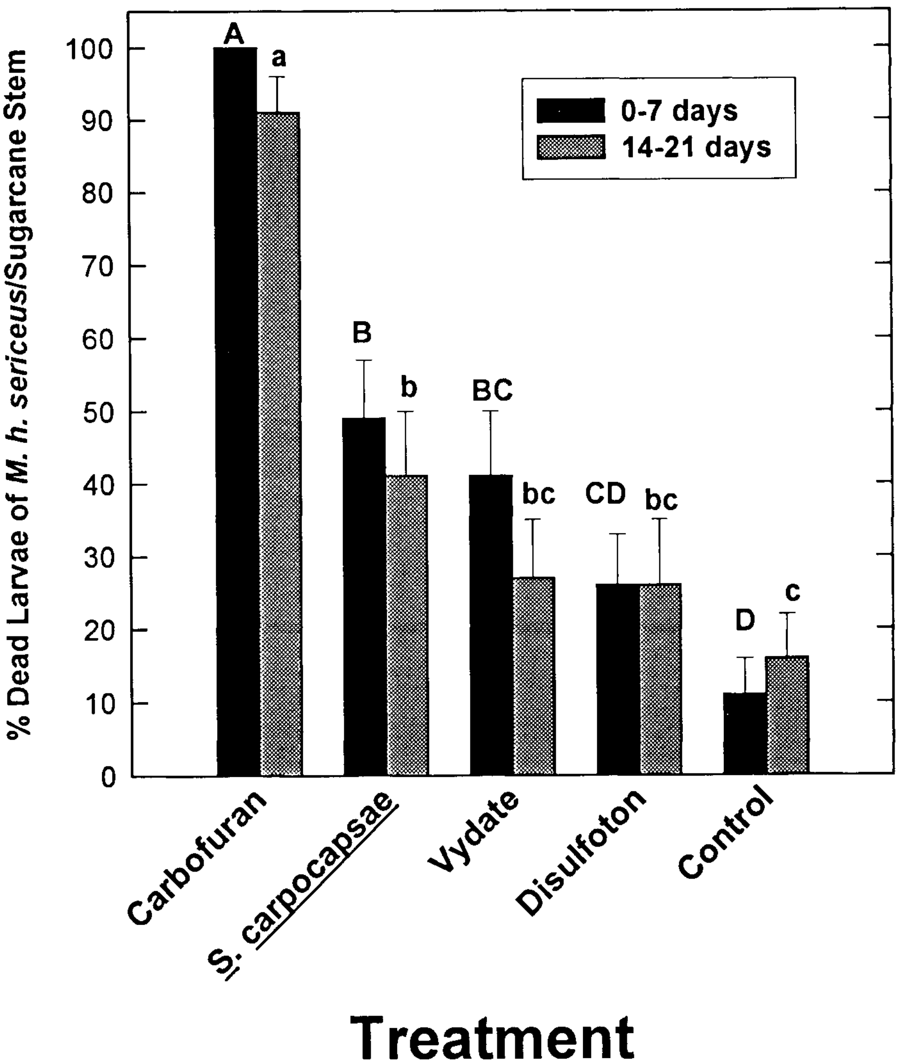

Fig. 3. Plot of the mean percentage of dead larvae of *Metamasius hemipterus sericeus* per sugarcane stem that were treated with different formulated systemic chemical insecticides or the entomopathogenic nematode, *Steinernema carpocapsae* (see Materials and Methods for rates of application) at different times after treatment. Means (± standard error) followed by the same upper or lower case letter are not significantly different (least-square-difference, $P > 0.05$). Percentage data were arcsin transformed prior to analysis; untransformed means are presented.

Table 1. Counts and percentage mortality of *Metamasius hemipterus sericeus* life stages from 6-year-old *Phoenix canariensis* palms 21 days after treatment with insecticides, *Steinernema carpocapsae*, or no treatment in Broward Co. FL (4 replicates).

Treatment	Control		Lindane		Imidacloprid		Acephate		*Steinernema carpocapsae*	
Stage	Mean No. (± SE) per Palm	% Dead	Mean No. per Palm	% Dead	Mean No. per Palm	% Dead	Mean No. per Palm	% Dead	Mean No. per Palm	% Dead
Free Larvae	53 ± 29 A	25 a	8 ± 5 B	0 a	2 ± 2 B	56 a	26 ± 11 AB	8 a	17 ± 11 AB	30 a
Larvae in Cocoons	27 ± 4 A	15 c	7 ± 2 BC	25 abc	1 ± 1 C	100 a	9 ± 6 B	17 bc	7 ± 2 B	92 ab
Pupae	26 ± 10 A	26 b	5 ± 2 BC	64 ab	3 ± 2 BC	100 a	15 ± 6 AB	38 b	13 ± 6 ABC	95 a
Adults in Cocoons	43 ± 19 A	16 d	20 ± 10 A	100 a	36 ± 18 A	50 cd	25 ± 7 A	69 bc	5 ± 3 A	88 ab
Free Adults	67 ± 35 A	18 c	68 ± 24 A	64 ab	20 ± 6 A	96 a	72 ± 17 A	39 bc	51 ± 18 A	31 bc
Total Weevils Present	215 ± 60 A	14 b	107 ± 31 AB	61 a	62 ± 12 B	66 a	146 ± 37 AB	39 ab	92 ± 26 AB	51 ab
Empty Cocoons	212 ± 52 A	–	347 ± 124 A	–	181 ± 74 A	–	324 ± 109 A	–	238 ± 22 A	–
Total Weevils+ Cocoons	427 ± 72 A	–	454 ± 143 A	–	243 ± 81 A	–	470 ± 145 A	–	330 ± 48 A	–

Means followed by the same upper case letter in a row are not significantly different according to a least-significant-differences (LSD) test ($P > 0.05$). Count data were transformed to square root (x + 0.5) values before analysis. Means followed by the same lower case letter are not significantly different by LSD ($P > 0.05$). Percentage data were transformed by arcsin before analysis. Untransformed means are presented.

cocoons (>60%) and lower numbers of larvae (free and in cocoons) than the control suggesting good contact activity (Table 1).

Treatment with imidacloprid caused >50% mortality for all stages of *M. h. sericeus* examined and lower numbers of recovered larvae (free and in cocoon) than the control (Table 1). Imidacloprid is a nicotinoid with systemic and contact activity. We used a higher rate (2.7 X) in this experiment than in the previous laboratory bioassays to account for the dynamics of uptake by the palm.

Steinernema carpocapsae was one of the most effective treatments for mortality of larvae, pupae, and adults (all in cocoons) (>88%), but was not effective against free larvae and adults (<31%) relative to the controls (Table 1). This is consistent with the previous experiments in this paper. The lack of efficacy of *S. carpocapsae* against free larvae may be due to poor control of free adults which were successful in oviposition as the nematode treatment waned or due to easier nematode access to the stages in the cocoons which occur closer to the periphery of the stem and petioles. Large numbers of IJs (>1,000) of *S. carpocapsae* were recovered from dead larvae, pupae, and adults within the cocoon demonstrating some recycling potential in the field. Also, nematodes were recovered from some of the free larvae examined. The infestation of adults in the cocoons by *S. carpocapsae* may actually reflect pupal infestations that were carried to the adult stage. All of the dead adults in cocoons with nematodes had either recently completed or were in the process of molting.

Palms treated with acephate at the labelled rate for ornamentals had higher levels of mortality than the controls for adults in cocoons only (Table 1).

None of the treatments that we tested in the *P. canariensis* field were close to eradicative with a single treatment (Table 1). Thus, any strategy aimed at reducing heavy infestations of *M. h. sericeus* will require repeat applications, probably over several months at 2 to 4-wk intervals, dependent upon weather conditions and persistence of the insecticide used. All of the chemicals tested in our study had good activity against the adults (Figs. 1, 2). This is similar to the related palmetto weevil, *R. cruentatus,* where several insecticides, including lindane and chlorpyrifos were active against adults and were suggested for prophylactic treatment of stressed palms (Giblin-Davis and Howard 1989). Our study suggests that the entomopathogenic nematode, *S. carpocapsae* may be used against the immature stages of *M. h. sericeus*, especially near the periphery of the palm. If a rotation of chemicals was to be used every 2 to 4 wks, *S. carpocapsae* could be integrated as one of the treatments. Another contact insecticide with some efficacy against adults of *M. h. sericeus* is carbaryl (Giblin-Davis et al. 1996).

Because of the high weevil production potential of *P. canariensis* (Table 1), it may not be economically feasible to cultivate this palm species in some areas. All growers of *P. canariensis* should be aware of the damage potential of this pest and the possible interaction with *R. cruentatus* which can be a pest by itself (Giblin-Davis, unpubl. data). Expensive and highly susceptible palm species, such as *P. canariensis, R. rivularis, R. regia,* and *H. verschafeltii* should not be planted in an area with high numbers of *M. h. sericeus* or near sugarcane and/or banana plantings where the weevil numbers can amass. Recent advances in pheromone and kairomone-based trapping of *M. h. sericeus* (Giblin-Davis et al. 1996, Perez et al. 1996) may help in the early detection and monitoring of weevil activity.

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References Cited

Giblin-Davis, R. M. and F. W. Howard. 1989. Vulnerability of stressed palms to attack by *Rhynchophorus cruentatus* (Coleoptera: Curculionidae) and insecticidal control of the pest. J. Econ. Entomol. 82: 1185-1190.

Giblin-Davis, R. M., J. E. Peña and R. E. Duncan. 1994. Lethal pitfall trap for evaluation of semiochemical-mediated attraction of *Metamasius hemipterus sericeus* (Coleoptera: Curculionidae). Florida Entomol. 77: 247-255.

Giblin-Davis, R. M., J. E. Peña, A. C. Oehlschlager and A. L. Perez. 1996. Optimization of semiochemical-based trapping of *Metamasius hemipterus sericeus* (Olivier) (Coleoptera: Curculionidae). J. Chem. Ecol. 22: (in press).

Peña, J. E., R. E. Duncan and V. Torres. 1990. Dynamics and control of the banana moth on foliage plants. Proc. Fla. Hort. Soc. 103: 189-192.

Peña, J. E., R. M. Giblin-Davis and R. E. Duncan. 1995. Impact of indigenous *Beauvaria bassiana* (Balsamo) Vuillemin on Banana weevil and rotten sugarcane weevil (Coleoptera: Curculionidae) populations in Banana in Florida. J. Agric. Entomol. 12: 163-167.

Perez, A. L., Y. Campos-Pedra, C. M. Chinchilla, A. C. Oehlschlager, G. Gries, R. Gries, G. Castrillo, R. M. Giblin-Davis, J. E. Peña, R. E. Duncan, L. M. Gonzalez, H. D. Pierce, Jr., R. McDonald and R. Andrade. 1996. Aggregation pheromones and host kairomones of the West Indian sugarcane weevil, *Metamasius hemipterus sericeus* (Olivier). J. Chem. Ecol. 22: (in press).

Russell, R. M., J. L. Robertson and N. E. Savin. 1977. POLO: a new computer program for probit analysis. Bull. Entomol. Soc. America. 23: 209-213.

SAS Institute. 1985. SAS user's guide: statistics, 5th ed. SAS Institute, Cary, NC.

Vaurie, P. 1966. A revision of the Neotropical genus *Metamasius* (Coleoptera, Curculionidae, Rhynchophorinae). Species groups I and II. Bull. American Mus. Nat. Hist. 131: 213-337.

Woodruff, R. E. and R. M. Baranowski. 1985. *Metamasius hemipterus* (Linnaeus) recently established in Florida (Coleoptera: Curculionidae). Florida Dept. Agric. & Consumer Serv. Division of Plant Industry, Entomology Circular No. 272. 4 pp.