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DYNAMICS AND CONTROL OF THE BANANA MOTH ON FOLIAGE PLANTS

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Abstract. **In 1986, the banana moth, *Opogona sacchari* Bojer caused serious damage to foliage plants, particularly to bamboo palms, *Chamaedorea elegans* and corn plants, *Dracaena* spp. Since then, this insect has attacked more than 24 plant species in Florida nurseries stock. The population dynamics of this insect were investigated during 1988-1989 in three commercial greenhouses in Dade County. Biological and chemical control methods were tested in bamboo and corn plants. Populations of *Opogona sacchari* were reduced with a single application of Sevin, Lorsban and Lannate. Populations of *O. sacchari* were reduced 90% with a single application to the soil of the entomophilic nematodes *Steinernema feltiae* and *Heterorhabditis heliothidis*. Nematodes persisted in the soil for 6 weeks after treatment.**

The banana moth, *Opogona sacchari* Bojer, has been recognized as a primary pest of ornamentals in Florida and as a pest of row crops in different regions of the world (3 and 5). The recorded distribution of *O. sacchari* includes Mauritius, Canary Islands, Madagascar, Italy, Belgium, Netherlands, Great Britain, Brazil, Peru, Barbados and the United States. Hosts recorded for this moth before 1990 included *Cordyline terminalis* (L.), *Dracaena fragrans* (L.), *Dracaena marginata* Lam., *Dracaena reflexa* Lam., *Yucca elephantipes* Regel, *Colocasia esculenta* Schott, *Philodendron scandens* Lindl., *Polyscias fruticosa* "elegans" (L.), *Dahlia* sp., *Aechmea fasciata* (Lindl.), *Guzmania lingulata* [Hort], *Carica papaya* L., *Ipomoea batatas* Lam., *Cycas revoluta* Thunberg, *Dioscorea* sp., *Gloxinia* sp., *Gladiolus* sp., *Albizia julibrissin* Durazz, *Enterolobium* sp., *Erythrina variegata* L., *Sansevieria laurantii* Wilden, *Ficus elastica* (H. A. Siebrecht), *Maranta leuconeura* nassangeana Schum., *Musa cavendishi* L., *Musa paradisiaca*, L., *Musa sapientum* L., *Strelitzia* sp., *Arecastrum* sp. *Bactris gasipaes* HBK, *Chamaedorea elegans* Mart., *Chamaedorea erumpens* H. E. Moore, *Chamaedorea seifrizii* Bunet, *Saccharum officinarum* L., *Zea mays* L., *Capsicum* sp., *Solanum melongena* L., *Solanum tuberosum* L., and *Clerodendrum* sp. (2).

Damage is caused by larvae of *O. sacchari* feeding on the stem, leaves, and roots of the host plants (4). Because the banana moth had apparently established an endemic population in commercial foliage greenhouses in Dade, Broward, and Palm Beach counties, and because little published information was available on banana moth from North America, we concluded that additional observations on the distribution, biology and control of *O. sacchari* were warranted.

Materials and Methods

Dyanamics. Sexual response of 2-3 day-old *O. sacchari* males to 2-3 day old virgin females was observed in the laboratory by Davis and Pena (2). Thus, to determine adult abundance, Pherocon 4C traps (n = 3) baited with *O. sacchari* virgin females (n = 4) were evenly distributed in 3 *Chamaedorea* and *Dracaena* greenhouses located in Dade County, Florida. Traps were positioned at 60 cm above the surface. The traps were inspected weekly for the presence of males from May 1988 through May 1989.

Chemical Control. Experiment 1. *Dracaena* and *Chamaedorea* (0.30 m tall) growing in 3.8 l containers were used to evaluate efficacy of selected insecticides against banana moth larvae. With the exception of Dysiston, all insecticides were applied by a hand sprayer at approximately 45-60 PSI to 20 plants/treatment. Counts of live larvae were made, 2 and 8 days after treatment.

Experiment 2. Efficacy of selected pesticides was evaluated against banana moth larvae in the laboratory. Discs (approximately, 10 cm in diameter) of banana pseudostem were dipped for 1 min. in solutions of the different pesticides, allowed to dry, and then infested with 3 larvae per disc. Counts of live larvae were made daily, for 7 days.

Biological Control. Experiment 1. Sixty bamboo palms, each planted in 3.8 l pots, were infested with six third-instar banana moth larvae at the base of each plant. Holes were made into the soil within a 5 cm radius of the plant stem before infesting with the larvae. There were three treatments consisting of 20 palms each. Treatments consisted of an infested control, infested plus *S. feltiae*, and infested plus *H. heliothidis* (Florida strain). Inoculations with the nematodes were made 8 days after larval infestation. Five hundred ml of water containing 1 x 10^5 nematodes per ml were poured evely over the soil surface. Larval mortality was recorded 4 days later. A second experiment was conducted to determine survival and infectivity of *H. heliothidis* and *S. feltiae* nematodes over time. Bamboo palms were infested with six banana moth larvae and treated with nematodes following the same procedure as described for the first greenhouse experiment. After 72 hours, larval mortality was recorded and larvae removed. The palms were reinfested with six live banana moth larvae. These procedures were repeated during 5 consecutive weeks. Data from laboratory and greenhouse experiments were subjected to analysis of variance and means were separated using Duncan's multiple-range test. In a laboratory experiment, rearing cups (30 ml) were filled with moist sand (% wt/wt) and 2 g of potato to provide food for the larvae. Each container was infested with third-instar *O. sacchari* larvae. *Steinernema feltiae* infective juveniles (5,640 per ml) were applied per container. Number of nematodes per ml were observed at 3, 4, 5, 6, and 7 days after treatment.

Results and Discussion

Dynamics. Banana moth male adults were trapped continuously in Dade County (Fig. 1). Adult populations generally increased in the spring, summer and early fall. Pop-

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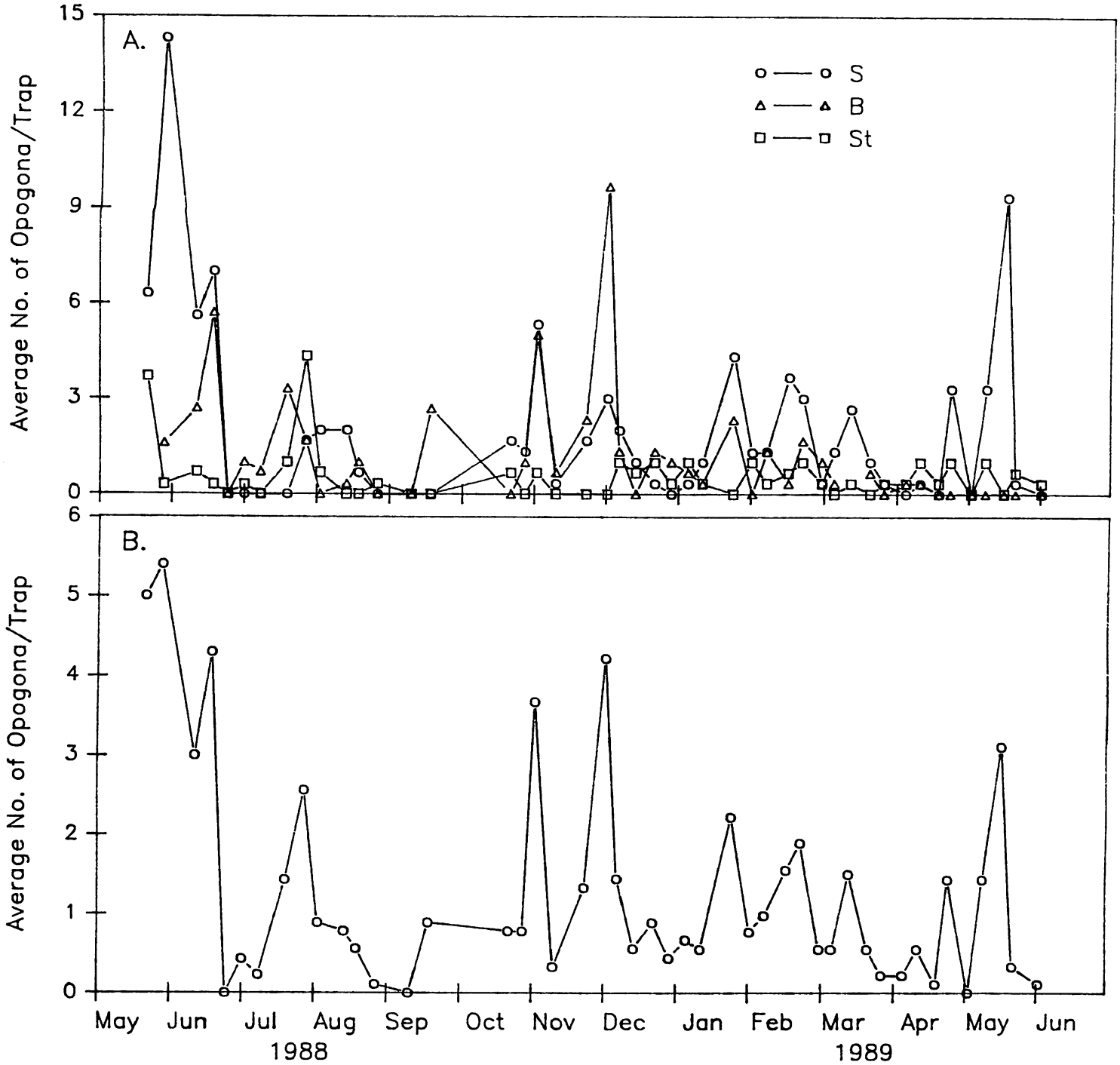

Fig. 1. *Opogona sacchari* male adult population, (A) at three different sites, (B) average density from the three sites in Dade County, 1988-1989.

ulations declined in the winter when temperatures were as low as 0.5°C. The observations of Davis and Pena (2) suggest that the number of generations to be expected under laboratory conditions (27°C) will be 5-7. Our data suggest that populations living under greenhouse conditions could produce 10 generations per year. Banana moth survival in greenhouse is based upon the interaction of three factors, availability of cultivated hosts, wild hosts, and the lack of a monitoring system to allow the nurserymen to control the pest before it reaches catastrophic proportions. The introduction of infested material, e.g., *Dracaena* sp., from other countries is also primarily responsible for high infestation levels observed. Because no estimates were made of wild hosts (e.g., native palms), and because of the variation on cultural practices that occurred in each greenhouse, it is difficult to wholly assess the dynamics of this pest under these conditions.

Chemical Control. Experiment 1. Susceptibility of third instar banana moth larvae was different on *Chamaedorea* and *Dracaena* plants. For *Dracaena*, Cygon and Lannate provided the lowest number of surviving larvae 2 days after treatment. Eight days after, their effect was similar to Lorsban 4E, Sevin, Cygon and Dysiston. Larvae were less susceptible to Dipel 2x, Lindane 25 and Vydate when applied to these plants (Table 1). Sevin, Lannate, Lorsban and Vydate were equally effective in controlling banana

Table 1. Chemical control of *Opogona sacchari* on *Dracaena* plants.

Treatment	Dose/Gal.[z]	Number of larvae alive after treatment 2	8 days
Check	0.00	0.73 ab	0.58 a
Methomyl	1.02	0.00 c	0.00 c
Chlorpyriphos	3.41	0.30 bc	0.00 c
Carbaryl	4.55	0.10 c	0.00 c
Dipel 2x	2.27 y	0.80 a	0.18 b
Lindane	0.60	0.09 c	0.07 b
Oxamyl	1.29	0.44 abc	0.28 b
Dimethoate	2.25	0.00 c	0.00 c
Disyston	0.534 x	0.15 c	0.00 c

[z]Grams a.i./Gal. [y]Grams Product/pot [x]Grams a.i./pot
[w]Numbers within a column followed by a different letter were significantly different DMRT (P = 0.05).

moth larvae in *Chamaedorea* palms compared to Dipel 2x, Dysiston, and Lindane 25 (Table 2). Phytotoxic effects were observed for Lannate on *Chamaedorea*.

Experiment 2. The effects of pesticides on larval survival indicated that Lannate L, Sevin 500 and Dursban 4E have a persistence of at least 7 days after treatment. Absolute control was obtained 3-4 days after treatment (Table 3). These results suggest that larval populations can be controlled with chemicals. However, the success of their application depends on a continuing larval and adult monitoring program. Up to this date, such a program is not available for Florida nurseries.

Table 2. Chemical control of *Opogona sacchari* on *Chamaedorea* plants.

Treatment	x Dose	Number of larvae alive after treatment ± 2	± 8 days
Check	0.00	0.90 a	0.38 a
Dipel 2x	2.27 z	0.50 ab	0.17 ab
Carbaryl	4.55	0.00 c	0.00 b
Methomyl	1.02	0.00 c	0.00 b
Dimethoate	2.25	0.20 bc	0.10 ab
Disyston	0.53 y	0.10 bc	0.40 a
Lindane	0.60	0.22 bc	0.10 ab
Chlorpyriphos	3.41	0.00 c	0.00 c
Oxamyl	1.29	0.00 c	0.00 c

[z]Grams Product/pot; [y]Grams a.i./pot;[x]Grams a.i./gal
[w]Numbers within a column followed by a different letter were significantly different DMRT (P = 0.05).

Table 3. Mortality rate of *Opogona sacchari* larvae on banana pseudostems treated with insecticides.

Treatment	z Dose 1	No. Larvae alive after treatment 2	3	4	5	6	7 Days
y							
Dipel 2x	2.27	3.00a	1.30a	0.71ab	1.00a	0.67a	0.33a
Methomyl	0.99	0.67bc	0.20c	0.00b	0.11b	0.00a	0.00a
Carbaryl	4.54	0.33c	0.00a	0.00b	0.00b	0.00a	0.00a
Chlorpyriphos	3.36	0.33c	0.40bc	0.00b	0.00b	0.00a	0.00a
Check	0.00	1.67a	1.40a	1.14a	9.44ab	0.54a	0.69a

[z]Grams a.i./gal; [y]Grams Product/Gal.
[x]Numbers within a column followed by a different letter were significantly different DMRT (P = 0.05).

Table 4. Effect of *Steinernema feltiae* strain All, *Heterorhabditidis heliothidis* strain NC on mortality of the banana moth, *Opogona sacchari*, 4 days after adding 1 x 10^5 nematodes to soil which had been infested 8 days earlier with six third-instar larvae in pots containing 20 *Chamaedorea elegans* plants.

Nematode	Mean dead larvae/pot	% Mortality
S. feltiae	6.0 a	100
H. heliothidis	6.0 a	100
Control	1.2 b	20

Means followed by a different letter are significantly different according to Duncan's multiple range test (P = 0.0001).

Biological Control. All larvae died when exposed to *H. heliothidis* strain FL and *S. feltiae* strain All, whereas mortality of control moths was 20% (Table 3). Plants were not stressed by larval attack in any of the treated plots when compared to the control plots.

Residual *H. heliothidis* strain NC was more effective in reducing new infestations of banana moth larvae than residual *S. feltiae* (Table 4). Appartently *S. feltiae* had a lower survival rate than *H. heliothidis* strain NC. The average temperature during the study was 24 ± 4°C. Nevertheless, banana moth larval control by nematodes appears to be feasible and further greenhouse research is warranted. Whether *H. heliothidis* persists in the soil 6 weeks after application remains to be shown. An average of 3,612 nematodes per ml were collected from *O. sacchari* larvae 3-7 days after treatment (Table 6). Number of nematodes per ml ranged from 0 to 29,200. These tests suggest that parasitic nematodes would have potential in controlling banana moth larvae under greenhouse conditions. These results suggest that parasitic nematodes would have longer soil persistence than insecticides. More studies are needed to clarify the potential of both in controlling banana moth larvae under greenhouse conditions. Management of banana moth in Florida nurseries cannot be in full effect

Table 5. Effect of *Heterorhabditis heliothidis* strain NC and *Steinernema feltiae* strain All, on mortality of *Opogona sacchari* larvae up to 5 weeks after adding 1 x 10^5 nematodes to soil which had been infected 8 days earlier with six third-instar larvae in pots containing 20 *Chamaedorea elegans* plants.

Treatment	No. dead larvae/plant 72 h	2 wk	3 wk	4 wk	5 wk	Total % Mortality
1[z]	0.7 a	1.0 a	2.2 a	1.8 a	1.4 a	23.3 a
2[y]	1.0 a	0.9 a	0.9 b	0.6 b	1.3 a	15.7 a
3[x]	0.2 a	0.2 b	0.3 b	0.2 b	0.4 a	4.3 b

[z]*H. heliothidis; S. feltiae;* Control
[w]Means in columns followed by a different letter are significantly different according to Duncan's multiple-range test (P = 0.05).

Table 6. Number of *Steinernema feltiae* nematodes collected from *Opogona sacchari* larvae.

Days After Treatment	Infective juveniles/ml
3	288
4	261
5	3,715
6	5,327
7	8,189

until monitoring techniques are completely studied. Otherwise, nurseries affected with this pest will rely on fixed calendar spray schedules, which may or may not control this pest.

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CONTROL OF SOME BACTERIAL DISEASES OF ORNAMENTALS WITH AGRIBOM[1]

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Abstract. **Agribrom was applied through an overhead mist system to determine efficacy against a variety of bacterial pathogens of ornamental plants. The first series of tests employed 55 ppm bromine delivered at the mist head every 30 min for 12 hour per day. Bromine treatments were initiated three days prior to pathogen inoculation. Disease severity was rated at different times following inoculation depending upon the specific disease. Agribrom gave a minimum of 40% control of the following diseases: Erwinia blight on *Philodendron selloum*, Pseudomonas leaf spot on chrysanthemum, and Xanthomonas leaf spots on English ivy, weeping fig, hibiscus, 'White Butterfly' syngonium, and anthurium. Bromine toxicity was noted on English ivy, weeping fig, and hibiscus at a rate of 55 ppm but not at 25 ppm (second series of tests). Agribrom provided less control of the diseases listed above when used at 25 ppm bromine. Diseases that were controlled at 25 ppm bromine included: Pseudomonas leaf spots on impatiens and bougainvillea and Xanthomonas blight on geranium.**

Bacterial diseases cause substantial losses in many floral, foliage and landscape crops throughout Florida. Currently available bactericides have limited usefulness due to lack of efficacy (1, 6), development of resistance (5, 7, 9, 10), or phytotoxicity (8). Development of bactericides for use on ornamental crops remains a low priority for the majority of pesticide manufacturers. During the past three years considerable research has been conducted on bactericidal effects of the fungicide fosetyl aluminum (Aliette 80WP)(2, 3). Although this fungicide may significantly aid in control of some bacterial diseases under some conditions, it will not fill all needs for bactericides on ornamentals.

Agribrom (Great Lakes Chemical Corporation, West Lafayette, IN 47906), has been labeled as an algicide for several years and claims have been made regarding its effectiveness in controlling both fungal and bacterial diseases. The following research was conducted to partially evaluate its potential for bacterial disease control on eleven different ornamental crops.

Materials and Methods

Mist treatment. Two benches in a fiberglass-covered greenhouse were used for all tests. One bench received the Agribrom treatment while the other bench served as the nontreated control. An Agribrom stock solution was prepared every other day by adding 8 g of the powder to 3L hot tap water and placing on a hot plate until completely dissolved (usually 1 hour). The stock was then stored in a holding tank shielded from light exposure. The stock solution was added to the mist system by a Dosatron proportioner (Dosatron International Inc., Clearwater, FL 34615) set at 4% which diluted the solution delivered to the leaf surface to about 55 ppm for the first series of tests and 25 ppm for the second series of tests. The mist system operated for 35 sec every half hour for 12 hours per day. This treatment was started three days prior to inoculation and continued until test completion (up to one month).

Plant and pathogen preparation. Plants were obtained as seedlings or were rooted from cuttings. They were grown in Vergro potting medium usually in a 10-cm (4-in) pot until they were well established. Fertilizer was applied once at planting at about 1.5 g/pot of Sierra 17-6-12 controlled-release fertilizer (Grace-Sierra, Milpitas, CA 95035). A minimum of 10 plants was used for each of the following treatments: 1) noninoculated-control, 2) inoculated-control, 3) noninoculated - Agribrom treated, and 4) inoculated-Agribrom treated.

Inoculum was grown for 2 days on nutrient agar medium and adjusted to concentrations between 1×10^6 and 1×10^8 depending upon the disease pressure desired. Plants were removed from mist, inoculated by spraying to drip with a bacterial suspension and returned 2 hours later. Disease severity was determined after 2 days to 4 weeks according to its development and was reflected by the number of lesions per plant for the majority of the diseases tested. The plants and pathogens included are listed in Table 1. Several tests were repeated with one or both rates of bromine.

Results and Discussion

Agribrom, applied at the 55 ppm bromine rate, provided some degree of control for the majority of diseases

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