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This issue mailed August 8, 1986

THE 69th ANNUAL MEETING OF THE FLORIDA ENTOMOLOGICAL SOCIETY ANNOUNCEMENT AND CALL FOR PAPERS

The Florida Entomological Society will hold its 69th Annual Meeting on 6-8 August 1986 at the Sheraton Sand Key Hotel, Clearwater Beach, Florida. The location is 1160 Gulf Boulevard, Clearwater Beach, Florida 33515; telephone—1-813-595-1611. Room rates will be $66.00 either single or double. Pre-registration and registration fees will be released in the June, 1986 *Florida Entomologist* and the April Newsletter.

Since many will present papers please copy the sheet and submit before 1 June 1986, to:

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—Oral Presentation
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All submitted papers should be designed to be 8 minutes long with 2 minutes for discussion; visual materials must be restricted to 2x2 slides or overhead projector transparencies.

SELECTIVE ISOLATION OF THE ENTOMOPATHOGENIC FUNGI *BEAUVERIA BASSIANA* AND *METARHIZIUM ANISOPLIAE* FROM AN ARTIFICIAL POTTING MEDIUM

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ABSTRACT

A basal medium consisting of oatmeal agar was superior to seven other media for isolation of *Metarhizium anisopliae* and *Beauveria bassiana* from an artificial potting medium. A rate of 0.55 g/l of dodine and 5 mg/l of chlortetracycline allowed optimum recovery of *B. bassiana* alone. Decreasing the amount of dodine to 0.46 g/l and adding 0.38 g benomyl allowed recovery of both entomopathogens at high frequencies in the abscence of most other fungi. Addition of 10 mg/l crystal violet aided in visibility of the target fungi without affecting recovery frequencies. Exposure of culture plates to as little as 2 μmol $m^{-2}s^{-1}$ light delayed observation of colonies of both entomopathogens up to 7 days compared to cultures incubated in the dark.

RESUMEN

Un medio básico consistente de agar de avena fue superior a otros 7 medios para aislar a *Metarhizium anisoplia* y *Beauveria bassiana* de un medio de siembra artificial. Una razón de 0.55 g/l de dodine y 5 mg/l de clorotetraciclina permitió una recuperación de *B. bassiana* solamente. Disminuyendo la cantidad de dodine a 0.46 g/l y añadiendo 0.38 g de benomil permitió la recuperación de ambos entomopatógenos en frecuencias altas en la ausencia de la majoría de otros hongos. Añadiendo 10 mg/l de cristales de violeta ayudó la visibilidad del hongo sin afectar las frecuencias de su recobro. Exponiendo platos de cultura a niveles tan bajo de luz como 2 umol $m^{-2}s^{-1}$, demoró la observación de colonias de ambos entomopatógenos hasta 7 días en comparación con culturas incubadas en la oscuridad.

With increased concern over environmental impacts of chemical pesticides, considerable research has focused on biological pesticides. Entomopathogenic fungi such as *Beauveria bassiana* (Bals.) Vuill. and *Metarhizium anisopliae* (Metschn.) Sorokin have been investigated extensively over the past 10 to 15 years (Ferron 1981, Roberts and Campbell 1977). Interest in commercial application of these biological pesticides has led to development of information regarding their biology (Barnes et al. 1975, Campbell et al. 1983), ecology (Doberski and Tribe 1980), pathology (Doberski 1981, Gardner and Noblet 1978), and effects of chemical pesticides (Olmert and Kenneth 1974) under a wide range of conditions. Both bioassay with a susceptible insect host and direct isolation from soil, insect, or plant tissue have been utilized to evaluate reactions of these fungi to various conditions. Direct isolation of conidia of *B. bassiana* and *M. anisopliae* have primarily involved use of semi-selective culture media. One of the earliest media was based on one used for general isolation of soil fungi and contained glucose, oxgall, and peptone with rose bengal, chloramphenicol, and cycloheximide as antibiotics (Veen and Ferron 1966). Doberski and Tribe (1980) developed a medium based on similar ingredients with crystal violet substituted for rose bengal. This medium was used to isolate

B. bassiana and *M. anisopliae* from elm bark and soil. A medium with V-8 juice, glucose, yeast extract, and oxgall as the nutrient base amended with cycloheximide, streptomycin sulfate, and tetracycline was developed for general isolation of *B. tenella* from soils (Joussier and Catroux 1976). Sabouraud-dextrose medium and oxgall was used as another basal medium amended with penicillin G, streptomycin sulfate, oxytetracycline, cycloheximide, and binapacryl (Morocide®, a fungicide). This medium was developed for use in isolations from field soil maintained under laboratory conditions (Lingg and Donaldson 1981). More recently, Beilharz et al. (1982) discovered that dodine (n-dodecylguanidine acetate) selectively inhibited some soil fungi other than *B. bassiana* and *M.anisopliae* when added at the rate of 1.0 g formulated (Cyprex 65WP, American Cyanamid) product per liter. Each of these media was developed in response to a need by researchers to evaluate effects of various treatments on survival of these entomopathogens. The present paper describes a modification of one of these media (Beilharz *et al.* 1982) to maximize recovery of either *B. bassiana* or *M. anisopliae* from an artificial potting medium.

Materials and Methods

Preparation of the Basal Medium

The basal medium used for most trials was oatmeal agar prepared from 20 g Gerber Oatmeal Cereal For Baby (Gerber Products Co., MFR, Fremont, MI 49412) autoclaved for 20 min with 1 l of deionized water. The suspension was immediately filtered twice through four layers of cheesecloth, and the volume of filtrate adjusted to 1 l with deionized water. Agar (20 g/l) was ground in a mortar and pestle with various amounts of dodine and added to the oatmeal filtrate while stirring. The final medium was autoclaved for 20 min and cooled to 48°C prior to adding chlortetracycline (5 mg/l). One l of medium was used to pour 50 plates, (90 × 15 mm).

Preparation of the Fungi

An experimental wettable powder formulation of *Beauveria bassiana* (ABG 6112, Abbott Laboratories, North Chicago, IL) and a formulation of *Metarhizium anisopliae* (70-25 Mycogen Corporation, San Diego, CA) were used in all trials. A potting medium consisting of 3 parts Canadian peat and one part builder's sand was amended with 4 kg ground dolomitic limestone and 1 kg Micromax (micronutrient source from Sierra Chemical Co., Milpitas, CA) per m^3 and steam-treated at 95°C for ca. 1 hr. *Beauveria bassiana* or *M. anisopliae* or both were added to 500 g of the potting medium at the rate of 0.5 g formulation and mixed thoroughly by hand. The medium was used the same day it was prepared.

Dilution Plating Method and Incubation

Ten g samples of the potting medium-conidial preparation were added to 100 ml of sterilized deionized water (SDW) and placed on a rotary action shaker for 15 min. Serial dilutions were made with SDW, and 0.5 ml aliquots of the 10^{-3} and 10^{-4} dilutions were spread on the surface of five plates of each medium. Plates for all trials except those concerning light levels were incubated at 25 to 27°C with 10 μmol $m^{-2}s^{-1}$ light (Sylvania, Gro-lux, fluorescent bulbs) for 16 hr daily. Colony counts were determined at various times depending upon the trial. Specific trials with media and incubation conditions are described below.

Comparison of Oatmeal-Dodine Medium With Other Isolation Media

The oatmeal-dodine medium was compared to several media developed by others as well as basal media amended with dodine (variable rates) and chlortetracycline (5 mg/l). The following media were tested at least twice: 1) Lingg and Donaldson basal medium (1981) with dodine (0.62 g/l) and chlortetracycline amendments: 2) Doberski and Tribe (1980); 3) Martin's RB-M2 medium (Tuite, 1969); 4) Sabouraud's Dextrose agar (Difco) amended with 5 g per liter of yeast extract, dodine (0.62 g/l) and chlortetracycline; 5) Czapek's-Dox medium (Difco) amended with dodine (0.58 or 0.62 g/l) and chlortetracycline; 6) Pasteur's-MC sporulation medium (0.36 g KH_2PO_4, 1.05 g $NaHPO_4$ $7H_2O$, 0.6 g $MgSO_4$, 1.0 g KCl, 10.0 g dextrose, 0.7 g NH_4NO_3, 5.0 g yeast extract, and 20.0 g agar per liter) amended with dodine (0.58 or 0.62 g/l) and chlortetracycline; and 7) Potato Dextrose agar medium (Difco) amended with dodine (0.62 g/l) and chlortetracycline.

Effect of Dodine Rate on Recovery of Fungi

Dodine rates were varied from 0.16 to 0.62 g per liter using oatmeal agar as the basal medium. The following rates were used in at least one of five tests: 1) 0.65, 0.49, 0.32, and 0.16 g/l; 2) 0.65, 0.58, 0.52, and 0.46 g/l; 3) 0.52, 0.49, 0.46, and 0.39 g/l; 4) 0.52, 0.49, 0.46, and 0.39 g/l; and 5) 0.65, 0.62, 0.58, 0.55, 0.52, 0.49, 0.46, and 0.39 g/l.

Effect of Benomyl Rate on Recovery of Fungi

Benomyl (Benlate 50WP, E. I. Dupont Nemours, Inc., Wilmington, DE) is known to inhibit *in vitro* growth of both *B. bassiana* and *M. anisopliae* (Olmert and Kenneth 1974, Tedders 1981) at rates used to treat plants. The effect of very low rates on recovery of these two entomopathogens was tested. Benomyl (prepared as a stock suspension in SDW) was added to the basal medium prior to autoclaving. The following rates were used in three tests: 0, 0.25, 0.5, and 1.0 mg/l. Two additional tests were performed using 0, 0.25, 0.38 and 0.5 mg benomyl/l.

Effect of Crystal Violet Concentration on Recovery of Fungi

The medium of Doberski and Tribe (1980) contains 10 ppm crystal violet. When this rate of crystal violet was added to the oatmeal medium, *M. anisopliae* was not recovered, although *B. bassiana* recovery was unaffected in a preliminary trial. Various rates of crystal violet were therefore tested for a differential effect on recovery of the two fungi. Rates from 0 to 20 ppm were included: (Test 1) 0, 2, 10 and 20 mg/l (Test 2) 2.5, 5.0, 7.5 and 10 mg/l, and (Test 3) 0, 5, 10 and 15 mg/l.

Effect of Light Level During Incubation on Recovery of Fungi

Two types of tests were performed to evaluate the effect of light level on recovery of *B. bassiana* and *M. anisopliae* on oatmeal medium amended with 0.46 g dodine/l. In the first test, 25 plates were treated with 0.5 ml of a 10^{-4} soil dilution of either *M. anisopliae* or *B. bassiana*. Plates were arranged in five stacks of five plates each with the bottom plate in each stack wrapped in foil for each fungus. Stacks were incubated with 10 μmol $m^{-2}s^{-1}$ fluorescent light and colony counts recorded as soon as possible. The second type of test was performed with plates in a single layer under four light levels (10 plates per treatment): 1) wrapped in foil; 2) 2 μmol m^{-2} s^{-1}; 3) 5 μmol m^{-2} s^{-1}; and 4) 10 μmol m^{-2} s^{-1}. The second type of test was performed twice.

All data were analyzed for variance using the F test for significance.

Results and Discussion

Comparison of Oatmeal-Dodine Medium With Other Isolation Media

The mean number of colonies per plate was significantly affected by the medium used for isolation. *Beauveria bassiana* was recovered in high frequencies on oatmeal agar and Sabouraud medium amended with yeast extract, but not from other culture media utilized. *Metarhizium anisopliae* was recovered only from oatmeal agar medium. Mean recovery per plate for *B. bassiana* on oatmeal medium ranged from 29 to 92 colonies (10^{-4} dilution rate), while recovery for *M. anisopliae* ranged from 17 to 45 (10^{-4} dilution rate). These recovery frequencies relate to a percent recovery between 50 and 80 for the majority of trials.

Effect of Dodine Rate on Recovery of Fungi

An optimum rate of dodine was identified for isolation of each target fungus. The rate of 0.62 g/l dodine significantly reduced recovery of *M. anisopliae* (Table 1). Decreasing the rate/l to 0.55 g allowed a high recovery of *B. bassiana*, but was still too high for recovery of *M. anisopliae* which grew out only when the rate was decreased to 0.46 g/l. Rates of dodine from 0.32 to 0.62 generally did not influence recovery of *B. bassiana* (Table 1). Rates of dodine lower than 0.32 allowed good recoveries of the target fungi, but proved to be too low to inhibit germination and growth of several saprophytic soil fungi such as *Trichoderma* and *Rhizopus* spp. (data not included).

TABLE 1 Effect of various rates of dodine on recovery of *Beauveria bassiana* and *Metarhizium anisopliae* from an artificial potting medium.

	Mean recovery at 10^{-4} dilution									
	Beauveria bassiana (Tests)					*Metarhizium anisopliae* (Tests)				
Dodine g/l	1	2	3	4	5	1	2	3	4	5
0.32	19.2[a]	NT[b]	NT	NT	NT	193.0	NT	NT	NT	NT
0.39	NT	NT	10.2	17.4	21.0	NT	NT	20.2	8.2	19.6
0.46	NT	22.6	8.2	22.2	16.6	NT	67.8	25.2	10.8	21.0
0.49	25.0	NT	10.2	19.6	23.8	23.6	NT	0.8	0	16.0
0.52	NT	20.2	9.6	11.0	15.8	NT	4.0	7.6	0	5.8
0.55	NT	NT	NT	NT	19.2	NT	NT	NT	NT	5.2
0.58	NT	18.6	NT	NT	13.8	NT	0.8	NT	NT	4.0
0.62	NT	NT	NT	NT	13.4	NT	NT	NT	NT	2.6
0.65	16.4	0.4	NT	NT	0	0.4	0	NT	NT	0
Significance[c]	**	**	ns	ns	**	**	**	**	**	**

[a]Mean number of colonies for five replicate plates for each test.
[b]NT = Not tested.
[c]Significance level of the F test denoted as follows: ns = not significant, and ** $P<0.01$.

Effect of Benomyl on Recovery of Fungi

A rate of 0.25 mg/l of benomyl did not affect recovery of either fungus significantly while a rate of 0.38 mg/l reduced recovery of *B. bassiana* to undetectable levels, but did not affect recovery of *M. anisopliae*. Rates of 0.5 to 1.0 mg/l significantly decreased recovery frequencies of both (Table 2). Tests were performed using the oatmeal-dodine medium with dodine used at 0.46 g/l to allow recovery of *M. anisopliae*. Since this rate does allow occasional colonies of *Trichoderma* spp. to develop, the effect of low rates of benomyl proved beneficial in eliminating these contaminants. A rate of 0.38 mg/l of benomyl was chosen for addition to oatmeal-dodine medium when the 0.46 g/l rate of dodine was employed to eliminate saprophytes and select *M. anisopliae* over *B. bassiana*.

Effect of Crystal Violet Concentration on Recovery of Fungi

Although a preliminary test showed differential effects of crystal violet concentration on recovery of the entomopathogens, the results were not repeated in any subsequent test. Rates up to 10 mg/l did not affect recovery of either fungus, while those above 10 mg/l reduced recovery of the two entomopathogens similarly. Because oatmeal agar is an opaque, white medium and both organisms initially produce white to creamy colored colonies, the addition of 10 mg/l of crystal violet greatly improved colony visibility.

Effect of Light Level During Incubation on Recovery of Fungi

When plates of either *B. bassiana* or *M. anisopliae* were incubated in stacks under 10 μmol m^{-2} s^{-1} light, the recovery frequency and the number of days required for incubation were affected by their position in the stack (data not included in a table). Plates on the bottom of the stacks, which were wrapped in foil, could be counted two

TABLE 2. Effect of various rates of benomyl on recovery of *Beauveria bassiana* and *Metarhizium anisopliae* from an artificial potting medium.

	Mean recovery at 10^{-4} dilution							
	Beauveria bassiana (Tests)				*Metarhizium anisopliae* (Tests)			
Benomyl (mg/l)	1	2	3	4	1	2	3	4
0	12.2[a]	13.5	25.8	27.0	7.6	3.4	30.4	63.6
0.25	13.4	14.2	21.8	22.4	9.0	4.8	6.0	27.8
0.38	NT[b]	NT	0	0	NT	NT	9.7	20.2
0.50	0	0	0	0	10.1	0	0	0
1.00	0	0	NT	NT	0	0	NT	NT
Significance[c]	**	**	**	**	**	**	**	**

[a]Mean number of colonies for five replicate plates for each test.
[b]NT = Not tested.
[c]Significante level of the F test denoted as follows: ** $P<0.01$.

to five days earlier than those on the top of the stack. In addition, recovery frequencies of both target fungi were reduced up to 60% when incubated on the top of the stack compared to the foil wrapped plates. *B. bassiana* plates at the top of the stack yielded a mean of nine colonies/plate while those at the bottom yielded a mean of 28. Similarly, the number of *M. anisopliae* colonies was only 48 on the top of the stack compared to a mean of 115 at the bottom of the stack. Exposure of plates to various levels of light during incubation demonstrated that even 2 μmol m^{-2} s^{-1} light reduced recovery frequencies of the target fungi in some tests (Table 3). As in the previous test, colony counts for plates wrapped in foil were made approximately two to seven days earlier than plates in 10 μmol m^{-2} s^{-1} for *B. bassiana* and *M. anisopliae* respectively.

From these studies it can be concluded that a basal medium of oatmeal agar supports the highest recovery of both *B. bassiana* and *M. anisopliae* from artificial potting medium. Comparisons to most of the media developed by other researchers suggest that a single medium may not be effective under all the conditions encountered in research on these entomopathogens. It should be remembered, however, that there is a certain amount of natural variability of isolates of fungi and that our media may not be adequate for recovery of naturally occurring *B. bassiana* or *M. anisopliae*.

The effects of both dodine and benomyl on the recovery of these entomopathogens have led to the development of two selective media. Selective isolation of *B. bassiana* can occur if dodine is incorporated in the oatmeal medium at the rate of 0.55 g/l. Higher rates of dodine generally do not decrease recovery of the *B. bassiana*, but the previously used rate of 0.65 g/l significantly extends the period of time needed to incubate the plates. A much lower rate of dodine (0.46 g/l) must be used to allow high recoveries of *M. anisopliae*. Since this rate of dodine also allows good recovery of *B. bassiana* and certain soil saprophytes, the addition of benomyl to the medium at the rate of 0.38 g/l inhibits germination of these organisms and allows selective isolation of *M. anisopliae*. Decreasing the benomyl rate to 0.25 ppm will allow high recovery frequencies of both target fungi while keeping recovery of other soil fungi to a minimum.

A natural tendency of many researchers is to incubate culture plates under some level of artificial or natural light. Some effects of light on *B. bassiana* and *M. anisopliae* have been studied (Alves et al. 1979 1980, Zimmerman 1982). These studies do not

TABLE 3. EFFECT OF INCUBATION LIGHT LEVEL ON RECOVERY OF *BEAUVERIA BASSIANA* AND *METARHIZIUM ANISOPLIAE* FROM AN ARTIFICIAL POTTING MEDIUM.

	Mean recovery at 10^{-4} dilution					
	Beauveria bassiana (Tests)			*Metarhizium anisopliae* (Tests)		
Light level μmol m^{-2} s^{-1}	1	2	3	1	2	3
0 (in foil)	16.5[a]	34.4	41.4	30.2	10.4	23.4
2	11.6	33.0	24.0	30.0	8.6	22.3
5	9.8	30.0	25.6	22.2	13.0	20.9
10	8.4	25.4	32.8	17.0	10.0	18.2
Significance[b]	ns	ns	**	**	ns	**

[a]Mean number of colonies for five replicate plates for each test.
[b]Significance of the F test denoted as follows: ns = not significant, and ** P>0.01.

report the effects of relatively low light levels (10 μmol m^{-2} s^{-1}) during incubation of isolation plates. In the case of *B. bassiana*, light increases the time needed for recovery plates by 2 to 5 days. Incubation of *M. anisopliae* in as little as 10 μmol m^{-2} s^{-1} not only increases the incubation time, but also results in a significant decrease in recovery frequencies compared to plates incubated in the dark.

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MONITORING POPULATIONS OF *LIRIOMYZA TRIFOLII* (DIPTERA: AGROMYZIDAE) IN CELERY WITH PUPAL COUNTS

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ABSTRACT

Populations of *Liriomyza trifolii* (Burgess) were monitored in 16 commercial fields of celery during 1985 by taking 10 sets of 10 leaflet samples per field and counting puparia after 3, 7, and 14 days. Three indices of dispersion showed that the population had an aggregated distribution. Sample size for 3-day pupae counts were calculated to be 7 sets of 10 leaflets for 25% precision at densities of 5 or more puparia per 10 leaflets. The proposed sampling scheme requires between 30 and 45 minutes total sampling time per field and will allow the grower to monitor *L. trifolii* population trends and evaluate previous control actions. Sequential sampling plans may further reduce sampling time.

RESUMEN

Las poblaciones de *Liriomyza trifolii* (Burgess) se esudiaron en 16 parcelas comerciales de apio durante 1985. Diez grupos de muestras de diez hojas se obtuvieron de cada parcela, contandose las crisálidas después de 3, 7 y 14 días. Tres índices de dispersión montraron que la poblacion tenía una distribucion aglomerada. Se determinó que el tamaño de la muestra para el conteo de crisálidas despues de 3 días debe ser 7 grupos de 10 hojas para obtener una precisión de 25% en densidades de 5 o más crisálidas por cada 10 hojas. El sistema de muestreo propuesto requiere entre 30 y 45 minutos de tiempo para el muestreo de cada parcela y permitirá al productor el estudiar las tendencias de las poblaciones de *L. trifolii* y evaluar acciones de control previas. Planes de muestreo de secuencia pueden reducir aún más el tiempo de muestreo.

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Las poblaciones de *Liriomyza trifolii* (Burgess) se esudiaron en 16 parcelas comerciales de apio durante 1985. Diez grupos de muestras de diez hojas se obtuvieron de cada parcela, contandose las crisálidas después de 3, 7 y 14 días. Tres índices de dispersión montraron que la poblacion tenía una distribucion aglomerada. Se determinó que el tamaño de la muestra para el conteo de crisálidas despues de 3 días debe ser 7 grupos de 10 hojas para obtener una precisión de 25% en densidades de 5 o más crisálidas por cada 10 hojas. El sistema de muestreo propuesto requiere entre 30 y 45 minutos de tiempo para el muestreo de cada parcela y permitirá al productor el estudiar las tendencias de las poblaciones de *L. trifolii* y evaluar acciones de control previas. Planes de muestreo de secuencia pueden reducir aún más el tiempo de muestreo.

Liriomyza trifolii (Burgess), a serpentine leafminer, is a serious pest of celery, lettuce, tomatoes, and other vegetable and ornamental crops in Florida. This insect damages celery in at least 3 ways; by removing photosynthetic material from the leaves, by making avenues of entry for plant pathogens, and by causing cosmetic damage to the marketable portion of the crop.

There are a number of methods that have been considered as possible sampling methods for leafminers. Musgrave et al. (1979) calculated sample sizes for sweep net estimations of adult densities and for counts of live larvae of *L. sativae* in the foliage. A problem with sweep net samples is that on windy days the adult leafminers tend to stay low in the foliage and are not caught by the net. Also, if the foliage is wet from rain or dew, a sweep net is not useful.

Growers in south Florida tend to avoid counting live leafminer larvae in the leaves because it is tedious work and because it is easy to miss small larvae. Michelbacher et al. (1953) counted the number of mines in tomato leaves but, as Johnson et al. (1980) point out, this sampling method does not accurately estimate the current density because the mines remain long after the leafminers are gone. Parella and Jones (1985) developed sampling plans for yellow cards covered with sticky material to monitor adult leafminer populations in chrysanthemum greenhouses. Zehnder and Trumble (1985) developed sequential sampling plans for sticky cards in tomatoes as well as for the pupal tray method to be discussed later. At least one major celery grower in Florida has used sticky card to monitor leafminer adults. However, sticky cards are inconvenient to work with and often are fouled by blowing soil.

Johnson et al. (1980) recommended placing styrofoam trays under tomato foliage to catch the larvae as they emerge from the leaves and drop to the ground to pupate. This method is not practical in Florida because frequent strong winds blow the pupae from the trays or blow the trays away. Also, there are usually no rows in which to place the trays that will not be run over by farm equipment (J. T. Shaw, pers. comm.). A modification of this method that is used by Florida growers is to hold leaflet samples in a container for several days and then count the number of puparia that have emerged from the leaves. A drawback to this sampling method is the time lag between when samples are taken and when the information becomes available. The pupal rearing method provides information about leafminer ovipositional activity during some previous time interval. The current uses for this sampling method are to monitor population trends and to evaluate the effectiveness of previous control measures. An advantage of pupal rearing over the pupal trays (Johnson et al. 1980) is that it can also be used to estimate parasitism.

The objectives of this study were to determine the appropriate time interval to hold celery leaflet samples before counting the puparia, to determine the appropriate sample sizes for estimating *L. trifolii* densities, and to develop constant-precision-level sequential sampling plans at three levels of precision.

Materials and Methods

Sixteen celery fields near Belle Glade were sampled between February 5 and April 8, 1985. The approximately 11-ha fields were planted sequentially in time to provide an even supply of celery for market. Each field was sampled between 1 and 6 times, depending on the level of maturity of the crop at the initiation of the study. A total of 51 sets of sampling data was collected.

A field sample consisted of 10 sets of 10 terminal leaflets per set. The leaflets selected were from petioles that were mature, but had not yet begun to senesce. The ten leaflets collected at a site were selected randomly from 10 different plants and the 10 sites were

arranged systematically throughout the field to insure that all areas of the field were sampled. No sample sites were located within 15 m of the sides or ends of the fields to remove possible edge effects. Each field was treated uniformly with insecticides when determined to be necessary by the grower.

After collection in the field, the leaflets were placed in plastic bags and returned to a laboratory. Leaflets then were placed in 0.47-liter (1-pint) styrofoam cups and held in a laboratory at room temperature (23.0 ± 0.56°C). Three days after field collection, the leaves in each carton were removed and the leafminer puparia were counted. The leaves were then returned to the carton and again held at room temperature. The counting procedure was repeated 7 and 14 days after field collection, at which time the leaves were discarded because 14 days is an adequate length of time to insure that all eggs and larvae present had pupated (Leibee 1984).

There are a number of indices of dispersion that have been used to analyze the distribution of insect populations. The simplest of these is the variance to mean ratio. If $s^2 = m$, the population is assumed to be randomly distributed. $s^2 > m$ indicates aggregation and $s^2 < m$ indicates uniformity. Iwao (1968) introduced a regression method for measuring spatial dispersion. He used a parameter, mean crowding (m_c), proposed by Lloyd (1967): $m_c = m + ((s^2/m)-1)$. Mean crowding is defined as the mean number of other individuals per individual. Iwao found that when mean crowding was regressed on mean density, there was a direct linear relationship. Regression parameters a, the intercept, and b, the slope, are both indices of dispersion. The a-value is an index of basic contagion, and the b-value represents the density-contagiousness coefficient. Random distribution is suggested by $a = 0$ and $b = 1$, and aggregated distribution is indicated by $a > 0$ and $b > 1$.

According to Taylor (1961) the sample variance can be related to the sample mean by the power law:

$$s^2 = a\bar{x}^b \quad (1)$$

The mean ($\bar{x}$) and the variance (s^2) were calculated for each data set in this study and a linear regression of log s^2 on log $\bar{x}$ was computed. The a and b values determined from the regressions were used to calculate necessary sample sizes for various desired levels of precision using the equation published by Ruesink (1980):

$$n = \frac{a\bar{x}^{b-2}}{c^2} \quad (2)$$

where n = the number of samples and c = precision expressed as a fraction of the mean.

The a- and b-values from Taylor's power law also were used to develop constant-precision-level sequential sampling plans for three day pupal counts. The stop points were calculated by the formula (Green 1970):

$$\log T_n = \frac{\log (c/a)}{b-2} + \frac{b-1}{b-2} \log n \quad (3)$$

where T_n = cumulative number of pupae. Southwood (1978) considered 25% precision to be adequate for use in pest management programs.

Results and Discussion

Holding leaflets for 7 days resulted in approximately twice as many pupae as holding them for 3 days (Table 1). Holding the leaflets for 14 days produced a mean of 71.4 puparia per 10 leaflets, which is only 7.4% more than holding them for 7 days. Therefore, holding the leaves for longer than 7 days is not worthwhile. There was a wide range of mean densities, which is considered by Ruesink (1980) to be one of the requirements for using Taylor's power law.

TABLE 1. MEANS AND RANGES FOR NUMBER OF *L. TRIFOLII* PUPARIA DROPPING FROM 100 CELERY LEAFLETS PER FIELD (N = 51 FIELDS).

No. of days held	Mean	Range
3	32.1	1-224
7	66.5	3-258
14	71.4	3-270

TABLE 2. INDICES OF DISPERSION FOR PUPARIA OF *LIRIOMYZA TRIFOLII* IN CELERY FOR LEAFLETS HELD FOR 3, 7, AND 14 DAYS.

	Taylor's Power Law			Iwao's Regression	
No. of Days held	a	b	Variance/Mean	a	b
3	1.429	1.297	4.39	0.408	1.189
7	1.432	1.352	4.01	1.167	1.140
14	1.346	1.378	4.42	1.087	1.150

All 3 indices of dispersion calculated showed that leafminers have an aggregated distribution for each of the 3 durations for which leaflets were held (Table 2). These results agree with those of Beck et al. (1981), who found that active mines on whole plants were aggregated in their distribution in the field (Taylor's b-value = 1.51). Figure 1 illustrates the distribution of data points around the regression line generated by Taylor's power law for pupal counts.

The a- and b-values from Taylor's power law (Table 2) can be used to calculate sample sizes necessary to estimate leafminer densities (Table 3). Although there are no economic thresholds in use for leafminers in celery, means of 5 or fewer pupae reared from 10 leaflet samples held for 3 or 7 days would pose little threat of causing economic damage. Therefore, it appears from these data that the sample size of 10 sites used in this study is adequate for estimating leafminer densities of $\bar{x} > 5$ per 10 leaflets with an acceptable level of precision ($c = 0.25$). In most situations, it would be preferable to hold the samples for only 3 days before counting to reduce the lag time. If the leaves were returned to the cup after counting and held for another 4 days, information about oviposition nearer to the time of sampling could be obtained.

It takes approximately 20 to 30 min to take 10 sets of 10 leaflet samples from a field of about 11 ha. If the sets of 10 leaves are held in individual cups, it takes approximately 15 min to count the puparia at a density of 10 pupae per 10 leaflets. If the leaflets are small enough to be composited into a single or a couple of containers, the time required is reduced to about 8 minutes. Therefore, the total time required to sample a field is about 30 to 45 minutes. Because most of the field time is expended while walking, not much time is saved by taking fewer than 10 samples per field. Sampling time could be reduced further using sequential sampling (Table 4). This would not reduce the amount of time spent in the field, but could reduce the counting time considerably.

Pupal counts, then, are a relatively efficient method for monitoring leafminer population activity in celery. Precise measurements of leafminer densities can by achieved with few samples in a short period of time, although there is a 3- or 7-day lag time before the information is available. This sampling method is useful for monitoring population trends or evaluating the success of previous control measures. If economic

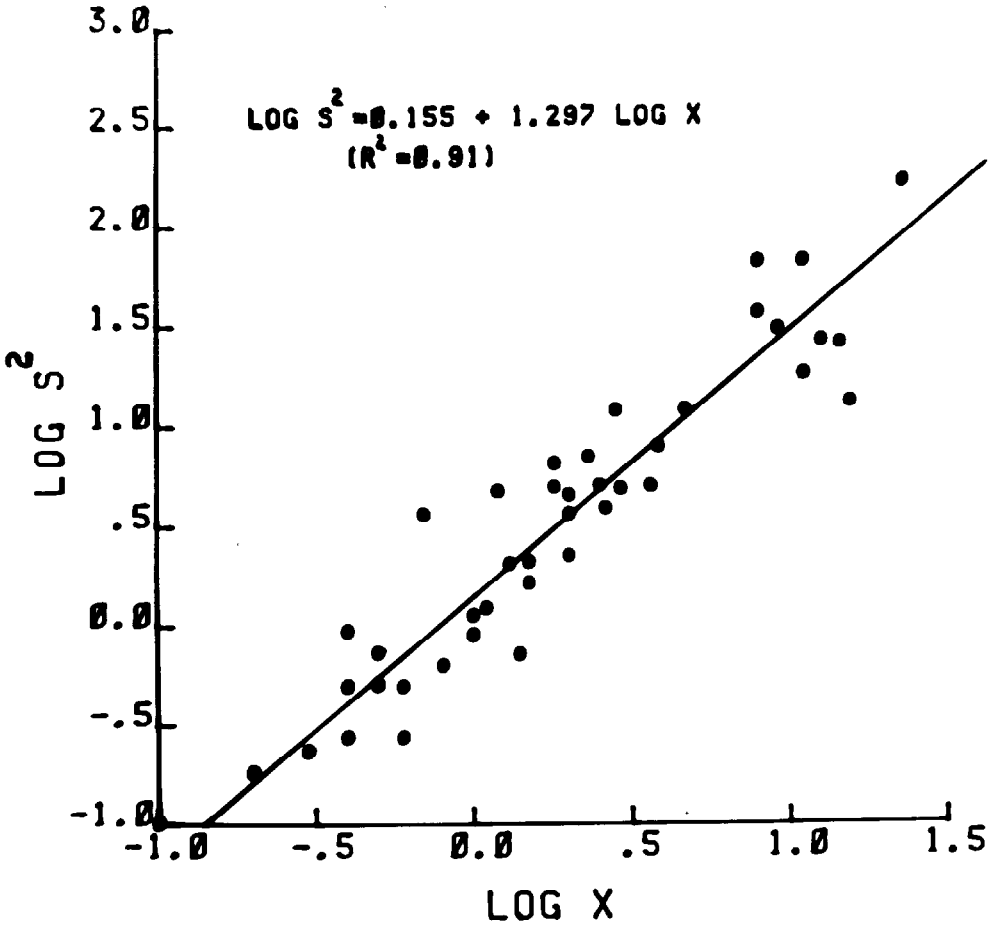

Fig. 1. Regression line describing relationship between log s^2 and log $\bar{x}$ for three day pupal counts of *Liriomyza trifolii*.

TABLE 3. NUMBER OF TEN LEAFLET SAMPLES NECESSARY TO ESTIMATE DENSITIES OF *L. TRIFOLII* IN CELERY AT THREE LEVELS OF PRECISION (C) AND VARIOUS MEAN DENSITIES ($\bar{x}$).

	No. of samples					
	3-Day Drops			7-Day Drops		
$\bar{x}$	c = 0.2	c = 0.25	c = 0.3	c = 0.2	c = 0.25	c = 0.3
0.5	58	37	26	56	36	25
1	36	23	16	36	23	16
3	17	11	7	18	11	8
5	12	7	5	13	8	6
10	7	5	3	8	5	4
20	4	3	2	5	3	2
50	2	1	1	3	2	1

TABLE 4. STOP POINTS FOR CONSTANT-PRECISION SEQUENTIAL SAMPLES FOR *LIRIOMYZA TRIFOLII* PUPAE AT THREE LEVELS OF PRECISION (C).

No. samples	Cumulative pupae counted		
	c = 0.20	c = 0.25	c = 0.30
1	162	86	51
2	121	64	38
3	102	54	32
4	90	48	28
5	82	43	26
6	76	40	24
7	71	38	22
8	67	36	21
9	64	34	20
10	61	32	19

thresholds are developed for leafminers on celery, a sampling method that will make estimates of the actual leafminer density may be required. But until that time, the pupal rearing method should be useful to celery growers in southern Florida to monitor *L. trifolii* populations and to evaluate the effectiveness of control practices.

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NITIDULIDAE ASSOCIATED WITH FRUIT CROPS IN RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

This is the first of a series of studies designed to compare sap beetles (Coleoptera: Nitidulidae) present at various locations in the state of Rio Grande do Sul in southern Brazil. Collections from strawberries, apple, peach, plum, and quince drops yielded 16 species in 7 genera. Almost twice as many species were found in the Pelotas area as near Vacaria. The most abundant species was *Carpophilus fumatus* Boheman. This is the first report of *C. fumatus* and of *Haptoncus sobrinus* Grouvelle from South America.

RESUMEN

Este artículo es el primero de una serie de estudios para comparar los nitidúlidos (Coleoptera: Nitidulidae) que se encuentran en el Estado de Rio Grande do Sul, en el sur del Brasil. El análisis de los frutos de fresa, manzana, durazno, ciruela, y membrillo, indicó que 16 especies pertenecientes a 7 géneros estaban presentes. Casi el doble número de especies se encontraron en el área de Pelotas cerca de Vacaria. La especie más abundante fue *Carpophilus fumatus* Boheman. Esta és la primera vez que se reporta a *C. fumatus* y a *Haptoncus sobrinus* Grouvelle en Sudamérica.

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This is the first of a series of studies on the sap beetles (Coleoptera: Nitidulidae) collected from fruit in Rio Grande do Sul. This, the southernmost State in Brazil is noted for its production of grains and fruit.

Literature documenting the occurrence of sap beetles on fruit and vegetable products in Brazil is scarce. References containing information about sap beetles in Brazil can be found in Lima (1953), Blackwelder (1945), and Silva et al. (1968). Salles and Williams (1983) were first to publish information on the pest status of *Lobiopa insularis* (Castelnau), the most serious strawberry pest in southern Brazil. Loss estimates range between 10-20% of total strawberry production, which during the 1983 season alone, amounted to 450-600 metric tons of strawberries.

Collection Procedures

We have compared nitidulid collections from the two main fruit growing areas of Rio Grande do Sul near the cities of Pelotas (Lat: 31S; Long: 53W) and Vacaria (Lat: 29S; Long: 51W).

Pelotas is the most important peach and strawberry producing area in Brazil; Vacaria is the most important apple producing region in R. G. do Sul. Pelotas is in rolling country a few meters above sea level, and the elevation of Vacaria is ca. 760 meters above sea level. These two fruit-growing regions are 600 km apart (see map Fig. 1). During the 1982 and 1983 growing seasons, fruits were collected at intervals from November to February. Samples (ca. 1 kilo/collection) of various kinds of ripe and overripe fruit from the ground surface were taken to the laboratory in plastic bags. Sap beetles were separated from the fruit and placed in small vials containing 70% alcohol.

Collections were labeled according to location, date and fruit type before forwarding to the following specialists for indentification: *Colopterus*—Dr. Larry E. Watrous, Field Museum of Natural History, Chicago; *Haptoncus*—Lorin R. Gillogly, USDA APHIS, San Pedro, CA; all others—Dr. W. A. Connell, University of Delaware, Newark. Numbers of each species were recorded from each collection.

Results and Discussion

There were twice the species at Pelotas (15) a warmer, more humid area as at Vacaria (8). Vacaria had only one species that was not reported from Pelotas (Table 1).

The most prevalent sap beetle species in these collections was *Carpophilus fumatus* Boheman. It was found at both locations in all kinds of fruit examined. This beetle is widely distributed in the tropics, but has not previously been reported from South America (W. A. Connell, Pers. Comm. 1983). Over half of the *C. fumatus* collections were from apple; quince was the second most common host. Apple and quince are closely related pome fruits. Even though *Carpophilus* is the most important genus of nitidulids causing injury to agricultural commodities world wide (Williams et al. 1983), with the exception of a single specimen of *C. humeralis* (Fab.), the only member of this genus encountered was *C. fumatus*.

The genus *Colopterus* was second in abundance with 108 individuals representing at least 4 species. *Colopterus* spp. are common in ripe and overripe fruits (L. E. Watrous, Pers. Com. 1984).

Two species of *Haptoncus* are present in Rio Grande do Sul; however, *H. sobrinus* Grouvelle was found only at Pelotas. This is a new locality record for *H. sobrinus* (L. R. Gillogly, Pers. Com. 1983). Previous distribution for this species was Bourbon, Seychelles, Madagascar, and the Caroline Islands (Gillogly 1962). Gillogly believes that

Fig. 1. Map of Brazil denoting sap beetle sampling places in the state of Rio Grande do Sul. (Pelotas and Vacaria). 1982/83.

unusual discontinuous distributions of nitidulids about the world may be explained by movement of "copra ships" in international commerce.

The "tropical strawberry sap beetle," *Lobiopa insularis*, is one of the most destructive nitidulids in both direct injury, caused to strawberry fruit by larvae and adults, and severe impact on the canning industry when larvae are found in cans of strawberries (Salles and Williams 1983). Collections of *L. insularis* adults presented in Table 1 are

TABLE 1. DISTRIBUTION AND ABUNDANCE OF NITIDULIDAE ON FRUIT CROPS IN RIO GRANDE DO SUL, BRAZIL.

Scientific Name	Host*					Total Collected	Location	
	A	Pe	Pl	S	Q		Pelotas	Vacaria
Carpophilus fumatus Boheman	179	33	7	25	50	294	√	√
Carpophilus humeralis (Fabricius)				1		1	√	
Colopterus flaveolus (Reitter)	8					8		√
Colopterus infimus (Erichson)	72					72	√	√
Colopterus macropterus (Fabricius)	1				1	2	√	√
Colopterus vulneratus (Erichson)	4					4	√	√
Colopterus sp. (Unidentified)						22**	√	√
Conotelus stenoides Murray				1		1	√	
Cryptarcha sp.	2					2	√	
Haptoncus luteolus (Erichson)	43			8	51	√	√	
Haptoncus sobrinus Grouvelle		14		5		19	√	
Lobiopa insularis (Castelnau)	10	14	5	41		70	√	√
Lobiopa sp.					2	2	√	
Stelidota ferruginea Reitter			4	1		5	√	
Stelidota strigosa (Gyllenhal)	4	7				11	√	√
Stelidota sp. #1		3				3	√	
Stelidota sp. #2		2				2	√	
Total no. sap beetles	323	73	16	74	61	569	—	—
Total no. species	9	6	3	6	4		15	8

* A = apple; Pe = peach; Pl = plum; S = strawberry; Q = quince.
** Hosts of unidentified specimens were not indicated.

not representatives of peak populations on strawberries since they were made after the usual harvest period. *L. insularis* was encountered on apple, peach, plum, and strawberry, but not on quince.

Diversity in *Stelidota* was equal to that in *Colopterus* with four species represented in each. There were not large numbers of any of the *Stelidota* species. However, all four species were found around Pelotas and only one near Vacaria.

No attempt was made to establish level of damage or importance for the species of nitidulids encountered. Rather in this study we compared the nitidulid complex on fallen fruit in two distinct ecological regions in Rio Grande do Sul.

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BIOLOGY OF THE SCOLYTIDAE AND PLATYPODIDAE (COLEOPTERA) IN A TROPICAL DECIDUOUS FOREST AT CHAMELA, JALISCO, MEXICO

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ABSTRACT

The feeding habits, degree of host specificity, and mating systems were examined for 96 species of Scolytidae and Platypodidae in a tropical deciduous forest at Chamela, Mexico. The dominant feeding habit was phloeophagy (59.4%), followed by xylomycetophagy (13.5%), myelophagy (13.5%), and xylophagy (12.5%). Most phloeophagous species were monophagous (limited to one plant genus); the other three groups were largely polyphagous. The mating systems found in order of importance were monogyny (40%), harem (heterosanguineous) polygyny (20.2%), inbred (consanguineous) polygyny (19.1%), and bigyny (18.1%). Monogynous species were mostly phloeophagous, to a lesser extent xylomycetophagous. Phloeophagy and xylophagy were equally represented among bigynous species. Harem polygynous species were almost exclusively phloeophagous while inbred polygynous species were mostly myelophagous or xylomycetophagous. All inbred polygynous species were polyphagous. The overall biological patterns of these beetles differed from those reported for Scolytidae and Platypodidae of temperate or tropical regions.

RESUMEN

Los hábitos alimenticios, grado de especificidad respeto al hospedero y sistemas de apareamiento se examinaron en 96 especies de Scolytidae y Platypodidae en un bosque tropical caducifolia en Chamela, México. El hábito alimenticio dominante era fleofagía (59.4%) seguido por xilomicetofagía (13.5%), mielofagía (13.5%) y xilofagía (12.5%). La mayoría de las especies fleófagas eran monófagas (limitadas a un género de plantas); los otros 3 grupos eran polífagos. Los sistemas de apareamiento encontrados en orden de importancia eran monoginia (40%), poliginia de harém (heterosanguinea) (20.2%), poliginia endógama (consanguinea) (19.1%), y biginia (18.1%). Especies monoginas eran principalmente fleófagas, o xilomicetófagas en menor grado. Floeofagia y xilofagia estaban igualmente representadas entre especies biginas. Especies poliginas de harém eran casi exclusivamente fleófagas; especies poliginas endógamas eran principalmente mielófagas o xilomicetófagas. Todas las especies poliginas endógamas eran polífagas. Los patrones globales de la biología de estos coleópteros diferieron de los reportados para Scolytidae y Platypodidae de otras regiones templadas o tropicales.

The Scolytidae and Platypodidae form a compact group, both taxonomically and ecologically. Most are borers of the woody tissues of shrubs, vines, and trees. The common names "bark beetles" and "ambrosia beetles" refer to the most common feeding habits found in the group; i.e. consuming phloem (inner bark) (phloeophagy) and ectosymbiotic fungi that grow in their galleries (xylomycetophagy), respectively. Other habits include the consumption of wood (xylophagy), pith in twigs and branches (myelophagy), herbaceous plants (herbiphagy) and fruits or seeds (spermatophagy) (Wood, 1982). Generally, feeding habit is characteristic of a given species although there is some overlap of feeding guilds.

Reproductive biology in the Scolytidae and Platypodidae has recently been reviewed by Kirkendall (1983). Mating systems of outbreeding species are monogyny or harem polygyny (heterosanguineous polygamy of Wood (1982)). Depending on the species either males or females initiate gallery construction in monogynous species, while males initiate attack in polygynous species. Bigyny is a special case of polygyny, in which a male initiates attacks and is associated with only two females. Another important mating system is inbred polygyny (spanandry of Beaver (1977, 1979); consanguineous polygamy of Wood (1982)) in which females mate with their siblings prior to emergence and then construct new galleries alone. In this last case, males are few in number, reduced in size and are flightless.

In a comparison of 2 tropical and 2 temperate areas Beaver (1979) reported that the ambrosial habit was more common in the humid tropics and that the overall degree of host specificity was lower (*i.e.*, more polyphagous) there. However, 3 of the 4 areas compared were large and ecologically heterogeneous (France, California, West Malaysia). The practice of inbred polygyny is more prevalent in tropical areas and is related to low host specificity (Browne 1961, Beaver 1977, Wood 1982).

We present here an analysis of the host tissues consumed, degree of host specificity, and mating systems for the Scolytidae and Platypodidae in tropical deciduous forest on the Pacific Coast of Mexico. Preliminary results were presented by Equihua et al. (1984). Our current analysis is based on our recent, more complete annotated checklist of the 96 species of Scolytidae and Platypodidae in the region (Equihua and Atkinson, in press).

Methods

The Estación de Biología Chamela is a biological reserve and field station of the National University of Mexico on the coast of Jalisco, Mexico (19°30′ N, 105°03′ W). The station covers 1600 ha, mostly below 150 m above sea level and is 2 km from the coast at its closest point. The mean annual temperature is 24.9°C and the 10 year average rainfall is 748 mm, most of which (80%) falls within the 4-month period from July through October (S. H. Bullock, Estación de Biología Chamela, personal communication). The vegetation of the station is mostly tropical deciduous forest with some tropical subdeciduous forest along the courses of the larger drainages (forest types from Rzedowski, 1978). Estuarine and riparian communities are found nearby. Despite the low rainfall and its strong seasonality a diverse flora occurs in this forest type, both in terms of numbers of species and variety of different life forms (Rzedowski 1978, Lott 1985). More than 750 species of vascular plants are known from the station (Lott 1985), of which approximately 60% are woody (Lott, personal communication).

We observed feeding habits (type of tissue consumed), mating systems, and degree of host specificity for most of the Scolytidae and Platypodidae at the station and nearby areas (within 5 km) from early 1982 until mid 1985. Feeding habits were inferred from observations on the location of adult and larval galleries. Degree of host specificity was

assigned based on our observations in the area, subjective judgment, and a critical review of the literature; doubtful cases were not included. We consider species that utilize host plants of the same genus as monophagous; those which utilize hosts within the same family or occasionally from related families as oligophagous; those that utilize several to many unrelated hosts are classified as polyphagous. Mating systems were inferred from the number and sex of adults constructing galleries and gallery architecture.

Results and Discussion

Feeding Habits

Phloeophagy is the dominant feeding habit; xylomycetophagy, xylophagy, and myelophagy are of approximately equal importance (Table 1). Only one spermatophagous species and no herbiphagous species were found. In the 2 temperate areas compared by Beaver (1979) phloeophagy was the dominant habit (more than 80%), followed by xylomycetophagy; in his two humid tropical areas xylomycetophagy predominated (57% in Fiji, 76% in West Malaysia) while phloeophagy was a distant second (30.3% and 11.6%, respectively). In the same study none of the other four feeding guilds included more than 10% of the total species in any locality. The relatively high importance of xylophagy (12.5%) and myelophagy (13.5%) in the Chamela fauna is unprecedented. The dominance of phloeophagy at Chamela is more similar to the pattern characteristic of temperate areas than to that of humid tropical ones. The relatively low importance of xylomycetophagous species at Chamela (13.5%) compared with that in humid tropical areas (Beaver 1979) may be related to the long (8 months) dry season, during which moisture may limit growth of ambrosial fungi in wood. In the Chamela area, ambrosia beetles were primarily limited to the shadier, more humid watercourses, particularly during the dry season, lending credence to the above hypothesis. In addition the relatively large number of xylophagous species, mostly Micracini, may partly exclude ambrosia beetles by competition for wood. Fungi are apparently present in the wood surrounding gallery systems of most (all?) xylophagous Scolytidae and Platypodidae and stain and/or alter the texture of the wood (Wood 1982, Atkinson, personal observations). Since xylophagous Scolytidae and Platypodidae directly consume xylem along with any included fungal hyphae they may be less limited by low atmospheric moisture than xylomycetophagous species that require an abundant growth of ambrosial fungi on their gallery walls.

Host Specificity

Monophagous species (50%) were slightly more numerous than polyphagous species (41%) in the Chamela fauna (Table 1). Eighteen species were excluded from the analysis because their degree of host specificity was not known; most belonged to the genera *Pseudothysanoes*, *Araptus*, and *Pityophthorus*. Based on our experience with other species of these genera, most are expected to be monophagous. Oligophagy is by far the least common of the 3 host-specificity categories, suggesting that it is the least successful adaptive strategy in tropical deciduous forest. The relative importance of the different host specificity categories at Chamela more nearly resembles temperate (57% in France, 70% in California restricted to single genus or species of host) than humid tropical (14% in Fiji, 4% in Malaysia) patterns (Beaver 1977, 1979).

Apparently the type and condition of host tissue consumed influences the degree of host specificity (Table 1). Although 15 combinations were possible (3 degrees of host specificity × 5 feeding habits), only 3 were well represented: phloeophagous

TABLE 1. CROSS-TABULATION OF FEEDING HABITS AND DEGREE OF HOST SPECIFICITY FOR 94 SPECIES OF SCOLYTIDAE AND PLATYPODIDAE IN A TROPICAL DECIDUOUS FOREST AT CHAMELA, MEXICO.

Feeding Habit	Degree of Host Specificity[a] (No. of spp.)				Total spp.	
	Monophagy	Oligophagy	Polyphagy	Unknown	No.	%
Phloeophagy	34	5	4	14	57	59.4
Xylomycetophagy	—	1	12	—	13	13.5
Myelophagy	2	—	11	—	13	13.5
Xylophagy	3	—	5	4	12	12.5
Spermatophagy	—	1	—	—	1	1.0
Total spp. No.	39	7	32	18	96	
% [b]	50.0	9.0	41.0	—[c]		

[a]Monophagy = restriction to one plant genus; Oligophagy = restriction to one plant family; Polyphagy = use of hosts from 2 or more unrelated plant families.
[b]Values based on the 78 species with known host specificity.
[c]18.8% of all 96 species.

monophages, xylomycetophagous polyphages, and myelophagous polyphages (35.4%, 12.5%, and 11.5% of all 96 species, respectively). Beaver (1977, 1979) reported that ambrosia beetles are basically polyphagous in both temperate and humid tropical areas, a conclusion supported here. He attributed decreased host specificity in xylomycetophagous species to several factors, of which the most important was that these feed on fungi rather than directly on host tissues. Perhaps more important is the association between utilization of dead tissues and polyphagy. Most ambrosia beetles breed in heartwood which consists of dead cells. A relatively high percentage of the myelophages (*Hypothenemus, Cryptocarenus*) and xylophages (*Hylocurus, Thysanoes*) at Chamela are also polyphagous. The species of these genera at Chamela breed in obviously dead hosts. Three of the 4 polyphagous phloeophages (*Hypothenemus*) are also found in dead, dry material.

The high degree of host specificity among the phloeophages probably reflects the fact that they usually breed in living or recently killed hosts which produce resin or latex (Table 2). The strong association of host-specific phloeophages with this type of defense system suggests that latex/resin defenses are effective against generalist phloeophages and have been a selective factor leading to host specialization (see Cates and Alexander 1982). The relative scarcity of host-specific Scolytidae in plants which do not produce latex or resin may indicate that they are at a competitive disadvantage with respect to generalist species or to other organisms (Cerambycidae, Buprestidae, Bostrichidae) in those hosts.

Although relatively few plants at Chamela are associated with host-specific Scolytidae and Platypodidae, all woody plants which we observed were subject to attack by one or more polyphagous species belonging to different feeding guilds. Apparently the presence or absence of a given species or guild is determined mostly by physical characteristics of the host plant and microhabitat.

MATING SYSTEMS

Monogyny is the most prevalent mating system in the Chamela fauna; bigyny, harem polygyny, and inbred polygyny are of similar rank (Table 3). The 2 species with unknown

TABLE 2. HOST PLANTS OF THE MONOPHAGOUS AND OLIGOPHAGOUS SCOLYTIDAE AND PLATYPODIDAE AT CHAMELA, MEXICO. (R = RESIN PRESENT, L = LATEX PRESENT, NC = NO CONGENERIC PLANTS IN CHAMELA AREA[a], PH = PHLOEOPHAGOUS, XM = XYLOMYECETOPHAGOUS, X = XYLOPHAGOUS, M = MYELOPHAGOUS, S = SPERMATOPHAGOUS).

Plant Family	Plant Species	Insect Species
Anacardiaceae	*Astronium graveolens* (R,NC)	*Pityophthorus indefessus* (ph)
	Mangifera indica (R,NC)[b]	*Hypocryphalus mangiferae* (ph)
	Spondias purpurea (R,NC)	*Pityophthorus nanus* (ph)
		Dendroterus luteolus (ph)
Apocynaceae	*Plumeria rubra* (L,NC)	*Scolytodes plumeriacolens* (ph)
		Scolytodes plumeriae (ph)
	Thevetia ovata (L,NC)	*Pityophthorus costabilis* (ph)
		Pityophthorus costatulus (ph)
Asclepiadaceae	*Sarcostemma clausum* (L,NC)	*Araptus delicatus* (m)
	several genera, fruits (l)	*Araptus fossifrons* (s)
Burseraceae	*Bursera arborea* (R)	*Dendroterus sallaei* (ph)
	Bursera instabilis (R)	*Phloeoterus burserae* (ph)
		Dendoterus luteolus (ph)
Cactaceae	*Stenocereus chrysocarpus* (R)	*Cactopinus atkinsoni* (ph)
	Stenocereus standleyi (R)	*Cactopinus setosus* (ph)
	Acanthocereus occidentalis (R,NC)	*Cactopinus setosus* (ph)
Combretaceae	*Conocarpus erecta* (NC)	*Scolytopsis puncticollis* (ph)
	Laguncularia racemosa (NC)	*Scolytopsis puncticollis* (ph)
Convolvulaceae	*Ipomoea wolcottiana* (L)	*Scolytogenes rusticus* (ph)
Euphorbiaceae	*Celaenodendron mexicanum* (L,NC)	*Pseudothysanoes thomasi* (ph)
	Croton spp. (L)	*Chramesus exul* (ph)
	Euphorbia colletioides (L)	*Araptus* sp.4 (m)
	Hippomane mancinella (L,NC)	*Cnemonyx splendens* (ph)
	Hura polyandra (L,NC)	*Cnemonyx equihuai* (ph)
Julianaceae	*Amphipterygium adstringens* (R,NC)	*Pityophthorus ingens* (ph)
Leguminosae	*Acacia* spp. (R)	*Hylocurus scitulus* (x)
	Cynometra oaxacana (NC)	*Pseudochramesus* sp. (ph)
	Lonchocarpus spp. (R)	*Chramesus vitiosus* (ph)
	several genera[c]	*Araptus* sp.1 (ph)
		Pseudothysanoes squameus (ph)
		Chaetophioeus minimum (ph)
		Chramesus securus (x)
		Platypus excisus (sm)
		Scolytus propinquus (ph)
Malpighiaceae	*Heteropterys laurifolia*	*Scolytus cristatus* (ph)
Moraceae	*Brosimum alicastrum* (L,NC)	*Phloeotribus setulosus* (ph)
		Pycnarthrum amersum (ph)
	Chlorophora tinctoria (L,NC)	*Pseudothysanoes spinatus*
	Ficus spp. (L)	*Araptus consobrinus* (ph)
		Gymnochilus reitteri (ph)
		Pycnarthrum furnerium (ph)
		P. hispidum (ph)
		P. reticulatum (ph)
		Scolytodes amoenus (ph)
		S. tenuis (ph)

(Cont. next page)

TABLE 2. HOST PLANTS OF THE MONOPHAGOUS AND OLIGOPHAGOUS SCOLYTIDAE AND PLATYPODIDAE AT CHAMELA, MEXICO. (R = RESIN PRESENT, L = LATEX PRESENT, NC = NO CONGENERIC PLANTS IN CHAMELA AREA[a], PH = PHLOEOPHAGOUS, XM = XYLOMYECETOPHAGOUS, X = XYLOPHAGOUS, M = MYELOPHAGOUS, S = SPERMATOPHAGOUS).

Plant Family	Plant Species	Insect Species
Nyctaginaceae	*Guapira* sp. (NC)	*Dendrosinus mexicanus* (x)
Ulmaceae	*Celtis iguaneus*	*Chramesus subopacus* (ph)
		Phloeotribus opimus (ph)
	Phyllostylon brasilense (NC)	*Phloeotribus* (sp. (ph)

[a]Based on Lott (1985, personal communication).
[b]Plant and host-specific insect introduced.
[c]Genera not the same for different beetles.

mating habits are species of *Pseudothysanoes*. All species of this genus with known mating habits are bigynous (Wood 1982, Atkinson and Equihua 1985a,b, Equihua and Atkinson, in press). Little comparative information is available on the relative importance of the various mating systems in different parts of the world except that inbred polygyny is the dominant habit in the humid tropics. (Browne 1961, Beaver 1977, 1979, Wood 1982). In this context, the relatively low ranking of inbred polygyny in the Chamela fauna is noteworthy. The high incidence of bigyny (18.1%) is unusual. If bigyny were considered a special case of harem polygyny then combining these 2 categories would make harem polygyny about equal in rank to monogyny in the Chamela fauna.

Mating systems were related to feeding habits and degree of host specificity. Monogyny was the most frequent mating system exhibited by phloeophagous insects, followed by harem polygyny and bigyny (Table 3). This mating system was also important among the xylomycetophagous species. Inbred polygyny was most common among the myelophages and xylomycetophages. Most xylophages were bigynous. All species exhibiting inbred polygyny were also polyphagous while species with harem polygyny were monophagous (8 spp.) or oligophagous (1 sp.) (Table 4). The largest group of bigynous species of known specificity were polyphagous. Monogynous species were mostly monophagous although an appreciable number were polyphagous.

Harem polygynous species at Chamela were basically phloeophagous and monophagous. This is consistent with the hypothesis of Kirkendall (1983) regarding the origin of this mating system, which has evolved at least 7 times independently in the Scolytidae. Kirkendall (1983) proposed that harem polygyny arose from monogyny in situations in which resource quality varied widely. This made it "profitable" for males to find and defend patches of high quality tissue and attract females instead of searching for females directly. Of all the tissues consumed by Scolytidae in living woody plants, phloeom (including the cambium), is initially the highest in nutrient value, and would change most in quality after the death of the plant.

Bigynous species were either phloeophagous or xylophagous (Table 3). The former were mostly monophagous while the latter were mostly polyphagous. In all but one case (*Scolytus propinguus*), these insects belong to the tribe Micracini. Most Micracini with known mating habits are bigynous except *Micracisella* spp. which are monogynous (Wood 1982, Kirkendall 1983, Atkinson and Equihua 1985a, b).

Species exhibiting inbred polygyny were associated with several feeding habits (Table 3) but all were polyphagous (Table 4). The Chamela species belong to two unre-

TABLE 3. CROSS-TABULATION OF FEEDING HABITS AND MATING SYSTEMS FOR 64 SPECIES OF SCOLYTIDAE AND PLATYPODIDAE IN A TROPICAL DECIDUOUS FOREST AT CHAMELA, MEXICO.

Feeding Habit	Mating System (No. of spp.)					Total spp.	
	Monogyny	Bygyny	Polygyny	Inbred Polygyny	Unknown	No.	%
Phloeophagy	27	9	18	3	—	57	59.4
Xylomycetophagy	8	—	—	5	—	13	13.5
Myelophagy	3	—	—	10	—	13	13.5
Xylophagy	2	8	—	—	2	12	12.5
Spermatophagy	—	—	1	—	—	1	1.0
Total spp. No.	40	17	19	18	2	96	
%[a]	42.6	18.1	20.2	19.1	—[b]		

[a]Values based on the 94 species with known mating systems.
[b]2.2% of all 96 species.

TABLE 4. CROSS-TABULATION OF DEGREE OF HOST SPECIFICITY AND MATING SYSTEMS FOR 96 SPECIES OF SCOLYTIDAE AND PLATYPODIDAE IN A TROPICAL DECIDUOUS FOREST AT CHAMELA, JALISCO.

Degree Specificity	Mating System					Total spp.	
	Monogyny	Bygyny	Polygyny	Inbred Polygyny	Unknown	No.	%[a]
Monophagy	28	2	9	—	—	39	50.0
Oligophagy	3	2	2	—	—	7	9.0
Polyphagy	8	6	—	18	—	32	41.0
Unknown	1	7	8	—	2	18	
Total spp. No.	40	17	19	18	2	96	
%[a]	42.5	18.1	20.2	19.1			

[a]Values based on the 78 (host specificity) or 94 (mating systems) species for which information is available.

lated tribes, the Cryphalini (*Hypothenemus*, *Cryptocarenus*) and the Xyleborini (all species). This strong correlation of inbred polygyny and polyphagy agrees strongly with the results of Beaver (1977) although the species he examined were mostly xylomycetophagous (Xyleborini) while most at Chamela were myelophagous (Cryphalini). No completely satisfactory explanation has been advanced for the origin of inbred polygyny, although it has evolved at least 5 times in the Scolytidae. Comparative studies of biology of species with comparable feeding habits but different mating systems would allow a better understanding of the relationship between resources and reproductive biology of the Scolytidae and Platypodidae.

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A NEW SPECIES OF MAN-BITING *CULICOIDES* FROM THE HIGH ANDES OF COLOMBIA (DIPTERA: CERATOPOGONIDAE)

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ABSTRACT

Culicoides suarezi Rodriguez and Wirth, NEW SPECIES, is described from 3230 m elevation on Monserrate near Bogota, Colombia, where it was collected while biting man. A key is presented to distinguish the 4 described species of the *andicola* group of the subgenus *Avaritia*, to which the new species belongs. All are anthropophilic and confined to the paramo regions of the Colombian Andes.

RESUMEN

Se describe una nueva especie, *Culicoides suarezi* Rodríguez y Wirth, colectada cuando picaba al hombre a una altura de 3230 m en Monserrate cerca de Bogotá, Colombia. Se presenta una clave para separar las 4 especies descritas del grupo de *andicola* del subgénero *Avaritia* al cual pertenece la nueva especie. Todas son antropolíficas y limitadas a las regiones de paramo de los Andes colombianos.

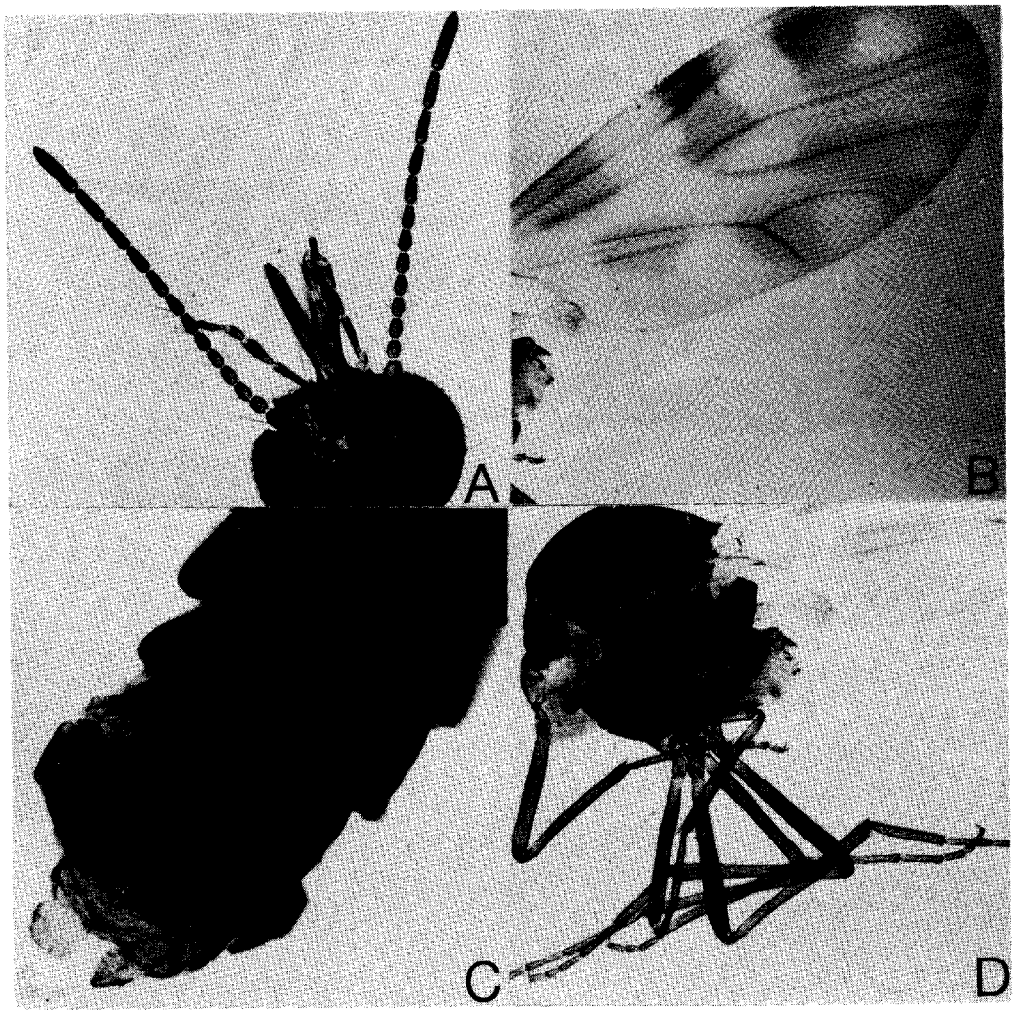
Very little has been published on the *Culicoides* biting midges of Colombia, although extensive collections have been made by V. H. Lee and P. Barreto of the Universidad de Valle on the Río Raposo, Dpto. Valle; J. E. Browne and M. A. Tidwell of Tulane University and the Universidad de Valle in the vicinity of Cali, Depto. Valle; and G. R. Defoliart and associates of the University of Wisconsin on the Río Anorí near Providencia, Dpto. Antioquia. The principal publications were descriptions of 6 new species from near Cali by Browne (1980), 8 new species from the Río Raposo by Wirth and Barreto (1978), and 1 new species from Florencia by Messersmith (1972). Wirth and Blanton (1973) reported 18 species from the Colombian Amazon and Wirth (1974) listed Colombian records of 17 additional species.

However, Wirth and Lee (1967) reported a very interesting *Culicoides* fauna from cool, wet situations at high altitudes in the central and western ranges of the Andes, describing 7 new species. Three of these species belong to a distinct group of the subgenus *Avaritia* that are endemic to the Paramo de Puracé between 3100 and 3320

m elevation. In addition they mentioned a 4th undescribed species of this group from similar elevations in Costa Rica. The purpose of the present contribution is to report and describe a 5th species of the *andicola* group from a paramo situation on Monserrate, 3230 m in Dpto. Cundinamarca near Bogotá. All the Colombian species of this group are avid feeders on human blood and 1 species, *A. puracensis* Wirth and Lee, is so abundant as to be an annoying pest on the Paramo de Puracé. A good description of the paramo habitats and an explanation of the morphological terminology used in our description can be found in the paper by Wirth and Lee (1967).

KEY TO COLOMBIAN SPECIES OF THE *CULICOIDES ANDICOLA* GROUP (FEMALES)

1. Pale wing markings extensive, poststigmatic pale spot in cell r5 covering distal ½ of 2nd radial cell, and broader than the dark area distal to it 2



EXPLANATION OF FIGURE

Fig 1. *Culicoides suarezi* female: A, head; B, wing; C, abdomen showing spermathecae; D, thorax including legs.

— Pale wing markings very restricted, poststigmatic pale spot in cell r5 covering less than distal ¼ of 2nd radial cell and narrower than the dark area distal to it .. 3

2. Third palpal segment slender, palpal ratio 3.4, sensory pit shallow; proboscis longer, P/H ratio 1.17 ..... *suarezi* n. sp.

— Third palpal segment swollen distally, palpal ratio 2.5-2.9, sensory pit depth; P/H ratio 1.00 ..... *andicola* Wirth and Lee

3. Larger species, wing length 1.52 mm; antennal segments 3, 11-15 with sensilla coeloconica; 3rd palpal segment with shallow sensory pit . *orjuelai* Wirth and Lee

— Smaller species, wing length 1.33 mm; antennal segments 3,13-15 with sensilla coeloconia; 3rd palpal segment with deep sensory pit . *puracensis* Wirth and Lee

Culicoides (Avaritia) suarezi Rodriguez and Wirth, NEW SPECIES

FEMALE HOLOTYPE: Wing length 1.39 mm; breadth 0.63 mm.

Head (Fig. 1A): Brown including antennae and palpi. Eyes hairy, contiguous for a distance equal to diameter of 2 facets. Antenna with lengths of flagellar segments in proportion of 25-20-20-21-21-20-23-26-31-31-40-42-65, antennal ratio (11-15/3-10) 1.18; sensilla coeloconica present on 3,11-15. Palpal segments with lengths in proportion of 10-45-45-21-30; 3rd segment slender with a shallow, round, distal sensory pit, palpal ratio 3.4. Proboscis long, P/H ratio 1.17; mandible with 17 teeth.

Thorax (Fig. 1D): Uniformly brown including legs. Wing (Fig. 1B) with distinct pattern of pale areas typical of the subgenus *Avaritia;* 2nd radial cell with distal ½ included in the poststigmatic pale spot; the pale markings intermediate in extent between those of *C. andicola* and those of *C. puracensis*. Costal ratio 0.61. Halter pale.

Abdomen (Fig. 1C): Brown. Spermathecae 2, oval with short slender necks; subequal, each measuring 0.048 by 0.039 mm; rudimentary 3rd spermatheca and sclerotized ring present.

HOLOTYPE: ♀ Colombia, Dpto. Cundinamarca, Bogotá D.E., Monserrate, 3230 m, biting human, 7.ix.1978, H. Strumm (deposited in National Museum of Natural History, Washington, D.C.).

DISCUSSION: This species is dedicated to Marco F. Suarez of the Servicio de Erradicación de Malaria in Bogotá in recognition of his long-standing interest in the *Culicoides* fauna of Colombia. Señor Suarez has worked since 1976 in assembling a collection and check list of Colombian *Culicoides* and first submitted the holotype of the new species to the junior author in 1978.

Culicoides suarezi can be distinguished from the 3 other described species of the *andicola* group by the characters given in the key. It is most similar to *C. andicola,* resembling it more than *orjuelai* and *puracensis* in its more prominent wing markings, the 5th palpal segment noticeably longer than the 4th, and the spermathecae with shorter, less tapering necks. *C. andicola,* however, has much more distinct wing markings than *suarezi,* and the 3rd palpal segment is stouter with deeper sensory pit.

END NOTE

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DESCRIPTIONS OF NEW SPECIES OF *CHEUMATOPSYCHE* (TRICHOPTERA: HYDROPSYCHIDAE) AND THE PRESUMED FEMALE OF *C. HELMA* ROSS FROM ALABAMA

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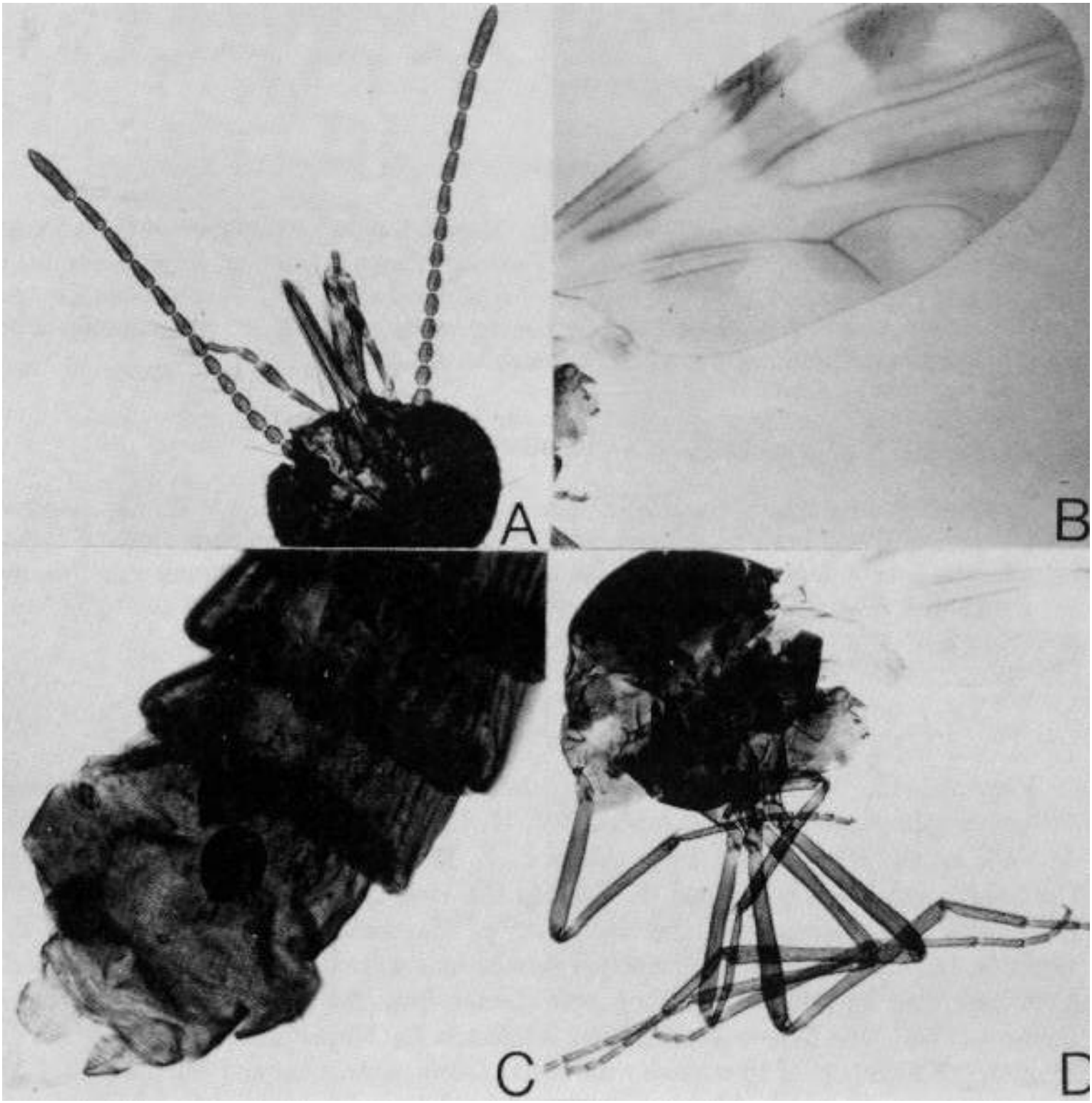
ABSTRACT

The presumed female of *Cheumatopsyche helma* Ross and 3 new species, *C. bibbensis*, *C. cahaba* and *C. kinlockensis*, are described and illustrated. Each is compared to the most similar congeners.

RESUMEN

Se describen e ilustra la supuesta hembra de *Cheumatopsyche helma* Ross y 3 especies nuevas, *C. bibbensis*, *C. cahaba* y *C. kinlockensis*. Cada una se compara con las congéneres más similares.

A recent survey of the caddisfly fauna of northern Alabama revealed the presence of 3 undescribed species of *Cheumatopsyche*. In collections from 2 localities in this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Se describen e ilustra la supuesta hembra de *Cheumatopsyche helma* Ross y 3 especies nuevas, *C. bibbensis*, *C. cahaba* y *C. kinlockensis*. Cada una se compara con las congéneres más similares.

A recent survey of the caddisfly fauna of northern Alabama revealed the presence of 3 undescribed species of *Cheumatopsyche*. In collections from 2 localities in this

portion of the state, males of *C. helma* Ross were identified. Because the female of this species is unknown, these 2 collections were resorted and the female *Cheumatopsyche* identified. A single female could not be assigned to any species and is presumed to be *C. helma*.

Terminology for genitalic structures generally follows that of Gordon (1974). In all descriptions, total specimen length is from the front of the head to the tip of the folded wings. Holotypes will be deposited in the United States National Museum of Natural History. Paratypes will be deposited at the Florida State Collection of Arthropods and the Illinois Natural History Survey.

Cheumatopsyche helma Ross

Fig. 1.

This female will key to couplet 34 in Gordon's (1974) key. This species is easily distinguished from all other *Cheumatopsyche* females by the shape of the clasper receptacles which have a short, broad chimney and an evenly bowed ventral margin and by the unique membranous areas in the median plate.

Female: Length—8 mm. Color of head and body brown, legs light brown proximally, brown distally; antennae light brown, without distinct markings; wings teneral. Each clasper receptacle wide and near dorsum of tenth tergum; in lateral view, with ventral margin strongly bowed, anterior and posterior corners level; chimney broad and twisted mesad; in dorsal view, long, tunnel-like, slightly bulbous at tip, lateral edge higher than mesal, inner opening directed caudad. Median plate with dorsal sclerite large and tongue-like at apex, membranous at sclerite midpoint and posterior edge; lateral extension cupped at tip and with membranous fold that loops verntrad; extensive membranous fold attached ventrally to tongue of dorsal sclerite and anterior margin of lateral extension; tip of dorsal sclerite bifid in dorsal view.

Locality.—Alabama: Clay Co., Cheaha Creek, 100 m. upstream from Lake Chinnabee, Cheaha State Park, 22-V-81, S. Harris and P. O'Neil, 1 female and 1 male.

Remarks.—This species was previously known only from the type locality, Gatlinburg, Tennessee. In Alabama, specimens were collected on the Piedmont Plateau,

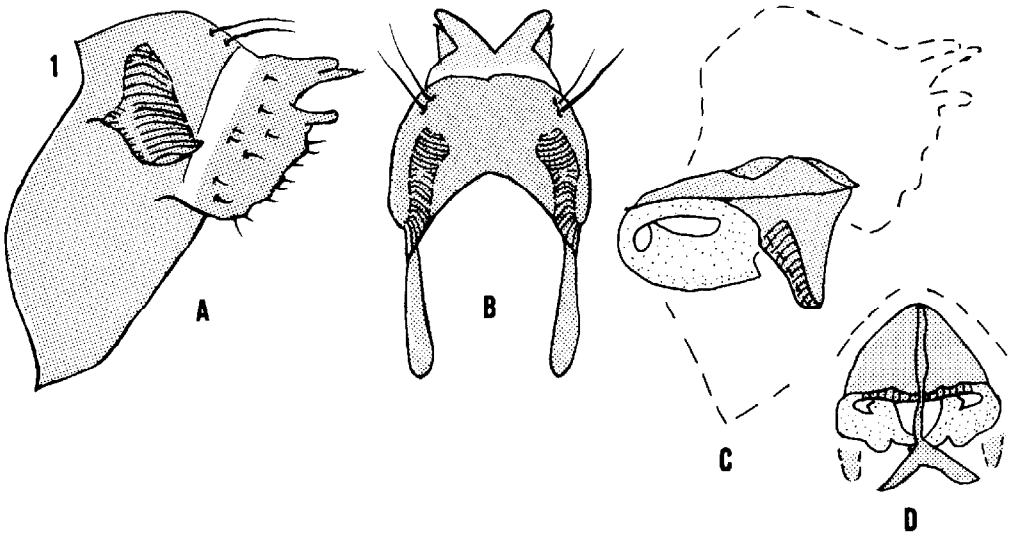


Fig. 1. C. *helma* female. Tenth and eleventh terga: A, lateral view; B, dorsal view. Median plate: C, lateral view; D, dorsal view.

Cheaha Creek, and lower Appalachian Mountains, Little River, DeKalb County; both fast-flowing, rocky streams.

Cheumatopsyche cahaba, NEW SPECIES

Fig. 2.

This species will key to couplet 13 in Gordon's (1974) key and can be distinguished from all other *Cheumatopsyche* spp. males by the long narrow cercus adhering to the anterior edge of the apical lobes of the tenth tergum and the flange on the dorsal edge of the phallotheca.

MALE: Length—7.5mm. Color of head and body brown, venter light brown; antennae yellow with distinct dorsal V-marks on the five basal segments; wings irrorate with large, light area at anal angle. Ninth segment annular, bearing long setae on dorsal lobes and latero-posterior margin, lateral apical lobe angular. Tenth tergum moderately elongate with long, narrow setose cerci adhering to anterior edge of apical lobes; in lateral view, lobes long and upright, projecting above dorsum and exposing mesal apex of tenth tergum, space between lobes and mesal apex filled by large cercus; in caudal view, lobes long and irregular, tapered at apices and widely separated. Clasper short, apex of basal segment not clearing dorsum of tenth tergum; apical segment approximately one-third length of basal segment, evenly tapering to abruptly narrowed tip. Phallotheca long with a dorsal flange near apex, base moderately bulbous.

FEMALE.—Unknown.

HOLOTYPE MALE.—ALABAMA; Jefferson Co., Cahaba River at Interstate 59, 25-VII-81, S. Harris and P. O'Neil.

ETYMOLOGY.—Named for the Cahaba River.

REMARKS.—*C. cahaba* appears to be restricted to the headwaters of the Cahaba River. At the type locality, the river is narrow, rocky bottomed and fairly rapid. Extensive collecting throughout the Cahaba basin in the lower Appalachian mountains by Harris and colleagues (Harris et al. 1984) failed to yield additional specimens.

Cheumatopsyche bibbensis, NEW SPECIES

Fig. 3.

This species will key to couplet 30 in Gordon's (1974) key. It is separated from all other *Cheumatopsyche* spp. males by the nipple-like apices of the apical lobes of the tenth tergum.

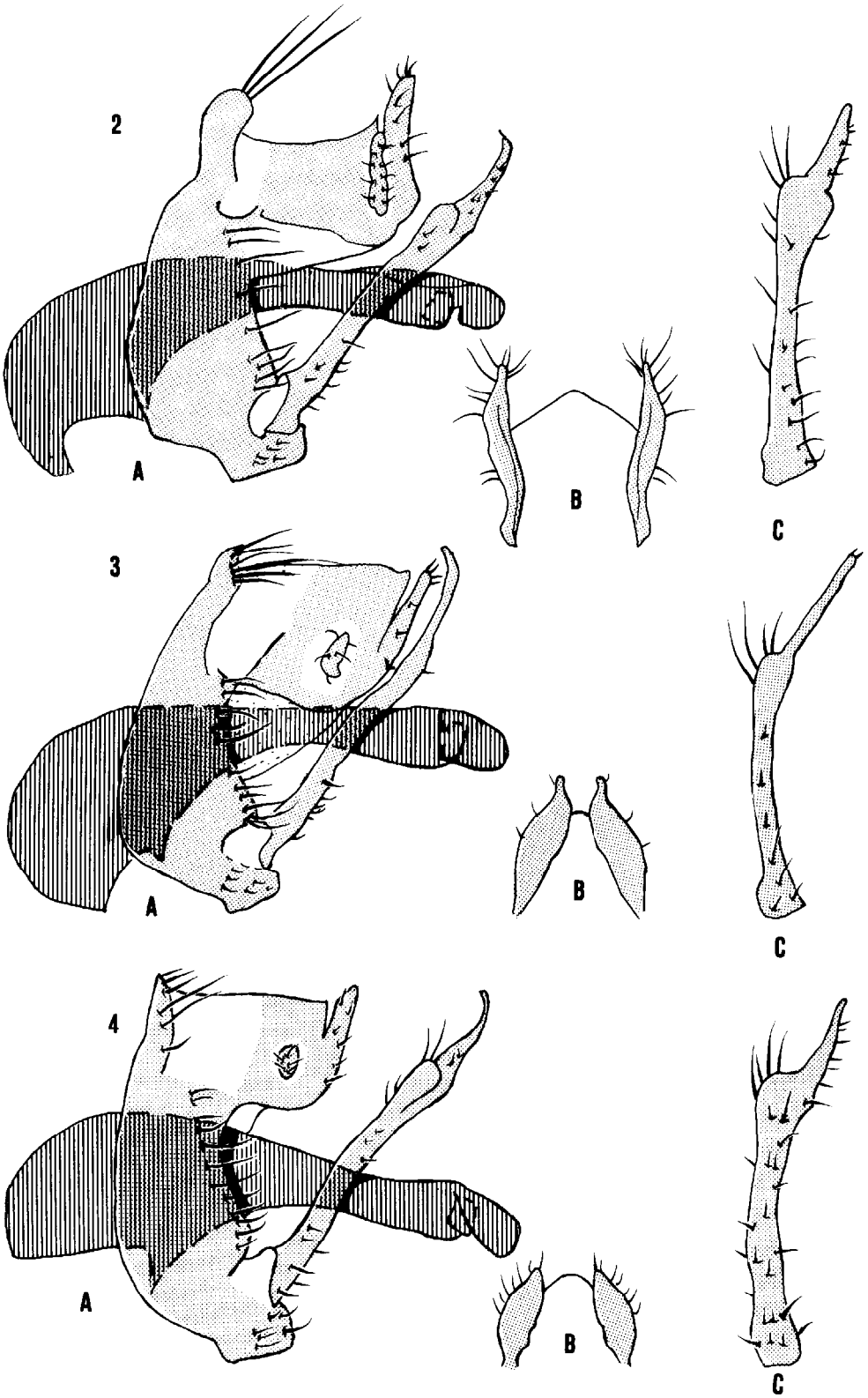
MALE: Length—6 mm. Color of head and body brown, legs light brown; antennae brown with no apparent markings; wings teneral. Ninth segment annular, bearing long setae on dorsal lobes and latero-posterior margin, lateral apical lobe angular. Tenth tergum long with large, setose cerci anteriad of apex, apically divided into long, dorsally projecting lobes; in lateral view, lobes at oblique angle, not projecting above dorsum of tenth tergum; in dorsal view, lobes widest at midpoint, constricting into nipple-like apices. Claspers short and exceedingly thin, apex of basal segment not clearing dorsum of tenth tergum; apical segment one-third length of basal segment, linear and narrowed slightly at tip in caudal view. Phallotheca with base moderately enlarged.

FEMALE.—Unknown.

HOLOTYPE MALE.—ALABAMA: Bibb Co., Cahaba River at Co. Hwy. 27, 6-X-82, S.C. Harris.

ETYMOLOGY.—Named for county of type locality.

REMARKS.—This species has been collected only from the type locality on the Cahaba River in an area where the river flows across an extensive limestone outcropping.



Figs. 2-4. Male genitalia. A, lateral aspect; B, caudal view of apical lobes of tenth tergum; C, caudal view of claspers. Fig. 2. *C. cahaba* n.sp.; Fig. 3. *C. bibbensis*, n.sp.; Fig. 4. *C. kinlockensis*, n.sp.

Cheumatopsyche kinlockensis, NEW SPECIES
Fig. 4.

This species will key to couple 38 in Gordon's (1974) key, but can be distinguished from *C. ela* Denning and *C. campyla* Ross by its short, tapered lobes of the tenth tergum. Overall, the genitalia of this species are most suggestive of *C. (harwoodi) harwoodi* Denning, but the diagonal upward slant of the dorsal edge of the apical lobes in lateral view and their tapered apices in caudal view render *C. kinlockensis* distinct.

MALE: Length—7.5 mm. Color of head and body brown, venter and antennae light brown; wings teneral. Ninth segment annular, bearing long setae on dorsal lobes and latero-posterior margin, lateral apical lobe broadly rounded. Tenth tergum long with small nodiform setose cerci anteriad of apex, divided apically into moderately long, dorsally projecting lobes; in lateral view, lobes at an oblique angle, extending slightly above mesal apex of the tenth tergum, dorsal edge of lobes slanted upward from anteriad to posteriad; in caudal view, lobes widest at midpoint, tapered at apices and widely separated. Claspers short, apex of basal segment slightly enlarged and not clearing dorsum of tenth tergum; apical segment approximately one-third length of basal segment, sinuate with base widened in caudal view. Phallotheca long, base moderately enlarged.

FEMALE.—Unknown.

HOLOTYPE MALE.—ALABAMA; Lawrence Co., Hubbard Creek below Kinlock Falls, on Forest Rd. 210, Bankhead National Forest, 28-V-83, S. C. Harris.

PARATYPES.—ALABAMA: as above, 1 male; as above except 28-V-85, 2 males.

ETYMOLOGY.—Named for Kinlock Falls.

REMARKS.—This species is known only from the type locality, a fast-flowing, rocky stream of the Cumberland Plateau.

ACKNOWLEDGMENT

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A NOVEL NEW NEOTROPICAL *NANOCLADIUS* (DIPTERA: CHIRONOMIDAE), SYMPHORETIC ON *TRAVERELLA* (EPHEMEROPTERA: LEPTOPHLEBIIDAE)

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ABSTRACT

The pupa and larva of *Nanocladius (Plecopteracoluthus) bubrachiatus* sp. nov. (Diptera: Chironomidae) are described from Honduras. This species lives in symphoretic association with the leptophlebiid mayfly *Traverella* sp. This is the first record of a *Nanocladius* living in symphoretic association with a mayfly. The larva is unusual in that it possesses a premento-hypopharyngeal fulcrum with long dorsocaudally directed arms. A key is included for the immature stages of *Nanocladius (Plecopteracoluthus).*

RESUMEN

Se describen la pupa y la larva de *Nanocladius (Plecopteracoluthus) bubrachiatus* sp. nov. (Diptera: Chironomidae) de Honduras. Esta especie vive en asociación sinforética con el leptoflebíido *Traverella* sp. Este es el primer récord de un *Nanocladius* viviendo en associación sinforética con una efímera. La larva es fuera de lo común ya que posee un fulcro del complejo premento-hipofaringeal con brazos largos dirigidos dorsocaudalmente. Se incluye una clave para los estados inmaduros de *Nanocladius (Plecopteracoluthus).*

Larvae of the orthoclad genus *Nanocladius* Kieffer are well known as symphoretic associates of Plecoptera (Steffan 1965, Saether 1977) or Megaloptera (Hilsenhoff 1968, Gotceitas & MacKay 1980). *Nanocladius* is composed of 2 subgenera, *N. (Nanocladius)* and *N. (Plecopteracoluthus).* Saether (1977) considered *Plecopteracoluthus* Steffan to be a subgenus of *Nanocladius* modified for symphoretic life. At least one species of *Nanocladius (Nanocladius)* is also symphoretic on Megaloptera (Gotceitas and MacKay 1980).

Most records of chironomid-mayfly symbiosis deal with parasitic relationships usually involving the chironomid genus *Symbiocladius* Kieffer. Arvy & Peters (1973) provide a detailed account of the chironomids and mayflies involved in such relationships.

I recently examined some mayfly nymphs of *Traverella* Edmunds (Ephemeroptera: Leptophlebiidae) from Honduras which had chironomid larvae attached to their bodies. The mayfly nymphs are similar to *Traverella* sp. A of Allen (1973). This paper describes the larva and pupa of a new species of *Nanocladius (Plecopteracoluthus)* from those nymphs and presents the first record of a symphoretic association between *N. (Plecopteracoluthus)* and a mayfly.

Terminology and abbreviations follow Saether (1980). All measurements are in micrometers unless otherwise stated, and consist of a range, mean, and the number of specimens measured in parentheses if different from the number (n) stated at the beginning of the description. Means are not given for samples of 3 or less. Postmentum length

is measured from the bottom of the division of the median teeth to the caudal margin of the postmentum.

DESCRIPTION

Nanocladius bubrachiatus sp. nov.

PUPA (n = 1).

Color. Light brown.

Total length 3.15 mm.

CEPHALOTHORAX. Thoracic horn elongate-ovate, with small spines (Fig. 1); 76 long, 22 wide at widest point; length/width ratio 3.45. Frontal setae 58 long, on small, low tubercles. Thoracic setal lengths: LAps 35; MAps 78; Pc_1 30; Pc_2 130; Pc_3 105; Dc_1 35; Dc_2 lost; Dc_3 and Dc_4 25; Dc_1 140 anterior to Dc_3, Dc_3 25 anterior to Dc_4.

ABDOMEN (Fig. 2). PSA present on S IV-VII, strongest on IV, becoming progressively weaker. PSB absent. Segment I with 1 L-seta (segment damaged), II and III with 2 L-setae, IV-VI with 3 L-setae, VII with 4 filamentous L-setae, VIII with 4 or 5 filamentous L-setae (one side with 4, the other with 5). T II without prominent caudomesal protuberance; with approximately 73 caudomesal hooklets, the longest 9 long. T III-VI with caudal rows of spines; T IV-VI also with weak median shagreen area; median spine patches absent on all tergites. Lengths and numbers of tergal caudal spines: T III with 150, longest 12; IV with 115, longest 8; T V with 71, longest 12; T VI with 43, longest 14. T VII-VIII with median shagreen patches. Anal lobe with fine anterodorsal shagreen; with 30-31 setae/side. Anal macrosetae weak, about 50 long, 2 wide.

FOURTH INSTAR LARVA (n = 2, unless otherwise stated).

Color. Head capsule light brown with darker posterior margin.

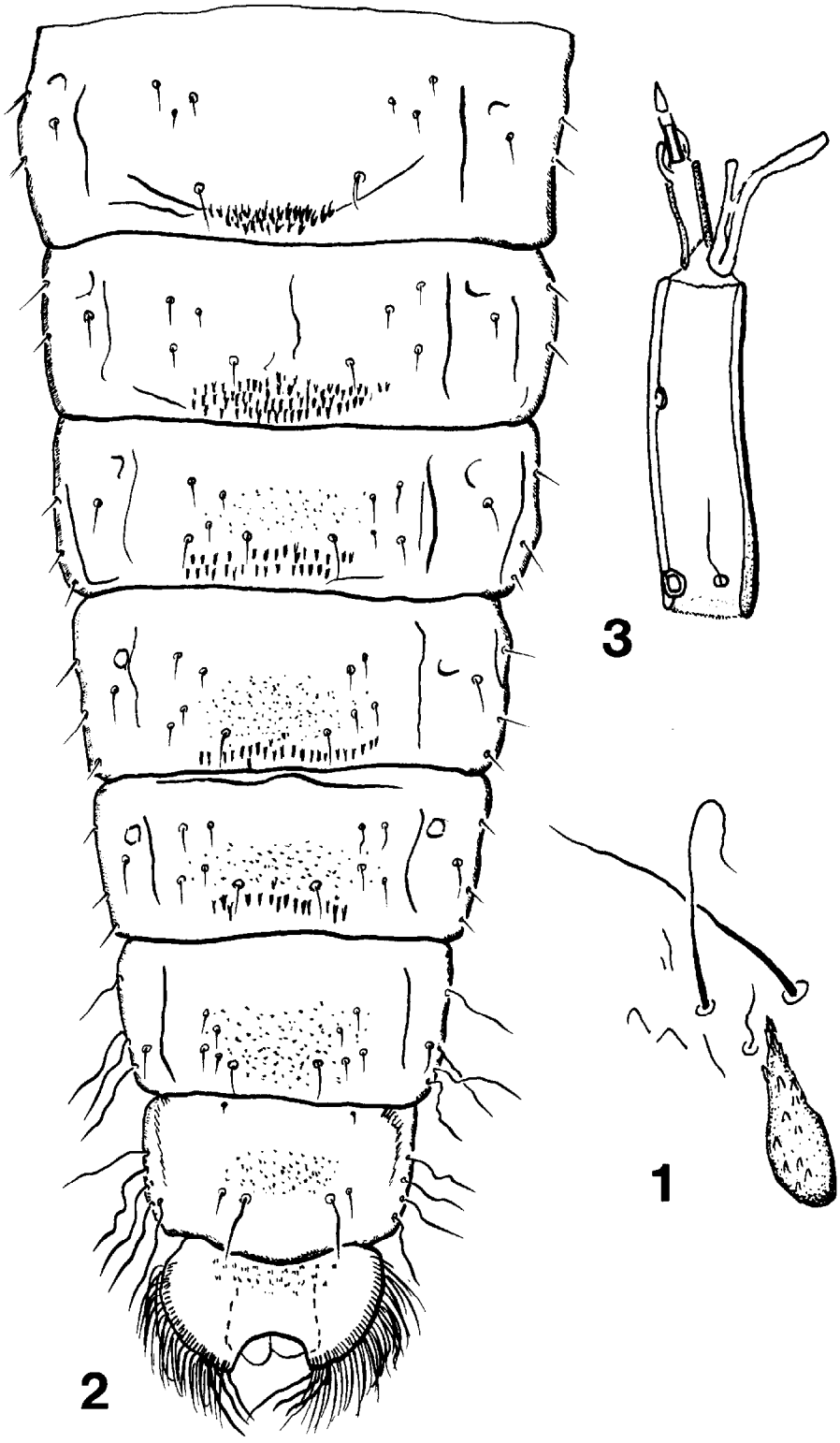
Total length 3.15 mm (1).

HEAD. Postmentum length 135-140. All labral setae simple; pecten epipharyngis of 3 simple, smooth, sharply-pointed spines. Antenna 4-segmented, with 3rd segment distally thinner (Fig. 3). Antennal segment lengths: 48-49; 15-16; 7-8; 4-5. AR 1.66-1.88. Antennal segment I 14-15 wide; apical blade 20-24 long; ring organ 2-3 from base; seta 1 from base; apical setal mark 27-29 from base. Mandible (Fig. 4) 87-96, 91 (4) long. Premandible (Fig. 5) 37-46 (3) long, with sharply bifid apex and 3 inner teeth. Mentum (Fig. 6) with 2 pointed ventromental teeth flanked by 2 anterolateral ventromental teeth, and 6 pairs of darker dorsomental teeth. Ventromental plates elongate and narrow (Fig. 6). Maxilla reduced (Fig. 7). Fulcrum of premento-hypopharyngeal complex with 2 large dorsocaudally directed arms, each arm about 90 μm high (Figs. 10-12).

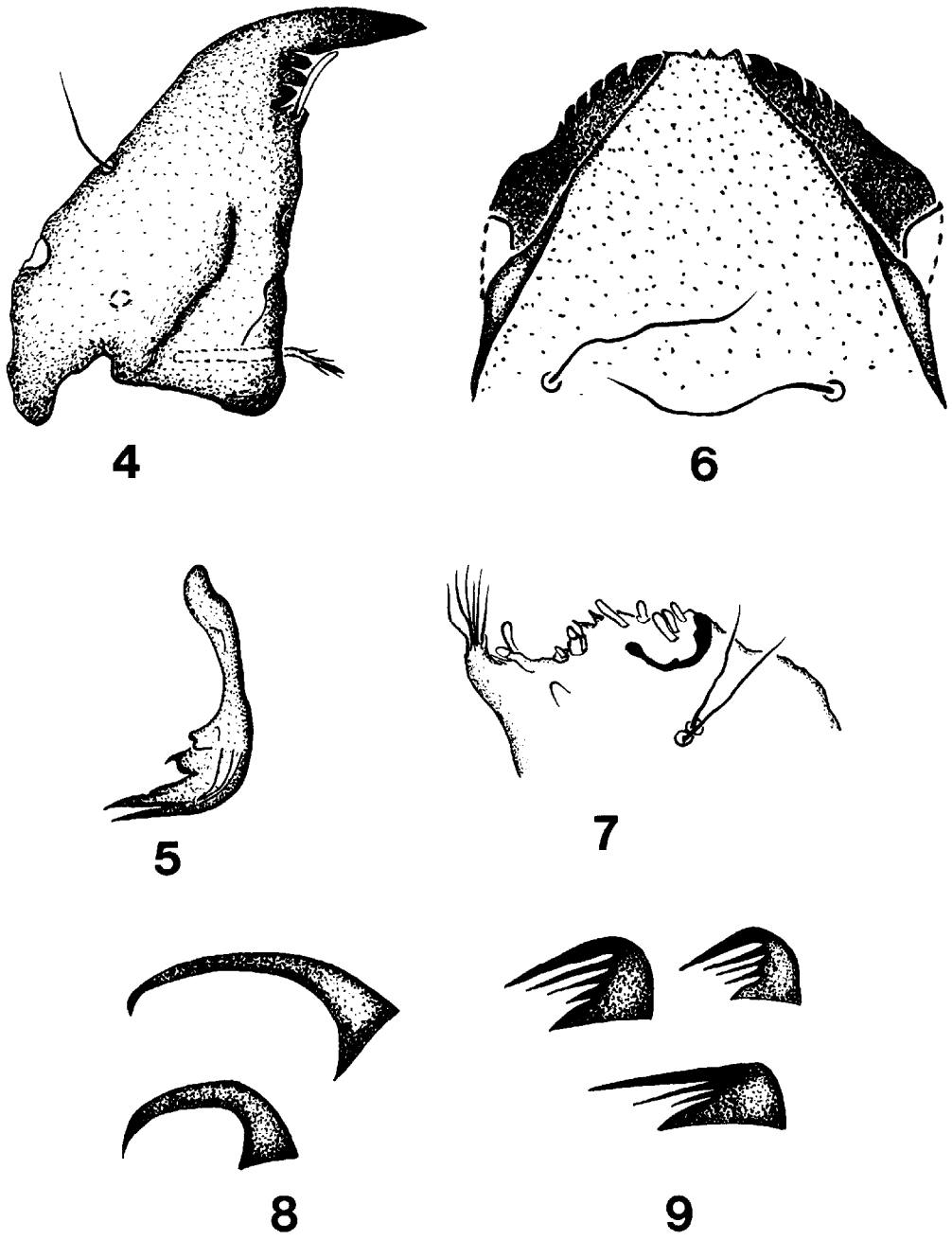
BODY. Distal claws of anterior parapods smooth (Fig. 8), mesal and proximal claws strongly serrated (Fig. 9). Body setae simple. Procercus 7-11 wide, 8-10 high; with 2 small (14-15 long) setae, 2 medium (45-65 long) setae and 3 large (130 long) setae. Dorsal anal tubules appear slightly larger than ventral anal tubules, both with an apparent medial constriction (Fig. 13).

IMAGINES. Unknown.

DIAGNOSIS. The pupa is separated from *N. (P.) branchicolus* Saether and *N. (P.) downesi* (Steffan) by the lack of median spine patches on T III-VII, and by the number of anal lobe setae: 30-31 in *N. (P.) bubrachiatus*, 15-20 in *N. (P.) downesi*, 49 in *N. (P.) branchicolus*. The larva is distinguished by the large dorsal arms of the fulcrum, the shape and number of teeth of the mentum and the 4-segmented antennae. Both larvae and pupae can also be distinguished by their phoretic association with *Traverella* sp.



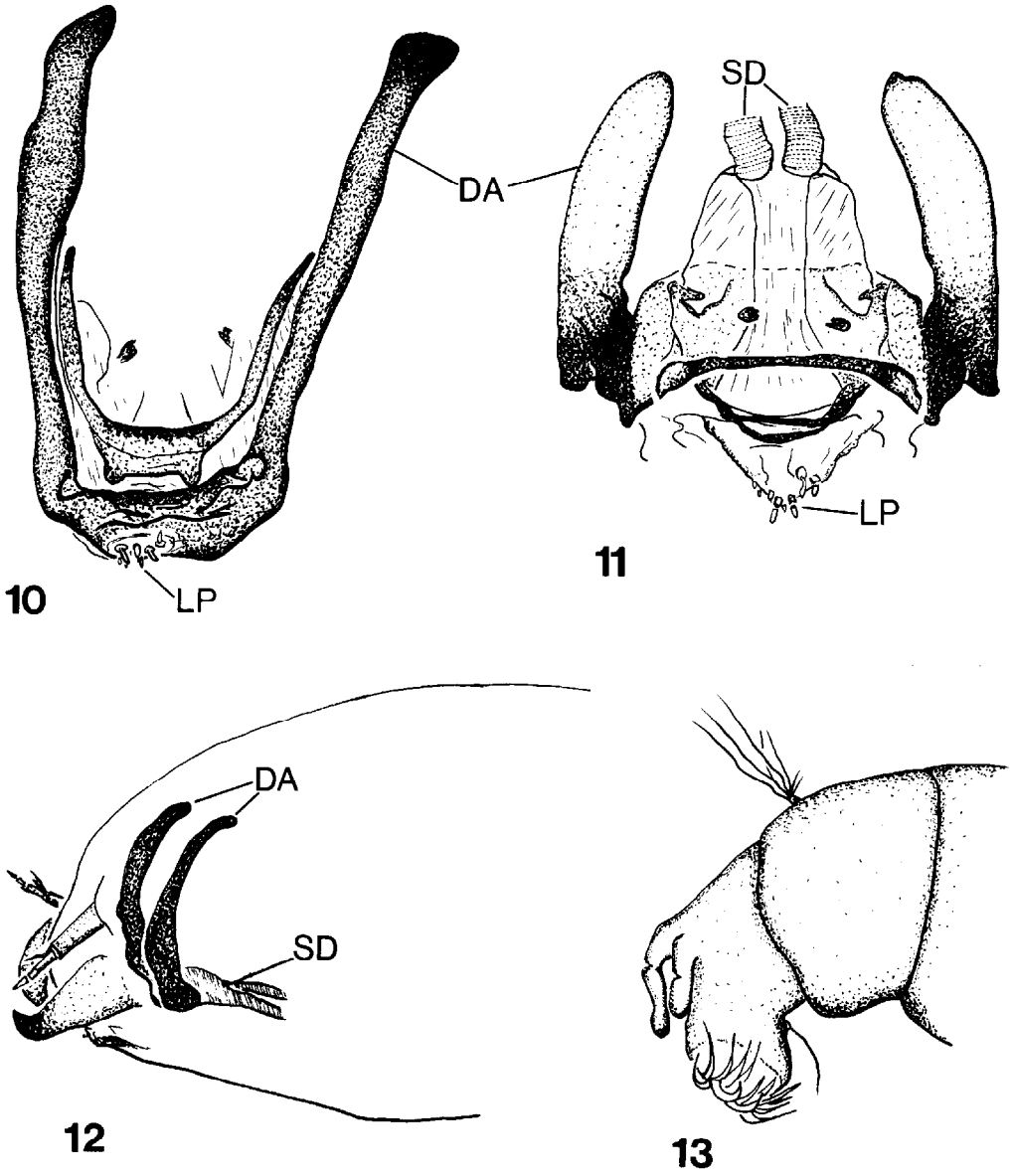
Figs. 1-3. *Nanocladius (Plecopteracoluthus) bubrachiatus:* 1) Pupal thoracic horn and precorneal setae; 2) pupal abdomen, dorsal (segment I missing); 3) larval antenna.



Figs. 4-9. *Nanocladius (Plecopteracoluthus) bubrachiatus,* larval structures: 4) mandible; 5) premandible; 6) mentum; 7) maxilla; 8) distal claws of anterior parapods; 9) proximal and mesal claws of anterior parapods.

ETYMOLOGY. From the Latin *bu,* meaning large, great; and the Latin *brachiatus,* meaning with arms or branches. The name refers to the large dorsolateral arms of the fulcrum of the larval premento-hypopharyngeal complex.

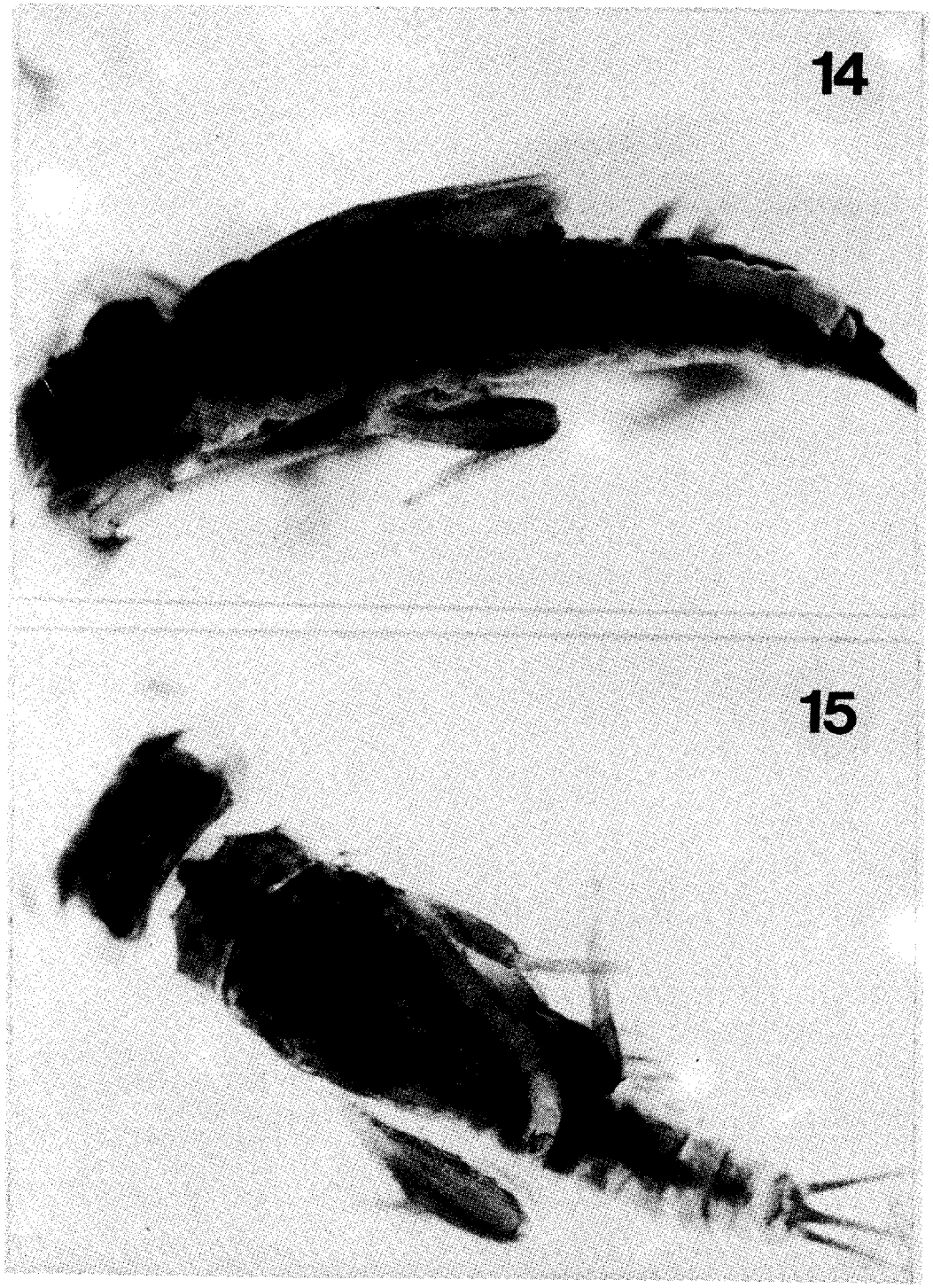
MATERIAL EXAMINED. *Holotype:* female pupa with larval exuviae, HONDURAS: Comayagua; Rio Humuya, 12 km NW Comayagua (milky R., thorn scrub), 19-VII-1977,



Figs. 10-13. *Nanocladius (Plecopteracoluthus) bubrachiatus*, larval structures: 10) premento-hypopharyngeal complex, frontal view; 11) same, dorsal view; 12) slightly oblique lateral view of head capsule, showing position of dorsal arms of fulcrum; 13) anal end (DA, dorsal arms of fulcrum; LP, labial palpi; SD, salivary ducts).

leg. L. B. & C. W. O'Brien, G. B. Marshall [on *Traverella* sp.]. *Paratypes* (4): 4 larvae on *Traverella* sp., same data as holotype.

TYPE INFORMATION. The holotype and one paratype will be deposited in the Florida State Collection of Arthropods, Tallahassee. Paratypes will be placed in my personal collection and in the Zoologische Staatssammlung, Munich, West Germany. One paratype remains attached to its mayfly host, preserved in alcohol; the other specimens are mounted in Euparal on microscope slides.



Figs. 14-15. *Traverella* sp. : 14) nymph with *N. (P.) bubrachiatus* larva attached above gills; 15) nymph with *N. (P.) bubrachiatus* larva attached on outside of wing pad; note empty tube at midline of wing pads.

Biology

The larvae of *N. (P.) bubrachiatus* live in symphoretic association with *Traverella* sp. Five *Traverella* nymphs were examined. Chironomid larvae and one pupa (with its larval exuviae still attached) were found in silken tubes attached to both the outside and inside edges of the nymphal wing pads, along the dorsolateral margin of the abdomen above the gills (Figs. 14-15), and between the hind coxae. Three of the nymphs had one larval tube on each; 2 nymphs had 2. Larvae (and the empty larval tubes) were located on both sides of the nymphs (3 on the right side, 3 on the left, one in the middle). All larvae and the one pupa examined were positioned with their heads facing the caudal end of the mayfly. None of the mayfly nymphs appeared to be damaged or malformed.

Traverella nymphs inhabit the rapids of medium-sized to large rivers, where they live under rocks (Edmunds et al. 1976), a habitat not unlike that of the Plecoptera which are utilized by other members of the subgenus *Plecopteracoluthus*. The "milky R., thorn scrub" listed in the collection site data refers to the milky color of the Rio Humuya where it flows through an area of thorn scrub (C. W. O'Brien, personal communication).

Remarks

The lack of both PSB and a caudomesal projection on T II of the pupa, and the straight elongate caudal apices of the ventromental plates of the larva place *N. (P.) bubrachiatus* in the subgenus *Plecopteracoluthus* as recognized by Saether (1977).

The most striking character distinguishing larval *N. (P.) bubrachiatus* from the other species in the subgenus is the premento-hypopharyngeal complex (Figs. 10-12). From each side of the fulcrum of the premento-hypopharyngeal complex (Saether 1980:25), a heavily sclerotized dorsal arm projects and bows gently caudad (Fig. 12). The arms are apparently not fused with the head capsule, as are the hypopharyngeal suspensorial bars of *Anopheles quadrimaculatus* Say illustrated by Menees (1962: Fig. 21). Hirvenoja (1973: Fig. 24_1) illustrated extended fulcrum arms in *Protanypus* spp. They are, however, much smaller than those in *N. (P.) bubrachiatus*. It was not possible to discern any muscle attachments to this structure in *N. (P.) bubrachiatus*.

The larvae of most *Nanocladius* species possess a ventromentum with 2 pointed median teeth flanked by low, rounded humps or in a planar area which extends to the anterolateral corners of the ventromentum (see Saether 1977: Figs. 10F, 16F, 19D). The ventromentum of *N. (P.) bubrachiatus* has 2 pointed median teeth flanked by another pair of pointed teeth at the anterolateral corners of the mentum (Fig. 6).

The larval antennae in *N. (P.) bubrachiatus* and *N. (P.) downesi* are apparently 4-segmented. In *N. (P.) bubrachiatus* the 3rd and 4th antennal segments appear to have been fused, indicated by a change in the antennal wall; the distal 1/5 of the 3rd segment is thinner than the basal portion (Fig. 3). Indications of a slight ring-like thickening of the antennal wall at this point are evident. Steffan's (1965) figure does not illustrate a similar construction for *N. (P.) downesi*.

Mature adults of *N. (P.) bubrachiatus* were not available. Saether (1977:6) stated: "because there are very few characters to separate the adults, an identification without associated pupae can only be regarded as tentative. The pupae, however, are easily distinguishable . . ." The pupa (and larva) of *N. (P.) bubrachiatus* are easily distinguished from the other described species of *Plecopteracoluthus* (see Diagnosis).

The developing female imago within the pupal skin is not sufficiently mature to examine thoroughly; developing ommatidia and seminal capsules are barely visible. However, the tarsi are sufficiently developed to observe that pulvilli are present. The 2 other species of *N. (Plecopteracoluthus)* possess pulvilli, although Steffan (1965)

stated that pulvilli were absent in *Plecopteracoluthus downesi*. However, his illustration (Steffan 1965: Fig. 7) clearly shows a pulvillus. Saether (1977) described *N. (P.) branchicolus* with pulvilli, and used the lack of pulvilli as a character to separate *N. (P.) downesi* from *N. (P.) branchicolus*. Because both species possess pulvilli, this character should be eliminated from Saether's adult keys; the other characters given in the keys will separate the 2 species.

The following key to the immature stages of *N. (Plecopteracoluthus)* is based on the descriptions of Steffan (1965), Saether (1977) and the present paper.

KEY TO IMMATURE STAGES OF *Nanocladius (Plecopteracoluthus)*

1. Pupae 2
— Larvae 4
2. Abdominal tergites V-VI without median spine patches; 30-31 setae on anal lobe; symphoretic on Leptophlebiidae (Ephemeroptera) ..... *N. (P.) bubrachiatus* sp. nov.
— Abdominal tergites V-VI with median spine patches; either 15-20 or about 50 setae on anal lobe; symphoretic on Perlidae (Plecoptera) 3
3. Anal lobe with 15-20 setae; median spine patches well developed only on T V-VI ..... *N. (P.) downesi* Steffan
— Anal lobe with about 49 setae; median spine patches well developed on T IV-VII ..... *N. (P.) branchicolus* Saether
4. Ventromentum with 4 pointed teeth; premento-hypopharyngeal complex with extremely large dorsocaudally directed fulcrum arms ..... *N. (P.) bubrachiatus* sp. nov.
— Ventromentum with only 2 pointed median teeth; premento-hypopharyngeal complex without extremely large fulcrum arms 5
5. First 2 pairs of dorsomental teeth fused, producing mentum with 11 teeth; antennae 4-segmented, AR about 2.3; living in gelatinous cases . *N. (P.) downesi* Steffan
— Mentum with 13 teeth; antennae 5-segmented, AR about 1.5; living in silken tubes ..... *N. (P.) branchicolus* Saether

ACKNOWLEDGMENTS

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SEX-BIASED SIZE VARIATION IN VELVET ANTS (HYMENOPTERA: MUTILLIDAE)

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ABSTRACT

The relative sizes of male and female Mutillidae were studied at the Archbold Biological Station in south-central Florida. Females are larger than males in *Dasymutilla pyrrhus* (Fox), *Pseudomethoca sanbornii aeetis* (Fox), and *P. oculata* (Banks). Males are larger than females in *Timulla d. dubitata* (Smith), *T. floridensis* (Blake), *Ephuta f. floridana Schuster, E. m. margueritae* Schuster, *E. s. slossonae* (Fox), *Dasymutilla archboldi* Schmidt and Mickel, and *Photomorphus paulus* (Bradley). There is no significant difference in *Dasymutilla asopus bexar* (Blake), *D. nigripes* (Fabricius), and *D. castor* (Blake). Sex-biased size variation may be associated with courtship behavior or host-seeking behavior.

RESUMEN

Se estudió el tamaño relativo de machos y hembras de Mutillidae en la Estación Biológica de Archbold en el centro-sur de la Florida. Las hembras son más grande que los machos en *Dasymutilla pirrhus* (Fox), *Pseudomethoca sanborinii aeetis* (Fox), y *P. oculata* (Banks). Los machos son más grande que las hembras en *Timulla d. dubitata* (Smith), *T. floridensis* (Blake), *Euphata f. floridana* Schuster, *E. m. margueritae* Schuster, *E. s. slossonae* (Fox), *Dasymutilla archboldi* Schmidt y Mickel, y *Photomorphus paulus* (Bradley). No hay diferencia significante en *Dasymutilla asopus bexar*

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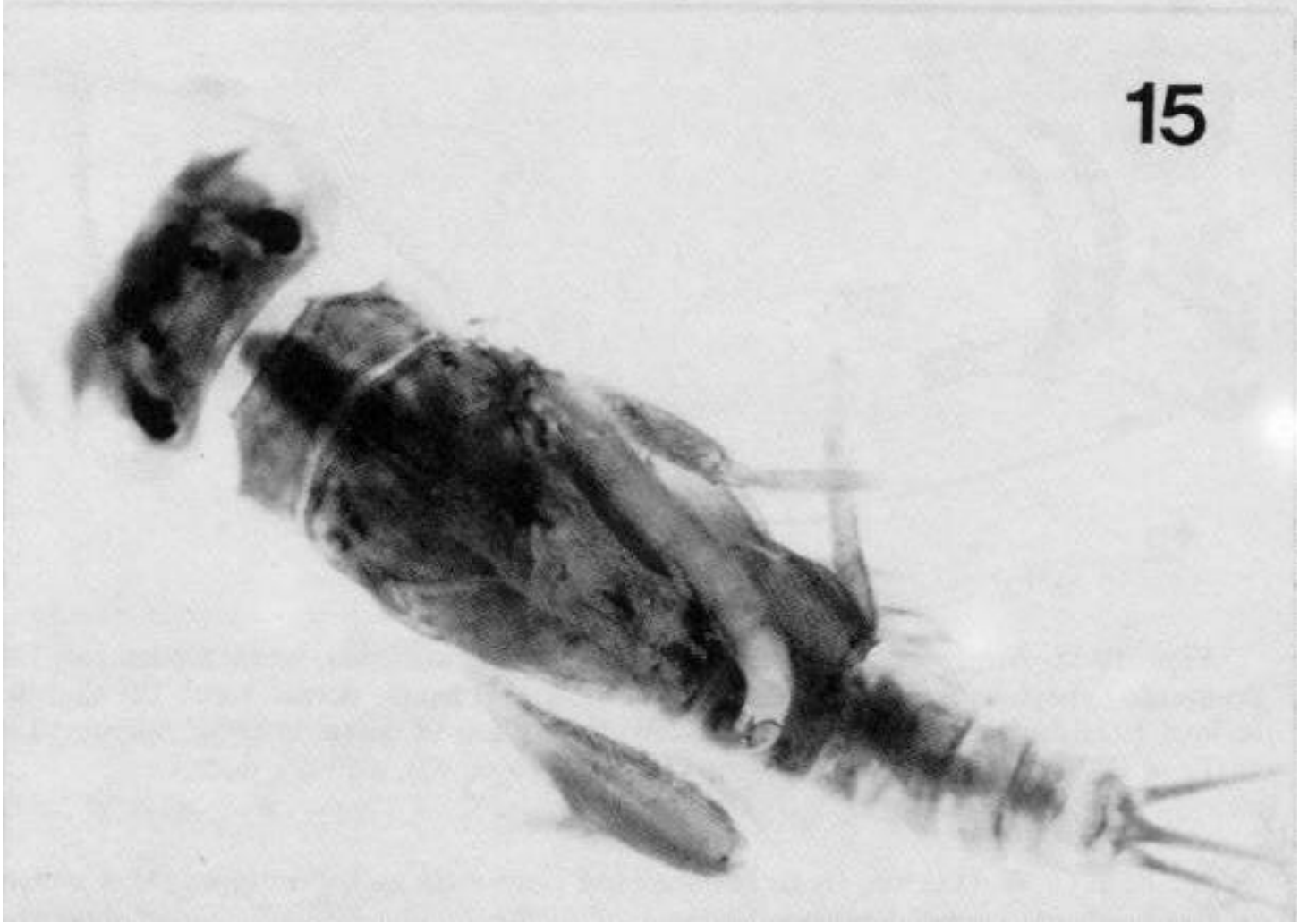
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(Blake), *D. nigripis* (Fabricius), y *D. castor* (Blake). Variaciones de tamaño parciales al sexo pudieran estar asociadas con el comportamiento de cortejo o la búsqueda de hospedero.

Among solitary parasitoid wasps, the size of the adult insect is limited by the size of the host consumed by the larva. The sex of the wasp is normally determined by whether the individual is haploid (male) or diploid (female) (Flanders 1946). A mated female can potentially determine the sex of an offspring by releasing or withholding stored sperm at the time of oviposition (Flanders 1946). Parasitoid wasps that attack larvae of varying sizes have the opportunity, if the wasp is able to gauge the size of the host, to allocate hosts to one sex or the other on the basis of size. Such sex-biased host allocation occurs in the braconid *Coeloides brunneri* Viereck (Ryan 1961), in the braconid *Heterospilus prosopidis* Viereck, and the pteromalid *Lariophagus distinguendus* (Foerster) (Charnov 1982), all of which tend to lay male eggs on small hosts and female eggs on large hosts.

Velvet ants (Mutillidae) are, in certain ways, particularly well suited for a survey of sex-correlated size variation in natural populations. All species for which hosts are known are solitary parasitoids that feed on fully grown host prepupae and pupae (Mickel 1928); continued host growth after the parasitoid has chosen the sex of her offspring does not complicate analysis. We assume that the larvae completely consume their hosts, as we know of no examples of solitary parasitoids that share a cell with a partially consumed host. There is obvious size variation in some species of velvet ants. At our study site, for example, female *Dasymutilla pyrrhus* (Fox) vary from 8.9 to 15.5 mm in length, and male *Timulla floridensis* (Blake) vary from 6.0 to 13.6 mm. Mickel (1928) showed that size variation in adult velvet ants is related to host size in the case of *Dasymutilla bioculata* (Cresson), whose bimodal size distribution (in both sexes) is correlated with the different sizes of its two host species. Preliminary surveys of collections of velvet ants from various sites indicated tendencies toward sex-biased size differences in some species, random size variation in other species, and little size variation in other species. Of particular interest was the relatively large size of males of a number of species. Velvet ants seem to offer an intriguing diversity in allocation of resources between the sexes.

Although museum collections give an indication of patterns in size variation, these collections do not make a good data base because many collectors preferentially capture large "fine" specimens. Moreover, the specimens in a normal collection do not reflect the consensus of size allocation by females of a population faced with the same spectrum of hosts. The range of host sizes available to polyphagous mutillids is likely to vary from place to place, and site data on museum specimens are seldom precise enough to ensure that specimens are from the same populations. As an example of this site effect, we have found that *Dasymutilla pyrrhus* on the coastal dunes of Sanibel Island (Florida) average significantly smaller than the same species at the Archbold Biological Station, presumably because the only abundant potential host at Sanibel seemed to be a relatively small sphecid, *Microbembex monodonta* (Say). The range of host sizes is also likely to vary from year to year and even season to season, depending on fluctuation in populations of various hosts. Therefore, study of size variation in a population of velvet ants requires specimens collected within the same time period and from a small area, preferably one with a rich variety of hosts. This study controls these variables in a survey of mutillid populations in one location over one season.

METHODS

The Archbold Biological Station (ABS) is an ecological reserve of about 4,300 acres in Highlands County in south-central Florida. The ABS is on the Lake Wales Ridge, whose well-drained sand soils are ideal for fossorial hosts of velvet ants; the ABS has over 30 species of mutillids, some of which are very abundant. Collections were made in an area of sand pine (*Pinus clausa* Chapman) scrub and adjacent firelanes. The study site was a triangular area roughly 300 × 200 × 250 m. The high mobility of mutillids observed within this area makes it unlikely that there are discrete subpopulations with different host populations within the study site. All specimens were collected in summer of 1984.

The hosts of many species of velvet ants are not known. Many hours of watching velvet ants at the ABS produced only a few observations of burrow-entering. The size allocations made by ovipositing velvet ants were therefore studied indirectly by capturing, drying, and weighing the adults that result from these allocations. Specimens were weighed rather than measured because the extreme sexual dimorphism in all species prevents comparisonof linear dimensions. Males were collect in flight with an insect net and in Malaise traps. Females were collected in #10 tin can pitfall traps and from the surface of the ground. These methods may have biased our results if there is size-related mortality in one sex that is not matched in the other sex. Dried specimens were weighed on a Mettler H6 digital analytical balance (Mettler Instrument Co., Hightown, N.J.). We were not able to separate weights of soft and hard tissue; the former may vary with the age and nutritional state of the adult. We believe that in all specimens the age-related differences in dried soft tissues are insignificant compared with the weight of the non-varying soft tissues and the extraordinarily massive exoskeleton. The results were analyzed with the Mann-Whitney U-test (two-tailed) Siegel, 1956). Most of the specimens are in the collection of the Archbold Biological Station, with voucher series in the collection of Dr. Donald Manley (Florence, S.C.) and the Florida State Collection of Arthropods, (Gainesville, FL).

RESULTS AND DISCUSSION

The results are summarized in Table 1. The 13 species can be divided into 3 groups: those in which the females tend to be heavier (3 species), those in which the males tend to be heavier (7 species), and those in which there is no clear correlation between six and weight (3 species).

SPECIES WITH LARGE FEMALES

The 3 species with large females follow the general rule among arthropods that where size dimorphism occurs the female is usually the larger sex, as can be seen in any collection of spiders or Orthoptera. The usual explanation for such dimorphism is that egg production and storage is directly related to size, whereas male reproductive success often depends more on agility and rapid development than on size (Darwin, 1881). Among provisioning and parasitoid Hymenoptera, which are able to allocate resources on the basis of sex, the limitation of resources results in a tendency to allocate more to females, for whom the reproductive penalty for small size is likely to be more severe. Additionally, it may be more efficient for a female to invest in a large number of small males rather than a few large males even when large males have higher reproductive success (Alcock et al. 1977).

TABLE 1. SIZE DIFFERENCES (DRY WT.) BETWEEN MALE AND FEMALE VELVET ANTS AT THE ARCHBOLD BIOLOGICAL STATION, FLORIDA.

Species	n ♂	n ♀	Mean wt. (mg) ♂	Mean wt. (mg) ♀	Wt. range (mg) ♂	Wt. range (mg) ♀	p[1]	Observed size Difference
Dasymutilla archboldi	30	47	15.7	4.2	5.1-28.0	1.3- 9.5	<0.0001	Males Larger
Ephuta f. floridana	5	6	4.4	2.8	3.4- 8.9	1.6- 4.4	0.026	Males Larger
Ephuta m. margueritae	8	4	3.4	2.0	2.3- 5.5	1.4- 2.8	0.014	Males Larger
Ephuta s. slossonae	20	31	9.0	2.8	3.8-19.3	1.4- 4.4	<0.0001	Males Larger
Photomorphus paulus	114	21	4.7	3.2	2.2- 8.1	1.7- 5.3	<0.0001	Males Larger
Timulla d. dubitata	12	68	35.5	8.2	13.9-63.5	3.1-26.0	<0.0001	Males Larger
Timulla floridensis	47	33	17.2	5.6	3.8-36.2	2.2-11.1	<0.0001	Males Larger
Dasymutilla asopus bexar	6	26	21.5	24.9	16.0-28.1	14.3-29.6	0.3974	NS[2]
Dasymutilla castor	71	77	10.5	8.4	3.5-12.4	3.4-11.5	0.3859	NS[2]
Dasymutilla nigripes	17	7	7.9	9.2	4.0-13.2	4.9-16.0	0.24	NS[2]
Dasymutilla pyrrhus	20	19	27.4	39.2	7.5-50.3	8.1-75.2	0.04	Females Larger
Pseudomethoca oculata	21	15	9.7	21.8	6.0-20.0	8.2-44.0	<0.0001	Females Larger
Pseudomethoca sanbornii aeetis	12	19	11.5	15.0	8.4-18.3	5.8-25.1	0.025	Females Larger

[1]Mann-Whitney two-tailed U-test.
[2]No significant difference.

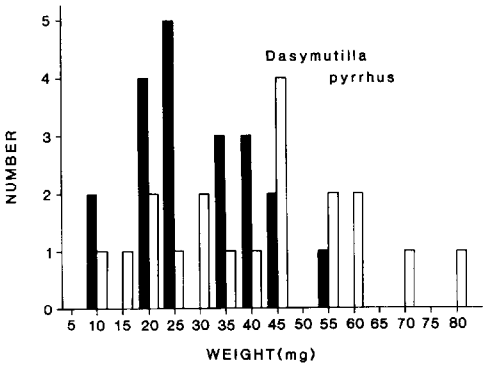
Dasymutilla pyrrhus (Fig. 1) was the only species of 5 studied in the genus in which females are clearly heavier than males. The females also show great variation and a high standard deviation (18.2) in weight. At the ABS, we have often observed this species around nest aggregations of *Bembix sayi* Cresson and we have seen *D. pyrrhus* entering the burrows of *B. sayi* and *B. texana* Cresson. A large number of *D. pyrrhus* were found around the nesting aggregations of *Microbembex monodonta* on Sanibel Island. Since this species tends to attack aggregating burrowers, the ability to develop and store a number of eggs at a time may be an advantage of large females. On the other hand, there is clearly no absolute size criterion for allocation of hosts to a particular sex in this species, and this flexibility may be important in a species that attacks aggregating hosts, as a rigid adherence to host size as a determinant of sex could result in highly skewed sex ratios where there are aggregations of a uniform host.

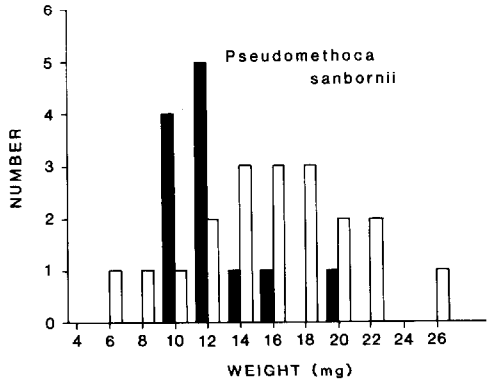
In *Pseudomethoca sanbornii aeetis* (Fox) (Fig. 2) and *P. oculata* (Banks) (Fig. 3) there may be an additional factor favoring large size in females. The head of the female of both species is greatly enlarged and might be used to block the host gallery if these species tend to spend a period of days in the host burrow, as in the case of *Pseudomethoca frigida* (Smith) (Brothers, 1972). The macrocephalic queens of eusocial halictid bees described by Wilson (1971) show a remarkable morphological convergence with female *Pseudomethoca* species. The known hosts of *Pseudomethca* are halictids (Krombein, 1979), and it appears that the mutillids and the eusocial species of halictids may have independently evolved the same features that permit domination of a halictid burrow.

Species With Large Males

In the genera *Timulla* (Figs. 4, 5) and *Ephuta* (Figs. 6-8), the larger size of males is probably related to the male habit of carrying the female during courtship and copulation. Phoretic copulation has been reported in *Timulla oajaca* (Blake) (Linsley, 1960) and *T. dubitata* (Smith) (Sheldon, 1970). We have captured phoretic couples of *T. floridensis* (Blake), *Ephuta sabaliana* Schuster and *E. floridana* Schuster. Phoretic copulation with concomitant large males has been described in the families Bethylidae and Tiphiidae as well as the Mutillidae (Evans, 1969). Large male size in certain Hymenoptera was noted by Darwin (1881, p. 279) who mentions the apterogynous tiphiid *Methoca ichneumonides* Latreille. "The explanation of this anomaly is that a marriage flight is absolutely necessary with the species, and the male requires great strength and size in order to carry the female through the air." In species with wingless females (including all Mutillidae), phoretic copulation may have an important dispersal function, as the female may thus cross barriers such as streams (Evans, 1969). Phoretically copulating males may gain an advantage over potential rivals by obtaining sole possession of the female during flight. It has recently been shown (O'Neill and Evans, 1983) that phoretic behavior is a highly effective strategy for larger individuals among males of a species of sphecid; the female in this case is fully winged. Whatever the selective pressures that led to phoretic behavior in *Timulla* and *Ephuta*, the antiquity of phoresy in these genera is shown not only by the consistently large male size, but also by the modifications of the male clypeus and frons to accommodate the head of the female (Sheldon, 1970).

While phoretic behavior may select for size dimorphism, another factor may also select for small size in females of non-phoretic and phoretic species. If a species attacks burrowing hosts of differing sizes, large females may have difficulty entering the burrows of small host species. Where large size is not important for defense or for rapid egg storage and production, one would expect selection for small size in females of polyphagous velvet ants.


Dasymutilla
pyrrhus
NUMBER
WEIGHT(mg)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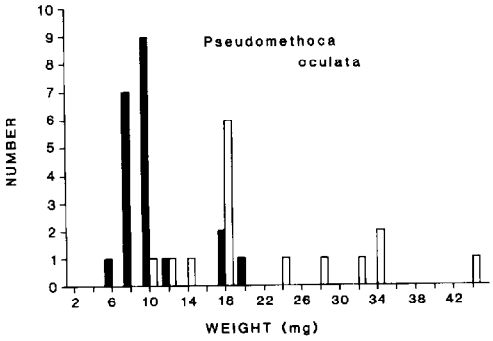
sanbornii
NUMBER
WEIGHT (mg)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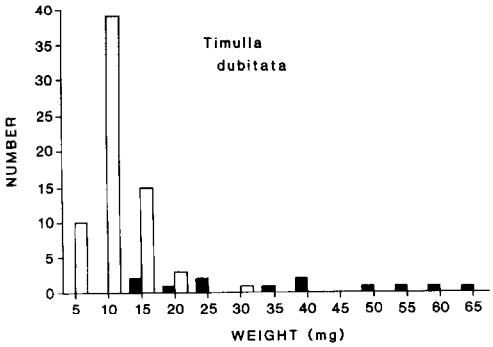
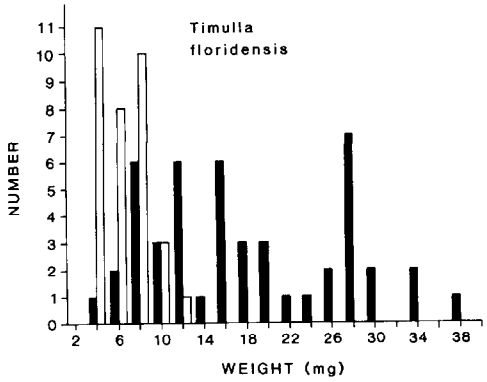
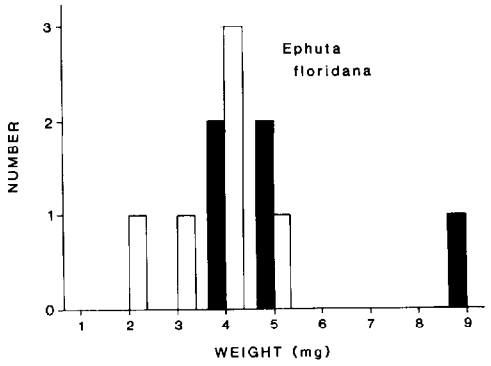
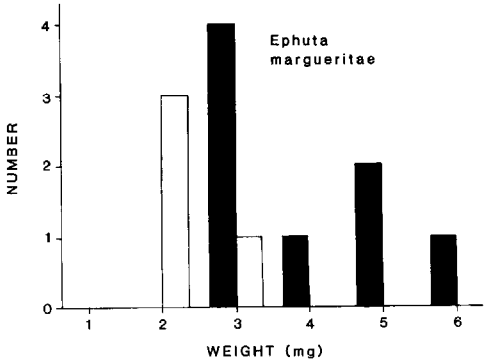
oculata
NUMBER
WEIGHT (mg)


Timulla
dubitata
NUMBER
WEIGHT (mg)


Timulla
floridensis
NUMBER
WEIGHT (mg)


Ephuta
floridana
NUMBER
WEIGHT (mg)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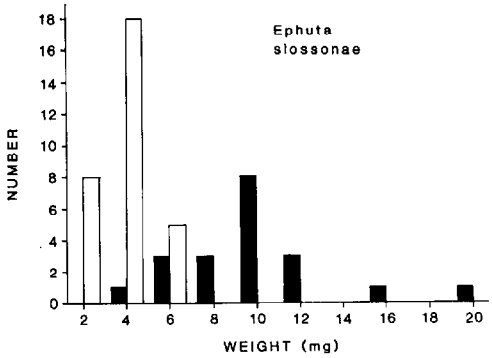
margueritae
NUMBER
WEIGHT (mg)


Ephuta
slossonae
NUMBER
WEIGHT (mg)

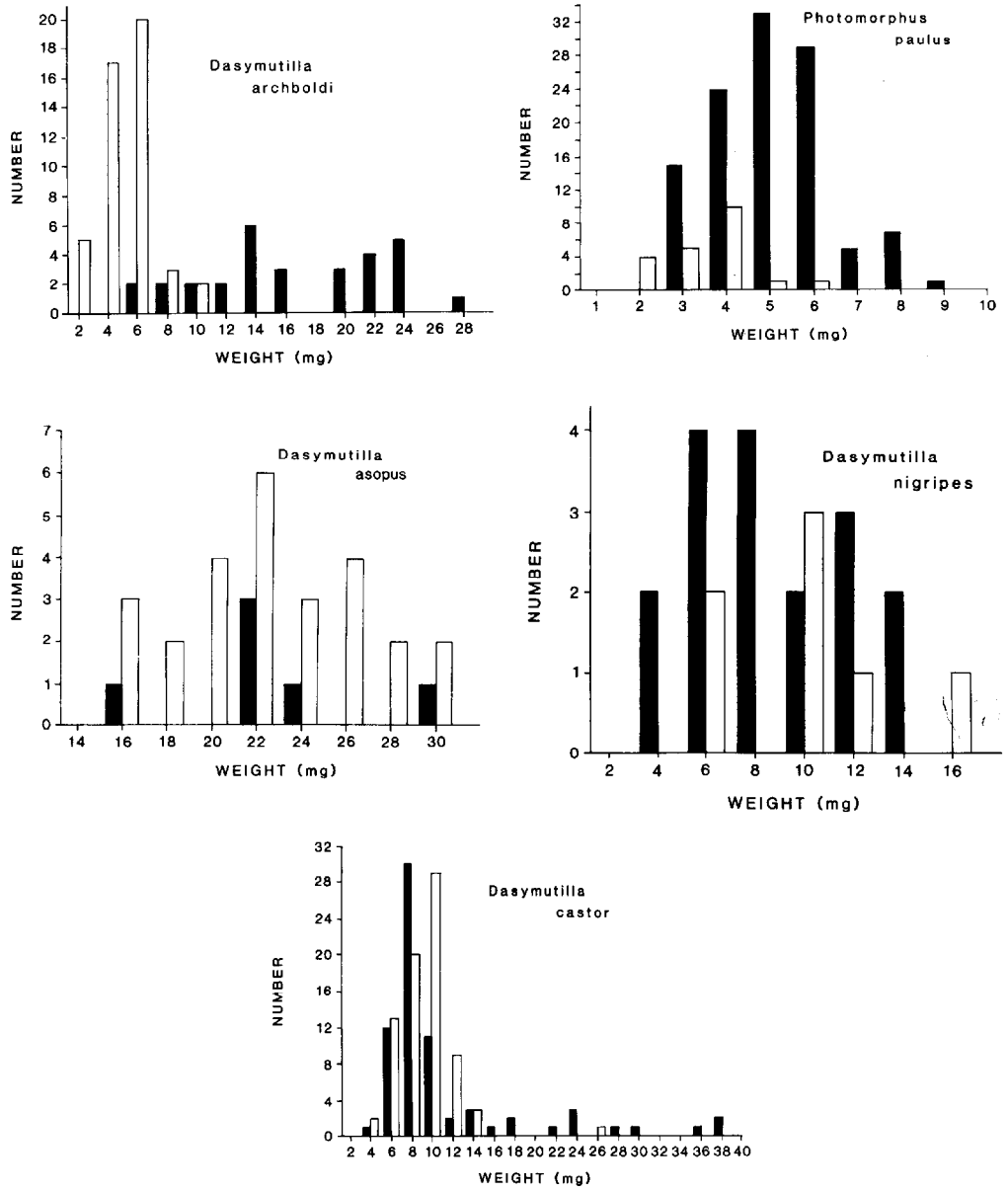


Fig. 1-13: Weights of Mutillidae spp. Solid bars are males, open bars are females.

This latter explanation for small female size may apply to *Dasymutilla archboldi* Schmidt and Mickel (Fig. 9), which shows a sexual size dimorphism as dramatic as those of *Ephuta* and *Timulla* species. There are no reports of phoretic copulation in *Dasymutilla* species, and male *Dasymutilla* show no modifications of the head or mandibles correlated with phoresy (Sheldon, 1970) or combat between males. Phoretic behavior in *D. archboldi* cannot be dismissed but seems highly unlikely. *Dasymutilla archboldi* appears to be a Florida endemic confined to a few former islands in the central part of the state, where the soil is very deep well-drained sand (Schmidt and Mickel, 1979). In the absence of some potential competitors, *D. archboldi* may have evolved an expanded host range to efficiently use both large and small hosts. No other eastern

Dasymutilla shows such striking and consistent size dimorphism. The most obvious relevant characteristic of the habitat of *D. archboldi* is the uniform sandy soil occurring over a large are; the consequence of this edaphic uniformity is that no burrowing bees or wasps, with the exception of *Bembix* and *Cerceris* species, appear to form aggregations. When hosts are diverse and very widely dispersed, small size in the female velvet ant is not limited by selection for rapid production and storage of many eggs, and adherence to host size as the determinant of sex is not likely to lead to gross imbalance in sex ratios.

Photomorphus paulus (Bradley) (Fig. 10) belongs to a genus whose biology is so poorly known that we hesitate to speculate on the significance of the relatively small size of the females. We suspect that phoresy does not occur in this species as we have captured hundreds of males in Malaise flight traps, and not one female. Out of a much smaller total number of *Ephuta* and *Timulla*, there were a number of females found in the traps, sometimes still in the grasp of the male.

There is a certain amount of overlap in the weights of males and females in all these species with large males. This overlap may be due to imprecise host measurement by ovipositing females, to negligible effects of size on fitness in either sex within the overlapping range, or to a tendency to balance sex ratios without ignoring any hosts.

Species Showing No Sex-Biased Size Variation

Dasymutilla asopus bexar (Blake) (Fig. 11) and *D. nigripes* (Fabricius) (Fig. 12) show no significant sex-bias in size variation, though both species vary considerably in weight in both sexes. Females in these species may be indiscriminate in resource allocation, or there might be a pattern of resource allocation that is too subtle to be revealed in the small number of individuals in these samples. *Dasymutilla castor* (Blake) (Fig. 13) seems to show a pattern in host size utilization even though the statistical analysis shows no difference in sizes of males and females. The graph of frequency distribution shows in the range of 4 to 14 mg a pair of more or less normal distribution curves, with the females clearly heavier, much as in *D. pyrrhus*. Above 14 mg, however, all but one of the 13 specimens were males. It is possible that in the lower size ranges the normal advantages of large female size prevail, but above a certain threshold the problem of gaining access to burrows may come into play as a selective pressure influencing the behavioral repertoire of the female.

Conclusion

The explanations of the data presented in this study are highly speculative and would not have been advanced if we had felt there was a practical method for eventually obtaining direct observations on the oviposition behavior and direct evidence of the effects of natural selection on various size classes of males and females. The principle value of the study is that it shows diversity of male-female size ratios in Mutillidae and focuses attention on the importance of resource allocation, which is only possible because of the male haploidy of higher Hymenoptera. Male haploidy might arise and be maintained as a mechanism to increase the maternal genome at the expense of the paternal genome (Bull, 1979); moreover male haploidy may be important in social Hymenoptera because it makes sisters more closely related to each other than to their offspring (Wilson, 1971). But the most direct benefit of male haploidy is that it permits optimal reproductive success by differential allocation of resources between the sexes in response to differences in the biological roles of the male and female.

ACKNOWLEDGMENTS

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THE STRIPED EARWIG, AND ANT PREDATORS OF SUGARCANE ROOTSTOCK BORER, IN FLORIDA CITRUS

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ABSTRACT

The relative abundance of ant and striped earwig (*Labidura riparia*) (Pallas) (Dermaptera: Libiduridae) populations was assessed in 78 central Florida citrus groves. Ants were predominant in 74 groves while the striped earwig was the dominant predator in 4 groves where ants were absent. Detailed studies were made in Winn and High Acres citrus groves. Winn grove, with residues of cyclodine chlorinated hydrocarbon insecticide in the soil, had a dense population of striped earwigs and no ants. High Acres citrus grove, with no insecticide soil residues, had a dense population of ants (ca. 30 species) and few striped earwigs, typical of the other 74 groves sampled. Without a natural population of ants, the striped earwig became a major nocturnal soil surface predator in the Winn grove.

Striped earwig predation was measured on monitored populations of *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae) first instar larvae placed on the soil surface under the citrus tree canopy. These earwigs, quiescent during the day, had a peak predation period of 3 to 4 hours after sunset. Thereafter predation decreased gradually and ceased before sunrise. Seasonal predation activity of the striped earwig was greatest between May and October.

RESUMEN

La abundancia relativa de poblaciones de hormigas y de la tijerata rayada (*Labiduro riparia*) (Pallas) (Dermaptera: Libiduridae) fue evaluada en 78 arboledas de cítricos del centro de la Florida. Las hormigas predominaron en 74 arboledas mientras que la tijereta rayada fue el depredador más dominante en 4 arboledas donde las hormigas estaban ausentes. Se hicieron estudios detallados en arboledas en Winn y High Acres. En la arboleda de Winn, con residuos en la tierra del insecticida ciclodine hidrocarburo clorinado, huvo una densa poblacion de tijeretas rayadas y no de hormigas. La arboleda de cítricos de High Acres, sin residuo de insecticidas en la tierra, tuvo una densa población de hormigas (aprox. 30 especies) y pocas tijeretas rayadas, que fue lo típico de las muestras de las otras arboledas. Sin una población natural de hormigas, la tijereta rayada se convirtió en un importante depredador nocturno en la superficie de la tierra en la arboleda de Winn.

Se midió la depredación de la tijereta rayada en poblaciones chequeadas del primer estadio larval de *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae) puesto en la superficie de la tierra debajo del dosel de los arboles cítricos. Estas tijeretas, en reposo durante el día, tuvieron el período de depredación más alto e 3 a 4 horas después de la puesta del sol. De aquí en adelante, depredación disminuyó gradualmente y cesó antes de la salida del sol. La actividad estacional depredadora de la tijereta rayada fue mayor de Mayo a Octubre.

The sugarcane rootstalk borer weevil, *Diaprepes abbreviatus* (L.), is an important curculionid pest of sugarcane and citrus in the West Indies. It was first reported attack-

ing citrus near Apopka, Florida, in 1964 (Woodruff 1964). The weevil egg masses are deposited between leaves which are bound together with an adhesive secretion. Jones and Schroeder (1983) reported the freshly hatched (144 to 224 h after oviposition) neonate larvae drop immediately (235 to 248 h after oviposition) to the soil surface under the tree canopy and remained on the soil surface no longer than 3 h, between 1100 and 2400 h before burrowing to feed on the roots. This larval root feeding eventually causes severe host decline and decreases fruit production. An area of about 20,000 ha, including Apopka, Florida is presently under quarantine.

Since the ban on the use of cyclodiene insecticides, effort has been directed toward evaluating alternative control methods. Whitcomb et al. (1982) and Richman et al. (1985) reported that *D. abbreviatus* neonate larvae are vulnerable to soil-surface arthropod predators. They documented the primary soil-surface predators in a Florida citrus grove to be a complex of ant species. Several of these ant species were effective predators when *D. abbreviatus* neonate larvae were placed on the soil surface for observation.

The striped earwig, *Labidura riparia* (Pallas) (Dermaptera: Labiduridae), is also an important predator of insect pests in cultivated fields in California (Schlinger et al. 1959) and several southeastern states (Clements 1968, Whitcomb 1973, Neal 1974, Nguyen & Workman 1975, Walker & Newman 1976, Buschman et al. 1977, Travis 1977, and Reinert 1978). Clements (1968) and Travis (1977) reported that the striped earwig was common in cultivated fields, including groves, in central Florida. Uncultivated fields, pastures, and wooded areas had few striped earwigs (Walker & Newman 1976). Tawfik et al. (1972) reported that "the striped earwig was strictly an animal tissue feeder; in other words a strict predator." Its life history was described by Tawfik et al. (1972) and Shepard et al. (1973).

To identify and evaluate possible biotic factors affecting first instars of sugarcane rootstalk borer larvae, *D. abbreviatus* (Coleoptera: Curculionidae), a survey for soil surface predators was initiated in 78 commercial citrus groves near Orlando, Florida. Two groves were selected to evaluate predation rates on the soil surface.

Methods

Arthropods were collected and identified from 78 citrus groves in Lake, Orange, and Polk counties in central Florida. Baited traps were placed monthly for a 72-h sampling period in the groves during June and July 1979 and for 12 months in 1980. Moist cat food was used as bait in open 7-dram snap vials. The vials with the bait were placed upright in 50 ml of 70% ethyl alcohol at the bottom of widemouthed 946 ml Mason jars. Alcohol was necessary to prevent the trapped insects from being eaten or decaying. Ten baited Mason jars per grove were randomly buried with the lid at soil surface under the citrus canopy for 72 h. The lids to the Mason jars had six holes (21.5 cm diameter) to allow insect predators to enter but prevent mammals and reptiles from reaching the bait or the trapped insects.

Detailed predation experiments were conducted in 2 commercial citrus groves, High Acres and Winn, located within the *D. abbreviatus* quarantine area northwest of Orlando, Florida. These 2 groves characterized the 2 extremes in soil-surface predator populations. Recommended pesticide practices (fungicides, scalicides, miticides, spray oils, etc.) were used in both groves by the commercial operator. Unlike High Acres, Winn had a history of chlorinated hydrocarbon soil insecticides used to control several weevil species between 1950 and the early 1970s. Since 1968, dieldrin (2/16/73, date sprayed), chlordane (9/15/71), 4/21/70), and heptachlor (5/13/69, 11/20/69) have been used.

Weed species complexes (measured using 10 1-m^2 samples in each grove), relative density of soil surface arthropod predators, and pesticide soil residues present were used to characterize the two groves. Predators were collected and identified from baited traps.

Sampling *L. riparia* is difficult because it is nocturnal. Maximum feeding activity of the striped earwig occurred just after sunset and continued at decreasing levels until all activity ceased before sunrise (Clements 1968, Shepard et al. 1973, Walker & Newman 1976, and Buschman et al. 1977). Striped earwig predation rates were evaluated by using first instars of *D. abbreviatus* larvae as prey in open 55 mm (depth) petri dishes. The *D. abbreviatus* larvae were obtained from USDA laboratory in Apopka, Florida. The open petri dishes were placed into the soil within the citrus tree drip line. This approximated the area of larval drop after hatching from foliar egg masses. Ten petri dishes with 20 weevil larvae each were placed beneath each of 4 randomly selected citrus trees for 20 minutes. This was repeated hourly for 24 h each Monday during the summer and fall of 1980. A camel hair brush was used to keep the crawling weevil larvae inside the dishes. Because of the small size of the weevil larvae (avg 1.2 mm by 0.5 mm) and soil surface debris, petri dishes were necessary for accurate nocturnal observations of larval predation by the striped earwig and other arthropods. Nocturnal observations were made with flashlights covered by transparent red cellophane. The number of larvae missing from each dish after each trial was calculated as predation percentage. The predation source was identified by observation.

Results and Discussion

Striped Earwig and Ant Population Density

Preliminary insect pitfall trap data collected during the second week of June 1979 demonstrated that the 2 groves selected for detailed experiments presented an extreme contrast in the relative abundance of insect predators on the soil surface. The striped earwig was the predominant predator (more than 97%) in Winn grove in 1980 (Tables 1 and 2). Few ants (0.2%) were observed or collected in this grove. The striped earwig was the predominant arthropod (avg 98%) in only 4 of the 78 groves sampled for surface predators. High Acres had an ant population, which was more typical of the 74 groves with a large ant population and no *L. riparia* (Table 3). Whitcomb et al. (1982), who surveyed High Acres, reported 30 ant species with 13 species predominating. High Acres was typical of 95% (74 of 78) of the groves sampled. The total number of ants ranged from 92.4% to 100% of the total predators (avg. 98.7%) in these groves. Whitcomb et al. (1982) also reported that of 2,613 first-instar *D. abbreviatus* larvae collected in High Acres, more than 75% were taken by 3 ant species *Pheidole dentata* Mayr (31.1%), *P. floridana* Emery (24.0%), and *Tetramorium simillimum* Roger (20.8%). The striped earwig comprised less than 3% (avg 0.9%) of the arthropod predators in any one grove. Richman et al. (1986) also demonstrated that the ants collected in these groves were the most important predator of the sugarcane rootstock borer neonate larvae.

Baited pitfall traps in Winn grove between 2100 and 2300 h (June 1980) attracted significantly ($P < 0.01$) more striped earwigs than unbaited traps (49.7:18.4 striped earwig/trap/2 h). The most effective baits were moist cat food with a strong odor (Friskies'® tuna and liver, etc.)

TABLE 1. PREDATORY GROVE INSECTS COLLECTED IN 10 PITFALL TRAPS IN WINN CITRUS GROVE (WINN) AND HIGH ACRES CITRUS GROVE (HA) IN CENTRAL FLORIDA (I NSECTS/TRAP).

Predatory Insects	June 8-14, 1979		June 12-18, 1980	
	Winn	HA	Winn	HA
Earwigs				
Labiduria riparia	370.0	0.0	264.8	0.0
Euborella annulipes (Lucas)	13.8	6.8	9.1	6.4
Ants	1.4	81.2	0.0	74.7
Others (Hemiptera, Coleoptera)	0.7	13.7	0.0	9.8

TABLE 2. PREDATORY INSECTS COLLECTED IN 10 PITFALL TRAPS FROM WINN CITRUS GROVE, 1980.

Sampling Dates	Predatory Insects (No./trap)		
	Earwigs *Labidura riparia* (Pallas)	*Euborellia annulipes* (Lucas)	Ants[3]
January 10-16	11.3	0.4	0.0
February 14-20	2.7	0.3	0.0
March 9-15	3.6	0.7	0.0
April 10-16	48.8[1]	4.8	0.3
May 9-15	152.7	4.1	0.1
June 12-18	264.8	9.1	0.0
July 20-26	103.9[2]	12.8	1.4
August 14-20	241.0[1]	8.4	0.3
September 9-15	79.4	2.8	0.1
October 11-17	97.6	3.4	0.0
November 13-19	40.3	1.8	0.0
December 14-20	29./9	2.5	0.0

[1]A large percentage (50%) of the *L. ripaira* trapped were immature.
[2]Consist of adult females observed in nests and not scavenging for food.
[3]The 2.2 ants collected per trap consisted of 0.9 *Pseudomyrmex elongata*, 0.7 *P. brunnea*, 0.4 *Pheidole moerens*, and 0.2 *Camponotus impressus*.

WEEDS

To help explain the two contrasting insect predator populations, weed species and density in Winn and High Acres groves were assessed. Regular cultivation and an annual use of herbicide kept Winn grove much freer of weeds than the seldom-cultivated High Acres grove. In monocultures, population levels of native predators, e.g. ants and earwigs, are directly influenced by weed complexes (Alteiri & Whitcomb 1979). Abundant species exclusive to each grove were hairy signalgrass (*Brachiaria piligera* (F. Meull.) and guineagrass (*Panicum maxumum* Jacq.) in the Winn grove, and crabgrass

TABLE 3. PREDATOR INSECTS COLLECTED IN 10 PITFALL TRAPS IN HIGH ACRES GROVE.

Insect Species	Insects collected (No./trap)			
	9-15 May	12-18 June	20-26 July	14-20 August
Formicidae[1]				
Pheidole floridana Emery	8.3	6.5	21.2	32.4
Pheidole dentata Mayr	14.9	13.7	28.4	15.1
Tetramorium similimum Roger	15.8	17.6	13.7	19.6
Conomyra edeni Buren	9.2	4.9	2.8	4.0
Pheidole moerens Wheeler	1.6	3.7	8.7	3.7
Solenopsis invicta Buren	3.7	1.8	13.0	4.1
Paratrechina bourboniza (Florel)	0.2	1.1	1.6	3.2
Others	0.1	5.9	2.3	7.0
Total	62.8	55.2	91.7	89.1
Dermaptera				
Labidura riparia (Pallas)	0.0	0.0	0.0	0.0
Euborellia annulipes (Lucas)	4.6	5.3	8.9	6.8
Total	4.6	6.3	8.9	6.8
Coleoptera	7.1	6.7	3.8	5.2
Hemiptera	0.9	2.4	4.9	3.3
Total (insects/trap)	75.4	69.6	109.3	104.4

[1]Identified with the help of Dr. Everett Nikerson, Division of Plant Industry, Gainesville, Florida.

(*Digitaria ciliaris* (Retz.) Koel.), southern sida (*Sida acuta* Burn. f.), two pigweeds (*Amaranthus viridus* L. and *A. hybridus*), and *Bidens alba* (L.) in High Acres.

Amaranthus sp. has served as a reservoir for numerous phytophagous insects and associated predators, including a ground beetle (*Lebia analis* Dej.) and several ant species (Alteiri & Whitcomb 1979). Ants trapped on *Amaranthus* sp. in High Acres included *Conomyrma* sp., *Solenopsis invicta* Buren, and several *Pheidole* sp., *Bidens alba* (L.), also found in High Acres, always had mealybug populations, *Planococcus ficus* (Signoret), at the soil root interface that were tended by the imported fire ant (*S. invita*). Thus, *Amaranthus* sp. and *Bidens alba*, abundant only in High Acres, were beneficial in maintaining ant populations.

SOIL INSECTICIDE RESIDUES

Surface soil from Winn and High Acres groves was analyzed for the presence of all soil insecticide residues by the Pesticide Research Laboratory, Institute of Food and Resources, University of Florida. Trace amounts (0.003 ppm) of DDD and DDE were found in soil from both High Acres and Winn groves. Soil samples from Winn grove also had residues from dieldrin (avg. 0.0009), chlordane (avg 0.100), heptachlor (avg 0.093), endrin (avg 0.039) and two unidentifiable cyclodiene insecticides (ppm between 0.002 and 0.115).

The extensive use of the cyclodiene chlorinated hydrocarbon insecticides and the continued existence of their residues help explain the eradication of soil-surface ant populations and the resulting buildup of striped earwig populations at Winn grove. Stoddard (1962), Workman (1963), and Gross & Spink (1969) reported that the striped earwig may be resistant to the chlorinated hydrocarbons heptachlor and chlordane. Clements (1968) found chlordane did not control the striped earwig. Striped earwig populations were maintained at low density levels by ant predation (Stoddard 1962, Gross & Spink 1969, and Price & Shepard 1977). Observations of earwig egg predation by ants were supported by laboratory studies by Watts and Whitcomb (unpublished). They found several ant species (*Pheidole dentata* Meyr, *Solenopsis invicta* Buren, and *Tetramorium bicarinatum* (Nylander)) each removed 100% of eggs from *L. riparia* egg masses (avg 36.4 eggs/batch) in less than 60 minutes. Dense striped-earwig populations increased in lawns and fields only after ant populations had been eliminated by the use of heptachlor (Stoddard 1962, Gross & Spink 1969).

Striped Earwig Predation

Results from observations of predation by the striped earwig on first-instar *D. abbreviatus* weevil larvae are presented in Figure 1. Earwigs fed on all or none of 20 weevil larvae per trial. One earwig would consume a dish of 20 weevil larvae in less than one minute and only one adult earwig was found inside a petri dish at one time. In an encounter between two earwigs, the smaller earwig usually left instantly or risked being cannibalized. The earwigs remained motionless or hid when white lights were used. This required the use of a flashlight with a dim red light to avoid this interruption during night observations. Once feeding was initiated, however, light, regardless of color, no longer inhibited their activity.

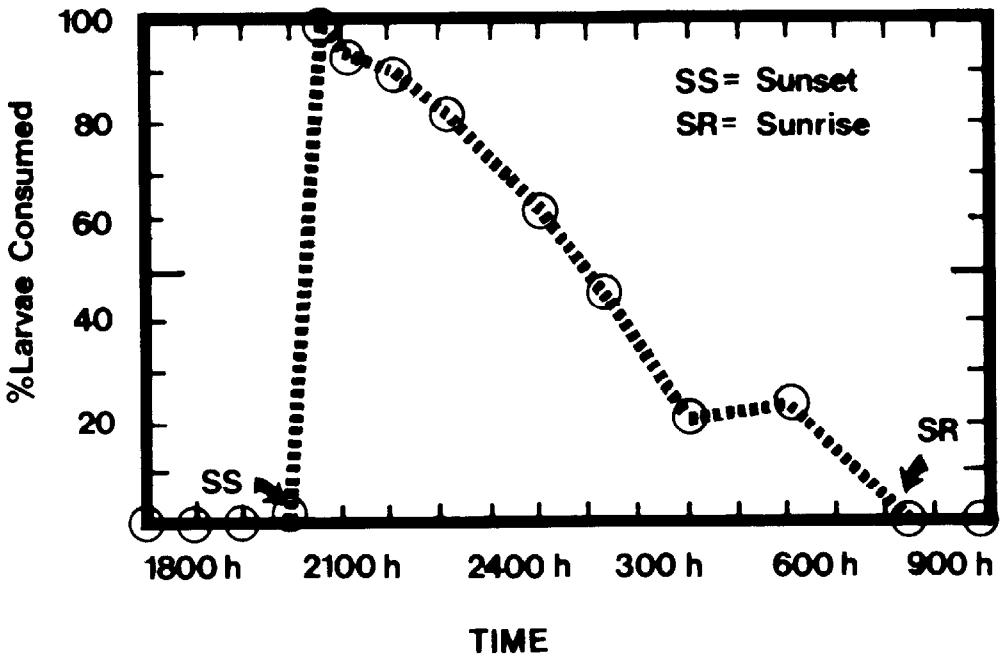

Figure 1. Percentage of *D. abbreviatus* neonate larvae consumed by striped earwig in open petri dishes in Winn citrus grove (12 observation days, 4 trial/h/day, 20 larvae/trial).

Observations of the striped earwig activity confirmed their nocturnal habits. Peak foraging and feeding activity occurred during the first 3 hours after sunset and gradually decreased throughout the night and ceased before sunrise. During the peak feeding period, more than 75% of all weevil larvae placed under the citrus canopy during the summer and fall of 1980 were consumed. The percentage eaten was calculated from the number of weevil larvae taken from an open petri dish during 20-minute intervals (Fig. 1). The amount of the first-instar weevil larvae consumed per night during this 3 hour time period ranged from 100% (June 16) to 64% (July 21). Feeding tests were conducted only from May to November when the weevil neonate larvae were available. Only in late November did earwig feeding activity decrease to less than 30%. This reflected the decrease in *L. riparia* activity in late fall (Table 2).

During daylight hours, striped earwigs were quiescent and hid in shaded resting sites protected by several layers of soil debris. Earwigs were rarely observed foraging during the day (0700-1900 h). However, at dusk (2000-2100 h) feeding activity of the striped earwig began. During the first few hours (2100-2400 h) they were most effective at removing the introduced *D. abbreviatus* larvae from the petri dishes. This was explained by the aggressive foraging and their concentration under the citrus tree canopies in the early evening. Feeding continued during most of the dark hours (2100-0700) but gradually became less effective after midnight as they dispersed and became less active. Before sunrise, they disappeared into protected resting sites.

Periodic decreases in feeding activity by the striped earwig during summer (i.e. 64%, July 21) parallel a lack of feeding activity by several adult females observed in shallow burrows near the feeding trials (Table 2). These females remained in their burrows protecting their brood for several days despite feeding by other striped earwigs. Even minor disturbances with various pointed devices failed to dislodge the female. Caussanel (1968), Tawfik et al. (1972), and Shepard et al. (1973), reported that females did not feed or leave their burrows while brooding eggs for up to 12 days.

Ants and the striped earwig are the predominant arthropod soil surface predators in central Florida citrus groves. However, they may be mutually exclusive. Ants were the predominant soil surface predator in the typical grove. Ant populations or the striped earwig may play a major role in reducing larval populations. Chlorinated hydrocarbon soil insecticide residues remain for years and effectively eliminate many soil-surface predators including Formicidae species. Groves without ant populations were characterized by nocturnal predation by dense populations of the striped earwigs. This unique condition was observed in 4 of 78 surveyed citrus groves in central Florida. Without the various ant species common to the citrus grove soil surface, large populations of striped earwigs become the dominant arthropod predator.

End Note

This is Florida Agricultural Experiments Station Journal Series No. 3402.

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OVIPOSITION OF THE PAPAYA FRUIT FLY *TOXOTRYPANA CURVICAUDA* GERSTAECKER AS AFFECTED BY FRUIT MATURITY

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ABSTRACT

A scale for assessing damage to papaya fruit by the papaya fruit fly *Toxotrypana curvicauda* Gerstaecker was used in the field to help detect egg and larval infestation. There were more eggs in green fruits than in ripe fruit, whereas more larvae were found in ripe fruit than in green fruit. Under laboratory conditions, papaya fruit fly preferred to oviposit in green papayas than in ripe fruit. In an experiment of the choice type, papaya fruit flies showed strong preference for oviposition in green wax domes than in yellow wax domes. The color preference of papaya fruit fly females was confirmed.

RESUMEN

Se utilizó en el campo una escala para evaluar el daño a la papaya por la mosca de la papaya, *Toxotrypana curvicauda* Gerstaecker para ayudar a detectar infestaciones de huevos y de larvas. Se encontró una mayor cantidad de huevos en los frutos verdes que en los frutos maduros, mientras que más larvas se encontraron en frutos maduros que en frutos verdes. Bajo condiciones de laboratorio, moscas de la papaya prefirieron poner los huevos en papayas verdes que en frutos maduros. En un experimento donde las moscas de la papaya podían escoger, ellas demostraron preferencia para poner los huevos en cúpulas de cera verde que en cúpulas de cera amarilla. Se confirmó el color preferido de la mosca de la papaya.

The papaya fruit fly (PFF) *Toxotrypana curvicauda* Gerstaecker almost exclusively uses the papaya *Carica papaya* L. (Knab & Yothers 1914) and occasionally fruit of mango *Mangifera indica* L. (Butcher 1952) as hosts. *Toxotrypana* occurs only in tropical America (Wolcott 1933) and in south Florida (Knab & Yothers 1914). Some cosmopolitan fruit flies, e.g., *Dacus dorsalis* Hendel, *D. cucurbitaceae* Coquillet and *Ceratitis capitata* (Weideman) also attack papaya in other tropical areas in the world (Seo et al. 1983) but generally they prefer ripe papayas.

Premature fruit maturity and fruit latex exudations have both been related to papaya fruit fly infestation (Knab & Yothers 1914). These plant reactions, however, could have been caused by other insects (Sloan 1946) or by pesticides (Sherman & Tanashiro 1959).

Stimuli eliciting the ovipositional response of PFF to its host are unknown. The PFF has been observed to oviposit in blossom buds and in a wide range of papaya fruits, 1.5 cm diam green fruit to 15 cm-diameter fruit that is almost completely ripe (Landolt & Hendrichs 1983) and undergoing a change in color from green to yellow. Factors such as fruit ripeness and color may play a role in the selection of fruits for oviposition.

In this study 3 aspects of the relationship between *T. curvicauda* and the papaya fruit have been considered:

(1) Are effects of PFF oviposition or larval activity precise measures of PFF population?

(2) To what extent do females discriminate between fruits with different degrees of ripeness?

(3) Does color affect oviposition?

Materials and Methods

Field Study

Visual observations of the possible effects of PFF infestations were made on 70 fruits collected from an insecticide-free commercial papaya planting (var. Cariflora) at Homestead, Florida, during August 1984. A visual classification of damaged and undamaged fruits was made. A grade scale of 0-6 was devised, based on personal observations and damage description by Mason (1922) and Knab and Yothers (1914) (Table 1). A RxC test of independence (Sokal & Rohlf 1969) was used to examine whether the percentages of fruits with eggs and larvae were independent of the papaya grade scale.

Laboratory Study

Papaya fruit flies used in color preference tests were obtained from a colony maintained in the laboratory at ca. 27°C under fluorescent lights that provided a photoperiod of LD 12:12. The colony was initiated with larvae that were collected in the field and which pupated in vermiculite. Adults were kept in screen cages (16.5 × 33 × 37 cm) and were provided with water (65 ml), sucrose (5.8 g) and honey. The effect of the degree of ripeness of papaya fruit on PFF ovipositional preference was studied. The ripeness of immature green, quarter-color, half-color, and ripe papayas was determined visually using the Nickerson Color Fan®. Fifteen females were exposed in each cage

TABLE 1. Classification of damaged and undamaged papaya fruits, var. Cariflora, based on field observations Homestead, Florida 1985.

Scale	Fruit description
0 =	Immature, green with no external symptoms of latex flow.
1 =	Immature, green, and with fresh latex flowing from the fruits, indicative of recent PFF oviposition.
2 =	Immature, green, and with dark-coagulated latex on the fruit, indicative of past PFF oviposition.
3 =	Fruit showing premature 1/4 color break, but firmly attached to the peduncle.
4 =	Fruit showing premature 1/4 color break, easily detached from peduncle, indicative of larval infestation.
5 =	Fruit showing 1/2 color break, firmly attached to the peduncle.
6 =	Fruit showing 1/2 color break, soft to the touch and with larval exit holes, indicative of present or past larval infestation.

(= one replicate) to the 4 different types of papaya fruits. This multiple choice experiment was replicated 8 times and conducted inside screen cages (16.5 × 22 × 37 cm). The number of perforations and eggs were recorded after 24 h. Data were analyzed by ANOVA and the means were separated by Duncan's Multiple Range Test. Later, an experiment of the multiple-choice type to determine PFF color preference was conducted inside screen cages. Oviposition substrates consisted of wax domes 7 cm in diameter and 3.5 cm high. To obtain domes of different hues that represented the colors of papaya fruit, green and yellow paraffin wax and petroleum jelly were mixed. Reflectance spectra of green and yellow colors were measured using the Nickerson Color Fan®. The color values were dark yellowish green = 10 GY 4/5, strong yellow green = 2.5 GY 6/8, strong greenish yellow = 7.5 Y 7/9, and strong orange yellow = 10 YR 7/10. Ten 6 day old females per cage (= one replicate) were tested. The experiment was replicated 6 times. The main criterion used for determining oviposition preference was the number of eggs that were laid in the dome. Counts of eggs were made daily and the positions of the domes in the cages were re-randomized daily. For the analysis of egg count data, analysis of variance was used and the means were separated by Duncan's Multiple Range Test at the P = 0.05 significance level.

Results

Field Study

The grade-scale study provided information on PFF oviposition and larval infestation of papaya fruit. Frequency of eggs and larvae in papaya fruit (Table 2) were dependent ($P < 0.05$) on the fruit grade scale. More eggs (Mean ± SE = 2.70 ± 1.87 and 2.04 ± 1.05; X^2 .005 [6] = 18.548) were obtained from fruit grades 1 and 2 than from any other types of fruit (0.0 ± 0.0). More larvae ($P < 0.05$; X^2 .005, [6] = 18.548 were obtained from 3, 4, 6, 2 and 1 grade-type fruit than from 0 or 5th grade. By using this grade scale, it was possible to partially determine egg and larval infestation in the field. The grade scale could be developed into a tool to help scouts select fruits with the best chance of containing PFF eggs or larvae.

Laboratory Study

The results of this multiple choice test (Table 3) demonstrated that females responded positively (P = 0.05) to a certain degree of fruit development, especially to

TABLE 2. Relationship between *Toxotrypana* eggs and larvae to different degrees of papaya ripeness and insect damage.

Grade scale	Mean eggs ± SE[a]	% fruit with eggs	Mean larvae ± SE[b]	% fruits with larvae
0	0.0 ±0.0	0	0.0 ±0.0	0
1	2.70±1.87	29	0.72±0.41	21
2	2.04±1.05	18	4.80±1.29	52
3	0.0 ±0.0	0	8.75±1.21	100
4	0.0 ±0.0	0	14.88±1.05	100
5	0.0 ±0.0	0	0.0 ±0.0	0
6	0.0 ±0.0	0	5.62±2.33	62

[a]X^2 .005 6 = 18.548; g—value (X^2 = 22.25) was significant at $P < 0.005$.
[b]X^2 .00t, 6 = 19.548; g—value (X^2 43.43) was significant at $P < 0.005$.

TABLE 3. OVIPOSITION OF *TOXOTRYPANA CURVICAUDA* FEMALES ON PAPAYA FRUITS WITH DIFFERENT DEGREES OF RIPENESS UNDER LABORATORY CONDITIONS (27±1°C; 75% R.H.).

Fruit characteristic	No. of perforations/ fruit[a]	Mean no. eggs/fruit	% total eggs
Immature green	10.5 a	55.0 a	68
Quarter color	3.3 b	3.81 b	5
Half color	5.4 b	9.45 b	12
Ripe	2.3 b	12.45 b	15

[a]Numbers followed by a different letter were significantly different at the P = 0.05 level.

TABLE 4. EFFECT OF GREEN AND YELLOW COLORS ON OVIPOSITION BY *T. CURVICAUDA* INTO PARAFFIN DOMES.

Color of dome	Avg. no. of eggs[a]	% of total
dark green	15 a	47
yellow green	6 b	18
greenish yellow	4 b	13
orange yellow	7 b	22

[a]Numbers followed by a different letter were significantly different at the P = 0.05 level.

immature dark green, and less to quarter color and ripe fruit. This behavior indicates that physical characteristics such as fruit color may be important for the selection of the oviposition site. Because changes in the chemical properties of ripening papaya fruit may also have an equally important effect on ovipositional behavior, the response of PFF females to color alone was determined.

The results (Table 4) demonstrated a strong color preference of the papaya fruit fly. About 46% of the eggs were laid in the dark green domes, followed by yellow green domes (18%) and orange-yellow domes (22%), and less for greenish yellow domes (13%). For example, the mean number of eggs laid in dark green domes was 15 (P = 0.05) compared to mean numbers of 6, 4 and 7 eggs laid in the other domes. The strong preference for the dark green domes indicated that this color constitutes a strong stimulus to the fruit-seeking papaya fruit fly females.

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THRIPS IN AND AROUND THE COCONUT PLANTATIONS IN JAMAICA, WITH A FEW TAXONOMICAL NOTES (THYSANOPTERA)

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ABSTRACT

In and around the coconut plantations in Jamaica, 107 species of thrips were collected or caught by sticky traps. Prior to this collection, thrips recorded from the island were highly limited. Species repeatedly collected from coconuts were *Franklinella bruneri* Watson, *F. kelliae* Sakimura, and *F. insularis* (Franklin) (flower feeders); *Anisopilothrips venustulus* (Priesner) and *Heliothrips haemorrhoidalis* (Bouché) (fruit feeders); *Hoplandrothrips flavipes* Bagnall (fungal growth feeder); and *Karnyothrips merrilli* (Watson) (predator). Of every species enumerated, their extra distributions within the Caribbean areas were searched through the published data as well as accumulated holdings in museum collections. Twenty-two species of *Frankliniella* were collected, and a key to them is provided. Two new synonymies are designated, and a species is partly redescribed.

RESUMEN

Dentro y alrededor de plantaciones de cocos en Jamaica, 107 especies de "thrips" fueron colectadas o atrapadas en trampas pegajosas. Anteriormente a esta colección, el registro de "thrips" de la isla era muy limitado. Especies repetidamente colectadas en cocos eran *Frankliniella bruneri* Watson, *F. kellia* Sakimura, y *F. insularis* (comedores de flores); *Anisopilothrips venustulus* (Priesner) y *Heliothrips haemorrhoidalis* (Bouche) (comedores de frutas); *Hoplandrothrips flavipis* Bagnall (comedores de hongos); y *Karnyothrip merrilli* (Watson) (depredador). De cada especie enumerada, su distribución extra dentro del área del Caribe fue indagada a traves de datos publicados,

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lo mismo que en materiales acumulados en colecciones de los museos. Se colectaron y se provee una clave para 22 especies de *Frankiniella*. Se designaron 2 nuevos sinónimos y una especie es parcialmente redescrita.

A thrips survey in and around the coconut plantations in Jamaica was conducted in the whole month of November 1964, upon request of a FAO project on searches among thrips for possible vector species of the lethal yellowing disease of coconut. About 15 years subsequent to that date, the disease was conclusively demonstrated to be transmitted by *Myndus crudus* Van Duzee (Homoptera: Cixiidae) (Howard et al. 1983). Thrips specimens were collected from weedy undergrowth, coconuts, and other trees and shrubs intermixed within the coconut plantations as well as in the surrounding areas. Thrips specimens caught by sticky traps, hung among coconut foliage in every plantation visited were examined also. The plantations visited were aligned along the north shore of the island from Buff Bay to Negril (Table 1). Supplemental but extensive general collections were made also in the vicinity of Kingston on the south shore (Table 1). The few specimens previously collected by T. H. Farr, Institute of Jamaica were examined also. Total numbers of specimen lots were 430 (Acc. No. 4208-48, 4301-4579 and other long non-numbered series), and the number of species recognized was 107. Names of host plants were provided by the Botany Department, University of the West Indies.

The Caribbean fauna of Thysanoptera has long been poorly known, and the only faunistic work published is the one of Puerto Rico (Medina Gaud 1961) enumerating 78 species. However, over the years since about 1910 many new species have been described from the Caribbean areas, and numerous specimens from various islands and shore countries have been accumulated in some museum collections, particularly at the United Stated National Museum of Natural History (USNMNH).

This survey fairly well covers the lowland species but is deficient for the highland indigenous species, since the few cursory collections made at Hardwar Gap (4000') were all that had been done over the extensive forested highland. The number of species previously recorded from Jamaica was 16 prior to this survey made in 1964, but it increased to 28 by the time of this writing in 1985. Among those previously recorded, the following 6 species, 3 of them being highland species, were not collected during this survey: *Arachisothrips millsi* Stannard, *Kurtomathrips morrelli* Moulton, *Eurythrips*

TABLE 1. LOCALITIES WHERE COLLECTIONS WERE MADE, WITH RAINFALL DATA.

Coconut Plantation Areas (on north shore):
- Buff Bay Area (annual rainfalls: about 100″; 22″ during Oct.-Nov. 1964 at Buff Bay):
  - Woodstock, Kildare, White River, Buff Bay River Estate, Orange Vale, Buff Bay, Silverstock, Benzenn, Dover, and Gray's Inn.
- Montego Bay Area (annual rainfalls: about 50 ″; 9″ during Oct.-Nov. 1964 at Montego Bay):
  - Bengal, Bryan Castle, Hague, Braco, and Falmouth (east of Montego Bay).
  - Barnett, Montego Bay, and Irwin (vicinity of Montego Bay).
  - Round Hill, Hill Top, and Negril (west of Montego Bay).

Non-coconut Plantation Areas (On south shore):
- Kingston and Vicinity (annual rainfalls: about 50″, higher on highland and lower on coastal strip; 7″ during Oct.-Nov. 1964 at Kingston):
  - Kingston, Hope Garden, Palisadoes, Hardwar Gap, Bodles, and Barnard Lodge.

batesi (Watson), *Orthothrips bilineatus* Stannard, *Plectothrips pallipes* Hood, and *Trisclerothrips hurricaneus* Stannard. In the following enumeration of the species, 20 species are incomplete in determination to the species level. Many of them are believed to be undescribed species. All such material will be available for any specialist who may be interested in it. A set of all the species will be deposited in the USNMNH collection and others.

For every species to be enumerated later, 1) brief taxonomical remarks, if any; 2) abbreviated remarks on host range and population status; and 3) extra distribution data within the Caribbean area that are all based on the published data and accumulated holdings in museum collections are given. The details on locality, date, host, numerical data on collected specimens, accession number, and the collector's name are all omitted, except in a few cases where such complete data are considered significant for future references. Most of the collections were made by the author, except all the sticky trap material that was collected by the late Walter Carter or Randall Latta of the FAO project. Numbers in parentheses in the enumeration of species are the author's accession numbers.

Nomenclatural Changes Proposed in this Paper

Ceratothripoides funestus (Hood, 1915:24) (= *Taeniothrips martorellorum* Medina, 1961:48), Syn. N. See p. 351.

Holopothrips fulvus Morgan, 1929:6 (= *Holopothrips anacardii* Hood, 1942:581), Syn. N. See p. 357.

Enumeration of the Species

Suborder Terebrantia

Family Aeolothripidae

Franklinothrips vespiformis (Crawford, 1909): Frequent on various plants everywhere, particularly in the wet Buff Bay area; predacious on other thrips. Known from Brazil (Para), Surinam, Trinidad, Grenada, Barbados, St. Vincent, Martinique, Dominica, Guadeloupe, Antigua, St. Thomas, Puerto Rico, Dominican Republic, Cuba, Jamaica, Florida, Texas, Mexico, Guatemala, Honduras, Nicaragua, Panama, Colombia, and Venezuela. *F. tenuicornis* Hood was not collected during this survey.

Family Heterothripidae

Heterothrips borinquen Hood, 1915: 1♀, Irwin, *Eupatorium villosum* (4429). Known only from Puerto Rico.

Family Thripidae

Anisopilothrips venustulus (Priesner, 1923): Frequent on *Cyathula prostrata* and young coconut fruits (found breeding there) in the wet Buff Bay area. Known from Surinam, Trinidad, Grenada, Guadeloupe, Puerto Rico, Dominican Republic, Bermuda, Jamaica, and Florida.

Aptinothripine sp. (C): Differs from *Baileyothrips* by head and pronotum striate and targal seta pair i far apart from each other. 7♀♀, Barnett, *Desmodium* sp. (4439a).

Aptinothripine sp. (D): Differs from *Chaetanaphothrips* by antennal I-III uniquely modified, mouth cone pointed, and tergite VIII without stippled areas. 1♂, Round Hill (Hill Top), *Mimosa pudica* (4484c).

Baileyothrips limbatus (Hood, 1935): 1♀, Woodstock, *Desmodium* sp. (4335b). Known from Panama. *B. arizonensis* is not synonymous.

Bregmatothrips gracilis Hood and Williams, 1915: 1♀, Woodstock, *Commelina diffusa* (4306b). Known from Trinidad, Patos Isle, Cuba, Jamaica, Florida, Georgia, and Louisiana.

Caliothrips insularis (Hood, 1927): Abundant and frequent on *Seteria palmifolia*. Known from Trinidad, Tobago, Grenada, Martinique, St. Croix, Puerto Rico, Cuba, Jamaica, Mexico, Panama, and Venezuela.

Caliothrips phaseoli (Hood, 1912): Abundant or frequent on *Colocasia esculenta* and *Ricinus communis*, and occasionally on some leguminous plants; caught by sticky traps. Known from Brazil (Para), Tobago, Dominica, Puerto Rico, Cuba, Florida, Texas, Mexico, Panama, and Colombia.

Ceratothripoides funestus (Hood, 1915) (= *Taeniothrips martorellorum* Medina, 1961, New Synonymy): The type was examined. Abundant on *Spigelia anthelmia*, and occasionally on some other plants in the wet Buff Bay area; caught by sticky traps. Known from Trinidad, Puerto Rico, Texas, and Mexico (Tobasco).

Chaetanaphothrips orchidii (Moulton, 1907): Frequent on *Cyathula prostrata;* once from young coconut fruit. Known from Trinidad, Guadeloupe, Puerto Rico, Florida, Louisiana, Mexico, Honduras, Costa Rica, and Panama.

Chaetisothrips striatus caribeanus Sakimura, 1969: 2♀♀, Montego Bay and Negril; *Porana paniculata*, sticky trap (4498a, 4500b). Known from Puerto Rico, Cuba, Mexico, and Honduras.

Chirothrips mexicanus Crawford, 1909: From *Eleusine indica;* caught by sticky traps. Known from Martinique, Antigua, St. Thomas, Puerto Rico, Dominican Republic, Cuba, Grand Cayman, Florida, Mississippi, Texas, Mexico, Costa Rica, Panama, and Colombia.

Chirothrips texanus Andre, 1939: From several grasses, fairly frequent in the drier areas; caught by sticky traps. Known from Georgia, Louisiana, Texas, and Mexico. Apparently the first collection from any of the Caribbean islands.

Corynothrips stenopterus Williams, 1913: 1♀, Woodstock, sticky trap (4573A). Known from Brazil (Para), Surinam, Guyana, Trinidad, Tobago, Grenada, St. Vincent, Barbados, Puerto Rico, Costa Rica, and Panama.

Dendrothripoides innoxius (Karny, 1914) (= *D. ipomeae* Bagnall): From *Ipomoea fistulosa* and a few other plants. Known from Trinidad, Grenada, Barbados, Guadeloupe, St. Croix, Dominican Republic, and Panama.

Dinurothrips hookeri Hood, 1913: Abundant on *Leonotis nepetifolia*, and also from *Cyathula prostrata* in the wet Buff Bay area. Known from Trinidad, Grenada, St. Lucia, Guadeloupe, Puerto Rico, Cuba, Jamaica, Florida, and Panama.

Echinothrips caribeanus Hood, 1955: Abundant or frequent on *Psophocarpus palustris* and *Cyathula prostrata* in the wet Buff Bay area. Known from Trinidad, St. Vincent, Martinique, Guadeloupe, Puerto Rico, and Panama.

Frankliniella spp.: Speciation of the flower-feeding genus *Frankliniella* apparently is centered in the Caribbean and Central American region from where more than 65 species have been described, and many more may be discovered in the future. In Jamaica, 22 species were collected during this survey, and they are the most abundant thrips there. Many species of this genus are poorly characterized and difficult to identify. The following key may serve for recognizing the Jamaican species. This key includes the 3 species that are to be described in another papaer now under preparation, but not the 4 others that belong to the different subdivisions of the genus.

Abbreviations for the names of setae used in the following key: aa: Anteroangular pronotal seta. am: Anteromarginal pronotal seta. io: Interocellar seta. IXi,ii, iii and Xi, ii: Major setae on abdominal IX and X, numbered outwardly from the meson. IXd:

Discal seta on abdominal IX. pai, ii: Posteroangular pronotal setae, numbered outwardly from the meson. pmii: Posteromarginal pronotal seta, second from the meson. po: Principal postocular seta, largest and usually 4th in the series from the meson, directed posterolaterally. In comparing lengths of 2 setae, the minimal visually recognizable differential usually is about 15% of the longer seta. In determining the slenderness of antennal style, numerical index used is a value of the combined length of VII and VIII including interspace that is divided by the basal width of VII. For details and explanatory illustrations, see Sakimura and O'Neill (1979).

KEY TO THE JAMAICAN SPECIES OF *FRANKLINIELLA*

1. Both io and po minute or nearly so and also both am and aa minute to subminute or rarely somewhat larger (*Minuta* group). Antenna 7-segmented, abdominal IX with all major setae shorter than X ..... *jamaicensis* Sakimura & O'Neill
   Those setae all developed or only po rarely subminute to small ..... (2)
2. Antennal III with pedicel simple and not dilated (Fig. 1) (*Intonsa* group) .. (3)
   Antennal III with pedicel variously dilated (Fig. 2-6) (*Tritici* group) ..... (11)
3. Brown to dark brown body ..... (4)
   Pale to yellow body ..... (6)
4. Mid and hind tibiae dark brown; am decidedly smaller than aa. Abdominal VIII with comb incomplete and short, X shorter than IX (0.8 times of IX). Male colored same as female ..... *insularis* (Franklin)
   Mid and hind tibiae totally or partly yellow; am subequal to aa in length ... (5)
5. Mid and hind tibiae totally yellow; abdominal VIII with comb nearly complete and very short, X as long as IX. Male yellow with brown head... ..... *citripes* Hood
   Hind tibia with distal half dark grayish brown; abdominal VIII with comb complete and moderately long, X longer than IX (1.2 times of IX). Male uniformly yellow ..... *varipes* Moulton
6. Yellow abdomen with grayish brown shadings and blotches along antecostae; io between posterior ocelli; antennal VI with linear attachment bases of both major sense cones. Pronotal am decidedly smaller than aa; abdominal VIII with comb incomplete and short ..... *schultzei* (Trybom) (pale form)
   Yellow abdomen without grayish brown shadings and blotches; io before posterior ocelli; antennal VI with circular attachment bases of sense cones. ..... (7)
7. Cephalic po nearly subminute (less than 20 μm long). Antennal III with a pair of ordinary dorsal setae; mouth cone long and slender; am smaller than aa ..... *exigua* Hood
   Cephalic po well developed (more than 30 μm) ..... (8)
8. Antennal III with a pair of ordinary dorsal setae (about 0.6 of the segment length) and ordinary sense cone. Antennal style stout (VII + VIII/VIIw: 2.6-2.9); head transverse (1.4 times as wide as long); abdominal VIII with comb complete but short ..... *bruneri* Watson
   Antennal III with a pair of fully developed long dorsal setae (0.75-0.90 of the segment length) and unusually long sense cone ..... (9)
9. Antennal style fairly stout (VII + VIII/VIIw: 3.3-3.6); head subtransverse (1.3 times as wide as long). Mouth cone very bulky ..... Sp. F
   Antennal style very slender (VII + VIII/VIIw: 4.4 - 4.5); head subquadrate (1.2 times as wide as long) ..... (10)

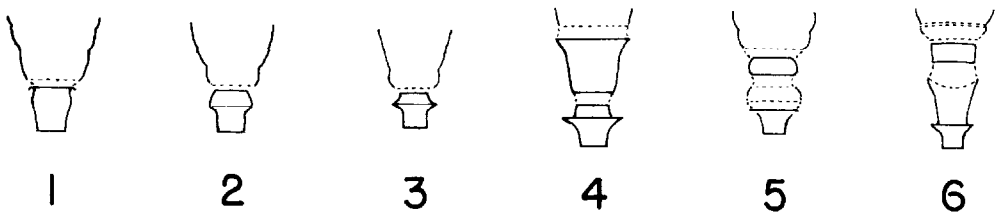

Fig. 1-6. Pedicels of antennal III of various *Frankliniella* spp.: 1, Simple undilated form (Minuta and Intonsa groups); 2-6, Dilated forms (Tritici group): 2, Mushroom form (Tritici subgroup); 3, Angulate ring form (Cubensis subgroup); 4, Cup and saucer form (Cephalica subgroup); 5-6, Miscellaneous forms (Miscellaneous subgroup): 5, *F. brevicaulis*; 6, *F. parvula.*

10. Mouth cone moderately long, subvertically directed, strongly recurved, bulky (often strongly twisted to a side in mounted specimens); abdominal VIII with comb very long (up to 15 μm) ..... Sp. P
    Mouth cone very long, subvertically directed, straight and tapered; abdominal VIII with comb short (6-8 μm) ..... Sp. C
11. Antennal III with pedicel in mushroom form (*Tritici* subgroup)(Fig. 2) ..... (12)
    Pedicel in angulate ring form (*Cubensis* subgroup)(Fig. 3) ..... (15)
    Pedicel in cup and saucer form (*Cephalica* subgroup)(Fig. 4) ..... (16)
    Pedicel in specific unique forms (Miscellaneous subgroup)(Fig. 5-6) ..... (17)
12. Pronotal am decidedly smaller than aa. Abdominal VIII with comb incomplete and very short ..... (13)
    Pronotal am subequal to aa. Yellow body without any brownish shadings, head transverse (1.4 times as wide as long), abdominal VIII with comb complete but very short ..... (14)
13. Grayish brown body with subtransverse head (1.3 times as wide as long); antennal III 2.4 times as long as wide ..... *salviae* Moulton
    Yellowish body with transverse head (1.4 times as wide as long); antennal III 2.8-2.9 times as long as wide (Not yet collected in Jamaica) .....
    ..... *tritici* (Fitch)(pale form)
14. Ocellar crescent brownish. Male: abdominal IXd long thick seta, VIII with no comb ..... *kelliae* Sakimura
    Ocellar crescent bright red. Male: abdominal IXd short thorn, VIII with comb complete but short (Not yet collected in Jamaica). ..... *difficilis* Hood
15. Pronotal am decidedly smaller than aa; po small (about 18 μm); abdominal VIII with comb nearly absent; yellow body with very weak grayish brown shading throughout; antennal II dark to grayish brown ..... *breviseta* Moulton
    Pronotal am subequal to aa; po well developed (about 31 μm); abdominal VIII with comb complete and long; yellow body without any grayish brown shading; antennal II pale to brownish yellow ..... *cubensis* Hood
16. Antennal II dorsoapically elevated strongly, and produced variably from slight to as much as about a half of the ventral segment length, always with a pair of strongly thickened blackish thorn-like setae at its apex. Yellow body usually with grayish brown median blotches on abdomen .
    ..... *cephalica* (Crawford)
    Antennal II dorsoapically elevated weakly but not produced at all, always with a pair of ordinary thin setae at its apex (in male apical setae slightly

thicker than that of female, but far thinner than that of *cephalica*). Abdomen without any grayish brown blotches ..... *borinquen* Hood

17. Antennal III with pedicel as illustrated (Fig. 5), III about 2.7 times as long as wide; io outside of ocellar triangle. Brown body with dark brown abdomen and all tibiae yellow ..... *brevicaulis* Hood
Antennal III with pedicel as illustrated (Fig. 6). III about 3.5 times as long as wide; io inside of ocellar triangle. Body color as in *brevicaulis;* male yellow with broad median grayish brown blotches on abdomen.... ..... *parvula* Hood

Frankliniella borinquen Hood, 1942: Abundant or frequent on *Allamanda cathartica, Hibiscus tiliaceus,* and *Poinciana pulcherrima;* also on many other plants in the drier surroundings, particularly in Kingston area; also rarely caught by sticky traps. Known from Puerto Rico and Mexico.

Frankliniella brevicaulis Hood, 1937: 2 ♀♀, 1♂, Hope Garden, *Bauhinia purpurea* (4410b). Known from Trinidad, Cuba, Panama, and Venezuela.

Frankliniella breviseta Moulton, 1948: From *Viola* sp. at Hardwar Gap (4000′); occasionally caught by sticky traps in the wet Buff Bay area. Known from Trinidad, Martinique, Cuba, and Florida.

Frankliniella bruneri Watson, 1926: The most common and abundant *Frankliniella* sp. throughout Jamaica when this survey was conducted, particularly in the wetter surroundings. Frequently and abundantly caught by sticky traps, and frequent on coconut inflorescence; abundant or frequent on *Gliricidia sepium, Malvaviscus arboreus, Taraxacum officinale,* and *Terminalis catappa;* also on many other plants. Known from Cuba, southern Texas, and throughout Mexico along the Gulf coast.

Frankliniella cephalica (Crawford, 1910): *F. melanommata* Williams is not synonymous. One of the common *Frankliniella* spp. in Jamaica. Abundant or frequent on *Agave sisalana, Bidens pilosa,* and *Tribulus cistoides,* and also on many other plants; often caught by sticky traps; more abundant in the wet Buff Bay area. Known from Trinidad, St. Vincent, Barbados, St. Lucia, Dominica, St. Croix, St. Thomas, Puerto Rico, Cuba, Florida, Alabama, Mississippi, Texas, Mexico, Panama and Colombia.

Frankliniella citripes Hood, 1916: 1♀, Bryan Castle, *Eupatorium odoratum* (4449b); also caught by sticky traps in the wet Buff Bay area. Known from Puerto Rico and Cuba.

Frankliniella cubensis Hood, 1925: Abundant on *Gouania lupuloides,* and also some other plants in Kingston area; often caught by sticky traps in Buff Bay area. Known from St. Croix, Puerto Rico, Haiti, Cuba, Florida, Mexico, Guatemala, and Panama.

Frankliniella sp. (C): To be described in another paper now under preparation. From *Desmodium* sp. and a few others in both Buff Bay and Montego Bay areas (4398Ad, 4348, 4388, 4433c, 4492).

Frankliniella exigua Hood, 1925: From *Eupatorium odoratum* and others all in the dry Montego Bay area (4449d, 4454c, 4463b, 4487c). Known from Georgia, Florida, Mississippi, Texas, and northeastern Mexico. First collection from any of the Caribbean islands.

Frankliniella sp. (EEE): Differs in male form from *F. citripes* by body uniformly grayish brown, mid and hind femora grayish brown, scale brown in basal portion, and tergite IX with discal seta fully developed. Apparently similar males from Brazil (Para) and Mexico remain unnamed in the USNM collection. 1♂, Hope Garden, *Rosa* sp. (4417b). Excluded in the key.

Frankliniella sp. (F): To be described in another paper now under preparation. *Acalypha hispida,* Hope Garden (4413).

Frankliniella sp. (G): Differs from *F. terminalis* and *bicolor* by stouter antenna, pronotal chaetotaxy, and incomplete comb of tergite VIII. 1♀, Hope Garden, *Lantana camara* (4414c). Excluded in the key.

Frankliniella insularis (Franklin, 1908) (= *F. fortissima* Priesner, 1925): Extremely variable in its body size, and also variable in color and size of antennal IV-V. One of the common *Frankliniella* spp. in Jamaica. Abundant or frequent on *Cajanus cajan, Canavalia maritima, Gliricidia sepium, Hibiscus rosa-sinensis,* and *Malvaviscus arboreus;* and also on many others everywhere; often and on occasions abundantly caught by sticky traps, but only occasionally collected from coconut inflorescence in Buff Bay area. Known throughout the Caribbean areas.

Frankliniella jamaicensis Sakimura and O'Neill, 1979: From *Eupatorium villosum,* Round Hill (Hill Top) (4487d); once caught by sticky trap at Woodstock. Known also from Cuba.

Frankliniella kelliae Sakimura, 1981: Had long been confused in Jamaica with *F. dificilis* which was not collected during the present survey. One of the common *Frankliniella* spp. there. Abundant or frequent on *Bauhinia purpurea, Caesalpinia coriaria, Calophyllum inophyllum, Cassia siamea,* and *Tithonia diversifolia;* and also many others; often and on occasions abundantly caught by sticky traps, and also often collected among coconut inflorescence; more abundant in the dry Montego Bay and Kingston areas. Known from Puerto Rico, Dominican Republic, Bahamas, Cuba, Jamaica, and Florida.

Frankliniella sp. (O): Differs from *F. deserticola* by color of antennal II-V, extremely slender antennal III, and tergite X 0.65 times as long as IX. 1♀, Hardwar Gap, 4000′, *Viola* sp. (4513a). This specimen is incomplete. Before being named, complete specimens are needed. Excluded in the key.

Frankliniella parvula Hood, 1925: Apparently monophagous and abundant on *Musa* spp. in dry as well as wet areas; also caught by sticky traps. Known from Trinidad, Grenada, St. Lucia, Puerto Rico, Dominican Republic, Jamaica, Mexico, Guatemala, Honduras, Costa Rica, Panama, and Colombia.

Frankliniella sp. (P): To be described in another paper now under preparation. 2♀♀, Orange Vale, *Cassia occidentalis* (4324a); also often caught by sticky traps in the wet Buff Bay area.

Frankliniella salviae Moulton, 1948: 1♀, Woodstock, *Synedrella nodiflora* (4303a). Known only from Mexico.

Frankliniella schultzei (Trybom, 1910) (pale form): From *Cajanus cajan, Ipomoea pes-caprae, Kallstroemia maxima,* and *Plumbago capensis* in the dry Kingston area only. This pantropic species was observed elsewhere also preferring dry surroundings. Known from St. Thomas, Puerto Rico, Dominican Republic, Jamaica, Florida, and Colombia. Only the Colombian specimens are dark form.

Frankliniella varipes Moulton, 1933: Abundant on *Lantana camara* (4374a, 4480a); often caught by sticky traps in the wet Buff Bay area. Known from southern Brazil and Peru. The first collection from the Caribbean area.

Frankliniella sp. (X): Differs from *F. kelliae* by anteromarginal pronotal seta larger than anteroangular seta, and unusually large interocellar seta and posteromarginal pronotal seta ii. 1♀, Hope Garden, *Bauhinia purpurea* (4410f). Excluded in the key.

Heliothrips haemorrhoidalis (Bouché, 1833): Frequent or on occasions abundant on coconut fruits (often found breeding) and occasionally caught by sticky traps in Buff Bay and Montego Bay areas; also from some other plants. Known from Brazil (Para), Surinam, Guyana, Trinidad, Grenada, Barbados, St. Lucia, Martinique, Dominica, Guadeloupe, Puerto Rico, Cuba, Jamaica, Florida, Alabama, Mexico, Honduras, Panama, and Colombia.

Hercinothrips femoralis (Reuter, 1891): From coconut fruit and *Emilia javanica*. Known from Martinique, Bermuda, Puerto Rico, Cuba, Florida, Georgia, Texas, and Mexico.

Leucothrips theobromae (Priesner, 1923): From *Clerodendrum speciosissimum*, *Phaseolus lunatus*, and *Stachytarpheta jamaicensis* in the wet Buff Bay area. Known from Surinam, Panama, and Colombia.

Microcephalothrips abdominalis (Crawford, 1910): From some composite plants in both wet Buff Bay and dry Montego Bay areas; occasionally caught by sticky traps. Known from Trinidad, Martinique, Bermuda, Puerto Rico, Cuba, Jamaica, Florida, Louisiana, Texas, Mexico, Guatemala, Costa Rica, and Panama.

Plesiothrips perplexus (Beach, 1896): From grass sweepings and others. Known from Guyana, Trinidad, Tobago, Antigua, Puerto Rico, Dominican Republic, Cuba, Florida, Texas, Panama, and Venezuela.

Psectrothrips interruptus (Hood, 1957) (= *Pseudothrips*): The present of a median split on tergite X was considered as a minor local peculiarity. 4♀♀, 6♂♂, Woodstock, sticky traps (4553f, 4556b, 4557, 4559d, 4564e). Known from Panama. An unnamed allied species from Barro Colorado Island, Panama (Zetek 5178) in the USNM collection was found not conspecific with this Jamaican species.

Rhamphothrips pandens Sakimura, 1983: From *Cassia siamea*, *Gouania lupuloides*, *Lantana camara*, *Pithecellobium dulce*, and sticky traps in the wet Buff Bay and the dry Montego Bay and Kingston areas. Known from Florida.

Salpingothrips minimus Hood, 1935: 1♂, Round Hill, *Desmodium* sp. (4475Ab). Known from Panama.

Scirtothrips sp.: Differs from *S. manihoti* and *mutistriatus* by wider frontal costa, hind vein of fore wing with 3 to 4 setae, and male with a prominent pair of drepana. 6♀♀, 1♂, Woodstock, *Coccoloba uvifera* (4365c).

Selenothrips rubrocinctus (Giard, 1901): Abundant on several trees including *Anacardium occidentale*, *Malpighia punicifolia*, *Mangifera indica*, and *Pimenta dioica*, and also on many other plants in both Buff Bay and Kingston areas; occasionally caught by sticky traps. Known throughout the Caribbean areas (collected in Jamaica as early as 1921 at Hill Garden).

Sericothrips burungae Hood, 1935: 4♀♀, Round Hill, *Eupatorium odoratum* (4479a). Known from Panama.

Sericothrips flavicollis Hood, 1954: 1♀, Kildare, *Sida* sp. (4326a). Known from southern Brazil; apparently the first collection from the Caribbean area.

Sericothrips geminus Hood, 1935: 9♀♀, 6♂♂, Hope Garden, *Cajanus cajan* (4407). Known from Puerto Rico and Panama.

Sericothrips gracilipes Hood, 1924: Differs from *S. campestris* from Florida. Abundant or frequent on *Macroptilium lathyroides*, *Malvastrum* sp. and *Sida* spp. everywhere in Jamaica. Known from Jamaica (previously collected in 1970), Texas and Mexico.

Sericothrips inversus Hood, 1928: Frequent on *Desmodium* sp. and also from *Digitaria* sp. Known from Trinidad, Dominica, and Panama.

Sericothrips portoricensis Morgan, 1925: From *Psophocarpus palustris*, and 2 other plants. Known from Brazil (Para), Trinidad, St. Lucia, Guadeloupe, Puerto Rico, Cuba, and Panama.

Sericothrips tricinctus Hood, 1928: 2♀♀, Woodstock, *Psophocarpus palustris* (4313b). Known from Trinidad, Martinique, Dominica, and Guadeloupe.

Thrips hawaiiensis (Morgan, 1913): The first collection of this African-Oriental-Pacific species from the Caribbean region. 1♀, Woodstock, sticky trap (4564f). Known from Florida, Georgia, and South Carolina (all collected after 1967).

SUBORDER TUBULIFERA

Family Phlaeothripidae—Subfamily Phlaeothripinae

Adraneothrips decorus Hood, 1938: Abundant on *Sporobolus indicus;* also from coconut inflorescence; occasionally caught by sticky traps in the wet Buff Bay area. Known from Cuba, Florida, Georgia, Texas, and Mexico.

Adraneothrips sp.: Differs from *A. imbecillus* from Peru by eye ventrally elongate, tube shorter, fore wing with double fringes, and tergite IX with setae i-ii not dilated. 1♀, Orange Vale, sticky trap (4541b).

Aleurodothrips fasciapennis (Franklin, 1908): Predator upon scales. From various plants including coconut fronds. Known from Brazil (Para), Grenada, Barbados, St. Vincent, St. Lucia, Dominica, Guadeloupe, St. Croix, Bermuda, Puerto Rico, Haiti, Cuba, Jamaica, Florida, Georgia, Louisiana, Texas, Mexico, Panama, and Venezuela.

Antillothrips cingulatus (Hood, 1919) (= *A. graminatus* Stannard, 1957): From *Malvastrum* sp. and *Sida* sp. in the dry Montego Bay area. Known from Trinidad, Puerto Rico, Jamaica, Florida, and Panama.

Carathrips mediamericanus (Hood, 1933): 2♀♀, Negril, sticky traps (4501c). Known from Panama.

Eschatothrips reticulotubus (Stannard, 1953): 1♀, Hardwar Gap, 4000′, beatings (4511b). Collected earlier at this same locality in 1950.

Eurythrips modestus (Bagnall, 1917): 1♀, Woodstock, sticky trap (4553c). Known from Brazil (Para), Trinidad, St. Vincent, Cuba, and Panama.

Eurythrips tarsalis Hood, 1925: 2♀♀, 1♂, Round Hill (Hill Top), *Sporobolus indicus* (4486b). Known from Brazil (Para), Florida, Georgia, and Texas.

Eurythrips sp.: Differs from *E. longilabris* from Florida and Texas by dark antennal I-II and strongly slenderized V-VIII with lanceolate VIII, dark legs, and tube dimension. Also differs from *E. batesi* previously reported from Jamaica by all the major setae acuminated at apex. 1♀, Woodstock, sticky trap (4561a).

Haplothrips gowdeyi (Franklin, 1908): From great many weeds, grasses, and ornamentals, often abundantly or frequently on many of them; neither seen among coconut inflorescence nor caught by sticky traps. A general flower feeder. The most abundant tubuliferan thrips throughout Jamaica, except in the forested high land. Known throughout the Caribbean areas including Jamaica.

Haplothrips graminis Hood, 1912: From grasses; Woodstock, Negril (4343b, 4460). Known from Bahama, Cuba, Florida, Alabama, Texas, and Mexico.

Haplothrips sp.: Differs from *H. humilis* from Panama by head nearly as long as wide and postocular seta small and dilated. An unnamed species from Cuba (Pinar City, grass, 12.VII.1940, J. C. Bradley) in the USNMNH collection is, however, not conspecific because its praepectus, probasisternum, and pelta are more degenerated than the Jamaican species. 32♀♀, 9♂♂, Woodstock, Kildare, Negril; *Rhynchospora nervosa*, *Cyperus diffusus* (4340c, 4347, 4400b, 4464b). A common sedge feeder.

Haplothrips (Anchylothrips) sp.: Differs from *H. (A.) preeri* from Texas and Florida by pale body, head 1.4 times as long as wide, and all the major setae dilated. Determined with advice from Kellie O'Neill. 4♀♀, 4♂♂, Round Hill (Hill Top), *Sporobolus indicus* (4486c).

Holopothrips sp.: Differs from *H. fulvus* Morgan, 1929:6 (= *H. anacardii* Hood, 1942: 581, New Synonymy; both types were compared) from Brazil (Bahia) by abdominal VIII-X dark grayish brown, longer head (1.3 times as long as wide) with well developed mid-dorsal seta, tergite IX with all major setae pointed, and male sternite VIII with divided subbasal and undivided subapical transverse glandular strips. 6♀♀, 7♂♂, Woodstock, *Coccoloba uvifera* (4365a).

Holothrips lucyae (Medina 1961:117) (= *Polyphemothrips*): The type was examined; its color description is supplemented as follows: A beautiful golden yellow large species with extensive grayish brown blotches and shadings; apical extremes of mid-hind femora and entire mid-hind tibiae and tarsi hyaline; abdominal pelta hyaline but from there on gradating to deep yellow on tube; subcutaneous pigments reddish brown. Grayish brown blotches and shadings: head with small light spots at both sides of anterior ocellus and along posterolateral corner of eyes; pronotum lightly shaded; pterothorax deeply shaded except distal ⅓ of mesial area; fore femur with small spot subapically along inner margin, mid-hind femora with 2 ill-defined and broad bands at base and also next to apical hyaline band leaving the middle yellow, fore tibia and fore-mid coxae lightly shaded; abdominal II-VIII with broad cross band along fore margin with a small break at middle and distally distending along lateral margins, more extensively on VII-VIII, IX with one light spot each on both sides along hind margin, tube with clearly-defined and broad apical band. Antennal I-II pale brownish yellow, III yellowish brown with distal ½ grayish brown, IV-VIII dark grayish brown; wing pale grayish brown with darker broad band at middle and narrow band at base; ocellar crescent brownish red; major setae yellow to light brown. Both sexes concolorous, body length (mm) 2.6-2.7 (♂), 3.4-3.5 (♀), tube about 2.3 (♂), 2.6 (♀) times as long as wide at base. A species with a manuscript name by Hood (2♀♀, 1♂, Brazil, Para, 1951, J. D. Hood) in the USNMNH collection was found conspecific with *H. lucyae*. 3♀♀, Barnett, Hope Garden, Round Hill; *Lantana camara, Malvaviscus arboreus, Sporobolus indicus* (4355b, 4438, 4486d). Known from Brazil (Para) and Puerto Rico.

Holothrips phaeura (Hood, 1941) (= *Polyphemothrips*): 1♂, Irwin, dead branches (4474a). Known from Florida. Determined with advice from Kellie O'Neill.

Hoplandrothrips erythrinae Priesner, 1925: 2♀♀, Bengal, young coconut fruits fallen on ground, R. Latta (4427a). Known from Brazil (para), Surinam, Cuba, Mexico, Panama, and Colombia.

Hoplandrothrips flavipes Bagnall, 1923: Frequent among the calyxes of coconut fruits on tree or fallen on ground and coconut inflorescence; often caught by sticky traps in both the wet Buff Bay and the dry Montego Bay areas. No collection was made from any other plant. Known from Brazil (Para), Venezuela, and Colombia.

Hoplandrothrips reynei Priesner, 1923: 1♀, 1♂, Irwin, Buff Bay; dead branches, sticky trap (4472a, 4570b). Known from Brazil (Para), Trinidad, Puerto Rico, Cuba, and Panama.

Hoplandrothrips sp.: Differs from *H. pallens* Hood from Cuba by subbasal seta iii of fore wing and lateral seta of tergite VII both dilated, and seta ii of tergite IX pointed. 1♀, 2♂♂, Round Hill, Woodstock, Buff Bay; all from sticky traps (4502c, 4564g, 4565b).

Hoplothrips angusticeps (Hood, 1908): 1♀, Kildare, caught in flight in a coconut grove (4562). Known from Georgia, Florida, and Costa Rica. A common bracket fungus feeder in the eastern U.S.; probably the first collection recorded from any Caribbean island (no specimen was found in the USNMNH collection).

Hoplothrips fungosus Moulton, 1928: 2♀♀, Woodstock, sticky traps (4554p, 4559a). Known from Brazil (Para) and Puerto Rico. A common bracket fungus feeder among various Pacific islands.

Hoplothrips moultoni (Hood, 1934): 1♀, Gray's Inn, sticky trap (4566c). Known from Panama.

Hoplothrips spp. (B, D): Both are presently unplaceable. B: 3♀♀, Woodstock, White River, sticky traps (4554q, 4567b). D: 2♀♀, Buff Bay, sticky traps (4570a).

Karnyothrips flavipes (Jones, 1912): 2♀♀, Round Hill, Woodstock-Kildare; both by sticky traps (4502a, 4555); not common. Scale feeder. Known from Trinidad, St. Vincent, Barbados, Bahamas, Bermuda, Puerto Rico, Dominican Republic, Florida, Georgia, Louisiana, Texas, Mexico, and Venezuela.

Karnyothrips melaleuca (Bagnall, 1911): From *Panicum maximum, Sporobolus indicus,* and coconut fronds; rarely caught by sticky traps. Scale feeder. Known from Brazil (Para), Guyana, Trinidad, Patos Isle, Tobago, Barbados, St. Vincent, St. Lucia, Dominica, St. Croix, Puerto Rico, Bahamas, Haiti, Cuba, Jamaica, Florida, Georgia, Louisiana, Texas, Mexico, and Panama.

Karnyothrips merrilli (Watson, 1920): Frequent on coconut inflorescence and fruit feeding on scales, and also occasionally caught by sticky traps; also from great many weeds, grasses, ornamentals, and crop plants. The most common and abundant *Karnyothrips* everywhere in Jamaica; scale feeder. Known from Guyana, Trinidad, Tobago, Grenada, St. Vincent, St. Lucia, Guadeloupe, Puerto Rico, Cuba, Jamaica, Florida, Georgia, Texas, Mexico, Honduras, Panama, and Colombia.

Karnyothrips ochropezus Hood, 1934: 1♀, Round Hill, *Chloris* sp. (4437a). Probably scale feeder. Known from Panama.

Leptothrips vittipennis Hood, 1938: From *Calliandra* sp., *Lantana camara, Malvastrum coromandelianum, Malvaviscus arboreus,* and coconut inflorescence; also occasionally caught by sticky traps in Buff Bay and Kingston areas. Probably mite feeder. Known from Panama.

Liothrips urichi Karny, 1923: 1♀, Round Hill (Hill Top), *Borreria laevis,* by R. Latta (4428). Known from Trinidad.

Liothrips sp.: Differs from *L. leucopus* Titschack from the western Mediterranean area, the only other congener with a combination of dark brown body and totally yellow legs but not closely related, by longer head (1.3 times as long as wide), uniformly dark grayish brown and more slender tube (3.2 times as long as wide), and pale major setae. 1♂, Hardwar Gap, 4000′, beatings in forest (4511a).

Macrophthalmothrips heinzei Mound, 1972: 2♀♀, Woodstock, Gray's Inn; Sticky traps (4554i, 4566b). The type series was collected subsequently in 1970 6 miles east of Woodstock.

Macrophthalmothrips helenae Hood, 1934: 4♀♀, Negril, sticky traps; Woodstock, *Saccharum officinarum;* Hope Garden, a legume in greenhouse by W. Carter (4501a, 4550c, 4573). Known from Cuba, Florida, Texas, Mexico, and Panama.

Orthothrips sp.: Differs from *O. caudatus* Priesner from Surinam by longer head (1.3 times as long as wide), antennal II totally dark grayish brown, stouter tube (2.6 times as long as wide), and tergite IX with seta i dilated. Also differs from *O. bilineatus* Stannard, described from Jamaica but not collected during the present survey, by dark tube, lanceolate-pedicellate antennal VIII, and fully developed cepharic and pronotal setae. 2♀♀, Kildare, sticky traps (4562c, 4572).

Phrasterothrips sp.: Differs from *P. conducans* Priesner from Paraguay and Brazil by antennal III with a single sense cone, inner epimeral seta ½ as long as outer seta, and tube in different profile. 1♀, Woodstock, sticky trap among wild sugar cane (4550d).

Pygmaeothrips columniceps Karny, 1920: Abundant on bracket fungus, occasionally also under bark or on dead branches in Montego Bay area. Apparently the first collection of this Oriental and Pacific species in the Caribbean area (no specimen was found in the USNMNH collection).

Sophiothrips squamosus Hood, 1933: 1♀, Buff Bay, sticky trap (4570c). Known from Trinidad, Cuba, and Panama.

Stephanothrips occidentalis Hood and Williams, 1925: 1♀, Hope Garden, *Panicum maximum* (4350a). Known from Brazil (Para), Trinidad, Bermuda, St. Croix, Puerto Rico, Cuba, Jamaica, Caymans, Florida, Mexico, and Panama.

Strepterothrips floridanus (Hood, 1938): 3♀♀, Woodstock, Dover; sticky traps (4554k, 4569b). Known from Guyana, Trinidad, Caymans, Cuba, Florida, Texas, and Mexico.

Tylothrips osborni (Hinds, 1902): 2♀♀, Woodstock, Negril; sticky trap, *Sida* or *Malvastrum* spp. (4468e, 4558). Known from Trinidad, Florida, and Panama.

Family Phlaeothripidae—Subfamily Idolothripinae

Compsothrips graminis (Hood, 1936) (= *Oedaleothrips*): 3♀♀, 4♂♂, Palisadoes sweepings, 8.XII.1957, by T. H. Farr (4575). Known from Venezuela (Patos Isle), Trinidad, St. Croix, Tortola, Bahamas, Mexico.

Diceratothrips bicornis Bagnall, 1908 (= *D. armatus* Bagnall): 1♀, Buff Bay, coconut inflorescence (4529a). Known from Brazil (Para), Surinam, Guyana, Trinidad, Mexico, Panama, and Venezuela.

Diceratothrips picticornis Hood, 1914 (= *D. wolcotti* Morgan; both type series were examined): 10♀♀, 6♂♂, Irwin, dead branches piled on the ground (4472c); 1♂, Benzenn, general sweepings (4395). Known from Puerto Rico, Cuba, Bahamas, and Panama.

Elaphrothrips laevicollis (Bagnall, 1910): 9♂♂, Bath Mountain, Rock Hall, Christiana, and east of Montego Bay (all high mountainous localities), all by sweepings except one from *Moghania strobilifera*, 1955-1959, by T. H. Farr (4574, 76, 77, 79). Known from Brazil (Para), Surinam, Guyana, Trinidad, Mexico, Honduras, Costa Rica, Panama, and Venezuela.

Ethirothrips brevis (Bagnall, 1921) (= *Dichaetothrips claripennis* (Moulton): 2♂♂, Woodstock, Bengal; sticky trap, on coconut fruit (4450, 4568e). Known from Trinidad, Haiti, Bahamas, Jamaica, Florida, and Mexico.

Gastrothrips anolis Morgan, 1925: 1♂, Round Hill (Hill Top), *Solanum corvum* (4485c). Known from Puerto Rico, Cuba, Caymans, and Panama.

Neosmerinthothrips sp.: Differs from *N. collaris* Bagnall known from St. Vincent, Dominica, and Puerto Rico, by shorter head (1.1 times as long as wide) with slenderer tube (2.4 times as long as wide), fore wing clear at base, anteromarginal pronotal seta well developed, and tergite IX with seta i subequal to seta ii and longer than tube. An unnamed species in the USNMNH collection (1♀, Haiti, Port-Au-Prince, dead branches with leaves, 29.VIII.1951, Hood coll. (2728)) is conspecific with this Jamaican sp. 1♂ and larvae, Bengal, coconut fruit, among calyx (4450). Known from Haiti.

Nesothrips lativentris (Karny, 1913) (= *Rhaebothrips*): Abundant or frequent on many different plants, particularly various grasses in the wet Buff Bay area as well as the dry Montego Bay and Kingston areas; never caught by sticky traps and only once collected on coconut fruit. A fungus spore feeder. Known from Trinidad, Virgin Islands, Puerto Rico, Dominican Republic, Bahamas, Cuba, Jamaica, Caymans, Florida, and Panama.

Species Associated with Coconut

Throughout the world, no thrips species has been known as a pest of the coconut crops, and practically nothing is known of the thrips fauna on coconut. Extensive sticky trappings among coconut fronds and inflorescences and repeated manual collections on different parts of coconut trees, as well as among the weedy undergrowth in and around the coconut plantations finally yielded some data (Table 2) on the thrips fauna on coconuts in Jamaica, and its sources of migrations onto coconuts. The inflorescences are interspersed among fronds and bloom periodically in short intervals throughout the year, and most thrips trapped were flower feeding species. Sometimes more than 300 thrips were trapped per week.

Of 56 species enumerated in Table 2, 48 were trapped, and 10 of them were collected also from coconuts, but the remaining 38 were not; another 8 were collected from coconuts but not trapped; all together 18 were collected from coconuts. Nineteen are flower feeders; 8, leaf-fruit feeders; 20, fungal hyphae and fungal decaying breakdown

TABLE 2. SPECIES EITHER DIRECTLY COLLECTED FROM INFLORESCENCE OR FRUITS OF, OR CAUGHT BY STICKY TRAPS HANGING AMONG THE FRONDS OF COCONUT. 1: COLLECTED; 2: TRAPPED; 1-2: COLLECTED AND ALSO TRAPPED; a: FOUND ALSO AMONG THE UNDERGROWTH OF COCONUT TREES; b: NOT FOUND AMONG THE UNDERGROWTH OF COCONUT TREES.

FLOWER FEEDERS;		
Chaetisothrips striatus caribeanus Sakimura	2 a	
Chirothrips mexicanus Crawford	2 a	
Chirothrips texanus Andre	2 a	
Frankliniella borinquen Hood	2 a	
Frankliniella breviseta Moulton	2 a	
Frankliniella bruneri Watson	1-2 a	(inflorescence, frequent)
Frankliniella caphalica (Crawford)	2 a	
Frankliniella citripes Hood	2 a	
Frankliniella cubensis Hood	2 a	
Frankliniella insularis (Franklin)	1-2 a	(inflorescence)
Frankliniella jamaicensis Sakimura & O'Neill	2 a	
Frankliniella kelliae Sakimura	1-2 a	(inflorescence, frequent)
Frankliniella parvula Hood	2 a	
Frankliniella sp. (P)	2 a	
Frankliniella varipes Moulton	2 a	
Microcephalothrips abdominalis (Crawford)	2 a	
Psectrothrips interruptus (Hood)	2 b	
Rhamphothrips pandens Sakimura	2 a	
Thrips hawaiiensis (Morgan)	2 b	
LEAF-FRUIT FEEDERS;		
Anisopilothrips venustulus (Priesner)	1 a	(young fruit, frequent)
Caliothrips phaseoli (Hood)	2 a	
Ceratothripoides funestus (Hood)	2 a	
Chaetanaphothrips orchidii (Moulton)	1 a	(young fruit, once)
Corynothrips stenopterus Williams	2 b	
Heliothrips haemorrhoidalis (Bouché)	1-2 a	(young fruit, frequent)
Hercinothrips femoralis (Reuter)	1 a	(fruit)
Selenothrips rubrocinctus (Giard)	2 a	
FUNGAL HYPHAE AND FUNGAL DECAYING BREAKDOWN PRODUCTS FEEDERS;		
Adraneothrips decorus Hood	1-2 a	(inflorescence)
Adraneothrips sp.	2 b	
Carathrips mediamericanus Hood	2 b	
Eurythrips modestus (Bagnall)	2 b	
Eurythrips sp.	2 b	
Hoplandrothrips erythrinae Priesner	1 b	(fallen fruit)
Hoplandrothrips flavipes Bagnall	1-2 b	(inflorescence, fruit)
Hoplandrothrips reynei Priesner	2 a	
Hoplandrothrips sp.	2 b	
Hoplothrips angusticeps (Hood)	2 b	
Hoplothrips fungosus Moulton	2 b	
Hoplothrips moultoni Hood	2 b	
Hoplothrips sp. (B)	2 b	
Hoplothrips sp. (D)	2 b	
Macrophthalmothrips heinzei Mound	2 b	
Macrophthalmothrips helenae Hood	2 a	
Orthothrips sp.	2 b	
Sophiothrips squamosus Hood	2 b	
Strepterothrips floridanus (Hood)	2 b	
Tylothrips osborni (Hinds)	2 a	

FUNGAL SPORE FEEDERS:		
Diceratothrips bicornis Bagnall	1 b	(inflorescence, once)
Ethirothrips brevis (Bagnall)	1-2 b	(fruit)
Neosmerinthothrips sp.	1 b	(fruit)
Nesothrips lativentris (Karny)	1 a	(fruit, once)
PREDATORS:		
Aleurodothrips fasciapennis Franklin	1 a	(frond, once)
Karnyothrips flavipes (Jones)	2 b	
Karnyothrips melaleuca (Bagnall)	1-2 a	(frond)
Karnyothrips merrilli (Watson)	1-2 a	(young fruit and inflorescence, frequent)
Leptothrips vittipennis Hood	1-2 a	(inflorescence)

products feeders; 4, fungal spore feeders; and 5, predators. All the flower and leaf-fruit feeders are Terebrantians, and most of them were trapped frequently and abundantly, and also were found abundantly living among the undergrowth of coconuts. All the fungal growth feeders and predators are Tubuliferans, all of them were only sporadically and sparsely trapped and were mostly not or sparsely present among the undergrowth in the immediate vicinity.

The flower feeder group was predominated by 12 species of *Frankliniella*, and the remainder were incidental transients. *F. bruneri, kelliae*, and *insularis* were trapped abundantly. Frequently, all 3 species were collected from inflorescence, the first species abundantly. All are polyphagous species and are the most common and abundant species of the genus in Jamaica. *F. breviseta, cephalica, cubensis*, and *varipes* were trapped occasionally in fair numbers, but they were not collected from inflorescence. *Anisopilothrips venustulus* and *Heliothrips haemorrhoidalis* of the leaf-fruit feeder group were frequently or abundantly trapped as well as often collected from young fruits where both were found breeding. No infestation of thrips was observed on the mature fronds, but observations were not made on the developing tender hearts.

Most of the fungal hyphae and fungal decaying breakdown products feeders were sporadic transients. An exception was *Hoplandrothrips flavipes* which was trapped often as well as collected in good numbers from young fruits. Coconut fruits appeared to be its preferred feeding niches. All the fungal spore feeders were collected rarely from fruits but only once from inflorescence, and only one was trapped. Among the predator group, *Karnyothrips merrilli*, a scale feeder, was trapped occasionally, but it was often collected from young fruits and among inflorescence. This species also was found abundantly among the undergrowth of coconuts. The rest of the group are incidental transients.

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A PRELIMINARY CHECKLIST OF THE STAPHYLINIDAE (COLEOPTERA) OF FLORIDA

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ABSTRACT

A preliminary checklist of the Staphylinidae of Florida (USA) is presented. It includes 324 species in 122 genera and gives bibliographical information on their original descriptions, their synonymies, and the publications in which they were recorded as occurring in Florida. The total size of the staphylinid fauna of Florida is estimated conservatively as 450 species. The species/area relationship suggests that this fauna is depauperate relative to the staphylinid fauna of western Europe.

RESUMEN

Se presenta una lista preliminar de las especies de Staphylinidae que se encuentran en Florida (E.U.A.). La lista incluye 324 especies en 122 géneros, y ofrece información bibliográfica sobre las descripciones originales, los sinonimos, y las publicaciones en las cuales se registraron las especies como ocurriendo en Florida. El tamaño total de la fauna estafilinida de Florida se estima conservativamente en 450 especies. La relación especies/área indica que esta fauna es depauperada respecto de la fauna estafilinida de Europa Occidental.

In numbers of described species, Coleoptera represent the largest order of the largest class of the largest phylum of the animal kingdom. At least in western Europe and in America north of Mexico, in numbers of described species Staphylinidae repre-

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In numbers of described species, Coleoptera represent the largest order of the largest class of the largest phylum of the animal kingdom. At least in western Europe and in America north of Mexico, in numbers of described species Staphylinidae repre-

sent the largest family of Coleoptera. However, the composition of the staphylinid fauna of only one large geographical area (western Europe) is at all adequately known.

Only two publications have dealt with the staphylinid fauna of Florida specifically and in detail. After collecting expeditions in 1875 and 1876, Schwarz (1878) named 99 species as occurring there and mentioned existence of about as many species which could not then be identified specifically; a section of the text was devoted to descriptions by LeConte (1878) of new species. Notman (1920) found 101 species represented in the collections of the American Museum of Natural History, and he described several of them as new.

In 1969 was published the first of a series of taxonomic revisions of the North American staphylinid fauna and including the Florida fauna. Several authors have contributed such revisions, usually at the generic level. These modern works differ from older taxonomic publications in that they are more thorough, are based on examination of long series of specimens whenever available, and they use reproductive structures as taxonomic characters. It may be fairly stated that in 1968 all North American staphylinid genera required modern taxonomic revision, but it has been possible to revise only a small proportion of the total fauna since then.

Although the number of named species recorded from Florida is now over 300, there is no single comprehensive treatment of them in the literature, and neither is such treatment now possible because taxonomic knowledge of the bulk of the species is inadequate. This checklist is preliminary because it is incomplete. It provides concise answers to the questions: what staphylinid species are known to occur in Florida, where in the literature is information available about them, and how did they come to be recorded as occurring in Florida? It also estimates the total size of the staphylinid fauna of Florida, and compares the species richness of that fauna with faunas of two areas in western Europe where the species composition is better known.

Methods

A species list was drafted by examination of two North American catalogs (Leng 1920 and supplements, Moore and Legner 1975). Curiously, the earlier catalog attributed many more species to Florida than did the latter. Over a period of about five years, I examined the entire literature relevant to nomenclature and occurrence of Staphylinidae in Florida, from which sources the drafted list was augmented and corrected.

Names of subfamilies and tribes are capitalized and centered in Table 1. Names of genera within each tribe, and of species within each genus, are in most cases arranged alphabetically. Taxa revised since 1968 are treated differently: an asterisk is placed to the left of the name of each taxon (subfamily, tribe or genus) revised, and names of species within each genus, and genera within each tribe are arranged in the order used by the author of the revision.

Synonyms of names of species are in most cases listed below the valid name, following an equivalence sign (=). This listing of synonyms is deliberately restricted to names used for species described from the southeastern United States and the neotropical region. However, in the case of taxa revised since 1968, and against whose names an asterisk is placed, no synonyms are listed.

Against the author name of each species (left column) is given in the central column the date and page of publication of each species name. This provides an index to the literature cited. In the right column, Table 1 lists the author, date and page of publication establishing occurrence of each species in Florida. In most cases, the right column gives the first record of occurrence of a species in Florida, but where a taxonomic

TABLE 1. STAPHYLINIDAE RECORDED FROM FLORIDA. THE COLUMN AT RIGHT CITES THE RECORD ESTABLISHING OCCURRENCE IN FLORIDA.

	subfamily PROTEININAE	
	tribe PROTEININI	
Proteinus Latreille		
P. thomasi Frank	1979: 333	ibid.
	subfamily OMALIINAE	
	tribe ANTHOPHAGINI	
**Eudectoides* Campbell		
E. crassicornis (LeConte)	1885: 4	Campbell 1978: 14
	tribe CORYPHIINI	
**Ephelinus* Cockerell		
E. notatus (LeConte)	1863: 58	Campbell 1978: 69
	tribe OMALIINI	
Omalium Gravenhorst		
O. foraminosum Mäklin	1852: 321	Leng 1920: 94 SM
O. humerosum Fauvel	1878: 209	Notman 1920: 693
O. repandum Erichson	1840: 878	Leng 1920: 94 SM
	subfamily PIESTINAE	
Hypotelus Erichson		
H. hostilis Fauvel	1865: 43	Leng 1920: 93
	subfamily OSORIINAE	
	tribe LISPININI	
Clavilispinus Bernhauer		
C. exiguus (Erichson)	1840: 830	Fauvel 1878: 180
= *C. rufescens* (LeConte)	1863: 59	LeConte 1877: 249
Nacaeus Blackwelder		
N. tenellus (Erichson)	1840: 830	Fauvel 1878: 179
= *N. tenuis* (LeConte)	1863: 60	Schwarz 1878: 442
= *N. flavipennis* (Fauvel)	1865: 58	
= *N. fauveli* (Sharp)	1887: 720	
Thoracophorus Motschulsky		
T. brevicristatus (Horn)	1871: 332	Blackwelder 1939: 22
T. costalis Erichson	1840: 909	Schwarz 1878: 442
	tribe OSORIINI	
Holotrochus Erichson		
H. brachypterus Fauvel	1905: 136	ibid.
= *H. minor* LeConte	1877: 216	ibid.
(nec Fauvel	1863: 437)	
Osorius Latreille		
O. brevicornis Notman	1920: 698	ibid.: 699
O. latipes (Gravenhorst)	1806: 198	Schwarz 1878: 442
O. parviceps Notman	1925: 12	ibid.
O. planifrons LeConte	1877: 215	Leng 1920: 98 SM
O. politus LeConte	1877: 215	ibid.
	subfamily OXYTELINAE	
	tribe COPROPHILINI	
**Bledius* Leach		
B. ceratus Blackwelder	1943: 118	Herman 1983: 135
B. politus Erichson	1840: 766	Herman 1976: 131
B. basalis LeConte	1863: 54	Herman 1976: 98
B. cordatus (Say)	1834: 461	Herman 1976: 85
B. dimidiatus LeConte	1877: 232	Herman 1976: 85
B. thinopus Herman	1976: 86	ibid.: 88
B. turbulentus Casey	1889a: 70	Herman 1976: 94
B. cognatus LeConte	1877: 231	Herman 1983: 14

B. wudus Herman	1983: 16	ibid.
B. mandibularis Erichson	1840: 765	Herman 1972: 193
B. rubiginosus Erichson	1840: 765	Herman 1983: 140
B. semiferrugineus LeConte	1863: 52	Herman 1972: 205
Carpelimus Leach		
C. agonus (Casey)	1889b: 356	Leng 1920: 96 SM
C. basicornis (Notman)	1920: 694	ibid.
C. convexulus (LeConte)	1877: 244	Leng 1920: 96 SM
C. fulvipes (Erichson)	1840: 804	Schwarz 1878: 442
= *C. rubripennis* (Fauvel)	1863: 440	
= *C. aequalis* (Gundlach)	1894: 300	
C. maculicollis (Notman)	1920: 693	ibid.: 694
C. obesus (Kiesenwetter)	1844: 375	
= *C. memnonius* (Fauvel)	1872: 151	Schwarz 1878: 442
(nec (Erichson)	1840: 806)	
= *C. spectatus* (Casey)	1889b: 345	ibid.: 346
C. quadripunctatus (Say)	1834: 459	Leng 1920: 96 SM
= *C. laticollis* (LeConte)	1863: 55	
Manda Blackwelder		
M. nearctica Moore	1964: 58	ibid.
**Microbledius* Herman		
M. litoreus Herman	1972: 129	ibid.
**Psamathobledius* Herman		
P. punctatissimus (LeConte)	1877: 226	Herman 1972: 138
Thinodromus Kraatz		
T. arcifer (LeConte)	1877: 245	Casey 1889b: 330
tribe OXYTELINI		
Anotylus Thomson		
A. exiguus (Erichson)	1840: 798	Casey 1893: 397
A. insignitus (Gravenhorst)	1806: 188	Schwarz 1878: 442
A. nanus (Erichson)	1840: 797	Notman 1920: 695
A. rugosus (Fabricius)	1775: 267	Leng 1920: 96
Apocellus Erichson		
A. sphaericollis (Say)	1834: 455	Schwarz 1878: 442
= *A. amabilis* (Sachse)	1852: 116	
= *A. longicornis* (Sachse)	1852: 116	
A. stilicoides LeConte	1877: 247	ibid.
Oxytelus Gravenhorst		
O. convergens LeConte	1877: 236	ibid.
O. incisus Motschulsky	1857b: 504	Frank & Thomas 1981b: 400
O. incolumis Erichson	1840: 791	Schwarz 1878: 442
O. pennsylvanicus Erichson	1840: 792	Frank & Thomas 1981b: 402
O. sculptus Gravenhorst	1806: 191	Schwarz 1878: 442
Platystethus Mannerheim		
P. spiculus Erichson	1840: 784	Frank 1976: 157
= *P. exiguus* Jacquelin du Val	1857: 41	
*subfamily OXYPORINAE		
**Oxyporus* Fabricius		
O. femoralis Gravenhorst	1802: 196	Campbell 1969: 241
O. vittatus Gravenhorst	1802: 195	Campbell 1969: 251
subfamily MEGALOPSIDIINAE		
Megalopinus Eichelbaum		
M. caelatus (Gravenhorst)	1802: 197	Schwarz 1878: 442
M. rufipes (LeConte)	1863: 51	Leng 1920: 98 SM
subfamily STENINAE		
Stenus Latreille		
S. alacer Casey	1884a: 135	ibid.: 136

= *S. fauvelianus* Sharp	1886: 646	
S. arculus Erichson	1840: 744	Schwarz 1878: 442
S. callosus Erichson	1840: 737	Schwarz 1878: 442
S. carolinae Casey	1884a: 116	Leng 1920: 99 SM
S. colonus Erichson	1840: 699	Casey 1884: 97
= *S. floridanus* Casey	1884a: 95	ibid.: 96
= *S. championi* Sharp	1886: 642	
= *S. inermis* Sharp	1886: 642	
= *S. chapini* Blackwelder	1943: 211	
S. cubensis Bernhauer	1910: 364	Puthz 1974a: 10
S. lutzi Notman	1920: 700	ibid.: 701
S. megalops (Casey)	1884a: 161	ibid.
S. meridionalis (Casey)	1884a: 185	ibid.: 186
S. nitescens (Casey)	1884a: 170	ibid.: 171
S. rostellifer Puthz	1972: 315	ibid.: 316
S. sectilifer Casey	1884a: 110	Notman 1920: 700
= *S. milleporus* Casey	1884a: 111	ibid.
= *S. teter* Notman	1920: 699	ibid.: 700
= *S. odius* Blackwelder	1943: 213	
S. tuberculatus Casey	1884a: 129	ibid.: 130

subfamily EUAESTHETINAE
tribe EUAESTHETINI

**Edaphus* Motschulsky		
E. nitidus Motschulsky	1857a: 7	Puthz 1974b: 917
E. americanus Puthz	1974b: 920	ibid.: 922
Euaesthetus Gravenhorst		
E. americanus Erichson	1840: 747	Casey 1884: 28
E. atomus Casey	1884b: 28	ibid.: 29
E. bicoloratus Casey	1924: 150	ibid.
E. floridae Casey	1884b: 21	ibid.: 22
E. punctatus Casey	1884b: 21	ibid.
E. similis Casey	1884b: 22	ibid.: 23

subfamily LEPTOTYPHLINAE
tribe NEOTYPHLINI

Cubanotyphlus Coiffait & Decou		
C. largo Frank	1984b: 1412	Frank & Thomas 1984a: 1414

subfamily PAEDERINAE
tribe PINOPHILINI

Araeocerus Nordmann		
A. picipes (Erichson)	1840: 671	Schwarz 1878: 441
Pinophilus Gravenhorst		
P. confusus Fall	1932: 56	ibid.
= *P. opacus* Casey	1910: 196	ibid.
(nec LeConte	1863: 49)	
P. latipes Gravenhorst	1802: 202	Schwarz 1878: 441
P. opacus LeConte	1863: 49	Schwarz 1878: 441
P. parcus LeConte	1863: 48	Schwarz 1878: 441
Palaminus Erichson		
P. contortus LeConte	1878: 397	ibid.
P. cribratus LeConte	1878: 397	ibid.
P. flavipennis LeConte	1878: 396	ibid.
P. larvalis LeConte	1863: 49	Schwarz 1878: 442
P. normalis LeConte	1878: 397	Leng 1920: 100 SM
P. pumilis LeConte	1878: 398	ibid.
P. testaceus Erichson	1840: 683	Notman 1920: 701

tribe PAEDERINI

Achenomorphus Motschulsky		
A. corticinus (Gravenhorst)	1802: 184	Schwarz 1878: 441
= *A. rufescens* (Nordmann)	1837: 148	
Acrostilicus Hubbard		
A. hospes Hubbard	1896: 299	ibid.
Astenus Dejean		
A. binotatus (Say)	1823: 154	Schwarz 1878: 441
A. fusciceps (Casey)	1905: 240	Notman 1920: 704
A. linearis (Erichson)	1840: 639	Schwarz 1878: 441
A. prolixus (Erichson)	1840: 639	Schwarz 1878: 441
A. spectrum (Casey)	1905: 238	Notman 1920: 704
Biocrypta Casey		
B. magnolia Blatchley	1917: 236	ibid.: 237
Dacnochilus LeConte		
D. laetus LeConte	1863: 47	Schwarz 1878: 441
Echiaster Erichson		
E. brevicornis (Casey)	1886: 215	Notman 1920: 704
= *E. virginicus* (Fall)	1901: 304	
Homaeotarsus Hochhuth		
H. badius (Gravenhorst)	1802: 53	Horn 1885: 89
H. bicolor (Gravenhorst)	1802: 179	Schwarz 1878: 441
H. cinctus (Say)	1834: 454	Schwarz 1878: 441
H. clavicornis (Casey)	1905: 47	ibid.
H. despectus (LeConte)	1863: 45	Horn 1885: 90
H. floridanus (LeConte)	1878: 389	ibid.
H. lugubris (LeConte)	1878: 393	ibid.: 394
H. obliquus (LeConte)	1878: 394	ibid.
= *H. parcus* (LeConte)	1878: 394	ibid.
H. pallipes (Gravenhorst)	1802: 179	Horn 1885: 101
Lathrobium Gravenhorst (sensu lato)		
L. americanum Duvivier	1883: 161	
= *L. anale* LeConte	1880: 177	Notman 1920: 702
(nec Lucas	1849: 117)	
L. collare Erichson	1840: 599	Leng 1920: 102 SM
L. dimidiatum Say	1834: 455	Schwarz 1878: 441
L. emarginatum Watrous	1981: 149	ibid.
L. floridae (Casey)	1905: 127	ibid.
L. floridanum (Casey)	1905: 108	ibid.
L. pallidulum LeConte	1880: 177	ibid.
L. parcum LeConte	1880: 176	ibid.
L. politum Gravenhorst	1802: 180	Leng 1920: 102 SM
L. tetricum (Casey)	1905: 110	
= *L. nigriceps* (Notman)	1920: 702	ibid.
= *L. canoaensis* Bierig	1934c: 325	
L. ventrale LeConte	1880: 177	ibid.
= *L. tricolor* Casey	1885: 133	
Lithocharis Dejean		
L. ochracea (Gravenhorst)	1802: 59	Notman 1920: 702
Myrmecosaurus Wasmann		
M. ferrugineus Bruch	1932: 1	Frank 1977: 31
Ophioomma Notman		
O. rufa Notman	1920: 705	ibid.
Paederus Fabricius		
P. floridanus Austin	1876: 10	ibid.
P. littoreus Austin	1876: 9	Notman 1920: 701
P. obliteratus LeConte	1878: 395	ibid.

Rugilus Samouelle		
R. angularis (Erichson)	1840: 634	Schwarz 1878: 441
R. dentatus (Say)	1834: 457	Leng 1920: 104 SM
Scopaeus Erichson		
S. carolinae Casey	1905: 205	Notman 1920: 703
S. exiguus Erichson	1840: 608	Schwarz 1878: 441
S. femineus (Moore & Legner)	1975: 492	ibid.
S. macilentus Casey	1905: 208	Notman 1920: 703
S. opacus (LeConte)	1863: 46	Schwarz 1878: 441
S. picipes Casey	1885: 137	Casey 1905: 206
Stamnoderus Sharp		
S. monstrosus (LeConte)	1863: 48	Schwarz 1878: 441
S. pallidus Casey	1905: 233	ibid.
Stilicopsis Sachse		
S. paradoxa Sachse	1852: 145	Schwarz 1878: 441
S. subtropica Casey	1910: 191	ibid.
Sunius Curtis		
S. confluentus (Say)	1834: 456	Frank 1981a: 388
S. debilicornis (Wollaston)	1857: 194	Blackwelder 1939: 23
S. minutus (Casey)	1905: 180	ibid.
S. testaceus (Casey)	1905: 190	ibid.
Thinocharis Kraatz		
T. exilis (Erichson)	1840: 627	Blackwelder 1939: 23
= *T. fragilis* (Sharp)	1886: 574	
= *T. minuta* (Sharp)	1886: 574	
= *T. delicatula* (Casey)	1905: 159	
= *T. pertenuis* (Casey)	1910: 188	
T. quadriceps (Notman)	1920: 703	ibid.
*subfamily XANTHOLININAE		
*tribe DIOCHINI		
**Diochus* Erichson		
D. schaumii Kraatz	1860: 27	Smetana 1982: 32
*tribe XANTHOLININI		
**Neoxantholinus* Cameron		
N. cristatus Smetana	1982: 64	ibid.: 57
**Nudobius* Thomson		
N. luridipennis Casey	1906: 383	Smetana 1982: 90
**Phacophallus* Coiffait		
P. tricolor (Kraatz)	1859: 110	Smetana 1982: 111
**Microlinus* Casey		
M. pusio (LeConte)	1880: 171	Smetana 1982: 115
**Lithocharodes* Sharp		
L. ruficollis (LeConte)	1863: 42	Smetana 1982: 125
L. nigripennis (LeConte)	1863: 42	Smetana 1982: 128
L. floridanus (LeConte)	1880: 170	Smetana 1982: 131
**Neohypnus* Coiffait & Saiz		
N. attenuatus (Erichson)	1839: 330	Smetana 1982: 204
N. bicolor Smetana	1982: 23	ibid.: 215
N. pusillus (Sachse)	1852: 124	Smetana 1982: 234
N. fusciceps (LeConte)	1880: 173	Smetana 1982: 241
N. melanops (Casey)	1906: 390	Smetana 1982: 244
N. emmesus (Gravenhorst)	1802: 176	Smetana 1982: 250
subfamily STAPHYLININAE		
tribe STAPHYLININI		
Belonuchus Nordmann		
B. pallidus Casey	1915: 449	ibid.
B. rufipennis (Fabricius)	1801: 597	

= *B. formosus* (Gravenhorst)	1806: 72	Schwarz 1878: 441
= *B. apicalis* (Dejean)	1833: 63	
= *B. moquinus* Casey	1884b: 125	
Cafius Curtis		
C. bistriatus (Erichson)	1840: 502	Frank et al. 1986
= *C. bilineatus* (Erichson)	1840: 503	
C. caribeanus Bierig	1934a: 68	Frank 1985: 61
C. rufifrons Bierig	1934a: 68	Frank et al. 1986
C. subtilis Cameron	1922: 121	Frank 1985: 62
Creophilus Samouelle		
C. maxillosus (Linné)	1758: 421	Schwarz 1878: 441
**Erichsonius* Fauvel		
E. crescenti Frank	1975a: 182	ibid.
E. parcus (Horn)	1884: 230	Notman 1920: 705
E. rusticus Frank	1975a: 194	ibid.: 203
E. rosellus Frank	1975a: 195	Frank 1981c: 100
E. alumnus Frank	1975a: 196	Frank 1981c: 100
E. floridanus Frank	1975a: 198	ibid.
E. civicus Frank	1975a: 201	Frank 1981c: 100
Gabrius Curtis		
G. nigritulus (Gravenhorst)	1802: 41	Fauvel 1889: 116
Gabronthus Tottenham		
G. mgogoricus Tottenham	1955: 185	Frank 1984a: 476
G. thermarum (Aube)	1850: 316	Frank 1984a: 475
Hesperus Fauvel		
H. apicialis (Say)	1834: 451	Frank 1984a: 478
H. baltimorensis (Gravenhorst)	1802: 163	Frank 1984a: 478
Laetulonthus Moore & Legner		
L. laetulus (Say)	1834: 449	Frank 1984a: 479
**Neobisnius* Ganglbauer		
N. paederoides (LeConte)	1863: 38	Frank 1981d: 18
N. ludicrus (Erichson)	1840: 514	Frank 1981d: 21
N. jocosus (Horn)	1884: 232	Frank 1981d: 28
N. sobrinus (Erichson)	1840: 512	Frank 1981d: 40
Philonthus Curtis		
P. alumnus Erichson	1840: 490	Horn 1884: 199
P. cautus Erichson	1840: 446	Horn 1884: 188
P. debilis (Gravenhorst)	1802: 35	Leng 1920: 107 SM
P. flavolimbatus Erichson	1840: 471	Notman 1920: 706
P. fulvipes (Fabricius)	1792: 526	Notman 1920: 706
P. gopheri Hubbard	1894: 308	ibid.
P. hepaticus Erichson	1840: 451	Schwarz 1878: 441
= *P. vilis* Erichson	1840: 451	
= *P. orphanus* Erichson	1840: 452	
= *P. pauxillus* Solsky	1868: 133	
= *P. parvimanus* Sharp	1885: 406	
P. lomatus Erichson	1840: 482	Notman 1920: 706
= *P. georgianus* Sachse	1852: 143	
P. longicornis Stephens	1832: 237	Castle & Laurent 1896: 303
= *P. feralis* Erichson	1840: 469	
= *P. fumosus* Solsky	1868: 134	
P. sericans (Gravenhorst)	1802: 171	
= *P. brunneus* (Gravenhorst)	1802: 172	Leng 1920: 107 SM
P. ventralis (Gravenhorst)	1802: 174	Frank 1984a: 480
**Platydracus* Thomson		
P. comes (LeConte)	1863: 36	Newton 1973: 294

P. pinorum (Casey)	1915: 427	Newton 1973: 304
P. praelongus (Mannerheim)	1831: 438	Newton 1973: 304
= *P. cicatricosus* (LeConte)	1863: 37	
P. tomentosus (Gravenhorst)	1802: 161	Newton 1973: 308
P. fossator (Gravenhorst)	1802: 164	Newton 1973: 312
P. temporalis (Casey)	1915: 429	Newton 1973: 314
P. femoratus (Fabricius)	1801: 594	Newton 1973: 316
P. caseyi (Scheerpeltz)#	1933: 1392	
= *P. quadraticeps* (Casey)	1924: 149	ibid.
(nec Ménétriés	1832: 143)	
P. cinnamopterus (Gravenhorst)#	1802: 164	Leng 1920: 108 SM
(# part of a species complex under revision)		
*tribe QUEDIINI		
**Heterothops* Stephens		
H. campbelli Smetana	1971: 22	Smetana 1981: 632
**Quedius* Stephens		
Q. peregrinus (Gravenhorst)	1806: 53	Smetana 1971: 59
Q. compransor Fall	1912: 40	Smetana 1978: 823
Q. mesomelinus (Marsham)	1802: 510	Smetana 1971: 77
Q. laticollis (Gravenhorst)	1802: 173	Smetana 1978: 826
Q. verres Smetana	1971: 174	Smetana 1976: 176
**Hemiquedius* Casey		
H. ferox (LeConte)	1878: 388	Smetana 1971: 239
**Anaquedius* Casey		
A. vernix (LeConte)	1878: 389	Smetana 1978: 831
**Acylophorus* Nordmann		
A. densus LeConte	1878: 387	ibid.
A. fallax Smetana	1971: 254	ibid.: 255
A. princeps Smetana	1971: 255	ibid.
A. lecontei Duvivier	1883: 136	Smetana 1971: 261
A. pusillus Smetana	1973: 1432	ibid.
A. longistylus Casey	1915: 426	Smetana 1971: 262
A. zdenae Smetana	1978: 836	Benjamin 1983: 347
**Atanygnathus* Jacobson		
A. bicolor (Casey)	1915: 424	Smetana 1971: 272
subfamily TACHYPORINAE		
tribe BOLITOBIINI		
Bryoporus Kraatz		
B. rufescens LeConte	1863: 33	Schwarz 1878: 440
= *B. testaceus* LeConte	1863: 33	
= *B. parvulus* Casey	1885: 151	
**Lordithon* Thomson		
L. angularis (Sachse)	1852: 122	Campbell 1982: 30
L. obsoletus (Say)	1834: 464	Campbell 1982: 65
Mycetoporus Mannerheim		
M. americanus Erichson	1839: 285	Leng 1920: 112
= *M. lucidulus* LeConte	1863: 33	
M. brunneus (Marsham)	1802: 524	
= *M. lepidus* Horn	1877: 121	ibid.
M. flavicollis LeConte	1863: 33	Horn 1877: 123
*tribe TACHYPORINI		
**Coproporus* Kraatz		
C. ventriculus (Say)	1834: 466	Campbell 1975: 183
C. pulchellus (Erichson)	1839: 247	Campbell 1975: 187
C. segnis (Sharp)	1883: 301	Campbell 1975: 188
C. hepaticus (Erichson)	1839: 249	Campbell 1975: 190

C. laevis LeConte	1863: 31	Campbell 1975: 196
**Sepedophilus* Gistel		
S. macer (Casey)	1895: 443	Campbell 1976: 22
S. velocipes (Casey)	1895: 442	Campbell 1976: 32
S. versicolor (Casey)	1885: 142	Campbell 1976: 42
S. basalis (Erichson)	1839: 225	Campbell 1976: 53
S. kiteleyi Campbell	1976: 55	ibid.
S. opicus (Say)	1834: 467	Campbell 1976: 57
S. scriptus (Horn)	1877: 112	Campbell 1976: 60
**Tachinus* Gravenhorst		
T. axillaris Erichson	1839: 261	Campbell 1973: 38
**Tachyporus* Gravenhorst		
T. jocosus Say	1834: 466	Campbell 1979: 62
subfamily ALEOCHARINAE		
tribe TRICHOPSENIINI		
Trichopsenius Horn		
T. depressus (LeConte)	1863: 30	Seevers 1938: 437
Xenistusa LeConte		
X. hexagonalis Seevers	1941: 324	ibid.: 326
tribe HYPOCYPHTINI		
Anacyptus Horn		
A. testaceus (LeConte)	1863: 30	Schwarz 1878: 440
*tribe DEINOPSINI		
**Deinopsis* Matthews		
D. illinoisensis Klimaszewski	1979: 52	Klimaszewski 1985: 142
D. franki Klimaszewski	1980: 110	ibid.: 113
**Adinopsis* Cameron		
A. bicornis Klimaszewski	1979: 71	Klimaszewski 1982b: 328
A. cuspidata Klimaszewski	1982b: 330	ibid.
A. myllaenoides (Kraatz)	1857a: 38	Klimaszewski 1979: 73
*tribe MYLLAENINI		
**Myllaena* Erichson		
M. potowatomi Klimaszewski	1982a: 192	ibid.: 193
M. currax Notman	1920: 710	Klimaszewski 1982a: 194
M. koasati Klimaszewski	1982a: 196	ibid.: 198
M. insipiens Casey	1911: 237	Klimaszewski 1982a: 204
M. seminole Klimaszewski	1982a: 213	ibid.: 211
M. cuneata Notman	1920: 710	Klimaszewski 1982a: 217
M. arcana Casey	1911: 239	Klimaszewski 1982a: 221
M. magnolia Klimaszewski	1982a: 221	ibid.: 226
tribe ALEOCHARINI		
**Aleochara* Gravenhorst		
A. bimaculata Gravenhorst	1802: 187	Klimaszewski 1984: 19
A. notula Erichson	1839: 167	Klimaszewski 1984: 21
A. verna Say	1836: 156	Klimaszewski 1984: 25
A. lacertina Sharp	1883: 148	Klimaszewski 1984: 41
A. puberula Klug	1834: 139	Klimaszewski 1984: 46
A. lustrica Say	1834: 468	Klimaszewski 1984: 74
A. lata Gravenhorst	1802: 186	Klimaszewski 1984: 79
A. gracilicornis Bernhauer	1901: 372	Klimaszewski 1984: 82
A. litoralis (Mäklin)	1853: 182	Klimaszewski 1984: 99
Genosema Notman		
G. pulchra (Kraatz)	1857a: 6	Schwarz 1878: 440
G. sexualis Notman	1920: 721	ibid.
Lophomucter Notman		
L. laevicollis Notman	1920: 722	ibid.: 723

Tinotus Sharp		
T. amplus Notman	1920: 723	ibid.
T. brunnipes Notman	1920: 724	ibid.
T. planulus Notman	1920: 724	ibid.: 725
	*tribe FALAGRIINI	
**Myrmecocephalus* Macleay		
M. cingulatus (LeConte)	1866: 370	Hoebeke 1985: 946
M. concinnus (Erichson)	1840: 51	Hoebeke 1985: 950
M. gracilis (Casey)	1906: 244	Hoebeke 1985: 952
**Falagria* Leach		
F. dissecta Erichson	1840: 49	Hoebeke 1985: 970
**Aleodorus* Say		
A. partitus (LeConte)	1866: 371	Hoebeke 1985: 986
**Lissagria* Casey		
L. laticeps (Notman)	1920: 732	Hoebeke 1985: 999
**Borboropora* Kraatz		
B. sulcifrons (Casey)	1893: 348	Hoebeke 1985: 1005
	tribe ATHETINI	
Acrotona Thomson		
A. hebeticornis Notman	1920: 730	ibid.
A. picescens Notman	1920: 729	ibid.
Asthenesita Casey		
A. pallens Casey	1893: 366	ibid.
Atheta Thomson		
A. aspericauda Bernhauer	1907: 400	ibid.
A. coriaria (Kraatz)	1856: 282	Frank 1981a: 388
A. fulviceps Notman	1920: 726	ibid.: 727
A. macrops Notman	1920: 725	ibid.: 726
Trichiusa Casey		
T. ursina Notman	1920: 725	ibid.
	tribe OXYPODINI	
Dexiogyia Thomson		
D. tenuicauda (Casey)	1911: 17	ibid.
Gnypeta Thomson		
G. floridana Casey	1906: 195	ibid.
Meronera Sharp		
M. venustula (Erichson)	1839: 55	Schwarz 1878: 440
	tribe MYRMEDONIINI	
Apalonia Casey		
A. seticornis Casey	1906: 324	ibid.
Dinocoryna Casey		
D. bisinuata Casey	1893: 320	ibid.: 321
= *D. foreli* (Wasmann)	1899: 410	
Ecitocala Frank		
E. rugosa Frank	1981b: 145	Frank & Thomas 1981a: 145
Ecitoxenidia Wasmann		
E. alabamae Seevers	1959: 77	Frank & Thomas 1981a: 139
Microdonia Casey		
M. nitidiventris (Brues)	1904: 250	Frank & Thomas 1981a: 141
M. occipitalis Casey	1893: 319	Frank & Thomas 1981a: 141
Zyras Stephens		
Z. angustulus (Casey)	1893: 323	ibid.: 324
	tribe BOLITOCHARINI	
Agaricochara Kraatz		
A. anomala (Notman)	1920: 718	ibid.

Bolitochara Mannerheim		
B. tenuicornis (Notman)	1920: 714	ibid.
Coenonica Kraatz		
C. puncticollis Kraatz	1857b: 46	Frank & Thomas 1984b: 416
Elachistarthron Notman		
E. ambiguum Notman	1920: 715	ibid.: 716
Eumicrota Casey		
E. atoma Casey	1906: 284	Seevers 1951: 738
E. corruscula (Erichson)	1839: 189	Seevers 1951: 734
E. minutissima Casey	1906: 284	Seevers 1951: 739
E. socia (Erichson)	1839: 189	Seevers 1951: 736
Euvira Sharp		
E. debilis Sharp	1883: 281	Bierig 1939: 25
Gyrophaena Mannerheim		
G. keeni Casey	1911: 185	Seevers 1951: 682
G. laetula (Casey)	1906: 300	Notman 1920: 719
Heterota Mulsant & Rey		
H. plumbea (Waterhouse)	1858: 6074	Frank & Thomas 1984b: 412
Homalota Mannerheim		
H. plana (Gyllenhal)	1810: 402	Schwarz 1878: 440
Orthodiatelus Notman		
O. innotabilis Notman	1920: 716	ibid.: 717
**Phanerota* Casey		
P. brunnessa Ashe	1986: 238	ibid.: 240
P. carinata Seevers	1951: 750	Ashe 1986: 241
P. cubensis Casey	1906: 228	Ashe 1986: 238
P. dissimilis (Erichson)	1839: 186	Ashe 1986: 241
P. fasciata (Say)	1834: 469	Ashe 1986: 241
Placusa Erichson		
P. despecta Erichson	1839: 197	Schwarz 1878: 440
Schistacme Notman		
S. obtusa Notman	1920: 712	ibid.: 713
Thecturota Casey		
T. fracta Casey	1911: 209	Notman 1920: 713
T. nevadica Casey	1911: 209	Notman 1920: 713
tribe PHILOTERMITINI		
Philotermes Kraatz		
P. cubitopilis Seevers	1957: 255	ibid.
P. fuchsii Kraatz	1857a: 15	Seevers 1938: 433
P. werneri Seevers	1957: 255	ibid.: 256
tribe OLIGOTINI		
Oligota Mannerheim		
O. chrysopyga Kraatz	1859: 45	Frank 1975b: 280
O. parva Kraatz	1862: 300	Notman 1920: 710
O. testaceorufa Bernhauer	1923: 144	Frank 1975b: 280
O. zonata Bierig	1934b: 115	Frank 1975b: 280

revision has been published since 1968, the right column gives the author, date and page of the revision. Provision of this third column allows verification of each record in the original literature. Omission of such a third column in most checklists and catalogs allows errors to be perpetuated in the literature (see Seevers 1978, for comments on such errors).

This checklist contains no new distributional records. It includes all known records published in the primary literature. The secondary literature (catalogs by Leng 1920 and supplements; Moore and Legner 1975) posed some difficulties. The Leng (1920) catalog listed > 20 species whose recording for Florida I could not discover in the primary literature. Eventually, with the help of D. R. Whitehead (USDA, Washington, DC) I discovered in the Smithsonian Institution Archives, a reprint of Schwarz's (1878) paper annotated by Schwarz with most of these species names. This appears to be the source of records cited by Leng (1920). I have considered this annotated reprint as a valid publication (Schwarz MS in the REFERENCES CITED) and have accepted these records (see e.g., 'Leng 1920: 98 SM' in the right column for *Osorius planifrons*). I have arbitrarily accepted existence of three additional species recorded apparently for the first time in the Leng (1920) catalog (*Hypotelus hostilis*, *Anotylus rugosus*, and *Mycetoporus americanus*) as validly recorded for Florida. I have deliberately excluded *Thoracophorus fletcheri* Wendeler, apparently recorded for the first time in the Moore and Legner (1975) catalog, because Moore (*in litt.*) could not recall how this came to be recorded for Florida.

RESULTS AND DISCUSSION

The foregoing pages list 324 species belonging to 122 genera as occurring in Florida. Illustrated keys to the adults of Florida species of most of these genera are lacking. Autecological studies have not been performed in Florida. This 'known fauna' is admitted to be only a part of the 'total fauna', so then what is the size of the 'total fauna' and how does the species/area relationship compare with those of other faunas?

The Florida staphylinid fauna is estimated conservatively as about 450 species as follows: (1) the taxa Omaliinae (part), *Bledius*, *Oxyporus*, *Edaphus*, Xantholininae, *Erichsonius*, *Neobisnius*, *Platydracus*, Quediini, *Lordithon*, *Coproporus*, *Sepedophilus*, *Tachinus*, *Tachyporus*, Deinopsini, Myllaenini, *Aleochara*, Falagriini and *Phanerota* have been revised taxonomically since 1968, and they were recorded as having 73 species in Florida before revision, 121 after revision; (2) the Florida list in 1968 (before the initiation of a series of modern revisions) contained 249 species, so if all taxa had been revised instantaneously the list could be estimated to contain 249 X 121/73 = 413 species; (3) even in the revised taxa not all Florida species were recorded during revision, and I am aware that seven species remain to be added to the 121 mentioned above (a 6% increase); (4) additionally, the presence of 14 species belonging to genera unrecorded for Florida in 1968 has subsequently been recorded, without taxonomic revision, a 3% increase (14 as percentage of 413); (5) therefore the estimate of 413 should be increased by roughly 9% to 450. Possible sources of error may be an underestimation of diversity within Aleocharinae: by analogy with the European fauna this subfamily might be expected to have a greater number of species than predicted.

Florida has an area of 152,000 km² and a conservatively estimated staphylinid fauna of 450 species. The British Isles have an area of 314,000 km² and a staphylinid fauna of 990 species [counted in Pope (1977)], whereas "Middle Europe" [Denmark to Austria] has an area of about 725,000 km² and a staphylinid fauna of 1,790 species [counted in Freude, Harde and Lohse (1964, 1974)]. On the basis of the species/area relationships for the two European areas and the slight slopes of most species/area curves (Williams

1964), the staphylinid fauna of Florida is depauperate relative to that of western Europe.

About a third of the Florida staphylinid fauna (1—324/450) remains unrecorded, so an accurate assessment of the origin of its components must await further study. The largest component is nearctic, with smaller neotropical, cosmotropical, and cosmopolitan components. Absence of a larger nearctic component probably has to do with absence of a mountain chain, so that species restricted to high altitudes in the southeastern USA are excluded from Florida. Absence of a larger neotropical component may well have to do with the distance of mainland Florida from large land areas to the south and west; even though a chain of small islands (the Florida Keys) leads southward, these may be inhospitable to many staphylinid species because they lack fresh water and other sorts of habitats elsewhere occupied by staphylinids.

It is estimated that about 126 species (450-324) remain to be added to the Florida list. Verification that this number is a reasonable estimate comes from my collection: specimens of about 60 species not mentioned in Table 1 await taxonomic treatment before incorporation. I find it entirely conceivable that a further 66 (126-60) species await discovery. Future work will consist not merely of adding species names to the list, but in changes of generic and even of tribal assignments, in recognition of additional synomymies, in realization that some species names on the list are due to misidentification or were recorded from Florida in error, and in preparation of illustrated keys for identification. All of this forms a necessary background to the mapping of species distributions and to the beginning of an understanding of the ecological roles performed by these species.

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USE OF ELCAR® TO REDUCE THE NUMBER OF CORN EARWORMS (LEPIDOPTERA: NOCTUIDAE) DEVELOPING IN FIELD CORN

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ABSTRACT

A single application of Elcar®, a commercial formulation of the *Heliothis* nuclear polyhedrosis virus, at the rate of 272 gm/ha, was made by airplane to two fields of hybrid corn in the early silking stage in northeastern Mexico. Elcar produced a greater reduction in number of corn earworm, *Heliothis zea* (Boddie), larvae on the hybrid with a tight husk extension than on the hybrid with a loose husk. There was no reduction in number of pupae produced on the hybrid with the loose husk. Although the 30% reduction in number of corn earworm pupae produced on the hybrid with the tight husk extension was not statistically significant, it closely paralleled the reduction in larvae which was statistically significant.

The Elcar treatment saved more kernels of corn on the hybrid with the loose husk than on the hybrid with the tight husk because the damage to the untreated hybrid with the loose husk was much greater than to the untreated hybrid with the tight husk.

RESUMEN

Una aplicación de Elcar®, una formulación comercial del virus nuclear polihedrosis de *Heliothis*, a razón de 272 gm/ha, fue hecha por avión temprano en la etapa floral de maíz híbrido en dos campos en el noreste de Mexico. Elcar produjo una mayor reducción en el número de larvas de *Heliothis zea* en el híbrido con extensiones de vainas apretadas que en híbridos con una vaina suelta. No se redujo el número de pupas producidas en el híbrido con la vaina suelta. Aunque una reducción de un 30% en el número de pupas de *H. zea* producidas en el híbrido con la extensión de la vaina apretada no fue estadisticamente significante, es bastante paralela a la reducción de larvas que eran estadisticamente significante.

El tratamiento de Elcar® salvó a más granos de maíz en el híbrido con la vaina suelta que en los híbridos con la vaina apretada porque el daño al híbrido no-tratado con la vaina suelta fue mucho mayor que el del híbrido no-tratado con la vaina apretada.

Uncontrolled populations of corn earworm (CEW), *Heliothis zea* (Boddie), on corn are capable of reproducing at the rate of at least one larva per ear, which can result in a tremendous population of moths for dispersal to other crops (Sparks & Mitchell 1979). Recent studies have provided increasing evidence of migration of CEW moths from northeastern Mexico and the Lower Rio Grande Valley of Texas into West and North Texas and other parts of the USA (Hartstack et al. 1982, Wolf et al. in press, Raulston et al. in press). The nuclear polyhedrosis virus (NPV) of *Heliothis* has been shown to have potential for suppression of CEW on corn (Tanada & Reiner 1962, Ignoffo et al. 1965, Young & Hamm 1966, Hamm & Young 1971). Therefore, we wanted to determine if one application of *Heliothis* NPV could reduce the population of CEW produced on corn in northeastern Mexico, thus reducing the population of CEW available for transport into the United States.

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Materials and Methods

Two fields of corn in the early silk stage were located west of Rio Bravo, Mexico. Both fields were on the east side of the road and separated by 0.5 km. One field was planted with Growers 2340, a yellow, single cross hybrid with a loose, open husk at the tip of the ear. The other field was planted with Asgrow RX-405-W, a white, single cross hybrid with a long, tight husk extension. The western half of each field was designated block 1, containing replicate 1 of treatment and control plots; the eastern half was designated block 2, containing replicate 2.

Elcar was applied by airplane on the evening of 17 May 1984 at the rate of 272 gm/ha in 30 liters of water. At time of treatment, more than 90% of the corn plants were silking, with most of the silks 1 to 3 days old. The plots were checked at 4, 8, and 15 days after treatment and counts were made of small, medium, and large larvae from 4 subsamples of 50 ears each for a total of 200 ears from each plot. The 4 subsamples were taken at intervals of ca. one-fifth the length of the plots and in from the edge of the plot ca. 45 m. Larvae were collected from the first 25 ears of each subsample and held individually on artificial diet to determine percent mortality due to NPV.

At 46 days after treatment, samples of 25 ears each were checked for larval exit holes or large amounts of damage to determine the percentage of ears that produced last-stage larvae. At this time, 8 soil samples, 1 $m^2 \times 10$ cm deep, from each plot, were examined for pupae and pupal cases. The soil samples were taken along 2 lines 50 rows apart. The first sample on each line was taken ca. 90 m into the plot and the 3 subsequent samples at ca. 45 m intervals. At 56 days after treatment, ears were sampled, at random, from 3 rows ca. 10 m in from the edge of the plots and the number of kernels missing from each ear was counted. Thirty ears were sampled from each plot of 2340 and 40 ears from each plot of RX-405-W because of the lower number of kernels destroyed in RX-405-W.

The data were analyzed using the analysis of variance procedure and a split plot design (SAS 1982).

Results and Discussion

The mean number and stage of CEW per silk mass one day before treatment was 1.6 eggs, 0.85 small larvae, 0.03 medium larvae, and 0.005 large larvae. At this time there was no significant difference due to hybrid or treatment and there was a 1.58% natural incidence of NPV in CEW larvae collected the day before treatment.

When silks were checked 4 days post-treatment (PT), there were no significant differences in numbers of small, medium, or large larvae. However, the larvae collected 4 days PT and held in the laboratory to determine percent mortality due to NPV showed a significant effect due to hybrid and a highly significant effect due to treatment (Table 1). The mortality due to NPV was higher in larvae collected from treated plots than from control plots and was higher in both treated and control plots of the tight husk hybrid RX-405-W than in the treated and control plots of the loose husk hybrid 2340.

By 8 days PT, there was a significant reduction in number of small CEW larvae due to treatment (Table 2). There was a greater reduction in number of small larvae on RX-405-W than on 2340. Both hybrid and treatment had highly significant effects on the percent NPV in larvae collected at 8 days PT.

By 15 days PT, there were highly significant reductions in number of small and medium CEW larvae and a significant reduction in number of large larvae due to treatment (Table 3). There were significant differences due to hybrid in number of small and large larvae. The significant hybrid X treatment interaction in number of small and medium larvae is probably the result of larvae feeding longer on the exposed silks of

RX-405-W whereas they could move under the husk to feed on uncontaminated silks more easily on hybrid 2340. This, and the higher incidence of NPV on RX-405-W at 8 days PT, could account for the much higher rate of reduction in larvae on RX-405-W than on 2340. There was a highly significant effect due to treatment on percent mortality due to NPV of larvae collected at 15 days PT, but there was no longer a significant effect due to hybrid. The percent NPV in larvae collected from 2340 at 15 days PT was higher than it was at 8 days PT, whereas the percent NPV in larvae collected from RX-405-W declined from the values at 8 days PT.

Figure 1 shows the decline of the CEW larval population as the corn silks matured and lower larval populations in plots of both hybrids treated with Elcar than in untreated plots. Figure 2 shows the higher incidence of NPV in larvae collected from Elcar-treated plots than from untreated plots of both hybrids. It also shows the increase in NPV in larvae collected 8 days PT over those collected 4 days PT. The general leveling off of the incidence of NPV between 8 and 15 days PT was associated with a

TABLE 1. MEAN NUMBER OF CORN EARWORM LARVAE IN THREE SIZE CATEGORIES PER EAR AT 4 DAYS PT, AND MEAN PERCENT MORTALITY DUE TO NPV BASED ON SAMPLES COLLECTED AT 4 DAYS PT.

Hybrid	Treatment	Number of larvae per ear			% NPV
		Small	Medium	Large	
2340	Control	1.600	0.600	0.090	4.72
2340	Elcar	1.095	0.815	0.195	41.32
RX-405-W	Control	1.960	0.545	0.085	14.19
RX-405-W	Elcar	1.555	0.650	0.085	51.43
		P>F	P>F	P>F	P>F
Hybrid		0.1591	0.3807	0.2821	0.0482*
Treatment		0.1277	0.2255	0.3202	0.0004**
Hybrid X treatment		0.8434	0.6454	0.3202	0.9310

*Significant at 0.05 level.
**Significant at 0.01 level.

TABLE 2. MEAN NUMBER OF CORN EARWORM LARVAE IN 3 SIZE CATEGORIES PER EAR AT 8 DAYS PT, AND MEAN PERCENT MORTALITY DUE TO NPV BASED ON SAMPLES COLLECTED AT 8 DAYS PT.

Hybrid	Treatment	Number of larvae per ear			% NPV
		Small	Medium	Large	
2340	Control	0.705	0.945	0.355	23.48
2340	Elcar	0.650	0.750	0.305	44.48
RX-405-W	Control	1.090	0.775	0.260	40.26
RX-405-W	Elcar	0.640	0.595	0.215	60.81
		P>F	P>F	P>F	P>F
Hybrid		0.0960	0.2219	0.1964	0.0027**
Treatment		0.0433*	0.1707	0.4711	0.0011**
Hybrid X treatment		0.0845	0.9500	0.9686	0.9336

*Significant at 0.05 level.
**Significant at 0.01 level.

TABLE 3. MEAN NUMBER OF CORN EARWORM LARVAE IN 3 SIZE CATEGORIES PER EAR AT 15 DAYS PT AND MEAN PERCENT MORTALITY DUE TO NPV BASED ON SAMPLES COLLECTED AT 15 DAYS PT.

Hybrid	Treatment	Number of larvae per ear			% NPV
		Small	Medium	Large	
2340	Control	0.190	0.325	0.565	28.39
2340	Elcar	0.185	0.280	0.315	52.50
RX-405-W	Control	0.200	0.350	0.330	37.58
RX-405-W	Elcar	0.080	0.150	0.150	45.55
		P>F	P>F	P>F	P>F
Hybrid		0.0243*	0.0749	0.0375*	0.749
Treatment		0.0097**	0.0050**	0.0301*	0.008**
Hybrid X treatment		0.0129*	0.0242*	0.6203	0.069

*Significant at 0.05 level.
**Significant at 0.01 level.

decline in number of larvae per ear (Fig. 1) and a decline in the proportion of small and medium larvae, which are more susceptible to virus than large larvae (Tables 2 and 3).

Based on the exit holes in the husks or extensive damage to the ears, a high percentage of ears produced one or more large larvae (Table 4) and there was a greater effect due to hybrid than to treatment. The virus treatment reduced the number of ears producing large larvae by only 1% in hybrid 2340 compared to 19.2% in RX-405-W. Based on the pupae and pupal cases found in the soil (Table 5), some of the large larvae were fall armyworms (FAW), *Spodoptera frugiperda* (J. E. Smith).

The number of pupae in the soil samples was quite variable. Due to this variability and to the low degrees of freedom with only 2 replicates per hybrid, there was no significant effect due to hybrid or treatment, although there was a slight increase in CEW pupae in the treated plots of hybrid 2340 and a 30% decrease in CEW pupae in treated plots of RX-405-W. Where there was a decrease in number of CEW pupae there was an increase in number of FAW pupae. If the percentage of FAW pupae found in the soil samples is used to correct the number of large larvae produced (Table 4), then the percent reduction in large CEW larvae becomes 30.3 on RX-405-W, rather than 19.1, which is very close to the 30.1% reduction in pupae on RX-405-W.

There was a highly significant effect due to hybrid and a significant effect due to treatment on the number of kernels destroyed per ear (Table 6).

TABLE 4. MEAN NUMBER OF EARS PER SAMPLE OF 25 WHICH PRODUCED A LARGE LARVA.

Hybrid	Treatment	No. of Ears	
2340	Control	24.88 = 99.52%	
2340	Elcar	24.63 = 98.52%	1.0% reduction
RX-405-W	Control	23.38 = 93.52%	
RX-405-W	Elcar	18.88 = 75.52%	19.2% reduction
		F	P>F
Hybrid		16.49	0.015*
Treatment		7.08	0.056
Hybrid X treatment		5.67	0.076

*Significant at 0.05 level.

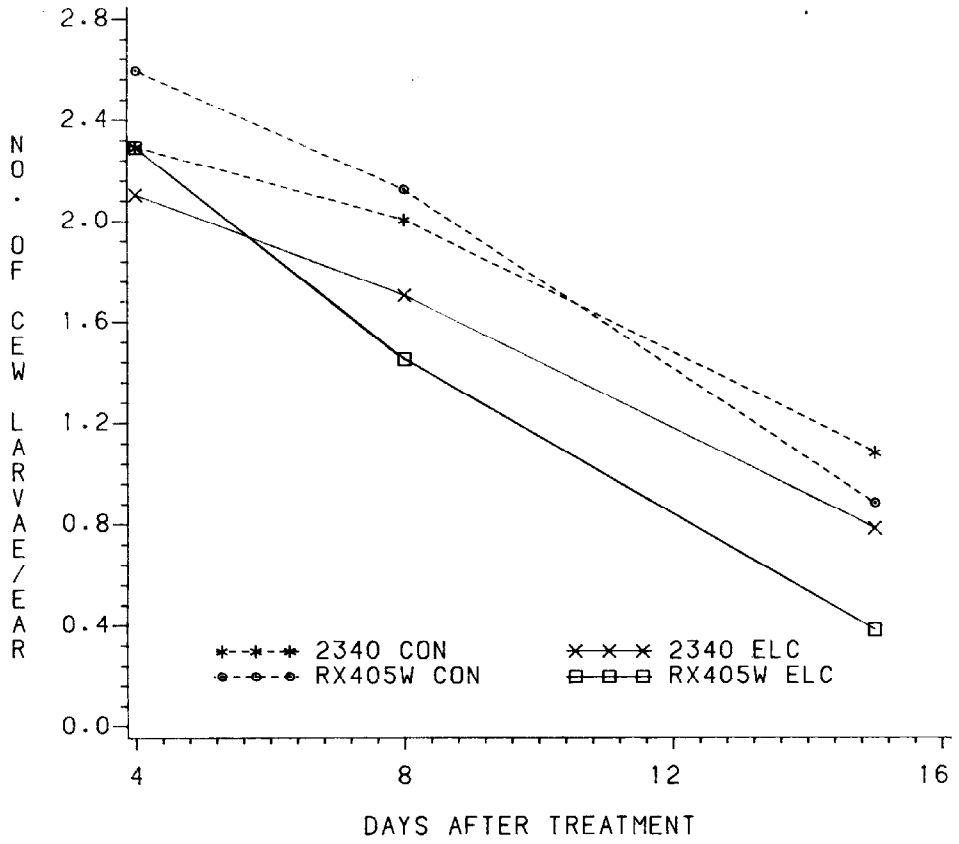

Fig. 1. Mean number of live corn earworm larvae per ear on two hybrids of field corn at 4, 8, and 15 days after treatment with Elcar compared to untreated.

The Elcar treatment saved more kernels on the loose husk hybrid, 2340, than it saved on RX-405-W with the tight husk extension, even though the opposite was true for reduction in large larvae and pupae. Apparently most larvae completed development in the silk channel and fed on only a few kernels of the hybrid with the tight husk extension. This would explain the much lower kernel damage in the control plots of RX-405-W than in the control plots of 2340. Therefore, even though the percent reduction in kernels destroyed was slightly higher for the hybrid with the tight husk extension

TABLE 5. MEAN NUMBER OF CORN EARWORM AND FALL ARMYWORM PUPAL CASES PER SQUARE METER (46 DAYS PT).

Hybrid	Treatment	No. pupal cases/sq.m				Plants/ sq. m	CEW pupae/ plant	
		CEW		FAW				
2340	Control	1.75		0.56		5.75	0.29	
2340	Elcar	1.88		0.44		5.88	0.32	
RX-405-W	Control	2.69		0.25		7.13	0.38	
RX-405-W	Elcar	1.88		0.50		7.06	0.27	
		F	P>F	F	P>F		F	P>F
Hybrid		2.92	0.1626	0.53	0.5057		0.26	0.6354
Treatment		1.57	0.2783	0.13	0.7335		0.92	0.3921
Hybrid X treatment		2.92	0.1626	1.20	0.3349		2.86	0.1662

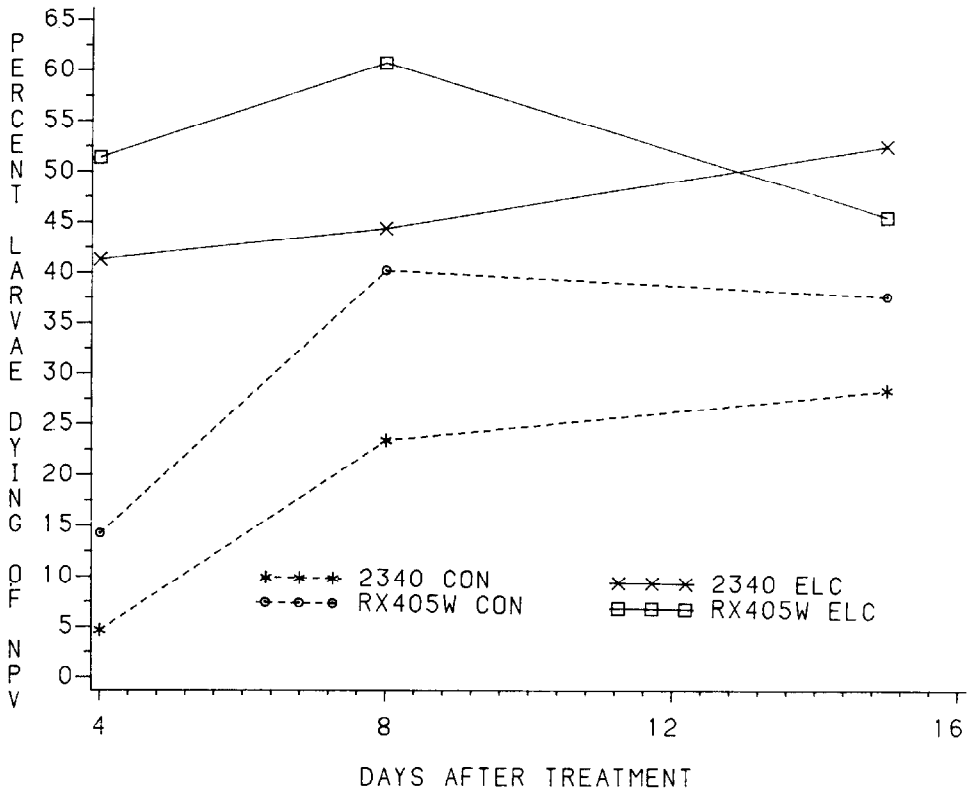

Fig. 2. Percent of corn earworm larvae dying of nuclear polyhedrosis virus after collection from two hybrids of field corn at 4, 8, and 15 days after treatment with Elcar or untreated.

than for the loose husk hybrid, the actual number of kernels saved by the virus treatment was much higher for the hybrid with the loose husk because of the higher number of kernels destroyed in the control plots.

The *Heliothis* NPV occurs naturally in the test area, which could account for the occurrence of NPV in the control plots. However, the incidence of NPV in the control plots may have been increased above the natural level by spray drifting from the treated plots, by movement of insects that were contaminated at the time of treatment, and by movement of parasites and predators that had stung or fed on NPV-infected larvae in the treated plots.

Ignoffo et al. (1973) reported a half-life for the *Heliothis* virus on corn silks of less than 1 day. Thus, most of the virus applied in the treatment would be inactivated within a day or two. In order for an ear to be protected further, at least one larva must consume an infective dose of the virus, enter the silk channel, and die, thus contaminating the ear with fresh virus. Therefore, those ears which did not have larvae feeding on the exposed silks at the time of treatment, or did not have larvae hatch and feed within one day of treatment, probably would not have been protected from later infestation by CEW.

Because 50% or fewer of the larvae sampled 4 days PT died of NPV (Table 1), we assume that no more than half of the ears that had only one larva at the time of treatment would have had virus-infected larvae dying and contaminating the ears. This helps explain why the mortality due to NPV peaked at 50 to 60% in the treated plots and demonstrates the importance of population density at the time of treatment when only a single application of the virus is made.

TABLE 6. MEAN NUMBER OF KERNELS DESTROYED PER EAR.

Hybrid	Treatment	Number of kernels destroyed	
2340	Control	20.31	
2340	Elcar	9.03	= 56% reduction
RX-405-W	Control	4.36	
RX-405-W	Elcar	1.65	= 62% reduction
		F	P>F
Hybrid		35.41	0.0040**
Treatment		12.74	0.0234*
Hybrid X treatment		4.78	0.0942

*Significant at 0.05 level.
**Significant at 0.01 level.

Multiple applications of the virus would increase the probability of larvae dying in plants if the silks that were not infested during the first application were infested during a subsequent application. Hamm and Hare (1982), working with the NPV of FAW, showed an increase in the percent mortality due to NPV when the same total amount of virus was divided into 2 or 3 applications. The high cost of aerial applications may prevent the use of multiple applications of the virus. However, multiple applications would be more practical for corn grown under sprinkler irrigation if the virus were applied through the irrigation system.

More research is needed to determine the effects of different corn hybrids on the effectiveness of the *Heliothis* NPV. Also, more research is needed on effects of the population density of the corn earworm and frequency of application of the virus on the control of CEW in corn in order to evaluate the potential of Elcar for reducing the population of CEW moths available for migration out of northeastern Mexico.

ENDNOTE

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GREENHOUSE AND FIELD EVALUATIONS OF GRANULAR SOIL INSECTICIDES FOR CONTROL OF SUGARCANE BEETLE, *EUTHEOLA RUGICEPS* (COLEOPTERA: SCARABAEIDAE) IN FIELD CORN

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ABSTRACT

Seven granular soil insecticides were tested in the greenhouse and field for control of adult *Eutheola rugiceps* (Lec.). Terbufos, isofenfos and phorate provided consistently good control. Chlorpyrifos, fensulfothion and ethoprop produced variable levels of control. Carbofuran was least effective of the insecticides tested.

RESUMEN

La efectividad de 7 insecticidas en granulos para la tierra, para el control del adulto *Eutheola rugiceps* (Lec.) fué examinada en vivieros y en el campo. Terbufos, isofenfos y phorate proveyeron consistentemente un buen control. Chlorpyrifos, fensulfothion y ethoprop producieron variables niveles de control. Carbofuran fué el menos efectivo de los insecticidos probados.

The sugarcane beetle, *Eutheola rugiceps* (Lec.), is an occasional pest of seedling corn in Louisiana. Adults damage corn by chewing into the subterranean portion of the plant, killing small seedlings and stunting large plants. In Louisiana beetle activity begins in late March and early April and peaks when corn is in the seedling stage.

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Eutheola rugiceps has been a significant pest of corn in the south. Its life history, damage and cultural control in corn was described by Baerg (1942), and Phillips and Fox (1926). Chemical control of the beetle in corn was investigated by Henderson et al. (1958) and Eden (1954). With the exception of phorate, the insecticides they tested are no longer available to corn producers.

No insecticides are presently registered for the control of this beetle. Since farmers routinely apply a soil insecticide for the control of the southern corn rootworm, granular insecticides registered for this use were evaluated for effectiveness against the sugarcane beetle.

Methods

The first experiments were conducted in 1981 and 1982 in a greenhouse using 12-cm-diameter, 2-liter plastic pots filled with soil. Soil used was a silt-sand alluvial soil, obtained from the immediate bank of the Mississippi River. It was deposited during the annual spring rise of the river, several months prior to the experiments, and had no known prior exposure to insecticides.

The granular insecticides carbofuran 10G, chlorpyrifos 15G, ethoprop 10G, fensulfothion 15G, isofenfos 20G, phorate 15G, and terbufos 15G were valuated at the rates of 1.12, 1.68 and 2.24 kg AI/ha. Carbofuran at .56 kg AI/ha was also tested in 1981. Insecticides were applied by hand in a manner that approximated in-furrow and band applications in the field. The furrow applications were made across the pots at a depth of 3.5 cm and covered with soil. Banded applications were sprinkled on the soil surface and covered with 5 mm of soil. In 1982, insecticides were applied at the 1.12 and 2.24 kg a.i./ha rates in simulated bands only. Pots were watered immediately after application. In 1981 pots were watered again 9 days later and beetles introduced 10 days after insecticide application. In 1982 the second watering and beetle introduction were 6 and 9 days respectively after insecticide application. Four replications of each insecticide treatment were used.

Ten beetles were placed in each pot and observed until they had burrowed into the soil. Pots were then covered with cardboard lids fitted with 3-mm mesh hardware cloth. Lids were weighted and pot bottoms covered with 4 layers of aluminum foil to prevent beetle escape. Pots were emptied, soil sifted, and living and dead beetles counted 5 and 6 days after introduction in 1981 and 1982 respectively. Greenhouse temperature during the experiments was 29 ± 2°C.

In the field chlorpyrifos 15G, ethoprop 10G, fensulfothion 15G, isofenfos 20G and terbufos 15G were evaluated. Carbofuran was consistently inferior in the greenhouse tests and was therefore not included in the field trial. Phorate was not field tested since it is not widely used by Louisiana corn producers. Insecticides were applied on May 13, 1983 as in-furrow and 20 cm wide band applications at 1.12 kg AI/ha using a two row John Deere model 71 planter. Banded insecticides other than ethoprop were applied over the open furrow, covered by the press wheel and further incorporated by drag chains. All ethoprop applications were made behind the press wheel and incorporated by drag chains. Pioneer Brand 3030 field corn was planted as the insecticides were applied.

A completely randomized block design was used with 3 replications. Each treatment consisted of a 2 × 2 × 2 m Saran screen cage placed over two treated rows and enclosing 9 corn plants. The cages were installed and 100 sugarcane beetles placed in each on May 27. Insecticides were evaluated on May 31 by sifting all the soil in the cage to a depth of 25 cm and counting the number of dead and live plants and dead and live beetles recovered.

TABLE 1. PERCENT MORTALITY OF SUGARCANE BEETLES IN A GREENHOUSE EVALUATION OF FOUR GRANULAR SOIL INSECTICIDES.

Insecticide and Formulation	Kg ai/hectare	Method of Application	% Mortality[1]
Isofenfos 20 G	1.12	Furrow	100.0 a
Isofenfos 20 G	1.12	Band	100.0 a
Isofenfos 20 G	2.24	Furrow	100.0 a
Isofenfos 20 G	1.68	Band	100.0 a
Terbufos 15 G	1.12	Furrow	100.0 a
Terbufos 15 G	1.12	Band	100.0 a
Terbufos 15 G	1.68	Band	100.0 a
Terbufos 15 G	2.24	Band	100.0 a
Phorate 15 G	1.12	Band	100.0 a
Phorate 15 G	2.24	Band	100.0 a
Isofenfos 20 G	1.68	Furrow	93.7 a
Terbufos 15 G	2.24	Furrow	93.7 a
Phorate 15 G	1.68	Band	93.7 a
Terbufos 15 G	1.68	Furrow	91.6 a
Isofenfos 20 G	2.24	Band	83.3 a
Carbofuran 10 G	2.24	Band	45.8 b
Carbofuran 10 G	1.68	Furrow	33.3 bc
Carbofuran 10 G	1.68	Band	31.2 bc
Carbofuran 10 G	2.24	Furrow	19.4 bcd
Carbofuran 10 G	1.12	Band	8.3 bcd
Carbofuran 10 G	0.56	Furrow	0.0 d
Carbofuran 10 G	1.12	Furrow	0.0 d
Carbofuran 10 G	0.56	Band	0.0 d
Check			0.0 d

[1]Means followed by the same letter do not differ significantly (P = 0.05) (DMRT).

The soil in the experimental area was a silt-sand recent alluvial soil with good drainage. Its last exposure to soil insecticides was two years earlier when a small plot test of carbofuran, isofenfos, phorate and terbufos was conducted. Fifteen cm of precipitation fell on the study area between planting and infestation. Temperature extremes at ground level within the cages during the infestation period were 35.6 and 15.6°C respectively.

Sugarcane beetles were collected one to two weeks prior to each experiment using black light traps. They were maintained in the laboratory in ten gallon aquaria half filled with silt-sand soil obtained from the immediate bank of the Mississippi River. Apple slices were fed to the beetles twice weekly.

Data were analyzed using analysis of variance and Duncan's multiple range test.

RESULTS AND DISCUSSION

Isofenos, phorate and terbufos produced the best results in the initial greenhouse test (Table 1). Carbofuran treatments were ineffective. In 1982, both rates of chlorpyrifos, fensulfothion, phorate and terbufos produced the best results and were statistically inseparable (Table 2). Ethoprop and isofenfos were less effective at the lower rate, and carbofuran was again ineffective at both high and low rates.

TABLE 2. PERCENT MORTALITY OF SUGARCANE BEETLES IN A GREENHOUSE EVALUATION OF SEVEN GRANULAR SOIL INSECTICIDES.

Insecticide and Formulation	kg ai/hectare	$\bar{X}$ % dead beetles[1]
Phorate 15 G	1.12	100.0 a
Phorate 15 G	2.24	97.5 ab
Isofenfos 20 G	2.24	97.5 ab
Terbufos 15 G	2.24	97.5 ab
Terbufos 15G	1.12	95.0 ab
Fensulfothion 20 G	2.24	92.5 abc
Chlorpyrifos 15 G	1.12	85.0 abc
Chlorpyrifos 15 G	2.24	85.0 abc
Fensulfothion 15 G	1.12	82.5 abc
Ethoprop 10 G	2.24	77.5 bc
Isofenfos 20 G	1.12	72.5 c
Ethoprop 10 G	1.12	52.5 d
Carbofuran 10 G	2.24	27.5 e
Carbofuran 10 G	1.12	17.5 ef
Check		00.0 f

[1]Means followed by the same letter do not differ significantly (P = 0.05) DMRT.

TABLE 3. PERCENT MORTALITY OF SUGARCANE BEETLES AND CORN PLANTS IN A FIELD EVALUATION OF FIVE GRANULAR SOIL INSECTICIDES AT 1.12 KG AI/HA IN FIELD CORN.

Insecticide and Formulation	Placement Method	$\bar{X}$ % Dead[1] Beetles	$\bar{X}$ % Dead Plants	Total Beetles Recovered
Terbufos 15 G	Band	86.8 a	51.9 a	138
Terbufos 15 G	Furrow	84.1 a	68.8 ab	134
Chlorpyrifos 15 G	Band	83.6 a	56.6 a	128
Isofenfos 20 G	Band	80.7 a	77.8 ab	144
Fensulfothion 15 G	Band	66.0 a	77.8 ab	117
Ethoprop 15 G	Band	20.0 b	96.3 b	55
Check		9.7 b	88.9 b	83

[1]Means followed by the same letter do not differ significantly (P = 0.05) DMRT.

In the field, terbufos, chlorpyrifos, isofenfos and fensulfothion were most effective (Table 3). Ethoprop was ineffective possibly due to its application as a band on top of the covered seed furrow allowing greater exposure to weather.

The percent of plants killed corresponded inversely to the effectiveness of the insecticide treatments with exception of the furrow application of terbufos. A possible explanation for the greater number of dead plants in this treatment could be the beetles' habit of burrowing just below the soil surface when feeding on corn. They would not be deep enough to directly contact the insecticide and therefore would be able to inflict more damage before being killed. In all treatments, all plants not counted as dead were damaged by the beetles. This was attributed to the large number of beetles used per cage in the experiment.

All the insecticides tested are registered for use on corn at or above the 1.12 kg AI/ha rate. In Louisiana, carbofuran has been the most frequently used insecticide for soil insect control in corn, terbufos and fensulfothion are also used. Based on the greenhouse experiments, growers should not expect sugarcane beetle control if carbofuran is used at planting. Isofenfos is no longer available for use on corn, therefore terbufos, fensulfothion or chlorpyrifos would be preferable if the sugarcane beetle is a recurrent problem.

ACKNOWLEDGMENTS

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BIBLIOGRAPHY OF IMPORTED FIRE ANTS AND THEIR CONTROL: SECOND SUPPLEMENT

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The red and black imported fire ants (IFA), *Solenopsis invicta* Buren and *S. richteri* Forel, now occupy more than 52 million ha in the southern United States. The literature on these controversial pests was collected in a bibliography (46) in 1978 and a supplement (370) in 1982. Since the first supplement was compiled, the flow of literature on IFA has increased to such an extent that a second supplement is warranted.

The primary source of citations for this supplement was the Agricultural Research Service Current Awareness Literature Service provided by the Lending Division, National Agricultural Library. This service is a computerized search of Biological Abstracts, Biological Abstracts/RRM, Chemical Abstracts, AGRICOLA (USDA's National Agricultural Library file), and the Commonwealth Agricultural Bureaux. Current Contents/Agricultural, Food, and Veterinary Sciences and Dissertation Abstracts were

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manually searched. Hard copies of all citations were examined for categorization. Some citations, mainly M.S. theses and popular articles, were provided by cooperative researchers. In addition, a number of citations were found serendipitously, by perusing scientific journals. This latter category of citations consisted mainly of secondary references; however some primary citations were found that had improper key words or indexing.

All scientific papers dealing with any aspect of IFA biology and control are included. Popular articles (category J) (newspapers excepted) are included as these are the articles that the public reads and asks scientists about. Secondary references (category I) are included because these references integrate and synthesize published information on IFA with information on other ants and social insects. Any papers dealing only with residues resulting from IFA chemical treatments in non-target organisms or with physiological effects of toxicants in non-target organisms are not included.

The literature search for this bibliography was completed in October 1985. I continue to solicit reprints or citations on IFA literature, particularly M.S. theses, Ph.D. Dissertations, and popular articles for inclusion in future supplements.

Annotations indicate the subject categories for each citation.

A = Taxonomy, Morphology
B = Biology, Ecology
C = Chemistry, Physiology
D = Medical, Economic Effects
E = Control; other than Biological
F = Biocontrol
G = Symbionts
H = Regulatory
I = Secondary References
J = Popular article
K = Bibliography
L = Extension

The citations in each category are listed in Table 1.

Mention of a proprietary product does not constitute an endorsement or recommendation for its use by the U.S. Department of Agriculture.

La hormiga roja importada y la hormiga negra importada, *Solenopsis invicta* Buren y *S. richteri* Forel, ocupan ahora mas de 52 millones de ha en el sur de los Estados Unidos. La literatura sobre estas debatidas plagas fue obtenida de una biliografía (46) en 1978 y de un suplemento (370) en 1982. Desde que el primer suplemento se compiló, el volumen de la literatura sobre *Solenopsis* ha aumentado a tal extremo que es justificado un segundo suplemento.

La fuente principal de las citaciones para este suplemento fue el "Agricultural Research Service Current Awareness Literature Service" proveido por el "Lending Division, National Agricultural Library". Este servicio consiste de una búsqueda computarisada de Resúmenes Biológicos, Resúmenes Biológicos/RRM, Resúmenes Químicos, AGRICOLA (archivo de la Biblioteca Agricola Nacional de USDA), y del "Commonwealth Agricultural Bureaux". Contenidos Actuales/Agricolas, Alimentos, y Ciencias Veterinarias y Resúmenes de Disertaciones fueron manualmente investigadas. Copias de todas las citaciones fueron examinadas para categorisarlas. Algunas citaciones, principalmente tesis de Masters (M.S.) y artículos populares, fueron suministrados por investigadores cooperadores. Además, un número de citaciones se encontraron accidentalmente escudriñando revistas científicas. Esta última categoría de

TABLE 1. CITATIONS IN EACH CATEGORY.

A	8, 36-39, 140, 230, 248, 256-259, 327, 342, 371, 372.
B	5-10, 28-30, 36-39, 55, 58, 60, 63, 64, 69, 71, 73, 70, 85-88, 95-97, 99, 100-107, 109-114, 117, 121-125, 128-134, 137, 139, 140, 146, 147, 153-155, 157, 159, 164, 174, 175, 179, 181, 188, 192, 198-204, 206, 208, 213, 216, 217, 219, 220, 227, 228, 230, 233, 234, 248, 249, 255, 257-259, 261, 263-265, 267, 268, 270, 271, 274-276, 279, 282, 287, 289-298, 302, 307-309, 311-313, 315-319, 326, 329, 330, 335, 339, 341-345, 358, 359, 361, 363-369, 371-373.
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D	1-4, 8, 20, 27, 33, 35, 59, 61, 63, 64, 72, 91, 92, 98, 119, 124, 127, 135, 138, 141, 142, 144, 148, 150, 172, 180, 189, 191, 193, 195, 197, 229, 231, 240, 241, 243-245, 254, 277-279, 281, 283, 289, 300, 301, 304, 310, 323.
E	10, 11, 15, 16, 19, 21, 22, 28, 31, 41-45, 47, 50-52, 54, 63-65, 75-78, 80, 84, 89, 93, 97, 98, 104, 108, 111, 118, 120, 131, 145, 149, 151, 152, 184-187, 190, 195, 196, 201-203, 206-209, 211, 218, 220-222, 224, 229, 238, 250-252, 269, 277, 278, 280, 284-287, 303, 322-324, 330, 331, 333, 346-357, 362.
F	25, 53, 74, 126, 167-171, 176, 226, 278, 287, 369.
G	83, 126, 136, 168, 177, 214, 235, 236, 266, 305, 334, 369.
H	12, 23, 24, 34, 94, 115, 116, 182, 183, 246, 247, 278, 287, 299, 300, 314, 323.
I	2, 8, 22, 27, 32, 35, 41, 45, 47, 50, 55, 57-62, 69, 72, 78, 87, 111, 121, 126, 128, 141, 142, 146, 148-150, 156, 158, 165, 166, 168-170, 177, 182, 183, 188, 193-197, 213, 220-222, 224, 229, 231, 238, 242, 243, 249, 264, 265, 278, 281, 283, 284, 287, 301, 304, 307, 316, 317, 320, 323, 325-327, 330, 337, 338, 341, 342, 346-348, 363-369.
J	11, 14-21, 56, 67, 68, 80, 81, 89, 93, 96, 135, 136, 143, 151, 173, 176, 190, 209, 214, 225, 241, 260, 266, 309, 321, 322, 324, 336.
K	46, 205, 370.
L	13, 26, 48, 49, 178, 215, 239, 306.

citaciones consistió principalmente de referencias secundarias; sin embargo, se encontró que algunas citaciones primarias tenían palabras claves o índices impropios.

Se incluyen todos los trabajos científicos que tratan con cualquier aspecto de la biología y control de *Solenopsis*. Artículos populares (categoria J) (exceptuando periódicos) son incluidos puesto que estos son los artículos que el público lee y pregunta sobre ellos. Se incluyen referencias secundarias (Categoria I) porque estas referencias integran y sintetizan información publicada sobre *Solenopsis* que contienen información sobre otras hormigas e insectos sociales. No se incluyen trabajos que tratan sobre residuos de tratamientos químicos con *Solenopsis* en los organismos que no fueron

objetivos, o trabajos con efectos fisiológicos de toxicantes en los organismos que no fueron su objetivo.

La búsqueda de la literatura para esta bibliografía fue completada en Octubre de 1985. Yo continuo solicitando copias o citaciones en la literatura sobre *Solenopsis*, particularmente Tesis de Masters, Disertaciones de Ph.D., y artículos populares para incluirlos en futuros suplementos.

Las anotaciones indican las categorías de los sujetos de cada citación.

A = Taxonomía, Morfología
B = Biología, Ecología
C = Química, Fisiología
D = Medicina, Efectos Económicos
E = Control; otro que Biológico
F = Biocontrol
G = Simbiótico
H = Regulatorio
I = Referencias Secundarias
J = Articulos Populares
K = Bibliografía
L = Extensión

Las citaciones en cada categoria están listadas en el Cuadro 1.

Mención de un producto registrado no constituye un endorso o recomendación de su uso por el Departamento de Agricultura de los Estados Unidos.

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SCIENTIFIC NOTES

VERTICILLIUM LECANII, A NEW FUNGAL PARASITE OF THE SCALE *PHILEPHEDRA TUBERCULOSA* N. SP. (HOMOPTERA: COCCIDAE) IN FLORIDA

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Philephedra tuberculosa n. sp., (Homoptera: Coccidae) (Nakahara and Gill 1985), is a new pest of many ornamentals and tropical fruit trees in Florida (Pena et al., data unpublished). The scale population peaks are found during the months of July-October coinciding with the rainy season in Southern Florida, where relative humidity ranges 80 ± 10%. The fungus *Verticillium lecanii* (Zimmenn) Viegas, was found throughout most of the Dade County area during August-October, 1983, infecting scale immature and adult stages. An epizootic of *V. lecanii* did not begin until after three moderate to heavy rains. The same pattern was observed during July-October, 1984, where approximately 4,000 fungus infected female scales were collected from leaves, petioles and branches of *Callophyllum* sp., and *Annona squamosa* (L.). *Verticillium lecanii* was isolated from the infested scales, and morphologically differs from the usual *Verticillium lecanii* form (B. L. Brady, Commonwealth Mycological Institute, U.K.) (McMillan and Pena 1985).

Although the fungus has previously been found on *Saissetia oleae* (Homoptera: Coccidae) in Florida (C. McCoy, Lake Alfred, IFAS, University of Florida, pers. comm.), it was not previously known to parasitize *Philephedra* n. sp. The fungus has also been reported on *Hoplocampa testudinea* Klug (Hymenoptera: Tenthredinidae) (Jaworska 1979), on *Coccus viridis* Green (Kohler 1980) and its use is considered promising against *Thrips tabaci* Lindeman (Binns et al. 1982). According to Ekbom (1981) 16 h of 100 RH are needed to obtain mycelial growth and to cause whitefly (*Trialeurodes vaporiorum* Westwood) death under green house conditions.

In a preliminary greenhouse experiment (27 ± 3°C, 75-86% RH, Photophase 14:10) a suspension of ca. 30,315 spores/ml was sprayed to a scale population infesting *A. squamosa* (6 month old) potted plants. An average of 1.4 females and 18 immature stages per leaf were observed before treatment. Percent survival of the population was observed every week during ca. 40 days. Percent survival ranged from 50-35% during the first 8 days and differed significantly ($P < 0.05$) from the control at 15 (14% survival), and 25 (12% survival) days after treatment. Thereafter, in a laboratory test (24°C 75 RH) four groups of 64 gravid female scales, field collected from *A. squamosa* leaves were confined into (100 × 25 mm) petri dishes and inoculated with *V. lecanii* suspensions (100, 1,000, 10,000 spores/ml, and control replicated 4 times). Five days after treatment, dosis of 1,000 and 10,000 spores/ml proved to cause higher infection than 100 spores/ml or the control (Table 1). Mortality rate in all treatments was significantly higher ($P < 0.05$) from the control at 10 and 15 days after treatment. The mortality levels were at least 1.6 times as high as the level of the control. The mortality rate for the control (48%) was expected since no antifungal agents had been used. However, the average of crawlers emerging from the nontreated scales was 23.6 times higher compared to the treated ones. Based on these results, *V. lecanni* is one of the most promising biotic mortality factors for *Philephedra* n. sp. in Florida.

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TABLE 1. MORTALITY OF *PHILEPHEDRA TUBERCULOSA* N. SP. EXPOSED TO DIFFERENT SPORE SUSPENSIONS OF *V. LECANII*.

Isolate spores/ml	% Scale mortality at days after treatment[a]			Average crawlers emerging/female
	5	10	15	
100	5 a*	66 a	95 a	5
1,000	13 b	45 a	76 a	0
10,000	9 b	63 a	99 a	0
Non-infected (Check)	2 a	8 b	48 b	119

[a]Means in the same column followed by different letters were significantly different ($P < 0.05$) by the Student-Newman Test.

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THE OCCURRENCE OF A VIRUS OF THE POX GROUP IN A FIELD POPULATION OF *CHIRONOMUS SALINARIUS* KIEFFER (DIPTERA: CHIRONOMIDAE) IN ITALY

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A larval population study on *Chironomus salinarius* Kieffer in two saltwater lakes surrounding the city of Orbetello, central Italy, was recently reported by Ali and Majori (1984). In this study, a part (18%) of the *C. salinarius* larval population in a sample taken from one station in June 1982 was patently infected with an entomopoxvirus. Further sampling of that station in June-July 1982 showed the overall disease incidence to be 6% (A. Ali, unpublished). A detailed description of the two lakes (East Lake and West Lake) is available in Ali and Majori (1984). The diseased larvae occurred at station 8 of sampling row G in the West Lake where the lake received domestic and industrial discharges. Patently infected larvae were recognized in the laboratory by the appearance of whitish areas beneath the integument of the entire body caused by massive accumulations of virus polyhedral bodies (PB). Infected 4th instars were randomly separated and placed in a rearing chamber (Biever 1965) to study their survival. Wet mount preparations (in saline) of larval smears of diseased larvae were observed under a phase-contrast microscope and the PB from cells of different host specimens were randomly measured.

For electron microscopy, infected 4th instar *C. salinarius* were fixed in a 2.5% glutaraldehyde in Millonig buffer (pH 7.4) for 1 hour. After rinsing in the buffer, the tissues were postfixed for an hour in 1% OsO_4, dehydrated in acetone series and embedded in Spurr's resin. Thin sections were examined with a Siemen's Elmiskop 102 and Zeiss EM 10 C electron microscope. Suspensions of purified virions (Huger et al. 1970) were negatively contrasted with 2% phosphotungstic acid at pH 7.2 and placed on carbon grids.

Microscopic examination of smears of infected larvae revealed oval shaped PB with a mean size of 7.30 × 5.52 μm but ranging in length from 3.4—13.23 μm and width of 2.47—9.26 μm. Phase-contrast microscopy showed that a variable number of PB may

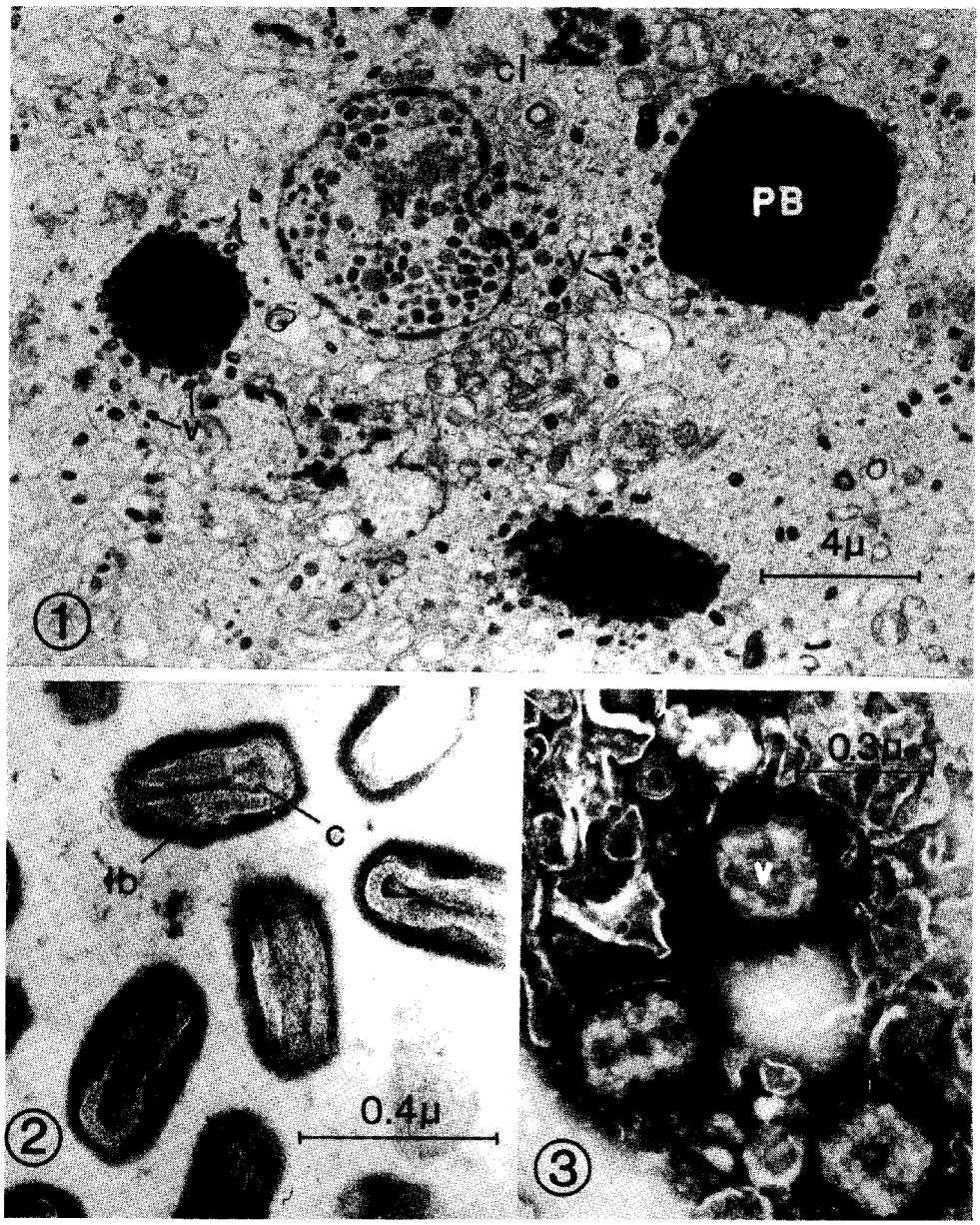

Fig. 1. Poxvirus infected hemocyte from 4th instar *Chironomus salinarius:* at least three polyhedral bodies (PB) are developing in this cell. Inclusion bodies are seen in the nucleus (N) with the chromatin marginated. Immature virions (v) are seen developing in the viral stroma. Concentric cytoplasmic lamella (cl) appears in the cytoplasm.

Fig. 2. Poxvirus virions in polyhedral body of *C. salinarius* showing a dumbbell shaped core (c) and lateral body (lb).

Fig. 3. Negatively stained free virions (v) illustrating the beaded surface characteristic of the poxvirus group.

develop per cell. As many as eight developing PB were observed in a single cell. In accordance with previously available descriptions of chironomid poxviruses, PB development appeared to be in the cytoplasm of hemocyte and fat body cells. The host cell pathology appears to be similar to that already described by Stoltz and Summers (1971). There are inclusion bodies of two types in the nuclei of infected cells and a margination of the chromatin (Fig. 1). Structures similar to the "concentric cytoplasmic lamellae" can be seen in the cytoplasm of infected cells. As with other entomopoxvirus infections, the most distinctive aspect of the cell is the dark staining polyhedral body. The virion appears to mature in the viral stroma surrounding the PB before being encased in the matrix of the PB, apparently at random. Accumulations of infected cells appear as white spots scattered irregularly throughout the body of the diseased larva. With the progression of infection, the normally deep red color of the larva gradually changes to a pale white color. Recognition of poxvirus infected *Chironomus* sp. midge larvae in early stages of disease is aided by the tendency of infected cells to collect in the dorsal region of the 9th abdominal segment just posterior to the heart (Harkrider & Hall 1975).

The cytological examination of infected larval cells revealed the structure of the virion corresponding to that of the subgroup 3 in the genus *Entomopoxvirus* previously described from chironomids and reviewed by Granados (1973). Each virus particle appeared to be composed of three distinct parts: the envelope, the two lateral bodies sandwiched between the envelope, and the centrally located core (Fig. 2). The core, as seen in longitudinal section, appeared typically dumbbell shaped. The overall dimensions of the virions were ca. 320 × 140 nm. The negatively stained whole mount of virions showed the presence of sphaeroid structures on the envelope surface (Fig. 3).

Among aquatic insects, only chironomid midges are reported to be hosts of entomopoxviruses (Anthony 1975). Specifically, Weiser (1969), Huger et al. (1970), Stoltz and Summers (1971), Federici et al. (1974), and Harkrider and Hall (1975) have reported entomopoxviruses in *Camptochironomus tentans*, *Chironomus luridus*, *C. attenuatus* (a junior synonym of *C. decorus*) and *C. plumosus*, *Goeldichironomus holoprasinus*, and *C. decorus*, respectively. The present study documents *C. salinarius* as an additional host species of the virus.

Entomopoxviruses have been shown to play a significant role in the natural regulation of nuisance midge populations (Harkrider and Hall 1978). In laboratory studies, Harkrider and Hall (1979) had demonstrated the important role of high midge population density in the precipitation of an epizootic of entomopoxvirus. However, the reported larval mortalities of field populations of chironomid species infected by poxviruses in different habitats range from <1% to 100% (Weiser 1948, Huger et al. 1970, Anthony 1975). In the present study, all infected 4th instar *C. salinarius* reared in the laboratory died before pupation. In the 2 lakes, 113 sites were systematically sampled, yet only one station (8G) supported significant numbers of diseased larvae. This site (8G) is located in an area receiving large quantities of domestic and industrial discharges. Perhaps pollutants in water and sediments in this area act as stress factors conducive to the viral disease. Alternatively, high nutrient availability in such a location may support dense larval populations resulting in overcrowding which initiates an epizootic; site 8G, by far, supported the highest density (33,330 larvae/m^2) compared to a mean larval density of 4213/m^2 for all sites (Ali and Majori 1984). While the entomopoxvirus appears to have some potential as a biological control agent, the understanding of the epizootiology of the virus is needed before this potential can be assessed.

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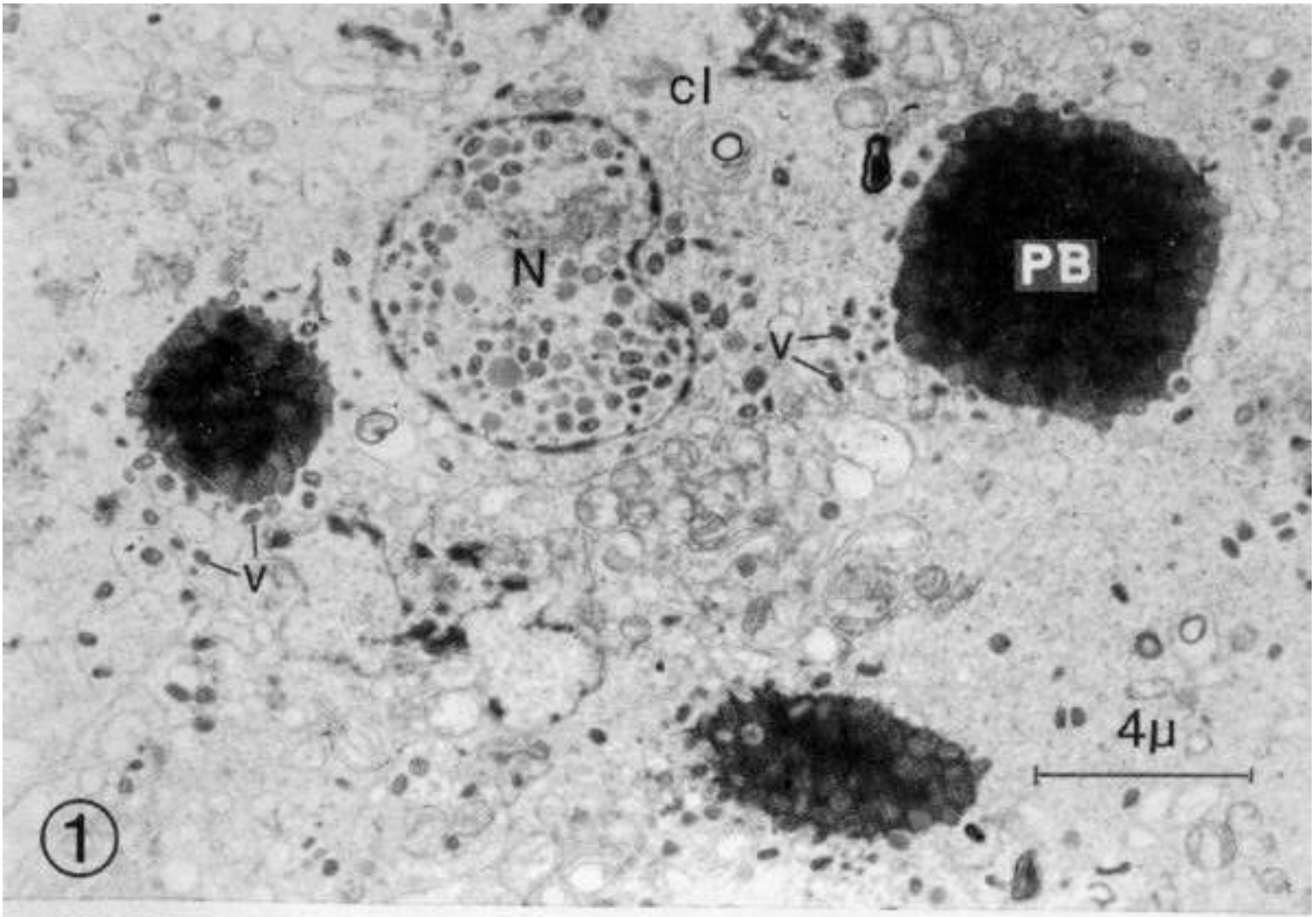
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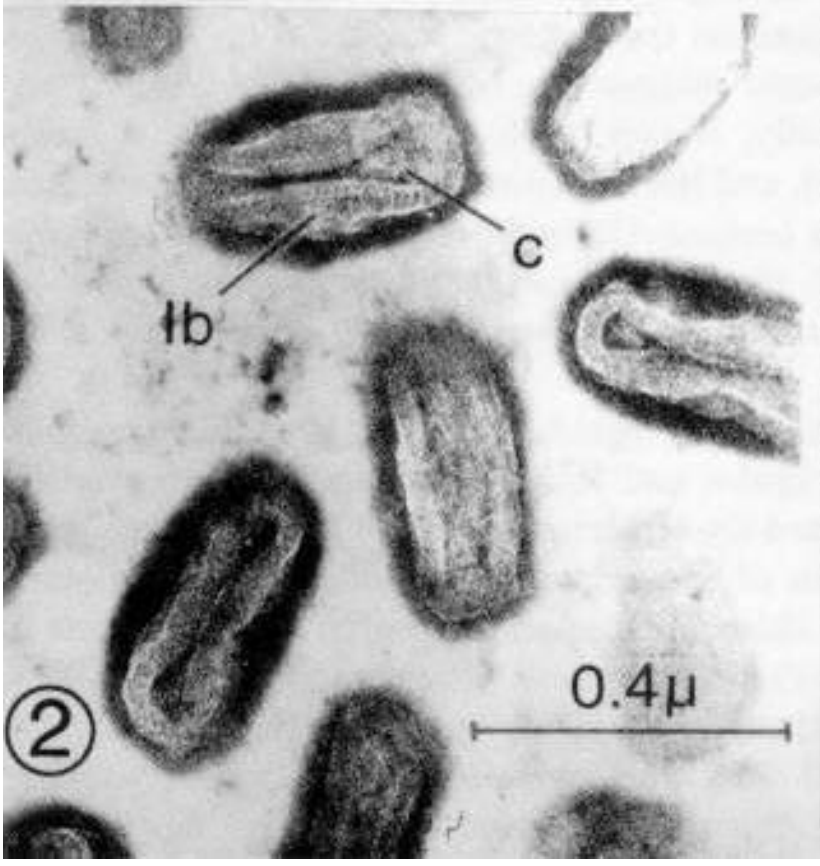
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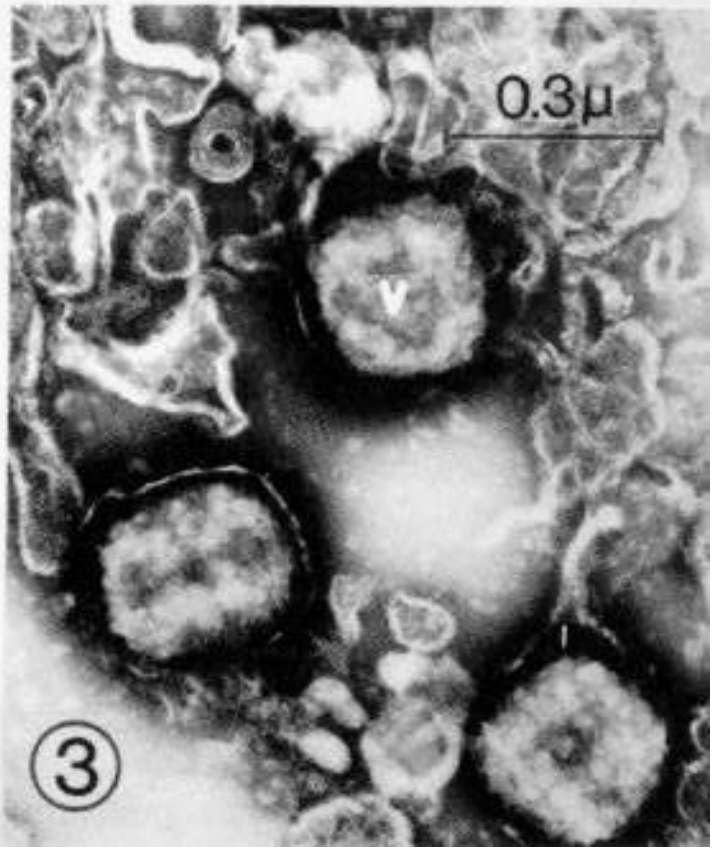
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OCCURRENCE OF THE GERMAN COCKROACH, *BLATTELA GERMANICA* (DICTYOPTERA: BLATTELIDAE), OUTDOORS IN ALABAMA AND TEXAS

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The German cockroach, *Blattella germanica* (L.), is the most serious indoor insect pest of apartments and food handling facilities worldwide (Ebeling 1975). Although this species is considered an indoor pest, there have been several reports of its occurrence outdoors (see references in Cornwell 1968). Because outdoor populations may serve as nuclei for reinfestations, control of outdoor populations could affect indoor control. Presently, insecticide treatments for *B. germanica* are performed exclusively indoors.

In July 1984, during an outdoor cockroach field study in Houston, Harris Co., Texas (Appel and Rust 1985), a total of 20 *B. germanica* was captured in live traps positioned throughout the 0.23 ha residential site. Adult females accounted for 50% of the trap catch whereas adult males and nymphs represented 20 and 30%, respectively. Four of the 9 traps that captured *B. germanica* were located under or next to houses. The remaining traps were located next to garages or fences, 10-15 m from the closest house. Trap sites and immediate surrounding areas were thoroughly inspected during daylight to locate cockroach harborage sites. Trap sites and nearby areas under houses had small (ca. 30) cockroach populations harboring in cracks between the joist and sill. No cockroaches were observed at or near exposed trap sites next to houses, garages, or fences. An unusual, mixed infestation of all stages of *B. germanica*, and smokybrown, *Periplaneta fuliginosa* (Serville) and American, *P. americana* (L.), cockroach nymphs was found in an old, severely cracked telephone pole.

Cockroaches were live trapped outdoors around homes and storage buildings in Auburn, Lee Co., and Mobile, Mobile Co., Alabama during the spring and early summer 1985. Of the 1997 cockroaches collected, 30% were *B. germanica*. About 20% of the *B. germanica* were adults and 64% of these were females. The area immediately surrounding each trap was examined for harborages. Fifteen of the 26 trap sites where *B. germanica* were captured were under raised construction houses with 0.6-0.8 m open crawl spaces. Small (5-50) to large (> 200) cockroach populations were observed in cracks, on brick foundation pillars, and in crawl space debris near these traps; each of these homes also had established indoor infestations. Because of free air movement in the open crawl spaces, environmental conditions under these houses, viz. temperature and relative humidity, were not significantly different from nearby open areas. Indoor temperatures were significantly lower than outdoor temperatures ($p \geq 0.05$, t-test), but there was no significant difference between indoor and outdoor relative humidities. The remaining 11 trap sites where *B. germanica* were caught included areas such as under trees, inside the base of a bird bath, and in wood piles.

These trap data indicate that *B. germanica* may become established outdoors, at least during the spring and summer. Most (ca. 60%) of the traps that caught *B. germanica* were located under homes with large, established, indoor cockroach infestations

immediately above the trap site. These cockroaches represent the overflow of indoor populations from saturated indoor harborages. Several sites where *B. germanica* were trapped, however, were located as far as 15 m from the nearest building. A foraging range of this size is unlikely for a small cockroach such as *B. germanica;* therefore, the outdoor harborage sites of these cockroaches were probably overlooked. Survival of *B. germanica* outdoors is probably related to the warm, humid environment of the southeastern United States, particularly during the spring and summer. Since outdoor populations may lead to indoor infestations or reinfestations, thorough inspection and treatment of outdoor harborage sites, especially under infested indoor areas, may be advisable.

We thank M. A. Foster and G. L. Miller, Auburn University, AL for their review of this manuscript. Alabama Agric. Exp. Stn. Journal Series No. 15-85860.

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FIRST RECORD OF THE CLEARWING MOTH, *CARMENTA ODDA* (LEPIDOPTERA: SESIIDAE) IN FLORIDA

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The clearwing moth, *Carmenta odda* (Sesiidae) was first described by Duckworth and Eichlin (1977) from a single specimen taken in a pheromone trap in Trenton, Edgefield, Co., South Carolina. It responded to the pheromone, *Z, Z*-3,13-octadecadienyl acetate, first developed by Tumlinson et al. (1974). Since that date additional specimens were taken by the junior author in South Carolina during August 1985 and an additional specimen in Georgia during June 1983.

During the spring and summer months of 1985, several synthetic pheromones dispersed from rubber septa (500 micrograms per treatment) were used for sampling

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clearwing moths at numerous locations in the Florida Panhandle. The treatments used were:

1) *E,Z*-3,13-octadecadienyl acetate
2) *Z,Z*-3,13-octadecadienyl acetate
3) 50:50 combination of (1) and (2)
4) *E,Z*-2,13-octadecadienyl acetate
5) *E,Z*-3,13-octadecadienyl alcohol
6) *E,Z*-2,13-octadecadienyl alcohol
7) 50:50 combination of (5) and *Z,Z*-3,13-octadecadienyl alcohol
8) 50:50 combination of (2) and (5)

Approximately 100 water traps were placed at regular intervals in virtually all the different types of habitats available.

On June 1, 1985 a trap baited with *Z,Z*-3,13-octadecadienyl acetate, located on State Highway 20 at Black Creek in Walton County, yielded a single specimen of *Carmenta odda*. The trap was situated in an open floodplain area recently bulldozed free of trees and surrounded by second-growth hardwoods including oaks, sweetgum, sweetbay, loblolly bay, redbay and red maple.

Three other sesiids taken in the same trap were *Synanthedon rubrofascia* (Hy. Edwards), *Synanthedon sapygaeformis* (Walker), and *Podosesia syringae* (Harris). Other pheromones at the same site and date recorded *Synanthedon decipiens* (Hy. Edwards), *Synanthedon arkansasensis* Duckworth and Eichlin, *Synanthedon pictipes* (Grote and Robinson), and *Sannina uroceriformis* Walker.

A second specimen of *C. odda* was taken on 2 June 1985 in a trap located along State Highway 81, 4 miles south of Ponce de Leon in Walton County. The site is an old abandoned field invaded with young oaks about 10 years old. It was attracted to a lure consisting of 50% *ZZ*-3,13-octadecadien-1-ol acetate and 50% *E,Z*-3,13-octadecadienyl acetate. The only other sesiid captured in the same trap was *S. rubrofascia*. Other pheromones at the same site and date recorded *S. uroceriformis*, *P. syringae*, and *Synanthedon fatifera* Hodges. The 2 localities yielding *C. odda* are approximately 12 air miles apart.

Carmenta odda has never been previously recorded for Florida. It is now known to occur in South Carolina, Georgia, and Florida, but must be considered among the rarest of clearwing moths based on specimens known to science (only 6). Perhaps more extensive collecting with synthetic pheromones will eventually change this situation.

T. D. Eichlin (Division of Plant Industry, California Department of Food and Agriculture, Sacramento, California) identified the specimens of *C. odda*.

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A SEX ATTRACTANT SYNERGIST FOR *TRICHOPLUSIA OXYGRAMMA* (LEPIDOPTERA: NOCTUIDAE)

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Trichoplusia oxygramma (Geyer) is closely related to the cabbage looper, *Trichoplusia ni* (Hübner), although it is not a pest species. Like many other Plusiinae, males are attracted in the field to traps baited with (*Z*)-7-dodecen-1-ol acetate (*Z*7-12:Ac), the major component of the sex pheromone of the female cabbage looper (Mitchell et al. 1972). During an experiment in which traps were baited with combinations of female cabbage looper sex pheromone components, *T. oxygramma* males were caught in traps baited with a combination of *Z*7-12:Ac and (*Z*)-9-tetradecen-1-ol acetate (*Z*9-14:Ac). We report here the result of a subsequent experiment demonstrating an increased sex attractant response by *T. oxygramma* males to *Z*7-12:Ac plus *Z*9-14:Ac compared to *Z*7-as:Ac alone, as indicated by trap catches.

Plastic bucket traps (Universal moth trap, International Pheromones, Merseyside, England) were baited with two lures; a 1-mg dosage of *Z*7-12:Ac or a combination of 1-mg *Z*7-12:Ac and 90 μg *Z*9-14:Ac on a rubber septum. This ratio of 10 to 0.9 for *Z*7-12:Ac to *Z*9-14:Ac approximates the ratio of those components reported by Bjostad et al. (1984) for the female cabbage looper pheromone and is similar to the ratio in our original experiment in which *T. oxygramma* males were trapped. Septa were pre-extracted, handled and loaded as described by Landolt and Heath (1986). Traps were hung from shrubs about 1 m above ground level in uncultivated fields near Gainesville, Florida during Sept. and Oct. 1985. Traps were positioned as four treatment pairs with about 24m between paired traps. These were checked and septa switched daily between paired traps. Septa were replaced after 1 week. Treatment means were separated by Student's t-test at $p \geq 0.05$.

Mean numbers of male *T. oxygramma* caught per week in traps baited with *Z*7-12:Ac plus *Z*9-14:Ac were significantly higher than in traps baited with *Z*7-12:Ac alone (Table 1), indicating a synergistic effect by *Z*9-14:Ac on the attractant response of male *T. oxygramma* to *Z*7-12:Ac. Although (*Z*)-9-14:Ac is a minor component of the sex pheromone of female *T. ni* (Bjostad et al. 1984), it did not have any synergistic effects on the response of *T. ni* males to *Z*7-as:Ac in a wind tunnel bioassay (Linn et al. 1984). Landolt and Heath (1986) also reported that numbers of male *P. includens* caught in traps were reduced greatly by the addition of *Z*9-14:Ac to *Z*7-12:Ac, indicating an inhibitory effect which may function in preventing interspecific courtship and mating between *Trichoplusia* spp. and *P. includens*. (*Z*)-9-Tetradecen-1-ol acetate also inhibits the attractant response (reduced trap catches) of two other species of Plusiinae, *Autographa californica* (Speyer) and *A. flagellum* (Walker), to *Z*7-12:Ac (Steck et al. 1979).

Mention of a commercial or proprietary product does not constitute an endorsement by the USDA.

TABLE 1. MEAN WEEKLY CATCHES OF *TRICHOPLUSIA OXYGRAMMA* (TOX) AND *PSEUDOPLUSIA INCLUDENS* (SBL) MALES IN TRAPS BAITED WITH *Z*7-12:AC OR A 10:0.9 RATIO OF *Z*7-12:AC TO *Z*9-14:AC.[1] GAINESVILLE, FL, SEPT-OCT 1985.

Bait	Mean ± S_χ, n = 7	
	TOX	SBL
*Z*7-12:Ac	0.4 ± 0.5 a	4.6 ± 4.5 b
*Z*7-12:Ac and *Z*9-14:Ac	4.9 ± 3.2 b	0.3 ± 0.5 a

[1]Means in the same column followed by the same letter are not different significantly by Student's t-test at p ( ) 0.05.

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FEEDING BEHAVIOR OF *TOXOTRYPANA CURVICAUDA* (DIPTERA: TEPHRITIDAE) ON YOUNG PAPAYA SEEDS

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Toxotrypana curvicauda Gerstaecker (Diptera: Tephritidae), the papaya fruit fly, is a major pest of papaya fruits in tropical America and as such, attempts have been made to rear larvae of this fly on semiartificial media (R. M. Baranowski, personal communication). Such efforts have not met with success, partly because first instar larvae feed on young seeds in the fruit's cavity while later instars feed on fruit pulp (Knab and Yothers 1914). Since seeds may play an important role in larval nutrition and the subsequent development of rearing media, we studied the feeding preferences of first instar larvae for different papaya seed layers.

The investigation utilized fruits and insects collected in Dade County, Florida, during May 1983. In a preliminary study, immature (10 cm diameter, green) papaya fruits were halved and newly hatched larvae (derived from eggs incubated at 26°C±1°C, 75% RH) were placed on the seeds. The larvae were observed for one hour with particular attention paid to larval feeding behavior on the gelatinous endosperm, the testa (which surrounds the endosperm), and the exterior layer, the sarcotesta (Fisher 1980). Larvae penetrated the seeds in two ways: a) by excavating the micropylar region, or b) by cutting a 0.2-0.3 mm perforation in the sarcotesta. Thereafter, the sarcotesta was not eaten further but the testa and endosperm were consumed. Subsequent examination of infested fruit from the field confirmed that the bulk of sarcotesta is not consumed by larvae, whereas the testa and endosperm are.

To test the preference of first instar larvae were placed on sarcotesta, testa and endosperm of bisected seeds. The seeds were taken from immature fruit and embedded cut side up in agar (3 g/200 ml) in covered petri dishes. Feeding activity was monitored at 0, 2, 8 and 24 hrs. Tests on each seed layer were replicated 12 times, with each replicate consisting of 1 individual/seed layer/petri dish. Twelve replicates were also run on whole seeds imbedded in agar. On intact seeds, only 8% of the larvae placed on intact seeds began feeding immediately (on the sarcotesta), but by 24 hrs 92% of the larvae had already penetrated the seed and were feeding on the endosperm. Larvae placed on the sarcotesta of cut seeds were seldom observed feeding on this tissue, with the most feeding activity at 8 hrs when 33% of the individuals were feeding. After 24 hrs, 50% of the larvae remained on the sarcotesta but were not feeding on it, 17% were on the sarcotesta and feeding on it and 33% had moved to agar for food. In contrast, the percentage of larvae feeding on the testa or endosperm ranged from 50 to 92% throughout the experiment. These results suggested that early first instar larvae are discriminating feeders, preferring the testa and endosperm over the sarcotesta. To test

the requirements of the larvae for seed material, first instar larvae (n = 20/treatment; 5 replicates) were placed either on immature seeds embedded in agar (3 g/200 ml) or on pieces (1 g) of immature green fruit pulp embedded in agar. After 2 days, a greater percentage of larvae were alive in petri dishes with immature seed (57% survival) than in petri dishes with pulp (15% survival))t-test, $P < 0.05$). After four days all larvae were dead. These results suggested that neonate papaya fruit fly larvae require the endosperm and testa for survival during their first instar.

Based on our studies, nutritional and phagostimulatory properties of the endosperm and testa should be taken into consideration when developing a suitable rearing medium for *T. curvicauda*. Conversely, the use of seed sarcotesta in semi-artificial diets may have a negative effect on larval development. Gibberellin and cytokinin-like substances have been identified in papaya seed arils (Gherardi and Valio 1976), but whether these substances play a role in papaya fruit fly feeding is not known.

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CARIBBEAN FRUIT FLY (DIPTERA: TEPHRITIDAE) MATING PROPENSITY TESTS—EFFECTS OF A "CHECKERBOARD" CAGE TOP

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Effectiveness of the sterile insect technique to control pest tephritids is enhanced by careful and continuous monitoring of mass-reared flies (Chambers 1977). A standard package of quick and easily analyzed quality control tests has been developed (Calkins et al. 1982); one test in this package is a simple mating propensity test that examines the number and speed of matings of flies released in large numbers in standard laboratory cages.

Many pest tephritids, including the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and the Caribbean fruit fly, *Anastrepha suspensa* (Loew), normally mate in the foliage of host trees, while adhering to the underside of leaves (Prokopy and Hendrichs 1979, Burk 1983, Arita and Kaneshiro 1985). I conducted two simple tests of mating propensity in *A. suspensa* to see if the number of matings or speed of mating initiation differed when a more natural cage environment was created, as compared with mating in normal laboratory cages.

Two similar experiments were carried out, the first in October-November 1980, the second in February-March 1981, in the Bioacoustics Laboratory of the USDA, ARS,

the requirements of the larvae for seed material, first instar larvae (n = 20/treatment; 5 replicates) were placed either on immature seeds embedded in agar (3 g/200 ml) or on pieces (1 g) of immature green fruit pulp embedded in agar. After 2 days, a greater percentage of larvae were alive in petri dishes with immature seed (57% survival) than in petri dishes with pulp (15% survival))t-test, $P < 0.05$). After four days all larvae were dead. These results suggested that neonate papaya fruit fly larvae require the endosperm and testa for survival during their first instar.

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Two similar experiments were carried out, the first in October-November 1980, the second in February-March 1981, in the Bioacoustics Laboratory of the USDA, ARS,

Insect Attractants, Behavior, and Basic Biology Laboratory (IABBBL), Gainesville, Florida. In each experiment, 25 males and 25 females were released into 20 × 20 × 20 cm narrow-plastic-mesh cages with plexiglass edges. Flies used were obtained from the long-established laboratory colony of the IABBBL. The control cage was unaltered; the experimental cage had eight 5 × 5 cm pieces of clean gray cardboard placed on the top (outside) of the cage in a checkerboard pattern. The checkerboard was intended to resemble the field situation of shaded leaves above displaying and mating flies. Cages were observed for one hour in the flies' late-afternoon period of sexual activity (flies were maintained on a 12-12 hour photoperiod). Temperature was 25±1°C. and relative humidity was 40±10%. Diffuse light from above was provided by the room's daylight-spectrum flourescent ceiling lights. Every five minutes, for one hour, I recorded the number of matings initiated, separately noting the number of mating pairs that were on the cage ceiling under a piece of cardboard and the number of mating pairs that were not under a piece of cardboard. Ten replicates, each consisting of one control cage and one experimental cage, were carried out in Test 1, 12 replicates in Test 2.

The checkerboard arrangement did not alter the total number of mating pairs in one hour in either experiment. In Test 1, 138 pairs mated in control cages (55%), as opposed to 136 in checkerboard cages (54%). In Test 2, the number of mating pairs was 193 for controls (64%), 207 for checkerboard cages (69%) (X^2: Test 1 = .03, Test 2 = 1.47; both n.s. (Bailey 1959)). Flies did greatly prefer to mate under the cardboard "leaves", however: in Test 1, 102 of 136 (75%) and in Test 2, 164 of 207 (79%) of matings took place under the pieces of cardboard (X^2: Test 1 = 34.0, Test 2 = 70.72, both $p < .005$).

Although total number of matings was not affected by the checkerboard arrangement, mating propensity was generally higher than in the control cages (Table 1). Mating propensity was quantified using Boller's mating propensity index, described in Boller et al. (1977). In this procedure, the number of matings in successive time intervals is multiplied by weighting factors, with early-initiated matings given greater weighting than late-initiated matings. The sum of these interval scores is then divided by the number of pairs of flies (= 25) to give the mean mating index (MMI) for each cage. In Test 1, MMI was higher in the checkerboard cages than in the controls in 7 of 10 replicates (Wilcoxon signed-ranks matched pairs test, n.s. (Siegel 1956)); in Test 2, MMI

TABLE 1. MATING PROPENSITY OF 25 PAIRS OF CARIBBEAN FRUIT FLIES IN 20 × 20 × 20 CM NORMAL OR "CHECKERBOARD TOP" LABORATORY CAGES.

Test 1:			Test 2:		
Replicate	Mean Mating Index		Replicate	Mean Mating Index	
	Control	Checkerboard		Control	Checkerboard
1	57.0	61.3	1	52.8	64.2
2	63.5	67.9	2	31.3	33.9
3	65.9	80.6	3	43.0	50.5
4	19.9	31.5	4	48.0	33.2
5	9.3	9.6	5	18.6	30.8
6	32.0	19.0	6	30.6	32.9
7	2.3	6.9	7	45.7	55.5
8	25.5	20.6	8	51.6	56.5
9	47.8	44.4	9	19.7	19.6
10	53.8	66.2	10	8.8	26.3
			11	15.9	24.1
			12	9.9	9.6

was higher in the checkerboard cages than in the controls in 9 of 12 replicates ($p < .05$).

The addition of checkerboard tops to cages used in laboratory mating propensity trials can significantly increase the mating propensity indices obtained. This indicates that the checkerboard configuration is preferred behaviorally by mating caribflies, and suggests it is a closer approximation to the situation faced by mating flies in nature. Since checkerboard tops can be incorporated easily into the design of laboratory mating propensity tests, use of this cage design should be considered for addition to existing quality control procedures for species that mate under leaves.

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DYSCINETUS MORATOR (COLEOPTERA: SCARABAEIDAE) AS A PEST OF CARROTS AND RADISHES IN FLORIDA

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Dyscinetus morator (Fab.) is a scarab found in most of the eastern United States and present throughout Florida (Woodruff 1970). Damage to caladium bulbs by the adult stage of this scarab has been confirmed in Highland County, Florida (Anonymous 1971). No other reports of economic damage by this insect in Florida have been published.

On March 1, 1985, *D. morator* adults were found on or inside damaged carrots and radishes in Brevard County, Florida. The damage observed on carrots was large, rough gouges on the sides of the carrot. The damage to radishes consisted of an entry hole and removal of all tissue from within the bulb, leaving only the outer surface intact. *D. morator* adults were collected from fields of damaged radishes and isolated in 500 ml plastic containers with undamaged carrots and radishes in soil. Subsequently, these plants received the same type of injury as those observed in the field, verifying adult *D. morator* as the causal agent of the observed damage. This constitutes the first published report of *D. morator* as a pest of carrots and radishes.

After the initial damage was observed, a thorough examination of surrounding fields was conducted by examining plants from ten row feet at ten locations per field. Six fields of radishes totalling over 25 ha were found with damage from the adult beetles. The damaged fields represented 46% of the radish fields present in the local area in early March. The percentage of damaged bulbs in the fields ranged from 24 to 65%. All three of the nearby carrot fields totalling about 12 ha had damage with 12 to 30% of the carrots in a given field rendered unmarketable. No *D. morator* larvae were observed in any of the damaged fields. On April 16, 1985, three *D. morator* adults were found feeding on heads of lettuce that had been grown in a field adjacent to the fields that had contained the damaged radishes.

Adult *D. morator* were collected in 15 watt blacklight traps which were set adjacent to sugarcane fields because *D. morator* was reported to be associated with sugarcane in southern Florida (Gordon and Anderson 1981). Six traps (1 trap/field) were operated

TABLE 1. MEAN NUMBER OF *DYSCINETUS MORATOR* CAPTURED PER BLACKLIGHT TRAP PER NIGHT IN SOUTH FLORIDA (AUGUST, 1982—JULY, 1985 AND PERCENTAGE OF TOTAL SCARABS COMPRISED BY *D. MORATOR*.[1]

Month	Mean	Standard Deviation	Percentage of Total Scarabs
August	28.9	42.3	94
September	8.6	12.0	85
October	154.2	216.8	99+
November	17.2	43.2	99+
December	92.7	161.6	100
January	32.7	65.2	100
February	180.8	186.0	100
March	157.7	338.8	99+
April	15.4	59.4	96
May	57.7	73.7	62
June	69.3	140.2	93
July	96.0	151.1	99+

[1]n = 18.

for one night approximately mid-month from August, 1982, until July, 1985. Three traps were located in Palm Beach County and three traps in Hendry County, both in southern Florida. Besides *D. morator*, other scarab species collected in the traps were counted. Table 1 shows the mean blacklight trap catches of *D. morator* for three years and the relative catch compared to other scarab species. Although the catches were sometimes erratic because of occasional adverse weather conditions, the data showed that adult *D. morator* are active in relatively large numbers throughout the year in southern Florida. The data also showed that *D. morator* is the most abundant scarab species caught in blacklight traps in all months in southern Florida. Therefore, the potential exists for damage by adult *D. morator* to fields of carrots or radishes at any time during the growing season.

We thank R. E. Woodruff for his identification of *D. morator*.

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STERILIZATION OF ADULT MALE FIELD CRICKETS *GRYLLUS INTEGER* (ORTHOPTERA: GRYLLIDAE) BY GAMMA RADIATION

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In this paper I report a dose of gamma radiation that will induce sterility in adult male field crickets. This work was undertaken as part of a larger study on sperm competition in the field cricket *Gryllus integer* (Backus, 1985).

The methods used in this study are outlined in Backus (1985). Fifteen virgin adult female *G. integer* were each mated twice to 1 of 15 adult male crickets within 24 hr of the male's exposure to 7,000 roentgens of gamma radiation (R males). Following mating females were allowed 11 days for oviposition in a container filled with 250 ml moist vermiculite. Oviposition dishes were examined daily for the presence of nymphs; any nymphs found were mouth-aspirated and counted. A control group consisted of 5 females mated with unirradiated (N) males and were treated similarly to females mated with R males.

Following 8 weeks, the soil in each oviposition dish was dried and examined under a dissecting microscope for the presence of unhatched eggs. All unhatched eggs were counted; any nymphs that had hatched and were remaining in the soil were counted and added to the number of emerged nymphs.

Productivity, the total number of eggs laid by a female, was determined by summing the number of nymphs emerged with the number of unhatched eggs. Mean productivity for females mated with R males was 337.5 (SD 201.4, Range 65-733), whereas mean productivity for females mated with N males was 291.2 (SD 128.3, Range 153-500). A Mann-Whitney U test revealed no significant difference in mean productivity between the 2 groups ($U = 35.5$, $p > 0.05$).

The mean proportion of eggs hatched for females mated with R males was 0.01 (SD 0.02, Range 0-0.04); for females mated with N males was 0.67 (SD 0.27, Range 0.19-0.86). There was a significant difference between these values ($U = 0$, $p < 0.05$; one-tailed).

The mean age of death for males in the R group was 22.8 days (SD 30, Range 16-28); for males in the N group was 59.2 days (SD 19.0, Range 27-77). There was a significant difference between the 2 groups of males for age of death ($U = 1$, $p < 0.05$, two-tailed).

The proportion of eggs hatched for females mated with N males was much greater than for females mated with males exposed to 7,000 roentgens of gamma radiation. The proportion of eggs hatched by females in the R group was so low that 7,000 roentgens was apparently sufficient to sterilize adult male *G. integer*. A second effect of this dosage appears to be a significantly shortened lifespan in R group males. The dosage of radiation used did not appear to affect male courtship or mating behavior (Backus, 1985). This was the only dosage of radiation tested and may be considered as a minimum as 1% of the eggs laid by females mated with R group males hatched.

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OBSERVATIONS ON *MANTOIDA MAYA* (ORTHOPTERA: MANTIDAE)

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The Little Yucatan Mantid, *Mantoida maya* Saussure and Zehntner, is a small (15 mm) ground-dwelling species native to Florida and Mexico (Blatchley 1920; Helfer, 1953), it appears to be relatively abundant at the Archbold Biological Station (Highlands Co., FL.), though live adult specimens are seldom seen and are apparently most active at night (Hubbell, 1945). Two small, continuously operated Townes traps set up in a dense stand of sand pine (*Pinus clausa* Chapman) have captured 198 individuals over a period of 3 years. These capture records indicate that the flight period is concentrated in July and August (196 specimens), and strongly suggest that there is one generation per year. A dramatic decrease in number of individuals in 1985 might be related to very dry conditions in fall of 1984, and winter and spring of 1985.

Immature *Mantoida maya* are difficult to see as they run through surface litter in their usual habitat of dimly lit hammocks and thickets of dense scrub. Immature individuals (Fig. 1) probably derive additional protection from their resemblance to ants and wingless ichneumonids. My work on ants at the Archbold Biological Station has led to occasional encounters with immature *M. maya* which I have mistaken at a distance of a few feet for a novel species of ant. The presumed mimetic features of *M. maya* are: 1) The red coloration of the head and thorax, contrasting strongly with the black abdomen, as in the abundant sympatric ants *Camponotus abdominalis floridanus* (Buckley) and *C. tortuganus* Emery; 2) the apically expanded oval abdomen, resembling the gaster of an ant; 3) the white band on the first 2 visible abdominal tergites, reducing the visual impact of the "petiole" area; 4) the white median band on the antennal flagellum, as in females of many ichneumonids. The immature mantids run in a series of short spurts, the antennae quivering rapidly. The visual contrast between adult and young in this species is far more dramatic than in any other U.S. mantid. It is the only mantid I know in which the shape, color, and behavior is defensively mimetic rather than cryptic.

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OBSERVATIONS ON *MANTOIDA MAYA* (ORTHOPTERA: MANTIDAE)

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The Little Yucatan Mantid, *Mantoida maya* Saussure and Zehntner, is a small (15 mm) ground-dwelling species native to Florida and Mexico (Blatchley 1920; Helfer, 1953), it appears to be relatively abundant at the Archbold Biological Station (Highlands Co., FL.), though live adult specimens are seldom seen and are apparently most active at night (Hubbell, 1945). Two small, continuously operated Townes traps set up in a dense stand of sand pine (*Pinus clausa* Chapman) have captured 198 individuals over a period of 3 years. These capture records indicate that the flight period is concentrated in July and August (196 specimens), and strongly suggest that there is one generation per year. A dramatic decrease in number of individuals in 1985 might be related to very dry conditions in fall of 1984, and winter and spring of 1985.

Immature *Mantoida maya* are difficult to see as they run through surface litter in their usual habitat of dimly lit hammocks and thickets of dense scrub. Immature individuals (Fig. 1) probably derive additional protection from their resemblance to ants and wingless ichneumonids. My work on ants at the Archbold Biological Station has led to occasional encounters with immature *M. maya* which I have mistaken at a distance of a few feet for a novel species of ant. The presumed mimetic features of *M. maya* are: 1) The red coloration of the head and thorax, contrasting strongly with the black abdomen, as in the abundant sympatric ants *Camponotus abdominalis floridanus* (Buckley) and *C. tortuganus* Emery; 2) the apically expanded oval abdomen, resembling the gaster of an ant; 3) the white band on the first 2 visible abdominal tergites, reducing the visual impact of the "petiole" area; 4) the white median band on the antennal flagellum, as in females of many ichneumonids. The immature mantids run in a series of short spurts, the antennae quivering rapidly. The visual contrast between adult and young in this species is far more dramatic than in any other U.S. mantid. It is the only mantid I know in which the shape, color, and behavior is defensively mimetic rather than cryptic.

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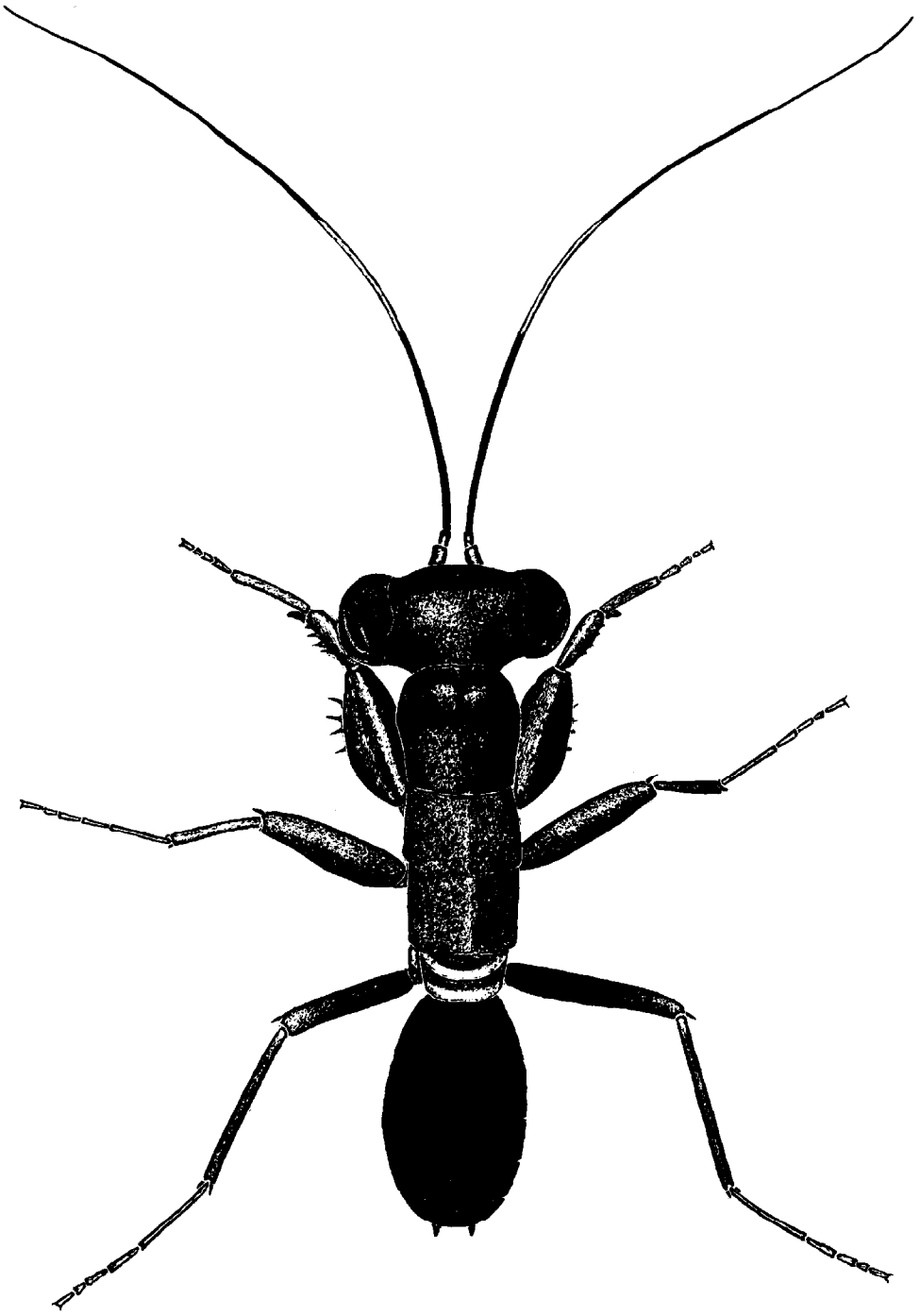

Fig. 1. Immature (3rd instar?) *M. maya*, actual length 7 mm; from photograph of live insect.

EFFECT OF THE WATER MITE *ARRENURUS PSEUDOTENUICOLLIS* (ACARIFORMES: ARRENURIDAE) ON THE LONGEVITY OF CAPTIVE *ANOPHELES QUADRIMACULATUS* (DIPTERA: CULICIDAE)

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Some species of the water mite genus *Arrenurus* are common parasites of mosquitoes. The larvae of these species find and cling to the external surfaces of host pupae and then attach to the adult hosts as they emerge. After approximately 6 days, the mites have become engorged and drop off their hosts, although mites held in small enclosures in the laboratory may remain attached throughout the entire life span of adult hosts. Engorged larvae that return to water metamorphose to the nymphal stage, which is predatory on crustaceans. After a period of feeding, the nymphs metamorphose to the adult stage, which has feeding habits like those of the nymphal stage.

As parasites, larval water mites can be expected to harm their hosts, and in fact, several studies have demonstrated a reduction in the longevity of mosquitoes by these mites (Miyazaki 1936, Lanciani and Boyt 1977, and Allan 1979), although Smith and McIver (1984b) found no mite-induced decline in the longevity of *Coquillettidia perturbans* (Walker).

In this study, the effect of the mite *Arrenurus pseudotenuicollis* Wilson on the longevity of the mosquito *Anopheles quadrimaculatus* Say was noted in a laboratory experiment. Mite cultures were established using engorged larvae collected from a parasitized population of *Anopheles crucians* Wiedeman in Gainesville, Florida. Eggs of a laboratory strain of the host were obtained from the USDA Insects Affecting Man and Animals Research Laboratory in Gainesville. Larval mosquitoes were reared on a diet of commercial fish food and brewers yeast in white enamel pans containing approximately 500 ml of tap water. Pupae were removed and transferred individually to small, screen-covered plastic vials containing approximately 10 ml of water. Larval mites in various numbers were added to some of the vials. A drop of corn syrup placed on the screen provided nutrient to the adult mosquito. The vials were held in partially covered plastic boxes housed in an environmental chamber maintained at 27°C and with a 12-hour light-dark cycle. The vials were checked daily, and for each mosquito death observed, the number of days survived and the number of engorged mites were recorded.

Unparasitized mosquitoes had significantly greater survivorship than parasitized mosquitoes of the same sex during their entire adult life span (Table 1; $P < 0.005$, logrank test; Peto et al. 1977), but the 2 groups had similar survivorship over the first 6.5 days of adult life, a period when most parasite growth is accomplished. Mite-induced death is normally due at least in part to the extraction of nutrient from the host hemolymph. However, since in this case no differential host death occurred when mite larvae were most actively draining host energy stores, these mites reduced long-term survivorship probably in other ways, some of which may be peculiar to the laboratory environment, e. g., the mite's presence on the host beyond the normal engorgement period might have upset the host's water balance (Åbro 1982, Smith and McIver 1984b).

Despite the suitability of *A. quadrimaculatus* to *A. pseudotenuicollis* in the laboratory, this mosquito is not as commonly parasitized by the mite as is *A. crucians* in local

TABLE 1. AVERAGE LONGEVITY IN DAYS OF ADULT MALE AND FEMALE MOSQUITOES BEARING VARIOUS NUMBERS OF PARASITIC WATER MITES. LUMPING WAS DONE TO INCLUDE AT LEAST 20 INDIVIDUALS IN EACH GROUP OF ENGORGED MITES PER HOST.

Engorged mites per host	Males			Females		
	Sample size	Longevity	Standard error	Sample size	Longevity	Standard error
0	94	20.73	0.82	79	17.99	0.90
1-2	61	19.28	0.93	51	14.39	0.78
3-5	33	17.85	1.26	36	14.36	1.17
6 or more	35	13.57	0.91	41	13.07	0.76

natural populations. Differences between host acceptability in the laboratory and host emphasis in the field may be caused by environmental factors, such as spatial and temporal nonoverlap between mites and mosquitoes, that prevent the mite from more thoroughly exploiting some host species in nature (Smith and McIver 1984a).

I wish to thank Lea Brady for laboratory assistance, James Thomas of the USDA for providing *A. quadrimaculatus* eggs, and the University of Florida, Division of Sponsored Research for research funds.

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COMPETITION AMONG LARVAL *TYRRELLIA CIRCULARIS* (ACARIFORMES: LIMNESIIDAE) ON THE HOST *DASYHELEA MUTABILIS* (DIPTERA: CERATOPOGONIDAE)

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One of the smallest insects parasitized by larval water mites is the ceratopogonid *Dasyhelea mutabilis* (Coquillett). Larval mites of the species *Tyrrellia circularis* Koenike initially attach to the pupal stage of the host, and as the adult fly emerges, the mites crawl to the abdominal surfaces where they attach and feed. After 3 to 7 days (at 27°C) the mites drop off the host and metamorphose to the non-parasitic nymphal stage. After a period of feeding as a predator on ceratopogonid eggs, larvae, and pupae, the mites metamorphose to the adult stage, which is also predatory on the immature stages of Ceratopogonidae (Lanciani 1978).

Since 2 or more larvae sometimes parasitize the same host individual, e.g., 63% of a sample of *D. mutabilis* pupae carried from 2 to 12 mite larvae (Lanciani 1978), competition may exist among parasites. To measure this potential competitive effect, field-collected female hosts that were parasitized in the laboratory by 1 to 5 mite larvae were isolated in plastic, screen-covered vials and placed in a constant-temperature chamber set at 27°C and with a 12-hour light-dark cycle. (Hosts bearing more than 5 mites could not be used because they died so quickly that no mites survived to the nymphal stage.) Hosts were fed a drop of corn syrup placed on the screen. After the mites fed and dropped off the host, they were removed from the vials and held in a 2% agar medium until they metamorphosed to the nymphal stage. All mites surviving to the nymphal stage were frozen and later dried at 60°C and weighed. Since newly emerged nymphal mites have fed only as parasitic larvae, their weight should be largely determined by the nutrient input from the host. Thus, if competition exists, the weights of newly emerged nymphs should be inversely proportional to the number of parasites on the same host because as this number increases, the quantity of food available per parasite should decrease.

The average dry weight of nymphal mites consistently decreases as the number of mites per host increases (Table 1). A linear regression analysis of the logarithmically transformed data (nymphal dry weight as the dependent variable and number of mites per host as the independent variable) yielded a slope of –0.70, which is significantly different from 0 ($P < 0.001$, t-test). The slope, which measures the decline in nymphal dry weight as the number of attached mites increases and therefore should reflect the level of competition, is high compared to those based on another water mite-host association involving *Hydrachna virella* Lanciani on *Buenoa scimitra* Bare. In that association, the slopes were –0.52 on host instar 2, –0.51 on host instar 3, –0.44 on host instar 4, –0.34 on host instar 5, and –0.23 on adult females (Lanciani 1984). Clearly the absolute value of the slopes, and thus the predicted level of parasite competition, increases as host size decreases. Since *D. mutabilis* is only approximately 14% of the weight of a second instar *B. scimitra*, the higher predicted level of competition among its parasites seems reasonable.

I wish to thank Lea Brady for laboratory assistance and the University of Florida, Division of Sponsored Research for research funds.

TABLE 1. AVERAGE DRY WEIGHTS OF RECENTLY EMERGED *TYRRELLIA CIRCULARIS* NYMPHS REARED FROM *DASYHELEA MUTABILIS* FEMALES BEARING FROM 1 TO 5 MITES. ALSO LISTED ARE THE STANDARD ERROR OF THE AVERAGE DRY WEIGHTS, NUMBER OF NYMPHS WEIGHED, AND NUMBER OF HOSTS IN EACH GROUP. OFTEN, NOT ALL MITES ON A HOST SURVIVED, SO THE NUMBER OF NYMPHS WEIGHED IS NOT NECESSARILY A PRODUCT OF THE NUMBER OF MITES PER HOST AND THE NUMBER OF HOSTS IN THAT GROUP.

Number of mites per host	Average nymphal dry weight (μg)	Standard error (μg)	Number of nymphs weighed	Number of hosts
1	3.51	0.12	54	59
2	2.76	0.08	111	56
3	1.99	0.07	86	30
4	1.51	0.05	71	26
5	1.13	0.07	35	13

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NOTES ON THE BIOLOGY OF ASPISOMA IGNITUM (L.) (COLEOPTERA: LAMPYRIDAE): A NEW FIREFLY RECORD FOR PUERTO RICO

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During the early hours of clear nights of December 1983 and January 1984 one of us (JASB) noticed many firefly flashes over an old field at Bayamón, Puerto Rico where the vegetation consisted mostly of Gramineae and Leguminosae bushes rarely higher than 1.5 m. Flashes had not been seen there in previous years. For several nights during January 1984 JASB and several neighborhood boys collected more than 30 fireflies in less than 90 minutes.

Comparison with specimens in the collection of the University of Puerto Rico, Agricultural Experiment Station, Río Piedras and perusal of pertinent literature (Maldonado-Capriles and Navarro 1967, Medina-Gaud and García-Tudurí 1977, Medina-Gaud and Martorell 1973, Wolcott 1948) suggested that the species was a new record for the island. Dr. J. Ramos, (University of Puerto Rico, Mayagëz) identified the firefly as *Aspisoma ignitum* (L.) (Fig. 1). This identification was confirmed by Dr. J. E. Lloyd (University of Florida, Gainesville, FL). The presence of this insect constitutes a new genus and species for the Puerto Rican entomofauna. With this firefly, a total of 12 lampyrids are known for Puerto Rico (Wolcott 1948).

The total length of the collected specimens ranges from 11.5 to 15 mm making this one of the largest lampyrids known for the island. Females were slightly longer than males (♀♀ $\bar{X}$ = 13.7 mm, sd = 0.8, n = 9; ♂♂ $\bar{X}$ = 12.8 mm, sd = 0.7 mm, n = 36).

Aspisoma ignitum can be distinguished from all other known fireflies of Puerto Rico by its color pattern: dull green, pronotum with yellow areas; elytra with eight longitudinal yellow lines and a short yellow band (about 2-3 × 1 mm) close to the anteroretrolateral area. The sexes can be distinguished by the ventral coloration of abdominal segments V-VII: males are bright yellow (Fig. 2), females have wide brown areas (Fig. 3). In addition, there are morphological differences on the margin of abdominal segment VII: on males there is a wide terminal concavity (Fig. 4) while females have a deep indentation (Fig. 5).

Flashing was first noticed at about 18:45 (30-60 minutes after sunset) and ceased about 19:30-20:00. Flying specimens seldom exceeded an altitude of about 3 m.; this observation agrees with that reported for San Andrés Is. (West Indies) by Farnworth (1969). These fireflies are relatively easy to capture because of their slow flight. Most of the individuals collected during the night were males and undoubtedly in this species, as in others, flying males locate stationary females (Lloyd 1971).

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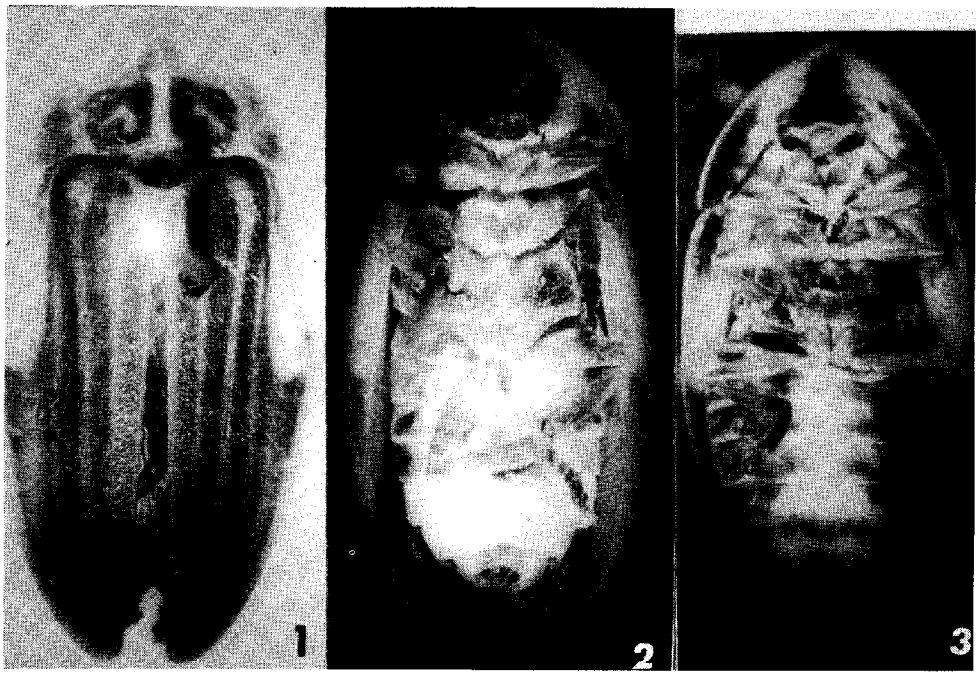

Plate 1. *Aspisoma ignitum* (l.)

Figs. 1-3. 1. Dorsal view. 2-3. Ventral views, 2. Male, 3. Female.

During the light hours (16:30-18:00) about 20 specimens were discovered, mainly among small branches near the upper part of bushes (mainly Leguminosae). Many specimens collected during this period were in copula (position ♂/♀, similarly oriented) (Fig. 6). In one instance a copulating pair was accompanied by a third specimen very closely associated to the anterior portion of the female.

According to Leng et al. (1914), Blackwelder (1944) and McDermott (1964), *A. ignitum* has been reported for Central America, México, Cuba, Hispaniola, several of the Lesser Antilles, Venezuela, Colombia and Brazil. In Puerto Rico this species has been collected in Carolina and in Bayamón, both in the San Juan Metropolitan Area. It has also been collected in Vieques, an island close to the east of Puerto Rico. The possibility that Wolcott (1948) overlooked this relatively large lampyrid seems unlikely and we consider that it might have reached the Puerto Rico region recently.

A single male was examined to determine the karyoformula using essentially schedule 5 as explained in Virkki (1983). The karyoformula of the species is 9 + X (Fig. 7), as reported earlier (Virkki 1963) and is typical of the family (Smith and Virkki 1978).

Material examined: Puerto Rico, Carolina, Piñones, Nov. 5, 1983 (N. Virkki), one adult ♂♂, Acc. Num. 2-83; Bayamón, Urb. Riverview, near roads 22 and 167, over grassland (J. Santiago-Blay, V. E. Serrano-Sevilla, J. A. Figueroa-Sevilla and W. Martínez), 41 ♂♂, 10 ♀♀. *Vieques Is.*, Isabel II, Jul. 7, 1983 (N. Virkki), one adult ♂♂, Acc. Num. 116-84. All specimens except 10, are deposited in the Entomology Museum collection of the Agricultural Experiment Station, Río Piedras, Puerto Rico.

We appreciate the collection efforts and kindness of: V. E. Serrano-Sevilla, J. A. Figueroa-Sevilla and W. Martínez. Dr. J. Ramos and Dr. J. E. Lloyd provided and corroborated, respectively, the identification of the specimens. Dr. N. Virkki (Univ. P. R., Agric. Exp. Sta., Crop Protection Dept., Río Piedras, PR) allowed the use of

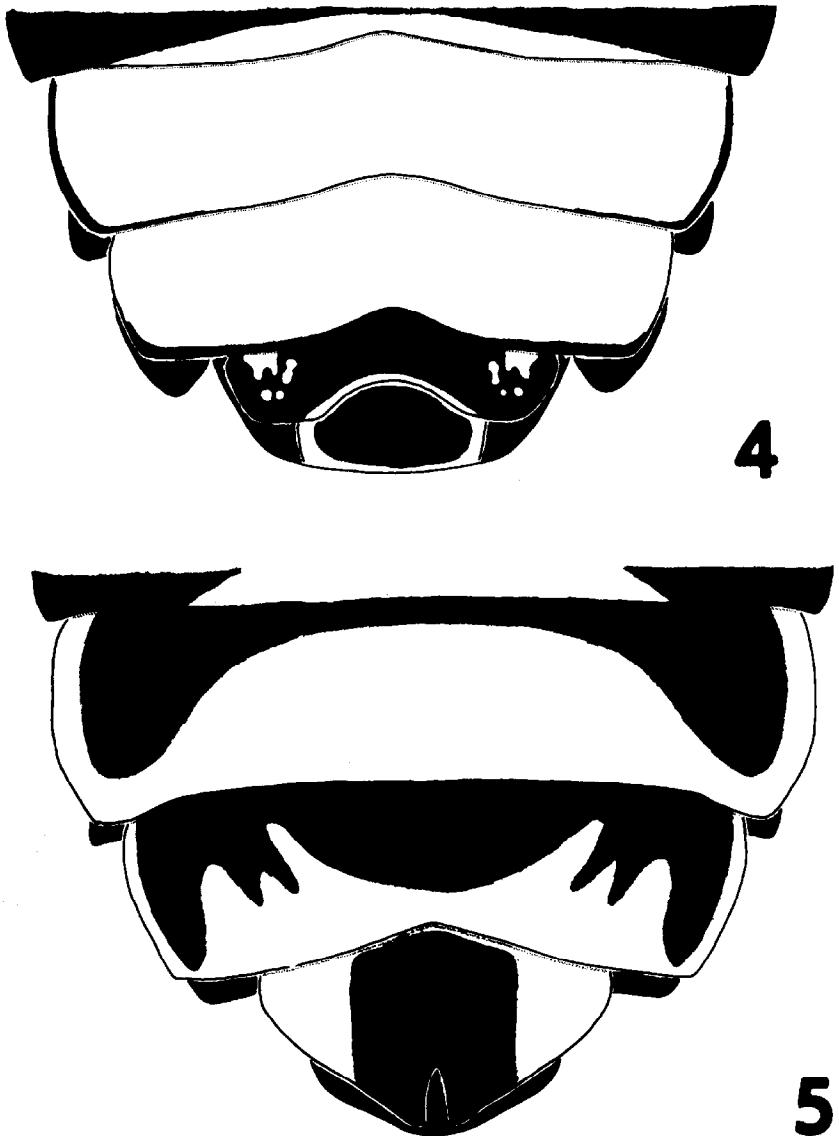

Plate 2. *Aspisoma ignitum* (L.)

Figs. 4-5. Terminal abdominal segments (ventral view). 4. Male, 5. Female.

laboratory space and facilities for the karyoformula determination. Dr. J. E. Lloyd, Dr. N. Virkki and Dr. J. T. Doyen (Dept. Entomol., Univ. Cal., Berkeley, CA) read the typescript and suggested changes. Mr. A. de la Cruz (Agric. Ext. Serv., Río Piedras) did part of the photographic work.

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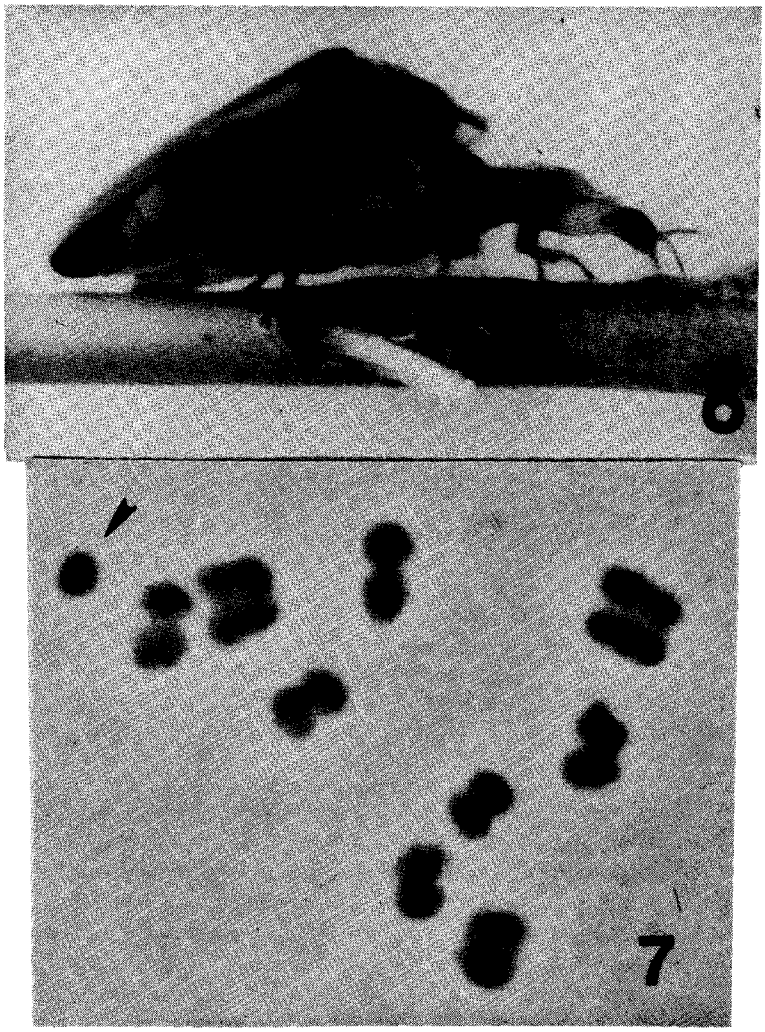

Aspisoma ignitum (L.)

Figs. 6-7. 6. Copulating pair. 7. Metaphase I: 9 + X (arrowhead indicates X chromosome).

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A SPECIES OF *TRIPLOSPORIUM* (ZYGOMYCETES: ENTOMOPHTHORALES) INFECTING *MONONYCHELUS PROGRESSIVUS* (ACARI: TETRANYCHIDAE) IN VENEZUELA

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The spidermite *Mononychelus progressivus* Doreste is considered an economically important pest of cassava, *Manihot* spp. in Venezuela mostly during the dry season; very little is known about its natural enemy complex. During a routine count of the *M. progressivus* population (beginning of the rainy season, May 1981) in an experimental cassava plot to evaluate plant resistance to this mite, several dead mites were found on the underside of the leaves. When the cadavers were mounted in lactophenol and examined using phase contrast microscopy, the following structures typical of an entomophthoraceous fungus were observed: 1) non-ramified club-shaped or oval hypal bodies with obtuse or slightly tapering ends 24-36 × 6-9 μm (average 28 × 8: n = 30, s = 4.3 and 0.8 = for length and width respectively) (Fig. 1) b) pyriform conidia with basal papillum and rugose wall 15-17 × 12-15 μm (average 16 × 14; n = 7, s = 1.5 and 1.1 respectively; larger dimension includes papillum length) and c) light-brown claviform anadhesive conidia 12-21 × 8-12 μm (average 19 × 10; n = 14, s = 1.8 and 1.3 for length and largest width respectively (Fig. 2). These conidia were produced by the pyriform conidia at the end of a thin filament (2 μm diameter).

The morphological characteristics of this fungus are very similar to those of the one found infecting the mite *Eutetranychus banksi* (McGregor) in Florida, described as *Entomophthora floridana* (Weiser and Muma 1966) and considered now (Humber et al. 1981) to be *Triplosporium floridanum* (Weiser and Muma). The Venezuelan fungus also appears very similar to the one isolated from the mite *Tetranychus evansi* Baker and Pritchard and classified as a *Triplosporium* species (Humber et al). Measurements of structures of the three fungi are presented in Table 1. Based on the above considerations the Venezuelan fungus belongs to the genus *Triplosporium*, and most likely in the species *T. floridanum*.

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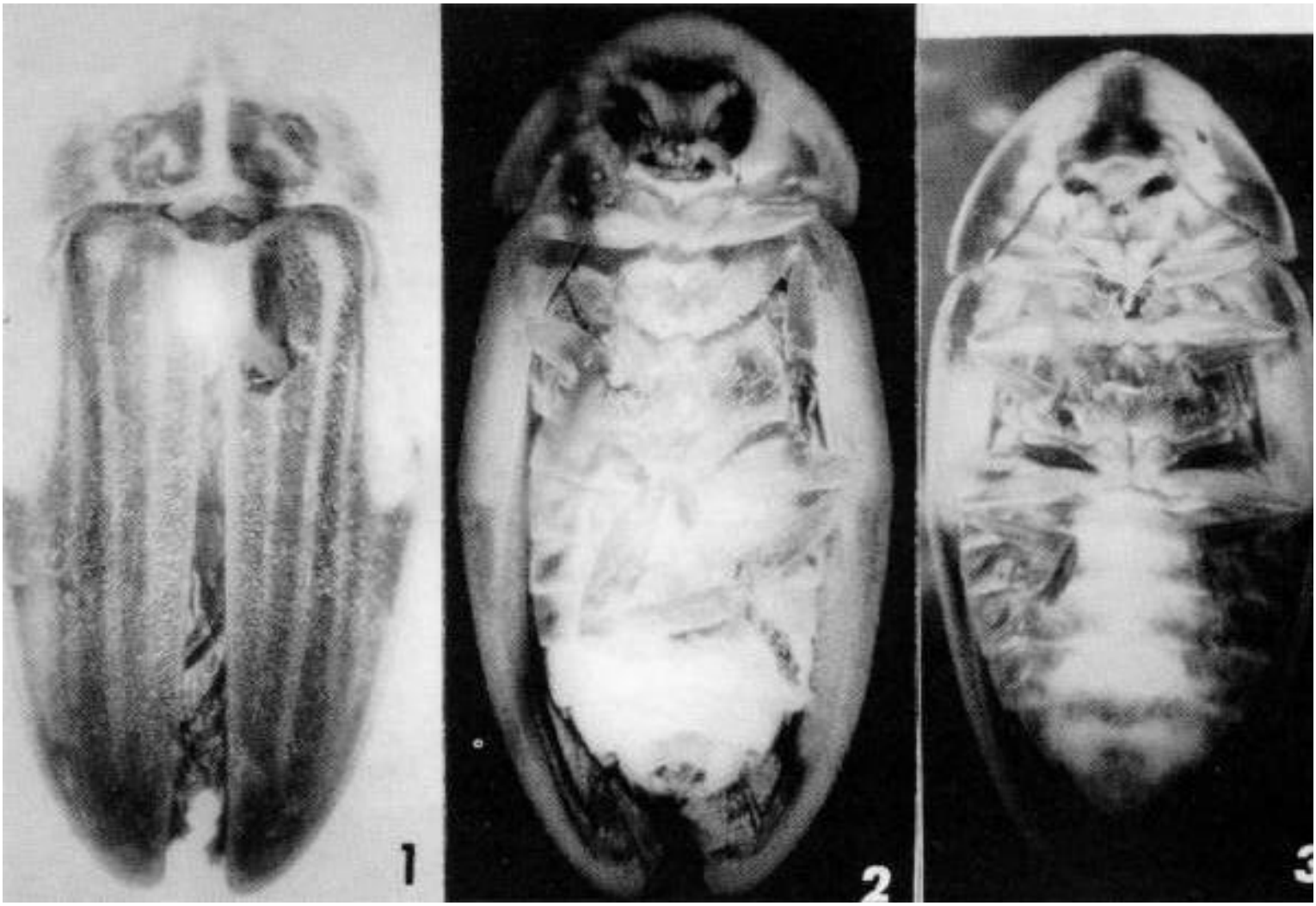
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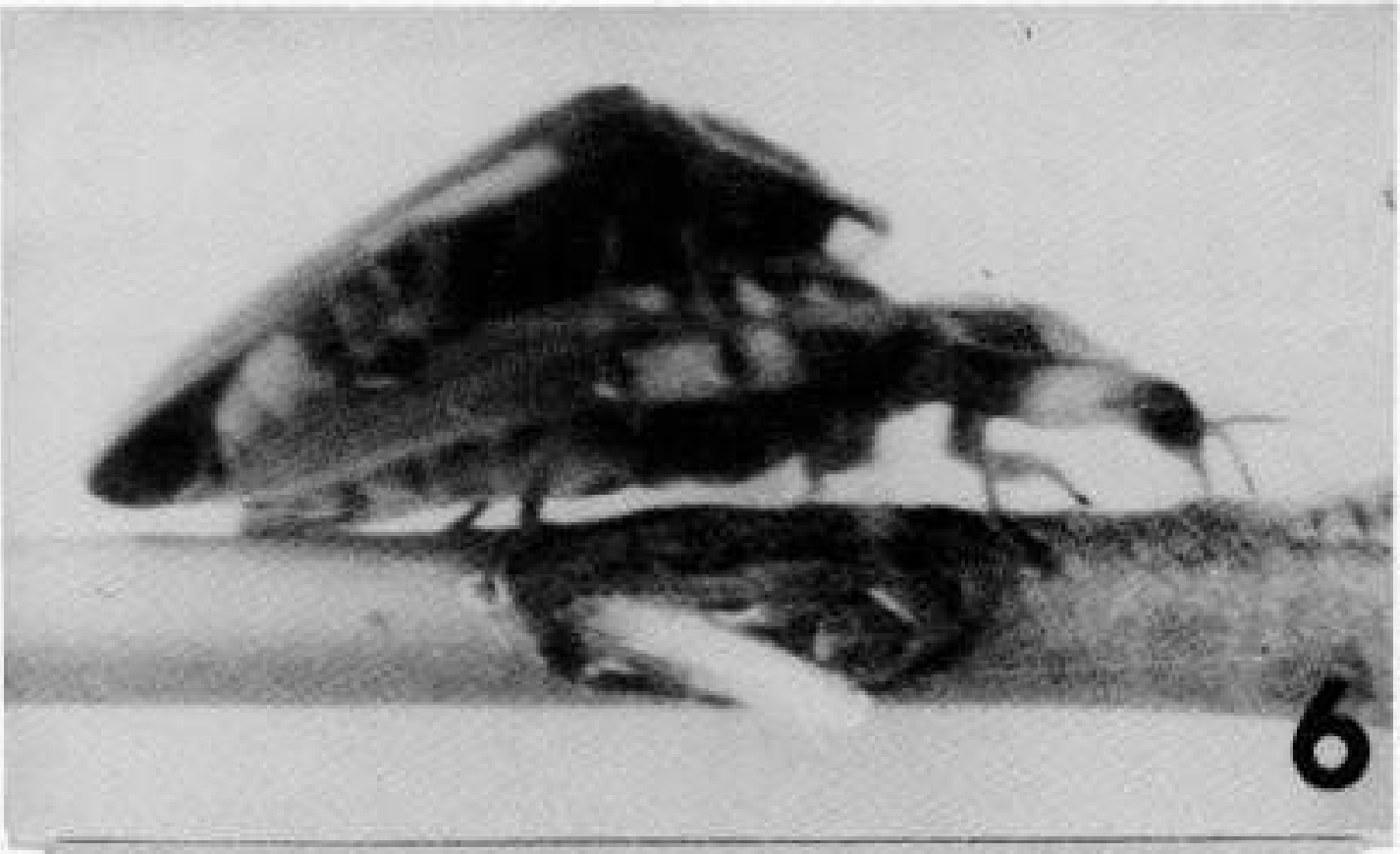

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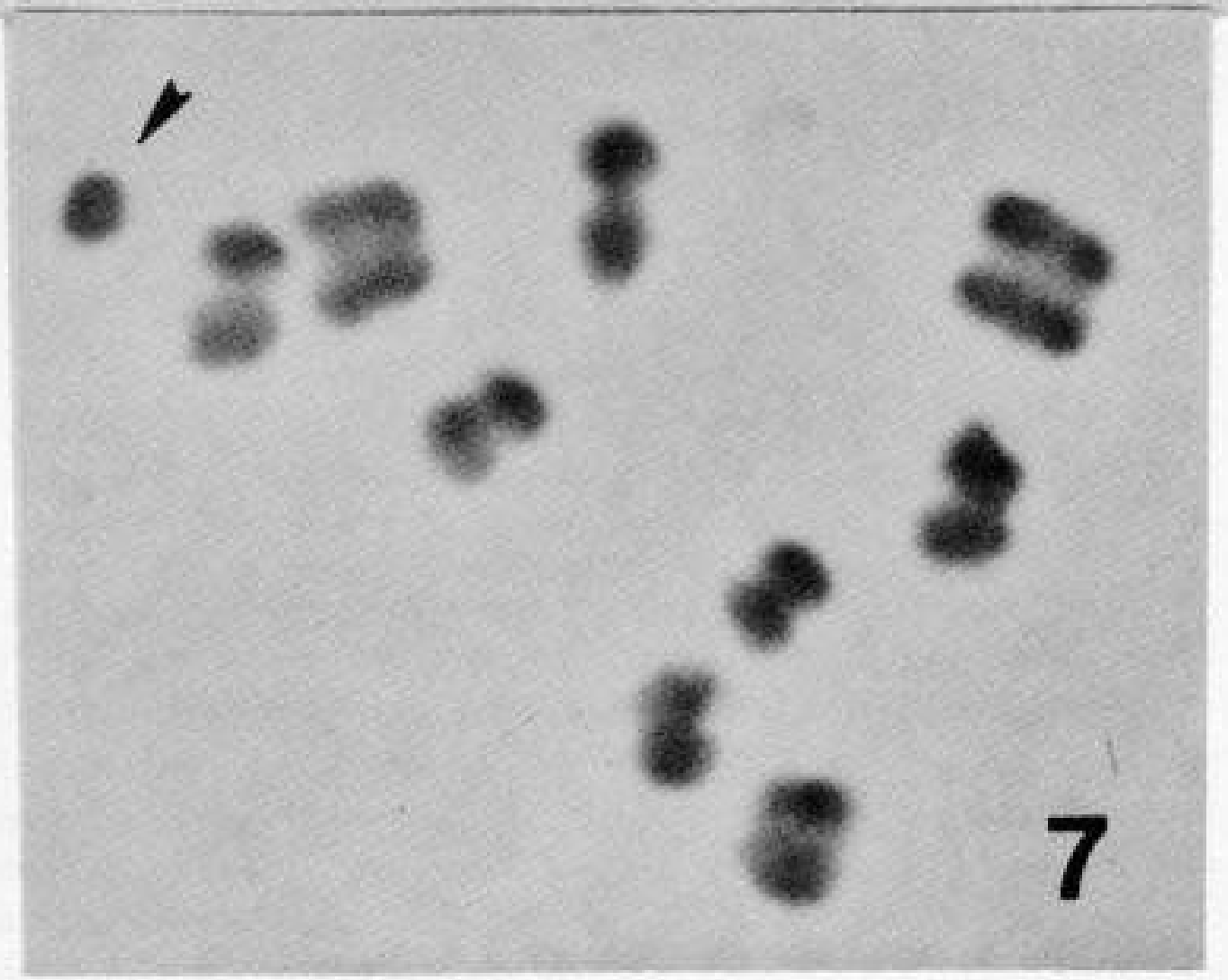

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The spidermite *Mononychelus progressivus* Doreste is considered an economically important pest of cassava, *Manihot* spp. in Venezuela mostly during the dry season; very little is known about its natural enemy complex. During a routine count of the *M. progressivus* population (beginning of the rainy season, May 1981) in an experimental cassava plot to evaluate plant resistance to this mite, several dead mites were found on the underside of the leaves. When the cadavers were mounted in lactophenol and examined using phase contrast microscopy, the following structures typical of an entomophthoraceous fungus were observed: 1) non-ramified club-shaped or oval hypal bodies with obtuse or slightly tapering ends 24-36 × 6-9 μm (average 28 × 8: n = 30, s = 4.3 and 0.8 = for length and width respectively) (Fig. 1) b) pyriform conidia with basal papillum and rugose wall 15-17 × 12-15 μm (average 16 × 14; n = 7, s = 1.5 and 1.1 respectively; larger dimension includes papillum length) and c) light-brown claviform anadhesive conidia 12-21 × 8-12 μm (average 19 × 10; n = 14, s = 1.8 and 1.3 for length and largest width respectively (Fig. 2). These conidia were produced by the pyriform conidia at the end of a thin filament (2 μm diameter).

The morphological characteristics of this fungus are very similar to those of the one found infecting the mite *Eutetranychus banksi* (McGregor) in Florida, described as *Entomophthora floridana* (Weiser and Muma 1966) and considered now (Humber et al. 1981) to be *Triplosporium floridanum* (Weiser and Muma). The Venezuelan fungus also appears very similar to the one isolated from the mite *Tetranychus evansi* Baker and Pritchard and classified as a *Triplosporium* species (Humber et al). Measurements of structures of the three fungi are presented in Table 1. Based on the above considerations the Venezuelan fungus belongs to the genus *Triplosporium*, and most likely in the species *T. floridanum*.

[1]Current address: Biosis, 1057 East Meadow Circle, Palo Alto, CA 94303.

TABLE 1. SIZE OF STRUCTURES FROM *TRIPLOSPORIUM* SPP. INFECTING THE MITES *E. BANKSI*, *T. EVANSI* AND *M. PROGRESSIVUS* IN FLORIDA, BRAZIL AND VENEZUELA RESPECTIVELY.

Locality	Hyphal bodies	Pyriform papillate conidia	Anadhesive conidia
Florida[1]	Not given	13-18 μm × 11-13 μm mean = 12 × 15 μm	15-20 μm × 10-20 μm Mean not given
Brazil[2]	24-48 μm × 3,5-6 μm Mean not given	12,4-17.7 μm × 9.4-14.2 μm Mean = 14.9 × 12.0 μm	15.3-20.1 μm × 7.1-13 μm Mean = 18.2 × 9.6 μm
Venezuela	24-36 μm × 3.5-6 μm Mean = 28 × 8 μm n = 30, s = 4.5, 0.8	15-17 μm × 12-15 μm Mean = 16 × 14 μm n = 7, s = 1.5, 1.1	12-21 μm × 8-12 μm Mean = 19 × 10 μm n = 14, s = 1.8, 1.3

[1]From Weiser and Muma 1966.
[2]From Humber *et al.* 1981.

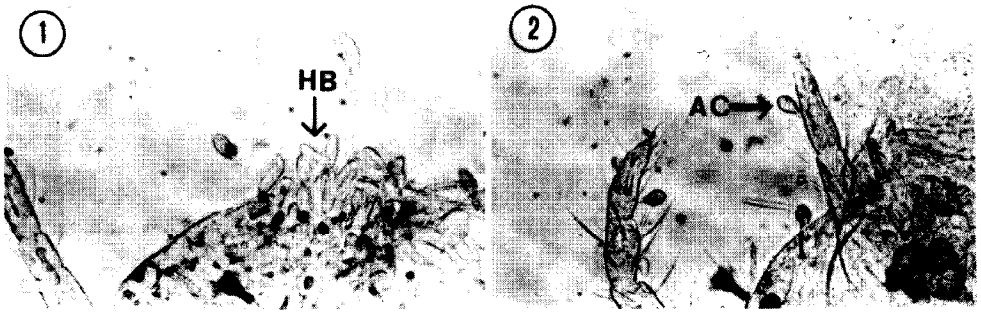

Fig. 1. Hypal bodies (HB) of *Triplosporium* sp. being released from body of *Mononychelus progressivus*. 224X.

Fig. 2. Anadhesive conidia (AC) of *Triplosporium* sp. attached to leg of *Mononychelus progressivus*. 264X.

I want to thank E. Doreste for providing infected mites and R. A. Humber (Boyce Thompson Institute for Plant Research, Ithaca, NY) for information on the current status of the genus name *Triplosporium*.

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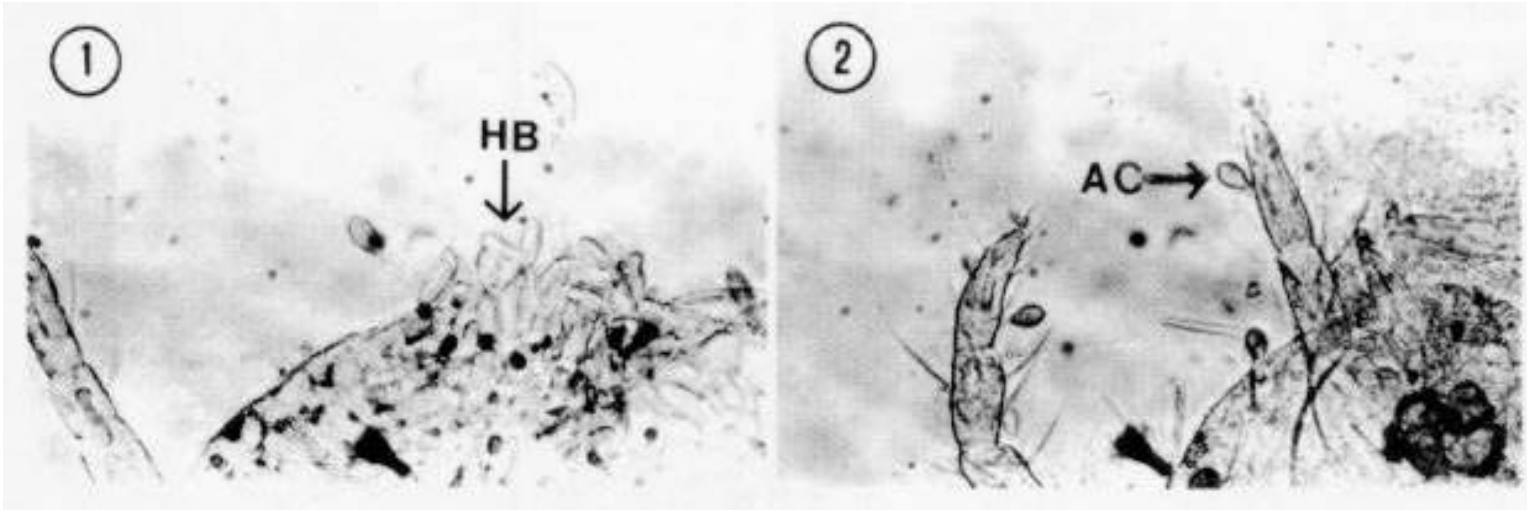
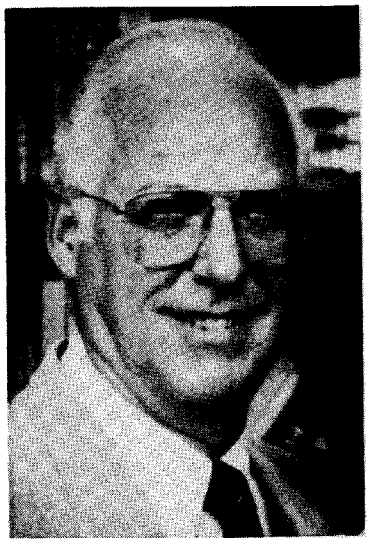

①
HB
②
AC



In Memoriam

Sam Spruill Fluker

1931–1986

Dr. Sam Fluker died March 12, 1986, at Washington Hospital Center in Washington, D.C., after suffering a heart attack. He was 54. Sam was a professor at the University of Florida, Institute of Food and Agricultural Sciences, carrying the titles of Pesticide Information Officer and Southern Region Pesticide Coordinator.

He was born on April 14, 1931, in Rhone, Texas. Sam retired as a Staff Sergeant with the U.S. Air Force after serving from 1948 to 1960. He then earned the B.S. degree from Texas Tech University in 1966 and the M.S. and Ph.D. degrees from the University of Hawaii in 1967 and 1969, respectively. He worked as an entomologist at the Missouri Fruit Experimental Station in 1969 and then moved to the University of Florida Agricultural Research Center in Monticello to study insects of pecan and peach. In 1973, Sam moved to Atlanta, Georgia, as an entomologist with the Environmental Protection Agency, and in 1980 he returned to the University of Florida to direct programs, collect and disseminate information relating to agricultural pesticide products, and train personnel in the safe and legal use of pesticides.

Sam was a member of numerous civic and professional organizations, including Sigma Xi; the Florida, Hawaii, and Georgia Entomological Societies; the Entomological Society of America; and the American Registry of Professional Entomologists. He served as Local Arrangements Chairman for the 1980 ESA meeting in Atlanta, was an examiner in the biological control category for ARPE, and served on the ECOP Task Force for the National Agricultural Pesticide Impact Assessment Program.

Dr. Fluker was an expert in the field of pesticide use and regulations. He was a fountain of information and shared his knowledge willingly with all. His gentle personality, knowledge, and cooperativeness earned the respect of all who knew him.

Sam is survived by his wife, Laura, of Micanopy, Florida; son, Steven, of Gulfport, Mississippi; daughter, Nancy Fluker Rains, of Tallahassee, Florida, and three grandchildren. He is also survived by his mother, Mrs. Ethel Fluker of Tampa, Florida; and two brothers and three sisters.

D. H. Habeck

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