GROWTH OF *ATTA LAEVIGATA* (HYMENOPTERA: FORMICIDAE) NESTS IN PINE PLANTATIONS

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ABSTRACT

We evaluated the survival, mortality and colony growth over time after worker emergence in colonies of *Atta laevigata* (Fr. Smith) ants in young pine tree plantations of *Pinus caribaea* (Mor) located in Estado Monagas, Venezuela. One hundred forty-four colonies were inspected during a 41-month period. Colony mortality one month after worker emergence was 45%. A small mortality peak was evidenced when colonies were 24 months old, coinciding with a dry season. About 23% of the colonies marked survived more than 3 years. During the first two years, colony growth was faster than during the next two years, as measured by the total number of nest entrances and the nest surface area. Multiple regression analyses showed a closer correlation between nest age and nest area than between nest age and number of nest entrances. Most of the nests grew in an eccentric way with respect to the site where the queen first established the nest. These results allow for a more rational pest management of pine plantations by using the knowledge on nest growth for decisions on pest control.

Key Words: *Atta laevigata*, ants, colony growth, pest management, pines, nests, Venezuela

RESUMEN

La sobrevivencia, mortalidad y crecimiento a través del tiempo de colonias de *Atta laevigata* (Fr. Smith) presentes en plantaciones recién establecidas de *Pinus caribaea* (Mor) en el Estado de Monagas, Venezuela, fueron evaluados después de la emergencia de las primeras obreras. Ciento cuarenta y cuatro colonias fueron observadas durante un período de 41 meses. La mortalidad de las colonias un mes después de haber sido marcadas fue del 45%. Un pequeño pico de mortalidad fue observado a los 24 meses de edad de las colonias coincidiendo con un período de sequía. Alrededor del 24% de las colonias marcadas sobrevivieron más de 3 años. El crecimiento de las colonias durante los dos primeros años fue mas rápido que en los dos años siguientes, tanto en el número total de entradas al nido como en el área de superficie del nido. Los análisis de regresión múltiple mostraron una correlación más cercana entre la edad y el área del nido que entre la edad y el número de entradas al nido. La mayoría de los nidos crecieron en forma excéntrica con respecto al sitio en el cual la reina estableció inicialmente el nido. Estos resultados permiten un manejo más racional de esta plaga en plantaciones de pino al utilizar el conocimiento sobre el crecimiento de sus nidos para tomar decisiones para su control.

Leaf-cutting ants are important pests in agriculture and forestry (Cherret & Peregrine 1976, Gonzales 1976). In Venezuela, *Atta laevigata* (Fr. Smith) is the main pest affecting the establishment and development of pine tree plantations, causing losses of over 50% in wood volume produced per hectare at populations over 30 nests/ha. (Hernández & Jaffé 1995). The most important aspects affecting pest management programs of these ants is the colonization dynamics of new areas and nest growth during the first stages of infestation.

Ants of the genus *Atta*, have colonies formed by many underground chambers joined by numerous tunnels. Externally the nests are characterized by numerous mounds of bare soil excavated by the ants when digging the tunnels and chambers (Autori 1941, Gonçalves 1964, Mariconi 1970). Maximum development of *Atta sexdens rubropilosa* (Forel) colonies occurs three years after foundation (Autori 1941). In *A. sexdens,* the first nest entrance appears 77-188 days after the nuptial flights. The second nest entrance appears 377-467 days, and 82 days after this time the colony may have up to 10 entrances (Mariconi 1970). According to these estimates, a two year old nest could show an area of approximately 10 m^2. In the case of *A. laevigata,* nest growth increases after the first two years, reaching in average an area of 24 m^2 when the nest is three years old (Salzemann & Jaffé 1990).

In this paper, we detail the growth and population dynamics of *A. laevigata* nests infecting young pine plantations.

MATERIALS AND METHODS

The study was carried out in a 100 hectare plot of young pines planted in 1991 at El Merey, the commercial pine plantations of CVG-PROFORCA, in Monagas and Anzoategui states, Venezuela. In these regions, CVG-PROFORCA has planted between 12,000 and 15,000 hectares of pines every year. The soils of the area are sandy, with a low natural fertility and a pH of 4.5. Annual precipitation occurs in two marked periods, a dry season from November to May and a rainy season from June to October. The average precipitation during the study (1990-1994) was 1255 mm per year, according to the meteorological station at El Merey, CVG-PROFORCA.

Nest Selection

We marked 144 incipient nests of *A. laevigata* and evaluated their activity in February 1992, corresponding to colonies founded after the nuptial flights of June 1991. These nests were approximately 8 months old, as the queen digs the nest after its nuptial flight at the beginning of the rainy season and remains in the sealed nest, which is opened only after the first adult workers emerge. Nests to be marked were selected at random by establishing 30 × 100 m transects and marking each nest found along these transects. All *Atta* nests present in the study area had been destroyed in April 1991, using cultural (burning of the savanna and plowing) and chemical (baits) control.

Evaluations

The next evaluation was carried out one month after the incipient nests were marked (about nine months of age). Only nest activity was checked as no nest growth was observed. Thereafter, the colonies were examined at 12, 16, 18, 23, 26, 35, 38, 41 and 48 months after nest foundation. In each one of these evaluations we determined the nest activity, the number of nest entrances, the surface area of the central nest conglomerate and the form of this conglomerate. Nest area was estimated by measuring the length and breadth of each nest. Nest area was calculated with the formula for the ellipse: $A = \pi ab$ where $a = ½$ length and $b = ½$ breadth of the nest. The position of

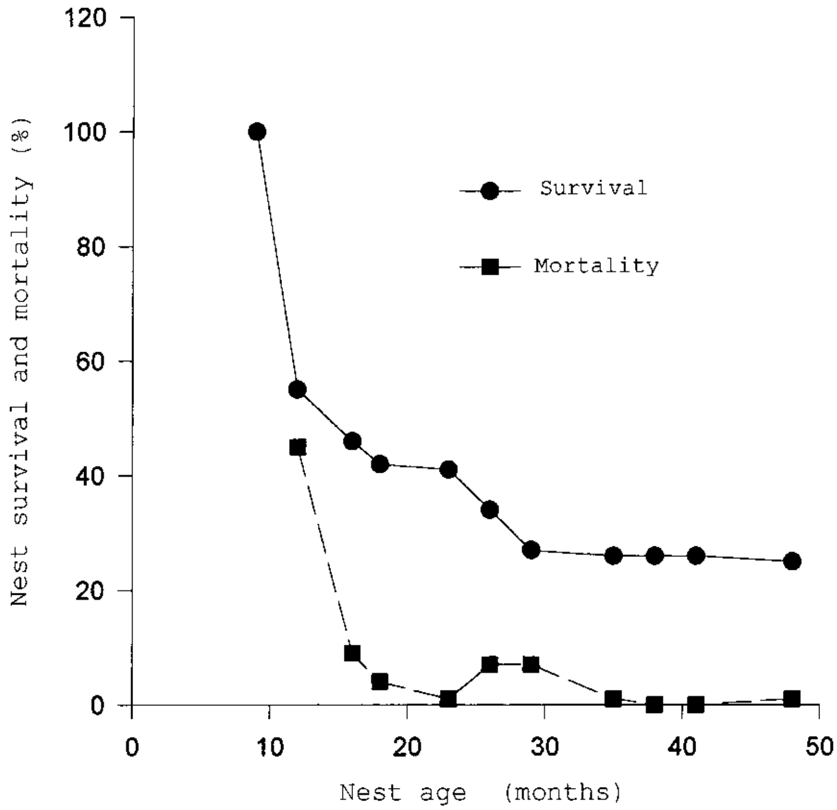

Fig. 1. Survival and nest mortality of *Atta laevigata* nest after the claustral stage, i.e. after the first workers emerged from incipient nests.

the nest with respect to the first nest entrance was determined by referring to the identifier stake used to mark the incipient nest. All data were analyzed using STATISTICA for MS-Windows.

Results

Nest Survival and Mortality

Figure 1 shows that only 55% of the nests survived more than one month after they were marked at nine months of age. Nest survival fell to 34% after 23 months, stabilizing at 25% after three years. That is, nest mortality was 45%/month one month after the first exploring workers emerged and then decreased to one digit values showing a smaller peak at about 25 months.

Nest Growth

The average nest areas for *A. laevigata* during the 48 month study are shown in Fig. 2. The rate of increase of the nest area was higher during the first 30 months than dur-

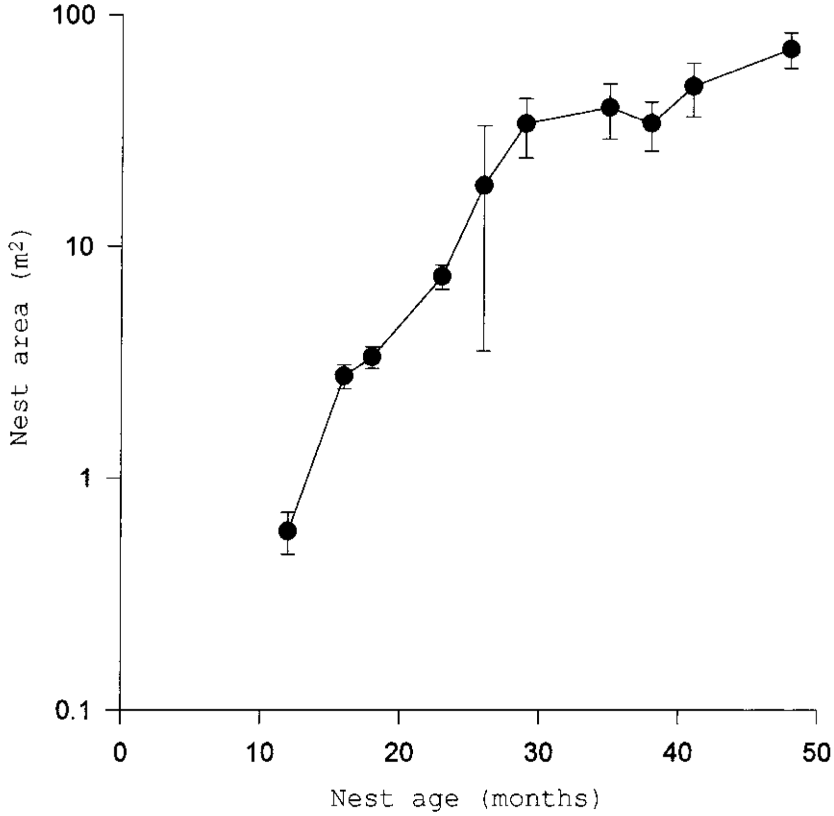

Fig. 2. Growth over time of nest area (in logarithmic scale) of *Atta laevigata* colonies in a new pine plantation. (Means and standard error).

ing the final two years. Colonies with 4 years of age had nests with an average size of 71 ± 13 m^2. The increase in nest area was accompanied by an increase in the number of nest entrances. During the first two years, the rate of increase in the number of nest entrances (Fig. 3) was also higher than during the last two years. The ratio of nest entrances to nest area (Fig. 4) decreased rapidly in young colonies and gradually in the older colonies. In other words, older colonies have fewer entrances per unit area of nest.

The age, nest area, and the number of nest entrances showed significant correlations among them ($p < 0.05$, Pearson correlation coefficient). These results confirm that nest area and the number of nest entrances are related to the age of the colony. A regression analysis of the nest area, number of nest entrances and age showed that nest area is a better predictor for nest age than the number of nest entrances ($R^2 = 0.52$ and 0.38 respectively). The regression equation for nest area was $NA = -12.577 + 6.7X$ and for nest entrances the equation was $NE = -16.679 + 18.6X$; where X is age in months.

From a total of 58 nests evaluated, 24% grew in a concentric way around the initial founding chamber, 60% eccentric to it and 16% leaving the initial chamber at the margin of the nest mound conglomerate.

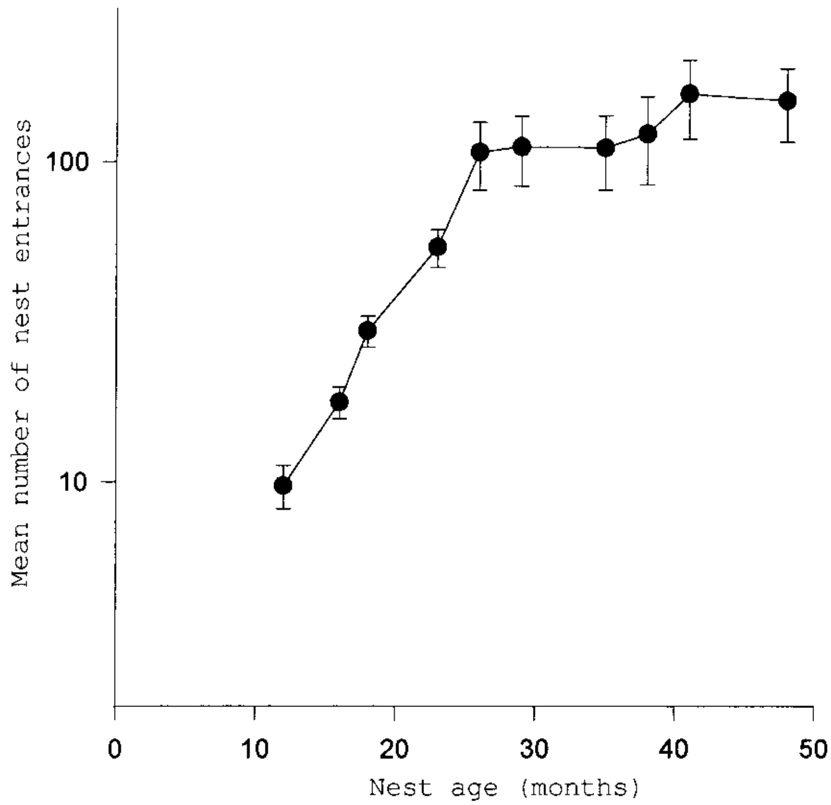

Fig. 3. Increase over time of the number of nest entrances (in logarithmic scale) of *Atta laevigata* nests in a new pine plantation. (Means and standard error).

Discussion

Mariconi (1970) reported that only about 3% of the inseminated queens established a nest. Our results show that colony mortality continues to be high, although less so, after the nests produced workers. Absolute nest size was small during the first two years although the growth rate was high. After this time nest growth and colony mortality decreased. The small peak in nest mortality found (Fig. 1) coincided with low precipitation during this period. The mortality peak was probably due to the fact that young colonies are more susceptible to low soil humidity than larger ones. We found that two year-old nests had an average area of 7.4 ± 6.3 m^2, which is similar to that reported for *A. sexdens* by Mariconi (1970). Three years-old nests reached an average area of 39 ± 33 m^2 which contrasts with the 24 m^2 reported by Salzemann & Jaffe (1990) for *A. laevigata* feeding on adult pine trees in areas close to this study site. The larger size reported here may be due to the fact that in our site, the savanna had still not been displaced by the pines and the ants could feed on a larger variety of plants.

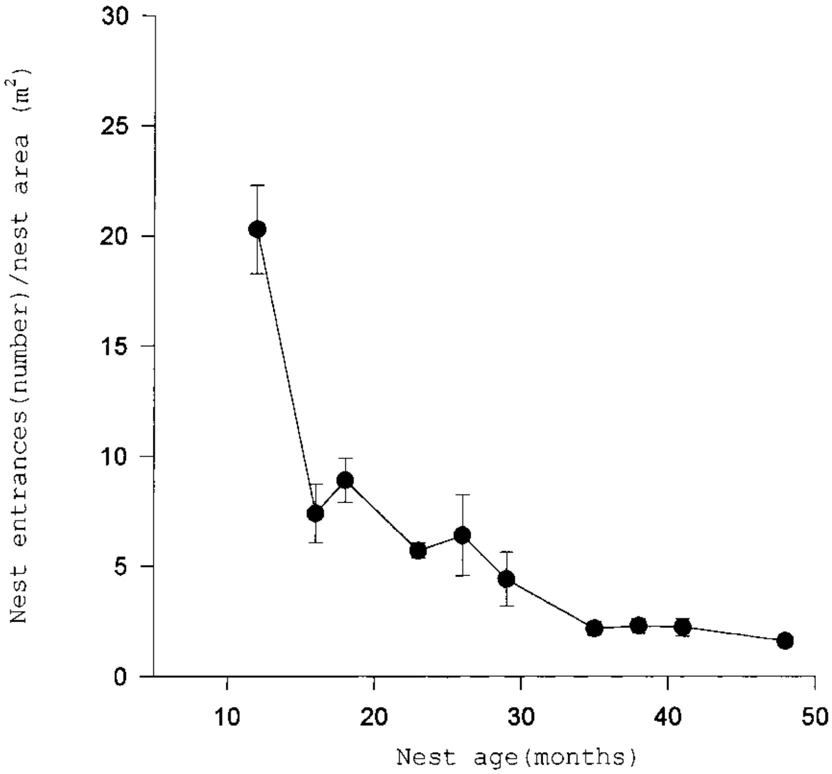

Fig. 4. Relation between number of nest entrance and nest area over time. (Means and standard error).

The results show that colony growth has at least two phases irrespective of the variable measured (nest area or number of nest entrances), and that after two years, colonies grow at a lower rate compared to the first two years. The proportional relationship between nest area and the number of nest entrances is not constant, as the number of nest entrances per nest area decrease during the first two years remaining approximately constant thereafter. Our analysis suggests that nest area is a better estimate of colony age than the number of nest entrances, at least for young nests.

In young pine tree plantations, where *A. laevigata* nests are eliminated before planting the pines, a fast re-colonization by this pest will occur. This means that an effective management of ant populations should include a pest density evaluation and eventual control of ant nests when pines are two years old (Hernández & Jaffé 1995). Nests will have suffered the largest amount of natural mortality and will still be small and thus easier to control, requiring lower amounts of toxic baits, having advantages both from an environmental and an economic point of view.

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heights (0 and 1 meter) and with aggregation pheromone alone, pheromone plus banana pseudostem, pheromone plus sugar cane, pheromone plus banana rhizome, and pheromone plus pineapple as baits. The results indicate that the most effective trap was the lid type placed at a 1 meter, using pheromone plus sugar cane as bait.

Key Words: olfactometric method, trap system, host odor

RESUMEN

En este trabajo se presenta una prueba de campo sobre la actividad de la feromona del gorgojo rayado, *Metamasius hemipterus* (L.), combinada con olores de sus plantas huéspedes y se describe um método olfatométrico que nos permite determinar en el laboratorio la eficacia de los semioquímicos a evaluar y un sistema de trampeo que nos permite determinar en el campo la efectividad de los cebos atrayentes. En el laboratorio se evaluó la respuesta del insecto usando un olfatómetro de caída de dos pocillos. Como fuentes aromáticas se usaron olores de las plantas huéspedes: a) seudotallo y cormo de *Musa* sp. variedad cambur manzano (AAB) y b) tallos de caña de azúcar *Saccharum* sp. Los resultados indican que las aromas de las plantas huéspedes atraen al insecto, que el aroma de la caña de azúcar es más atrayente que el del cormo de cambur manzano, y que el aroma del seudotallo es tan atrayente como el aroma del tallo de la caña de azúcar. Para el estudio de campo se diseñaron dos trampas de captura: trampa con tapa y trampa con embudo. Se evaluó la eficiencia de captura de estas trampas colocadas a dos alturas (0 y 1 metro) y usando como cebo atrayente la feromona de agregación sola, la feromona con el seudotallo de cambur manzano, la feromona con la caña de azúcar, la feromona con el cormo de cambur manzano, y la feromona con piña. Los resultados indican que la trampa más atrayente fue la trampa con tapa colocada a un metro de altura con feromona mas caña de azúcar como cebo.

Due to the problems posed by the use of synthetic insecticides for pest control, including environmental degradation and the pests' development of resistance to insecticides (Getz and Gutierres, 1982; Jaffé et al. 1993), there is a growing use of natural enemies and semiochemicals in integrated insect pest control programs. That approach is of considerable practical utility for controlling some Coleoptera pests (Vilela and Castro, 1987).

The sugar cane weevil *Metamasius hemipterus* (L.) (Coleoptera: Curculionidae) is a serious sugar cane pest (Restrepo et al. 1982). Some authors (Cárdenas, 1976; Boscan and Godoy, 1988) also view it as a secondary agricultural pest for Musaseae. In its larval stage *M. hemipterus* damages sugar cane stalks and Musaseae pseudostems. As it feeds in those zones, it digs tunnels, destroys tissue, and weakens the plant.

The use of poisoned sugar cane and Musascea traps to control these beetles (Restrepo et al. 1982; Nava and Sosa, 1985) has revealed that this species, like many other insects (Bell, 1991), uses volatile semiochemicals probably originating in fermented pieces of Musasea pseudostem and sugar cane stalk to orient it to the plant. Using pitfall traps in southern Florida (USA), Giblin-Davis et al. (1994) showed that the sugar cane weevil is attracted by sugar cane, musasea pseudostem, palm crown, and sugar cane stem aromas.

Pure attractants isolated from host plants or pheromonal compounds may be useful as bait to lure the insects into traps for monitoring or control purposes.

Rochat et al. (1993) used a collection method based on supelpack and desorption with dichloromethane, then gas chromatography coupled with mass spectrometry, to isolate and identify 4 methyl-5-nonanol as the main component of an aggregation pheromone produced by male *M.hemipterus*. The same compound is also present in the aggregation pheromone of another rhynchophorine, *Rhynchophorus vulneratus*. The sugar cane weevil pheromone was subsequently synthesized by Mori et al. (1993).

Traps with attractant semiochemicals, pheromones, and kairomones have been successfully used for coleoptera control of the boll weevil *Anthonomus grandis* Hardee, (1982), wood-attacking scolitids (Borden, 1993), and the coconut weevil (Hernández et al. 1992; Oehlschlager et al. 1993). Hence, massive trapping of sugar cane weevils may be a viable method for control.

Castrillo et al. (1995) reported that the pheromone emitted by the male is (4S,5S) 4-methyl-5-nonanol; (+/-) 2-methyl-4-heptanol) in 8: 1 proportion. In April 1995 we received 50 devices for releasing the pheromone. Each lure will release a constant amount of pheromone per day in the field during 2-3 months (Oehlschlager, pers. comm).

In this study we field tested the behavioral activity of the *M. hemipterus* pheromone mixed with the odors of its host plants, and developed (1) an olfactometric method for laboratory determination of the effectiveness of the semiochemicals and (2) a field trap system with which to determine the effectiveness of baits in attracting sugar cane weevils in the field. Using those olfactometric methods we measured the attraction of sugar cane weevils to semiochemicals from their host plants and the aggregation pheromone described for this species.

Materials And Methods

Capture and Maintenance of Adults.

The insects were collected in a plantation of edible musaseae plants shaded by cacao trees near the Simón Rodríguez University Río Negro Experiment Station in Acevedo District of Miranda State, Venezuela (10°20' North, 66°11 West, at 42 meters above sea level, with 2050 mm of annual precipitation). The plantation produces a mix of banana and plantain varieties including: "pineo" (genotype AAA), "plátano" (AAB), "topocho" (ABB), and "cambur manzano" (AAB).

The place is not a commercial musaseae or sugar cane plantation. Moreover, chemical insecticides or herbicides are not used in the experimental plot.

The insects were caught with sandwich-type retention traps (Castrillón, 1989) which use pseudostem tissues as attractors. The insects were then taken to the laboratory in individual plastic containers 7.5 cm high by 9 cm in diameter, the lid perforated to allow air flow. In the laboratory the insects were kept in plastic containers, in groups of 10. The adults were given a piece of sugar cane for food. The specimens were kept in the laboratory, at 23-27°C and 70-90% relative humidity, with 12 hours of light and 12 of darkness per day. Under these conditions the adults fed twice a week on sugar cane pieces of 80 to 100 g, cut lengthwise.

Olfactometric Methods

The Pavis and Minost (1992) double-pitfall olfactometer (Fig. 1) was adapted to determine attraction of the aggregation pheromone to adults. This device was built as a cylindrical chamber (25 cm in diameter by 30 cm high), connected to two jars containing the odor sources. The duration of each piece of experiment was of six hours (9:00 to 14:00), using 20 insects placed on the platform at a time. The number of insects that

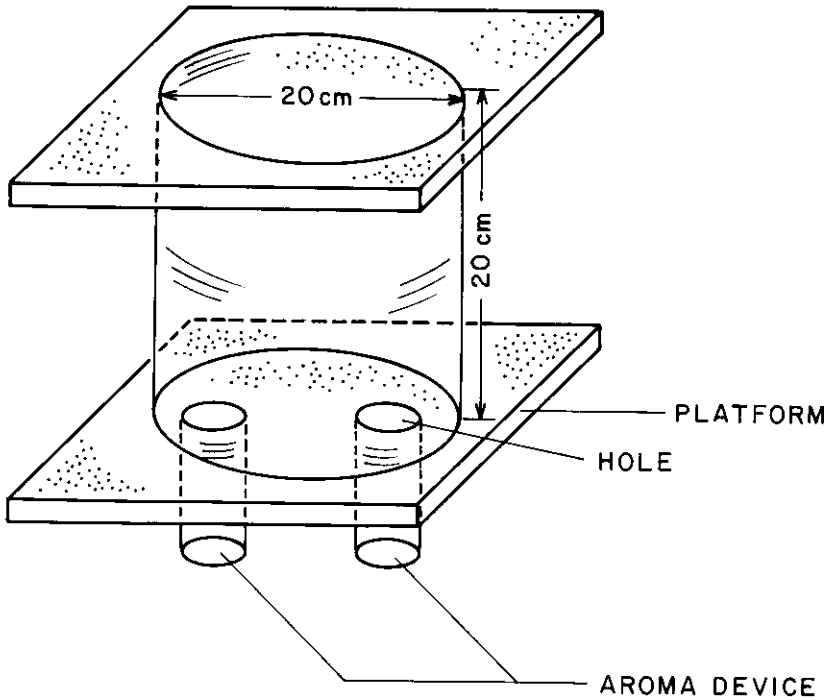

Fig. 1. Double-Pitfall Olfactometer.

had fallen into each jar was counted at the end of each period without distinction by sex. The tests were carried out in a room with dimmed daylight and a normal photoperiod. The environment was kept clean with extractor fans to remove odors not related to the experiment.

Odor Sources

The odor sources used for the biotests were 50 grams of vegetable tissue taken from "cambur manzano" banana clone pseudostems and rhizomes without flowers or fruit (AAB genomic composition), 50 grams of pineapple, and 50 grams of sugar cane stalk (*Saccharum* sp). The vegetable material was collected at the aforementioned Musaseae plantation, located in the vicinity of the Simón Rodríguez University Río Negro Experiment Station.

Field Capture Tests

The traps were placed in a shaded area of an edible Musaseae plantation between May and July 1995, arranged in a straight line perpendicular to the prevailing wind direction, with alternation of the treatments under examination; they were placed approximately at 10 m apart, and checked at 2 or 3 day intervals. The experiments were conducted between May 22 and July 19, 1995.

Two distinct trap designs were tested to compare their capture efficiency:

Design 1: Funnel trap (Fig. 2). This kind of trap is composed of a plastic cylinder 10 cm in diameter by 14 cm high, with a 5 cm-high funnel in its top half. A layer of water approximately 3 cm deep was placed at the bottom of the trap to keep the insects from escaping. The aroma sources were suspended from a wire half way down the cylinder.

Design 2: Perforated lid trap. This trap uses the same plastic cylinder, with no funnel but with a lid having 20 holes approximately 4 mm in diameter. A layer of water approximately 3 cm deep was placed at the bottom of the trap to prevent escape. The aroma sources were suspended from a wire half way down the cylinder.

Evaluation of pheromone device activity.

The following baits were used to evaluate the pheromone's field effectiveness in the pheromone release device (PRD) described by Castrillo et al. (1995) and Camm Oehlsclager pers. comm. in perforated lid trap. Lures of pheromones (4S, 5S) 4-methyl-5-nonanol; (+/-) 2-methyl-4-heptanol) in 8: 1 proportion.

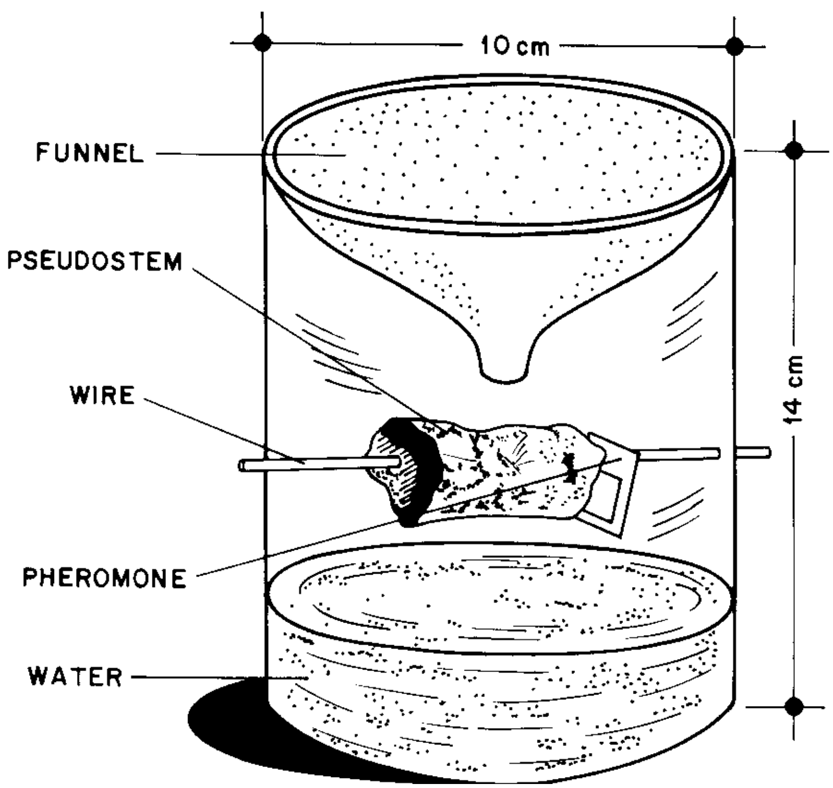

Fig. 2. Funnel Trap.