BIOLOGICAL CONTROL OF THE TERMITE *HETEROTERMES TENUIS* (HAGEN) (ISOPTERA: RHINOTERMITIDAE) BY *BEAUVERIA BASSIANA* (BALS.) VUILL IN CENTRAL MOTZORONGO, VERACRUZ, MÉXICO WITH CARDBOARD TRAPS

By

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ABSTRACT

THE SUBTERRANEAN termite, *Heterotermes tenuis* (Hagen), has become a major economic pest in sugarcane fields of Mexico, particularly in Veracruz State, due to the damage and losses they cause to the crop. Colonies are difficult to locate due to termite biology and the habitats they infest. In the absence of effective control tactics, we developed the use of the entomopathogen, *Beauveria bassiana*, combined with attractant traps, as an economic and environmentally friendly method of control. This entomopathogen has been shown to be effective on various agricultural pests. The technique is especially attractive because it has no polluting effects on the environment. For these reasons, we chose it as the control agent for traps constructed out of corrugated cardboard. We evaluated two entomopathogenic fungi: strain CP 095, *B. bassiana* and *Metarhizium anisopliae*, METAMOTZ 093, plus two insecticides (fipronil and imidacloprid). Four trials were conducted in sugarcane fields of Central Motzorongo. Field surveys were conducted weekly. Under laboratory conditions the best results were obtained with *B. bassiana* at 7 days causing 100% mortality, whereas with *M. anisopliae* the highest mortality occurred at 9 days. Pathogenicity of *B. bassiana* based on termites found dead in a growth chamber was 90% but 70% effective when combined with *M. anisopliae*, which diminishes its effectiveness.

Introduction

The subterranean termite, *Heterotermes tenuis* (Hagen) (Isoptera: Rhinotermitidae), is one of the most important pests of sugarcane in Brazil, Guatemala and Mexico. According to Novaretti (1985), infestations at planting, at crop maturity and after harvest can cause yield losses up to 10 t/ha per year.

Control of subterranean termites is currently very expensive and not effective due to the difficulty of targeting colonies which are widely dispersed in the soil. Restrictions on the use of highly toxic chemical insecticides have led to research on alternative management strategies for controlling termites. Insecticide applications are now based on levels of pest infestation as determined from surveys and species identification (Macedo *et al.*, 1997).

Monitoring of termite populations has been a major breakthrough in technological developments in the control of subterranean termites, which is being adopted by sugarcane producers. Surveys of population levels and identification of harmful species in sugarcane fields have allowed for more efficient use of termiticides.

The use of toxic attractants in traps for termite control is a promising alternative that has been investigated in several countries (Macedo *et al.*, 1997; Almeida *et al.*, 1998).

The combined use of traps with attractants to enhance contact of the pest with a toxin is now recommended by researchers. In a control strategy for *H. tenuis* with traps of corrugated cardboard

impregnated with an insecticide and entomopathogenic fungi, it is also important to consider the fungicidal effects of the product to be used (Castiglioni *et al.*, 2003).

In addition to their toxic effects, the products used in traps for control of subterranean termites should be slow-acting, non-repellent and transmitted between individuals of the colony.

Thus, when treating a portion of the community, the toxic agent can be distributed throughout the colony when the workers return from feeding. Such slow-acting insecticides can cause the collapse of a colony of termites (Castiglioni and Vendramim, 2003).

The strategy of monitoring and control of termites using traps as attractants (bait), is based on the principle of contact of the microbe or chemical agents with those insects attracted to the bait and transmitting these back to the entire colony (Almeida *et al.*, 1998).

The corrugated cardboard traps are attractive to termites and have been used for monitoring populations of this pest in sugarcane and forest systems. Biological agents such as *B. bassiana* can also be used in combination with a sublethal dose of an insecticide in the traps (Almeida, 1994).

Such a monitoring technique has been used with forest termites by Iñiguez and Talavera (2006) in the state of Colima, Mexico, with very good results.

Their procedure consisted of burying a 1 litre plastic bucket with holes drilled in the bottom, sides and the lid. A roll of corrugated paper (cellulose source) that serves as food for termites is placed inside.

The goal of this study was to determine the efficiency and pathogenicity of *B. bassiana* for biological control of subterranean termites in sugarcane, using traps made of corrugated cardboard in Central Motzorongo.

Materials and methods

This study was carried out in 2008 during the maturation phase of sugarcane (August–November). Traps were monitored every seven days during this four month period.

Two insecticides and two entomopathogenic fungi were assessed as shown in Table 1. Four trials were laid in distinct agroclimatic areas. Each treatment was replicated four times.

Table 1—Active ingredients evaluated in the traps for the control of termites in Central Motzorongo.

Treatments	Rate/hectare	Concentration
Beauveria bassiana	1 kg	2×10^{12}
Metarhizium anisopliae	200 g	2×10^{12}
B. bassiana and *M. anisopliae*	1 kg and 200 g	2×10^{12}
Imidacloprid	30 g	15%
Fipronil	20 mL	30%
Control	–	–

Preparation of the traps

The active ingredient was dissolved in 15 litres of water in a 20 litre container. Corrugated cardboard rolls serving as traps were submerged in this solution for one minute for the impregnation of the active ingredient.

Distribution of traps in the field

The distribution of traps impregnated with the active ingredient for control of subterranean termites in sugarcane was set up with 20 traps per hectare according to procedures outlined by Macedo and Macedo (2004) so that the traps were distributed evenly in treated areas.

The traps used as attractants at Central Motzorongo were made of corrugated cardboard with chemical and biological ingredients as shown in Figure 1.

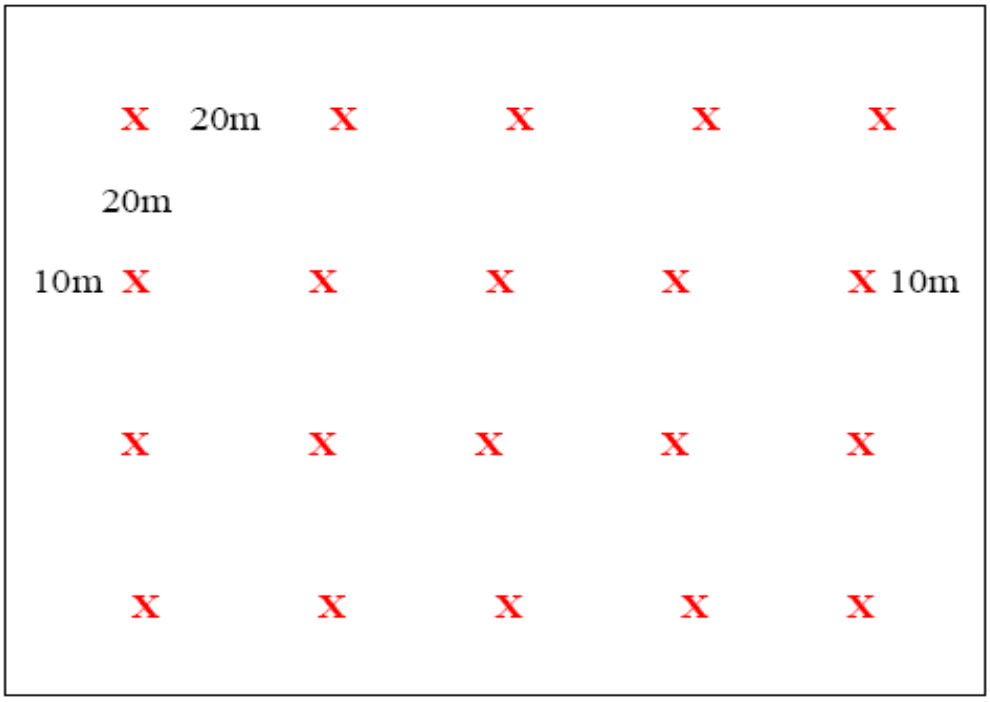

Fig. 1—Diagram of the distribution of traps per site (one hectare) for control of subterranean termites.

Placement of traps in the field

Traps, 7.5 cm diameter × 23 cm high, made of corrugated cardboard were used. These were buried 20 cm deep so that 3 cm was visible above ground for easy location of the traps for assessments.

Results

Samples were taken fortnightly during September and October 2008. At each sampling date, live termites collected were transferred to the laboratory to determine percent of mortality for each of the treatments.

Dead termites were placed in a growth chamber and incubated at 25°C for 10 days to determine the cause of death.

We determined the average daily mortality of termites at 10 days in the laboratory by placing 20 worker termites in a petri dish containing field soil and bait formulation.

Four replicates per treatment were used to calculate the average mortality of individuals killed for each of the treatments evaluated.

Once the percentage daily mortality in treatments with *B. bassiana* and *M. anisopliae* was determined, termites were again placed in a growth chamber in the laboratory at 25°C, to observe if the death was due to the entomopathogenic fungi.

We placed twenty termites per treatment in each of four petri dishes and noted the development of mycelia on the cadavers.

As shown in Figure 2, *B. bassiana* showed a mortality of 100% of the population evaluated seven days after, whereas treatment with *M. anisopliae* alone and in combination with *B. bassiana*, 100% mortality was attained after eight days, while only 60% mortality was observed at the end of the observation period of ten days for the control.

No live termites were found in the traps impregnated with chemical insecticides because the highly toxic ingredients cause immediate death of the workers.

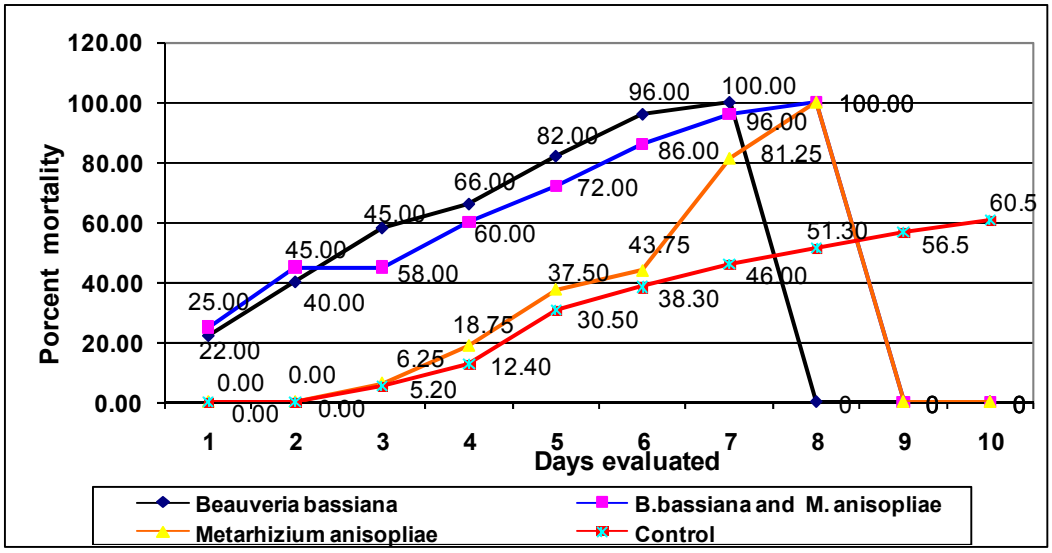

Fig. 2—Mortality of termites in function of observation time in the treatments evaluated.

Mycelium formation and sporulation occurred on 90% of the termites from the *B. bassiana* treatment, and 70% in the treatment in combination with *M. anisopliae*.

This technique is cost effective due to the low-cost of materials that are used such as the corrugated cardboard and the entomopathogenic agents (Table 2).

Table 2—Cost per hectare for the use of traps as attractants for control of termites in Central Motzorongo.

Types of control	Cost of traps per hectare ($)	Cost active ingredient ($)	Cost labour ($)	Total cost per hectare ($)
Traps (with *Beauveria bassiana*)	60	90	160	320.00
Traditional (with chemical insecticide)	–	1800	200	2000.00

Results and discussion

Using the corrugated cardboard technique, we found that this material is very attractive to termites, as the cellulose contained in this material is easily digestible by termites. Our results confirm the findings of Macedo *et al.* (2004). On average, 2300 termites were found per trap. The traps cause the termites to divert their attention from the sugarcane, and a reduction in damage to the basal internodes of stalks in the field was observed.

Additionally, there is a ripple effect whereby the entomopathogenic agents are spread to the rest of the colony by the contact of infected termites with uninfected ones. The natural dispersal of entomopathogenic fungi is slow and lengthy in contrast to insecticides. This method therefore enhances the rate of spread of the entomopathogen to the colony and degrades quickly.

Conclusions

Corrugated cardboard is a very attractive material to termites, as the cellulose contained in this material is more easily digestible. This control option is ecologically safe as the material is biodegradable.

As for the active ingredients used in the traps, better results were obtained with entomopathogenic fungus *B. bassiana*, with a mortality of 100% of the population and one of pathogenicity 90%.

This technique reduces the cost to control this pest as well as serves as an environmentally friendly method of controlling damaging termite infestations.

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LUTTE BIOLOGIQUE CONTRE LE TERMITE *HETEROTERMES TENUIS* (HAGEN) (ISOPTERA: RHINOTERMITIDAE) PAR *BEAUVERIA BASSIANA* (BALS.) VUILL EN UTILISANT DES PIÈGES EN CARTON AU MOTZORONGO CENTRAL, VERACRUZ, MEXIQUE

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MOTS CLÉS: Termites, Champignon Entomopathogène, Pièges, Lutte, Pathogènicité.

Résumé

LE TERMITE souterrain, *Heterotermes tenuis* (Hagen), est devenu un ravageur majeur dans les champs de la canne à sucre au Mexique, particulièrement dans l'état de Veracruz, de par les dégâts et pertes causées à la culture. Les colonies sont difficilement localisées de par la biologie de l'insecte et le type habitat infesté. En l'absence d'une stratégie de lutte efficace, nous avons préconisé l'utilisation de l'entomopathogène *Beauveria bassiana* en combinaison avec des pièges attractifs, comme moyen de lutte économique et respectueux de l'environnement. Cet entomopathogène a démontré une efficacité contre plusieurs ravageurs agricoles. La technique est

particulièrement intéressant comme elle n'a aucun effet polluant. Pour cette raison, nous l'avons choisi comme agent de lutte en utilisant des pièges construit avec le carton ondulé. Nous avons évalué deux champignons entomopathogènes : la souche CP 095, *B. bassiana* et *Metarhizium anisopliae*, METAMOTZ 093, en sus de deux insecticides (fipronil et imidacloprid). Quatre essais ont été établis dans des champs de canne à sucre au Motzorongo Central. Les prospections ont été effectuées toutes les semaines. Sous les conditions de laboratoires, les meilleurs résultats ont été obtenus avec *B. bassiana* à 7 jours, occasionnant 100% de mortalité, alors qu'avec *M. anisopliae* la mortalité la plus élevée a été observée après 9 jours. Le pathogènicité du *B. bassiana* en fonction des termites morts dans une chambre de culture était de 90%. L'efficacité était réduite à 70% en combinaison avec le *M. anisopliae*.

CONTROL BIOLÓGICO DE LA TERMITA *HETEROTERMES TENUIS* (HAGEN) (ISOPTERA: RHINOTERMITIDAE) EMPLEANDO *BEAUVERIA BASSIANA* (BALS.) VUILL EN TABLEROS TRAMPAS, EN EL CENTRAL AZUCARERO MOTZORONGO, VERACRUZ, MÉXICO

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PALABRAS CLAVE: Termitas, Hongos Entomopatógenos, Trampas, Control, Patogenicidad.

Resumen

LA TERMITA subterránea, *Heterotermes tenuis* (Hagen), se ha convertido en una plaga económica importante en los campos de México, en particular en el Estado de Veracruz, debido a los daños y perjuicios que causan a los cultivos de de caña de azúcar. Las colonias son difíciles de localizar debido a la biología de las termitas y de los hábitats que infestan. A falta de tácticas eficaces de control, se ha desarrollado el uso del entomopatógeno, *Beauveria bassiana*, combinada con trampas atrayentes, como un método económico y ambientalmente amigable de control. Este entomopatógeno ha demostrado ser eficaz en diversas plagas agrícolas. La técnica es especialmente atractiva porque no tiene efectos contaminantes sobre el medio ambiente. Por estas razones, hemos elegido como el agente de control de las trampas construidas de cartón corrugado. Se evaluaron dos hongos entomopatógenos: CP cepa 095 de *B. bassiana* y *Metarhizium anisopliae*, METAMOTZ 093, además de dos insecticidas (Fipronil e Imidacloprid). Se realizaron cuatro ensayos en los campos de caña de azúcar del Central Motzorongo. Las evaluaciones de campo se llevaron a cabo semanalmente. En condiciones de laboratorio los mejores resultados se obtuvieron con *B. bassiana* a los 7 días, causando una mortalidad del 100%, mientras que con *M. anisopliae* la mortalidad más alta se produjo en 9 días. La patogenicidad de *B. bassiana* sobre la base de las termitas muertas en una cámara de crecimiento fue del 90%, pero el 70% de efectividad cuando se combinó con *M. anisopliae*, debido a disminución a su eficacia.