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Natural occurrence of *Beauveria bassiana* in *Hypothenemus hampei* (Coleoptera: Curculionidae) populations in unsprayed coffee fields

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Abstract

Three unsprayed coffee farms (farm 1, 2 and 3) were studied for the natural occurrence of the insect pathogenic fungus *Beauveria bassiana* in *Hypothenemus hampei* populations throughout the rainy season of 2004 (July–November) and 2005 (July–December). *B. bassiana* infections were found during most sampling dates in both years, on all three farms. The *B. bassiana* infection levels were higher in 2005 than in 2004 with mean prevalence of 12.1% and 2.7%, respectively. No consistent significant differences in infection level between farms were found in any of the years. *B. bassiana* infection levels fluctuated widely throughout the season, and peaked at 13.5% on farm 3 in 2004 and at 44.0% on farm 1 in 2005. The *H. hampei* population was significantly higher in 2004 than in 2005, with 6.9% of the berries infested in 2004 and only 0.7% in 2005. In both years, the *H. hampei* infestation level was significantly higher on farm 2. No consistent significant differences in *H. hampei* infestation levels were found between sampling dates on any of the farms. *H. hampei* infestation levels fluctuated throughout both seasons, and peaked at 15.3% on farm 2 in 2004 and 2.2% on farm 2 in 2005. No consistent density dependent correlation between *H. hampei* infestation level and *B. bassiana* infection level was found. Correlations between climatic conditions and *B. bassiana* or *H. hampei* were not found.

Keywords: Coffee berry borer; *Hypothenemus hampei*; Infestation level; *Beauveria bassiana*; Infection level; Biological control; Natural occurrence; Natural enemy

1. Introduction

The coffee berry borer, *Hypothenemus hampei* (Coleoptera: Curculionidae) is the most important pest of coffee throughout the world (Le Pelley, 1968; Dufour et al., 1999; Soto-Pinto et al., 2002; Bustillo, 2005). In America, *H. hampei* was first observed in Brazil in 1913 and is now prevalent in all Central American countries, Colombia, Mexico, and the Dominican Republic (Guharay and Monterrey, 1997; Borbón et al., 2001; Canet and Garcia, 2005).

Hypothenemus hampei causes damage to berries by the boring action of adults and larvae (Le Pelley, 1968). When rainy season starts, females emerge from fallen berries and start boring new berries, about 120 days after flowering when berries have about 20% of dry weight. They then make galleries where they lay their eggs. Larvae feed on berries from 10 to 26 days (Le Pelley, 1968; Wrigley, 1988; Guharay and Monterrey, 1997; Baker, 1999) and often destroy them completely. This could result in total bean loss and premature fruit fall if the attack occurs early in the season (Guharay and Monterrey, 1997; Damon,

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2000). After hatching from pupae inside the berries, sibling mating occurs, and females leave the berries in search of berries in which to oviposit (Guharay and Monterrey, 1997; Mathieu et al., 2001). The main source of *H. hampei* infestation are infested berries that have fallen on the ground (Chamorro et al., 1995; Cure et al., 1998; Bustillo et al., 1999).

Hypothenemus hampei is very difficult to control due to its cryptic life cycle, which is spent inside the coffee berry (Damon, 2000; Haraprasad et al., 2000; Rehner et al., 2006). The most common control methods used are chemical control and cultural practices. Cultural practices include picking berries that are ripe early in the season and picking berries left on the plant after the harvest season. It also includes collection of berries that have fallen on the ground. Manual control reduces *H. hampei* populations, but it is labor intensive and not economically feasible (Bustillo et al., 1999; Kimani et al., 2002). Few insecticides effectively control *H. hampei* (Rhodes and Mansingh, 1981; Damon, 2000). The chlorinated hydrocarbon endosulfan (chemical group: cyclodiene organochlorine), has been effectively used against the *H. hampei*. However, this highly toxic chemical has negative effects on human health and the environment (Brun et al., 1989; Damon, 2000; Wegbe et al., 2003) and has been banned in several countries (Posada and Vega, 2005) and will soon be banned in Central America (CN-MIP et al., 2002). In addition, *H. hampei* resistance to endosulfan has been reported (Brun, 1989). The difficulties encountered by growers in controlling the insect have resulted in a search for effective biological control strategies that are sustainable and environmentally friendly.

The insect pathogenic fungus *Beauveria bassiana* (Ascomycota: Hypocreales) has been widely reported as a natural enemy of *H. hampei* (De La Rosa et al., 1997; Damon, 2000; Samuels et al., 2002; De Oliveira et al., 2003; Bustillo and Posada, 1996; Guharay and Monterrey, 1997; Trejo and Fúnez, 2004; Bustillo, 2005), and is the most common entomopathogen infecting *H. hampei* (Bustillo et al., 2002). According to Damon (2000), natural *B. bassiana* infections are common and epizootics may occur, especially on the ground in fallen berries and under cool conditions with high relative humidity and heavy shade. *B. bassiana* is used as an inundative microbial control agent against *H. hampei* in several countries in Latin America (Bustillo and Posada, 1996; Guharay and Monterrey, 1997; Van Lenteren and Bueno, 2003). To our knowledge there are, however, no systematic studies revealing the importance, occurrence and dynamics of *B. bassiana* as a naturally occurring enemy in *H. hampei* populations throughout the season, over several years and in several locations. The aim of this research was therefore to conduct a systematic study where the natural occurrence of *B. bassiana* in three different unsprayed coffee farms was observed regularly throughout the rainy season over two successive years. This information would contribute towards an understanding of the natural control levels occurring in unsprayed coffee farms which might be useful in implementing strategies for biological control.

2. Materials and methods

2.1. Location

The study was carried out from July to November 2004 and from July to December in 2005 at three different coffee farms in Matagalpa, in the northern coffee growing zone of Nicaragua. Farm 1 (La Flor) was located at 13°06′06″N, 85°47′33″W, 750 m above sea level and about 200 m from farm 2 (Verania) and about 2 km from farm 3 (Quitasueño). Farm 2 was located at 13°04′52″N, 85°47′32″W, 730 m above sea level and about 2 km from farm 3. Farm 3 was located at 13°07′10″N, 85°48′13″W at 800 m above sea level. One field on each coffee farm was selected for the survey. The coffee fields selected on farm 1 had an area of 1.5 ha, farm 2 had an area of 1.0 ha and farm 3 had an area of 2.0 ha. The plant density was about 5200 plants per ha and the estimated yield was 750 kg, 600 kg and 1500 kg per ha on farm 1, 2 and 3, respectively. Neither synthetic pesticides nor *B. bassiana* had been used in the last 5 years on any of the farms. Mechanical (machete) weed control and pruning of dead and diseased branches was carried out on all farms. Berries that were ripe early in the season and berries left on the plant after the harvest season were picked to prevent build up of *H. hampei* populations only on farm 3. During this study, however, berries were not picked in the sampling plots on any of the farms. Fertilization was only carried out on farm 3.

On all three farms coffee (*Coffea arabica* L.) was grown under shade. In the sampling plot on farm 1, the coffee varieties were Caturra and Catimor and age of plants were 9 and 6 years, respectively. Shade species were *Erythrina* sp., *Gliricidia sepium*, *Citrus* sp., and *Musa* sp. On farm 2, the coffee varieties were Bourbon, Caturra and Catimor and age of plants were 26 years (Bourbon and Caturra) and 11 years (Catimor). Shade species were *Erythrina* sp., *Guazuma ulmifolia*, *Juglans olanchana* and *Musa* sp. On these farms shade regulation was not performed. On farm 3 the coffee variety was Catuai and the age of plants was 15 years. Shade species were *Inga* sp., and *Musa* sp., and shade regulation was performed by pruning shade trees at the beginning of the rainy season. Shade levels were estimated in 2005. Shade estimations were conducted at the four sites where *H. hampei* was counted by using a spherical densitometer (Lemmon, 1956). The shade level on each coffee field was obtained by averaging the shade percentages measured at the four sites of the field.

The rainy season was from March to November in 2004 and from May to December in 2005, and the total precipitation was 2005 mm in 2004 and 2011 mm in 2005. Higher precipitation levels were observed in June in both 2004 and 2005 at 417 and 470 mm, respectively.