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The passionvine mealybug, *Planococcus minor* (Maskell) (Hemiptera: Pseudococcidae), and its natural enemies in the cocoa agroecosystem in Trinidad

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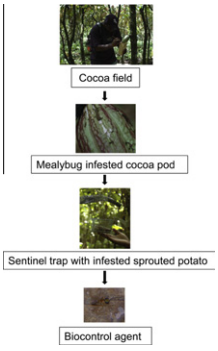
HIGHLIGHTS

- *Planococcus minor* is found in Trinidad where little was known about the pest.
- The mealybug was widely distributed on cocoa and infestation levels were low.
- Cocoa field sites were surveyed for natural enemies.
- We identified key natural enemies attacking the mealybug.
- Their identification is a key step in the biological control process.

GRAPHICAL ABSTRACT



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ABSTRACT

Planococcus minor (Maskell) is native to South Asia, but it is also present in several Neotropical locations including the island of Trinidad in the southern Caribbean. The mealybug poses a serious threat to uninfested countries in this region as well as the mainland U.S. As part of an effort to gather much needed information on *P. minor*, 33 cocoa (*Theobroma cacao* L.) field sites on the island were surveyed in 2006 with a view to assess the occurrence and pest status of the mealybug. *P. minor* was identified from 20 field sites, indicating that it was well distributed across the island on this crop, which appeared to be a reliable indicator host plant. Infestation levels were generally low and populations were sparsely distributed across the field sites categorized into three habitat types. The following year, nine field sites were surveyed for natural enemies of *P. minor* using laboratory-infested potatoes in sentinel traps. Species from four insect orders and six families were collected and identified. The major predators belonged to the families Cecidomyiidae and Coccinellidae. Two primary parasitoids, *Leptomastix dactylopii* Howard (Encyrtidae) and *Coccidoxenoides perminutus* (Girault) (=*Pauridia peregrina* Timberlake, =*Coccidoxenoides peregrinus* (Timberlake)) (Encyrtidae), were reared from different mealybug stages, along with several hyperparasitoids. The primary parasitoids were probably introduced fortuitously. These diverse natural enemies were recovered throughout the sampling period from the different habitat types. The identification of key natural enemies associated with *P. minor* has important implications for the implementation of biological control in newly infested areas.

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1. Introduction

The passionvine mealybug, *Planococcus minor* (Maskell) (Hemiptera: Pseudococcidae) is a polyphagous pest that can potentially damage many tropical and subtropical plants (Commonwealth Agricultural Bureau, 2003; Venette and Davis, 2004). This mealybug is native to south Asia (Cox, 1989), but is considered a serious pest in countries such as India (Reddy et al., 1997; Tandon and Verghese, 1987) and Taiwan (Ho et al., 2007). In addition to its polyphagous nature, *P. minor* has many other characteristics of a highly invasive species including: ease of spread on traded commodities such as fruit (Venette and Davis, 2004), a relatively short life cycle (Martinez and Suris, 1998) and a high reproductive potential (Maity et al., 1998). Whereas it is not known when *P. minor* first invaded the Neotropics, the insect is now present in at least 21 countries/territories (Williams and Granara de Willink, 1992). As a consequence, and also due to its frequent interception at ports-of-entry in the U.S., *P. minor* has been identified as a serious pest threat (Miller et al., 2002).

Intriguingly, there have been no reports of serious crop losses by *P. minor* in the Neotropics, including Trinidad, and anecdotal evidence suggested that the mealybug was not considered a major pest on the island. Given its broad host range, it is difficult to explain why population levels of *P. minor* have remained low throughout the region. Against this background, and as part of a strategic offshore research initiative targeting high risk pest threats to the U.S., studies were initiated in Trinidad with a view to generate pertinent information on *P. minor* and its natural enemies. Trinidad was selected because of its confirmed populations of the mealybug (Williams and Granara de Willink, 1992) and relative proximity to the U.S.

Specifically, the study set out to: (1) assess the occurrence and pest status of *P. minor* in Trinidad, including its distribution on the island, its host plant range, and its levels of infestation on host plants in different habitats; and (2) determine what, if any, natural enemies were attacking the mealybug, including their identity, relative abundance and occurrence in different habitats, and potential for use in biological control. In order to realize objective 2, it was also essential to develop a reliable method for the survey of natural enemies, especially given the potential co-occurrence of mealybug species that were difficult to distinguish morphologically.

2. Materials and methods

2.1. Maintenance of host material and colony of P. minor

The initial colony of *P. minor* originated from gravid females that were inadvertently collected on cocoa (*Theobroma cacao* L.) pods infested with *Maconellicoccus hirsutus* (Green) and destined for use in a colony of the latter by personnel at the Central Experiment Station, Ministry of Agriculture, Land and Marine Resources (MALMR), Trinidad. The suspect *P. minor* females were isolated and 1st generation offspring (adult females) were sent for expert identification at the USDA-ARS Systematic Entomology Laboratory, Beltsville, MD. The colony of *P. minor* was initiated in May, 2006 on sprouted potatoes, 'Cavendish' variety (*Solanum tuberosum* L.) in a room at 25 ± 2 °C, 60 ± 10% RH, and complete darkness at the experiment station and transferred to laboratory facilities at CABI Caribbean and Latin America Office, Curepe in May, 2007. Rearing methods were similar to those used by Meyerdirk et al. (1998). Each week, 25 potatoes were individually infested with five adult females with ovisacs. These weekly infestations ensured a continuous supply of different mealybug life stages. Infested potatoes were ready for field use after 4–5 weeks.

2.2. Occurrence and pest status of P. minor

Consultations with staff at the Central Experiment Station indicated that *P. minor* could be found on cocoa, but was difficult to find on other plant species. Subsequently, the mealybug was collected at nearby cocoa field sites during a preliminary survey in May 2006. It was therefore decided to use this crop as the primary indicator host plant during the survey. During the preliminary survey, plant parts (pods, flowers, and leaves) on the main trunk of each tree from ground level to 1.5 m were examined for the presence of *P. minor*. All stages from 2nd instar nymphs to adult females were counted with the aid of a 5–10× folding pocket magnifier and a 4-digit tally register. Very low and sparse numbers of mealybugs were found on flowers and leaves as compared to pods; therefore, the latter was chosen as the principal sampling unit on individual trees.

A total of 33 cocoa field sites were surveyed from June 30 to July 27, 2006. Ten trees were randomly selected for visual inspection and estimation of *P. minor* abundance at each field site. Each tree was considered a replicate. A qualitative composite infestation score to estimate mealybug abundance was devised based on the number of mealybugs counted on the pods on each tree *in situ*, and ranged from 0 to 5. No mealybugs were scored as 0, <10 mealybugs were scored as 1, 10 to 100 were scored as 2, >100–200 were scored as 3, >200–500 were scored as 4, and >500 were scored as 5. This score range was based on the range of infestation levels seen for other mealybugs such as *M. hirsutus*, which was observed in very high numbers on some pods. Live mealybug specimens were collected from the pods using a camel hair brush in order to positively confirm their identity as *P. minor*. Other plant species were also visually inspected and scored for *P. minor* at field sites using the same procedure where possible. Most of these plants were listed hosts of *P. minor* and were grown as part of mixed crop systems at 12 field sites. Weed species were identified from Fournet and Hammerton (1991).

Field sites were categorized into three habitat types to determine the influence of existing plant diversity on *P. minor* abundance. Type 1 sites were commercial plots receiving regular crop maintenance and weed management and >2 hectares in size. Type 2 sites were abandoned plots where no crop maintenance or weed management was practiced and ranged from 0.25 to 2 ha in size. Type 3 sites (<0.25 ha) were mixed crop systems with vegetable and root crops planted alongside cocoa trees and receiving regular crop maintenance and weed management. Insecticides were not applied to any of these field sites or known to have been used within the immediate area during the survey period.

2.3. Natural enemies of P. minor

Nine cocoa field sites were surveyed for predators and parasitoids of *P. minor* from June 26 to October 19, 2007. These field sites were used the previous year for surveys of *P. minor* and were selected based on preliminary observations of natural enemy activity. Field sites were grouped into three habitat types as previously outlined. In order to overcome the challenges of finding patchy, low populations of the mealybug at the field sites and to ensure collections of natural enemies were positively associated with *P. minor*, laboratory-infested potatoes were used in sentinel traps. The sentinel trap consisted of a wire cage measuring 12 × 8 × 8 cm in which an infested sprouted potato with 200–300 mealybugs of all life stages was placed (Fig. 1). These cages were securely hung from horizontal branches up to 2.0 m from ground level on randomly chosen trees (1–3 cages/field site) and spaced 10–15 m apart. The number of cages deployed depended on the approximate size of each field site. Field sites less than 0.25 ha were allocated a single cage, 2 cages were placed at sites