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SHORT COMMUNICATION

Population fluctuations in the pink hibiscus mealybug and its natural enemies in *Annona squamosa* (Annonaceae) in Roraima, Brazil

Marcelo NEGRINI[1]*, Elisangela G. F. MORAIS[2], Jéssica S. R. BATISTA[3], Edvan A. CHAGAS[2]

[1] Universidade Federal de Roraima (UFRR), Programa de Pós-Graduação em Recursos Naturais (PRONAT), Av. Capitão Ene Garcez 2413, CEP 69304-000, Boa Vista, RR, Brasil

[2] EMBRAPA Roraima, Pesquisa, Rodovia BR-174 Km 8, Distrito Industrial, CEP 69301 970, Boa Vista, RR, Brasil

[3] Instituto Federal de Roraima, Av. Glaycon de Paiva 2496, Pricumã, CEP 69303-340, Boa Vista, RR, Brasil

* Corresponding author: marcelo.nnegrini@gmail.com

ABSTRACT

Maconellicoccus hirsutus (Hemiptera, Pseudococcidae), a species of economic interest, especially for fruit plants, is expanding on the South American continent. Information about the population dynamics of this pest associated with control by natural enemies and cultural practices is fundamental for its management. Our objective was to study the population fluctuations in *M. hirsutus* and its natural enemies in a sugar-apple (*Annona squamosa*) orchard in Roraima, northern Brazil. Trees were evaluated monthly over a 12-month period. Infestation rates by *M. hirsutus* and its parasitism were also estimated for potential host plants around the study area. Highest infestation occurred in August and February-March. Alternative hosts were infested during the off-season, mainly fruit. Lacewings and the parasitoid *Anagyrus kamali* (Hymenoptera, Encyrtidae) were abundant natural enemies. Average parasitism by *A. kamali* in fruits was 50%, with highest rates in periods of greatest infestation by *M. hirsutus*. Fruitification pruning reduced *M. hirsutus* populations.

KEYWORDS: *Anagyrus kamali*, biological control, *Maconellicoccus hirsutus*

Flutuação populacional da cochonilha-rosada e seus inimigos naturais em *Annona squamosa* (Annonaceae) em Roraima, Brasil

RESUMO

Maconellicoccus hirsutus (Hemiptera, Pseudococcidae), praga de inúmeras espécies, especialmente frutíferas, está se expandindo no continente sul-americano. Informações sobre sua dinâmica, inimigos naturais e práticas culturais são importantes para seu manejo. Nosso objetivo foi estudar as flutuações da população em *M. hirsutus* e seus inimigos naturais em um pomar de ata (*Annona squamosa*) em Roraima, Brasil. As árvores foram avaliadas mensalmente ao longo de um período de 12 meses e as taxas de infestação por *M. hirsutus* e parasitismo foram estimadas. A maior infestação ocorreu em agosto de 2014 e entre fevereiro e março de 2015. Hospedeiros alternativos foram infestados durante a entressafra da ata. Bicho-lixeiro e o parasitoide *Anagyrus kamali* (Hymenoptera, Encyrtidae) foram os inimigos naturais mais importantes. O parasitismo médio por *A. kamali* nos frutos foi de 50%, com maiores taxas nos períodos de maior infestação por *M. hirsutus*. A poda de frutificação reduziu as populações de *M. hirsutus.*

PALAVRAS-CHAVE: *Anagyrus kamali*, controle biológico, *Maconellicoccus hirsutus*

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The pink hibiscus mealybug, *Maconellicoccus hirsutus* Green (Hemiptera, Pseudococcidae), native to South Asia (Williams 1996), is a serious pest that was introduced to the Americas in the 1990s (Sagarra and Peterkin 1999). In Brazil, *M. hirsutus* was detected in 2010 in the northern region, in Roraima state (Marsaro Júnior *et al*. 2013), in 2012 in the southwestern region, in Espírito Santo state (Culik *et al*. 2013 ab), and subsequently in the states of Bahia (CEPLAC/CEPEC 2014) and Santa Catarina (Alexandre *et al*. 2014) in 2013, and Pernambuco (Oliveira *et al*. 2014), Alagoas (Broglio *et al*. 2015), São Paulo (Peronti *et al*. 2016) and Mato Grosso (Morais *et al*. 2015) in 2014.

Maconellicoccus hirsutus is polyphagous, causing high economic damage to fruits and trees (Rosas-García and Parra-Brancamonte 2011; CEPLAC/CEPEC 2014; Oliveira *et al*. 2014; Broglio *et al*. 2015; Chong *et al*. 2015), and attacks practically all host plant structures, but preferably seedlings and young stems, flowers and fruits (Vitullo *et al*. 2009). It sucks sap, and its toxic saliva causes shortening of internodes, curling and crinkling of leaves, and deformation and early fall of fruits and flowers. Indirect damage is caused by development of sooty mold, a fungus that covers plant structures, and its waxy layer preventing fruit and ornamental plant trade (Nardo and Tambasco 1998; Kairo *et al*. 2000).

Fluctuations in pest populations in perennial crops are often correlated to climatic conditions, the productive period of the crop and associated natural enemies (Chagas *et al*. 1982; Garcia and Corseuil 1998; Arioli *et al*. 2005). Therefore, our aim was to study the annual population fluctuations in *M. hirsutus* on cultivated sugar-apple, *Annona squamosa* L. (Annonaceae) in association with resource availability and the mealybug's natural enemies.

The study was conducted in a sugar-apple (*Annona squamosa* L.) orchard of approximately 1.5 hectares in the municipality of Cantá, Roraima state, Brazil (2°43'55"N, 60°38'14"W, 74 masl). The climate is tropical, with a dry season in winter (AW type, Koppen classification), and average annual rainfall of 1,420 mm, with a rainy season from May to August (INMET 2015). Until 2014, the trees were not pruned, and infestation by *M. hirsutus* was high on fruits. From 2014 onwards two annual fructification pruning's followed by spraying with a bordeaux mixture and mineral oil were conducted, except in the evaluated trees. In the trees with high population density of *M. hirsutus*, the pruning and phytosanitary treatments were conducted only in February 2014.

Data were collected monthly from April 2014 to March 2015. A row of 20 sugar-apple trees was monitored by, counting the number of *M. hirsutus* and their natural enemies on four organs (branch, bud, flower and fruit). Nine units of each organ were assessed per tree, three in each basal, middle and apical position. We also evaluated possible hosts in a 200-m radius around the orchard belonging to *Mangifera indica* L. (Anacardiaceae), *Averrhoa carambola* L. (Oxalidaceae), *Annona muricata* (Annonaceae), *Xylopia aromatica* (Lam.) Mart. (Annonaceae), *Cocos nucifera* L. (Arecaceae) and *Gossypium* sp. (Malvaceae).

Mealybug infestation was measured using a scale (Suresh and Chandra 2008) based on 0 (null), 1-10 (low), 11-20 (medium) and > 20 (high) individuals per shoot. Infested fruits of *A. muricata* and *A. carambola* were collected to assess parasitism rates in the laboratory by counting the total number and number of parasitized mummies of *M. hirsutus*. Each fruit was individually placed into a transparent plastic container covered with anti-aphid screen until emergence of parasitoid adults. Emerged parasitoids were removed and counted (males and females) every three days, until the 18th day, and females and placed in 70% ethanol for identification. The population density of *M. hirsutus* was compared between first (pruned) and second (not pruned) harvest by means of a t-test.

Numbers of adults, nymphs and ovisacs of *M. hirsutus* per sugar-apple fruit were highest in August of 2014 and February-March of 2015 (Figure 1A). Pruning in February 2014 kept the area free of infestation until July, while the absence of pruning for the second harvest (January-February) allowed adult, ovisac and nymph numbers to increase significantly ($p = 0.006$) (Figure 1A). 99.5% of the infestation by *M. hirsutus* was on fruits, and 0.5% on buds. The average of infested fruit was only 5.2% and the highest infestation rates occurred in September 2014 (11,1%) and February 2015 (13,2%) (Figure 1B). Only 17.1% fruits had high infestation level, 14.3% medium and 68.6% low. *Maconellicoccus hirsutus* was also found on *A. carambola* and *A. muricata* fruits during the vegetative period of *A. squamosa*.

The natural enemies of *M. hirsutus* observed in the sugar-apple orchard were the parasitoid *Anagyrus kamali* Mourse (Hymenoptera, Encyrtidae) and lacewing eggs (Neuroptera, Chrysopidae). Mean oviposition mass of lacewings was 33.75 eggs. Parasitism rates were higher in the months of greatest infestation by *M. hirsutus* (Figure 1). Parasitized mummies were an average 19.2% in the field, and 55.1% (15.1-78.8%,) in the laboratory. *Anagyrus kamali* also parasitized *M. hirsutus* infesting *A. carambola* and *A. muricata* fruits (48.3% and 39.7%, respectively) (Table 1).

Table 1. Parasitism rate, mean number of mummies parasitized per fruit and mean number of parasitoid individuals of *Anagyrus kamali* (Hymenoptera, Encyrtidae) that emerged from sugar-apple, starfruit and soursop fruits.

Culture (fruit)	Parasitism rate (%)	N parasitized mummies	N parasitoids
Annona squamosa	55.1	26.1	32.7
Annona muricata	48.3	388.6	165.7
Averrhoa carambola	39.7	142.0	70.5
Average	49.7 ± 3.2	142.9 ± 65.4	70.5 ± 23.1

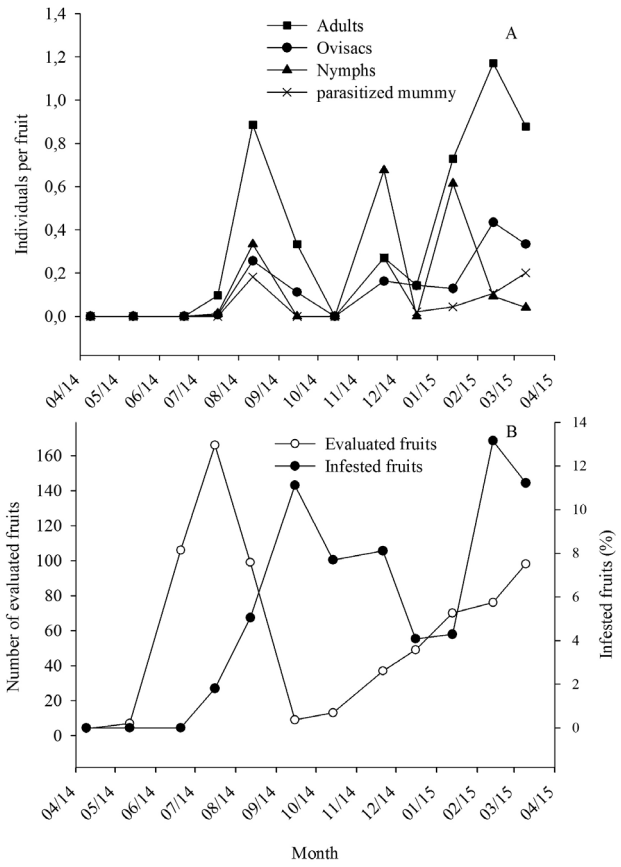

Figure 1. A. Population dynamics of adults, nymphs and ovisacs of *Maconellicoccus hirsutus* (Hemiptera, Pseudococcidae) and of parasitized mummies per fruit throughout the yearly cycle and; B. Number of evaluated and infested (5) fruits throughout the yearly cycle.

The population peaks of *M. hirsutus* coincided with the fructification of sugar-apples. Pruning unharvested fruits and infested branches is standard in fruit production and induces flowering and fruiting (Paiva and Fioravanço 1994) and is also important for pest management. Pruning and burning infested material followed by insecticide application are recommended for the management of *M. hirsutus* (Sagarra and Peterkin 1999).

The preferential infestation of sugar-apple fruits by *M. hirsutus* may be related to their nutritional quality and syncarpous structure, which provides protection for the mealybugs. The presence of *M. hirsutus* on other fruit species only during the harvest period of sugar-apples confirms its preference for the latter host (Culik *et al*. 2013*a,b*). The low infestation rate of fruit was likely related to biological control by *A. kamali*. This parasitoid was likely introduced with *M. hirsutus* in Brazil (Marsaro Júnior *et al*. 2013) and Colombia (Evans *et al*. 2012; Rodríguez 2012), and has high specificity to *M. hirsutus* (Sagarra *et al*. 2001) with high efficiency in its biological control (Michaud and Evans 2000; Roltsch *et al*. 2006; Garcia-Valente *et al*. 2009; Reddy *et al*. 2009; Isiordia-Aquino *et al*. 2012).

Biological control with the parasitoid *Anagyrus kamali* and crop management, mainly fructification pruning, are effective strategies for reducing the population levels of *M. hirsutus*. Monitoring and control in adjacent plants should be part of integrated management strategies.

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