Natural factors affecting the whitefly infestation on cassava

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ABSTRACT. The objective of this study was to determine the effects of predators, parasitoids, leaf chemical composition and levels of leaf nitrogen and potassium, total rainfall, mean temperature, sunlight and relative humidity on the attack rate of the whitefly *Aleurothrixus aepim* (Goeldi) on the cassava plants *Manihot esculenta* Crantz. It was observed a negative correlation between nymphs of whitefly and mean temperature and nymphs and adults with total rainfall. There were observed relationships between Aelothripidae with eggs, nymphs and adults of whitefly; *Encarsia* sp., spider Araneidae and Syrphidae with adults of whitefly; and *Hyaliodes vitreus* with nymphs of whitefly. Ants of the genus *Crematogaster* were observed associated to nymphs of this whitefly. The peaks 25.503 and 47.763min. (retention time) correlated with whitefly adults. Even though different factors, such as ecological and physiological conditions of plants, besides parasitoids and predators, can affect population fluctuation of the whitefly; the most important one for this insect seems to be the plant phenology (leaf senescense).

Key words: *Aleurothrixus aepim*, *Manihot esculenta*, bioecology, insect/plant interaction, weather.

RESUMO. Fatores naturais afetando a infestação de mosca-branca em mandioca. O objetivo deste estudo foi determinar os efeitos dos predadores, os parasitóides, a composição química e os níveis foliares de nitrogênio e de potássio, a pluviosidade total, a temperatura média, a insolação e a umidade relativa no ataque de mosca-branca *Aleurothrixus aepim* (Goeldi) em plantas de mandioca *Manihot esculenta* Crantz. Foi observada a correlação negativa entre ninfas de mosca-branca e a temperatura média e de ninfas e de adultos com pluviosidade total. Observaram-se relações entre Aelothripidae com ovos, ninfas e adultos de mosca-branca; *Encarsia* sp., aranhas Araneidae e dípteros Syrphidae com adultos de mosca-branca, além de *Hyaliodes vitreus* com ninfas desse inseto. Formigas do gênero *Crematogaster* estiveram associadas às ninfas de mosca-branca. Os picos 25,503 e 47,763min. (tempo de retenção) estiveram correlacionados com adultos dessa praga. Ainda que diferentes fatores como condições ecológicas e fisiológicas das plantas, além de parasitóides e de predadores possam afetar a flutuação populacional da mosca-branca, o mais importante visto para este inseto parece ser a fenologia da planta (senescência das folhas).

Palavras-chave: *Aleurothrixus aepim*, *Manihot esculenta*, bioecologia, interação inseto/planta, clima.

Introduction

The cassava (*Manihot esculenta* Crantz) (Euphorbiaceae) represents an important source of carbohydrates and it is the fourth most important food (after rice, sugar and corn) in the world (Bellotti *et al*., 1999). Production of cassava in Brazil is concentrated mainly in the Northeast area, with about 50% of the national production and an average of 10 tons/ha (Henry, 1995). Due to its rusticity, the cassava is usually cultivated by small producers in semi-arid areas with poor rainfall distribution and low fertility soils. Such conditions and the occurrence of pests and diseases (Bellotti *et al*., 1999) can reduce its productivity, which can reach 21.3 tons/ha in good growing conditions (Henry, 1995).

One of the most serius cassava pests in Brazil is the whitefly *Aleurothrixus aepim* (Goeldi) (Homoptera: Aleyrodidae) (Farias, 1994). This insect sucks the sap of cassava leaves, which turns them yellowish and grubbed. It also transmits virus and its honeydew can serve as substratum for fungi growing. High populations of this whitefly can reduce productivity and their contact can also give the cassava a bitter flavour (Farias and Santos Filho, 1996).

Several factors can affect populations levels of arthropods in cassava plants but low losses due to insect attack have been reported in regions with high rainfall (Montagnini and Jordan, 1983). Fertilizers can also affect attack rate of *A. aepim* in cassava plants, because an excess of N or a deficiency of K can lead to a higher accumulation of amino acids which, in turn, can increase attack rates of sucking insects (Marschner, 1995). Compounds present in cassava plants, such as hydrogenated cyanide (HCN) and laticifers, represent a chemical barrier to exotic arthropods which did not coevoluated with this plant (Bellotti and Riss, 1994).

Natural enemies, such as species of *Encarsia* (Hymenoptera: Aphelinidae), have been reported as parasitoids of whitefly *A. aepim* nymphs in cassava fields (Castillo, 1996). Also, predators have been used to control whitefly population in several plants (Legaspi *et al.*, 1994; Dean and Schuster, 1995; Gerling, 1996; Legaspi *et al.*, 1996a,b; Liu and Stansly, 1996a,b) and, in some cases, a positive effect was obtained (Hoelmer *et al.*, 1994; Heinz and Nelson, 1996).

Hence, the objective of this study was to evaluate the relationships of predators, parasitoids, leaf chemical composition and levels of leaf nitrogen and potassium, total rainfall, mean temperature, sunlight and relative humidity on whitefly infestation on cassava.

Material and methods

The experiment was conducted in a commercial cassava *M. esculenta* var. "Cocoa" plantation, from February to December 1999, *Viçosa,* state of *Minas Gerais*, Brazil. Plants were not pulverized with pesticides. Stem pieces were utilized to install the cassava plants. The spacing utilized between plants was 1.0 x 0.60m, with the total cultivated area was 5.000m^2. The first eight peripheric rows and the 15 plants on each side of the row formed the outer border, while the remaining plantation was considered to be the useful area. The chemical and entomological evaluations were conducted when the plants were six months old. However, no evaluations were conducted in September since there were no leaves on the plants.

The beating tray method (Stansly, 1995) was used to obtain weekly number estimations of *A. aepim* adults, besides predators and parasitoids, in the apex of 10 cassava plants. This method consisted of beating the apex of each plant in a 34 x 26 x 5cm white tray and counting the insects in it. Insects lodged into the tray were collected with an aspirator or tweezers and individually held in 8 x 2cm glass flasks containing 70% ethanol for identification. Nymphal parasitism levels and number of *A. aepim* eggs and nymphs on cassava plants were evaluated weekly with a 40x magnifying lens. One medium lobe of the abaxial face of one apical leaf was collected in 10 cassava plants and kept in transparent white plastic bags, sealed and transported to the laboratory for counting the number of *A. aepim* individuals (Farias *et al.*, 1991). For each sample (one medium lobe), six fields in the median part (equidistant from the median vein and the margin) were analyzed.

The gas chromatography/mass spectrometry (GC/MS) (Shimadzu, Model QP 5000) analysis was made with fully expanded leaves from the apex of 20 cassava plants (one leaf per plant) every month. These leaves were collected and placed in plastic bags, sealed and transported to the laboratory. Fresh leaves (10g) were cut with scissors and immersed in 100mL bi distilled hexane for 24h. The hexane extract was dehydrated with anhydrous Na_2SO_4, evaporated to dryness at 30ºC in a rotatory evaporator, sealed in nitrogen and stored in a freezer until analysis. One evaluation was made for cassava leaves monthly collected.

Hexane extracts were analyzed by GC/MS with an auto sampler and a computer based system to accumulate data, and a mass spectra database (John Wiley) with 160.000 compounds using the following conditions: initial temperature 33ºC and programmed to 80ºC at 20ºC/min finally to 250ºC and 5ºC/min. The injector and transfer line temperatures were 180 and 230ºC respectively. The split ratio was 5 with He as the carrier gas. All analyses were carried out on a DB1 fused capillary column (J and W Scientific, USA, 30m x 0.25mm and film thickness of 0.25μm). The mass spectrometer was scanned between 40 - 550 amu and the minimum area utilised for peak integration was 390.000 ions/second. Retention time for peaks with total ion current (TIC) higher than 3.9×10^5 ions/second were recorded and compounds identified with mass spectral database. Only those compounds with a similarity index higher than 71% were considered. Further identification through standards was not attempted.

One expanded leaf from the apex of each one of 20 cassava plants was collected monthly and taken to the laboratory for determination of leaf N and K. These leaves were placed in Kraft paper bags, dried in a oven with forced air circulation at 67ºC during three days and then ground in a Wiley mill (20 mesh). K was determined with Flame Photometer (Coleman, Model 22) and N was analysed by the Nessler method (Jackson, 1958). Three evaluations were made for each monthly collection.

Viçosa's climatic data [mean temperature (minimum + maximum/2), sunlight, total rainfall and relative humidity] were daily collected during the experimental period. All data were submitted to Pearson' correlation ($p < 0.10$), using the System of Statistical and Genetics Analysis (SAEG) of the Universidade Federal de Viçosa.

Results and discussion

The population of *A. aepim* peaked in May (nymphs and adults) and June (eggs), decreasing until August and the insect was not observed after September (Figure 1), probably due to negative correlation between nymphs of whitefly and mean temperature ($r = -0.61$, $P = 0.0232$) and nymphs and adults with total rainfall ($r = -0.51$, $P = 0.0539$ and $r = -0.49$, $P = 0.0639$, respectively) (Figures 1 and 2) and/or leaf senescence associated with dry season and cold and/or insect attack (data not shown).

Another factors that can regulate the whitefly population are the natural enemies. We observed relationships between Aelothripidae (Thysanoptera) with eggs ($r = 0.77$, $P = 0.0026$), nymphs ($r = 0.77$, $P = 0.0027$) and adults of whitefly ($r = 0.52$, $P = 0.0515$); *Encarsia* sp. (Hymenoptera: Aphelinidae) ($r = 0.51$, $P = 0.0495$), spider Araneidae ($r = 0.52$, $P = 0.0501$) and Syrphidae (Diptera) ($r = 0.44$, $P = 0.0861$) with adults of whitefly besides of *Hyaliodes vitreus* (Distant) (Heteroptera: Miridae) with nymphs of whitefly ($r = 0.68$, $P = 0.0108$) (Figure 1). No parasite-infected whitefly nymphs were detected. Ants of the genus *Crematogaster* (Hymenoptera: Formicidae) were observed associated to nymphs of this whitefly ($r = 0.55$, $P = 0.0394$) (Figure 1).

We observed the decreased intensities of eleven peaks, recorded in the total ion chromatogram of the hexane extracts on GC/MS analysis, together with leaf N in the long dry and cold season in Viçosa (Table 1 and Figures 2 and 3). The peaks 25.503 and 47.763min. (retention time) correlated with adults of whitefly ($r = 0.76$, $P = 0.0148$ and $r = 0.60$, $P = 0.0591$, respectively) (Figures 1 and 3). No signifincant relationships ($P > 0.05$) of leaf N and K were observed on the whitefly population.

A decrease in whitefly *A. aepim* population was most likely due to leaf senescence associated with dry season and cold and/or insect attack which, in turn, was associated with the compounds with (r_t) of 25.503 and 47.763min. This can be reinforced by the fact that high populations of this whitefly have been observed on vigorous cassava plants, which usually coincides with the rainy season (Embrater, 1982; Farias *et al*., 1991; Farias, 1994). However, other studies have showed a negative effect of rainfall on nymphs and adults of the whitefly *A. aepim* (Montagnini and Jordan, 1983).

Predators such as spiders, thrips and Syrphidae and the parasitoid *Encarsia* sp. were positively correlated with population levels of the whitefly *A. aepim*, which indicates that these natural enemies depend on their prey. *H. vitreus* seems to be the most important one for natural control of this pest, because a population increase of this predator could cause a considerable decrease on numbers of whitefly nymphs. Such results agree with Farias (1985), who reported this predator as an important natural enemy of another cassava pest, *Vatiga illudens* (Drake) (Heteroptera: Tingidae).

Nymphs of *A. aepim* showed protocooperation with ants of the genus *Crematogaster*, with a mutual relationship between these species, which is important for the survival of Homoptera species (Picanço *et al*., 1997). This occurs because such ants can protect this whitefly against predators and parasitoids. At the same time, they feed on faecal remains and, indirectly, they promote a higienization of places occupied by whitefly (Picanço *et al*., 1997). The absence of parasitism on nymphs of this whitefly may be due to a low population of *Encarsia* sp., used to control whitefly population in some plants (Gerling, 1996; Liu and Stansly, 1996a), and also to the presence of *Crematogaster* sp.

Table 1. Identification of the compounds in the hexane extract of leaves from the apex cassava based on the mass spectral database

Retention time (min)	Compound Identified	Similarity Index (SI)
25.503	Hexadecanoic acid or palmitic acid	86
28.195	11,14,17 eicosatrienoic acid methyl ester	82
46.403	D-friedoolean-14-en-3-one	83
46.806	?	----
46.819	(+)-aromadendrene	79
46.825	Globulol, veridiflorol or viridiflorol	79
47.198	?	----
47.222	(E)-farnesene, trans-farnesol	78
47.763	Olean-12-ene	71
47.775	Velerdiol	75
48.253	Trans-caryophyllene	78

Peaks were identified although similarity indices were very low

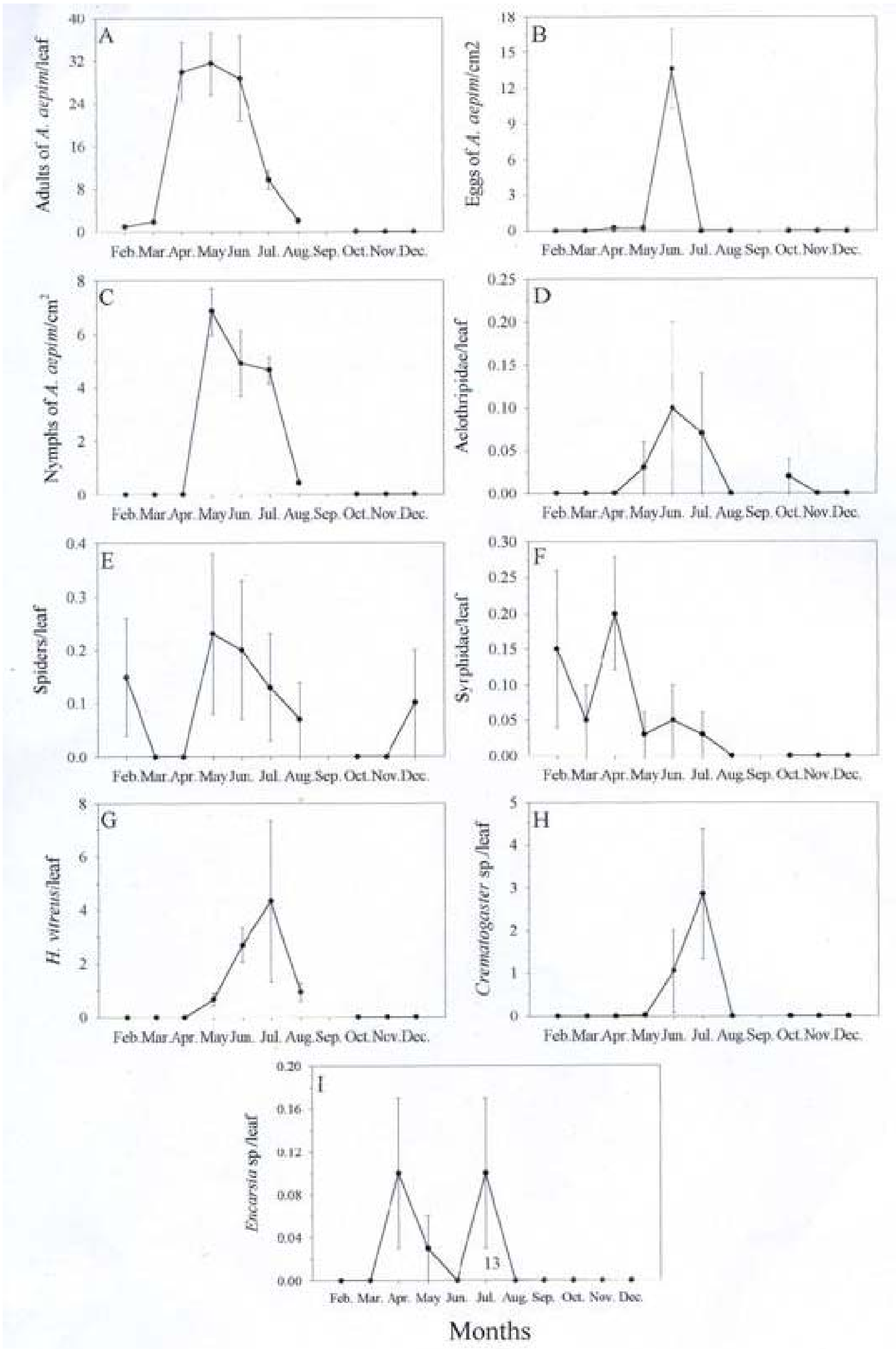

Figure 1. Fluctuations of adults/leaf (A), eggs/cm^2 (B) and nymphs/cm^2 (C) of *Aleurothrixus aepim*, Aelothripidae/leaf (D), Spiders/leaf (E), Syrphidae/leaf (F), *Hyaliodes vitreus*/leaf (G), *Crematogaster* sp./leaf (H) and *Encarsia* sp./leaf (I) on cassava. The symbols represent the average of 40 leaves and the vertical bars indicate mean standard errors. *Viçosa,* state of *Minas Gerais*

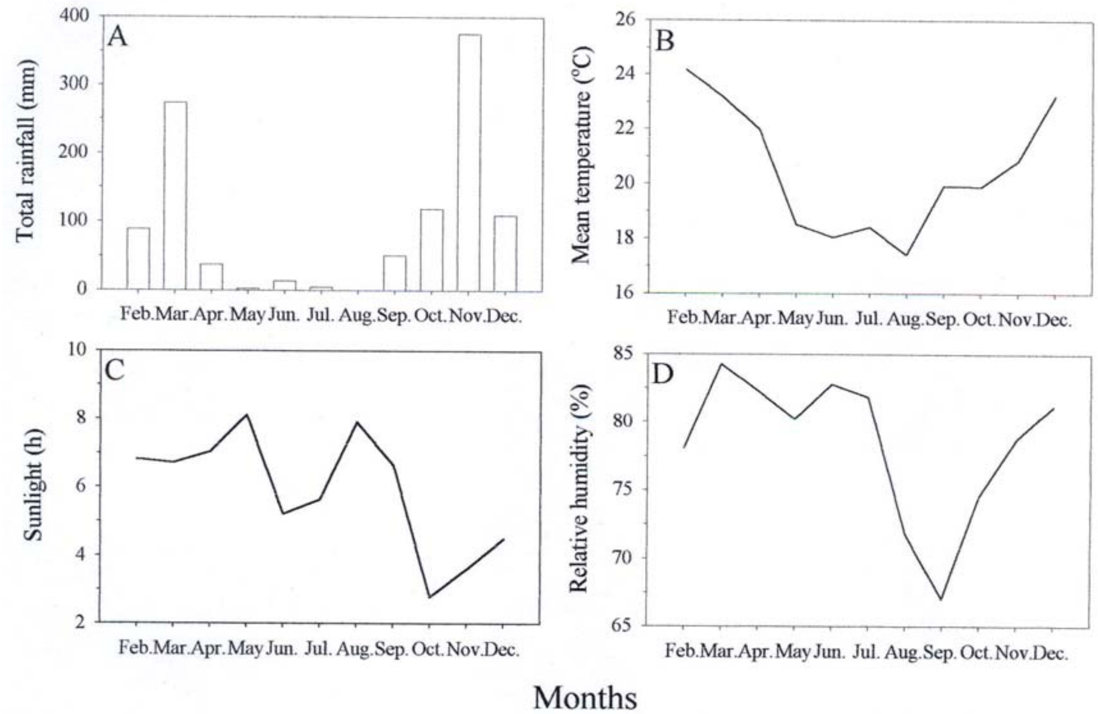

Figure 2. Total rainfall distribution (mm) (A), mean temperature (minimum + maximum/2) (B), sunlight (h) (C) and relative humidity (%) (D) during experimental period in Viçosa-MG. The symbols represent, in general, the rainfall accumulated and the average of the mean temperature, sunlight and relative humidity of 30 days

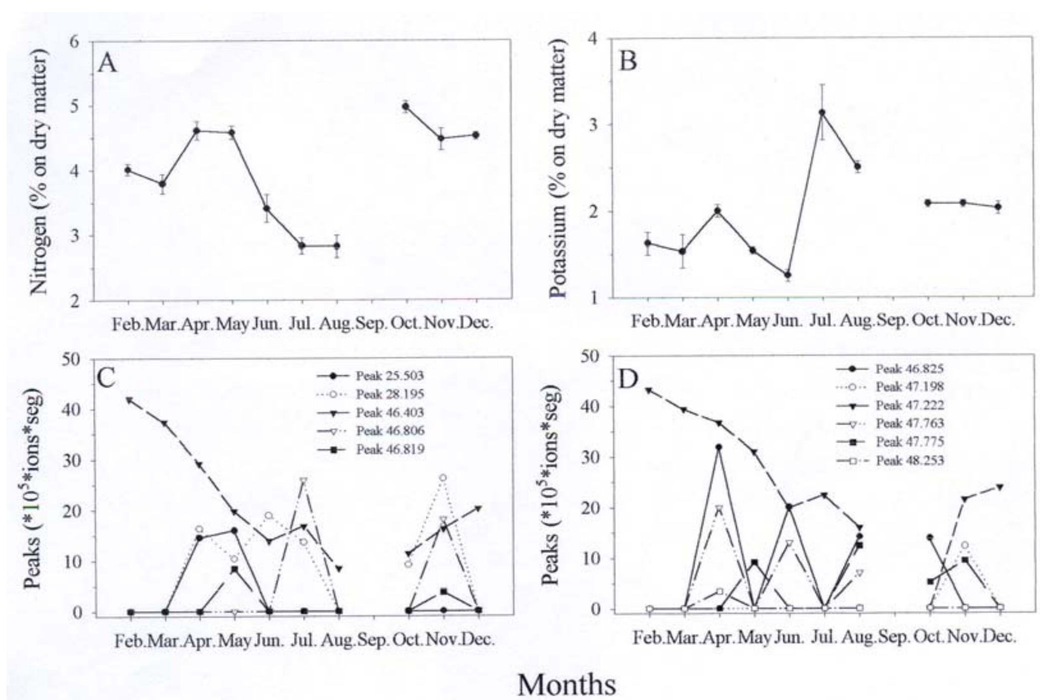

Figure 3. Fluctuations of leaf N (A) and K (B) levels (% in dry matter) and the intensities of eleven peaks (C and D) obtained on gas chromatography/mass spectrometry analysis of hexane extract of cassava leaves. The symbols represent the average of three evaluations for N and K and one evaluation for the peaks and the vertical bars indicate mean standard errors. *Viçosa,* state of *Minas Gerais*

The eleven major compounds (Table 1) identified in the hexane extracts using the mass spectral data base have not been reported in the literature for cassava. Although these compounds were identified with a high similarity index (SI), their identity should be confirmed by other methods. Hence, we plan to isolate these compounds in large quantities and identify them by more precise spetroscopic methods, besides conducting bioassays with compounds with (r_t) of 25.503 and 47.763min., since it is positively correlated with whitefly adults. Compounds present in cassava which are known to affect insect populations are the hydrogenated cyanide (HCN) and laticifers, because they have a negative effect on exotic pests, but a very low impact on those which had evoluted with this host (Bellotti and Riss, 1994; Bellotti *et al.*, 1999). On the other hand, it was not possible to detect the effect of N and K levels in cassava plants leaves with whitefly, maybe due to the small variation of these nutrients in the leaves during the experimental period.

In summary, even though different factors, such as ecological and physiological conditions of plants, besides parasitoids and predators, can affect whitefly *A. aepim* population fluctuation, the most important one for this insect seems to be the plant phenology (leaf senescense). However, it is recommended to increase studies with the predator *H. vitreus*, in order to evaluate its real potential as natural enemy of the whitefly *A. aepim* in programs for integrated management of this pest.

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