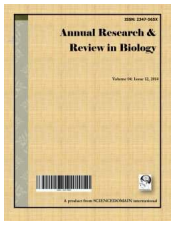

Annual Research & Review in Biology
11(1): 1-7, 2016, Article no.ARRB.28668
ISSN: 2347-565X, NLM ID: 101632869

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Population Dynamic of Citrus Blackfly, *Aleurocanthus woglumi* (Hemiptera: Aleyrodidae), in Tahiti Lime in the eastern of the State of São Paulo, Brazil

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Authors' contributions

This work was carried out in collaboration between all authors. Author AR designed the study, wrote the protocol, anchored the field study and interpreted the data. Authors NF and RI anchored the laboratory activities, managed the literature searches and produced the initial draft. All authors read and approved the final manuscript

Article Information

DOI: 10.9734/ARRB/2016/28668
Editor(s):
(1) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
Reviewers:
(1) Alon Silberbush, Ben-Gurion University of the Negev, Beer Sheva, Israel.
(2) Rameshwar Singh Rattan, EI Dupont India Pvt Ltd, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/16005

Original Research Article

Received 30th July 2016
Accepted 25th August 2016
Published 1st September 2016

ABSTRACT

Citrus blackfly, *Aleurocanthus woglumi* is a serious citrus insect pest. The objective of this study was to determine the population dynamic of the CBF in a commercial citrus orchard in the State of São Paulo, Brazil. The experiment was conducted in a commercial orchard of Tahiti acid lime (*Citrus latifolia* Tanaka). Twenty-six evaluations of the *A. woglumi* population were conducted in 10 randomly selected plants from 23 Aug 2011 to 15 Aug 2012. Data from population dynamics originated in total collection of 200 leaves per collection, and the infestation rate calculated per leaf. In total, 15.87% of the leaves were infested by eggs, showing 0.45 clutch per leaf, and 2.82 clutches per infested leaf. The acme of egg population occurred in August 2011 (52.92 eggs/leaf), and the lowest egg population was in July 2012 (1.84 egg/leaf). We counted 44,420 eggs, with a mean of 22.16 eggs per clutch. The lowest and highest number of eggs per egg mass were 7 and 53, respectively. The western quadrant showed significantly more *A. woglumi* egg masses than the northern. From total leaves, 22.63% were infested by nymphs, with an average of 22.41 nymphs per

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infested leaf. The quantities of *A. woglumi* nymphs in the western and eastern quadrants were similar, and higher, than the other quadrants.

Keywords: Insecta; Rutaceae; citrus pest; ecology; distribution.

1. INTRODUCTION

Globalisation of tropical fruits and the rapid expansion of export markets, have resulted in exotic plants growing out of their centres of origin. This has implied the existence of an arthropod complex for each different region from those observed of crop´s area of origin [1]. Citrus plants are hosts to a large number of pests in the world. In citrus there are about 875 species of insects and mites registered [2], and 144 species of those species are known as pests [3].

Popularly known as whiteflies or blackflies, species of insects of the Aleyrodidae family (Hemiptera), are widely distributed geographically, living on a large number of wild and ornamental plants. Some are considered pests in crops of economic importance [4]. Aleyrodidae has 1,200 described species, which have divided into two subfamilies: Aleyrodinae and Aleurodicinae. The Aleurodicinae subfamily contains endemic species, considered more primitive and, distributed mainly in South America and Central America. Included in the subfamily Aleyrodinae are the most species of economic importance [5].

Citrus blackfly (CBF), *A. woglumi* is native to Southeast Asia and considered a serious citrus pest [6,7,8]. It is widespread in tropical and subtropical regions of Africa, North America, Central America and South America, the Caribbean and Oceania [9,10,11]. CBF was detected, for the first time in Brazil, in July 2001, in the municipality of Belém, State of Pará [12]. This pest has spread to many Brazilian states. The difficulties for the management of *A. woglumi* are due, among other limitations, to the lack of knowledge about the pest ecology under our field conditions [6,13].

CBF eggs are ovoid and have a pedicel, which is an extension of the chorion fixed to abaxial surface. The female lays 35-100 eggs on the underside of the leaves, preferably under developed ones. CBF female lay 8, a maximum of 50 and an average of 28.42 eggs per spirals [12]. Males and females feed on buds and young leaves [7,13]. Direct damages have caused by the continuous sucking nutrients from the leaves by nymphs and adults feeding. Indirect damages are due to development of sooty mold on the leaves.

Citrus species are primary hosts of *A. woglumi*, but the pest can infest more than 300 plant species [9], including fruit and ornamental crops. In Brazil, trees of oranges, tangerines, acid limes, trifoliate oranges and Rangpur limes are highly susceptible to CBF infestation. The objective of this study was to determine the population dynamic of the CBF in a commercial citrus orchard.

2. MATERIALS AND METHODS

2.1 Plot Location and Orchard Management

The experiment was conducted in a commercial orchard of Tahiti acid lime (*Citrus latifolia* Tanaka) grafted on Rangpur lime (*Citrus limonia* L. Osbeck), which was 11 years-old. The experiment was set in São Luiz Farm, Municipality of Artur Nogueira, State of São Paulo, Brazil (22º36'15.78"S; 47º09´10.26"W; 617 m). The area has a CWA-type climate, characterized as humid temperate climate, with dry winter and hot summer [14]. The orchard consisted of eight lines of 24 plants (192 plants). The plants had an average height of 4.5 meters, spaced at 7.0 x 4.0 meters. Foliar applications of spiromesifen and sulphur were made on 16 Aug 2011, and sulphur and imidacloprid on 18 Oct 2011. The orchard has fertilized on 12 Nov 2011 with 1.50 Kg/tree of NPK fertilizer (6-12-12).

2.2 Experiment Design

Twenty-six evaluations of *A. woglumi* population were conducted in 10 selected plants from 23.08.2011 to 15.08.2012. Two plants per line were choosen among five consecutive lines. Sampled trees were spaced at least 10.6 meters from each other. In each quadrant (North, South, East and West) of selected plants five mature leaves were randomly collected from 0.5 to 2 meters high and from 20 cm to 100 cm in depth. The leaves of each quadrant were packed in polyethylene bags and transported to the Laboratory of Economic Entomology of Biological Institute, in Campinas SP. The transportation of leaves occurred inside of covered Styrofoam

boxes, containing Gelox®. The number of active clutches (without egg eclosion), eggs per clutch and live nymphs were counted on abaxial leaf surfaces [15], under a stereomicroscope.

2.3 Data Analyses

Data from population dynamics were originating in total collection of 200 leaves per collection, and the infestation rate calculated per leaf. Daily weather data were obtained from a meteorological station, located about 11.5 km from the study area. Number of CBF egg masses and nymphs per leaf was analyzed by one-way ANOVA followed by Tukey´s test, using the software Assistat 7.7 version [16].

3. RESULTS

During the period of the study, the monthly average minimum temperature ranged from 11.0º to 19.8º C, and the maximum average temperature varied from 24.4º to 31.8º C. The monthly average of relative humidity (RH) ranged from 34.7 to 67.2%. The cumulative rainfall reached 1,469 mm (Fig. 1).

In total, 730 leaves were infested by CBF eggs (15.87% of total leaves). Based on all collected leaves (4,600), there were obtained 2,056 active clutches (egg masses) of CBF, reaching an average 0.45 clutch per leaf and 2.82 clutches per infested leaf. The acme of egg population (Fig. 2) was reached on 23 Aug 2011 (52.92 eggs/leaf) and the lowest egg population on 13 Jul 2012 (1.84 egg/leaf).

From all infested leaves, we counted 44,420 eggs, with a mean of 22.16 eggs per clutch. The lowest and highest number of eggs per egg mass were 7 and 53, respectively. The highest frequency of clutches showed 18 eggs (7.9%), with a predominance of frequencies between 12 and 30 eggs (Fig. 3).

In terms of intra-tree distribution, 194, 466, 630, and 766 clutches were found in the northern, southern, eastern and western quadrants, with a corresponding 9.4%, 22.7%, 30.6% and 37.3%, respectively. The western quadrant showed significantly more CBF egg masses than the northern (Tukey´s test, $P < 0.05$), but the oviposition on the western quadrant was similar to the southern and eastern quadrants (Fig. 4).

The number of CBF nymphs reached 26,376 during the experiment. From total leaves, 22.63% were infested by nymphs, with an average of 22.41 nymphs per infested leaf. In early April 2012, the acme of the population was detected, with 47% of infested leaves by CBF nymphs, with an average of 13.02 nymphs per leaf (Fig. 5).

From 1,177 infested leaves, 15.1%, 18.0%, 32.4%, and 34.5% were obtained in the northern, southern, eastern and western quadrants, respectively. The quantities of CBF nymphs (Fig. 6) in the western and eastern quadrants were similar and higher than the other quadrants (Tukey´s test, $P < 0.05$).

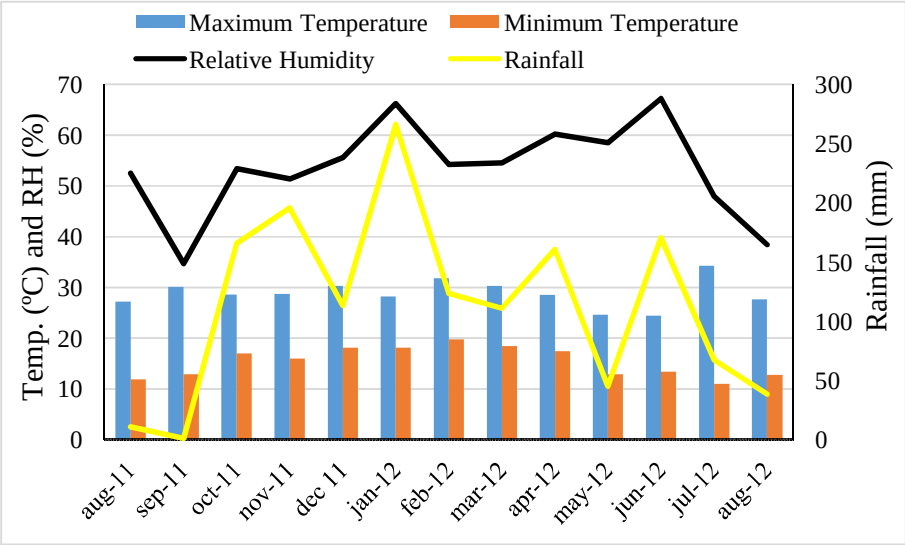

Fig. 1. Climogram of monthly mean temperature, rainfall and relative humidity (RH) in Artur Nogueira, SP, Brazil (2011-2012)

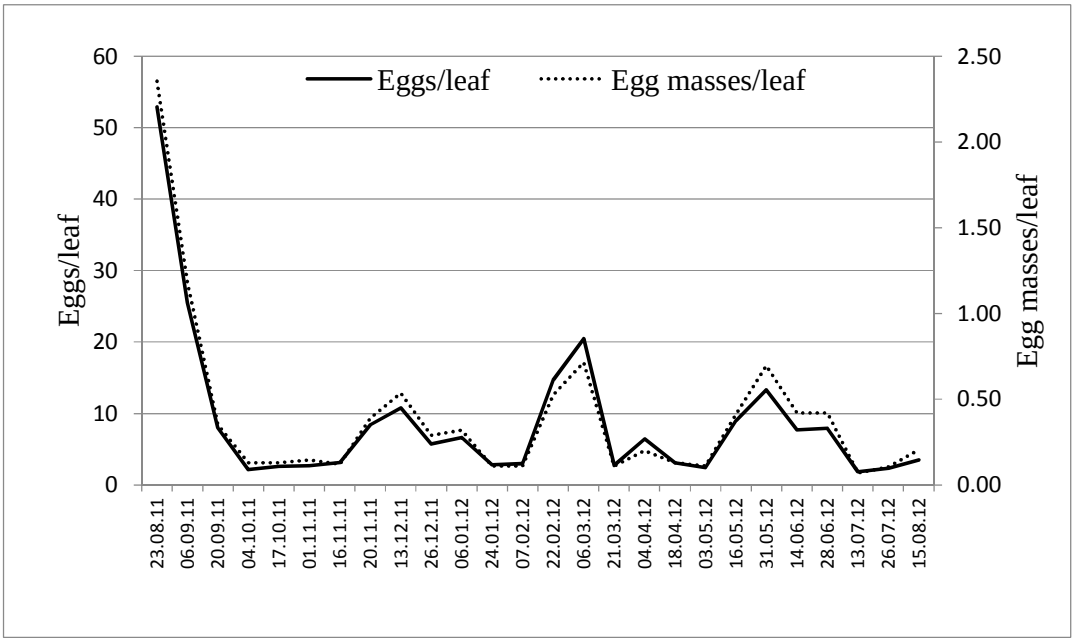

Fig. 2. Number of eggs of *Aleurocanthus woglumi* in Tahiti acid lime. Artur Nogueira, SP, Brazil

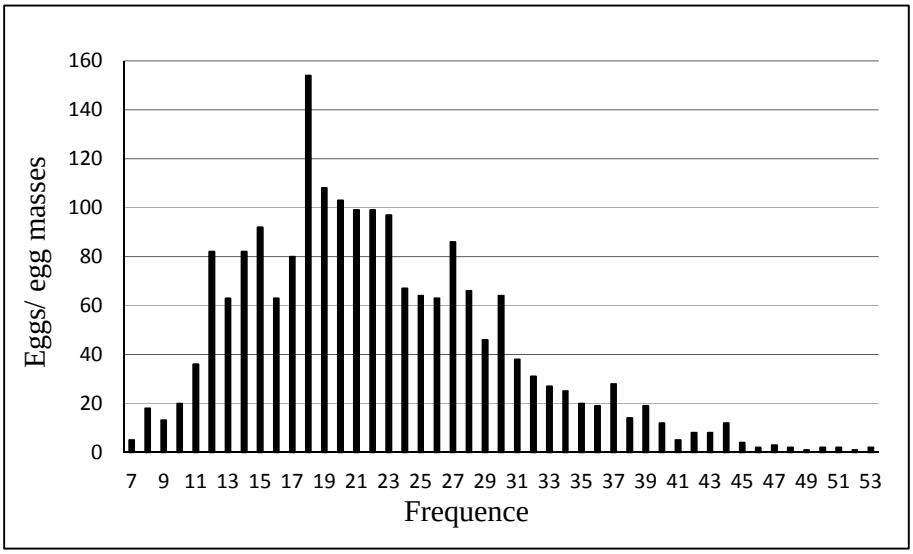

Fig. 3. Frequence of eggs per egg masses of *Aleurocanthus woglumi* in Tahiti acid lime. Artur Nogueira, SP, Brazil, from Aug 2011 to Aug 2012

4. DISCUSSION

There was a reduction of *A. woglumi* nymphs after first spraying pesticides (16/08/2011). This resulted in the reduction of the population of CBF nymphs, which added to the effect of the second spraying pesticides (18/10/2011), with a mean of 1.03 nymph per leaf. This population reduction most likely occurred due to the effect of pesticides on mortality of CBF eggs, nymphs and adults, and also, due to the incidence of entomopathogenic fungi *Aschersonia aleyrodis* Webber and *Aegerita webberi* H.S. Fawc. during late winter and early spring.

In the present study, only one ground application of spiromesifen was made in late autumn 2011 and one foliar spraying of imidacloprid was applied in early spring 2011. Spiromesifen was applied to control the broad mite

Polyphagotarsonemus latus (Banks). In Brazil, only imidacloprid received authorization by federal regulatory agencies to spraying against CBF in citrus crops. Field observations in many citrus orchards showed a short period of population suppression of *A. woglumi* caused by imidacloprid, no longer than two weeks (personal communication).

The intra-tree distribution of the *A. woglumi* did not occur similarly among the quadrants. There was a tendency of higher CBF immatures on the western quadrant, whose sites reached 37.3% and 34.4% of egg masses and nymphs, respectively. Probably, females prefer the oviposition sites of the canopy, which provides higher humidity and, consequently, higher egg viability. The smaller CBF immature population occurred in the northern quadrant. These observations can affect the strategy of integrated pest management, in terms of sampling methods.

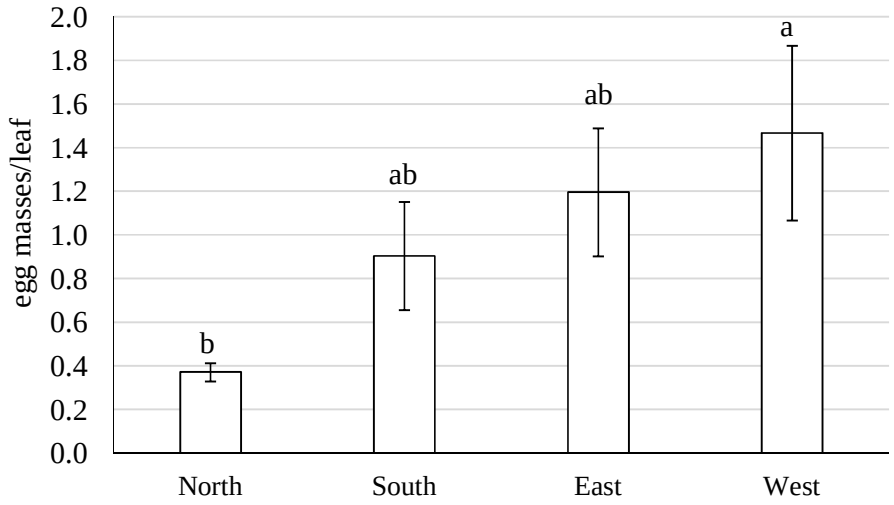

Fig. 4. Number of egg masses of *Aleurocanthus woglumi* in different quadrants in Tahiti acid lime. Artur Nogueira, SP, Brazil, from Aug 2011 to Aug 2012

Means (± SE) followed by the same letter indicate no significant difference by Tukey´s test (P < 0.05)

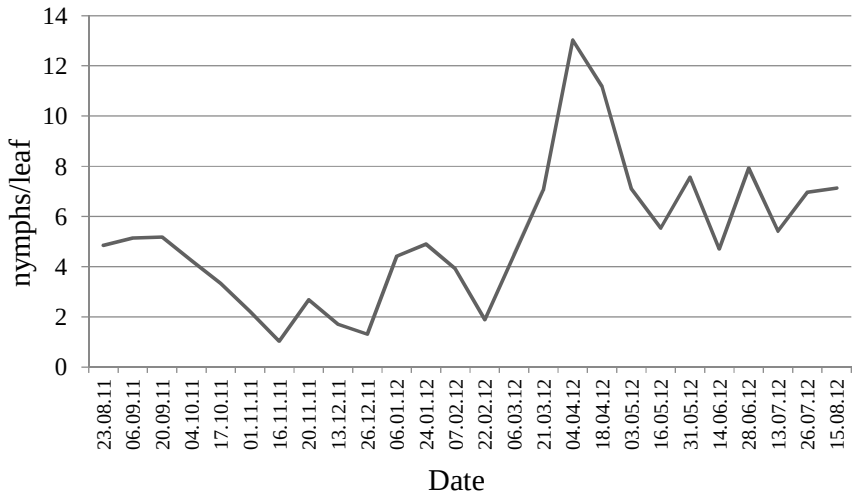

Fig. 5. Number of nymphs of *Aleurocanthus woglumi* in Tahiti acid lime. Artur Nogueira, SP, Brazil

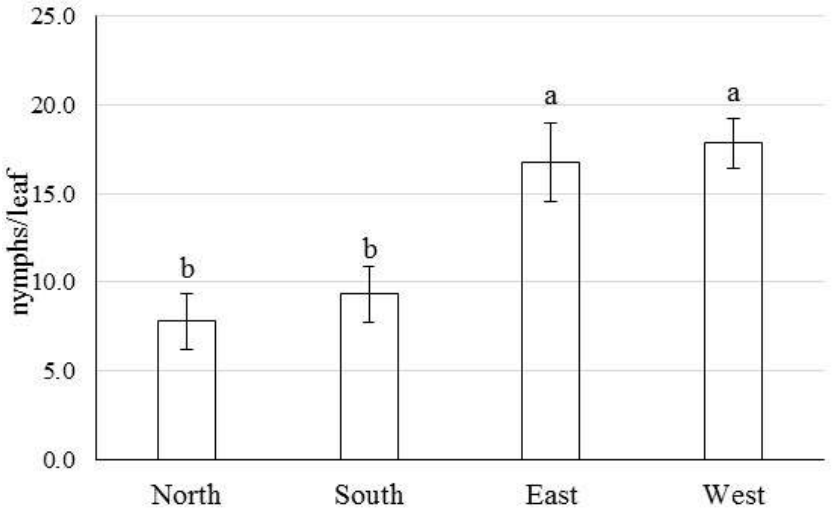

Fig. 6. Number of nymphs per leaf of *Aleurocanthus woglumi* in different quadrants in Tahiti acid lime. Artur Nogueira, SP, Brazil, from Aug 2011 to Aug 2012

Means (± SE) followed by the same letter indicate no significant difference by Tukey´s test (P < 0.05).

The southern quadrant was the most heavily infested by eggs of *A. woglumi* under high infestation of sweet orange orchard [12]. Factors such as variety, size of canopy, growing space, fertilization, and the entomofauna interaction can affect the intra-tree distribution.

Approximately 83% of the CBF egg masses obtained in sweet orange trees had from 16 to 41 eggs [12]. In the present study, 72.8% of egg masses were included in this range of values. The advantage gained by *A. woglumi* for aggregating its spirals is unknown, because it does not seem to increase survival of the immature stages [17].

Based on the highest oviposition and the highest survival of the immature stage of the CBF, Tahiti acid lime is considered the most suitable host to *A*. *woglumi* in comparison with sweet orange, mandarin and mango in the laboratory [18]. *Citrus* genus is a primary host for *A. woglumi* [7]. After detection in the state of São Paulo, the *A. woglumi* population became a serious pest on infested citrus orchards, including sweet orange, mandarin and Tahiti acid lime.

The aggregation behaviour of CBF increase the initial damage in newly infested orchards. Thus, the transportation of fruit seedling and infested leaves is the main way to spread the pest to long distances. In environmental conditions of São Paulo, CBF adults feed on new flushes and the females laid the eggs only on mature leaves. In the present study, no egg spiral was detected on the adaxial surface.

5. CONCLUSION

The present study showed population peaks of *Aleurocanthus woglumi* in Tahiti lime in August (spring) for eggs and from March to May (autumn) for nymphs. The majority of clutches showed between 12 and 30 eggs, with average of 22.16 eggs. The oviposition of *A. woglumi* on the western quadrant it was similar to the southern and eastern quadrant. Western and eastern quadrants showed the highest number of *A. woglumi* nymphs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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