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Fruit flies in a guava orchard in Indiana county, São Paulo, southeastern Brazil

Moscas de las frutas en el cultivo de guayaba en Indiana, São Paulo, Brasil

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ABSTRACT

The experiment was performed from September, 2011 until April, 2012 in order to determine the infestation stage of fruits, the population dynamics and the diversity of fruit files (Diptera: Tephritidae) in a guava orchard in the western region of São Paulo State, Brazil. The population dynamics of fruit flies were obtained from three McPhail plastic traps baited with hydrolyzed protein. To evaluate the infestation of fruit flies, 180 fruits were chosen in which fifteen of them were fortnightly bagged or unbagged. Fruit length and diameter were measured to define the fruit development stage most susceptible to natural fruit fly infestation. We captured a total of 300 Tephritidae specimens: 102 specimens of *Anastrepha spp*. (34.1%) and 198 of *Ceratitis capitata* (Wied.) (65.9%). Four species of *Anastrepha fraterculus* (Wied.), were recovered from McPhail traps: *A. obliqua* (Macquart), *A. striata* Schiner and *A. sororcula* Zucchi. A total of 31 adults were found in the fruits: 2 *C. capitata* (6.5%) and 29 *Anastrepha* (93.5%); *A. obliqua* and *A. sororcula*. Fruits with 2.6-cm of mean diameter were infested by fruit flies.

Key words: *Anastrepha spp*., *Ceratitis capitata*, *Psidium guajava*, population dynamics.

RESUMEN

El experimento fue realizado entre septiembre de 2011 hasta abril de 2012 con el objetivo de evaluar la fase de infestación de frutos, la dinámica poblacional y la diversidad de moscas de la fruta (Diptera: Tephritidae) en guayabales en la región oeste del estado de São Paulo, Brasil. La dinámica poblacional fue cuantificada por medio de tres trampas amarillas modelo McPhail con sustancia a base de proteína hidrolisada. Para evaluar la infestación por moscas de la fruta se escogieron 180 frutos que fueron colocados y sacados de los sacos cada quince días. Se midió longitud y diámetro de los frutos para determinar la fase de desarrollo susceptible al ataque de las moscas de la fruta. Se recogieron 300 individuos de Tephritidae en las trampas, de las cuales 102 (34,1%) fueron especies de Anastrepha *spp. y 198 (65,9%) de* Ceratitis capitata *(Wied.). Se identificaron cuatro especies de* Anastrepha *spp.:* A. fraterculus *(Wied.),* A. obliqua *(Macquart),* A. striata *Schiner y* A. sororcula *Zucchi. Se identificaron 31 adultos en los frutos, siendo dos (6,5%) de* C. capitata *y 29 (93,5%) del* Anastrepha spp. *(*A. obliqua *y* A. sororcula*). Se observó que los frutos con diámetro superior a 2,6 cm fueron sensibles al ataque de moscas de la fruta.*

Palabras clave: Anastrepha spp*.,* Ceratitis capitata*,* Psidium guajava*, dinámica poblacional.*

Introduction

Guava (*Psidium guajava* L.) is currently grown as a crop in most of the tropical and subtropical regions in the world. With its origin in tropical America, guava plants are naturally distributed from Mexico to southern Brazil. Essentially based on family labor, guava cropping has great economic and social importance (Pereira, 1995).

In Brazil, São Paulo State is by far the largest national producer of guava, with around 1.8 million producing trees. Guava yield data from 2001 indicated an estimated production of 172,300 ton. This high volume of guava production was intended for both table consumption and industry (IEA, 2011).

Despite the high importance of guava as a commodity in Brazil, the amount of guava exports is very low (Costa *et al*., 2007). The commercialization restricted to the within-country market is basically due to strict quarantine regulations abroad. The prevalence of an exotic pest such as fruit flies (Diptera: Tephritidae) associated with guava fruits

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is possibly the most important factor limiting guava exports (Gould and Raga, 2002).

In fact, fruit flies are considered major pests for several fruit trees worldwide because of their constancy and polyphagous habits. Particularly in Brazil, guava crops are extremely susceptible to fruit fly infestation. The fruit fly species *Anastrepha* and *Ceratitis capitata* (Wied) are probably the most prevalent guava pests in Brazil (Pereira and Martinez Junior, 1986; Raga *et al.,* 2005).

Fruit fly infestation is influenced by the degree of fruit development and ripening. Fruit flies cannot easily penetrate the resistant epidermis of young guava fruits. Fruit flies are not attracted by fully ripe fruits, which would represent a short period for insect development. (Salles, 1994). The optimum guava fruit size for fruit fly infestation is the two cm-diameter growth stage (Souza-Filho *et al*., 2009).

One aspect of fundamental importance in the management of fruit flies is the monitoring of the existing population in orchards, which should provide information that adequately represents the behavior of the populations (Scoz *et al*., 2006). Trap evaluation and food baits were performed by Scoz *et al*. (2006). They showed that alternative traps different from the McPhail design, built from 2 liter transparent and green PET bottles, are efficient in capturing *A. fraterculus.*

This study aimed to determine the population dynamics, the infestation stage of the fruit and the diversity of fruit flies from guava orchards in the western region of São Paulo State, Brazil, to subsidize an integrated pest management program and to help make family fruit farming viable.

Material and Methods

This study was conducted in a commercial guava orchard located in Indiana county, SP, Brazil (22°10'05.6"S, 51°15'24.8"W and 446 m altitude) from September 2011 to April 2012. The orchard was planted with four-year old guava cv. Paluma with trees distributed in a 6 x 7 m spacing and conducted under conventional system during the experiment.

To determine the population dynamics of the adult fruit flies, three McPhail-type traps containing 400 mL of attractive solution composed of 5% v/v of hydrolyzed protein (BioAnastrepha®) were used. One of the traps was installed in the center of the orchard, while the other two were set near the outskirts, in opposite positions. The attractive solution was renewed weekly and insects from the previous week were collected and taken to the laboratory to proceed with the tephritid classification.

Fifteen days after flowering (October 5th, 2011), when the fruits presented an average diameter of 1.30 cm, 180 guava fruits were randomly chosen and bagged to determine the fruit growth stage most susceptible to Tephritidae infestation. Every two weeks fifteen fruits were bagged or unbagged, making a total of 30 fruits per evaluation (Table 2). A colored band was tied to the fruit to indicate the exposure date and the corresponding fruit growth stage exposed to fruit fly infestation.

When ripe, the fruit were collected and transported to the laboratory, where they were placed in 500 mL cups containing a mixture of vermiculite and sand, covered with aluminum foil and strapped with an elastic band. After approximately 25 days,the fruits were removed and the substrates containing pupae were maintained until the emergence of the flies.

The *Anastrepha* spp. fruit flies were separated and preserved in glass bottles filled with 70% alcohol for posterior identification. Because *C. capitata* is the only species of the genus *Ceratitis* in Brazil, the number of specimens were recorded and then discarded once no further identification would be necessary (Zucchi, 2000a). The female *Anastrepha* were identified based on the terminalia, observing the specific aculeus characteristics according to the keys of Steyskal (1977) and Zucchi (2000b). To measure the population level of the *Anastrepha* spp. and *C. capitata* in the orchard, the numbers of individuals collected weekly were transformed into flies.trap^{-1}.day^{-1} (FTD).

Results and Discussion

Population dynamics of fruit flies

From October 2011 to February 2012 a total of 300 Tephritidae specimens were collected from the traps installed in the guava orchard. There were a total of 34.3% *Anastrepha* spp. specimens (24.3% males and 75.7% females) and 65.7% *C. capitata* specimens (31.5% males and 68.5% females). *A. obliqua* Macquart, *A. fraterculus* (Wied.), *A. sororcula* Zucchi and *A. striata* Schinner were captured in the traps, with predominance of *A. obliqua* (Table 1).

Surveys carried out by Montes *et al*. (2012) in the same area of this study in western São Paulo

Table 1. Fruit flies collected in McPhail traps in a guava orchard in the county of Indiana, SP, Brazil. From Sept/2011 to Apr/2012.

Species of fruit flies	Specimens collected in the traps (nº)			Relative frequency (%)
	Male	Female	Total	
Ceratitis capitata Wied.	62	135	197	65.67
Anastrepha spp.	25	78	103	34.33
Total	87	213	300	100.00
Species of Anastrepha				
*Anastrepha fraterculus (*Wied.)	.	.	10	12.82
Anastrepha sororcula Zucchi	.	.	25	32.05
Anastrepha obliqua Macquart	.	.	39	50.00
Anastrepha striata Schinner	.	.	4	5.13
Total	.	.	78	100.00

State recorded the occurrence of the same *Anastrepha* species, *C. capitata,* and five other species of Lonchaeidae: *Neosilba certa* (Walker), *N. inesperata* Strikis & Prado, *N. pendula* (Bezzi), *N. pradoi* Strikis & Perena and *N. zadolicha* McAlphine & Steyskal on peaches, coffee, mangoes, siriguela (*Spondias purpurea*), cassava, pumpkin and citrus crops. The authors also recorded the occurrence of *A. barbiellinii* Lima, *A. montei* Lima, *A. pseudoparalella* (Loew), *A. daciformis* Bezzi, *A. haywardi* Blanchard, *A. zenildae* Zucchi, *A. leptozona* Hendel, *A. bistrigata* Bezzi, *A. amita* Zucchi, *A. dissimilis* Stone, *A. distincta* Greene, *A. elegans* Blanchard and an unidentified species of *Anastrepha*.

Raga *et al.* (2005) reported an infestation by *C. capitata, A. fraterculus, A. bistrigata, A. sororcula, A. obliqua, A. montei* and *A. dissimilis* in guavas from São Paulo State. Araújo and Zucchi (2003) recorded a similar result in guava orchards from Mossoró, Rio Grande do Norte State (Northeastern Brazil), reporting the occurrence of *C. capitata* and six *Anastrepha* species on traps: *A. zenildae, A. sororcula, A. obliqua, A. montei, A. dissimilis and Anastrepha* sp.

From October 26th to December 7th 2011 no *Anastrepha* were captured. A population peak of *Anastrepha* spp. was observed on February 1st 2012, reaching a FTD value of 5.6 (Figure 1), when the orchard already had developing fruits. In Mossoro, Araújo and Zucchi (2003) also noted that between November and December guavas were free from fruit fly infestation

Adults of *C. Capitata* represented the most abundant trap-captured species in the guava orchard (Figure 2), differing from other studies on fruit fly diversity from the same location. The high abundance of *C. capitata* is due probably to the proximity of the guava orchard to a coffee plantation, which is the preferential host of this fly species. The coffee trees in the adjacent area were not fruiting, and so would not attract the flies. In Presidente Prudente, SP, the predominance of *C. capitata* was also noticed in trap surveys conducted on peaches, coffee and mango trees (Montes *et al*. 2010; 2011 b; 2012). A distinct result was documented by Azevedo *et al.* (2010) in Crato, Ceara (Northeastern Brazil), in which a low constancy index of *C. capitata* individuals was observed. However, the mostly-dry semi-arid weather conditions of Northeastern Brazil, which are completely distinct from the humid summer of Southeastern Brazil, might have interfered with the occurrence of *C. capitata*.

The population peaks of the two fruit fly groups were similar in the month of February. In Monte Alegre do Sul, SP, Souza-Filho *et al*. (2009) recorded a population peak of *A. fraterculus* in March, August, and September, when the fruits ripen.

Fruit fly infestation in guavas

From the fruits collected for surveying fruit fly infestation, a total of 28 adult specimens of *Anastrepha* spp. (14 males and 14 females) and two males of *C. capitata* were recovered. The occurrence of *A. obliqua* and *A. sororcula* was recorded in guava fruits (Table 2). The other *Anastrepha* species that were captured have probably developed in hosts located near the guava orchard. In Presidente Prudente, SP, studies conducted by Montes *et al*. (2010; 2011a and b; 2012) documented a predominance of *Anastrepha* in siriguela, citrus fruits and cassava.

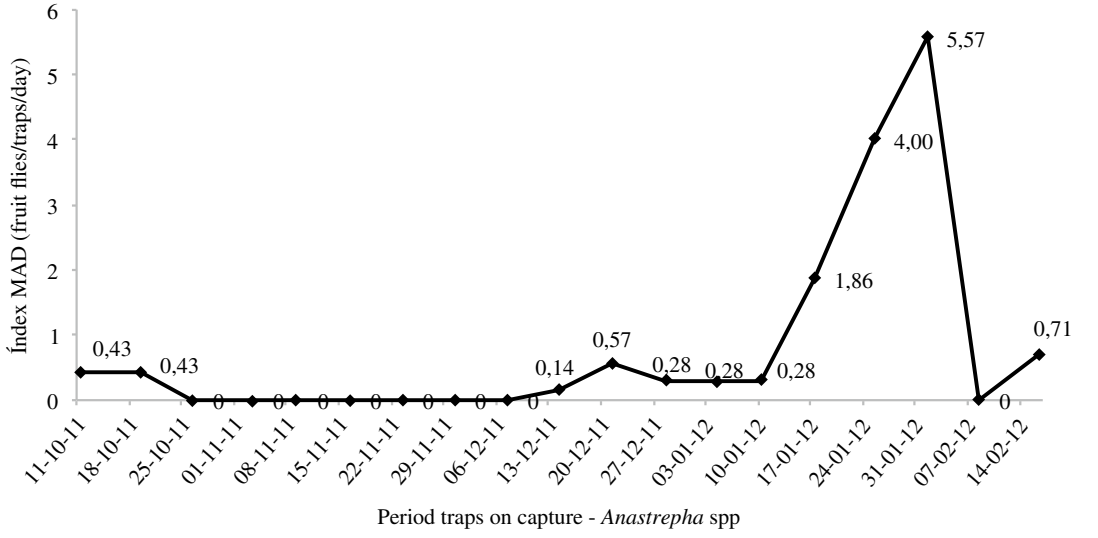

Figure 1. Population variation of *Anastrepha spp.* in McPhail traps, in guavas. Indiana, SP, Brazil. From Oct./2011 to Feb./2012.

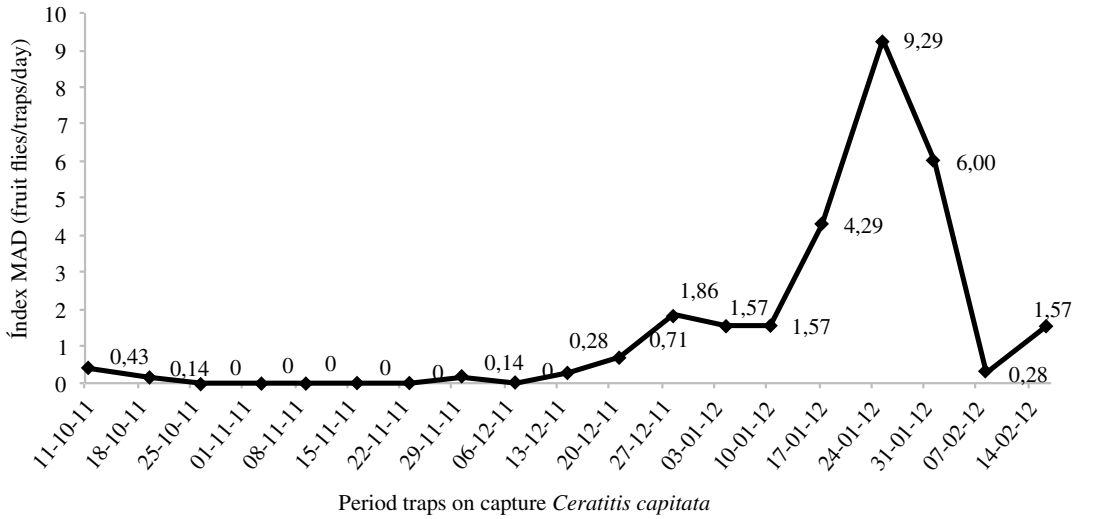

Figure 2. Population variation of *Ceratitis capitata* in McPhail traps, in guavas. Indiana, SP, Brazil. From Oct/2011 to Feb/2012.

Souza-Filho *et al*. (2009), indentified four species of *Anastrepha* in guava, loquat, and peach orchards located in Monte Alegre do Sul, SP county, between 2002-2003. In guava fruits, particularly, *A. bistrigata* Bezzi, *A. fraterculus* (Wied.), *A. obliqua* Macquart, *A. sororcula* Zucchi and *C. capitata* (Wied.) were reported.

In the semi-arid Rio Grande do Norte, Araújo and Zucchi, 2003 verified that *A. zenildae* and *A. sororcula* are more adapted to that region. However, in northern Minas Gerais (Southeastern Brazil), Canal *et al.,* (1998, 1998a) reported the predominance of *A. zenildae.* This distinct occurrence of fruit fly species can be explained by the influence of various factors in the rate of fruit fly infestation (Nascimento *et al.,* 1982), such as the variety planted and the proximity to other orchards (Araújo and Zucchi, 2003).

The fruit bagging and unbagging experiment demonstrated that *C. capitata* and *Anastrepha* adults can initiate oviposition in fruits as small as

Table 2. Adult fruit fly rate during guava fruit growth from Paluma lineage with regard to the fortnightly bagging and unbagging period. Indiana, SP, Brazil. 2011.

Treatment	Half of bagging and unbagging fruits							% infested fruits	
Bagging	0	1	2	3	4	5	6	*Anastrepha* spp.	C. capitata
05/10/2011	X	X	X	X	X	X	X	0.0	0
19/10/2011		X	X	X	X	X	X	0.0	0
03/11/2011			X	X	X	X	X	0.0	0
16/11/2011				X	X	X	X	0.0	0
30/11/2011					X	X	X	0.0	6.7
14/12/2011						X	X	6.7	0
28/12/2011							X	0.0	0
Unbagging	0	1	2	3	4	5	6		
19/10/2011	X							0.0	0
03/11/2011	X	X						27.3	9.1
16/11/2011	X	X	X					7.1	0
30/11/2011	X	X	X	X				25.0	0
14/12/2011	X	X	X	X	X			20.0	0
28/12/2011	X	X	X	X	X	X		25.0	0

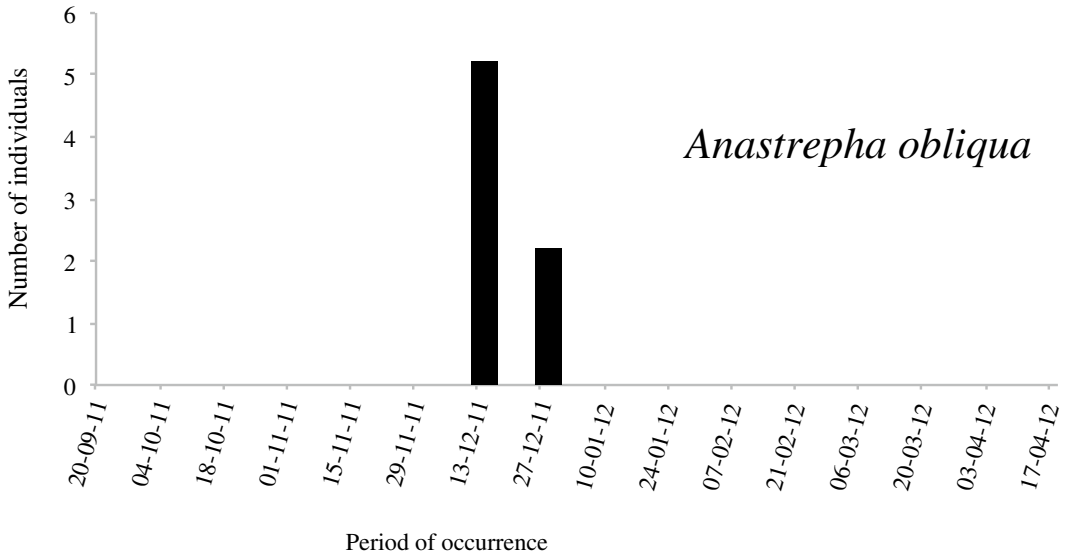

Figure 3. *Anastrepha obliqua* and *A. sororcula* infestation in guava fruits with regard to the fruit exposition period. Indiana, SP, Brazil. From Sept/2011 to Apr/2012.

2.6-cm diameter, at nine weeks of development. A similar result was obtained by Souza-Filho *et al*. (2009) in Monte Alegre do Sul, SP, where a fruit fly attack in guava, loquat and peaches with 2-cm diameter fruits was identified. The highest rate of fruit infestation was 9.1% for *C. capitata* and 27.3% for *Anastrepha* (Table 2).

Diaz and Vasquez (1993) verified that the *Anastrepha* spp. adults could begin oviposition in young guavas around nine weeks after flowering. However, the emerged adult rate increased following fruit growth, indicating that conditions became more favorable as fruits developed.

Levels of *C. capitata* infestation in our study differed from the results of Moura and Moura (2011) in Fortaleza, Ceará. In their study, a greater increase of the *C. capitata* adult rate was observed compared to the *Anastrepha* spp. rate.

The lower *C. capitata* incidence rate relative to *Anastrepha* demonstrated the non-preference of the Mediterranean fly for the guava "Paluma" orchard. This fact is probably due either to the harder

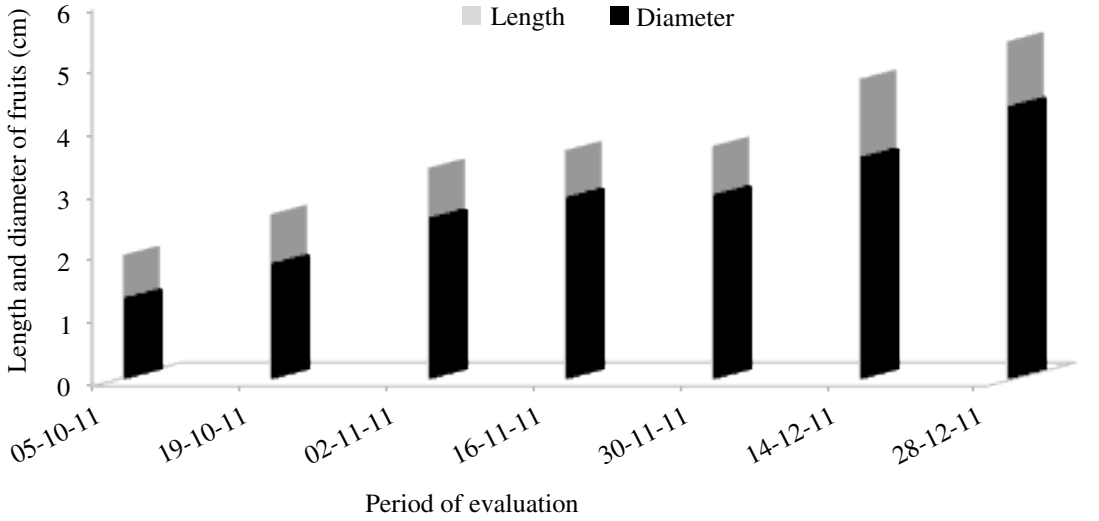

Figure 4. Fortnightly evaluation of fruit growth. Indiana, SP, Brazil. From Oct to Dec/2011.

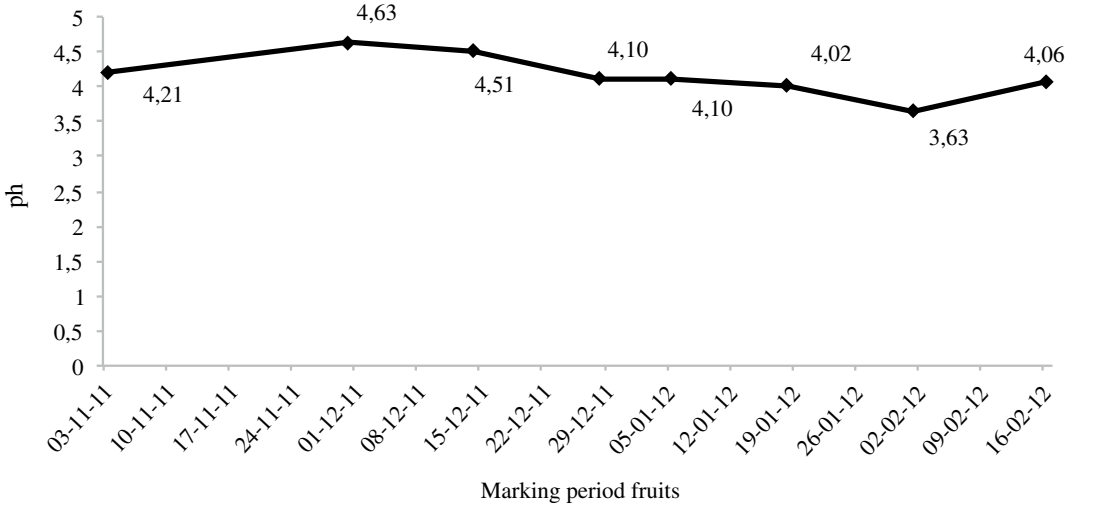

Figure 5. Chemical evaluation of guava fruit (pH). Indiana, SP, Brazil. From Nov/2011 to Feb/2012.

epidermis of the fruits or to the fruit coloration being unattractive to the females. Even though *C. capitata* was predominant in the trap collection, the flies did not attack the guava trees. They were probably infesting nearby hosts and were attracted to the solution used in the traps in our study orchard.

Fruit fly infestation and the physical – chemical fruit characteristics

The fruit pH was constant during growth, leading to no correlation between fruit pH and fruit fly population levels (Figure 5). Souza-Filho *et al*. (2009) only observed insignificant pH changes during fruit maturation, therefore, pH values did not have a direct correlation with the *Anastrepha spp.* population rate.

Conclusion

Guava fruits in their early stages of development (as small as 2.6-cm diameter) were already susceptible to attack by fruit flies. Fruit size was a reliable physical character as a susceptibility parameter for fruit fly attack. *Anastrepha* spp. were predominant in guava fruit infestation in Indiana county, SP, Southeastern Brazil.

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