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Frugivorous flies and their parasitoids associated with Surinam cherry fruits

Moscas frugívoras e seus parasitoides associados a frutos de pitanga

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ABSTRACT: The aim of this study was to know and assess natural infestation of frugivorous flies (Diptera: Tephritidae and Lonchaeidae) and their parasitoids in Surinam cherry fruits. The survey was conducted in an organic orchard, located in the municipality of Maceió, Alagoas. From October 2010 to January 2011, mature green, half-ripe and ripe Surinam cherry were collected. Infestation index was higher for mature green and half-ripe fruits. Five species of frugivorous flies were identified: *Anastrepha fraterculus*, *Anastrepha obliqua*, *Anastrepha sororcul*, *Ceratitis capitata* (Diptera: Tephritidae), and *Neosilba pendula* (Diptera: Lonchaeidae). It were identified the parasitoids: *Doryctobracon areolatus*, *Opius bellus, Utetes anastrephae* and *Asobara anastrephae* (Hymenoptera: Braconidae), being *D. areolatus* with highest percentage of parasitism in all maturation stages. *N. pendula* was recorded in Brasil associated to *Eugenia uniflora* L. (Myrtaceae). *O. bellus*, *U. anastrephae* and *A. anastrephae* were also recorded for the first time in the State of Alagoas. Mature green and half-ripe Surinam cherries are the most fruit fly infested, and the parasitism rate is higher in half-ripe and ripe fruits.

KEYWORDS: Diptera; Tephritidae; Lonchaeidae; Braconidae.

RESUMO: O objetivo deste estudo foi conhecer e avaliar a infestação natural por moscas frugívoras (Diptera: Tephritidae e Lonchaeidae) e seus parasitoides em frutos de pitanga. O levantamento foi conduzido em pomar orgânico, localizado no município de Maceió, Alagoas. Nos meses de outubro de 2010 a janeiro de 2011, coletaram-se frutos de pitanga verdes, "de vez" e maduros. O índice de infestação foi maior nos frutos verdes e "de vez". Foram identificadas cinco espécies de moscas frugívoras: *Anastrepha fraterculus*, *Anastrepha obliqua*, *Anastrepha sororcula*, *Ceratitis capitata* (Diptera: Tephritidae) e *Neosilba pendula* (Diptera: Lonchaeidae). Identificaram-se as espécies de parasitoides: *Doryctobracon areolatus*, *Opius bellus, Utetes anastrephae* e *Asobara anastrephae* (Hymenoptera: Braconidae), sendo *D. areolatus* com maior porcentagem de parasitismo em todos os estágios de maturação. Registra-se no Brasil a associação entre *N. pendula* e *Eugenia uniflora* L. (Myrtaceae). Relatam-se também pela primeira vez as ocorrências de *O. bellus*, *U. anastrephae* e *A. anastrephae* no estado de Alagoas. Em pitanga, os frutos verdes e "de vez" foram mais infestados por moscas-das-frutas, e a porcentagem de parasitismo foi maior em frutos "de vez" e maduros.

PALAVRAS-CHAVE: Diptera; Tephritidae; Lonchaeidae; Braconidae.

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The Surinam cherry tree (*Eugenia uniflora* L.) (Myrtaceae) is attacked by several pests, being trunk and stem borers, fruit flies and leaf-cutting ants among the main ones (Fraife Filho et al., 2013). Fruit flies of Tephritidae family, mainly *Anastrepha* genus and the species *Ceratitis capitata* (Wiedemann, 1824), are the major phytosanitary problem of Brazilian fruit culture because they cause high yield losses and chemical control is expensive. These insects cause losses of US$ 120 million a year for Brazilian fruit market and US$ 2 billion to world fruit production (Moscamed, 2012).

Injuries inflicted by fruit flies are not only caused by oviposition in fruits but also by the larval feeding habits that consist of perforation inside fruits, causing modification of taste, early maturation, fruit decaying and their fall (Aguiar-Menezes et al., 2004). Depending on the fructiferous plant species, the wounding caused by fly oviposition can be entrance for fungi and bacteria (Santos et al., 2008).

Fruit flies are geographically widespread and they infest a wide range of cultivated and wild fruits in all the regions and different climates in Brazil (Zucchi, 2000). There are reports of 6 species of frugivorous flies associated with *E. uniflora*: Tephritidae: *Anastrepha fraterculus* (Wiedemann, 1930), *Anastrepha obliqua* (Macquart, 1835), *Anastrepha sororcula* (Zucchi, 1979) and *Ceratitis capitata* (Wiedemann, 1824); and Lonchaeidae: *Neosilba zadolicha* (McAlpine & Steyskal, 1982) and Neosilba n. sp.3 (Alvarenga et al., 2009; Silva et al., 2011; Nunes et al., 2012; Veloso et al., 2012; Dias et al., 2013).

In Alagoas State, knowledge about the tephritid fauna is poor, and the information available is limited to a few sites. In this context, surveys of fruit flies species need to be intensified in the region as they are of great importance for a better understanding of tephritids and therefore they serve as basis for future studies of other areas of knowledge, such as Ecology, Biology and even establishing control programs.

Yet there are good perspectives of Surinam cherry for commercial use, there is little information available on damage caused by fruit flies. Within this context, this study aimed at knowing and assessing the natural infestation of frugivorous flies (Diptera: Tephritidae and Lonchaeidae) and their parasitoids in Surinam cherry fruits *E. uniflora* L. in the municipality of Maceió, Alagoas, Brazil.

The study was conducted in Surinam cherry organic orchards, located in the municipality of Maceió, Alagoas, Brazil (9º40'S, 35º42'W, altitude 110 m). Three collections were performed during the period within October 2010 and January 2011. The fruits were randomly collected in different heights and maturation stages: mature green (green peel), half-ripe (orange peel) and ripe (red peel). Sample size was variable and dependent on fruit availability. Samples were sent to "Laboratório de Entomologia do Centro de Ciências Agrárias (CECA)" at Universidade Federal de Alagoas (UFAL), Rio Largo, Alagoas, where they were cleaned with water and sodium hypochlorite (1%), weighed and placed in plastic pots with sterile sand (substrate for pupation).

Pupae were individualized after 15 days of packaging fruits. Fruit fly adults and their parasitoids were preserved in ethanol 70% and then identified. A dichotomous key based on female aculeus basis was used to identify the flies, in accordance with Malavasi; Zucchi (2000). For parasitoids, identification was based on wings and mouth parts (Canal; Zucchi, 2000). The Lonchaeidae were identified by MSc. Pedro Carlos Strikis (Universidade Estadual de Campinas, São Paulo, Brazil).

Infestation index was calculated dividing the number of pupae by the number of collected fruits. Parasitism was estimated by the formula P= (parasitized pupae/total number pupae) x 100.

Out of 750 Surinam cherries, 714 fruit fly puparia were collected, from which 372 flies emerged, 311 of Tephritidae family (147♀ and 164♂) and 61 Lonchaeidae (38♀ and 23♂) (*Neosilba* sp.). From Tephritidae, 99.7% belonged to *Anastrepha* genus and 0.3% was *C. capitata*. Five fruit fly species were identified: *A. fraterculus*, *A. obliqua*, *A. sororcula*, *C. capitata* and *N. pendula*. The fruit flies *A. fraterculus*, *A. obliqua* and *N. pendula* were found in fruits of all maturation stages. *A. fraterculus* and *N. pendula* were found in higher numbers in mature green and half-ripe fruits, while *A. obliqua* was more abundant in mature green Surinam cherries. *A. sororcula* was found both on mature green and half-ripe Surinam cherries, but it was predominant in green. Only one *C. capitata* individual was collected that emerged from a ripe Surinam cherry (Table 1).

It was observed a decrease of infestation index with the advance of Surinam cherry maturation. The infestation index was higher for mature green and half-ripe Surinam cherries, which were of 1.13 and 1.18 puparia/fruit, respectively. The index for ripe fruits was drastically reduced to 0.55 puparia/fruit (Table 2). This study shows that there is a trend of frugivorous flies preferentially infesting mature green *E. uniflora*.

Surinam cherry is among the fruit tree that is infested by the highest species diversity of *Anastrepha*, as it also happens in

Table 1. Frugivorous fly species (Diptera: Tephritidae and Lonchaeidae) emerged from Surinam cherry of three maturation stages. Maceió, Alagoas, from October 2010 to January 2011.

Frugivorous species	Number of individuals			Total
	Mature green	Half-ripe	Ripe	
Tephritidae[1]				
Anastrepha fraterculus	53	41	3	97
Anastrepha obliqua	18	12	13	43
Anastrepha sororcula	5	1	0	6
Ceratitis capitata	0	0	1	1
Lonchaeidae[2]				
Neosilba pendula	10	8	5	23
Total	86	62	22	170

[1]Females; [2]males.

other trees, such as umbu-cajá (*Spondia* sp., Anacardiaceae), wax jambu (*Syzygium malaccense*, Myrtaceae), mango (*Mangifera indica*, Anacardiaceae), guava (*Psidium guajava*, Myrtaceae), red mombin (*Spondias purpurea*, Anacardiaceae), citrus (*Citrus* spp., Rutaceae) and star fruit (*Averrhoa carambola*, Oxalidaceae) (Carvalho, 2005; Gattelli et al., 2008; Sá et al., 2008; Santos et al., 2011; Costa, 2012; Santos, 2012). The species *A. fraterculus* was found in all maturation stages, representing 57% of all identified frugivorous flies, and 66% within the *Anastrepha* genus. This species is considered a primary pest of major importance in Argentina, Uruguay and South and Southeast States of Brazil (Malavasi et al., 2000).

Surveys in commercial papaya orchards and Atlantic Forest remnants in Linhares, Espírito Santo, showed that *A. fraterculus* was the most polyphagous species, infesting 14 host fruit trees, from 3 different families, being Myrtaceae the most infested by *A. fraterculus* (Uramoto et al., 2008). In Anagé-BA, *A. fraterculus* infested seven fruit trees, five of which were exotic: red mombin, West Indian cherry (*Malpighia* sp., Malpighiaceae), cajarana (*Spondias* sp., Anacardiaceae), guava and mango (Sá et al., 2008).

Bomfim et al. (2010), who studied fruit fly infestations in umbu-cajá, found that *A. obliqua* was predominant in fruits of all maturation stages. By comparing this data with the one from current study, it is inferred that the same Tephritidae species is able to infest fruits of different maturation stages in other host species.

It was obtained 126 specimens of parasitoids in fruits of all maturation stages that were identified as *Doryctobracon areolatus* (Szépligeti, 1911), *Opius bellus* (Gahan, 1939), *Utetes anastrephae* (Viereck, 1913) and *Asobara anastrephae* (Muesebeck, 1958). *D. areolatus* was predominant in fruits of all maturation stages, but half-ripe and ripe cherries presented the highest parasitism rates (Table 3).

The species *D. areolatus* was found in higher numbers in all maturation stages, corroborating results of Gonçalves et al. (2006) that affirmed the species is the most abundant in Alagoas State. *D. areolatus* is the most common parasitoid species of *Anastrepha* in Brazil (Ohashi et al., 1997; Silva; Silva, 2007). This species is widespread and abundant among puparium parasitoids of Tephritidae (Leonel Júnior et al., 1995; Araújo et al., 1996; Bittencourt et al., 2012). Predominance of *D. areolatus* is related not only to its ability in locating and parasitizing but also to the capacity of parasitizing young larvae, and therefore being earlier than other parasitoids (Carvalho, 2005). The parasitoid *O. bellus* was also present in Surinam cherries of all maturation stages, although the parasitoid preferred mature green and half-ripe fruits.

The lowest parasitism rate was obtained in mature green Surinam cherries probably due to the underestimation or absence of larval parasitoids, once the fruits were harvested earlier and then was exposed to parasitism for a shorter time than cherries from advanced maturation stages (Stark et al., 1991). Furthermore, an important factor in the parasitism rates of Tephritidae flies is the fruit maturation stage, being mature green the ones most resistant to parasitism (Hernández-Ortiz et al., 1994).

Surinam cherry mature green and half-ripe are the most infested by fruit flies, and the highest parasitism rate was found in half-ripe and ripe fruits. *N. pendula* was recorded for the first time in Brazil associated to *E. uniflora*. *O. bellus*, *U. anastrephae* and *A. anastrephae* in the State of Alagoas. Therefore, expands the known geographic distribution of *N. pendula* in *E. uniflora* for Brazil, well as of the natural enemies to state of Alagoas.

Table 2. Infestation index for frugivorous flies (Diptera: Tephritidae and Lonchaeidae) emerged from Surinam cherry, in three maturation stages. Maceió, Alagoas, from October 2010 to January 2011.

Maturation stages	Infestation index				
	Fruits (*n*)	Weight (kg)	Puparia (*n*)	Puparia/fruit	Puparia/kg
Mature green	250	0.5	282	1.13	564.0
Half-ripe	250	0.8	294	1.18	367.5
Ripe	250	0.8	138	0.55	172.5

Table 3. Number and parasitism rate of parasitoid species, emerged from fruit fly puparia from three maturation stages of Surinam cherry. Maceió, Alagoas, from October 2010 to January 2011.

Maturation stage	Parasitoid species (*n*)				Parasitism (%)
	D. areolatus	*O. bellus*	*U. anastrephae*	*A. anastrephae*	
Mature green	14	12	0	0	9.2
Half-ripe	28	13	11	0	17.7
Ripe	36	4	7	1	34.8
Total	78	29	18	1	

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