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Diversity of frugivorous flies (Tephritidae e Lonchaeidae) in three municipalities in southern Bahia

Diversidade de moscas frugívoras (Tephritidae e Lonchaeidae) em três municípios da região sul da Bahia

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ABSTRACT: The main goal of this paper was to know the species diversity of frugivorous flies (Tephritidae and Lonchaeidae) in Ilhéus, Uruçuca and Wenceslau Guimarães, municipalities in southern Bahia. In each sampled place five McPhail traps were used containing 5% corn hydrolyzed protein (Bio Anastrepha©), from July 2011 through December 2012. The captured adults were placed in plastic pots containing 70% alcohol, until identification, characterized according to diversity indexes of Shannon-Wiener, Margalef and equitability, and categorized according to the total number of captured flies: 2.24% species of genus *Neosilba* McAlpine (Lonchaeidae), and 97.76% species of genus *Anastrepha* Schiner, with 12 species reported, and *Ceratitis capitata*. The index fly/trap/day (FTD) oscillated from zero to 1.35 with the highest capture in March and April 2012, coinciding with the fructification period. The frugivorous flies captured were *Anastrepha antunesi* Lima, *A. bahiensis* Lima, *A. consobrina* (Loew), *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. leptozona* Hendel, *A. obliqua* (Macquart), *A. parallela* (Wied.), *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. zenildae* Zucchi, *C. capitata* (Wied.), *Neosilba glaberrima* (Wied.) and *Neosilba zadolicha* McAlpine & Steyskal. *Anastrepha fraterculus* was the species with the highest index of frequency, dominance, abundance and constancy. It is the first register of *A. consobrina* in the state of Bahia.

KEYWORDS: faunistic analysis; McPhail trap; Tephritoidea.

RESUMO: O principal objetivo deste estudo foi conhecer a diversidade de espécies de moscas frugívoras (Tephritidae e Lonchaeidae) em Ilhéus, Uruçuca e Wenceslau Guimarães, municípios da região sul da Bahia. No período de julho/2011 a dezembro/2012, foram instaladas cinco armadilhas do tipo McPhail em cada local de amostragem, tendo como atrativo alimentar proteína hidrolisada de milho (Bio Anastrepha©) a 5%. Os adultos capturados nas armadilhas, após a triagem, foram acondicionados em potes plásticos com álcool etílico 70% até a identificação. Cada espécie de *Anastrepha* foi caracterizada pelos índices de diversidade de Shannon-Wiener, Margalef e equitabilidade e categorizada quanto à sua dominância, abundância, frequência e constância na comunidade. Do total de moscas capturadas, 2,24% corresponderam a exemplares de *Neosilba* McAlpine (Lonchaeidae) e 97,76% a exemplares de moscas-das-frutas, com registro de 12 espécies de *Anastrepha* e *C. capitata*. O índice mosca/armadilha/dia (MAD) variou de 0 a 1,35, com maior captura nos meses de março e abril de 2012, coincidindo com o período de frutificação. Registraram-se as ocorrências de *Anastrepha antunesi* Lima, *A. bahiensis* Lima, *A. consobrina* (Loew), *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. leptozona* Hendel, *A. obliqua* (Macquart), *A. parallela* (Wied.), *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. zenildae* Zucchi, *Ceratitis capitata* (Wied.), *Neosilba glaberrima* (Wied.) e *Neosilba zadolicha* McAlpine & Steyskal. *Anastrepha fraterculus* atingiu os índices máximos de dominância, frequência, constância e abundância. Registrou-se, pela primeira vez, a espécie *A. consobrina* no estado da Bahia.

PALAVRAS-CHAVE: análise faunística; armadilha McPhail; Tephritoidea.

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INTRODUCTION

Frugivorous flies (Diptera: Tephritoidea) cause great economic losses to Brazilian market of fruits and vegetables due to premature fruit drop and to product devaluation for *in natura* consume and industrialization (Aluja; Mangan, 2008; Minzão; Uchôa-Fernandes, 2008).

There are several species of fruit flies infesting fruit orchards in Brazil: *Anastrepha* Schiner and *Ceratitis capitata* (Wied.) (Tephritidae), by *Neosilba* McAlpine, *Dasiops* Rondani and *Lonchaea* Fallén (Lonchaeidae) (Uchôa-Fernandes et al., 2003; Strikis; Prado, 2005; Zucchi, 2008). Amongst them, fruit flies from family Tephritidae play a major role due to restriction to transit of fresh fruits and quarantine impositions by importing countries (Malavasi et al., 2000). Studies of faunistic parameters of some fruit flies pest species are fundamental in order to establish strategies of integrated management (Bittencourt et al., 2011; Santos et al., 2011; Sá et al., 2012). In northeastern of Brazil, the most frequent fruit flies species are *A. fraterculus*, *A. zenildae* Zucchi, *A. obliqua* (Macquart), *A. sororcula* Zucchi and *A. serpentina* (Wied.), and previous studies carried out in southern Bahia reported *A. fraterculus* as the predominant species (Santos et al., 2004; Bittencourt et al., 2006a; Feitosa et al., 2008; Santos et al., 2008; Dutra et al., 2009; Azevedo et al., 2010; Santos et al., 2011; Sá et al., 2012; Araújo et al., 2013).

The faunistic indexes (Simpson, Shannon-Wiener, Margalef, abundance, dominance, frequency and constancy) are used to characterize a community, and show that determinant factors of the degree of species abundance are usually linked to ecological components of the habitat and host richness. Some works have shown that, despite many species may be present in some areas, only one or two are considered frequent and dominant (Silveira Neto et al., 1976; Ferrara et al., 2005; Uramoto et al., 2005). Previous knowledge of ecological aspects of species present in orchards and its population dynamics through the year, amongst others faunistic parameters, are important when practicing integrated management of frugivorous flies (Aguiar-Menezes et al., 2008).

So, taking into account the importance of frugivorous flies and the diversity of native fruits in the proximities of remnants of the Atlantic forest in the region, the objectives of this paper were: broaden the knowledge about the diversity of fruit flies in southern Bahia; evaluate the faunistic indexes of Shannon-Wiener, Margalef, equitability, abundance, constancy, dominance and frequency of Tephritidae flies; and evaluate the population fluctuation using the index fly/trap/day (FTD).

MATERIAL AND METHODS

This work was carried out from July 2011 until December 2012 in three domestic orchards with diverse hosts, located in areas of Atlantic forest remnants in the municipalities of Ilhéus (14º54'S; 39º07'W; 121 m), Uruçuca (14°34'S; 39°10'W; 128 m) e Wenceslau Guimarães (21º18'S; 40º56'W; 143 m), in southern Bahia. In this region the climate is tropical hot humid, with mean annual temperature of 25ºC and relative humidity of 85%, according to data from Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC).

In each property, five McPhail traps were fixed in fruit trees approximately 1.5 m above ground. The traps contained, as food attractant, 5% corn hydrolyzed protein (Bio Anastrepha©), and they were placed randomly at the borders of orchards next to the forest. The traps were inspected weekly and captured insects transferred to plastic vials of 50 mL containing 70% ethanol, at the same time the traps were washed and attractant renewed. The samples were labeled with the following information: date and place of collect, and strap number. Then, they were taken to the laboratory of Biologic Control of Universidade Estadual de Santa Cruz (UESC), in order to proceed the insect taxonomic identification.

Fruit flies adults sampled were counted and sexed. With the aid of optic stereomicroscope and microscope, females of *Anastrepha* were identified based on wing pattern (wing stripes), thorax pattern and morphometric characters of aculeo tip (Zucchi, 2000a). Males of *Anastrepha* and specimens of *C. capitata* were counted and discharged. Specimens of Lonchaeidae were identified by Pedro Carlos Strikis, a taxonomist specialized in Lonchaeidae flies.

Each species of *Anastrepha* were ranked according to the indexes of Shannon-Wiener, Margalef and equitability, and categorized according to its dominance (SD = super-dominant, D = dominant, and ND = not dominant), abundance (sa = super-abundant, va = very abundant, c = common, d = disperse), frequency (SF = super-frequent, VF = very frequent, F = frequent, and LF = low frequent) and constancy (W = constant, Y = accessory, Z = incidental) in the community (Silveira Neto et al., 1976; Uramoto; Walder; Zucchi, 2005).

Faunistic indexes were calculated using the software ANAFAU, developed at the Department of Entomology and Acarology from Escola Superior de Agronomia "Luiz de Queiroz", of Universidade de São Paulo (USP), Piracicaba, São Paulo. All specimen of frugivorous flies were deposited in the Entomological Collection of the Laboratory of Biological Control at UESC. Population fluctuation of fruit flies is presented by the total number of Tephritidae specimens captured monthly, and population density is expressed in FTD.

RESULTS AND DISCUSSION

In the three municipalities, 1,783 specimens of fruit flies, 1,743 specimens of Tephritidae (1,271 females and 526 males)

and 40 specimens of Lonchaeidae (38 females and 2 males) were captured.

The genus *Anastrepha* represented 99.44% (1,207 females and 521 males) of Tephritidae flies, and *C. capitata* represented 0.86% (ten females and five males). So, *Anastrepha* was considered the predominant species.

In Bahia 31 species of *Anastrepha* (Zucchi, 2008) were already registered, and among these 12 were registered in this study: *Anastrepha antunesi* Lima, *A. bahiensis* Lima, *A. consobrina* (Loew), *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. leptozona* Hendel, *A. obliqua* (Macquart), *A. parallela* (Wied.), *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. zenildae* Zucchi and *A. consobrina* was the last one registered for the first time in Bahia.

Anastrepha fraterculus was predominant in the three municipalities, corresponding to 66.45% of the captured females reaching the highest indexes of dominance, frequency, constancy and abundance (Tables 1 to 3). The highest percentage of capture of *A. fraterculus* is here related to the fact of its poliphagous behavior and the existence of many species of Myrtaceae (its preferred host) in sampled areas. Others studies in this region also showed the dominance of this species (Bittencourt et al., 2006a; Dutra et al., 2009; Santos et al., 2008; Santos et al., 2011) and in others regions of Brazil (Araújo et al., 2013; Uramoto et al., 2004, 2005).

Anastrepha obliqua (11.46%), also a poliphagous species, was dominant, very abundant, very frequent and constant in Ilhéus and Wenceslau Guimarães. The occurrence of this species in the sampled areas is likely related to the presence of yellow mombin (*Spondias mombin* L.), hog plum (*Spondias purpurea* L.) (Anacardiaceae) and star fruit (*Averrhoa carambola* L., Oxalidaceae). These hosts were close to the places where the traps were located and are considered its preferred hosts (Zucchi, 2008).

The presence of fruits of Myrtaceae (guava *Psidium guajava* L.; Brazilian cherry *Eugenia uniflora* Berg.; araçá-boi *Eugenia stipitata*; jambo-red *Syzygium malaccense* L.) could have favored the frequency of *A. sorocula* and *A. zenildae* in Wenceslau Guimarães, once these hosts fruits ripe in different seasons (Zucchi, 2008; Bittencourt et al., 2011; Melo et al., 2012).

Probably the presence of fruits of *Helicostylis tomentosa* (Moraceae) and guava (Myrtaceae) in Ilhéus propitiated the presence of *A. bahiensis*, since this fruit is the host of this species.

The specimens of *A. parallela* were captured in traps placed inside the Atlantic forest remnants and in areas of cocoa plantation (*Theobroma cacao* L.) and cupuassu (*Theobroma grandiflorum* L.), both belonging to family Malvaceae — there are records of this species infesting fruits of these family (Zucchi, 2000b, 2008).

The other captured species (*A. distincta*, *A. serpentina*, *A. leptozona*, *A. antunesi*, *A. grandis* and *A. consobrina*) showed low frequency in the area, presenting indexes lower than 2% (Tables 1 to 3). It is the first report of *A. consobrina* in Bahia; this species was recorded in the states of Maranhão, Espírito Santo, Rio de Janeiro and São Paulo (Zucchi, 2008).

The results reported in the present work confirm the poliphagous behavior of *A. fraterculus*, *A. obliqua*, *A. bahiensis*, *A. sororcula* and *A. zenildae*, species that have a wide geographic distribution in Brazil and are considered important pests with relevant economic impact (Zucchi, 2000a, 2008), except for *A. bahiensis*.

The biggest diversity of *Anastrepha* in Ilhéus (Shannon-Wiener=1.41), reporting 10 species, is likely related to the greater diversity of available hosts where traps were placed. In Uruçuca, the traps were placed in an orchard close to an Atlantic forest remnant, and probably this fact was responsible

Table 1. Faunistic analysis of *Anastrepha* species captured in McPhail traps in Ilhéus, July/2011 – December 2012.

Species	Females	Dominance	Abundance	Frequency	Constance
A. fraterculus	329	SD	sa	SF	W
A. obliqua	74	D	va	VF	W
A. bahiensis	44	ND	va	VF	Y
A. parallela	23	ND	c	F	Y
A. serpentina	21	ND	c	F	Y
A. distincta	17	ND	c	F	Y
A. leptozona	14	ND	c	F	Y
A. antunesi	7	ND	d	LF	Z
A. grandis	7	ND	d	LF	Z
A. zenildae	8	ND	d	LF	Y

Shannon-Wiener index: 1.4149; Margalef index: 1.4288; equitability index: 0.6145; SD: super-dominant; D: dominant; ND: not dominant; sa: super-abundant; va: very abundant; c: common; d: disperse, SF: super-frequent; VF: very frequent; F: frequent; LF: low frequent; W: constant; Y: acessory; Z: incidental.

for a greater Margalef index (1.8006) and lower number of captured species. In Wenceslau Guimarães the Margalef index was lower (0.9811), due to the dominance of *A. fraterculus*. The high values of Shannon-Wiener and Margalef indexes resulted from the high frequency of *A. fraterculus*, and the relatively high value of equitability showed an equitable distribution of abundance among species in Ilhéus and Uruçuca. The proportional number of specimens of *A. antunesi*, *A. bahiensis*, *A. obliqua*, *A. parallela* and *A. sororcula* decreased the dominance effect of *A. fraterculus* (Tables 1 to 3). The Shannon-Wiener index reported in this work was similar to that reported for Belmonte, in southern Bahia, that had a value of 1.35 in which nine species of Tephritidae were registered (Santos et al., 2011).

The population fluctuation of fruit flies was variable in relation to the studied areas. The greater number female capture occurred in April/2012, probably to the availability and diversity of ripening fruits [yellow sapote (*Pouteria caimito* Ruiz & Pav.), araçá-boi, yellow mombin, star fruit, guava e jambo-red]. No specimen of Tephritidae was captured in July/2012, probably because there were no ripening fruits. This fact shows the importance of the presence of ripening fruits to the occurrence of fruit flies in an orchard (Araújo et al., 2013; Ronchi-Teles; Silva, 2005).

The FTD index showed little variation during the period of this work. In some months, the value was zero, due to the absence of fruits in the orchards.

In Uruçuca the lowest index of FTD was obtained through the sampling period (0.00 to 0.06), with a little rise during the fructification period of yellow mombin (*S. mombin*) (March/2012).

In Ilhéus the FTD index kept low values with rise in March and April/2012, reaching 1.17. In Wenceslau Guimarães there was a little oscillation in the number of captures females, except for April/2012, when the highest FTD index (1.35) was registered (Fig. 1).

FTD index variation was related to the availability of host fruits (Uramoto et al., 2004), with higher values during the period of fruit ripening. In this period, females oviposit in the fruits and the adults emerge in the subsequent months. After the gathering of the fruit for consumption, by the residents of the properties, the fruit flies adults emerge and migrate to other places in search for food and oviposition sites. It makes the FTD index decreases.

Table 2. Faunistic analysis of captured *Anastrepha* species in McPhail traps in Uruçuca, Bahia, July/2011 – December 2012.

Species	Females	Dominance	Abundance	Frequency	Constance
A. fraterculus	18	SD	sa	SF	W
A. antunesi	3	D	va	VF	Y
A. parallela	3	D	va	VF	Y
A. bahiensis	1	ND	c	F	Y
A. distincta	1	ND	c	F	Y
A. obliqua	1	ND	c	F	Y
A. serpentina	1	ND	c	F	Y

Shannon-Wiener index: 1.2387; Margalef index: 1.8006; equitability index: 0.6366; SD: super-dominant; D: dominant; ND: not dominant; sa: super-abundant; va: very abundant; c: common; SF: super-frequent; VF: very frequent; F: frequent; LF: low frequent; W: constant; Y: acessory; Z: incidental.

Table 3. Faunistic analysis of *Anastrepha* species captured in McPhail traps in Wenceslau Guimarães Bahia, July/2011–December 2012.

Species	Females	Dominance	Abundance	Frequency	Constance
A. fraterculus	465	SD	sa	SF	W
A. obliqua	65	D	va	VF	Y
A. sororcula	61	D	va	VF	Y
A. zenildae	18	ND	c	F	Y
A. bahiensis	8	ND	c	F	Y
A. distincta	6	ND	c	F	Y
A. consobrina	5	ND	c	F	Y
A. grandis	2	ND	d	LF	Z
A. leptozona	5	ND	c	F	Y

Shannon-Wiener index: 1.2396; Margalef index: 0.9811; equitability index: 0.4465; SD: super-dominant; D: dominant; ND: not dominant; sa: super-abundant; va: very abundant; c: common; d: disperse; SF: super-frequent; VF: very frequent; F: frequent; LF: low frequent; W: constant; Y: acessory; Z: incidental.

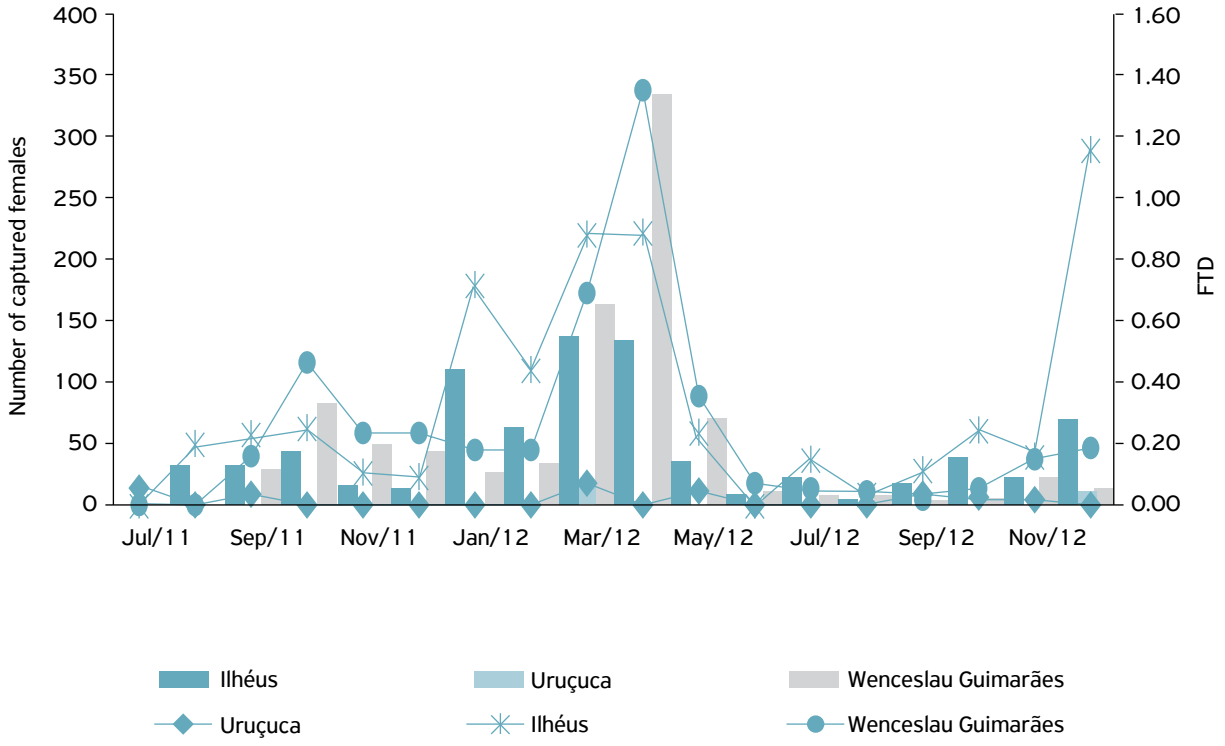

Figure 1. Total number of captured females and fly/trap/day (FTD) index of *Anastrepha* captured in McPhail traps in Ilhéus, Uruçuca and Wenceslau Guimarães, Bahia, July/2011 – December/2012.

From Lonchaeidae flies, only specimens of *Neosilba* were captured (38 females and 2 males). The species found were *Neosilba glaberrima* (Wied.) (n=1), in Wenceslau Guimarães, and *N. zadolicha* McAlpine & Steyskal (n=1), in Uruçuca. The highest number of captures occurred in Wenceslau Guimarães (n=28), probably because the traps were placed in an orchard of *Malpighia glabra* L.

It is worth noting that there is no attractant developed to date to species of *Neosilba*. This may underestimate the populations of *Neosilba* species, as well as the number of species.

The presence of *N. glaberrima* was already recorded for Bahia (Bittencourt et al., 2006b); this species infests different species of fruits (Lopes et al., 2008; Melo et al., 2012). *Neosilba zadolicha* was assigned as an important pest of citrus in the state of Mato Grosso do Sul (Uchôa-Fernandes et al., 2003), and in the region of Recôncavo Baiano this species was recorded infesting fruits of umbu-cajá (*Spondias tuberosa* × *S. mombin*) (Santos et al., 2004).

Specimens of *C. capitata* were captured only in traps installed in the municipalities of Wenceslau Guimarães (n=7) and Ilhéus (n=8). The location, diversity and quantity of native hosts in the areas where the traps were installed were probably the factors that contributed to the predominance of species of *Anastrepha* and low capture *C. capitata* index, similar to the results obtained by Uramoto et al. (2004).

CONCLUSION

Anastrepha antunesi Lima, *A. bahiensis* Lima, *A. consobrina* (Loew), *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. leptozona* Hendel, *A. obliqua* (Macquart), *A. parallela* (Wied.), *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. zenildae* Zucchi, *Neosilba glaberrima* (Wiedemann), and *N. zadolicha* McAlpine & Steyskal are the species of frugivorous flies reported in the southern of Bahia. For the first time *A. consobrina* (Loew) is reported in the state of Bahia. In this region, the genus *Anastrepha* Schiner was predominant in relation to *Ceratitis capitata* (Wied.). *Anastrepha fraterculus* presented the highest population level in the region. The peaks of FTD recorded for *Anastrepha* species were coincident with the period of ripening fruits available to oviposition and so to the development of larvae and abundant food.

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