CROP PROTECTION

Faunistic Analysis of *Anastrepha* spp. (Diptera: Tephritidae) on a Guava Orchard under Organic Management in the Municipality of Una, Bahia, Brazil

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Análise Faunística de *Anastrepha* spp. (Diptera: Tephritidae) em um Pomar de Goiaba sob Manejo Orgânico, no Município de Una, BA

RESUMO - Foi realizado estudo para caracterizar as populações de moscas-das-frutas em pomar orgânico de goiaba (*Psidium guajava* cv. Paluma) no município de Una, Sul da Bahia, por meio da análise faunística dos espécimes capturados em armadilhas McPhail de janeiro de 2004 a março de 2007. Foram capturados 22.673 espécimes de *Anastrepha* (15.306 fêmeas e 7.367 machos). Treze espécies de *Anastrepha* foram registradas. *A. fraterculus* e *A. obliqua* foram as mais frequentes e dominantes, perfazendo 90,1% de todos as fêmeas capturadas nas armadilhas. *A. fraterculus* foi a espécie predominante (mais frequente, constante e dominante). O alto valor do índice de Simpson (0,62) e os baixos valores dos índices de Shannon-Wiener (0,83) e equitabilidade (0,49) indicaram a dominância e a alta frequência de *A. fraterculus* e *A. obliqua* no pomar de goiaba, mesmo na presença de outras espécies frutíferas potencialmente hospedeiras de moscas-das-frutas.

PALAVRAS-CHAVE: Insecta, mosca-das-frutas, diversidade, armadilha McPhail, fruticultura orgânica

ABSTRACT - We carried out a study to characterize fruit fly populations on an organic guava orchard (*Psidium guajava* cv. Paluma) in the municipality of Una, southern region of the state of Bahia, Brazil, using faunistic analysis of the adult fruit fly specimens captured in McPhail traps from January 2004 through March 2007. A total of 22,673 specimens of *Anastrepha* (15,306 females and 7,367 males) were captured. Thirteen species of *Anastrepha* were recorded. *A. fraterculus* and *A. obliqua* were the more frequent and dominant species, accounting for 90.1% of all females captured in the traps. *A. fraterculus* was the predominant species (more frequent, constant and dominant). The high value of the Simpson index (0.62) and the low values of Shannon-Wiener (0.83) and equitability (0.49) indices indicated the dominance and high frequency of *A. fraterculus* and *A. obliqua* on the guava orchard despite the presence of other fruit species as potential hosts of fruit flies.

KEY WORDS: Insecta, fruit fly, diversity, McPhail trap, organic fruit crop

The genus *Anastrepha* Schiner comprises over 200 species and represents the most diverse genus of Tephritidae in the Americas (Norrbom *et al* 1999, Norrbom & Korytkowski 2007). These species are endemic to the Neotropical region and are restricted to tropical and subtropical areas, ranging from the southern United States to northern Argentina and most of the Caribbean Islands (Aluja 1994).

In Brazil, 101 *Anastrepha* species have been registered, seven of which are considered economically important infesting hosts in 35 families (Zucchi 2008). Many Myrtaceae species are important fruit fly hosts, especially in the genera *Psidium*, *Eugenia* and *Syzygium* (Zucchi 2000, 2007, Jesus *et al* 2008).

Guava (*Psidium guajava*) is endemic to the Neotropical region (Thaipong, Boonprakob 2005) and is one of the preferred fruit fly hosts in Brazil (Araujo, Zucchi 2003, Raga *et al* 2006). Brazil is responsible for the largest production of guava in the world, most of which is concentrated in the states of São Paulo, Pernambuco and Bahia (Ministério da Agricultura, Pecuária e Abastecimento 2002). Despite its increasing importance regarding fruit production, few studies on faunistic analysis of fruit flies have been carried out in the

state of Bahia. There is only one previous study that focused on the eastern region, Recôncavo Baiano (between 38°30' and 40°09'S latitude and 12°18' and 13°36'W longitude) (Nascimento *et al* 1983).

Fruit fly species diversity and dominance can be affected by ecological background such as abundance and diversity of host plant species, composition of orchards and surrounding ecosystems or agroecosystems, as well as by altitudinal gradients (Aluja 1994, Aluja *et al* 1996). These analyses provide important information to determine the target species and locations for future programs of fruit fly control in a given region (Uramoto *et al* 2005).

In the current study, we examine population dynamics of fruit flies on a guava orchard under organic management in southern Bahia, Brazil, focusing on faunistic analysis over a three-year period. Our results offer insight into the diversity, dominance, and frequency of fruit fly species, which allows for the improved characterization of this insect community.

Material and Methods

The study site was an organic guava orchard of 0.5 ha within a 30 ha farm located in the municipality of Una, BA (15º17´S, 39º04´W, and 71 m above sea level). The farm is surrounded by mature coastal rainforest. The native vegetation is classified as tropical lowland rainforest. Climate is defined as Af (tropical wet) with a mean annual temperature of 24.7ºC and 1,827 mm of rainfall, with no distinct rainy season. The orchard is comprised of 100 trees of *Psidium guajava* cv. Paluma and has been free of any pesticide applications for over 10 years. The guava trees are interspersed with banana (*Musa* sp., Musaceae), cacao (*Theobroma cacao*, Malvaceae), cassava (*Manihot esculenta*, Euphorbiaceae) and rubber trees (*Hevea brasiliensis*, Euphorbiaceae). The farm also has smaller areas planted with other potential fruit fly hosts in the families Anacardiaceae (*Spondias cytherea*, *S. purpurea* and *S. mombin*), Annonaceae (*Annona muricata*), Ebenaceae (*Diospyros kaki*), Malpighiaceae (*Malpighia punicifolia*), Mimosaceae (*Inga edulis*), Moraceae (*Morus nigra*), Myrtaceae (*Psidium guineense*, *Eugenia stipitata*, *Eugenia uniflora* and *Syzygium malaccencis*), Oxalidaceae (*Averrhoa carambola*) and Sapotaceae (*Achras sapota*).

Fruit flies were captured using 10 plastic McPhail traps with a yellow bottom set up in guava trees on the orchard. Traps were placed in the central part of the tree canopy at 1.5 m from the ground surface and distributed within the orchard as follows: two traps in the central part of the orchard (18 m of distance from each other) and eight traps in the periphery of the orchard (5 m of distance from the orchard edge and at 12 m of distance from the central traps). Traps were baited with 700 ml of 5% hydrolyzed protein and serviced on a weekly basis. All captured insects were transferred to plastic vials filled with 70% ethanol and taken to the laboratory for identification. The sampling was carried out from January 2004 to March 2007.

All captured females of the genus *Anastrepha* were individually identified to species. Voucher specimens were deposited at the Laboratório de Entomologia, Universidade Estadual de Santa Cruz (UESC), Ilhéus, BA and at the Laboratório de Moscas-das-frutas, Universidade Federal Rural do Semi-Árido (UFERSA), Mossoró, RN, Brazil.

Faunistic analysis was performed based on the indices of frequency, dominance, constancy, species richness, and the diversity indices of Simpson, Shannon-Wiener (H'), and equitability (modified Hill index). These indices were determinate as described by Silveira Neto *et al* (1976) and Uramoto *et al* (2005).

Results and Discussion

A total of 22,673 specimens of *Anastrepha* (15,306 females and 7,367 males) were captured in the three-year sampling period. The number of specimens varied with the year of collection. In 2004, 6,425 specimens of *Anastrepha* (4,396 females and 2,029 males) were captured. In 2005, the traps caught the highest number of *Anastrepha* (6,954 females and 3,487 males, totaling 10,441). In 2006/2007, there was a decrease of specimen number captured: 5,806 specimens of *Anastrepha* (3,955 females and 1,851 males). The increase on the number of flies trapped in 2005 was probably due to a markedly larger number of available fruits in the orchard and surrounding area, as well as to the higher temperatures observed in that year. These factors could have favored a higher emergence of adults, resulting in a high population peak observed in April 2005 (Dutra *et al*, unpublished data).

Thirteen *Anastrepha* species were recorded (Table 1), and this species richness is within the range reported in other inventories carried out in the state of Bahia. In a previous study carried out in the municipality of Una, Bittencourt *et al* (2006) reported only six species during a sampling period of three months. Nascimento *et al* (1983) carried out a three-year study in six locations in the Recôncavo Baiano, and reported a total of 20 species, ranging from seven to 17 species in Nova Soure (11°11'S; 38°26'W) and in Cruz das Almas (12°41'S; 39°03'W), respectively. In the municipalities of Juazeiro, BA (9°26'S; 40°26'W) and Petrolina, PE (9°26'S; 40°33'W), nine species were registered (Nascimento & Carvalho 2000).

In our study, most of the species captured presented low frequency of occurrence. This result suggests that adults of the low frequent species were not resident on the guava orchard, but they came from other hosts nearby the farm and/or the surrounding forest area. The study area is surrounded by one of the few and largest remnants of the highly endangered mature coastal rainforest in Brazil (Faria *et al* 2006). The Brazilian Atlantic rainforest is considered one of the richest biomes on earth, and southern Bahia harbors high species richness, high levels of endemism and local sites of diversity of trees in families that comprise species which are known hosts of *Anastrepha*, such as Fabaceae, Malpighiaceae, Myrtaceae, Rutaceae, and Sapotaceae (Thomas *et al* 1998, Faria *et al* 2006, Martini *et al* 2007). Thus, the forest areas surrounding the guava orchard can provide an important reservoir for tephritid populations that probably migrate to the orchard. The movement of fruit flies from the adjacent native vegetation, particularly forest fragments, into orchards

Table 1 Characterization of *Anastrepha* specimens on an organic guava orchard by faunistic indices in the municipality of Una, BA, from January 2004 to March 2007.

Species	N[1]				Frequency (%)			
	Total	Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3
A. fraterculus (Wiedemann)	11,803	3,745	5,135	2,923	77.1	85.2	73.8	73.9
A. obliqua (Macquart)	1,991	434	1,068	489	13.0	9.9	15.4	12.4
A. sororcula Zucchi	828	8	394	426	5.4	0.2	5.7	10.8
A. zenildae Zuchi	276	97	131	48	1.8	2.2	1.9	1.2
A. distincta Greene	226	109	73	44	1.5	2.5	1.0	1.1
A. montei Lima	76	0	63	13	0.5	0	0.9	0.3
A. pickeli Lima	52	0	46	6	0.3	0	0.7	0.2
A. manihoti Lima	17	0	14	2	0.1	0	0.2	0.05
A. serpentina (Wiedemann)	15	0	14	1	0.1	0	0.2	0.02
A. bahiensis Lima	9	0	8	1	0.06	0	0.1	0.02
A. dissimilis Stone	7	0	7	0	0.05	0	0.1	0
A. leptozona Hendel	5	2	1	2	0.03	0.04	0.01	0.05
A. antunesi Lima	1	1	0	0	0.006	0.02	0	0
Species richness (S)	13	7	12	11				
Simpson index	0.62	0.74	0.57	0.57				
Shannon-Wiener index	0.83	0.56	0.91	0.87				
Equitability (Modified Hill)	0.49	0.48	0.50	0.54				

Species	Dominance[2]				Constancy[3]			
	Total	Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3
A. fraterculus	d	d	d	d	87.0 (w)	80.7 (w)	85.2 (w)	98.2 (w)
A. obliqua	d	n	d	d	47.6 (y)	36.8 (y)	51.9 (w)	57.9 (w)
A. sororcula	n	n	n	d	21.2 (z)	10.5 (z)	31.5 (y)	21.0 (y)
A. zenildae	n	n	n	n	27.1 (y)	29.8 (y)	27.8 (y)	24.5 (y)
A. distincta	n	n	n	n	37.0 (y)	36.8 (y)	42.6 (y)	29.8 (y)
A. montei	n	n	n	n	17.6 (z)	--	38.9 (y)	15.8 (z)
A. pickeli	n	n	n	n	14.7 (z)	--	40.7 (y)	5.3 (z)
A. manihoti	n	n	n	n	5.3 (z)	--	13.0 (z)	3.5 (z)
A. serpentina	n	n	n	n	3.5 (z)	--	9.3 (z)	1.8 (z)
A. bahiensis	n	n	n	n	4.1 (z)	--	11.1 (z)	1.8 (z)
A. dissimilis	n	n	n	n	4.2 (z)	--	11.1 (z)	--
A. leptozona	n	n	n	n	2.3 (z)	1.7 (z)	1.8 (z)	3.5 (z)
A. antunesi	n	n	n	n	0.6 (z)	1.7 (z)	--	--

[1]N = total of captured females; [2]d: dominant; n: non-dominant; [3]w: constant; y: accessory; z: accidental; Total: 2004-2007; Year 1: 2004-2005; Year 2: 2005-2006; Year 3: 2006-2007

was demonstrated by Vargas *et al* (1990), Aluja (1996) and Kovaleski *et al* (1999).

Only two, out of the 13 *Anastrepha* species captured, were dominant: *A. fraterculus* (Wiedemann) and *A. obliqua* (Macquart) (Table 1). The former was the most frequent species. Eight species showed a frequency lower than 1% and were responsible for 1.2% of all females captured. *A. fraterculus* was the only species characterized as constant, occurring in 87.0% of the collections. Three species (*A. obliqua*, *A. zenildae* Zucchi and *A. distincta* Greene) were accessory, and the remaining species were accidental (Table 1).

The high value of the Simpson index and the low values

of Shannon and equitability indices were a result of the dominance and high frequency of *A. fraterculus* and *A. obliqua*, which accounted for 90.1% of all flies captured. Interestingly, of the 13 species captured in traps on the guava orchard, only *A. fraterculus*, *A. sororcula*, and *A. zenildae* actually use guava as a preferred host in this region of Bahia (Souza-Filho *et al* 2007).

Previous studies carried out in the state of Bahia, more precisely in the Recôncavo Baiano region, also registered the dominance of *A. fraterculus* and *A. obliqua* in most localities regardless of the species richness reported (S = 20) (Nascimento *et al* 1983). Studies conducted on guava orchards in northern Minas Gerais (Corsato 2004) reported 18 species of *Anastrepha*, however, the dominance of only two species, *A. zenildae* and *A. sororcula*, was observed. Two recent studies on guava orchards in the state of Rio de Janeiro also revealed the dominance of *A. fraterculus*, despite the species richness reported (S = 16) in the northwestern region (Ferrara *et al* 2005) as well as in the northern region (S = 14) (Aguiar-Menezes *et al* 2008).

The dominance of certain species of *Anastrepha* on commercial fruit orchards, when one or two species account for more than 90% of all adults trapped even though other *Anastrepha* species may be captured, was already reported in studies conducted in Mexico and Costa Rica (Aluja *et al*. 1996), as well as in different regions of Brazil (Nascimento & Zucchi 1981, Araujo & Zucchi 2003, Silva *et al* 2006).

Aluja *et al* (1996) demonstrated that an association between the most common single species trapped on a particular orchard and the fruit crop cultivated on the orchard in question can indicate the fruits of this crop as a suitable host for oviposition and larval development. The high frequency, dominance and constancy of *A. fraterculus* on the guava orchard in our study are probably due to its preference for guava (Katiyar *et al* 2000, Raga *et al* 2006, Souza-Filho *et al* 2007). The higher frequency of *A. obliqua* when compared to the remaining 11 species is probably due to its preference for Anacardiaceae hosts, several of which were present in the study area.

However, climatic conditions and altitude may also explain the difference of relative frequencies among *Anastrepha* species. According to Malavasi *et al* (2000), in the northeastern region of Brazil, *A. fraterculus* predominates on the coastal regions, which are more humid, and *A. zenildae* and *A. sororcula* occur predominantly in the inland areas and are better adapted to dry climates. Una is a coastal municipality, where *A. fraterculus* was the predominant species (most frequent, dominant and constant), while in studies carried out on commercial guava orchards in Mossoró, Rio Grande do Norte, and in the northern region of the state of Minas Gerais, both located in a semiarid region, the predominant species were *A. zenildae* and *A. sororcula* (Canal *et al* 1998, Araujo & Zucchi 2003, Corsato 2004). In the northwestern region of the state of Rio de Janeiro, the predominance of *A. fraterculus* was also verified on guava orchards in the municipalities of Italva, Itaperuna (Ferrara *et al* 2005), Cambuci and Itaocara (Aguiar-Menezes *et al* 2008).

Many different biotic and abiotic stimuli can account for the presence of the lesser abundant *Anastrepha* species in environments that do not provide optimal host plants, such as commercial orchards (Aluja *et al* 1996). The authors suggest that the odor of ripening fruit, shelter conditions of perennial trees, and emission of volatiles by certain tree species that are similar to those found in the sexual pheromones of fruit flies could draw adult fruit flies into the orchard.

In this study, we registered the occurrence of 13 *Anastrepha* species and verified the presence of a large number of accidental species. Most species showed a low frequency and were not dominant in any of the years on the orchard under study. However, *A. fraterculus* was the most frequent species and the only one that was dominant and constant over the three-year study, indicating its importance as a pest of guava in the region. The high frequency of *A. obliqua* is probably due to other potential fruit hosts in the vicinity of the guava orchard, since previous studies (Souza-Filho *et al* 2007) have not registered this species infesting guavas in the region.

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