English Version

Infestation of coffee plantation by fruit flies (Diptera: Tephritidae): associated species and natural parasitism on the Midwest region of Bahia, Brazil[1]

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Abstract

Fruit flies (Diptera: Tephritidae), the main plague on the global fruitculture, assumed great importance in coffee plantation, since they determine early fall of fruits, increase on the amount of floaters and lost on the dink's quality. The South-west of the state of Bahia has important fruitculture and coffee plantations, and there are gaps in knowledge about bioecology of tephritid that can support actions of management of these plagues. This work had as objectives to obtain the rates on the infestation on coffee (*Coffea arabica* L.) by tephritids, associated species and their community structure, besides the natural parasitism of this plagues in shaded and full sun cultivation in the coffee region of Planalto de Vitória da Conquista, BA. The work consisted in the survey of the number of adults with cultivation located in Barra da Choça (shaded and full sun Catuaí Amarelo cutivar) and Vitória da Conquista (full sun Mundo Novo cultivar) and in the larval monitoring, by the harvest of the fruits, in the plantations already mentioned and in the municipalities of Planalto (full sun Catuaí Vermelho and Catuaí Amarelo cultivars) and Vitória da Conquista (full sun Catuaí Amarelo). The FTD index ranged from 3.1 to 18.6 with capture of *C. capitata* and eight Anastrepha species. *C. capitata* is the most numerous (90.42%), independent of the cultivar and the cultivation system. The average infestation index ranged from 112.79 (full sun Mundo Novo) to 168.89 puparium/kg of fruit(Shaded Catuaí Amarelo). Four tephritids were associated to the coffee: *C. capitata, A. amita, A. distincta e A. fraterculus*, this one being the first registration about *A. amita* and coffee association. It was verified the presence of parasitoid *Utetes anastrephae* (Viereck, 1913), with low index of parasitism (2.13% a 4.40%).

Key-words: *Ceratitis capitata*; *Anastrepha; Coffea arabica*; *Utetes anastrephae*; faunistic analysis

Introduction

State of Bahia, Brazil, has an expressive coffee crop with increasing crop volume, consisting in three main productive regions: West, Atlantic and Planalto. The third includes the sub-regions of Vitória da Conquista Plateau, Jequié/Santa Inês and Chapada Diamantina. Various phytosanitary problems occur in them, among them the fruit flies (Diptera: Tephritidae).

Fruit flies infest the Brazilian coffee crops, especially the species *Ceratitis capitata* (WIEDEMANN, 1824) and various species of the genus *Anastrepha*. Coffee crops have as their main host the species *C. capitata* (VARGAS et al., 1983; HARRIS and LEE, 1986; RAGA et al., 1996 a,b). Tephritid occur in the coffee crops in the begging of the fruit maturation stage and attack, mainly, mature fruits, increasing significantly the quality of the coffee beverage and, consequently, the market price practiced by the producer, moreover they provide early fruit fall, reduction of husked coffee production and increase on the production of floaters and "sweeping" coffee[1] (GERALDO et al., 2002; SOUZA et al., 2005).

With the increasing economic importance

1 "Sweeping coffee" is the coffee that naturally falls and it is collected by sweeping

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on the coffee crops in Bahia, fruit flies constitute an impediment to the fruit exportation in Brazil. Strict quarantine barriers are imposed by importing countries, hindering the exportation of Brazilian fruits. The fruit boundaries in Bahia are expanding, and there are situations of proximity between coffee plantations and fruits orchards. Producing areas of fruits, especially mangoes are located on the municipalities with semi-arid climate of Southwest Bahia. The drying of a considerable part of the coffee production of Vitória da Conquista and Barra do Choça, BA, is made of yards of bare soil, located on the municipalities where orchards are establishing. However, to the coffee crops there is no strategy of fruit flies management defined, especially on the monitoring of population suppression.

On the coffee production region of Vitória da Conquista Plateau the forestation of the coffee plantations, mainly with grevillea, it is a practice used to minimize the problems caused by drought that occurs at certain times of the year, and its effects on plague-arthropods are little known. Aspects of the forestation effect on the coffee crops over fruit flies were studied by Souza et al. (2005) and Aguiar-Menezes et al. (2007) to the conditions of Valença, RJ, with no information about the conditions of Bahia.

It is considered that bioecological knowledge of the fruit flies and their parasitoids in coffee crops of the Midwest region of Bahia are fundamental to support strategies of integrated management of these plagues in an area with environmental particularities, and crop management. It may be cited the improvement of the Sterile Insect Technique (SIT), already used on the region on pilot scale with the delivery of sterile males of *Ceratitis capitata* on the cluster of fruits, and the use of cultural strategies aimed at primary hosts of flies (SÁ et al., 2008) as benefits of studies of this nature.

This work had as objectives to identify the infestation of coffee crops on the Midwest region of Bahia by fruit flies, tephritid species involved and their parasitoids, as well as aspects of their community structure, aiming to support actions of management of these plagues on the coffee plantation and fruit growing regions.

Material and Methods

The work was developed in coffee crops (*Coffea arabica* L.) located on the municipalities of Barra do Choça (14° 49' S and 40° 38' W, 860 m), Vitória da Conquista (14° 48' S e 40° 54' W, 870 m) and Planalto (14° 40' S e 40° 28' W, 943 m) and on the Entomology Laboratory of the State University of the Midwest of Bahia, Vitória da Conquista, BA.

In Vitória da Conquista, it was selected crops on the Agricultural Field of UESB, composed by the variety Mundo Novo, with spacing of 1.0 m x 2.0 m full sun, and in Distrito de Capinal, formed by the variety Catuaí Amarelo, in spacing 1.5 m x 4.0 m, also full sun. In Barra do Choça, sampling was performed in two coffee crops of the variety Catuaí Amarelo, with spacing of 2.0 m x 4.5 m, one with full sun, and the other afforested with grevillea (*Grevillea robusta* A. Cunn.) in the spacing 4.0 m x 5.5 m. In Planalto, it was selected plants from the varieties Catuí Amarelo and Catuí Vermelho, cultivated full sun, with spacing of 2.0 m x 4.0 m.

In order to capture tephritid adults, areas of one hectare were demarcated on UESB crops in Vitória da Conquista and Barra do Choça, with distribution of five McPhail traps containing 400 mL of 7% hydrolyzed protein, one in the periphery and four inside the coffee crop. Samplings were made weekly, in the period from April to August 2003, following the procedures of withdrawn of the captured content, washing, refueling with protein and reinstallation of the traps. Flies were replaced to plastic bottles, tagged and taken to the laboratory, for sorting, separation of genera *Ceratitis* and *Anastrepha*, counting and sexing of the specimens of *Anastrepha* and fixation in 70% alcohol.

By the total number of flies, it was calculated the FTD index (fly/trap/day). The averages of captured tephritids were submitted to t test, with 5% of probability. It was aimed to know the community structure of *Anastrepha* spp. trough faunistic indices, i.e. frequency, constancy, dominance, richness and diversity, based on Silveira Neto et al. (1976):

Relative frequency (F), in which F = frequency percentage, n = number of individuals of each species, N = total number of individuals obtained in each sampling.

$$F = \frac{n}{N} \times 100$$

Constancy (C), in which C = constancy percentage, p = number of samplings containing the species, N = total number of samplings.

$$C = \frac{p}{N} \times 100$$

Subsequently, the species were separated in categories, according to the classification proposed by Bodenheimer (1995) in: constant species (W) – present in more than 50% of the samplings; accessory species (Y) – presence ranging from 25 to 50% of the samplings and accidental species (Z) – present in less than 25% of the samplings. It was considered a dominant species the one that presented frequency superior to 1/S, in which S is the total number of species on the community. Richness (S) was obtained by the total number of species observed on the community. Diversity (α) was obtained by the relation between the number of species (S) and the number of individuals of a community (N).

$$\alpha = \frac{(S-1)}{LN}$$ in which, LN = natural logarithm of N

The sampling of the coffee was performed in biweekly intervals at random in the plant and in the soil, with variable size of samples due to the fruit availability. They were packed in paper bags and transported to the laboratory, making a total of 6.905 kg of fruit from Barra do Choça and UESB *campus* and 4.205 kg from Planalto and Distrito de Capinal, Vitória da Conquista municipality. On the laboratory, fruits were placed in plastic trays containing vermiculite and, later, packed in screenhouse without air-conditioning.

After 12 to 13 days, vermiculite was sifted to obtain pupae, which were transported to glass bottles containing a fine layer of vermiculite and covered with voil tissue, aiming the emergence of fruit flies adults and parasitoids. The identification of the tephritid genera was performed based on the general body size and description of the pattern wing (ZUCCHI, 2000). Anastrepha species were identified by the biologist Maria Consuelo Andrade Nunes, from Agency of Agricultural Defense of Bahia, ADAB, Salvador, BA and parasitoids were identified by Dr. Rômulo da Silva Carvalho, researcher of EMBRAPA/CNPMF, Cruz das Almas, BA. The infestation indices were expressed by the number of puparium by kilo of fresh fruit (puparium/Kg).

The percentage of parasitism on the fruit flies was calculated based on Hernándes-Ortiz et al. (1994):% parasitism = (number of parasitoids emerged/number of pupae obtained) X 100.

Results and Discussion

It was sampled 188,901 tephritids in McPhail traps, in which 170,928 belonging to the *C. capitata* species and 17,973 of the *Anastrepha* genera (Table 1), with predominance of *C. capitata*, which participated with 99.80% on the coffee crop Mundo Novo (Table 1). Similar results were obtained by Souza et al. (1975) and Raga et al. (1996b, 2001 and 2002) in coffee plants in the state of São Paulo, and by Martins et al. (1998) in coffee plants of Espírito Santo, as well as other introduced plant crops (CANAL et al., 1998; MARTINS et al., 1998). In Bahia, to the conditions of Recôncavo Sul, Sub-Médio São Francisco and Northest Region, there is a predominance of *Anastrepha* species on agricultural areas (NASCIMENTO and ZUCCHI, 1981; NASCIMENTO et al., 1982; NASCIMENTO and CARVALHO, 2000), while *C. capitata* has a predominance on the mangoes orchards located on the region of Serra Geral (NASCIMENTO and CARVALHO, 2000) and Midwest (SÁ, 2006).

Significant differences between the densities of tephritid were found only between Catuaí Amarelo

Table 1. Total number, percentage and FTD índices (fly/trap/day) of fruit flies adults obtained in McPhail traps, on the municipalities Barra do Choca, BA, and Vitória da Conquista, BA.

Genus/ Species	Espécimes * (nº)	%	MAD	Coffe variety		
				Catuaí Amarelo		Mundo Novo
				Shaded	Full Sun	Full Sun
Ceratitis capitata	170,928	90.49	74.48	35,139	54,685	81,104
Anastrepha	17,973	9.51	7.83	12,590	5,221	162,000
Total	188,901	100.00	82.31	47,729	59,906	81,266

** Male and female*

coffee shaded and Mundo Novo (full sun); with no differences between the areas cultivated with Catuaí Amarelo in the cultivation systems studied and between the coffees full sun (Table 2). Some factors as the small difference (approximately 500 m) between Catuaí Amarelo coffee plants shaded and full sun and the presence of various fruits (avocado, acerola, banana, cashew, starfruit, citrus, guava, mangoes, peach and red mombin) and other hosts scattered on the property may explain the similarities on the density of fly. Tephritids may disperse on variable distances, from 1 km (SOTO-MANITU and JIRÓN, 1989) to 72 km (BATEMAN, 1972). On the same way, the significant differences found between fruit flies quantities in shaded Catuaí coffee and full sun Mundo Novo, probably, are related to the hosts present on the different areas and fruit color. According to Raga et al. (2001 and 2002), fruit flies have preference for reddish fruits.

FTD indices (fly/trap/day) obtained were relatively high (Table 3), considering pattern established to the fruitculture of exportation. Higher abundance of fruit flies occurred on the months from June to August on Catuaí variety and from April to June on Mundo Novo coffee. On this coffee plantation, the crop was ended in May, while in Barra do Choça, field with Catuaí variety, the last fruits were harvested in July, when there was, in general, a decrease on the number of tephritids on the month subsequent to the end of the harvest (Table 3).

Regarding *Anastrepha* genera, to the flies without species identification it was attributed the denomination *Anastrepha* spp. It was identified eight species (*A. fraterculus*, *A. distincta*, *A. amita*, *A. obliqua*, *A. pickeli*, *A. pseudoparellela*, *A. consobrina* e *A. bahiensis*) (LIMA, 1937), included in three infrageneric groups (*fraterculus*, *spatulata* e *pseudoparallela*), according to the classification of Norrbom et al. (1999) (Table 4). The samples identified on this work, in general, were monomorphic, following the pattern presented on the species description, with an exception of *A. fraterculus*, which presented variation on the wings and the apex of the spine, similar to what occurred on the work of Uramoto et al. (2004).

All *Anastrepha* species collected on the present work were already assigned to Bahia state (NASCIMENTO et al., 1981; 1982; NASCIMENTO and CARVALHO, 2000). The faunistic indices were calculated, disregarding the species *Ceratitis capitata* and the *Anastrepha* spp. samples, aiming to characterize the communities in terms of specific composition of *Anastrepha* (Table 4). Richness was higher in Catuaí Amarelo, with eight species, variety in which the diversity was also higher. On a general way, richness found was low in relation to the results obtained by other authors in other harvests (NASCIMENTO et al., 1981; 1983; CANAL, 1998; URAMOTO et al., 2004; GARCIA et al., 2003), in which the number of species was above 15.

The diversity indices were similar to other studies, and may be considered relatively low (CANAL, 1998; GARCIA et al., 2003). However, they differ from each other, particularly between Catuaí Amarelo and Mundo Novo, showing differences between communities. According to Silveira Neto et al. (1976), the value of diversity indices tend to be low where the limiting factors and the competition interspecific act strongly. *A. fraterculus* species was more frequent on the two studied regions (85.71% to 91.80%), agreeing with the results obtained in other crops (NASCIMENTO et al., 1982; CALZA et al., 1988), even in captivity (SOUZA et al., 2005) (Table 4).

In accordance with Aluja et al. (1996), even when various species of *Anastrepha* are present on an area, only one or two represent more than 90% of all the flies collected on traps. In Catuaí coffee, the

Table 2. Average number of fruit flies in relation to the cultivation system and the variety of the coffee plant, in Barra do Choça and Vitória da Conquista municipalities, BA

Coffee Variety / Cultivation system	Averages *
Catuaí Amarelo/Shaded	9,945.8 a
Catuaí Amarelo/Full Sun	11,981.2 ab
Mundo Novo/Full Sun	16,253.2 b

** Averages followed by the same letter do not differ, by t test, with 5% of probability*

Table 3. Total number of fruit flies *C. capitata* and *Anastrepha* collected in McPhail traps, in five months, in Barra do Choça, BA and Vitória da Conquista, BA municipalities, 2003.

Months	Genera / Species*	Coffee Variety					
		Catuaí Amarelo Shaded	FTD	Catuaí Amarelo Not shaded	FTD	Mundo Novo Not shaded	FTD
April	*Anastrepha*	1,039	3.1	103,000	1.6	30,000	48.6
	C. capitata	356,000		616,000		21,831	
May	*Anastrepha*	936,000	9.0	171,000	5.9	74,000	57.1
	C. capitata	3,098		2,482		25,605	
June	*Anastrepha*	7,768	46.4	3,977	39.3	33,000	43.5
	C. capitata	13,091		13,690		19,538	
July	*Anastrepha*	2,809	37.4	913,000	46.7	04,000	24.2
	C. capitata	14,022		20,078		10,902	
August	*Anastrepha*	38,000	10.2	57,000	39.7	21,000	7.2
	C. capitata	4,572		17,819		3,228	
TOTAL *Anastrepha*		12,590		5,221		162	
TOTAL *C. capitata*		35,139		54,685		81.104	

* *Male and Female*

constant species were *A. fraterculus*, *A. distincta*, *A. amita* and *A. obliqua*, whereas the others (*A. bahiensis*, *A. consobrina*, *A. pickeli* and *A. pseudoparallela*) were accidental. In Mundo Novo coffee, *A. fraterculus* and *A. obliqua* were accidental. Among the species of *Anastrepha*, *A. fraterculus* presents the higher number of host plants known, being considered one of the species more polyphagous, developing in 67 host species, followed by *A. obliqua*, which develops in 28 (ZUCCHI, 2000).

It is probable that the occurrence of *A. amita* may be due to the presence of wild plants in the studied region; Zucchi (2000) associated this fly to plants of the family Verbenaceae, while in the studies of Sá et al. (2008) the species was found in fruits of umbu, which is a typical semiarid plant. The presence

Table 4. Faunistic analysis of fruit flies species with McPhail traps in places in three locations in Barra do Choça, BA, and Vitória da Conquista, BA municipalities. April to August 2003.

Location	**Barra do Choça Catuaí Amarelo**				**Vitória da Conquista Mundo Novo**			
Fly species	**N**	**F**	**C**	**D**	**N**	**F**	**C**	**D**
A. amita	176	1.71	W	n	-	-	-	-
A. bahiensis	01	0.01	Z	-	-	-	-	-
A. consobrina	02	0.02	Z	-	-	-	-	-
A. distincta	599	5.83	W	n	-	-	-	-
A. fraterculus	9,434	91.80	W	d	6	85.71	Z	d
A. obliqua	56	0.54	W	n	1	14.29	Z	n
A. pickeli	06	0.06	Z	-	-	-	-	-
A. pseudoparallela	03	0.03	Z	n	-	-	-	-
Total	10,277	100	-	-	7	100.00	-	-
Percentage		99.93				0.07		
ID		3.37				1.44		
R		8.00				2.00		

N: Number of flies captured, F: Frequency (%), R: Richness, ID: Diversity Index

C: Constancy, W: Constant, Y: Accessory, Z: Accidental

D: Dominancy, d: Dominant, n: Non dominant.

of hosts as apple guava may have contributed to the capture of *A. bahiensis*, while *A. consobrina* may be affected by the presence of native Passifloraceae (ZUCCHI, 2000). By contrast, to the *A. pickeli*, it was not found hosts from the family Bombaceae and Euphorbiacea in the property in Barra do Choça. Regarding to the specie *A. pseudoparallela*, various hosts were found on the experimental areas, such as cashew, mangoes, red mombin, umbu and guava, although this specie is mainly associated to the Passifloraceae family.

In regard to the infestation levels, on Catuaí Amarelo coffee plants shaded the average was 163.89 puparium/kg of fruit, presenting a variance from 10.53 to 500.00, whereas in the full sun coffee plant of the same variety, the average infestation index was 133.17 puparium/kg of fruit, with a variation of 0.00 – 276.47. The variety Mundo Novo in full sun presented average infestation level of 112.79 puparium/kg of fruit, with a variation of 82.05 – 165.85. In Distrito de Capinal and in Planalto, the indices were estimated in a single sample, obtaining the values of 351.51 puparium/kg in Catuaí Amarelo (Capinal) and of 78.77 puparium/kg of fruits in Catuaí Vermelho (Planalto).

Data suggest effect of the shading on the average infestation indices, fact also evidenced by Souza et al. (2005), who verified an average infestation index significantly higher in Icatu Amarelo coffee cultivated in shaded system with banana plants (*Musa* sp. var. 'Prata') and *Erithrina verna* Vell. (Leguminosae), in Valença, RJ. The average data obtained are similar to those described by Raga et al. (1996b, 2001, 2002), considering the same coffee variety. Raga et al. (2002) found average infestation indices of 124.90 pupae/kg of fruits, presenting variations of 0.00 – 876.7 pupae/kg of fruit from Mundo Novo variety. Aguiar-Menezes et al. (2007), when studying the behavior of the cultivars Catuaí Vermelho 144, Icatu Amarelo IAC 3282, Catuaí Amarelo 2SL, Obatã IAC 1669-20, Oeiras 6851 and Tupi IAC 1669/33, verified less susceptibility to the tephritids on the fruits of Icatu Amarelo and Catuaí Amarelo in both cultivation systems studied, which are shaded and full sun in Valença, RJ.

From fruits collected in this work, it was obtained 804 samples of fruit flies, with 89.18% of the *C. capitata* species and 10.82% of the *Anastrepha* species, corroborating the larger incidence of *C. capitata* on the collections with traps and with a study developed by Raga et al. (1996b), which indicated emergence of 75,6% of *C. capitata*, 7.4% of *Anastrepha* spp. (fraterculus group) and 17% of Lonchaeidae. In Barra da Choça, from the *Anastrepha* species captured on traps, only *A. fraterculus* and *A. distincta* emerged from the fruits, and they had already been associated with the host coffee. From the *A. amita* species it was obtained an adult, coming from fruits collected in Planalto, which id the first register of association of this species with coffee plants.

In Vitória da Conquista, the association with Mundo Novo coffee plants was proved only to the species *C. capitata.* In coffee plants located in Valença, RJ, Souza et al. (2005) found the species *C. capitata*, A. *fraterculus*, *A. obliqua* e *A. sororcula* and six Lonchaeidae, with a predominance of *Anastrepha* over *C.capitata*. It was obtained 14 parasitoids of the species *Utetes anastrephae* Viereck (Braconidae: Opiinae), with 10 species coming from the coffee Catuaí Amarelo from Barra do Choça, five in each area. In the coffee Mundo Novo, only one adult parasitoid was obtained. From the fruits collected in Planalto, it was obtained tree parasitoids in fruits of Catuaí Vermelho.

Overall the parasitism was low, being observed in May in Catuaí Amarelo under full sun (2.13%) and Mundo Novo (2.94%) and in July in Catuaí Amarelo shaded (4.4%) and under full sun (4.4%) and in Catuaí Vermelho under full sun (2.34%). Raga et al. (2002), also verified low natural parasitism rates in coffee plants (0.16% to 0.40%). Other authors have reported low natural parasitism rates in fruit flies in different species of host fruits (CAÇADOR, 1977; LEONEL Jr. et al., 1996; GALLI and RAMPAZZO 2000). Raga et al. (2001) found parasitism from the species *U. anastrephae* in coffee Catuaí Vermelho and Catuaí Amarelo. In Brazil, the occurrence of this species had already been registered by Leonel Jr. et al. (1995, 1996), Canal and Zucchi (2000), Aguiar-Menezes et al. (2001) and Raga et al. (2001).

More recently, Souza et al. (2005) indentified nine species of fruit fly species in coffee plants, six of them are braconids - *Asobara anastrephae* (Muesebeck),

Doryctobracon areolatus (Szépligeti), *Doryctobracon brasiliensis* (Szépligeti), *U. anastrephae*, *Opius bellus* Gahan and *Opius* sp. – and three are frigitidae - *Aganaspis pelleranoi* (Brèthes), *Diceratas pis flavipes* (Kieffer) e *Odontosema anastrephae* (Borgmeier). The parasitism percentage estimated by the authors was 8.8% and 12.4% in coffee shaded and full sun. The low parasitism rages may be related to the small period of time between obtaining the puparium and disposal of material on the laboratory.

Carvalho (2001) detected occurrence of diapauses in larva/pupa of fruit fly parasitoids, including *U. anastrephae* with a maximum period of 414 days. On the present work, the period between the obtaining of the fly puparium and the evaluation of the parasitoid emergence did not exceed 30 days. The knowledge about diapauses on the stages of larva and pupa, are of extreme importance to obtain results more precise about natural parasitism ranges in fruit flies.

The present work indicated that *C. capitata* is predominant on the coffee region of Vitória da Conquista Plateau, however it also shows that *Anastrepha* species already have good adaptation to the coffee plants, with variations on the structure of their communities in function of the coffee variety. Regarding the genera *Anastrepha*, *A. fraterculus* is the most frequent and dominant, independent on the coffee variety and hosts present on the area. From species associated to coffee fruits, i.e., *C. capitata*, *A. fraterculus*, *A. distincta* e *A. amita*, the two first must be observed by the phytossanity defense of the region. This study was the first register of the association of *A. amita and Coffea Arabica* in Brazil.

Coffee plants studied presented high *C. capitata* infestation rages, with, however, no scientific basis that allow to relate infestation levels with potential losses that they represent. This work was not able to evidence the effects of afforestation of coffee plantations on the occurrence of tephritids, either quantitative or qualitative. On the integrated management of the coffee plant plagues, one must consider selective phitossanity products, because although in low ranges, there is natural fruit fly parasitism in coffee plants in the Midwest region of Bahia.

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