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Field assessment of baits for frugivorous flies (Tephritidae and Lonchaeidae)

Olívia Oliveira dos Santos[1]*, Sávio de Oliveira Ribeiro[1], Maria Aparecida Leão Bittencourt[2], Maria Aparecida Castellani[1], Raquel Pérez-Maluf[1], Ana Elizabete Lopes Ribeiro[1] and Aldenise Alves Moreira[1]

[1]Departamento de Fitotecnia e Zootecnia, Universidade Estadual do Sudoeste da Bahia - UESB; Estrada Bem Querer, Km 04,45083-900, P.O.Box 95, Vitória da Conquista, Bahia, Brazil.

[2]Departmento de Ciências Agrárias e Ambientais, Universidade Estadual de Santa Cruz - UESC, Rodovia Jorge Amado; 45662-900, P.O.Box 110, Ilhéus, Bahia, Brazil.

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Hydrolyzed proteins are used as attractive agents in McPhail traps for monitoring of fruit flies (Tephritidae). There has been no defined role for monitoring of insects belonging to the Lonchaeidae family. Currently, there is a great concern in using most efficient and low-cost attractive materials. Thus, this study aimed at assessing the attractiveness of solid and liquid baits in capturing of frugivorous flies (Tephritidae and Lonchaeidae). Therefore, we carried out four trials in coffee plantations (*Coffea arabica* L.) during two different periods (May/ 2013 and July/ 2014). A randomized block design with four treatments and five replications was used in the first period, and ten treatments with four replications the following year. Two distinct experiments were carried out, one using baits in solid and another in liquid form, which consisted of applying 10 g for trap (solid) or 200 mL solution of the same compounds diluted in water (5%: p/ v). In 2013, we tested yeast extract with and without sugar, brewer's yeast, citrus pulp and hydrolyzed protein as control. In 2014, five additional baits were tested: açai, plum and grape flours, passion fruit fiber and poultry feces. In all experiments, a 5% hydrolyzed protein solution was used as control. Eight days after being set, traps were assessed. Even the yeast extract, with and without sugar, and the brewer's yeast, in solid form, were as attractive as control treatment in capturing flies. The poultry feces and yeast extract, with and without sugar in solution form, can be used to replace hydrolyzed protein in capturing tephritids. Lonchaeids are barely attracted by the hydrolyzed protein. Additionally, yeast extract and poultry feces can be used for monitoring and biodiversity studies of the Lonchaeidae fauna.

Key words: Fruit growing, monitoring, trap, protein.

INTRODUCTION

The term frugivorous flies is used to indicate all flies belonging to the Tephritidae and Lonchaeidae families, while fruit flies refers only to the Tephritidae family (Zucchi, 2000). Tephritids are major economic pests of fruit plantations worldwide, being responsible for yield losses due to damages on fruit that make them unavailable for *in natura* consumption, as well as having importance as quarantine pests (Aluja and Mangan, 2008;

Jenkins et al., 2011). The Lonchaeidae family has been long overlooked by researches because of a lack of taxonomic knowledge; however, there has been an increasing interest in studying such insects since lonchaeids have been collected during tephritids' monitoring. In addition, these insects have also been assigned as primary pest in *Malpighia punicifolia* L. (Araújo and Zucchi, 2002), *Citrus reticulada* Blanco (Lopes et al., 2008), *Passiflora edulis* f. *Flavicarpa* (Aguiar-Menezes et al., 2004) and *Manihot esculenta* (Lourenção et al., 1996; Gistoli and Prado, 2011).

Four genera of the Tephritidae family are found in Brazil: *Rhagoletis* Loew, 1862, *Bactrocera* Macquart, 1835, *Ceratitis* MacLeay, 1829 and *Anastrepha* Schiner, among which the two latter have most importance (Zucchi, 2000, 2008). Whereas the Lonchaeidae family is represented by the genera *Lonchaea* Fallén 1847, *Dasiops* Rondani 1856 and *Neosilba* McAlpine 1962 (Zucchi, 2008; Strikis et al., 2011).

Coffee plants are considered preferred hosts for fruit flies, mainly for the species *C. capitata* (Wiedemann, 1824) and *Anastrepha fraterculus* (Wiedemann, 1830), since this plant provides shelter during periods of low availability of hosts in the field (Montes et al*.,* 2012). The coffee tree has also major importance for the maintenance of frugivorous fly populations, even though these insects are not taken as main pests for this crop. However, these insects may threaten a few fruits commercially grown *in natura*, becoming their primary pest (Souza Filho et al., 2003).

Fruit fly monitoring is an important tool for decision-making in pest control managements and consists of using Jackson's traps based on sexual pheromone as well as McPhail traps, which contain 5% corn hydrolyzed protein (Carvalho, 2005). The use of traps and standard attractive increase monitoring operation costs for small farmers; therefore, alternative materials such as plastic bottles, fruit juice or sugarcane molasses are often employed in samplings.

A capture system has not been established yet for monitoring of lonchaeids, which are usually collected through the same attractive traps used for tephritids (Raga et al., 2006), since there are still few studies on such group of flies.

Researches using new compounds as attractive bait for fruit fly capturing have been developed for several authors (Fontellas-Brandalha and Zucoloto, 2004; Feitosa et al., 2008; Weldon and Taylor, 2011; Piñero et al., 2015).

In recent years, there has been an increased concern to find efficient and low-cost attractive materials. As well, some studies have indicated good prospects for solid baits (Conway and Forrester, 2007; Epsky et al., 2011; Lasa et al., 2014), which have shown some advantages in water use and less time for trap supply, which can be used in monitoring and biodiversity studies.

The current study aimed at assessing the attractiveness of solid and liquid baits in capturing of frugivorous flies (Tephritidae and Lonchaeidae), which may be further indicated in pest management programs and biodiversity studies.

MATERIALS AND METHODS

The studies were carried out in coffee plantations (*Coffea arabica* L.) of "Catuaí Amarelo" and "Catuaí Vermelho" varieties. The plantations are located in Santa Fé farm (14º 44' 8.7" S; 40º 26' 06" W), in the city of Planalto-BA, Brazil. The treatments consisted of baits in solid and liquid form making two different and sequential experiments. The experiments were performed under a randomized block design. Four treatments (baits) and five replications (traps) were tested in 2013, and 10 treatments with four replications in 2014, in a total of 25 and 40 plots, respectively (Table 1). The plots were composed of McPhail traps with each attractive material, being set on plants at 1.50 m height from soil and 20-m equidistant, with a 10-m border. Ten grams of each product was weighed and then distributed to the base of traps. Hydrolyzed protein was used as a control treatment for all experiments. 10 g was used for each trap (solid) or 200 mL solution of the same compounds diluted in water (5%: p/v) (liquid), as per the manufacturer's recommendations.

The compounds were selected based on their commercial composition. Therefore, compounds with a predominance of proteins (yeast extract - Bionis®, brewer's yeast and corn hydrolyzed protein), of carbohydrates and fibers from fruit (açaí, plum and grape flours, citrus pulp and passion fruit fiber), plus poultry feces, which are considered important sources of protein for fruit flies in nature was used (Christenson and Foote, 1960).

The evaluations were made eight days after traps were set for all experiments, which is considered a trap attractive refill period when using hydrolyzed protein in orchards under official monitoring. The flies captured in field traps were sorted, counted and divided according to genus and/ or species.

The identification of the *C. capitata* species was made based on descriptions of Zucchi (2000). For *Anastrepha*, we have solely used females, identifying them by a apical spine pointing outward, with the aid of a stereomicroscope (40x) and biological microscope (100x), according to the method described by Zucchi (2000). Yet the lonchaeids were identified at genus level by morphological characters in the chest and abdomen.

Statistics

The statistical analysis was carried out for data of the most abundant fly species. The data under non-normal distribution were submitted to non-parametric mean comparisons using the Friedman's test ($p > 0.05$); the remaining data underwent variance analysis and means were compared by the Tukey's test at 5% probability, using ASSISTAT 7.7 beta.

*Corresponding author. E-mail:olvagro@yahoo.com.br.

Table 1. Treatments used in the field experiments on the attractiveness of baits to frugivorous flies.

Experiment*	Treatment
2013	T1 = Bionis® with sugar; T2 = Bionis® without sugar; T3 = Dehydrated citrus pulp; T4= Brewer's yeast; T5 (Control) = Hydrolyzed protein**
2014	T1= Bionis® with sugar; T2 = Bionis® without sugar; T3 = Dehydrated citrus pulp; T4= Brewer's yeast; T5 = Plum flour; T6 = Açaí flour; T7 = Passion fruit fiber; T8 = Grape flour; T9 = Poultry feces; T10 (Control) = Hydrolyzed protein

*Two subsequent experiments in each year, being the first with solid baits and then with liquid ones; **All experiments in solution at 5%.

RESULTS AND DISCUSSION

In 2013, 1.611 flies were caught, being 84 (5.2%) with solid compounds and 1,527 (94.7%) with 5% solutions (Table 2). Tephritids prevailed in all collections, making 98.8% of solid treatments and 94.0% of liquid ones. The most abundant species was *C. capitata,* representing 95.2 and 96.0% of flies caught in solid and liquid experiments, respectively (Table 2). The genus *Anastrepha* was represented by the species *A. fraterculus* (2.4% in solid and 3.2% in liquid) and *A. consobrina* (Loew, 1873) (1.2%). Among the lonchaeids, only representatives from the genus *Neosilba* were captured, contributing in 1.2 and 0.8% of flies captured with solid and liquid baits, respectively (Table 2). In absolute terms, hydrolyzed protein was the most attractive treatment for tephritids, being responsible for 39.2% of tephritid capture in solid experiments and 38.3% in liquid ones. For lonchaeids, the product Bionis, with and without sugar, was most attractive, collecting 92.3% of the flies in both experiments, demonstrating thus a low attractiveness of proteins to these flies.

Both Bionis® (with - T1, and without sugar - T2) and brewer's yeast (T4), in solid form, showed an attractiveness similar to the hydrolyzed protein (control - T5) for female and total (male plus female) captures of the *C. capitata*, among which citric pulp had the lowest attractiveness (Table 3). Regarding the evaluations of the same products, in liquid form, the results were similar for female collections; however, no significant difference was seen for total captures. Male captures were less expressive compared to female ones for all treatments (Table 3). Adults belonging to the *C. capitata* species, particularly females at sexual maturity had greater preference for protein-based materials, which was ingested according to the foraging behavior and mating of these insects (Cohen and Voet, 2002).

The population of *A. fraterculus* captured was low. Moreover, solid treatments did not take any specimen of this species, except for control (Table 4). The Bionis in solution, with and without sugar, did not differ significantly from the hydrolyzed protein to the total number of adults captured. The yeast extract, with and without sugar, and the brewer's yeast were as attractive as the hydrolyzed protein for females. However, these treatments did not differ as to the males, except for citrus pulp that had the worst performance when collecting adults of *A. fraterculus*.

The hydrolyzed protein has shown to be a highly attractive lure to tephritids. This compound is similar or slightly higher than several others, e.g. guava juice (Azevedo et al., 2012), syrup (Raga et al., 2006), corn steep liquor and sugarcane molasses (Montes and Raga, 2006), 25% grape juice (Scoz et al., 2006), vinegar (Monteiro et al., 2007), hydrolyzed enzymatic protein and ammonium acetate and putrescine (Lasa et al., 2014), and yeast (Santos et al., 2010). Few studies demonstrate lower attractiveness by hydrolyzed protein relative to other baits. For instance, Epsky et al. (2011) carried studies that showed compounds based on mixture of ammonium acetate and putrescines are most attractive.

Some studies have shown that yeasts are attractive lures to tephritids, with higher than or similar to different corn hydrolysate baits (Santos et al., 2008) as observed for 25% grape juice in this study (Monteiro et al., 2007).

An amount of 14,382 flies were caught in 2014, among which 2,109 (14.6%) in solid baits and 12,273 (85.3%) in the same compounds diluted in water at 5% (Table 5). Again, tephritids were predominant, reaching 99.6% in studies with solid baits and 99.7% with liquid ones. The species *C. capitata* has also prevailed, accounting for 87.9 and 96.6% of all captured flies in solid and liquid baits, respectively (Table 5). The genus *Anastrepha* was represented for the species *A. fraterculus* (11.7 and 3.1%) and *A. manihoti* Lima, 1934 (0.04%). Among lonchaeids, solely specimens belonging to the *Neosilba* genus were taken, representing 0.4 and 0.3% in studies using solid and liquid baits, respectively (Table 2).

Bionis® (com - T1, and without sugar - T2) and Brewer's yeast (T4), in solid form, were as attractive as hydrolyzed protein (control - T5) (Table 6). Studies on yeasts (Torula) indicated upper attractiveness of this compound when compared to Biolure, which is based on ammonia and putrescine to capture flies of the species *Anastrepha ludens* (Loew, 1873) (Conwany and Forrester, 2007).

Not all liquid baits differed from hydrolyzed protein, except for grape flour that was less attractive to *C. capitata* (Table 6). Although not significant, sugarless yeast extract and poultry feces showed the highest

Table 2. Number and percentage (%) of frugivorous flies captured by solid and liquid baits in a coffee plantation in the city of Planalto - BA, Brazil. May of 2013.

Treatment	Solid baits								Liquid baits					
	C. capitata		*A. fraterculus*		*A. consobrina*		*Neosilba* spp.		*C. capitata*		*A. fraterculus*		*Neosilba* spp.	
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
T1 (Yeast extract with sugar)	15	18.7	0	-	0	-	1	100.0	210	14.4	12	24.5	7	58.4
T2 (Yeast extract without sugar)	18	22.5	0	-	0	-	-	-	360	24.5	13 (9M)*	26.5	4	33.3
T3 (Citrus pulp)	0	-	0	-	0	-	-	-	69	4.7	1 (1M)*	2.0	0	-
T4 (Brewer's yeast)	17	21.2	0	-	0	-	-	-	263	17.9	2	4.0	0	-
T5 Control (Hydrolyzed protein)	30	37.6	2	100.0	1	100.0	-	-	564	38.5	21 (4M)*	42.9	1	8.3
Total	**80**	**100.0**	**2**	**100.0**	**1**	**100.0**	**110**	**0.0**	**1.466**	**100.0**	**49**	**100.0**	**12**	**100.0**
Overall total							**84**	**5.2**					**1.527**	**94.7**

Table 3. Average number (± standard deviation) of captured *C. capitata* in solid baits, in a coffee plantation in the city of Planalto - BA, Brazil. May of 2013.

Treatments	Solid			Liquid		
	Females	Males	Total	Females	Males	Total
T1 (Yeast extract with sugar)	1.8 ± 1.1^{ab}**	1.0 ± 0.5^{a}**	2.8 ± 1.2^{ab}**	38.4 ± 3.2^{ab}**	8.8 ± 2.1^{a} *	47.2 ± 3.8^{a}*
T2 (Yeast extract without sugar)	1.8 ± 0.1^{ab}	1.6 ± 0.3^{a}	3.4 ± 0.2^{ab}	65.8 ± 1.9^{a}	16.4 ± 1.5^{a}	82.2 ± 2.4^{a}
T3 (Citrus pulp)	0.0 ± 0.0^{b}	0.0 ± 0.0^{b}	0.0 ± 0.0^{b}	18.7 ± 1.5^{b}	2.6 ± 0.6^{a}	17.6 ± 1.5^{a}
T4 (Brewer's yeast)	2.0 ± 0.4^{ab}	1.4 ± 0.5^{a}	$3.4 \pm 0,4^{ab}$	45.6 ± 1.2^{ab}	8.0 ± 1.0^{a}	53.4 ± 1.3^{a}
T5 Control (Hydrolyzed protein)	3.4 ± 1.0^{a}	1.2 ± 0.5^{a}	4.6 ± 1.0^{a}	96.4 ± 2.2^{a}	17.2 ± 1.2^{a}	113.6 ± 1.3^{a}
CV (%)					56.6	31.1

*Means followed by the same letter within a column do not differ from each other by the Tukey's test at 5% probability. The data were transformed into log x+1. ** Means followed by the same letter do not differ from each other by the non-parametric Friedman's test (p>0.05).

average of captures for *C. capitata* compared to control. The attractiveness of odor released by the baits to adults of *C. capitata* may be influenced by its nutritional status, that is, protein-deficient adults may associate the odor as being a protein source by means of olfactory receptors (Manrakhan and Lux, 2008).

Among solid baits, the hydrolyzed protein remained most attractive to *A. fraterculus*. However, yeast extract (T1 and T2), citric pulp (T3), beer yeast (T4), passion fruit fiber (T7) and poultry droppings (T9) had no difference with control for collections of *A. fraterculus* (Table 7); thus, they still deserve more attention. Studies on protein-based commercial baits have shown a high efficiency in capturing *Anastrepha* spp. flies (Raga et al., 2006), as well protein is regarded as an important nutrient for fruit flies, directly influencing the insect longevity and sexual performance in adults (Oviedo et al., 2011).

Differently, the results for liquid form baits demon-strated a greater attractiveness of plum flour against other treatments. The release of volatile substances by compounds might have been responsible to attract adults of *A. fraterculus*. For Kendra et al. (2005), the response of *Anastrepha supensa* (Loew, 1862) females to the releasing of volatile compounds as ammonia, for example, is related protein intake period.

A fewer specimens of lonchaeids were found

Table 4. Average number (± standard deviation) of *A. fraterculus* captured in solid and liquid baits, in a coffee plantation in the city of Planalto - BA, Brazil. May of 2013.

Treatments	Solid			Liquid		
	Females	Males	Total	Females	Males	Total
T1 (Yeast extract with sugar)	0.0 ± 0.0^{b}*	0.0 ± 0.0^{a}*	0.0 ± 0.0^{b}*	3.2 ± 0.6^{ab}*	0.6 ± 0.7^{ab} *	3.8 ± 0.7^{ab}*
T2 (Yeast extract without sugar)	0.0 ± 0.0^{b}	0.0 ± 0.0^{a}	0.0 ± 0.0^{b}	3.0 ± 0.7^{ab}	1.4 ± 0.5^{a}	4.4 ± 0.8^{a}
T3 (Citrus pulp)	0.0 ± 0.0^{b}	0.0 ± 0.0^{a}	0.0 ± 0.0^{b}	0.0 ± 0.0^{b}	0.2 ± 0.4^{ab}	0.2 ± 0.4^{b}
T4 (Brewer's yeast)	0.0 ± 0.0^{b}	0.0 ± 0.0^{a}	0.0 ± 0.0^{b}	0.2 ± 0.4^{ab}	0.0 ± 0.0^{b}	0.2 ± 0.4^{b}
T5 Control (Hydrolyzed protein)	0.4 ± 0.3^{a}	0.0 ± 0.0^{a}	0.4 ± 0.3^{a}	4.2 ± 0.1^{a}	0.6 ± 0.5^{ab}	4.8 ± 0.7^{a}

*Means followed by the same letter do not differ from each other by the non-parametric Friedman's test ($p>0.05$).

Table 5. Number and percentage (%) of frugivorous flies captured by solid and liquid baits in a coffee plantation in the city of Planalto - BA, Brazil. July of 2014.

Treatments	Solid baits								Liquid baits					
	C. capitata		*A. fraterculus*		*A. manihoti*		*Neosilba* spp.		*C. capitata*		*A. fraterculus*		*Neosilba* spp.	
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
T1 (Yeast extract with sugar)	157	8.5	31(15M)*	12.6	0	-	3	33.3	1.111	9.4	59 (20M*)	15.5	13	39.5
T2 (Yeast extract without sugar)	179	9.6	82(24M)*	33.3	1	100.0	6	66.6	2.593	21.9	89 (91M)	23.5	2	6.1
T3 (Citrus pulp)	36	1.9	1	0.4	0	-	0	-	1.269	10.7	7 (18M)*	1.8	-	-
T4 (Brewer's yeast)	207	11.2	(1M)*	1.2	0	-	0	-	635	5.3	1 (6M)*	0.2	3	9.1
T5 (Plum flour)	52	2.8	0	-	0	-	0	-	1.266	10.7	50 (34M)*	13.2	1	3.0
T6 (Açaí flour)	38	2.1	0 (1M)*	-	0	-	0	-	811	6.8	9 (19M)*	2.4	1	3.0
T7 (Passion fruit fiber)	91	4.9	5 (5M)*	0.8	0	-	0	-	915	7.7	23 (17M)*	6.1	1	3.0
T8 (Grape flour)	17	0.9	0	-	0	-	0	-	113	0.9	1	0.2	-	-
T9 (Poultry feces)	142	7.7	19 (10M)*	7.7	0	-	0	-	2.066	17.4	29 (12M)*	7.6	11	33.3
T10 Control (Hydrolyzed protein)	935	50.4	105(74M)*	42.7	0	-	0	-	1.081	9.1	112(11M)*	29.5	1	3.0
Total	**1.853**	**100.0**	**246**	**-**	**1**	**100.0**	**9**	**-**	**11.860**	**100.0**	**380**	**100.0**	**33**	**100.0**
Overall total							**2.109**	**14.6**					**12.273**	**85.3**

*M = Number of male flies belonging to the genus Anastrepha caught in traps at different treatments.

compared to tephritids, with hydrolyzed protein showing low or even null attractiveness to the species *Neosilba* sp. (Tables 2 and 3). Yeast extract with and without sugar, in both solid and in liquid form, plus the bird feces in liquid form enabled the capturing of the vast majority of insects. These baits should be indicated for biodiversity studies as well as monitoring of this group of flies. The genus *Neosilba* comprises species of great economic interest; therefore, its population monitoring is of upmost importance, once they affect commercial fruits (Strikis et al., 2011).

In solid form, yeast extract and beer yeast have potential as alternatives to the use of hydrolyzed

Table 6. Average number (± standard deviation) of *C. capitata* captured by solid and liquid baits in a coffee plantation in the city of Planalto - BA, Brazil. July of 2014.

Treatments	Solid			Liquid		
	Females	Males	Total	Females	Males	Total
T1 (Yeast extract with sugar)	29.5 ±1.6^{bcd}*	9.7 ± 0.8^{ab}*	39.2±1.2^{abcd}*	164.5±1.1^{a}*	115.0±2.0^{a}*	277.7±2.1^{ab}*
T2 (Yeast extract without sugar)	36.2 ±0.5^{abc}	10.0 ±1.0^{ab}	46.2 ±1.8^{abc}	491.5±1.9^{a}	183.5±4.8^{a}	675.0±7.4^{a}
T3 (Citrus pulp)	7.2 ±1.4^{cde}	1.7 ±0.8^{b}	9.0 ±0.8^{cde}	195.0±6.2^{a}	83.7±3.7^{ab}	278.7±7.4^{ab}
T4 (Brewer's yeast)	45.0±1.5^{ab}	7.0 ±0.3^{ab}	52.0±1.3^{ab}	110.7±3.6^{ab}	58.7±3.7^{ab}	169.5±4.4^{ab}
T5 (Plum flour)	9.5±1.1^{de}	3.5± 0.8^{ab}	13.0±1.7^{bcde}	203.5±0.2^{a}	113.0±3.7^{ab}	316.5±5.5^{ab}
T6 (Açaí flour)	7.2 ±1.1^{bcd}	1.7 ±0.7^{b}	9.0 ±1.3^{de}	171.5±9.4^{ab}	69.5±7.1^{ab}	241.0±11.8^{ab}
T7 (Passion fruit fiber)	22.7 ±0.6^{bc}	5.7±0.4^{ab}	28.5 ±1.1^{bcd}	158.4±6.1^{ab}	64.5±5.0^{ab}	222.7±7.8^{ab}
T8 (Grape flour)	3.7±1.7^{e}	0.5 ± 0.4^{b}	4.2± 0.7^{e}	19.7±1.1^{b}	8.5±1.5^{b}	28.2±1.5^{b}
T9 (Poultry feces)	29.2±1.7^{bcd}	6.2± 0.9^{ab}	35.5 ±1.9^{bcd}	392.7±5.8^{a}	108.2±1.4^{ab}	501.0±5.2^{a}
Control (Hydrolyzed protein)	205.7±4.1^{a}	28.0±1.7^{a}	233.7 ± 4.4^{a}	212.7±1.2^{a}	57.5±1.8^{ab}	270.2±1.1^{ab}
CV (%)	22.0	49.0	21.9	16.8	48.5	40.6

*Means followed by the same letter within a column do not differ from each other by the Tukey's test at 5% probability. The data were transformed into log x+1.

Table 7. Average number (± standard deviation) of *A. fraterculus* captured in solid and liquid baits in a coffee plantation in the city of Planalto - BA, Brazil. July of 2014.

Treatments	Solid			Liquid		
	Females	Males	Total	Females	Males	Total
T1 (Yeast extract with sugar)	7.0 ±0.3^{ab}**	4.0 ±0.7^{ab}**	11.0±0.6^{ab}**	13.7±1.2^{ab}*	6.5±0.7^{ab}**	20.2±1.2^{ab}*
T2 (Yeast extract without sugar)	17.7 ±0.6^{ab}	8.7 ±0.8^{ab}	26.5±0.9^{ab}	23.7±1.1^{a}	9.5±1.4^{a}	33.2±2.0^{a}
T3 (Citrus pulp)	0.2 ±0.5^{ab}	0.0 ±0.0^{b}	0.2 ±0.5^{ab}	2.0±1.1^{bc}	1.5±0.5^{ab}	3.5±1.1^{bc}
T4 (Brewer's yeast)	0.7 ±0.2^{ab}	0.2 ±0.5^{ab}	1.0 ±0.4^{ab}	1.5±0.5^{bc}	0.7±0.5^{ab}	2.2±0.2^{bc}
T5 (Plum flour)	0.0±0.0^{b}	0.0± 0.0^{b}	0.0 ±0.0^{b}	12.5±2.2^{abc}	6.5±1.1^{ab}	19.0±2.4^{ab}
T6 (Açaí flour)	0.0±0.0^{b}	0.2 ±0.5^{b}	0.2 ±0.5^{ab}	2.2±1.0^{bc}	1.5±0.7^{ab}	3.7±1.2^{bc}
T7 (Passion fruit fiber)	1.2 ±0.5^{ab}	1.2±0.6^{ab}	2.5 ±0.8^{ab}	6.5±1.8^{abc}	2.0±1.1^{ab}	8.5±7.8^{abc}
T8 (Grape flour)	0.0 ±0.0^{b}	0.0 ± 0.0^{b}	0.0± 0.0^{b}	0.2±0.5^{c}	0.0±0.0^{b}	0.2±0.5^{c}
T9 (Poultry feces)	4.5±0.4^{ab}	3.2± 0.5^{ab}	7.7 ±1.2^{ab}	12.5±1.4^{abc}	3.0±0.7^{ab}	15.7±5.2^{ab}
Control (Hydrolyzed protein)	32.2±2.8^{a}	13.2±1.5^{a}	45.7 ±3.2^{a}	12.0±0.6^{ab}	33.0±0.4^{ab}	15.0±0.7^{ab}
CV (%)				29.2		43.7

* Means followed by the same letter within a column do not differ from each other by the Tukey's test at 5% probability. The data were transformed into log x+1. ** Means followed by the same letter do not differ from each other by the non-parametric Friedman's test (p>0.05).

protein for *C. capitata* and *A. fraterculus*. In liquid form, all baits had an increase in attractiveness, except for grape flour, which was less attractive to both species of flies. It is also noteworthy mention that poultry feces were attractive, especially in liquid form, for the capture of both species of flies. Females seem to be showing a greater selectivity for baits than males do. Good catches provided by poultry liquid material might be derived from ammonium release when decaying, being attractive to the flies. Such attractiveness of poultry droppings have been reported in a few species as the case of *Rhagoletis pomonella* (Wash, 1867) (Prokopy et al., 1993a) and *A. suspensa* (Epsky et al., 1997). For *C. capitata*, this attractiveness varies with the source and excrement conditions. Droppings of birds and lizards are most attractive than mammal feces, since the first two show uric acid decomposition that is more attractive than the urea decomposition (Prokopy et al., 1993b). The rates of decomposition and ammonium release to the atmosphere could vary with interactions between biotic and abiotic factors as microbial activities, temperature and rainfall (Mazor, 2009).

From an economic point of view, the use of yeast extract (Bionis, with or without sugar) would be most expensive since this product costs around US$ 8.26 per kilo (Biogirin, 2014), while a liter of hydrolyzed protein (Bio Anastrepha®) costs US$ 2.77, excluding transportation expenses. Poultry feces would probably have much lower costs; however, the lack of suppliers with standardized products could hinder this process.

Conflict of interests

The authors have not declared any conflict of interests.

REFERENCES

Aguiar-Menezes EL, Nascimento RJ, Menezes EB (2004). Diversity of fly species (Diptera: Tephritoidea) from *Passiflora* spp. and their hymenopterous parasitoids in two municipalities of the southeastern Brazil. Neot. Ent. 33 (1):113-116.

Aluja M, Mangan RL (2008). Fruit Fly (Diptera:Tephritidae) Host status determination: Critical conceptual, methodological, and regulatory considerations. An. Rew. Ent. 53: 473-502.

Araújo EL, Zucchi RA (2002). Hospedeiros e níveis de infestação de *Neosilba pendula* (Bezzi) (Diptera: Lonchaeidae) na região de Mossoró/Assu, RN. Arq. Inst. Biol. 69(2):91-94.

Azevedo FR, Gurgel LS, Santos MLL, Sllva FB, Moura MAR, Nere DR (2012). Eficácia de armadilhas e atrativo alimentares alternativos na captura de moscas-das-frutas em pomar de goiaba. Arq. Inst. Biol. 79(3):343-352.

Biogirin (2014). Arte em ingredientes naturais. Available online at: http://www.biorigin.net/biorigin/index.php/br/. Accessed: 20, October, 2014.

Carvalho RS (2005). Metodologia para monitoramento populacional de moscas-das-frutas em pomares comerciais. Available online at: http://www.cnpmf.embrapa.br/publicacoes/circulares/circular_75.pdf. Accessed: 20, October, 2014.

Christenson LD, Foote RH (1960). Biology of fruits flies. Ann. Rev. Ent. 5:171-192.

Cohen H, Voet H (2002). Effect of physiological state of young *Ceratitis capitata* females, on resource foraging behavior. Ent. Exp. App.104(1):345-351.

Conway HE, Forrester OT (2007). Comparison of mexican fruit fly (Diptera:Tephritidae) capture between McPhail traps with torula and multilure traps with biolures in South Texas. Flor. Ent. 90(3):579-580.

Epsky ND, Dueben BD, Heath RR, Lauzon CR, Prokopy RJ (1997). Attraction of *Anastrepha suspense* (Diptera: Tephritidae) to volatiles from avian fecal material. Fla. Entomol. 80:270-277.

Epsky ND, Kendra PE, Peña J, Heateh RR (2011). Comparison of synthetic sood-based lures and liquid protein baits for capture of *Anastrepha suspensa* (Diptera: Tephritidae) adults. Flor. Entol. 94(2):180-185.

Feitosa SS, Silva PRR, Pádua LEM, Carvalho EMS, Paz JKS, Paiva DR (2008). Flutuação populacional de moscas-das-frutas (Diptera: Tephritidae) associadas a variedades de manga no município de José de Freitas-Piauí. Rev. Bra. Frult. 30(1):112-117.

Fontellas-Brandalha TML, Zucoloto FS (2004).Selection of oviposition sites by wild *Anastrepha obliqua* (Macquart) (Diptera: Tephritidae) based on the nutritional composition. Neot. Ent. 33(5):557-562.

Gistoli L, Prado AP (2011). Cassava shoot infestation by larvae of *Neosilba perezi* (Romero &Ruppell) (Diptera: Lonchaeidae) in São Paulo State, Brazil. Neot. Ent. 40(3):312-315.

Jenkins DA, Epsky ND, Kendra PE, Heath RR, Goenaga R (2011). Food-based lure performance in three locations in Puerto Rico: attractiveness to *Anastrepha suspensa* and *A. obliqua* (Diptera: Tephritidae). Flor. Ent. 94(2):186-194.

Kendra PE, Montgomery WS, Mateo DM, Puche H, Epsky ND, Heath RR (2005). Effect of age on EAG response and attraction of female *Anastrepha suspensa* (Diptera: Tephritidae) to ammonia and carbon dioxide. Env. Ent. 34(3):584-590.

Lasa R, Velázquez OE, Ortega R, Acosta E (2014). Efficacy of commercial traps and food odor attractants for mass Trapping of *Anastrepha ludens* (Diptera: Tephritidae). J. Econ. Ent. 107(1):198-205.

Lopes EB, Batista JL, Albuquerque IC, Brito CH (2008). Moscas frugívoras (Tephritidae e Lonchaeidae): ocorrência em pomares comerciais de tangerina (*Citrus reticulata* Blanco) do município de Matinhas, Estado da Paraíba. Act. Scient. Agron. 30:639-644.

Lourenção AL, Lorenzo, Ambrosano GMB (1996). Comportamento de clones de mandioca em relação a infestação por *Neosilba perezi* (Romero & Ruppell) (Diptera: Lonchaeidae). Sci. Agric. 53:1-3.

Manrakhan A, Lux SA (2008). Effect of food deprivation on attractiveness of food sources, containing natural and artificial sugar and protein, to three African fruit flies: *Ceratitis cosyra*, *Ceratitis fasciventris*, and *Ceratitis capitata*. Ent. Exp. Appl. 127(1):133-143.

Mazor M (2009). Competitiveness of fertilizers with proteinaceous baits applied in Mediterranean fruit fly, *Ceratitis capitata* Wied. (Diptera: Tephritidae) control. Crop Prot. 28(1):314-318.

Monteiro LB, Mio LLM, Motta ACV, Serrat BM, Cuquel FL (2007) Avaliação de atrativos alimentares utilizados no monitoramento de mosca-das-frutas em pessegueiro na Lapa – PR. Rev. Bras. Frutic. 29(1):072-074.

Montes SMNM, Raga A, Souza FMF, Striks PC, Santos PC (2012). Moscas-das-frutas em cultivares de cafeeiros de Presidente Prudente, SP. Cof. Sci. 7(2):99-109.

Oviedo A, Nestel D, Papadoupolos NT, Ruiz MJ, Prieto SC, Willink E, Vera MT (2011). Management of protein intake in the fruit fly *Anastrepha fraterculus*.J. Ins. Phys. 57(1):1622-1630.

Piñero JC, Mau RFL, Vargas RI (2015). A comparative assessment of the response of three fruit fly species (Diptera:Tephritidae) to a spinosad-based bait: effect of ammonium acetate, female age, and protein hunger. Bull. Ent. Res.101:373-381.

Prokopy RJ, Cooley SS, Galarza L, Bergweiler C, Laurozon CR (1993a) Bird droppings compete with bait sprays for *Rhagoletis pomonella* flies (Diptera: Tephritidae). Can. Ent.125:413-422.

Prokopy RJ, Hsu CL, Vargas RIL (1993b). Effect of source and condition of animal excrement on attractiveness to adults of *Ceratitis capitata* (Diptera: Tephritidae). Environ. Ent. 22:453-458.

Raga A, Machado RA, Dinardo W, Strikis PC (2006). Eficácia de atrativos alimentares na captura de moscas-das-frutas em pomar de citros. Brag. 65(2):337-345.

Santos OO, Andrade LL, Bittencourt MAL (2008). Moscas-das-frutas (Diptera: Tephritidae) em armadilhas tipo McPhail e frutos hospedeiros no município de Ilhéus, Bahia. Magis. 20(4):398-402.

Santos OO, Oliveira RA, Ferraz MF, Bittencourt MAL (2010). Flutuação populacional de moscas-das-frutas (Diptera:Tephritidae) utilizando atrativos alimentares na região Sul da Bahia. Rev. Agrotrop. 22(3):129-136.

Scoz PL, Botton M, Garcia MS, Pastori PL (2006). Avaliação de atrativos alimentares e armadilhas para o monitoramento de *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae) na cultura do pessegueiro (*Prunus persica* (L.) Batsh). Ides 24(2):7-13.

Souza FMF, Raga A, Zucchi RA (2003). Moscas-das-frutas no Estado de São Paulo: ocorrência e danos. Lar. 24(1):45-69.

Strikis PC, Deus EG, Silva RA, Pereira JDB, Jesus CR, JUNIOR MASARO AL (2011). Conhecimento sobre Lonchaeidae na Amazônia Brasileira. pp. 205-215. In: Moscas-das-frutas na Amazônia Brasileira: Diversidade, hospedeiros e inimigos naturais. (Silva R. A., LEMOS WP, Zucchi RA Eds). Embrapa, Macapá, Amapá, Brasil.

Weldon CW, Taylor PW (2011). Sexual development of wild and mass-reared male Queensland fruit flies in response to natural food sources. Ent. Exp. Appl. 139:17-24.

Zucchi RA (2008).Fruit flies in Brazil-*Anastrepha* species and their hosts plants. Available at: http://www.lea.esalq.usp.br/anastrepha/edita_infos.htm. Accessed: 10, March, 2013.

Zucchi RA (2000). Alimentação e nutrição de moscas-das-frutas. In: Moscas-das-frutas de importância econômica no Brasil. Conhecimento básico e aplicado (MALAVASI A., ZUCCHI R. A. Eds). Holos, Ribeirão Preto, São Paulo, Brasil. pp. 67-102.