

ECOLOGY, BEHAVIOR AND BIONOMICS

Biodiversity of Frugivorous Flies (Diptera: Tephritoidea) Captured in Citrus Groves, Mato Grosso do Sul, Brazil

MANOEL A. UCHÔA-FERNANDES¹, ISAIAS DE OLIVEIRA¹, ROSA M.S. MOLINA¹ AND ROBERTO A. ZUCCHI²

¹Lab. Insetos Frugívoros, C. postal 241, Depto. Ciências Biológicas, Universidade Federal de Mato Grosso do Sul, Rod. Dourados-Itahum, km 12, 79804-970, Cidade Universitária, Dourados, MS, e-mail: uchoa@ceud.ufms.br

²Depto. Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ-USP, Caixa Postal 9, 13418-900, Piracicaba, SP e-mail: razucchi@esalq.usp.br

Neotropical Entomology 32(2):239-246 (2003)

Biodiversidade das Moscas Frugívoras (Diptera: Tephritoidea) Capturadas em Pomares de Citros, Mato Grosso do Sul

RESUMO - Este trabalho apresenta uma análise faunística das espécies frugívoras de Tephritoidea (Diptera), capturadas em três pomares de citros dos municípios de Anastácio e Terenos-MS, durante 25 meses. Armadilhas plásticas McPhail com proteína hidrolisada de milho a 5% foram penduradas em plantas de *Citrus sinensis* (L.) e *C. reticulata* (L.) a 1,70 m do nível do solo e espaçadas a 30 m. As espécies de Tephritidae capturadas foram: *Anastrepha alveatoides* Blanchard, *A. bezzii* Lima, *A. castanea* Norrbom, *A. daciformis* Bezzi, *A. dissimilis* Stone, *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. haywardi* Blanchard, *A. leptozona* Hendel, *A. macrura* Hendel, *A. montei* Lima, *A. obliqua* (Macquart), *A. pickeli* Lima, *A. punctata* Hendel, *A. rheediae* Stone, *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. striata* Schiner, *A. turpiniae* Stone, *A. undosa* Stone, *A. zenildae* Zucchi; três espécies não-descritas - *Anastrepha* sp.1, *Anastrepha* sp.2, *Anastrepha* sp.3 e *Ceratitidis capitata* (Wied.). Os Lonchaeidae capturados foram: *Dasiops* sp.; *D. inedulius* Steyskal, *Lonchaea* sp. e *Neosilba* spp. A mosca-do-mediterrâneo, *C. capitata* foi a espécie mais abundante e freqüente, sendo dominante nos pomares de ambos os municípios. No pomar do município de Anastácio, as espécies mais abundantes foram: *Anastrepha daciformis*, *A. obliqua*, *A. pickeli*, *A. punctata*, *A. sororcula* e *A. fraterculus*. Nos pomares de Terenos, *A. dissimilis*, *A. punctata*, *A. sororcula*, *A. daciformis*, *A. striata* e *A. pickeli* foram as espécies mais abundantes.

PALAVRAS-CHAVE: Moscas-das-frutas, Lonchaeidae, laranja, tangerina

ABSTRACT - This paper presents a faunistic analysis of the frugivorous species of Tephritoidea (Diptera) captured in three citrus groves in the municipalities of Anastácio (Chácara Laranjal, 20° 31' 36" S, 55° 50' 12" W, 170 m) and Terenos (Chácara Suzuki, 20° 26' 12" S, 55° 04' 54" W, 308m), MS, Brazil, during a 25 month period. McPhail traps with 5% hydrolyzed corn protein were hung in *Citrus sinensis* (L.) and *C. reticulata* (L.) trees, spaced 30 m apart. The Tephritidae species caught were: *Anastrepha alveatoides* Blanchard, *A. bezzii* Lima, *A. castanea* Norrbom, *A. daciformis* Bezzi, *A. dissimilis* Stone, *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. haywardi* Blanchard, *A. leptozona* Hendel, *A. macrura* Hendel, *A. montei* Lima, *A. obliqua* (Macquart), *A. pickeli* Lima, *A. punctata* Hendel, *A. rheediae* Stone, *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. striata* Schiner, *A. turpiniae* Stone, *A. undosa* Stone, *A. zenildae* Zucchi, three undescribed species - *Anastrepha* sp.1, *Anastrepha* sp.2; *Anastrepha* sp.3 and *Ceratitidis capitata* (Wied.). The frugivorous Lonchaeidae caught were: *Dasiops* sp.; *D. inedulius* Steyskal, *Lonchaea* sp. and *Neosilba* spp. The Mediterranean Fruit Fly, *C. capitata*, was the most abundant and frequent, being the dominant species in the groves of both municipalities. In the *Citrus* grove in Anastácio the most abundant species were: *Anastrepha daciformis*, *A. obliqua*, *A. pickeli*, *A. punctata*, *A. sororcula* and *A. fraterculus*. In the *Citrus* groves in Terenos, *A. dissimilis*, *A. punctata*, *A. sororcula*, *A. daciformis*, *A. striata* and *A. pickeli* were the most abundant species.

KEY WORDS: Fruit fly, Lonchaeidae, orange, tangerine

The Brazilian frugivorous flies of economic importance belong to the Tephritidae and Lonchaeidae (Tephritoidea) families. Tephritidae is better known because it contains the largest number of described species associated with fruits. According to Zucchi (2000), the tephritids that damage Brazilian pomiculture belong to two genera: *Anastrepha* Schiner (several native species) and *Ceratitis* McLeay. *Anastrepha* is the biggest and economically most important genus of fruit flies from the Americas. One hundred and ninety-seven species have been described to date (Norrbon *et al.* 1999) of which 94 had been previously recorded in Brazil (Zucchi 2000).

In Brazilian orchards the frugivorous pest species of flies are represented by several species of *Anastrepha*, *Ceratitis capitata* (Wied.) (Tephritidae) and the lonchaeids of the genera *Neosilba* (as *Silba*) and *Dasiops* (Souza *et al.* 1986, Uchôa-Fernandes & Zucchi, 1999).

Knowledge of the frugivorous Lonchaeidae is still incipient in Latin America in spite of the economic importance of the *Neosilba* (Loureção *et al.* 1996, Sánchez *et al.* 1991) and *Dasiops* species (Penâranda *et al.* 1986, Norrbom & McAlpine 1997).

The diversity of frugivorous Tephritoidea has been evaluated in several regions of the world by using two sampling methods: 1) the capture of adults in traps, generally McPhail models, with food baits and, 2) the rearing of adults from larvae found infesting fruit.

This paper presents the first study of species richness of frugivorous tephritoids caught in plastic McPhail traps in the state of Mato Grosso do Sul. A faunistic analysis of the frugivorous Tephritidae species and Lonchaeidae genera is discussed.

Material and Methods

Plastic McPhail traps were hung in three citrus groves: one planted with oranges (8 ha), in Chácara Laranjal, Anastácio (20° 31' 36" S, 55° 50' 12" W, 170m); the second also planted with oranges (21 ha) and the third planted with tangerines (7 ha). The last two are one km apart, located in Chácara Suzuki, Colônia Jamic, Terenos (20° 26' 12" S, 54° 04' 54" W, 308 m). The distance between the grove in Anastácio and the two in Terenos is about 110 km.

The Chácara Laranjal is located in a transition area between the "cerrado" and "pantanal" ecosystems. Chácara Suzuki is in a typical Cerrado ecosystem. In the Chácara Laranjal orange grove, eight traps were placed (2/ha) and 28 traps were placed in the two groves (orange and tangerine) in Chácara Suzuki (1 trap/ha).

The traps were baited with hydrolysed corn protein Tephritid™ (5%), supplied by the Laboratório de Moscas-das-Frutas, Departamento de Biologia, Instituto de Biociências, USP. They were spaced about 30 m apart in a diagonal line in the groves, at about 1.70 m above the soil level hung in the branches of the citrus canopy. The traps were washed and filled with the food bait every seven days. All captured insects were picked up and placed in labeled vials with 90% alcohol for later screening and identification of the tephritids and lonchaeids collected. All the traps in the

three citrus groves were monitored on the same day, from March 22, 1994 to March 23, 1996.

The climatic data were supplied by the Section of Meteorology of Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA: Gado de Corte) in Campo Grande, MS. These data were used in the population studies of both groves (Anastácio and Terenos).

The insects caught in the traps were screened in the Laboratório de Controle Biológico de Insetos, Universidade Federal de Mato Grosso do Sul (UFMS) in Aquidauana. The tephritids, lonchaeids and otitids were fixed in 70% alcohol and identified in the Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", USP, Piracicaba-SP. The species of the *Anastrepha* genus were identified by the morphology of the female aculeus. Some diagnostic characteristics, such as the chromatic pattern of the body and wings, were also considered, according to the identification keys (Lima 1934, Stone 1942, Blanchard 1961, Steyskal 1977b, Zucchi 2000).

The genus *Ceratitis* is represented in Brazil only by *C. capitata* (Wied.) (Uchôa-Fernandes & Zucchi 1999), which is easily recognized by the diagnostic characteristics discussed by Foote (1980). The Lonchaeidae genera were identified using keys and original descriptions (McAlpine 1960, Korytkowski & Ojeda 1971, McAlpine & Steyskal 1982, McAlpine 1987, Norrbom & McAlpine 1997). *Neosilba zadolicha* McAlpine was identified by the morphology of the male terminalia (McAlpine & Steyskal 1982) and *Dasiops inedulisa* Steyskal by the shape of its aculeus (Norrbon & McAlpine 1997).

The voucher specimens of the tephritids and frugivorous lonchaeids were deposited in the Zoological Collection at UFMS (ZUFMS), in Campo Grande, MS and in the Collection at the Departamento de Entomologia, Fitopatologia e Zoologia Agrícola da ESALQ-USP, Piracicaba, SP.

Faunistic Analysis. The analysis of the frugivorous Tephritoidea was based on abundance, frequency, diversity and dominance indices (Silveira Neto *et al.* 1976, Southwood 1995). Due to the proximity of the tangerine and orange groves in Terenos, the data were analysed together.

The indices of diversity refer to the relationship between the number of sampled species and individuals of a community or ecosystem (Southwood 1995). Those indices were calculated by the method of Shannon-Weaver (1949) mentioned by Southwood (1995) and by the equation proposed by Margalef, in Silveira Neto *et al.* (1976):

$$\alpha = \frac{S-1}{\ln N}$$

Where: α = index of diversity, S = number of sampled taxa, \ln = Neperian logarithm of the number of collected individuals, N = total number of collected specimens in the sampled area.

Frequency is the percentage of the number of individuals of a certain species, in relation to the total number of sampled individuals in the sampled environment (Silveira Neto *et al.* 1976). The index of frequency was calculated

by the following equation:

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

Where: F = frequency (%), n = number of sampled specimens of each species, N = total number of individuals of all collected species. From the obtained data a frequency class was established for the species, according to the confidence interval (CI) of an average of 5% probability. The following classes were established: infrequent (if) – when the percentage of the number of caught individuals of the species was smaller than the lower limit of CI at 5% probability; frequent (f) - when the percentage of the number of caught individuals of that species was found within the CI at 5% probability; very frequent (vf) - when the percentage of the number of individuals of the species was larger than the upper limit of the CI at 5% probability.

Abundance refers to the number of individuals of a certain taxa by unit of surface or volume and it varies by space and time (Southwood 1995). The abundance was calculated employing the standard deviation and the confidence interval of an average of 1% and at 5% probability. To estimate the abundance of the species, the following classes were adopted: rare (r) - when the number of caught individuals of the species was smaller than the lower limit of the CI at 1% probability; dispersed (di) – when the number of caught individuals of the species was located within the lower limits of the CI at 5% and at 1% probability; common (c) – when the number of caught individuals of the species was located inside the CI at 5% probability; abundant (a) – when the number of caught individuals of the species was within the upper limits of the CI at 5% and at 1% probability; very abundant (va) – when the number of caught individuals of the species was larger than the upper limit of the CI at 1% probability.

The index of dominance corresponds to the proportion of the total of caught individuals that belong to the dominant species (Southwood 1995). An organism is considered dominant when it receives the impact of the environment and adapts to it (Silveira Neto *et al.* 1976). The index of

dominance was calculated by the equation presented by Sakagami & Laroca (1971):

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

Where: LD = limit of dominance; S = total number of species in each sample. A species is considered dominant (do) when its frequency is larger than the limit of dominance (LD). All indices were calculated using the ANAFAU software developed by Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ / USP.

Results and Discussion

Adults Caught in McPhail Traps. Fewer frugivorous flies were caught in the orange grove at Anastácio, probably due to the smaller number of McPhail traps (8), while 28 traps were hung in the two groves at Colônia Jamic (Terenos).

Tephritidae collected, besides *Anastrepha* and *C. capitata*, were species of the genera *Hexachaeta* and *Tomoplagia*, both without economic importance (Table 1).

The McPhail traps caught a relatively small number of frugivorous flies in the 25-month period. However, 25 species of *Anastrepha* and *C. capitata* were captured, showing the usefulness of those traps in studies of the diversity of Tephritoidea in the field (Steyskal 1977a, Drew & Hancock 1994).

Tephritidae. Considering that the survey was carried out over two years, the number of *Anastrepha* spp. individuals was very low (794), when compared to the values obtained in other regions in Brazil, with similar periods of collection and number of traps used. On the coast of Rio Grande do Norte, 20,284 specimens of *Anastrepha* spp. were caught (Maia-Lima 1997); in the Recôncavo Baiano region, 17,700 specimens (Nascimento & Zucchi 1981) and in the region of Goiânia 2,642 individuals were caught (Veloso 1997). The number of *C. capitata* individuals captured was also low in this research, when compared to results obtained in the regions

Table 1. Tephritoidea (Diptera) genera with species caught in 36 plastic McPhail traps with food bait, hung in three *Citrus* groves in Anastácio and Terenos, MS (March 22, 1994 to March 23, 1996).

Genera	Anastácio (8 traps)			Terenos (28 traps)			Total
	Males	Females	Subtotal	Males	Females	Subtotal	
Tephritidae							
<i>Anastrepha</i>	174	128	302	278	214	492	794
<i>Ceratitis</i>	59	182	241	35	138	173	414
<i>Hexachaeta</i>	16	20	36	6	6	12	48
<i>Tomoplagia</i>	313	95	408	463	112	575	983
Lonchaeidae							
<i>Dasiops</i>	5	14	19	12	32	44	63
<i>Lonchaea</i>	60	402	462	46	295	341	803
<i>Neosilba</i>	306	1,173	1,479	792	3,695	4,487	5,966
<i>Notogramma</i> & other Otitidae	-	-	30,815	-	-	77,844	108,659
Total			33,762			83,968	117,730

cited above. However, it should be mentioned that during the 106 weeks of the samplings, about 50% of the time either the solution in the traps dried up or it was full of sinantropic flies. These results, at least partially, can be attributed to two factors: 1) climate - strong sunlight and low relative air humidity, causing the evaporation of the liquid food bait in the traps and 2) the invasion of the traps by flies, mainly, muscids, calliphorids and sarcophagids, migrants from poultry farms in the vicinity of the groves (Colônia Jamic). According to field observations, it is suggested that the interval used to replace the food bait needs to be shortened to three or four days in these regions of Mato Grosso do Sul.

The species of *Anastrepha* caught in the traps were:

Anastrepha alveatoides Blanchard, *A. bezzii* Lima, *A. castanea* Norrbom, *A. daciformis* Bezzi, *A. dissimilis* Stone, *A. distincta* Greene, *A. fraterculus* (Wied.), *A. grandis* (Macquart), *A. haywardi* Blanchard, *A. leptozona* Hendel, *A. macrura* Hendel, *A. montei* Lima, *A. obliqua* (Macquart), *A. pickeli* Lima, *A. punctata* Hendel, *A. rheediae* Stone, *A. serpentina* (Wied.), *A. sororcula* Zucchi, *A. striata* Schiner, *A. turpiniae* Stone, *A. undosa* Stone, *A. zenildae* Zucchi and three new species of *Anastrepha*, not described yet.

The most abundant species of *Anastrepha* were *A. dissimilis*, *A. punctata* and *A. daciformis* (113, 35 and 29 individuals, respectively). In the majority of caught species the number of specimens ranged from one to eight (Table 2).

Table 2. Species of fruit flies and frugivorous lonchaeids (Diptera: Tephritidae and Lonchaeidae) caught in 36 plastic McPhail traps with food bait, hung in three *Citrus* groves in Anastácio and Terenos, MS (March 22, 1994 to March 23, 1996).

Taxa of Tephritoidea	Place and n. of specimens		
	Chácara Laranjal, Anastácio	Colônia Jamic, Terenos	Total of individuals
Tephritidae			
<i>Anastrepha</i> spp.	174 (males)	278 (males)	452 (males)
<i>A. alveatoides</i> Blanchard, 1961	5	2	7
<i>A. bezzii</i> Lima, 1934	1	0	1
<i>A. castanea</i> Norrbom, 1998	0	1	1
<i>A. daciformis</i> Bezzi, 1909	15	14	29
<i>A. dissimilis</i> Stone, 1942	4	109	113
<i>A. distincta</i> Greene, 1934	0	2	2
<i>A. fraterculus</i> (Wied., 1830)	18	2	20
<i>A. grandis</i> (Macquart, 1846)	0	1	1
<i>A. haywardi</i> Blanchard, 1937	1	2	3
<i>A. leptozona</i> Hendel, 1914	1	0	1
<i>A. macrura</i> Hendel, 1914	4	0	4
<i>A. montei</i> Lima, 1934	6	2	8
<i>A. obliqua</i> (Macquart, 1835)	11	0	11
<i>A. pickeli</i> Lima, 1934	10	7	17
<i>A. punctata</i> Hendel, 1914	11	24	35
<i>A. rheediae</i> Stone, 1942	6	2	8
<i>A. serpentina</i> (Wied., 1830)	0	1	1
<i>A. sororcula</i> Zucchi, 1979	14	28	42
<i>A. striata</i> Schiner, 1868	9	11	20
<i>A. turpiniae</i> Stone, 1942	5	1	6
<i>A. undosa</i> Stone, 1942	2	0	2
<i>A. zenildae</i> Zucchi, 1979	4	2	6
<i>Anastrepha</i> sp.1	0	1	1
<i>Anastrepha</i> sp.2	1	0	1
<i>Anastrepha</i> sp.3	0	1	1
<i>Anastrepha</i> sp. (damaged)	0	1	1
<i>Ceratitis capitata</i> (Wied., 1824)	241	173	414
Tephritidae (total)	543	665	1,208
Lonchaeidae			
<i>Dasiops</i> spp.	17	24	41
<i>D. inedulisi</i> Steyskal, 1980	2	20	22
<i>Lonchaea</i> spp.	462	341	803
<i>Neosilba</i> spp.	1,479	4,487	5,966
Lonchaeidae (total)	1,960	4,872	6,832

Anastrepha spp. = specific identification only of females

Considering the sampling data for Tephritidae occurrence, *A. dissimilis* was the only species collected throughout the period in the traps. *A. sororcula*, *A. striata*, *A. turpiniae* and *C. capitata* were captured in several months. Almost 50% of the *Anastrepha* species captured (*A. bezzii*, *A. castanea*, *A. distincta*, *A. grandis*, *A. haywardi*, *A. leptozona*, *A. macrura*, *A. obliqua*, *A. rheediae*, *A. serpentina*, *A. undosa* and the three new ones), were recovered only in some months of the year. Probably these flies are specialists and therefore their occurrence can be determined by the fruiting season of their hosts.

Lonchaeidae. Species of three Lonchaeidae genera (*Dasiops*, *Lonchaea* and *Neosilba*) were also caught in the traps. The most abundant genus was *Neosilba* (Fig. 1). However, when frequency is taken into account, *Anastrepha* and *Lonchaea* species were almost as frequent as the *Neosilba* species (Fig. 2).

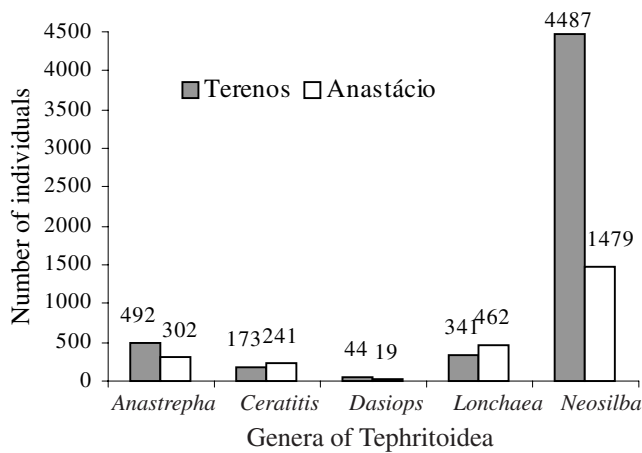


Figure 1. Abundance of frugivorous fly (Tephritoidea) by genera, caught in 36 plastic McPhail traps with food bait, hung in three *Citrus* groves in Anastácio and Terenos, MS (March, 22, 1994 to March, 23, 1996).

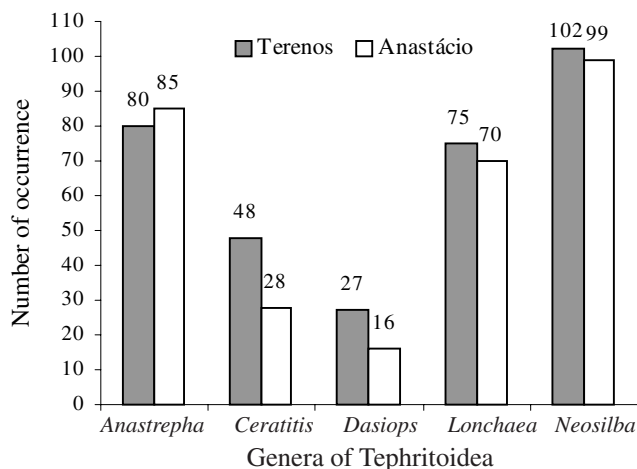


Figure 2. Frugivorous fly frequency (Tephritoidea) by genera, caught in 36 plastic McPhail traps with food bait, hung in three *Citrus* groves in Anastácio and Terenos, MS (March, 22, 1994 to March, 23, 1996).

Neosilba species were collected in greater abundance (5,966 specimens), representing more than 74% of the total, followed by *Lonchaea* spp. (803 specimens) and *Dasiops* spp. (63 individuals) (Table 1). Lonchaeids of the *Dasiops* and *Neosilba* genera occurred during every month of the year. Some species of *Dasiops* are economically important, because they attack flowers and fruit of cultivated or wild Passifloraceae. In this last case these flies are considered natural enemies of some undesirable *Passiflora*, because potentially they can be used as biocontrol agents of the weed Passifloraceae (Norrbon & McAlpine 1997).

The true ecological niche of the neotropical species of *Lonchaea* is not known. There are references to *Lonchaea* larvae preying on xylophagan beetles in the Nearctic Region (Alfaro & Borden 1980; Hulme 1989, 1990); feeding on decaying wood and on fungus that grows in trees, in the Palearctic Region (Kovalev 1974, 1979).

The Otitidae species collected in the traps were not quantified (except *N. cimiciforme*) due to the difficulty of identification and, the great number of caught flies of that family (108,659 individuals - Table 1), representing more than 92% of the total.

Faunistic Analysis and Biodiversity. Twenty-six fruit fly species were collected in the traps, 25 belonging to the *Anastrepha* genera; 22 named and three new species, and *C. capitata*. The Mediterranean fruit fly, *C. capitata*, occurred as over abundant, extremely frequent and over dominant, being the predominant species in the orange groves of both municipalities. In the grove at the *Chácara Laranjal*, Anastácio, *A. daciformis*, *A. obliqua*, *A. pickeli*, *A. punctata* and *A. sororcula* were very abundant, very frequent and constant, occurring as dominant species, while *A. fraterculus* was very abundant, very frequent and *A. striata* was common and frequent (Table 3). In the grove at Colônia Jamic, in Terenos, *A. dissimilis* was characterized as over abundant and extremely frequent, being predominant. *Anastrepha punctata*, *A. sororcula*, *A. daciformis*, *A. striata* and *A. pickeli* were very abundant and very frequent (Table 3).

When the species composition of fruit flies collected in this survey is compared with surveys carried out in other Brazilian regions, remarkable differences are observed, probably due to the climate and floristic composition, peculiar to each biome. In the North of Minas Gerais state, for example, *A. zenildae* was very abundant and dominant (Canal *et al.* 1998). However, in this research *A. zenildae* was not well represented in the traps. In the grove at Terenos, *A. dissimilis* was the most abundant species (Table 3). Although *A. fraterculus* was the most common and dominant species in several Brazilian regions, as pointed out in the Recôncavo Baiano, Bahia (Nascimento *et al.* 1993), in Espírito Santo (Martins *et al.* 2000), in Rio Grande do Sul (Kovaleski *et al.* 1999) and in Rio Grande do Norte (Maia-Lima 1997), in this survey, it only occurred as a dominant species in Anastácio and in Terenos it was an accidental occurrence in the McPhail traps (Table 3).

The diversity indices found in the two locations were: 1) the Shannon & Weaver index or the H index = 1.6488 (variance of H = 0.0041; n = 384) in the Terenos grove. In

Table 3. Faunistic analysis of fruit fly species (Diptera: Tephritidae) caught in 29 plastic McPhail traps with food bait in two orange groves in Anastácio and Terenos, MS March 22, 1994 to March 23, 1996).

Species	Chácara Laranjal, Anastácio			Colônia Jamic, Terenos		
	Frequency	Abundance	Dominance	Frequency	Abundance	Dominance
<i>A. alveatoides</i>	f	c	ndo	f	c	ndo
<i>A. bezzii</i>	if	r	ndo	0	0	0
<i>A. castanea</i>	0	0	0	if	di	ndo
<i>A. daciformis</i>	vf	va	do	vf	va	do
<i>A. dissimilis</i>	if	di	ndo	ef	oa	ovd
<i>A. distincta</i>	0	0	0	f	c	ndo
<i>A. fraterculus</i>	vf	va	do	f	c	ndo
<i>A. grandis</i>	0	0	0	if	di	ndo
<i>A. haywardi</i>	if	r	ndo	f	c	ndo
<i>A. leptozona</i>	if	r	ndo	0	0	0
<i>A. macrura</i>	if	di	ndo	0	0	0
<i>A. montei</i>	f	c	ndo	f	c	ndo
<i>A. obliqua</i>	vf	va	do	0	0	0
<i>A. pickeli</i>	vf	va	do	f	c	do
<i>A. punctata</i>	vf	va	do	vf	va	do
<i>A. rheediae</i>	f	c	ndo	f	c	ndo
<i>A. serpentina</i>	0	0	0	if	di	ndo
<i>A. sororcula</i>	vf	va	do	vf	va	do
<i>A. striata</i>	f	c	do	vf	va	do
<i>A. turpiniae</i>	if	di	ndo	if	di	ndo
<i>A. undosa</i>	if	r	ndo	if	di	ndo
<i>A. zenildae</i>	if	di	ndo	f	c	ndo
<i>Anastrepha</i> sp.1	0	0	0	if	r	ndo
<i>Anastrepha</i> sp.2	if	r	ndo	0	0	0
<i>Anastrepha</i> sp.3	0	0	0	if	r	ndo
<i>C. capitata</i>	ef	oa	ovd	ef	oa	ovd

Frequency: ef = extremely frequent, vf = very frequent, f = frequent, if = infrequent and 0 = no occurrence

Abundance: oa = over abundant, va = very abundant, a = abundant, c = common, di = disperse, r = rare and 0 = no occurrence

Dominance: ovd = overdominant, do = dominant, ndo = non-dominant and 0 = no occurrence

the grove at Anastácio, $H = 1.5677$ (variance of $H = 0.0070$; $n = 369$). By the Margalef equation, $\mu = 3.1929$ and 3.2145 for Terenos and Anastácio, respectively. In Goiás, the Margalef index was $\mu = 1.5$, where 18 species of fruit flies were collected, 17 *Anastrepha* spp. and *C. capitata* (Veloso 1997). In the north of Minas Gerais, the μ value was 2.26, with a diversity of 21 species: 20 *Anastrepha* spp. and *C. capitata* (Canal et al. 1998). Therefore, in Mato Grosso do Sul (Terenos and Anastácio), the diversity indices for fruit flies were the highest ever found in Brazil.

In Rio Grande do Norte, 13 species of *Anastrepha* and *C. capitata* were caught in McPhail traps (Araújo et al. 2000). In the Recôncavo Baiano, Nascimento & Zucchi (1981) collected 21 species of fruit fly. Martins et al. (2000) collected 23 species of *Anastrepha* in Espírito Santo. Therefore, when a general analysis of fruit fly species richness in several regions of Brazil is made, it can be concluded that in the Cerrado of Mato Grosso do Sul, there is a larger diversity of fruit flies and lonchaeids species than in any other Brazilian region already sampled with McPhail traps.

The faunistic analysis among the genera of the frugivorous Tephritoids (Table 4) showed that, in the *Citrus* groves in Anastácio and Terenos, the species of *Neosilba* were very

abundant, very frequent and constant, being dominant. In the groves in Terenos, the species of *Anastrepha*, *C. capitata* and *Lonchaea* spp. were very abundant and frequent. In the grove at Anastácio, the species of these three genera were common and frequent. The species of *Dasiops* were very abundant in Terenos and common and frequent in Anastácio.

Using McPhail traps, Uchôa-Fernandes & Zucchi (2000) reported 22 new records of fruit flies for Mato Grosso do Sul: *C. capitata* and 21 species of *Anastrepha* (including *A. haywardi* and *A. alveatoides*), in addition to the discovery of three new *Anastrepha* species. None of those Tephritidae species caught in the traps was associated with damage in the *Citrus* fruits in the groves. Only *Neosilba* sp. were reared from infested orange and tangerine fruits (unpubl. data).

Acknowledgments

To Prof. Dr. Aldo Malvasi - Departamento de Biologia, Universidade de São Paulo (USP), São Paulo-SP, for furnishing the traps and food bait; Prof. Dr. Sivaldo Silveira Neto - Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ-USP, for help with faunistic analysis, Dr. Allen L. Norrbom (National Museum of

Table 4. Faunistic analysis of the Tephritoidea (Diptera) genera with frugivorous species caught in 29 plastic McPhail traps with food bait in two orange groves in Anastácio and Terenos, MS (March 22, 1994 to March 23, 1996).

Genera	Chácara Laranjal, Anastácio			Colônia Jamic, Terenos		
	Frequency	Abundance	Dominance	Frequency	Abundance	Dominance
<i>Anastrepha</i>	f	c	ndo	f	va	ndo
<i>Ceratitis</i>	f	c	ndo	f	va	ndo
<i>Dasiops</i>	f	c	ndo	f	va	ndo
<i>Lonchaea</i>	f	c	ndo	f	va	ndo
<i>Neosilba</i>	vf	va	do	vf	va	do

Frequency: vf = very frequent, f = frequent and if = infrequent

Abundance: va = very abundant, a = abundant, c = common, di = disperse and r = rare

Dominance: do = dominant and ndo = non-dominant

Natural History, Washington-D.C., USA), for confirming the identity of *Dasiops inedulis*, *Neosilba zadolicha* and identification of *Notogramma cimiciforme* and Professor Elsbeth A. Flunker (WI, USA) for the revision of the version in English.

Literature Cited

- Alfaro, R.I. & J.H. Borden. 1980.** Predation by *Lonchaea corticis* (Diptera: Lonchaeidae), on the white pine weevil, *Pissodes strobi* (Coleoptera, Curculionidae). Can. Entomol. 112: 1259-1270.
- Araújo, E.L., F.A. Maia-Lima & R.A. Zucchi. 2000.** Moscas-das-frutas nos estados brasileiros: Rio Grande do Norte, p. 223-226. In A. malavasi & R.A. Zucchi (eds.), Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado. Ribeirão Preto, FAPESP-Holos, 327p.
- Blanchard, E.E. 1961.** Especies argentinas del género *Anastrepha* Schiner (sens. lat.) (Diptera, Trypetidae). Rev. Invest. Agr. 15: 221-342.
- Canal, N.A., C.D. Alvarenga & R.A. Zucchi. 1998.** Análise faunística de espécies de moscas-das-frutas (Dip., Tephritidae) em Minas Gerais. Sci. Agr. 55: 15-24.
- Drew, R.A.I. & D.L. Hancock. 1994.** The *Bactrocera dorsalis* complex of fruit flies (Diptera: Tephritidae: Dacinae) in Asia. Bull. Entomol. Res. Suppl. 2: 1-68.
- Foote, R.H. 1980.** Fruit fly genera South of the United States. Washington, USDA, 79p. (U.S.D.A., Science and Education Administration, Technical Bulletin 1600).
- Hulme, M.A. 1989.** Laboratory assessment of predation by *Lonchaea corticis* (Diptera: Lonchaeidae) on *Pissodes strobi* (Coleoptera: Curculionidae). Environ. Entomol. 18: 1011-1014.
- Hulme, M.A. 1990.** Field assessment of predation by *Lonchaea corticis* (Diptera: Lonchaeidae) on *Pissodes strobi* (Coleoptera: Curculionidae) in *Picea sitchensis*. Environ. Entomol. 19: 54-58.
- Korytkowski, C.A. & P.D. Ojeda. 1971.** Revision de las especies de la familia Lonchaeidae en el Peru (Diptera, Acalyptratae). Rev. Peru. Entomol. 14: 87-116.
- Kovaleski, A., K. Uramoto, R.L. Sugayama, D.N.A. Canal & A. Malavasi. 1999.** A survey of *Anastrepha* Schiner (Diptera, Tephritidae) species in the apple growing area of the state of Rio Grande do Sul, Brasil. Revta. Bras. Ent. 43: 229-234.
- Kovalev, V.G. 1974.** Species of the genus *Lonchaea* Fallén close to *L. limatula* Collin (Diptera, Lonchaeidae). Rev. Entomol. I'URSS 53 : 447-453.
- Kovalev, V.G. 1979.** New and little-known species of Lonchaeidae (Diptera) from the Moscow Region. Entomol. Rev. 57: 131-139.
- Lima, A. da C. 1934.** Moscas-das-frutas do gênero *Anastrepha* Schiner, 1868. Mem. Inst. Oswaldo Cruz 28: 487-575.
- Lourenção, A.L., J.O. Lorenzi & G.M.B. Ambrosano. 1996.** Comportamento de clones de mandioca em relação a infestação por *Neosilba perezii* (Romero & Ruppell). Sci. Agr. 53: 304-308.
- Maia-Lima, F.A. 1997.** Aspectos bioecológicos de espécies de *Anastrepha* e *Ceratitis capitata* (Diptera: Tephritidae) em três áreas do litoral oriental do Estado do Rio Grande do Norte. São Paulo. Tese de doutorado, Instituto de Biociências, USP, São Paulo, 128p.
- Martins, D.S., K. Uramoto & A. Malavasi. 2000.** Moscas-das-frutas nos estados brasileiros: Espírito Santo, p. 253-258. In A. Malavasi & R.A. Zucchi (eds.), Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e Aplicado. Ribeirão Preto, FAPESP-Holos, 327p.
- McAlpine, J.F. 1960.** Diptera (Brachycera) Lonchaeidae. South Afr. Anim. Life 7: 327-376.
- McAlpine, J.F. 1987.** Lonchaeidae, p.791-796. In J.F. McAlpine, (ed.), Manual of Nearctic Diptera. Vol. 2. Biosystematics Research Institute, Ottawa, Research Branch, Agriculture Canada, Monograph 28, 1332p.

- McAlpine, J.F. & G.C. Steyskal. 1982.** A revision of *Neosilba* McAlpine with a key to the world genera of Lonchaeidae (Diptera). *Can. Entomol.* 114: 105-137.
- Nascimento, A.S. do, J.S. Morgante, A. Malavasi & K. Uramoto. 1993.** Occurrence and distribution of *Anastrepha* in melon production areas in Brazil, p.39-42. In M. Aluja & P. Liedo (eds.), *Fruit flies: biology and management*. New York, Springer-Verlag, 492p.
- Nascimento, A.S. do & R.A. Zucchi. 1981.** Dinâmica populacional das moscas-das-frutas do gênero *Anastrepha* (Dip., Tephritidae) no recôncavo baiano. I – Levantamento das espécies. *Pesq. Agropec. Brasil.* 16: 763-767.
- Norrbom, A.L. 1998.** A revision of the *Anastrepha daciformis* species group (Dip., Tephritidae). *Proc. Entomol. Soc. Wash.* 100: 160-192.
- Norrbom, A.L. & J.F. McAlpine. 1997.** A revision of the neotropical species of *Dasiops* Rondani (Diptera: Lonchaeidae) attacking *Passiflora* (Passifloraceae). *Memoir. Entomol. Soc. Wash.* 18: 189-211.
- Norrbom, A.L., R.A. Zucchi & V. Hernández-Ortiz. 1999.** Phylogeny of the genera *Anastrepha* and *Toxotrypana* (Trypetinae: Toxotripanini) based on morphology. *Cap.* 12, p. 229-341. In M. Aluja & A.L. Norrbom (eds.), *Fruit flies (Tephritidae): Phylogeny and evolution behavior*. Washington, CRC Press, 944p.
- Peñaranda, A. de, P.C. de Ulloa & M.R. de Hernández. 1986.** Biología de la mosca de los botones florales del maracuyá *Dasiops inedulis* (Diptera: Lonchaeidae) en el Valle del Cuaca. *Rev. Colomb. Entomol.* 12: 16-22.
- Sánchez, A., H. Blanco, G. Calvo & P. Shannon. 1991.** Evaluation de cuatro insecticidas para el control de la mosca del Chile *Neosilba* spp. (Diptera: Lonchaeidae), bajo dos sistemas de manejo. *Man. Integr. Plagas* 20-21: 57-60.
- Sakagami, S.F. & S. Laroca. 1971.** Relativa abundance, phenology and flower visits of apid bees in eastern Paraná, Southern Brazil (Hymenoptera: Apidae). *Koniyu* 39: 217-230.
- Silveira Neto, S., O. Nakano, D. Barbin & N.A. Vila Nova. 1976.** Manual de ecologia dos insetos. São Paulo, Ceres, 420p.
- Southwood, T.R.E. 1995.** *Ecological methods: with particular reference to the study of insect populations.* 2 ed. London, Chapman & Hall, 524p.
- Souza, H.M.L. de, O.H.O. Pavan, I.D. Silva. & S. R. Matioli. 1986.** New fruit flies bait solutions. *Rev. Bras. Entomol.* 30: 251-255.
- Steyskal, G.C. 1977a.** History and use of the McPhail Trap. *Fla. Entomol.* 60:11-16.
- Steyskal, G.C. 1977b.** Pictorial key to species of the genus *Anastrepha* (Diptera: Tephritidae). Washington, Entomol. Soc. Wash, 35p.
- Stone, A. 1942.** The fruit flies of the genus *Anastrepha*. Washington: USDA (USDA, Miscellaneous Publication, 439), 112p.
- Uchôa-Fernandes, M.A. & R.A. Zucchi. 1999.** Metodología de colecta de Tephritidae y Lonchaeidae frugívoros (Diptera:Tephritoidea) y sus parasitoides (Hymenoptera). *An. Soc. Entomol. Brasil* 28: 601-610.
- Uchôa-Fernandes, M.A. & R.A. Zucchi. 2000.** Moscas-das-frutas nos estados brasileiros: Mato Grosso e Mato Grosso do Sul, p. 241-245. In A. Malavasi & R.A. Zucchi (eds.), *Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado*. Ribeirão Preto, FAPESP-Holos, 327p.
- Veloso, V.R.S. 1997.** Dinâmica populacional de *Anastrepha* spp. e *Ceratitis capitata* (Wied., 1824) (Diptera: Tephritidae) nos cerrados de Goiás. Tese de doutorado. Escola de Agronomia, Universidade Federal de Goiás, Goiânia, 115p.
- Zucchi, R.A. 2000.** Taxonomia, p. 13-24. In A. malavasi & R.A. Zucchi (eds.), *Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado*. Ribeirão Preto, FAPESP-Holos, 327p.

Received 22/10/01. Accepted 28/02/03.