

CROP PROTECTION

Fruit Fly (Diptera: Tephritoidea) Infestation in Citrus in the State of São Paulo, Brazil

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Infestação de Moscas-das-Frutas (Diptera: Tephritoidea) em Citros no Estado de São Paulo

RESUMO - No período de fevereiro de 1998 a maio de 2000, frutos de diferentes variedades e híbridos de citros foram coletados para determinar os níveis de infestação e o complexo de espécies de Tephritoidea/parasitóides, nas condições do estado de São Paulo. O total de 12.239 frutos (1.416,93 kg) foi coletado em 25 municípios. Do total das amostras foram recuperados 5.252 pupários e 3.039 adultos de Tephritoidea. Aproximadamente 78,1% dos adultos foram Tephritidae [77,1% de *Anastrepha* sp. e 1,0% de *Ceratitis capitata* (Wied.)], e 21,9%, Lonchaeidae (*Neosilba* spp.). Todas as fêmeas de *Anastrepha* foram identificadas como *A. fraterculus* (Wied.). Adultos de Braconidae, Diapriidae e Eucolilinae emergiram das amostras de citros. Os índices médios de infestação foram 0,4 pupário/fruto e 3,7 pupários/ kg de frutos. As laranjas doces foram as variedades cítricas mais susceptíveis ao ataque de espécies de Tephritoidea, em número de pupários/fruto. Em amostras isoladas, 'Tangerina Cravo' (*Citrus reticulata*) e 'Laranja Azeda' (*Citrus aurantium*) apresentaram os maiores índices de infestação por fruto (3,4 e 2,4 pupários, respectivamente). Algumas amostras de 'Kunquat' (*Fortunella* sp.) e 'Tangerina Cravo' alcançaram níveis altos de infestação (64,0 e 37,9 pupários/kg de frutos, respectivamente). As laranjas doces são as variedades mais suscetíveis à infestação de Tephritoidea no estado de São Paulo. O parasitóide *D. areolatus* (Opiinae) foi o braconídeo mais freqüente durante o levantamento.

PALAVRAS-CHAVE: Insecta, Tephritidae, Lonchaeidae, índice de infestação

ABSTRACT - From February 1998 to May 2000, fruits of different citrus varieties and hybrids were collected in order to assess the fruit fly infestation levels and tephritoid/parasitoid complex in the state of São Paulo. A total of 12,239 fruits (1,416.93 kg) was collected in 25 municipalities. From all the samples 5,252 puparia and 3,039 adults of Tephritoidea were recovered. About 78.1% of all adults collected were Tephritidae [77.1% de *Anastrepha* sp. and 1.0% de *Ceratitis capitata* (Wied.)] and 21.9% were Lonchaeidae (*Neosilba* spp.). All females of *Anastrepha* were identified as *A. fraterculus* (Wied.). Adults of Braconidae, Diapriidae and Eucolilinae emerged from the citrus samples. Mean infestation indices were 0.4 puparium/ fruit and 3.70 puparia/kg of fruits. Sweet oranges were the most susceptible to Tephritoidea infestations when the number of puparia/fruit was considered. In isolated samples, 'Cravo mandarin' (*Citrus reticulata*) and sour orange (*Citrus aurantium*) showed the highest infestation indices (3.4 and 2.4 puparia/fruit, respectively). Some samples of 'Kunquat' (*Fortunella* sp.) and 'Cravo' mandarin reached high levels of infestation (64.0 and 37.9 puparia/kg of fruits, respectively). The sweet oranges were the most susceptible to Tephritoidea infestations in the state of São Paulo. The parasitoid Opiinae *D. areolatus* was the most abundant braconid species.

KEY WORDS: Insecta, Tephritidae, Lonchaeidae, infestation index

Tephritid species have caused tremendous losses in fruit production and imposed limits on the export market in several countries. According to White & Elson-Harris (1994), the family Tephritidae includes 4,000 species arranged in 500

genera. Five genera are considered of worldwide economic importance: *Anastrepha* Schiner, *Bactrocera* Macquart, *Ceratitis* MacLeay, *Dacus* Fabricius and *Rhagoletis* Loew.

From about 195 species of *Anastrepha* found in America,

94 were reported in Brazil (Zucchi 2000a). *Ceratitis capitata* (Wied.) was detected 100 years ago infesting peach and sweet orange in the state of São Paulo (Ihering 1901) and nowadays, it is established in all Brazilian regions, including urban areas. *Anastrepha fraterculus* (Wied.) (Lima 1926, Puzzi & Orlando 1965, Malavasi et al. 1980, Salles 1995, Raga et al. 1997, Souza Filho 1999), *Anastrepha obliqua* (Macquart) (Bressan & Teles 1991, Aguiar-Menezes & Menezes 1997, Souza Filho 1999) and *Anastrephae turpiniae* Stone (Uchôa-Fernandes et al. 2002) have been reported in citrus in Brazil.

The state of São Paulo is responsible for 80% of the Brazilian citrus yield. From unsprayed citrus orchards, the fruit dropping caused by fruit flies is estimated in 25-50%. In the central growing region, early oranges are susceptible to tephritid infestation after they reach 50% of their full size (Souza Filho & Raga 1998). This study was conducted to evaluate the diversity of Tephritoidea and the natural infestation levels in citrus in the state of São Paulo. The tephritoid/parasitoid complex in citrus was also studied.

Material and Methods

From February 1998 to May 2000, 150 fruit samples of 25 varieties and one hybrid of citrus were collected from 25 municipalities of the state of São Paulo. A total of 12,239 fruits (1,416.93 kg) were collected at random on the top and from the ground under the trees. Samples were obtained from unsprayed trees and brought to the Laboratório de Entomologia Econômica, Instituto Biológico, located in the municipality of Campinas, São Paulo state, Brazil. The fruits were counted, weighed and placed into fruit-holding boxes containing sand at the bottom and a piece of cotton cloth at the top. About 15 days later, the sand in the boxes was sieved to remove fruit fly puparia, which were counted and transferred to a glass cage (6,000 cc) with a little amount of dry sand at the bottom and kept at $25 \pm 2^\circ\text{C}$ and $70 \pm 10\%$ of relative humidity for 25 days to allow the maximum emergence rate. Adults were fed on a mixture of sugar/yeast extract (3:1) and water. After complete emergence, adults were killed in a freezer and placed in labeled vials with 70% alcohol for identification. *Anastrepha* specimens were identified based on Stone (1942), Steyskal (1977) and Zucchi (2000b). Braconids were identified according to Leonel Jr. et al. (1996).

Results and Discussion

Table 1 summarizes the results of fruit fly diversity in different citrus varieties and hybrids, their infestation indices and parasitoids.

Considering all collections, 5,252 puparia and 3,039 adults of Tephritoidea (females + males) were recovered, with the following distribution: 78.1% of Tephritidae (77.1% of *Anastrepha* sp. and 1.0% of *C. capitata*) and 21.9% of Lonchaeidae (*Neosilba* spp.).

From overall collections the mean infestation indices were 0.4 puparium/fruit and 3.7 puparia/kg of fruits. Among sweet oranges (*C. sinensis*), 'Pera', 'Hamlin', 'Natal' and 'Bahia' were the most infested varieties (0.8, 0.8, 0.9 and 1.0 puparium/fruit, respectively). 'Pera' is the most important variety

cultivated in São Paulo, accounting for 41% of the sweet orange trees (Teófilo Sobrinho et al. 2001).

'Kunquat' (*Fortunella* sp.), sour orange (*C. aurantium*), 'Rio' mandarin (*C. deliciosa*) and 'Cravo' mandarin (*C. reticulata*) seem also to be good citrus hosts for tephritoids, with mean infestation indices of 7.4, 6.0, 4.7 and 3.7 puparia/kg of fruits. In isolated samples, 'Cravo' mandarin and sour orange showed the highest values of puparia per fruit: 3.4 and 2.4, respectively. Some samples of 'Kunquat' and 'Cravo' mandarin reached very high levels of infestation (64.0 and 37.9 puparia/kg of fruits, respectively). No puparium was recovered from 'Persian Lime' (*Citrus latifolia*), 'Trifoliata' orange (*Poncirus trifoliata*) and 'Grapefruit' (*Citrus paradisi*).

The percentage of fruit fly incidence in citrus varieties which produced at least 10 adults is presented in the Fig. 1. About 80% of citrus samples were infested by fruit flies.

Only *A. fraterculus* was identified from a total of 1,105 *Anastrepha* females. This species occurred in all varieties which produced Tephritoidea adults (Fig. 1), except in 'Folha Murcha' orange and 'Rangpur' lime. Of the 20 varieties and one hybrid of citrus registered as *A. fraterculus* host in the present study, the occurrence of this tephritid in 'Murcott' tangor (*C. reticulata* x *C. sinensis*) and 'Cidra' (*C. medica*) represents the first report in the state of São Paulo.

Our results showed that 90% of citrus samples were not infested by mediterranean fruit fly (Fig. 1). This species had been reported with emphasis as a serious pest of citrus in earlier studies conducted in the state of São Paulo (Puzzi & Orlando 1965, Bressan & Teles 1991). Status changing of medfly in citrus may be attributed to the intensive urbanization process of the sampled counties. In the same sampled regions, tropical almond (*Terminalia catappa*) is a preferential host of *C. capitata* in urban areas (Souza Filho 1999) while coffee is the primary host in the rural zones (Raga et al. 1996, Raga et al. 2002). 'Cidra' is listed as medfly host for the first time in the state of São Paulo.

In the present study, *Neosilba* spp. (Lonchaeidae) were present in 38% of the citrus samples (Fig. 1), infesting *C. sinensis*, *C. aurantium*, *C. reticulata*, 'Murcott' tangor, *Fortunella* sp., and *C. limonia*. 'Kunquat' had the highest relative incidence of *Neosilba* spp. (62.3%).

Lonchaeidae species are important pests of several horticultural crops (Norrbom & McAlpine 1997). In Brazil, the economic importance of Lonchaeidae is underestimated, although its occurrence has been reported by several authors since the beginning of the last century. An opportunistic behaviour is attributed to this group because it is supposed that females lay the eggs on previously ovipositioned fruit. However, our observations indicated that this theory may not be true in all cases because only *Neosilba* spp. emerged from some citrus samples.

In this study, only 366 adults of parasitoids emerged from the collections. Braconids represented 97.3% of all specimens collected, with 93.2% of *Doryctobracon areolatus* (Szèpligeti), 3.6% of *Doryctobracon brasiliensis* (Szèpligeti) and 0.5% of *Opius* sp. According to Leonel Jr. et al. (1995), *D. areolatus*, which occur from Argentina to the southern USA, is the most common braconid species in Brazil. All three braconids recorded in the present study had already been reported in

Table 1. Host citrus plants of Tephritoidea in the state of São Paulo (February 1998 to May 2000).

Botanical name	Common name	Total n ^o samples ¹	Total n ^o fruits	Total weight/kg	Infestation indices ²		<i>C. capitata</i>		<i>Anastrepha</i> sp.		<i>Neosilba</i> spp.	Parasitoids
					Puparia/fruit	Puparia/kg	♀	♂	♀	♂		
<i>C. sinensis</i>	'Pera' orange	23 (21)	1,950	260.90	0.8 (0.0-2.2)	6.4 (0.0-12.9)	8	3	452	475	238	193 ³ <i>D. areolatus</i> 05 <i>D. brasiliensis</i> 01 <i>L. anastrephae</i> 01 <i>Trichopria</i> sp.?
<i>C. sinensis</i>	'Hamlin' orange	5 (5)	759	99.90	0.8 (0.3-1.4)	5.8 (0.1-13.8)	1	2	120	122	97	73 <i>D. areolatus</i>
<i>C. sinensis</i>	'Natal' orange	9 (9)	489	80.33	0.9 (0.1-1.4)	5.45 (0.1-7.6)	0	1	73	63	98	17 <i>D. areolatus</i>
<i>C. sinensis</i>	'Lima' orange	8 (7)	643	65.09	0.2 (0.0-0.8)	1.7 (0.0-9.0)	0	0	14	47	6	6 <i>D. areolatus</i>
<i>C. sinensis</i>	'Valencia' orange	7 (7)	969	146.32	0.3 (0.1-0.9)	2.2 (0.3-4.6)	0	0	68	94	6	2 <i>D. areolatus</i> 1 <i>L. anastrephae</i> 1 <i>Trichopria</i> sp.?
<i>C. sinensis</i>	'Bahia' orange	7 (7)	309	60.46	1.0 (0.4-2.2)	5.3 (0.1-6.3)	0	1	84	80	22	9 <i>D. areolatus</i> 5 <i>Trichopria</i> sp.?
<i>C. sinensis</i>	'Baianinha' orange	4 (4)	239	34.04	0.2 (0.1-0.4)	1.4 (0.7-1.7)	0	0	9	8	5	2 <i>D. areolatus</i> 4 <i>D. brasiliensis</i>
<i>C. sinensis</i>	Sweet oranges Uncertain varieties	11 (7)	765	100.02	0.3 (0.0-1.1)	2.2 (0.0-8.7)	2	2	53	47	1	7 <i>D. areolatus</i>
<i>C. sinensis</i>	'Barão' orange	2 (2)	102	12.25	0.2 (0.1-0.7)	1.9 (0.3-7.3)	0	0	2	7	0	1 <i>D. areolatus</i>
<i>C. sinensis</i>	'Folha Murcha'	2 (2)	103	20.64	0.1 (0.1-0.3)	0.4 (0.1-0.3)	0	0	0	0	1	-
<i>C. sinensis</i>	'Sanguinea' orange	1 (1)	112	13.50	0.1	0.8	0	0	3	3	0	1 <i>Trichopria</i> sp.?
<i>C. sinensis</i>	'Selecta' orange	1 (1)	28	8.50	0.2	0.6	0	0	3	1	1	-
<i>C. aurantium</i>	Sour orange	5 (4)	211	28.25	0.8 (0.0-2.4)	6.0 (0.0-21.7)	0	0	54	66	17	5 <i>D. areolatus</i>
<i>C. reticulata</i>	'Cravo' mandarin	15 (11)	642	74.07	0.4 (0.0-3.4)	3.7 (0.0-37.9)	2	0	44	58	59	9 <i>D. areolatus</i>
<i>C. reticulata</i>	'Ponkan' mandarin	13 (10)	889	130.69	0.2 (0.0-1.8)	1.5 (0.0-12.1)	4	0	11	24	10	-
<i>C. deliciosa</i>	'Rio' mandarin	3 (2)	367	17.92	0.2 (0.0-0.6)	4.7 (0.0-9.8)	0	0	2	2	0	-
<i>C. deliciosa</i>	'Cleopatra' mandarin	2 (1)	368	13.92	0.003	0.07	-	-	-	-	-	-
<i>P. trifoliata</i>	'Trifoliata' orange	2 (0)	541	21.78	-	-	-	-	-	-	-	-
<i>C. reticulata</i> <i>x C. sinensis</i>	'Murcott' tangor	12 (9)	1061	130.41	0.3 (0.0-1.1)	2.8 (0.0-8.8)	0	0	100	102	11	17 <i>D. areolatus</i> 4 <i>D. brasiliensis</i>
<i>Fortunella</i> sp.	'Kunquat'	6 (5)	965	9.97	0.1 (0.0-0.3)	7.4 (0.0-64.0)	4	0	10	38	86	2 <i>Opius</i> sp.
<i>C. limonia</i>	'Rangpur' lime	8 (3)	650	62.73	0.02 (0.0-0.2)	0.2 (0.0-2.6)	0	0	0	0	6	-
<i>C. latifolia</i>	Persian lime	1 (0)	44	5.69	-	-	-	-	-	-	-	-
<i>C. paradisi</i>	Grapefruit	1 (0)	8	4.40	-	-	-	-	-	-	-	-
<i>C. grandis</i>	Toranja	1 (1)	8	5.70	0.4	0.5	0	0	1	1	0	-
<i>C. medica</i>	'Cidra'	1 (1)	17	9.45	0.3	0.6	1	0	2	1	0	-
Total		150 (120)	12,239	1,416.93	0.4	3.7	22	9	1,105	1,239	664	366

¹Number of collected samples (Number of infested samples)²Mean (the lowest and the highest infestation/variety)³Number of specimens

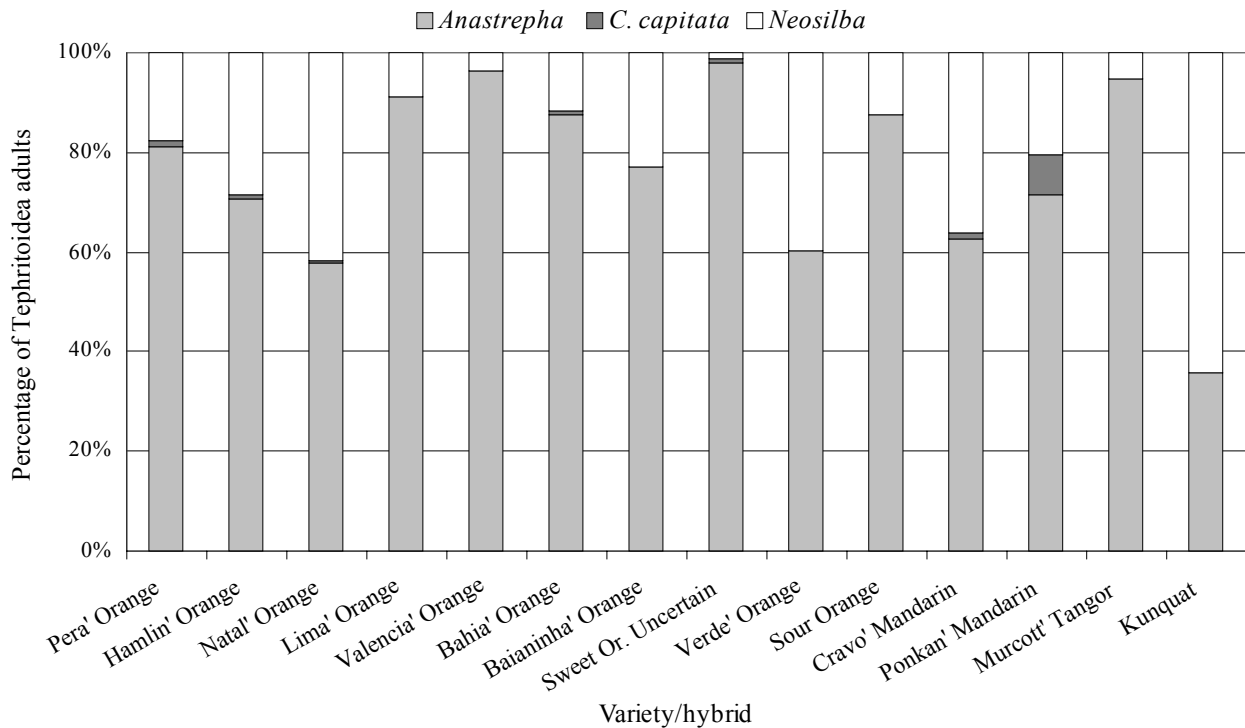


Figure 1. Percentage of fruit fly incidence in citrus varieties that produced at least 10 adults in São Paulo state (February 1998 to May 2000).

A. fraterculus in Brazil (Leonel Jr. et al. 1995, Souza Filho 1999, Zucchi 2000a).

Lopheucoila anastrephae (Rowle) (Figitidae) and *Trichopria* sp. (Diapriidae) were also obtained, representing 0.5% and 2.2% of the total number of parasitoids, respectively. Wharton et al. (1998) mentioned that *L. anastrephae* is related to *A. fraterculus*, *C. capitata* and *Neosilba* spp. in Latin America. In Brazil, Guimarães et al. (1999) reported *L. anastrephae* in citrus infested by *A. fraterculus*.

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