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TEPHRITOID FLIES (DIPTERA, TEPHRITOIDEA) AND THEIR PLANT HOSTS FROM THE STATE OF SANTA CATARINA IN SOUTHERN BRAZIL

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ABSTRACT

A total of 12,540 ripe fruits belonging to 46 species in 25 plant families were sampled from either the trees or the ground in 6 municipalities in the state of Santa Catarina, Brazil between 2002 and 2006 to determine which fruit fly species developed on various host plants. Each fruit was weighed and placed into a plastic flask filled with sterilized sand 7 cm deep, and the opening of the flask was covered with sheer fabric. The flasks were kept under controlled conditions ($25 \pm 3^\circ\text{C}$, $70 \pm 10\%$ RH and 12h photophase). After 7 d, the pupae were sifted from the sand and transferred to Petri dishes lined with filter paper. Twenty-one species of Tephritoidea were recovered consisting of 13 species of Tephritidae, 6 of Lonchaeidae, and 2 of Ulidiidae. We present new host records for some species of fruit flies.

Key Words: Tephritidae, Lonchaeidae, Ulidiidae, fruit pests, new host records

RESUMEN

Este trabajo dirigido a la evaluación de las especies de moscas de la fruta y sus plantas hospederas en el estado de Santa Catarina Brasil. Un total de 12.540 frutos maduros que pertenecen a 46 especies y 25 familias de arboles o del suelo en seis municipios del estado de Santa Catarina, Brasil entre 2002 y 2006 fueran muestradas. Cada fruto fue pesado y se coloca en un frasco de plástico cubierto con Voil, con 7 cm de arena esterilizada. Los frascos fueron mantenidos en condiciones controladas ($25 \pm 3^\circ\text{C}$, UR $70 \pm 10\%$ y 12h de photophase). Después de siete días, la arena se tamiza y la pupas fueron transferidas a placas de petri con papel filtro como sustrato. Veintiún especies de Tephritoidea fueron recuperados - 13 especies de Tephritidae, seis especies de Lonchaeidae, y dos de Ulidiidae. Se presentan los registros de para algunas especies de fruta o moscas.

Translation provided by the authors.

Approximately 70 species of Tephritidae are considered important pests of fruit production worldwide. The majority of the species of economic importance belong to 5 genera: *Anastrepha*, *Bactrocera*, *Ceratitidis*, *Dacus*, and *Rhagoletis* (Garcia 2009). The genus *Neosilba* of the family Lonchaeidae (McAlpine & Steyskal 1982) includes 16 described species (Strikis & Prado 2005), some of which cause severe damage to certain species of fruit crops in the American tropics.

Field surveys of fruit flies (Tephritoidea) and their host plants and parasitoids are essential for understanding the bioecology of the economically important genera and species in this superfamily (Bateman 1972). The creation of the common market, Mercosul, involving Brazil, Argentina, Paraguay and Uruguay, has elevated the importance of such studies because knowledge of these pest species, their hosts and natural enemies is key to containing their destructive effects as

trade in fruits between these countries expands. In Brazil, most of the pest tephritids belong to the genus *Anastrepha*, but host plants are known for only 44% of the species (Zucchi 2007).

Santa Catarina has the most host plant records, 81, for species of Tephritidae among the Brazilian states (Garcia 2011). However, only 46 plant species belonging to 18 families are recorded in the state as hosts for fruit flies in the genus *Anastrepha* (Nora et al. 2000).

This work reports new information from a survey of fruit fly species and their host plants in the state of Santa Catarina, Brazil.

MATERIALS AND METHODS

Fruit Sampling

Between 2002 and 2006, a total of 12,540 ripe fruits from 46 plant species belonging to 25 fami-

lies were sampled. Fruits were picked from the plants, or freshly fallen fruits were gathered from the ground below them. Sampling occurred in 6 municipalities of Santa Catarina, Brazil: Anchieta (26° 53'S and 53° 33'W), Chapecó (27° 06'S and 53° 16'W), Cunha Porã (26° 07'S and 53°W 16'), Palmitos (27° 06'S and 53° 16'W), São Carlos (27° 07' S and 53° 00' W), and Xanxerê (26° 87' S and 52°W' 40). Each fruit was weighed and placed into a plastic flask containing 7 cm of sterilized sand, and the opening of the flask was covered with sheer fabric. The flasks were kept under controlled conditions (25 ± 3°C, 70 ± 10% RH and 12h photophase). After 7 d, the sand was sifted and the pupae transferred to Petri dishes with filter paper as substrate.

Identification of fruit flies and host plants

Characters of the females, primarily of the aculeus, and body and wing markings, were considered in identifying species of *Anastrepha* (Zucchi 2000) identified by Garcia and Zucchi. *Ceratitis capitata* (Wiedemann) is the only species of *Ceratitis* in Brazil and was easily recognized by the description by Zucchi (2000). Lonchaeidae were identified by Dr. Pedro Strikis, and other Tephritidae and *Notogramma cimiciforme* Loew (Ulidiidae) were identified by Norrbom. The host plant species were identified by the botanists Dr. Sérgio Augusto de Loreto Bordignon, Dr. Rosiane Berenice Denardin, and Lúcia Salengue. Some voucher specimens of fruit flies and host plants were deposited at the Zoobotanic Museum of the University of Chapecó.

Data Analysis

The infestation indexes were calculated in 2 ways: (1) by dividing the total number of puparia obtained by the number of fruits in the sample (puparia/fruit); or (2) by dividing the total number of puparia by the total mass (kg) of fruits in the sample (puparia/kg). The host plants of *Anastrepha* obtained in this work were compared to the lists of hosts assembled by Norrbom (2004) and Zucchi (2007, 2008) with the aim of providing new host records for Brazil.

RESULTS AND DISCUSSION

Twenty-one species of Tephritoidea were recovered: 13 species of Tephritidae, 6 of Lonchaeidae, and 2 of Ulidiidae (= Otitidae) (Table 1). The species, *Parastenopa guttata* Aczél and *P. montana* Aczél, are new records of fruit flies for the state of Santa Catarina, and the total number of known species of Tephritidae from the state is now 81 (Garcia 2011). The development of flies from the fruit of yerba maté, *Ilex paraguariensis* A. St. Hil., is reported for the first time. Two spe-

cies of the genus *Parastenopa*, *P. guttata* and *P. montana*, were reared. The only *Parastenopa* species previously known to attack this plant were reared from stems or from leaf galls of the Paraguay tea psyllid, *Gyropsylla spegazziniana* Lizer & Trelles (Hemiptera, Psyllidae) (Blanchard 1929; psyllid as *Metaphalara spegazziniana*), although the North American *P. limata* (Coquillett) breeds in the fruit of several *Ilex* species (Benjamin 1934; Phillips 1946). Araticum, *Annona rugulosa* (Schltdl.) H. Rainer (Annonaceae), *Inga sellowiana* Benth. (Fabaceae), and the iguana hackberry, *C. iguanaea* (Jacq.) Sarg. (Ulmaceae) are recorded for the first time as host plants of *Anastrepha fraterculus* (Wiedemann). Rio Grande cherry, *Eugenia involucrata* DC., is recorded for the first time as a host plant of *Anastrepha obliqua* (Macquart); and sete-capas, *Campomanesia guazumifolia* (Cambess.) O. Berg. (Myrtaceae), is recorded as a host plant of *Anastrepha sororcula* Zucchi. Strawberry guava, *P. cattleianum* Sabine (Myrtaceae), is recorded for the first time as host plant of both *A. obliqua* and *A. sororcula* in Brazil. Previously strawberry guava had been reported as a host of *A. obliqua* in Guatemala (Eskafi & Cunningham, 1987).

The greatest infestations based on the number of puparia per fruit were found in pumpkin, *Cucurbita pepo* L. (6.59), followed by pineapple guava, *Acca sellowiana* (O. Berg) Burret (6.23), and common guava, *Psidium guajava* L. (6.16). Regarding the parameter puparia/kg, the greatest infestations occurred in strawberry guava, *P. cattleianum* (422), followed by pineapple guava, *P. cattleianum* (278), yerba maté, *I. paraguariensis* A. St. Hil. (260), and wild cherry, *P. avium* (L.) L. (232). Considering both parameters, pineapple guava, *P. cattleianum*, was the species most infested by fruit flies.

The highest number of plant hosts was recorded for *A. fraterculus* (20 plant species from 8 families) (Table 1); predominantly fig, *Ficus carica* L. (Moraceae) (75.0% of the total of samples collected were infested); guavirova, *Campomanesia xanthocarpa* O. Berg, (60.7%); guaviju, *Myrcianthes pungens* (O. Berg) D. Legrand (57.1%); Surinam cherry, *Eugenia uniflora* L. (55.3%); wild cherry, *P. avium* (L.) L. (Rosaceae) (52.0%); pineapple guava, *P. cattleianum* (51.7%); common guava, *P. cattleianum* (51.4%); guava (48.0%), *Campomanesia guazumifolia* (45.4%) (Myrtaceae); and carambola, *Averrhoa carambola* L. (Oxalidaceae), (35.3%).

Nine new host plants of *A. fraterculus* were recorded in Brazil: araticum, *A. rugulosa* (Annonaceae); *Inga sellowiana* (Fabaceae); common fig, *F. carica* (Moraceae); pineapple guava, *P. cattleianum* (Myrtaceae); jaboticaba, *Myrciaria cauliflora* (Mart.) O. Berg (Myrtaceae); *Campomanesia guazumifolia* (Myrtaceae); wild cherry, *P. avium* (Rosaceae); bergamot orange, *Citrus reticulata*

TABLE 1. PLANTS SAMPLED WITH THEIR RESPECTIVE ORIGIN (O), FRUIT WEIGHT (FW), NUMBER OF FRUITS SAMPLED (N), NUMBER OF PUPAE (P), AVERAGE NUMBER OF PUPAE PER FRUIT (P/N), AND AVERAGE NUMBER OF PUPAE PER KG (P/KG). N = NATIVE AND E = EXOTIC. NUMBER IN PARENTHESES FOLLOWING FLY SPECIES NAMES = NUMBER OF SPECIMENS REARED.

Plant Species	O	FW (kg)	# fruits <i>n</i>	# pupae P	P/n ± SE	P/kg ± SE	Tephritidae	Lonchaeidae & Ulidiidae
Annonaceae								
Araticum, <i>Annona rugulosa</i>	N	4.64	102	33	0.32 ± 0.1	7.10 ± 2.4	<i>A. fraterculus</i> (3)	<i>Neosilba zadolicha</i> (18)
Aquifoliaceae								
Erva-mate, <i>Ilex paraguariensis</i>	N	1.00	2465	259	0.11 ± 0.1	259.70 ± 20.5	<i>Parastenopa</i> spp.(254)	
Cactaceae								
<i>Pereskia aculeata</i>	N	0.37	50	45	0.90 ± 0.2	121.62 ± 10.4	<i>A. barbiellinii</i> (19)	
Cucurbitaceae								
Abóbora, <i>Cucurbita pepo</i>	E	139.77	68	448	6.59 ± 2.1	3.21 ± 1.8	<i>A. grandis</i> (310)	<i>Dasiops</i> sp. (8) <i>Euxesta</i> sp.(12) <i>Neosilba padroii</i> (40) <i>Euxesta</i> sp. (22) <i>Lonchaea</i> sp. (12) <i>Neosilba padroii</i> (10)
Chuchu, <i>Sechium edule</i>	E	8.94	120	46	0.38 ± 0.1	5.15 ± 3.2		
Melancia, <i>Citrullus lanatus</i>	E	58.30	14	2	0.14 ± 0.1	0.03 ± 0.1	<i>A. grandis</i> (2)	
Melão, <i>Cucumis melo</i>	E	10.80	13	12	0.92 ± 0.3	1.11 ± 0.7		
Pepino, <i>Cucumis sativus</i>	E	8.22	43	11	0.26 ± 0.1	1.34 ± 0.8		
Ebenaceae								
Caqui, <i>Diospyros kaki</i>	E	9.47	126	367	2.91 ± 1.1	38.74 ± 12.0	<i>A. fraterculus</i> (11) <i>C. capitata</i> (293)	
Euphorbiaceae								
Mandioca, <i>Manihot esculenta</i>	N	0.52	210	2	0.01 ± 0.0	3.83 ± 1.3	<i>A. montei</i> (2)	
Fabaceae								
Ingá, <i>Inga sellowiana</i>	N	1.75	246	49	0.20 ± 0.2	27.97 ± 6.2	<i>A. fraterculus</i> (5) <i>C. capitata</i> (4)	<i>Lonchaea</i> sp. (12) <i>Neosilba</i> sp. (19)
Moraceae								
Figo, <i>Ficus carica</i>	E	1.22	52	22	0.42 ± 0.2	18.10 ± 8.3	<i>A. fraterculus</i> (16)	
Myrtaceae								
Araçá, <i>Psidium cattleianum</i>	N	5.67	670	2393	3.57 ± 1.3	421.99 ± 25.1	<i>A. fraterculus</i> (1220) <i>C. capitata</i> (10)	<i>Neosilba zadolicha</i> (5) <i>Neosilba padroii</i> (7) <i>Neosilba</i> sp. (6)

TABLE 1. (CONTINUED) PLANTS SAMPLED WITH THEIR RESPECTIVE ORIGIN (O), FRUIT WEIGHT (FW), NUMBER OF FRUITS SAMPLED (N), NUMBER OF PUPAE (P), AVERAGE NUMBER OF PUPAE PER FRUIT (P/N), AND AVERAGE NUMBER OF PUPAE PER KG (P/KG). N = NATIVE AND E = EXOTIC. NUMBER IN PARENTHESES FOLLOWING FLY SPECIES NAMES = NUMBER OF SPECIMENS REARED.

Plant Species	O	FW (kg)	# fruits n	#pupae P	P/n ± SE	P/kg ± SE	Tephritidae	Lonchaeidae & Ulidiidae
Cereja, <i>Eugenia involucrata</i>	N	2.85	516	155	0.30 ± 0.1	54.47 ± 13.0	<i>A. fraterculus</i> (79) <i>C. capitata</i> (15)	<i>Neosilba padroii</i> (6)
Goiaba, <i>Psidium guajava</i>	N	12.47	236	1454	6.16 ± 2.4	116.64 ± 10.9	<i>A. fraterculus</i> (697) <i>A. obliqua</i> (14) <i>A. sororcula</i> (7) <i>C. capitata</i> (13)	<i>Neosilba padroii</i> (29)
Goiaba-do-campo, <i>Acca sellowiana</i>	N	1.79	80	498	6.23 ± 3.2	277.80 ± 23.2	<i>A. fraterculus</i> (254)	
Guaviju, <i>Myrcianthes pungens</i>	N	0.25	52	21	0.40 ± 0.1	84.31 ± 13.3	<i>A. fraterculus</i> (12)	
Guavirova, <i>Campomanesia xanthocarpa</i>	N	2.61	717	53	0.07 ± 0.0	20.27 ± 6.8	<i>A. fraterculus</i> (32)	
Jabuticaba, <i>Myrcetia cauliflora</i>	N	0.16	25	3	0.12 ± 0.1	18.75 ± 7.7	<i>A. fraterculus</i> (3)	
Pitanga, <i>Eugenia uniflora</i>	N	4.49	1699	406	0.24 ± 0.1	90.37 ± 15.6	<i>A. fraterculus</i> (223)	<i>Neosilba padroii</i> (12)
Sete-capotes, <i>Campomanesia guazumifolia</i>	N	4.51	398	799	2.01 ± 1.0	177.08 ± 23.1	<i>A. fraterculus</i> (360) <i>A. obliqua</i> (4) <i>A. sororcula</i> (5) <i>A. fraterculus</i> (51) <i>C. capitata</i> (43)	<i>Neosilba padroii</i> (5)
Uvaia, <i>Eugenia pyriformis</i>	N	1.60	334	148	0.44 ± 0.2	92.48 ± 17.9		<i>Neosilba padroii</i> (3)
Oxalidaceae								
Carambola, <i>Averrhoa carambola</i>	E	3.31	65	25	0.38 ± 0.1	7.56 ± 3.12	<i>A. fraterculus</i> (9) <i>A. obliqua</i> (2)	<i>Neosilba padroii</i> (12)
Passifloraceae								
Maracujá, <i>Passiflora edulis</i>	N	26.58	298	628	2.11 ± 0.5	23.63 ± 15.7	<i>A. dissimilis</i> (9) <i>A. pseudoparallela</i> (363) <i>C. capitata</i> (12)	<i>Lonchaea</i> sp. (185) <i>Neosilba padroii</i> (29)
Rosaceae								
Ameixa, <i>Prunus domestica</i>	E	5.24	148	267	1.80 ± 1.2	50.94 ± 10.8	<i>A. fraterculus</i> (148)	<i>Neosilba</i> sp. (14)
Cereja-do-mato, <i>Prunus avium</i>	E	0.40	36	94	2.61 ± 1.1	232.45 ± 27.9	<i>A. fraterculus</i> (47)	
Nêspera, <i>Eriobotrya japonica</i>	E	12.79	1263	1285	1.02 ± 0.7	100.44 ± 30.1	<i>A. fraterculus</i> (218) <i>C. capitata</i> (816)	
Pera, <i>Pyrus communis</i>	E	9.85	96	52	0.54 ± 0.2	5.28 ± 2.6	<i>A. fraterculus</i> (33)	<i>Lonchaea</i> sp. (14)
Pêssego, <i>Prunus persica</i>	E	27.32	652	1151	1.77 ± 0.9	42.13 ± 18.1	<i>A. fraterculus</i> (372) <i>C. capitata</i> (322)	<i>Neosilba zadolicha</i> (43) <i>Neosilba</i> sp. (41)
Rutaceae								
Bergamota, <i>Citrus reticulata</i>	E	8.67	138	44	0.32 ± 0.1	5.07 ± 3.3	<i>A. fraterculus</i> (12)	<i>Neosilba padroii</i> (12)

TABLE 1. (CONTINUED) PLANTS SAMPLED WITH THEIR RESPECTIVE ORIGIN (O), FRUIT WEIGHT (FW), NUMBER OF FRUITS SAMPLED (N), NUMBER OF PUPAE (P), AVERAGE NUMBER OF PUPAE PER FRUIT (P/N), AND AVERAGE NUMBER OF PUPAE PER KG (P/KG). N = NATIVE AND E = EXOTIC. NUMBER IN PARENTHESES FOLLOWING FLY SPECIES NAMES = NUMBER OF SPECIMENS REARED.

Plant Species	O	FW (kg)	# fruits <i>n</i>	#pupae P	P/n ± SE	P/kg ± SE	Tephritidae	Lonchaeidae & Ulidiidae
Laranja, <i>Citrus sinensis</i>	E	17.20	176	105	0.60 ± 0.2	6.10 ± 4.0		<i>Notogramma cimiciforme</i> (9) <i>Neosilba padraoi</i> (69)
Sapindaceae								<i>Notogramma cimiciforme</i> (29)
Camboatá-vermelho, <i>Cupania vernalis</i>	N	5.80	63	2	0.03 ± 0.0	0.34 ± 0.2		<i>Neosilba padraoi</i> (2)
Sapotaceae								
Aguaí, <i>Chrysophyllum gonocarpum</i>	N	0.24	87	9	0.10 ± 0.1	37.50 ± 12.3	<i>A. elegans</i> (7)	
Solanaceae								
Joá, <i>Solanum sisimbrifolium</i>	N	0.22	32	13	0.41 ± 0.2	59.09 ± 29.5		<i>Neosilba padraoi</i> (12)
Tomate, <i>Lycopersicon esculentum</i>	E	6.57	193	107	0.55 ± 0.3	16.29 ± 8.2		<i>Neosilba padraoi</i> (52)
Ulmaceae								
Esporão-de-galo, <i>Celtis iguanaea</i>	N	911.66	807	608	0.75 ± 0.3	0.67 ± 0.2	<i>A. fraterculus</i> (3) <i>R. pastranai</i> (577)	<i>Neosilba padraoi</i> (3)

Blanco (Rutaceae); and iguana hackberry, *C. iguanaea* (Jacq.) Sarg. (Ulmaceae).

Pereskia aculeata Mill., also known as Ora-pro-nobis or Barbados gooseberry, was found to be a host plant for *Anastrepha barbiellinii* Lima; and *Campomanesia guazumifolia* (Myrtaceae) was recorded for the first time as a host plant for both *A. obliqua* and *A. sororcula*.

Native plant species served as hosts of 12 fruit fly species from 4 genera of Tephritidae, whereas exotic plant species served as hosts of only 4 species from 2 genera. *Ceratitis capitata* developed in 9 plant species from 5 families, with the following order of predominance: khaki, *Diospyros kaki* Thunb. (Ebenaceae) (93.1% of the fruits sampled were infested); medlar, *Eriobotrya japonica* (Thunb.) Lindl. (Rosaceae) (63.5%); uvaia, *Eugenia pyriformis* Cambess. (Myrtaceae) (29.2%); and peach, *P. persica* (L.) Batsch (28.1%). Some fruit fly species occurred exclusively in 1 plant species: *Anastrepha barbiellinii* in ora-pro-nobis, *Pereskia aculeata*; *Anastrepha grandis* (Macquart) only in pumpkin, *C. pepo*; *Rhagoletotrypeta pastranai* Aczél only in esporão-de-galo, *Celtis iguanaea* (Jacq.) Sarg.; *Anastrepha dissimilis* Stone and *A. pseudoparallela* (Loew) only in *Passiflora edulis* Sims; *Anastrepha montei* Lima only in cassava, *Manihot esculenta* Crantz; and *Parastenopa guttata* and *P. montana* only in yerba maté, *I. paraguayensis* St. Hil.

Lonchaeid flies were recorded from 22 host plant species from 9 families of which 12 were native and 10 exotic. Araújo & Zucchi (2002) have also described the indiscriminate infestation of native and exotic fruits by Lonchaeidae. *Neosilba padroi*, a species described recently by Strikis & Lerena (2009), had the highest number of host species (7 native, 15 exotic) belonging to 8 families; the lance fly, *Lonchaea* sp., had 4 host species (2 native and 2 exotic) in 4 families; *Neosilba zadolicha* McAlpine & Steyskal had 3 host species (1 native and 2 exotic) in 3 families; and *Dasiops* sp. occurred only in *C. pepo* (exotic). *Neosilba zadolicha* occurred in araticum, *A. rugulosa* (Annonaceae), araçá, *P. cattleianum* (Myrtaceae), and peach, *P. persica* (Rosaceae). *Spondias* spp. (Anacardiaceae) (Santos et al. 2004) and medlar, *Eriobotrya japonica* (Strikis & Prado 2009) also may serve as hosts of *N. zadolicha*.

The Ulidiidae occurred only in 5 exotic species of Rutaceae and Cucurbitaceae; *Euxesta* sp. occurred only in Cucurbitaceae and *N. cimiciforme* Loew only in Rutaceae. *Euxesta* sp. occurred on 3 plant species, with predominance in chayote, *Sechium edule* (Jacq.) Sw., (48.9%). *N. cimiciforme* occurred only in bergamot orange, *C. reticulata* Blanco, and orange, *Citrus sinensis* (L.) Osbeck. This species has a wide geographic range in the New World and is a scavenger recorded from a wide variety of plants (Steyskal 1963). Unlike our results, Uchôa-Fernandes et al. (2003) and

Aguiar-Menezes et al. (2004) obtained specimens of *N. cimiciforme* in passion fruit (*Passiflora* sp.), with occurrences also in tangerine, *C. reticulata*, and orange, *C. sinensis*. Such differences may be due to the interpopulation differences or seasonal availability of host plants in different regions (Selvion 2000).

Pumpkin was infested by 4 species of flies belonging to 3 families. Guava, passion fruit, and peach were infested by 5 species each, and these fruits were found to support infestations only of species of Tephritidae and Lonchaeidae.

Under the conditions in which this research was conducted, we conclude that a wide diversity of fruit-bearing plant species in the state of Santa Catarina was attacked by 22 species of tephritoid flies. The most predominant fly was *A. fraterculus*, and *P. cattleianum* was the host species most frequently infested by these flies.

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