

## FRUGIVOROUS FLIES (Diptera: Tephritidae and Lonchaeidae) INTERACTIONS WITH PARASITOIDS AND NEW HOSTS

Léo R. F. Louzeiro<sup>1</sup>, Adalton Raga<sup>1</sup>, Miguel F. de Souza-Filho<sup>1</sup>; Laura J. Gislotti<sup>2</sup>

<sup>1</sup>Instituto Biológico, Alameda dos Vidoeiros 1097, CEP 13101-680, Campinas, SP, Brazil  
E-mail: leo.rfl@hotmail.com, adalton.raga@sp.gov.br

<sup>2</sup>Universidade Federal da Grande Dourados, CEP 79804-970, Dourados, MS, Brazil

### ABSTRACT

Fruits of two cultivars of guava, *Psidium guajava* L., ('Tailandesa' and 'Kumagai') and garlic passion fruit, *Passiflora tenuifila* Killip were collected to evaluate the infestation and co-infestation of frugivorous flies and the associated parasitoids and new hosts. Five species of Tephritoidea were recovered in Tailandesa guavas, three species in Kumagai guavas and three species in garlic passion fruit. This is the first report of a frugivorous fly infesting *P. tenuifila*. Individualization of the fruit samples was used to determine the co-infestation between *Anastrepha* spp., *Ceratitis capitata* and *Neosilba* spp. in each fruit. There was a fly/parasitoid association for *Doryctobracon areolatus* and *Lopheucoila anastrephae* with *Anastrepha fraterculus* in guavas. Infestation indices and emergence rate demonstrated that Tailandesa and Kumagai guavas are hosts capable of withstanding an infestation index  $\geq 50$  pupae/fruit and have an emergence rate  $\geq 75\%$ . The ability of some hosts to maintain and sustain the population of frugivorous flies at high levels may interfere with pest management.

**Keywords:** *Anastrepha fraterculus*, *Neosilba zadolicha*, *Ceratitis capitata*, *Psidium guajava*, *Passiflora tenuifila*

## INTERAÇÕES DE MOSCAS FRUGÍVORAS (DIPTERA: TEPHRITIDAE E LONCHAEIDAE) COM PARASITÓIDES E NOVOS HOSPEDEIROS

### RESUMO

Foram coletados frutos de duas cultivares de goiaba, *Psidium guajava* L., (Tailandesa e Kumagai) e de maracujá-alho, *Passiflora tenuifila* Killip, para avaliar a infestação e co-infestação de moscas frugívoras e os parasitoides associados e novos hospedeiros. Foram recuperadas cinco espécies de Tephritoidea em goiabas Tailandesa, três espécies em goiabas Kumagai e três espécies em maracujá-alho. Esse é o primeiro relato de mosca frugívora infestando *P. tenuifila*. A individualização das amostras de frutos foi utilizada para determinar a co-infestação entre

*Anastrepha* spp., *Ceratitis capitata* e *Neosilba* spp. em cada fruto. Houve uma associação entre mosca e parasitoide para *Doryctobracon areolatus* e *Lopheucoila anastrephae* com *Anastrepha fraterculus* em goiabas. Os índices de infestação e a taxa de emergência demonstraram que as goiabas Tailandesa e Kumagai são hospedeiras capazes de gerar  $\geq 50$  pupas/fruto e uma taxa de emergência de  $\geq 75\%$ . A capacidade de alguns hospedeiros de manter e sustentar a população de moscas frugívoras em níveis elevados pode interferir no manejo de pragas.

**Palavras-chave:** *Anastrepha fraterculus*, *Neosilba zadolicha*, *Ceratitis capitata*, *Psidium guajava*, *Passiflora tenuifila*

## INTRODUCTION

In the Tephritoidea are included Tephritidae (fruit flies) and Lonchaeidae (lance flies) families, which exhibit the main pests of horticulture in the Neotropical Region (NICÁCIO & UCHÔA, 2011). A larger sampling effort conducted over the last four decades allowed to achieve 121 species of *Anastrepha* Schiner (Tephritidae) in Brazil (ZUCCHI & MORAES, 2008). In the Americas, 51 species of native parasitoids of Tephritidae species of economic importance are reported, where species of Braconidae and Figitidae corresponding to 64.7% of the total diversity (GARCIA et al., 2020).

Specimens of the Lonchaeidae family are moderately small (3–6 mm in length), stout-bodied and hairy acalyptratae flies (MacGOWAN et al., 2016). In studies of Tephritoidea hosts, more emphasis has been placed on Lonchaeidae infestations, especially because some species of *Neosilba* McAlpine (Lonchaeidae) are primary invaders (STRIKIS & PRADO, 2005; RAGA et al., 2015) or they are associated with *Anastrepha* spp. and *Ceratitis capitata* (Wiedemann) (RAGA et al., 2011; BONFIM et al., 2014). Larvae of *Neosilba* spp. develop in a variety of plants including their fruits, flowers, buds or terminal shoots, and large populations can be found inflicting economic damage on fruit (McALPINE & STEYSKAL, 1982; GALEANO-OLAYA & CANAL, 2012).

The purpose of this study was to present the infestation rates and diversity of Tephritoidea (Tephritidae and Lonchaeidae) and associated parasitoids in two tropical fruit species and the new hosts.

## MATERIAL AND METHODS

Guava (*Psidium guajava* L., Myrtaceae) samples consisting of 100 units of the Tailandesa cultivar (red pulp) and 50 of the Kumagai cultivar (white pulp), in addition to 150 garlic passion fruit (*Passiflora tenuifila* Killip, Passifloraceae), were collected between 12–17 December 2018 in the municipality of Campinas, São Paulo, Brazil, to detect possible Tephritoidea co-infestations. Organic guavas were collected at a local fruit-producing farm (22°59'39.31" S, 47°05'37.61" W), and garlic passion fruits were collected from the Instituto Biológico landscape (22°54'25.59" S, 47°01'06.66" W). Fruit samples were brought to the laboratory, individually weighted, and stored in plastic boxes (1 L) containing vermiculite substrate that was covered with voile cloth and bound with an elastic. The fruits were opened, and the vermiculite was sieved to recover the pupae at 15 and 21 days of storage. Pupae were counted and replaced in the original plastic boxes until fly emergence. The adults were counted and kept in a glass with 70% ethanol until identification.

We used identification keys for Tephritidae (ZUCCHI, 2000), Lonchaeidae (McALPINE & STEYSKAL, 1982; STRIKIS & PRADO, 2009), Braconidae (MARINHO et al., 2018) and Figitidae (GUIMARÃES et al., 2003). The infestation indices, percentage of pupal viability and parasitism index were the fruit fly biological parameters (MATRANGOLO et al., 1998).

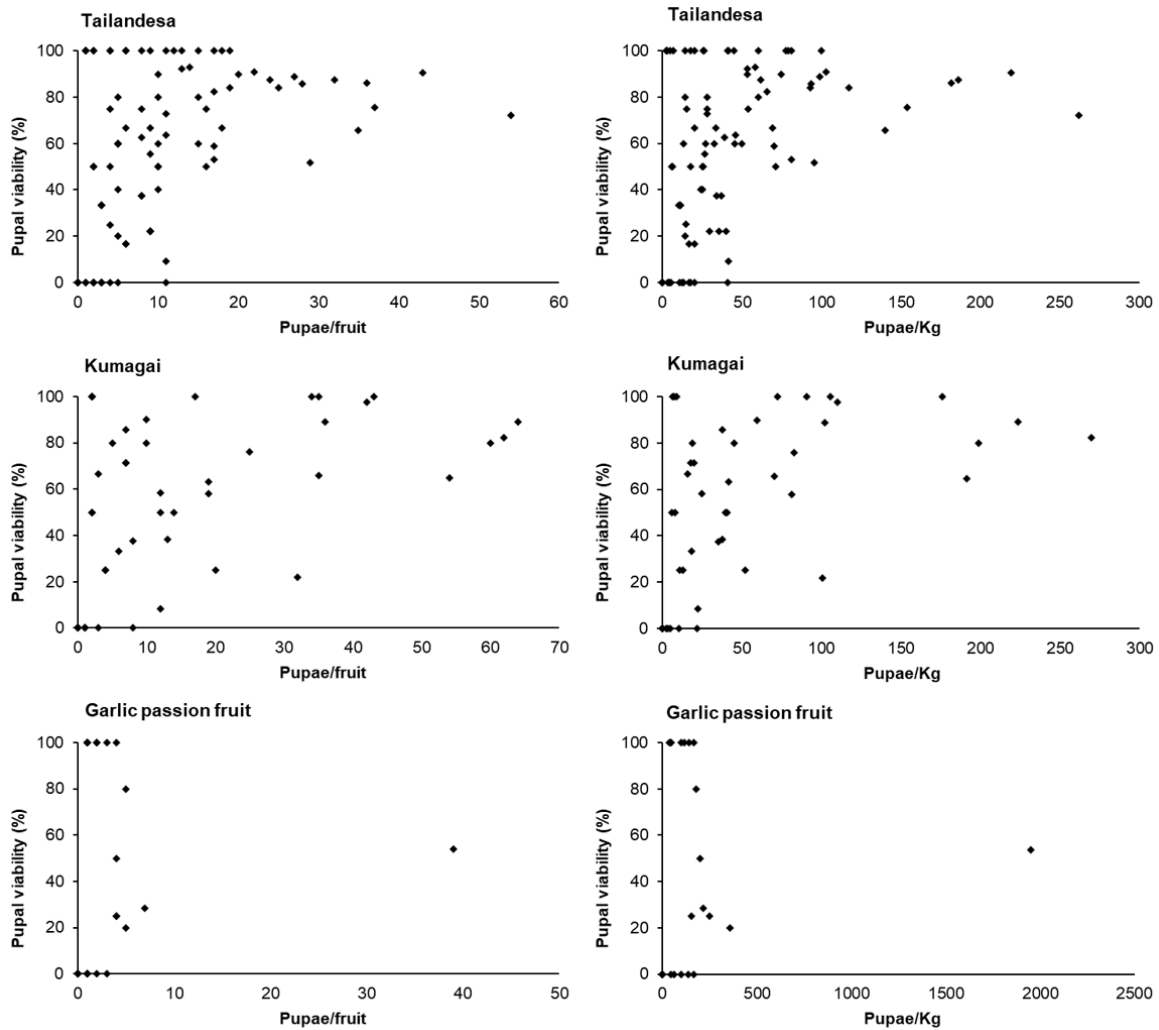
## RESULTS AND DISCUSSION

Pupae of Tephritidae and Lonchaeidae were recovered from both guava cultivars (Table 1). The infestation rates of Tephritidae based on pupae per fruit, pupae per kg and adults per fruit were higher than Lonchaeidae ones. However, only lonchaeids were detected in garlic passion fruit (Table 1). The Tailandesa and Kumagai guava cultivars were considered to be suitable hosts of tephritid flies because they had a high proportion of the pupae per fruit, pupae per kg and pupal viability. Tephritidae pupal viability in Kumagai was higher than in Tailandesa. Garlic passion fruit may not be a suitable host for Lonchaeidae because it had low pupal viability (Figure 1).

**Table 1.** Means weight of fruit, means ( $\pm$ SE) infestation indices and parasitism index of guavas and garlic passion fruit, Campinas, São Paulo State, Brazil. December 2018.

Fruit	Weight (kg)	Pupae per fruit		Pupae per Kg		Adults per fruit		Pupal viability (%)		Parasitism index (%)
		Tephritidae	Lonchaeidae	Tephritidae	Lonchaeidae	Tephritidae	Lonchaeidae	Tephritidae	Lonchaeidae	
		Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	Mean $\pm$ SE (min-max)	
Guava 'Tailandesa' (n=100)	0.270 (0.118-0.456)	10.18 $\pm$ 1.04 (0-54)	0.68 $\pm$ 0.20 (0-11)	42.11 $\pm$ 4.85 (0-262.1)	2.51 $\pm$ 0.73 (0-45.5)	7.23 $\pm$ 0.87 (0-39)	0.27 $\pm$ 0.10 (0-7)	68.4 (0-100)	81.6 (25-100)	0.53 (0-42.8)
Guava 'Kumagai' (n=50)	0.308 (0.168-0.540)	15.12 $\pm$ 2.56 (0-64)	1.02 $\pm$ 0.32 (0-12)	50.19 $\pm$ 9.06 (0-269.5)	3.49 $\pm$ 1.08 (0-31.8)	10.88 $\pm$ 2.21 (0-57)	0.16 $\pm$ 0.07 (0-2)	67.1 (8.3-100)	67.6 (8.3-100)	0.57 (0-15)
Garlic passion fruit (n=150)	0.019 (0.004-0.032)	-	0.60 $\pm$ 0.27 (0-39)	-	29.82 $\pm$ 13.61 (0-1,950)	-	0.30 $\pm$ 0.14 (0-21)	-	51.7 (0-100)	-

**FRUGIVOROUS FLIES (Diptera: Tephritidae and Lonchaeidae) INTERACTIONS WITH PARASITOIDS AND NEW HOSTS**



**Figure 1.** Relationship between infestation indices and pupal viability (%) in Tailandesa guavas (n = 100; Tephritidae only), Kumagai guavas (n = 50; Tephritidae only) and garlic passion fruit (n = 150; Lonchaeidae only). Campinas, São Paulo State, Brazil. December 2018.

*Anastrepha fraterculus* (Wiedemann) was predominant in both guava cultivars, corresponding to 52.5% and 79.0% of the Tephritoidea adults that emerged from the Tailandesa and Kumagai samples, respectively (Table 2). *Ceratitidis capitata* accounted for 26.3% and 8.8% of Tephritidae adults in the Tailandesa and Kumagai guavas, respectively. Both fruit fly species are common in commercial and wild guavas in the Brazilian southeast (AGUIAR-MENEZES & MENEZES, 2000; RAGA et al., 2006; JOÃO et al., 2014; QUERINO et al., 2014). Only one female of *Anastrepha sororcula* Zucchi was recorded from Tailandesa guava. This shows that even with

the predominance of *A. fraterculus* and *C. capitata* in fruit orchards in the Southeast region of Brazil (RAGA et al., 2011), other species of Tephritidae can infest and cause fruit losses.

**Table 2.** Total of pupae and adults and diversity of Tephritoidea recovered from guavas and garlic passion fruit. Campinas, São Paulo State, Brazil. December 2018.

Fruit	Pupae		Adults		<i>Anastrepha</i> spp.	<i>C. capitata</i>	<i>Dasiops</i> spp.	<i>Neosilba</i> spp.	Recovered species
	Tephritidae	Lonchaeidae	Tephritidae	Lonchaeidae					
Guava Tailandesa (n=100)	1018	68	727	27	536	191	-	27	<i>A. fraterculus</i> (232), <i>A. sororcula</i> (1), <i>C. capitata</i> (191), <i>N. pendula</i> (1), <i>N. zadolicha</i> (17)
Guava Kumagai (n=50)	756	51	544	8	497	48	-	8	<i>A. fraterculus</i> (192), <i>C. capitata</i> (48), <i>N. zadolicha</i> (3)
Garlic passion fruit (n=150)	-	90	-	46	-	-	2	44	<i>N. glaberrima</i> (5), <i>N. inesperata</i> (1), <i>N. zadolicha</i> (10)

From garlic passion fruit emerged *Neosilba glaberrima* (Wiedemann), *Neosilba inesperata* Strikis & Prado, *Neosilba zadolicha* McAlpine & Steyskal and *Dasiops* spp. (Table 2). All mentioned species are reported for the first time in *P. tenuifila*. *Neosilba zadolicha* belongs to the subgroup *pendula* (GALEANO-OLAYA & CANAL, 2012) and has been reported in many host fruits around the country (SANTOS et al., 2004; MONTES et al., 2010; UCHÔA & NICÁCIO, 2010; RAGA et al., 2015; BALDO et al., 2017; CASTILHO et al., 2017; GISLOTI et al., 2017; COELHO et al., 2018; SANTOS et al., 2018; SOUZA et al., 2019). In the State of São Paulo, *N. zadolicha* has been reported in 42 host plants (FRUIT FLIES IN THE STATE OF SÃO PAULO – BRAZIL, 2019), especially among the families Annonaceae, Myrtaceae, Rosaceae, Rutaceae, Sapotaceae and Solanaceae (RAGA et al., 2011), in addition to being an important citrus pest (LOUZEIRO et al., 2021).

The individualization of the fruit samples facilitated the study of the fly/parasitoid association for *Doryctobracon areolatus* (Szépligeti) (Braconidae; four specimens) and *A. fraterculus* in Tailandesa guavas, and *Lopheucoila anastrephae* (Rhower) (Figitidae) and *A. fraterculus* in Tailandesa (three specimens) and Kumagai guavas (seven specimens). The number of the fruits providing the co-infestation between *Anastrepha* spp., *C. capitata* and *Neosilba* spp. was described in Table 3.

**FRUGIVOROUS FLIES (Diptera: Tephritidae and Lonchaeidae) INTERACTIONS WITH PARASITOIDS AND NEW HOSTS**

**Table 3.** Number of fruit with co-infestation by Tephritoidea species, under field conditions. AF = *A. fraterculus*, AS = *A. sororcula*, CC = *C. capitata*, NE = *Neosilba* spp., NZ = *N. zadolicha*, NG = *N. glaberrima*, NI = *N. inesperata*. Campinas, São Paulo State, Brazil. December 2018.

	AF x CC	AF x NE	CC x NE	AF x CC x NE	NZ x NG	NG x NI	AF x AS x CC	AF x CC x NZ
Guava Tailandesa	23	3	1	2	-	-	1	1
Guava Kumagai	5	1	3	1	-	-	-	-
Garlic passion fruit	-	-	-	-	3	1	-	-

This study is a brief report on the infestation and co-infestation of frugivorous flies and the relationship between fly/host and fly/parasitoid. The Tailandesa and Kumagai guavas proved to be capable of sustaining high infestations of tephritid flies ( $\geq 50$  pupae/fruit) and providing a high survival rate of the immature ( $\geq 75\%$ ), even over the highest rates of infestation. Knowing the host importance of various fruits for polyphagous frugivorous flies can help in pest management.

**ACKNOWLEDGEMENTS**

This study was funded in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) [grant number 001]. We thank the researcher Valmir A. Costa (Instituto Biológico, São Paulo, Brazil) for identifying *L. anastrephae*.

**REFERENCES**

AGUIAR-MENEZES, E. L.; MENEZES, E. B. 2000. Moscas-das-frutas nos Estados Brasileiros: Rio de Janeiro. In: MALAVASI, A.; ZUCCHI, R.A. (Eds). **Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado**. Ribeirão Preto: Holos, p. 259-263.

BALDO, F.B.; BERTON, L.H.C.; GISLOTI, L.J.; RAGA, A. 2017. New records of *Anastrepha grandis* (Diptera, Tephritidae) and *Neosilba zadolicha* (Diptera, Lonchaeidae) in Cucurbitaceae species in Brazil. **Journal of Agriculture and Ecology Research International**, Hooghly, v. 13, n. 2, p. 1-7.

BOMFIM, D. A.; GISLOTI, L.J.; UCHÔA, M.A. 2014. Fruit flies and lance flies (Diptera: Tephritoidea) and their host plants in a conservation unit of the Cerrado biome in Tocantins, Brazil. **Florida Entomologist**, Gainesville, v. 97, n. 3, p. 1139-1147.

CASTILHO, A.P.; LEMOS, W.P.; STRIKIS, P.C.; SOUSA, M.S.M.; ADAIME, R. 2017. Species of *Neosilba* (Diptera: Lonchaeidae) recorded in citrus-producing region in the state of Pará, Brazil. **Biotemas**, Florianópolis, v. 30, n. 3, p. 85-87.

COELHO, J.B.; ARAÚJO, E.S.; SILVA, L.B.; STRIKIS, P.; LOPES, G.N. 2018. Record of *Neosilba zadolicha* McAlpine & Steyskal (Diptera: Lonchaeidae) in mandacaru fruits. **Arquivos do Instituto Biológico**, São Paulo, v. 85, p. 1-3.

- FRUIT FLIES IN THE STATE OF SÃO PAULO – BRAZIL. 2019. São Paulo: Instituto Biológico. Available at: <<http://www.mosfrut.com.br>> Accessed on: Jul, 10, 2020.
- GALEANO-OLAYA, P.E.; CANAL, N.A. 2012. New species of *Neosilba* McAlpine (Diptera: Lonchaeidae) and new records from Colombia. **Papéis Avulsos de Zoologia**, São Paulo, v. 52, n. 31, p. 361-385.
- GARCIA, F.R.M.; OVRUSKI, S.M.; SUÁREZ, L.; CANCINO, J.; LIBURD, O.E. 2020. Biological control of Tephritid fruit flies in the Americas and Hawaii: A Review of the use of parasitoids and predators. **Insects**, Basel, v. 11, 662. Doi:10.3390/insects11100662
- GISLOTI, L.J.; UCHOA, M.A.; PRADO, A. 2017. New records of fruit trees as host for *Neosilba* species (Diptera, Lonchaeidae) in southeast Brazil. **Biota Neotropica**, Campinas, v. 17, n. 1, e20160213. Doi: 10.1590/1676-0611BN-2016-0213
- GUIMARÃES, J.A.; GALLARDO, F.E.; DIAZ, N.B.; ZUCCHI, R.A. 2003. Eucoilinae species (Hymenoptera: Cynipoidea: Figitidae) parasitoids of fruit-infesting dipterous larvae in Brazil: identity, geographical distribution and host associations. **Zootaxa**, Auckland, v. 278, n. 1, p. 1-23.
- JOÃO, R.E.S.; MONTES, S.M.N.M.; RAGA, A. 2014. Fruit flies in a guava orchard in Indiana County, São Paulo, Southeastern Brazil. **Idesia**, Arica, v. 32, n. 3, p. 101–107.
- LOUZEIRO, L.R.F.; SOUZA-FILHO, M.F.; RAGA, A.; GISLOTI, L.J. 2021. Incidence of frugivorous flies (Tephritidae and Lonchaeidae), fruit losses and the dispersal of flies through the transportation of fresh fruit. **Journal of Asia-Pacific Entomology**, Amsterdam, v. 24, n. 1, p. 50–60.
- MATRANGOLO, W.J.R.; NASCIMENTO, A.S.; CARVALHO, R.S.; MELO, E.D.; JESUS, M. 1998. Parasitóides de moscas-das-frutas (Diptera: Tephritidae) associados a fruteiras tropicais. **Anais da Sociedade Entomológica do Brasil**, Jaboticabal, v. 27, n. 4, p. 593-603.
- MacGOWAN, I.; KWON, T.; JI, O.; KIM, I. 2016. The Lonchaeidae (Diptera) of South Korea with descriptions of four new species. **Journal of Asia-Pacific Entomology**, Amsterdam, v. 19, p. 115–125.
- MARINHO, C.F.; COSTA, V.A.; ZUCCHI, R.A. 2018. Annotated checklist and illustrated key to braconid parasitoids (Hymenoptera, Braconidae) of economically important fruit flies (Diptera, Tephritidae) in Brazil. **Zootaxa**, Auckland, v. 4527, n. 1, p. 21-36.
- McALPINE, J.F.; STEYSKAL, G.C. 1982. A revision of *Neosilba* McAlpine with a key to the world genera of Lonchaeidae (Diptera). **The Canadian Entomologist**, Cambridge, v. 114, p. 105-137.
- MONTES, S.M.N.M.; RAGA, A.; BOLIANI, A.C.; STRIKIS, P.C.; SANTOS, P.C. 2010. Infestación natural de Lonchaeidae (Diptera) en variedades de melocotón. **Revista Colombiana de Entomología**, Bogotá, v. 36, n. 2, p. 223-228.
- NICÁCIO, J.; UCHÔA, M.A. 2011. Diversity of frugivorous flies (Diptera: Tephritidae and Lonchaeidae) and their relationship with host plants (Angiospermae) in environments of South Pantanal region, Brazil. **Florida Entomologist**, Gainesville, v. 94, n. 3, p. 443–466.
- QUERINO, R.B.; MAIA, J.B.; LOPES, G.N.; ALVARENGA, C.D.; ZUCCHI, R.A. 2014. Fruit fly (Diptera: Tephritidae) community in guava orchards and adjacent fragments of native vegetation in Brazil. **Florida Entomologist**, Gainesville, v. 97, n. 2, p. 778-786.
- RAGA, A.; SOUZA FILHO, M.F.; PRESTES, D.A.O.; AZEVEDO FILHO, J.A.; SATO, M.E. 2006. Susceptibility of guava genotypes to natural infestation by *Anastrepha* spp. (Diptera: Tephritidae) in the municipality of Monte Alegre do Sul, state of São Paulo, Brazil. **Neotropical Entomology**, Londrina, v. 35, n. 1, p. 121-125.

- RAGA, A.; SOUZA-FILHO, M.F.; MACHADO, R.A.; SATO, M.E.; SILOTO, R.C. 2011. Host ranges and infestation indices of fruit flies (Tephritidae) and lance flies (Lonchaeidae) in São Paulo State, Brazil. **Florida Entomologist**, Gainesville, v. 94, n. 4, p. 787-794.
- RAGA, A.; SOUZA-FILHO, M.F.; STRIKIS, P.C.; MONTES, S.M.N.M. 2015. Lance fly (Diptera: Lonchaeidae) host plants in the State of São Paulo, Southeast Brazil. **Entomotropica**, Maracay, v. 30, n. 7, p. 57-68.
- SANTOS, W.S.; CARVALHO, C.A.L.; MARQUES, O.M. 2004. Registro de *Neosilba zadolicha* McAlpine & Steyskal (Diptera: Lonchaeidae) em Umbu-cajá (Anacardiaceae). **Neotropical Entomology**, Londrina, v. 33, n. 5, p. 653-654.
- SANTOS, O.O.; CASTELLANI, M.A.; BITTENCOURT, M.A.L.; MOREIRA, A.A.; STRIKIS, P.C. 2018. Frugivorous flies (Diptera: Lonchaeidae) hosts in the State of Bahia, Brazil and registers of new bitrophic interactions. **Brazilian Journal of Biology**, São Paulo, v. 78, n. 3, p. 591-592.
- SOUZA, G.K.; PIKART, T.G.; STRIKIS, P.C.; OLIVEIRA, V.L.; BENDER, M.; BOFF, P.; BOFF, M.I.C. 2019. Lance flies (Diptera: Lonchaeidae) associated with *Acca sellowiana* (Myrtaceae) in Lages, Santa Catarina, Brazil. **Florida Entomologist**, Gainesville, v. 102, n. 1, p. 249-250.
- STRIKIS, P.C.; PRADO, A.P. 2005. A new species of the genus *Neosilba* (Diptera: Lonchaeidae). **Zootaxa**, Auckland, v. 828, p. 1-4.
- STRIKIS, P.C.; PRADO, A.P. 2009. Lonchaeidae associados a frutos de nêspera, *Eryobotria japonica* (Thunb.) Lindley (Rosaceae), com a descrição de uma espécie de *Neosilba* (Diptera: Tephritoidea). **Arquivos do Instituto Biológico**, São Paulo, v. 76, n. 1, p. 49-54.
- UCHÔA, M.A.; NICÁCIO, J. 2010. New records of Neotropical fruit flies (Tephritidae), lance flies (Lonchaeidae) (Diptera: Tephritoidea), and their host plants in the South Pantanal and adjacent areas, Brazil. **Annals of the Entomological Society of America**, College Park, v. 103, n. 5, p. 723-733.
- ZUCCHI, R. A. 2000. Taxonomia. In: MALAVASI, A.; ZUCCHI, R.A. (Eds). **Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado**. Ribeirão Preto: Holos, p. 13-24.
- ZUCCHI, R.A.; MORAES, R.C.B. 2008. **Fruit flies in Brazil - *Anastrepha* species, their host plants and parasitoids**. Available at: <<http://www.lea.esalq.usp.br/anastrepha>> Accessed on: Nov. 23, 2020.

Received in: April, 29, 2021

Accepted in: June, 15, 2021