



Survey of Tephritidae and Lonchaeidae (Diptera), their host plants and parasitoids in the state of Sergipe, Brazil

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ABSTRACT: This is the first survey of Tephritidae and Lonchaeidae, their host plants and parasitoids in the state of Sergipe, Brazil. Fruits of several plant species were sampled in orchards, backyards, and farmers markets of 13 municipalities, from October 22 to 26, 2018 and from January 7 to 11, 2019. We collected 89 fruit samples (4,930 fruits, 111.5 kg) from 28 plant species belonging to 17 families. Larval infestation occurred in 29 fruit samples belonging to 11 plant species from eight families. We also used McPhail traps baited with Ceratrap®, in five municipalities. Five species of fruit flies (*Anastrepha* spp. and *Ceratitidis capitata*), three species of lance flies (*Neosilba* spp.), nine of host plants, and associated parasitoids (1 species) were recorded for the first time in the state of Sergipe.

Key words: *Anastrepha*; *Ceratitidis capitata*; *Neosilba*; *Doryctobracon areolatus*; fruit flies; lance flies; trap.

Levantamento de Tephritidae e Lonchaeidae (Diptera), suas plantas hospedeiras e parasitoide no estado de Sergipe, Brasil

RESUMO: Este é o primeiro levantamento de espécies de Tephritidae e Lonchaeidae, suas plantas hospedeiras e parasitoide no estado de Sergipe, Brasil. Foram amostrados frutos de diversas espécies em pomares, quintais e feiras livres de 13 municípios, de 22 a 26 de outubro de 2018 e de 7 a 11 de janeiro de 2019. Foram coletadas 89 amostras de frutos (4.930 frutos; 111,5 kg) de 28 espécies vegetais pertencentes a 17 famílias. Houve infestação de larvas em 29 amostras de frutos pertencentes a 11 espécies vegetais de 8 famílias. Também foram usadas armadilhas tipo McPhail com o atrativo Ceratrap®, em cinco municípios. Cinco espécies de tefritídeos (*Anastrepha* spp. e *Ceratitidis capitata*), três de lonqueídeos (*Neosilba* spp.), nove de hospedeiros e uma de parasitoide são registradas pela primeira vez no estado de Sergipe.

Palavras-chave: *Anastrepha*; *Ceratitidis capitata*; *Neosilba*; *Doryctobracon areolatus*; moscas-das-frutas; lonqueídeos; armadilha.

1. INTRODUCTION

The state of Sergipe is the second major producer of orange and lemon in northeastern Brazil and the state produces almost all the orange juice of the region. Nevertheless, despite the yield of orange (3rd place of average yield/ha) and several native fruits, studies on dipterans associated to fruits have been neglected in Sergipe.

Several species of fruit flies (Tephritidae) are important pests worldwide. In Brazil, these dipterans are represented by native species of *Anastrepha* and two introduced species – *Ceratitidis capitata* (Mediterranean fruit fly) and *Bactrocera carambolae* (carambola fruit fly). Species of *Anastrepha* are pests – *A. fraterculus* (lato sensu), *A. obliqua*, *A. sororcula*, *A. grandis* and *A. pseudoparallela* – and occur in several Brazilian states

(e.g. MALAVASI; ZUCCHI, 2000). The Mediterranean fruit fly, introduced at the beginning of the 20th century, is widely distributed in Brazil (ZUCCHI, 2015). The carambola fruit fly, detected in Brazil in 1996, has a restricted distribution to states of Amapá, Pará and Roraima, kept under official control by the Ministry of Agriculture, Livestock and Supply (BRASIL, 2018).

Some species of Lonchaeidae may damage fruits and other structures of some fruit trees (UCHÔA, 2012; ADAIME et al., 2017). However, damages caused by lance flies have less economic importance than those caused by Tephritidae, as they attack few species of fruit trees and are not considered quarantine species. Damages caused by Tephritidae and lance flies are caused by larvae, which

develop inside the fruits, making them unfit for consumption and commercialization.

In the Americas, Brazil holds most studies on diversity of fruit flies; however, no studies on fruit flies or lance flies have been conducted in the state of Sergipe. Therefore, this study presents the results of the first survey on dipterans in fruits and traps in the state of Sergipe, Brazil.

2. MATERIALS AND METHODS

2.1. Sampling sites

Fruits were sampled in 13 municipalities (Aracaju, Areia Branca, Barra dos Coqueiros, Canindé de São Francisco, Itabaiana, Itaporanga D'Ajuda, Lagarto, Poço Redondo, Ribeirópolis, Salgado, São Cristóvão, Siriri and Tobias Barreto) (Table 1). However, collections with traps were carried out in only five municipalities (Table 2).

Sergipe has high average temperatures and small annual temperature variation, presenting average range below 5°C and rainfall decreasing from the coast to the inner part of the state. Sergipe has three climatic zones: Tropical humid, along the coast (East); Tropical sub-humid or Transitional Semi-Arid (Agreste) and Hinterland (Sertão) (SANTOS, 2019; SEMARH, 2019). During the collections in January the average temperature was 26.5°C, with an average precipitation of 49mm (Litoral and Agreste) and 27.3°C and 38mm (Sertão). In October, the average temperature was 25.4°C, with an average rainfall of 56mm (Litoral and Agreste) and 27.3°C and 9mm in the Sertão.

2.2. Fruit sampling

Fruits potentially infested by frugivorous larvae were collected in orchards and backyards, from October 22 to 26, 2018 and from January 7 to 11, 2019. Samples were collected randomly, and newly-dropped fruits were collected in the soil and/or directly from the plants sampled. All sampling sites had their geographical coordinates registered by *Global Positioning System* (GPS) (Table 1). In municipalities of Barra dos Coqueiros, Lagarto, Ribeirópolis, Tobias Barreto and Salgado, the fruits were purchased at farmers markets.

Fruits of the same species were grouped and packed in plastic containers, wrapped with organza bag, duly labeled, and transported to the Laboratory of Entomology at Embrapa Tabuleiros Costeiros in Aracaju. In the laboratory, fruits were counted, weighed and arranged in plastic trays on a thin layer of moistened sand. The trays were covered with organza fabric fastened by elastic alloy (SILVA et al., 2011).

Fruits were examined every five days for 20 days to remove the puparia, which were transferred to transparent plastic bottles containing a thin layer of moist vermiculite. The bottles were covered with organza fabric with the lids punctured, and inspected daily until insect emergence. Humidity in trays and pots was kept by replacing water, using a pissette. Emerged insects (flies and parasitoids) were kept alive for 24 hours to fix the wing patterns, and after killed, they were placed into micro tubes containing 70% ethanol, duly labeled, for later identification. The scientific names of plant species are in accordance with The Plant List (2013) and Flora do Brasil (2020).

2.3. Sampling with traps

We used 10 McPhail traps of transparent plastic with bottom opening, containing 400mL of bait Ceratrap®,

installed 1.8 m above the ground. All sampling sites where the traps were installed had their geographical coordinates recorded by GPS (Table 2). The traps were installed on 10/22/18 and 01/07/19 and were checked only once on 10/26/18 and 01/11/19, respectively, when the insects were transferred to flasks containing 70% ethanol and duly labeled.

2.4. Fly identification

Identification of flies and parasitoids was based exclusively on adults. Specific identification of *Anastrepha* was based on females (aculeus apex) and *C. capitata* on males and females (external morphological features) (MF Souza-Filho). Identification of lance flies was based on males (PC Strikis). Identification of braconids was based on Marinho et al. (2018). *Anastrepha fraterculus* corresponds to a complex of cryptic species; however, considered as *lato sensu* in this paper. Voucher specimens are deposited at the Plant Protection Laboratory at Embrapa Amapá.

2.5. Data analyses

The following calculations were performed for each fruit sample: (1) infestation index [number of puparia divided by sample weight (puparia/kg of fruit)] and (2) parasitism rate (number of parasitoids divided by number of puparia, multiplied by 100).

Table 1. Fruit collection sites in municipalities of Sergipe.

Tabela 1. Pontos de coleta de frutos em municípios de Sergipe.

Spots*	Municipalities	Latitude S	Longitude W
1	São Cristóvão	10°58'18.0"	37°10'43.1"
2	São Cristóvão	10°58'19.8"	37°12'59.9"
3	Itaporanga D'Ajuda	10°59'45.2"	37°20'0.03"
4	Itaporanga D'Ajuda	10°58'49.3"	37°24'01.1"
5	Itaporanga D'Ajuda	10°58'20.3"	37°27'01.9"
6	Itaporanga D'Ajuda	10°56'44.3"	37°28'45.3"
7	Areia Branca	10°45'41.6"	37°18'05.4"
8	Areia Branca	10°45'38.2"	37°18'20.8"
9	Areia Branca	10°46'11.3"	37°22'05.6"
10	Itabaiana	10°44'17.3"	37°24'22.2"
11	Poço Redondo	09°42'59.2"	37°45'48.6"
12	Poço Redondo	09°42'37.3"	37°46'12.7"
13	C. de São Francisco	09°42'31.6"	37°46'09.7"
14	C. de São Francisco	09°40'58.7"	37°48'43.8"
15	C. de São Francisco	09°40'16.5"	37°49'04.2"
16	C. de São Francisco	09°40'01.3"	37°49'11.3"
17	C. de São Francisco	09°41'10.6"	37°49'01.0"
18	C. de São Francisco	09°40'49.3"	37°48'28.4"
19	Siriri	10°34'36.9"	37°07'36.4"
20	Itaporanga D'Ajuda	10°58'49.3"	37°24'01.1"
21	Itaporanga D'Ajuda	11°12'50.4"	37°13'01.2"
22	Aracaju	10°59'58.7"	37°03'24.3"
23	Areia Branca	10°45'45.9"	37°18'08.5"
24	Itabaiana	10°43'32.5"	37°23'48.8"
25	Itaporanga D'Ajuda	10°59'50.0"	37°19'52.0"
26	São Cristóvão	10°59'23.9"	37°13'05.2"
27	São Cristóvão	11°00'12.6"	37°12'36.2"
28	Aracaju	10°57'06.1"	37°03'14.9"
29	Aracaju	10°56'06.4"	37°04'45.6"

*Fruits from municipalities of Barra dos Coqueiros, Lagarto, Ribeirópolis, Tobias Barreto, and Salgado were purchased at farmers markets and were not included in this table.

Table 2. Collection sites with McPhail traps in municipalities of Sergipe (January 7 to 11, 2019).

Tabela 2. Pontos de coleta com armadilhas tipo McPhail em municípios de Sergipe (7 a 11 de janeiro de 2019).

Municipalities	Latitude S	Longitude W
Aracaju	10°57'06.1"	37°03'14.9"
	11°04'19.3"	37°07'20.3"
Areia Branca*	10°45'41.6"	37°18'05.4"
Itabaiana	10°44'17.3"	37°24'22.2"
	10°43'32.5"	37°23'48.8"
Itaporanga D'Ajuda*	10°58'49.3"	37°24'01.1"
	10°58'20.3"	37°27'01.9"
	10°56'44.3"	37°28'45.3"
	11°12'50.4"	37°13'01.2"
	10°59'50.0"	37°19'52.0"
São Cristóvão	10°59'45.2"	37°20'0.03"
	10°58'18.0"	37°10'43.1"
	10°58'18.0"	37°10'43.1"

*Sampling carried out from Oct 23-26, 2018.

3. RESULTS

We collected 89 fruit samples (4,930 fruits, 111.5 kg) from 28 plant species belonging to 17 families (Table 3) with the highest number of samples of *Malpighia emarginata* (12 samples) and *Mangifera indica* (11 samples).

Infestation occurred in 29 samples (32.6%), belonging to 11 plant species from eight families (Table 3). Infestation rates varied, with the highest index recorded in a sample of *Manihot esculenta* (366.7 puparia/kg of fruit) in the municipality of Areia Branca (Table 3).

We obtained 1,153 puparia, from which we observed emergence of five species of Tephritidae (*A. fraterculus*, *A. obliqua*, *A. pickeli*, *A. sororcula* and *Ceratitidis capitata*) and three species of lance flies (*Neosilba certa*, *N. inesperata* and *N.*

pendula) and one parasitoid species (*Doryctobracon areolatus*) (Table 3).

Ceratitidis capitata was associated to more hosts (6 species in 6 families) than the other species of flies collected. Among species of *Anastrepha*, *A. obliqua* was associated with four host plants (2 families), *A. fraterculus* in two host families, and *A. pickeli* and *A. sororcula* infested only one host (Table 3). *Ceratitidis capitata* and *A. obliqua* were the most widely distributed species occurring in six municipalities (Figure 1). *Anastrepha fraterculus* and *A. pickeli* occurred in four municipalities, *A. sororcula* in three and *A. pseudoparallela* in only one (Figure 1).

From fruits sampled in farmers markets, *A. obliqua* was obtained in *Spondias purpurea* (São Cristóvão) and *C. capitata* and *A. sororcula* in *Psidium guajava* (Canindé de São Francisco) (Table 3).

Three species of *Neosilba* – *N. certa*, *N. inesperata* and *N. pendula* – infested *Malpighia emarginata*; however, *N. certa* also infested *Citrus reticulata* (Table 3).

In the traps, we captured specimens of *Anastrepha obliqua* (292 ♀), *A. fraterculus* (9 ♀), *A. pickeli* (7 ♀), *A. sororcula* (4 ♀), *A. pseudoparallela* (3 ♀ and 60 ♂), *C. capitata* (43 ♀ and 9 ♂) and *Neosilba* sp. (1 ♀) (Table 4). *Ceratitidis capitata* and *A. obliqua* were collected in more municipalities (5 and 4, respectively) than the other species sampled by traps (Table 4).

Doryctobracon areolatus (Szépligeti) (Hymenoptera: Braconidae) was the only parasitoid collected. Only eight specimens of the parasitoid were collected associated to *A. obliqua* in *Averrhoa carambola* (Areia Branca and São Cristóvão) and in *Spondias dulcis* (Itaporanga D'Ajuda). Parasitism rates were 2.8% in *S. dulcis* in the municipality of Itaporanga D'Ajuda and 5.1% and 4.5% in *A. carambola*, in the municipalities of Areia Branca and São Cristóvão, respectively.

Table 3. Flies (Tephritidae and Lonchaeidae) and their hosts in municipalities of the state of Sergipe. October 2018 and January 2019.

Tabela 3. Moscas (Tephritidae e Lonchaeidae) e respectivos hospedeiros em municípios do estado de Sergipe. Outubro de 2018 e janeiro de 2019.

Families* Species	Spots#	Flies / Parasitoids	Dates	F (n)	M (kg)	PP(n)	I (PP/kg)
<i>Anacardiaceae</i>							
<i>Anacardium humile</i> A.St.-Hil.	R**	-	01/08/19	10	0.32	0	0
<i>Anacardium occidentale</i> L.	SC ¹	-	10/22/18	4	0.52	0	0
	SC ²⁶	-	01/07/19	12	0.72	0	0
<i>Mangifera indica</i> L.	SC ¹	Ao (2♀), 2♂A	10/22/18	14	1.36	6	4.4
	AB ⁹	Ao (1♀), 2♂A	10/23/18	13	1.30	3	2.3
	PR ¹¹	-	10/24/18	8	1.30	0	0
	CSF ¹⁴	-	10/24/18	3	1.85	0	0
	CSF ¹⁷	-	10/24/18	9	3.60	0	0
	CSF ¹⁸	-	10/24/18	11 ^a	4.85	0	0
	S ¹⁹	Ao (1♀), 2♂A	10/25/18	12 ^b	2.90	4	1.4
	I ¹⁰	-	01/07/19	10 ^a	1.56	0	0
	I ²⁴	-	01/07/19	9 ^c	1.56	0	0
	ID**	-	01/07/19	12 ^c	3.36	0	0
	SC ¹	2♂A	01/07/19	15 ^a	4.50	6	1.3
<i>Spondias dulcis</i> Parkinson	SC ¹	-	10/22/18	3	0.16	0	0
	SC ¹	-	10/26/18	5	0.16	0	0
	ID ²⁵	Ao (3♀), 7♂A, Da (1)	01/07/19	37	1.30	36	27.7
<i>Spondias purpurea</i> L.	PR ¹²	-	10/24/18	255	1.70	0	0
	CSF ¹⁴	-	10/24/18	56	1.30	0	0
	CSF ¹⁷	Ao (1♀), 1♂A	10/24/18	172	3.70	6	1.6
	SC**	Ao (10♀), 6♂A	01/10/19	83	0.69	28	40.6
	A ²⁹	Cc (11♀+19♂)	01/10/19	54	0.30	32	106.7

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Table 3. Flies (Tephritidae and Lonchaeidae) and their hosts in municipalities of the state of Sergipe. Continuation...
Tabela 3. Moscas (Tephritidae e Lonchaeidae) e respectivos hospedeiros em municípios do estado de Sergipe. Continuação...

Families* Species	Spots#	Flies / Parasitoids	Dates	F (n)	M (kg)	PP(n)	I (PP/kg)
Annonaceae							
<i>Annona muricata</i> L.	SC ²	-	10/22/18	1	1.86	0	0
	ID ⁴	-	10/22/18	2	1.56	0	0
	AB ⁷	-	10/23/18	1	1.04	0	0
	CSF ¹⁷	-	10/24/18	3	2.10	0	0
<i>Xylopia</i> sp.	ID ³	-	10/22/18	149	0.08	0	0
Apocynaceae							
<i>Hancornia speciosa</i> Gomes	BC**	-	10/25/18	54	0.58	0	0
	ID ²¹	-	10/26/18	71	1.68	0	0
Fabaceae							
<i>Tamarindus indica</i> L.	ID ⁴	-	10/22/18	10	0.46	0	0
Combretaceae							
<i>Terminalia catappa</i> L.	AB ⁷	-	10/23/18	19	0.48	0	0
	A ²²	Cc (34♀ + 49♂); Af (1♀), 2♂A	01/07/19	43	1.14	132	115.8
	SC ²⁷	-	01/07/19	103	1.50	0	0
	A ²⁸	-	01/07/19	30	1.24	0	0
Euphorbiaceae							
<i>Manihot esculenta</i> Crantz	SC ¹	Ap (7♀), 8♂A	10/22/18	117	0.24	27	112.5
	AB ⁷	Ap (6♀), 9♂A	10/23/18	22	0.06	22	366.7
	S ¹⁹	Ap (26♀), 34♂A	10/25/18	209	0.85	90	105.9
Lythraceae							
<i>Punica granatum</i> L.	I ¹⁰	-	10/23/18	6	0.64	0	0
	CSF ¹⁴	-	10/24/18	7	4.00	0	0
Malpighiaceae							
<i>Bunchosia armeniaca</i> (Cav.) DC.	AB ²³	-	01/07/19	56	0.30	0	0
<i>Byrsonima crassifolia</i> (L.) Kunth	BC**	-	01/08/19	-	0.30	0	0
	BC**	-	01/08/19	-	0.30	0	0
<i>Malpighia emarginata</i> DC.	SC ¹	-	10/22/18	8	0.06	0	0
	ID ³	-	10/22/18	39	0.10	0	0
	ID ⁴	Cc (2♀ + 2♂)	10/22/18	82	0.62	7	11.3
	AB ⁷	-	10/23/18	31	0.20	0	0
	AB ⁸	-	10/23/18	36	0.32	0	0
	AB ⁸	-	10/23/18	126	0.62	0	0
	CSF ¹³	Ni (1♂)	10/24/18	298	1.36	1	0,7
	CSF ¹⁵	-	10/24/18	125	1.10	0	0
	AB ²³	Cc (20♀ + 23♂); Ni (1♂), 3♀N	01/07/19	400	1.22	105	86.1
	AB ²³	Cc (8♀+11♂); Ne (1♂), 2♀N	01/07/19	200	0.38	45	118.4
	ID ³	Cc (3♀+2♂)	01/07/19	238	0.91	5	5.5
	SC ¹	Cc (1♂); Np (4♂), 1♀N	01/07/19	104	0.50	7	14.0
Malvaceae							
<i>Theobroma cacao</i> L.	Sa**	-	10/26/18	10	3.44	0	0
Moraceae							
<i>Ficus</i> sp.	ID ²⁰	-	10/26/18	61	0.30	0	0
<i>Morus nigra</i> L.	AB ⁷	-	10/23/18	46	0.04	2	50.0
Myrtaceae							
<i>Eugenia uniflora</i> L.	SC ¹	-	10/22/18	176	0.70	0	0
	AB ⁷	Af (3♀)	10/23/18	14	0.02	3	150.0
<i>Psidium guajava</i> L.	CSF**	Cc (19♀ + 29♂)	10/23/18	16	2.39	74	30.9
	PR ¹¹	-	10/24/18	32 ^d	5.50	0	0
	PR ¹¹	-	10/24/18	10 ^d	1.58	0	0
	PR ¹²	-	10/24/18	12 ^d	1.54	0	0
	CSF ¹³	-	10/24/18	16 ^c	1.20	0	0
	CSF ¹⁴	-	10/24/18	10 ^d	1.54	0	0
	CSF ¹⁶	-	10/24/18	12 ^c	1.20	0	0
	CSF**	Cc (1♂); As (8♀), 9 ♂A	01/08/19	18	1.86	18	9.7
	CSF**	Cc (17♀ + 13♂)	01/08/19	14	1.58	42	26.6
Oxalidaceae							
<i>Averrhoa carambola</i> L.	SC ¹	Ao (7♀), 8♂A	10/22/18	2	0.16	16	100.0
	AB ⁸	Ao (13♀), 12 ♂A, Da (2)	10/23/18	19	0.70	39	55.7
	AB ⁷	Cc (9♀ + 9♂); Ao (25♀), 22 ♂A	01/07/19	18	1.02	114	111.7
	ID ²⁵	Cc (23♀+46♂); Ao (1♀), 3 ♂A	01/07/19	12	0.88	150	170.5
	SC ¹	Cc (1♀+1♂); Ao (31♀), 29♂A, Da (5)	01/07/19	34	0.60	110	183.3

Table 3. Flies (Tephritidae and Lonchaeidae) and their hosts in municipalities of the state of Sergipe. Continuation...
Tabela 3. Moscas (Tephritidae e Lonchaeidae) e respectivos hospedeiros em municípios do estado de Sergipe. Continuação...

Families* Species	Spots#	Flies / Parasitoids	Dates	F (n)	M (kg)	PP(n)	I (PP/kg)
Passifloraceae							
<i>Passiflora edulis</i> Sims	SC ²	-	10/22/18	3	0.54	0	0
	ID ⁶	-	10/22/18	26	1.70	0	0
	AB ⁷	-	10/23/18	6	0.64	0	0
	L**	-	10/23/18	10	1.50	0	0
	CSF ¹⁷	-	10/24/18	11	2.90	0	0
Rutaceae							
<i>Citrus sinensis</i> (L.) Osbeck	ID ⁵	-	10/22/18	27	5.86	0	0
<i>Citrus reticulata</i> Blanco	AB ⁹	Cc (12♀ + 8♂); Nc (1♂)	10/23/18	4	0.52	23	44.2
	TB**	-	01/08/19	1	0.18	0	0
Sapotaceae							
<i>Manilkara zapota</i> (L.) P. Royen	SC ¹	-	10/22/18	6	0.96	0	0
	I**	-	10/23/18	10	1.06	0	0
	Sa**	-	01/08/19	11	1.38	0	0
	SC**	-	01/10/19	10	0.55	0	0
Solanaceae							
<i>Capsicum</i> sp.	CSF ⁴	-	10/22/18	8	0.08	0	0
	AB ⁷	-	10/23/18	4	0.06	0	0
<i>Capsicum frutescens</i> L.	CSF ¹⁷	-	10/24/18	185	0.25	0	0
Verbenaceae							
<i>Duranta erecta</i> L.	AB ⁸	-	10/23/18	679	0.28	0	0

*The scientific names are in accordance with The Plant List (2013) and Flora do Brasil (2020). # Municipalities: A: Aracaju, AB: Areia Branca, BC: Barra dos Coqueiros, CSF: Canindé de São Francisco, I: Itabaiana, ID: Itaporanga D'Ajuda, L: Lagarto, PR: Poço Redondo, R: Ribeirópolis, Sa: Salgado, SC: São Cristóvão, S: Siriri, TB: Tobias Barreto. For coordinates of sampling sites (from 1 to 29), see Table 1. **Fruits purchased at farmers markets. ^aManga Rosa; ^bManga Comum; ^cManga Espada; ^dVariety Paluma; ^eGoiabeira espontânea. F=number of fruits; M=mass; PP=puparia; I=infestation; Af: *Anastrepha fraterculus*; Ao: *Anastrepha obliqua*; Ap: *Anastrepha picklei*; As: *Anastrepha sororcula*; ♂A: males of *Anastrepha*; Cc: *Ceratitis capitata*; Nc: *Neosilba certa*; Ni: *Neosilba inesperata*; Np: *Neosilba pendula*; ♀N: *Neosilba* sp.; Da: *Doryctobracon areolatus*. F = Number of fruits; M = mass.

Table 4. Flies (Tephritidae and Lonchaeidae) caught in McPhail traps in the state of Sergipe.

Tabela 4. Moscas (Tephritidae e Lonchaeidae) capturadas em armadilhas tipo McPhail no estado de Sergipe.

Municipality	Period	Latitude S	Longitude W	Species*
Aracaju	Jan/2019	11°04'19.3"	37°07'20.3"	Cc (1♀), Ao (2♀), 1♀ N
	Out/2018	10°45'41.6"	37°18'05.4"	Cc (1♂), Ao (1♀), Ap (1♀)
Areia Branca	Jan/2019	10°45'41.6"	37°18'05.4"	Cc (11 ♀ + 3♂), Ao (10♀), 1 ♂A
Itabaiana	Jan/2019	10°44'17.3"	37°24'22.2"	Cc (3♀)
	Jan/2019	10°43'32.5"	37°23'48.8"	Cc (1♀)
	Out/2018	10°59'45.2"	37°20'0.03"	Cc (1♂)
Itaporanga D'Ajuda	Jan/2019	10°59'50.0"	37°19'52.0"	Cc (3♀), Ao (2♀)
	Jan/2019	10°59'45.2"	37°20'0.03"	Cc (8♀), Ao (9♀), Ap (6♀), Af (4♀), As (2♀), 9 ♂A
São Cristóvão	Jan/2019	10°58'18.0"	37°10'43.1"	Cc (14♀+4♂), Ao (182♀), Af (2♀), As (1♀), 37 ♂A
	Jan/2019	10°58'18.0"	37°10'43.1"	Cc (1♀), Ao (86♀), Af (3♀), Aps (3♀), As (1♀), 22 ♂A

*Af: *Anastrepha fraterculus*; Ao: *Anastrepha obliqua*; Ap: *Anastrepha picklei*; Aps: *Anastrepha pseudoparallela*; As: *Anastrepha sororcula*; ♂A: males of *Anastrepha*; Cc: *Ceratitis capitata*; ♀N: females of *Neosilba*.

Table 5. Flies (Tephritidae and Lonchaeidae) reported for the state of Sergipe, Brazil.

Tabela 5. Moscas (Tephritidae e Lonchaeidae) reportadas para o estado de Sergipe, Brasil.

Species	Municipalities
<i>Anastrepha fraterculus</i> (Wiedemann)	A, AB, ID
<i>Anastrepha obliqua</i> (Macquart)	A, AB, CSF, ID, SC, S
<i>Anastrepha sororcula</i> Zucchi	CSF, ID, SC
<i>Anastrepha picklei</i> Lima	AB, ID, SC, S
<i>Anastrepha pseudoparallela</i> (Loew)	SC
<i>Ceratitis capitata</i> (Wiedemann)	A, AB, CSF, I, ID, SC
<i>Neosilba certa</i> (Walker)	AB
<i>Neosilba inesperata</i> Strikis & Prado	AB, CSF
<i>Neosilba pendula</i> (Bezzi)	SC

Municipalities: A: Aracaju, AB: Areia Branca, CSF: Canindé de São Francisco, I: Itabaiana, ID: Itaporanga D'Ajuda, SC: São Cristóvão, S: Siriri.

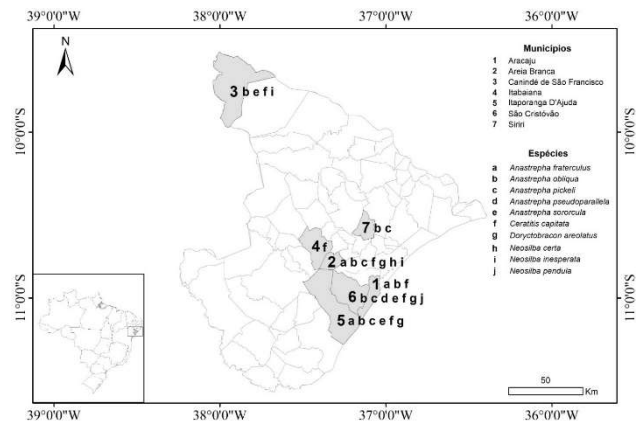


Figure 1. Geographic distribution of species of frugivorous flies and parasitoid in the state of Sergipe.

Figura 1. Distribuição geográfica das espécies de moscas frugívoras e parasitoide no estado de Sergipe.

4. DISCUSSION

Since 1980, *A. fraterculus*, obtained from an occasional sample of guava in São Cristóvão, was the only record of fruit flies for the state of Sergipe (MALAVASI et al., 1980). After almost four decades, this paper presents the results of the first survey on Tephritidae and Lonchaeidae in the state of Sergipe. Consequently, with the exception of *A. fraterculus* record in *P. guajava* (MALAVASI et al., 1980), all other results presented in this paper (flies, host plants and parasitoid) are new for the state of Sergipe. Therefore, four species of *Anastrepha*, *Ceratitis capitata*, three of *Neosilba*, one of parasitoid braconid and nine of hosts are new records for the state (Table 5 and Figure 1).

Anastrepha obliqua and *C. capitata* infested the largest number of hosts (Table 3). *Ceratitis capitata* was obtained mainly in exotic hosts, and guava was the only native host attacked by this species. This data may be indicative of recent presence of *C. capitata* in Sergipe and, therefore, has not yet adapted to native hosts. On the other hand, the species occurs in the neighboring states of Alagoas, Bahia and Pernambuco (ZUCCHI; MORAES, 2012). *Anastrepha obliqua* and *C. capitata* are among the most polyphagous flies in Brazil, as they are associated to 50 and 94 plant species, respectively (ZUCCHI; MORAES, 2008; 2012). Despite passion fruit sampling, preferred host of *A. pseudoparallela*, in five municipalities, no specimens of this species were obtained from this host. In the traps, only 10 specimens of *A. pseudoparallela* were collected (Table 4).

The municipalities sampled are located in the coastal, transitional semi-arid and hinterland regions. However, more flies were collected in the coastal and more urbanized area of Sergipe (Aracaju and São Cristóvão) in comparison to the other regions. Of the 13 municipalities sampled, in only five of them dipterans were captured in traps (Table 4).

The sampling was conducted in an area with several fruit trees and close to a fragment of the Atlantic Rainforest, a favorable factor for richness and diversity (ARAUJO et al., 2008; DUTRA et al., 2009). Several factors are related to diversity and abundance of fruit flies; however, climate generally regulates the development of native hosts and natural antagonism between species (ALUJA et al., 1997). The occurrence of fruit fly species depends on preference of hosts and is affected by the landscape, that is, the forest-growing system (MONTEIRO et al., 2018). According to these authors, in the metropolitan region of Curitiba (Paraná State – Brazil), many orchards are near or surrounded by fragments of the Atlantic Forest, which leads to interspecific competition. Although many native and cultivated plant species are not considered to be the main hosts of fruit flies, these plants play a crucial role in the multiplication of flies and their natural enemies. The Atlantic Forest has one of the largest diversities of plant and animal species (MARTINI et al., 2007) and contains native and exotic host plants for fruit flies.

Considering that the three species of lance flies have infested marketable fruits in some municipalities, studies should be intensified to estimate losses in acerola and tangerine caused by these species. Acerola is infested by *N. certa* and *N. inesperata* in the state of São Paulo (RAGA et al., 2015) and by *N. pendula* in the state of Bahia (LEITE et al., 2016). *Neosilba certa* was also recorded in tangerine in the state of Rio de Janeiro (SOUZA et al., 2008).

Only one species of parasitoid braconid (*D. areolatus*) was obtained from fruit samplings (*A. obliqua* in *A. carambola* and *S. dulcis*). This parasitoid is the most common and widely distributed in Brazil (CANAL; ZUCCHI, 2000, MARINHO et al., 2018), also in South America (OVRUSKI et al., 2000). Parasitism rates were low, compared to other surveys conducted in Brazil. Natural parasitism varies in the different fruit producing regions, since it is influenced by several factors (OVRUSKI et al., 2000).

Considering the socioeconomic importance of fruit growing for the state of Sergipe, further surveys on dipterans are recommended, regarding economic losses, their host plants, geographic distribution and time of occurrence. This knowledge is crucial for the adoption of management strategies for effective control of these agricultural pests and reduction of damages to the fruit production. Studies on parasitoids, which act on the natural population regulation of fruit flies, are also recommended.

5. CONCLUSIONS

In addition to *Anastrepha* species and *Ceratitis capitata*, *Neosilba* species infest marketable fruits in the state of Sergipe.

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7. REFERENCES

- ADAIME, R.; SOUSA, M. S. M.; JESUS-BARROS, C. R.; DEUS, E. G.; PEREIRA, J. F.; STRIKIS, P. C.; SOUZA-FILHO, M. F. Frugivorous flies (Diptera: Tephritidae, Lonchaeidae), their host plants, and associated parasitoids in the extreme north of Amapá State, Brazil. **The Florida Entomologist**, Lutz, v. 100, n. 2, p. 316-324, 2017. DOI: <https://dx.doi.org/10.1653/024.100.0229>
- ALUJA, M.; JIMÉNEZ, A.; CAMINO, M.; PIÑERO, J.; ALDANA, L.; CASTREJÓN, V.; VALDÉS, M. E. Habitat Manipulation to Reduce Papaya Fruit Fly (Diptera: Tephritidae) Damage: Orchard Design, Use of Trap Crops and Border Trapping. **Journal of Economic Entomology**, Lanham, v. 90, n. 6, p. 1567-1576, 1987. DOI: <https://dx.doi.org/10.1093/jee/90.6.1567>
- ARAUJO, E. L.; SILVA, R. K.; GUIMARÃES, J. A.; SILVA, J. G.; BITTENCOURT, M. A. L. Levantamento e flutuação populacional de moscas-das-frutas (Diptera: Tephritidae) em goiaba *Psidium guajava* L., no município de Russas (CE). **Revista Caatinga**, Mossoró, v. 21, n.1, p.138-146, 2008.
- BRASIL, 2018. Instrução Normativa nº 38, de 1 de outubro de 2018. **Diário Oficial [da] União**, Brasília, DF, 2 out. 2018, Seção 1, p. 14.

- CANAL, N. A.; ZUCCHI, R. A. Parasitóides - Braconidae. In: Malavasi, A.; ZUCCHI, R. A. (Ed.). **Moscas-das-frutas de Importância Econômica no Brasil**. Ribeirão Preto, Holos, 2000. p. 119-126.
- DUTRA, V. S.; SANTOS, M. S.; SOUZA FILHO, Z. A.; ARAUJO, E. L.; SILVA, J. G. Faunistic analysis of *Anastrepha* spp. (Diptera: Tephritidae) on a guava orchard under organic management in the municipality of Una, Bahia, Brasil. **Neotropical Entomology**, Londrina, v. 38, n. 1, p. 133-138, 2009. DOI: <http://dx.doi.org/10.1590/S1519-566X2009000100015>
- FLORA DO BRASIL - em construção. Jardim Botânico do Rio de Janeiro, 2020. Disponível em: <<http://floradobrasil.jbrj.gov.br/>>. Acesso em: 08 mai. 2020
- LEITE, S. A.; CASTELLANI, M. A.; RIBEIRO, A. E. L.; COSTA, D. R. da; BITENCOURT, M. A. L.; MOREIRA, A. A. Fruit flies and their parasitoids in the fruit growing region of Livramento de Nossa Senhora, Bahia, with records of unprecedented interactions. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 39, n. 4: 2016. (e-592) DOI: <https://dx.doi.org/10.1590/0100-29452017592>
- MALAVASI, A.; MORGANTE, J. S.; ZUCCHI, R. A. Biologia de moscas-das-frutas (Diptera: Tephritidae) I. Lista de hospedeiros e ocorrência. **Revista Brasileira de Biologia**, Rio de Janeiro, v. 40, n. 1, p. 9-16, 1980.
- MALAVASI, A.; ZUCCHI, R. A. **Moscas-das-frutas de importância econômica no Brasil**: conhecimento básico e aplicado. Ribeirão Preto: Holos, 2000. 324 p.
- MARINHO, C. F.; COSTA, V. A.; ZUCCHI, R. A. 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, 2018. DOI: <https://dx.doi.org/10.11646/zootaxa.4527.1.2>
- MARTINI, A. M. Z.; FIASCHI, P.; AMORIM, A. M.; PAIXÃO, J. L. A hot-point within a hot-spot: a high diversity site in Brazil's Atlantic Forest. **Biodiversity and Conservation**, London, v. 16, n. 11, p. 3111-3128, 2007. DOI: <https://dx.doi.org/10.1007/s10531-007-9166-6>
- MONTEIRO, L. B.; TOMBA, J. A. S.; NISHIMURA, G.; MONTEIRO, R. S.; FOELKEL, E.; LAVIGNE, C. Faunistic analyses of fruit fly species (Diptera: Tephritidae) in orchards surrounded by Atlantic Forest fragments in the metropolitan region of Curitiba, Paraná state, Brazil. **Brazilian Journal of Biology**, São Carlos, v. 79, n. 3, p. 395-403, 2018. DOI: <http://dx.doi.org/10.1590/1519-6984.178458>
- OVRUSKI, S. M.; ALUJA, M.; SIVINSKI, J.; WHARTON, R. A. Hymenopteran parasitoids on fruit-infesting Tephritidae (Diptera) in Latin America and the Southern United States: diversity, distribution, taxonomic status and their use in fruit fly biological control. **Integrated Pest Management Reviews**, v. 5, n. 2, p. 81-107, 2000. DOI: <https://dx.doi.org/10.1023/A:1009652431251>
- RAGA, A.; SOUZA-FILHO, M. F.; STRIKIS, P. C.; MONTES, S. M. N. M. Lance fly (Diptera: Lonchaeidae) host plants in the State of São Paulo, Southeast Brazil. **Entomotópica**, v. 30, n. 7, p. 57-68, 2015.
- SANTOS, M. dos R. **Observatório de Sergipe**. Disponível em: <<http://observatorio.se.gov.br/geografia-e-cartografia/mapas-e-cartogramas/>>. Acesso em: 31 de janeiro de 2019.
- SEMARH/SERGIPE. **Sistema de Informações sobre Recursos Hídricos do Estado de Sergipe: Clima**. Disponível em: <<http://www.semarh.se.gov.br>>. Acesso em: 01 de fevereiro de 2019.
- SILVA, R. A.; DEUS, E. G.; RAGA, A.; PEREIRA, J. D. B.; SOUZA-FILHO, M. F.; COSTA NETO, S. V. Monitoramento de moscas-das-frutas na Amazônia: amostragem de frutos e uso de armadilhas. In: SILVA, R. A.; LEMOS, W. P.; ZUCCHI, R. A. (Ed.). **Moscas-das-frutas na Amazônia brasileira**: diversidade, hospedeiros e inimigos naturais. Macapá: Embrapa Amapá, 2011. p. 33-50.
- SOUZA, J. F.; SOUZA, S. A. S.; AGUIAR-MENEZES, E. L.; FERRARA, F. A. A.; NASCIMENTO, S. A.; RODRIGUES, W. C.; CASSINO, P. C. R. Diversity of fruit flies in citrus groves in the municipality of Araruama, RJ. **Ciência Rural**, Santa Maria, v. 38, p. 518-521, 2008. DOI: <http://dx.doi.org/10.1590/S0103-84782008000200035>
- The Plant List. **Version 1.1. Published on the Internet**; <http://www.theplantlist.org/>. 2013. Acesso em: 08 mai. 2020
- UCHÔA, M. A. Fruit flies (Diptera: Tephritoidea): biology, host plants, natural enemies, and the implications to their natural control. In: LARRAMENDY, M. L.; SOLONESKI, S. (Ed.). **Integrated pest management and pest control**: current and future tactics. Rijeka: InTech, 2012. p. 271-300.
- ZUCCHI, R. A. Mosca-do-mediterrâneo, *Ceratitidis capitata* (Wiedemann). In: VILELA, E. F.; ZUCCHI, R. A. (Ed.). **Pragas introduzidas no Brasil**: insetos e ácaros. Piracicaba: FEALQ, 2015. p. 153-172.
- ZUCCHI, R. A.; MORAES, R. C. B. **Fruit flies in Brazil** – *Anastrepha* species their host plants and parasitoids. 2008. Disponível em: <www.lea.esalq.usp.br/anastrepha/>. Acesso em: 20 mar. 2019.
- ZUCCHI, R. A.; MORAES, R.C.B. 2012. **Fruit flies in Brazil** - Hosts and parasitoids of the Mediterranean fruit fly. Disponível em: <www.lea.esalq.usp.br/ceratitidis/>. Acesso em: 07 maio 2020.