



Biota Neotropica
ISSN: 1676-0611
cjoly@unicamp.br
Instituto Virtual da Biodiversidade
Brasil

Adaime da Silva, Ricardo; Lopes Lima, Adilson; Oliveira Xavier, Samara Larissa; Rodrigues da Silva, Wilson; Fidelis Marinho, Cláudia; Zucchi, Roberto Antonio
Anastrepha species (Diptera: Tephritidae), their hosts and parasitoids in southern Amapá State, Brazil
Biota Neotropica, vol. 11, núm. 3, julio-septiembre, 2011, pp. 431-436
Instituto Virtual da Biodiversidade
Campinas, Brasil

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***Anastrepha* species (Diptera: Tephritidae), their
hosts and parasitoids in southern Amapá State, Brazil**

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SILVA, R.A., LIMA, A.L., XAVIER, S.L.O., SILVA, W.R., MARINHO, C.F. & ZUCCHI, R.A. ***Anastrepha* species (Diptera: Tephritidae), their hosts and parasitoids in southern Amapá State, Brazil.** Biota Neotrop. 11(3): <http://www.biotaneotropica.org.br/v11n3/en/abstract?short-communication+bn03511032011>

Abstract: This work was carried out to record the species of *Anastrepha*, their host plants and associated parasitoids in Laranjal do Jari and Vitória do Jari, Amapá State. Fleshy fruits of 17 species of 13 families were sampled, from February to July of 2006, in main districts of both municipalities. Nine species of *Anastrepha* and six species of braconid parasitoids were sampled during this study.

Keywords: Amazon, Fruit flies, Hymenoptera, Braconidae, Tephritoidea.

SILVA, R.A., LIMA, A.L., XAVIER, S.L.O., SILVA, W.R., MARINHO, C.F. & ZUCCHI, R.A. **Espécies de *Anastrepha* (Diptera: Tephritidae), seus hospedeiros e parasitoides no sul do estado do Amapá, Brasil.** Biota Neotrop. 11(3): <http://www.biotaneotropica.org.br/v11n3/pt/abstract?short-communication+bn03511032011>

Resumo: O presente trabalho foi realizado com o objetivo de registrar as espécies de *Anastrepha*, suas plantas hospedeiras e parasitoides associados nos municípios de Laranjal do Jari e Vitória do Jari, estado do Amapá. Frutos carnosos de 17 espécies de 13 famílias foram amostrados, de fevereiro a julho de 2006, nos principais distritos dos dois municípios. Nove espécies de *Anastrepha* e seis espécies de braconídeos parasitoides foram coletadas durante o estudo.

Palavras-chave: Amazônia, Moscas-das-frutas, Hymenoptera, Braconidae, Tephritoidea.

Introduction

The majority of studies on fruit flies (Diptera: Tephritidae) from tropical regions focus on species of economic importance and there is poor information on their native hosts (Uramoto et al. 2008). However, this knowledge is relevant to the understanding of tephritid behavior in nature (Aluja 1999). Surveys on fruit flies, their hosts and parasitoids are fundamental for a better understanding of the biology and ecology of these insects (Zucchi 2000). Studies on tephritid populations in native areas adjacent to commercial orchards should therefore be encouraged (Deus et al. 2009). The reported geographic distribution and host plants in an area should be included in catalogs, thus producing the basic reference for technicians involved in quarantine activities (Zucchi 2000).

In Amapá State, studies on fruit flies have been intensified in recent years. Twenty-five species of *Anastrepha* have been reported, with considerable amounts of information on their hosts and parasitoids (Silva et al. 2011). However, very little information is available on the southern part of the State, and no systematized survey has ever been conducted in that region. The species previously recorded in that area are *Anastrepha distincta* Greene, *A. turpiniae* Stone, and *A. striata* Schiner in Laranjal do Jari, and *A. striata* in Vitória do Jari, besides the parasitoid *Doryctobracon areolatus* (Szépligeti) in Vitória do Jari (Creão 2003).

The purpose of this work was to record the species of *Anastrepha* found on cultivated and wild hosts, and their parasitoids in the southern part of Amapá State, Brazil.

Material and Methods

Fruits were sampled from February to July 2006, in the municipalities of Laranjal do Jari and Vitória do Jari, in the southern part of the State of Amapá. Random fruits ripening or ripe were collected from each plant or taken from ground if recently fallen, in municipalities and neighboring communities namely Tira-Couro, Água Branca do Cajari, Martins, Marinho, São Benedito, and Ramal Sombra da Mata (Laranjal do Jari), Ramal do Marapi, Ramal da Horta, and Ramal de Vitória do Jari (Vitória do Jari). Fruits were stored in coolers, covered with organza cloth, then transported to the Laboratory of Entomology at Embrapa Amapá, in Macapá.

In laboratory, the fruits were counted, weighed and placed on plastic trays over a layer of sterilized wet sand. Trays were covered with organza cloth, fastened in place with rubber bands, and examined every three days. Puparia were transferred to transparent plastic flasks (8 cm diameter) conditioned with a thin layer of wet vermiculite, and covered with organza fastened with a perforated lid, then placed in climate controlled chambers under temperature (27 ± 0.5 °C), relative humidity ($70 \pm 5\%$) and photophase (12 hours). Observations were made daily. Fruit flies and parasitoids were stored in glass flasks containing 70% ethanol.

Results and Discussion

1. Fruit flies

Seventeen plant species of 13 families were sampled (Tables 1 to 3). However, only seven species were infested by fruit flies (guava, *Psidium guajava*; ingá-cipó, *Inga edulis*; hog plum, *Spondias mombin*; goiaba-de-anta, *Bellucia grossularioides*; quina, *Geissospermum argenteum*; abiu, *Pouteria caimito*; and manilkara, *Manilkara huberi*) (Tables 1 and 2).

Nine species of *Anastrepha* were collected: *Anastrepha antunesi* Lima, *Anastrepha atrigona* Hendel, *Anastrepha coronilli* Carrejo & González, *Anastrepha distincta* Greene, *Anastrepha fraterculus*

Wiedemann, *Anastrepha obliqua* Macquart, *Anastrepha serpentina* Wiedemann, *Anastrepha sororcula* Zucchi, and *Anastrepha striata* Schiner (Tables 1 and 2). All mentioned species were collected in the municipality of Laranjal do Jari, from 3,890 fruits (99.0 kg) sampled (Table 1). In Vitória do Jari, only *A. atrigona*, *A. coronilli*, *A. distincta* and *A. striata* were obtained from 831 fruits (18.7 kg) (Table 2).

All of the *Anastrepha* species collected had been previously reported from Amapá (Silva et al. 2011). Seven species constitute new reports for Laranjal do Jari: *A. antunesi*, *A. atrigona*, *A. coronilli*, *A. fraterculus*, *A. obliqua*, *A. serpentina*, and *A. sororcula* (Table 1). Three species were collected in Vitória do Jari for the first time: *A. atrigona*, *A. coronilli*, and *A. distincta* (Table 2).

Guava was the host with most *Anastrepha* species (Table 1). In Amapá, it has been reported as a host for nine species (Silva et al. 2011). *Anastrepha striata* was the predominant species in guava from Laranjal do Jari and the only species obtained from guava in Vitória do Jari (Tables 1 and 2). This species has been the predominant tephritid found in guava throughout the State of Amapá (Silva & Silva 2007, Silva et al. 2007a, 2010, Deus et al. 2009).

The highest infestation rates were observed in fruits of quina, with an average of 614.9 puparia/kg in Laranjal do Jari (Table 1) and 162.0 puparia/kg in Vitória do Jari (Table 2). In a single sample of quina from Laranjal do Jari, a total of 1,047.3 puparia/kg was counted. In hosts of economic relevance, the infestation rates were different in each municipality, for example, ingá-cipó yielded 9.5 puparia/kg in Vitória do Jari and 56.1 puparia/kg in Laranjal do Jari, and guava had 23.7 puparia/kg in Laranjal do Jari and 53.4 puparia/kg in Vitória do Jari.

Anastrepha atrigona was sampled in quina, *A. coronilli* in goiaba-de-anta, *A. distincta* in ingá-cipó, and *A. serpentina* in abiu and manilkara, as already reported from other municipalities of Amapá (Silva et al. 2011). The rate of infestation found in quina (614.9 puparia/kg) was higher than the rate reported by Xavier et al. (2006) in the same municipality (525.9 puparia/kg) and by Deus et al. (2009) in two municipalities in central Amapá (241.02 and 422.22 puparia/kg).

Plant species considered to be economically relevant to the State of Amapá, such as hog plum (*Spondias mombin*), ingá-cipó (*Inga edulis*), guava (*Psidium guajava*), and abiu (*Pouteria caimito*), had widely variable infestation rates by fruit flies across different locations in the State. For example, if compared with the data reported by Silva et al. (2010), the infestation rates observed in this work in guava were lower than those reported for the municipalities of Macapá (406.25 puparia/kg), Porto Grande (446.71 puparia/kg) and Mazagão (536.00 puparia/kg). In ingá-cipó and abiu, the rates reported here were lower than those reported for Mazagão (152.72 and 195.33 puparia/kg, respectively). On the other hand, the infestation rate in hog plum (58.0 puparia/kg in Laranjal do Jari) was lower than the rate reported in Macapá (141.8 puparia/kg) by Silva et al. (2005).

Ten species of seven plant families were not infested by *Anastrepha* (Table 3). However, among these species, cashew (*Anacardium occidentale*), biribá (*Rollinia mucosa*), ajuru (*Chrysobalanus icaco*), muruci (*Byrsonima crassifolia*), jaca (*Artocarpus heterophyllus*), star fruit (*Averrhoa carambola*) and orange (*Citrus sinensis*) have already been reported as hosts of *A. striata* in Amapá. *Anastrepha striata* is the most abundant and polyphagous tephritid species in the State (25 hosts in 16 botanical families), with a clear preference for Myrtaceae (Silva et al. 2011).

2. Parasitoids

In Laranjal do Jari, a total of 188 parasitoids (Braconidae) belonging to six species were collected: *Doryctobracon areolatus* (Szépligeti), *Doryctobracon crawfordi* (Viereck), *Asobara anastrephae*

Table 1. Infestation rates by fruit flies and parasitism rates in fruits collected in Laranjal do Jari, Amapá, Brazil (February to July 2006).

Family common name (scientific name)	Samples* C/I (n)	Fruits (n)	Mass (g)	Puparia (n)	Infestations (puparia/kg)		Anastrepha spp.	Parasitism** (%)	Parasitoids
					Mean ± SE	Range			
Anacardiaceae									
Hog plum (<i>Spondias mombin</i>)	3/3	1,480	12,002	630	58.0 ± 26.7	18.6-108.8	<i>A. obliqua</i> (127) <i>A. antunesi</i> (5) Males (122)	0.6-5.3	<i>Doryctobracon areolatus</i> (14) <i>Asobara anastrephae</i> (3) <i>Opius bellus</i> (1) <i>Uteetes anastrephae</i> (1)
Apocynaceae									
Quina (<i>Geissospermum argenteum</i>)	2/2	276	4,114	1,135	614.9 ± 432.3	182.6-1,047.3	<i>A. atrigona</i> (103) Males (138)	2.5-8.6	<i>Doryctobracon</i> sp.2 (36) <i>Asobara anastrephae</i> (19) <i>Opius bellus</i> (1) <i>Doryctobracon crawfordi</i> (1)
Melastomataceae									
Goiaba-de-anta (<i>Bellucia grossularioides</i>)	4/4	524	5,047	112	38.6 ± 32.61	3.9-136.4	<i>A. coronilli</i> (17) Males (21)	0-14.3	<i>Doryctobracon areolatus</i> (13)
Mimosaceae									
Ingá-cipó (<i>Inga edulis</i>)	10/7	82	15,587	760	56.1 ± 19.39	2.2-117.9	<i>A. distincta</i> (218) Males (95)	0-1.4	<i>Doryctobracon areolatus</i> (2)
Myrtaceae									
Guava (<i>Psidium guajava</i>)	22/21	1,169	53,120	1,117	23.7 ± 4.27	4.3-67.0	<i>A. striata</i> (302) <i>A. fraterculus</i> (18) <i>A. sororcula</i> (5) <i>A. obliqua</i> (1) Males (339)	0-31.3	<i>Doryctobracon areolatus</i> (73) <i>Doryctobracon</i> sp.2 (10) <i>Asobara anastrephae</i> (1)
Sapotaceae									
Abiu (<i>Pouteria caimito</i>)	3/2	248	8,100	1,023	126.7 ± 34.74	92.0-161.5	<i>A. serpentina</i> (379) <i>A. antunesi</i> (1) Males (320)	0	-
Manilkara (<i>Manilkara huberi</i>)	2/2	111	1,013	46	61.4 ± 46.69	14.7-108.1	<i>A. serpentina</i> (7) Males (2)	20.0-30.6	<i>Doryctobracon areolatus</i> (13)

*C/I: Collected/Infested (other data refer only to infested samples). **Lowest and highest value.

Table 2. Infestation rates by fruit flies and parasitism rates in fruits collected in Vitória do Jari, Amapá, Brazil (February to July 2006).

Family common name (scientific name)	Samples* C/I (n)	Fruits (n)	Mass (g)	Puparia (n)	Infestations (puparia/kg)		<i>Anastrepha</i> spp.	Parasitism** (%)	Parasitoids
					Mean	SE			
Apocynaceae									
Quina (<i>Geissospermum argenteum</i>)	2/2	306	3,394	290	162.0 ± 85.09		76.9-247.1 <i>A. atrigona</i> (29) Males (47)	0-1.6	<i>Doryctobracon</i> sp.2 (2) <i>Asobara anastrephae</i> (2)
Melastomataceae									
Goiaba-de-anta (<i>Bellucia grossularioides</i>)	3/3	335	2,791	56	21.5 ± 7.86		9.3-36.2 <i>A. coronilli</i> (9) Males (19)	0	-
Mimosaceae									
Ingá-cipó (<i>Inga edulis</i>)	4/2	43	5,128	45	9.5 ± 2.90		6.6-12.4 <i>A. distincta</i> (22) Males (6)	0	-
Myrtaceae									
Guava (<i>Psidium guajava</i>)	9/7	147	7,379	273	53.4 ± 13.76		7.4-114.7 <i>A. striata</i> (78) Males (102)	0-16.7	<i>Doryctobracon areolatus</i> (11) <i>Doryctobracon</i> sp.2 (3)

*C/I: Collected/Infested (other data refer only to infested samples). **Lowest and highest value.

Table 3. Species not infested by fruit flies (February to July 2006).

Families Common names (scientific names)	Laranjal do Jari			Vitória do Jari		
	Samples (n)	Fruits (n)	Mass (g)	Samples (n)	Fruits (n)	Mass (g)
Anacardiaceae						
Cashew (<i>Anacardium occidentale</i>)	3	26	1,645	-	-	-
Mango (<i>Mangifera indica</i>)	2	28	5,677	-	-	-
Annonaceae						
Biribá (<i>Rollinia mucosa</i>)	1	7	1,061	-	-	-
Graviola (<i>Annona muricata</i>)	-	-	-	1	1	920
Chrysobalanaceae						
Ajuru (<i>Chrysobalanus icaco</i>)	-	-	-	1	366	2,152
Malpighiaceae						
Acerola (<i>Malpighia puniceifolia</i>)	1	58	249	1	37	107
Muruci (<i>Byrsonima crassifolia</i>)	1	96	389	5	732	3,613
Moraceae						
Jaca (<i>Artocarpus heterophyllus</i>)	1	1	3,225	-	-	-
Oxalidaceae						
Star fruit (<i>Averrhoa carambola</i>)	6	143	10,097	2	29	2,609
Rutaceae						
Orange (<i>Citrus sinensis</i>)	4	70	8,032	1	7	1,046

(Muesebeck), *Opius bellus* Gahan, *Utetes anastrephae* (Viereck), and one new species of *Doryctobracon* not formally described to date [*Doryctobracon* sp.2 in Marinho's thesis (2009)] (Table 1). *Doryctobracon crawfordi* was recently recorded from Brazil (States of Amapá and Roraima) (Zucchi et al. 2011). Only 14 parasitoids were registered in Vitória do Jari, which belonged to three species: *D. areolatus*, *A. anastrephae*, and *Doryctobracon* sp.2 (Table 2).

Doryctobracon areolatus was the predominant parasitoid species in both municipalities (Tables 1 and 2). The second most abundant parasitoids were *Doryctobracon* sp.2 and *Asobara anastrephae* in both municipalities. In Laranjal do Jari, few specimens of *Opius bellus* and *U. anastrephae* and only one specimen of *Doryctobracon crawfordi* were collected. *Doryctobracon areolatus* is the most abundant braconid parasitoid of fruit flies in the State of Amapá (Silva & Silva 2005, Silva et al. 2007a, b, 2010, Deus et al. 2009), and is also considered to be the most widely distributed throughout Brazil (Leonel Junior et al. 1995, Canal & Zucchi 2000) and Latin America (Ovruski et al. 2000). The predominance of this species compared to other native parasitoids may be associated not only with its greater ability to locate hosts, but also its ability to infest larvae at early instars (Matrangolo et al. 1998).

The highest parasitism rate was found in guava, in Laranjal do Jari (Table 1). The rate observed in this work (31.3%) was higher than in Mazagão (3.45%), Serra do Navio (6.18%), Pedra Branca do Amapari (6.38%) and Santana (17.24%); similar to the rate observed in Macapá (30%); and lower than what was reported in Porto Grande (45.50%) (Deus et al. 2009, Silva et al. 2010). This work provides the first record of parasitism of *A. serpentina* by *D. areolatus* in manilkara fruits in Brazil (Table 1). Manilkara was already known to be a host of *A. serpentina* in Amapá, but without association with parasitoids (Deus et al. 2009).

Low parasitism rates were observed in hog plum (0.6 to 5.3%). These values are lower than those reported for the same host in the municipalities of Itaubal do Piririm (11.9%), Ferreira Gomes (21.7%), and Macapá (23.6%) (Silva et al. 2005, 2007a, Silva & Silva 2007).

Fruit flies in hog plum, quina and guava showed the highest diversity of parasitoids. *Anastrepha atrigona* is strongly associated with quina (Deus et al. 2009), which is infested exclusively by this species in Amapá (Silva et al. 2011).

Acknowledgements

The authors thank the Agência de Desenvolvimento da Amazônia (ADA) and the Secretaria de Estado da Ciência e Tecnologia do Amapá for financial support to their research. We also thank Mr. Carlos Alberto Moraes, a staff member at Embrapa Amapá, for assistance in the field.

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Received 30/04/2011

Revised 19/08/2011

Accepted 07/09/2011