New Findings on Lonchaeidae (Diptera: Tephritoidea) in the Brazilian Amazon

Author(s): Lailson do Nascimento Lemos, Ricardo Adaime, Salustiano V. Costa-Neto, Ezequiel da Glória de Deus, Cristiane Ramos de Jesus-Barros and Pedro Carlos Strikis
Source: Florida Entomologist, 98(4):1227-1237.
Published By: Florida Entomological Society
DOI: http://dx.doi.org/10.1653/024.098.0433
URL: http://www.bioone.org/doi/full/10.1653/024.098.0433

New findings on Lonchaeidae (Diptera: Tephritoidea) in the Brazilian Amazon

Lailson do Nascimento Lemos[1], Ricardo Adaime[2,], Salustiano V. Costa-Neto[3], Ezequiel da Glória de Deus[1], Cristiane Ramos de Jesus-Barros[2], and Pedro Carlos Strikis[4]*

Abstract

Distribution and host data of Lonchaeidae species (Diptera: Tephritoidea) in the state of Amapá, Brazil, are presented. Adults of 10 species in the genera *Neosilba*, *Dasiops*, and *Lonchaea* were reared from 23 plant species in 18 families. *Neosilba laura* Strikis and *Neosilba parapeltae* Strikis are reported for the first time in the Amazon, and *Dasiops inedulis* Steyskal and *Neosilba perezi* Romero & Ruppel are reported for the first time in Amapá State. Additionally, 24 new host associations are documented.

Key Words: *Neosilba*; infestation; orchard

Resumo

Dados de distribuição e hospedeiros de espécies de Lonchaeidae (Diptera: Tephritoidea) no estado do Amapá, Brasil, são apresentados. Adultos de 10 espécies nos gêneros *Neosilba*, *Dasiops* e *Lonchaea* foram obtidos de 23 espécies de plantas em 18 famílias. *Neosilba laura* Strikis e *N. parapeltae* Strikis são reportadas pela primeira vez na Amazônia, e *Dasiops inedulis* Steyskal e *Neosilba perezi* Romero & Ruppel são reportadas pela primeira vez no estado do Amapá. Adicionalmente, 24 novas associações com hospedeiros são documentadas.

Palavras Chave: *Neosilba*; infestação; fruticultura

Lonchaeids (Diptera: Lonchaeidae), commonly known as lance flies, are minute insects (3–6 mm long) with glossy, dark blue bodies and hyaline or very pale brown wings, found mainly in humid or shaded places. Larvae are associated with decomposing organic matter, mainly wood, flowers, and fruits. However, some species are primary invaders of fruits and flower buds (McAlpine 1961; Norrbom & McAlpine 1997) and may have a significant economic impact on fruit crops (MacGowan & Okamoto 2013).

Lonchaeidae contain approximately 545 species, grouped into 2 subfamilies (Dasiopinae and Lonchaeinae) and 8 genera (*Chaetolonchaea* Czerny, *Dasiops* Rondani, *Earomyia* Zetterstedt, *Lamprolonchaea* Bezzi, *Lonchaea* Fallén, *Neosilba* McAlpine, *Protearomyia* McAlpine, and *Silba* Macquart). The subgenus *Setisquamalonchaea* Morge is currently considered synonymous with *Silba* (MacGowan & Okamoto 2013; MacGowan 2015).

Tephritidae and Lonchaeidae are the most and second-most, respectively, economically important dipteran families in South America, and some species of *Dasiops* and *Neosilba* are primary pests of fruit crops. For plant species of economic importance, including citrus (*Citrus* species; Sapindales: Rutaceae), ambarella (*Spondias dulcis* Soland. ex Forst. f.; Sapindales: Anacardiaceae), and passionfruit (*Passiflora* species; Malpighiales: Passifloraceae), lonchaeids can be more abundant and more important as pests than Tephritidae (Uchôa 2012).

Although infestations of fruits of economic importance by lonchaeids have been reported in Brazil since the 1930s, these insects generally were neglected in surveys of fruit flies, mainly due to a lack of taxonomic knowledge. In the 1990s, the large number of lonchaeid puparia obtained in these surveys renewed interest in lonchaeid research, especially in southeastern Brazil (Araújo & Zucchi 2002). Recently, a number of studies on Lonchaeidae species have been conducted in Brazil, motivated by advances in taxonomic knowledge of Brazilian species. The species reported in Brazil belong to the genera *Dasiops*, *Lonchaea*, and *Neosilba*.

These studies have revealed that species of *Neosilba* are primary pests of certain crops, including cassava (*Manihot esculenta* Crantz; Malpighiales: Euphorbiaceae) (Lourenção et al. 1996); acerola (*Malpighia emarginata* [Moc. & Sessé] ex. DC; Malpighiales: Malpighiaceae) (Araújo & Zucchi 2002); citrus (*Citrus* species) (Uchôa-Fernandes et al. 2002, 2003); coffee (*Coffea arabica* L.; Gentianales: Rubiaceae) (Aguiar-Menezes et al. 2007); and tangerine (*Citrus reticulata* Blanco; Sapindales: Rutaceae) (Lopes et al. 2008). *Dasiops frieseni* Norrbom & McAlpine has been reported to damage fruits of sour passionfruit (*Passiflora edulis* Sims; Malpighiales: Passifloraceae) (Souza-Filho et al. 2002), and *Dasiops inedulis* Steyskal has been reported to damage passionfruit flower buds (Lunz et al. 2006).

[1]Universidade Federal do Amapá, Programa de Pós-Graduação em Biodiversidade Tropical, Macapá, Amapá, 68902-280, Brazil
[2]Embrapa Amapá, Macapá, Amapá, 68903-419, Brazil
[3]Instituto de Pesquisas Científicas e Tecnológicas do Amapá (IEPA) Macapá, Amapá, 68900-000, Brazil
[4]Independent Researcher, Av. Paschoal Ardito, No. 886, 13473-010, Americana, São Paulo, Brazil
*Corresponding author; E-mail: ricardo.adaime@embrapa.br

Lonchaeids were first reported in the Brazilian Amazon in the state of Amazonas by Silva (1993), who reported species of *Neosilba* associated with 19 fruit-bearing species. Costa (2005) subsequently reported *Neosilba major* (Malloch), *Neosilba zadolicha* McAlpine & Steyskal, and *Neosilba* sp. in a study conducted at the Adolpho Ducke Forest Reserve, in the city of Manaus. New studies were completed more recently, contributing significantly to knowledge on Lonchaeidae in the Amazon (Querino et al. 2010; Strikis et al. 2011; Adaime et al. 2012; Deus et al. 2013).

Lonchaeids have numerous native and exotic hosts in the Brazilian Amazon, many species of which are found exclusively in forest environments. *Neosilba glaberrima* (Wiedemann) and *N. zadolicha* are the most polyphagous and widely distributed lonchaeid species in this region (Strikis et al. 2011). Despite an increase in research, little is known about the ecology and biology of lonchaeids. This study reports new findings on the distribution of Lonchaeidae species and their hosts in the Brazilian Amazon.

Materials and Methods

STUDY SITE

We conducted this study on 3 farms located in the municipalities of Mazagão, Porto Grande, and Santana, state of Amapá, Brazil (Fig. 1). All 3 properties contained commercial orchards with adjoining areas of native forest.

The area in Mazagão (0.1°S, 51.25°W) exhibits native floodplain forest vegetation, which undergoes daily flooding due to tides. Common species include *Platymiscium duckei* Huber (Fabales: Fabaceae), *Virola surinamensis* (Rolander) Warb. (Magnoliales: Myristicaeceae), *Calycophyllum spruceanum* (Benth.) Hook,f. ex K. Schum. (Gentianales: Rubiaceae), and *Carapa guianensis* Aubl. (Sapindales: Meliaceae). The commercial orchard area occupies an area of approximately 10 ha, with cultivated fruit trees including tahiti lime (*Citrus aurantifolia* Swingle var. 'Tahiti'; Sapindales: Rutaceae), passionfruit (*P. edulis*), and soursop (*Annona muricata* L.; Magnoliales: Annonaceae), grown for the manufacture of fruit concentrate or to be sold in natura.

The area in Porto Grande (0.6°N, 51.45°W) exhibits dense forest vegetation, with numerous tree species, including *Protium* species (Sapindales: Burseraceae), *Caryocar villosum* (Aubl.) Pers. (Malpighiales: Caryocaraceae), and *Dipteryx odorata* (Aubl.) Willd. (Fabales: Fabaceae). The property is approximatly 100 ha, of which 30% is used for the cultivation of fruit trees, mainly hog plum (*Spondias mombin* Jacq.; Sapindales: Anacardiaceae), araza (*Eugenia stipitata* McVaugh; Myrtales: Myrtaceae), and soursop (*A. muricata*).

The area in Santana (0.03°S, 51.21°W) exhibits secondary forest vegetation, with *Eschweilera tenuifolia* Miers (Ericales: Lecythidaceae), *Ficus pertusa* L.f., (Rosales: Moraceae), and *Pourouma guianensis* Aubl. (Rosales: Urticaceae) as predominant species. The commercial orchard

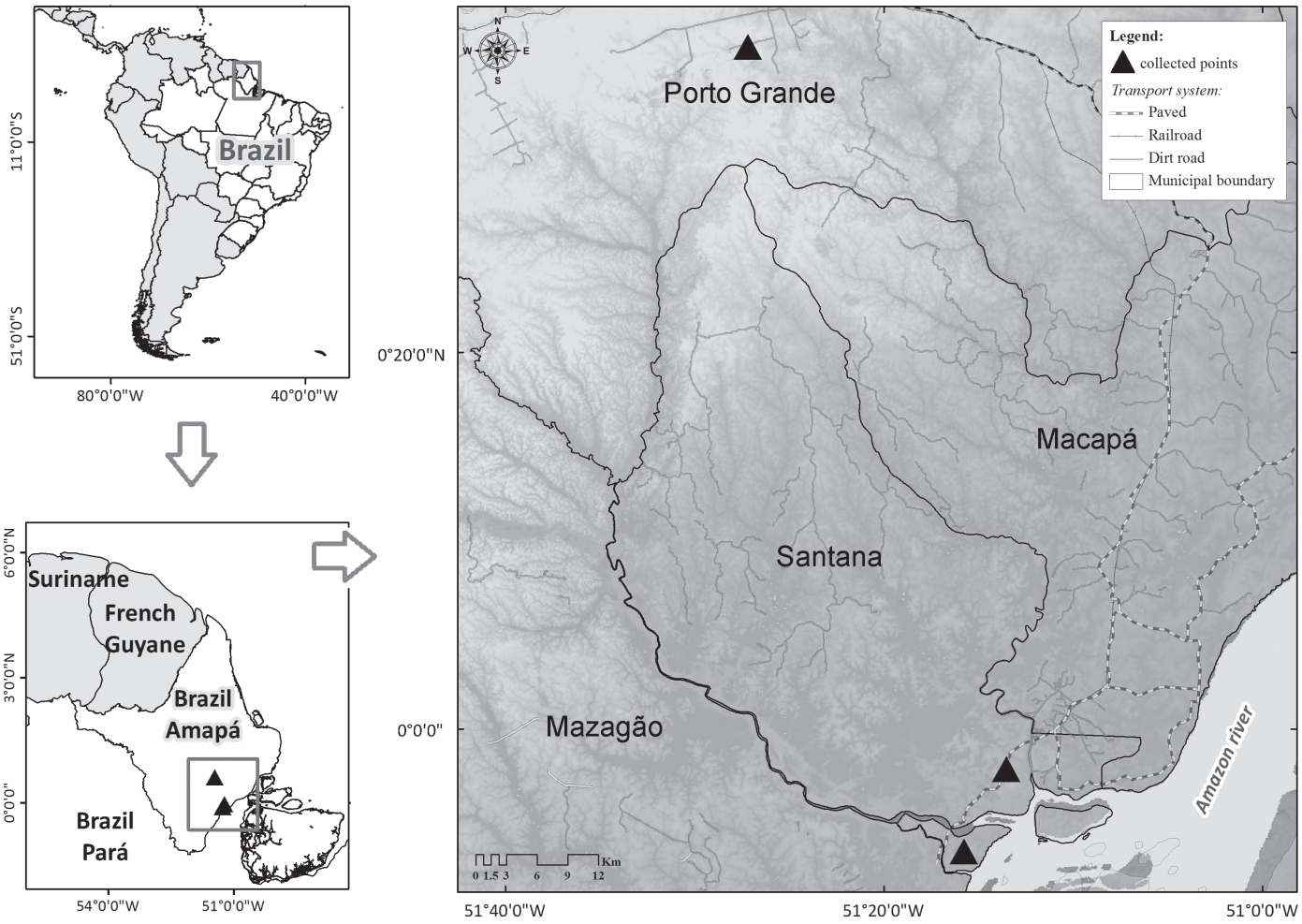

Fig. 1. State of Amapá with markers (black triangles) indicating the sampling site locations.

is approximately 20 ha, and the main species are acerola (*M. emarginata*), guava (*Psidium guajava* L.; Myrtales: Myrtaceae), and passionfruit (*P. edulis*). As classified by Köppen, the climate type at the study sites is Am, characterized as hot and humid with a short dry season in the spring. Rainfall is distributed bewteen 2 well-defined periods: a rainy season (Jan to Jul), which receives about 80% of all annual rainfall in the area, and a dry season (Aug to Dec). Temperatures are elevated throughout the year, with an annual average of 25 to 27 °C (low of 22 °C and high of 34 °C) (IBGE 2010).

FRUIT COLLECTION AND PROCESSING

Every fruit tree species in the orchards was sampled. Within the native vegetation areas, 1 parcel of 40 × 250 m (1 ha) was delimited in each area. Once per month from Jan to Dec 2012, fruits were collected from various plant species, either directly from the plant or by retrieving recently fallen fruit. Samples were transported in stackable plastic crates to the Entomology Laboratory at Embrapa Amapá, where the fruits were weighed on a digital scale. For preparation of the samples, the fruits were processed and individualized according to the sample size criterion established by Silva et al. (2011): 15 units, for small fruit; 10 units, for medium-sized fruit; and 3 units, for large or elongated fruit. In each sample, each individual fruit was considered as 1 subsample.

The collected fruits were placed either individually into tubular, transparent plastic vials (8 cm diameter × 6 cm height), with vented lids lined with organza; or, in the case of large or elongated fruit, on rectangular plastic trays (33 × 18 × 6 cm LWH), also covered with organza held in place by rubber bands. Both types of containers included a thin layer of sterilized sand as a substrate for pupation.

ACQUISITION OF PUPARIA AND ADULT INSECTS

Every 3 d, the sand was examined and lonchaeid puparia were removed with spatulas. The puparia were transferred into transparent plastic vials (8 cm diameter), with vented lids covered with organza, containing a thin layer of moistened vermiculite. The adult insects that emerged were killed, transferred to Eppendorf tubes containing 70% ethanol, and labeled for subsequent identification.

Identification of Insects

Specimens obtained were identified according to McAlpine & Steyskal (1982) and Strikis (2011).

Identification of Botanical Material

Branches with attached reproductive structures (flowers and/or fruits), were collected and vouchered as herbarium specimens using typical mounting and preservation techniques (Fidalgo & Bononi 1984). Plant species was identified with identification keys and by comparison with specimens available at the Herbário Amapaense, the herbarium at the Amapá State Institute for Scientific and Technological Research.

DATA ANALYSES

The following infestation rates were calculated: 1) percentage of fruits infested = (number of fruits infested ÷ number of fruits collected) × 100; 2) number of puparia per fruit = number of puparia obtained ÷ number of infested fruits in the sample.

Results

In total, 412 plant samples were collected (78 plant species in 32 families, 4,554 fruits, 323.4 kg) (Table 1). Infestation was observed in 50 of the samples (12.1%), representing 23 plant species (18 families; Table 1). In total, 856 Lonchaeidae puparia were obtained, from which emerged specimens of 10 species in the genera *Neosilba*, *Dasiops*, and *Lonchaea*.

MAZAGÃO

In total, 129 samples were collected, consisting of 1,495 fruits of 42 species (20 families; Table 1). Infestation by lonchaeids was observed in 15 samples: 59 fruits of 7 plant species (7 families), from which 457 puparia were obtained (Tables 1 and 2). *Metrodorea flavida* K. Krause (Sapindales: Rutaceae) showed the highest percentage of infested fruits (70.0%), and *A. muricata* had the highest infestation load (39 puparia/fruit) (Table 2).

Seven species of Lonchaeidae were obtained: *N. glaberrima*, *N. laura* Strikis, *N. pendula* (Bezzi), *N. pseudozadolicha* Strikis, *N. zadolicha*, *D. inedulis*, and 1 *Lonchaea* species (Table 2) that was in poor condition and unidentifiable. *Neosilba zadolicha* was the most abundant species (66 specimens), occurring from Apr to Jul and infesting 5 host species (Table 2).

PORTO GRANDE

In total, 154 samples were collected, consisting of 1,524 fruits of 41 species (24 families). Infestation by lonchaeids was observed in 16 samples: 41 fruits of 8 plant species (7 families), from which 176 puparia were obtained (Tables 1 and 3). *Artocarpus altilis* (Parkinson) Forsberg (Rosales: Moraceae) showed the highest percentage of infested fruits (66.7%), and *A. muricata* had the highest infestation load (11 puparia/fruit) (Table 3).

Six species were reared: *N. glaberrima*, *N. laura*, *N. pendula*, *N. pseudozadolicha*, *N. zadolicha*, and 1 unidentified *Lonchaea* species (Table 3). *Neosilba glaberrima* infested the greatest number of hosts (6), followed by *N. zadolicha* and *N. pseudozadolicha* (3). *Neosilba zadolicha* was the most abundant species (31 specimens). In total, 44 specimens of *Neosilba* were obtained from *E. stipitata*, specifically 20 specimens of *N. zadolicha*, 3 of *N. glaberrima*, 1 of *N. pseudozadolicha*, and 20 females (Table 3). Except for Oct and Nov, specimens were obtained from at least 1 sampled host in all other months (Table 3).

SANTANA

In total, 129 samples were collected, consisting of 1,535 fruits of 40 plant species (23 families). Infestation was observed in 19 samples: 43 fruits of 12 plant species (12 families), from which 223 puparia were obtained (Tables 1 and 4). *Inga edulis* Mart. (Fabales: Fabaceae) showed the highest percentage of infested fruits (100%) (Table 4). The highest infestation load was observed on shoots of *M. esculenta* (11puparia/shoot) (Table 4).

Eight species were reared: *Neosilba bella* Strikis, *N. glaberrima*, *N. parapeltae* Strikis, *N. pendula*, *N. perezi* Romero & Ruppel, *N. pseudozadolicha*, *N. zadolicha*, and *D. inedulis*. *Neosilba zadolicha* infested the greatest number of hosts (5), followed by *N. glaberrima* (4). *Neosilba zadolicha* was the most abundant species (59 specimens). The fruits of *P. guajava* yielded specimens from 3 species of *Neosilba* (*N. glaberrima*, *N. pseudozadolicha*, and *N. zadolicha*) in 6 mo of the year (Table 4).

Table 1. Number of samples and fruits collected and infested by Lonchaeidae in 3 municipalities of the state of Amapá, Brazil, Jan to Dec 2012.

Fruit tree species/families sampled Scientific name	Common name	Family	Origin native (N), introduced (I)	Municipality											
				Mazagão				Porto Grande				Santana			
				NSC	NFC	NSI	NFI	NSC	NFC	NSI	NFI	NSC	NFC	NSI	NFI
Alibertia edulis (L. C. Rich.) A. Rich. ex DC	Puruí	Rubiaceae	N	0	0	0	0	2	30	0	0	0	0	0	0
Anacardium occidentale L.	Cashew	Anacardiaceae	I	1	10	0	0	0	0	0	0	2	20	0	0
Annona muricata L.	Soursop	Annonaceae	I	1	3	1	1	4	12	3	3	2	6	1	2
Artocarpus altilis (Parkinson) Fosberg	Breadfruit	Moraceae	I	0	0	0	0	4	12	2	4	0	0	0	0
Artocarpus heterophyllus Lam.	Jackfruit	Moraceae	I	0	0	0	0	2	6	0	0	3	9	0	0
Astrocaryum aculeatum G. Mayer	Tucumã	Arecaceae	N	0	0	0	0	0	0	0	0	1	15	0	0
Astrocaryum murumuru Mart.	Murumuru	Arecaceae	N	6	60	0	0	0	0	0	0	0	0	0	0
Attalea phalerata Mart. ex Spreng.	Urucuri	Arecaceae	N	7	70	0	0	0	0	0	0	0	0	0	0
Averrhoa carambola L.	Star fruit	Oxalidaceae	I	0	0	0	0	9	90	3	14	0	0	0	0
Bactris gasipaes Kunth.	Peach-palm	Arecaceae	N	0	0	0	0	2	30	0	0	0	0	0	0
Bactris maraja Mart.	Maraja	Arecaceae	N	1	15	0	0	0	0	0	0	0	0	0	0
Bellucia grossularioides (L.) Triana	Goiaba-de-anta	Melastomataceae	N	0	0	0	0	2	30	0	0	0	0	0	0
Byrsonima crassifolia (L.) HBK	Nance	Malpighiaceae	N	0	0	0	0	0	0	0	0	5	75	0	0
Capsicum chinense Jacq.	Yellow lantern chili	Solanaceae	I	8	120	0	0	1	15	1	4	3	45	0	0
Calophyllum brasiliense Cambess.	Jacareuba	Calophyllaceae	N	1	15	1	1	0	0	0	0	0	0	0	0
Carica papaya L.	Papaya	Caricaceae	I	1	3	0	0	5	15	0	0	6	90	0	0
Caryocar glabrum (Aubl.) Pers.	Water sawari	Caryocaraceae	N	0	0	0	0	1	10	0	0	0	0	0	0
Cayaponia ferruginea Gomes-Klein	Fruta de cutia	Cucurbitaceae	N	0	0	0	0	0	0	0	0	1	15	0	0
Cheiloclinium cognatum (Miers) A.C. Sm.	Bacupari	Celastraceae	N	2	30	0	0	0	0	0	0	3	45	0	0
Cissus amapaenses Lombardi	Uva-do-mato	Vitaceae	N	0	0	0	0	0	0	0	0	2	30	0	0
Citrus aurantifolia Swingle var. 'Tahiti'	Tahiti lime	Rutaceae	I	9	90	0	0	0	0	0	0	3	30	0	0
Citrus aurantium L.	Bitter orange	Rutaceae	I	0	0	0	0	10	100	0	0	0	0	0	0
Citrus latifolia Tanaka	Tahiti lime	Rutaceae	I	0	0	0	0	0	0	0	0	2	20	0	0
Citrus limonia Osbeck	Rangpur	Rutaceae	I	8	80	0	0	8	80	0	0	11	110	1	1
Citrus reticulata Blanco	Tangerine	Rutaceae	I	2	20	0	0	4	40	0	0	5	50	0	0
Citrus sinensis (L.) Osbeck	Orange	Rutaceae	I	4	40	0	0	0	0	0	0	1	10	0	0
Coffea arabica L.	Coffee	Rubiaceae	I	0	0	0	0	0	0	0	0	3	45	1	1
Combretum laxum Jacq.	Pombeiral	Combretaceae	N	0	0	0	0	2	30	0	0	0	0	0	0
Conceveiba guianensis Aubl.	Arraieira	Euphorbiaceae	N	0	0	0	0	0	0	0	0	1	15	0	0
Cucumis anguria L.	Bur cucumber	Cucurbitaceae	N	5	75	0	0	1	15	0	0	1	15	0	0
Cucumis sativus L.	Cucumber	Cucurbitaceae	I	5	15	0	0	0	0	0	0	1	3	1	1
Eschweilera tenuifolia Miers	Matá-matá (flower bud)	Lecythidaceae	N	0	0	0	0	0	0	0	0	4	60	1	1
Eugenia stipitata McVaugh	Araza	Myrtaceae	N	0	0	0	0	11	110	3	11	0	0	0	0
Ficus pertusa L.f.	Apuí	Moraceae	N	2	30	0	0	2	30	0	0	1	15	0	0
Geissospermum sericeum Miers	Quinarana	Apocynaceae	N	0	0	0	0	2	20	0	0	0	0	0	0
Guarea guidonia (L.) Sleumer	American muskwood	Meliaceae	N	0	0	0	0	1	15	0	0	0	0	0	0
Gustavia augusta L.	Jenipaparana	Lecythidaceae	N	0	0	0	0	0	0	0	0	1	10	0	0
Inga edulis Mart.	Ice-cream-bean	Fabaceae	N	2	6	0	0	0	0	0	0	5	15	2	6
Licania macrophylla Benth.	Anoerá	Chrysobalanaceae	N	5	45	0	0	0	0	0	0	1	15	1	2
Malpighia emarginata Moc. & Sessé ex. DC	Acerola	Malpighiaceae	I	1	15	0	0	4	60	0	0	9	135	0	0

NSC, number of samples collected; NFC, number of fruits collected; NSI, number of samples infested; NFI, number of fruits infested.

Table 1. (Continued) Number of samples and fruits collected and infested by Lonchaeidae in 3 municipalities of the state of Amapá, Brazil, Jan to Dec 2012.

Fruit tree species/families sampled Scientific name	Common name	Family	Origin native (N), introduced (I)	Municipality											
				Mazagão				Porto Grande				Santana			
				NSC	NFC	NSI	NFI	NSC	NFC	NSI	NFI	NSC	NFC	NSI	NFI
Mammea americana L.	Apricot	Clusiaceae	I	0	0	0	0	3	30	0	0	0	0	0	0
Mangifera indica L.	Common mango	Anacardiaceae	I	2	20	0	0	1	10	0	0	2	20	0	0
Mangifera indica L. var. 'Tommy Atkins'	Tommy Atkins mango	Anacardiaceae	I	0	0	0	0	7	21	0	0	0	0	0	0
Manicaria saccifera Gaertn.	Wine palm	Arecaceae	N	1	15	0	0	0	0	0	0	0	0	0	0
Manihot esculenta Crantz	Cassava (sprout)	Euphorbiaceae	N	0	0	0	0	1	15	0	0	1	15	1	2
Manilkara huberi (Ducke) A. Chev.	Manilkara	Sapotaceae	N	2	30	0	0	0	0	0	0	0	0	0	0
Manilkara zapota (L.) P. Royen	Sapodilla	Sapotaceae	N	0	0	0	0	12	120	0	0	0	0	0	0
Maximiliana maripa (Aubl.) Mart.	American oil palm	Arecaceae	N	0	0	0	0	1	15	0	0	0	0	0	0
Metrodorea flavida K. Krause	Laranjinha	Rutaceae	N	4	60	2	14	0	0	0	0	0	0	0	0
Myrciaria jaboticaba (Vell.) Berg.	Jaboticaba	Myrtaceae	N	0	0	0	0	1	15	0	0	0	0	0	0
Myriaspora egensis DC	Verde-peludo	Melastomataceae	N	0	0	0	0	3	45	0	0	4	60	0	0
Oenocarpus bacaba Mart.	Bacaba	Arecaceae	N	1	15	0	0	1	15	0	0	6	90	0	0
Parinari excelsa Sabine	Guinea plum	Chrysobalanaceae	N	1	15	0	0	0	0	0	0	0	0	0	0
Passiflora edulis Sims	Passionfruit (flower bud)	Passifloraceae	N	5	75	3	8	0	0	0	0	3	45	1	1
Passiflora edulis Sims	Passionfruit (fruit)	Passifloraceae	N	8	80	1	2	0	0	0	0	2	20	0	0
Persea americana Mill	Avocado	Lauraceae	I	0	0	0	0	4	12	0	0	4	12	0	0
Physalis angulata L.	Lanceleaf groundcherry	Solanaceae	I	1	15	0	0	0	0	0	0	0	0	0	0
Pourouma guianensis Aubl.	Mapatirana	Urticaceae	N	0	0	0	0	1	15	0	0	0	0	0	0
Pouteria caimito Radlk.	Abiu	Sapotaceae	N	1	10	0	0	0	0	0	0	1	10	0	0
Pouteria gardneri (Mart. & Miq.) Baehni	Aguaí-una	Sapotaceae	N	0	0	0	0	1	15	0	0	0	0	0	0
Pouteria macrophylla (Lam.) Eyma	Cutite	Sapotaceae	N	0	0	0	0	4	40	1	1	0	0	0	0
Protium heptaphyllum (Albl.) Marchand	Brazil resintree	Burseraceae	N	1	15	0	0	0	0	0	0	0	0	0	0
Protium sp. Sandwith	Resintree	Burseraceae	N	1	15	0	0	1	15	0	0	0	0	0	0
Psidium guajava L.	Guava	Myrtaceae	I	4	40	3	8	0	0	0	0	12	120	7	13
Quararibea guianensis Albl.	Guyanas swizzlestick tree	Malvaceae	N	3	45	3	23	0	0	0	0	0	0	0	0
Rollinia mucosa (Jacq.) Baill.	Biribá	Annonaceae	N	0	0	0	0	3	9	0	0	0	0	0	0
Solanum gilo L.	Scarlet eggplant	Solanaceae	I	3	30	1	2	0	0	0	0	0	0	0	0
Solanum paniculatum L.	Jurubeba	Solanaceae	N	0	0	0	0	1	15	0	0	4	60	1	2
Spondias dulcis Parkinson	Ambarella	Anacardiaceae	I	0	0	0	0	11	110	2	3	0	0	0	0
Spondias mombin L.	Hog plum	Anacardiaceae	N	3	45	0	0	6	90	0	0	5	75	0	0
Spondias purpurea L.	Purple mombin	Anacardiaceae	I	7	105	0	0	9	135	0	0	0	0	0	0
Strychnos asperula Sprague & Sandwith	Gogó-de-guariba	Loganiaceae	N	0	0	0	0	0	0	0	0	1	15	1	11
Symphonia globulifera L.f.	Chewstick	Clusiaceae	N	3	45	0	0	0	0	0	0	0	0	0	0
Syzygium jambolanum Skeels	Java plum	Myrtaceae	I	1	15	0	0	0	0	0	0	1	15	0	0
Syzygium malaccense (L.) Merr. & L. M. Perry	Malay apple	Myrtaceae	I	3	30	0	0	2	20	1	1	2	20	0	0
Tapirira obtusa (Benth.) J. D. Mitch.	Fruto de pombo	Anacardiaceae	N	0	0	0	0	0	0	0	0	3	45	0	0
Theobroma cacao L.	Cacao	Malvaceae	I	1	3	0	0	4	12	0	0	0	0	0	0
Trattinnickia rhoifolia Willd.	Amesclão	Burseraceae	N	0	0	0	0	0	0	0	0	1	15	0	0
Trichilia rubra C. DC	Cachuá	Meliaceae	N	1	15	0	0	0	0	0	0	0	0	0	0
Trymatococcus amazonicus Poepp.& Endley	Inharé	Moraceae	N	1	15	0	0	0	0	0	0	0	0	0	0
No. of species = 78		No. of families = 32		129	1,495	15	59	154	1,524	16	41	129	1,535	19	43

NSC, number of samples collected; NFC, number of fruits collected; NSI, number of samples infested; NFI, number of fruits infested.

Table 2. Lonchaeidae host plants, infestation rates of fruits, and months of occurrence in Mazagão, Amapá, Brazil, Jan to Dec 2012.

				Infestation rates		Month of occurrence												
Plant species	Fruits (*n*) C/I	Mass (g) C/I	P (*n*)	% FI	P/F[a]	J	F	M	A	M	J	J	A	S	O	N	D	Lonchaeidae (*n*)
Psidium guajava	30/8	1,538.3/404.9	86	26.7	10.8				x	x	x x							*N. zadolicha* (22) *N. glaberrima* (2) females (26)
Annona muricata	3/1	3,654.6/1,554.9	39	33.3	39.0				x x									*N. zadolicha* (3) *Lonchaea* sp.1 (11) females (18)
Quararibea guianensis	45/23	504.7/71.8	118	51.1	5.1				x	x	x							*N. zadolicha* (11) females (27)
Calophyllum brasiliensis	15/1	441.7/27.9	4	6.7	4.0												x	*N. pseudozadolicha* (1)
Solanum gilo	10/2	431.1/70.9	11	20.0	5.5						x x							*N. glaberrima* (2) *N. pendula* (1) females (6)
Metrodorea flavida	20/14	240.6/193.8	148	70.0	10.6						x x	x x						*N. zadolicha* (26) *N. pseudozadolicha* (2) *N. laura* (1) females (44)
Passiflora edulis (fruit)	10/2	1,180.5/190.9	16	20.0	8.0						x							*N. zadolicha* (4) females (8)
Passiflora edulis (flower bud)	45/8	201.8/36.0	35	17.8	4.4			x			x	x						*D. inedulis* (15) females (9)
Total	178/59	8,193.3/2,551.1	457															

C, collected; I, infested; P, puparia; % FI, percentage of fruits infested; P/F, puparia/fruit.
[a]Calculation based exclusively on infested fruits.

Table 3. Lonchaeidae host plants, infestation rates of fruits, and months of occurrence in Porto Grande, Amapá, Brazil, Jan to Dec 2012.

				Infestation rates		Month of occurrence												
Plant species	Fruits (*n*) C/I	Mass (g) C/I	P (*n*)	% FI	P/F[a]	J	F	M	A	M	J	J	A	S	O	N	D	Lonchaeidae (*n*)
Eugenia stipitata	30/11	5,448.6/1,578.2	92	36.7	8.4	x							x					*N. glaberrima* (3)
							x	x										*N. zadolicha* (20)
								x					x					*N. pseudozadolicha* (1)
																		females (20)
Spondias dulcis	20/3	1,431.9/290.7	8	15.0	2.7							x		x				*N. glaberrima* (2)
																	x	*N. pseudozadolicha* (1)
																	x	*N. zadolicha* (3)
Averrhoa carambola	30/14	898.7/170.9	19	46.7	1.4							x						*N. bella* (1)
													x					*N. glaberrima* (1)
Pouteria macrophylla	10/1	412.6/39.5	2	10.0	0.5												x	*N. glaberrima* (2)
Artocarpus altilis	6/4	8,100.5/5,260.0	17	66.7	4.3				x	x								*N. glaberrima* (7)
Annona muricata	9/3	7,851.0/1,596.4	33	33.3	11.0			x									x	*N. zadolicha* (8)
											x							*N. glaberrima* (2)
								x			x							*Lonchaea* sp.1 (5)
Syzygium malaccense	15/1	683.9/30.6	1	6.7	1.0									x				*N. pendula* (1)
Capsicum chinense	15/4	122.3/12.0	4	26.7	1.0		x											*N. pseudozadolicha* (1)
Total	135/41	24,949.5/8,978.3	176															

C, collected; I, infested; P, puparia; % FI, percentage of fruits infested; P/F, puparia/fruit.
[a]Calculation based exclusively on infested fruits.

Table 4. Lonchaeidae host plants, infestation rates of fruits, and months of occurrence in Santana, Amapá, Brazil, Jan to Dec 2012.

Plant species	Fruits (*n*) C/I	Mass (g) C/I	P (*n*)	Infestation rates		Month of occurrence												Lonchaeidae (*n*)
				% FI	P/F[a]	J	F	M	A	M	J	J	A	S	O	N	D	
Licania macrophylla	15/2	76.4/16.9	1	13.3	0.5				x									*N. bella* (1)
Coffea arabica	15/1	18.0/0.9	1	6.7	1.0					x								*N. bella* (1)
Strychnos asperula	15/11	99.4/74.1	55	73.3	5.0	x												*N. zadolicha* (22) females (24)
Psidium guajava	70/13	5,645.7/1,324.9	57	18.6	4.4	x x		x x	x			x	x x		x			*N. zadolicha* (16) *N. glaberrima* (2) *N. pseudozadolicha* (2) females (13)
Annona muricata	3/2	1,191.1/562.9	7	66.7	3.5	x												*N. glaberrima* (1) females (1)
Inga edulis	6/6	4,446.2/2,492.8	57	100.0	9.5		x x		x x									*N. zadolicha* (9) *N. glaberrima* (10) females (18)
Solanum paniculatum	15/2	14.9/1.2	2	13.3	1.0							x						*N. pendula* (1)
Citrus limonia	10/1	996.5/149.5	8	10.0	8.0	x x												*N. glaberrima* (3) *N. zadolicha* (10) females (4)
Passiflora edulis (flower bud)	15/1	94.0/5.3	3	6.7	3.0	x												*D. inedulis* (2)
Eschweilera tenuifolia (flower bud)	15/1	59.2/4.2	1	6.7	1.0			x										*N. parapeltae* (1)
Manihot esculenta (sprout)	15/2	45.7/9.3	22	13.3	11.0			x										*N. perezi* (4) females (2)
Cucumis sativus	3/1	473.3/146.9	9	33.3	9.0				x									*N. zadolicha* (2)
Total	197/43	13,160.4/4,788.9	223															

C, collected; I, infested; P, puparia; % FI, percentage of fruits infested; P/F, puparia/fruit.
[a]Calculation based exclusively on infested fruits.

Discussion

Our results contribute significantly to the knowledge of Lonchaeidae species that occur in the Amazon and their plant hosts, and we document 2 new records in the Amazon (*N. laura* and *N. parapeltae*) and 2 records in the state of Amapá (*D. inedulis* and *N. perezi*). We also report 24 new associations between lonchaeid species and hosts in the Amazon (Table 5), contributing towards a better understanding of Lonchaeidae–host relationships in this region of Brazil.

Neosilba species are polyphagous, and Uchôa (2012) reported that 5 species of *Neosilba* were of economic importance to the continent: *N. zadolicha*, *N. pendula*, *N. glaberrima*, *N. perezi*, and *N. inesperata* Strikis & Prado. In our study, the species that infested the greatest numbers of hosts were *N. zadolicha* (11 plant species in 9 families) and *N. glaberrima* (10 plant species in 9 families). These are the most polyphagous and most widely distributed lonchaeids in the Amazon region (Strikis et al. 2011), and are among the species with the highest economic importance for South America (Uchôa 2012).

Neosilba laura and *N. parapeltae* were described only recently (Strikis 2011), and there is no information about their biology. *Neosilba laura* was obtained from a fruit of *M. flavida* in Mazagão, a lonchaeid–host association reported for the first time here (Table 2). *Neosilba parapeltae* was obtained from a flower bud of *E. tenuifolia* in Santana, and this is possibly the first report of this host plant being used by the lonchaeid species (Table 2).

Neosilba perezi was obtained from sprouts of *M. esculenta* in Santana (Table 4). *Neosilba perezi* is a pest of cassava crops, with oc-

Table 5. Lonchaeidae species and their hosts in 3 municipalities of the state of Amapá, Brazil, Jan to Dec 2012.

	Host		
Lonchaeidae	Family	Species	Municipality
*Dasiops inedulis**	Passifloraceae	*Passiflora edulis*	Santana and Mazagão
Lonchaea sp.1	Annonaceae	*Annona muricata*	Mazagão and Porto Grande
Neosilba bella	Chrysobalanaceae	*Licania macrophylla****	Santana
	Oxalidaceae	*Averrhoa carambola****	Porto Grande
	Rubiaceae	*Coffea arabica ****	Santana
Neosilba glaberrima	Anacardiaceae	*Spondias dulcis****	Porto Grande
	Annonaceae	*Annona muricata*	Santana and Porto Grande
	Fabaceae	*Inga edulis*	Santana
	Moraceae	*Artocarpus altilis*	Porto Grande
	Myrtaceae	*Eugenia stipitata****	Porto Grande
		Psidium guajava	Santana and Mazagão
	Oxalidaceae	*Averrhoa carambola*	Porto Grande
	Rutaceae	*Citrus limonia****	Santana
	Sapotaceae	*Pouteria macrophylla*	Porto Grande
	Solanaceae	*Solanum gilo****	Mazagão
*Neosilba laura***	Rutaceae	*Metrodorea flavida****	Mazagão
*Neosilba parapeltae***	Lecythidaceae	*Eschweilera tenuifolia****	Santana
Neosilba pendula	Myrtaceae	*Syzygium malaccense****	Porto Grande
	Solanaceae	*Solanum gilo****	Mazagão
		*Solanum paniculatum****	Santana
*Neosilba perezi**	Euphorbiaceae	*Manihot esculenta*	Santana
Neosilba pseudozadolicha	Anacardiaceae	*Spondias dulcis****	Porto Grande and Santana
	Calophyllaceae	*Calophyllum brasiliensis****	Mazagão
	Myrtaceae	*Eugenia stipitata****	Porto Grande
		*Psidium guajava****	Santana
	Rutaceae	*Metrodorea flavida****	Mazagão
	Solanaceae	*Capsicum chinense****	Porto Grande
Neosilba zadolicha	Anacardiaceae	*Spondias dulcis****	Porto Grande
	Annonaceae	*Annona muricata*	Mazagão and Porto Grande
	Cucurbitaceae	*Cucumis sativus****	Santana
	Fabaceae	*Inga edulis*	Santana
	Loganiaceae	*Strychnos asperula****	Santana
	Malvaceae	*Quararibea guianensis*	Mazagão
	Myrtaceae	*Eugenia stipitata****	Porto Grande
		Psidium guajava	Santana and Mazagão
	Passifloraceae	*Passiflora edulis****	Mazagão
	Rutaceae	*Citrus limonia****	Santana
		Metrodorea flavida	Mazagão

*First report in Amapá.
**New report in the Brazilian Amazon.
***New association with host for this lonchaeid species in the Amazon.

curence varying by region and time of year (Lourenção et al. 1996). In the Amazon, *N. perezi* has been reported in the state of Rondônia (Oliveira 1987), under the name *Silba pendula*. Cassava is a significant social and economic species as a food staple and source of family income, but damage from this pest has not yet been quantified; this is the first report of *N. perezi* in the state of Amapá.

Dasiops inedulis was obtained from flower buds of *P. edulis*, a new distribution record for this species in the state of Amapá. *Dasiops inedulis* is an important pest of *Passiflora* flower buds in South America (Peñaranda et al. 1986; Uchôa-Fernandes et al. 2002). In the state of Pará, it is considered the most important pest of passionfruit plants, causing production losses of up to 100% (Lemos 2009).

Specimens of *Lonchaea* sp.1 were reared from fruits of *A. muricata* only. An additional unidentfied of *Lonchaea* species has already been reported in the states of Amazonas and Amapá. In Brazil, only localized reports of *Lonchaea* have been made, with no information about its biology and ecology, indicating a need for new surveys to discover additional potential hosts (Strikis et al. 2011).

Infestation rates varied widely (Tables 2–4). The greatest percentages of infested fruits were observed on fruits of native species, such as *I. edulis*, in Santana (Table 4). In previous studies conducted in the Amazon region, Silva et al. (2010) and Deus et al. (2013) reported infestation by lonchaeids of this plant species. The largest infestation (i.e., number of puparia/fruit) was observed on fruits of *A. muricata* in Mazagão (Table 2). This plant species represents a significant source of income for inhabitants of the Amazon region, who use it to make soursop concentrate.

We did not rear any parasitoids in this work, although 8 species of parasitoid Eucoilinae (Figitidae) are associted with larvae of *Neosilba* in Brazil (Uchôa 2012). Figitid parasitoids search for host larvae located inside fruits that have already fallen to the ground and that have an orifice for entry, as the females of these parasitoids have short ovipositors (Uchôa 2012). Because fruits were collected directly from host palnts, figitid parasitoids may not have had an opportunity to parasitize larvae. An interesting finding in this study was the wide diversity of Lonchaeidae host plants sampled in native forest areas. Of the 10 species we reared, 6 were associated with hosts located in native forest areas. In addition, the 2 new reports for the Brazilian Amazon were associated with native hosts (Table 5).

Because some lonchaeid species are pest species, researchers have become increasingly interested in studying these flies. However, little is known about the ecology and biology of lonchaeid flies in Brazil. This work identifies the state of Amapá as a region with the greatest recorded lonchaeid species richness in the Amazon, and suggests that additioanl survey and rearing work be conducted.

Acknowledgments

We dedicate this paper to Cheslavo A. Korytkowski, science doctor at the University of Panama, who sadly passed away on 12 May 2015, for his great scientific contribution to knowledge on Lonchaeidae species. We thank the students Danilo Baia do Nascimento, Maria do Socorro Miranda de Sousa, Luana dos Santos Pinheiro, Francisco Andrew Pacheco, Oziel Barroso Baía, Sarron Feliphe, and Jonh Carlo Reis. We also thank our colleagues at Embrapa Amapá: Felipe Galdino Machado, Carlos Alberto Moraes, Manoel Jonas de Jesus Viana, and Marcelo Luiz de Oliveira. We gratefully acknowledge the Brazilian Council for Scientific and Technological Development–CNPq, for the Research Productivity Fellowship granted to R. Adaime.

References Cited

Adaime R, Strikis PC, Souza-Filho MF, Lima CR, Lasa R. 2012. First report of Lonchaeidae (Diptera) infesting fruits of *Byrsonima crassifolia* in Brazil. Revista Colombiana de Entomología 38: 363-364.

Aguiar-Menezes EL, Souza SAS, Santos CMA, Resende ALS, Strikis PC, Costa JR, Ricci MSF. 2007. Susceptibilidade de seis cultivares de café arábica às moscas-das-frutas (Diptera: Tephritoidea) em sistema orgânico com e sem arborização em Valença, RJ. Neotropical Entomology 36: 268-273.

Araújo EL, Zucchi RA. 2002. Hospedeiros e níveis de infestação de *Neosilba pendula* (Bezzi) (Diptera: Lonchaeidae) na região de Mossoró/Assu, RN. Arquivos do Instituto Biológico 69: 91-94.

Costa SGM. 2005. Himenópteros parasitóides de larvas frugívoras (Diptera: Tephritoidea) na reserva florestal Adolpho Ducke, Manaus, Amazonas, Brasil. Master's thesis, Instituto Nacional de Pesquisas da Amazônia, Universidade Federal do Amazonas, Manaus, Amazonas, Brazil.

Deus EG, Pinheiro LS, Lima CR, Sousa MSM, Guimarães JA, Strikis PC, Adaime R. 2013. Wild hosts of frugivorous dipterans (Tephritidae and Lonchaeidae) and associated parasitoids in the Brazilian Amazon. Florida Entomologist 96: 1621-1625.

Fidalgo O, Bononi VLR. 1984. Técnicas de coleta, preservação e herborização de material botânico. Instituto de Botânica, São Paulo, Brazil.

IBGE. 2010. Produto. Mapas de climas do Brasil. Updated in 2010, http://www.ibge.gov.br/home/geociencias/default_prod.shtm#MAPAS (last accessed 11 Dec 2013).

Lemos WP. 2009. Controle integrado de pragas em fruteiras amazônicas. Instituto Frutal, Fortaleza, Brazil.

Lopes EB, Batista JL, Albuquerque IC, Brito CH. 2008. Moscas frugívoras (Tephritidae e Lonchaeidae): ocorrência em pomares comerciais de tangerina (*Citrus reticulata* Blanco) do município de Matinhas, Estado da Paraíba. Acta Scientiarum Agronomy 30: 639-644.

Lourenção AL, Lorenzi JO, Ambrosano GMB. 1996. Comportamento de clones de mandioca em relação à infestação por *Neosilba perezi* (Romero & Rupell) (Diptera: Lonchaeidae). Scientia Agricola 53: 304-308.

Lunz AM, Souza LAS, Lemos WP. 2006. Reconhecimento dos Principais Insetos-Praga do maracujazeiro (Documentos, 245). Embrapa Amazônia Oriental, Belém, Brazil.

MacGowan I. 2015. Lonchaeidae Online, http://lonchaeidae.myspecies.info/number-species#overlay-context= (last accessed 29 Sep 2015).

MacGowan I, Okamoto T. 2013. New species of Lonchaeidae (Diptera: Schizophora) from Japan and a re-evaluation of genus *Setisquamalonchaea* Morge. Entomological Science 16: 196-202.

McAlpine JF. 1961. A new species of *Dasiops* (Diptera: Lonchaeidae) injurious to apricots. The Canadian Entomologist 93: 539-544.

McAlpine JF, Steyskal GC. 1982. A revision of *Neosilba* McAlpine with a key to the world genera of Lonchaeidae (Diptera). The Canadian Entomologist 114: 105-137.

Norrbom AL, McAlpine JF. 1997. A revision of Neotropical species of *Dasiops* Rondani (Diptera: Lonchaeidae) attacking *Passiflora* (Passifloraceae). Memoirs of the Entomological Society of Washington 18: 189-211.

Oliveira FNS. 1987. Caracterização botânico-agronômica de cultivares de mandioca (*Manihot esculenta* Crantz) em Porto Velho, Rondônia. Boletim de Pesquisa, 6. Embrapa/UEPAE, Porto Velho, Brazil.

Peñaranda A, Ulloa PC, Hernández MR. 1986. Biología de la mosca de los botones florales del maracuyá *Dasiops inedulis* (Diptera: Lonchaeidae) en el Valle del Cauca. Revista Colombiana de Entomología 12: 16-22.

Querino RB, Costa SGM, Ronchi-Teles B, Strikis PC, Zucchi RA. 2010. Interação de larvas frugívoras (Diptera, Tephritidae e Lonchaeidae) e seus hospedeiros na Reserva Florestal Adolpho Ducke, Manaus, Amazonas, Brasil. Boletim de Pesquisa e Desenvolvimento, 88. Embrapa Meio-Norte, Teresina, Piauí, Brazil.

Silva NM. 1993. Levantamento e análise faunística de moscas-das-frutas (Diptera: Tephritidae) em quatro locais do Estado do Amazonas. Doctoral thesis, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, São Paulo, Brazil.

Silva RA, Deus EG, Raga A, Pereira JDB, Souza-Filho MF, Costa Neto SV. 2011. Monitoramento de moscas-das-frutas na Amazônia: amostragem de frutos e uso de armadilhas, pp. 33-50 *In* Silva RA, Lemos WP, Zucchi RA [eds.], Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. Embrapa Amapá, Macapá, Amapá, Brazil.

Souza-Filho MF, Raga A, Sato ME, Zucchi RA. 2002. Infestação de *Dasiops frieseni* Norrbom & McAlpine (Diptera: Lonchaeidae) em frutos de maracujá-azedo (*Passiflora edulis* f. *flavicarpa*), p. 2013 *In* Resumos do 19º Congresso Brasileiro de Entomologia. Instituto Nacional de Pesquisas da Amazônia, Fundação Universidade do Amazonas, Manaus, Amazonas, Brazil.

Strikis PC. 2011. Description of 11 new species of genus *Neosilba* (Diptera: Lonchaeidae) from Brazil, its hosts and geographical distribution. Trends in Entomology 7: 67-79.

Strikis PC, Deus EG, Silva RA, Pereira JDB, Jesus CR, Marsaro Júnior AL. 2011. Conhecimento sobre Lonchaeidae na Amazônia brasileira, pp. 205-216 *In* Silva RA, Lemos WP, Zucchi RA [eds.], Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. Embrapa Amapá, Macapá, Amapá, Brazil.

Uchôa MA. 2012. Fruit flies (Diptera: Tephritoidea): biology, host plants, natural enemies, and the implications to their natural control, pp. 271-300 *In* Larramendy ML, Soloneski S [eds.], Integrated Pest Management and Pest Control: Current and Future Tactics. InTech, Rijeka, Croatia.

Uchôa-Fernandes MA, Oliveira I, Molina RMS, Zucchi RA. 2002. Species diversity of frugivorous flies (Diptera: Tephritoidea) from hosts in the Cerrado of the State of Mato Grosso do Sul, Brazil. Neotropical Entomology 31: 515-524.

Uchôa-Fernandes MA, Oliveira I, Molina RMS, Zucchi RA. 2003. Biodiversity of frugivorous flies (Diptera: Tephritoidea) captured in citrus groves, Mato Grosso do Sul, Brazil. Neotropical Entomology 32: 239-246.