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New records of fruit flies (Diptera: Tephritidae), host plants and associated parasitoids in the state of Acre, Brazil

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ABSTRACT: Some fruit flies species are significant agricultural pests. In the state of Acre, located in northern Brazil, knowledge about this biological group is limited due to the scarcity of surveys conducted to date. This study aimed to enhance understanding of the diversity of fruit flies, their host plants, and parasitoids in Acre through fruit sampling in two municipalities. In Acrelândia, 13 samples were collected (11.60 kg of fruit from nine plant species) between March and June 2023, resulting in the identification of three species of fruit flies and two species of parasitoids. In Rio Branco, seven samples were collected (7.23 kg of fruit from five plant species) in October 2022, March 2023, and June 2023, leading to the identification of two species of fruit flies. This study reports the following tephritid species *Anastrepha anopla* Norrbom & Korytkowski, *Anastrepha montei* Lima, and *Anastrepha pickeli* Lima, along with the parasitoid *Doryctobracon adaimei* Marinho & Penteado-Dias, for the first time in the state of Acre.

Key words: Amazon; Braconidae; fruit production; geographical record; Tephritoidea

Novos registros de moscas-das-frutas (Diptera: Tephritidae), plantas hospedeiras e parasitoides associados no estado do Acre, Brasil

RESUMO: Algumas espécies de moscas-das-frutas são importantes pragas agrícolas. No estado do Acre, região Norte do Brasil, o conhecimento sobre esse grupo biológico é escasso, resultado de poucos levantamentos realizados. O objetivo deste trabalho foi ampliar o conhecimento sobre a diversidade de moscas-das-frutas, suas plantas hospedeiras e parasitoides no estado do Acre, por meio da amostragem de frutos realizada em dois municípios. Em Acrelândia foram coletadas 13 amostras (11,60 kg de frutos de nove espécies vegetais), de março a junho/2023, sendo obtidas três espécies de moscas-das-frutas e duas de parasitoides. Em Rio Branco foram coletadas sete amostras (7,23 kg de frutos de cinco espécies vegetais), em outubro/2022, março/2023 e junho/2023, sendo reportadas duas espécies de moscas-das-frutas. Neste trabalho, as espécies de tefritídeos *Anastrepha anopla* Norrbom & Korytkowski, *Anastrepha montei* Lima e *Anastrepha pickeli* Lima, além do parasitoide *Doryctobracon adaimei* Marinho & Penteado-Dias, são reportadas pela primeira vez no estado do Acre.

Palavras-chave: Amazônia; Braconidae; fruticultura; distribuição geográfica; Tephritoidea

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Introduction

Fruit flies (Diptera: Tephritidae) are the main pests of global fruit growing, due to their direct economic impact (females lay eggs in the fruits and the larvae feed on the pulp, making the fruits unfit for consumption and commercialization) and the severe quarantine restrictions imposed by many countries to prevent their entry (Aluja, 1994; Follett & Neven, 2006; Aluja & Mangan, 2008).

The Legal Amazon, which covers the states of Acre, Amapá, Amazonas, Mato Grosso, Pará, Roraima, Rondônia, and Tocantins, and part of Maranhão (west of the 44th meridian) (IBGE, 2022), is a vast geographical area with hard-to-reach locations. This, coupled with the shortage of qualified human resources, represents a major challenge to the development of bioecological studies on fruit flies (Sousa et al., 2021).

Despite these limitations, scientific knowledge about fruit flies in the Legal Amazon has advanced significantly in the last 20 years. As a result, 78 species of *Anastrepha* Schiner are reported, half of them endemic, in addition to two exotic species that were introduced in the region: *Bactrocera carambolae* Drew & Hancock (carambola fruit fly) and *Ceratitis capitata* (Wiedemann) (Mediterranean fruit fly) (Diptera: Tephritidae). Hymenoptera parasitoids, especially those of the Braconidae family, stand out as the main natural enemies of fruit flies. So far, 11 species of parasitoids (Braconidae and Figitidae) have been recorded in the region (Sousa et al., 2021).

Although expensive and laborious, it is important that surveys based on fruit sampling be conducted in all states of the Brazilian Amazon to increase knowledge about fruit flies and their parasitoids. The state of Acre is among the priority areas for new studies, as it has been little covered so far (Sousa et al., 2021; Adaime et al., 2023a). To date, only spot samplings have been carried out in eight municipalities, with the recording of eight species of fruit flies, nine host plants species, and four parasitoid species (Adaime et al., 2023a). Thus, the objective of this work was to expand knowledge about the diversity of fruit flies, their host plants, and associated parasitoids in the state of Acre.

Materials and Methods

Fruit collections were carried out in urban and rural areas of the municipalities of Acrelândia (March to June/2023) and Rio Branco (October/2022, March/2023, and June/2023), state of Acre, Brazil. The sampling was carried out randomly, collecting fruits directly from the plants and/or intact fruits that had recently fallen to the ground. All collection points had their geographical coordinates recorded by a GPS device (Table 1). The samples, composed of several grouped fruits, were placed in plastic containers, wrapped with organza bags, properly identified, and later transported to the Entomology Laboratory of Embrapa Acre, in Rio Branco.

In the laboratory, the procedures recommended by Silva et al. (2011) were followed for grouped fruit samples. The fruits were counted, weighed, and arranged in plastic trays on a thin layer of moistened sand. The trays were covered with organza held by elastic band. The material was examined every three days, and puparia were removed when found and transferred to transparent plastic pots containing a thin layer of moistened vermiculite. The pots were covered with organza and a perforated lid, being inspected daily. The humidity in the trays and pots was maintained by replenishing water, with the aid of a wash bottle. Fruit flies and parasitoids that emerged were stored in glass vials containing 70% ethanol for later identification.

In addition to the fruit fly specimens obtained from the sampled host fruits, an adult specimen of the genus *Anastrepha* Schiner was randomly collected in the municipality of Rio Branco on January 29, 2013, and later the species was identified by the specialist Dr. Allen L. Norrbom (USDA) in March 2020.

The other specimens of *Anastrepha* were identified using the dichotomous key proposed by Zucchi *et al*. (2011). The identification was based on the observation of the terminalia of the females, apex of the extruded aculeus, using a stereomicroscope and an optical microscope (40×). Other characteristics, such as the patterns of the wing bands, mesonotum, metathorax, and subscutellum, were also examined. The parasitoids wasps (Hymenoptera: Braconidae) were identified as described by Marinho et al. (2018).

The data obtained were analyzed through the following calculations: 1) infestation index: puparia obtained/fruit mass collected, in kilograms; 2) emergence: (number of emerged fruit flies + number of emerged parasitoids)/total number of puparia x 100; 3) parasitism percentage: (number of emerged parasitoids/number of puparia) × 100.

Results and Discussion

Considering the two sampled municipalities, 20 fruit samples (18.83 kg) were collected from 13 plant species belonging to 10 families (Table 1). There was an infestation of fruit flies in six samples (30%), belonging to four plant species from four families (Table 2). Exactly 253 puparia were obtained, from which specimens of five fruit flies species (Diptera: Tephritidae) and two parasitoids (Hymenoptera: Braconidae) emerged.

In Acrelândia, 13 samples (358 fruits, 11.60 kg) were collected from nine species belonging to seven families (Tables 1 and 2). There was an infestation in *Manihot esculenta* Crantz (264.3 and 500 puparia kg^{-1}) and in *Bellucia grossularioides* (L.) Triana (250 puparia kg^{-1}). From fruits of *M. esculenta* specimens of two species of fruit flies were obtained [*Anastrepha montei* Lima and *Anastrepha pickeli* Lima] and two species of parasitoids [*Doryctobracon adaimei* Marinho & Penteado-Dias and *Utetes anastrephae* (Viereck)] (Table 2). This is the first record of *A. montei*, *A. pickeli* and *D. adaimei* in the state of Acre. From fruits of *B. grossularioides* specimens of *Anastrepha coronilli* Carrejo & González (Table 2) were obtained, a fact already reported in Acre by Adaime et al. (2023a).

Table 1. Collection points of plant species sampled in Acrelândia and Rio Branco, state of Acre, Brazil.

Samples	Dates	Geographic coordinates		Species* – Families
		Latitude S	Longitude W	
Acrelândia				
1	March 22, 2023	10°00'45.4"	66º56'19.4"	*Manihot esculenta* Crantz – Euphorbiaceae
2	April 10, 2023	10°00'42.9"	66º57'54.5"	*Inga edulis* Mart. – Fabaceae
3	April 10, 2023	10°00'38.5"	66°56'17.7"	*Citrus aurantium* L. – Rutaceae
4	April 10, 2023	10°00'38.5"	66°56'17.7"	*Citrus limon* (L.) Osbeck – Rutaceae
5	April 10, 2023	10°00'38.5"	66°56'17.7"	*Citrus reticulata* Blanco – Rutaceae
6	April 10, 2023	10°00'35.3"	66°55'59.6"	*Malpighia emarginata* DC. – Malpighiaceae
7	April 10, 2023	10°00'37.3"	66°56'02.6"	*Malpighia emarginata* DC. – Malpighiaceae
8	April 10, 2023	10°00'37.3"	66°56'02.6"	*Annona muricata* L. – Annonaceae
9	April 10, 2023	10°00'35.3"	66°55'59.6"	*Citrus reticulata* Blanco – Rutaceae
10	April 19, 2023	10°00'52.1"	66º58'5.6"	*Bellucia grossularioides* (L.) Triana – Melastomataceae
11	April 19, 2023	10°00'55.2"	66º58'5.8"	*Manihot esculenta* Crantz – Euphorbiaceae
12	May 22, 2023	09°59'35.9"	66°56'26.2"	*Genipa americana* L. – Rubiaceae
13	June 12, 2023	10°00'45.4"	66°56'19.4"	*Genipa americana* L. – Rubiaceae
Rio Branco				
1	October 5, 2022	10°01'01.8"	67º40'28.3"	*Inga edulis* Mart. – Fabaceae
2	October 17, 2022	09°50'47.8"	67°36'16.2"	*Psidium guajava* L. – Myrtaceae
3	October 21, 2022	09°57'53.0"	67°48'50.3"	*Spondias mombin* L. – Anacardiaceae
4	October 21, 2022	09°58'00.5"	67°49'49.7"	*Spondias mombin* L. – Anacardiaceae
5	March 30, 2023	10°01'41.4"	67º48'14.3"	*Averrhoa carambola* L. – Oxalidaceae
6	March 30, 2023	10°01'41.3"	67°48'14.2"	*Plinia cauliflora* (Mart.) Kausel – Myrtaceae
7	June 27, 2023	10°01'41.4"	67º48'14.3"	*Averrhoa carambola* L. – Oxalidaceae

*According to WFO (2024).

Table 2. Fruit flies and associated parasitoids in the municipalities of Acrelândia and Rio Branco, state of Acre, Brazil.

Samples	Fruits (n)	Weight (kg)	P[a] (n)	I[b] (P kg^{-1})	E[c] (%)	Species obtained	PP[d] (%)
Acrelândia							
1	86	0.14	37	264.3	70.3	*Anastrepha montei* (2♀) *Anastrepha pickeli* (9♀) *Anastrepha* sp. (12♂) *Doryctrobracon adaimei* (1♀) *Utetes anastrephae* (2♀)	8.1
2	5	1.65	0	-	-	-	-
3	9	1.88	0	-	-	-	-
4	19	1.95	0	-	-	-	-
5	11	1.02	0	-	-	-	-
6	49	0.26	0	-	-	-	-
7	82	0.51	0	-	-	-	-
8	6	1.79	0	-	-	-	-
9	7	0.99	0	-	-	-	-
10	22	0.22	55	250.0	76.4	*Anastrepha coronilli* (20♀) *Anastrepha* sp. (22♂)	0
11	41	0.06	30	500.0	63.3	*Anastrepha montei* (3♀) *Anastrepha pickeli* (6♀) *Anastrepha* sp. (5♂) *Doryctrobracon adaimei* (2♀+3♂)	16.7
12	11	0.64	0	-	-	-	-
13	10	0.49	0	-	-	-	-
Rio Branco							
1	5	1.08	113	104.6	42.5	*Anastrepha distincta* (39♀) *Anastrepha* sp. (9♂)	0
2	8	0.74	0	-	-	-	-
3	13	0.70	0	-	-	-	-
4	15	0.85	0	-	-	-	-
5	30	2.78	10	3.6	100	*Anastrepha distincta* (2♀) *Anastrepha* sp. (1♂) *Ceratitis capitata* (2♀+5♂)	0
6	83	0.32	0	-	-	-	-
7	10	0.76	8	10.5	100	*Ceratitis capitata* (2♀+6♂)	0

[a]P = puparia; [b]I = infestation; [c]E = emergence; [d]PP = percentage of parasitism.

In Rio Branco, seven samples (164 fruits, 7.23 kg) were collected from five species belonging to four families (Tables 1 and 2). There was an infestation in *Averrhoa carambola* L. (3.6 and 10.5 puparia kg^{-1}) and in *Inga edulis* Mart. (104.6 puparia kg^{-1}). From fruits of *A. carambola* specimens of *Anastrepha distincta Greene and Ceratitis capitata* (Wiedemann) were obtained (Table 1). The occurrence of *A. distincta* in *A. carambola* is uncommon, but it has already been reported in the state of Amapá (Jesus-Barros et al., 2012). In turn, the occurrence of *C. capitata* in *A. carambola* had already been recorded in Acre (Adaime et al., 2017). In this work, the emergence of 100% of the *C. capitata* specimens is highlighted, indicating that the pest is well adapted to the host, which is an introduced (exotic) plant, a factor that greatly influences its distribution, expanding its geographical dispersion (Selivon, 2000; Zucchi & Moraes, 2024). In addition, as a highly polyphagous species, *C. capitata* is favored in its colonization in highly anthropized areas (urban region) where there are many exotic cultivated fruits, as is the case in the municipality of Rio Branco (Selivon, 2000; Dias et al., 2023). Specimens of *A. distincta* were obtained from fruits of *I. edulis*, a fact already reported in Acre and several other states of the Brazilian Amazon, especially Amapá (Adaime et al., 2023b).

The only specimen of *Anastrepha* collected in Rio Branco was identified as *Anastrepha anopla* Norrbom & Korytkowski, constituting the first record in the state of Acre. This species had already been recorded in Brazil (state of Amazonas) and Ecuador by Norrbom & Korytkowski (2012) when they described it, however, also without being associated with a host plant.

After the results presented in this work, the state of Acre now has a record of 11 fruit flies species (Table 3) and five parasitoid wasp species (Table 4). It is noteworthy that so far only eight of the 22 municipalities in the state have been covered by at least one study on fruit flies. In Xapuri, interestingly, there was fruit sampling, with no record of fruit flies (Pereira et al., 2010).

As highlighted by Adaime et al. (2023a), survey samplings, mainly of wild species, need to be intensified in the state of Acre. In this way, we consider that studies of this nature are important for the advancement of knowledge about fruit flies in Acre and the Amazon as a whole.

Table 3. Fruit fly species recorded in municipalities of the state of Acre, Brazil.

Species	Municipalities	References
Anastrepha anopla Norrbom & Korytkowski	Rio Branco	Present study
Anastrepha coronilli Carrejo & González	Capixaba	Pereira et al. (2010)
Anastrepha distincta Greene	Bujari, Rio Branco, Sena Madureira	Thomazini et al. (2003), Pereira et al. (2010)
Anastrepha leptozona Hendel	Rio Branco, Senador Guiomard	Thomazini et al. (2003), Azevedo et al. (2018)
Anastrepha montei Lima	Acrelândia	Present study
Anastrepha obliqua (Macquart)	Brasiléia, Bujari, Capixaba, Rio Branco, Senador Guiomard	Thomazini et al. (2003), Thomazini et al. (2006), Thomazini & Albuquerque (2009), Pereira et al. (2010), Azevedo et al. (2018)
Anastrepha pickeli Lima	Acrelândia	Present study
Anastrepha serpentina (Wiedemann)	Senador Guiomard	Azevedo et al. (2018)
Anastrepha striata Schiner	Brasiléia, Bujari, Epitaciolândia, Rio Branco, Sena Madureira, Senador Guiomard	Thomazini et al. (2003), Thomazini et al. (2006), Pereira et al. (2010), Adaime et al. (2017), Azevedo et al. (2018)
Anastrepha tumida Stone	Rio Branco	Thomazini et al. (2003)
Ceratitis capitata (Wiedemann)	Rio Branco, Senador Guiomard	Adaime et al. (2017), Azevedo et al. (2018)

Table 4. Parasitoid species (Hymenoptera: Braconidae) of fruit flies recorded in municipalities of the state of Acre, Brazil.

Species	Municipalities	References
Asobara anastrephae (Muesebeck)	Rio Branco	Azevedo et al. (2018)
Doryctrobracon adaimei Marinho & Penteado-Dias	Acrelândia	Present study
Doryctrobracon areolatus (Szépligeti)	Bujari, Capixaba, Rio Branco	Thomazini & Albuquerque (2009), Pereira et al. (2010)
Opius bellus Gahan	Bujari	Thomazini & Albuquerque (2009)
Utetes anastrephae (Viereck)	Bujari	Thomazini & Albuquerque (2009)

Conclusions

This study significantly expanded the knowledge of fruit flies fauna in the state of Acre, Brazil.

Surveys conducted in two municipalities resulted in the first state records of three fruit flies species (*Anastrepha anopla*, *Anastrepha montei*, and *Anastrepha pickeli*) and one associated parasitoid (*Doryctobracon adaimei*).

The detection of *Ceratitis capitata* in *Averrhoa carambola* fruits, along with a high emergence rate, underscores the successful establishment of this exotic species in urban environments.

As a result of this research, the known diversity in Acre increased to 11 fruit fly species and five parasitoid species.

These findings highlight the importance of systematic fruit sampling, especially in underexplored regions such as Acre, to improve the understanding of local biodiversity and support the development of monitoring strategies and integrated pest management programs.

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Compliance with Ethical Standards

Author's contributions: Conceptualization: RAS; Data curation: VVLS; Formal analysis: MSMS, MFSF; Investigation: RSS, VVLS; Methodology: RAS, MFSF; Resources: RSS; Supervision: RSS; Writing – original draft: RAS, MSMS, MFSF; Writing – review & editing: RAS, RSS, MFSF.

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