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Overview and Checklist of Parasitoids (Hymenoptera, Braconidae and Figitidae) of *Anastrepha* Fruit Flies (Diptera, Tephritidae) in the Brazilian Amazon

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MSMS and JEVS managed the literature searches and wrote the first draft of the manuscript. Authors DEN, RAZ and RA discussed the collected data and wrote the final version. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Fruit-bearing plants in the Brazilian Amazon are mainly attacked by species of *Anastrepha*, of which about half are endemic to the region. However, tritrophic relations (fly/plant/parasitoid) have only been established for some 25% of the species of *Anastrepha* in the region. At present, 11 species of hymenopterous parasitoids (Braconidae and Figitidae) have been recorded in the Brazilian Amazon. Parasitoids in general, especially those of the family Braconidae, stand out as the most effective natural enemies of fruit flies of the genus *Anastrepha*. *Doryctobracon areolatus* is the most abundant parasitoid and it is associated with the largest number of *Anastrepha* species in the region. Some fruiting species, for example *Bellucia grossularioides* (L.) Triana and

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Geissospermum argenteum Woodson, have been studied aiming at biological control of fruit flies, because they act as reservoirs or multipliers of fruit fly parasitoids. Although research has advanced significantly in the past 20 years, there is a shortage of studies in nearly all states in the region, due to the huge area of the Brazilian Amazon.

Keywords: Biological control; diversity; parasitism; tritrophic relationships.

1. INTRODUCTION

Studies of bio-ecology and the potential of hymenopterous parasitoids for biological control of fruit flies in Brazil have been increasing in recent decades, for four main reasons: (1) clarification on the identity of fruit fly parasitoids [1]; (2) improvement of techniques for mass rearing of exotic parasitoids – *Diachasmimorpha longicaudata* (Ashmead) and *Fopius arisanus* (Sonan) – and native species – *Doryctobracon areolatus* (Szépligeti), *Doryctobracon brasiliensis* (Szépligeti) and *Aganaspis pelleranoi* (Brèthes) – for control of *Anastrepha fraterculus* (Wiedemann) and *Ceratitis capitata* (Wiedemann), principally in the South region of Brazil [2,3,4,5]; (3) growing restrictions on application of toxic chemicals for pest control and the increased public awareness of food safety; and (4) effort to preserve biodiversity of agro-ecosystems, through ecologically friendly strategies, which are aimed at maintaining and increasing the population of natural enemies of pests [6].

In the Brazilian Amazon, braconid parasitoids of fruit flies belong to the subfamilies Alysiinae (*Asobara*) and Opiinae (*Doryctobracon*, *Opius* and *Utetes*) and the figitids belong to the subfamily Eucoilinae (*Aganaspis* and *Odontosema*) [7].

Because of the importance of parasitoids for regulation of fruit fly populations, this review compiles and updates information on the Braconidae and Figitidae, with emphasis on their species richness and geographic distribution in the Brazilian Amazon. The potential of fruit-bearing plants as reservoirs or multipliers of parasitoids and research trends for biological control of fruit flies in the Brazilian Amazon were also discussed.

2. THE BRAZILIAN AMAZON: A CHALLENGE FOR STUDIES OF FRUIT FLIES AND THEIR PARASITOIDS

The Brazilian Amazon covers the states of Acre, Amapá, Amazonas, Mato Grosso, Pará, Roraima, Rondônia and Tocantins, and part of Maranhão (to the west of the 44º meridian) [8], and it corresponds to about 60% of the total area of Amazon (more than 6.5 million km^2).

The cultivation of fruit-bearing species in the Amazon has large agro-industrial potential. There are approximately 200 species that bear edible fruits, half of which are native species, the great majority occurring in the wild [9]. This scenario suggests that the Amazon has the potential to become a large supplier of fruits. The utilization of these species, both in natural conditions and under cultivation, is important for the development of sustainable agriculture, bringing various social benefits [10]. Despite the recognition of this potential for fruit production, a major factor limiting commercial-scale production is the presence of pests, mainly fruit flies, a group of insects that cause the greatest damage to global agriculture [11].

Studies on fruit flies in the Brazilian Amazon was incipient until the early 1990s. Since then, significant advances have been achieved, in particular through implementation of the Amazon Network for Research on Fruit Flies (Phase I: 2007-2010 and Phase II: 2011-2014). Great advances have been made regarding scientific knowledge in the past 15 years, especially in the states of Amapá, Pará and Roraima [12]. A compilation of these results were published in the book "Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais" [7].

In the Brazilian Amazon, 78 species of *Anastrepha* have been recorded, about half of them are endemic. The most recent compilation of records of fruit flies and their host plants can be found in the database "*Anastrepha* species and their hosts in the Brazilian Amazon" [13]. Besides of the native species of *Anastrepha*, two exotic species have been recorded in the region. The first is *Bactrocera carambolae* Drew & Hancock, the carambola fruit fly, the only species of the genus in South America. It was first detected in Amapá, Brazil, in 1996 [14]. The second is *Ceratitis capitata*, the Mediterranean fruit fly, detected in the Amazon region in 1996

[15]. In the Brazilian Amazon, this pest was not recorded only in the states of Amapá and Amazonas [16,17].

Fruit samplings has been carried out mainly in the states of Amapá and Pará, where there are several available records of fruit flies, their host plants and parasitoids.

3. FRUIT FLY PARASITOIDS IN THE BRAZILIAN AMAZON

Studies on fruit fly parasitoids were neglected in the region for many years. The first records were of *D. areolatus*, *Opius bellus* Gahan, *Utetes anastrephae* (Viereck) and *Asobara anastrephae* (Muesebeck), collected in the municipalities of Manaus and Iranduba in Amazonas [18]. However, further research on fruit fly parasitoids were carried out in the following decades. Two species from Brazilian Amazon were described at the end of 2020s. One of these species (*D. whartoni* Marinho & Penteado-Dias) is known only in the Amapá state. Information on the parasitized fruit flies, associated host plants, geographical distributions and respective citations are presented in the Checklist.

Eleven species of fruit fly parasitoids have been recorded in Brazilian Amazon, but most species belong to Braconidae (8 species). *Doryctobracon areolatus* is the most widespread species, having been found in all states of the region, followed by *O. bellus*, that so far has not been recorded in Mato Grosso (Fig 1, Checklist). Some braconids, such as *D. longicaudata*, *F. arisanus* (exotic), *D. areolatus* and *D. brasiliensis* (native) have been used for the biological control of fruit flies [1].

The diversity of figitids that parasitize fruit flies in the Amazon is poorly known, restricted to a few occasional collections in Amazonas, Amapá, Pará and Roraima [19, 20]. The record of *Tropideucoila rufipes* Ashmead in the state of Amazonas [21], it is a missidentification, as it is actually *Trichopria* sp. aff. *anastrephae* (Diapriidae) (Jorge A. Guimarães, personal communication). As this is a single record that requires further studies, this diapriid was not discussed herein.

Studies on fruit flies and their natural enemies are hampered mainly, in the Brazilian Amazon, by the shortage of technicians and the focus of researchers on other groups of economically important insects. Another difficulty is the limited means of access (transportation) to the different ecosystems, since many municipalities cover large areas with limited transportation infrastructure [22]. For example, only two papers have been published on the occurrence of fruit fly parasitoids in Maranhão, the most recent one 20 years ago [23, 24] (Checklist).

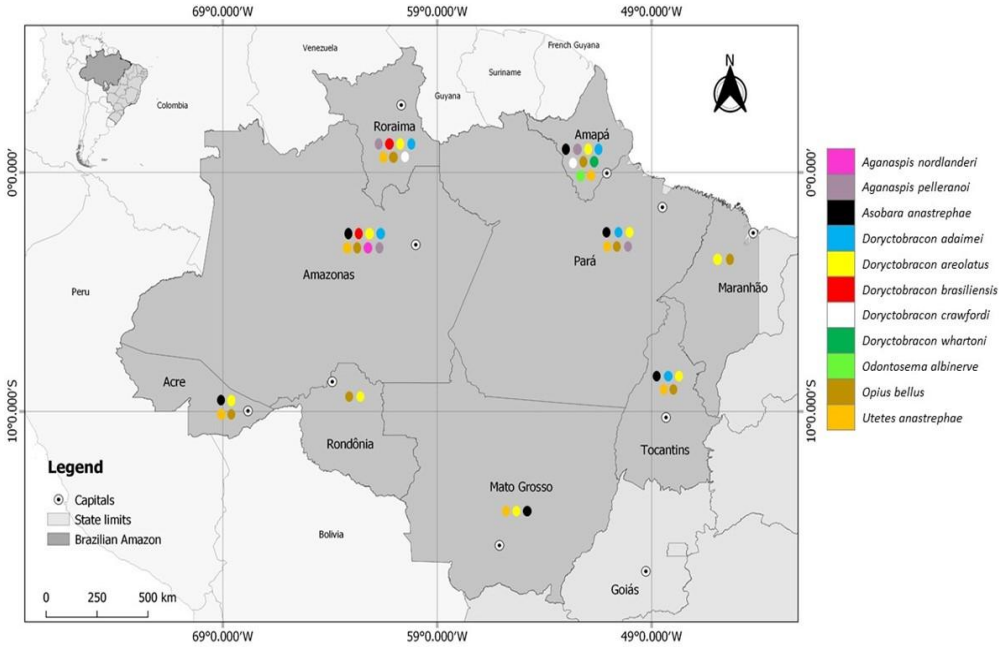

Fig. 1. Distribution of parasitoids of *Anastrepha* fruit flies in the nine states of the Brazilian Amazon

These difficulties are most severe in Amazonas, the largest Brazilian state in area, with strong potential for the development of fruit cultivation, but there is no information about the main pests and their natural enemies in this state. The studies in Amazon state have been concentrated in only a few collection sites [25, 26, 27].

4. TRITROPHIC RELATIONSHIPS

The relationship among fruit flies, host plants and parasitoids is a key for the establishment of conservation biological control programs. Therefore, fruit sampling from a single species of host plant, should be assessed to determine the level of fruit infestation, in order to correctly establish the association of each fruit fly species and host plant species, and to generate information about the diversity and abundance of natural enemies [28].

Doryctobracon areolatus has been found to parasitize 19 species of *Anastrepha* on 50 plant species, distributed in 18 botanical families. *Opius bellus* is associated with 12 species of *Anastrepha* on 22 host plants belonging to 13 botanical families. *Doryctobracon brasiliensis* and *D. whartoni* are associated only with *Anastrepha fractura* Stone and *Anastrepha atrigona* Hendel, respectively. With regard to figitids, *A. nordlanderi* and *A. pelleranoi* have been collected mainly in Amazonas and Amapá, where they have been found associated with four and eight species of *Anastrepha*, respectively (Checklist).

In Mato Grosso state, the first fruit fly collections using food-baited traps were carried out only in 2000, and several species were recorded [17, 26, 29, 30]. The first record of fruit fly parasitoid in the state was *D. areolatus* on *A. striata* in fruit of *P. cattleianum* (Myrtaceae), in the municipality of Sinop (Checklist) [31]. Two years later, *U. anastrephae* and *A. anastrephae* were reported for the first time in the state (Checklist) [17].

'Hosts plants' for fruit fly species and their associated natural enemies are scarce in Acre, Rondônia and Tocantins. In Tocantins, for example, there are only records of parasitism of *A. anastrephae*, *D. areolatus* and *O. bellus* on *A. obliqua* in *Mangifera indica* and *D. areolatus* and *D. adaimei* (such as *Dorycobracon* sp.) on *A. coronilli* in *Bellucia grossularioides* [32].

There are no reports of native parasitoids of the exotic species *B. carambolae* and *C. capitata* in the Brazilian Amazon [7]. Nevertheless, in 2000, two releases of the exotic parasitoid *D. longicaudata* were performed in Amapá aiming to control *B. carambolae* [33]. After these releases, no specimens of *D. longicaudata* have been recovered in the various surveys carried out in Amapá since 2004. Thus, *Fopius arisanus* (egg parasitoid) was introduced for biological control of *B. carambolae* [34,35].

5. CONSERVATION BIOLOGICAL CONTROL OF *Anastrepha* FRUIT FLIES IN THE BRAZILIAN AMAZON

Conservation biological control involves the maintenance and increase in the natural enemies of pests that are already present in the environment [36,37]. In the Amazon region, this kind of biological control has attracted the attention of researchers in the last two decades, because some wild plant species are important reservoirs or multipliers of fruit fly parasitoids [12].

Spondias mombin L., *Bellucia grossularioides* (L.) Triana and *Geissospermum argenteum* Woodson found in the Brazillian Amazon have the potential of been reservoirs of fruit fly parasitoids [12].

Spondias mombin (yellow mombin or hog plum) is a native species exploited mainly via extractivism, with few initiatives for planting in commercial orchards. However, in recent years the commercialization of this fruit has been expanding along with the market for native fruits from the Amazon region. It is considered a parasitoid multiplier plant, with parasitism indices of 50% of fruit fly puparia [12,38,39]. *Doryctobracon areolatus* and *O. bellus* have been associated with *S. mombin* in five Brazilian Amazon states. In Amapá, five parasitoid species are often found in samples of mombin fruit infested with *Anastrepha* spp. (Checklist). *Spondias mombin* fruit is frequently collected in the Amazon region. The highest parasitism recorded for this host plant species was 52.7% in fruits sampled in the state of Pará (Table 1).

Bellucia grossularioides grows in areas with both altered and unaltered vegetation. It has high capacity to adapt to a wide range of soil types. It is among the most important pioneer species in terms of number of individuals per area in the Central Amazon. It produces flowers and fruits for long periods or continuously throughout the year [40,41]. In a study conducted in several states in the Brazilian Amazon, parasitism rates of up to 28% of fruit fly puparia were recorded (Table 1). Seven parasitoid species have been associated with *B. grossularioides*, of which

D. areolatus was predominant [42, Checklist and Table 1].

Geissospermum argenteum, known in Amapá as "quina" [12], is frequently used by traditional communities for the treatment of malaria [43,44]. In a recent study carried out in a fragment of upland forest in the south of the state of Amapá, the potential of this plant species as a reservoir for fruit fly parasitoids was evaluated [45]. The estimates showed a positive linear relationship between fruit production of *G. argenteum*, density of fruit flies and parasitoids, that is, the greater the fruit production, the greater the quantity of fruit flies and parasitoids. The average density of parasitoids per kg of fruit (3.52) and per tree (38.9) were relatively low. However, this corresponded to about 2,500 parasitoids per ha. In this reservoir plant, parasitism is generally less than 10%, but this is compensated by the high rate of infestation by fruit flies of no economic importance and by the diversity of associated generalist parasitoids (Checklist).

Some plant species with fruit fly parasitism has been found be greater than 10% (Table 1). It is not possible to present the percentages for the states of Maranhão, Mato Grosso and Tocantins, because data published, such as, quantity of fruits sampled, number of puparia and number of parasitoids in each sample, were not evaluated.

Loreya mespiloides Miq. and *Bellucia egensis* (Mart. Ex DC.) Penneys, FA Michelangeli, Judd & Almeda have presented significant parasitism percentages of fruit fly by braconids. In samples of *L. mespiloides* from municipality of Amajari, Roraima state, the fruit fly parasitism by *D. adaimei* was 62.3%. In *B. egensis*, the highest parasitism rate reached 42.9% (Table 1). These host plants have high potential as reservoirs of fruit fly parasitoids and should be better studied aiming their use for biological control of economically important fruit flies in the Amazon region.

6. CHECKLIST OF PARASITOIDS OF *Anastrepha* FRUIT FLIES AND ASSOCIATED PLANTS IN THE BRAZILIAN AMAZON

6.1 Figitidae

6.1.1 *Aganaspis nordlanderi* Wharton

Distribution. Amazonas: Manaus [46], Presidente Figueiredo [47].

Hosts. *A. antunesi* ex *Spondias mombin* [47], *A. coronilli* ex *Bellucia grossularioides* [46], *A. fractura* ex *Maquira sclerophylla* [48], *A. striata* ex *Psidium guajava* [21].

6.1.2 *Aganaspis pelleranoi* (Brèthes)

Distribution. Amazonas: Manaus [46], Presidente Figueiredo [47]. Amapá: Ferreira Gomes and Serra do Navio [49], Macapá, Mazagão, Porto Grande, and Santana [50], Oiapoque [33], Pedra Branca do Amapari [51], Tartarugalzinho [52]. Pará: Afuá and Melgaço [53], Altamira [54]. Roraima: Amajari [55], Boa Vista [56].

Hosts. *A. antunesi* ex *Spondias mombin* [47], *A. atrigona* ex *Pouteria durlandii* [46], *A. bahiensis* ex *Brosimum potabile* [52], *A. coronilli* ex *Bellucia grossularioides* [47,49], *A. fractura* ex *Maquira sclerophylla* [48], *A. obliqua* ex *Spondias mombin* [49, 56], *A. obliqua* ex *Eugenia patrisii* [46], *A. obliqua* ex *Averrhoa carambola* [54], *A. striata* ex *Psidium guajava* [33, 47], *A. striata* ex *Spondias mombin* [33], *A. turpiniae* ex *Psidium guajava* [47].

6.2 Braconidae

6.2.1 *Asobara anastrephae* (Muesebeck)

Distribution. Acre: Rio Branco [57]. Amazonas: Manaus [58], Novo Airão [26], Presidente Figueiredo [47]. Amapá: Itaubal do Piririm [59], Laranjal do Jari and Vitória do Jari [28], Macapá [60], Mazagão [61], Oiapoque [33], Pedra Branca do Amapari and Serra do Navio [51], Porto Grande and Pracuúba [49], Santana [62]. Mato Grosso: Nova Guarita [17]. Pará: Altamira [54], Belém [63], Castanhal [64], Igarapé-Açu and São Francisco do Pará [65], Tomé-Açu [66]. Tocantins: Brejinho de Nazaré, Monte do Carmo, Palmas, and Porto Nacional [32].

Hosts. *A. antunesi* ex *Spondias mombin* [47], *A. atrigona* ex *Geissospermum argenteum* [51], *A. bahiensis* ex *Ampelocera edentula* [48], *A. bahiensis* ex *Pouroma cecropiaefolia* [47], *A. coronilli* ex *Bellucia grossularioides* [51], *A. fractura* ex *Salacia* sp. [47], *A. fraterculus* ex *Chrysobalanus icaco* [49], *A. obliqua* ex *Spondias mombin* [18, 57, 62, 65], *A. obliqua* ex *Averrhoa carambola* [54, 65], *A. obliqua* ex *Malpighia glabra* [66], *A. obliqua* ex *Malpighia punicifolia* [67], *A. obliqua* ex *Mangifera indica* [32], *A. striata* ex *Psidium guajava* [33], *A. striata* ex *Spondias mombin* [33].

Table 1. Percentage of *Anastrepha* parasitism on fruit flies infesting several plant species in the Brazilian Amazon

States	Plant species	Mass(kg)	Puparia (n)	Infestation (puparia/kg)	Parasitoid species	Parasitism (%)	References
Acre	*Bellucia grossularioides*	0.6	49	81.7	*Doryctobracon areolatus*	10.2	[71]
	Spondias mombin	2.4	468	195.0	*Doryctobracon areolatus*	29.5	[70]
					Opius bellus		
					Utetes anastrephae		
Amapá	*Bellucia egensis*	0.25	35	139.5	*Doryctobracon areolatus*	42.9	[91]
	Bellucia grossularioides	0.79	175	220.9	*Doryctobracon areolatus*	28.0	[49]
					Aganaspis pelleranoi		
	Spondias mombin	2.3	149	64.7	*Doryctobracon areolatus*	46.9	[49]
					Opius bellus		
Amazonas	*Malpighia glabra*	1.3	79	60.7	*Doryctobracon areolatus*	41.7	[47]
					Opius bellus		
	Manihot esculenta	2.2	393	178.6	*Doryctobracon areolatus*	34.1	[47]
					Opius bellus		
					Utetes anastrephae		
	Spondias mombin	3.1	586	189.0	*Asobara anastrephae*		[47]
					Doryctobracon areolatus	30.0	
					Opius bellus		
					Utetes anastrephae		
					Aganaspis nordlanderi		
					Aganaspis pelleranoi		
Pará	*Malpighia emarginata*	1.27	150	118.1	*Doryctobracon areolatus*	30.7	[63]
					Opius bellus		
					Utetes anastrephae		
	Spondias mombin	1.20	560	466.7	*Doryctobracon areolatus*	52.7	[63]
					Opius bellus		
Rondônia	*Averrhoa carambola*	2.2	45	20.5	*Doryctobracon areolatus*	22.0	[71]
					Opius bellus		
Roraima	*Loreya mespiloides*	0.68	122	178.6	*Doryctobracon areolatus*	62.3	[55]
					Doryctobracon adaimei		
	Manihot esculenta	1.19	133	111.8	*Doryctobracon areolatus*	38.3	[56]
	Spondias purpurea	1.84	119	64.7	*Doryctobracon areolatus*	46.2	[56]
					Opius bellus		
					Utetes anastrephae		

6.2.2 *Doryctobracon adaimei* Marinho & Penteado-Dias

Distribution. Amazonas: Presidente Figueiredo [47]. Amapá: Calçoene and Oiapoque [68], Laranjal do Jari and Vitória do Jari [28], Pedra Branca do Amapari and Serra do Navio [51], Porto Grande [60], Tartarugalzinho [69]. Pará: Belém [63]. Roraima: Amajari [55]. Tocantins: Palmas [32].

Hosts. *A. atrigona* ex *Geissospermum argenteum* [51], *A. coronilli* ex *Bellucia grossularioides* [32, 42], *A. coronilli* ex *Loreya mespiloides* [55], *A. striata* ex *Psidium guajava* [28, 47], *A. striata* ex *Psidium araca* [63].

6.2.3 *Doryctobracon areolatus* (Szépligeti)

Distribution. Acre: Bujari and Rio Branco [70], Capixaba [71]. Amazonas: Barcelos, Rio Preto da Eva, and Tefé [26], Manaus [58], Presidente Figueiredo [47]. Amapá: Amapá, Cutias do Araguari, Ferreira Gomes, Itaubal do Piririm, Macapá, Mazagão, Porto Grande, Serra do Navio, and Vitória do Jari [72], Calçoene [73], Laranjal do Jari [28], Oiapoque [26], Pedra Branca do Amapari [51], Pracuúba [42], Santana [60], Tartarugalzinho [69]. Maranhão: Santa Inês [24], São Luís [23]. Mato Grosso: Nova Guarita [17], Sinop [31]. Pará: Afuá [74], Altamira [54], Belém [75], Belterra, Breves, Gurupá, Melgaço, and Santarém [53], Capitão Poço [76], Castanhal, Igarapé-Açu, and São Francisco do Pará [65], Tomé-Açu [66]. Rondônia: Ouro Preto do Oeste [71], Porto Velho [47]. Roraima: Amajari [55], Boa Vista and Pacaraima [26], Bonfim and Cantá [56], Normandia [77]. Tocantins: Palmas and Porto Nacional [32].

Hosts. *A. amita* ex *Citharexylum poeppigii* [55], *A. antunesi* ex *Spondias mombin* [47, 78], *A. atrigona* ex *Geissospermum argenteum* [51], *A. bahiensis* ex *Ampelocera edentula* [48], *A. bahiensis* ex *Helicostylis scabra* [79], *A. bahiensis* ex *Helicostylis tomentosa* [46], *A. bahiensis* ex *Pouroma cecropiaefolia* [47], *A. coronilli* ex *Bellucia grossularioides* [32, 46, 51, 56, 71], *A. coronilli* ex *Bellucia dichotoma* [48], *A. coronilli* ex *Loreya mespiloides* [55], *A. distincta* ex *Inga edulis* [28, 65, 80], *A. distincta* ex *Inga laurina* [49], *A. fraterculus* ex *Terminalia catappa* [18], *A. fraterculus* ex *Psidium guajava* [78], *A. fractura* ex *Maquira sclerophylla* [48], *A. fractura* ex *Salacia* sp. [47], *A. leptozona* ex *Pouteria caimito* [47, 49], *A. manihoti* ex *Manihot esculenta* [55], *A. obliqua* ex *Anacardium occidentale* [47], *A. obliqua* ex *Averrhoa carambola* [47, 54, 71], *A. obliqua* ex *Eugenia stipitata* [81], *A. obliqua* ex *Eugenia uniflora* [65, 82], *A. obliqua* ex *Malpighia emarginata* [65, 83, 84], *A. obliqua* ex *Malpighia glabra* [47, 66], *A. obliqua* ex *Malpighia punicifolia* [75, 77], *A. obliqua* ex *Mangifera indica* [32, 47], *A. obliqua* ex *Myrciaria dubia* [18], *A. obliqua* ex *Psidium acutangulum* [80], *A. obliqua* ex *Psidium guajava* [70], *A. obliqua* ex *Spondias mombin* [47, 56, 60, 64, 70], *A. obliqua* ex *Spondias purpurea* [56], *A. obliqua* ex *Syzygium jambos* [65], *A. pickeli* ex *Manihot esculenta* [47], *A. pseudanomala* ex *Couma utilis* [85], *A. pulchra* ex *Pouteria oblanceolata* [86], *A. serpentina* ex *Citrus sinensis* [76, 87], *A. serpentina* ex *Manilkara huberi* [28], *A. serpentina* ex *Manilkara zapota* [67], *A. serpentina* ex *Pouteria caimito* [47, 64, 80], *A. serpentina* ex *Pouteria gardneri* [88], *A. striata* ex *Artocarpus heterophyllus* [89], *A. striata* ex *Pouteria caimito* [33], *A. striata* ex *Psidium acutangulum* [80], *A. striata* ex *Psidium cattleianum* [31], *A. striata* ex *Psidium guajava* [17, 21, 33, 84, 90], *A. striata* ex *Psidium guineense* [56, 71], *A. striata* ex *Spondias mombin* [33], *A. striata* ex *Syzygium malaccense* [73], *A. turpiniae* ex *Spondias mombin* [72], *A. turpiniae* ex *Terminalia catappa* [47], *A. zacharyi* ex *Bellucia egensis* [91], *A. zenildae* ex *Psidium guajava* [88], *A. zenildae* ex *Ziziphus mauritiana* [92].

6.2.4 *Doryctobracon brasiliensis* (Szépligeti)

Distribution. Amazonas: Manaus [26]. Roraima: Boa Vista and Pacaraima [26].
Hosts. *A. fractura* ex *Salacia* sp. [47].

6.2.5 *Doryctobracon crawfordi* (Viereck)

Distribution. Amapá: Laranjal do Jari [28], Porto Grande [49]. Roraima: Amajari [93], Pacaraima [56].

Hosts. *A. atrigona* ex *Geissospermum argenteum* [28], *A. coronilli* ex *Bellucia grossularioides* [49], *A. serpentina* ex *Pouteria caimito* [56].

6.2.6 *Doryctobracon whartoni* Marinho & Penteado-Dias

Distribution. Amapá: Pedra Branca do Amapari [51].

Hosts. *A. atrigona* ex *Geissospermum argenteum* [51]

6.2.7 *Odontosema albinerve* Kieffer

Distribution. Amapá: Porto Grande [50].

6.2.8 *Opius bellus* Gahan

Distribution. Acre: Bujari [70]. Amazonas: Manaus [58], Presidente Figueiredo [47]. Amapá: Calçoene [73], Ferreira Gomes [94], Laranjal do Jari [28], Macapá, Mazagão, and Santana [60], Oiapoque [72], Pedra Branca do Amapari and Serra do Navio [51], Porto Grande [49], Tartarugalzinho and Vitória do Jari [42]. Maranhão: Caxias and Santa Inês [24]. Pará: Afuá, Breves, Gurupá, and Melgaço [53], Altamira [54], Belém [75], Castanhal, Igarapé-Açu, and São Francisco do Pará [65], Tomé-Açu [66]. Rondônia: Ouro Preto do Oeste [71]. Roraima: Amajari [55], Boa Vista [90], Bonfim, Cantá, Normandia, and Pacaraima [56]. Tocantins: Araguatins [95], Brejinho de Nazaré and Porto Nacional [32].

Hosts. *A. antunesi* ex *Spondias mombin* [96], *A. atrigona* ex *Geissospermum argenteum* [51], *A. atrigona* ex *Pouteria durlandii* [46], *A. bahiensis* ex *Pouroma cecropiaefolia* [47], *A. coronilli* ex *Bellucia grossularioides* [47, 73], *A. fractura* ex *Salacia* sp. [47], *A. fraterculus* ex *Psidium guajava* [78], *A. hastata* ex *Cheiloclinium cognatum* [97], *A. manihoti* ex *Manihot esculenta* [47, 55], *A. obliqua* ex *Averrhoa carambola* [54, 71], *A. obliqua* ex *Eugenia stipitata* [81, 90], *A. obliqua* ex *Eugenia uniflora* [82, 90], *A. obliqua* ex *Malpighia emarginata* [65], *A. obliqua* ex *Malpighia glabra* [47, 66], *A. obliqua* ex *Malpighia punicifolia* [67, 75], *A. obliqua* ex *Spondias mombin* [47, 60, 65, 70, 90], *A. obliqua* ex *Spondias purpurea* [90], *A. obliqua* ex *Syzygium jambos* [65], *A. striata* ex *Psidium guineense* [71], *A. striata* ex *Spondias mombin* [78], *A. turpiniae* ex *Spondias mombin* [72], *A. zenildae* ex *Psidium guajava* [88].

6.2.9 *Utetes anastrephae* (Viereck)

Distribution. Acre: Bujari [70]. Amazonas: Manaus [26], Presidente Figueiredo [47]. Amapá: Calçoene [73], Ferreira Gomes [94]), Laranjal do Jari [28], Macapá and Santana [60], Mazagão [99], Oiapoque [33], Porto Grande [72], Serra do Navio [51]. Mato Grosso: Nova Guarita and Sinop [17]. Pará: Altamira [54], Belém [75], Tomé-Açu [66]. Roraima: Amajari [55], Bonfim [77], Normandia and Pacaraima [56]. Tocantins: Araguatins [95], Brejinho de Nazaré [32].

Hosts. *A. antunesi* ex *Spondias mombin* [47, 78], *A. bahiensis* ex *Ampelocera edentula* [48], *A. coronilli* ex *Bellucia grossularioides* [47], *A. manihoti* ex *Manihot esculenta* [18], *A. obliqua* ex *Averrhoa carambola* [54], *A. obliqua* ex *Malpighia glabra* [66], *A. obliqua* ex *Malpighia punicifolia* [67, 75], *A. obliqua* ex *Mangifera indica* [18], *A. obliqua* ex *Spondias mombin* [47, 49, 56, 70], *A. obliqua* ex *Spondias purpurea* [17, 56], *A. pickeli* ex *Manihot esculenta* [47], *A. striata* ex *Psidium guajava* [33], *A. striata* ex *Spondias mombin* [33,78], *A. turpiniae* ex *Spondias mombin* [72].

7. CONCLUSION

The Brazilian Amazon is undoubtedly endowed with rich biodiversity, including many species of parasitoids that can act in the biological control of fruit flies, but have not yet been widely studied or identified. The vast geographic expanse of the region, with remote sites having difficult access, poses a challenge to the scientific community. Additionally, the scarcity of qualified human resources for conducting bio-ecological studies of fruit flies represents another constraint.

It is crucial for studies to sample fruit-bearing plants, although relatively expensive, to be performed in all states of the Brazilian Amazon, to increase knowledge of the richness of the fruit fly parasitoid species and their geographic distribution. The priority areas are the states of Acre, Maranhão, Mato Grosso, Rondônia and Tocantins, which so far have been mostly neglected in studies of this type. Additionally, studies should be prioritized using individual fruit method [22], which although laborious, is very useful to understand the tritrophic relationship involving species of fruit fly, their host fruit and parasitoid.

It is also necessary to establish or adapt methods for laboratory rearing of some parasitoid species that occur in the region, to facilitate biological studies of these species. In this regard, there is a particular need to study *D. adaimei* and *D. whartoni*, parasitoids recently described from specimens collected in the Brazilian Amazon, whose biological parameters are not known. The use of these parasitoids could help support biological control programs, which are essential to control fruit flies according to management strategies over large areas by combining sterile insect technique and application of toxic bait.

Studies seeking to increase conservation biological control of fruit flies should be encouraged. It is essential to investigate the potential of wild plant species which could be

reservoirs or multipliers of parasitoids. Some of these species are already being studied, such as *B. grossulariodes*, *G. argenteum* and *S. mombin*, which augurs well for the biological control of fruit flies in Brazil and scientific community at large.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Marinho CF, Costa VA, Zucchi RA. Annotated checklist and illustrated key to braconid parasitoids (Hymenoptera, Braconidae) of economically important fruit flies (Diptera, Tephritidae) in Brazil. Zootaxa. 2018; 4527(1):021–036.
DOI:
https://doi.org/10.11646/zootaxa.4527.1.2
2. Nava DE, Botton M. Bioecologia e controle de *Anastrepha fraterculus* e *Ceratitis capitata* em pessegueiro. Embrapa Clima Temperado, Pelotas. 2010;315.
3. Gonçalves RS, Andreazza F, Lisbôa H, Grützmacher AD, Valgas RA, Manica-Berto R, Nörnberg SD, Nava DE. Basis for the development of a rearing technique of *Aganaspis pelleranoi* (Hymenoptera: Figitidae) in *Anastrepha fraterculus* (Tephritidae: Diptera). J. Econ. Entomol. 2016;109(3):1094-1101.
Doi: 10.1093/jee/tow069.
4. Gonçalves RS, Nunes AM, Poncio S, Manica-Berto R, Nornberg SD, Grutzmacher AD, Nava DE. Bionomics, thermal requirements and life table of the fruit fly parasitoid *Doryctobracon areolatus* (Hymenoptera: Braconidae) under various thermal regimes. Biol. Control. 2018; 127:101-108.
DOI: 10.1016/j.biocontrol.2018.08.025
5. Poncio S, Nunes AM, Gonçalves RS, Lisboa H, Manica-Berto R, Garcia MS, Nava DE. Strategies for establishing a rearing technique for the fruit fly parasitoid: *Doryctobracon brasiliensis* (Hymenoptera: Braconidae). J. Econ. Entomol. 2018;111(3):1087-1095.
DOI: https://doi.org/10.1093/jee/toy058
6. Paranhos BJ, Nava DE, Malavasi A. Biological control of fruit flies in Brazil. Pesqui. Agropecu. Bras. 2019; 54:1-14.
DOI: https://doi.org/10.1590/S1678-3921.pab2019.v54.26037
7. Silva RA, Lemos WP, Zucchi RA, editores. Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. 1ª ed. Amapá: Embrapa; 2011.
8. IBGE. Amazônia Legal;2019. Accessed June 19, 2020.
Available:https://www.ibge.gov.br/geociencias/cartas-e-mapas/mapas-regionais
9. Cavalcante PB, editor. Frutas comestíveis na Amazônia. 7º ed. Pará: Museu Paraense Emílio Goeldi; 2010.
10. Souza AGC, Silva SEL. Frutas nativas da Amazônia. In: 20º Congresso Brasileiro de Fruticultura, 54º Annual Meeting of the Interamerican Society for Tropical Agriculture, Vitória, Espirito Santo; 2008.
11. Aluja M, Mangan RL. Fruit fly (Diptera: Tephritidae) host status determination: critical conceptual, methodological, and regulatory considerations. Annu. Rev. Entomol. 2008;53:473–502.
DOI:https://doi.org/10.1146/annurev.ento.53.103106.093350
12. Adaime R, Lima AL, Sousa MSM. Controle biológico conservativo de moscas-das-frutas na Amazônia brasileira. Innov. agron. 2018;64:47-59.
13. Adaime R, Sousa MSM, Pereira JF. *Anastrepha* species and their host in the Brazilian Amazon. 2016.
Accessed 15 May 2020.Available: http://anastrepha.cpafap.embrapa.br
14. Silva OLR, Suman R, Silva JR. Mosca da carambola (*Bactrocera carambolae* Drew & Hancock). Brasília: Ministério da Agricultura e do Abastecimento, Alerta Quarentenário. 1997;1.
15. Ronchi-Teles B, Silva NM. Primeiro registro de ocorrência da mosca-do-mediterrâneo, *Ceratitis capitata* (Wied.) (Diptera: Tephritidae) na Amazônia Brasileira. An. Soc. Entomol. Brasil. 1996; 25(3):569-570.
DOI: https://doi.org/10.37486/0301-8059.v25i3.1179
16. Castilho AP, Brandão CAC, Ayres AR, Pereira JF, Adaime R. Distribuição geográfica e plantas hospedeiras de

Ceratitis capitata (Wiedemann) (Diptera: Tephritidae) na Amazônia brasileira. In: Jasper M, editor. Coletânea Nacional Sobre Entomologia. Paraná: Atena; 2019.

17. Silva MES, Wochner MA, Sousa MSM, Barreto MR, Adaime R. Moscas-das-frutas (Diptera: Tephritidae), suas plantas hospedeiras e parasitoides (Hymenoptera: Braconidae) no norte do estado do Mato Grosso, Brasil. Nativa. 2019; 7(5):513-519. DOI: 10.31413/nativa.v7i5.7461
18. Canal NAD, Zucchi RA, Silva NM, Silveira-Neto S. Análise faunística dos parasitóides (Hymenoptera, Braconidae) de *Anastrepha* spp. (Diptera, Tephritidae) em Manaus e Iranduba, Estado do Amazonas. Acta Amaz. 1995; 25(3-4). DOI: https://doi.org/10.1590/1809-43921995253246
19. Guimarães JA, Zucchi RA. Chave de identificação de Figitidae (Eucoilinae) parasitoides de larvas frugívoras na região Amazônica. In: Silva RA, Lemos WP, Zucchi RA, editores. Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. 1ª ed. Amapá: Embrapa; 2011.
20. Sousa MSM, Adaime R, Pereira JF. Fruit fly parasitoids in the Brazilian Amazon;2016. Accessed 12 May 2020.Available: http://parasitoid.cpafap.embrapa.br
21. Silva NM, Silva FCC, Cruz DS. Ocorrência de parasitoides de *Anastrepha striata* (Diptera: Tephritidae) no estado do Amazonas. In: 14º Simpósio de Controle Biológico, Teresópolis, Rio de Janeiro;2015.
22. Silva RA, Deus EG, Raga A, Pereira JDB, Souza Filho MF, Costa Neto SV. Monitoramento de moscas-das-frutas na Amazônia: amostragem de frutos e uso de armadilhas. In: Silva RA, Lemos WP, Zucchi RA, editores. Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. 1ª ed. Amapá: Embrapa; 2011.
23. Leonel Junior FL, Zucchi RA, Wharton RA. Distribution and tephritid hosts (Diptera) of braconid parasitoids (Hymenoptera) in Brazil. Int. J. Pest Manag. 1995;41(4):208-213. DOI: 10.1080/09670879509371951
24. Oliveira FL, Araujo EL, Chagas EF, Zucchi RA. Maranhão. In: Malavasi A, Zucchi RA, editors. Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado. São Paulo: Holos; 2000.
25. Silva NM. Levantamento e análise faunística de moscas-das-frutas (Diptera: Tephritidae) em quatro locais do estado do Amazonas. Doctoral Thesis, Universidade de São Paulo, Piracicaba, São Paulo;1993.
26. Ronchi-Teles B. Ocorrência e flutuação populacional de espécies de moscas-das-frutas e parasitóides com ênfase para o gênero *Anastrepha* (Diptera: Tephritidae) na Amazônia Brasileira. Doctoral Thesis, Instituto Nacional de Pesquisas da Amazônia / Universidade Federal do Amazonas, Manaus, Amazonas; 2000.
27. Deus EG, Silva RA, Ronchi-Teles B, Zucchi RA. Conhecimento sobre moscas-das-frutas no Estado do Amazonas. In: Silva RA, Lemos WP, Zucchi RA, editores. Moscas-das-frutas na Amazônia brasileira: diversidade, hospedeiros e inimigos naturais. 1ª ed. Amapá: Embrapa; 2011.
28. Silva RA, Lima AL, Xavier SLO, Silva WR, Marinho CF, Zucchi RA. *Anastrepha* species (Diptera: Tephritidae), their hosts and parasitoids in southern Amapá State, Brazil. Biota Neotrop. 2011; 11(3):431-436. DOI: https://doi.org/10.1590/S1676-06032011000300037
29. Uchoa MA, Zucchi RA. Moscas-das-Frutas nos Estados Brasileiros. Mato Grosso e Mato Grosso do Sul. In: Malavasi A, Zucchi RA, editores. Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado. São Paulo: Holos; 2000.
30. Pontes AV. Biodiversidade de moscas frugívoras (Diptera: Tephritoidea) amostradas com armadilhas McPhail no sudeste de Mato Grosso, Brasil. Master's Dissertation, Universidade Federal da Grande Dourados, Dourados, Mato Grosso do Sul; 2006.
31. Souza MSM, Silva RA, Barreto MR, Wochner MA, Silva MES. Primeiro registro de parasitismo de *Anastrepha striata* Schiner (Diptera: Tephritidae) na região norte de Mato Grosso. In: 15º Simpósio de Controle Biológico, Ribeirão Preto, São Paulo;2017.
32. Bomfim DA, Uchôa-Fernandes MA, Bragança MAL. Hosts and Parasitoids of Fruit Flies (Diptera: Tephritoidea) in the

State of Tocantins, Brazil. Neotrop. Entomol. 2007;36(6):984-986.
DOI: https://doi.org/10.1590/S1519-566X2007000600025

33. Carvalho RS. Estudos de laboratório e de campo com o parasitóide exótico *Diachasmimorpha longicaudata* Ashmead (Hymenoptera: Braconidae) no Brasil. Doctoral Thesis, Universidade de São Paulo, São Paulo;2003.
34. Adaime R. Parasitoides no controle biológico de Tefritídeos na Amazônia brasileira. In: 26º Congresso Brasileiro de Entomologia; 9º Congresso Latino-americano de Entomologia, Maceió, Alagoas; 2016.
35. Lima AL, Jesus-Barros CR, Bariani A, Almeida RP, Adaime R. Potencial de uso de *Fopius arisanus* (Sonan) (Hymenoptera: Braconidae) para o controle de *Bactrocera carambolae* Drew & Hancock (Diptera: Tephritidae) no Brasil. In: 15º Simpósio de controle biológico, Ribeirão Preto, São Paulo;2017.
36. Hoy MA. Biological control of arthropod pests: traditional and emerging technologies. Am. J. Agric. Economic 1988; 3(2-3):63–68.
DOI:https://doi.org/10.1017/S0889189300002198
37. Nordlund DA. Biological control, integrated pest management and conceptual models. Biocontrol News & Info. 1996;17(2):35-44.
38. Sacramento CK, Souza FX. Cajá. In: Santos-Serejo JLD, Sampaio CV, Coelho YS, editores. Fruticultura tropical: espécies regionais e exóticas. Brasília: Embrapa Informação Tecnológica; 2009.
39. Deus EG, Sousa MSM, Adaime R. Taperebá. In: Silva NM, Adaime R, Zucchi RA, editors. Pragas agrícolas e florestais na Amazônia, 1ª ed. Brasília: Embrapa; 2016.
40. Bentos TV, Mesquita RCG, Williamson GB. Reproductive phenology of Central Amazon pioneer trees. Trop. Conserv. Sci. 2008; 1:186-203.
DOI:https://doi.org/10.1177/194008290800100303
41. Santos GGA, Santos BA, Nascimento HEM, Tabarelli M. Contrasting demographic structure of short- and long-lived pioneer tree species on Amazonian forest edges. Biotropica. 2012; 44(6):771-778.
DOI: https://doi.org/10.1111/j.1744-7429.2012.00882.x
42. Adaime R, Sousa MSM, Santos JCR, Deus EG. Pioneer tree species as fruit flies parasitoids reservoir in the Brazilian Amazon. Biota Neotrop. 2018; 18(2):1-8.
DOI: 10.1590/1676-0611-bn-2017-0428
43. DeFilipps RA, Maina SL, Crepin J. Medicinal plants of the Guianas (Guiana, Surinam, French Guiana). 2004.
Accessed 18 July 2020.Available: http://botany.si.edu/bdg/medicinal/Medicinal_ plants_master.pdf
44. Sousa MSM, Baia D, Deus EG, Adaime R, Cunha AC. Índices de infestação de *Geissospermum argenteum* Woodson (Apocynaceae) por *Anastrepha atrigona* Hendel (Diptera: Tephritidae) em Laranjal do Jari, Amapá. In: 1st International Symposium, 5th Meeting of the Post-Graduate Program in Tropical Biodiversity, Macapá, Amapá;2014.
45. Sousa MSM, Santos JEV, Toledo JJ, Nava DE, Adaime R. *Geissospermum argenteum* (Angiosperma: Apocynaceae): a reservoir of parasitoids of fruit flies (Diptera: Tephritidae) in an upland forest in the Brazilian Amazon. Agric. For. Entomol. 2021.
DOI: 10.1111/afe.12432.
46. Tregue-Costa AP. Biodiversidade de espécies de *Anastrepha* spp. Schiner, 1868 (Diptera: Tephritidae) e seus parasitoides na Reserva Florestal Adolpho Ducke, Manaus, Amazonas, Brasil. Master's Dissertation, Instituto Nacional de Pesquisas da Amazônia/Universidade Federal do Amazonas, Manaus, Amazonas;2004.
47. Dutra VS, Ronchi-Teles B, Garcia MVB, Adaime R, Silva JG. Native hosts and parasitoids associated with *Anastrepha fracture* and other *Anastrepha* species (Diptera: Tephritidae) in the Brazilian Amazon. Fla Entomol. 2013; 96(1):270-273.
DOI: https://www.jstor.org/stable/23608909
48. Costa SGM, Querino RB, Ronchi-Teles B, Hairstyle-Days AMM, Zucchi RA. Parasitoid diversity (Hymenoptera: Braconidae and Figitidae) on frugivorous larvae (Diptera: Tephritidae and Lonchaeidae) at Adolpho Ducke Forest Reserve, Central Amazon Region, Manaus, Brazil. Braz. J. Biol. 2009; 69:363-370.
49. Deus EG, Pinheiro LS, Lima CR, Sousa MSM, Guimarães JA, Strikis PC, Adaime

R. Wild hosts of frugivorous dipteran (Tephritidae and Lonchaeidae) and associated parasitoids in the Brazilian Amazon. Fla Entomol. 2013;96:1621-1625.

50. Silva RA, Pereira JDB, Lemos LN, Silva WR. Espécies de *Anastrepha* associadas a frutíferas de expressão socioeconômica no Estado do Amapá, Brasil. Rev. Agricul. 2010; 85:207-217.
51. Deus EG, Silva RA, Nascimento DB, Marinho CF, Zucchi RA. Hospedeiros e parasitoides de espécies de *Anastrepha* (Diptera, Tephritidae) em dois municípios do Estado do Amapá. Rev. Agricul. 2009; 84:194-203.
52. Silva RA, Silva WR, Lima CR, Costa-Neto SV, Souza-Filho MF, Guimarães JA, Zucchi RA. Novo registro de hospedeiro de *Anastrepha bahiensis* Lima (Diptera: Tephritidae) no Brasil e parasitóide associado. O Biológico, 2009.
53. Pereira JDB. Contribuição ao conhecimento de moscas-das-frutas (Tephritidae e Lonchaeidae) no Pará: diversidade, hospedeiros e parasitóides associados. Master's Dissertation, Universidade Federal do Amapá, Macapá, Amapá, 2009.
54. Santos AO. Parasitóides (Hymenoptera: Braconidae) de moscas-das-frutas (Diptera: Tephritidae) em frutos de caramboleira (*Averrhoa carambola* L.) no campus Universitário da UFPA em Altamira - PA. Course Completion Paper, Universidade Federal do Pará, Altamira, Pará, 2014.
55. Marsaro Júnior AL, Silva RA, Silva WR, Lima CR, Flores AS, Ronchi-Teles B. New records of *Anastrepha* (Diptera: Tephritidae), its hosts and parasitoids in the Serra do Tepequém, Roraima state, Brazil. Rev. Agricul. 2010; 85:15-20.
56. Marsaro Júnior AL, Adaime R, Ronchi-Teles B, Lima CR, Pereira PRVS. *Anastrepha* species (Diptera: Tephritidae), their hosts and parasitoids in the extreme north of Brazil. Biota Neotrop. 2011; 11(4):117-123.
DOI: https://doi.org/10.1590/S1676-06032011000400012
57. Azevedo TS, Vasconcelos AS, Santos RS, Sousa MSM, Adaime R. Levantamento de moscas frugívoras em dois municípios do Estado do Acre, Brasil. Biotemas. 2018; 31(3):25-31.
58. Silva NM. Estudos sobre competição interespecífica entre espécies de *Anastrepha* (Diptera; Tephritidae) e seus parasitóides no Amazonas. Full Professor's Thesis. Universidade Federal do Amazonas, Manaus, Amazonas, 1998.
59. Silva RA, Nascimento DB, Deus EG, Souza GD, Oliveira LSP. Hospedeiros e parasitóides de *Anastrepha* spp. (Diptera: Tephritidae) em Itaubal do Piririm, Estado do Amapá. Cienc Rural. 2007; 37(2):557-560. DOI: https://doi.org/10.1590/S0103-84782007000200041
60. Silva RA, Jordão AL, Marinho CF, Sá LAN, Oliveira MRV. Braconidae parasitóides de moscas-das-frutas em quatro municípios do Estado do Amapá. In: 9º Simpósio de Controle Biológico, Recife, Pernambuco, 2005.
61. Sousa MSM, Jesus-Barros CR, Yokomizo GK, Lima AL, Adaime R. Ocorrência de moscas-das-frutas e parasitoides em *Spondias mombin* L. em três municípios do estado do Amapá, Brasil. Biota Amaz. 2016; 6(2):50-55.
62. Silva RA, Xavier SLO, Souza Filho MF, Silva WR, Nascimento DB, Deus EG. Frutíferas hospedeiras e parasitóides (Hym., Braconidae) de *Anastrepha* spp. (Dip., Tephritidae) na Ilha de Santana, Estado do Amapá, Brasil. O Biológico, 2007.
63. Castilho AP, Silva LC, Sousa MSM, Santos JEV, Lemos WP, Adaime R. Novas associações de Tephritidae e Lonchaeidae (Diptera) e suas plantas hospedeiras na Amazônia Oriental. Biotemas. 2019; 32(3):65-72.
DOI:https://doi.org/10.5007/2175-7925.2019v32n3p65
64. Ayres ÁR, Santos PRF, Cavalcante IP, Santos FR, Araújo FLS. Ocorrência de moscas-das-frutas e seus parasitoides obtidos de frutos comercializados em feiras livres no Município de Castanhal-Pará. In: 26º Congresso Brasileiro de Entomologia; 9º Congresso Latino-americano de Entomologia, Maceió, Alagoas, 2016.
65. Ayres AR. Moscas-das-frutas (Diptera: Tephritidae) na região nordeste do Pará. Doctoral Thesis, Universidade Federal Rural do Semiárido, Mossoró, Rio Grande do Norte, 2015.
66. Silva LC, Lemos WP, Oliveira TA. Cultivos de acerola abrigam diferentes espécies de parasitoides de *Anastrepha obliqua*

(Macquart) (Dip., Tephritidae) no polo de fruticultura de Tomé-Açu, Pará. In: 25º Congresso Brasileiro de Entomologia, Goiânia, Goiás, 2014.

67. Souza NS. Interações tritróficas entre moscas-das-frutas, suas plantas hospedeiras e seus parasitoides nas Regiões Nordeste e Sudeste do Estado do Pará. Master's Dissertation, Universidade Federal do Pará, Belém, Pará, 2014.
68. Sousa MSM, Santos JCR, Jesus CR, Yokomizo GKI, Deus EG, Pereira JF, Adaime R. Goiabeiras comuns contribuem para expansão da área de distribuição de *Bactrocera carambolae* na Amazônia brasileira. In: Pacheco JTR, Kawanishi JY, Nascimento R, orgs. Meio Ambiente e Desenvolvimento Sustentável. Paraná: Atena; 2019.
69. Souza MSM, Pereira JDB, Oliveira MN, Lemos LN, Jesus CR, Michelotto MD, Silva RA. Infestação de goiaba (*Psidium guajava* L.) em dois estágios de maturação por moscas-das-frutas (Diptera: Tephritidae) em Tartarugalzinho, AP. In: 1º Encontro Amapaense de Pesquisa Entomológica, Macapá, Amapá, 2008.
70. Thomazini MJ, Albuquerque ES. Parasitóides (Hymenoptera: Braconidae) de *Anastrepha* Schiner (Diptera: Tephritidae) no estado do Acre. Acta Amaz. 2009; 39(1):245-248. DOI: https://doi.org/10.1590/S0044-59672009000100030
71. Pereira JDB, Buriti DP, Lemos WP, Silva WR, Silva RA. Espécies de *Anastrepha* Schiner (Diptera: Tephritidae), seus hospedeiros e parasitóides nos Estados do Acre e Rondônia, Brasil. Biota Neotrop. 2010; 10 (3):441-446.
72. Creão MIP. Moscas-das-frutas (Diptera: Tephritidae): espécies, distribuição, medidas da fauna e seus parasitóides (Hymenoptera: Braconidae) no Estado do Amapá. Master's Dissertation, Instituto Nacional de Pesquisas da Amazônia / Universidade Federal do Amazonas, Manaus, Amazonas, 2003.
73. Adaime R, Sousa MSM, Jesus-Barros CR, Deus EG, Pereira JF, Strikis PC, Souza-Filho MF. Frugivorous flies (Diptera: Tephritidae, Lonchaeidae), their host plants, and associated parasitoids in the extreme north of Amapá State, Brazil. Fla Entomol. 2017; 100(2):316-324.
74. Silva WR, Jesus CR, Silva RA. Infestação natural de taperebá (*Spondias mombin* L., Anacardiaceae) por *Anastrepha* spp. (Diptera: Tephritidae), no município de Afuá, Pará. O Biológico. 2006; 68:810-812.
75. Ohashi OS, Dohara R, Zucchi RA, Canal NA. Ocorrência de *Anastrepha obliqua* (Macquart, 1835) (Dip, Tephritidae) em acerola (*Malpighia punicifolia* L.) no Estado do Pará. An. Soc. Entomol. Brasil. 1997; 26(2):389-390. DOI: https://doi.org/10.1590/S0301-80591997000200024
76. Castilho AP. Índices de infestação e parasitismo de *Anastrepha serpentina* (Wiedemann) (Dip. Tephritidae) em diferentes sistemas de cultivo de laranja em Capitão Poço, Pará. Master's Dissertation, Universidade Federal do Pará, Belém, Pará, 2013.
77. Amorim JEL. Diversidade de espécies de *Anastrepha* (Diptera: Tephritidae), seus parasitóides e hospedeiros em quintais agroflorestais no Estado de Roraima. Master's Dissertation, Universidade Federal do Amazonas, Manaus, Amazonas, 2003.
78. Adaime R, Jesus-Barros CR, Souza-Filho MF. Moscas-das-frutas (Diptera: Tephritidae) obtidas de frutos comercializados em feiras públicas de Macapá, Amapá. Amapá: Embrapa, Boletim de pesquisa e desenvolvimento, 85; 2014.
79. Ronchi-Teles B, Dutra VS, Tregue Costa AP, Aguiar-Menezes EL, Mesquita ACA, Silva JG. Natural host plants and native parasitoids associated with *Anastrepha pulchra* and other *Anastrepha* species (Diptera: Tephritidae) in Central Amazon, Brazil. Fla Entomol. 2011; 94(2):347-349. DOI: 10.1653/024.094.0232
80. Marsaro Júnior AL, Ronchi-Teles B, Pereira JDB, Lima CR, Silva Júnior RJ, Silva RA. Associação de *Doryctobracon areolatus* (Hymenoptera: Braconidae) com *Anastrepha* spp. (Diptera: Tephritidae) no município de Pacaraima, Estado de Roraima, Brasil. In: 11º Simpósio de controle biológico, Bento Gonçalves, Rio Grande do Sul, 2009.
81. Chaves EB. Diversidade de espécies de moscas-das-frutas (*Anastrepha* spp.) na cultura do araçá-boi (*Eugenia stipitata* McVaugh) em duas áreas no município de Manaus-AM. Master's Dissertation, Instituto Nacional de Pesquisas da Amazônia / Universidade Federal do

Amazonas, Manaus, Amazonas; 2016.

82. Lemos WP, Araujo SCA, Silva RA, Silva WR. Parasitóides de *Anastrepha obliqua* (Macquart) (Dip., Tephritidae) em pitangueira no Município de Belém, Pará. In: 23º Congresso Brasileiro de Entomologia, Natal, Rio Grande do Norte, 2010.
83. Ayres AR, Pinto MMD, Silva RS, Queiroz LGN, Rodrigues ANC. Moscas-das-frutas e seus parasitoides em plantio de acerola no município de Castanhal – PA. In: 26º Congresso Brasileiro de Entomologia, 9º Congresso Latino-americano de Entomologia, Maceió, Alagoas, 2016.
84. Façanha TP. Sistemas de cultivos de agricultores familiares: Diversidade de moscas-das-frutas, seus hospedeiros e inimigos naturais em Igarapé-Açú e Marapanim, Pará. Master's Dissertation, Universidade Federal do Pará, Belém, Pará, 2017.
85. Jesus CR, Silva RA, Souza Filho MF, Deus EG, Zucchi RA. First Record of *Anastrepha pseudonomala* Norrbom (Diptera: Tephritidae) and its Host in Brazil. Neotrop. Entomol. 2010; 39(6):1059-1060. DOI: https://doi.org/10.1590/S1519-566X2010000600036
86. Ronchi-Teles B, Dutra VS, Silva JG. Host Plant of *Anastrepha pulchra* (Diptera: Tephritidae) in Central Amazon, Brazil — Mistaken Identity Resolved. Fla Entomol. 2011; 94(3):719-720. DOI: https://doi.org/10.1653/024.094.0347
87. Lemos WP, Castilho AP, Araujo MR, Silva RA, Kato OR. Parasitismo de *Anastrepha serpentina* (Wiedemann) (Dip., Tephritidae) em diferentes sistemas de cultivos de laranja no município de Capitão Poço, Pará. In: 13º Simpósio de Controle Biológico, Bonito, Mato Grosso do Sul, 2013.
88. Lemos LN, Deus EG, Nascimento DB, Jesus-Barros CR, Costa-Neto SV, Adaime R. Species of *Anastrepha* (Diptera: Tephritidae), their host plants, and parasitoids in small fruit production areas in the State of Amapá , Brazil. Fla Entomol. 2017; 100(2):403-410. DOI: 10.1653 / 024.100.0201
89. Silva RA, Pereira JDB, Lemos LN, Jesus CR, Lima AL, Lima CR. Novos registros de hospedeiros de *Anastrepha striata* Schiner (Diptera: Tephritidae) no Estado do Amapá, Brasil. O Biológico, 2009.
90. Marsaro Júnior AL, Lovato L, Ronchi-Teles B, Silva RA, Griffel SCP. Levantamento de hospedeiros e parasitóides de *Anastrepha* spp. (Diptera: Tephritidae) no município de Boa Vista, Estado de Roraima. In: 22º Congresso Brasileiro de Entomologia, Uberlândia, Minas Gerais, 2008.
91. Adaime R, Jesus-Barros CR, Uramoto K, Norrbom AL, Zucchi RA. First record of *Anastrepha zacharyi* Norrbom (Diptera, Tephritidae) in Brazil, and notes on its host plant and parasitoid. Proc. Entomol. Soc. Wash. 2016; 118(4):636-640. DOI: 10.4289/0013-8797,118.43636
92. Ronchi-Teles B, Marsaro Júnior AL, Lovato L, Silva RA. Ocorrência de *Anastrepha zenildae* Zucchi (Diptera: Tephritidae) e seu parasitóide em frutos de *Ziziphus mauritiana* (Rhamnaceae) em Roraima. In: 22º Congresso Brasileiro de Entomologia, Uberlândia, Minas Gerais, 2008.
93. Zucchi RA, Marinho CF, Silva RA. First Record of the Fruit Fly Parasitoid *Doryctobracon crawfordi* (Viereck) (Hymenoptera: Braconidae) in Brazil. Neotrop Entomol. 2011; 40(6):711-712. DOI: https://doi.org/10.1590/S1519-566X2011000600014
94. Silva WR, Silva RA. Levantamento de moscas-das-frutas e de seus parasitóides no Município de Ferreira Gomes, Estado do Amapá. Cienc Rural. 2007; 37(1):265-268.
95. Santos FRS, Silva CM, Santos GJ, Coimbra TS, Santos WS. Parasitóides (Hymenoptera: Braconidae) associados à *Anastrepha* (Diptera: Tephritidae) em frutos da cajazeira no município de Araguatins-TO. In: 13º Simpósio de Controle Biológico. Bonito, Mato Grosso do Sul, 2013.
96. Nascimento DB, Adaime R, Cunha AC, Silva JG. Influência dos parâmetros biométricos de frutos de *Spondias mombin* L. sobre os índices de infestação por *Anastrepha* spp. (Diptera: Tephritidae) e parasitismo. Biota Amaz. 2015; 5(3):83-87. DOI: http://dx.doi.org/10.18561/2179-5746/biotaamazonia.v5n3p83-87
97. Jesus CR, Pereira JDB, Oliveira MN, Silva RA, Souza Filho MF, Costa Neto SV, Marinho CF, Zucchi RA. New records of fruit flies (Diptera: Tephritidae), wild hosts and parasitoids (Hymenoptera: Braconidae) in the Brazilian Amazon. Neotrop Entomol. 2008; 37(6):733-734.

DOI: https://doi.org/10.1590/S1519-566X2008000600017

98. Deus EG, Silva RA. Novo registro de hospedeiro para *Anastrepha fraterculus* (Wiedemann) e *Anastrepha zenildae* Zucchi no Brasil e parasitóides associados. O Biológico; 2009.

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