

***Anastrepha* species (Diptera: Tephritidae), their hosts and parasitoids in the extreme north of Brazil**

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Abstract: This work was carried out in five municipalities of the State of Roraima, Brazil, aiming to record the occurrence of *Anastrepha* species, their host plants and parasitoids. Fleshy fruits of 21 species of 10 families were sampled from September/2007 to September/2008. We collected 10 species of *Anastrepha* (*Anastrepha bahiensis* Lima and *Anastrepha montei* Lima were reported for the first time in Roraima) and five species of parasitoids (4 Braconidae and 1 Figitidae). *Doryctobracon areolatus* (Szépligeti) was the most abundant parasitoid.

Keywords: fruit flies, diversity, Amazon, *Anastrepha bahiensis*, *Anastrepha montei*.

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Resumo: O presente trabalho foi realizado em cinco municípios do estado de Roraima, Brasil, com o objetivo de registrar a ocorrência de espécies de *Anastrepha*, suas plantas hospedeiras e parasitoides. Foram coletados frutos carnosos de 21 espécies pertencentes a 10 famílias botânicas de setembro/2007 a setembro/2008. Foram identificadas 10 espécies de *Anastrepha* (*Anastrepha bahiensis* Lima e *Anastrepha montei* Lima foram registradas pela primeira vez em Roraima) e cinco espécies de parasitoides (4 Braconidae e 1 Figitidae). *Doryctobracon areolatus* (Szépligeti) foi o parasitoide mais abundante.

Palavras-chave: moscas-das-frutas, diversidade, Amazônia, *Anastrepha bahiensis*, *Anastrepha montei*.

Introduction

Fruit flies (Diptera: Tephritidae) are some of the most relevant pest species in the world, due to their direct economic impact and the quarantine restrictions enforced by many countries in order to prevent certain species from entering their territories (Aluja & Mangan 2008). Knowledge on the species of a given region can only be obtained by a direct survey of host fruits. This method enables the accurate association of an insect to its host plant species, unlike the more commonly used methods of collection via lures and traps (Zucchi 2000).

Fruit fly surveys, their host plants and parasitoids in the Brazilian Amazon have been intensified in recent years. The state of Roraima is located in the extreme north of the Brazilian Amazon, occupying an area of 224,298.98 km² between latitudes 5° 16' N and 1° 25' S; and longitudes 58° 55' W and 64° 48' W (Instituto... 2010a), corresponding to 2.6% of the Brazilian territory or 5.3% of the Amazonian Biome (Funcate 2006, cited by Marsaro Júnior et al. 2011). Fruit farming is a very significant source of revenue and employment in the state of Roraima. The main cultivated fruits are banana, papaya, orange, lime, pineapple, melon and watermelon (Instituto... 2010b). In addition to these crops, a wide diversity of native and exotic fruit trees is also cultivated in domestic orchards in many municipalities in the state. Many of these fruit trees are known to be or can potentially be hosts to species of *Anastrepha* (Marsaro Júnior et al. 2011).

The first studies on *Anastrepha* species occurring in the state of Roraima were conducted in the 1990s (Rafael 1991, Ronchi-Teles et al. 1995). Seventeen species of *Anastrepha* have been recorded in the region up to the present, but the host plants of six of them [*Anastrepha atrigona* Hendel, *Anastrepha flavipennis* Greene, *Anastrepha hamata* (Loew), *Anastrepha rafaelli* Norrbom & Korytkowski, *Anastrepha turpiniae* Stone and *Anastrepha zucchii* Norrbom] remain unknown in Roraima. Six species of parasitoids have also been reported in Roraima, namely five Braconidae and one Figitidae (Marsaro Júnior et al. 2011).

The purpose of this study was to record the occurrence of *Anastrepha* species, their host plants and parasitoids in municipalities located in northeast Roraima, where knowledge on fruit flies was scarce.

Material and Methods

Fleshy fruits were collected between September 2007 and September 2008 in five municipalities of Roraima: Boa Vista, Bonfim, Cantá, Normandia and Pacaraima (Figure 1). The samples were collected randomly from plants that bore a good quantity of maturing or mature fruits, which were picked directly off the plant or collected from the ground (recently fallen fruits). The fruits were packed in coolboxes equipped with screens, and then taken to the Laboratório de Entomologia at Embrapa Roraima in Boa Vista. In the laboratory, the fruits were counted, weighed and arranged on plastic trays over a layer of moistened vermiculite. The trays were covered with organza cloth and fastened in place with rubber bands. The material was examined every three days. Any found puparia were removed and transferred to transparent plastic flasks containing a thin layer of moistened vermiculite. The flasks were covered with organza, fastened in place with a vented lid, then placed in climate controlled chambers under controlled temperature (27 ± 0.5 °C), relative humidity (70 ± 10%) and photophase (12 hours).

The fruit flies and parasitoids that emerged were stored in glass flasks containing 70% ethanol and were subsequently identified with the keys published by Zucchi (2000) and Canal & Zucchi (2000).

Voucher specimens were deposited in the collections of the Instituto Nacional de Pesquisas da Amazonia (INPA) and Embrapa Amapá.

Results

Twenty-one species of potential fruit fly hosts were sampled, ranging across 10 botanical families. A total of 5,601 fruits were collected, weighing 109.94 kg (Tables 1-5).

Infestation was detected in all of the sampled plant species. Ten species of *Anastrepha* were found, namely: *Anastrepha antunesi* Lima, *Anastrepha bahiensis* Lima, *Anastrepha coronilli* Carrejo & González, *Anastrepha distincta* Greene, *Anastrepha manihoti* Lima, *Anastrepha montei* Lima, *Anastrepha obliqua* (Macquart), *Anastrepha serpentina* (Wiedemann), *Anastrepha sororcula* Zucchi and *Anastrepha striata* Schiner.

Five species of parasitoids were obtained: four Braconidae [*Doryctobracon areolatus* (Szépligeti), *Doryctobracon crawfordi* (Viereck), *Opius bellus* Gahan and *Utetes anastrephae* (Viereck)] and one Figitidae [*Aganaspis pelleranoi* (Brèthes)].

A list of *Anastrepha* species, their hosts and parasitoids collected in each sampled municipality is shown below.

1. Boa Vista

A total of 55 samples of 10 plant species was collected, totaling 1,579 fruits (33.4 kg) (Table 1). From the 47 infested samples (85.5% of the total), we obtained 2,643 puparia which originated individuals of four species of *Anastrepha*: *A. obliqua*, *A. sororcula*, *A. striata* and *A. zenillidae*. The lowest and highest infestation rates were observed in rose apple (0.4 puparium.kg⁻¹) and hog plum (245.7 puparia.kg⁻¹), respectively. Guava fruits showed the highest species richness (3), with predominance of *A. striata* (99.4%).

Parasitism was registered in *Anastrepha* larvae/pupae emerged from hog plum, jocote, umbu-cajá, Brazilian guava, guava, and Indian jujube, with the highest percentage in the last species (18.2%) (Table 1). Two species of Braconidae (*D. areolatus* and *O. bellus*) and one Figitidae (*A. pelleranoi*) were obtained, the most abundant being *O. bellus* (81.0%).

2. Pacaraima

A total of 31 samples of 10 plant species was collected, totaling 1,339 fruits (31.2 kg) (Table 2). From the 28 infested samples (90.3% of the total), we obtained 1,742 puparia which originated individuals of nine species of *Anastrepha*: *A. antunesi*, *A. bahiensis*, *A. distincta*, *A. manihoti*, *A. montei*, *A. obliqua*, *A. sororcula*, *A. serpentina* and *A. striata*. The lowest and highest infestation rates were observed in jaboticaba (25.0 puparia.kg⁻¹) and abiu (172.2 puparia.kg⁻¹), respectively.

Parasitism was registered in *Anastrepha* larvae/pupae infesting hog plum, cassava, ice-cream-bean, Brazilian guava, Para guava, guava, and abiu (Table 2). Cassava presented the highest percentage of parasitism (38.3%). Four species of Braconidae were obtained: *D. areolatus*, *D. crawfordi*, *O. bellus* and *U. anastrephae*. The most abundant species was *D. areolatus* (82.2%).

3. Bonfim

A total of 31 samples of 10 plant species was collected, totaling 1,227 fruits (22.06 kg) (Table 3). From the 26 infested samples (83.9% of the total), we obtained 1,078 puparia from which individuals of four species of *Anastrepha* were recovered: *A. bahiensis*, *A. distincta*, *A. obliqua* and *A. striata*. The lowest and highest infestation rates were observed in cashew (0.6 puparium.kg⁻¹) and hog plum (345.2 puparia.kg⁻¹), respectively.

Anastrepha spp., their hosts and parasitoids in the extreme north of Brazil

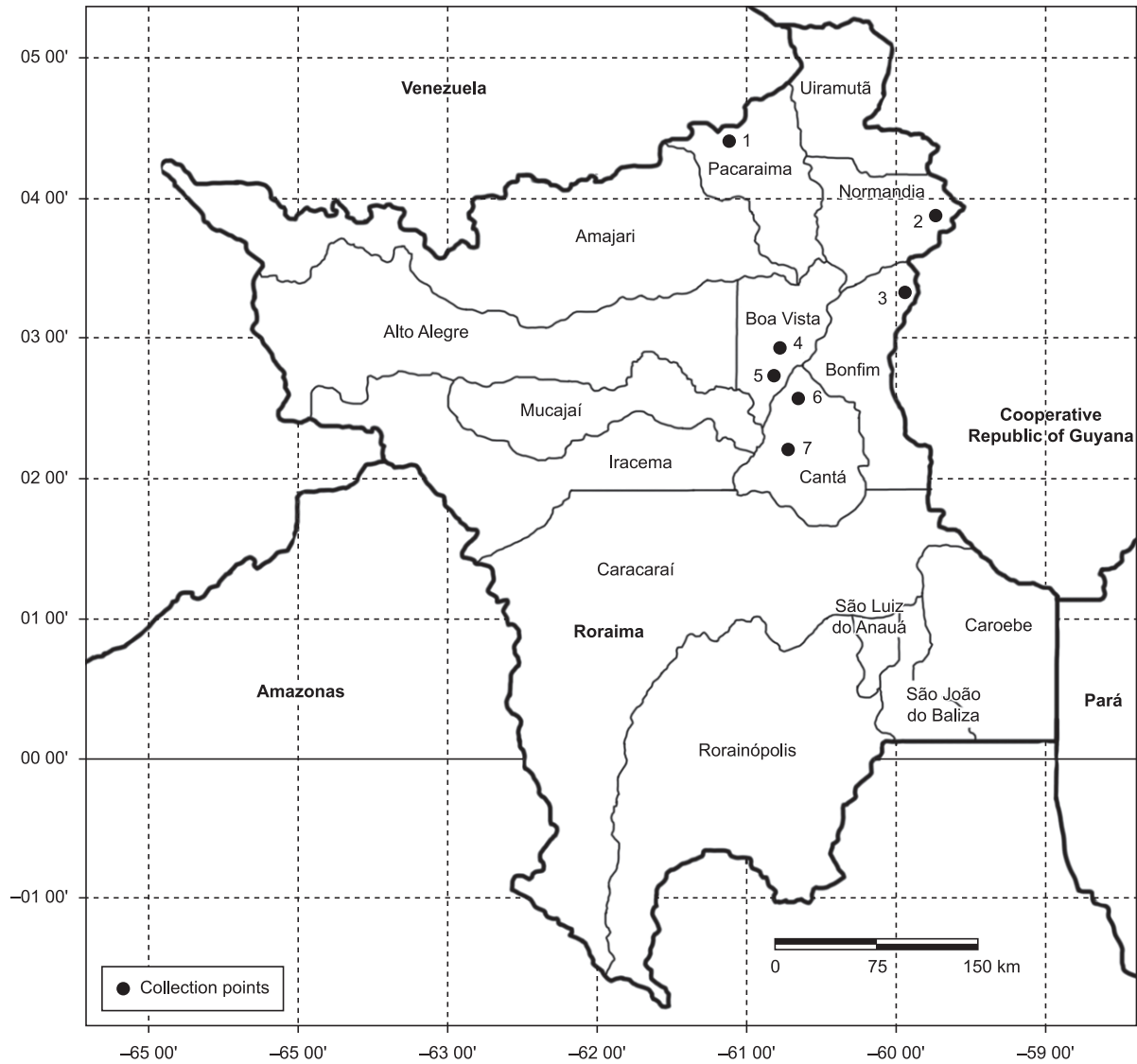


Figure 1. Map of the state of Roraima indicating the localities where *Anastrepha** host fruits were collected in the five studied municipalities. ***Locality 1 (Pacaraima)** - *Spondias mombin*, *Manihot esculenta*, *Inga edulis*, *Psidium* sp., *Psidium acutangulum*, *Psidium guajava*, *Myrciaria cauliflora*, *Eugenia uniflora*, *Eriobotrya japonica* and *Pouteria caimito*; **Locality 2 (Normandia)** - *S. mombin*, *Spondias purpurea*, *M. esculenta*, *I. edulis*, *Malpighia puniceifolia* and *P. guajava*; **Locality 3 (Bonfim)** - *Anacardium occidentale*, *S. mombin*, *S. purpurea*, *Inga laurina*, *I. edulis*, *M. puniceifolia*, *Psidium guineense*, *Psidium* sp., *E. uniflora* and *P. guajava*; **Locality 4 (Boa Vista)** - *S. purpurea*, *P. guineense* and *P. guajava*; **Locality 5 (Boa Vista)** - *S. mombin*, *Spondias* sp., *Syzygium* sp., *Eugenia stipitata*, *Averrhoa carambola* and *Zizyphus mauritiana*; **Locality 6 (Cantá)** - *S. mombin*, *S. purpurea*, *I. edulis*, *M. puniceifolia* and *Psidium* sp.; **Locality 7 (Cantá)** - *Bellucia grossularioides* and *P. guajava*.

Table 1. Infestation rates of several plant species by fruit flies and percentage of parasitism in Boa Vista, Roraima (September 2007 to September 2008).

| FAMILY Common name/Scientific name | Samples C/I* (n) | Fruits (n) | Mass (kg) | Puparia (n) | Infestation Puparia.kg ⁻¹ | <i>Anastrepha</i> spp. | Parasitism** (%) | Hymenoptera |
|---|---------------------|---------------|--------------|----------------|---|--|---------------------|---|
| ANACARDIACEAE | | | | | | | | |
| Hog plum (<i>Spondias mombin</i> L.) | 10/10 | 268 | 2.21 | 543 | 245.7 | <i>A. obliqua</i> (127) males (161) | 13.1 | <i>O. bellus</i> (70) <i>A. pelleranoi</i> (1) |
| Jocote (<i>Spondias purpurea</i> L.) | 10/10 | 396 | 3.98 | 542 | 136.2 | <i>A. obliqua</i> (136) males (194) | 4.1 | <i>O. bellus</i> (22) |
| Umbu-cajá (<i>Spondias</i> sp.) | 1/1 | 14 | 0.28 | 60 | 214.3 | <i>A. obliqua</i> (30) males (15) | 10.0 | <i>O. bellus</i> (6) |
| MYRTACEAE | | | | | | | | |
| Brazilian guava (<i>Psidium guineense</i> Sw.) | 5/5 | 43 | 1.31 | 156 | 119.1 | <i>A. striata</i> (31) males (68) | 2.6 | <i>D. areolatus</i> (4) |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

Table 1. Continued...

| FAMILY Common name/Scientific name | Samples C/I* (n) | Fruits (n) | Mass (kg) | Puparia (n) | Infestation Puparia.kg ⁻¹ | Anastrepha spp. | Parasitism** (%) | Hymenoptera |
|--|---------------------|---------------|--------------|----------------|---|---|---------------------|--------------------------|
| Araza (<i>Eugenia stipitata</i> Mc Vaugh) | 5/4 | 42 | 4.25 | 169 | 39.8 | <i>A. obliqua</i> (70) males (65) | 0 | - |
| Guava (<i>Psidium guajava</i> L.) | 10/10 | 232 | 11.35 | 994 | 87.6 | <i>A. striata</i> (343) <i>A. obliqua</i> (1) <i>A. zenildae</i> (1) males (399) | 0.8 | <i>D. areolatus</i> (8) |
| Pitanga (<i>Eugenia uniflora</i> L.) | 4/3 | 219 | 0.59 | 94 | 159.3 | <i>A. obliqua</i> (25) males (25) | 0 | - |
| Rose apple (<i>Syzygium</i> sp.) | 2/1 | 26 | 2.55 | 1 | 0.4 | <i>A. sororcula</i> (1) males (0) | 0 | - |
| OXALIDACEAE | | | | | | | | |
| Star fruit (<i>Averrhoa carambola</i> L.) | 4/1 | 61 | 4.22 | 29 | 6.9 | <i>A. obliqua</i> (2) males (3) | 0 | - |
| RHAMNACEAE | | | | | | | | |
| Indian jujube (<i>Zizyphus mauritiana</i> Lam.) | 4/2 | 278 | 2.66 | 55 | 20.7 | <i>A. zenildae</i> (19) males (16) | 18.2 | <i>D. areolatus</i> (10) |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

Table 2. Infestation rates of several plant species by fruit flies and percentage of parasitism in Pacaraima, Roraima (September 2007 to September 2008).

| FAMILY Common name/Scientific name | Samples C/I* (n) | Fruits (n) | Mass (kg) | Puparia (n) | Infestation Puparia.kg ⁻¹ | Anastrepha spp. | Parasitism** (%) | Hymenoptera |
|---|---------------------|---------------|--------------|----------------|---|--|---------------------|--|
| ANACARDIACEAE | | | | | | | | |
| Hog plum (<i>Spondias mombin</i> L.) | 2/2 | 85 | 1.11 | 150 | 135.1 | <i>A. obliqua</i> (44) <i>A. antunesi</i> (2) males (43) | 7.3 | <i>O. bellus</i> (10) <i>U. anastrephae</i> (1) |
| EUPHORBIACEAE | | | | | | | | |
| Cassava (<i>Manihot esculenta</i> Crantz) | 2/2 | 596 | 1.19 | 133 | 111.8 | <i>A. manihoti</i> (26) <i>A. monteii</i> (1) males (36) | 38.3 | <i>D. areolatus</i> (51) |
| FABACEAE | | | | | | | | |
| Ice-cream-bean (<i>Inga edulis</i> Mart.) | 4/4 | 50 | 8.96 | 326 | 36.4 | <i>A. distincta</i> (148) males (89) | 0.9 | <i>D. areolatus</i> (3) |
| MYRTACEAE | | | | | | | | |
| Brazilian guava (<i>Psidium</i> sp.) | 2/2 | 71 | 1.86 | 125 | 67.2 | <i>A. striata</i> (32) <i>A. obliqua</i> (4) males (37) | 19.2 | <i>D. areolatus</i> (24) |
| Para guava (<i>Psidium acutangulum</i> DC.) | 2/2 | 49 | 4.34 | 109 | 25.1 | <i>A. striata</i> (17) <i>A. obliqua</i> (22) males (39) | 0.92 | <i>D. areolatus</i> (1) |
| Guava (<i>Psidium guajava</i> L.) | 10/10 | 222 | 10.47 | 443 | 42.3 | <i>A. striata</i> (133) males (163) | 3.4 | <i>D. areolatus</i> (15) |
| Jabuticaba [<i>Myrciaria cauliflora</i> (DC.) O. Berg] | 1/1 | 61 | 0.36 | 9 | 25.0 | <i>A. obliqua</i> (2) <i>A. sororcula</i> (1) males (3) | 0 | - |
| Pitanga (<i>Eugenia uniflora</i> L.) | 4/2 | 162 | 0.48 | 37 | 77.1 | <i>A. obliqua</i> (12) males (14) | 0 | - |
| ROSACEAE | | | | | | | | |
| Loquat [<i>Eriobotrya japonica</i> (Thunb.) Lindl.] | 2/1 | 7 | 0.09 | 7 | 77.8 | <i>A. bahiensis</i> (1) males (1) | 0 | - |
| SAPOTACEAE | | | | | | | | |
| Abiu [<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.] | 2/2 | 36 | 2.34 | 403 | 172.2 | <i>A. serpentina</i> (144) males (131) | 7.4 | <i>D. areolatus</i> (17) <i>D. crawfordi</i> (13) |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

Parasitism was registered in *Anastrepha* larvae/pupae infesting hog plum, Brazilian guava (*Psidium guineense*), guava and jocote (Table 3). The highest percentage of parasitism was observed in *Anastrepha* larvae/pupae infesting hog plum (10.7%), from which three species of Braconidae were obtained: *O. bellus*, *D. areolatus* and *U. anastrephae*. *Doryctobracon areolatus* accounted for 52.6% of collected parasitoids.

4. Normandia

A total of 14 samples of 6 plant species was collected, totaling 696 fruits (16.27 kg) (Table 4). All samples were infested, yielding 351 puparia from which individuals of four species of *Anastrepha* emerged: *A. distincta*, *A. manihoti*, *A. obliqua* and *A. striata*. The lowest and highest infestation rates were observed in ice-cream-bean (8.8 puparia.kg⁻¹) and hog plum (140.0 puparia.kg⁻¹), respectively.

Table 3. Infestation rates of several plant species by fruit flies and percentage of parasitism in Bonfim, Roraima (September 2007 to September 2008).

| FAMILY Common name/Scientific name | Samples C/I* (n) | Fruits (n) | Mass (kg) | Puparia (n) | Infestation Puparia.kg ⁻¹ | <i>Anastrepha</i> spp. Parasitism** (%) | Hymenoptera |
|--|---------------------|---------------|--------------|----------------|---|--|---|
| ANACARDIACEAE | | | | | | | |
| Cashew (<i>Anacardium occidentale</i> L.) | 3/1 | 27 | 3.09 | 2 | 0.6 | <i>A. obliqua</i> (1) males (1) | - |
| Hog plum (<i>Spondias mombin</i> L.) | 4/4 | 90 | 0.73 | 252 | 345.2 | <i>A. obliqua</i> (58) males (62) | <i>O. bellus</i> (24) <i>D. areolatus</i> (2) <i>U. anastrephae</i> (1) |
| Jocote (<i>Spondias purpurea</i> L.) | 1/1 | 84 | 0.86 | 104 | 120.9 | <i>A. obliqua</i> (28) males (41) | <i>D. areolatus</i> (3) <i>U. anastrephae</i> (2) |
| FABACEAE | | | | | | | |
| Sacky sac bean [<i>Inga laurina</i> (Sw.) Willd.] | 1/1 | 39 | 0.77 | 7 | 9.1 | <i>A. distincta</i> (5) males (0) | - |
| Ice-cream-bean (<i>Inga edulis</i> Mart.) | 2/2 | 60 | 10.20 | 20 | 2.0 | <i>A. distincta</i> (8) males (2) | - |
| MALPIGHIACEAE | | | | | | | |
| Acerola (<i>Malpighia punicifolia</i> L.) | 6/3 | 564 | 1.83 | 14 | 7.7 | <i>A. obliqua</i> (7) males (3) | - |
| MYRTACEAE | | | | | | | |
| Brazilian guava (<i>Psidium guineense</i> Sw.) | 6/6 | 156 | 1.86 | 337 | 181.2 | <i>A. striata</i> (78) <i>A. bahiensis</i> (1) males (101) | <i>D. areolatus</i> (1) |
| Brazilian guava (<i>Psidium</i> sp.) | 1/1 | 74 | 0.26 | 40 | 153.8 | <i>A. striata</i> (10) males (15) | - |
| Guava (<i>Psidium guajava</i> L.) | 6/6 | 47 | 2.46 | 292 | 118.7 | <i>A. striata</i> (74) males (128) | <i>D. areolatus</i> (24) |
| Pitanga (<i>Eugenia uniflora</i> L.) | 1/1 | 86 | 0.31 | 10 | 32.3 | <i>A. obliqua</i> (4) males (4) | - |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

Table 4. Infestation rates of several plant species by fruit flies and percentage of parasitism in Normandia, Roraima (September 2007 to September 2008).

| FAMILY Common name/Scientific name | Samples C/I* (n) | Fruits (n) | Mass (kg) | Puparia (n) | Infestation Puparia.kg ⁻¹ | <i>Anastrepha</i> spp. Parasitism** (%) | Hymenoptera |
|--|---------------------|---------------|--------------|----------------|---|---|---|
| ANACARDIACEAE | | | | | | | |
| Hog plum (<i>Spondias mombin</i> L.) | 1/1 | 10 | 0.05 | 7 | 140.0 | <i>A. obliqua</i> (2) males (1) | <i>D. areolatus</i> (1) |
| Jocote (<i>Spondias purpurea</i> L.) | 3/3 | 190 | 1.84 | 119 | 64.7 | <i>A. obliqua</i> (13) males (17) | <i>D. areolatus</i> (48) <i>U. anastrephae</i> (6) <i>O. bellus</i> (1) |
| EUPHORBIACEAE | | | | | | | |
| Cassava (<i>Manihot esculenta</i> Crantz) | 1/1 | 155 | 0.33 | 7 | 21.2 | <i>A. manihoti</i> (4) males (2) | - |
| FABACEAE | | | | | | | |
| Ice-cream-bean (<i>Inga edulis</i> Mart.) | 3/3 | 33 | 8.38 | 74 | 8.8 | <i>A. distincta</i> (25) males (20) | - |
| MALPIGHIACEAE | | | | | | | |
| Acerola (<i>Malpighia punicifolia</i> L.) | 2/2 | 229 | 0.83 | 12 | 14.5 | <i>A. obliqua</i> (5) males (5) | <i>D. areolatus</i> (1) |
| MYRTACEAE | | | | | | | |
| Guava (<i>Psidium guajava</i> L.) | 4/4 | 79 | 4.84 | 132 | 27.3 | <i>A. striata</i> (50) males (42) | <i>D. areolatus</i> (4) |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

Parasitism was registered in hog plum, jocote, acerola, and guava (Table 4). Jocote had the highest percentage of parasitism (46.2%). Three species of Braconidae were obtained: *D. areolatus*, *O. bellus* and *U. anastrephae*. *Doryctobracon areolatus* accounted for 88.5% of collected parasitoids.

5. Cantá

A total of 11 samples of 7 plant species was collected, totaling 760 fruits (6.7 kg) (Table 5). All samples were infested, yielding 438 puparia from which individuals of four species of *Anastrepha* were recovered: *A. coronilli*, *A. distincta*, *A. obliqua* and *A. striata*. The lowest and highest infestation rates were observed in ice-cream-bean (1.3 puparium/kg) and jocote (291.2 puparia/kg), respectively.

Parasitism was registered in *Anastrepha* larvae/pupae infesting hog plum, jocote, acerola, goiaba-de-anta ("tapir guava"), and guava (Table 4). Larvae infesting Brazilian guava showed the highest percentage of parasitism (16.7%). Two species of Braconidae were obtained: *D. areolatus* (48.5%) and *O. bellus* (51.5%).

Discussion

Among the 10 species of *Anastrepha* obtained in this study, two (*A. bahiensis* and *A. montei*) are first records in the state of Roraima.

Anastrepha bahiensis was obtained in loquat (*Eriobotrya japonica*) in Pacaraima (Table 2) and in Brazilian guava (*Psidium guineense*) in Bonfim (Table 3). Ten host species of *A. bahiensis* are known, belonging to the families Moraceae (4 species), Myrtaceae (4), Annonaceae (1), and Ulmaceae (1) (Zucchi 2008, Zucchi et al. 2011a). This work is the first report of loquat and Brazilian guava as hosts of *A. bahiensis* in Brazil. This record of *A. bahiensis* in Pacaraima and Bonfim expands the distribution of this species in Brazil, which previously ranged across eight states including only two in the northern region (Amapá and Amazonas).

Anastrepha montei was collected from cassava (*Manihot esculenta*) in Pacaraima (Table 2). This species had already been found in 11 Brazilian states. This is the second time that *A. montei* is reported in the Brazilian Northern region, as it had already been found in the state of Tocantins (Zucchi 2008).

In addition to loquat (*Eriobotrya japonica*) and Brazilian guava (*Psidium guineense*), other seven plant species are listed for the first

time as hosts of *Anastrepha* in Roraima: umbu-cajá (*Spondias* sp.), rose apple (*Syzygium* sp.), star fruit (*Averrhoa carambola* L.), Brazilian guava (*Psidium* sp.), jabuticaba (*Myrciaria cauliflora*), cashew (*Anacardium occidentale* L.), and sacky sac bean (*Inga laurina*).

This study also provided a better understanding of the geographic distribution of *Anastrepha* species in the sampled area. First records of species were made in the municipalities of Boa Vista (*A. sororcula*), Pacaraima (*A. antunesi*, *A. bahiensis*, *A. manihoti*, *A. montei*, and *A. sororcula*), Bonfim (*A. bahiensis*), and Normandia (*A. manihoti*). In the municipality of Cantá, all of the observed species are reported for the first time at the location (*A. coronilli*, *A. distincta*, *A. obliqua*, and *A. striata*).

Anacardiaceae showed the highest infestation rates. In hog plum, infestation ranged from 135.1 puparia.kg⁻¹ in Pacaraima to 345.2 puparia.kg⁻¹ in Bonfim (Tables 2 and 3). In jocote, infestation ranged from 64.7 puparia.kg⁻¹ in Normandia to 291.2 puparia.kg⁻¹ in Cantá (Tables 4 and 5). Interestingly, an even higher infestation rate (532.6 puparia.kg⁻¹) had already been obtained in a sample of hog plum collected in Amajari, Roraima (Marsaro Júnior et al. 2010). These rates are high if compared to the highest value already observed in the state of Amapá (141.8 puparia.kg⁻¹), where a significant number of samples has already been assessed (Silva et al. 2011).

Anastrepha obliqua and *A. striata* were the species with the largest number of host plant. *Anastrepha obliqua* was associated to 12 plant species (6 Myrtaceae, 4 Anacardiaceae, 1 Malpighiaceae, and 1 Oxalidaceae) and *A. striata* to five (4 Myrtaceae and 1 Anacardiaceae).

Regarding parasitoids, all recorded species had already been reported in Roraima. The most recently reported was *D. crawfordi* (Zucchi et al. 2011b). Out of the 407 parasitoid specimens observed in this study, 57.2% were *D. areolatus*, the parasitoid most widely distributed in Brazil (Leonel Junior et al. 1995, Canal & Zucchi 2000) and Latin America (Ovruski et al. 2000). *Doryctobracon areolatus* was the most abundant parasitoid species in the municipalities of Pacaraima (Table 2) and Normandia (Table 4). In the municipalities of Bonfim (Table 3) and Cantá (Table 5), the populations of *D. areolatus* and *O. bellus* were almost equally abundant. In Boa Vista, *O. bellus* was the most abundant species (81.0%) (Table 1). In species of Anacardiaceae, *O. bellus* was predominant and was sometimes the

Table 5. Infestation rates of several plant species by fruit flies and percentage of parasitism in Cantá, Roraima (September 2007 to September 2008).

| FAMILY | Samples | Fruits | Mass | Puparia | Infestation | <i>Anastrepha</i> spp. | Parasitism** | Hymenoptera |
|--|----------|--------|------|---------|--------------------------|---|--------------|--------------------------|
| Common name/Scientific name | C/I* (n) | (n) | (kg) | (n) | Puparia.kg ⁻¹ | | (%) | |
| ANACARDIACEAE | | | | | | | | |
| Hog plum (<i>Spondias mombin</i> L.) | 2/2 | 73 | 0.82 | 165 | 201.2 | <i>A. obliqua</i> (42) <i>A. striata</i> (1) males (77) | 9.1 | <i>O. bellus</i> (15) |
| Jocote (<i>Spondias purpurea</i> L.) | 1/1 | 32 | 0.34 | 99 | 291.2 | <i>A. obliqua</i> (26) males (34) | 2.0 | <i>O. bellus</i> (2) |
| FABACEAE | | | | | | | | |
| Ice-cream-bean (<i>Inga edulis</i> Mart.) | 1/1 | 9 | 1.50 | 2 | 1.3 | <i>A. distincta</i> (2) males (0) | 0 | |
| MALPIGHIAEAE | | | | | | | | |
| Acerola (<i>Malpighia punicifolia</i> L.) | 3/3 | 369 | 1.23 | 21 | 17.1 | <i>A. obliqua</i> (8) males (5) | 4.8 | <i>D. areolatus</i> (1) |
| MELASTOMATAEAE | | | | | | | | |
| Goiaba-de-anta [<i>Bellucia grossularioides</i> (L.) Triana.] | 1/1 | 32 | 0.50 | 16 | 32.0 | <i>A. coronilli</i> (6) males (4) | 12.5 | <i>D. areolatus</i> (2) |
| MYRTACEAE | | | | | | | | |
| Brazilian guava (<i>Psidium</i> sp.) | 1/1 | 197 | 0.60 | 12 | 20.0 | <i>A. striata</i> (3) males (5) | 16.7 | <i>D. areolatus</i> (2) |
| Guava (<i>Psidium guajava</i> L.) | 2/2 | 48 | 1.71 | 123 | 71.9 | <i>A. striata</i> (43) males (52) | 8.9 | <i>D. areolatus</i> (11) |

*C/I: Collected/Infested (other data expressed in the table refer exclusively to infested samples).

only species found (Tables 1-3 and 5). Specifically in hog plum, 95.2% of observed parasitoid individuals were *O. bellus*. The remainder belonged to three species: *A. pelleranoi*, *U. anastrephae* and *D. areolatus*. The parasitism rates in hog plum ranged from 7.3% in Pacaraima (Table 2) to 14.3% in Normandia (Table 4). The species is therefore important as a natural reservoir of parasitoids.

Conclusions

Based on fruit samplings performed in municipalities in the northeast region of the state of Roraima, Brazil, it is possible to conclude that:

- *Anastrepha obliqua* is the most abundant and polyphagous species;
- Hog plum presents the highest rates of infestation by *Anastrepha*;
- *Doryctobracon areolatus* and *Opius bellus* are the most abundant parasitoid species.

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