Scientific Note

Artifices of Anastrepha obliqua (Macquart, 1835) (Diptera: Tephritidae) for survival in umbu, endemic fruit from Brazil

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Abstract. We studied the interaction involving umbu, fruit flies and parasitoids in the Brazilian cerrado biome in Piauí state. The fruits were collected in Baixa Grande do Ribeiro and Uruçuí in the period from February to April 2013 and were analyzed in Laboratory. In this study is being published the first occurrence of Anastrepha obliqua (Macquart, 1835) in umbu fruits and two parasitoids, Aganaspis pelleranoi (Brèthes, 1924) and Opius bellus (Gahan, 1930), in Piauí. Where 77.8 % of the fruits were infested by A. obliqua, with 149.4 pupae / kg (2.4 pupae / fruit) and the parasitism rate was 2.7 %. Natural parasitism is not very significant, however, less pupae were found in fruits with parasitized larvae, suggesting that the fly avoids oviposition. Additionally, it was found that the A. obliqua performs multiple oviposition in umbu during host selection and multiple infestations is a factor that increases the likelihood of emergence of A. obliqua during the colonizion of umbu. The tritrophic interaction among S. tuberosa, A. obliqua and O. bellus was discussed.

Keywords: Tritrophic interaction, fruit fly, fruit host, parasitoid.

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The only species of fruit fly recorded in umbu fruits was *A. obliqua*, suggesting that the unidentified males also belong to the species *A. obliqua*. The species *A. obliqua* is the first fruit flies recorded in the Alto Parnaíba region in the Piauí state. Umbu is the first host fruit registered for *A. obliqua* in the Piauí state. The occurrence of *A. obliqua* in Piauí had already been verified only through Mcpahll traps. Parasitizing *A. obliqua* on umbu fruits, a specimen of *Aganaspis pelleranoi* (Brêthes, 1924) (Hymenoptera: Figitidae) and 35 specimens of *O. bellus* were found.

The average fruit infestation index was 149.4 pupae per kg (2.4 pupae per fruit), with 77.8% of the sampled fruits showing infestation by *A. obliqua* in both locations (Tab. 2). Of the 429 samples, 334 were infested and 95 were exempt from the presence of *A. obliqua*. The infestation index was lower than the previous results recorded in the Caatinga biome, where practically all the umbu fruits sampled were infested by *A. obliqua* (Lima Junior et al. 2007; Bomfim et al. 2010). Most of the sampled fruits weighed more than 15 g (67.4%) and these fruits were preferred by *A. obliqua* (Tab. 3). Therefore, the size of the umbu fruit influences the host selection by *A. obliqua*. Larger fruits provide a more adequate larval support for the survival of the immature phase.

The West Indian Fruit Fly has a high rate of infestation in umbu fruits, however, natural parasitism in the study region is not very significant (average parasitism: 2.7%), 4.1% in the municipality of Baixa Grande do Ribeiro and 1.4% in Uruçuí, however, parasitism data are higher than those recorded in the Caatinga biome (0.7%) (Bomfim et al. 2010). In addition, less pupae were found in fruits with the presence of parasitoids (Fig. 2), suggesting that the fly avoids oviposition in fruits with parasitized larvae, that is, the presence of the parasitoid may result in greater energy expenditure by *A. obliqua* females in the search for a suitable host fruit. However, fly’s behavior is consistent because may limited encounter rate in the natural environment and avoid or escape parasitoid attack. In addition, it was verified that the *A. obliqua* pupae parasitized by *O. bellus* have less weight (i.e., *A. obliqua* pupae: 0.0159 ± 0.0003 (n=242) and pupae parasitized: 0.0083 ± 0.0004 (n=22)), suggesting that the parasitized larvae have less nutritional demand. The parasitoid induces changes in host phenotype, but we don’t know what they are the fitness benefits.

In the samples, a variable number from zero to 12 pupae per fruit was found, where the presence of one pupa per fruit was recorded in 101 samples (30.2%) and in 233 samples (69.8%) two or more pupae were found by fruit (Fig. 1A). It is known that the females of *A. obliqua* lay only one egg per oviposition (see Aluja 1994), which allows us to conclude that the West Indian Fruit Fly performs multiple ovipositions on umbu fruits during host selection. Our results suggest that a female may perform more than one oviposition per fruit or co-infestation with conspecifics may occur. The fruit can support multiple ovipositions and nutritionally supply several larvae. Pupae in the samples did not show drastic weight fluctuations due to the different population densities (Fig. 1B). However, a low pupal viability was found in the study (39.3%) (Fig. 1C).

Multiple infestations are a factor that increases the probability of emergence of *A. obliqua* adults during the colonization of umbu fruits. It was found that in fruits with higher pupae densities the probability of guaranteeing the perpetuation of the species is higher (Fig. 1D). The lesser the fruit infestation, the greater the risk of no *A. obliqua* emergence (Fig. 1D). In only 23% of the fruits infested with one pupa per fruit, adults emerged while in densities from eight pupae per fruit 100% of the infested fruits allowed the emergence of at least one organism (Fig. 1D). Therefore, high population densities can contribute effectively to the emergence of adults to guarantee the perpetuation of the species. This explains why the female performs multiple ovipositions per fruit or oviposites on fruits infested by conspecifics during host selection.

The parasitoid *O. bellus*, predominant in this study, is an important parasitoid of *Anastrepha* species in the Neotropical region (Garcia et al. 2020). The parasitoid *O. bellus* has already been found parasitizing *A. obliqua* in guava fruits, *Psidium guajava* L. (Bittencourt et al. 2012), pitanga, *Eugenia uniflora* L. (Aguiar-Menezes & Menezes 2001), starfruit, *Averrhoa carambola* L. (Aguiar-Menezes & Menezes 2001; Pereira

| Municipality | Fruits (n) | Weight (Kg) | Pupae (n) | Infested fruits (%) | Infestation pupae/Kg | Infestation pupae/fruit |
|--------------|-----------|-------------|-----------|-------------------|---------------------|-----------------------|
| Baixa Grande do Ribeiro | 80 | 1.1 | 291 | 87.5 (70) | 264.5 | 3.6 |
| Uruçuí         | 349 | 5.8 | 740 | 75.6 (264) | 127.5 | 2.1 |
| **Total**      | 429 | 6.9 | 1,031 | 77.8 (334) | 149.4 | 2.4 |

Figure 1. Exploration of umbu fruits by *Anastrepha obliqua* (Macquart, 1835). (A) Levels of infestation in the samples; (B) Pupae weight from different levels of infestation; (C) Pupae viability from different levels of infestation; (D) Contribution to the perpetuation of the species at different levels of infestation.

Figure 2. *Anastrepha obliqua* (Macquart, 1835) infestation in umbu fruits with and without parasitism.
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et al. 2010), acerola, Malpighia glabra (L. (Dutra et al. 2013) seriguela, S. purpurea (Aguir Menezes & Menezes 2001) and cajá, S. mombin (Thomazini & Albuquerque 2009; Jesus-Barros et al. 2012; Dutra et al. 2013).

Umbu presents itself as the appropriate host for colonization of fruit flies in the period from February to April (fruit sampling period), since the native vegetation of the cerrado has a lower supply of fruits at the end of the rainy season. As a hypothesis, it suggests that multiple ovipositions are the result of a high population in an environment of low host availability. The West Indian Fruit Fly performs multiple oviposition in umbu during host selection and multiple infestations is a factor that increases the likelihood of emergence of A. obliqua during the colonization of umbu. However, not all fruits were infested by A. obliqua, so the female had a choice, but did not hesitate to explore an infested host. In this context, several questions are posed: a) Does the fly prefer a host free from competitors or is it encouraged to oviposit in the presence of conspecifics? b) Is the host’s pheromone marking (reviewed by Silva et al. 2012) not effective to prevent multiple infestations in this interaction? c) Is multiple infestations a strategy to prevent parasitism and guarantee the perpetuation of the species? These intriguing questions must be investigated for a better understanding of this tritrophic interaction.

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Authors’ Contributions

MAS, GCDBS and JGO provided funding support. MAS and GCDBS provided the conceptualization and performed the project administration and supervision. JGO, PLSJ and DSL performed the investigation; MAS, JGO and GNL contributed to the taxonomic identification and formal analysis; MAS, GCDBS, JGO, GNL, PL SJ and DSL wrote the manuscript - original draft, review and editing.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

References

Aguiar-Menezes, E. L.; Menezes, E. B. (2001) Parasitismo sazonal e flutuação populacional de Opiniae (Hymenoptera: Braconidae), parasitoides de espécies de Anastrepha (Diptera: Tephritidae), em Sérpédica, RN. Neotropical Entomology, 30(4): 613-623. doi: 10.1590/S1519-566X2010000400016

Aluja, M. (1994) Bionomics and management of Anastrepha. Annual Review of Entomology, 39: 155-178. doi: 10.1146/annurev.en.39.010194.001103

Alvarenga, C. D.; Alves, D. A.; Silva, M. A.; Lopes, E. N.; Lopes, G. N. (2010) Moscas-das-frutas (Diptera: Tephritidae) em pomares de três municípios do norte do Estado de Minas Gerais. Revista Caatinga, 23(2): 25-31.

Alvarenga, C. D.; Matrangolo, C. A. R.; Lopes, G. N.; Silva, M. A.; Lopes, E. N.; Alves, D. A.; Nascimento, A. S.; Zucchi, R. A. (2009) Moscas-das-frutas (Diptera: Tephritidae) e seus parasitoides em plantas hospedeiras de três municípios do norte do Estado de Minas Gerais. Arquivos do Instituto Biológico, 76(2): 195-204. doi: 10.1590/1808-1657v76p1952009

Araujo, E. L.; Medeiros, M. K. M.; Silva, V. E.; Zucchi, R. A. (2005) Moscas-das-frutas (Diptera: Tephritidae) no semi-árido do Rio Grande do Norte: plantas hospedeiras e índices de infestação. Neotropical Entomology, 34(6): 889-894. doi: 10.1590/S1519-566X2005000600003

Bittencourt, M. A. L.; Santos, O. O.; Brito, E. A.; Araujo, E. L.; Marinho, C. F. (2012) Parasitóides (Braconidae) associados à Anastrepha (Tephritidae) em frutos hospedeiros do litoral Sul da Bahia. Revista Ciência Agronômica, 43(4): 811-815. doi: 10.1590/S1806-66902012000400024

Bittencourt, M. A. L.; Silva, A. C. M.; Silva, V. E. S.; Bomfim, Z. V.; Guimarães, J. A.; Souza Filho, M. F.; Araujo, E. L. (2011) Moscas-das-frutas (Diptera: Tephritidae) e seus parasitoides (Hymenoptera: Braconidae) associados às plantas hospedeiras no Sul da Bahia. Neotropical Entomology, 40(3): 405-406. doi: 10.1590/S1519-566X2011000300016

Bomfim, Z. V. Carvalho, R. S.; Carvalho, C. A. L. (2010) Relações interspecíficas entre parasitoides nativos de moscas-das-frutas e o braconídeo exótico Diachasmimorpha longicaudata em frutos de ‘umbu-cajá’. Ciência Rural, 40(1): 77-82. doi: 10.1590/S0103-847820100005000237

Carvalho, R. S. (2005) Diapause in fruit fly parasitoids in the Recôncavo Baiano, Brazil. Neotropical Entomology, 34(4): 613-618. doi: 10.1590/S1519-566X2005000400012

Dutra, V. S.; Ronchi-Teles, B.; Garcia, M. V. B.; Adaime, R.; Silva, J. G. (2013) Native hosts and parasitoids associated with Anastrepha fratercula and other Anastrepha species (Diptera: Tephritidae) in the Brazilian Amazon. Florida Entomologist, 96(1): 270-273. doi: 10.1653/024.096.0144

Garcia, F. R. M.; Ovruski, S. M.; Suárez, L.; Cancino, J.; Liburd, O. E. (2020) Biological control of Tephritid fruit flies in the Americas and Hawaii: a review of the use of parasitoids and predators. Insects, 11(10): 662. doi: 10.3390/insects11100662

Jesus-Barros, C. R.; Adaime, R.; Oliveira, M. N.; Silva, W. R.; Costa-Neto, S. V.; Sousa-Filho, M. F. (2012) Anastrepha (Diptera: Tephritidae) species, their hosts and parasitoids (Hymenoptera: Braconidae) in five municipalities of the state of Amapá, Brazil. Florida Entomologist, 95(3): 694-705. doi: 10.1653/024.095.0320

Lima Junior, C. A.; Santos, W. S.; Carvalho, C. A. L. (2007) Moscas-das-frutas (Diptera: Tephritidae) associados ao umbucajá (Anacardiaceae) no Vale do rio Paraguáu, Bahia, Brazil. Revista Brasileira de Agrociência, 13(3): 399-402.

Marinho, C. F.; Costa, A. V.; Zucchi, R. A. (2018) Annotated checklist and illustrated key to braconid parasitoids (Hymenoptera, Braconidae) of economically important fruit flies (Diptera, Tephritidae) in Brazil. Zootaxa, 4527(1): 21-36. doi: 10.11646/zootaxa.4527.1.2

Pereira, J. D. B.; Buriti, D. P.; Lemos, W. P.; Silva, W. R.; Silva, R. A. (2010) Espécie de Anastrepha Schiner (Diptera: Tephritidae), seus hospedeiros e parasitoides nos Estados do Acre e Rondônia, Brasil. Biota Neotropical, 10(3): 441-446. doi: 10.15676/0603201000030037

Ruiz-Arace, R.; Barr, N. B.; Owen, C. L.; Thomas, D. B.; Mcpherson, B. A. (2012) Phylogeny of Anastrepha obliqua Inferred With mtDNA Sequencing. Journal of Economic Entomology, 105(6): 2147-2160. doi: 10.1603/EC12211

Santos, R. P. D.; Silva, J. G.; Miranda, E. A. (2020) The past and current potential distribution of the fruit fly Anastrepha obliqua (Diptera: Tephritidae) in South America. Neotropical Entomology, 49(2): 284-291. doi: 10.1590/13744-019-00741-1

Silva, M. A.; Bezerra-Silva, G. C. D.; Mastrangelo, T. (2012) The host marking pheromone application on the management of fruit flies - a review. Brazilian Archives of Biology and Technology, 55(6): 835-842. doi: 10.1516/bacbte.2012-000000000005

Sivinski, J.; Pinero, J. Aluja, M. (2000) The distributions of parasitoids (Hymenoptera) of Anastrepha fruit flies (Diptera: Tephritidae) along an altitudinal gradient in Veracruz, Mexico. Biological Control, 18(3): 258-269. doi: 10.1006/bcon.2000.0836

Thomazini, M. J.; Albuquerque, E. S. (2009) Parasitoids (Hymenoptera: Braconidae) de Anastrepha Schiner (Diptera: Tephritidae) no
Zucchi, R. A.; Moraes, R. C. B. (2008) Fruit flies in Brazil - *Anastrepha* species their host plants and parasitoids. [http://www.lea.esalq.usp.br/anastrepha/](http://www.lea.esalq.usp.br/anastrepha/). Access on: 20.x.2013.

Zucchi, R. A. (2000) Taxonomia. In: Malavasi, A.; Zucchi, R.A. (Eds.), *Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado*, pp. 13-24. Ribeirão Preto: Holos.