Research Article

Faunistic analysis of fruit flies (Diptera: Tephritidae) in a guava orchard and semideciduous forest fragment in Central-West Region of Brazil

Análisis de la fauna de moscas de la fruta (Diptera: Tephritidae) en un huerto de guayaba y en un fragmento de bosque semideciduo en la región centro-oeste de Brasil

Paulo Ricardo Barbosa de Souza[1], Bruno do Amaral Crispim[1] and Angela Canesin[1*]

[1] *Faculty of Biological and Environmental Sciences - FCBA, Federal University of Grande Dourados – UFGD. Rod. Dourados-Itahum, km 12, CEP 79804-970, Dourados-MS. E-mail: prbs06@gmail.com*

ZooBank: urn:lsid:zoobank.org:pub: 3236B721-FE8A-48C0-8BC6-4063E9E0A11C
https://doi.org/10.35249/rche.46.1.20.04

Abstract. The fruit flies (Diptera: Tephritoidea), are the dipteran with greater economic importance, including pest species of various fruit crops such as guava. For the management of these pests, it is essential to know what species are present in the culture, as well as in the surrounding native vegetation, which may serve as a reservoir for these species. The objective of this research was to characterize and compare through faunistic analysis (frequency, abundance, constancy, equitativity, richness and diversity) populations of *Anastrepha* Schiner and *Ceratitis capitata* (Wiedemann) and a commercial guava orchard in a fragment of adjacent native semideciduous forest in Central-West Region of Brazil. The fruit flies were collected from January 2008 to March 2009, through McPhail traps containing 5% solution of corn syrup. A total of 4,180 fruit fly specimens were collected in the forest fragment, and 20,108 in the guava orchard. Besides *C. capitata*, nine species of *Anastrepha* were found in the forest, with *A. undosa* Stone occurring exclusively in this ecosystem. In the orchard, *C. capitata* and eleven *Anastrepha* species were collected, three of them exclusively found in this ecosystem: *A. amita* Zucchi, *A. zenildae* Zucchi, and *A. distincta* Greene. The species *A. sororcula* Zucchi and *A. fraterculus* (Wiedemann) were classified as superabundant, constant, superdominant and superfrequent in both ecosystems. The species richness and abundance were higher in the guava orchard than in the forest fragment.

Key words: Agricultural Entomology, insect management, pomiculture, Neotropical fauna.

Resumen. Las moscas de la fruta (Diptera: Tephritoidea), son los dípteros con mayor importancia económica, siendo consideradas especies plagas de diversos cultivos frutales como la guayaba. Para el manejo de estas plagas, es esencial saber qué especies están presentes en el cultivo, así como en la vegetación nativa circundante, que puede servir como reservorio de estas especies. El objetivo de esta investigación fue caracterizar y comparar a través de un análisis faunísticos (frecuencia, abundancia, constancia, equitatividad, riqueza y diversidad) poblaciones de *Anastrepha* Schiner y *Ceratitis capitata* (Wiedemann) en un huerto de guayaba comercial en un fragmento de bosque semideciduo nativo adyacente en Región Centro-Oeste de Brasil. Las moscas de la fruta se recolectaron desde enero de 2008 hasta marzo de 2009, a través de trampas McPhail que contenían una solución al 5% de jarabe de maíz. Se recolecto un total de 4.180 ejemplares de moscas de la fruta en el fragmento de bosque y 20.108 en el huerto de guayaba. Además de *C. capitata*, se encontraron nueve especies de *Anastrepha* en el bosque, con *A. undosa* Stone exclusivamente en este ecosistema. En el huerto, se recolectaron *C.*

Received 19 November 2019 / Accepted 9 January 2020 / Published online 31 January 2020
Responsible Editor: José Mondaca E.

capitata y once especies de *Anastrepha*, tres de ellas encontradas exclusivamente en este ecosistema: *A. amita* Zucchi, *A. zenildae* Zucchi y *A. distincta* Greene. Las especies *A. sororcula* Zucchi y *A. fraterculus* (Wiedemann) se clasificaron como superabundantes, constantes, superdominantes y superfrecuentes en ambos ecosistemas. La riqueza y abundancia de especies fue mayor en el huerto de guayabo que en el fragmento de bosque.

Palabras clave: Entomología Agrícola, fauna neotropical, manejo de insectos pomicultura.

Introduction

The Tephritidae family includes the true fruit flies, are considered the most agriculturally important, with a number of species recognized as pests of cultivated plants (Norrbom 2010). In Brazil, four fruit fly genera with agricultural importance are recorded: *Anastrepha* Schiner, *Bactrocera* Macquart, *Ceratitis* MacLeay e *Rhagoletis* Loew (Carvalho *et al*. 2012), being *Anastrepha* and *Ceratitis* the most important pest of pomiculture (Zucchi 2000).

Anastrepha is represented in the New World by 213 endemic species (Uramoto *et al*. 2008), four of them considered important pests of guava crops in Brazil: *A. fraterculus* (Wiedemann), *A. sororcula* Zucchi, *A. striata* Schiner, and *A. zenildae* Zucchi (Araújo *et al*. 2013).

Ceratitis capitata (Wiedemann), the Mediterranean fly, occurs in virtually all the tropical and warm temperate regions of the globe (Zucchi 2000). In Brazil, *C. capitata* infests preferentially fruits of introduced plants (Malavasi & Morgante 1980), but has also been recorded infesting native fruits as guava (Araújo *et al*. 2013). *Ceratitis capitata* is considered the fruit fly species with highest potential of adaptation and polyphagy in Brazil (Malavasi *et al*. 1980; Zahler 1990).

Guava (*Psidium guajava* L.) is native to Brazil and Neotropical Americas, but it is cultivated in warmer regions of many countries around the world (Singh & Pal 2008). Fruit flies are important guava pests (Zucchi 2000), causing the early falling and depreciation of fruits either for fresh consumption or industrialization (Ferrara *et al*. 2005). At the present, *C. capitata* and at least sixteen *Anastrepha* species have been identified as guava pests (Zucchi 2007; Souza-Filho *et al*. 2009), although the composition of these species may differ regarding a number of factors, like the geographic region (Araujo *et al*. 2013) and environment, i.e. native vegetation or orchard (Bomfim *et al*. 2007).

In Brazil, faunistic analyses of fruit flies associated to guava orchards have been conducted in the States of Rio de Janeiro (Aguiar-Menezes *et al*. 2008), Bahia (Dutra *et al*. 2009), and Ceará (Azevedo *et al*. 2010; Moura & Moura 2006). On the other hand, natural preserved ecosystems are reservoirs for fruit flies populations and their natural enemies (Malavasi & Morgante 1980), from where important information on the biology, ecology and evolution of those flies could be obtained (Aluja *et al*. 2003). Faunistic analyses of fruit flies associated to native vegetation are only provided for the Brazilian states of Mato Grosso do Sul (Canesin & Uchoa 2007; Almeida *et al*. 2019; Nicásio *et al*. 2019; Oliveira *et al*. 2019) and Tocantins (Bomfim *et al*. 2007).

This study aimed to identify, characterize and compare populations of fruit flies in a commercial orchard of guava and surrounding native forest fragment in Itaporã, Mato Grosso do Sul State, Central-West Region of Brazil, by means of faunistic analysis.

Material and Methods

This study was conducted in a commercial guava orchard (21°54'23"S, 54°42'34"W, altitude 310 m) and surrounding semi deciduous forest fragment (21°54'18"S, 54°42'24"W, altitude

315 m) of about 4.0 ha in Itaporã, Gleba Santa Terezinha, Mato Grosso do Sul State, Central-West Region of Brazil. The fruit flies were collected with McPhail traps baited with 5% corn enzymatic hydrolyzed solution, pH 8.5 to 9.0 adjusted with borax. Sampling was made from January 2008 to March 2009, using 29 McPhail traps in the guava orchard, and from September 2008 to March 2009, with 17 McPhail traps in the forest fragment. The traps were linearly disposed, distanced at least 40 m from each other, in about 1.6 m from the ground level, in the shad. Removals of the collected material, along with bait repositions, were made weakly.

The fruit flies collected were identified and quantified in the Entomology Laboratory of the Universidade Federal da Grande Dourados—UFGD. As the taxonomy of this genus is primarily based on females, the faunistic analysis were based only in female *Anastrepha* numbers. The species were identified to the specific level with identification keys of Steyskal (1977), Zucchi (2000), and Uramoto (2007), after been fixed in 70% ethanol. Voucher specimens were deposited in the Museu da Biodiversidade (UFGD).

The faunistic analysis (Silveira-Neto *et al*. 1976) was based on the following parameters, calculated with the software ANAFAU (Moraes *et al*. 2003):

Frequency: F = n/N x 100, where, F = frequency (%), n = number of individuals of a species, N=total number of individuals collected. The frequency values obtained were classified as: super-frequent (SF)—frequency higher than the upper bound of the 99% confidence interval; very frequent (VF)—frequency higher than the upper bound of the 95% confidence interval; frequent (F)—frequency nested between the lower and upper bounds of the 95% confidence interval; infrequent (I)— frequency lower than the lower bound of the 95% confidence interval.

Dominance (method of Sakagami & Laroca (1971)): LD = (1/S) x 100, where: LD = dominance limit (%), S = total number of species of the sample. The dominance values obtained were classified as: super-dominant (SD) — dominance higher than the upper bound of the 99% confidence interval; very dominant (VD) —dominance higher than the upper bound of the 95% confidence interval; dominant (D) —dominance nested between the lower and upper bounds of the 95% confidence interval; nondominant (ND) —dominance lower than the lower bond of the 95% confidence interval.

Abundance: Number of individuals in relation to the sampled area, with variation on time (populational) and space (between different communities). The values obtained were classified as: super abundant (sa) —abundance higher than the upper bound of the 99% confidence interval; very abundant (va) —abundance nested between the upper bounds of the confidence intervals of 99 and 95%; common (c) —abundance nested between the lower and upper bounds of the 95% confidence interval; incidental (i)—abundance nested between the lower bounds of the confidence intervals of 99 and 95%.

Constancy: Percentage of sample units on which a species was present. Constant: (w): present in more than 50% of the sample units; accessory (y): present in 25% to 50% of the sample units; accidental (z): present in less than 25% of the sample units.

Equitativity: Refers to how the abundance of each species is distributed in a community. When all species are equally abundant, equitatitivity has its maximum value, and decreases tending to zero as the relative abundances differ in this equality.

Diversity: Margalef diversity index (α) depends on the species richness (total number of species in a community) and species abundance. The comparison between the Margalef index for the forest fragment and orchard was made by overlapping the confidence intervals.

Results

In this work, only populations of species of *Anastrepha* and *C. capitata* were analyzed, due to their economic importance and because they were the most abundant taxa captured in the fruit flies community.

Twelve species of *Anastrepha* were identified: *A. amita* Zucchi, *A. daciformis* Bezzi, *A. distincta* Greene, *A. fraterculus* (Wiedemann), *A. montei* Lima, *A. obliqua* (Macquart), *A. pseudoparallela* (Loew), *A. sororcula* Zucchi, *A. striata* Schiner, *A. turpiniae* Stone, *A. undosa* Stone, and *A. zenildae* Zucchi.

In the fragment of semideciduous forest, 4,171 specimens of *Anastrepha* were captured, along with nine specimens of *C. capitata*. Nine species of *Anastrepha* were detected in the forest, with *A. undosa* occurring exclusively in this ecosystem (Fig. 1). In the orchard, 19,952 specimens of *Anastrepha* and 156 of *C. capitata* were captured, with the occurrence of 11 species of *Anastrepha*, three of them exclusively found in this ecosystem: *A. amita*, *A. zenildae*, and *A. distincta* (Fig. 1).

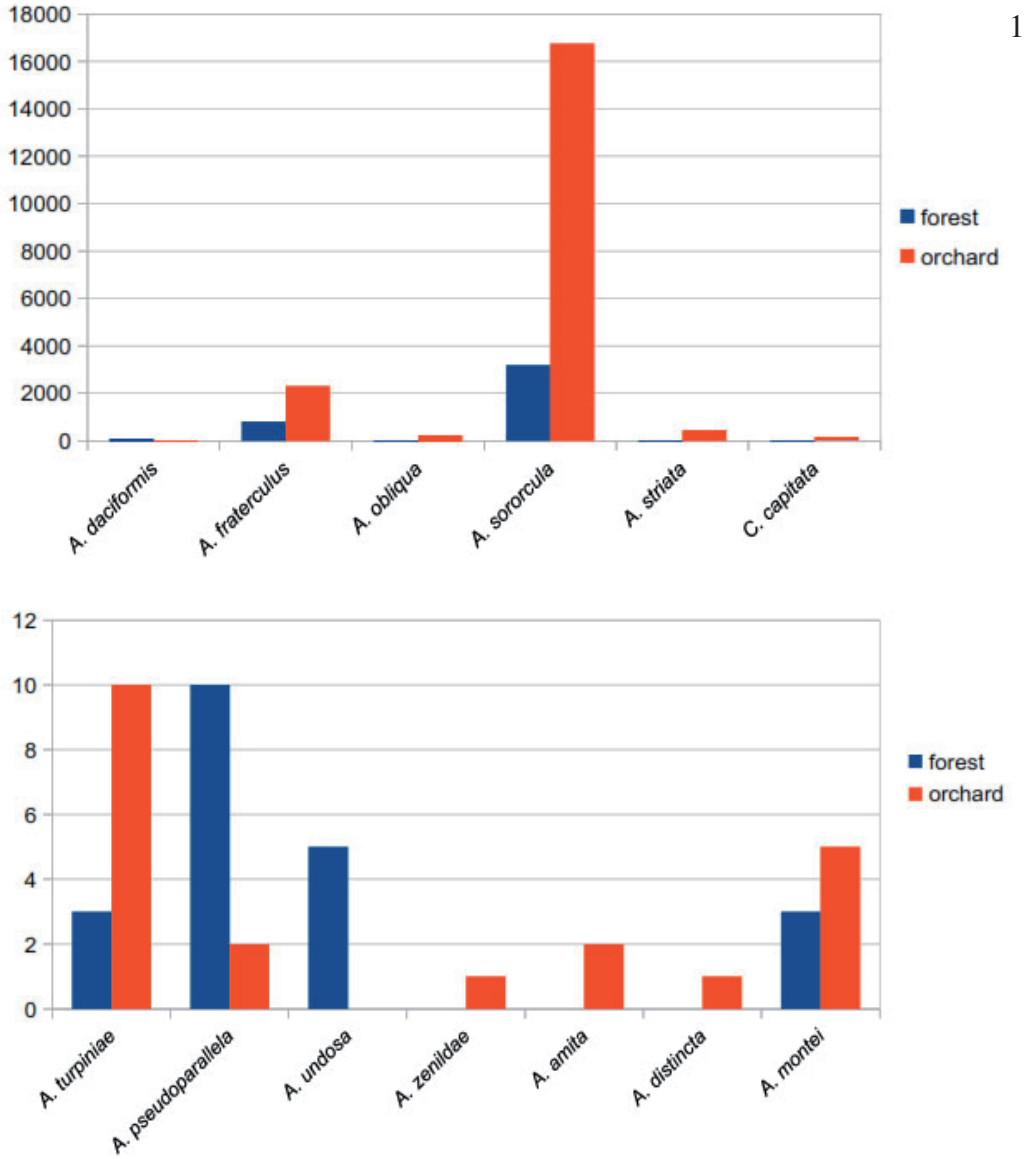

Figure 1. Number of female specimens of the six more abundant species (top) and seven less abundant species (bottom) of fruit flies caught with McPhail traps, in a fragment of semideciduous forest, and in a commercial orchard of guava in Itaporã, MS, Brazil, from 2008 to 2009.

In the forest, the species with the highest values in the faunistic analysis were *A. sororcula*, *A. fraterculus* and *A. daciformis*, with the former species comprising 76.2% of female fruit flies captured. These three species were classified as super-dominant, super-abundant, and super-frequent. The remaining species showed frequencies lower than 1% (Table 1). Regarding constancy, *A. sororcula* and *A. fraterculus* were classified as constant, while *A. daciformis* was classified as accessory. Four species were classified as accidental: *A. montei*, *A. turpiniae*, *A. undosa*, and *C. capitata*.

Table 1. Results of the faunistic analysis conducted for fruit fly species captured with McPhail traps in a semideciduous forest fragment and in a commercial orchard of guava in Itaporã, MS, Brazil, from 2008 to 2009.

Species	Number of specimens		Frequency		Dominance		Abundance		Constancy	
	Forest	Orchard	Forest	Orchard	Forest	Orchard	Forest	Orchard	Forest	Orchard
A. amita	-	2	-	F	-	ND	-	c	-	z
A. daciformis	114	6	SF	F	SD	D	sa	c	y	z
A. distincta	-	1	-	I	-	ND	-	i	-	z
A. fraterculus	791	2316	SF	SF	SD	SD	sa	sa	w	w
A. montei	3	4	I	F	ND	D	i	c	z	z
A. obliqua	31	249	VF	SF	D	SD	va	sa	y	w
A. pseudoparallela	8	2	F	F	ND	ND	c	c	y	z
A. sororcula	3185	16888	SF	SF	SD	SD	sa	sa	w	w
A. striata	31	473	VF	SF	D	SD	va	sa	y	w
A. turpiniae	3	10	I	VF	ND	D	i	va	z	y
A. undosa	5	-	F	-	ND	-	c	-	z	-
A. zenildae	-	1	-	I	-	ND	-	i	-	z
C. capitata	9	156	F	SF	ND	SD	c	sa	z	w

Abbreviations: SF: super-frequent; VF: very frequent; F: frequent; I: infrequent; SD: super-dominant; D: dominant; ND: nondominant; sa: super-abundant; va: very abundant; c: common; i: incidental; w: constant; y: accessory; z: accidental; -: not detected.

In the orchard, *A. sororcula*, *A. fraterculus*, *A. obliqua*, *A. striata* and *C. capitata* showed the highest frequency values and were classified as super-dominant, super-abundant, and super-frequent. *Anastrepha sororcula*, however, corresponded to 84.5% of the female fruit flies captured. The remaining seven species were classified in other categories in terms of frequency, dominance and abundance. Regarding constancy, five species were constant, one accessory and six accidental (Table 1). In addition to the species richness (forest 10; orchard: 12), the number of specimens of *Anastrepha* and *C. capitata* together were expressively higher in the orchard (20,108) that in the forest (4,180) (Table 1), however it must be considered that the sampling effort (number of traps used) was greater in the orchard. The difference

in the values of these two parameters was reflected in Margalef diversity index values (forest: $\alpha = 1.078$; orchard: $\alpha = 1.111$), which were statistically different ($p = 0.005$) in both types of ecosystem, as shown by the overlapping of the confidence intervals CI (forest: CI => [0.736, 0.737]; orchard: H => [0.586; 0.586]).

The equitativity index (Table 2) was higher in forest (0.32) than in the orchard (0.23), showing that the forest abundance was more evenly distributed among species.

Table 2. Species richness and values of diversity and equitativity indexes obtained for fruit fly species captured with McPhail traps in a semideciduous forest fragment and in a commercial orchard of guava in Itaporã, MS, Brazil, from 2008 to 2009.

Parameters	Forest	Orchard
Species richness (S)	10	12
Diversity index [Margalef (α)]	1.07	1.11
Equitativity index	0.32	0.23

Discussion

Only three non-economically important fruit fly species (according to Norrbom *et al.* 2010) were recorded: *A. amita*, exclusively found in the orchard; *A. undosa*, exclusively collected in the forest; and *A. montei*, collected in both environements or sites, all of them found in very low abundances (Fig. 1).

Several factors can influence the fruit fly occurrence, including the availability of host fruits in the forest fragment during the non-fruiting period of guava in the orchard. The dominant species in both ecosystems may found climate conditions and favorable hosts for the establishment of populations. Species occurring in most of the sampled period may found, due to its polyphagia, native and exotic hosts, throughout the year.

The abundance of *Anastrepha* species captured in this study differ from other studies conducted in guava orchard using McPhail traps. In Santa Catarina State, southern Brazil, *A. fraterculus* was the dominant species (Garcia *et al.* 2003; Garcia & Lara 2006). *Anastrepha fraterculus*, *A. obliqua*, and *A. sororcula* were the most abundant of the 14 fruit fly species found in the north and northwest of Rio de Janeiro State (Aguiar-Menezes *et al*. 2008). In four municipalities of Minas Gerais State, southeast Brazil, 20 species of fruit flies were found, with *A. obliqua* being the most abundant species (Canal *et al.* 1998). In Tocantins State, northern Brazil, 19 species were identified, with *A. zenildae* and *C. capitata* as the most abundant species (Bomfim *et al*. 2007). In a study conducted in Ceará State (Moura & Moura 2006), only three fruit fly species were associated with guava, namely *A. sororcula*, *A. zenildae* and *C. capitata*, with the last species being the most abundant. Azevedo *et al.* (2010), in the same state, found *A. zenildae*, *A. sororcula*, *A. fraterculus*, *A. obliqua*, and *C. capitata* associated with guava. Among the cited species, *A. zenildae* and *A. sororcula* were dominant and constant in the studied region.

In a previous study conducted in a much larger fragment of semideciduous forest in Mato Grosso do Sul State (about 300 ha), Canesin & Uchôa (2007) obtained 14 species of Tephritidae, with *A. elegans* Blanchard considered as the dominant species. This species seems to be only associated with native vegetation, and was not recorded in the present study. The noticeable prevalence of species with agricultural importance in the forest fragment of the present study may indicate its high degree of disturbance, or insufficient size to bear native fruit fly populations.

The pattern of population distribution of the species of fruit flies in the present work differs from a previous study by Aluja (1994) concerning the number of dominant species. In that study although a large number of fruit fly species occurred, only two or three were dominant (Aluja 1994). In the present work, five super-dominant species were found in the orchard, as mentioned above.

Acknowledgment

We thank UFGD for the Scientific Initiation Scholarship granted to the first author, and CAPES for the post-doctoral fellowship of the third author. We thank Larissa Camil Tannus, Maykon Avalo Berndt, and Charlotte Cerqueira Soares for collaboration in collecting and sorting of fruit flies. We also thank Larissa Camil Tannus for preparing the Tephritidae for identification. Finally, we are very grateful to Mr. Cezar Janzeaki for allowing the conduction of this work in his property.

Literature Cited

Aguiar-Menezes, E.L., Souza, S.A.S., Lima-Filho, M., Barros, H.C., Ferrara, F.A.A. and Menezes, E.B. (2008) Análise faunística de moscas-das-frutas (Diptera: Tephritidae) nas regiões norte e noroeste do Estado do Rio de Janeiro. *Neotropical Entomology*, *37*(1): 8-14.

Almeida, L.B.M., Coelho, J.B., Uchoa, M.A. and Gisloti, L.J. (2019) Diversity of fruit flies (Diptera: Tephritoidea) and their host plants in a conservation unit from midwestern Brazil. *Florida Entomologist*, *102*: 562-570.

Aluja, M. (1994) Bionomics and management of *Anastrepha*. *Annual Review of Entomology*, *39*: 155-178.

Aluja, M., Rull, J., Sivinski, J., Norrbom, A.L., Wharton, R.A., Macías-Ordóñez, R., Díaz-Fleischer, F. and López, M. (2003) Fruit flies of the genus *Anastrepha* (Diptera: Tephritidae) and associated native parasitoids (Hymenoptera) in the tropical rainforest biosphere reserve of Montes Azules, Chiapas, Mexico. *Environmental Entomology*, *32*(6): 1377-1385.

Araujo, E.L., Ribeiro, J.C., Chagas, M.C.M., Dutra, V.S. and Silva, J.G. (2013) Moscas-das-frutas (Diptera: Tephritidae) em um pomar de goiabeira, no semiárido brasileiro. *Revista Brasileira de Fruticultura*, *35*(2): 471-476.

Azevedo, F.R., Guimarães, J.A., Simplício, A.F. and Santos, H.R. (2010) Análise faunística e flutuação populacional de moscas-das-frutas (Diptera: Tephritidae) em pomares comerciais de goiaba na região do cariri cearense. *Arquivos do Instituto Biológico*, *77*(1): 33-41.

Bomfim, D.A., Uchôa-Fernandes, M.A. and Bragança, M.A.L. (2007) Biodiversidade de moscas-das-frutas (Diptera: Tephritoidea) em matas nativas e pomares domésticos de dois municípios do Estado do Tocantins, Brasil. *Revista Brasileira de Entomologia*, *51*: 217-223.

Canal, N.A., Alvarenga, C.D. and Zucchi, R.A. (1998) Análise faunística de espécies de moscas-das-frutas (Diptera: Tephritidae) em Minas Gerais. *Scientia Agricola*, *55*(1): 15-24.

Canesin, A. and Uchôa, M.A. (2007) Análise faunística e flutuação populacional de moscas-das-frutas (Diptera, Tephritidae) em um fragmento de floresta semidecídua em Dourados, Mato Grosso do Sul, Brasil. *Revista Brasileira de Zoologia*, *24*(1): 185-190.

Carvalho, CJ.B., Rafael, J.A., Couri, M.S. and Silva, V.C. (2012) Diptera Linnaeus, 1758. *In*: Rafael J.A. *et al*. (Eds), Insetos Do Brasil, Diversidade E Taxonomia. Holos, Editora, Ribeirão Preto, P. 701-743.

Dutra, V.S., Santos, M.S., Souza-Filho, Z.A., Araujo, E.L. and Silva, J.G. (2009) Faunistic analysis of *Anastrepha* spp. (Diptera: Tephritidae) on a guava orchard under organic management in the municipality of Una, Bahia, Brazil. *Neotropical Entomology*, *38*(1): 133-138.

Ferrara, F.A.A., Aguiar-Menezes, E.E., Uramoto, K., Marco Jr, P. de, Souza, S.A.S. and Cassino, P.C.R. (2005) Análise faunística de moscas-das-frutas (Diptera: Tephritidae) da região noroeste do estado do Rio de Janeiro. *Neotropical Entomology*, *3*(2): 183-190.

Garcia, F.R.M., Campos, J.V. and Corseuil, E. (2003) Análise faunística de espécies de moscas-das-frutas (Diptera: Tephritidae) na região oeste de Santa Catarina. *Neotropical Entomology*, *32*(3): 239-246.

Garcia, F.R.M. and Lara, D.B. (2006) Análise faunística e flutuação populacional de moscas-das-frutas (Diptera, Tephritidae) em pomar cítrico no município de Dionísio Cerqueira, Santa Catarina. *Biotemas*, *19*(3): 65-70.

Malavasi, A. and Morgante, J.S. (1980) Biologia de moscas-das-frutas (Diptera, Tephritidae). II: Índices de infestação em diferentes hospedeiros e localidades. *Revista Brasileira de Biologia*, *40*(1): 17-24.

Malavasi, A., Morgante, J.S. and Zucchi, R.A. (1980) Biologia de moscas-das-frutas (Diptera, Tephritidae). I: Lista de hospedeiros e ocorrência. *Revista Brasileira de Biologia*, *40*(1): 9-16.

Moraes, R.C.B., Haddad, M.L., Silveira-Neto, S. and Reyes, A.E.L. (2003) Software para análise faunística - anafau. *In*: Simpósio de encontro biológico, 8, São Pedro. Resumos Siconbiol, 8, São Pedro, p. 195.

Moura, A.P. and Moura, D.C.M. (2006) Espécies de moscas-das-frutas (Diptera: Tephritidae) associadas à cultura da goiabeira (*Psidium guajava* Linnaeus) em Fortaleza, Ceará. *Arquivos do Instituto Biológico*, *73*(1): 65-71.

Nicácio, J.N., Oliveira, I., Uchoa, M.A., Faccenda, O., Abot, A.R. and Garcia, F.R.M (2019) Spatial distribution and control levels of *Anastrepha* Spp. (Diptera: Tephritidae) in guava orchards. *Anais da Academia Brasileira de Ciências* (online), *91*: E20180428.

Norrbom, A.L. (2010) Tephritidae (Fruit Flies, Moscas De Frutas). *In*: Brown B.V. *et al*. (Eds), Manual ff Central American Diptera. Nrc Research Press, Ottawa, 2: 909-954.

Oliveira, I., Uchoa, M.A., Pereira, V.L., Nicácio, J.N. and Faccenda, O. (2019) *Anastrepha* species (Diptera: Tephritidae): Patterns of spatial distribution, abundance, and relationship with weather in three environments of midwestern Brazil. *Florida Entomologist*, *102*: 113-120.

Silveira-Neto, S., Nakano, O., Barbin, D. and Villa-Nova, N.A. (1976) Manual de ecologia dos insetos. Agronômica Ceres, São Paulo, 420 pp.

Singh, S.P. and Pal, R.K. (2008) Controlled atmosphere storage of Guava (*Psidium guajava* L.) fruit. *Postharvest Biology and Technology*, *47*: 296-306.

Souza-Filho, M.F., Raga, A., Azevedo-Filho, J.A., Strikis, P.C., Guimarães, J.A. and Zucchi, R.A. (2009) Diversity and seasonality of fruit flies (Diptera: Tephritidae and Lonchaeidae) and their parasitoids (Hymenoptera: Braconidae and Figitidae) in orchards of guava, loquat and peach. *Brazilian Journal of Biology*, *69*(1): 31-40.

Steyskal, G.C. (1977) Pictorial key to species of the genus *Anastrepha* (Diptera: Tephritidae). *The Entomological Society of Washington, Washington*, D.C., USA, 35 pp.

Uramoto, K. (2007) Diversidade de moscas-das-frutas (Diptera, Tephritidae) em pomares comerciais de papaia e em áreas remanescentes da mata atlântica e suas plantas hospedeiras nativas, no município de Linhares, Espírito Santo. (Ph.D. Dissertation). Escola Superior de Agricultura "Luiz De Queiroz", Universidade de São Paulo, Piracicaba, 105 pp.

Uramoto, K., Martins, D.S. and Zucchi, A.R. (2008) Fruit flies (Diptera, Tephritidae) and their associations with native host plants in a remnant area of the highly endangered atlantic rain forest in the state of Espírito Santo, Brazil. *Bullentin of Entomological Research*, *98*: 457-466.

Zahler, P.M. (1990) Moscas-das-frutas em três pomares do distrito federal: levantamento de espécies e flutuação populacional. *Ciência e Cultura*, *42*(2): 177-182.

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

Zucchi, R.A. (2007) Diversidad, distribución y hospederos del género *Anastrepha* em Brasil. *In*: Hernández-Ortiz, V. (Ed.), Moscas de la fruta en Latinoamérica (Diptera: Tephritidae): diversidad, biología y manejo. S y G Editores, México, D.F., p. 77-100.