

Ecology/Ecologia

Effect of an accidental fire on *Anastrepha* fruit fly (Diptera: Tephritidae) community in a conservation area of the Cerrado Biome

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Abstract. The effects of vegetation burning on populations and species composition of *Anastrepha* fruit flies in environments of the Cerrado are unknown. Thus, this study investigated the influence of fire on a community of fruit flies in two Cerrado environments, namely, typical Cerrado (savanna-like) and forested Cerrado. We collected species of *Anastrepha*, using McPhail traps weekly from 2 May 2011 to 30 April 2013. Collection data were analyzed using non-metric multidimensional scaling (NMDS) to characterize the patterns of variation in species composition, comparing the species abundance (numbers of individuals) before and after the fire event. The NMDS results showed an influence of both annual season and fire on the populations of fruit flies in the forested Cerrado, and a trend of population growth after the fire event in the typical Cerrado. The curves of species accumulation indicated a greater diversity of species in the post-fire than the pre-fire period, and the species diversity did not reach stabilization within the post-fire observation period. The diversity of habitats formed by burning and rapid regeneration of the flora after the fire could be responsible for the increase in species abundance and species richness of fruit flies in comparison with the pre-fire period.

Keywords: Conservation, Diversity; Frugivorous insects; Species richness; Trypetinae.

Efeito de um incêndio acidental na comunidade de *Anastrepha* spp. (Diptera: Tephritidae) em uma área de conservação do Bioma de Cerrado

Resumo. Os efeitos de queima da vegetação sobre as populações e a composição de espécies de moscas das frutas do gênero *Anastrepha* em ambientes do cerrado ainda são desconhecidos. Assim, este estudo investigou a influência do fogo em uma comunidade de moscas das frutas em dois ambientes de Cerrado: Cerrado típico e Cerradão. Foram coletadas espécies de *Anastrepha*, usando armadilhas McPhail semanalmente, no período de 2 maio de 2011 a 30 abril de 2013. Os dados das coletas foram analisados empregando-se escalonamento não-métrico multidimensional (NMDS) para caracterizar os padrões de variação na composição de espécies, comparando a abundância e diversidade das espécies antes e após o incêndio. Os resultados NMDS mostraram uma influência da época do ano e do fogo sobre as populações de moscas das frutas no Cerradão e uma tendência de crescimento da população após a passagem do fogo no Cerrado típico. Curvas de acumulação de espécies indicaram uma maior diversidade de espécies no período pós-fogo em comparação ao período anterior ao incêndio, e a diversidade de espécies não atingiu a estabilização dentro do período de observação após o incêndio. A diversidade de habitats formados pela queimada e rápida regeneração da flora após tal incêndio pode ter sido responsável pelo aumento na abundância de indivíduos e riqueza de espécies de *Anastrepha* em comparação com o período anterior à passagem do fogo.

Palavras-chave: Conservação; Diversidade; Insetos frugívoros; Riqueza em espécies; Trypetinae.

Fire is one main determinant of the environmental structure and population dynamics in the savannas (UEHARA-PRADO *et al.* 2010). Its effects cause changes in the community structure of arthropods due to changes in the plant community (HARTLEY *et al.* 2007; FRIZZO *et al.* 2011). If differing types of fire regimes, different ecological conditions before and after fire events and differing degrees of adaptation of organisms to fire events are ignored, results from population studies may not adequately describe typical arthropod communities in the regions under study (MORETTI *et al.* 2004). Whereas fire is beneficial and life sustaining in ecosystems that have evolved with fire, it may be harmful in ecosystems composed mainly of plants and animals that are not adapted to fire (HARDESTY *et*

al. 2005). Hence, fire events may have positive effects on some organisms and negative effects on others (SWENGEL 2001; PANZER 2002; FRIZZO *et al.* 2011). Furthermore, the richness of ecological communities may be affected through direct or indirect impacts of fire (SWENGEL 2001; FRIZZO *et al.* 2011).

The Cerrado is one of the most threatened ecosystems worldwide, currently ranked number 6 on the list of priority environments for biodiversity conservation (MYERS *et al.* 2000). It is the richest tropical savanna in the world (FRIZZO *et al.* 2011), and fire has been considered an important component in its species dynamics (KLINK & MACHADO, 2005). This biome occurs mainly in the central part of Brazil and supports a mosaic of vegetation types

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with heterogeneous plant communities (SANO *et al.* 2008; ADENEY *et al.* 2009). Its rich biodiversity of endemic species has not been well documented and has received less attention than that of the Amazonian and Atlantic forests in terms of conservation measures. Only 2.2% of the Cerrado is legally protected in the form of protected areas (KLINK & MACHADO 2005). Such areas, although not large enough to maintain viable populations of many species, are greatly needed because they are an effective way to maintain biodiversity (ADENEY *et al.* 2009). According to SANO *et al.* (2008), Tocantins is one of three Brazilian states that have preserved the largest portion (79%) of Cerrado.

The use of controlled fire in protected areas, as practiced in other savannas worldwide, can be a form of habitat diversification in the Cerrado and could enhance biological diversity (PARR & BROCKETT 1999). A fire event usually influences the fauna at both: population and community levels, and at least in part, the fauna of the Cerrado is resilient to fire (FRIZZO *et al.* 2011). The influence of fire or other environmental disturbances on the abundance and richness of species can differ between certain trophic levels. Such disturbances probably induce changes in key functions in the ecosystems (OBER & DEGROOTE 2011). Through the use of models, WOOTTON (1998) demonstrated that disturbances may change dominance of species, causing sudden changes in trophic interactions. A disturbance also can interact with other ecological processes, affecting the patterns of species abundance and species diversity.

Studies on fire in forests suggest that arthropod populations take a few years to recover from the fire event (CAMANN *et al.* 2008). It is possible that the frequency and annual season in which fire events occur in forests could adversely affect moisture, soil composition, composition of flora, fauna, and rates of succession (UEHARA-PRADO *et al.* 2010). Generally, responses of arthropods to fire are species specific and vary according to the frequency of fires, the elapsed time between the burnings and the features of the specific animal or plant group under study (FRIZZO *et al.* 2011).

Most studies demonstrating the effects of fire on insect communities make no references to frugivorous insects. Furthermore, most studies on Tephritoidea focus on the fruit flies' economic importance as pests of fruit and vegetables and on their natural enemies. Fruit flies have shown great potential for applied ecological studies (UCHOA 2012), but the effects of fire events on their communities in the Cerrado are unknown. We hypothesized that species abundance and species richness of fruit flies in the Cerrado could decrease after a fire event. Thus, the aims of this study were to examine how the community of fruit flies will respond to an accidental fire event and to provide data that could aid in biodiversity conservation for the biome Cerrado.

MATERIAL AND METHODS

Study Area. The study was carried out from 2 May 2011 to 30 April 2013 in the Parque Estadual do Lajeado (PEL), located at 10°00'24"S, 48°17'03"W; 10°00'13"S, 48°15'45"W; 10°11'50"S, 48°12'56"W; 10°11'25"S, 48°10'37"W and 10°09'14"S, 48°09'54"W in the city of Palmas, capital of Tocantins State, Brazil, with an area of approximately 9,931 ha (SEPLAN 2005). PEL is an integral protection conservation area (Law 9.985/2000, integrant of the Sistema Nacional de Unidades de Conservação-SNUC, Brazil). It presents grassland Cerrado (typical savanna-like Cerrado) and forested Cerrado.

During the period of this research, the mean monthly temperature ranged from 19.8 °C to 38.6 °C, precipitation from 0 mm to 397 mm, and air relative humidity from 34.5% to 87.5%. The climatic data were obtained from the Instituto Nacional de Meteorologia (INMET), Brazil.

Data Collection. Eighteen McPhail traps baited with a hydrolyzed corn protein solution (5% v/v), positioned 1.8 m from ground level and installed on previously selected points. Traps were spaced at least 500 m away from each other in transects covering environments of typical Cerrado (12 traps) and forested Cerrado (six traps), according to classification of RIBEIRO & WALTER (2008) for Brazilian savannas. The number of traps was proportional to the size of each environment. All traps were checked weekly to collect the captured fruit flies and to renew the bait, from 02 May 2011 to 30 April 2013.

In the first half of September 2012, an accidental and uncontrolled fire event occurred in PEL, burning about 50% of the total area. Ten traps were lost in the fire, which were replaced in the following week, and data collection after the fire event continued for over seven months, following the same method as before the burning period. The traps installed in the areas not burned out were between 100 m and 2.000 m from the areas that were burned.

The trapped *Anastrepha* species were stored in vials with 80% ethanol. The species identification was based on morphological characters such as the chromatic patterns of adult's body and wings; shape and dimensions of the apex of females' aculeus (by M. A. Uchoa). After identification, voucher specimens of the fruit flies were deposited in the Coleção Entomológica do Museu da Biodiversidade (MuBio-UFGD), Dourados-MS, Brazil.

Data Analysis. We used data from all traps from September 2011 to April 2012 and from September 2012 to April 2013. A non-metric multidimensional scaling (NMDS) analysis with Euclidean distance was used to characterize patterns in the variation of *Anastrepha* species composition before and after the fire. This analysis was performed considering the presence and absence these fruit fly species, using the PAST 1.75b software (HAMMER *et al.* 2005). The graphical representation was done using the software Statistica 7 (STATSOFT 2004).

To analyze the abundance of the collected *Anastrepha* species before and after the fire, figures with means and standard deviations of the numbers of adults caught in McPhail traps were plotted using Statistica 7 software (STATSOFT 2004). To identify an increasing or decreasing trend in the species abundance, we used regression analysis, considering the average number of days after the first data reading.

Curves of species accumulation were plotted for the typical Cerrado and the forested Cerrado to investigate the pattern of stabilization of species richness in the periods corresponding to before and after the fire event. For this analysis, we used the software EstimateS 8.2 (COLWELL 2009).

RESULTS

During the two-year period, 903 individuals were captured in the 18 traps, belonging to 19 species of *Anastrepha* fruit flies (Table 1). Four species (*Anastrepha macrura* Hendel, *Anastrepha* nr. *mucronota* Stone, *Anastrepha phaeoptera* Lima and *Anastrepha serpentina* (Wiedemann)) were captured only before the fire, and five species (*Anastrepha bahiensis* Lima, *Anastrepha binodosa* Stone, *Anastrepha* nr. *longicauda* Lima, *Anastrepha turpiniae* Stone and *Anastrepha zernyi* Lima) were caught only after the passage of fire. Seven species (*A. bahiensis*, *A. binodosa*, *Anastrepha haywardi* Blanchard, *A. nr. longicauda*, *A. macrura*, *A. phaeoptera* and *Anastrepha manihoti* Lima) were new records for Tocantins State.

In the forested Cerrado, the average abundance of *Anastrepha* species before the fire event was lowest in September, rising in the following months, with a peak in December. From December onwards, the average number of individuals of different *Anastrepha* species decreased. After the fire, a similar pattern

Table 1. Patterns of fruit fly's species populations (Diptera: Tephritidae), caught in McPhail traps in a conservation unity from Cerrado biome, before and after an accidental fire (Parque Estadual do Lageado, Palmas, To, Brazil, May 2011 to April 2013).

Species	2011												2012												2013			
	Before the fire												After the fire															
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr				
<i>Anastrepha amita</i> Zucchi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha bahiensis</i> Lima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha binodosa</i> Stone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Anastrepha distincta</i> Greene	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	1	0	2	0	0	0	0	0	0	0	0
<i>Anastrepha fraterculus</i> (Wiedemann)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	6	5	0	10	0	1				
<i>Anastrepha haywardi</i> Blanchard	0	0	0	0	0	1	0	5	4	4	1	0	0	0	0	0	0	0	2	3	1	1	0	1	0	0	0	1
<i>Anastrepha macrura</i> Hendel	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha manihoti</i> Lima	66	66	3	0	0	0	0	4	9	3	27	5	3	0	0	0	0	0	0	0	3	9	15	32				
<i>Anastrepha nr. longicauda</i> Lima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Anastrepha nr. mucronota</i> Stone	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha obliqua</i> (Macquart)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0
<i>Anastrepha phaeoptera</i> Lima	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha pickeli</i> Lima	10	6	1	0	0	0	1	1	8	6	4	4	2	0	0	0	0	0	3	2	1	7	13	6				
<i>Anastrepha serpentina</i> (Wiedemann)	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anastrepha sororcula</i> Zucchi	0	0	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	1	1	0	3	2	0				
<i>Anastrepha striata</i> Schiner	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Anastrepha turpiniae</i> Stone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	3	0	0	0	0	0	0	0	0
<i>Anastrepha zenilidae</i> Zucchi	0	0	0	0	0	1	3	3	0	0	0	0	0	0	0	1	1	0	1	2	0	0	0	0	0	0	0	0
<i>Anastrepha zernyi</i> Lima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Anastrepha</i> spp. ♂♂	86	70	6	1	1	7	4	19	21	18	16	64	24	19	2	5	2	6	23	69	25	24	49	74				
Species richness	2	2	2	1	1	5	3	9	4	4	3	2	2	2	1	4	1	4	6	10	5	6	3	4				
Total / Month	162	142	10	1	1	14	10	35	34	40	26	95	33	24	2	11	3	13	37	90	34	55	79	114				

was seen from September to January, followed by two abundance peaks in February and in April (Figure 1). In the typical Cerrado, there was an increasing trend in the mean abundance of individuals of *Anastrepha* species in the two periods, with greater values in the post-fire than the pre-fire period (Figure 1).

The function of the regression analysis considering the average number of days after the first collection in the forested Cerrado was $y = 6.5437 - 0.0174x$ ($R^2 = 0.1059$) before the fire and $y = 6.2416 + 0.0008x$ ($R^2 = 0.0002$) after the fire. For the typical Cerrado, this function was $y = -9.2228 + 0.3299x$ ($R^2 = 0.6655$) before the fire, indicating an average population increase of 3.3 flies every 10 days. For the period after the fire, the function was $y = -165.6111 + 0.4440x$ ($R^2 = 0.7452$), indicating an average population increase of 4.4 flies every 10 days (Figure 2).

For the forested Cerrado, the NMDS ordination (stress = 0.05916) indicated that both seasonal variation and fire event (i.e., burning of vegetation and soil) had an effect on the variation in species composition. For both factors, the NMDS values were greater after the fire event than before the passage of fire (Figure 3).

In the typical Cerrado, the NMDS ordination (stress = 0.3715) also indicated influences related to both seasonal variation and fire event. The variation in species composition was greater in the period after the fire than before the fire, whereas seasonal variation was less after than before the fire event, with indication of convergence between the two periods (Figure 3).

The curves of species accumulation indicated a greater diversity of *Anastrepha* species in the post-fire period compared with the pre-fire period. For both periods, the curves did not reach stabilization (Figure 4).

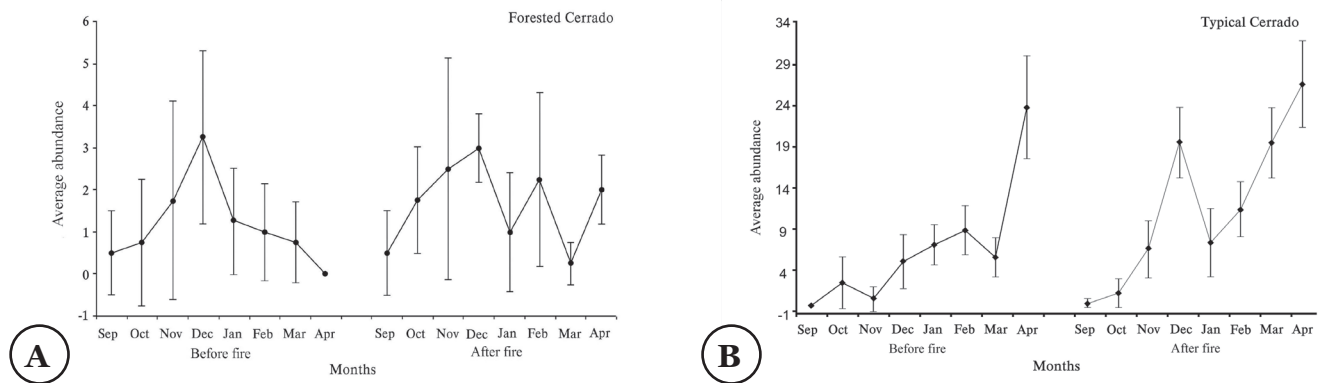


Figure 1. Patterns of fruit fly species abundance (Diptera: Tephritidae) [mean +SD] in the two environments forested Cerrado and typical Cerrado before (1 September 2011 to 30 April 2012) and after (1 September 2012 to 30 April 2013) a fire event in the Parque Estadual do Lageado, Palmas, Tocantins, Brazil.

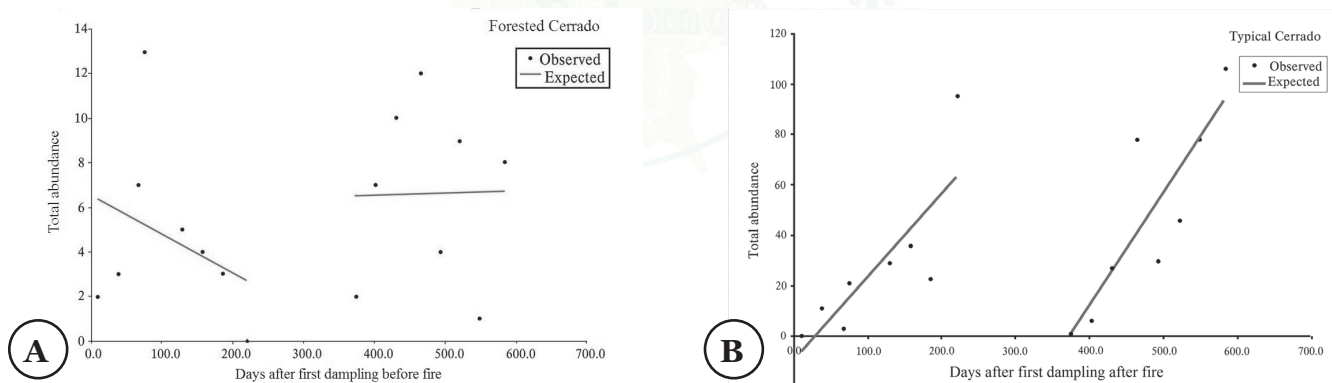


Figure 2. Total abundance of fruit fly species (Diptera: Tephritidae) in days after the first adult sampling with McPhail traps in forested Cerrado and typical Cerrado before (1 September 2011 to 30 April 2012, days 1 to 240) and after a fire event (1 September 2012 to 30 April 2013, days 360 to 600) in the Parque Estadual do Lageado, Palmas, Tocantins, Brazil.

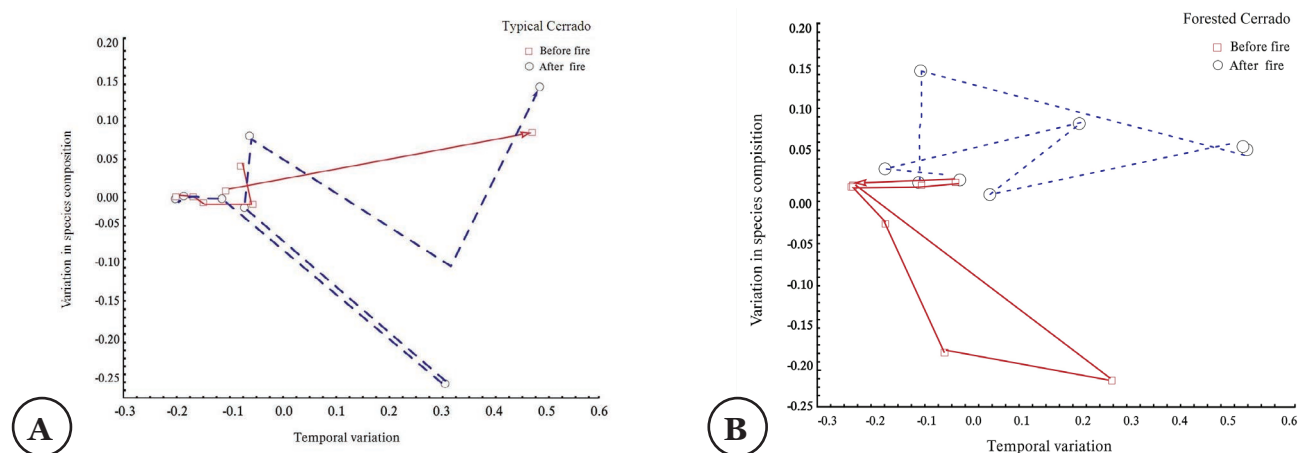


Figure 3. Ordination of fruit fly species (Diptera: Tephritidae) composition in areas of forested Cerrado and typical Cerrado by non-metric multidimensional scaling (NMDS) analysis in the corresponding months before (1 September 2011 to 30 April 2012) and after a fire event (1 September 2012 to 30 April 2013) in the Parque Estadual do Lageado, Palmas, Tocantins, Brazil (the line that connects the dots indicates the temporal trajectory).

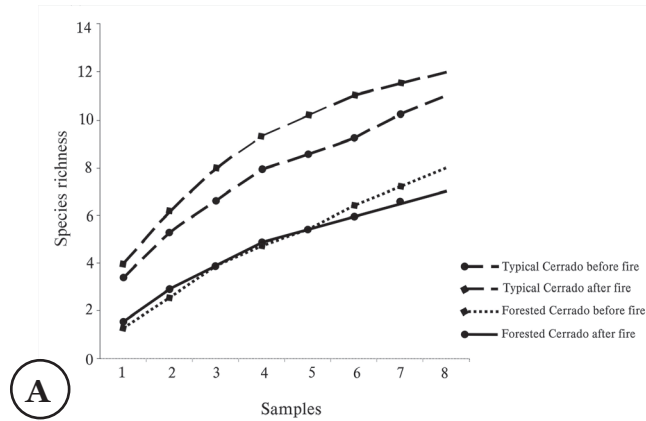


Figure 4. Curves of fruit fly species (Diptera: Tephritidae) accumulation based on all the samples taken in all areas of the Parque Estadual do Lageado, Palmas, Tocantins, Brazil, before (1 September 2011 to 30 April 2012) and after a fire event (1 September 2012 to 30 April 2013).

DISCUSSION

Protected areas play an important role in the conservation of natural environments. Because uncultivated host plants occur in these areas, there is a great possibility of finding stenophagous and monophagous species of fruit flies (see ALUJA & MANGAN 2008 classification), which generally are not found in agricultural systems. Thus, the likelihood of finding new fruit fly species increases when sampling is carried out in preserved environments, as evidenced by new records from the Amazonian and Atlantic forests of Brazil (ZUCCHI 2007; NORRBOM & UCHOA 2011). However, few records of Tephritidae in natural environments are available for the Cerrado biome of Brazil. Previous to this research, 21 species of fruit flies had been recorded in the state of Tocantins, with 17 *Anastrepha* and four *Neosilba* species (BOMFIM *et al.* 2007, 2014). In this survey, seven new records were added, namely: *A. bahiensis*, *A. binodosa*, *A. haywardi*, *A. nr. longicauda*, *A. macrura*, *A. phaeoptera* and *A. manihoti*, resulting in 24 *Anastrepha* species now reported from Tocantins State.

Natural environments harbor unique communities of endemic species, and the structure and heterogeneity of the landscape are important in structuring communities of herbivores, which in turn are affected by fire (KIM & HOLT 2012). The naturally occurring fires in the Cerrado form a mosaic of burned and unburned areas, resulting in great habitat heterogeneity and diverse resource availability (FERRENBORG *et al.* 2006). The re-growth of plants in burned areas creates vigorous vegetation, which is attractive to many species of insects - including fruit flies - that can use this environment as refuge, feeding and breeding sites. However, the patchy resource availability does not support large populations. Accordingly, the observed abundance of different species of *Anastrepha* recorded in this study was low.

Impact of Fire on Species Abundance. Positive effects of fire on species abundance and species richness in Diptera and other insects have been observed (HARTLEY *et al.* 2007). In our survey, the abundance of *Anastrepha* species, measured as numbers of adult flies captured per trap per day, showed different patterns for the periods before and after the fire, with increased numbers after the passage of fire. This is opposed to our previous hypothesis, but the increase may be explained by the availability of new plant resources, which in the Cerrado generally increases within a few weeks after a burning, in response to the release of mineral compounds (UEHARA-PRADO *et al.* 2010). The rapid re-growth of the flora, with flowering and fruiting of many plant species, allowed *Anastrepha* species to re-colonize the area quickly. The population peaks of species of *Anastrepha* observed in the course of this survey likely coincided with the fruiting periods of their host plants, as has been shown by RONCHI-TELES & SILVA (2005) for these fruit flies in the Amazonian forest. PRADA *et al.* (1995) found that a fire had caused intense flowering in daisies, resulting in a

positive effect on the abundance of tephritid species associated with the inflorescences of these Asteraceae.

We furthermore observed an ongoing population growth of the *Anastrepha* species after the fire in the typical Cerrado, indicating that a plateau had not been reached. The complete restoration of insect populations in burned areas of the Cerrado usually lasts between one and two years (PANZER 2002). Thus, our sampling likely occurred within the period of intense re-colonization of the burned area.

Impact of Fire on Species Richness. The fire event also influenced the species richness of *Anastrepha* species in the Cerrado biome. The variation in species composition in the periods before and after the fire, despite showing similarities at the end of the sampling period, was different between the forested and the typical Cerrado. It is common for newly disturbed environments to show particular trajectories in the formation of communities, which are influenced by the scale, intensity and frequency of disturbances (CONNELL & SLATYER 1977). The effect of fire on species richness depends on the characteristics of the fire (mainly intensity) and the sensitivity of each species. In general, two kinds of fires, infrequent ones with high-intensity, or very frequent ones, cause major impacts on the ecosystems (FRIZZO *et al.* 2011).

The curves of species accumulation, an expression of the species diversity in a community, herein showed a higher asymptote in the post-fire than the pre-fire period, indicating an increase in species richness of *Anastrepha* after the fire event. These results agree with those of FERRENBORG *et al.* (2006), who found a positive effect of fire on the diversity of arthropods. Both curves (in the typical Cerrado, and in the forested Cerrado) did not reach stabilization, suggesting that the species diversity in that areas had not reached their maxima. Thus, it is possible that more species of fruit flies could have been caught if the samplings had continued.

Re-Colonization after a Fire Event. Disturbance by fire can affect the species richness in ecological communities through direct and/or indirect effects (SWENGEL 2001). These effects cause changes in the community structure of plants and in turn of phytophagous arthropods (HARDESTY *et al.* 2005; FRIZZO *et al.* 2011). When certain plant species become limited or unavailable, monophagous species may experience local extinction whereas generalist or polyphagous species may be able to utilize alternative resources (FRIZZO *et al.* 2011). For those herbivores, that are specialized on certain plant structures (e.g., flowers or fruit), very frequent fires can make these resources completely unavailable (WRIGHT & SAMWAYS 1999). On the other hand, fire can release nutrients and accelerate the cycle of fruiting in some species of plants adapted to the Cerrado environments, where the fire is a common and frequent element, thus favoring populations of certain species of fruit flies.

Eggs and larvae of *Anastrepha* species are endophytic, living within their host fruit. By the end of the third instar, the larvae exit their host fruit and burrow 2 to 5 cm deep into the soil to pupate and to complete their metamorphosis into adults (UCHOA 2012). Fruit fly populations may suffer the effects of fire due to burning of the host plants and of the soil. On the other hand, the buried pre-pupae and pupae may survive a rapid passage of fire. Furthermore, MARINI-FILHO (2000) found that leaf miner insects that pupate above ground could survive a fire when they were on islands of unburned vegetation or stayed at a height where the temperature was not hot enough to kill the larvae. In that research (MARINI-FILHO 2000), found that the origin of re-colonization was both endogenous and exogenous.

The results of research on dispersal of polyphagous fruit flies species from the genus *Anastrepha* in the environments are controversial. There are publications that highlight a low mobility, between 100-250 m in Mexico (HERNÁNDEZ *et al.* 2007), from 600-800 m in Brazil (KOVALESKY *et al.* 1999). On the other hand, some papers report a high dispersive capacity, ranging from 9 km in Mexico (see THOMAS & LOERA-GALLARDO 1998), up to 135 km of displacement, as reported by CHRISTENSEN & FOOTE (1960) from USA.

The results herein suggest a re-colonization of the burned areas from the month of October. All *Anastrepha* species captured in the first three months after the fire were polyphagous, which may explain the rapid re-colonization of the area. Populations of abundant Tephritidae species, like those commonly reported as pests (polyphagous), tend to re-establish quickly after fire events, whereas geographically restricted and rare species (monophagous) tend to require more time for recovery their populations after an environment burning, as reported by SWENGEL (2001).

In this research the question remains: whether the re-colonization by *Anastrepha* species in the burned areas was of endogenous or exogenous origin. Some publications have shown that polyphagous species of *Anastrepha* are able to disperse in few days or weeks, between 9-135 km (Thomas and Loera-Gallardo, 1998; Christensen and Foote, 1960), reinforcing the possibility of re-colonization, starting from the unburned areas (exogenous re-colonization). On the other hand, it is also possible that pupae buried in the soil have survived and re-colonized the environment after the fire event (endogenous re-colonization). So, future research is needed to clear this doubt.

Recovery after a Fire Event. Open and well-drained savannas of the Cerrado biome are adapted to fire and, according to the classification of HARDESTY *et al.* (2005), are fire-dependent ecosystems. This may explain the response of the community of *Anastrepha* captured in the typical Cerrado after the fire, demonstrating high resilience. Although the fire likely caused extensive mortality of the insects, the vegetation could quickly recover and produce fruit, attracting species of frugivorous Tephritidae, including local species, to re-colonize the burned environment (SWENGEL 2001; UEHARA-PRADO *et al.* 2010). In addition, pupae buried in the soil may have survived a fast burning in the typical Cerrado.

SGARDELIS *et al.* (1995) found a significant reduction in the abundance and diversity of insect species after a fire, with a trend toward recovery in the second year after the fire. PIVELLO & COUTINHO (1992) also suggested that it takes at least two years for areas affected by a fire to regenerate and reach their original diversity. Although herein the surveyed period after the fire event was not long enough to sample the expected number of *Anastrepha* species in the Cerrado biome, the results clearly showed that the fire affected the abundance and diversity of captured species. Our results further revealed the typical pattern of populations of frugivorous tephritid species in natural environments, with low species abundance and high species richness.

In this research, the community of *Anastrepha* species was influenced by both: annual seasons and fire effect in the two examined environments (typical Cerrado and forested Cerrado). In both environments, greater species diversity was found in the period after than in the period before the fire.

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REFERENCES

- Adeney, J.M., N.L. Christensen Jr. & S.L. Pimm, 2009. Reserves protect against deforestation fires in the Amazon. *PloS One* 4: e5014. DOI: <https://doi.org/10.1371/journal.pone.0005014>.
- Aluja, M. & R.L. Mangan, 2008. Fruit fly (Diptera: Tephritidae) host status determination: critical conceptual, methodological, and regulatory considerations. *Annual Review of Entomology*, 53: 473-502. DOI: <https://doi.org/10.1146/annurev.ento.53.103106.093350>.
- Bomfim, D.A., M.A. Uchoa & M.A.L. Bragança, 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. DOI: <https://doi.org/10.1590/S0085-56262007000200012>.
- Bomfim, D.A., L.J. Gisloti & M.A. Uchoa, 2014. Fruit flies and lance flies (Diptera: Tephritoidea) and their host plants in a conservation unit of the Cerrado biome in Tocantins, Brazil. *Florida Entomologist*, 97: 1139-1147. <https://doi.org/10.1653/024.097.0321>.
- Camann, M., N.E. Gillette, K.L. Lamoncha & S.R. Mori, 2008. Response of forest soil Acari to prescribed fire following stand structure manipulation in the southern Cascade Range. *Canadian Journal of Forest Research*, 38: 956-968. DOI: <https://doi.org/10.1139/x07-241>.
- Christenson, L.E. & R.E. Foote, 1960. Biology of fruit flies. *Journal of Economic Entomology*, 5: 171-192.
- Colwell, R.K., 2009. EstimateS: statistical estimation of species richness and shared species from samples. Version 8.2. User's guide and application. Available on: <<http://purl.oclc.org/estimates>>. Accessed in: 10.iii.2014.
- Connell, J.H. & R.O. Slatyer, 1977. Mechanisms of succession in natural communities and their role in community stability and organization. *American Naturalist*, 111: 1119-1144. DOI: <https://doi.org/10.1086/283241>.
- Ferrenberg, S.M., D.W. Schwillk, E.E. Knapp, E. Groth & J.E. Keeley, 2006. Fire decreases arthropod abundance but increases diversity: early and late season prescribed fire effects in a Sierra Nevada mixed-conifer forest. *Fire Ecology*, 2: 79-102. DOI: <https://doi.org/10.4996/fireecology.0202079>.
- Frizzo, T.L.M., C. Bonizário, M.P. Borges & H.L. Vasconcelos, 2011. Revisão dos efeitos do fogo sobre a fauna de formações savânicas do Brasil. *Oecologia Australis*, 2: 365-379. DOI: <https://doi.org/10.4257/oeco.2011.1502.13>.
- Hammer, Q., D.A.T. Harper & P.D. Ryan, 2005. Past: paleontology statistics software for education and data analysis. *Paleontology Electronic*, 4: 1-9.
- Hardesty, J., Myers, R., W. Fulks & J. Grace, 2005. Fire, ecosystems and people: a preliminary assessment of fire as

- a global conservation issue. The George Wright Forum, 22: 78-87.
- Hartley, M.K., W.E. Rogers & E. Siemann, 2007. Responses of prairie arthropod communities to fire and fertilizer: balancing plant and arthropod conservation. *American Midland Naturalist*, 157: 92-105. DOI: [https://doi.org/10.1674/0003-0031\(2007\)157\[92:ropact\]2.0.co;2](https://doi.org/10.1674/0003-0031(2007)157[92:ropact]2.0.co;2).
- Hernández, E., D. Orozco, S.F. Breceda & J. Domínguez, 2007. Dispersal and longevity of wild and mass-reared *Anastrepha ludens* and *Anastrepha obliqua* (Diptera: Tephritidae). *Florida Entomologist*, 90: 123-135. DOI: [https://doi.org/10.1653/0015-4040\(2007\)90\[123:dalowa\]2.0.co;2](https://doi.org/10.1653/0015-4040(2007)90[123:dalowa]2.0.co;2).
- Kim, T.N. & R.D. Holt, 2012. The direct and indirect effects of fire on the assembly of insect herbivore communities: examples from the Florida scrub habitat. *Oecologia*, 168: 997-1012. DOI: <https://doi.org/10.1007/s00442-011-2130-x>.
- Klink, C.A. & R.B. Machado, 2005. Conservation of the Brazilian Cerrado. *Conservation Biology*, 19: 707-713. DOI: <https://doi.org/10.1111/j.1523-1739.2005.00702.x>.
- Kovaleski, A., R.L. Sugayama & A. Malavasi, 1999. Movement of *Anastrepha fraterculus* from native breeding sites into apple orchards in southern Brazil. *Entomologia Experimentalis et Applicata*, 91: 457-463. DOI: <https://doi.org/10.1046/j.1570-7458.1999.00514.x>.
- Marini-Filho, O.J., 2000. Distance-limited re-colonization of burned Cerrado by leaf-miners and galls in central Brazil. *Environmental Entomology*, 29: 901-906. DOI: <https://doi.org/10.1603/0046-225x-29.5.901>.
- Moretti, M., M.K. Obrist & P. Duelli, 2004. Arthropod biodiversity after forest fires: winners and losers in the winter fire regime of the Southern Alps. *Ecography*, 27: 173-186. DOI: <https://doi.org/10.1111/j.0906-7590.2004.03660.x>.
- Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. Fonseca & J. Kent, 2000. Biodiversity hotspots for conservation priorities. *Nature*, 403: 853-858. DOI: <https://doi.org/10.1038/35002501>.
- Norrbom, A.L. & M.A. Uchoa, 2011. New records and species of *Anastrepha* (Diptera: Tephritidae) from Brazil. *Zootaxa*, 2835: 61-67.
- Ober, H.K. & L.W. DeGroot, 2011. Effects of litter removal on arthropod communities in pine plantations. *Biodiversity and Conservation*, 20: 1276-1286. DOI: <https://doi.org/10.1007/s10531-011-0027-y>.
- Panzer, R., 2002. Compatibility of prescribed burning with the conservation of insects in small, isolated prairie reserves. *Conservation Biology*, 16: 1296-1307. DOI: <https://doi.org/10.1046/j.1523-1739.2002.01077.x>.
- Parr, C.L. & B.H. Brockett, 1999. Patch-mosaic burning: a new paradigm for savanna fire management in protected areas? *Koedoe*, 42: 117-130. DOI: <https://doi.org/10.4102/koedoe.v42i2.237>.
- Pivello, V.R. & L.M. Coutinho, 1992. Transfer of macronutrients to the atmosphere during experimental burnings in an open Cerrado (Brazilian savanna). *Journal of Tropical Ecology*, 8: 487-497. DOI: <https://doi.org/10.1017/s0266467400006829>.
- Prada, M., O.J. Marini-Filho & P.W. Price, 1995. Insects in flower heads of *Aspilia foliacea* (Asteraceae) after a fire in a central Brazilian savanna: evidence for the plant vigor hypothesis. *Biotropica*, 27: 513-518. DOI: <https://doi.org/10.2307/2388965>.
- Ribeiro, J.F. & B.M.T. Walter, 2008. As principais fitofisionomias do bioma Cerrado, p. 153-212. In: Sano, S.M., S.P. Almeida & J.F. Ribeiro (Eds). *Cerrado: ecologia e flora*, volume 1. Embrapa Informação Tecnológica. 279 p.
- Ronchi-Teles, B. & N.M. Silva, 2005. Flutuação populacional de espécies de *Anastrepha* Schiner (Diptera: Tephritidae) na região de Manaus, AM. *Neotropical Entomology*, 34: 733-741. DOI: <https://doi.org/10.1590/s1519-566x2005000500004>.
- Sano, E.E., R. Rosa, J.L.S. Brito & L.G. Ferreira, 2008. Mapeamento semidetalhado do uso da terra do bioma Cerrado. *Pesquisa Agropecuária Brasileira*, 43: 153-156. DOI: <https://doi.org/10.1590/s0100-204x2008000100020>.
- SEPLAN - Secretaria do Meio Ambiente e Planejamento, 2005. Plano de manejo do parque Estadual do Lajeado. Goiânia. 286 p.
- Sgardelis, S.P., J.D. Pantis, M.D. Argyropoulou & G.P. Stamou, 1995. Effects of fire on soil macroinvertebrates in a Mediterranean phryganic ecosystem. *International Journal of Wildland Fire*, 5: 113-121. DOI: <https://doi.org/10.1071/wf9950113>.
- Statsoft INC., 2004. Statistica: data analysis software system. version 7. Available on: <<http://www.statsoft.com>>. Accessed in: 20.v.2014.
- Swengel, A.B., 2001. A literature review of insect responses to fire, compared to other conservation managements of open habitat. *Biodiversity and Conservation*, 10: 1141-1169.
- Thomas, D.B. & J. Loera-Gallardo, 1998. Dispersal and longevity of mass-released, sterilized Mexican Fruit Flies (Diptera: Tephritidae). *Environmental Entomology*, 27: 1045-1052. DOI: <https://doi.org/10.1093/ee/27.4.1045>.
- Uchoa, M.A., 2012. Fruit flies (Diptera: Tephritoidea): biology, host plants, natural enemies, and the implications to their natural control, p. 271-300. In: Larramendy, M.L. & S. Soloneski (eds.), *Integrated pest management and pest control - current and future tactics*. Rijeka. InTech. Available on: <http://cdn.intechopen.com/pdfs/29609/InTech-Fruit_flies_diptera_tephritoidea_biology_host_plants_natural_enemies_and_the_implications_to_their_natural_control.pdf>.
- Uehara-Prado, M., A.M. Bello, J.O. Fernandes, A.J. Santos, I.A. Silva & M.V. Cianciaruso, 2010. Abundance of epigeic arthropods in a Brazilian savanna under different fire frequencies. *Zoologia* 27: 718-724. DOI: <https://doi.org/10.1590/s1984-46702010000500008>.
- Vincent, K., K. Moening & H. Colter, 2009. Effects of annual fire on the litter fauna populations and soil compositions of an upland white-oak forest. *Tillers*, 6: 17-20.
- Wootton, J.T., 1998. Effects of disturbance on species diversity: a multitrophic perspective. *American Naturalist*, 152: 803-825.
- Wright, M.G. & M.J. Samways, 1999. Plant characteristics determine insect borer assemblages on *Protea* species in the Cape Fynbos, and importance for conservation management. *Biodiversity and Conservation*, 8: 1089-1100.
- Zucchi, R.A., 2007. Diversidad, distribución y hospederos del género *Anastrepha* en Brasil, p. 67-100. In: Hernández-Ortiz, V. (ed.). *Moscas de la fruta en Latinoamérica* (Diptera: Tephritidae): diversidad, biología y manejo. SyG editores.

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