control group are less pronounced but still statistically significant ($\chi^2 = 62.1$ and $\chi^2 = 38.62$, correspondingly; $f = 1$, $p = 0.05$).

We also observed clear-cut differences in the survival dynamics between females and males for the above genotypes. Under optimal conditions heterozygous males exhibited survival advantage starting from the beginning of life cycle up to the stage of mass mortality. The LT10 point of $hsf^{1}/+$ and $+/hsf^{1}$ flies occurred 33 and 9 days later than in the control group, correspondingly. However, intervals between LT50 (control) – LT50 ($hsf^{1}/+$) and - LT50 ($+/hsf^{1}$) were equal to only 3 and 6 days, respectively. The survival curves of heterozygous males differed from those of the control group not so dramatically ($\chi^2 = 2.3$ and $\chi^2 = 14.54$; $f = 1$, $p = 0.05$) as in the females.

At 29°C sex specific differences in survival dynamics were also observed in the compared groups. Thus, $hsf^{1}/+$ males appeared to be less sensitive to the stressful conditions of maintenance. The differences at both T10 and LT50 points increased between $hsf^{1}/+$ mutants and control. Survival curves of heterozygous males $hsf^{1}/+$ and $+/hsf^{1}$ and control were significantly different ($\chi^2 = 91.5$ and $\chi^2 = 7.7$, correspondingly; $f = 1$, $p = 0.05$).

In general it is possible to conclude that the dynamics of aging and survival of *hsf*- heterozygotes appeared to depend on the direction of cross, stage of life cycle, sex, and response to elevated temperature.

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Distribution of drosophilids breeding in *Solanum lycocarpum* (Solanaceae) fruits.

Valadão, H., and R. Tidon. Programa de Pós-Graduação em Ecologia, Universidade de Brasília, Campus Darcy Ribeiro, Brasília, DF 70910-900, Brazil.

One of the main goals of community ecology is to understand species distribution through space and time. Temporal environmental variations, such as temperature and humidity, can substantially change community structure and dynamics (Hone and Clutton-Brock, 2007; Shimadzu *et al.*, 2013), particularly in insects (Wolda, 1988). Seasonal changes can alter developmental rates and adult reproduction, and consequently the survival of the offspring. Because seasonal changes can also alter the availability of resources throughout the year in terms of abundance and quality, the probability of encountering suitable resources also changes over time.

The drosophilids in the Brazilian Savanna are an excellent system in which to study the effects of seasonality, because this biome is characterized by the alternation of dry and rainy seasons. The average annual rainfall is 1,500 mm, but the rains are strongly concentrated in the rainy season (Eiten, 1972), which occurs from November to March. In the wet months, when the richness and abundance of drosophilids are very high (Mata and Tidon, 2013; Mata *et al.*, 2015; Tidon, 2006), many plant species produce fleshy fruits (Oliveira, 1998) that are used as breeding sites. Conversely, drosophilid populations are constricted in the dry season (May to September), when relatively few food resources can be found.

In this study, we examine a local frugivorous drosophilid community exploiting *Solanum lycocarpum* St. Hil. (Solanaceae), a neotropical species with fruits that provide a patchy resource for the feeding and breeding of these flies. The focus of the study is to investigate the effects of temporal variation of fruits on the community of drosophilids.

Materials and Methods

Solanum lycocarpum, an abundant neotropical species of the central regions of South America, is a small tree with fruits of 8-15 cm in diameter and an average weight of 500 g. Due to its size, this fleshy fruit (Figure 1) is an important resource for drosophilids in this region (Leão and Tidon, 2004).

Figure 1. Fruits of *Solanum lycocarpum*.

Collections of *S. lycocarpum* fruits were performed in the Instituto Brasileiro de Geografia e Estatística (IBGE) Ecological Reserve (15 º 56'S, 47 º 53'W), located 35 km south of Brasília and protecting approximately 10,000 ha together with two other continuous reserves. We performed a screening in several areas of IBGE, but only one area showed trees with fruits. Fallen fruit from five nearby trees (located up to 5 m from each other) were monthly collected during the peak months of the rainy season (January, February and March) and the dry season (July, August and September). During the dry season, a period of low availability of fruits, all fruits were collected. On the rainy season, when fruits are abundant, up to 30 fruits were randomly collected each month. Collected fruits were transported to the laboratory in plastic bags, and were individually weighed (wet weight). They were then individually placed in plastic containers with moist vermiculite containing a solution of Nipagin (methyl 4-hydroxibenzoae, Vetec Química Fina LTDA, Rio de Janeiro, RJ, Brazil), an inhibitor of filamentous fungi. After this, each container was covered with a piece of cloth. The adult flies that emerged were removed every two days using an entomological vacuum apparatus and identified to the species level with identification keys (Freire-Maia and Pavan, 1949) and analysis of the male terminalia (Malagolowkin, 1952; Vilela and Bächli, 1990; Vilela and Val, 1985). All the adults collected were deposited in the collection of the Evolutionary Biology Laboratory at the University of Brasília.

Results

A total of 146 *Solanum lycocarpum* fruits were collected: 85 during the rainy season and 61 during the dry season, and overall these resources supported 12,745 drosophilids of 20 species (Table 1). The mean weight of fruit did not differ between the two seasons (rainy = 494.96 g, dry = 467.46 g, $t = 0.666$, df = 144, $P = 0.507$), but the density of flies was significantly higher in the wet season (rainy = 0.321 flies/g, dry = 0.011 flies/g, $W = 4607.5$, $P < 0.001$). Four drosophilid species could be considered for analysis of proportional usage of the fruits, due to sample size in both seasons: *Zaprionus indianus*, *Drosophila simulans*, *D. melanogaster,* and *D. mercatorum*. The proportional usage of the fruits was different between the two seasons for these species individually and for all species combined (Table 2).

Discussion

The abundance of drosophilids in *Solanum lycocarpum* was 35 times higher in the rainy season than in the dry season, supporting previous findings (Mata and Tidon, 2013; Mata *et al*., 2015; Tidon, 2006). As in the Brazilian Savanna most fruits are available only in the rainy season (Valadão, unpublished data), the rarity of flies in the dry season could be due a shortage of resources. However, the low density of flies and the high proportion of unexploited fruits, in the dry season, do not support this hypothesis.

Table 1. Dipterans reared from *Solanum lycocarpum* fruits in the peak rainy and dry seasons, in the IBGE Ecological Reserve.

Taxon	Rainy season	Dry season
*Scaptodrosophila latifasciaeformis** Duda	5874	0
Drosophila mercatorum Patterson and Wheeler	2925	60
*Zaprionus indianus** Gupta	1353	102
*D. melanogaster** Meigen	1058	98
D. sturtevanti Duda	691	0
*D. hydei** Sturtevant	369	3
*D. simulans** Sturtevant	156	53
*D. immigrans** Sturtevant	81	0
D. cardini Sturtevant	71	2
D. willistoni Sturtevant	35	0
*D. malerkotliana** Parshad and Paika	35	0
*D. busckii** Coquillett	24	0
D. mediostriata Duda	18	0
D. cardinoides Dobzhansky and Pavan	15	0
D. nebulosa Sturtevant	9	3
Rhinoleucophenga sp 1	4	7
*D. ananassae** Doleschall	10	0
D. trapeza Heed and Wheeler	8	0
D. paramediostriata Townsend and Wheeler	6	0
D. mediopunctata Dobzhansky and Pavan	3	0
Total	12745	406

* Exotic species in the Neotropical Region

The precise causes of the seasonal drosophilid bottlenecks in the Brazilian Savanna are not currently known, but some hypotheses can be raised to explain this pattern. In the dry season, for example, the fruits could be not found by females, or they were not suitable as a breeding site. As all the fruits were obtained in a small area, the second option is more reasonable. In that case, even though the fruits are present throughout the year, they are not an available resource for drosophilids when adverse environmental conditions constraint the development of yeasts and bacteria on which these flies feed. These differences in resource availability could change the distribution patterns of the individuals. Additionally, seasonality can also affect drosophilid abundance by modifying individual reproductive parameters. It is well known that lower temperatures and shorter days can promote ovarian diapause and cause an interruption in egg production (Saunders *et al.*, 1989). This strategy could explain the bottlenecks observed in populations of *Drosophila* in the Brazilian Savanna when the mean temperature in the dry season is potentially sufficient to cause 80% of the population to undergo ovarian diapause (Emerson *et al.*, 2009).

Table 2. Proportion of fruits of *Solanum lycocarpum* colonized by drosophilids in the peak rainy and dry seasons, in the IBGE Ecological Reserve.

Species	Rainy season	Dry season	χ^2	*P*
Z. indianus	0.65	0.16	31.943	0.000
D. simulans	0.24	0.07	6.907	0.009
D. melanogaster	0.49	0.18	13.795	0.000
D. mercatorum	0.75	0.10	58.375	0.000
All species	0.89	0.26	58.148	0.000

In sum, our study has revealed that the rarity of drosophilids in the Brazilian Savanna, often observed in the dry season, is probably not caused by a lack of fruits. We provided alternative explanations for the temporal fluctuations of these flies, which will be tested in future work.

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Revised list of drosophilid species recorded in the Brazilian Savanna.

Roque, F.[1,2], L. Mencarini[2], and R. Tidon[2]. [1]Instituto Federal de Brasília, Planaltina, DF – BRAZIL; [2]Instituto de Biologia, Universidade de Brasília, Brasília, DF – BRAZIL; Corresponding author: francisco.roque@ifb.edu.br.

Introduction

The Brazilian Savanna, an environment also known as Cerrado, is found within the interior of Brazil and originally covered an area of about 2 million km^2 in South America (Oliveira and Marquis, 2002). The landscape´s typical vegetation consists of savanna and small forests with significantly varying structures (Oliveira-Filho and Ratter, 2002) that contribute to its status as the most biodiverse savanna on Earth. Over the last few decades, large-scale cattle ranching and the emergence of industrial plantations, such as those used for soybeans, *Glycine max* [L.] Merr. have extensively transformed the Brazilian Savanna. Disturbances caused by both the urban, and agricultural expansion have increasingly threatened its rich biodiversity (Klink and Machado, 2005). Currently, this region is considered one of 34 *biodiversity hotspots* around the world because of its high endemicity and the extreme threats that it faces (Mittermeier *et al*., 2005). Accordingly, documenting biodiversity in this area is an important step toward obtaining critical subsidies necessary for its preservation and conservation.

The most recent compilation of drosophilid species recorded in the Brazilian Savanna was provided by Roque and Tidon (2013). This list was based upon unpublished data, along with that available in Chaves and Tidon (2005, 2008), Roque *et al*. (2006), Blauth and Gottschalk (2007), Roque and Tidon (2008), Mata *et al*. (2008), and Valadão *et al*. (2010). They concluded that drosophilid fauna of the Cerrado consisted of 128 species. Subsequent findings by Blauth *et al*. (2013), Paula *et al*. (2014), Junges and Gottschalk (2014), and Vidal and Vilela (2015) eventually added more species to this list.

In this study, we analyzed the current records of drosophilid species proposed by Roque *et al*. (2006), Mata *et al*. (2008), Roque and Tidon (2008, 2013), and Valadão *et al*. (2010). We then updated the existing list of species, adding the information available after 2013. The revised list better organizes the existing knowledge and presents a more realistic checklist of the drosophilids recorded in the Brazilian Savanna.

Material and Methods

Initially, we analyzed the most current, existing, records of drosophilids for the Cerrado, provided by Roque *et al*. (2006), Mata *et al*. (2008), Roque and Tidon (2008, 2013), and Valadão *et al*. (2010). We went through each of the original species descriptions and verified the specific characteristics for each. Afterwards