Influence of Various Farmland Habitats on Abundance of Taeniaptera (Diptera: Micropezidae)

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Influence of various farmland habitats on abundance of *Taeniaptera* (Diptera: Micropezidae)

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Abstract

Stilt-legged flies play an important ecological role in the process of decomposition of organic matter and, on occasion, in the biological control of insects. Currently, there are 46 known species of *Taeniaptera* Macquart (Diptera: Micropezidae), and their occurrence is reported in various environments throughout the tropics. In contrast, population information on their temporal and spatial distribution is scarce in areas of the Cerrado biome in Brazil, where habitats are highly disturbed and fragmented by agricultural practices and, therefore, the abundance of the group may change. This study assessed abundance of *Taeniaptera* species in habitats associated with farmland, and determined the change in abundance throughout the year. The stilt-legged flies were sampled in various habitats, namely, organically produced vegetable crops, fallow areas, agroforestry, and native vegetation associated with 4 farms located in the Federal District. In each habitat, one Malaise trap was installed, which remained in place for 72 h, at 14 d intervals, from Mar 2012 to Feb 2013. In total, 486 individuals were collected and identified as members of the species *T. lasciva* (F.), *T. annulata* (F.), and *Taeniaptera* sp. The mean abundance of flies was highest in vegetable crops when compared with other habitats, and the abundance was relatively steady throughout the year. Among the habitats sampled, vegetable crop systems were the most suitable habitats for conserving *Taeniaptera* species.

Key Words: micropezids; *Taeniaptera lasciva*; Cerrado vegetation; organic vegetable crop; abundance

Resumen

Las moscas de patas largas juegan un papel ecológico importante en el proceso de descomposición de la materia orgánica y, en ocasiones, en el control biológico de insectos. Actualmente, hay 46 especies conocidas de *Taeniaptera* Macquart (Diptera: Micropezidae), y su incidencia se reporta en diversos ambientes en los trópicos. Por el contrario, información sobre distribución temporal y espacial de poblaciones es escasa en áreas del bioma del Cerrado en Brasil, donde los hábitats están muy perturbados y fragmentados por las prácticas agrícolas y, por lo tanto, la abundancia del grupo puede cambiar. Este estudio evaluó la abundancia de especies de *Taeniaptera* en hábitats asociados con tierras de cultivo, y determino los cambios durante todo el año. Se tomaron muestras de las moscas de patas largas en diversos hábitats, es decir, en cultivos de hortalizas producidos organicamente, áreas de barbecho, agrosilvicultura y vegetación nativa asociada con 4 campos ubicados en el Distrito Federal. En cada hábitat, se instaló una trampa Malaise, que permaneció en el lugar durante 72 horas, en intervalos de 14 dias, desde el marzo del 2012 a febrero del 2013. En total, 486 individuos fueron recolectados e identificados como miembros de la especie *T. lasciva* (F.), *T. annulata* (F.) y *Taeniaptera* sp. El promedio de la abundancia de las moscas fue más alta en los cultivos de hortalizas en comparación con otros hábitats, y la abundancia fue relativamente constante durante todo el año. Entre los hábitats incluidos en la muestra, los sistemas de cultivo de hortalizas fueron los hábitats más adecuados para la conservación de las especies de *Taeniaptera*.

Palabras Clave: micropezidos; *Taeniaptera lasciva*; vegetación de cerrado; cultivos de hortalizas orgánicas; abundancia

The stilt-legged fly genus *Taeniaptera* Macquart is one of the most common taxa in the family Micropezidae (Diptera), and most of the species occur in the Neotropical region. Currently, 46 species are known in the world, of which 23 are reported from Brazil (Ferro & De Carvalho 2014; Catalogue of Life 2015). They are found in a variety of environments such as forest, meadows, marshes, woods, and wetlands (Albuquerque 1980a,b).

The species of this genus provide important ecosystem services by participating in the decomposition process of organic matter and in the biological control of insects. However, little is known about the feeding habits of larvae and adults of stilt-legged flies. Larvae of *Taeniaptera annulata* (F.) and *T. lasciva* (F.) have been reported in decaying banana stumps, in rotted roots of cassava, in decomposed fruit, in roots of fig trees, and in decaying sugarcane cuttings, whereas *T. trivittata* Macquart has been observed emerging from rotten *Typha* (Typhaceae) stems (Fischer 1932; Cresson 1938; Steyskal 1964; Silva et al. 1968; Marshall 2010). Adults of *T. lasciva* have been recorded as predators of sugarcane borer (*Diatraea saccharalis* [F.]; Lepidoptera: Crambidae) in Barbados (Bennett & Alam 1985).

Most studies on stilt-legged flies in Brazil are focused on taxonomy and systematics (Albuquerque 1980a,b, 1981; Albuquerque & Papavero 2002; Ferro & De Carvalho 2014; Harterreiten-Souza et al. 2014a). The first ecological study in the region was made by Albuquerque (1991), who described the Taeniapterinae fauna present on Maracá and Pacaraima islands, in Roraima State. However, information on environmental factors affecting the abundance of the group, especially in environments disturbed by agricultural practices, is lacking.

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The Cerrado biome has predominantly savanna-like vegetation, and was classified as a "hot spot" of diversity in the tropical region (Oliveira & Marquis 2002). Nowadays, it is highly threatened by agricultural expansion, resulting in fragmentation of native vegetation and shifts in the landscape to a mosaic of disturbed plots (Klink & Machado 2005; Beuchle et al. 2015). In general, increased populations of insects were found in habitats with higher resource availability and food concentration (Haenke et al. 2009; Romabai devi et al. 2011; Amaral et al. 2013). Furthermore, the abundance may respond positively to an increase in air temperature and rainfall (Auad 2003; Silva et al. 2011).

The objective of this study was to compare the distribution of *Taeniaptera* species among different farmland habitats, namely, vegetable crops, fallow areas, agroforestry, and native vegetation, and to determine their abundance throughout the year. Our initial working hypothesis was that *Taeniaptera* populations may differ between different biotic and abiotic habitats associated with the farms. Knowledge of fly and habitat interactions may provide some insight into management of the environment that allows us to preserve the flies and their environmental relationships.

Materials and Methods

STUDY SITE

The study was conducted from Mar 2012 to Feb 2013 in areas within the Cerrado biome. The climate in the region of the study has a well-defined seasonal variation with a dry season from May to Sep, and a rainy season from Oct to Apr. In general, the average temperature ranges from 22 to 27 °C and precipitation averages 1,200 mm/yr. However, low temperatures (<15 °C) and relative humidity (<15%) can be observed during the dry season (Klink & Machado 2005).

Four organic farms that produce vegetables were selected for this study. They were located in Taguatinga (48.071233°S , 15.829178°W), Ceilândia (48.252683°S, 15.824447°W), Paranoá (47.641011°S, 15.761664°W), and Lamarão (47.497206°S, 15.974353°W) in the Federal District, Brazil. Sampling was conducted simultaneously in the habitats available on each farm, and all farms were sampled simultaneously in the same week. Vegetable crops, fallow, agroforestry, and native vegetation habitats were sampled in Taguantinga; vegetable crops, fallow, and agroforestry were sampled in Ceilândia; and vegetable crops, fallow, and native vegetation were available and sampled in Paranoá and Lamarão. One Malaise trap was installed in each habitat, and operated for 72 h at 14 d intervals. Voucher specimens of captured *Taeniaptera* species are housed in the Entomological Collection of Departamento de Zoologia, Universidade de Brasília.

HABITAT CHARACTERIZATION

Vegetable Crops

Vegetable crops were annuals with short phenological cycles (about 4 mo), intercropped or planted as monocultures, with a predominance of brassicas (e.g., collards, cauliflower, broccoli, cabbage), and other species such as lettuce, pumpkin, eggplant, chayote, corn, tomatoes, okra, and celery. These crops were irrigated by sprinkling. In addition, grasses (e.g., *Brachiaria* [Poaceae]) and weeds (e.g., *Ageratum conyzoides* [Asteraceae], *Amaranthus deflexus* [Amaranthaceae], *A. spinosus* [Amaranthaceae], *Bidens pilosa* [Asteraceae]) grew commonly in the neighborhood and inside the cultivated area. In this type of habitat, there is intensive land use and disturbance related to crop management (Henz & Alcântara 2009).

Fallow

Fallow is an interruption of agricultural activities to protect or improve soil quality. This interruption can be characterized by the temporary abandonment of the area, with a landscape dominated by grasses (e.g., *Brachiaria*), weeds (e.g., *A. conyzoides*, *A. deflexus*, *A. spinosus, B. pilosa*, *Ricinus communis* [Euphorbiaceae], *Thitonia diversifolia* [Asteraceae]), or by planting a cover crop with forage plants (e.g., *Mucuna* sp. [Fabaceae], *Sorghum bicolor* [Poaceae], *Pennisetum americanum* [Poaceae], *Canavalia ensiformes* [Fabaceae]) (Altieri 2012). This area was not irrigated.

Agroforestry

These areas are characterized by the presence of shrubs and trees, and serve to diversify the local landscape and increase interaction between the organisms for the conservation of species (Farrell & Altieri 2012). The plants vary in shape, size, and phenology, with low dependence on external inputs. Part of the vegetation is managed for food production, and tree species are maintained over time (Gliessman 2005). This area was not irrigated by sprinklers.

Native Vegetation

Native vegetation comprises predominantly mesophytic vegetation along the streams. The trees reach a height of approximately 20 m and tree cover of 80%. These areas are considered part of the legal conservation reserve and are important repositories of biodiversity in the Cerrado (Neto et al. 2005).

STATISTICAL ANALYSES

The sex ratio of each species was calculated and expressed as the percentage of males to females (male:female). The abundance of stilt-legged flies in different habitats was evaluated by Kruskal–Wallis analysis of variance. Abundance distribution among the months was evaluated by Kruskal–Wallis analysis of variance, and abundance between the dry (Jun to Sep) and rainy (Nov to Feb) seasons was compared using a separate-variance *t* test. All analyses were done in the software Statistica 7.1 (Statsoft, Inc. 2005).

Results

In total, 486 individuals representing 3 species of *Taeniaptera* were collected (*T. lasciva*, *T. annulata*, and *Taeniaptera* sp.) on farms during this study, as well as other species of micropezids, such as *Mycropeza dactyloptera* Harterreiten-Souza, Sujii & Pujol-Luz, *Plocoscelus conifer* (Hendel), *Plocoscelus brevipennis* (Walker), and *Cliobata* sp. Among *Taeniaptera* species, *T. lasciva* was more abundant than *T. annulata* and *Taeniaptera* sp. ($H = 23.16$; df = 2,148; $P < 0.001$), representing about 90% of the total sample population. Even with the predominance of a single species, all occurred in different localities in the Federal District.

The sex ratio of *T. lasciva* was 53:47, with a balanced proportion between males and females. The other species, *T. annulata* (5:95) and *Taeniaptera* sp. (11:89), were predominately females (Table 1).

The monthly abundance (mean ± SE) of *Taeniaptera* was higher in vegetable crops (17.17 ± 4.02) than fallow (3.25 ± 0.70), agroforestry (0.67 ± 0.22), and native vegetation (2.50 ± 0.51) ($H = 28.99$; df = 3,48; $P < 0.0001$) (Fig. 1). The mean abundance of *Taeniaptera* did not differ among the months ($H = 4.88$; df = 11,48; $P = 0.937$) or between the dry (Jun to Sep) and rainy seasons (Nov to Feb) ($t = -0.23$; df = 21,84; $P = 0.821$) (Fig. 2). *Taeniaptera lasciva* and *T. annulata* were collected

Table 1. Number of flies and sex ratio (male:female) of *Taeniaptera* species collected in various farmland habitats in the Federal District, Brazil, Mar 2012 to Feb 2013.

Species	Male	Female	Total	Sex ratio
Taeniaptera lasciva	230	204	434	53:47
Taeniaptera annulata	1	8	9	5:95
Taeniaptera sp.	2	41	43	11:89

throughout the whole year, whereas *Taeniaptera* sp. was collected only in the months of Mar, May, Sep, Nov, and Jan.

Discussion

Taeniaptera lasciva was the most abundant species sampled, and this species displayed a balanced ratio between males and females. A balanced sex ratio confers a certain advantage for the species due to increased genetic variability and a reduction in the energy costs of looking for a sexual partner, which is particularly important for the survival of the population in a heterogeneous and constantly disturbed environment (Schowalter 2011). However, this sex ratio was not observed for *T. annulata* and *Taeniaptera* sp. Their sex ratio was consistent with the general pattern of micropezids, which usually display a higher prevalence of females than males (Albuquerque 1991). Although females of the latter 2 species were more abundant than males, individuals of both sexes were collected in various months throughout the year, suggesting reproductive synchronization or aggregation behavior among individuals, thereby contributing to the maintenance of the group's population over time (Begon et al. 2007).

The *Taeniaptera* species had wide regional distribution and were found in all environments of the agricultural landscape. However, vegetable cropping seems to favor the abundance of stilt-legged flies. In these areas, there is a predominance of herbaceous plants that harbor a variety of host insects, which can serve as a food source for both larvae and adults (Bennett & Alam 1985; Marshall 2010). There is limited information about the feeding habits of *Taeniaptera*, but a recent study published by Barnes (2015) showed that larvae of *Compsobata univitta* (Walker) can be grown on rotting lettuce and spinach, vegetables commonly found in these systems. The adults were also commonly found walking within and around cultivated plants (e.g., *Brachiaria*, *C. ensiformes*, *Mucuna*, juvenile *T. diversifolia*, *R. communis*, *Ipomoea batatas* [Convolvulaceae] and *Colocasia esculenta* [Araceae]), feeding on extrafloral nectaries, or drinking water retained by the leaves. These plants can contribute to a better quality of habitat in the agricultural landscape by providing food resources for these species.

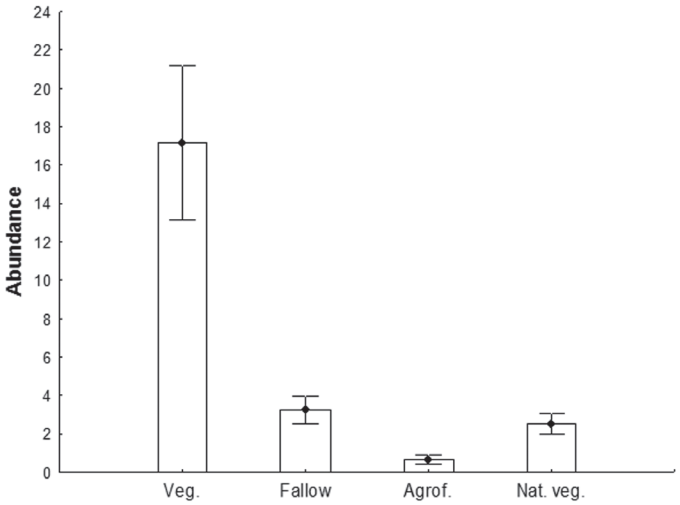

Fig. 1. Monthly abundance (mean ± SE) of *Taeniaptera* collected in various farmland habitats: vegetable crops (veg.), fallow, agroforestry (agrof.), and native vegetation (nat. veg.) in the Federal District, Brazil.

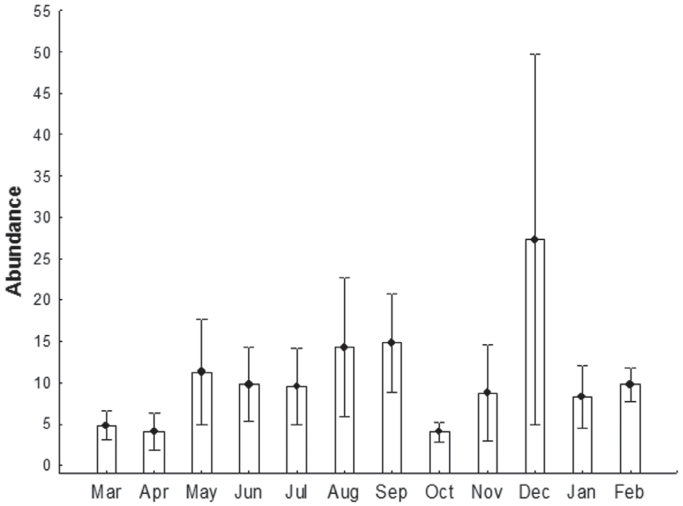

Fig. 2. Abundance distribution (mean ± SE) of *Taeniaptera* collected during Mar 2012 to Feb 2013 in various farmland habitats in the Federal District, Brazil.

Agricultural environments with ecologically based agricultural practices, even with constant human disturbance, provided favorable conditions for the occurrence and establishment of *Taeniaptera* species. Vegetable crops associated with some vegetation diversification practices, such as polyculture and maintenance of weeds, sprinkler irrigation, and lack of pesticides, also may favor the abundance of *Taeniaptera* in relation to fallow, agroforestry, or native vegetation.

Although vegetable crops seemed to be the best habitat for *Taeniaptera*, the maintenance of the species in these areas may be interrupted due to constant disturbance resulting from agricultural practices such as frequent harvest and plant species turnover. In a landscape context, the fallow, agroforestry systems, and native vegetation can be alternative places to mitigate these effects and act as secondary habitats or refugia, contributing to the permanence and maintenance of the species over time. For example, crops of banana (*Musa* [Musaceae]), sugarcane (*Saccharum* [Poaceae]), and cassava (*Manihot* [Euphorbiaceae]) are commonly used in agroforestry systems (for more details see Harterreiten-Souza et al. 2014b) to diversify the product marketed by the farmer. After harvesting, the remains of these plants (trunks and foliage) are incorporated into the soil and can function as a breeding site that supports the development of *Taeniaptera* larvae (Fischer 1932; Cresson 1938; Silva et al. 1968; Marshall 2010).

The abundance of *Taeniaptera* did not vary significantly through the course of the year. This finding shows a certain plasticity of the group for the climatic variations of the region and agrees with the general distribution patterns found for Diptera in the Cerrado (Pinheiro et al. 2002; Silva et al. 2011).

Based on our observations, organically produced vegetable crops favored the abundance of *Taeniaptera* species. These crops can function as a primary habitat due to the availability of food resources (e.g., quantity and quality) and favorable soil and microclimate conditions arising from irrigation. However, the vegetation surrounding the cultivated area also appears to have a role in population dynamics, such as the dispersion of species among areas, thereby contributing to the conservation of species locally over time. A general pattern of abun-

dance was found in this study, but the identifications of the mechanisms that affect directly the group still need to be evaluated.

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