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Authors: Harterreiten-Souza, Érica Sevilha, Pujol-Luz, José Roberto, Capellari, Renato Soares, Bickel, Daniel, and Sujii, Edison Ryoiti

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Diversity and spatial distribution of predacious Dolichopodidae (Insecta: Diptera) on organic vegetable fields and adjacent habitats in Brazil

Érica Sevilha Harterreiten-Souza[1,4], *José Roberto Pujol-Luz*[1], *Renato Soares Capellari*[2], *Daniel Bickel*[3], *and Edison Ryoiti Sujii*[4,*]

Abstract

Adults of the fly family Dolichopodidae (Diptera) are general predators on small soft-bodied invertebrates, and often are abundant in agroecosystems. However, information about their diversity and spatial distribution in agricultural landscapes are scarce. Using structured sampling, we identified the species of Dolichopodidae associated with organic vegetable crops, fallow, agroforestry, and native vegetation in the Federal District of Brazil, and evaluate their richness and abundance. We collected 70 species Dolichopodidae distributed in 17 genera and 9 subfamilies. Of these, some 80% of the specimens belong to the following 5 taxa: *Chrysotus spectabilis* (Loew), *Thrypticus violaceous* Van Duzee, *Condylostylus depressus* (Aldrich), *Condylostylus* "*caudatus* group" females, and *Condylostylus erectus* Becker (all Diptera: Dolichopodidae). Habitats with vegetable crops harbored a higher abundance and number of species (diversity α), with a gradual reduction towards more forested environments of native vegetation. This is an inverse gradient with the general patterns of community studies with other taxa. We also verified the importance of less disturbed habitats over time in the agricultural landscape, such as agroforestry and native vegetation, as complementary habitats for the maintenance and conservation of dolichopodid species in particular, a scenario to be tested for other insect groups.

Key Words: biological control; Neotropical region; Cerrado; habitat management; species richness; organic agro-ecosystems

Resumo

Os adultos da família das moscas Dolichopodidae (Diptera) são predadores generalistas de pequenos invertebrados de corpo mole, sendo geralmente abundantes em agroecossistemas. No entanto, informações sobre sua diversidade e distribuição espacial em paisagens agrícolas são escassas. A partir de amostragens locais, identificamos as espécies de Dolichopodidae associadas a hortaliças orgânicas, pousio, agrossilvicultura e vegetação nativa no Distrito Federal, Brasil, e avaliamos sua riqueza e abundância. Foram coletadas 70 espécies de Dolichopodidae distribuídas em 17 gêneros e 9 subfamílias. Destes, cerca de 80% dos espécimes pertencem aos seguintes 5 táxons: *Chrysotus spectabilis* (Loew), *Thrypticus violaceous* Van Duzee, *Condylostylus depressus* (Aldrich), *Condylostylus* "grupo *caudatus*" e *Condylostylus erectus* Becker (todos dípteros: Dolichopodidae). Habitats com hortaliças abrigavam a maior abundância e número de espécies (diversidade α), com uma redução gradual em direção a ambientes mais florestados de vegetação nativa. Este é um gradiente inverso com os padrões gerais de estudos comunitários com outros táxons. Também verificamos a importância de habitats menos perturbados ao longo do tempo na paisagem agrícola, como agrofloresta e vegetação nativa, como habitats complementares para a manutenção e conservação de espécies de diclopodídeos em particular. Este é um cenário a ser testado para outros grupos de insetos.

Palavras Chave: controle biológico; Região neotropical; Cerrado; manejo de habitat; riqueza de espécies; agroecossistemas orgânicos

Insects perform essential ecological processes, such as pollination, nutrient cycling, and biological control, which are important for ecosystem functioning (Schowalter 2011). However, these services are threatened due to the loss of insect species diversity caused by the destruction and fragmentation of native vegetation and the production of agricultural crops with high environmental impact, such as conventional monoculture systems with high pesticide and herbicide usage (Tilman et al. 1994; Hunter 2002; Fahrig 2003; Bettiol 2010). These environmental disturbances may lead to changes in the community structure, such as differential species abundance and dominance, and the higher probability of population outbreaks (Andow 1983, 1991; Altieri & Letourneau 1984; Ponti et al. 2007).

An alternative to mitigate such effects are the ecologically based production systems with sustainable practices, including maintenance of non-commercial plant diversity in the agricultural landscape and avoiding the use of synthetic chemical pesticides (Altieri et al. 1983; Landis et al. 2000; Bengtsson et al. 2005; Magdoff 2007). Organic ecologically based production systems aim to combine high primary

[1]Universidade de Brasília, Departamento de Zoologia, 70910-900, Brasília, Federal District, Brazil; E-mail: erica.shs@gmail.com (E. S. H. S.), jrpujol@unb.br (J. R. P. L.)
[2]Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro, Campus Uberaba, 38064-790, Uberaba, Minas Gerais, Brazil;
E-mail: renatocapellari@iftm.edu.br (R. S. C.)
[3]Australian Museum, 6 College Street, Sydney, New South Wales 2010, Australia; E-mail: dan.bickel@austmus.gov.au (D. B.)
[4]Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA Recursos Genéticos e Biotecnologia, 70770-917, Brasília, Federal District, Brazil;
E-mail: esujii@gmail.com (E. R. S.)
*Corresponding author: E-mail: esujii@gmail.com

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productivity, conservation of local biodiversity, and favor ecosystem services such as biological control of pests over pesticide application (Gliessman 2005). For this task, it is important to know the species used in biocontrol and understand their abundance in different habitats.

The long-legged flies (Diptera: Dolichopodidae) are one of the richest families of Diptera, with 7,358 species in 268 genera worldwide (Yang et al. 2006; Pape et al. 2011). There are over 1,200 species recorded in the Neotropical region, but it is known that this number is far from being final, since the group is still poorly studied in the Neotropics. In Brazil, 30 genera and 194 species have been recorded, but this is a fraction of the true faunal richness that is largely undescribed (Capellari 2018).

Dolichopodid flies usually are found in warm and humid environments, especially in forested habitats near streams, although some groups also have adapted to drier and colder environments in semi-arid and temperate forests (Bickel 1994, 2009; Brooks 2005). Thus, the vegetation characteristics and microclimatic conditions may be decisive in structuring the local assembly of dolichopodids. Despite the relative high number of described species, little is known about the relationships of the Dolichopodidae in agricultural environments, and species richness and abundance in different agroecosystem habitats.

A general pattern observed for insects is the increase in species diversity according to the increase of the agricultural landscape complexity. This may be facilitated by replacing monoculture by polyculture, planting hedges with floristic species around the plots, maintaining spontaneous vegetation in fallow areas, and conserving local native vegetation (Letourneau et al. 2011; Amaral et al. 2013; Pacheco et al. 2013; Souza et al. 2015).

From previous studies, only unidentified species of *Condylostylus* Bigot have been reported from Neotropical agricultural systems (Togni et al. 2010; Harterreiten-Souza et al. 2014; Lundgren et al. 2014). Harterreiten-Souza et al. (2014) found that *Condylostylus* species are more abundant in areas with vegetable crops compared to agroforestry systems. Considering the dolichopodid diversity in Brazil, the adaptability to the environmental conditions of agricultural systems and the high abundance in field collections, studies on the diversity and structure of the dolichopodid assemblies may reveal important data for conservation and ensure availability of their ecosystem services.

In this work we evaluated how the richness and abundance of Dolichopodidae species associated with organic farms is expressed in different adjacent habitats. As such, we tested the following hypotheses: (i) open and disturbed habitats harbor greater species abundance and dominance due to local management characteristics and abundance of some prey, and (ii) forested habitats, or less disturbed habitats, harbor greater species diversity and equitability due to the greater complexity of the vegetation of these habitats. Knowledge of the distribution of abundance and diversity of these flies and their interactions with habitats may provide support for the conservation of biological control.

Material and Methods

STUDY AREA

The study was carried out in the Federal District, Brazil, located in the Cerrado biome, with temperature ranges between 22 °C and 27 °C and annual precipitation of 1,200 mm. The dry season usually occurs from May to Sep when the temperature generally ranges from 10 to 26 °C and relative humidity is lower than 15%. The rainy season comprises the mo of Oct to Apr, when more than 85% of the annual rainfall occurs, and daily temperatures range from 18 to 30 °C (Klink & Machado 2005).

Four organic vegetable farms located in the Federal District, Brazil, were selected for this study (Fig. 1). The locality of each farm and its geographical coordinates (decimal degrees) are: (I) Ceilândia (48.252683°S, 15.824447°W), (II) Taguatinga (48.071233°S, 15.829178°W), (III) Paranoá (47.641011°S, 15.761664°W), and (IV) Lamarão (47.497206°S, 15.974353°W). The Dolichopodidae were sampled during the same wk in the habitats available on each property. Habitats with vegetable crops, fallow, agroforestry, and native vegetation were sampled in Taguatinga (II); vegetable crops, fallow, and agroforestry were sampled in Ceilândia (I); and vegetable crops, fallow, and native vegetation were sampled in Paranoá (III) and Lamarão (IV).

CHARACTERIZATION OF HABITATS

Vegetable Crops

Annual cultures were planted in consortium or monoculture, predominantly brassicas (kale, cauliflower, broccoli, cabbage), and other species such as lettuce, pumpkin, eggplant, squash, corn, tomato, okra, and celery. Plots had harvest cycles of approximately 4 mo and were irrigated by water sprinklers. In addition, grasses (e.g. *Brachiaria* [Poaceae]) and spontaneous plants (weeds such as: *Ageratum conyzoides* L. [Asteraceae], *Amaranthus deflexus* L. [Amaranthaceae], *Amaranthus spinosus* L. [Amaranthaceae], *Bidens pilosa* L. [Asteraceae]) were found frequently surrounding the cultivated area. In this type of habitat, there is intense land use and frequent disturbance related to crop management and area rotation (Henz & Alcântara 2009).

Fallow

This is a field where there is an interruption of agricultural activities to protect or improve soil quality. This interruption can be characterized by the temporary abandonment of the area, forming a landscape dominated by grasses (e.g., *Brachiaria*), weeds (e.g., *A. conyzoides*, *A. deflexus*, *A. spinosus*, *B. pilosa*, *Ricinus communis* L. [Euphorbiaceae], *Thitonia diversifolia* (Hemsl.) A. Gray [Asteraceae]), or green cover plants (e.g., *Stizolobium aterrimum* Piper & Tracy [Fabaceae], *Sorghum bicolor* [L.] Moench [Poaceae], *Pennisetum americanum* [L.] Leeke [Poaceae], *Canavalia ensiformes* [L.] DC [Fabaceae]) (Altieri 2012). This area was not irrigated.

Agroforestry

Areas are characterized by the presence of shrubs and trees, to diversify the local landscape and serving to increase interactions between organisms for species conservation (Farrell & Altieri 2012). The plants vary in shape, size, and phenology, without chemical inputs. Part of the vegetation is managed for wood production, whereas other tree species are maintained for canopy cover over time (Gliessman 2005).

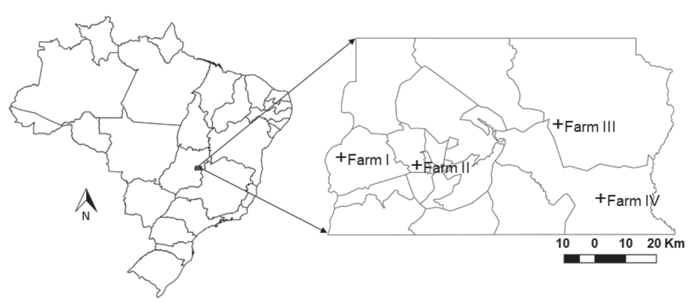

Fig. 1. Organic vegetable farms sampled in Ceilândia (I), Taguatinga (II), Paranoá (III), and Lamarão (IV), Federal District, Brazil.

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These plots were not irrigated and they have a variable duration of 3 to 5 yr. After this period they are renewed.

Native Vegetation

There is a predominance of mesophytic vegetation. The trees are approximately 20 m in height and there is 80% tree cover. These areas are set aside as a legal reserve and are considered important repositories of biodiversity in the Cerrado (Netto et al. 2005).

METHODS OF COLLECTION AND IDENTIFICATION

Insect collections were carried out every 2 wk during the mo of Mar 2012 to Feb 2013 in the morning when most of the insects are active, which facilitates capture (Antonini et al. 2005). A Malaise trap was installed in each habitat and collected insects for 72 continuous h. The collected material was sent to the Laboratory of Ecology and Biosafety of Embrapa Genetic Resources and Biotechnology, Brasilia, Distrito Federal, Brazil, and was sorted and identified to species level. The initial identification to genus level was performed using Bickel (2009).

Unnamed species (due to the absence of males or unavailability of suitable material for identification) were sequentially numbered within the genus and treated as morphospecies for future identification, or confirmation of new species.

DATA ANALYSIS

The Margalef, Simpson, and Shannon-Weaver indexes were used to describe the diversity, dominance, and equitability of species in different habitats (Harper 1999). The Whittaker index (1960) was used to calculate the beta diversity coupled between habitats (Koleff et al. 2003; Magurran 2013). The similarity of the species among the habitats also was compared by means of a cluster analysis using the Morisita index (Horn 1966). The relative importance of the species was calculated to identify key taxa, accounting for a difference observed between groups of samples (Clarke 1993). The abundance distribution of species was adjusted to the normal log model, and the Chi^2 test was used to evaluate the quality of fit (Magurran 2013). All the above analyses were performed in the statistical software PAST (Hammer et al. 2001). Nonparametric variance analysis (Kruskal-Wallis) was used to compare the influence of different habitats on the abundance of dolichopodidae with the software Statistica, version 7.1 (Statsoft Inc., Tulsa, Oklahoma, USA). Pairwise comparisons among habitats were performed using the Tukey's post hoc test with the software SigmaPlot, version 12.0 (Systat Software Inc., San Jose, California, USA).

Results

A total of 4,472 individuals were collected belonging to 17 genera and 70 species (Table 1). *Chrysotus* (23 spp., 2,323 individuals) and *Condylostylus* (16 spp., 1,247 individuals) were the most abundant and species-rich genera.

Only 5 of the 70 species identified stood out due to the high relative abundance in the total samples. Each presented more than 100 individuals and together represented 80% of the total abundance (Table 2).

The average abundance (± Standard Error) of Dolichopodidae flies showed a significant difference between habitats, being higher in vegetables (21.78 ± 10.66), followed by fallow (15.60 ± 6.65), agroforestry (3.68 ± 1.76), and native vegetation (1.56 ± 0.64) (H = 46.24; df = 3, 280; $P < 0.0001$) (Fig. 2).

The distribution curve of the abundance of Dolichopodidae species shows that most species are moderately abundant, varying from 3 to 99 individuals per species. Some are dominant (5 species, each with more than 100 individuals), and other less abundant (11 species recorded as doubletons), or rare (16 species as singletons) (Fig. 3).

The distribution of relative abundance of species also was evaluated by habitat, and all fit to the normal log distribution model, with a large number of species with intermediate abundance and few dominant and rare species (Fig. 4).

Habitats with vegetable crops harbored a greater number of species and local diversity (α), with a gradual reduction towards more forested environments of native vegetation. On the other hand, the dominance of some species and low equitability of the abundance was verified when compared with the other habitats (Table 3).

More open environments in the agricultural landscape, such as the vegetable and fallow areas, harbored a larger number of exclusive species (34 spp.) than more forested areas, such as agroforestry (2 spp.) and native vegetation (4 spp.). Only 11 species were collected in all areas (Fig. 5).

Consistently, agroforestry habitats and native vegetation presented higher values of beta (β) diversity in relation to the habitats of vegetables and fallow than compared to vegetables and fallow to each other (Table 4).

Cluster analysis (Bray-Curtis) grouped 2 different clusters based on composition. Areas of fallow and vegetables shared a greater similarity of species (more than 75%) when compared to the other environments (less than 25%) (Fig. 6).

Discussion

Farms that produce vegetables under organic management in Brazil presented high species richness and abundance of flies from the family Dolichopodidae, which previously was unknown. Of the 17 genera collected in this study, 16 are new records for the Federal District, and *Achalcus* and *Corindia* (both Diptera: Dolichopodidae) are new records for Brazil (Yang et al. 2006). Seven new species of *Mberu* (Diptera: Dolichopodidae) were identified, although previously only 1 species was known in Brazil (Capellari & Amorim 2011). Undescribed species also were identified with confidence for the genera *Chrysotus* (at least 2 species) and *Dactylomyia* (1) (both Diptera: Dolichopodidae).

Condylostylus is the only genus of Dolichopodidae commonly cited in studies on insect communities associated with agricultural environments in Brazil (Seffrin et al. 2006; Togni et al. 2010; Harterreiten-Souza et al. 2014). Nevertheless, it was not the most abundant genus found in this study. *Chrysotus* stood out not only in terms of abundance but also in number of species, and is a good example of a small-sized insect genus with many species awaiting description in the Neotropical region.

Medetera (Diptera: Dolichopodidae) species have been registered commonly in association with forested environments, acting as important agents of biological control of borer beetles, especially of the family Scolytidae (Aukema & Raffa 2004). We observed that its distribution is not restricted to forested environments only, but may occur also in more open environments, such as vegetables and fallow. This could be due to the association of some borer species with herbaceous plants (Beaver 1976) or arboreal trees surrounding the cultivated area, such as eucalyptus (Flechtmann et al. 2001). *Thrypticus* and possibly *Corindia* are the only phytophagus genera

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Table 1. Composition and abundance of Dolichopodidae flies collected on different organic vegetable farms, in different habitats, such as vegetable crops, fallow, agroforestry, and native vegetation during the period from Mar 2012 to Feb 2013, Federal District, Brazil.

Composition	Vegetable crops	Fallow	Agroforestry	Native vegetation	Total
Achalcinae					
Achalcus sp. 1	1	1	0	0	2
Diaphorinae					0
Achradocera barbata (Loew)	8	0	0	0	8
Achradocera contracta (Van Duzee)	1	1	0	0	2
Chrysotus brevicornis Van Duzee	44	21	0	2	67
Chrysotus crosbyi Van Duzee	45	3	6	0	54
Chrysotus aff. *discolor* Loew	35	17	1	1	54
Chrysotus maculatus (Parent)	0	0	0	1	1
Chrysotus mundus (Loew)	18	20	7	12	57
Chrysotus spectabilis (Loew)	1,394	399	91	38	1,922
Chrysotus spinipes Van Duzee	3	1	0	0	4
Chrysotus aff. *integer* Robinson	0	0	1	0	1
Chrysotus aff. *orichalceus* Gosseries	1	0	1	0	2
Chrysotus sp. 1	0	4	0	0	4
Chrysotus sp. 2	10	1	0	0	11
Chrysotus sp. 3	20	10	5	0	35
Chrysotus sp. 4	1	5	0	1	7
Chrysotus sp. 5	0	0	1	0	1
Chrysotus sp. 6	1	0	0	0	1
Chrysotus sp. 7	1	0	0	0	1
Chrysotus sp. 8	1	2	2	0	5
Chrysotus sp. 9	2	0	0	0	2
Chrysotus sp. 10	40	4	2	1	47
Chrysotus sp. 11*	11	0	1	0	12
Chrysotus sp. 12*	5	2	0	8	15
Chrysotus sp. n. 13	16	1	1	0	18
Chrysotus sp. n. 14	1	0	1	0	2
Lyroneurus adustus (Wiedemann)	12	4	1	1	18
Lyroneurus annulatus (Macquart)	13	3	0	0	16
Lyroneurus suavis Loew	5	0	4	0	9
Dolichopodinae					
Paraclius sp. 1	1	2	0	0	3
Paraclius sp. 2	0	0	0	3	3
Pelastoneurus sp. 1	3	0	0	0	3
Medeterinae					
Corindia sp. 1	14	0	0	0	14
Corindia sp. 2	2	0	0	0	2
Medetera sp. 1	53	9	3	3	68
Medetera sp. 2	6	2	0	0	8
Medetera sp. 3	3	0	0	0	3
Medetera sp. 4	2	0	0	0	2
Medetera sp. 5	0	1	0	0	1
Thrypticus sp. 1	459	156	26	20	661
Neurigoninae					
Dactylomyia sp. n. 1	9	0	0	0	9
Viridigona sp. 1	0	0	0	3	3
Mberu sp. n. 1	2	0	0	0	2
Mberu sp. n. 2*	1	0	0	0	1
Mberu sp. n. 3*	21	8	1	0	30
Mberu sp. n. 4	12	0	0	0	12
Mberu sp. n. 5	0	0	0	1	1
Mberu sp. n. 6	1	0	0	0	1
Mberu sp. n. 7	1	0	0	0	1
Peloropeodinae					
Micromorphus sp. 1*	1	0	2	0	3

*Only females collected; sp. n. = undescribed and new species.

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Table 1. (Continued) Composition and abundance of Dolichopodidae flies collected on different organic vegetable farms, in different habitats, such as vegetable crops, fallow, agroforestry, and native vegetation during the period from Mar 2012 to Feb 2013, Federal District, Brazil.

Composition	Vegetable crops	Fallow	Agroforestry	Native vegetation	Total
Plagioneurinae					
Plagioneurus univitattus Loew	1	0	0	0	1
Sciapodinae					
Amblypsilopus sp. 1	2	3	3	3	11
Condylostylus depressus (Aldrich)	285	146	82	7	520
Condylostylus erectus Becker	59	86	0	0	145
Condylostylus graenicheri (Van Duzee)	9	1	1	0	11
Condylostylus longicornis (Fabricius)	25	14	2	1	42
Condylostylus terminalis Becker	47	22	2	1	72
Condylostylus "*caudatus* group"*	268	126	7	0	401
Condylostylus sp. 1	2	1	1	0	4
Condylostylus sp. 2	0	1	0	0	1
Condylostylus sp. 3	26	11	2	0	39
Condylostylus sp. 4	2	0	1	0	3
Condylostylus sp. 5	1	1	0	0	2
Condylostylus sp. 6*	1	0	0	0	1
Condylostylus sp. 7	1	1	0	0	2
Condylostylus sp. 8	0	1	0	0	1
Condylostylus sp. 9	1	0	0	0	1
Condylostylus sp. 10	2	0	0	0	2
Sympycninae					
Sympycnus sp. 1	0	1	0	0	1
Sympycnus sp. 2	1	0	0	2	3

*Only females collected; sp. n. = undescribed and new species.

known in Dolichopodidae (Bickel 2009). The larvae of *Thrypticus* are well known as miners in the petioles and stems of monocotyledonous plants of the families Pontederiaceae, Poaceae, Cyperaceae, and Juncaceae (Dyte 1993; Bickel & Hernández 2004), and larvae of *Corindia* already have been reared from *Heliconia* branches (Heliconiaceae) (Bickel 2009).

Open habitats and those disturbed by agricultural practices, such as vegetable plots, contributed to an increase in the abundance of dolichopodids. This can be explained by the general feeding habit and the broad ecological tolerance of some species (Bickel 1994). The predominance of herbaceous plants in these habitats harbors a variety and quantity of insects and other invertebrates, which could serve as prey and a source of food for the dolichopodids, as well as for maintenance of their populations over time (Ulrich & Ollik 2004; Henz & Alcântara 2009). However, the food availability found in these areas does not appear to influence species dominance, suggesting that other factors, such as niche requirements, including moisture from irrigation (Begon et al. 2007), may have an influence on the assemblage structuring of the group, although this hypothesis still should be investigated.

The Dolichopodidae assemblages presented a good fit to the log normal distribution model in all evaluated habitats. This model commonly describes natural assemblies in equilibrium, and any deviation from this distribution of abundance should be indicative of habitat disturbance (Hill & Hamer 1998; Magurran 2013). Further, we could interpret that most of the dominant species found are residents (present in all habitats), in contrast with those few abundant species that are transient with 34 species present only in disturbed habitats, such as vegetable crops and fallow areas, where environmental conditions favored their establishment (Magurran & Henderson 2003; Ulrich & Ollik 2004). This result differs from the generally observed patterns for insect communities in natural or disturbed ecosystems in the tropical region, where more than a third of the species are rare or have a single individual in the samples (singletons) (Basset et al. 1998; Novotný & Basset 2000; Harterreiten-Souza et al. 2011).

The greater diversity of dolichopodids in the habitats of vegetable cultivation and fallow, when compared to agroforestry and native vegetation, present an inverse gradient with greater diversity in more disturbed habitats with predominance of herbaceous

Table 2. Relative importance and accumulated value of the most abundant Dolichopodidae flies collected in different habitats, such as vegetable crops, fallow, agroforestry, and native vegetation during the period from Mar 2012 to Feb 2013, Federal District, Brazil.

Taxa	Relative importance	Accumulated (%)	Habitats			
			Vegetable crops	Fallow	Agroforestry	Native vegetation
Chrysotus spectabilis	29,14	43,4	1,394	399	91	38
Thrypticus sp. 1	9,545	58,3	459	156	26	20
Condylostylus depressus	9,208	70,1	285	146	82	7
Condylostylus "*caudatus* group"	6,873	79,2	268	126	7	0
Condylostylus erectus	2,98	82,4	59	86	0	0

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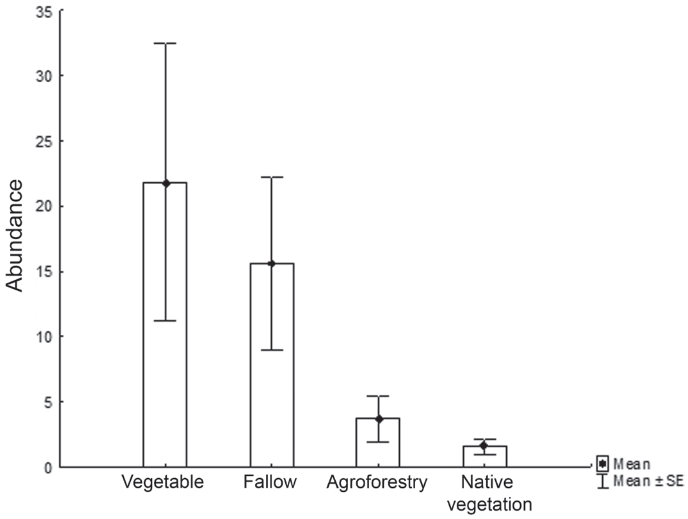

Fig. 2. Mean abundance (± SE) of Dolichopodidae flies collected in different rural properties with vegetable crops, fallow, agroforestry, and native vegetation in the Federal District, Brazil.

vegetation, contrary to the general patterns of community studies with other taxa. Generally, a reduction of biodiversity occurs due to the modification of natural habitats and intensification of land use (Pimm & Raven 2000; Flynn et al. 2010; Pacheco et al. 2013; Uchida & Ushimaru 2014; Lu et al. 2016).

This unexpected pattern may be partially explained by the organic management adopted on all sampled farms. For example, a meta-analysis study showed a positive effect on species richness and abundance of predatory insects in organic systems when compared with conventional systems (Bengtsson et al. 2005). In addition, in these areas there is a greater structural complexity of the landscape at different spatial scales, with consortium or polyculture plantations on a local scale, and in the surrounding areas with shrub species used as barriers between the plots, and maintenance of the spontaneous and native vegetation (Medeiros et al. 2011; Souza et al. 2015). Cropping systems with more diverse vegetation in the landscape are able to maintain high biodiversity and offset high-intensity management or local disturbance (Tscharntke et al. 2005, 2012; Letourneau et al. 2011), promoting more resilient agroecosystems, capable of reorganizing biodiversity after a disturbance (Tscharntke et al. 2011).

Furthermore, it was found that less disturbed habitats, such as agroforestry and native vegetation, are important also for the

Table 3. Descriptive indices of assemblages of Dolichopodidae flies collected in different habitats of vegetables, fallow, agroforestry, and native vegetation during the period from Mar 2012 to Feb 2013, Federal District, Brazil.

	Habitats			
	Vegetables	Fallow	Agroforestry	Native vegetation
Richness	59	38	28	19
Individuals	3,013	1,092	258	109
Margalef	7.913	5.289	4.862	3.837
Dominance_D	0.2503	0.1932	0.239	0.1812
Equitability_J	0.5183	0.5889	0.5928	0.739

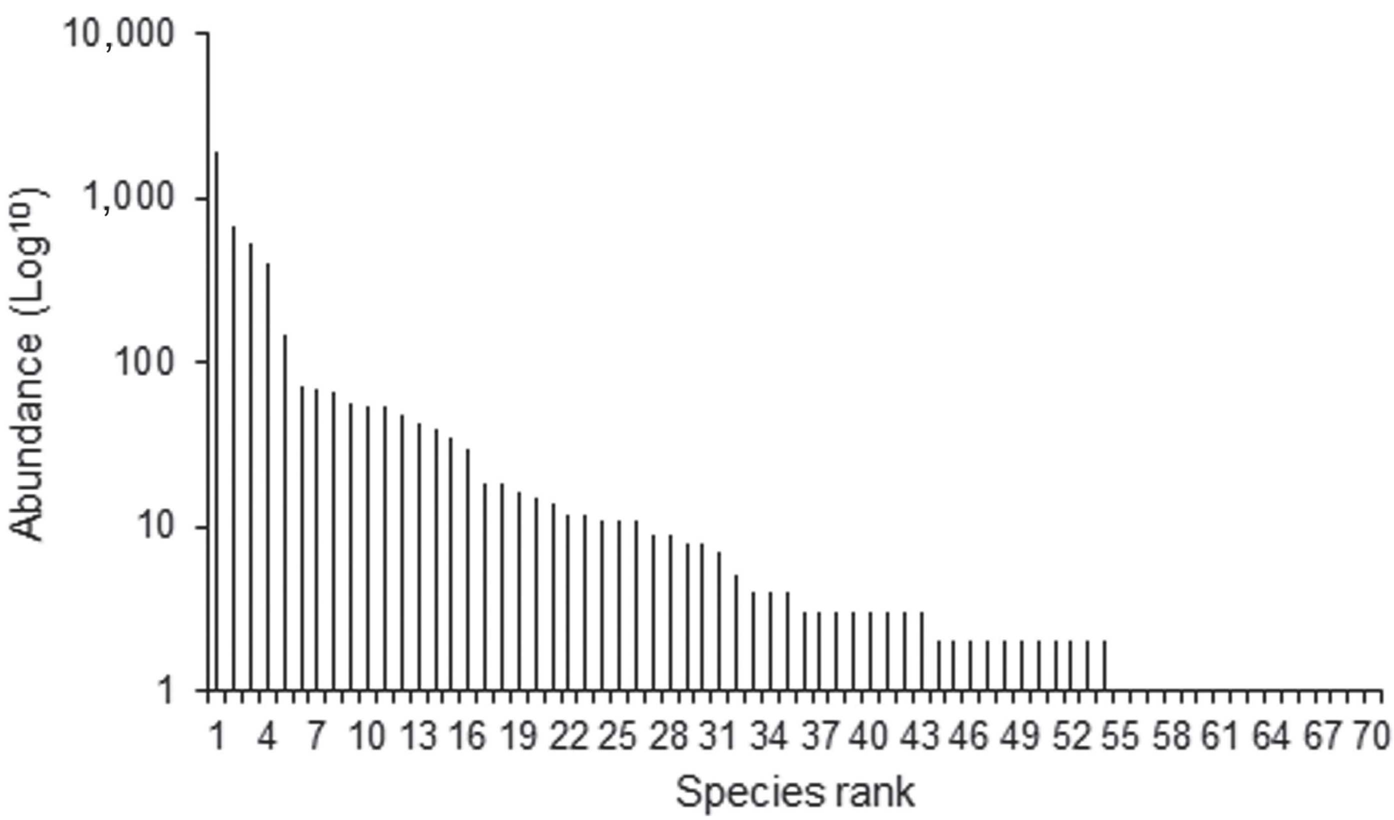

Fig. 3. Distribution of relative abundance by species of Dolichopodidae flies collected on organic farms producing vegetables in the Federal District, Brazil.

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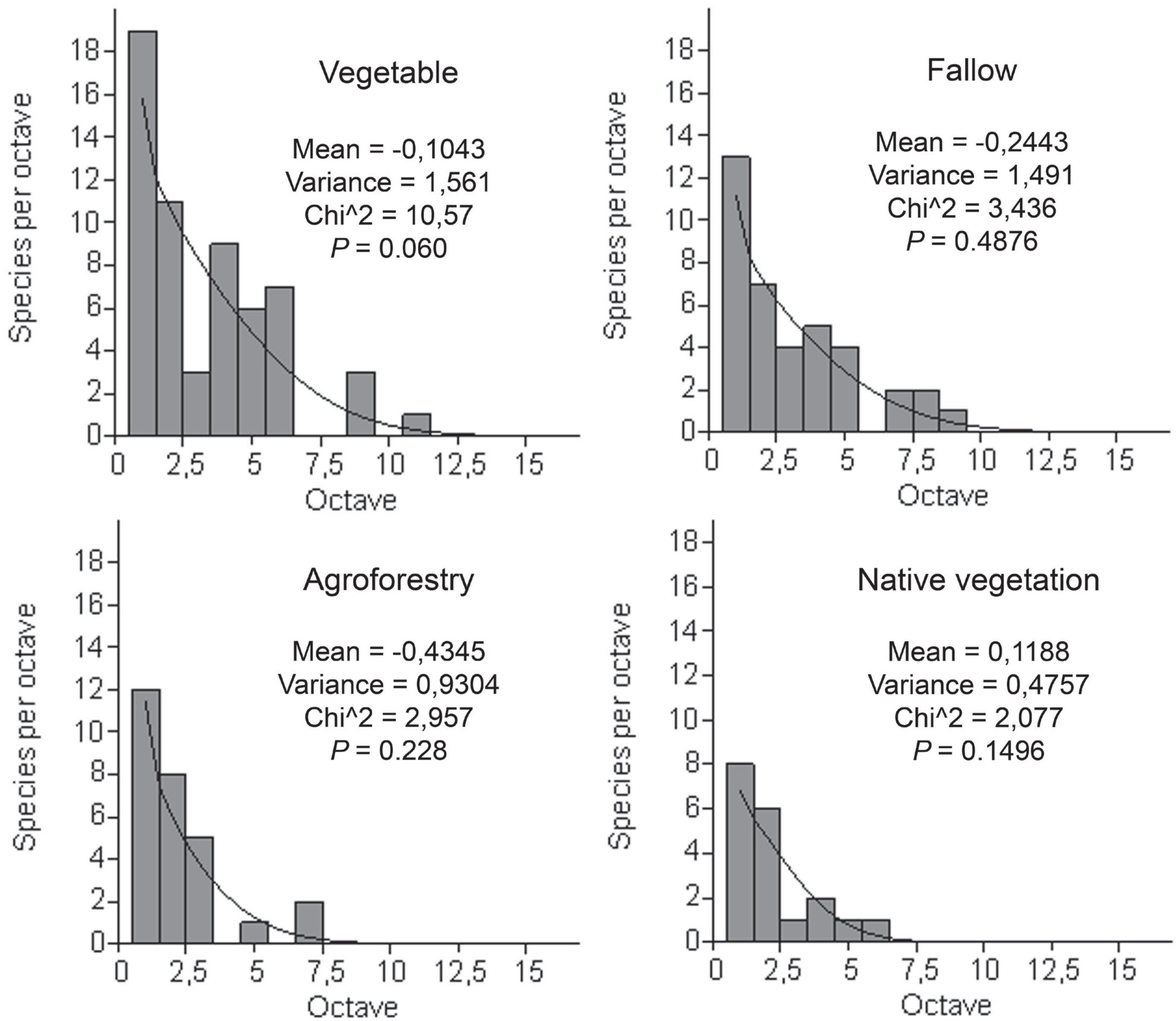

Fig. 4. Adjustment to the log normal distribution model of the Dolichopodidae assembly per habitat on organic farms producing vegetable in the Federal District, Brazil.

conservation of Dolichopodidae species. In these areas, there was a turnover in species composition and less overlap with disturbed areas. This change in composition possibly is related to groups of species that are more susceptible to disturbance, or not adapted to the environment modified by man as observed previously for some species of Calliphoridae and Drosophilidae (Nuorteva 1963; Mello et al. 2007; Mata & Tidon 2013). Additionally, the change in composition may be a response to a more specialized behavior regarding the nutritional habits of immature stages, but this needs further investigation. Thus, the maintenance of these habitats in the agricultural landscape is important for the conservation of dolichopodids over time.

The greater abundance and richness of Dolichopodidae species observed in organic farming of vegetable habitats suggests that they

Table 4. Beta diversity (Whittaker 1960) of assemblages of Dolichopodidae flies collected in different habitats of vegetables, fallow, agroforestry, and native vegetation during the period of Mar 2012 to Feb 2013, Federal District, Brazil.

Habitats	Vegetables	Fallow	Agroforestry	Native vegetation
Vegetables	0	0,3196	0,4023	0,6153
Fallow	0,3196	0	0,3939	0,50878
Agroforestry	0,4023	0,3939	0	0,5319
Native vegetation	0,6154	0,5088	0,5319	0

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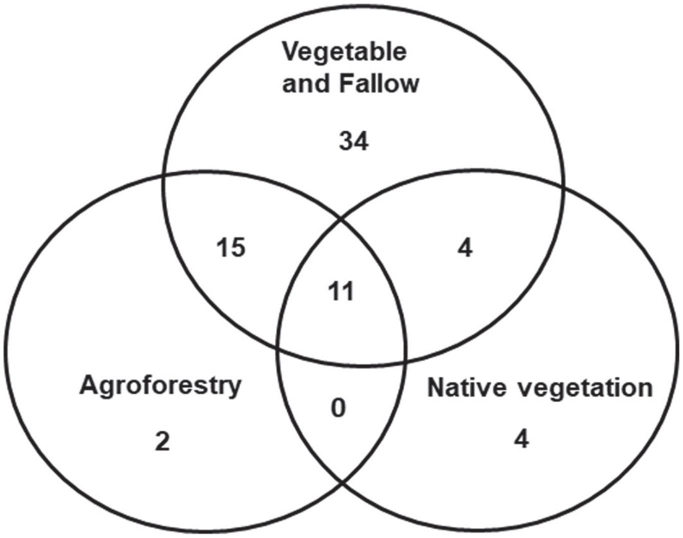

Fig. 5. Number of exclusive and shared (intersections) Dolichopodidae species in vegetable crops and fallow habitats, agroforestry, and native vegetation.

may function as primary habitats or potential quantitative sources of individuals to neighboring habitats, such as native vegetation and agroforestry, due to resource availability (e.g., quantity and quality). On the other hand, vegetation around the cultivated area also plays a role in conservation and population dynamics, such as species dispersal between primary (source) and temporary (sink) habitats, thus contributing to the maintenance of species over time. A general pattern of abundance and diversity has been found in this study, but the identification of mechanisms that directly affect the group needs further evaluation.

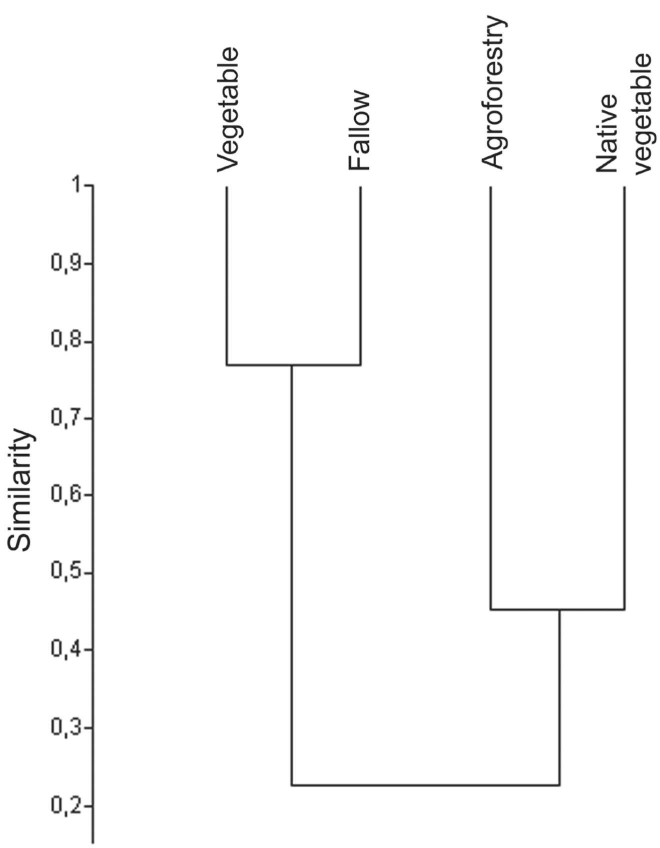

Fig. 6. Grouping of assemblies Dolichopodidae flies in different habitats: vegetables, fallow, agroforestry, and native vegetation based on coefficient similarity (Bray-Curtis) on organic farms cultivating vegetables in the Federal District, Brazil.

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