Parasitoid wasps in the Brazilian Savanna: adding complexity to the *Drosophila*-fruit system.

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Introduction

The *Drosophila*-wasp system is suited to disentangling physiological, genetic, and ecological interactions occurring among the partners of a host-parasitoid association. Moreover, understanding parasitoids may also contribute to comprehending the ecology and evolution of *Drosophila*, which cannot miss out the possible impact of parasites. Several species of wasps parasitize immature stages of drosophilids. They are considered parasitoids, because they can kill the host: they oviposit on fly larvae or pupae, and at the end of development the imago that emerges from the drosophilid pupa is a wasp.

In 1986, Carton *et al.* provided a substantial paper on the hymenopteran parasitoids associated with drosophilids. This overview raised a number of questions that were studied throughout subsequent decades, particularly host immune resistance and factors of parasitoid virulence and their possible pleiotropic effects (Prevost, 2009). The field ecology of these wasps, on the other hand, has been less studied. Geographical distribution, taxonomy, and host range are insufficiently documented for the four major groups of *Drosophila* parasitoids, especially in the tropical regions of America and Africa, where many new species remain to be described (Fleury *et al.*, 2009).

In this study, we analyze wasps and drosophilids that emerged from fruits collected in four ecological reserves in the Federal District of Brazil, located in the center of the Brazilian savanna.

Material and Methods

The landscape of the Brazilian savanna, locally known as the Cerrado biome, is a mosaic of vegetation types ranging from grasslands to forests (Ratter *et al.*, 1997). The average annual rainfall is 1500 mm, but the rains are heavily concentrated in the wet season, between November and March (Eiten, 1972), when most plants are fructifying. This study was conducted in four protected areas of the Federal District, located in the center of the biome: Estação Ecológica de Águas Emendadas - ESECAE (15° 34'26" S, 47° 34'58" W), Parque Nacional de Brasília - PNB (15° 43'56" S, 47° 55'53" W), Jardim Botânico de Brasília - JBB (15° 52'42" S, 47° 50'17" W), and Reserva Ecológica do IBGE (15° 56'31" S, 47° 52'41" W).

During each collection event, two collectors searched for 120 minutes for fallen fruit on the ground in each protected area. On these occasions, fruits of various species were collected, intact or partially degraded in different stages of decay. No more than 50 fruits from each plant species were collected in each area/day, but collectors rarely found more than this amount of fruit. Fruits were identified using field guides (Silva-Júnior, 2005; Silva-Júnior and Pereira, 2009; Kuhlmann, 2012), and in some cases a specialist was consulted. In the laboratory, the fruits were stored individually in plastic containers with vermiculite moistened with a solution of Nipagin ®, an inhibitor of filamentous fungi. These containers were covered with a thin, translucent piece of cloth to retain the insects that emerged from the fruit. All fruits were stored at a constant temperature (25°C). The flies and wasps that emerged from the fruits were removed every other day and stored in microtubules with 70% alcohol. The identification of the flies was based on taxonomic keys (Freire-Maia and Pavan, 1949), descriptions (Chassagnard and Tsacas, 1993), and on the male terminalia in the case of cryptic species (Vilela and Bächli, 1990). Wasps were determined based on taxonomic keys to the families (Triplehorn and Johnson, 2011) and to the genera (Burks, 1971; Wharton *et al.*, 1997; Buffington and Ronquist, 2006). Voucher specimens were deposited in the drosophilid collection of the Evolutionary Biology Laboratory of the *Instituto de Ciências Biológicas* at the *Universidade de Brasília*.

Results

We observed wasps emerging from eight species of plants: *Alibertia edulis* (Rubiaceae), *Cariocar brasiliense* (Cariocaraceae), *Diospyros hispida* (Ebenaceae), *Garcinia gardneriana* (Clusiaceae), *Erythroxylum suberosum* (Erythroxylaceae), *Syzygium jambos* (Myrtaceae), besides a species of *Syagrus sp*. (Arecaceae) and a non-identified yellow fruit. The abundance of emerged wasps and drosophilids (from the genera *Drosophila*, *Scaptodrosophila* and *Zaprionus*) is shown in Table 1.

Wasp samples were dominated by the genera *Aphaereta*, *Eurytona*, and *Leptopilina*, whereas drosophilids were represented mostly by *Drosophila paulistorum*, *D. cardini*, *D. simulans*, and *Scaptodrosophila latifasciaeformis* (Figure 1).

Table 1. Abundance of wasps and drosophilids emerging from rotting fruits collected in four protected areas of the *Federal District*, located in the center of the Brazilian savanna, from October 2010 to March 2011.

	Alibertia edulis	*Cariocar brasiliensis*	*Diospyros hispida*	*Erythroxylum suberosum*	*Garcinia gardneriana*	*Syagrus sp.*	*Syzygium jambos*	yellow fruit	total
Aphaereta	1	4	0	0	9	1	6	19	40
Eurytoma	0	0	20	0	0	0	0	0	20
Leptopilina	0	0	0	0	0	0	16	1	17
Nordlandiella	0	2	0	0	0	0	0	2	4
Bracon	0	0	0	0	0	0	0	2	2
Hormius	0	0	0	0	0	0	0	2	2
Apanteles	0	0	0	1	0	0	0	0	1
Total wasps	1	6	20	1	9	1	22	26	86
D. cardini	0	2	0	0	0	0	0	0	2
D. mediopunctata	1	0	0	0	0	0	0	1	2
D. mediostriata	0	1	0	0	0	0	0	0	1
D. mercatorum	0	3	0	0	0	0	0	0	3
D. nebulosa	0	56	0	0	0	0	2	22	80
D. paulistorum	0	1	0	0	0	0	0	0	1
D. willistoni	0	17	0	0	35	0	0	23	75
S. latifasciaeformis	0	0	0	0	6	0	0	0	6
D. malerkotliana	0	5	0	0	0	0	0	46	51
D. simulans	0	4	0	0	0	0	5	0	9
Z. indianus	2	32	0	0	0	0	9	3	46
Total drosophilids	3	121	0	0	41	0	16	95	276

E. suberosum (n=1, October 2010); *Syagrus sp*. (n=1, November 2010); *S. jambos* (n=6, November 2010); *A. edulis* (n=1, January 2011); *C. brasiliensis* (n=3, January 2011); *D. hispida* (n=2, February and March 2011), *G. gardneriana* (n=4, March 2011), yellow fruit (n=15, December 2010 to March 2011).

Discussion

Four of the seven genera of wasps belong to the family Braconidae, one of the most species-rich families of insects. The vast majority of braconids are primary parasitoids of other insects, especially upon the larval stages of Coleoptera, Diptera, and Lepidoptera but also including some hemimetabolus insects (aphids, Heteroptera, Embiidina) (Tree of Life, 2014). Almost one half of the emerged wasps belong to the cosmopolitan genus *Aphaereta* (Alysiinae), which includes 16 described New World species reared from at least 15 families of Diptera, mainly calyptrate muscoid flies (Wharton *et al*., 1997). The accurate identification of *Aphaereta* species is extremely difficult, because these species are exceedingly variable, and some of them attack a wide range of hosts in a variety of situations, promoting interpopulation variation (Wharton, 1977). The cosmopolitan genus *Bracon* (Braconinae) is extremely large, and in most parts of the world represents the vast majority of braconines collected. They are parasitoids of a wide range of coleopterous, lepidopterous, dipterous, and stem boring sawflies (Symphita) (Quicke and Sharkey, 1989). In

our samples, however, *Bracon* corresponded to only 2% of the wasps. Wasps of the genus *Hormius* (Hormiinae) also corresponded to 2% of the sample, and the parasitoids include gregarious ectoparasites of Lepidoptera living in silken retreats, mainly Gelechiidae and Tortricidae (Quicke, 2015). Little is known about this genus, despite specimens being fairly common. Finally, the wasps of the genus *Apanteles* (Microgastrinae), a common and extremely diverse genus (probably nearly 1000 species in New World), are mostly associated with Lepidoptera (Wharton *et al*., 1997); their relative abundance in this study was about 1%.

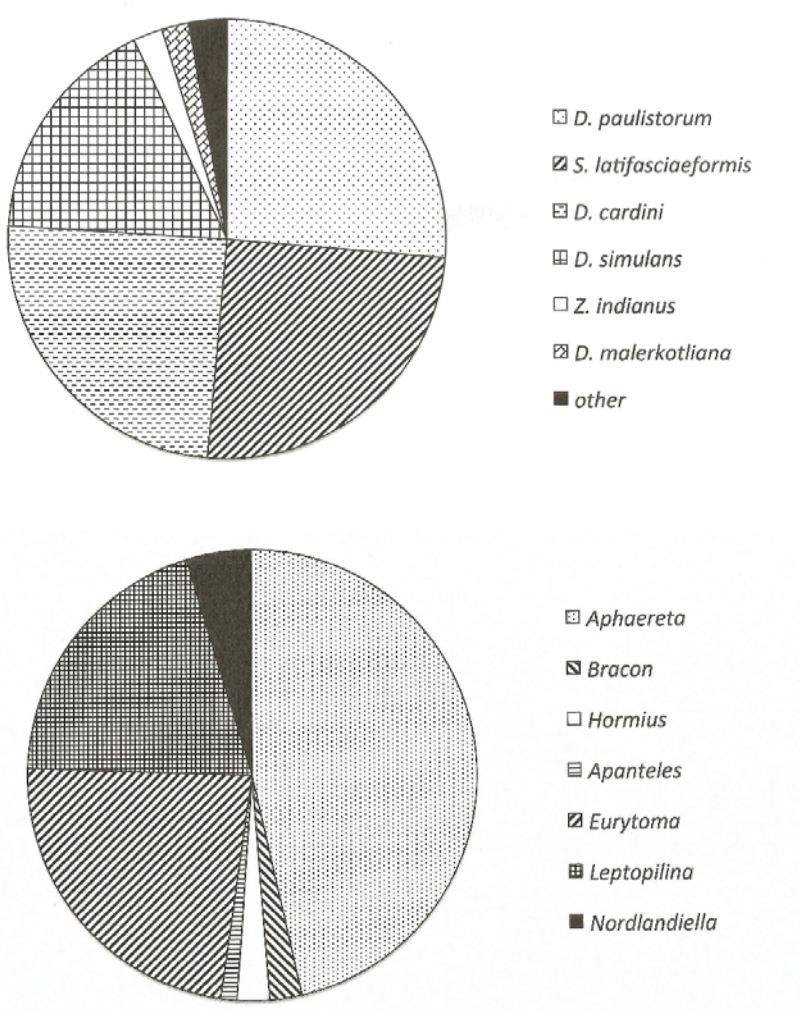

Figure 1. Relative abundance of drosophilids (above) and parasitoids (below) emerging from rotting fruits collected in four protected areas of the *Federal District*, located in the center of the Brazilian savanna, from October 2010 to March 2011.

The genus *Eurytoma* (Eurytomidae, Eurytominae) was the second in abundance (23% of specimens). This is the largest and most difficult genus in the family Eurytomidae, and includes hundreds of species throughout the world. Many of them are placed in *Eurytoma* not because they are greatly like the type-species, but because it has not as yet been possible to place them elsewhere. Almost all the generic characteristics of *Eurytoma* are, as a result, subject to exceptions. Some species of *Eurytoma* are phytophagous, others pass part of their larval development as parasites and then complete their growth by feeding on plant tissues (Burks, 1971). Most species of *Eurytoma* attack gall formers, especially Tephritidae, Cecidomyiidae, and Cynipidae. A few species parasitize Coleoptera or Lepidoptera. There are also species that parasitize sawflies, bees, wasps, and even primary parasites such as Braconidae and Echneumonidae (Gibson *et al*., 1997).

Finally, we found two genera of the family Figitidae. Both belong to the subfamily Eucoilinae, which are solitary endoparasitoids that oviposit in the larval stage of cyclorrhaphous Diptera. Eucoilines have been reared from hosts representing a wide range of microhabitats, and several species have been reared from flies breeding in fruit (Naturewatch, 2014). *Leptopilina* is one of the best-know genera of *Drosophila* parasitoids (Prevost, 2009), and it has already been collected in the Brazilian Savanna infesting *Zaprionus indianus* (Marchiori *et al.*, 2003). In this study it corresponded to 20% of the wasps emerged in fruits. *Nordlandiella*, on the other hand, is a less well-known genus and corresponded to about 5% of our sample.

Here we recorded seven wasp genera and 11 drosophilid species that emerged from fruits collected in the Brazilian Savanna. Therefore, we have no direct information on the parasitoid-host relationship, only an indication of the number of drosophilid species that can potentially be parasitized (Offenberger and Klarenberg, 1994). Besides, the identification of the wasps at the species level was virtually impossible. Our

goal, in future work, is to invest taxonomic efforts in parasitoid identification and/or descriptions, and to reveal the complex relationships among plant species (fruits), Drosophilids, and parasitoids.

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Records of *Zaprionus indianus* and *Drosophila suzukii indicus* as invasive fruit pests from mid valley region of Garhwal Uttarakhand, India.

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Abstract

The present work is the first record of *Zaprionus indianus* Gupta and *Drosophila suzukii indicus* Parshad and Paika (Diptera: Drosophilidae) as invasive fruit pests from mid valley region of Garhwal, Uttarakhand. Different life stages of these flies were observed in Sweet orange (*Citrus sinensis* L.) and Guava (*Psedium guajava*). The female *Drosophila suzukii indicus*, widely known as spotted wing *Drosophila*, with