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Beta diversity of four braconid subfamilies (Braconidae, Agathidinae, Braconinae, Doryctinae and Macrocentrinae) of the Ria Lagartos Biosphere reserve in Yucatan, Mexico, with some considerations on biological habits

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Abstract

The species diversity composition and phenological behaviour of four braconid subfamilies (Hymenoptera: Braconidae: Agathidinae, Braconinae, Doryctinae and Macrocentrinae) were monitored in three vegetation communities (dune vegetation, tropical deciduous forest and savannah) of the Ria Lagartos Biosphere Reserve (RLBR) in Yucatan, Mexico. Braconid wasps were collected with Malaise traps every 15 days over one year (June 2008 to June 2009). A total of 2,476 specimens were inventoried comprising 233 species and 63 genera. The composition of braconids and their lifestyles differed among the three vegetation communities studied. Doryctinae was the most diverse and abundant subfamily in RLBR (40 genera, 145 species, 990 specimens) and the tropical deciduous forest recorded the maximum abundance and diversity (H'= 4.1; alpha value= 1.059), with 61 exclusive species. Phenological sequence indicates an influence of the rainy season in braconid diversity, but its effects differed among braconid subfamilies and among the vegetation communities. Finally, the importance of the RBRL as a conservation site for this hymenopterous wasp is discussed.

Keywords
Neotropical, braconid wasps, abundance, conservation

Introduction

Parasitic Hymenoptera are extremely rich in species of terrestrial ecosystems, especially in tropical areas, and they are a group with a principally parasitoid lifestyle (Noyes 1989, Shaw and Hochberg 2001). Their sensitivity to environmental perturbations makes them good indicators of diversity and environmental stability (Delfín-González and Burgos 2000, Shaw and Hochberg 2001).

Braconidae is the second most diverse family in Parasitic Hymenoptera with about 40,000 species, although its richness is estimated at approximately 100,000 (Hanson and Gauld 2006). Specimens vary in size from 1 to 30 mm. The family is cosmopolitan (Gauld and Bolton 1988, Hanson and Gauld 2006) and members are parasitoids of other insects, mainly Diptera, Coleoptera, Lepidoptera and some Heteroptera (Askew 1971, Gillot 2005). Certain braconid females, called Idiobiont, feed on the host immediately, preventing further development, while others, called Koinobiont, allow the host to continue to reach maturity at a delayed rate. In both types of parasitism, the result is the same: death and potential reduction of future host populations (Quicke 1997). In a few cases, another feeding habit reported in braconids is phytophagy as gall formers (Marsh 1991, Infante et al. 1995, Wharton and Hanson 2005, Penteado-Dias and de Carvalho 2008, Chavarria et al. 2009, Centrella and Shaw 2010, 2013).

Knowledge of the diversity of braconids in Mexico is limited, with only a fraction of the potential species identified (Figueroa-De la Rosa et al. 2003), and few studies characterize the faunal composition of any site (Chay-Hernández et al. 2006, Pérez-Urbina et al. 2011, Ruiz-Guerra et al. 2015). In contrast, the composition and phenology of Braconidae has been documented in several regions of Brazil (Cirelli and Penteado-Dias 2003a, b, Scatolini and Penteado-Dias 2003, Barbieri and Penteado 2012, Souza et al. 2012).

The Ria Lagartos Biosphere Reserve (RLRB) in Yucatán, Mexico, belongs to the Yucatan Peninsula biogeographical province, characterized by areas not exceeding 200 m. altitude with a marine climatic influence. This biogeographic province includes ecosystems that are considered the most threatened globally and have only been the focus of a few faunistic studies (Ramírez-Barahona et al. 2009).

The diversity of Braconidae can be used as an indicator of environmental quality in tropical regions (Delfín-González and Burgos 2000, Barbieri and Penteado 2012), however this has never been evaluated in terms of Neotropical Mexican fauna. This research is the first undertaking of Mexican origin to document the diversity, relative abundance and annual distribution of adult activity of four braconid subfamilies in a region, employing a systematic sampling of three vegetative communities.

Materials and methods

Study area

The Ria Lagartos Biosphere Reserve is in the state of Yucatan, in the Southern Mexico (21°37'29.56"N and 21°23'00.96"N; 88°14'33.35"W and 87°30'50.67"W; 60,347.82 hectares, 100 masl) (Fig. 1). The biosphere is bordered on the north by the Gulf of Mexico; on the south by the municipalities of Tizimin, Rio Lagartos and San Felipe; on the west by the Dzilam State Reserve; and on the east by the Yum Balam Wildlife Protection Area. The climate in most of the reserve is very dry. Temperatures are homogeneous and range between 23 to 27 °C (Arriaga et al. 2002, CONANP 2007, CNA 2006). From June to October, the region receives 62% of the total annual rainfall, with the remaining 38% occuring during the dry season (November to May). The region also experiences between October and February a strong cold northeasterly wind which blows along the shore of the Gulf of Mexico called Norte. (Cuevas-Jiménez and Euán-Ávila 2009). Coastal dune vegetation is integrated with tropical xerophyte species, small and succulent big palms, as *Acanthocereus tetragonus* (L.), *Agave sisalana* Perrine, *A. vivipara* L., *Coccoloba uvifera* (L.)L., *Coccothrinax readii* H.J.Quero, *Pseudophoenix sargentii* H.Wendl. ex Sarg., *Opuntia dillenii* (Ker Gawl.) Haw., and *Thrinax radiata* Lodd. Ex Schult. & Schult.f. The dominant plants in the tropical deciduous forest are chandelier-shaped and succulent plants, mainly *Cephalocereus gaumeri* Britton & Rose, *Nopalea gaumeri* Britton & Rose, *Pterocereus gaumeri* (Britton & Rose) Th. acDoug. & Miranda, *Stenocereus griseus* (Hwa.) Buxb. This type of vegetation is expands from central to eastern areas of Ria Lagartos. Savannah are extensive areas covered with a mixed association of *Cladium* sp., *Phragmites australis* (Cav.) Trin. Ex Steud., and *Typha* sp. (INE 1999, CONANP 2007).

Specimen collection

A systematic sampling was taken from the three dominant types of vegetation on the reserve: tropical deciduous forest, savannah and dune vegetation. Cauich-Kumul et al. (2012) describe the ecological and botanical characteristics of each vegetation mentioned above. Among each type of vegetation, two sites were selected, each approximately two hectares in size. Two bidirectional Malaise traps (Townes 1972) were placed in the center of each area to prevent edge effects (Fig. 1). The traps (12 in total) collected samples for 365 days, from June 2008 to June 2009, and the collecting pots were replaced every two weeks (Gonzalez-Moreno and Bordera 2011).

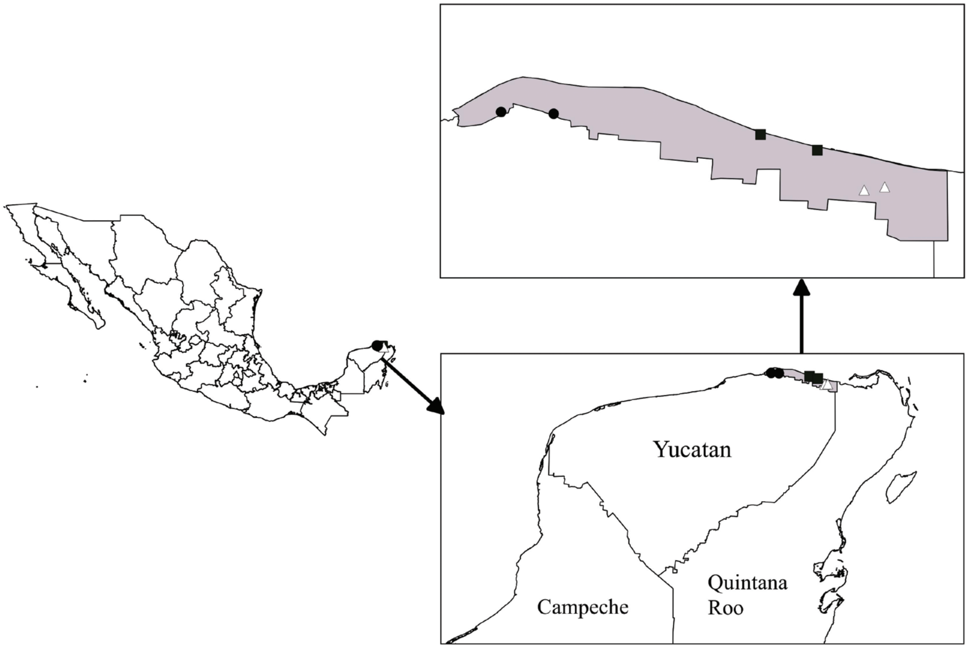

Figure 1. Ria Lagartos Biosphere Reserve, Yucatan, Mexico; black dots= savannah sites; black squares= dune sites; white triangles= tropical deciduous forest sites).

The braconid wasps were stored and handled in accordance with the curatorial standards proposed by Wharton et al. (1998). The taxonomic identification of the specimens was determined using specialized literature (Sharkey 1990, Berta de Fernandez 1998, Marsh 2002, Leathers and Sharkey 2006, Sarmiento-Monroy 2006) and verified by comparisong with specimens held at the Colección Entomológica Regional (CER-UADY) and the Hymenoptera Institute (University of Kentucky). The identified specimens were then deposited at CER-UADY.

Data analysis

Richness was characterized by the number of species found (Moreno and Halffter 2001) and using rarefaction curves (Jiménez-Valverde and Hortal 2003). The Shannon-Wiener index (*H'*) was used to assess diversity and evenness (E) of the four braconid subfamilies in each vegetation type, based on richness and abundance data (Halffter et al. 2001, Feinsinger 2003). The Solow test (1993) was employed to detect differences in braconid diversity among habitats, using Species Diversity and Richness 3.02 software (Henderson and Seaby 2002). To simultaneously compare patterns of species abundance and diversity among vegetation types, rank-abundance curves (Magurran 1988, Feinsinger 2003) were created. Beta diversity (spatial β) was calculated using the index of complementarity (Price 1984). This index highlights the difference in the species list from two habitats or communities as a percentage, to determine if the replacement of species is linked to factors such as the distance between habitats, vegetation structure or environmental heterogeneity (Colwell and Coddington 1994, Halffter and Moreno 2005, Pineda et al. 2005). Phenological graphs evaluated braconid flight patterns, with reference to the wet (June to August) and dry (March-May) seasons.

Classification of braconid biological host development strategies (koinobiont, idiobiont, phytophage) was followed according to Harvey et al. (2013). Reported information were used for the taxa identified (Shaw and Huddleston 1991, Wharton et al. 1998, Marsh 2002).

Results

Species richness

2,476 specimens of the four subfamilies were collected and classified under 63 genera and 233 species; 77 taxa were determined as morphospecies; 29 of these lack taxonomic keys; 15 are new species (Table 1). The subfamily with the highest number of species and specimens was Doryctinae, 145 and 990, respectively; Agathidinae exhibited the second highest, with 39 species and 942 specimens. The two subfamilies constitute 78.9% of all species and 78% of all specimens collected in the RLBR (Table 1).

The genus with the highest number of species was *Heterospilus* (18), followed by *Ecphylus* (17), *Bracon* (16), *Allorhogas* and *Macrocentrus* (10). Together these genera represented 30.4% of the species collected. The remaining 61 genera were represented by one to seven species. The tropical deciduous forest represented 39.2% of the specimens (168 species). Savannah and dune vegetation presented similar abundance and species richness (761 and 116; 745 and 120, respectively) (Table 2, 3).

Rarefaction curves do not reach an asymptote (Fig. 2), indicating that there are many uncollected species. Tropical deciduous forest composition could potentially be more diverse, and dune vegetation and savannah share similar numbers of species.

The tropical deciduous forest had the highest diversity value, according to the Shannon-Wiener index, while the lowest value was collected from savannah vegetation (Table 4). The Solow diversity contrast test (Delta values) demonstrated that the tropical deciduous forest is statistically more diverse than the savannah and dune vegetation; and the dune vegetation is more diverse than the savannah vegetation ($\alpha<0.05$) (Table 4).

Tropical deciduous forest community

This community was the richest in number of species and had the greatest equality value (Table 2, 3, 4). The most abundant species in this vegetation were: *Alabagrus albispina* (Cameron), with 139 specimens; *Macrocentrus* sp8, with 103 individuals; and *Heterospilus* sp17, with 34 specimens (Fig. 3). *Alabagrus albispina* and *Macrocentrus*

Table 1. Braconidae richness and abundance in the RLBR, Yucatan, Mexico.

Subfamily	Generic richness	Species richness	Abundance
Agathidinae	14	39	942
Braconinae	5	31	222
Doryctinae	40	145	990
Macrocentrinae	4	18	322
Total	63	233	2476

Table 2. Braconidae richness and abundance in three vegetation communities in the RLBR, Yucatan, Mexico.

Plant community	Subfamilies	Genera	Species	Specimens
Dune Vegetation	4	42	120	745
Savannah	4	44	116	761
Tropical Deciduous Forest	4	89	168	970

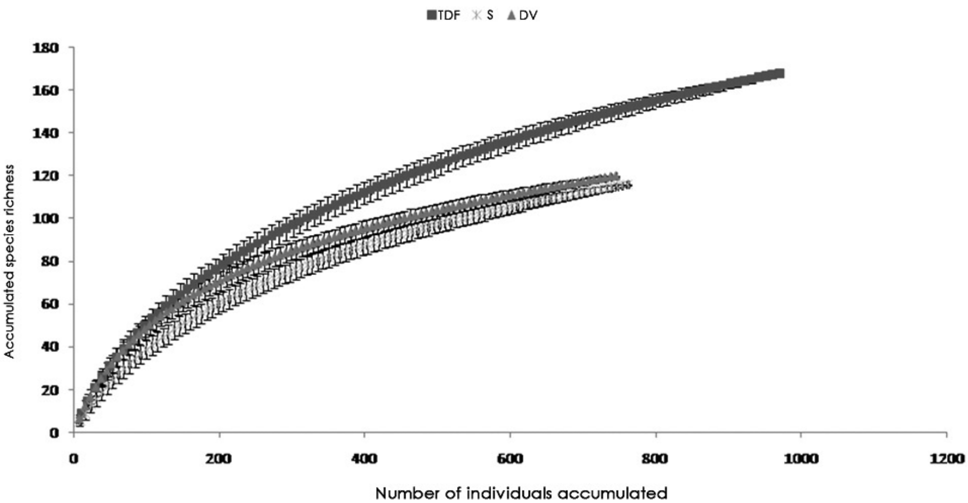

Figure 2. Species accumulation and rarefaction curves in three vegetation communities in the Ria Lagartos Biosphere Reserve, Yucatan, Mexico (TDF= Tropical Deciduous Forest, S= Savannah and DV= Dune Vegetation).

sp8 provide most of the abundance for this area (10%). The idiobiont strategy predominated, with 115 species, principally Doryctinae. Koinobionts were represented by 42 species. This type of community had the highest number of potential phytophagous species, with 11 species of *Allorhogas* (Table 3).

Savannah community

This vegetation type was the least equitable community studied, but the second with highest abundance, with a total of 761 specimens collected. The dominant species

Table 3. Life strategies and habitats for Braconidae genera collected in Ria Lagartos reserve, Yucatan, Mexico.

Subfamily	Genus	Host development strategy			Habitat		
		Idiobiont	Koinobiont	Phytophagous	Dune	Savannah	Tropical deciduous forest
Agathidinae	*Alabagrus*		X		X	X	X
	Amputoearinus		X		X		
	Cremnops		X				X
	Zacremnops		X			X	X
	Zelomorpha		X		X	X	X
Braconinae	*Atanycolus*	X			X	X	X
	Bracon	X			X	X	X
	Compsobraconoides	X			X		X
	Digonogastra	X			X	X	X
Doryctinae	*Acrophamus*	X			X	X	X
	Allorhogas			X	X	X	X
	Caigangia	X			X	X	X
	Callihormius	X			X	X	X
	Coiba	X			X	X	X
	Curtisella	X				X	
	Ecphylus	X			X	X	X
	Glyptocolastes	X			X	X	X
	Gymnobracon	X					X
	Hansoonorum	X				X	X
	Hecabolus	X				X	
	Heterospathius	X				X	X
	Janzenia	X			X		
	Johnsonius	X				X	X
	Labania				X		X
	Leluthia	X			X	X	X
	Masonius	X				X	X
	Notiospathius	X		X	X	X	X
Doryctinae	*Odontobracon*	X			X	X	X
	Pedinotus	X					X
	Pioscelus	X			X		X
	Platydoryctes	X			X	X	X
	Psenobolus				X	X	X
	Rhaconotus	X			X	X	X
	Spathius	X			X		
	Stenocorse	X		X	X		X
Macrocentrinae	*Austrozele*		X			X	
	Dolichozele		X				X
	Hymenochaoinia		X		X	X	X
	Macrocentrus		X		X	X	X

were *A. albispina*, with 340 individuals, followed by *Lytopilus* sp2, with 22 specimens (Fig. 3). Idiobiont species were more species-rich than koinbionts, with 77 and 32 species, respectively. The number of potential phytophagous species was equal to that one found among dune vegetation (7) (Table 3).

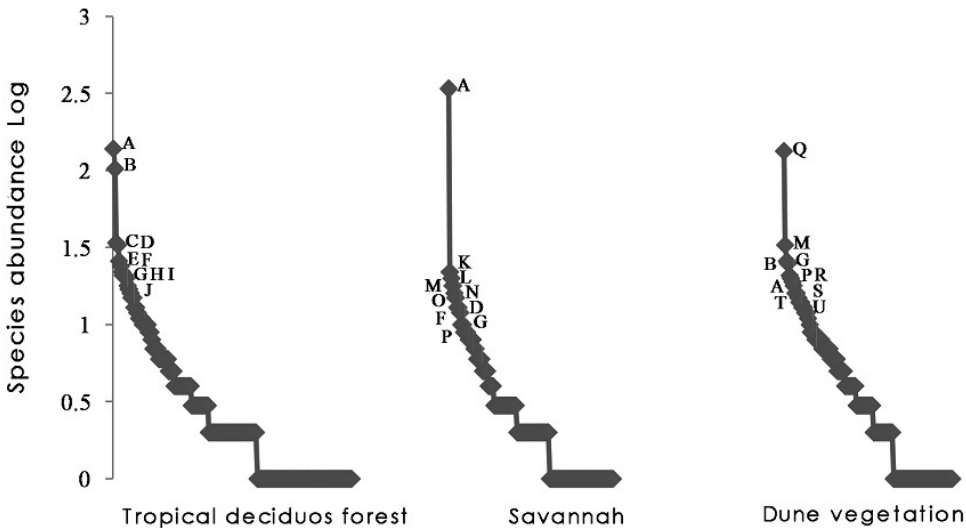

Figure 3. Braconidae rank/abundance curves in three vegetation communities in the RLBR (only the most abundant species are included). A= *Alabagrus albispina*, B= *Macrocentrus* sp8, E= *Macrocentrus* sp2, S=*Macrocentrus* sp6, C= *Heterospilus* sp17, D= *Heterospilus* sp2, F= *Heterospilus* sp12, G= *Heterospilus* sp8, H= *Heterospilus* sp3, I= *Heterospilus* sp4, J= *Heterospilus* sp6, N= *Heterospilus* sp1, K= *Lytopilus* sp2; L= *Bracon* sp4, O= *Bracon* sp2, M= *Zelomorpha arizonensis*, P= *Zelomoropha lenisterna*, Q= *Cremnops ferrugineus*, R= *Cremnops melanoptera*, T= *Coiba woldai* and U= *Zacremnops cressoni*.

Dune vegetation community

This vegetation community had richness and equity values similar to that of tropical deciduous forest (Table 4), but it was less abundant in specimens (Table 2). The dominant species were *Cremnops ferrugineus* (Cameron) and *Zelomorpha arizonensis* Ashmead, which provided the highest abundance recorded for this area, with 134 and 33 specimens, respectively (Fig. 3). The composition of life history strategies was similar to that reported for savannah vegetation, with 29 koinobiont and 84 idiobiont species. The number of potential phytophagous species was also similar to that observed in the savannah (7 species) (Table 3).

Beta diversity (β)

The results obtained through the index of complementarity indicate that the tropical deciduous forest and the savannah had the highest value, with 83% and 77 species shared. The second highest value was for tropical deciduous forest and dune vegetation at 80%, sharing 88 species. Finally, for the savannah and dune vegetation the complementarity index was 69% with 64 shared species (Fig. 4). Overall, the values calculated represent relatively high beta diversity for Braconidae in the RLBR.

Table 4. Diversity indexes and number of braconid species collected according biological host development strategies and three vegetation communities in the RLBR.

	Tropical deciduous forest	Savannah	Dune vegetation
Shannon-Wienner (H')	4.1	3.1	3.9
Delta ($\alpha < 0.05$)	1.059	0.144	0.915
Koinobiont	42	32	29
Idiobiont	115	77	84
Phytophagous	11	7	7

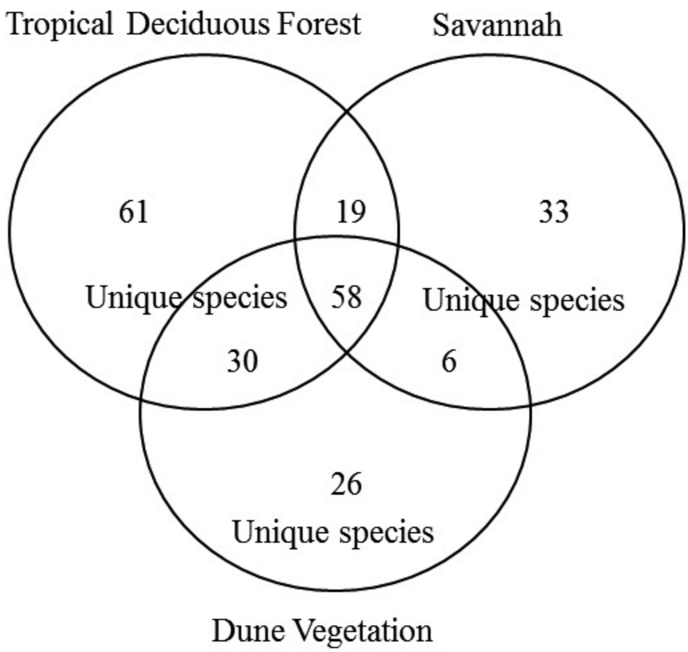

Figure 4. Exclusive and shared Braconidae (Insecta: Hymenoptera) species in three vegetation communities in the RLBR, Yucatan, Mexico.

Braconidae phenology

Braconidae wasps are active throughout the year, but the number of species and individuals varied across the collection period. 73 species were collected in the rainy season, while 64 were collected during the driest months. June was the month with the highest species richness during the rainy season (66 species), while April exhibited the highest species richness during the dry season (57 species). In November and December (*Nortes* season), braconid activity was low, with only 34 species collected and a maximum richness reported in November with just 26 species. *Amazondoryctes bicolor* Barbalho

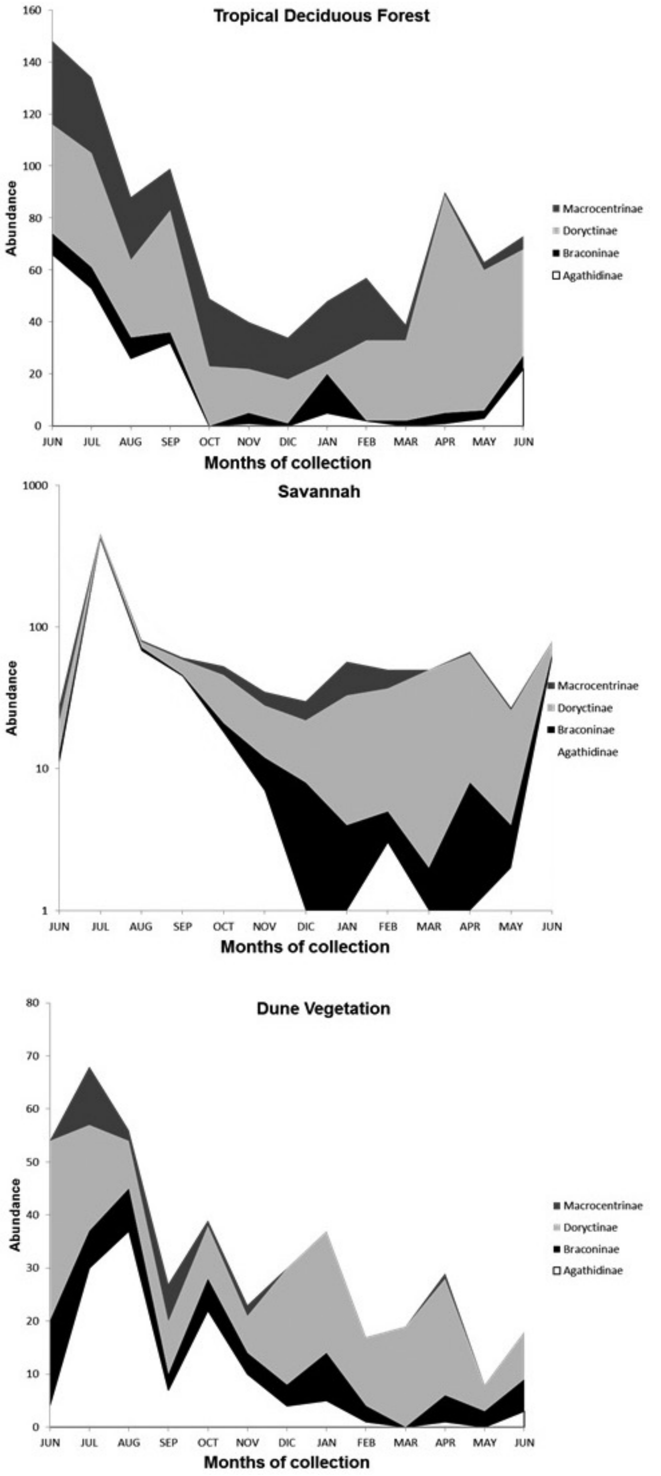

Figure 5. Phenology of four Braconidae subfamilies (Agathidinae, Braconinae, Doryctinae and Macrocentrinae) in three vegetation communities in the RBRL, Yucatan, Mexico.

and Penteado-Dias, *Coiba woldai* Marsh, *Hansonorum carolinae* Marsh, *Odontobracon janzeni* Marsh, *O. nigra* Marsh, *O. nigriceps* Cameron, *Rhaconotus chrysochaitus* Marsh and *R. rugosus* Marsh, were collected throughout the year. Except in the tropical deciduous forest, Agathidinae was abundant in all the vegetation zones, peaking in June (tropical deciduous forest), July (savannah) and August (dune vegetation) (Figure 5). In the tropical deciduous forest, Doryctine abundance peaked in June. Agathidinae was the subfamily least represented in the tropical deciduous forest. Macrocentrinae abundance was highest in the dune vegetation and in the tropical deciduous forest.

Discussion

The 233-species recorded in this study exceed the diversity and abundance reported by other authors for a single ecosystem; Whitfield and Lewis (1999) mentioned 23 subfamilies, 84 genera and 251 morphospecies in Arkansas, USA; Idris and Hasmawati (2002) reported 19 subfamilies and 95 morphospecies in disturbed Sengalor forests of Malaysia. In Brazil, the number of subfamilies recorded from one locality varies widely, from 10–17 subfamilies, 19–56 genera, but without a clear definition of the species collected (Scatolini and Penteado-Dias 2003, Barbieri and Penteado 2012, Souza et al. 2012). In Mexico, the only comparable study is from Chay-Hernández et al. (2006), who collected 21 subfamilies, 84 genera and 342 species in cultivated areas in Yucatan; and Pérez-Urbina et al. (2011), with 25 subfamilies, 130 genera and 156 species in a locality from Tamaulipas. The latter study showed that braconids exceeded the diversity of its sister group, Ichneumonidae, in the same locality. González-Moreno and Bordera (2012) recorded 148 Ichneumonidae species for the RLBR. Ruiz-Guerra et al. (2015) recorded 65 species and 15 subfamilies in a region of Veracruz. Our results suggest that Yucatan State has the highest number of braconid species and genera in the country.

The greater diversity of braconid wasps reported in this study, as compared to other studies, is most likely a result of using 12 Malaise traps to take samples, which is the best method for catching ichneumonoids (Papp 1999, Fraser et al. 2008). Replicas of sampling sites were also made. Species richness of Ichneumonoidea is underestimated globally, and in Neotropical environments the systematic use of Malaise trapping is increasing our knowledge of its diversity (Sääksjärvi et al. 2004, Cauich-Kumul et al. 2012, González-Moreno and Bordera 2012).

With the results obtained in this work, the community of Braconidae in Yucatan is becoming the most identified in Mexico, in terms of diversity and taxonomic classification, even with many taxa still to describe (López-Martínez et al. 2011, Cauich-Kumul et al. 2014).

Diversity of Braconidae in the three vegetation sites sampled

The braconid subfamily alpha diversity reported here may be the result of plant complexity and the resulting diversity of host availability. Tropical deciduous forests in the Yucatan have up to 103 different species of woody plants in a small area (0.1 hectare) (Gutierrez et al. 2011). By example, a large proportion of palm genera and subfamilies reported from Mexico are in Yucatan tropical deciduous forests (Alvarado-Segura et al. 2012).

In RLBR Doryctinae had the highest abundance and species richness. This is the second most diverse subfamily of Braconidae, with at least 200 genera in the Neotropics (Marsh 2002). In the present study we collected 145 species belonging to 40 genera (Table 1), representing 20.5% of all Neotropical doryctine genera. The subfamily exhibits a broad host range primarily on larval Coleoptera (Bruchidae, Bostrichidae, Buprestidae, Cerambycidae, Curculionidae, Proterrhinidae), but also on Lepidoptera (Brachodidae, Crambidae, Gelechiidae, Phycitidae, Pyralidae and Pyraustidae) (van Achterberg and Shaw 2010), and rarely Symphyta (Xiphydriidae) and Embioptera (Belokobylskij et al. 2004). Phytophagy is another biological habit registered for doryctines (Marsh 1991, Infante et al. 1995, Penteado-Dias and de Carvalho 2008, Chavarria et al. 2009, Centrella and Shaw 2010). This variety of habits provides Doryctinae with numerous possibilities to exploit biological resources in different ecosystems.

In contrast, the low abundance and diversity of Braconinae may be a consequence of the distribution of its subfamily. Although it is cosmopolitan, it is more diverse in the Old-World tropics (Penteado-Dias et al. 2007).

With respect to the diversity between habitats, the greatest similarity occurred in the tropical deciduous forest and dune vegetation communities (88 species in common). We suggest that the low β diversity found in the studied area may be the result of a higher proportion of generalist idiobionts species (Askew and Shaw 1986). The changes in the spatial structure, such as patch types or an increase in patch isolation, could modify the capacity of these organisms to disperse. Likely, the generalist idiobiont species cannot disperse effectively because of a change in structure, suffering decreases in regional population sizes (Fahrig and Merriam 1994). In addition, the three ecosystems have completely different vegetation cover that could impact the species diversity (CONANP 2007).

Life strategies: koinobionts, idiobionts and phytophagous

Molecular evidence suggests that the common ancestor of Ichneumonoidea was a concealed host idiobiont parasitoid (Belshaw and Quicke 2002). Koinobiosis is considered a more derived characteristic than idiobiosis in Braconidae, despite the high percentage of koinobiont species (Wharton 1993, Kasparian 1996). The specialization of the koinobiont species in the subfamilies studied in the RLBR is common and is possibly due to the strong selection pressure which led them to modify and develop certain characteristics to maintain these high abundance levels over time (Thompson 1994).

The idiobiont life strategy (generalists) was consistent among the four subfamilies and in all three types of vegetation studied. It was present in greater abundance in the tropical deciduous forest (49%). In this habitat *A. albispina* had the greatest number of individuals. The koinobiont life strategy had the highest proportion of species in the tropical deciduous forest (18%) and in the dune vegetation (12%) (Table 3). However, our findings cannot explain the influence of vegetation type on the braconid biological traits distribution. Perhaps, the inclusion of highly diverse koinobiont subfamilies like Microgastrinae, Alysiinae and Opiinae could provide more clarity on this topic. Based on previous works (Owen and Owen 1974, Rathcke and Price 1976, Janzen 1981, Hawkins 1990), koinobionts species richness is lower in the tropics, but richness of generalist idiobiont species exhibit high values. However, Askew and Shaw (1986), Wharton (1993) and Hawkins (1994) argue that idiobionts species are less abundant in the tropics. Chay (1999), Cicero (2002), González (2002), Burgos (2003) and Chay-Hernández et al. (2006), mention that koinobionts species increase according to the degree of habitat disturbance, which can be compared to the study of Restello and Penteado-Dias (2006) in Brazil, where they conclude that braconids are more abundant in areas with some degree of modification.

Phytophagy has been a well-known phenomenon identified in Braconidae since 1989, when Macêdo and Monteiro reported an undetermined species of *Allorhogas* as a consumer of Leguminosae seeds. Phytophagous braconids primarily produce galls on stems and fruits, from feeding on seeds or fruits, and feed on species of Araceae, Burseraceae, Fabaceae, Melastomataceae, Mimosaceae, Moraceae, Proteaceae, Rubiaceae and Solanaceae. The phytophagic life strategy occurs primarily in the Neotropics, in species of *Allorhogas*, *Bracon*, *Monitoriella* and *Psenobolus* (Marsh, 1991, Infante et al. 1995, Ramirez and Marsh 1996, Marsh et al. 2000, Marsh 2002, Flores et al. 2005, Centrella and Shaw 2010, Martinez et al. 2011, Perioto et al. 2011, Shimbori et al. 2011, Centrella and Shaw 2013). The number of potential phytophagous species collected in the RLBR are represented in 75% of the genera known with this biological trait and indicate a future need to determine the interactions between host plants and phytophagous braconids, its abundance and its role in the vegetation composition.

Braconidae phenology

The largest number of individuals and species (1050 and 73, respectively) was collected during the rainy season (June-July), a result which correlates with that reported by Falcó et al. (2006); while the lower specimen abundance and species-richness occurred in the dry season (February-March), with 233 individuals and 57 species. Rain favors the profusion of plants and its associated phytophagous and xylophagous insects, which are the potential hosts on which parasitoids depend (Falcó et al. 2006). The rainy season is also when foliage, fruits and seeds provide niches and nutrients for the development of herbivore species.

Our results do not match those reported by González (2002), who concluded that Braconidae communities reach higher abundances in the dry season. Rain is considered a factor that negatively affects the movement of small Hymenoptera species (Speight et al. 1999). Evidently, this was not the case in our study, as similar abundances or small sized species of the four Braconidae subfamilies were collected in both dry and rainy seasons.

The seasonality of koinobiont braconids is determined by the phenology of their hosts (Memmott et al. 1994, Wolda 1988). Idiobionts typically have a wider host range (Sharkey 1993) and are not necessarily synchronized with the life cycle of any one host, but rather by abiotic factors (Memmot et al. 1994). Random patterns might be expected over time.

Ría Lagartos Biosphere Reserve significance

The RLBR is the only nesting site of the pink flamingo (*Phoenicopterus ruber* L. *ruber*) in Mexico (Fraga 2006), with a high fish species-richness in the coastal area (Peralta-Meixueiro and Vega-Cendejas 2011) and a growing reported insect richness (González-Moreno and Bordera 2011, 2012, Cauich-Kumul et al. 2014). Cué-Bär et al. (2006) granted the RLBR and other Mexican areas with priority conservation status, based on the unique composition of tree species. Floral richness has a direct impact on the Hymenoptera richness, which has been demonstrated in the sister group of Braconidae, Ichneumonidae (Sääksjärvi et al. 2006).

Conclusion

Ria Lagartos Biosphere Reserves with distinctive vegetation types support a vast diversity of four braconid wasp subfamilies (Agathidinae, Braconinae, Doryctinae, Macrocentrinae) in Yucatan, Mexico. It benefits one of the most diverse and abundant braconid subfamilies, Doryctinae, which recorded 40 genera, 145 species, and 990 specimens. Such abundance of species allows us to hypothesize about the existence of several parasitism relationships and the existence of many unknown hosts.

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Supplementary material 1

Life strategies and habitats for Braconidae species collected in Ria Lagartos Biosphere Reserve, Yucatan, Mexico

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