

Diversity of hymenopteran parasitoids (Hymenoptera: Chalcididae) associated with teak (*Tectona grandis*) forests

Rogério Goularte Moura Gomes de Oliveira^{1*} Evoneo Berti Filho¹ Otávio Peres Filho² Fernando da Paixão Sales¹ Joana América Castellar da Cunha³

¹ Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo (ESALQ/USP), Av. Pádua Dias, 11, Caixa Postal 09, 13418-900, Piracicaba-SP, Brazil.

² Faculdade de Engenharia Florestal, Universidade Federal de Mato Grosso (UFMT), Av. Fernando Corrêa da Costa, 2367, Boa Esperança, 78060-900, Cuiabá-MT, Brazil.

³ Universidade Federal de São Carlos (UFSCar), Rodovia Anhanguera, km 174 - SP-330, 13600-970, Araras-SP, Brazil.

* Author for correspondence: rogerio@arboreo.net

Received: 29 April 2014 / Accepted: 10 May 2014 / Published: 29 June 2014

Abstract

This research evaluated the diversity of hymenopteran parasitoids (Hymenoptera: Chalcididae) at different reforestation sites of *Tectona grandis*. Insects were collected with Malaise traps from October 2009 to September 2010. One collected a total of 414 Chalcididae specimens distributed in 3 genera and 16 species. *Brachymeria* and *Conura* were the most representative genera with 14 species. The site bordered by pasture vegetation presented a higher number of collected specimens when compared to the other sites. *Brachymeria pandora* and *Ceyxia ventrispinosa* occurred as super dominant, super abundant, super frequent and constant species.

Key words: Teak; Malaise trap; Diversity, *Brachymeria*; *Conura*.

Diversidade de himenópteros parasitoides (Hymenoptera: Chalcididae) em reflorestamento de teca (*Tectona grandis*)

Resumo

O objetivo deste trabalho foi avaliar a diversidade de himenópteros parasitoides (Hymenoptera: Chalcididae) em diferentes sítios de reflorestamento de *Tectona grandis*. Foram feitas coletas semanais, usando armadilhas de Malaise, de outubro de 2009 a setembro de 2010. Foram coletados 414 espécimens de Chalcididae, distribuídos em 3 gêneros e 16 espécies. *Brachymeria* e *Conura*, com 14 espécies, foram os gêneros mais representativos. Comparado aos outros sítios, o sítio com vegetação de pastagem adjacente apresentou maior número de espécimens coletados. *Brachymeria pandora* e *Ceyxia ventrispinosa* ocorreram como espécies super dominantes, super abundantes, superfrequentes e constantes.

Palavras-chave: Teca; Armadilha de Malaise; Diversidade; *Brachymeria*; *Conura*.

Introduction

Currently there is a great interest in knowing the functioning of forest ecosystems, especially concerning their productivity. Ecologically speaking, not only the productivity is important, but also the maintenance of long-term equilibrium, which depends largely on the cycling of nutrients, which in turn depends on the interactions among organisms in the environment. This process occurs in both natural and man-made ecosystems, being strongly influenced by the complexity of life forms that make up the food chain (Lira et al. 1999). The initial stage of the knowledge of natural resources available in a given region corresponds to the collecting and taxonomic identification of the species that compose the fauna and the flora thus

obtaining data for further more detailed studies on the ecological characteristics of their habitats. Such studies may eventually lead the techniques for the rational exploration of biotic and abiotic resources of the environment studied (Prado 1980).

Tectona grandis is a forest species widely planted in Mato Grosso State, where it was introduced in 1967, and has been commercially planted since 1971. Nowadays one can find plantations in the following Brazilian states: Acre, Amazonas, Amapá, Bahia, Goiás, Mato Grosso do Sul, Minas Gerais, Pará, Paraná, Rondônia, São Paulo and Tocantins (AMEF 2002; Schleder 2004; ABRAF 2013). The forester Edmundo Navarro de Andrade, from the Forest Station of Rio Claro, State of São Paulo, and the Botanical Garden of Rio de Janeiro, State of Rio de Janeiro, reported the cultivation of this forest species in the beginning of the twentieth century. Later on Professor Heládio do Amaral Mello from the College of Agriculture Luiz de Queiroz, in Piracicaba, State of São Paulo, set an experimental planting of *T. grandis* in 1953, and observed that this forest species was very promising for wood production, when compared to other native forest species used in the experiment (Sampaio 1930; Mello 1963). Parasitoids, the largest group of species in the Hymenoptera, are common and abundant in all the terrestrial ecosystems. They may develop internally (endoparasitoids) or externally (ectoparasitoids) in a number of arthropods, especially insects. Because they are extremely important on the control of other insect populations, due to their ability in responding to the population density of their hosts, they are widely used in biological control programs (Lasalle 1993; Parra et al. 2002).

As to the Brazilian savanna areas several surveys were carried out in different regions with native vegetation, and cotton and soybean crops in order to identify the families of Hymenoptera parasitoids occurring in these environments, as well as their relative frequencies (Perioto 1991; Marchiori et al. 2001; Braga 2002; Perioto et al. 2002a; Perioto et al. 2002b; Cirelli and Pentead-Dias 2003; Marchiori et al. 2003a; Scatolini and Pentead-Dias 2003; Silva et al. 2003).

Due to the lack of information on Chalcididae parasitoids (Hymenoptera) in plantations of *Tectona grandis*, this research aimed at studying the parasitoid diversity and determine the richness and faunal indices of parasitoids in reforestation of *T. grandis*. The data obtained were used to evaluate the similarity among the environments and estimate the number of species at each site.

Material and methods

The sampling of Hymenoptera parasitoids was performed in “cerrado” (savannah) and *T. grandis* reforestation areas located in Cáceres, State of Mato Grosso,

Brazil which geographic coordinates are 15° 11' 09'' South Latitude, and 58° 11' 20'' West Longitude. Altitude between 110 and 130 meters high, total area of 7,378.30 ha, being 233.88 ha planted in 2006; 207.67 ha planted in 2005; and 3,712.34 ha planted in 2000 and 2001; 1,247.65 ha of pasture; 1,527.37 ha of legal reserve; 16.74 ha of permanent preservation areas; 7.88 ha of remnant native vegetation, and 123.77 ha of wildlife corridors.

The area of adjacent savanna is composed by native vegetation of pioneer formations, wooded savanna ("cerradão") and grassy-woody savanna (field). These three vegetation types (phytophysognomies) represent 75% of the vegetation covering in the subregion of Cáceres. The pioneer formations are vegetation of first occupation with fluvial influence (Abdon and Silva 2006).

One sets 5 Malaise traps model Townes (1972a) in an area embracing reforestation of *Tectona grandis* and native vegetation fragments (Figures 2 and 3). The advantages of using this type of trap is that it captures either day or night insects by intercepting their flights, for it does not depends on any attractive substance (Townes 1972b; Owen et al. 1981). The trap 1 was set inside the native forest fragment (site 1). The trap 2 was set inside *T. grandis* cultivation with adjacent native vegetation (site 2). The trap 3 was set within *T. grandis* cultivation with adjacent vegetation of *T. grandis* (site 3). The trap 4 was set inside *T. grandis* cultivation with adjacent pasture vegetation (site 4) and trap 5 was set inside *T. grandis* cultivation with adjacent vegetation of pasture and native forest (site 5).

The parasitoids were sampled weekly from October 2009 to September 2010. The collecting recipients were removed from the traps and the contents were transferred to plastic bottles (240 mL) properly identified and labeled and then transported to the laboratory of Forest Entomology, Department of Entomology and Acarology, "Luiz de Queiroz" College of Agriculture, University of São Paulo, in Piracicaba, State of São Paulo. The collected materials were taken off the plastic bottles, passed through a fine sieve and separated in the laboratory by using a stereoscopic microscope and transferred to glass vials in 70% ethanol, properly labeled, and stored. The identification of the family of parasitoids was accomplished by using dichotomous keys (Triplehorn and Johnson 2011). The studies of population dynamics were performed using as a basis the data of the sampling in the traps. Concerning the population analysis one employed faunal indices compared with each other, according to the methodology proposed by Silveira Neto et al. (1976).

Results and discussion

One collected 414 specimens belonging to of Chalcididae distributed in 3 genera and 16 species. *Conura* with 14 species (90%) was the most representative number of species collected. Quantitatively, *Brachymeria* and *Conura* were the most representative genera, corresponding respectively to 120 and 197 individuals (Table 1).

This is the first report of these respectively parasitoids on *Tectona grandis* forest in Brazil, however, in other countries they have already been recorded. According to Javaregowda (2005) *Brachymeria euploea*, *B. obscura*, *B. hearwy*, *B. lasus*, *B. lugubris* and *Psilochalcis carinigena* were cited occurring in *Hyblaea puera* pupae (Lepidoptera: Hyblaeidae) in *Tectona grandis* plantations in Dehradun, Nilambur and Kerala in India by Mathur (1960); Mohanadas (1996) and Nair et al. (1997). Sudheendrakumar (1986), researching diversity natural enemies of *Hyblaea puera* and *Eutectona machaeralis* in plantations of *Tectona grandis* in Kerala, found pupae parasitized by *Brachymeria lasus* and *Brachymeria himeattevae*.

Brachymeria is a cosmopolitan genus with about 200 described species, of which at least 42 occur in the Neotropics (Delvare 2006). Noyes (2003) listed a large number of hosts in about 30 families of Lepidoptera. In Brazil the species of *Brachymeria* parasitize pupae of several species of Lepidoptera which are considered forest pests (Ohashi 1984). Ohashi (1978) demonstrated that *B. ovata* parasitism reached about 80% of pupae of *Eupseudosoma aberrans* and *E. involuta* (Lepidoptera: Arctiidae), being the most efficient parasitoid. He also noted that this parasitoid attacks other important forest pests like *Thyrintina arnobia* (Lepidoptera: Geometridae); *Euselasia euploea eucerus* (Lepidoptera: Riodinidae) and *Glena* sp. (Lepidoptera: Geometridae).

Table 1. Amount and percentage (%) of genera, species and individuals taxonomically identified and collected with Malaise traps in plantations of *Tectona grandis* located in Cáceres, State of Mato Grosso, Brazil.

Genera	Species		Individuals	
	Amount	%	Amount	%
<i>Brachymeria</i>	1	5.00	120	28.99
<i>Ceyxia</i>	1	5.00	97	23.43
<i>Conura</i>	14	90.00	197	47.58
Total	16	100.00	414	100.00

The occurrence of *B. pandora* was recorded in South America, in British Guiana (Crawford 1914) as a larval parasitoid of undetermined species of Hesperidae, and in Venezuela, as parasitoid of pupae of *Calpodex ethlius* (Lepidoptera: Hesperidae). In Brazil, more specifically in Goiás, Espírito Santo and Rio de Janeiro states, *B. pandora* was found parasitizing pupae of *Historisodius* (Lepidoptera: Nymphalidae) and in Rio Grande do Sul parasite *Argon lota* (Lepidoptera: Hesperidae) (Marchiori et al. 2003b; Gil-Santana and Tavares 2005; Salgado-Neto et al. 2010).

Conura spp. are parasitoids mainly of Lepidoptera pupae, but some occur in Coleoptera, Hymenoptera, and occasionally other insects; some species are secondary parasitoids of Braconidae and Ichneumonidae (Boucek and Halstead 1997). This is a very large group and in the Neotropical region may have more than a thousand species, and most of them not-described yet (Delvare 2006). Only in Brazil there are more than 150 registered species (Noyes 2003). According to Tavares (personal communication) *Ceyxia vestrispinosa* is a parasitoid of several specimens of Crabronidae wasps (Hymenoptera) family and also other wasps that build mud nests.

In faunal analysis of collected and identified individuals in the studied sites, species *Brachymeria pandora* and *Ceyxia ventrispinosa* occurred as the most dominant, abundant, frequent and constant species.

Conura maculata and *Conura nigrifrons* (Figure 1A-B) were also considered important species because they were classified as dominant and associated to the maximum indices of abundance, frequency and constancy. Among sixteen species collected, *Conura destinata*, *Conura* sp.3, *Conura* sp.4 and *Conura* sp.5 had the lowest indices (non-dominant, scattered, not frequent or accidental) (Table 2).

B. pandora and *C. ventrispinosa* were considered super frequent corresponding to 52.42% of total parasitoids captured. *Conura destinata*, *Conura immaculata*, *Conura* sp.3, *Conura* sp.4, *Conura* sp.5, *Conura* sp.8, *Conura* sp.9 and *Conura* sp.10 occurred as accidental. The indices of diversity and evenness of Shannon-Wiener for the data of species occurrence obtained on five sites were calculated (Table 3).

The indices showed that environments with similar diversity species between sites 2 and 3, with the population

predominance of *Brachymeria pandora*. The site 1, with native forest fragment, showed greater evenness index reflecting greater uniformity of individuals, probably due to the heterogeneity of the site, with the largest number of individuals and species, resulting in high diversity. However, Dajoz (1974) states that the more homogeneous is the ecosystem, usually it has the smaller number of species, but each one with large population densities, affecting the diversity of the site. These data corroborate with the results obtained in sites 3 and 4 (Table 3).

ANOVA test was applied at different sites and it was found a significant difference ($p > 0.05$) between the results obtained for the sites 1, 2, 3, 4 and 5, confirming statistical difference on floristic and climatic conditions to which they are subjected.

The site 4 with adjacent pasture vegetation and *T. grandis* obtained the highest results for the species *B. pandora*, *C. ventrispinosa*, *Conura nigrifrons* and *C. maculata*. One observed that adjacent vegetation may have influenced the occurrence of Chalcididae.

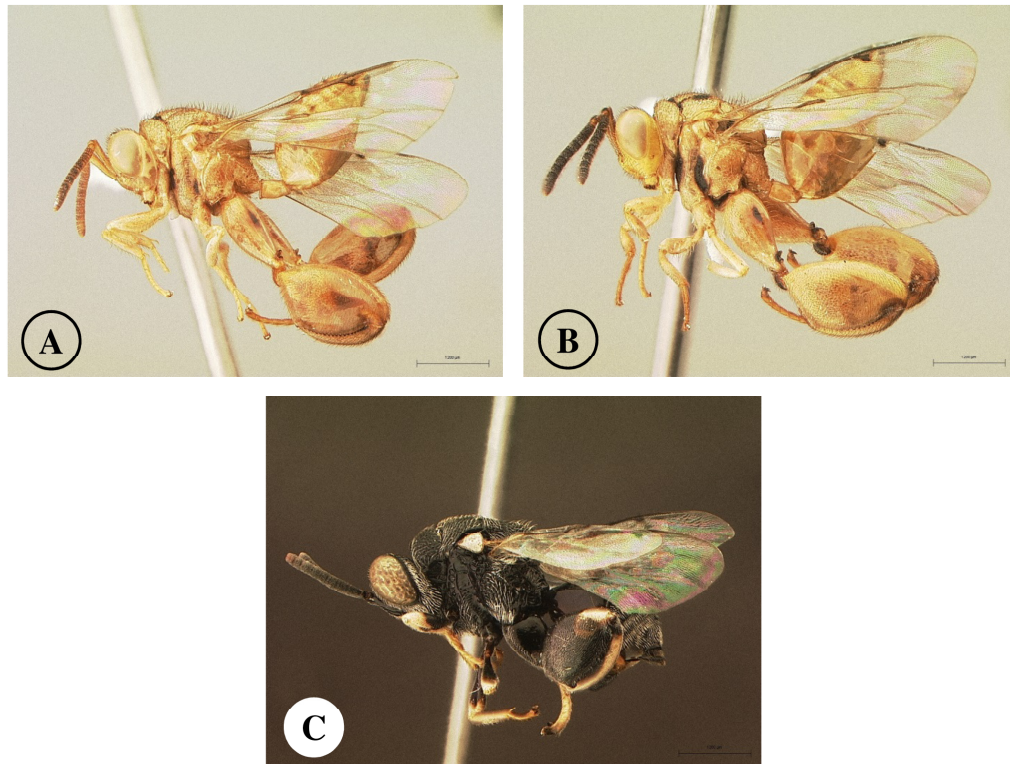


Figure 1. Faunal analysis of collected and identified individuals in the studied sites. (A) *Conura maculata*. (B) *Conura nigrifrons*. (C) *Brachymeria pandora*. Bar = 1,200 μm . (Pictures: Pamella Machado Saguiah).

Table 2. Faunal analysis of Chalcididae species collected in plantations of *Tectona grandis* located in Cáceres, State of Mato Grosso, Brazil.

Species	Dominance	Abundance	Frequency (%)	Constancy
<i>Brachymeria pandora</i>	Sd	sa	sf	w
<i>Ceyxia ventrispinosa</i>	Sd	sa	sf	w
<i>Conura destinata</i>	Nd	d	pf	z
<i>Conura immaculate</i>	Nd	d	pf	z
<i>Conura maculata</i>	D	ma	mf	w
<i>Conura nigrifrons</i>	D	ma	mf	w
<i>Conura</i> sp.1	Nd	c	f	y
<i>Conura</i> sp.2	Nd	c	f	y
<i>Conura</i> sp.3	Nd	d	pf	z
<i>Conura</i> sp.4	Nd	d	pf	z
<i>Conura</i> sp.5	Nd	d	pf	z
<i>Conura</i> sp.6	Nd	d	pf	y
<i>Conura</i> sp.7	Nd	d	pf	y
<i>Conura</i> sp.8	Nd	c	f	z
<i>Conura</i> sp.9	Nd	c	f	z
<i>Conura</i> sp.10	Nd	c	f	z

Dominance = (nd) not dominant, (d) dominant (sd) super dominant; Abundant = (d) dispersed, (c) common, (r) rare, (ma) very abundant, (sa) super abundant; Frequency (%) = (pf) less frequent, (f) frequent, (mf) very frequent, (sf) super frequent; Constancy = (w) constant, (y) accessory, (z) accidental.

Marchiori et al. (2003b), in a survey done in pasture and bush land, found that the fauna of Chalcididae in these environments was similar, being *B. pandora* abundant on the pasture environment. *B. pandora*, *Ceyxia ventrispinosa*, *Conura nigrifrons*, *C. immaculata*, *Conura* sp.1, *Conura* sp.6, *Conura* sp.7 and *Conura* sp.8 were common in five areas sampled.

Concerning the analysis performed with the studied sites (Table 3), the largest calculated values of diversity and evenness occurred at site 1 (forest) and site 2 (teak / bushland).

The lowest diversity and evenness occurred at sites 3 and 4. Where *B. pandora* and *C. ventrispinosa* were predominated species. Fowler and Venticinqu (1997) grouped information about biodiversity in deforested areas compared with areas of forest and found that the abundance of species is relatively low in the woods, but with higher richness.

Hanson and Gauld (1995), when referring to samples taken by Malaise traps in Costa Rica, stated that the diversity collected of Hymenoptera increases when the traps are set in native forest adjacent areas.

Brachymeria pandora showed population peaks in the rainy season in November 2009 and in March 2010. In the

other months this species occurred at low population densities.

The population peaks of *Ceyxia ventrispinosa* occurred in March and May 2010. During the sampling period the annual rainfall ranged from 50.6 mm (April) to 334 mm (February).

Some evaluated correlations were positive and significant, to agree with the higher frequency of chalcids in the reforestation of *T. grandis*.

The maximum and minimum temperatures ranged from 29.9°C (May 2010) to 36.6°C (September 2010) compared to 13.5°C (July 2010) to 22.8 °C (November 2009).

The results of the correlations between populations of Chalcididae species, average of the minimum and maximum temperatures and the rainfall accumulated during the collection period were register (Table 4.)

Between October 2009 and September 2010 the correlations among species of Chalcididae, minimum temperature and rainfall were positive and significant ($p > 0.05$) with the population fluctuation of *Conura maculata* ($r = 0.33$, $r = 0.28$), *Ceyxia ventrispinosa* ($r = 0.47$, $r = 0.32$), *Brachymeria pandora* ($r = 0.46$, $r = 0.43$), *Conura nigrifrons* ($r = 0.28$, $r = 0.25$) and total of collected Chalcididae ($r = 0.36$, $r = 0.34$) (Table 4).

Table 3. Number of individuals (NI), number of species (NS), Shannon - Wiener index (SWI) and Margalef index (MI) per sample point in area with *Tectona grandis* located in Cáceres, State of Mato Grosso, Brazil.

Environment	NI	NS	SWI	MI	Equitability
Site 1 (native vegetation)	35	16	2.632	4.219	94%
Site 2 (teak/ native vegetation)	27	9	1.922	2.427	87%
Site 3 (teak/teak)	99	14	1.967	2.829	75%
Site 4 (teak/pasture)	183	16	2.085	2.879	75%
Site 5 (teak/pasture/ native vegetation)	70	11	2.003	2.354	84%

Table 4. Pearson correlation index (r) between frequencies of Chalcididae species and abiotic factors (rainfall, maximum and minimum temperatures) in area with *Tectona grandis* located in Cáceres, State of Mato Grosso, Brazil.

Abiotic factors ⁽¹⁾	<i>Conura maculata</i>	<i>Ceyxia ventrispinosa</i>	<i>Conura nigrifrons</i>	<i>Brachymeria pandora</i>	Total of Chalcididae
Rainfall	0.28*	0.32*	0.25*	0.43*	0.34*
Minimum temperature	0.33*	0.47*	0.28*	0.46*	0.36*
Maximum temperature	0.19 ^{ns}	0.41*	0.35*	0.48*	0.46*

⁽¹⁾ Collection period: October 2009 at September 2010. ^{ns} no significant ($p \geq 0.05$). * significant ($p < 0.05$).

Conclusions

The highest frequency of capture of Chalcididae occurred in the rainy season.

The adjacent vegetation influenced the frequency and diversity of Chalcididae.

The influence of rainfall on populations of parasitoids in the region may have occurred indirectly, in other words, rainfall provided favorable conditions for development and multiplication of hosts, and then increased the population during the rainy season.

The native vegetation is a natural resource for the maintenance of parasitoids diversity in areas with cultivation of *T. grandis*.

The influence of climate in the fluctuations, even at a microclimate level, may change the behavioral activities of individuals in the population.

Acknowledgements

To the Doctors Valmir Antonio Costa (Biological Institute) and Marcelo Tavares Teixeira (Federal University of Espírito Santo) for the identification of insects and to the biologist Pamella Machado Saguiah for the photos.

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