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Composition of the Families of Parasitoids Wasp in the Parque Nacional da Serra da Canastra, Minas Gerais, Brazil

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Abstract. This study aimed to produce an inventory of the parasitoid Hymenoptera for the Parque Nacional da Serra da Canastra, using the vegetation sweep method. Between September 2009 the October 2010, 6,489 exemplars were collected, belonging to eight superfamilies and 24 families. Eulophidae, Braconidae, Platygastridae, Pteromalidae and Encyrtidae were the families with the highest relative abundance, being responsible for 18.6%, 18.5%, 15.8%, 10.3%, and 9.8% the total number of collected, respectively. Nineteen families combined contributed less than 4% of the sample. The greatest diversity occurred at sample points located on the base of the Chapadão da Canastra, influenced, probably, by the phytophysiognomic gradient in this region. A similarity analysis this study with other surveys of parasitoid wasps in the Cerrado, besides a preliminary table of Pimplinae (Ichneumonidae) genus is presented.

Keywords: Cerrado; inventory; parasitoid wasp; Pimplinae; sweeping

Composição de Famílias de Vespas Parasitoides no Parque Nacional da Serra da Canastra, Minas Gerais, Brasil

Resumo. O objetivo deste estudo foi verificar a composição faunística de Hymenoptera parasitoide do Parque Nacional da Serra da Canastra, utilizando o método de varredura de vegetação. Foram coletadas no período de setembro de 2009 a outubro de 2010, um total de 6.489 exemplares, pertencentes a oito superfamílias e 24 famílias. Eulophidae, Braconidae, Platygastridae, Pteromalidae, Encyrtidae foram as famílias com a maior abundância relativa, sendo responsáveis por 18,6%, 18,5%, 15,8%, 10,3% e 9,8% do número total coletado, respectivamente. Dezenove famílias combinadas tiveram abundancia menor que 4%. As maiores diversidades foram observadas nos pontos localizados na base do chapadão da Canastra, influenciadas, provavelmente, pelo gradiente fitofisionômico desta região. Uma análise de similaridade entre este estudo com outros inventários de vespas parasitoides no Cerrado, além de uma tabela preliminar de gêneros de Pimplinae (Ichneumonidae) é apresentada.

Palavras-Chave: Cerrado; inventário; Pimplinae; varreduras vegetação; vespas parasitoides

In Brazil faunal surveys of families of parasitoid Hymenoptera mostly occur in either agricultural systems (e.g. Dall'Oglio *et al.* 2000; Perioto *et al.* (2002a, 2002b); Perioto *et al.* 2004; Souza *et al.* 2006; Dorfey *et al.* 2011; Ferreira *et al.* 2013) or protected areas (e.g. Azevedo & Santos 2000; Azevedo *et al.* 2002; 2003; Perioto *et al.* 2003; 2005; 2008; Alencar *et al.* 2007; Feitosa *et al.* 2007).

The Cerrado is often classified in accounts of world vegetation as a "savanna" (e.g. Hills & Randall 1968), and in a very wide sense of that much-abused word it is. However, it is found in almost the whole possible range of structural forms: forest (with closed tree canopy), arboreal woodland (with open tree canopy), tree and scrub woodland (trees more scattered and sharing prominence with scrub elements, all woody plants together forming an open layer), closed scrub open scrub, grassland with scattered low shrubs only (the last three "savanna" in the strict structural sense), and grassland without any evidently visible woody plants (Eiten 1972).

The Parque Nacional Serra da Canastra is the second largest protected area in the state of Minas Gerais. It contributes approximately 3.9% of the 5.2 million hectares of Cerrado protected within federal conservation units (Mma/Ibama 2005), and is now a major tourist attraction. The park was set up to preserve the water quality of the headwaters of the São Francisco River, as well conserve as the region´s flora and fauna, which has many endemic species (Ibdf 1981).

To date, a few were the surveys of insect fauna in the region, which alone justifies the need to intensify the studies, that not only will make public the biological species diversity place, as contribute with to public agencies that require local data to implement environmental protection policies.

Abreu & Zampieron (2009) conducted a pioneering study of the parasitic Hymenoptera fauna of the Parque Nacional Serra da Canastra (PNSC). At a single site they used two types of traps: Malaise and Moericke. Subsequently, Pádua & Zampieron (2012) using the vegetation sweeping method sampled the Serra da Babilônia tableland, an area within the park buffer zone still that suffers extensive human impact.

Accordingly, aim of this study was to conduct a broad-scale assessment of the faunal composition of parasitoid Hymenoptera of the Parque Nacional Serra da Canastra.

MATERIALS AND METHODS

Created by Decree No. 70,355 of April 3, 1973, Parque Nacional Serra da Canastra covers an area of approximately 200,000 hectares, across the municipalities of São Roque de Minas,

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Vargem Bonita, Sacramento, Delfinópolis, Capitólio and São João Batista do Glória, Minas Gerais. The climate is tropical seasonal, with a temperate dry winter (22-23°C), and an average annual rainfall of between 1,200 and 1,800 mm (Mma/Ibama 2005).

The predominant vegetation is Cerrado, with varied sub-types such as: mesophyllic hill forest, cerrado *sensu stricto*, grassland cerrado, rock-dominated areas and gallery forests. Altitude ranges from 800-1,500 m (Ibdf 1981).

The survey was conducted at four sample points within the park, with two points at high elevations in the Chapadão da Canastra (Mma/Ibama 2005), and two points lower down, near the Casca D'anta waterfall (Figure 1).

Sample point I (20°13'00.6"S; 46°28'38.4"W) was at an altitude of 1462 meters, and was in grass-dominated vegetation on a rock-strewn plain, rocky outcrops were numerous and there was a high incidence of wind. The site was some 35 km from Point II.

Sample point II (20°08'20.2"S; 46°47'20.4"W) was at an altitude of 1353 m, and located on an ecotone between Cerrado grassland and a forest fragment located in depression. It also has a high incidence of wind and was 34 km from Point III.

Sample point III (20°18'48.4"S; 046°31'46.1"W), was located at the base of the plateau and was in an area outside the Park. It had an altitude of 854 m, and here the sweeping method was performed in the ecotone between a formation of Cerrado *sensu stricto* and grassland**.** This Point was also close (150 m) to riparian vegetation on the banks of the São Francisco River. It was approximately one kilometer from Point IV.

Sample point IV (20°18'27.3"S; 046°31'28.9"W), was also located at the base of the plateau, in dense riparian vegetation, with both cerrado *sensu stritu* and anthropogenically-disturbed areas such as roads and houses close-by. The altitude was 920 m. It was 12 km distant from point I.

The sampling was done by the vegetation sweeping method, simultaneously using four sweep nets each with 43 cm circumference coupled with a cotton fabric, supported by an 18.5 cm cord.

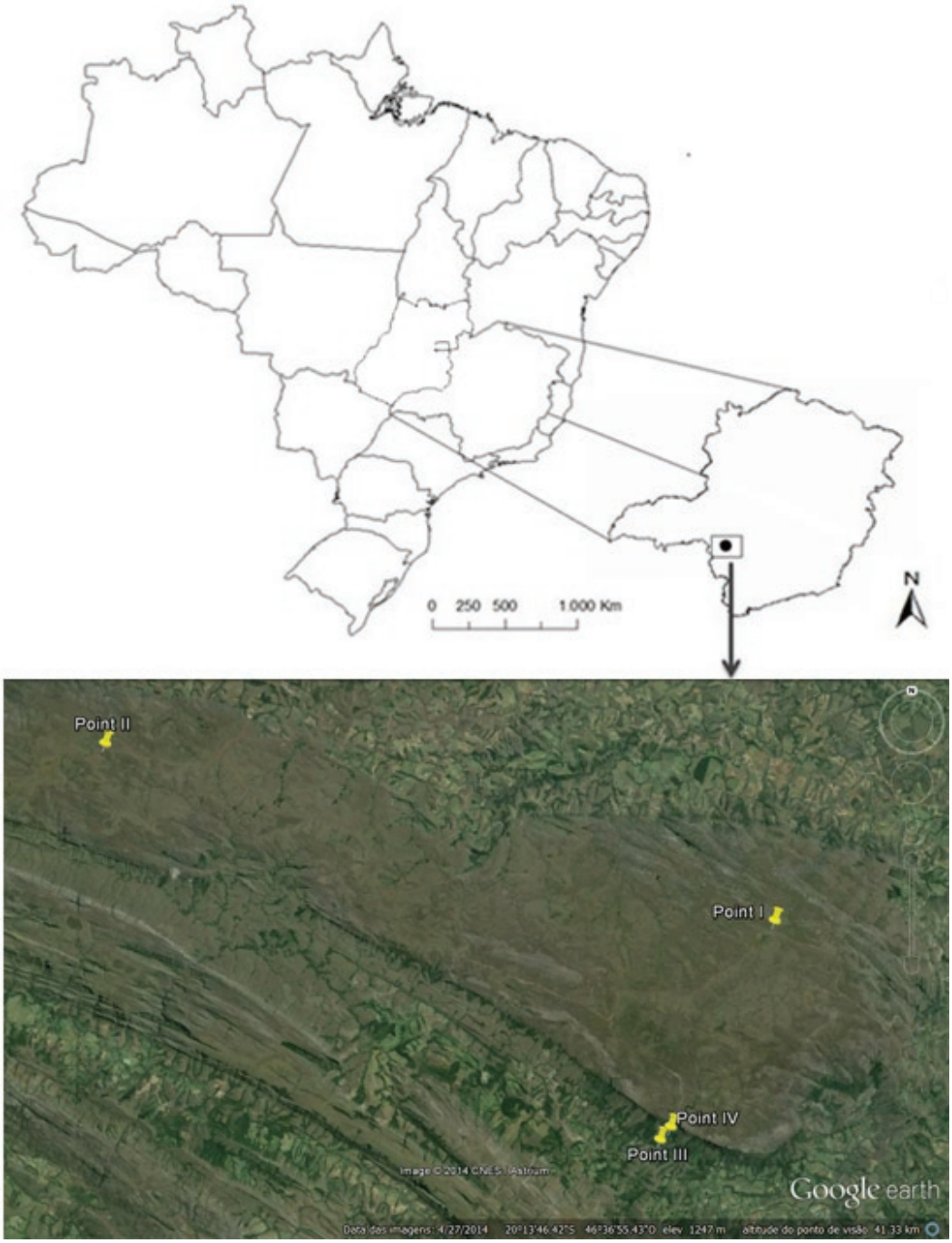

Figura 1. Location of the points in the Parque Nacional da Serra da Canastra.

Sampling was carried out between September 2009 and October 2010, and totaled 45 samples sweepings from all four sites. Each monthly sample was a result of 15 minutes of simultaneous collection effort, by four people (total excluding time for stops to removal of collected material). The technique was applied randomly to vegetation from ground level to a height of approximately two meters. During data collection, the insects captured were transferred to killing bags containing cotton pads soaked in ethyl acetate, so as to fix the material collected. Sample collection was influenced by rainfall, hence collecting did not occur in October/2009 and March 2010, while in December 2009 and February 2010 sampling occurred on wet vegetation, which reduced capture efficiency (Table 1).

All the material was screened in the Entomology Laboratory of the Fundação de Ensino Superior de Passos (FESP), Minas Gerais. Being included the families pertaining to the series "Parasitic" (Terebrantia) and superfamily Chrysidoidea (Aculeata) followed the identification and classification of Sharkey (2007). All material was preserved in vials with 70% alcohol, with the exception of Pimplinae which were mounted on entomological pins and identified according to Gauld (1991), with identifications subsequently checked by an expert (see acknowledgements).

The wet collections were deposited in the Entomology Laboratory of the Fundação de Ensino Superior de Passos (FESP), Minas Gerais, and pimplinids were deposited in the Entomological Collection DCBU the Federal University of São Carlos (UFSCar), São Paulo.

To calculate relative abundance we used the formula AR = n/N x 100, where n = number of individuals of each family, N = total number of individuals collected. To create Dominance (D), Shannon diversity (H') and Equitability (J') indices the program PAST 2.00 (Hammer *et al.* 2001) was used. To check the similarity between areas on the faunal composition was used the Jaccard index (C) (Southwood 1978) obtained by the program R, version 3.1.0 (R Development Core Team 2014), using the package Vegan (Oksanen *et al.* 2013).

RESULTS AND DISCUSSION

A total of 6,489 exemplars of parasitoid wasps were collected, in eight superfamilies and 24 families (Table 1). Three Pimplinae genera (Table 2) were also identified.

Neotheronia, *Pimpla* and *Zonopimpla* were genera of pimplineds collected in this study, through the sweeping technique. *Neotheronia* species are mainly idiobionts parasitoids of pupae and prepupae in cocooned lepidopteran and/or hyperparasitoids of Ichneumonidae and Tachinidae parasitoids of such hosts. *Pimpla* species are idiobionts endoparasitoids of pupae lepidopteran concealed in leaf litter, moss, leaf rolls in herbaceous vegetation or in the soil (Gauld *et al.* 1998). *Zonopimpla* species are solitary parasitoids or gregarious of pupae and prepupae of holometabolous insects concealed in leaf mines, galls or cocooned (Gauld 1991).

In comparison, Kumagai (2002) collected a total of 13 genera of the same subfamily at the Ecological Station of Universidade Federal de Minas Gerais/MG, using a Malaise trap, in which the three genera cited in this study, was also captured. Traditional collecting methods involving simple hand-netting, supplemented by sweeping, will produce reasonable numbers of pimplines and other ichneumonoids, especially in warm overcast weather. However, Malaise traps, is probably the best means of obtaining large, general samples from most habitats (Fitton *et al.* 1988).

The sweepings made at the base of the plateau collected 4,583 individuals, whereas that the specimens collected in the high part totaled 1,906 individuals. This must be related to the structural difference of the vegetation characteristic of high part, where there is high incidence of winds and the campestral formation of Cerrado is predominant, with isolated patches of forest. Unlike the base of the plateau, where the incidente of winds is less constant and structural complexity of vegetation is larger, with formation of Cerrado with more strata and major influence of river and riparian vegetation.

Table 1. Superfamilies and families of parasitoid wasps sampled by means of sweep net in the Parque Nacional da Serra da Canastra/MG in the period of September/2009 to October/2010.

Superfamily	Family	S/09	N/09	D/09	J/10	F/10	A/10	M/10	J/10	J/10	A/10	S/10	O/10	Total
Ceraphronoidea		11	0	0	9	0	19	13	25	16	6	8	27	134
	Ceraphronidae	9	0	0	9	0	19	13	24	16	6	7	27	130
	Megaspilidae	2	0	0	0	0	0	0	1	0	0	1	0	4
Chalcidoidea		299	97	9	185	7	498	354	640	263	198	412	383	3345
	Agaonidae	0	0	0	0	0	0	0	1	0	0	1	1	3
	Aphelinidae	3	0	0	0	0	4	16	49	3	0	5	6	86
	Chalcididae	22	5	0	5	1	5	9	10	5	8	10	6	86
	Encyrtidae	44	14	0	11	2	71	74	144	73	43	94	68	638
	Eucharitidae	3	3	0	5	0	5	2	5	0	1	5	0	29
	Eulophidae	141	38	4	73	2	195	137	236	79	70	101	133	1209
	Eupelmidae	16	3	0	8	0	9	16	22	11	5	14	18	122
	Eurytomidae	36	16	4	13	0	40	23	28	13	15	24	38	250
	Mymaridae	7	4	0	3	0	11	12	18	4	7	13	22	101
	Perilampidae	7	6	0	0	0	1	1	1	0	1	3	2	22
	Pteromalidae	10	1	0	58	2	146	49	100	63	39	125	74	667
	Signiphoridae	1	1	0	0	0	2	4	8	4	3	9	5	37
	Torymidae	6	6	1	6	0	2	5	14	0	2	3	3	48
	Trichogrammatidae	3	0	0	3	0	7	6	4	8	4	5	7	47
Chrysidoidea		12	12	2	21	0	10	10	36	14	7	14	10	137

to be continued...

Table 1. Continued...

Superfamily	Family	S/09	N/09	D/09	J/10	F/10	A/10	M/10	J/10	J/10	A/10	S/10	O/10	Total
	Bethylidae	12	10	1	21	0	9	8	32	11	7	13	10	137
	Dryinidae	0	2	1	0	0	1	2	4	3	0	1	17	155
Cynipoidea		0	25	4	15	2	34	14	20	4	6	3	10	137
	Figitidae	0	25	4	15	2	34	14	20	4	6	3	10	137
Diaprioidea		28	22	3	19	0	30	10	30	21	3	0	8	174
	Diapriidae	28	22	3	19	0	30	10	30	21	3	0	8	174
Evanioidea		28	7	1	6	0	3	0	3	1	1	2	8	60
	Evaniidae	28	7	1	6	0	3	0	3	1	1	2	8	60
Ichneumonoidea		254	197	25	127	31	178	105	181	100	65	126	69	1458
	Braconidae	191	156	20	105	27	157	94	143	90	53	109	58	1203
	Ichneumonidae	63	41	5	22	4	21	11	38	10	12	17	11	255
Platygastroidea		159	45	1	84	2	166	94	145	69	46	77	138	1026
	Platygastridae	159	45	1	84	2	166	94	145	69	46	77	138	1026
Total		**791**	**442**	**45**	**499**	**42**	**1099**	**693**	**1080**	**534**	**344**	**710**	**660**	**6489**

Table 2. Species of Pimplinae sampled with nets sweep in the Parque Nacional da Serra da Canastra/MG in the period of September/2009 to October/2010.

Tribe	Specie	Total
Pimplini		
	Neotheronia sp.1	1
	Neotheronia sp.2	3
	Pimpla sp.1	2
Ephialtini		
	Zonopimpla sp.1	1
	Zonopimpla sp.2	1

According Rizini (1979), above 900 meters typically occurs what we call clenched altitude. Points I and II are exactly in this band (1,468 m and 1,353 m), characterized as a cerrado in this category.

To Rodela (1998) the savanna altitude can be considered as transitions of savanna to rupestrian field, containing plant species of the two formations. Therefore, in these physiognomy there specific endemismo of the flora of the rupestrian fields mixing species of cerrado, attributing atypical character, transitional and biodiverse.

Some authors have reported on their studies several factors responsible for the variation in vegetation mosaic of the Cerrado, such as climate, fire and human actions (Coutinho 1990; Pivello & Coutinho 1996; Ratter *et al.* 1997; Dezzeo *et al.* 2004). Phytogeographic patterns for the Cerrado have been established also through the studies by different researchers (Ratter & Dargie 1992).

Ratter *et al.* (1996), analyzing 98 Cerrado areas distributed throughout the national territory, encountered a pattern of phytogeographic distribution formed by six groups, which were classified according to locality: a group to south, a group southeast, a group central, a group in the midwest, a group to the north and a group formed by the Cerrado jammed at Amazon. In this work, the climate, and particularly precipitation and the time of the dry season were factors important for the distribution of vegetation of Cerrado, as well as the effect of altitude. Environmental factors cited by these authors are probably also responsible for the formation of different floristic groups presented in the State of Minas Gerais.

Coutinho (1978) emphasizes that the Cerrado is composed of five different vegetation types, which have two extremes, one forest physiognomy called cerradão, where there is predominance of woody vegetation and physiognomy campestral, the grassland, where besides herbaceous vegetation, encountering are also small subshrubs. The others phytophysiognomies, Cerrado *sensu stricto* and cerrado grassland, are vegetation ecotone between cerradão and grassland.

Eulophidae, Braconidae, Platygastridae, Pteromalidae and Encyrtidae together were the most abundant families, giving 73% of the total sample (4,743 exemplars).

The abundance of Braconidae was higher than the other families for six months of the collecting, while Eulophidae was highest for four months, already Platygastridae and Pteromalidae for one month each. Eulophidae, Braconidae, Platygastridae and Ichneumonidae occurred in all samples by month (Table 3).

The relative abundance of families at the sample sites is given in Table 3. At Point I the family Eulophidae was most abundant, followed by Encyrtidae and Platygastridae. At Point II the family Braconidae was most abundant, followed by Eulophidae and Platygastridae. At points III and IV Braconidae and Platygastridae were the most abundant families, sequentially, first and second most abundant. Braconids have a high degree of specialization, tending to attack and feed on a very narrow range of hosts (Wharton *et al.* 1997). This, and their often specialized suite of biological and behavioral adaptations (Shaw & Huddleston 1991), means the group has strong potential as bio-indicators for biological monitoring (Barbieri Junior & Penteado-Dias 2012). The xeromorphic nature of the Cerrado biome favors the

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Table 3. Abundance of individuals and relative abundance (Ra) of parasitoid wasp for each point sample through of technique of sweeping in the Parque Nacional da Serra da Canastra, Minas Gerais.

Famílias	Point I	Ra (%)	Point II	Ra (%)	Point III	Ra (%)	Point IV	Ra (%)	Total
Agaonidae	0	0	1	0.01	1	0.01	1	0.0	3
Aphelinidae	20	0.3	17	0.26	22	0.33	27	0.4	86
Bethylidae	15	0.23	41	0.63	10	0.15	72	1.1	138
Braconidae	68	1.04	300	4.62	327	5.03	508	7.8	1203
Ceraphronidae	7	0.1	8	0.12	52	0.8	63	1.0	130
Chalcididae	9	0.13	19	0.29	36	0.55	22	0.3	86
Diapriidae	1	0.01	10	0.15	9	0.13	154	2.4	174
Dryinidae	3	0.04	6	0.09	3	0.04	5	0.1	17
Encyrtidae	120	1.84	119	1.83	195	3	204	3.1	638
Eucharitidae	15	0.23	11	0.16	0	0	3	0.0	29
Eulophidae	227	3.49	227	3.49	286	4.4	469	7.2	1209
Eupelmidae	10	0.15	21	0.32	54	0.83	37	0.6	122
Eurytomidae	17	0.26	48	0.73	110	1.69	75	1.2	250
Evaniidae	7	0.1	22	0.33	6	0.09	25	0.4	60
Figitidae	18	0.27	22	0.33	39	0.6	58	0.9	137
Ichneumonidae	34	0.52	59	0.9	30	0.46	132	2.0	255
Megaspilidae	0	0	3	0.04	0	0	1	0.0	4
Mymaridae	9	0.13	9	0.13	29	0.44	54	0.8	101
Perilampidae	2	0.03	4	0.06	2	0.03	14	0.2	22
Platygastridae	71	1.08	157	2.4	315	4.84	483	7.5	1026
Pteromalidae	41	0.63	79	1.21	281	4.33	266	4.1	667
Signiphoridae	7	0.1	2	0.03	19	0.29	9	0.1	37
Torymidae	4	0.06	11	0.16	14	0.21	19	0.3	48
Trichogrammatidae	1	0.01	4	0.06	30	0.46	12	0.2	47
Total	706	10.87	1200	18.49	1870	28.81	2713	42	6489

Braconidae community whose hosts (which include Lepidoptera, Coleoptera and Diptera) often occupy niches hidden in plant tissues (Cirelli & Penteado-Dias 2003). The eulophids comprise the largest family of Chalcidoidea (Noyes 2013), and their biology is also extremely diverse, including ecto- or endoparasitoids of many families and orders of insects (Melo *et al.* 2012). There are also phytophagous and predatory species (Gauthier *et al.* 2000). Platygastrids are widely represented in all regions of the globe. They parasitize eggs and larvae or larvae of gall midges, or, less often, eggs of cicadas, weevils, some heteropterans, and leaf beetles (Kozlov 1978).

Agaonidae, Megaspilidae and Eucharitidae were the only families that were not found at all sample sites. According to Azevedo & Santos (2000), these families along with, Aulacidae, Embolemidae, Gasteruptiidae, Heloridae, Leucospidae, Liopteridae, Megalyridae, Ormyridae, Pelecinidae, Perilampidae, Plumariidae, Sclerogibbidae, Scolebythidae, Stephanidae, Tanaostigmatidae are both poorly studied and uncommon in parasitoid wasps inventories.

Indices of dominance, diversity and evenness calculated for the four collection points are shown in Table 4.

For parasitic hymenoptera, differences in collection efforts can influence the number and diversity of captured families (Azevedo *et al.* 2002), and the lack of standardized collection techniques for the group often complicates faunal comparisons between sampled environments, although it does provide an reasonable idea of the proportions of the most abundant groups (Huber 2009).

Consequently, through different collection methods and sampling efforts have been used, it is instructive to compare the current study with others conducted in the Cerrado of Minas Gerais and Goiás. The number of families sampled in this study (24) was greater than that of Marchiori & Penteado-Dias (2002) using Moericke traps, and Pádua & Zampieron (2012) using the sweeping method, which collected 21 and 20 families, respectively. It is less than the study of Moraes *et al.* (2012) who collected a total of 28 families using three collection methods (Malaise and Moericke traps, and sweep net).

Comparing the similarity (Jaccard index) calculated for the few entomofaunal inventories of Cerrado parasitic Hymenoptera (Figure 2), it appears that the present study is most similar to that of Marchiori & Penteado-Dias (2002) in terms of total number of individuals and the diversity of families. It does not resemble to profile of the study by Moraes *et al.* (2012) who collected a fewer individuals, but a greater diversity of families, including some (Ormyridae, Tanaostigmatidae, Ibaliidae and Pelecinidae) that are considered rare in surveys of parasitoids and to be scarce wasps in biological collections (Azevedo & Santos 2000).

The Cerrado, in general, is home to a great diversity of herbivorous insects, since the phytophysionomic gradient is great, varying from grassland-dominated landscapes to highly forested ones (Sano & Almeida 1998). Cerrado has a rich flora (Ratter *et al.* 2003), and thus is a large repository of potential host insects, which in turn attract such families of parasitoids as Braconidae, Eulophidae

Tabela 4. Diversity indices calculated for the four points made by sweeping through the program PAST 2.00 (Hammer *et al.* 2001).

Indices	Point I	Point II	Point III	Point IV
Number of families	23	25	23	25
Individuals	706	1200	1870	2713
Dominance (D)	0,1567	0,1281	0,1086	0,1051
Shannon Diversity Index (H')	2,341	2,454	2,481	2,539
Equitability (J')	0,7468	0,7623	0,7914	0,7889

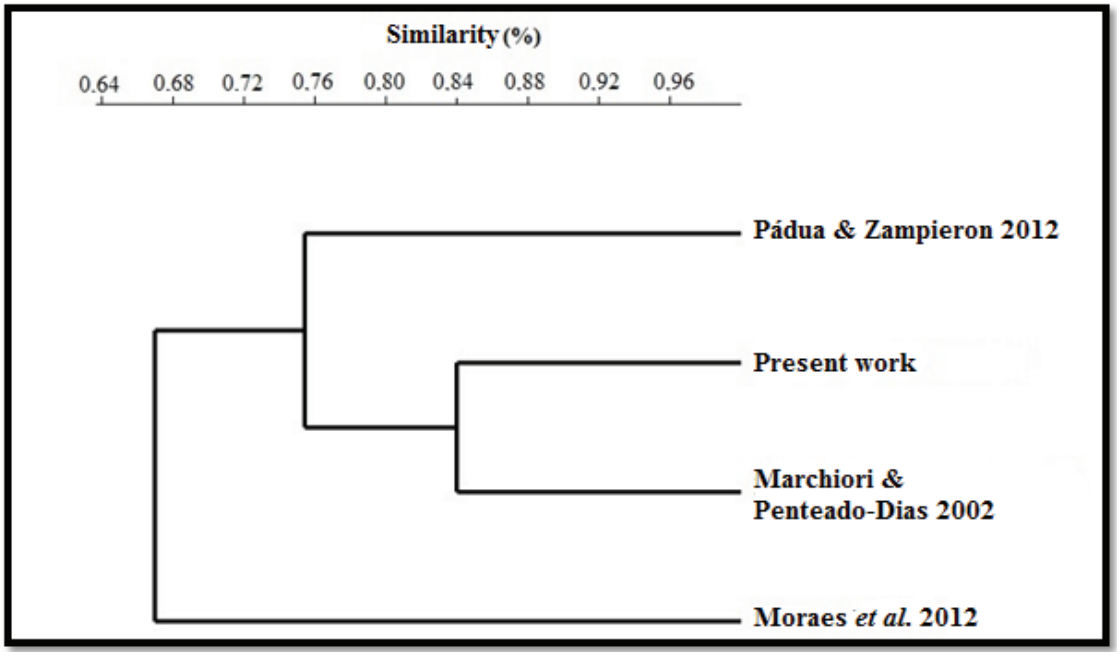

Figura 2. Similarity dendrogram (Jaccard) the works of surveys of families of Hymenopteran parasitoids performed in the Cerrado.

and Pteromalidae (the most well-represented families in this study) as well as other, rarer, families. Nascimento & Penteado-Dias (2005) collected Braconidae, Eulophidae, Pteromalidae, Ichneumonidae Eupelmidae that are specifically associated with Cerrado legume species, and which are parasitoids of larvae or pupae of Coleoptera and Lepidoptera living within their fruits.

Several studies have reiterated the importance of the Cerrado in which is dipped the Parque Nacional Serra da Canastra in southwest of Minas Gerais, especially in maintaining tri-trophic relationships there existing. According to Mma (2002), among the Conservation United already created, the Serra da Canastra, undoubtedly, fits into the group of extremely high biological importance, medium anthropic pressure and high biological diversity and interesting relationships.

There are few studies surveys of Hymenoptera parasitoids for the Cerrado, particularly for the Parque Nacional da Serra da Canastra. The current survey showed that the park has a large biodiversity of parasitoid wasps, which, it is hoped will serve as an incentive for future studies of the biological parameters of these insects and their hosts.

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