



General Entomology

Hymenoptera fauna, with emphasis on Ichneumonidae from an area of Caatinga in Northeast Brazil

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Abstract. The objectives of this study were to carry out a survey of families of Hymenoptera, with emphasis on Ichneumonidae, in an area of Caatinga, and register the occurrence of new species, if any, for the biome. Samples were taken with Malaise traps between September and November 2008 in a native area of vegetation of Serra do Lima, municipality of Patu, Rio Grande do Norte, Brazil. 7,562 hymenopterans, from 11 superfamilies and 31 families, were collected. The most abundant superfamilies were: Chalcidoidea (2,887 specimens / 38.33% of the total), Platygastroidea (1,572 / 20.87%) and Vespoidea (1,131 / 15.02%) which constituted more than 70% of the captured hymenopterans. A total of 160 specimens of Ichneumonidae from 17 subfamilies were sampled, of which four are new records for Rio Grande do Norte: (Lycorininae, Nesomesochorinae, Phygadeuontinae and Tryphoninae). Altogether, 26 genera were recognized, with 16 new records for the state. *Cryptophion espinozai* Gauld & Janzen (Campopleginae) and *Labena marginata* Szépligeti (Labeninae) were registered for the first time in Caatinga. The obtained data demonstrate a considerable diversity of the studied groups in this area and also affirms the necessity of additional studies to establish the richness of this fauna in a more extensive and conclusive way.

Keywords: Biodiversity; Faunistic inventory; Semiarid.

In the order Hymenoptera, there are about 115 thousand described species, but it is estimated that this number can be greater than 250 thousand (HANSON & GAULD 2006). In the Neotropical region, 21 superfamilies and 76 families of Hymenoptera have been found (FERNÁNDEZ 2006), and 70 families have been cataloged for the Brazilian territory (PENTEADO-DIAS & BRAGA 2002; OLIVEIRA *et al.* 2020). Although the fauna of this order is estimated to have about 70 thousand species for Brazil (MELO *et al.* 2012), only 10,456 species, distributed in 1,610 genera have been registered until now (OLIVEIRA *et al.* 2020).

Among the families of Hymenoptera, Ichneumonidae is one of the most prominent, as it is one of the largest families in the animal kingdom, with about 25 thousand described species, and an estimate of more than 100 thousand species (GAULD *et al.* 2002; Yu *et al.* 2016). In general, Ichneumonidae consists of species of solitary parasitoids; most species with known biology attack larvae and pupae of Lepidoptera, Coleoptera and Hymenoptera (GAULD 1991). Due to their parasitoid habit, ichneumonids have potential importance for the biological control of holometabolic phytophagous insects, which can act as agricultural pests.

The Caatinga biome covers about 10% of the 8,516 thousand km² of Brazilian territory, and is located in the semiarid region of Northeast Brazil. It is the only biome that is exclusively Brazilian, but only 2% of its area is covered for environmental preservation (IBGE 2004; LEAL *et al.* 2005). Despite its extent,

knowledge of Hymenoptera biodiversity in this biome is still quite incipient; the diversity of genera and species of this order being known primarily due to the descriptions and reports of the occurrence of Apidae, Braconidae, Bethyidae, Chrysididae, Eulophidae, Eurytomidae, Ichneumonidae, Sclerogibbidae and Plumariidae (ZANELLA 2000; ONODY & PENTEADO-DIAS 2002; PENTEADO-DIAS & SCATOLINI 2003; FERNANDES *et al.* 2012, 2014b, 2014c, 2017; ANDENA & CARPENTER 2014; BARBOSA & AZEVEDO 2014; SHIMBORI *et al.* 2014; SILVA 2014; ZANELLA & LUCENA 2014; BORTONI *et al.* 2016; LUCENA *et al.* 2016; CASTRO & PENTEADO-DIAS 2017; FERNANDES *et al.* 2019).

The only inventory of Hymenoptera families in Caatinga areas of Rio Grande do Norte (RN) was carried out by FERNANDES *et al.* (2014a), who verified the presence of 36 families. Regarding Ichneumonidae, the little information available for the state is from the lists and descriptions of the species (AGUIAR *et al.* 2013; SANTOS & AGUIAR 2013; FERNANDES *et al.* 2014b; SHIMBORI *et al.* 2014). In Brazil, this family is represented by 1,019 species and 233 genera, however, for RN only eight species have been registered so far (FERNANDES *et al.* 2020).

In many areas of Caatinga biome, including mountainous regions and its slopes, which form microclimates within the semiarid environment, there is no information on the diversity of Hymenoptera. The studies carried out in these regions may present taxa, which are still undiscovered, in addition to the ecological importance of the information. Thus, the objectives of this work were to carry out a survey of

families of Hymenoptera with emphasis on Ichneumonidae, present in an area in Caatinga, located in Serra do Lima, Patu, RN, and record any occurrence of new species in the studied area.

MATERIAL AND METHODS

The studied specimens were collected using two Malaise traps about 100 m apart, installed at Sítio Miranda (6°6'18" S / 37°37'41" W, 248 m above sea level [asl]), in Serra do Lima, municipality of Patu, RN, Brazil. The traps remained active throughout the collection period.

A monthly sampling was carried out for the months of September, October and November 2008 (dry season). Despite being located in the semiarid region, the average annual temperature in this region is 26.6 °C, with a relative humidity of 66% and rainfall of 873 mm (EMPARN 2016). During the installation of traps, despite the drought period, some plants had abundant green leaves, especially those situated near water bodies (Figure 1).

Hymenoptera families were identified according to FERNÁNDEZ & SHARKEY (2006). Subsequently, the status of superfamily and family nomenclature was updated according to AGUIAR *et al.* (2013). For bees, the classification used by MELO & GONÇALVES (2005) was maintained, considering all bees as Apidae *sensu lato*. Subsequently, Ichneumonidae were identified in a subfamily according to PALACIO & WAHL (2006), and GAULD (2006). The Cryptinae specimens had their nomenclature updated based on the recent proposal by SANTOS (2017). Each subfamily was subsequently identified in genera based on specialized literature for each group.

For a preliminary comparison of the sampled material, the richness of families obtained from the two areas of the Caatinga biome was analyzed: Mossoró - RN (5°01'25" S / 37°22'57" W, 59 m asl) (material previously collected by

FERNANDES *et al.* 2014a) vs. Patu (present study). For this, a family rarefaction curve was elaborated based on the number of individuals sampled in each study. The rarefaction curves were obtained by the bootstrap process with resampling, to obtain a confidence interval for family richness, similar to that proposed for species by MORENO *et al.* (2008). Bootstrap analyses were calculated with EstimateS Win9.1 software (COLWELL 2013), using 2,000 randomizations and 95% of confidence interval.

The analyzed material was deposited in the Entomological Collection of the Laboratório de Sistemática e Bioecologia de Parasitoides e Predadores (LRRP) of the Instituto Biológico, Ribeirão Preto, São Paulo, Brazil (NW Perieto, curator).

The distribution map was created using SimpleMappr online software (SHORTHOUSE 2010).

RESULTS

Were obtained 7,562 specimens of Hymenoptera belonging to 11 superfamilies and 31 families (Table 1).

Although the quantity of specimens captured decreased over the sampling time, 2,867 specimens (September), 2,745 (October) and 1,950 (November), the richness remained constant with 27 families. Platygastridae was the most abundant family in all sampled months, with 667 specimens collected in September, 675 in October and 230 in November.

The richness of the families captured in Mossoró - RN (by FERNANDES *et al.* 2014a) was higher than the present study, which can be seen in Figure 2.

In all, 37 families were captured at the studied areas, 30 of them in both localities. Eucharitidae, Leucospidae, Sclerogibbidae, Proctotrupidae, Rhopalosomatidae and Pergidae were collected only in Mossoró and Sphecidae only in Patu.



Figure 1. Collection area at the time of installation of Malaise traps, Serra do Lima, Patu, Rio Grande do Norte, 2008.

Table 1. Number and relative abundance of Hymenoptera collected in an area of Caatinga biome, Serra do Lima, Patu, RN, between September and November 2008.

Superfamily/Family	September	October	November	Total	RF	SRF
Apoidea	95	109	160	364	4.81	-
Apidae (<i>sensu lato</i>)	50	31	93	174	2.30	47.8
Crabronidae	45	77	67	189	2.50	51.9
Sphecidae	0	1	0	1	0.01	0.3
Ceraphronoidea	112	132	32	276	3.65	-
Ceraphronidae	112	132	32	276	3.65	100.0
Chalcidoidea	1214	1064	609	2887	38.18	-
Aphelinidae	167	189	23	379	5.01	13.1
Chalcididae	52	29	90	171	2.26	5.9
Encyrtidae	160	69	77	306	4.05	10.6
Eulophidae	166	147	76	389	5.14	13.5
Eupelmidae	23	20	13	56	0.74	1.9
Eurytomidae	11	16	6	33	0.44	1.1
Mymaridae	237	394	83	714	9.44	24.7
Perilampidae	2	0	1	3	0.04	0.1
Pteromalidae	103	40	75	218	2.88	7.6
Torymidae	1	2	4	7	0.09	0.2
Trichogrammatidae	228	137	131	496	6.56	17.2
Signiphoridae	64	21	30	115	1.52	4.0
Cynipoidea	10	60	3	73	0.97	-
Figitidae	10	60	3	73	0.97	100.0
Chrysoidea	314	178	242	734	9.71	-
Bethylidae	296	149	212	657	8.69	89.5
Chrysididae	4	7	2	13	0.17	1.8
Dryinidae	14	22	28	64	0.85	8.7
Diaprioidea	51	60	36	147	1.94	-
Diapriidae	51	60	36	147	1.94	100.0
Evanoidea	2	5	8	15	0.20	-
Evaniidae	2	5	8	15	0.20	100.0
Ichneumonoidea	95	220	47	362	4.79	-
Braconidae	79	91	32	202	2.67	55.8
Ichneumonidae	16	129	15	160	2.12	44.2
Platygastridae	667	675	230	1572	20.79	-
Platygastridae	667	675	230	1572	20.79	100.0
Vespoidea	307	242	582	1131	14.96	-
Formicidae	162	155	460	777	10.28	68.7
Mutillidae	56	24	37	117	1.55	10.3
Pompilidae	75	37	44	156	2.06	13.8
Tiphiidae	2	0	0	2	0.03	0.2
Vespidae	12	26	41	79	1.04	7.0
Tenthredinoidea	0	0	1	1	0.01	-
Argidae	0	0	1	1	0.01	100.0
Total	2867	2745	1950	7562		

RF = Relative frequency of Hymenoptera superfamilies and families in comparison to the total samples collected. SRF = Relative frequency of Hymenoptera collected in comparison to the total hymenopterans of the superfamily to which they belong.

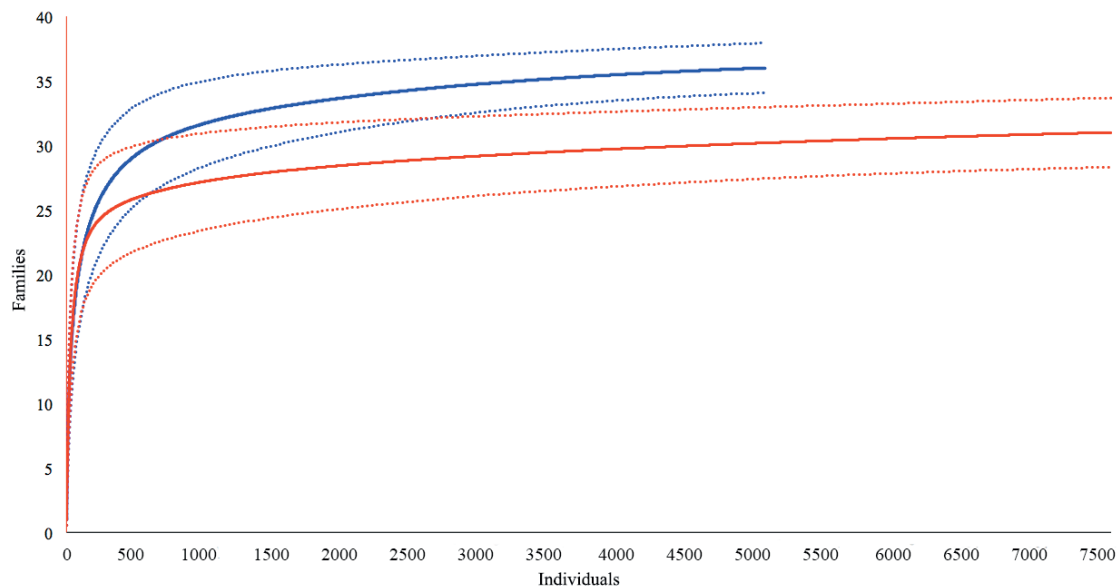


Figure 2. Family rarefaction curve (bootstrap) based on captured individuals, for two locations in Caatinga, Mossoró - RN (Blue) and Patu - RN (Red).

The 160 collected specimens of Ichneumonidae belong to 17 subfamilies and 26 genera, of which 16 are new records for RN (Table 2).

Table 2. Ichneumonidae subfamilies and genera collected in an area of Caatinga biome, Serra do Lima, Patu, RN.

Subfamily	Genera
Anomaloniinae	<i>Anomalon</i>
Brachycyrtinae	<i>Brachycyrtus</i>
Campopleginae	<i>Casinaria</i>
	<i>Charops</i>
	<i>Cryptophion</i> *
	<i>Xanthocampoplex</i> *
Cre mastinae	<i>Pristomerus</i> *
	<i>Trathala</i> *
	<i>Xiphosomella</i> *
Cryptinae	<i>Mesatoporus</i>
	<i>Polycyrtidea</i> *
Ichneumoninae	<i>Diacantharius</i> *
Labeniinae	<i>Labena</i>
Lycoriniinae*	<i>Lycorina</i> *
Mesochorinae	<i>Mesochorus</i>
Metopiinae	<i>Triece</i> *
Nesomesochorinae*	<i>Nonnus</i> *
Ophioninae	<i>Enicospilus</i>
Orthocentrinae	<i>Orthocentrus</i>
Phygadeuontinae*	<i>Isdromas</i> *
Pimplinae	<i>Hymenopimecis</i> *
	<i>Neotheronia</i> *
	<i>Pimpla</i>
	<i>Zaglyptus</i> *
Tersilochinae	<i>Allophrys</i> *
Tryphoninae*	<i>Netelia</i> *

* First record in Rio Grande do Norte.

DISCUSSION

Seventy families of Hymenoptera have been registered for Brazil so far (PENTEADO-DIAS & BRAGA 2002; OLIVEIRA *et al.* 2020), however, for RN only 38 families have been registered (PENTEADO-DIAS & SCATOLINI 2003; FERNANDES *et al.* 2014a; COSTA *et al.* 2016).

Six families sampled in this study do not have parasitoid habits: Apidae *sensu lato* (some have kleptoparasitic habits), Crabronidae (predators, with some kleptoparasitic species), Formicidae (predators, mycophages, etc.), Vespidae (predators), Sphecidae (predators, with some ectoparasitoid species) and Argidae (phytophagous).

Of the most abundant superfamilies, AGUIAR *et al.* (2013) reported the existence of approximately 23 thousand species of Chalcidoidea in the world however, this group is still relatively less studied. Approximately 12 thousand species of insects are registered as their hosts which demonstrates the huge potential for parasitism and its importance as a factor of biotic mortality in different environments. GRISSELL & SCHAUFF (1997) pointed out that groups of insects belonging to Chalcidoidea have great diverse biological habits, with at least 14 different life strategies, including mainly solitary, gregarious, hyperparasitoid and polyembryonic habits.

As for Platygastridae, the superfamily is composed only of Platygastridae [in the classification adopted in the present study, AGUIAR *et al.* (2013)] however, in most inventories, it is still common to be divided into Platygastridae and Scelionidae (traditional classification).

Despite their abundance, and being frequently sampled, it is important to point out that the majority of Hymenoptera surveys carried out in Brazil have not taken into account the specimens of Vespoidea, Apoidea and Symphyta. The data obtained indicate that the diversity of Caatinga biome has not yet been studied for these groups, therefore further studies regarding the fauna of Hymenoptera are necessary in this region, and a deeper study of the already collected material, identification of genera and species are necessary as well.

Regarding the habits, 26 families of parasitoid hymenopterans sampled in this study is similar to that reported by FERNANDES *et al.* (2014a). This number is also similar to those found in other biomes in Brazil, such as in the Atlantic Forest of Espírito Santo and São Paulo (AZEVEDO *et al.* 2002; PERIOTO & LARA 2003, respectively), in the Amazon Rainforest of Amazonas (FEITOSA

et al. 2007) and in the Cerrado of São Paulo and Minas Gerais (PERIOTO *et al.* 2008; PÁDUA & ZAMPIERON 2012, respectively).

Some long-term sampling in the same collection area proved to be effective for capturing uncommon Hymenoptera families in the surveys with Malaise traps, such as Chrysidae, Dryinidae, Monomachidae, Pelecinidae and Sclerogibbidae (LUCENA *et al.* 2012; LARA & PERIOTO 2014; VERSUTI *et al.* 2014; PERIOTO *et al.* 2016; FERNANDES *et al.* 2017).

For the Ichneumonidae fauna, 14 subfamilies and 13 genera were previously registered for the Caatinga biome in RN (SHIMBORI *et al.* 2014). Thus, four subfamilies are registered for the first time in this biome for the state of RN (Lycorininae, Nesomesochorinae, Phygadeuontinae and Tryphoninae).

As for the genera, *Cryptophion*, *Xanthocampoplex* (Campopleginae), *Pristomerus*, *Trathala*, *Xiphosomella* (Cremastinae), *Polycyrtidea* (Cryptinae), *Diacantharius* (Ichneumoninae), *Lycorina* (Lycorininae), *Trieces* (Metopiinae), *Nonnus* (Nesomesochorinae), *Isdromas* (Phygadeuontinae), *Hymenoepimecis*, *Neotheronia* and *Zaglyptus* (Pimplinae), *Allophrys* (Tersilochinae) and *Netelia* (Tryphoninae) are registered for the first time in the state of RN. With the exception of *Lycorina*, *Neotheronia*, *Netelia*, *Nonnus*, *Trathala*, *Xanthocampoplex* and *Xiphosomella* that have already been associated with the Caatinga biome (SHIMBORI *et al.* 2014; FERNANDES *et al.* 2019); the other genera mentioned above are also associated with this biome for the first time.

Thus, from these results, 18 subfamilies and 30 genera were registered in the Caatinga biome, specifically in the state of RN. After adding these results with those of SHIMBORI *et al.* (2014) and FERNANDES *et al.* (2019), the Caatinga biome as a whole represents 18 subfamilies and 47 genera. SHIMBORI *et al.* (2017) listed 19 genera of Ichneumonidae in the state of Mato Grosso do Sul (in areas of Pantanal) and AZEVEDO *et al.* (2015) recorded the occurrence of 100 genera for Espírito Santo (in areas of Atlantic Forest). In the present study, although the sampling is done only for three months, the material collected

demonstrates a considerable diversity of Ichneumonidae in this biome, as well as in other biomes mentioned earlier. It is possible that, with greater sampling effort and with deeper taxonomic studies, this diversity may increase considerably in coming years.

We must also take into account that so far only eight species of Ichneumonidae have been registered for RN (FERNANDES *et al.* 2020). In the present study, the species *Cryptophion espinozai* Gauld & Janzen (Campopleginae) and *Labena marginata* Szépligeti (Labeninae) were recognized and are recorded for the first time in the Caatinga biome.

In Brazil, *C. espinozai* (Figure 3) has been registered only in Minas Gerais and São Paulo (GAULD & JANZEN 1994; ONODY *et al.* 2013; FERNANDES *et al.* 2020). The distribution of species *L. marginata* in the Brazilian territory was unknown. In its original description by SZÉPLIGETI (1914), it was only mentioned that the species *L. marginata* had been collected in Brazil, without pointing out the place of collection. Thus, the present study also mentions the place of occurrence of this species in Brazil for the first time.

The results presented in this study demonstrate that the areas of Caatinga biome are home to a substantial diversity of Hymenoptera families that is similar to other Brazilian biomes, and that this diversity still needs to be better sampled and studied, which may reveal the presence of unknown species. Thus, it is essential to develop more studies in this biome to know the diversity of this group of insects in this environment that is still little explored.

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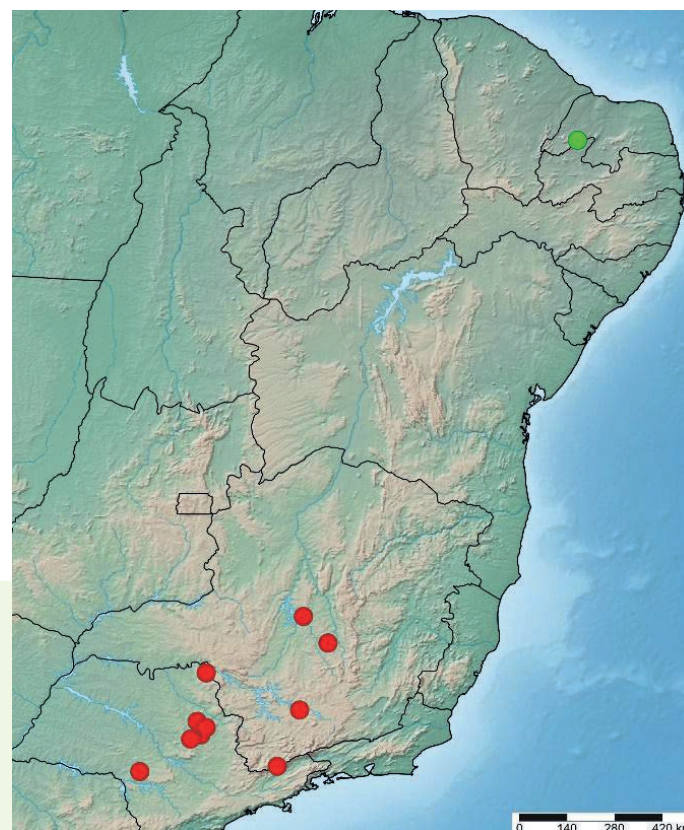


Figure 3. Distribution map of *Cryptophion espinozai* Gauld & Janzen in Brazil. New record (green) and previous records (red).

the first author (PNPD / CAPES). We would also like to thank the National Institute of Science and Technology of Hymenoptera Parasitoides in the Southeast of Brazil (HYMPAR / Southeast - CNPq / FAPESP / CAPES).

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