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CHALCIDIDAE (HYMENOPTERA) ASSOCIATED WITH A SEMIARID REGION IN BAHIA, BRAZIL[1]

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ABSTRACT - Chalcididae is a family of parasitoids with wide distribution and great richness, with almost 1,500 described species. Its diversity might be greater than that known today, mainly due to the few existing studies and its taxonomic complexity. Studies in semiarid regions are scarce and necessary to contribute to the biogeographic knowledge of the neotropical fauna. Therefore, the objective of this work was to record Chalcididae species that occur in the municipality of Barra do Choça, in the Semiarid region of the state of Bahia, Brazil. Five Malaise traps were distributed in two areas with native vegetation and an area with eucalyptus plantation, which were monitored monthly for two consecutive years. The insects were sorted and specimens of the family Chalcididae were identified at the species level, when possible. A total of 182 specimens from five genera (*Aspirrhina* Kyrbi, 1883; *Brachymeria* Westwood, 1829; *Conura* Spinola, 1837; *Dirhinus* Dalman, 1818, and *Haltichella* Spinola, 1811), and 18 species were identified and 32 were morphotyped. The genus *Conura* was the most abundant and the most diverse, with 12 species identified and 30 potential new species. The native vegetation presented higher abundance and higher taxonomic wealth, mainly in the area at initial stage of succession (capoeira). The eucalyptus area presented low diversity, with predominance of *Brachymeria* species. The species *C. nigricornis* presented the highest relative frequency. This study constitutes the first list of Chalcididae species in the Semiarid region of Brazil. The sampling carried out in the state Bahia showed an important diversity of Chalcididae species when compared to other regions of Brazil.

Keywords: Chalcidoidea. *Conura nigricornis*. Parasitoid.

CHALCIDIDAE (HYMENOPTERA) ASSOCIADOS A UMA REGIÃO DO SEMIÁRIDO DA BAHIA, BRASIL

RESUMO - Os Chalcididae são parasitoides com distribuição ampla e grande riqueza com quase 1.500 espécies descritas. Apresentam potencial de diversidade maior, principalmente em função dos poucos estudos e da complexidade taxonômica associada. Estudos em regiões semiáridas são escassos e necessários para contribuir com conhecimento biogeográfico da fauna Neotropical, portanto o objetivo desse trabalho foi registrar as espécies de Chalcididae que ocorrem no município de Barra do Choça, Bahia, inserido no no semiárido da Bahia. Foram utilizadas cinco armadilhas do tipo Malaise distribuídas em duas áreas de vegetação nativa e uma constituída demonocultura, com monitoramento mensal por dois anos consecutivos. Os insetos foram triados e os espécimes da família Chalcididae identificados em nível de espécie, quando possível. Totalizaram-se 182 espécimes, distribuídos em cinco gêneros (*Aspirrhina* Kyrbi, 1883; *Brachymeria* Westwood, 1829; *Conura* Spinola, 1837; *Dirhinus* Dalman, 1818 e *Haltichella* Spinola, 1811), 18 espécies identificadas e 32 morfotipadas. O gênero *Conura* foi o mais abundante e também o mais, com 12 espécies nomeadas e potencialmente 30 novas espécies. A vegetação nativa apresentou maior abundância e maior riqueza taxonômica, principalmente na capoeira. O eucalipto teve baixa diversidade com predominância de *Brachymeria*. A espécie *C. nigricornis* se apresentou com maior frequência relativa. Este estudo constitui a primeira lista de espécies de Chalcididae no semiárido. As amostragens realizadas no semiárido baiano evidenciaram uma diversidade relevante de Chalcidade quando comparada com outras regiões brasileiras.

Palavras-chave: Chalcidoidea. *Conura nigricornis*. Parasitoide.

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INTRODUCTION

Tropical regions tend to have a high diversity of species of parasitoids of the Hymenoptera order than temperate regions (NOYES, 1989). However, despite of these insects to contribute to essential processes of the ecosystems, there is a lack of interest in the development of faunistic studies associated them with some biomes in Brazil (MARCHIORI, 2021). The scarcity of information on the fauna of this group is even higher when considering drier regions, such as the Caatinga biome in Brazil (SHIMBORI et al., 2014; SHIMBORI et al., 2017; FERNANDES et al., 2020).

Hymenoptera parasitoids from the family Chalcididae (Latreille, 1817) are predominantly found alone, associated mainly with Lepidoptera and Diptera larvae, and some species present hyperparasitoid dynamics (TIBCHERANI; ARANDA; MELLO, 2016; NOYES, 2019). The representatives of this family are widely distributed, encompassing 87 genera and 1,464 known species (NOYES, 2019), but the total number of species is considered well higher, as it is a little-known group.

In Brazil, there are 258 species distributed in 19 genera; *Conura, Brachymeria*, and *Ceyxia* are the most diverse genera (TAVARES, 2018). Chalcididae are characterized by a potential to control populational densities of hosts species and are used in conservative (DELVARE, 2017) and natural (DELVARE; GENTY, 1992) biological control programs, as several of their hosts are species of economic interest by being agroforestry pests. The species *Brachymeria pandora* (Crawford, 1914), for example, can be a potential agent for the control of defoliating pest species in eucalyptus plantations, such as *Thyrinteina leucocerae* (Rindge) (Geometridae) (ZACHÉ et al., 2012).

Regional studies on the biodiversity of parasitoid wasps including semiarid regions can contribute to the identification of new species with potential to be applied in biological control (MARCHIORI, 2021). Faunistic studies on Hymenoptera parasitoids have been conducted for several crop species (DALL'OGLIO et al., 2003; SPERBER et al., 2004; NAKAYAMA et al., 2008; PERIOTO et al., 2002; SPERBER et al., 2012), including those in the semiarid regions (FERNANDES et al., 2014; COSTA et al., 2016) and in the state of Bahia (PALMA-SANTOS; PÉREZ-MALUF, 2010), but still are mostly based on the family and subfamily levels (ARANDA; GRACIOLLI, 2015).

Few studies on diversity of Chalcididae in Brazil are found, including those conducted by Oliveira et al. (2014) in different sites with plantations of *Tectona grandis* in the Cerrado biome of the state of Mato Grosso, and by Marchiori, Penteado-Dias and Tavares (2003) in pastures and native forest areas in the state of Goiás.

The references for Chalcididae species in Brazil are the list of species developed for the state of Espírito Santo with the record of 149 species from 11 genera (TAVARES; ARAUJO, 2007) and the list of species of the state of Mato Grosso do Sul, which encompasses mainly species associated with the Pantanal and Cerrado biomes, with the record of 22 species from four genera (SHIMBORI et al., 2017).

In Bahia, the records of species include *Chalcis danunciae* Saguiah and Tavares (SAGUIAH; DAL MOLIN; TAVARES, 2020); *Ceyxia pseudovillosa*, *Conura morleyi* (Ashmead), *Melanosmicra acutodentata* (Cameron), *M. rugosa* and *Zavoya cooperi* (Bouček) (NOYES, 2019), *Ceyxia ventrispinosa*, and *Ceyxia concitator* (ANDRADE; TAVARES, 2009). As far as known to date, Bahia still does not have a compilation confirming the number of Chalcididae species found, nor studies on the faunistic composition of this family in the Semiarid region. The list of species in the present research is a contribution at the state level and the first in the Semiarid region of Brazil.

The objective of this work was to record Chalcididae species that occur in the Planalto da Conquista region, in the Semiarid region of the state of Bahia, Brazil, focused on contributing with biogeographic information on neotropical fauna.

MATERIAL AND METHODS

Study area

The parasitoids were collected in the municipality of Barra do Choça, in the southwest region of the state of Bahia, which is in the Semiarid region of Brazil, according to the Deliberative Council (CONDEL) of the Superintendency for the Development of the Northeast (Sudene), by the Resolutions no. 107/2017 and no. 115/2017. The region presents a plain to slightly wavy relief, mean altitude of 840 m, a Cwb, tropical highland climate, according to the Köppen classification, mean annual temperature of 25 °C, and mean annual rainfall depth of 850 mm (BARBOSA et al., 2017).

The area encompasses three phytophysiognomies, one monoculture and two native vegetation at different stages of succession, classified as Montana Semi-Deciduous Seasonal Forest according to the classification of Ivanauskas and Assis (2012). The first phytophysiognomy consisted of a plantation of *Eucalyptus urophylla* (approximately 30 ha); the second phytophysiognomy is classified as capoeira, according to the Brazilian Institute of Geography and Statistics (IBGE, 2012), presenting vegetation at initial stage of succession, dominated by individuals with up to 5 m height and predominance of pioneers species (approximately 6 ha); and the third phytophysiognomy was a secondary forest fragment

consisted of individuals of the higher stratum with approximately 15 m height (approximately 86 ha). The areas were not separated, but adjacent.

Collections were carried out monthly using Malaise traps, model Townes (1972), for two consecutive years (January 2016 to December 2017). Five traps were distributed, two in the interior of the eucalyptus plantation, namely, Point 1 (14°52'33.59"S and 40°41'45.25"W) and Point 2 (14°52'35.99"S and 40°41'43.03"W), one in the capoeira, Point 3 (14°52'45.99"S and 40°41'40.34"W), and two in the forest, Point 4 (14°52'57.16"S and 40°41'37.78"W) and 5 (14°52'55.3"S and 40°41'36.00"W) (Figure 1), adopting a methodology similar to that used by Dall'Oglio et al. (2003).

The traps were installed at the ground level, at 200 m and 300 m from the eucalyptus plantation edge (Point 1 and Point 2, respectively) and from the forest edge (Point 4 and Point 5). The distance between the two traps was 100 m to avoid distances lower than 100 m from the edge of these areas. The distance from the capoeira edge to Point 3 was approximately 250 m.

The Chalcididae species were identified by a taxonomist (PhD Bruno Cancian de Araujo; Zoologischer Staatsammlung Munchen, Germany) with the aid of specific literature, such as Andrade and Tavares (2009), Bouček (1992), Delvare (1992), Navarro-Tavares and Tavares (2008), and Saguiah, Dal Molin, and Tavares (2020). All specimens were deposited in the Entomological Collection of the Department of Biological Sciences of the Federal University of Espírito Santo, Vitória, Brazil, under the care of the curator PhD Marcelo Texeira Tavares. The images of the species collected were obtained through a LAS Montage extended focus system coupled to a Leica Z16 APO stereomicroscope and a DFC495 camera.

Figure 1. Satellite image of the area with the sampling points of the studied phytophysiognomies and the respective geographic coordinates. Points 1 and 2: plantation of *Eucalyptus urophylla*; Point 3: Capoeira; and Points 4 and 5: Secondary Forest. Planalto da Conquista, Bahia, Brazil.

The composition of the Chalcididae community was characterized by adopting faunistic indexes of relative frequency, wealth, abundance, constancy, and dominance, according to methodology proposed by Silveira Neto et al. (1976). In addition, the Shannon diversity (H') and evenness (J) indexes (PRICE et al., 2011) were estimated, as well as Chao-1 wealth estimator and rarefaction curve for each phytophysiognomy, using the statistical program Past 2.16 (2012) (HAMMER; HARPER; RYAN, 2001).

The species were categorized by constancy [constant (W) = presence in more than 50% of the samples; accessory (Y) = presence in 25-50% of the samples; and accidental (Z) = presence in less than 25% of the samples] and dominance [non-dominant and dominant: species that presented relative frequency higher than or equal to 1/S, where S = wealth of species] indexes. The combination of these two indexes were used to classify the species as common (constant and dominant), intermediate (accessory and dominant; accessory and not dominant; constant and not dominant; accidental and dominant), and rare (accidental and not dominant), as adopted by Scatolini and Penteado-Dias (2003).

RESULTS AND DISCUSSION

The 182 individuals collected were from five genera: *Aspirrhina* Kyrbi, 1883; *Brachymeria* Westwood, 1829; *Conura* Spinola, 1837; *Dirhinus* Dalman, 1818; and *Haltichella* Spinola, 1811 (Figure 2) and 50 morphospecies (18 identified species and 32 morphotypes) (Table 1).

The wealth of species found in the samples was high when compared to a study in the Cerrado biome, with similar sample effort, conducted by Oliveira et al. (2014), which presented higher abundance and lower wealth of species (414 and 16, respectively). This difference in diversity of Chalcididae species between biomes is expected, as each one is characterized by specific micro-environmental factors and disturbances that consequently result in differences in flora and fauna diversities.

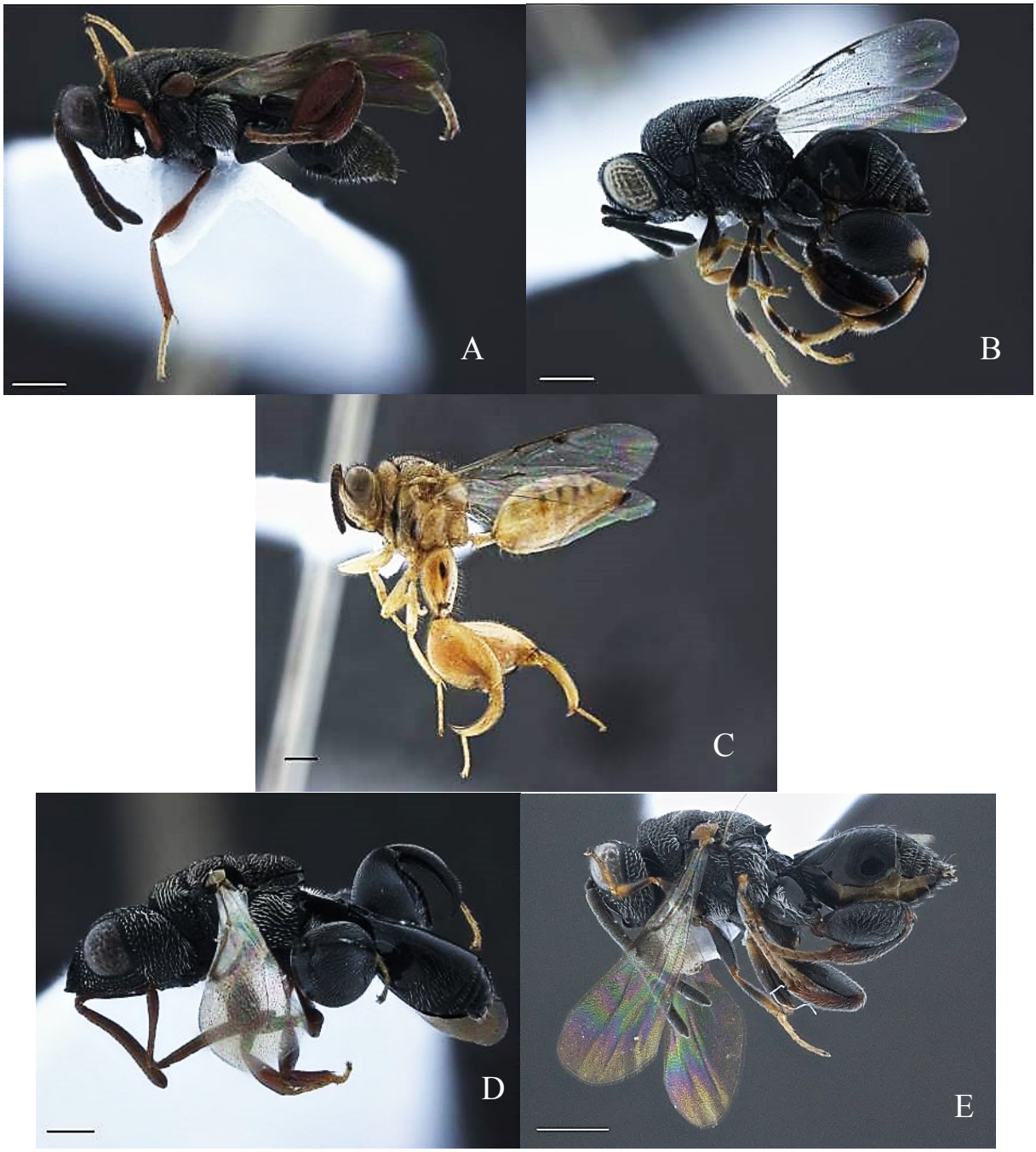

Figure 2. Lateral perspective of species from the five genera found: (A) *Aspirrhina dubitator* (Walker, 1862), (B) *Brachymeria panamensis* (Holmgren 1868), (C) *Conura nigricornis* (Fabricius, 1798), (D) *Dirhinus texanus* (Ashmead, 1896), (E) *Haltichella ornaticornis* Cameron, 1884. Scale bar = 1 mm.

Table 1. Wealth, abundance, relative frequency, constancy, and dominance of species of Chalcididae (Hymenoptera, Chalcidoidea) collected in Planalto da Conquista, Bahia, Brazil, from 2016 to 2017.

Species	E	C	SF	Total	RF (%)	Category
Aspirrhina dubitator (Walker, 1862)			1	1	0.55	R
Aspirrhina remotor (Walker, 1862)			1	1	0.55	R
Brachymeria panamensis (Holmgren 1868)		1		1	0.55	R
Brachymeria russelli Burks, 1960		2		2	1.10	R
Brachymeria sp.1		3		3	1.65	R
Conura (grupo *arcuaspina*) sp.25			3	3	1.65	R
*Conur*a (grupo *arcuaspina*) sp.26			1	1	0.55	R
Conura (grupo *biannulata)* sp.6			2	2	1.10	R
Conura (grupo *elongata*) sp.1		2	2	4	2.20	I
Conura (grupo *femorata*) sp.10		1		1	0.55	R
Conura (grupo *femorata*) sp.11		2		2	1.10	R
Conura (grupo *femorata)* sp.12	3	1		4	2.20	I
Conura (grupo *femorata*) sp.8	4		1	5	2.75	I
Conura (grupo *femorata*) sp.9		2	1	3	1.65	R
Conura (grupo *femorata*) sp.7	1	6	1	8	4.40	I
Conura (grupo *flava*) sp.21			3	3	1.65	R
Conura (grupo *flava*) sp.22		1		1	0.55	R
Conura (grupo *immaculata*) sp.2		3	3	6	3.30	I
Conura (grupo *immaculata*) sp.3		1	1	2	1.10	R
Conura (grupo *immaculata*) sp.4		1		1	0.55	R
Conura (grupo *immaculata*) sp.5		4		4	2.20	I
Conura (grupo *maculata*) sp.17		2		2	1.10	R
Conura (grupo *maculata*) sp.18		3	1	4	2.20	I
*Conur*a (grupo *maculata*) sp.19		1	1	2	1.10	R
*Conur*a (grupo *pygmaea*) sp.14	3	4		7	3.85	I
Conura (grupo *pygmaea*) sp.15		2		2	1.10	R
*Conur*a (grupo *pygmaea)* sp.16	1			1	0.55	R
Conura (grupo *rufodorsalis)* sp.23		1		1	0.55	R
Conura (grupo *rufodorsalis)* sp.24			2	2	1.10	R
Conura (grupo *transitiva)* sp.13		10		10	5.49	I
Conura (grupo *vau*) sp.20	1	5	2	8	4.40	I
Conura amoena (Say, 1836)		8	1	9	4.95	I
Conura camescens Delvare, 1992		1		1	0.55	R
Conura debilis (Say, 1836)		2		2	1.10	R
Conura femorata (Fabricius, 1804)	4	1		5	2.75	I
Conura fusiformis (Ashmead, 1904)		2		2	1.10	R
Conura immaculata (Cresson, 1865)		2		2	1.10	R
Conura maculata (Fabricius, 1787)	2			2	1.10	R
Conura magistrettii (Blanchard, 1941)		9		9	4.95	I
Conura mayri (Ashmead, 1904)	1	2		3	1.65	R
Conura nigricornis (Fabricius, 1798)	2	18	6	26	14.29	I
Conura nigropleuralis (Ashmead, 1904)		1	8	9	4.95	I
Conura pulchripes (Cameron, 1909)		1		1	0.55	R
Conura sp.27			1	1	0.55	R
Conura sp.28		1		1	0.55	R
Conura sp.29		4		4	2.20	I
Conura sp.30			1	1	0.55	R
Dirhinus texanus (Ashmead, 1896)		2		2	1.10	R
Haltichella ornaticornis Cameron, 1884			3	3	1.65	R
Haltichella sp.1		1	1	2	1.10	R
Abundance	22	113	47	182	100	
Number of insects/trap	11	113	23.5			
Richness (S)	10	37	23	50		
Shannon (H')	2.15	3.20	2.87			
Equitability (J)	0.93	0.89	0.92			
Chao-1	12.0	44.5	28.6			

E = eucalyptus plantation; C = capoeira; SF = secondary forest; RF = relative frequency; I = intermediate; R. rare.

Regarding the phytophysiognomies studied, the traps in the native vegetation presented higher abundance and higher taxonomic wealth (Table 1), mainly those in the capoeira (113 insects per trap and 37 species). The phytophysiognomy of the eucalyptus plantation presented low diversity (11 insects per trap and 10 species), with the collection of only one genus, *Conura* (Table 1, Figure 3).

Oliveira et al. (2014) also found higher wealth of Chalcididae in areas with native vegetation compared to areas with plantations of *Tectona grandis*. The structural complexity of the habitat is directly related to the wealth and abundance of Hymenoptera insects (ARANDA; GRACIOLLI, 2015). In addition, in the same study area, including this same phytophysiognomy, Paula (2018) conducted entomological faunistic surveys during the same period of the collections of Chalcididae and easily found presence of plant species at flowering and fruiting stages, which may have served as an environment for refuge, shelter, and feeding resources for these parasitoids. Oliveira et al. (2014) and Schoeninger et al. (2019) pointed out that native vegetation constitutes a refuge for the maintenance of diversity of parasitoids in monocultures. This can be also be the case in the present study, denoting the need for preservation of these environments.

Souza et al. (2010) evaluated social wasps (Vespidae) and found that environments formed by vegetation at different stages of succession or under recovery processes may have higher number of prays due to the high wealth of plants, which also increases their diversity.

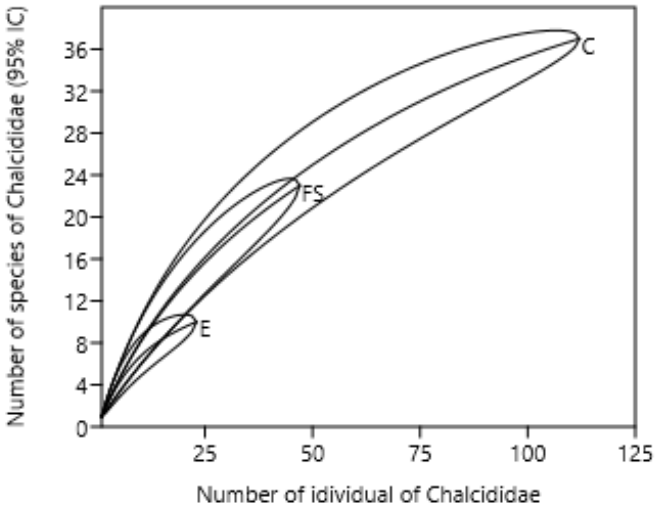

Figure 3. Rarefaction curve of Chalcididae species collected using Malaise traps in different phytophysiognomies, plantation of *Eucalyptus urophylla* (E), Capoeira (C), and Secondary Forest (FS), from January 2016 to December 2017. Confidence Interval (IC): 95%.

The genus *Conura* presented higher abundance within the Chalcididae collected (88%), and the highest wealth of species (42) (Table 1); similar results were found by Oliveira et al. (2014) in plantations of *T. grandis* in the Cerrado biome. In addition, Marchiori, Penteado-Dias, and Tavares (2003), using a collection methodology different from that used in the present study, reported *Haltichella* as the genus presenting most abundance and wealth of species.

Conura presented higher abundance in the capoeira (68%) followed by the secondary forest (25%) and the eucalyptus plantation (14%). The species *Conura nigricornis* (Figure 2C) presented higher relative frequency (14%) (Table 1), mainly in the capoeira. This species parasites Lepidoptera species of the family Limacodidae (*Adoneta* sp.; *Adoneta spinuloides* (Herrich-Schaffer, 1854), *Limacodes* sp.; *Parasa* sp., and *Parasa indetermina* (Boisduval, 1832) (NOYES, 2019).

Conura species are considered as parasitoids with wide distribution; they are generalists and have insect hosts from several Coleoptera, Diptera, and Lepidoptera families (DELVARE; ARIAS-PENNA, 2006). In addition, this genus presents a complex systematic, with at least three subgene3ra, three species complexes, and 63 groups, constituting the highest wealth of Chalcididae species (NOYES, 2019), consisting mainly of the species found in the studies of Tavares and Araujo (2007), Shimbori et al. (2017), and Araujo et al. (2019).

Most of the species found are still not described (30 new species), representing potential biotypes (Table 1). Some specimens found in this research had not defined identifications at specific levels because Chalcididae encompasses a group of many species to be described, which slows the taxonomic advance for this group (TAVARES; ARAUJO, 2007). The genus *Brachymeria* was found for 100% of the species in the capoeira. Oliveira et

al. (2014) also found this genus in the interior of plantations of *T. grandis*, as in an area with *T. grandis* plantations with adjacent pasture. The main genera found in the present study (*Conura* and *Brachimeria*) are highlighted by their wealth and abundance in the capoeira, which implies that this environment has favorable conditions for their survival, including presence of food and hosts.

Brachymeria wasps are parasitoids of Lepidoptera, Diptera, Coleoptera, and Hymenoptera species (BOUČEK, 1992) and are important for the biological control of insect-pests (DELVARE; ARIAS-PENNA, 2006). In the forest area, *Brachymeria* species are being studied for future applications in biological control programs for the main defoliating Lepidoptera species of Eucalyptus in Brazil. The pest-species that occur in Eucalyptus plantations in the state of Bahia include *Brachymeria ovata* (Say), a parasitoid of *Eupseudosoma aberrans* (Schaus), *E. involuta* Sepp (Arctiidae) (OHASHI; BERTI FILHO, 1988), and *Sarsina violascens* (Herrich–Schaeffer) (Lymantriidae); *Brachymeria pandora* (Crawford), a parasitoid of *Thyrinteina leucoceraea* Rindge (ZACHÉ et al., 2012); and *Brachymeria pseudovata* Blanchard, a parasitoid of *Oiketicus kirbyi* Guilding (Psychidae) (COSTA LIMA, 1945).

None of the species collected was considered as common due to their occurrence in the samples (dominant and constant) and most species had rare occurrence (accidental and not dominant) (Table 1), denoting a little distribution of species over the sampling period and small populations. Species of this faunistic category seems to be little studied for their functions in the environments and should be better understood, not only as a category, but as important species that need to be preserved due to the functions that they may have in the environment (MOUILLOT et al., 2013).

CONCLUSION

The present study shows a record of 18 Chalcididae species in the Semiarid region of the state of Bahia, Brazil.

The samplings showed a significant diversity of Chalcididae when compared to other regions of Brazil, and that they need to be further studied.

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