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Checklist of Social (Polistinae) and Solitary (Eumeninae) Wasps from a Fragment of Cerrado "Campo Sujo" in the State of Mato Grosso do Sul

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Abstract
Cerrado is one of the richest biomes in the world but it is still very threatened by human actions that affect not only the flora, but also the fauna, and certainly the largest known group, the insects. We present here a list of species of Polistinae and Eumeninae wasps, based on three different methodologies in a fragment of Cerrado "campo sujo", very affected by livestock raising, on Paranaíba, Mato Grosso do Sul state. We recorded 22 species of Polistinae within 8 genera, with *Polybia* and *Agelaia* as the most representative. For Eumeninae, 21 species within 10 genera were recorded, with *Montezumia* and *Pachodynerus* as the most representative. Furthermore, this work shows the first records of Eumeninae on Mato Grosso do Sul state and some new of Polistinae, compared to the literature.

Introduction

Wasps are commonly known by their great variety of nest construction and, sometimes, their painful stings. With more than 5,000 species (Pickett & Carpenter, 2010), Vespidae has six known subfamilies (Carpenter, 1982; Pickett & Carpenter, 2010): Euparagiinae, Stenogastrinae, Masarinae, Eumeninae, Polistinae and Vespinae. In Brazil, only Masarinae, Eumeninae and Polistinae are recorded (Carpenter & Marques, 2001).

Polistinae wasps are the well-studied group, although it comprises only one fifth of the diversity of the family (Pickett & Carpenter, 2010). They are used as a model of evolution of social behavior but, besides that, they are considered as important "ecological engineers" (Jones et al. 1994), because they change the physical environment and affect the availability of resources for other organisms (Kears et al., 1998; Alonso & Agosti, 2000; Kaspari, 2000). Besides that, they contribute for the soil formation, biological control, pollination (Van Mele & Cuc, 2000). According to Pickett and Carpenter (2010), this cosmopolitan subfamily has 958 described species in 26 genera, but the main diversity is in the Neotropical region, mainly in Brazil, with 21 genera and 304 recognized species (Carpenter, 2004).

Commonly known as "Potter wasps" due to the shape of the brood cells of some species, Eumeninae is the most diverse in Vespidae with more than 3,500 described species in 210 genera and Brazil has approximately 277 species in 31 genera (Pickett & Carpenter, 2010). These wasps have solitary behavior, however there are some species with primitively social behavior, like *Zethus miniatus* de Saussure, which groups of females build communal nests made by plant material and resin (Bohart & Stange, 1965; West-Eberhard, 1987).

According to MMA (2010), the Cerrado has 5% of all biodiversity from the planet. It is the richest biome in the world, although it is one of the most threatened. In Brazil, it is the second in extension and, until 2008 the biome had

already lost almost 50% of the original vegetation, because it has conducive characteristics to agriculture, livestock and the demand for charcoal for the steel industry. This dynamics of substitution includes deforestation and forest fire, causing environmental changes, habitat fragmentation, species extinction, invasion of exotic species, erosion, aquifer pollution, siltation of rivers and the imbalance of the carbon cycle.

Although it is obvious the importance of the Cerrado and its biodiversity and preservation (Oliveira & Marquis, 2002), there are still a few studies focusing on insects, mainly wasps, which still need more research on their taxonomy, phylogenetic, behavior and ecology. For these reasons, this study was conducted to improve the knowledge or Polistinae and Eumeninae of Cerrado, giving the first records of solitary wasps to Mato Grosso do Sul state, and updating those from Polistinae.

Material and Methods

The study was conducted on Paranaíba municipality, State of Mato Grosso do Sul, more specifically at "Fazenda Prata" (19º 48'45.83'' S; 51º 06' 25.22'' O), in a "campo sujo" Cerrado, characterized by a mixed flora, comprised of forests and grassland elements. Besides that, the area has herbaceous vegetation, with predominance of Poaceae, many shrubs and arboretums (Coutinho, 1978, 2002).

Data sampling was carried out on a monthly basis, between October 2009 and September 2010, for five consecutive days, except in November due to constant rainfall. Three methodologies were used to evaluate the diversity of Polistinae and Eumeninae:

i) Ten "attractive traps" were made by using PET bottles, where two openings were made with approximately 50 cm^2 on center (adapted from Jacques et al., 2012) and later they were strung and hung (using string) on vegetation between a 1.5 m and 2.0 m from the soil. Inside the bottles we put industrial orange juice solution (about 200 ml juice per bottle) to attract the wasps. Each month, we chose a random transect and set the "attractive traps" up along a 200 m, transect 20 m apart from each other. The traps were installed on the first and third days, the insects were collected and the orange juice was exchanged. On the fifth day, the same procedure was performed. The insects were kept on 70% alcohol for being pinned and identified later;

ii) active collection, with entomological net. In each collection, 40 plants with flowers were chosen randomly and the insects were collected during five minutes per plant;

iii) Attractive solution (Noll & Gomes, 2009). This method uses a 10l dorsal spray bag, which contained the attractive solution made of a water based solution of crystal sugar (sucrose – 200g/l) and salt (sodium chloride – 25 g/l). The attractive solution was sprayed in 10 points equally separated within a 200 m transect. At each point, an average of 500 ml of solution was applied. The application was done following a zigzag pattern from left to right, generally applied on green vegetation, with solar incidence in an area of 3 m^2. After the application of the attractive solution, each point was individually observed for five minutes and wasps that visited these points were collected with an entomological net.

After collecting wasps at the 10 points, the solution was applied again at every point. Four applications were made during the day, usually between the periods from 10:00 h to 16:00 h.

Results and Discussion

Polistinae

We collected 574 specimens of social wasps, belonging to 22 species within eight genera: *Agelaia*, *Apoica*, *Brachygastra*, *Mischocyttarus*, *Parachartergus*, *Polistes*, *Polybia* and *Synoeca* (Table 1). The most representative genus was *Polybia* (46.51%), followed by *Polistes* and *Mischocyttarus*, although this last had only one or two species collected. *Polybia* Lepeletier is the group within Epiponini (Vespidae: Polistinae) with the great number of species (58, being 44 in Brazil), and it is considered the most common genera of social wasps on South America (Richards, 1978; Carpenter & Marques, 2001). The most collected species was *Agelaia pallipes* (Table 1), having almost a half of the abundance of social wasps (42.68%). *Agelaia* is the third most representative genus on Epiponini and has species that build huge nests with millions of wasps (Zucchi et al., 1995; Carpenter, 2004). The other species whose had the most representative were *Polybia sericea* (20.55%), *P. occidentalis* (13.24%) and *P. ignobilis* (10.10%).

There are only a few studies on the distribution, colony density and species seasonality from the Cerrado: Diniz and Kitayama (1998) in Mato Grosso state, Henriques et al. (1992) and Raw (1998b) in Distrito Federal, Mechi (1996) and Mechi and Moraes (2000) in São Paulo, Elpino-Campos et al. (2007) and Souza and Prezoto (2006) in Minas Gerais and Pereira & Antonialli-Junior (2011) and Pereira-Bomfim and Antonialli-Junior (2012) in Mato Grosso do Sul (in a Riparian Forest). In other ecosystems, Silva-Pereira and Santos (2006) studied wasp diversity in "Campos Rupestres", Silveira (2002) and Silveira et al. (2008) in Amazon Rainforest, Santos et al. (2007) in Mangrove, Atlantic Forest and Restinga Vegetation and Souza et al. (2010) in Riparian Forest.

The predominance of *Agelaia pallipes* was similar to the results of Elpino-Campos et al. (2007), who collected 29 species of social wasps distributed in 10 genera in four different areas, and Mechi (1996) collected 32 species within nine genera in two different areas. Diniz and Kitayama (1998) sampled 36 species, the large part of them belong-

Table 1. Species of social wasps sampled in "Fazenda Prata", Paranaíba, state of Mato Grosso do Sul.

Species	Abundance	Proportion (%)
Agelaia pallipes (Olivier)	245	42.6
Apoica flavissima Van der Vetch	2	0.34
Brachygastra augusti (de Saussure)	1	0.17
Brachygastra lecheguana (Latreille)	5	0.87
Brachygastra moebiana (de Saussure)	1	0.17
Mischocyttarus frontalis (Fox)	1	0.17
Mischocyttarus latior (Fox)	1	0.17
Mischocyttarus cerberus Ducke	2	0.34
Mischocyttarus mattogrossoensis Zikán	1	0.17
Parachartergus smithii (de Saussure)	4	0.69
Polistes canadensis (Linnaeus)	7	1.21
Polistes billardieri Fabricius	12	2.09
Polistes subsericeus de Saussure	5	0.87
Polistes versicolor (Olivier)	16	2.78
Polybia ignobilis (Haliday)	58	10.10
Polybia jurinei (de Saussure)	8	1.39
Polybia liliacea (Fabricius)	5	0.87
Polybia occidentalis (Olivier)	76	13.24
Polybia paulista (Von Ihering)	1	0.17
Polybia ruficeps (Richards)	1	0.17
Polybia sericea (Olivier)	118	20.55
Synoeca surinama (Linnaeus)	4	0.69
TOTAL	574	100

ing to the genera *Polybia*, who was the most representative, *Polistes* and *Mischocyttarus*. This last, in this work, was very few sampled, with only five specimens (Table 1). Raw (1998b) and Henriques et al. (1992) studied colonies of social wasps, while the first sampled 13 species within eight genera (*Polybia* was the most representative), the second found only seven colonies of four species.

Until now, there were no studies of diversity of social wasps in Mato Grosso do Sul state. A study on "riparian forest" (Pereira & Antonielli-Junior, 2011) sampled 18 species belonging to six genera, with *Polybia* as the most representative, but *Agelaia* pallipes had almost half of the total abundance. In addition to the list of species from Pereira and Antonielli-Junior (2011) and Pereira-Bomfim and Antonielli-Junior (2012), we present here new records of species from Mato Grosso do Sul state: *Apoica pallens, Brachygastra lecheguana, B. moebiana, Mischocyttarus frontalis, M. latior, M. cerberus, M. mattogrossoensis* and *Polistes canadensis*.

Eumeninae

This work presents the first records for Eumeninae species in Mato Grosso do Sul. We collected 53 specimens of solitary wasps belonging to 21 species within 10 genera (Table 2). The most representative genera were *Montezumia* and *Pachodynerus*, followed by *Zethus* and the most sampled species was *Montezumia nigriceps* (15%), *Pachodynerus brachygaster* (13.2%) and *Alphamenes campanulatus* (11.3%). Eumenines have solitary behavior and build their nests, commonly, with plant resin, mud, in pre-existing cavities and even on surfaces (Evans, 1966; Cowan, 1991; Camillo et al., 1995, 1997). For these reasons, maybe it is more difficult to capture them than social wasps, whose build a variety kinds of nests, many times with characteristics that make possible to identify genera or even species (Wenzel, 1998).

One of the most representative work that sampled specimens of Eumeninae from Cerrado was Mechi (2006), who collected 35 species within 16 genera, but there are other authors who sampled solitary wasps Cerrado, but they used trap-nests methodology, which restrict the sampling to species that make nests on pre-existing cavities (Camillo et al., 1995; Camillo & Assis, 1997). On other ecosystems, Hermes and Köhler (2004) collected 37 species in the Green Belt of "Rio Grande do Sul" and Morato (2001), on Central Amazon, colleted four species, although all of them were identified to genera.

In the last years, due to anthropic actions (especially agriculture and pasture), the physiognomies found in Mato Grosso do Sul have suffered intense degradation. These modifications cause environmental fragmentation

Table 2. Species of solitary wasps sampled in "Fazenda Prata", Paranaíba, state of Mato Grosso do Sul.

Species	Abundance	Proportion (%)
Alphamenes campanulatus (Fabricius)	6	11.3
Alphamenes insignis (Fox)	1	1.8
Alphamenes sp1	1	1.8
Alphamenes sp2	2	3.7
Ancistroceroides venustus (Brèthes)	4	7.5
Cyphomenes anisitsii (Brèthes)	3	5.6
Hypalastoroides brasiliensis (de Saussure)	2	3.7
Hypalastoroides nitidus Giordani Soika	2	3.7
Montezumia azurescens (Spinola)	1	1.8
Montezumia nigriceps (Spinola)	8	15.0
Montezumia petiolata Saussure	1	1.8
Pachodynerus brachygaster (Saussure)	7	13.2
Pachodynerus brevithorax (Saussure)	1	1.8
Pachodynerus guadulpensis (Saussure)	1	1.8
Pachodynerus reticulatus (Cameron)	1	1.8
Pachymenes laeviventris (Fox)	2	3.7
Parancistrocerus areatus (Fox)	1	1.8
Zeta argilaceum (Linnaeus)	3	5.6
Zethus hilarianus (Saussure)	3	5.6
Zethus miscogaster (Saussure)	2	3.7

and degradation, which promotes population reduction, local extinctions and consequently biodiversity loss (Primack, 2002). Besides the Cerrado, Mato Grosso do Sul has areas that consist of different physiognomies, like Pantanal and Chaco, with marsh, seasonal forests and paths, constituting a mosaic ecosystem (Spichiger et al., 2004; Morrone, 2006; Uetanabaro et al., 2007). Despite the biogeographic importance of the state, there are still few studies concerning the local fauna, mainly invertebrates diversity, ecology, behavior and phylogenetic relationships.

Comparison of methodologies

According to table 3, the "attractive traps" sampled 76.31% of the total abundance collected (438 wasps), six genera and 13 species of polistinae wasps. Active search had 9.23% (53), seven genera and 11 species, while attractive attractive solution had 14.46% (83), six genera and 15 species. Even this last methodology did not collected the most abundance of wasps, it sampled the greatest richness, corroborating with Gomes and Noll (2009) and Noll and Gomes (2009), which showed that this method is very effective on capture social wasps.

The table 4 show the efficiency of the sampling methods on solitary wasps. The attractive solution and active search were the most effective methods, with 24 wasps (44.44%), 16 species within 9 genera and 28 wasps (51.86%), 13 species within 10 genera, respectively. The attractive traps sampled only two species of two different genera, with 3.7% of the total abundance. The first work that collected Eumeninae using the attractive solution method was Noll and Gomes (2009), which collected 61 wasps, being the third group more representative (Polistinae and Ichneumonidae were first and second). As they, this work shows that this method is very effective not only for social wasps, but for solitary too, even on different ecosystems.

Table 3. Abundance and proportion of social wasps collected by using different sampling methods.

Species	A.S.	Act.	A.T.	Tot.
Agelaia pallipes (Olivier)	28	3	214	245
Apoica flavissima Van der Vetch	0	0	2	2
Brachygastra augusti (de Saussure)	1	0	0	1
Brachygastra lecheguana (Latreille)	4	0	1	5
Brachygastra moebiana (de Saussure)	0	1	0	1
Mischocyttarus frontalis (Fox)	1	0	0	1
Mischocyttarus latior (Fox)	1	0	0	1
Mischocyttarus cerberus Ducke	1	1	0	2
Mischocyttarus mattogrossoensis Zikán	1	0	0	1
Parachartergus smithii (de Saussure)	3	1	0	4
Polistes canadensis (Linnaeus)	0	0	7	7
Polistes billardieri Fabricius	2	9	1	12
Polistes subsericeus de Saussure	0	1	4	5
Polistes versicolor (Olivier)	0	1	15	16
Polybia ignobilis (Haliday)	4	5	49	58
Polybia jurinei (de Saussure)	2	0	6	8
Polybia liliacea (Fabricius)	0	0	5	5
Polybia occidentalis (Olivier)	13	3	60	76
Polybia paulista (Von Ihering)	1	0	0	1
Polybia ruficeps (Richards)	1	0	0	1
Polybia sericea (Olivier)	20	27	71	118
Synoeca surinama (Linnaeus)	0	1	3	4
Total	83	53	438	574
Proportion	14.46%	9.23%	76.31%	100%

A.S. = Attractive Solution
Act. = Active
A.T. = Attractive Traps
Tot. = Total

Table 4. Abundance and proportion of solitary wasps collected by using different sampling methods.

Species	A.S.	Act.	A.T.	Tot.
Alphamenes campanulatus (Fabricius)	3	3	0	6
Alphamenes insignis (Fox)	1	0	0	1
Alphamenes sp1	1	0	0	1
Alphamenes sp2	2	0	0	2
Ancistroceroides venustus (Brèthes)	2	2	0	4
Cyphomenes anisitsii (Brèthes)	2	1	1	4
Hypalastoroides brasiliensis (de Saussure)	1	1	0	2
Hypalastoroides nitidus Giordani Soika	1	1	0	2
Montezumia azurescens (Spinola)	1	0	0	1
Montezumia nigriceps (Spinola)	2	6	0	8
Montezumia petiolata Saussure	0	0	1	1
Pachodynerus brachygaster (Saussure)	1	6	0	7
Pachodynerus brevithorax (Saussure)	1	0	0	1
Pachodynerus guadulpensis (Saussure)	0	1	0	1
Pachodynerus reticulatus (Cameron)	0	1	0	1
Pachymenes laeviventris (Fox)	0	2	0	2
Parancistrocerus areatus (Fox)	0	1	0	1
Zeta argilaceum (Linnaeus)	1	2	0	3
Zethus hilarianus (Saussure)	3	0	0	3
Zethus miscogaster (Saussure)	1	1	0	2
Zethus romandinus (Saussure)	1	0	0	1
Total	24	28	2	54
Proportion	44.44%	51.86%	3.7%	100%

A.S. = Attractive Solution
Act. = Active
A.T. = Attractive Traps
Tot. = Total

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