

ORIGINAL ARTICLE

Survey of social wasps (Hymenoptera, Vespidae, Polistinae) in Amazon rainforest fragments in Acre, Brazil

Bruno GOMES¹, Samilla Vanessa de Lima KNIDEL¹, Heroílson da Silva MORAES¹, Marjorie da SILVA^{2*}

¹ Universidade Federal do Acre, Centro de Ciências Biológicas e da Natureza, Rodovia BR 364, Km 04, Distrito Industrial, 69915-900, Rio Branco - AC, Brazil,

² Universidade Estadual Paulista "Júlio de Mesquita Filho", Instituto de Biociências, Letras e Ciências Exatas, Rua Cristóvão Colombo, 2265, Jardim Nazareth, 15054-000, São José do Rio Preto - SP, Brazil.

* Corresponding author: marjoriebio@gmail.com

ABSTRACT

The State of Acre, in the southwestern Brazilian Amazon, harbors high biodiversity and a high degree of endemisms. Nevertheless, there are few studies on the diversity of social wasps occurring in this region. This study presents a list of social wasps (Hymenoptera, Vespidae, Polistinae) collected actively with attractive bait in three rainforest fragments in Acre. A total of 758 wasps belonging to 11 genera and 36 species were collected. Nineteen species were new distribution records for Acre and three others were new records for Brazil. Based on our results, further investigations should lead to a significant increase in Polistinae diversity in this region, producing information for biogeographic studies and management of natural areas.

KEYWORDS: distribution records, Neotropical Region, swarm-founding wasps, Western Amazon

Levantamento de vespas sociais (Hymenoptera, Vespidae, Polistinae) em fragmentos de floresta Amazônica no Acre, Brasil

RESUMO

O estado do Acre é parte da Amazônia Ocidental brasileira, uma área que abriga uma grande biodiversidade e alto grau de endemismos. Contudo, poucos estudos investigaram a diversidade de vespas sociais nesta região. Este trabalho apresenta os resultados de uma amostragem de vespas sociais (Hymenoptera, Vespidae, Polistinae) em três fragmentos de floresta primária no estado do Acre. As vespas foram coletadas ativamente com o uso de solução atrativa. Um total de 758 vespas, pertencentes a 11 gêneros e 36 espécies, foi amostrado, sendo 19 dessas espécies novos registros de distribuição para o Acre e três novos registros para o Brasil. Nossos resultados indicam que novas investigações devem levar a um aumento significativo da diversidade de espécies de vespas Polistinae conhecida para a região. Nosso estudo produziu subsídios de grande utilidade para estudos biogeográficos e fornece informações importantes para a tomada de decisões sobre o manejo de áreas naturais.

PALAVRAS-CHAVE: registro de espécies, Região Neotropical, vespas enxameadoras, Amazônia Ocidental

INTRODUCTION

Tropical forests represent only 7% of biomes of the planet, however, these ecosystems host more than half of all known species of plants and animals (Wilson 1988; May 2010; Miranda *et al.* 2012). The Brazilian Amazon rainforest has one of the greatest biodiversities in the world, including the greatest diversity of social wasps (Silveira 2002; Somavilla *et al.* 2014; Barbosa *et al.* 2016). The western Amazon (which includes parts of Bolivia, Colombia, Ecuador, Peru, and western Brazil) is one of the most biodiverse regions of the planet for many taxa (Brown 1977, 1991; Calouro 1999; Carpenter and Marques 2001; Ceballos and Ehrlich 2006; Carvalho and Esposito 2010; Barbosa *et al.* 2016). The region maintains large areas of intact tropical forest and stable climate conditions, which, combined with richer soils originated from Andean sediments, is likely related to the west–east diversity gradient that has been found for some groups of Amazonian organisms, such as trees and mammals (Ceballos *et al.* 2005; Hoorn *et al.* 2010; Cheng *et al.* 2013). Moreover, it is an area close to the Andes of Peru and Bolivia, regions known for endemic species of different groups of organisms (Löwenberg-Neto and Carvalho 2009; Sigrist and Carvalho 2009; Haseyama and Carvalho 2011).

Polistinae is the most diverse group among the social wasps, with more than 900 species described. The subfamily is divided in the tribes Ropalidiini, Polistini, Mischocyttarini and Epiponini. Except for Ropalidiini, the other tribes are represented in Brazil. *Polistes* Latreille, *Mischocyttarus* de Saussure, and the 19 genera of Epiponini compose the Brazilian fauna of wasps, totalizing about 300 species, of which 104 are endemic (Carpenter and Marques 2001; Carpenter 2004; Noll 2013). The states of Minas Gerais, São Paulo and Bahia concentrate more than half of all social wasp surveys carried out in Brazil to date (Barbosa *et al.* 2016). On the other hand, no published records on social wasp fauna exist so far for nine of the 27 Brazilian states (Barbosa *et al.* 2016). In the Amazon region the low density of researchers and complex logistics result in comparatively fewer biodiversity surveys, usually concentrated near the large urban centers of the region, that are more accessible and where most specialists work, especially in the eastern Amazon region.

The Acre state is located in the southwestern Brazilian Amazon and covers a territory of 164,123 km² (IBGE 2014) with more than 90% of its area still covered by primary forest (Salimon and Brown 2000). Several studies have demonstrated the existence of areas with a high biodiversity and high degree of endemism in this state (Souza *et al.* 2003) for plants (Prance 1973; Silveira *et al.* 1997; Goldenberg and Meirelles 2011), mammals (Calouro 1999), birds (Haffer 1987; Whitaker and Oren 1999; Guilherme 2001; Guilherme and Borges 2011), amphibians (Lima *et al.* 2007), some insect orders (Brown

1991), including ants (Oliveira *et al.* 2009; Miranda *et al.* 2012), paper wasps (Morato 2001), lepidopterans (Brow, 1977), coleopterans (Vaz-de-Melo 1999), dipterans (Carvalho and Esposito 2010) and other arthropods, such as Opiliones (Villarreal-Manzanilla and Pinto-Da-Rocha 2006). Yet, very little is known about the diversity of social wasps in this part of the Amazon, since only two surveys carried out in Acre included social wasps (Richards 1978; Morato *et al.* 2008).

Insect samplings are usually highly underestimated (Troudet *et al.* 2017), although this group represents around 80% of all living animals (Smithsonian 2017). In this way, species inventories are important tools to improve the basic knowledge on species distribution and abundance in little known and highly biodiverse regions, such as the Amazon, and constitutes valuable information to guide conservation policies. In this study, we present the results of a survey of social wasps (subfamily Polistinae) carried out in three forest fragments in the southeastern part of the state of Acre.

MATERIAL AND METHODS

Study areas

Three fragments of Amazon rainforest, close to the city of Rio Branco in the east of the state of Acre, Brazil (Figure 1), were sampled. Reserva Florestal Humaitá (HU) is located in the municipality of Porto Acre (9°44'44"S, 67°40'60"W), with an area of 3.665ha and an average altitude of 198 m. Fazenda Experimental Catuaba (CA) is located in the municipality of Senador Guiomard (10°04'40"S, 67°37'35"W), with an area of 1.281 ha and 191 m of average altitude. Parque Zoobotânico (PZ) is the zoobotanical park of the Federal University of Acre (Universidade Federal do Acre) (9°57'16"S, 67°52'17"W), and is located in an urban region of the capital city Rio Branco, with an average altitude of 165 m and an area of 100 ha (Storck-Tononet *et al.* 2013).

The region where the three areas are located is characterized by open forest with the presence of bamboos (locally known as *tabocais*), common in the Andean region in Peru, and palm trees (Silveira 2005). The *tabocais* are dense, with a high density of lianas and bamboos, and an open canopy with an average height of 20–40 m (Daly and Silveira 2008). The predominant type of soil in the region is latosol and the landscape is slightly hilly (Daly and Silveira 2008).

The average annual temperature varies between 22 and 24 °C. Lowest temperatures occur in August (about 12 to 14 °C) (Mesquita and Paiva 1995; Mesquita 1996). Average annual rainfall is 1944 mm, varying between 1566 and 2425 mm. The climate is tropical wet, with well-defined hot/dry (winter) and hot/rainy (summer) seasons. The rainy period occurs from October to April and the driest period from June to August. May and September are transitional months between seasons (Duarte 2005).

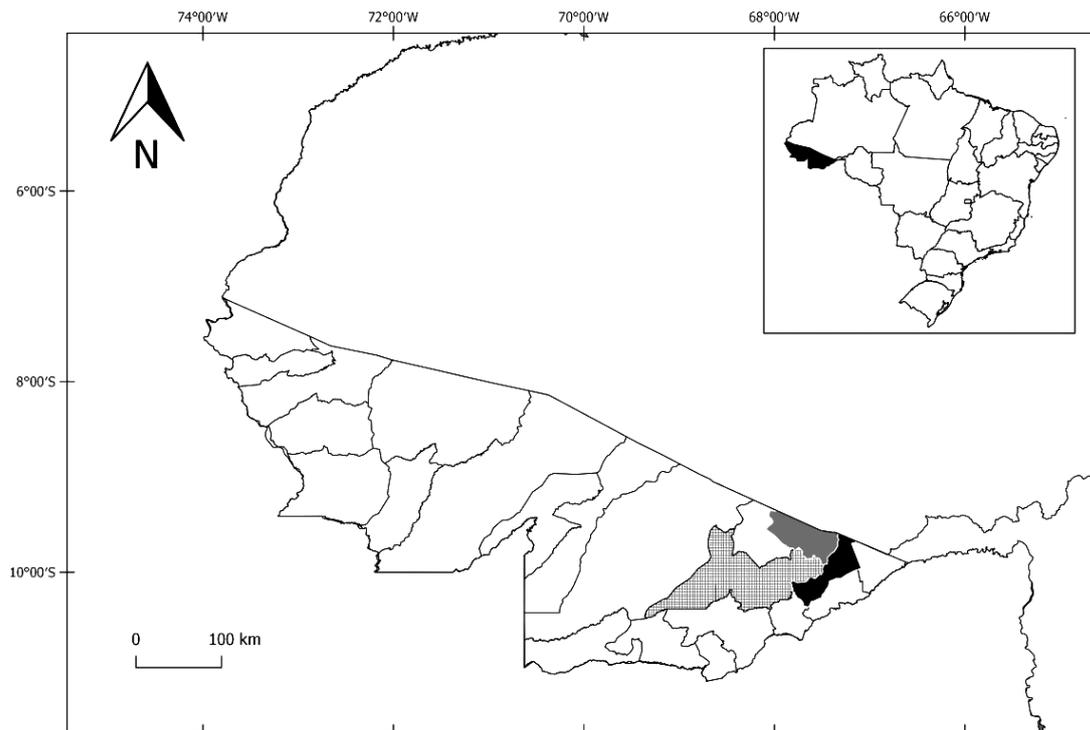


Figure 1. Map of Acre state showing the location of the municipalities of Porto Acre (dark grey), Rio Branco (light grey) and Senador Guimard (black), where the three study sites were located. The inset shows Acre state (black) in the map of Brazil.

Sampling method

Wasps were sampled from April to November of 2014 along previously open trails in the forest. Specimens were attracted by a solution sprayed on the vegetation and collected actively using an entomological net (adapted from Noll and Gomes 2009). A comparison among sampling techniques showed this to be the most effective, especially for social wasps, as it rendered a greater richness and abundance with lower sampling effort (Noll and Gomes 2009). To apply the attractant liquid in vegetation, we used a costal sprayer (5L), which was filled with a solution containing 50 g salt and 200 g sugar per liter of water.

In each study area, sampling occurred on eight 100-m trails drawn linearly, distant approximately 20 meters from each other, on a previously open track. Spraying of the attractive solution was carried out at five points on each trail, separated by 20 m from each other. At each point we applied an average of 500 ml solution on an area of 4 m² of vegetation. The liquid was reapplied every two hours. Later, the points were observed individually for ten minutes between 14:00 and 17:00 and wasps were collected. Collection time totalled 60 hours and sampling distance totalled 2.4 km overall in the three study areas. The specimens were collected under IBAMA/SISBio permit nr. 43174-1.

Species preservation and data analysis

After collection, specimens were killed by putting them in a container with ethyl acetate and posteriorly stored in microtubes containing ethanol absolute. Wasps were identified with the dichotomous identification keys proposed by Richards (1978), Cooper (2000) and Carpenter and Marques (2001). Part of the material was identified by specialists and deposited in the zoological collection of the Museu Paraense Emílio Goeldi, in Belém, Pará state, Brazil, and the zoological collection of Universidade Federal do Acre, in Rio Branco, Acre state, Brazil.

RESULTS

A total of 758 social wasp specimens were collected, representing 36 species and 11 genera (Table 1). We collected 389 specimens from 21 species and seven genera in PZ, 162 specimens from 16 species and seven genera in CA, and 207 specimens from 26 species and eight genera in HU, where the greatest diversity was recorded (Table 1). Regarding species composition, only eight species were sampled in all three areas. PZ and HU shared five species, while four species were collected in HU and CA, and only two species were collected only in PZ and CA. HU presented the largest number of exclusive species (9), followed by PZ (6) and CA (2) (Figure 2).

Agelaia was the most abundant genus, collected more frequently in CA (83% of all sampled individuals in this area) and HU (77,5%) while in PZ, *Angiopolybia* was most abundant (43%). *Polybia* was the richest genus for all study areas, followed by *Agelaia* (Table 1). It is possible that the large number of *Angiopolybia zischkai* (166) individuals sampled in

PZ was due to the presence of a nest near the collection point, although no nest was observed during sampling.

From the 36 species sampled, 19 were new records for Acre state (Table 1) and three of them – *Agelaia bazeae*, *A. pleuralis* and *Polybia simillima* – were recorded for the first time in Brazil (Figure 3).

Table 1. Species richness, abundance and number of exclusive species of social wasps (Polistinae) collected in Parque Zoobotânico (PZ), Fazenda Experimental Catuaba (CA) and Reserva Florestal Humaitá (HU) in the state of Acre, Brazil.¹ new record for Acre, ²new record for Brazil.

Species	Number of specimens			
	PZ	CA	HU	Total
Polistini				
<i>Polistes pacificus liliaciosus</i> Saussure ¹	5	-	-	5
<i>Polistes deceptor</i> Schulz ¹	-	-	2	2
Mischocyttarini				
<i>Mischocyttarus carbonarius</i> (Saussure, 1854) ¹	1	-	-	1
<i>Mischocyttarus flavicans</i> (Fabricius, 1804) ¹	2	-	-	3
<i>Mischocyttarus labiatus</i> (Fabricius, 1804)	11	-	3	14
<i>Mischocyttarus metathoracicus</i> (Saussure, 1854) ¹	-	1	2	3
<i>Mischocyttarus surinamensis</i> (Saussure, 1854)	-	-	1	1
<i>Mischocyttarus synoecus</i> Richards, 1940 ¹	1	-	10	11
<i>Mischocyttarus</i> group <i>prominulus</i> sp.	-	-	2	2
Epiponini				
<i>Agelaia pleuralis</i> Cooper, 2000 ²	51	2	2	55
<i>Agelaia angulata</i> (Fabricius, 1804)	-	17	35	52
<i>Agelaia bazeae</i> (Richards, 1943) ²	-	-	1	1
<i>Agelaia brevistigma</i> (Richards, 1978) ¹	-	-	1	1
<i>Agelaia fulvofasciata</i> (DeGeer, 1773)	2	68	48	118
<i>Agelaia myrmecophila</i> (Ducke, 1905)	9	23	44	76
<i>Agelaia pallipes cuzcoensis</i> (Schrottky, 1911)	40	-	1	41
<i>Agelaia testacea</i> (Fabricius, 1804)	10	25	30	65
<i>Angiopolybia obidensis</i> (Ducke, 1904) ¹	-	3	-	3
<i>Angiopolybia zischkai</i> Richards, 1978 ¹	166	-	-	166
<i>Brachygastra augusti</i> (Saussure, 1854)	-	-	4	4
<i>Brachygastra propodealis</i> Bequaard, 1942 ¹	-	-	1	1
<i>Charterginus fulvus</i> Fox, 1904 ¹	-	-	1	1
<i>Leipomeles dorsata</i> (Fabricius, 1804) ¹	3	2	1	6
<i>Parachartergus flavofasciatus</i> (Cameron, 1906) ¹	-	6	1	7
<i>Polybia catillifex</i> Moebius, 1856 ¹	11	-	-	11
<i>Polybia dimidiata</i> (Olivier, 1791) ¹	8	2	-	10
<i>Polybia eberhardae</i> Cooper, 1993 ¹	-	-	2	2
<i>Polybia gorytoides</i> Fox, 1898 ¹	3	2	1	6
<i>Polybia jurinei</i> Saussure, 1854	1	1	-	2
<i>Polybia liliacea</i> (Fabricius, 1804)	1	-	4	5
<i>Polybia rejecta</i> (Fabricius, 1798)	3	1	4	8
<i>Polybia rufitarsis</i> Ducke, 1904 ¹	-	2	2	4
<i>Polybia simillima</i> Smith, 1862 ²	58	4	1	63
<i>Polybia striata</i> (Fabricius, 1787)	1	-	3	4
<i>Pseudopolybia vespiceps</i> (Saussure, 1863) ¹	1	-	-	1
<i>Synoeca virginea</i> (Fabricius, 1804)	-	3	-	3
Richness	21	16	26	36
Abundance	389	162	207	758
Exclusive species	6	2	9	17

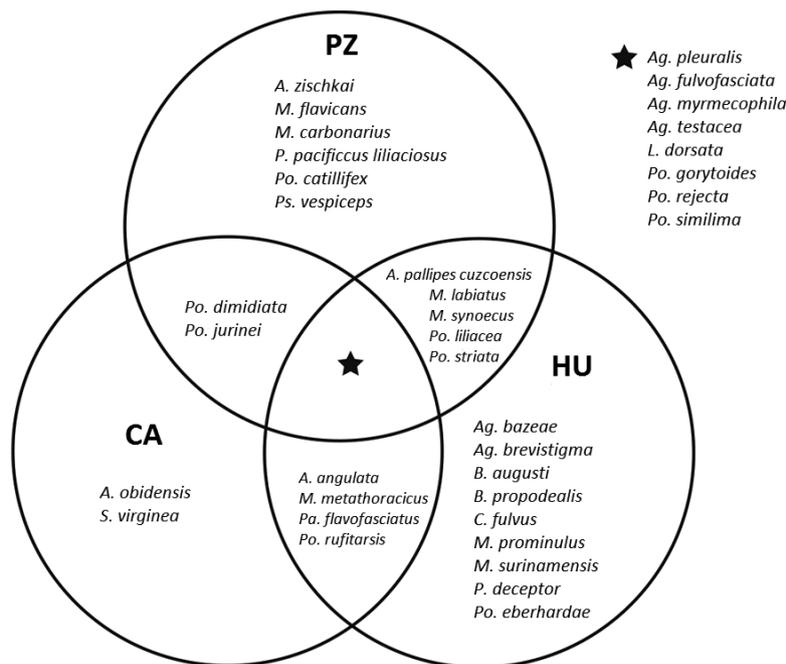


Figure 2. Venn Diagram showing the exclusive and shared species of Polistinae among the three study areas in the state of Acre, Brazil. The asterisk indicates species that were present in all three areas. CA, Catuaba; HU, Humaitá; PZ, Parque Zoobotânico; Ag, *Agelaea*; An, *Angiopolybia*; B, *Brachygastra*; C, *Charterginus*; L, *Leipomeles*; M, *Mischocyttarus*; P, *Polistes*; Pa, *Parachartergus*; Po, *Polybia*; Ps, *Pseudopolybia*; S, *Synoeca*.



Figure 3. Frontal, dorsal and lateral view of species sampled in southeastern Acre as new records for Brazil. A-C, *Agelaea baezae*; D-F, *Agelaea pleuralis*; G-I, *Polybia similima*. Ventral margin of clypeus reddish tinged (A); tegula less accuted (B); pronotal keel broader (C). Antenna with scape black above, yellow beneath and pedicel and flagellum ferruginous (D); dorsum with extensive brown or black maculation (red rectangle - E); lamellate anterior margin of pronotum not markedly sinuate below fovea (F). Eyes bare, malar space very short, clypeus in contact with the eyes for a distance greater the height of antennal sockets (white rectangle - G); pronotal keel distinct on the shoulders, proeminence in front of the fovea strong but not sharp (I). Structures are indicated by asterisks. This figure is in color in the electronic version.

DISCUSSION

Our results represent a significant addition to the known diversity of social wasps in the eastern Amazon, of which only scarce information was available until now. From the 19 species recorded for the first time in Acre, the majority was already known to occur in the Amazon, mainly in the states of Amapá, Amazonas and Pará. They were also recorded in Peru, which borders with Acre, so their presence in this state was expected. Similarly, the records of *Polybia dimidiata*, *Leipomeles dorsata* and *Pseudopolybia vespiceps* in Acre was not surprising, because they are widespread in Brazil and other countries in South America. However, the record of *Polistes deceptor* extends its range of distribution significantly, once there were only two records for this species before: in Pará (the holotype) and São Paulo state (Richards 1978; IUNH 2017) in southeastern Brazil. The same can be said of *Polybia catillifex*, previously registered only in the states of Amazonas, Rio de Janeiro and São Paulo. For *Angiopolybia zischkai* and *Brachygastra propodealis*, there was only one previous record for Brazil (Gomes 2013; Barbosa *et al.*, 2016), in the state of Rondônia, also located in the western Amazon region.

Regarding the three species sampled for the first time in Brazil, they had their distribution range significantly extended. *Agelaia bazeeae* had been previously recorded in Ecuador, Colombia and Panama, while *A. pleuralis* had records in Costa Rica and Colombia (Richards 1978; Cooper 2000; IUNH 2017). *Polybia simillima* was previously registered in Belize, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Panama and Venezuela (Richards 1978; IUNH 2017). These new distribution records shed a light on how little we know of a potentially very high but still unexplored species richness of social wasps in the western Amazon region. Despite the highest diversity of social wasps being found in the Amazon region, our findings suggest that many species of the Amazon wasp fauna have been collected only in other biomes.

The genera *Agelaia* and *Angiopolybia* were the most abundant, an expected result as they are present in all inventories of social wasps in Amazonian rainforest (Richards 1978; Barbosa *et al.* 2016). *Mischocyttarus* is the genus with the highest number of species of social wasps (around 240), of which 117 occur in Brazil (Carpenter and Marques 2001), yet in our samples *Polybia* was the most diverse genus. *Polybia* is the genus with the largest number of species within Epiponini.

In a survey of wasps from Parque Nacional da Serra do Divisor (PNSD), also in Acre, a total of 20 species of Polistinae were sampled (Morato *et al.* 2008). We sampled 15 more species than the latter authors, and only six (*Mischocyttarus labiatus*, *Agelaia angulata*, *A. fulvofasciata*, *A. myrmecophyla*, *Polybia rejecta* and *Synoeca virginea*) were also sampled by them. One possible explanation for the difference in species composition between the two surveys is the difference in altitude between the study sites. PNSD is hilly to mountainous,

with altitudes of 200 up to 580 m (Brazil 1977). In addition, different sampling methods were used. In a survey of social wasps in the state of Pará, Brazil (eastern Amazon) that compared different sampling methods, the active search method was far more efficient than Malaise traps (Silveira 2002). Likewise, Noll and Gomes (2009) collected the greatest number of species and individuals of social wasps using the active search method combined with an attractive solution.

The Amazon region has the highest diversity of Polistinae species (Richards 1978; Carpenter and Marques 2001; Silveira 2002; Barbosa *et al.* 2016). In the Brazilian Amazon, 20 genera and more than 200 species have been recorded, which represents about two thirds of the Brazilian diversity of social wasps (Silveira 2002). Currently 125 species have been reported for the state of Amazonas, despite only four studies on social wasps having been carried out in the state to date (Barbosa *et al.* 2016), which clearly indicates that the diversity of wasps in the region is still vastly underestimated.

CONCLUSIONS

We recorded 36 species of social wasps in three forest fragments in the southeast of Acre state, in the southwestern Brazilian Amazon. *Polybia* was the most species-rich genus in the overall sample, while *Agelaia* and *Angiopolybia* were the most abundant. Nineteen species were first records for Acre. These new records significantly increased the range for some species and filled distribution gaps for others. Our records of *Angiopolybia zischkai* and *Brachygastra propodealis* represented the second record for each species in Brazil. We also produced the first records of *Agelaia baezae*, *A. pleuralis* and *Polybia simillima* for Brazil. There was relatively low species overlap among the three sampled fragments, as well as with the species sampled in the higher-altitude area of Parque Nacional da Serra do Divisor, in eastern Acre. These differences in species composition reinforce the need for more research on the biodiversity of swarm-founding wasps in the western part of the Brazilian Amazon. The results obtained in this study indicate that further investigations should significantly increase the species diversity of wasps in this region and add more information to the knowledge of Polistinae diversity.

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