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RESEARCH ARTICLE - WASPS

Occurrence of social wasps (Hymenoptera: Vespidae) in farming of organic tobacco (*Nicotiana tabacum* L.) in south of Brazil

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Abstract

This work aims to recognize and record the occurrence of species of social wasps (Polistinae) in organic tobacco crops, as well as to point out possible species that may be used in future biological control programs. The research was conducted in Virginia-type tobacco farming with organic management in two regions in south of Brazil. The collections were carried out with Malaise trap, during the harvests 2008/2009, 2009/2010 and 2010/2011. A total of 2.738 individual of wasps, from which 23 species distributed in six genera was collected. *Polistes* was the most diverse genus (eight species), followed by *Polybia* (7), *Mischocyttarus* (4), *Agelaia* (2) and *Bachygastra* and *Protonectarina* with one species. *Polybia scutellaris* was the most abundant species, being considered eudominant. *Agelaia multipicta* and *Polybia sericea* with are also among the most abundant. This information is relevant for the insertion of social wasps with potential agents in the biological control of tobacco pests.

Introduction

Vespidae comprise species that are remarkably abundant, widely distributed (Carpenter & Marques, 2001), and actively participate in local food webs (Santos et al., 2007). The most common subfamilies in Brazil are Polistinae, Eumeninae and Masarinae (Carpenter & Marques, 2001; Pickett & Carpenter, 2010).

Polistinae comprise the most diverse group, with more than 950 species described worldwide (Pickett & Carpenter, 2010), of which about 300 species occur in Brazil (Carpenter & Marques, 2001; CTFB, 2017). The Polistinae social wasps are important components of Neotropical ecosystems due to their ubiquity and diversity, as well as their complex interactions with other organisms (Silveira, 2002; Somavilla et al., 2016).

The growing interest in studies on the diversity of social wasps is due to the recognized ecological importance, mainly

as predators, in agricultural system environments (Carvalho & Souza, 2002; Prezoto et al., 2008; Prezoto et al., 2016). Predatory wasps play a key role in pest control, preferring to prey on caterpillar (Lepidoptera), which are economically important, such as *Spodoptera frugiperda* (Smith, 1797), *Alabama argillacea* (Hübner, 1823), *Anticarsia gemmatalis* Hübner, 1818 and *Heliothis virescens* (Fabricius, 1777), and others, which constitute the most common pests on small farms in tropical environments (Picanço et al., 2012; Prezoto et al., 2019; Lourido et al., 2019). According to Prezoto et al. (2008), social wasps capture adult and/or immature insects to feed their offspring. Recently, Lourido et al. (2019) reported seven species of social wasps as predators of larvae of *Diaphania hyalinata* (Linnaeus, 1767) (Lepidoptera), considered Cucumber Pest in Amazonas. According Jacques et al. (2015) the presence of wasps of the genus *Polistes* in different cultures is associated with reduced damage caused



by pests on cotton (Kirkton, 1970), tobacco (Lawson et al., 1961), cabbage (Gould & Jeanne, 1984), coffee (Gravena, 1983) and corn (Prezoto & Machado, 2009), showing the importance of this genus for studies on the biological control of pests. Thus, in addition to contributing to the regulation of insect pest populations, the presence of social wasps may also contribute to the reduction of insecticide use, with natural biological control being a significant contribution to this process (Gallo et al., 2002). Therefore, the knowledge of the richness and biology of social wasps present in crop systems can contribute to future studies aiming the use of these as a tool in the biological control in agroecosystems.

Tobacco (*Nicotiana tabacum* L.) is a plant belonging to the family Solanaceae, native to tropical and subtropical Americas, with medium height of 90 to 150 cm, according to their variety (Kuppert & Thomas, 2010). It is a culture of recognized importance for Brazil, especially for Rio Grande do Sul, where it is widely cultivated, with all its leaves being used in the commercial production of cigarettes and cigars (Kuepper & Thomas, 2010). Despite the great economic importance and capacity to generate jobs in various sectors, the issue of environmental sustainability should be the focus of attention.

Many problems are caused by the large area devoted to growing tobacco, as well as the great demand on use of synthetic products for their maintenance, causing environmental impacts and damages the health of farmers and the population in general (Specht, 2006). Considering this, more substantial researches, as well as effective actions that are able to reduce the environmental impacts of tobacco crop without a production affect, assume great importance and urgency.

In order to obtain information on biodiversity that subsidizes IPM, research entomofauna surveys is of fundamental importance it allows the recognition of pest insects and their natural enemies. Aiming at the current needs of cropping systems to the detriment of conservation and maintenance of the environment, this work aims to recognize and record the occurrence of species of social wasps (Polistinae) in organic tobacco crops, as well as to point out possible species that may be used in future biological control programs.

Material and methods

The research was conducted in Virginia-type tobacco farming with organic management in two municipalities (Santa Cruz do Sul and Passa Sete) located in south of Brazil (Fig 1). Organic tobacco farming in Santa Cruz do Sul is located at ADET (Worldwide Center for Agronomic Development, Extension and Training), a property of Japan Tobacco International (JTI), and in Passa Sete, on a private property with the same conditions. The adopted management is annually inspected and certified by CEE 2092/91 (European Union) and USA NOP – 7 CFR Part 205 (USA National Organic Program).

Santa Cruz do Sul (29°43'59"S, 52°24'52"W) is a city that covers an area of 733.5 Km², located in the Centro Oriental Riograndense mesoregion, as well as the geomorphological complex of Periferic Sul-Riograndense Depression, in a low altitudes belt, with no more than 150 m (Leifheit, 1978). According to Köppen's classification, climate is subtropical humid. The medium temperature is 20.1°C, with the high of 26.4°C and minimum of 13.8°C. About the annual precipitations, occur in a period of 91-153 days, with variation between 858,8 and 2.325,4 mm (Hoppe, 2005; Diedrich et al., 2007; Ruoso, 2007). The municipality of Passa Sete (29°27'12" S, 52°57'41" W), covers a total area of 303.58 Km², with an average elevation of 590 m. According to Köppen's classification, climate is subtropical humid. The medium temperature is 17.4°C, with the high of 28.0°C and minimum of 8.4°C. About the annual precipitations, the medium temperature is 1.565 mm (Prefeitura Municipal de Passa Sete, 2019).

Tobacco farming in Santa Cruz do Sul has an area of 160 x 85 m, while the crop located in Passa Sete corresponds to an area of 60 x 30 m. In each crop, three *Malaise* traps (Townes, 1972) were arranged, distant from each other by approximately 30 m. The collections were carried out weekly during 2008/2009, 2009/2010 and 2010/2011 harvest in Santa Cruz do Sul and only in the 2009/2010 harvest in Passa Sete. It should be noted that each harvest corresponds to the period from November to March in each year, and that only the 2009/2010 harvest in both locations was evaluated in this paper.

The identification and quantification of the collected specimens of social wasps were realized at Laboratory of Entomology of University de Santa Cruz do Sul, with stereoscope microscope and based on the taxonomic identification keys proposed by Richards (1978) and Carpenter and Marques (2001), as well as by comparison with previously identified species from Santa Cruz do Sul Collection (CESC). The vouchers were deposited in the CESC' Collection.

The relative frequency and dominance calculations were based on Bodenheimer (1955). The dominance index expresses the relationship between the number of individuals of a given species and the total number of individuals of all species found. The classification adopted was eudominant (>10%), dominant (5-10%), subdominant (2-5%), recessive (1-2%) and rare (<1%).

Results

Throughout tobacco harvests, were collected 2.738 individual of wasps, from which 23 species distributed in six genera, 47% of occurred in Rio Grande do Sul state (total of 49 species recorded until now for the state) by Somavilla et al. (2010). *Polistes* was the most diverse genera with eight species, followed by *Polybia* (7), *Mischocyttarus* (4), *Agelaia* (2) and *Bachygastra* and *Protonectarina* with one species (Table 1).

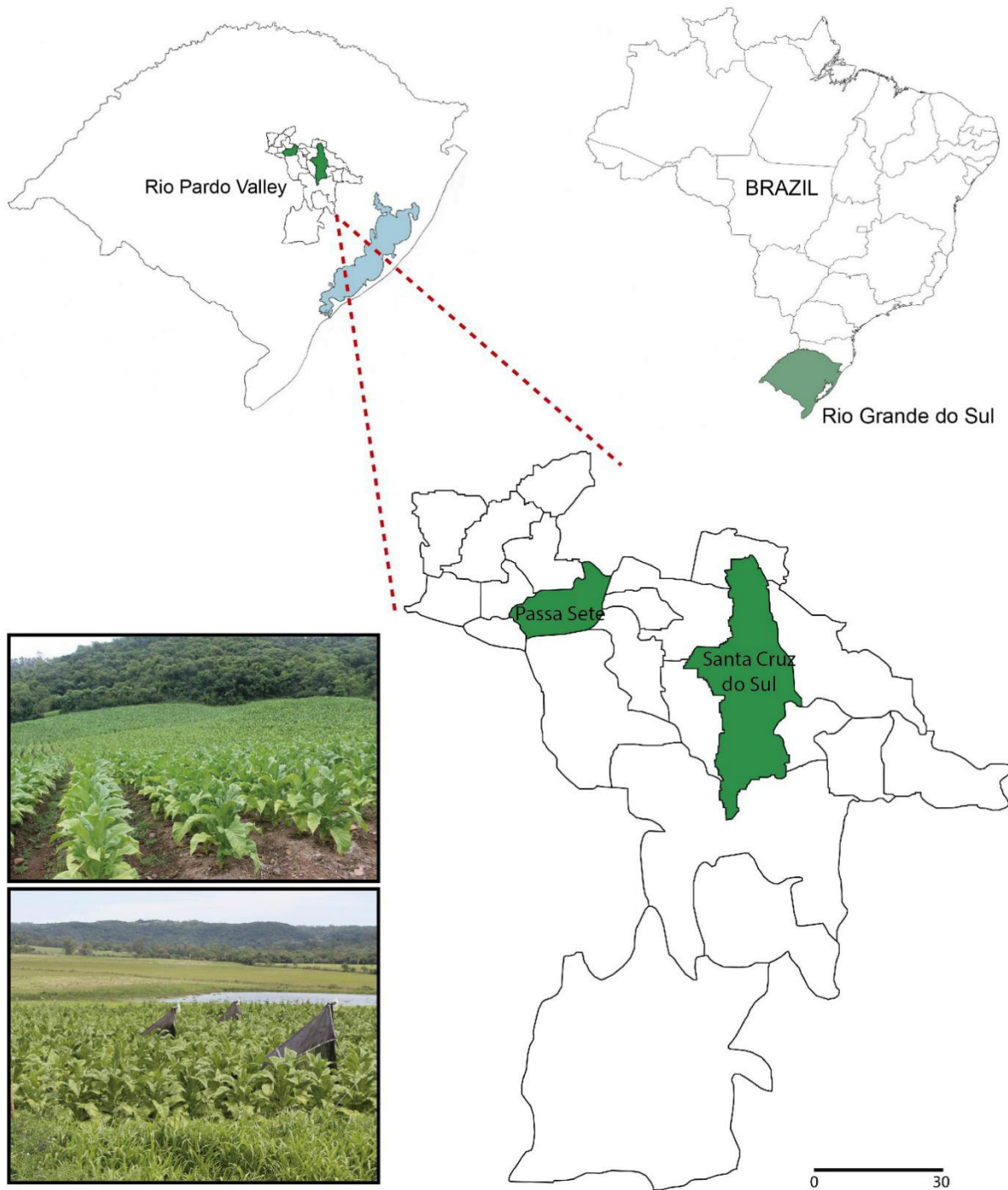


Fig 1. Location of study areas at national, state and municipal levels. Left images of tobacco crops under organic management. Source: Modified from Laboratory of Geoprocessing of the University of Santa Cruz do Sul.

Polybia scutellaris was the most abundant species with 54% of the wasps collected and a relative frequency of 54,71%, being considered eudominant. *Agelaiia multipicta* with 281 individuals, *Polybia sericea* with 225 individuals, *Polybia ignobilis* (180), *Agelaiia vicina* (167), and *Brachygastra lecheguana* (136) are also among the most abundant. *Polistes*, the most specious genera among the social wasps, the present study a low abundance was verified, only 105 specimens were collected.

Discussion

Wasp surveys are lacking in agricultural ecosystems in Brazil, making this a pioneer study for the tobacco crop. The Polistinae richness and composition obtained in this study were similar than previous studies conducted in different crops. For example, in an area of Silvipastoral culture of Embrapa Dairy Cattle Research Center in Minas Gerais, a total of 205 social wasps specimens, distributed in 13 morphospecies

Table 1. Species of social wasps recorded for the farming of organic tobacco (*Nicotiana tabacum* L.) at two different municipalities in Rio Grande do Sul state. FR = Relative Frequency; Dom = Dominance, classification: Eudominant (▲), Dominant (▶), Subdominant (■), Recessive (◊), Rare (○).

Species	ADET Santa Cruz/RS	Passa Sete/RS	Total	FR (%)	Dom
<i>Agelaia multipicta</i> Haliday, 1836	X	X	281	10,26	▲
<i>Agelaia vicina</i> de Saussure, 1854	X	X	167	6,09	▶
<i>Brachygastra lecheguana</i> (Latreille, 1824)	X	X	136	4,96	■
<i>Mischocyttarus cassununga</i> (von Ihering, 1903)	X		15	0,54	○
<i>Mischocyttarus drewseni</i> (de Saussure, 1853)	X	X	46	1,68	◊
<i>Mischocyttarus riograndensis</i> Richards, 1978	X		2	0,07	○
<i>Mischocyttarus rotundicollis</i> (Cameron, 1912)	X	X	5	0,18	○
<i>Polistes actaeon</i> (Haliday, 1836)		X	1	0,03	○
<i>Polistes billiardieri</i> Fabricius, 1804	X		5	0,18	○
<i>Polistes brevifissus</i> Richards, 1978	X		2	0,07	○
<i>Polistes cavapytiformis</i> Richards, 1978	X	X	53	1,93	◊
<i>Polistes cavapyta</i> de Saussure, 1853	X		4	0,14	○
<i>Polistes cinerascens</i> de Saussure, 1854	X		3	0,11	○
<i>Polistes simillimus</i> Zikán, 1951		X	5	0,18	○
<i>Polistes versicolor</i> (Olivier, 1791)	X	X	32	1,16	◊
<i>Polybia fastidiosuscula</i> de Saussure, 1854	X	X	34	1,24	◊
<i>Polybia ignobilis</i> (Haliday, 1836)	X	X	180	6,57	▶
<i>Polybia minarum</i> Ducke, 1906	X	X	7	0,25	○
<i>Polybia paulista</i> H. von Ihering, 1896		X	9	0,32	○
<i>Polybia platycephala</i> (Richards, 1978)	X	X	12	0,43	○
<i>Polybia scutellaris</i> (White, 1841)	X	X	1.498	54,71	▲
<i>Polybia sericea</i> (Olivier, 1791)	X	X	225	8,21	▶
<i>Protonectarina sylveirae</i> (de Saussure, 1854)	X	X	16	0,58	○
			2738		

and four genera were captured (Aquad et al., 2010) and in *Eucalyptus* plantation in Minas Gerais, a total of 1613 social wasp specimens, distributed in 12 species (de Souza et al., 2011). In forest fragments with different surrounding matrices of sugarcane and *Citrus* crops in São Paulo, a total of 1460 social wasp specimens, distributed in 29 morphospecies and 10 genera were captured (Tanaka Junior & Noll, 2011). Most recent, Somavilla et al. (2016), collected 977 specimens of social wasps, in 52 species in organic and conventional guarana cultivation in the north of Manaus, Amazonas.

The superiority of both richness and abundance of social wasps in tobacco crops may be related to the period of cultivation and flowering, coinciding with the months of collection. Wasps exhibit opportunistic behavior and are attracted to environments that provide greater amounts of resources such as water and food, which makes them explore cultivated environments, less complex in phytophysiology (Santos et al., 2009; de Souza et al., 2012; Brugger et al., 2011).

Although *Polistes* is one of the most diverse genera among the social wasps, in the present study a low abundance was verified, only 105 specimens. A similar result was observed in *Mischocyttarus*, which, although having four species, had

only 68 individuals collected. Among the genera found nests, *Polistes* and *Mischocyttarus* nests by independent foundation represents only 6,3% of all wasps, with the rest of the genera having swarming behavior (Epiponini genera), represented by 93.7% of the specimens collected. Greater occurrences of swarming individuals were observed in studies by Silveira (2002), Souza et al. (2014), Somavilla et al. (2016). This can be explained by the benefits resulting from this behavior in the process of founding colonies.

The social wasp *Polybia scutellaris* is very abundant species in Rio Grande do Sul state (Somavilla et al., 2010). Furthermore, this species found colonies in open areas and close an urban environment, such as the edge of tobacco crop. This result may be related to the fact that these species construct larger nests, constituting colonies populous, what makes them frequent in the environments where the nests are located (Richards, 1978; Zucchi et al., 1995; Hunt et al., 2001).

The high abundance of *Polybia* and *Agelaia* registered in the current and other studies indicates that species of these genera find it easy to colonize several different types of microhabitats due to their protected nests, method of foundation and great number of individuals, which gives

their colonies greater chances of success (Hermes & Köhler, 2004). In this study, their abundance was higher in the interior of the tobacco crop, showing a great capacity for dispersion, unlike the results of others studies where usually the uniform environments and interior of the crops lower their abundance, and suggests that these species encounter barriers to use resources outside the better-conserved environments (Klein et al., 2015).

Interestingly, the six most abundant species of this study, namely *Agelaia multipicta*, *A. vicina*, *Brachygastra lecheguana*, *Polybia ignobilis*, *P. scutellaris*, and *P. sericea*, are species with wide distribution in Rio Grande do Sul, being registered in several localities in the state (Somavilla et al., 2011), in this way, the great abundance in this study, together with the wide distribution and habit of predation, can be considered species with potential in the biological control of tobacco, especially caterpillars of Lepidoptera, the most important pests in the culture.

Another important factor is that the presence of these social wasps may be contributing to the decrease of tobacco pests in the field, although this has not been evaluated, since the social wasps also have the habit of nesting in one place (probably in the adjacent vegetation) and feeding themselves in another place, in this case within the crop, and this has been proven with the large number of individuals and species at this location (Silva-Pereira & Santos, 2006). Thus, it is more advantageous for these wasps to nest near these sites, resulting in smaller non-foraging energy costs.

This information is relevant since identifying and studying these predatory insects, especially in agricultural environments, are the first steps to identifying the best species to use in biological pest control. In this way, such information can support control strategies for tobacco pests, associated with integrated pest management. Finally, we suggest some wasps species (like *Agelaia*, *Polybia* and *Polistes*) should be considered for a potential use in a biological control program of tobacco pests and other agricultural pests in the Rio Grande do Sul region, due to its high index of captured in Malaise trap and intense foraging activity.

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