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Record of Parasitoids in nests of social wasps (Hymenoptera: Vespidae: Polistinae)

A Somavilla[1,4], K Schoeninger[1], AF Carvalho[2], RST Menezes[3], MA Del Lama[2], MA Costa[3], ML Oliveira[1]

1- Instituto Nacional de Pesquisas da Amazônia, Petrópolis, Manaus, AM, Brazil
2- Universidade Federal de São Carlos, São Carlos, SP, Brazil
3- Universidade Estadual de Santa Cruz, Ilhéus, BA, Brazil

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Corresponding author
Alexandre Somavilla
Coord. de Biodiversidade, Instituto Nacional de Pesquisas da Amazônia
Av. André Araújo, 2936, Petrópolis, 69067-375, Manaus, AM, Brazil
E-Mail: alexandre.s@hotmail.com

Abstract

The aim of this study was to record the parasitoid species found in social wasps nests sampled in different localities in Brazil. We sampled nests of *Mischocyttarus cassununga*, *Mischocyttarus consimilis*, *Mischocyttarus imitator*, *Polistes canadensis*, *Polistes cinerascens*, *Polistes versicolor*, *Angiopolybia pallens*, *Leipomeles spilogastra*, *Polybia jurinei* and two indeterminate species of *Mischocyttarus*. Thus, we observed that nests of *M. cassununga*, *M. imitator* and *Mischocyttarus* (*Phi*) sp.1 were parasitized by *Toechorychus guarapuavus* (Ichneumonidae) and nests of *M. consimilis, M. imitator* and *Mischocyttarus* sp.2 were parasitized by *Toechorychus fluminensis* (Ichneumonidae). Nests of *P. versicolor* and *P. cinerascens* were parasitized by *Elasmus polistis* (Eulophidae) and nest of *P. canadensis* was parasitized by *Simenota depressa* (Trigonalidae); nest of *A. pallens* and *L. spilogastra,* was infested by *Brachymeria* sp.1 and *Brachymeria* sp.2 (Chalcididae), respectively. Nests of *M. cassununga* and *Polybia jurinei* were parasitized by *Megaselia scalaris* (Phoridae).

Introduction

Polistinae wasps primarily use plant materials to build their nests and can be divided into two groups according to nesting behavior and architecture: independent- and swarm-founding species (Carpenter, 1991; Wenzel, 1998). Independent-founding species (Polistini, Mischocyttarini and some Old World Ropalidiini) build unprotected combs that are small in size with few brood cells (Jeanne, 1980; Carpenter & Marques, 2001). Swarming-founding species (Epiponini and most Ropalidiini) in turn builds large nests with thousands of cells protected by an envelope (Jeanne, 1980; Carpenter & Marques, 2001).

Paper wasp (Hymenoptera: Vespidae: Polistinae) nests are frequently invaded by natural parasitoids of eggs, larvae and pupae. The nest of a social wasp is an environment rich in resources for many predators and parasitoids, which might be attracted and can cause high costs to the colony (Soares et al., 2006). Larvae and pupae are the target of many of these natural enemies including ants, birds, and parasitoid hymenopterans (Makino, 1985; Yamane, 1996; Clouse, 2001). Despite the paucity of studies on the subject, the attack by hymenopterans parasitoids might be one of the main causes of mortality among social wasps in the early stages of development (Wenzel, 1998). In spite of that, there are few attempts to reporting parasitism in these social wasps (Makino, 1985; Yamane, 1996; Clouse, 2001). Consequently there are few records concerning natural enemies of paper wasps and how harmful such natural enemies might be for a wasp colony.

To Brazil, Soares et al. (2006) reported a species of *Pachysomoides* sp. (Ichneumonidae) and *Megaselia scalaris* (Diptera, Phoridae) parasitizing *Mischocyttarus cassununga* (Von Ihering) nests in Minas Gerais; Dorfey and Köhler (2011) reported *Elasmus polistis* Berks, 1971 parasitizing *Polistes versicolor* (Oliver, 1792) nests in Rio Grande do Sul; and Trindade et al. (2012) and Santos and Noll (2013) reported the occurrence of *Seminota marginata* (Westwood, 1874) in *Apoica flavissima* (Van der Vecht, 1973) nests in São Paulo.

The aim of this study was to record parasitoids found in social wasps nests, sampled during several years of survey in different localities in Brazil.

Material and Methods

During several collection trips, between 2009 and 2013, across Brazilian biomes as Atlantic rainforest (Gramado [RS], Sinimbu [RS], Ibirapitanga [BA], Maricá [RJ], Ubatuba [SP], Viçosa [MG]), Pantanal (Dourados [MS]), Caatinga (Jacobina [BA]) and Amazonia (Manaquiri [AM], Manaus [AM], Rorainópolis [RR]) we removed entire nests of polistine species from the field and separated all adults from the offspring. The later were put in plastic recipients covered by voile tissue and maintained in laboratory to remove individuals from the emerged social wasps.

The combs containing offspring were maintained during approximately 40 days at 28°C and relative humidity of 70% ± 5%, in a biochemical oxygen demand (BOD) incubator and monitored daily until adults emerged. After the 40 days, we verified the emergence of polistines and parasitoids as well as the nests were open for counting of cells. However, for the nest of *Angiopolybia pallens* (Olivier, 1792) and *Mischocyttarus consimilis* Zikán, 1949, this procedure could not be performed since the nest were damaged.

Most of the individuals (hosts and parasitoids) were fixed in absolute ethanol and some samples were pinned and are deposited in the Coleção Zoológica de Invertebrados of the Instituto Nacional de Pesquisas da Amazônia (INPA) and in the Laboratório de Genética Evolutiva de Himenópteros of the Universidade Federal de São Carlos (LGEH-UFSCar). Voucher nests were deposited in both collections as well. Specimens were identified using the following identification keys: Richards (1978) and Carpenter and Marques (2001) for social wasps, Burks (1960) and Boucek (1992) for parasitoid wasps and Brown (2010) for Phoridae.

Results

We sampled two nests of *Mischocyttarus cassununga* (R. von Ihering, 1903), one nest from Viçosa, in the state of Minas Gerais and one nest from Ubatuba, in the state of São Paulo; one nest of *Mischocyttarus consimilis* Zikán, 1949 from Dourados, in the state of Mato Grosso do Sul; two nests of *Mischocyttarus imitator* (Ducke, 1904) (Fig 1A, 1B), one nest from Viçosa, in the state of Minas Gerais and other from Maricá, in the state of Rio de Janeiro; one nest of *Mischocyttarus* (*Phi*) sp.1 from Jacobina, in the state of Bahia; one abandoned nest of *Mischocyttarus* sp.2 from Manaus, in the state of Amazonas, five nests of *Polistes canadensis* (Linnaeus, 1758) (Fig 2A, 2B, 2C) from Manaquiri, Amazonas, one nest of *Polistes cinerascens* de Saussure, 1854 from Sinimbu, in the state of Rio Grande do Sul; two nests of *Polistes versicolor* (Olivier, 1791) (Fig 3A, 3B) from Gramado and Sinimbu, Rio Grande do Sul; one nest of *Angiopolybia pallens* (Lepeletier, 1836) (Fig 4A, 4B) from Ibirapitanga, Bahia; one nest of *Leipomeles spilogastra* Cameron, 1912 (Fig 5A, 5B) from Rorainópolis, in the state of Roraima and one nest of *Polybia jurinei* de Saussure, 1854 from Manaus, Amazonas (Table 1).

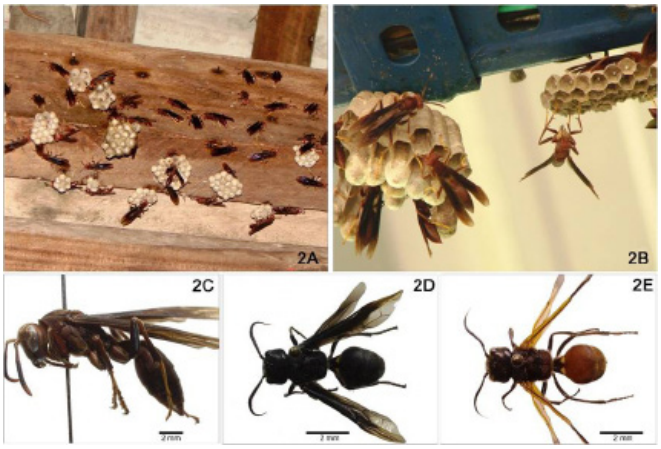

Fig 2. (A, B) *Polistes canadensis* nests; (C) *Polistes canadensis* habitus; (D, E) Two color forms to *Seminota depressa*.

The abovementioned nests were infected by hymenopterans or by dipterans parasitoids, as follows (see also Table 1):

(1) Mischocyttarini: *M. cassununga* was parasitized by *Toechorychus guarapuavus* Tedesco, 2013 (Ichneumonidae) and *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae), *M. consimilis* was parasitized by *Toechorychus fluminensis* Tedesco, 2013 (Ichneumonidae) and *M. imitator* was parasitized by *T. guarapuavus* (Fig 1C) and *T. fluminensis*.

(2) Polistini: Nests of *P. cinerascens* and *P. versicolor* were parasitized by *Elasmus polistis* Burks, 1971 (Fig 3C) (Eulophidae) and nests of *P. canadensis* were parasitized by *Seminota depressa* DeGeer, 1773 (Fig 2D, 2E) (Trigonalidae).

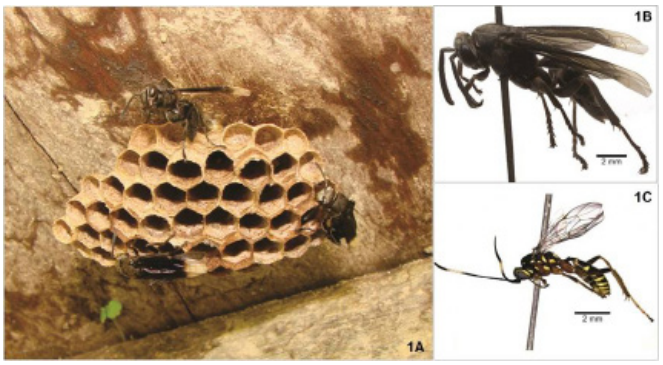

Fig 1. (A) *Mischocyttarus imitator* nest; (B) *Mischocyttarus imitator* habitus; (C) *Toechorychus guarapuavus* habitus.

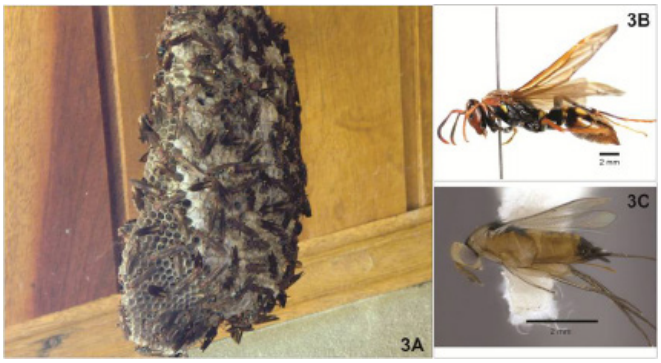

Fig 3. (A) *Polistes versicolor* nest; (B) *Polistes versicolor* habitus; (C) *Elasmus polistis* habitus.

Table 1. Records of parasitoids in nests of social wasps sampled in different localities of Brazil. Number of emerged adult social wasps from the nest (Host N); number of parasitoids emerged from the nest (Parasitoid N); Comb and number of cells from the comb (Comb / cell N).

Host	Parasitoid	Host N	Parasitoid N	Comb/ cell N	Locality
Mischocyttarus cassununga (R. von Ihering, 1903)	*Toechorychus guarapuavus* Tedesco, 2013 (Ichneumonidae)	52	30 (30♂)	1/149	Viçosa, MG: UFV, (20º45'S, 42º52'W)
Mischocyttarus cassununga (R. von Ihering, 1903)	*Megaselia scalaris* Loew, 1866 (Phoridae)	03	50	1/23	Ubatuba, SP: RPPN Angelin Rainforest (23º26'S, 45º04'W)
Mischocyttarus consimilis Zikán, 1941	*Toechorychus fluminensis* Tedesco, 2013 (Ichneumonidae)	05	01 (01♂)	1/-	Dourados, MS (22°13'S, 54°51'W)
Mischocyttarus imitator (Ducke, 1792)	*Toechorychus guarapuavus* Tedesco, 2013 (Ichneumonidae)	35	04 (04♂)	1/104	Viçosa, MG: Mata do Paraíso (20º45'S, 42º52'W)
Mischocyttarus imitator (Ducke, 1792)	*Toechorychus fluminensis* Tedesco, 2013 (Ichneumonidae)	06	03 (03♂)	1/45	Maricá, RJ: Estrada do Espraiado (22°55'S, 42°47'W)
Mischocyttarus (*Phi*) sp.1	*Toechorychus guarapuavus* Tedesco, 2013 (Ichneumonidae)	08	02 (02♂)	1/124	Jacobina, BA (11°11'S, 40°29' W)
Mischocyttarus sp.2 (abandoned nest)	*Toechorychus fluminensis* Tedesco, 2013 (Ichneumonidae)	00	01 (01♂)	1/12	Manaus, AM: Ducke Reserve (02º55'S, 59º58'W)
Polistes canadensis (Linnaeus, 1758)	*Seminota depressa* DeGeer, 1773 (Trigonalidae)	41	09 (09♂)	5/131	Manaquiri, AM: BR319 (3°26'S, 60°26'W).
Polistes cinerascens de Saussure, 1854	*Elasmus polistis* Berks, 1971 (Eulophidae)	16	14 (12♀, 02♂)	1/150	Sinimbu, RS: RPPN UNISC (29°23'S, 52°32'W)
Polistes versicolor (Olivier, 1792)	*Elasmus polistis* Berks, 1971 (Eulophidae)	121	357 (240♀, 117♂)	1/696	Gramado, RS (29º22'S, 50º52'W)
Polistes versicolor (Olivier, 1792)	*Elasmus polistis* Berks, 1971 (Eulophidae)	52	439 (258♀, 181♂)	1/950	Sinimbu, RS: RPPN UNISC (29°23'S, 52°32'W)
Angiopolybia pallens (Olivier, 1792)	*Brachymeria* sp.1 (Chalcididae)	828	11 (11♀)	6/-	Ibirapitanga, BA: BR101 (14º09'S, 59º22'W)
Leipomeles spilogastra (Cameron, 1912)	*Brachymeria* sp.2 (Chalcididae)	15	04 (04♀)	3/165	Rorainópolis, RR: BR 174 (00º56'N, 60º25'W)
Polybia jurinei de Saussure, 1854	*Megaselia scalaris* Loew, 1866 (Phoridae)	11	02	1/68	Manaus, AM: Ducke Reserve (02º55'S, 59º58'W)

Fig 4. (A) *Angiopolybia pallens* nest; (B) *Angiopolybia pallens* habitus; (C) *Brachymeria* sp.1 habitus.

(3) Epiponini: Nests of *A. pallens* (Fig 4A) and *L. spilogastra* (Fig. 5A) were parasitized by *Brachymeria* sp.1 (Fig 4C) and *Brachymeria* sp.2 (Fig 5C) (Chalcididae) respectively, and in the nest of *P. jurinei* was recorded parasitism by *Megaselia*

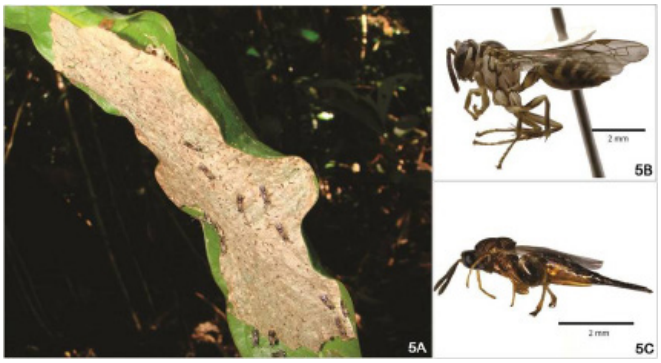

Fig 5. (A) *Leipomeles spilogastra* nest; (B) *Leipomeles spilogastra* habitus; (C) *Brachymeria* sp.2 habitus.

scalaris (Phoridae).

Furthermore, we observed a dominance of males from species *Seminota* and *Toechorychus* which emerged from *Mischocyttarus* and *Polistes* nests, respectively, compared with *Elasmus* and *Brachymeria* which there was dominance of emerging females.

Individuals of Chalcididae started to emerge two days after collection of the nests extending to the seventh day. Individuals of Ichneumonidae started to emerge seven days after collection of the nests extending to the twelfth day. For individuals of *Seminota depressa* and *Elasmus polistis* the emergency period took place over thirty days. For *Megaselia scalaris*, we were not able to register the emergency period.

Discussion

In this study we reported parasitism in seven nests of five *Mischocyttarus* de Saussure species, eight nests of three species of *Polistes* Latreille and only in three nests of three Epiponini species. Moreover, it was possible to verify a higher number of parasitoids per nest in *Polistes* and *Mischocyttarus* when compared to Epiponini (Table 1). Social insects such as the Polistinae wasps might be more susceptible to the attack of parasitoids when living in colonies with absence of brood keepers while foraging (Clouse, 1997; 2001). Another factor that may contribute to the attack of parasitoids is the absence of a nest-protecting envelope. *Polistes* and *Mischocyttarus* are independent-founding groups with remarkable non-enveloped nests. Epiponini species in turn shows swarm-founding behavior build nest envelopes that protect fragile brood. Strassmann (1981) suggests that swarm-founding species are less susceptible to parasitism once adults protect constantly the nest, preventing the invasion of possible enemies. Thus, the difference of parasitoidism between species with enveloped and species with non-enveloped nests and its significance must be further investigated.

Most Ichneumonidae are ecto or endoparasitoids of arthropods, usually attacking immature instars of holometabolous insects of the order Lepidoptera, Coleoptera, Diptera and Neuroptera (Clausen, 1940; Askew, 1971; Hanson & Gauld, 1995). These insects are considered important in biological control since they are parasitoids that always kill the host (Kumagai & Graf, 2000). There are few reports of Ichneumonidae parasitizing paper wasp nests and this lack of information is mostly due to the great difficult in detecting symptoms of parasitism in nests of these social insects. Until now, there are records only for *Mischocyttarus*, *Polistes* and *Dolichovespula* Rohwer. Species of *Toechorychus* Townes (Ichneumonidae) are apparently parasitoids in nests of Vespidae and pupae of Lepidoptera, but host records were previously known only for two species: *Toechorychus abactus* (Cresson, 1874) and *Toechorychus cassunungae* (Brauns, 1905) are known to attack species of *Mischocyttarus* (Brauns, 1905; Bertoni, 1911; Costa-Lima, 1962; Makino, 1985) and *Toechorychus albimaculatus* (Taschenberg, 1876) attack *P. canadensis* (Makino, 1985)

Seminota (Trigonalidae) has been reported as a parasitoid of some genera of social wasps such as *Apoica* Lepeletier, *Mischocyttarus*, *Parachartergus* R. von Ihering, *Polistes* and *Pseudopolybia* Von Dalla Torre (Makino, 1985; Weinstein & Austin, 1991; Carmean & Kimsey, 1998) but little is known on the biology of these associations being that Weinstein and Austin (1991) considered paper wasps as the secondary host of Trigonalidae. On the other hand, Santos and Noll (2013) observing the emergence of parasitoid *Seminota marginata* (Westwood, 1874) in one nest of *Apoica flavissima* Van der Vecht, 1972 suggested that social wasps may be both primary and secondary hosts of such parasitoids as they extract and chew vegetable fiber. We observed that individuals of *S. depressa* which emerged from the nests of *P. canadensis* had variations regarding the pigmentation on the integument (Fig 2D, 2E), one totally black with blackened wings and the other with black head and mesosoma, brown metasoma, and hyaline wings. The size and pattern of bristles and score were similar in both forms.

Elasmus Westwood, 1833 species are in mostly a parasitoid of Lepidoptera, although some Hymenoptera, particularly Braconidae and Ichneumonidae have also been recorded as hosts (Gibson, 1993; Graham, 1995). *E. polistis*

was reported in nests of *P. versicolor* (Dorfey & Köhler, 2011). We report for the first time *E. polistis* parasitizing *Polistes cinerascens*. We could observe that a large amount of *E. polistis* (796) emerged from two differents nests of *P. versicolor* and this can be explained due to the size of referred nest that was large and contained 1.646 cells.

In nests of Epiponini we observed parasitism by two species of *Brachymeria* Westwood, 1829 (Chalcididae), which are primary or hyperparasitoids of Lepidoptera (mostly young pupae) and only one species of Diptera (mostly mature larvae) (Fernández & Sharkey, 2006). Many Neotropical *Brachymeria* are associated to social wasp nests while some parasitize moths developing in wasp nests. Social wasps known as hosts for *Brachymeria* belong to the genera *Agelaia* Lepeletier, *Angiopolybia* Araujo, *Brachygastra* Petry, *Chartergus* Lepeletier, *Metapolybia* Ducke, *Polistes*, *Polybia* Lepeletier and *Synoeca* de Saussure (Boucek, 1992). In this study we reported for the first time *Brachymeria* parasitizing *Leipomeles spilongastra*.

Megaselia scalaris (Phoridae) is a cosmopolitan insect that is primarily a detritivore and might act as facultative predator of immature hosts (Disney & Berghof, 2005). It has been recorded the presence of eggs and larvae of this dipteran in honeycombs of *Apis mellifera* Linnaeus, 1758 resulting in the nest abandonment (Ronna, 1936). This fly has already been reported in nests of *Mischocyttarus cerberus* Ducke 1918, *Protopolybia acutiscutis* (Cameron, 1907), *Polybia occidentalis* (Olivier, 1791) and *Polybia simillima* Smith, 1862, causing serious injuries to the colonies (Young, 1984; Giannotti, 1998; London & Jeanne, 1998). In this study we reported for the first time *Megaselia scalaris* parasitizing *Polybia jurinei*.

With regard to the sex ratio of parasitoids that emerged from nests of social wasps, this can be influenced by many factors, such as environmental conditions and the body size of hosts (Townes, 1958; Hamilton, 1967; Taylor & Stern, 1971; Boldt et al., 1973; Vinson, 1997). Eggs deposited in hosts with larger body size can give rise to females descendants (as observed in this study to *Elasmus* and *Brachymeria*) since they require more resources to their development and consequently eggs deposited in hosts with smaller body size can give rise to male descendants (as observed in this study to *Toechorychus* and *Seminota*) (Taylor & Stern, 1971; Boldt et al., 1973). Strassmann (1981) suggested that males typically emerge first and can wait for the females emerge to mate. Moreover, it is possible the occurrence of females egg-laying in another pupa from the same nest in which it has emerged (Macom & Landolt, 1995), which contributes to a high number of parasitoids in the same nest as observed in this study.

Concluding Remarks

In this study we reported for first time *Toechorychus guarapuavus* and *Toechorychus fluminensis* parasitizing nests of *Mischocyttarus cassununga*, *Mischocyttarus consimilis* and *Mischocyttarus imitator*; *Elasmus polistis* parasitizing *Polistes cinerascens* and *Brachymeria* sp. parasitizing a nest of *Leipomeles spilongastra*. We also reported for the first time *Megaselia scalaris* parasitizing *Polybia jurinei*. However, further studies involving more species should bring to light about relationships between Neotropical paper wasps and their parasitoids.

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