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Scientific Note

Social wasps (Vespidae: Polistinae) harvesting food bodies of *Cecropia* Loefl. (Urticaceae) in Central Amazon

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Abstract. Social wasps are among the most curious non-ant insects known to harvest food bodies of *Cecropia* Loefl. The aim of this note is to describe for the first time: (1) interactions between wasp species which harvest food bodies; (2) interactions of these wasps with other insects associated to *Cecropia* (ants, assassin bugs); (3) the use of a food resource different from müllerian bodies; and (4) wasp species whose association with *Cecropia* was unknown until now. All records were made in Manaus region and in Uatumã Sustainable Development Reserve (Amazonas State, Brazil), with the aid of a digital camera. The wasp and ant species involved were captured for later identification. The recorded wasp species were: *Charterginus xanthura* Saussure, 1854, *Protopolybia chartergoides* Gribodo, 1891, *Protopolybia minutissima* Spinola, 1851, and *Synoeca virginea* Fabricius, 1804 (Hymenoptera: Vespidae). The findings corroborate the importance of food bodies not only for *Azteca* Forel, 1878 ants, but also for other social insects.

Keywords: agonistic interactions, müllerian bodies, parasites of mutualism, pearl bodies.

Most *Cecropia* Loefl. (Urticaceae) species present attractive elements for ants of the genus *Azteca* Forel, 1878 (Formicidae: Dolichoderinae), with emphasis on food bodies, being the müllerian bodies (MBs) the best studied (e.g., Müller 1876; Marshall & Rickson 1973). They are produced at trichilia, tufts of unicellular and pluricellular hairs present at the lower part of the petiole base of most *Cecropia* species (Janzen 1969; Berg & Rosselli 2005). The second type of food resource produced by *Cecropia* are the pearl bodies (PBs), structures found randomly on the petiole of young leaves and, mainly, at the abaxial surface of the leaves (especially on primary veins) (Rickson 1976; Gutiérrez-Valencia et al. 2017). In exchange for housing and food, *Azteca* ants promote, among other benefits, defense against herbivorous insects (Vasconcelos & Casimiro 1997; Oliveira et al. 2015), and the elimination of lianas and other plants which may compete for light with their host (Janzen 1969; Davidson et al. 1988). The association between *Cecropia* and *Azteca* is so intricate that some authors consider it an example of obligate mutualism (e.g., Hölldobler & Wilson 1990; Price 1997).

Among the most curious examples of insects considered parasites of the *Azteca-Cecropia* mutualism are some social wasp species (Vespidae: Polistinae) which have been reported to feed on MBs (e.g., Richards 1978; La Pierre et al. 2007; Borges et al. 2017; Felizardo et al. 2017). Those studies demonstrate how the wasps are dependent on some *Cecropia* species.

The aim of this note is to describe for the first time: (1) interactions between wasp species which harvest food bodies; (2) interactions of these wasps with other insects associated to *Cecropia*; (3) the use of a food resource different from müllerian bodies; and (4) wasp species whose association with *Cecropia* was unknown until now.

The records of the present note were carried out in the outskirt of Manaus city (Amazonas, Brazil), in Tarumã-Ponta Negra Environmental Protection Area (Tarumã-Ponta Negra EPA) (03º01'10,54"S / 60º04'44"W); and in Uatumã Sustainable Development Reserve (Uatumã SDR) (02º08'43,95"S / 59º00'21,45"W), in the municipality of São Sebastião do Uatumã (Amazonas, Brazil), locations approximately 150 km apart (Fig. 1). In Manaus, records were obtained on non-consecutive days between January and February 2020 and between October 2020 and February 2021. In Uatumã SDR, only one observation was carried out in March 2020. The records were concentrated in the morning, between 08:30 and 12:00, and in the afternoon, between 15:00 and 18:30. The observations were made on young plants, whose height was favorable for taking records from the ground level, ranging from 1.50 to 3.00 m tall and, for the most part, did not yet present *Azteca* spp. colonies inside their stems. The behaviors described below were randomly recorded through videos and photographs, with the aid of a digital camera (Panasonic Lumix DMC-FZ18), to be analyzed later. The wasp and ant species involved were captured using an entomological net or manually, using a glass jar with a lid, and identified, being the voucher specimens deposited into the National Institute for Amazonian Research's (INPA) Invertebrate Biological Collection. Wasp species were identified using the identification keys proposed by Richards (1978) and Somavilla & Carpenter (2021); ants were identified using the Longino (2007) revision of *aurita* species group and were also compared with vouchers of the INPA's Myrmecological Collection. *Cecropia* species were identified according to the descriptions presented in Berg (1978) and Berg & Rosselli (2005) and through comparisons with vouchers from INPA's herbarium.

Charterginus xanthura Saussure, 1854 (Hymenoptera: Vespidae) was recorded harvesting MBs at *Cecropia concolor* Willd., *Cecropia palmata* Willd. (Fig. 2A), *Cecropia purpurascens* C.C. Berg, *Cecropia* aff. *membranacea*, and *Cecropia* aff. *obtusa* in Manaus. In Uatumã SDR, it was recorded at a *C. purpurascens* tree. From two to five individuals of this wasp species were observed feeding simultaneously on the same plant.

Protopolybia chartergoides Gribodo, 1891 (Hymenoptera: Vespidae) wasps were recorded harvesting MBs at *Cecropia ulei* Snethl., *C. concolor*, *C. palmata*, *C.* aff. *membranacea*, and *C.* aff. *obtusa* in Manaus and at *C. purpurascens* in Uatumã SDR (Fig. 2B), the plants of most of these species being the same where the records of *C. xanthura* were carried out. In relation to *C. xanthura*, *P. chartergoides* was less

frequent and less abundant in Manaus, with at most two wasps visiting the same plant simultaneously. Unlike *C. xanthura*, the second species was seen with up to two individuals sharing the same trichilia.

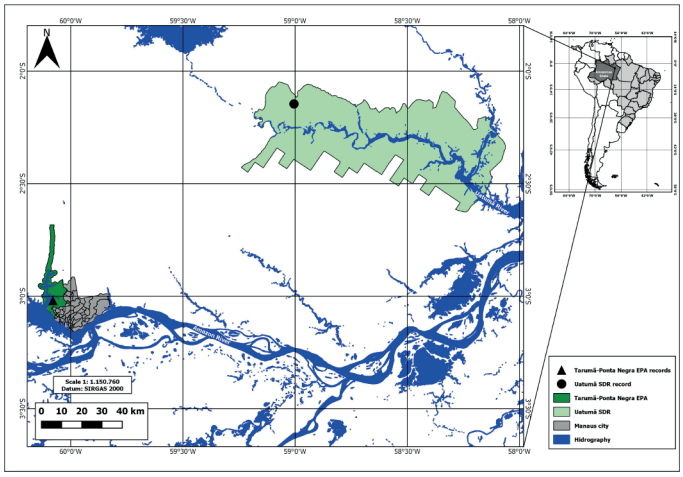

Figure 1. Map of the collection sites: Tarumã-Ponta Negra EPA (black arrow) and Uatumã SDR (black dot).

Individuals of *Protopolybia minutisima* Spinola, 1851 (Hymenoptera: Vespidae) were record only in Manaus, exclusively in some of the same individuals of *C. concolor* where *C. xanthura* and *P. chartergoides* were observed. One to three individuals of this species were observed at the same plant, feeding on MBs. However, these wasps were most frequently seen walking over the abaxial surface of the leaves (mainly over the primary veins) and through the petioles, harvesting PBs (Fig. 2C).

An individual of *Synoeca virginea* Fabricius, 1804 (Hymenoptera: Vespidae) was recorded harvesting PBs at young leaves of *C. concolor* not yet colonized by *Azteca* in Manaus (Figs. 2D, 2E). Another smaller individual, probably of a similar species in the same genus, was observed at the same plant and showing the same behavior, but was not collected and identified.

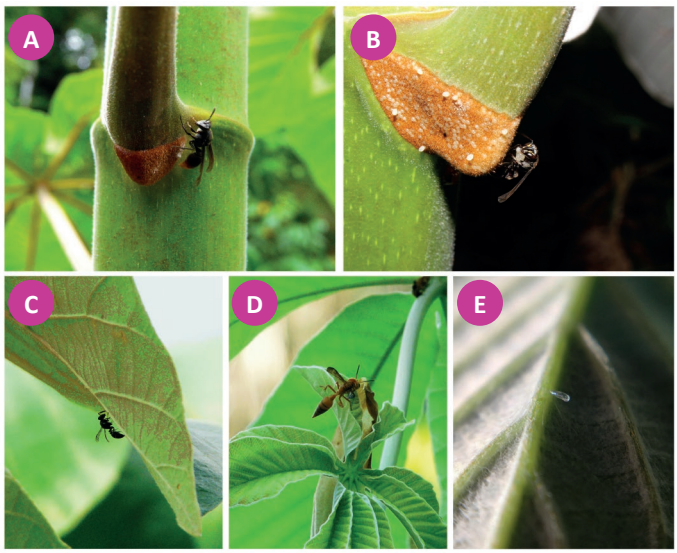

Figure 2. Wasps species recorded feeding on *Cecropia*. **A**. *C. xanthura* harvesting müllerian bodies at a *C. palmata* tree. **B**. *P. chartergoides* harvesting müllerian bodies at *C. purpurascens*. **C**. *C. minutissima* harvesting pearl bodies on a *C. concolor* leaf. **D**. *S. virginea* feeding on pearl bodies at the same species. **E**. Detail of a pearl body on a primary vein of a *C. concolor* leaf.

Since several of the aforementioned species were observed at the same plant, simultaneous visits were commonly recorded, sometimes producing agonistic interactions. These meetings were only recorded in Tarumã-Ponta Negra EPA, Manaus.

The most notable interaction was recorded between *P. chartergoides* and *C. xanthura* in a *C.* aff. *membranacea* tree. Individuals of the former species, although less abundant, proved to be dominant, often repelling individuals of the second, either by attacking an individual of *C. xanthura* already perched on a trichilia or by threat, turning around, with open wings, in towards any wasp of the other species which tried to land on an already occupied trichilia (Fig. 3A). *C. xanthura*, however, was persistent, taking advantage of distractions of the individual of the other species to approach the trichilia from behind of the occupant or from the opposite side of the structure, landing and harvesting as many MBs as possible until it was discovered and again expelled. In other observed interactions, when it landed closer to *P. chartergoides*, *C. xanthura* kept flapping its wings, ready to fly at the slightest sign of threat. In a few situations, however, it was seen approaching the trichilia in hover flight, managing to harvest MBs even next to *P. chartergoides* and without landing on the trichilia.

A similar behavior was recorded for *C. xanthura* in relation to *P. minutissima*. The former species was seen expelling the second, smaller, from the trichilia of a *C. concolor* individual where it was harvesting MBs. The repelled *P. minutissima* individual then flew to a nearby leaf or to the opposite side of the branch, carrying the collected MB or waiting until the larger wasp had moved away before being able to harvest (Fig. 3B). The same behavior was not observed when *P. minutissima* was collecting PBs.

Wasps were also recorded interacting directly or indirectly with other insects associated with the genus *Cecropia*, especially ants. In Manaus, *C. xanthura* was observed harvesting MBs at a *C. palmata* tree recently colonized by *Azteca alfari* Emery, 1893 (Hymenoptera: Formicidae) (Fig. 3C). When it landed on a trichilia, it kept flapping its wings until it was spotted by the patrolling ants, quickly taking off with as many MBs as it could carry (Fig. 3D).

Camponotus novogranadensis Mayr, 1870 (Hymenoptera: Formicidae), although not seen feeding on either MBs or PBs (according to our observations, its interest in *Cecropia* appears to be only the honeydew produced by aphids and other associated Hemiptera), has been shown to be an extremely territorial and aggressive ant, investing energetically against any wasp of the species *C. xanthura*, *P. chartergoides*, and *P. minutissima* that was located in *C. concolor* and *C. palmata* trees patrolled by the ant in Manaus (Fig. 3E). Finally, in Uatumã SDR, individuals of *C. xanthura* were seen harvesting MBs at *C. purpurascens* trichilia occupied by *Zelus araneiformis* Haviland, 1931 (Hemiptera: Reduviidae) (cf. Bérenger & Pluot-Sigwalt 1997), avoiding, however, the same side of the trichilia occupied by the assassin bug (Fig. 3F).

The wasps recorded in the present study (Tab. 1) were predominantly seen at *Cecropia* trees not yet colonized by *Azteca* spp., like in previous studies (e.g., La Pierre et al. 2007; Felizardo et al. 2017), and this is clearly due to the difficulty imposed by the defense provided by the ants. The record of *C. xanthura* collecting MBs in *Cecropia* is the first carried out in the Brazilian Amazon. In most observations, the small wasp *P. minutissima* was seen not exploiting the trichilia, but traversing the surface of leaves and petioles of young *C. concolor* trees in search of PBs. This implies that, despite social wasps being generally considered dietary generalists (Richards 1978), the distinct and non-overlapping resources found in *Cecropia* suggest that various species may exploit different food sources at the same plant. On the other hand, *S. virginea* seems to exploit only PBs at *Cecropia* trees. The consumption of PBs by wasps has never been recorded before.

The current study is the first record of interspecific interactions between wasps of the genera *Charterginus* Fox, 1898 and *Protopolybia* Ducke, 1905 (Hymenotpera: Vespidae), including competition for the resources of the same triquilia. *C. xanthura* was the only species so far recorded harvesting MBs in the presence of *Azteca* spp., and more than that, robbing a resource typically exploited by ants, which La Pierre et al. (2007) consider an example of cleptobiosis (see Curio 1976).

Our records emphasize the role of *Cecropia* for several wasp species, highlighting the food bodies as potential key resources for those insects, although in different degrees.

Table 1. Records of the wasps species and the respective *Cecropia* species where they were collected.

Wasp/plant	*Cecropia concolor*	*Cecropia palmata*	*Cecropia purpurascens*	*Cecropia ulei*	*Cecropia* aff. *membranacea*	*Cecropia* aff. *obtusa*
Charterginus xanthura	X	X	X	-	X	X
Protopolybia chartergoides	X	X	X	X	X	X
Protopolybia minutissima	X	-	-	-	-	-
Synoeca virginea	X	-	-	-	-	-

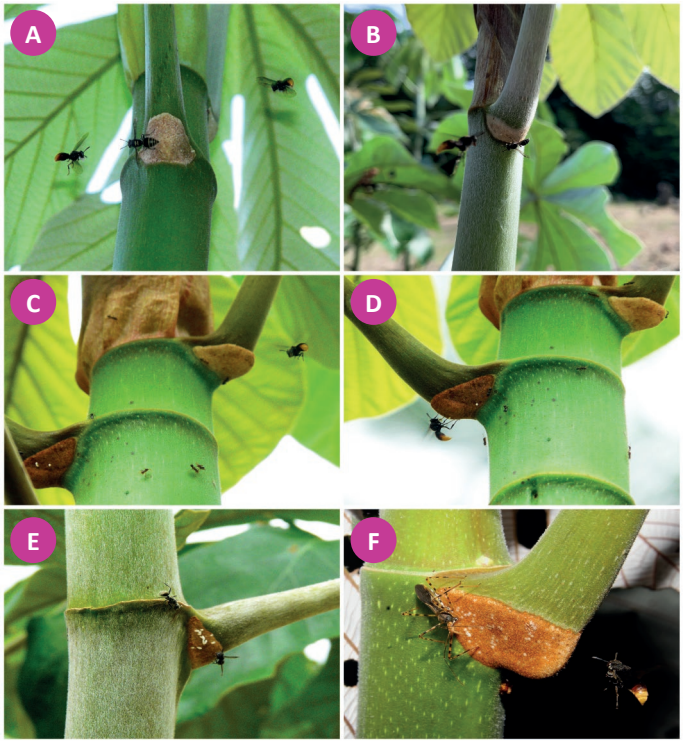

Figure 3. Interactions between wasps and other insects. **A**. *P. chartergoides* on a *C.* aff. *membranacea* trichilia (in the center), threatening with open wings a *C. xanthura* wasp (on the left) while a second one approaches from the rigth. **B**. *C. xanthura* (on the left) assalting a *P. minutissima* individual at a *C. concolor* trichilia. **C**. *C. xanthura* individual (on the right and above) approaching a trichilia of a *C. palmata* tree occupied by *A. alfari* ants (on the branch). **D**. The same individual harvesting müllerian bodies while keeps its wings flapping. **E**. *C. novogranadensis* ant (on the left and above) about to expel a *P. minutissima* individual from a *C. concolor* trichilia. **F**. *C. xanthura* wasp (on the right) approaching a *C. purpurascens* trichilia where a *Z. araneiformis* assassin bug (on the left) feeds.

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Authors' Contributions

DPPA: Conceptualization, Methodology, Investigation, Writing - original draft; AS: Investigation, Validation, Writing - review & editing; IOF: Investigation, Validation, Writing - review & editing. LOD: Investigation, Validation, Writing - review & editing.

Conflict of Interest Statement

The authors declare no conflict of interest.

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