



A species-level association in *Pheidole* Westwood (Hymenoptera: Formicidae) ants with a parasitoid wasp of the genus *Orasema* Cameron (Hymenoptera: Eucharitidae) in Brazil

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ABSTRACT

Eucharitid wasps are exclusive parasitoids of ants and certain groups of eucharitids have specific associations with their hosts. This type of specificity is widely documented in more inclusive groups (subfamilies and/or genus-groups). However, we do not know if this specificity occurs in less inclusive groups (such as species or populations) or if it is more strongly influenced by local and/or regional environmental constraints. We provide a new association record between *Pheidole gibba* Mayr, 1887 and *Orasema chunpi* Burks, Heraty & Dominguez, 2018, while expanding their known distribution to the Brazilian state of Bahia.

Myrmicinae is the most speciose and widespread subfamily of ants; they comprehend circa 7000 described species (Bolton, 2020) - almost 50% of the total number of species for the family - occurring in almost all geographic regions in the globe (Baccaro et al., 2015). Members of the subfamily have a wide range of strategies for reproduction, nidification, and food acquisition (Baccaro et al., 2015). Among all ants, the myrmicine *Pheidole* Westwood is the most diverse ant genus, with 1,095 valid species (Bolton, 2020) of which their high levels of morphological variation may reflect numerous distinct feeding and nidification strategies (Wilson, 2003; Moreau, 2008). Due to their high diversity and ability to explore a variety of resources, *Pheidole* is a ubiquitous group of ants in almost every terrestrial ecosystem (Wilson, 2003; Economo et al., 2015). Its high-prevalence in natural and human-modified landscapes can be of extreme importance to explore drivers of host-parasitoid interactions.

Orasema Cameron is a chalcidoid wasp genus belonging to the ant-parasitoid Eucharitidae. The genus is restricted to the New World and is considered the most diverse group among the genera of Oraseminae (Burks et al., 2017), with 67 described species (Heraty, 2019). Species

belonging to this genus are known parasitoids of Myrmicinae ants, with unverified records in Dorylinae and Formicinae (Heraty, 2002; Lachaud and Pérez-Lachaud, 2012).

In the initial stages of their life-cycles *Orasema* species have associations with plants, which serve as oviposition sites. It is believed that, apart from the specificity of eucharitid subfamilies towards their ant hosts, some species of these wasps chose specific groups of plants to oviposit whereas other choose particular plant structures irrespective of different plant groups (Baker et al., 2020). Hence, researchers often document associations between eucharitid parasitoids and their host plants (e.g. Varone et al., 2010; Torrén, 2013) to understand the mechanisms that enable these parasitoids to directly interact with their hosts and how they subsequently gain access to the ant nest.

Known associations between *Orasema* species and their *Pheidole* hosts are relatively scarce in the country. Only twenty-three *Orasema* species have been documented in association with ant hosts and, from those, only ten *Pheidole* hosts are unambiguously recognized to species level (Baker et al., 2020).

Specimens were collected at the Reserva Serra Bonita (Serra Bonita Reserve), at the Camacan municipality, state of Bahia, Brazil. This reserve is part of the Serra Bonita Reserve Complex, comprised by a group of four RPPNs (Private Reserve of Natural Heritage), administered by the Uiraçu

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Institute. It currently protects an area of 1800 ha, with expectations of expansion to 7500 ha of conserved area (Sanchez-Lalinde et al., 2011). The reserve complex is located between the cities of Camacan and Pau-Brasil, within the Atlantic Rainforest, characterized by high relative humidity and elevated temperatures, with the absence of a dry season (Köppen, 1936). The sampling event took place mid-July 2018, during winter. A nest of *Pheidole gibba* was found within an exposed tree trunk, approximately 40cm diameter in an intermediate state of decomposition, with moderate rigidity and low humidity. Several *Pheidole* specimens were collected and transferred to vials containing 90% ethanol. We used the identification keys provided by Burks et al. (2018) and Wilson (2003) to establish the specific identity of *Orasema* and *Pheidole*, respectively. All specimen observations and image acquisition were made at the Laboratory of Systematics and Ant

Biology at the Universidade Federal do Paraná – Brazil and biological vouchers were deposited at Padre Jesus Santiago Moure Entomological Collection (DZUP) in the same institution.

Two specimens of *Orasema chunpi* (Fig. 1) were collected within the dead trunk that housed the colony of *Pheidole gibba* (Fig. 2). Both *Orasema* specimens were found inside the larval chamber, and it was not possible to identify additional specimens of the parasitoid.

One specimen of *O. chunpi* was identified on site as an obtect pupa, while the second as a newly-emerged adult, with some parts of the previous developmental stage still attached to its body (mainly mouthparts and apical half of the flagellum).

On-site, direct interaction performed by *Pheidole* workers towards the parasitoid specimens was not observed. There is few documented information on how immature stages of *Orasema* interacts with immature

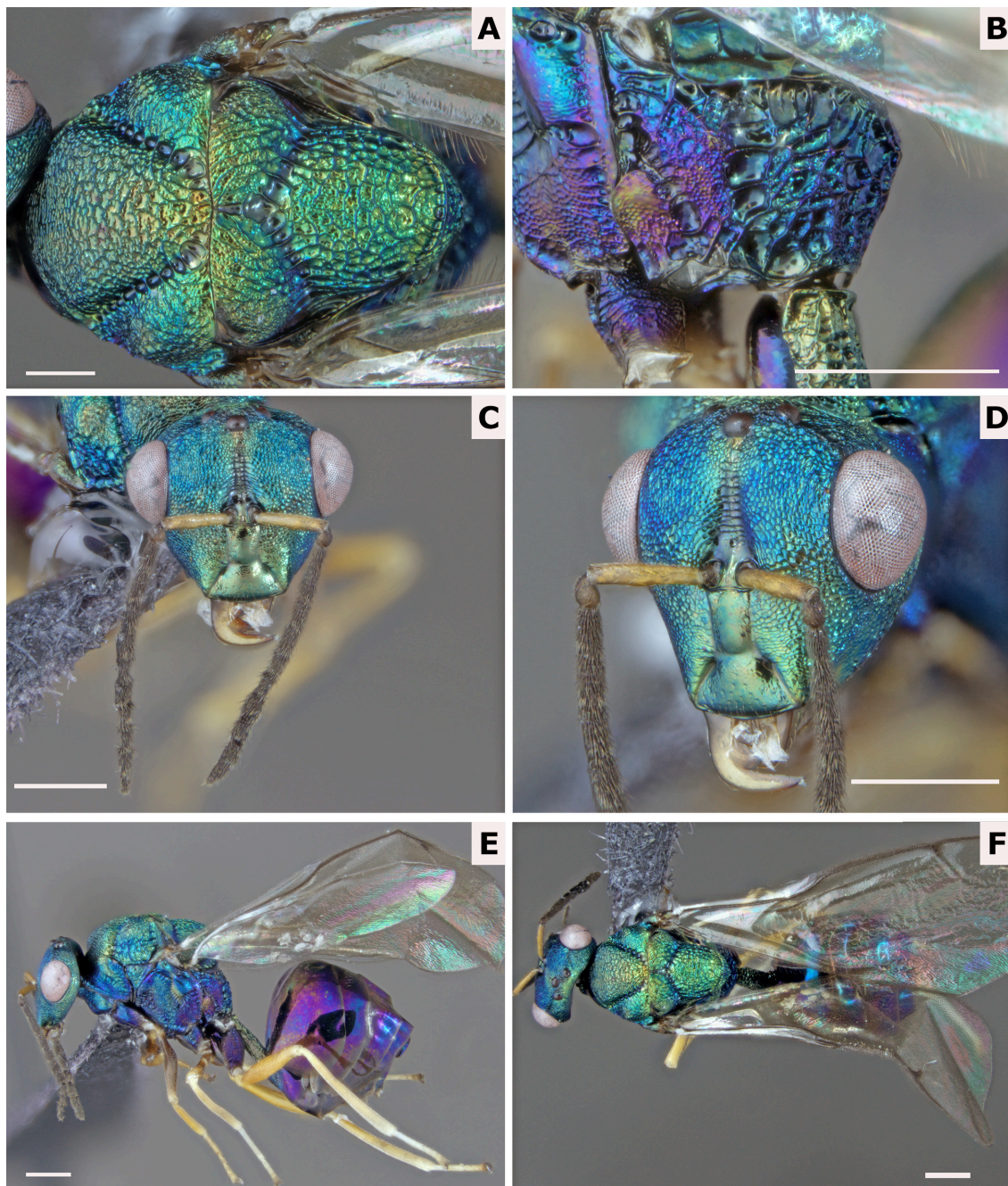


Figure 1. *Orasema chunpi* in dorsal mesosoma (A), posterior-oblique propodeal (B), frontal (C), fronto-oblique (D), lateral (E), and dorsal (F) view. Scale 0.5mm.

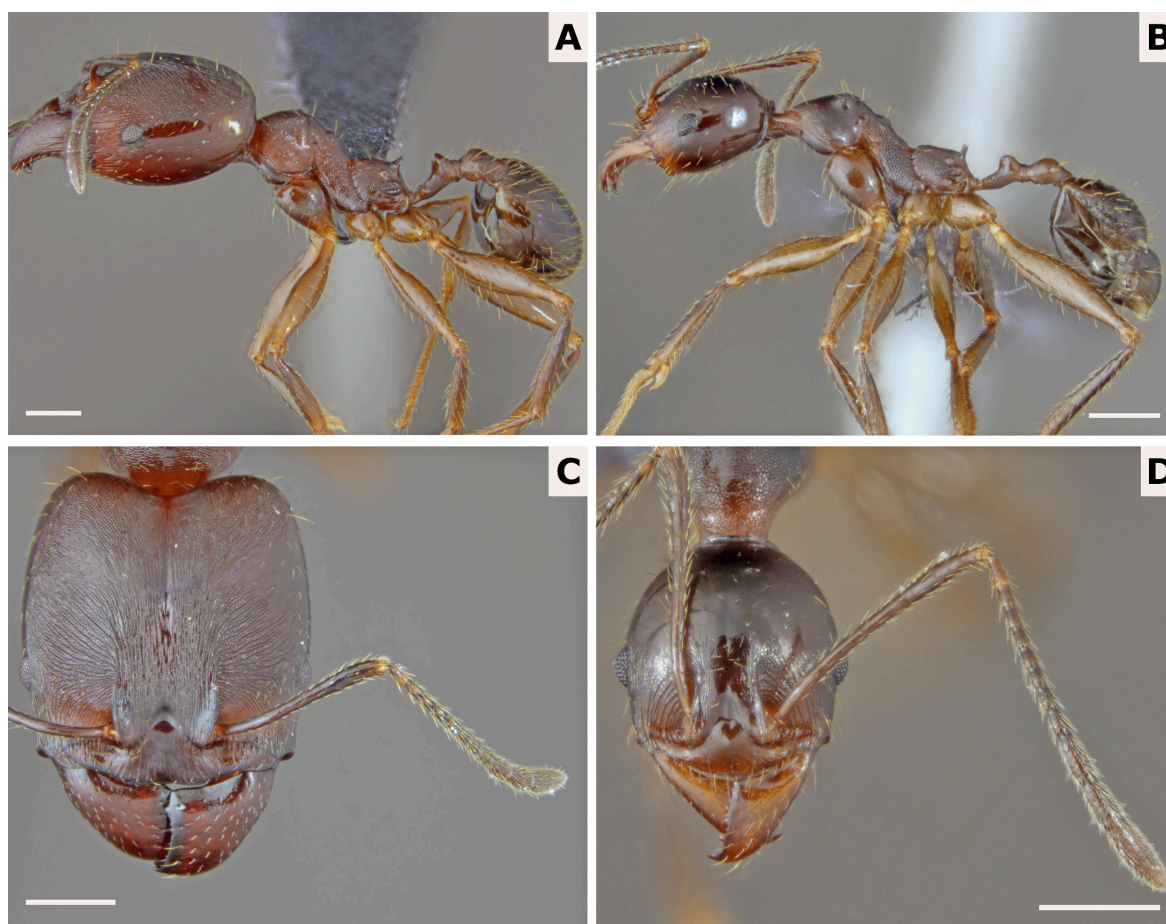


Figure 2. *Pheidole gibba* major in lateral (A) and frontal (C) view. Minor in lateral (B) and frontal (D) view. Scale 0.5mm.

host ants within the nest (Wheeler, 1907; Vander Meer et al., 1989), with most records describing interactions between adult individuals from both groups, especially after pupal emergence of the wasp (Pérez-Lachaud et al., 2015).

According to Wilson (2003), *P. gibba* belongs to the *tristis* species group, which are known to occupy predominantly forest habitats, with some species being partly or wholly arboreal. Most species belonging to this group collect and store seeds, and, according to Wilson (2003), the major workers are commonly timid. However, in this occasion, *P. gibba* was moderately aggressive during the nest opening, with some major and minor workers acting aggressively towards the collector, while the remaining individuals escaped carrying the brood. There is no documentation on the biology of *P. gibba*.

Recently, Baker et al. (2020) summarized the strategies performed by *Orasema* parasitoids to reach their host's nests. Generally, the behavior is similar to other eucharitid genera, with the planidia interacting with a host plant to circumvent the colony's defenses and access the larval host through adult phoresis. In several *Orasema* species, however, it is believed that other arthropods (e.g. thrips and immature cicadellids) act as intermediate hosts (Wheeler and Wheeler, 1937; Clausen, 1940a, 1940b; Heraty, 1994, 2000), serving as transport to the planidia, being carried by scavenger or predaceous ants back to the nest, where they are placed in direct contact with the larval host (Heraty, 2000).

The present work expands the distribution of both species, providing more knowledge on their overall distribution range. It also sheds light on the specific association of two poorly known genera and their biology, providing insights on ant-eucharitid interactions at species-level.

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Conflicts of interest

The authors declare no conflicts of interest.

Compliance with ethical standards

The specimens were collected in accordance to national legislation and its regulatory resolutions, Lei nº 6.938/1981 (Política Nacional do Meio Ambiente) and Lei Complementar nº 140/2011, and the material is deposited in the Coleção Entomológica Padre Jesus Santiago Moure, Departamento de Zoologia da Universidade Federal do Paraná, as imposed by law.

Author contribution statement

TSRS and ACF designed the study, conducted species' identifications and obtained the high-resolution images. ACF collected the specimens and prepared the figure plates. TSRS and ACF wrote the first version of the manuscript. Both authors revised the manuscript and read and approved the final version.

References

- Baccaro, F. B., Feitosa, R. M., Fernández, F., Fernandes, I. O., Izzo, T. J., Souza, J. L. P., Solar, R., 2015. Guia para os gêneros de formigas do Brasil. Editora INPA, Manaus, 388 pp.
- Baker, A. J., Heraty, J. M., Mottern, J., Zhang, J., Hines, H. M., Lemmon, A. R., Lemmon, E. M., 2020. Inverse dispersal patterns in a group of ant parasitoids (Hymenoptera: Eucharitidae: Oraseminae) and their ant hosts. *Syst. Entomol.* 45 (1), 1-19. <http://dx.doi.org/10.1111/syen.12371>.
- Bolton, B., 2020. An Online Catalog of the Ants of the World. Available in: <http://antcat.org> (accessed 19 February 2020).
- Burks, R. A., Heraty, J. M., Dominguez, C., Mottern, J. L., 2018. Complex diversity in a mainly tropical group of ant parasitoids: Revision of the *Orasema stramineipes* species group (Hymenoptera: Chalcidoidea: Eucharitidae). *Zootaxa* 4401 (1), 1-107. PMID:29690288. <http://dx.doi.org/10.11646/zootaxa.4401.1.1>.
- Burks, R. A., Heraty, J. M., Mottern, J., Dominguez, C., Heacox, S., 2017. Biting the bullet: revisionary notes on the Oraseminae of the Old World (Hymenoptera, Chalcidoidea, Eucharitidae). *J. Hym. Res.* 55, 139-188. <http://dx.doi.org/10.3897/jhr.55.11482>.
- Clausen, C. P., 1940a. The immature stages of Eucharidae (Hymenoptera). *J. Wash. Acad. Sci.* 30, 161-170.
- Clausen, C.P., 1940b. The oviposition habits of the Eucharidae (Hymenoptera). *J. Wash. Acad. Sci.* 30, 504-516.
- Economo, E. P., Klimov, P., Sarnat, E. M., Guénard, B., Weiser, M. D., Lecroq, B., Knowles, L. L., 2015. Global phylogenetic structure of the hyperdiverse ant genus *Pheidole* reveals the repeated evolution of macroecological patterns. *P. R. Soc. B Biol. Sci.* 282 (1798), 20141416. <http://dx.doi.org/10.1098/rspb.2014.1416>.
- Heraty, J. M., 1994. Classification and evolution of the Oraseminae in the Old World, with revisions of two closely related genera of Eucharitinae (Hymenoptera: Eucharitidae). Royal Ontario Museum, Toronto, 174 pp. (Life Sciences Contributions, 157).
- Heraty, J. M., 2000. Phylogenetic relationships of Oraseminae (Hymenoptera: eucharitidae). *Ann. Entomol. Soc. Am.* 93 (3), 374-390. [http://dx.doi.org/10.1603/0013-8746\(2000\)093\[0374:PROOHE\]2.0.CO;2](http://dx.doi.org/10.1603/0013-8746(2000)093[0374:PROOHE]2.0.CO;2).
- Heraty, J. M., 2002. A revision of the genera of Eucharitidae (Hymenoptera: Chalcidoidea) of the World. *Mem. Am. Ent. Soc.* 68, 1-359.
- Heraty, J. M., 2019. Catalog of World Eucharitidae. University of California, Riverside. Available in: <https://hymenoptera.ucr.edu/EucharitidaeCatalog2017.pdf> (accessed 6 August 2019).
- Köppen, W., 1936. Das geographische system der klimat. In: Köppen, W., Geiger, R. (Eds.), *Handbuch der klimatologie*. Berlin: Gebruder Borntraeger.
- Lachaud, J. P., Pérez-Lachaud, G., 2012. Diversity of species and behavior of hymenopteran parasitoids of ants: a review. *Psyche* 2012, 134746.
- Moreau, C. S., 2008. Unraveling the evolutionary history of the hyperdiverse ant genus *Pheidole* (Hymenoptera: formicidae). *Mol. Phylogenet. Evol.* 48 (1), 224-239. PMID:18394929. <http://dx.doi.org/10.1016/j.ympev.2008.02.020>.
- Pérez-Lachaud, G., Bartolo-Reyes, J. C., Quiroa-Montalván, C. M., Cruz-López, L., Lenoir, A., Lachaud, J. P., 2015. How to escape from the host nest: imperfect chemical mimicry in eucharitid parasitoids and exploitation of the ants' hygienic behavior. *J. Insect Physiol.* 75, 63-72. PMID:25770980. <http://dx.doi.org/10.1016/j.jinsphys.2015.03.003>.
- Sanchez-Lalinde, C., Velez-Garcia, F., Cornelio, A. C., Silveira, L. F., Alvarez, M. R., 2011. Records of the Harpy Eagle (*Harpia harpyja*) in the Serra Bonita reserves complex, Camacan, Bahia, with evidence of breeding. *Rev. Bras. Ornitol.* 19 (3), 436-438.
- Torréns, J., 2013. A review of the biology of Eucharitidae (Hymenoptera: Chalcidoidea) from Argentina. *Psyche* 2013, 1-14. <http://dx.doi.org/10.1155/2013/926572>.
- Vander Meer, R. K., Jouvenaz, D. P., Wojcik, D. P., 1989. Chemical mimicry in a parasitoid (Hymenoptera: Eucharitidae) of fire ants (Hymenoptera: Formicidae). *J. Chem. Ecol.* 15 (8), 2247-2261. PMID:24272384. <http://dx.doi.org/10.1007/BF01014113>.
- Varone, L., Heraty, J. M., Calcaterra, L. A., 2010. Distribution, abundance and persistence of species of *Orasema* (Hymenoptera: Eucharitidae) parasitic on fire ants in South America. *Biol. Control* 55 (1), 72-78. <http://dx.doi.org/10.1016/j.biocontrol.2010.06.017>.
- Wheeler, G. C., Wheeler, J., 1937. New hymenopterous parasitoids of ants (Chalcidoidea, Eucharidae). *Ann. Entomol. Soc. Am.* 30 (1), 171-172. <http://dx.doi.org/10.1093/aesa/30.1.163>.
- Wheeler, W. M., 1907. The polymorphism of ants, with an account of some singular abnormalities due to parasitism. *Bull. Am. Mus. Nat. Hist.* 23, 1-93.
- Wilson, E. O. 2003. *Pheidole in the New World: a Dominant, Hyperdiverse ant Genus*. Harvard University Press, Cambridge.