

Diversity of solitary wasps (Vespidae, Eumeninae) in Deciduous Seasonal Forest in the state of Minas Gerais, Brazil

Diversidade de vespas solitárias (Vespidae, Eumeninae) em floresta estacional decidual no estado de Minas Gerais, Brasil

Leonardo Dutra **BARBOSA**^{1, 5}; Gabriel de Castro **JACQUES**¹; Marcos Magalhães de **SOUZA**²; Gabriel Teófilo-Guedes **SILVA**³ & Marcel Gustavo **HERMES**⁴

ABSTRACT

Eumeninae is the subfamily with the highest number of species among Vespidae family, with more than 3,750 species and 210 genera identified worldwide. Some ecosystems are subsampled, such as the deciduous seasonal forest, also known as dry forest. Thus, this study aims to execute the inventory of the Eumeninae community in deciduous seasonal forest in the Parque Estadual da Mata Seca, Minas Gerais. The study took place from February to December 2021, executing active search and using malaise traps. A total of 90 individuals, belonging to 30 species, was collected, which characterize this study as the fourth highest list of Eumeninae for Brazil, even with a smaller sampling effort than other similar studies. In this study, 40% of the collected species are rare, having been collected only once. The most abundant species were *Pachodynerus brevithorax* (Saussure, 1853), *Hypalastoroides brasiliensis* (Saussure, 1856), *Pachymenes ater* (Saussure, 1852) and *Montezumia petiolata* (Saussure, 1855). This research shows how the Neotropical Eumeninae fauna is still little explored, indicating the need for more research to be conducted with this taxon, especially in environments without exploration such as the deciduous seasonal forest.

Keywords: conservation units; dry forest; Hymenoptera; seasonality.

RESUMO

Eumeninae é a subfamília com o maior número de espécies na família Vespidae, com mais de 3.750 espécies e 210 gêneros identificados no mundo. Alguns ecossistemas são subamostrados, como a floresta estacional decidual, também conhecida por mata seca. Sendo assim, este trabalho tem o objetivo de realizar o inventário da comunidade de Eumeninae em floresta estacional decidual no Parque Estadual da Mata Seca, Minas Gerais. O trabalho ocorreu de fevereiro a dezembro de 2021, por meio de busca ativa e armadilhas do tipo Malaise. Um total de 90 indivíduos pertencentes a 30 espécies foi coletado, o que faz do presente trabalho a quarta maior listagem de eumeníneos para o Brasil, mesmo com um esforço amostral menor que outros trabalhos similares. Neste estudo 40% das espécies são raras, sendo coletadas apenas uma vez. As espécies mais abundantes foram *Pachodynerus brevithorax* (Saussure, 1853), *Hypalastoroides brasiliensis* (Saussure, 1856), *Pachymenes ater* (Saussure, 1852) e *Montezumia petiolata* (Saussure, 1855). Este trabalho mostra como a fauna neotropical de Eumeninae é ainda pouco explorada, indicando a necessidade de mais pesquisas a serem realizadas com esse táxon, principalmente em ambientes ainda não explorados, como a floresta estacional decidual.

Palavras-chave: Hymenoptera; mata seca; sazonalidade; unidades de conservação.

Recebido em: 1.º fev. 2022

Aceito em: 8 abr. 2022

¹ Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais (IFMG), Laboratório de Biologia, Faz. Varginha, Rodovia Bambuí/Medeiros, km 5 – CEP 38900-000, Bambuí, MG, Brasil.

² Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais (IFSULDEMINAS), Laboratório de Zoologia, Inconfidentes, MG, Brasil.

³ Universidade Estadual de Campinas (Unicamp), Instituto de Geociências, Departamento de Geologia e Recursos Naturais, Campinas, SP, Brasil.

⁴ Universidade Federal de Lavras (UFLA), Departamento de Biologia, Lavras, MG, Brasil.

⁵ Autor para correspondência: leonardo.dutra150@gmail.com.

INTRODUCTION

The Vespidae family consists of six subfamilies, forming a monophyletic group, exhibiting solitary, pre-social and eusocial behavior (CARPENTER, 1982). The subfamilies Eumeninae, Euparagiinae and Masarinae include the species of solitary habit while the social species belong to the subfamilies Polistinae, Stenogastrinae, and Vespinae (CARPENTER & MARQUES, 2001).

Eumeninae is the subfamily with the highest number of species among wasps, with more than 3,750 species and 210 genera identified worldwide (PERRARD *et al.*, 2017). In Brazil, about 325 species of 30 genera are recorded (HERMES *et al.*, 2022).

The wasps of this subfamily are popularly known as “pot-wasp” or “wasp-potter”, because of their nest, which most often resembles a pot where the oviposition is performed (PICKETT & CARPENTER, 2010). These wasps have three types of nesting habits: 1- The “builders”, which built their nests using clay; however, some species of genera *Calligaster* Saussure, 1852 and *Zethus* Fabricius, 1804, can use chewed leaves (BOHART & STANGE, 1965); 2- The “excavators”, which dig their nests directly in the soil in the form of tubes (SOMAVILLA & KÖHLER, 2008); 3- The “tenant”, which can nest in pre-existing cavities, such as holes in trunks and abandoned nests of other insects, such as wasps of the genus *Monobia* Saussure, 1852 that can occupy bee nests of bees of the genus *Xylocopa* (Latreille, 1802) (MAHLMANN *et al.*, 2015).

These wasps are predators of larvae of other insects, which are transported inside their nests to feed their offspring (O’NEILL, 2001). Some genera of the subfamily Eumeninae, such as *Pachodynerus* (Saussure, 1870) and *Monobia*, prey on insects of economic importance, and in the biological control of the fall armyworm *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae) (SOUSA *et al.*, 2011). Moreover, they also feed on pollen and nectar, assisting in the pollination of plants (SOMAVILLA & KÖHLER, 2012).

Despite the ecological relevance of these wasps, some ecosystems are subsampled, such as the deciduous seasonal forest, also known as dry forest, a phytophysiognomy which still lacks consensus on which domain it should be included, being Atlantic Forest (OLIVEIRA-FILHO *et al.*, 2006), Cerrado (RIBEIRO & WALTER, 2008), or Caatinga (PRADO, 2005). The dry forest is characterized by two well-defined climatic seasons, one dry and the other rainy, causing drastic changes in its physiognomy (BELEM *et al.*, 2021).

Biological inventories aim to recognize the number of species in a given area, providing materials to be used in future research and incorporated into collections. Besides, the collected specimens can contribute to the study of ecology, description of species, determination of areas of endemism, and priority protection areas (WEN *et al.*, 2015). Wasps show a very close relationship with the phytophysiognomy matrix and can be used to evaluate some environmental variables, indicating the integrity and complexity of the ecosystem in which they are inserted (LOYOLA & MARTINS, 2008). The Neotropical Eumeninae fauna is still little known, indicating the need for more research analyzing this taxon (FERREIRA *et al.*, 2019). Thus, this study aims to carry out an inventory of the Eumeninae community in a seasonal deciduous forest in the Parque Estadual da Mata Seca, Minas Gerais.

MATERIAL AND METHODS

This study was conducted in the Parque Estadual Mata Seca (PEMS), located in the municipalities of Manga and Itacarambi, in the northern part of the state of Minas Gerais, Brazil (14°52’00’S 43°59’57’W), with an area of 15,360.07 hectares, and that houses remnants of deciduous seasonal forest, also called dry forest. The park is in a transition area between the Caatinga and Cerrado biomes, with high plant diversity (SANTOS *et al.*, 2007). It has two well-defined climatic seasons, one rainy followed by another with a long dry period, showing the tree stratum predominantly deciduous, with more than 70% of individuals devoid of foliage at the unfavorable time (SÁNCHEZ-AZOFEIFA *et al.*, 2005).

There were 24 days of collection, in four field campaigns, each with six continuous days (February, May, July, and November 2021), with four researchers, totaling 144 hours of sampling

effort per researcher. The technique used for the collection was active search, performed with the aid of entomological net in areas close to water resources, in lentic and lotic ecosystems, in rocky outcrops, and other places that provide resources for wasps, moving along roads and pre-existing trails (Figure 1), in the period from 9:00am to 2:00pm hours and from 5:00pm to 6:00pm, due to the excessive heat in the afternoon. Moreover, two Malaise traps were installed in the field throughout the collection period, and the individuals were collected every 15 days, totaling eight collections for each trap.

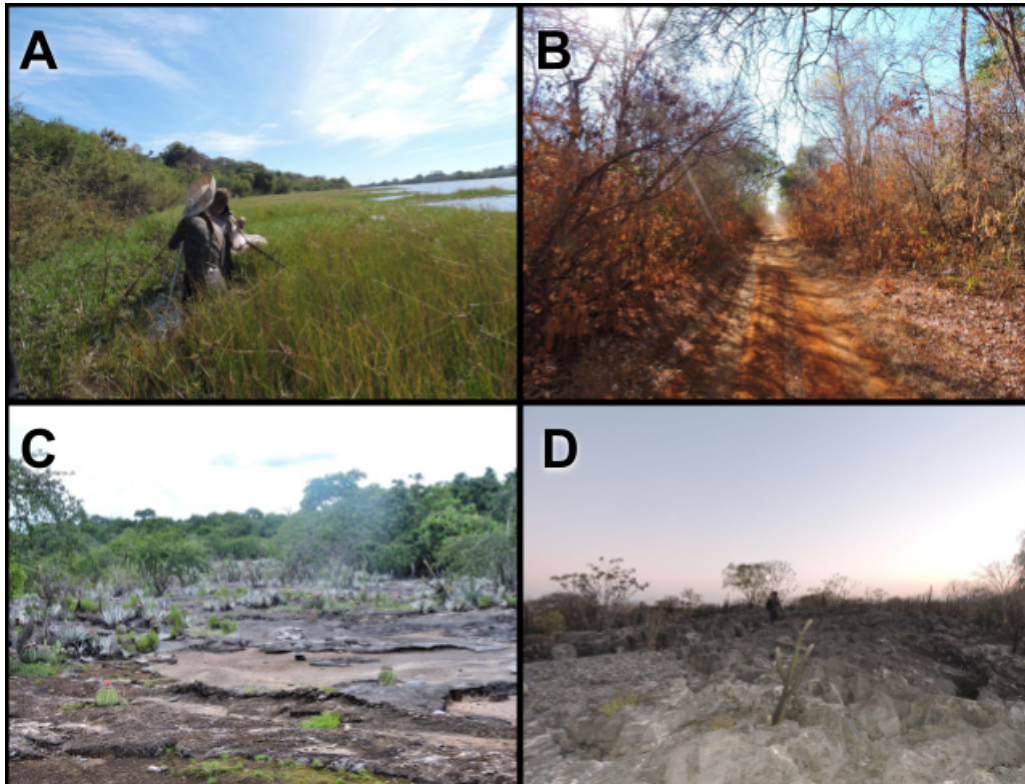


Figure 1 – Sampling areas for Eumeninae collection in the study. A. Lentic ecosystem. B. Pre-existing road. C and D. Rocky outcrops. Source: primary.

The specimens were sent for identification to the taxonomist Dr. Marcel Gustavo Hermes, from the Universidade Federal de Lavras, where they were also deposited and incorporated into the collection. The accompanying documents of this sampling are Collection license SISBio 76140-1 and IEF-MG 038/2020.

A cluster analysis was performed between the diversity of solitary wasps of this study with the diversity obtained in different studies executed in Brazil (Table 1) that also used active search. This was done because studies that use only traps register a smaller number of individuals and this could bring an erroneous result, when performing the analysis. To make this analysis, only the wasps identified up to species level were used, and the Jaccard similarity index was executed via Past program (HAMMER *et al.*, 2005), which considers only the presence and absence of the species.

Table 1 – Studies of diversity of solitary wasps (Eumeninae) in Brazil that use active search. *Legend for sampling: A.S - Active Search / A.T - Attractive Trap / M - Malaise / M.T - Møericke Trap/ S.T - Attractive Solution (spray / water and sugar).

Study	State	Biome	Sampling*	Species richness
AUKO <i>et al.</i> , 2017	Mato Grosso do Sul	Cerrado	M.T / A.S / M	66
SOMAVILLA & KÖHLER, 2012	Rio Grande do Sul	Atlantic Forest	A.S	43
HERMES & KÖHLER, 2004	Rio Grande do Sul	Atlantic Forest	A.S	37
GRANDINETE & NOLL, 2013	Mato Grosso do Sul	Cerrado	A.T / A.S / S.T	21
AUKO & SILVESTRE, 2013	Mato Grosso do Sul	Cerrado	A.T/ A.S. /M.	20
SILVEIRA <i>et al.</i> , 2008	Amazonas	Amazon Rainforest	A.S. / M	14
RIBEIRO <i>et al.</i> , 2019	Rio de Janeiro	Atlantic Forest	A.S	9

RESULTS AND DISCUSSION

In total, 90 individuals from 11 genera and 30 morphospecies of solitary wasps (Eumeninae) were collected (Table 2), recording the fourth highest diversity in Brazil (Table 1). The three studies with greater diversity (HERMES & KÖHLER, 2004; SOMAVILLA & KÖHLER, 2012; AUKO *et al.*, 2017) had a larger sampling effort, with collections over several years. This study, on the other hand, obtained its data over only one year. The Parque Estadual Mata Seca has a rich plant diversity that, associated with pedological, geomorphological and climatic aspects, stands out as one of the most significant sources of biodiversity in Minas Gerais (BELEM *et al.*, 2021), which helps to explain the diversity of Eumeninae obtained.

Table 2 – Species and abundance of solitary wasps (Vespidae: Eumeninae) in the Parque Estadual Mata Seca, Minas Gerais, Brazil.

Specie	Abundance
<i>Alphamenes</i> sp.	2
<i>Cyphomenes anisitsii</i> (Brèthes, 1906)	5
<i>Hypalastoroides brasiliensis</i> (de Saussure, 1856)	11
<i>Hypalastoroides</i> sp.	1
<i>Hypancistrocerus</i> sp.1	1
<i>Hypancistrocerus</i> sp.2	1
<i>Monobia</i> sp.1	1
<i>Monobia</i> sp.2	2
<i>Montezumia azurescens</i> (Spinola, 1851)	3
<i>Montezumia infernalis</i> (Spinola, 1851)	2
<i>Montezumia nigriceps</i> (Spinola, 1841)	2
<i>Montezumia petiolata</i> de Saussure, 1855	9
<i>Omicron</i> sp.1	1
<i>Omicron</i> sp.2	1
<i>Omicron tegulare</i> (Fox, 1899)	1
<i>Omicron tuberculatum</i> (Fox, 1899)	1
<i>Pachodynerus brachygaster</i> (de Saussure, 1853)	2

continua...

Continuação da tabela 2

Specie	Abundance
<i>Pachodynerus brevithorax</i> (de Saussure, 1853)	12
<i>Pachodynerus grandis</i> Wiilink & Roig-Alsin, 1998	1
<i>Pachodynerus laplatae</i> (de Saussure, 1870)	2
<i>Pachodynerus nasidens</i> (Latreille, 1817)	1
<i>Pachymenes ater</i> de Saussure, 1852	9
<i>Pachymenes bipartitus</i> (Fox, 1899)	3
<i>Pachymenes laeviventris</i> (Fox, 1899)	1
<i>Stenosigma allegrum</i> (Zavattari, 1912)	1
<i>Zeta argillaceum</i> (Linnaeus, 1758)	4
<i>Zethus</i> sp.1	1
<i>Zethus</i> sp.2	2
<i>Zethus</i> sp.3	3
<i>Zethus spegazzinii</i> (Brèthes, 1906)	4
Abundance	90
Richness	30

The most abundant species were *Pachodynerus brevithorax* (Saussure, 1853), *Hypalastoroides brasiliensis* (Saussure, 1856), *Pachymenes ater* (Saussure, 1852) and *Montezumia petiolata* (Saussure, 1855).

Pachodynerus brevithorax is a species found in all regions of Brazil (HERMES *et al.*, 2022) that chase on different types of prey, such as spiders and larvae of Lepidoptera, cockroaches, crickets, locusts and beetle larvae (SOMAVILLA & KÖHLER, 2008; TOREZAN-SILINGARD, 2011). This wasp can dig a nest in the soil or use clay to build a new nest (SOMAVILLA & KÖHLER, 2008).

Hypalastoroides brasiliensis has already been reported in the Atlantic Forest and Cerrado biomes, but this is the first record for the deciduous seasonal forest phytophysognomy (HERMES & KÖHLER, 2004; GRANDINETE & NOLL, 2013; AUKO *et al.*, 2017).

Pachymenes ater is an abundant species in southern Brazil (HERMES & KÖHLER, 2004; SOMAVILLA & KÖHLER, 2012), also occurring in the southeast and state of Bahia (HERMES *et al.*, 2022), and its distribution shows typical patterns of faunistic elements of the Atlantic Forest (CARNAVAL & MORITZ, 2008).

Montezumia petiolata occurs in all regions, except in the South (HERMES *et al.*, 2022), and it can occupy nests of other wasp species, such as *Brachymenes dyscherus* (Saussure, 1852) (CAMILO, 2001).

Using similarity analysis (Figure 2; Table 3), this study demonstrated to be more similar to studies performed in the Cerrado, showing the following similarities: 33.33% with the study by Grandinete & Noll (2013), with nine species being collected in both studies; 29.62% with the study by Auko & Silvestre (2013), with eight species in common; and 19.64% with the study by Auko *et al.* (2017), with 11 species in common.

This result raises the discussion whether the Brazilian deciduous seasonal forest is a phytophysognomy that composes the Atlantic Forest Biome (OLIVEIRA-FILHO *et al.*, 2006), Cerrado (RIBEIRO & WALTER, 2008), or Caatinga (PRADO, 2005). The Parque Estadual Mata Seca is in a transition area between the Cerrado and Caatinga biomes (SANTOS *et al.*, 2007), which may explain the greater similarity of the wasp fauna of this study with the Cerrado. The literature lacks studies addressing Eumeninae in Caatinga, disabling comparison.

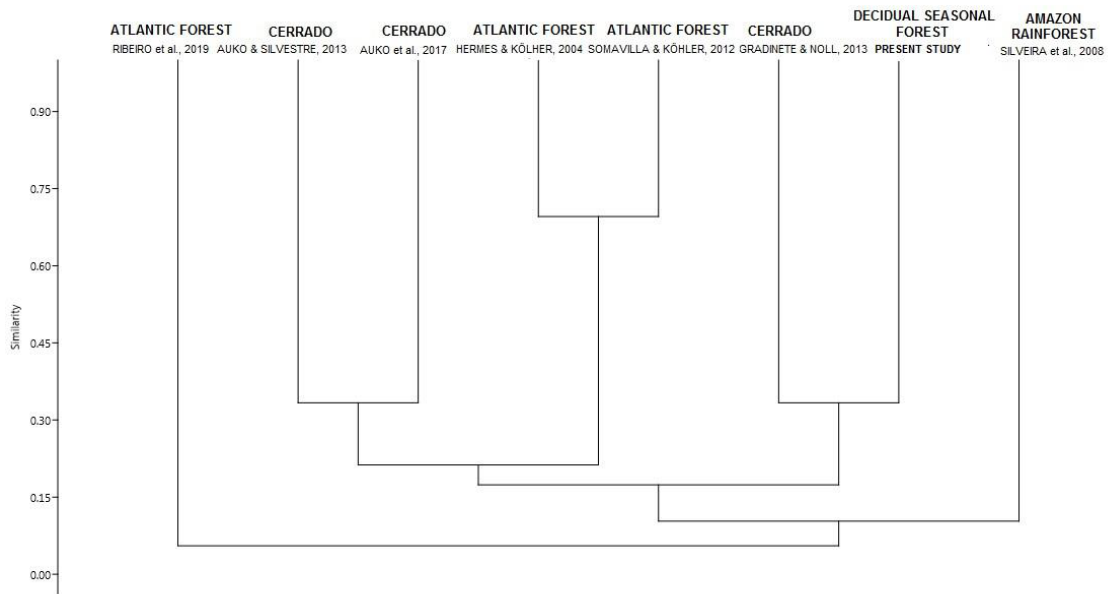


Figure 2 – Cluster analysis between the faunas of solitary wasps (Eumeninae) of different diversity studies that used active search. Source: primary.

Table 3 – Cluster analysis between solitary wasp faunas (Eumeninae) of different diversity studies that employed active search, using Jaccard similarity index.

	Somavilla & Köhler, 2012 (Atlantic Forest)	Hermes & Köhler, 2004 (Atlantic Forest)	Silveira et al., 2008 (Amazon Rainforest)	Auko & Silvestre, 2013 (Cerrado)	Grandinete & Noll, 2013 (Cerrado)	Auko et al., 2017 (Cerrado)	Ribeiro et al., 2019 (Atlantic Forest)	Present study (Deciduous Seasonal Forest)
Somavilla & Köhler, 2012 (Atlantic Forest)	1	0,695652	0,086957	0,212766	0,137255	0,219178	0,108696	0,2
Hermes & Köhler, 2004 (Atlantic Forest)	0,695652	1	0,069767	0,204545	0,102041	0,214286	0,068182	0,12
Silveira et al., 2008 (Amazon Rainforest)	0,086957	0,069767	1	0,136364	0,130435	0,075472	0,055556	0,12
Auko & Silvestre, 2013 (Cerrado)	0,212766	0,204545	0,136364	1	0,178571	0,333333	0	0,296296
Grandinete & Noll, 2013 (Cerrado)	0,137255	0,102041	0,130435	0,178571	1	0,160714	0,038462	0,333333
Auko et al., 2017 (Cerrado)	0,219178	0,214286	0,075472	0,333333	0,160714	1	0	0,196429
Ribeiro et al., 2019 (Atlantic Forest)	0,108696	0,068182	0,055556	0	0,038462	0	1	0,115385
Present study (Deciduous Seasonal Forest)	0,2	0,12	0,12	0,296296	0,333333	0,196429	0,115385	1

Only the studies of Hermes & Köhler (2004) and Somavilla & Köhler (2012) obtained a high similarity value (69.56%), and this occurs because both studies were conducted in areas close to the Atlantic Forest in southern Brazil. In general, there was a low similarity between the diversity studies of Eumeninae. This may be associated to the scarce knowledge about the group in Brazil (FERREIRA *et al.*, 2019), since most of the morphospecies are identified only up to the gender level. Eumeninae generic classification has undergone constant changes and many taxa require modern reviews with phylogenetic foundation (CARPENTER & GARCETE-BARRETT, 2002). However, even with this difficulty of identification, these data indicate that, possibly, it is conceivable to find many unique species in different habitats.

In this study, 40% of the collected species are rare, having been collected only once. Besides, it is the first record of *Zethus spgazzinii* (Brethes, 1906) in Brazil (HERMES *et al.*, 2022). Among the species, four have their first record for the state of Minas Gerais, that are: *Hypalastoroides brasiliensis* (Saussure, 1856), recorded before only in Mato Grosso do Sul and Rio Grande do Sul (HERMES & KÖHLER, 2004; GRANDINETE & NOLL, 2013; AUKO *et al.*, 2017); *Omicron tegulare* (Fox, 1899), recorded before only in Mato Grosso, Rio de Janeiro, and Rio Grande do Sul (SOMAVILLA *et al.*, 2010; AUKO *et al.*, 2017); *Pachodynerus laplatae* (Saussure, 1870), recorded before only in Rio Grande do Sul and Santa Catarina (SOMAVILLA *et al.*, 2010); and *Pachymenes bipartitus* (Fox, 1899), recorded before only in Mato Grosso and São Paulo (HERMES *et al.*, 2022).

CONCLUSIONS

This study shows how the Neotropical Eumeninae fauna is still little explored, indicating the need for more research with this taxon, especially in environments without exploration, such as the deciduous seasonal forest.

ACKNOWLEDGEMENTS

To Instituto Federal de Minas Gerais (IFMG) – *Campus Bambuí* and Instituto Federal do Sul de Minas (IFSULDEMINAS) – *Campus Inconfidentes* for the logistics. To the manager and monitors of the Parque Estadual Mata Seca for the support in the field. To the trainees who were members of the field team and assisted in the data collection. To Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) for granting the collection license.

REFERENCES

- Auko, T. H., Carbonari, V., Ribeiro, D. G. & Silvestre, R. Checklist of wasp (Hymenoptera, Vespidae) from Mato Grosso do Sul, Brazil. *Iheringia*. 2017; 107 (Supl.), e2017125. Série Zoologia.
doi: <http://dx.doi.org/10.1590/1678-4766e2017125>
- Auko, T. H. & Silvestre, R. Composição faunística de vespas (Hymenoptera: Vespoidea) na Floresta Estacional do Parque Nacional da Serra da Bodoquena, Brasil. *Biota Neotropica*. 2013. 13(1): 292-299.
doi: <http://dx.doi.org/10.1590/S1676-06032013000100028>
- Belem, R. A., Oliveira, C. V. & Veloso, M. D. M. Os fatores edáficos e antropogênicos e suas correlações com as fitofisionomias do Parque Estadual da Mata Seca, Manga/MG. *Revista Cerrados*. 2021. 19(1): 298-328.
doi: <http://dx.doi.org/10.46551/rc24482692202113>
- Bohart, R. M. & Stange, L. A. A revision of the genus *Zethus* Fabricius in the Western Hemisphere (Hymenoptera: Eumenidae). University of California Publications in Entomology. 1965; 40: 1-208.
- Camilo, E. Inquilines of *Brachymenes dyscherus* nests with special reference to *Monobia schrottkyi* (Hymenoptera, Vespidae, Sphecidae). *Biological Tropical*. 2001; 49(3/4): 1005-1012.
- Carnaval, A. C. & Moritz, C. Historical climate modelling predicts patterns of current biodiversity in the Brazilian Atlantic forest. *Journal of Biogeography*. 2008; 35: 1187-1201.
doi: <http://dx.doi.org/10.1111/j.1365-2699.2007.01870.x>

- Carpenter, J. M. The phylogenetic relationships and natural classification of the Vespoidea (Hymenoptera). *Syst. Entomol.* 1982; 7: 11-38.
- Carpenter, J. M. & Garcete-Barrett, B. R. A key to the Neotropical genera of Eumeninae (Hymenoptera: Vespidae). *Boletín del Museo Nacional de Natural del Paraguay.* 2002; 14(1/2): 52-73.
- Carpenter, J. M. & Marques, O. M. Contribuição ao estudo dos vespídeos do Brasil (Insecta, Hymenoptera, Vespidae). *Cruz das Almas: Universidade Federal da Bahia;* 2001. 147 p. Série Publicações Digitais. v. 2.
- Ferreira, W. D., Hermes, M. G., Garcete-Barret, B. R. & Carpenter, J. M. Two new species of *Pirhosigma* Giordani Soika (Vespidae, Eumeninae), with an updated catalog for the genus. *Journal of Hymenoptera Research.* 2019; 71: 225-240.
doi: <http://dx.doi.org/10.3897/jhr.71.35754>
- Grandinete, Y. C. & Noll, F. B. Checklist of social (Polistinae) and solitary (Eumeninae) wasps from a fragment of Cerrado “Campo Sujo” in the State of Mato Grosso do Sul. *Sociobiology.* 2013; 60(1): 101-106.
doi: <http://dx.doi.org/10.13102/sociobiology.v60i1.101-106>
- Hammer, O., Harper, D. A. T. & Ryan, P. D. Past: paleontological statistics software package for education and data analysis. *Palaeontologica Electronica.* 2005; 4: 1-9.
- Hermes, M. & Köhler, A. Chave ilustrada para as espécies de Vespidae (Insecta, Hymenoptera) ocorrentes no Cinturão Verde de Santa Cruz do Sul, RS, Brasil. *Caderno de Pesquisa, série Biologia.* 2004; 16(2): 65-115.
- Hermes, M. G., Somavilla, A. & Andena, S. R. Vespidae. In: *Catálogo taxonômico da fauna do Brasil.* PNUD; 2022. [Acesso em: 22 jan. 2022]. Disponível em: <http://fauna.jbrj.gov.br/fauna/faunadobrasil/3729>.
- Loyola, R. D. & Martins, R. P. Habitat structure components are effective predictors of trap-nesting Hymenoptera diversity. *Basic and Applied Ecology.* 2008; 9: 735-742.
- Mahlmann, T., Lima, R., Santana, T., Oliveira, F. F. & Coutinho, J. G. E. Padrão de nidificação de *Monobia angulosa* Saussure (Vespidae) durante estação seca prolongada na região da Chapada Diamantina, Bahia, com notas sobre nidificação em ninho abandonado de *Xylocopa cearensis* Ducke (Apidae). *EntomoBrasilis.* 2015; 8(1): 12-16.
doi: <http://dx.doi.org/10.12741/ebrasilis.v8i1.462>
- Oliveira, F. X., Andrade, L. A. & Félix, L. P. Comparações florísticas e estruturais entre comunidades de floresta ombrófila aberta com diferentes idades, no município de Areia, PB, Brasil. *Acta Botanica Brasilica.* 2006; 20(4): 861-873.
doi: <http://dx.doi.org/10.1590/S0102-33062006000400011>
- Oliveira-Filho, A. T., Scolforo, J. R. S., Oliveira, A. D. & Carvalho, L. M. T. Definição e delimitação de domínios e subdomínios das paisagens naturais do estado de Minas Gerais. In: Scolforo, J. R. & Carvalho, L. M. T. *Mapeamento e inventário da flora nativa e dos reflorestamentos de Minas Gerais.* Lavras: UFLA; 2006. 561 p.
- O'Neill, K. M. *Solitary wasps: behavior and natural history.* Ithaca, New York: Cornell University Press; 2001. 406 p.
- Perrard, A., Grimaldi, D. & Carpenter, J. M. Early lineages of Vespidae (Hymenoptera) in Cretaceous amber. *Systematic Entomology.* 2017; 42(2): 379-386.
doi: <http://dx.doi.org/10.1111/syen.12222>
- Pickett, K. M. & Carpenter, J. M. Simultaneous analysis and the origin of 83 eusociality in the Vespidae (Insecta: Hymenoptera). *Arthropod Systematics & Phylogeny.* 2010; 68(1): 3-33.
- Prado, D. E. As caatingas da América do Sul. In: Leal, I., Tabarelli, M. & Silva, J. M. C. (Org.). *Ecologia e conservação da caatinga.* Recife: Editora UFPE; 2005. p. 3-73.
- Ribeiro, D. G., Silvestre, R. & Garcete-Barrett, B. R. Diversity of wasps (Hymenoptera: Aculeata: Vespidae) along an altitudinal gradient of Atlantic Forest in Itatiaia National Park, Brazil. *Revista Brasileira de Entomologia.* 2019; 63(1): 22-29.
doi: <https://doi.org/10.1016/j.rbe.2018.12.005>

- Ribeiro, J. F. & Walter, B. M. T. As principais fitofisionomias do bioma cerrado. In: Sano, S. M., Almeida, S. P & Ribeiro, J. F. Ecologia e flora. Brasília: Embrapa; 2008. p. 152-212.
- Sánchez-Azofeifa, G. A., Quesada, M., Rodriguez, J. P., Nassar, J. M., Stoner, K. E., Castillo, A., Garvin, T., Zent, E. L., Calvo-Alvarado, J. C., Kalacska, M. E. R., Fajardo, L., Gamon, J. A., Cuevas-Reyes, P. Research priorities for Neotropical dry forests. *Biotropica*. 2005; 37(4): 477-485.
- Santos, G. M. M., Cruz, J. D. da, Bichara Filho, C. C., Marques, O. M., Aguiar, C. M. L. Utilização de frutos de cactos (Cactaceae) como recurso alimentar por vespas sociais (Hymenoptera, Vespidae, Polistinae) em uma área de caatinga (Ipirá, Bahia, Brasil). *Revista Brasileira de Zoologia*. 2007; 24: 1052-1056.
- Silveira, O. T., Costa Neto, S. V., Silveira, O. F. M. Social wasps of two wetland ecosystems in Brazilian Amazonia (Hymenoptera, Vespidae, Polistinae). *Revista Acta Amazonica*. 2008; 38(2): 333-334.
- Somavilla, A. & Köhler, A. Preferência floral de vespas (Hymenoptera, Vespidae) no Rio Grande do Sul, Brasil. *EntomoBrasilis*. 2012; 5(1): 21-28.
doi: <http://dx.doi.org/10.12741/ebrasilis.v5i1.152>
- Somavilla, A. & Köhler, A. Species of the genus *Pachodynerus* (Hymenoptera: Vespidae, Eumeninae) in the Rio Grande do Sul state, Brazil. *Caderno de Pesquisa Série Biologia*. 2008; 20: 6-17.
- Somavilla, A., Köhler, A. E. & Hermes, M. H. Contribuição aos estudos dos Vespidae ocorrentes no estado do Rio Grande do Sul (Insecta, Hymenoptera). *Revista Brasileira de Biociências*. 2010; 8(3): 257-263.
- Sousa, E. H. S., Matos, C. B. M. & Almeida, S. R. Forest fragments contribution to the natural biological control of *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Maize. *Brazilian Archives of Biology and Technology*. 2011; 54(4): 755-760.
- Torezan-Silingard, H. M. Predatory behavior of *Pachodynerus brevithorax* (Hymenoptera: Vespidae, Eumeninae) on endophytic herbivore beetles in the Brazilian Tropical Savanna. *Sociobiology*. 2011; 57(1): 181-189.
- Wen, J., Ickert-Bond, S. M., Appelhans, M. S., Dorr, L. J. & Funk, V. A. Collections-based systematics: opportunities and outlook for 2050. *Journal of Systematics and Evolution*. 2015; 53(6): 477-488.
doi: <http://dx.doi.org/10.1111/jse.1218.1>