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SHORT NOTE

Range expansion of the Cleptoparasitic Orchid Bee *Aglae caerulea* in the Pantanal of Mato Grosso, Brazil

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Abstract

Several authors have suggested that gallery forests play an essential role as mesic corridors, opening the way to the colonization of the Cerrado by forest-dependent species with ranges centered in the neighboring Amazon and Atlantic forests. One such species is the cleptoparasitic *Aglae caerulea* Lepeletier de Saint-Fargeau & Audinet-Serville, which has had its geographical distribution expanded by various records made in gallery forests in areas of that biome. We report here the occurrence of *A. caerulea* in a gallery forest located in Santo Antônio do Leverger municipality, in Mato Grosso, Brazil. Eleven males were collected in the Pantanal of Barão de Melgaço, in Mato Grosso, Brazil. The results presented reinforce the need for further research to understanding better the distributional range limits of *A. caerulea* in southern South America, now that the species has been recorded for the first time almost 30 km from the flooded plains of the Pantanal.

The employment of chemicals such as terpenes to attract male orchid bees since the late 1960s (Dodson et al., 1969; Williams & Whitten, 1983) has led to several studies into the taxonomy and biogeography of euglossines. However, among the dozens of pure chemical substances produced by the industry, one salt, in particular, has stood out in the discovery of unusual species of the tribe: this is methyl cinnamate, a commercially available crystal and the most powerful chemical bait for *Aglae caerulea* Lepeletier de Saint-Fargeau and Audinet-Serville in the Neotropics (Williams & Dodson, 1972; Morato, 2001; Anjos-Silva et al., 2006; Martins et al., 2016; Anjos-Silva, 2019a,b).

Several authors pointed out that the diversity of species in the gallery forests in the Cerrado is a consequence of recurrent connections between the Amazon and Atlantic Forests during the last glaciation periods. These events caused gallery forests in the Cerrado to present similar diversity of species to that of the east of the Amazon Forest and the north of the Atlantic Forest (Oliveira-Filho & Ratter, 1995; Costa, 2003; Wang et al., 2004; Fouquet et al., 2012; Batalha-Filho et al., 2013; Sobral-Souza et al., 2015). Some authors have highlighted that gallery forests play an important role as mesic corridors, opening the way to colonization of the Cerrado by forest-dependent species with ranges centered in the neighboring Amazon and Atlantic Forests (Sick, 1966; Willis, 1992; Moura and Schlindwein, 2009; Silva et al., 2013; Martins et al., 2016). Given the importance of gallery forests as alternative dispersion paths for several species, including *A. caerulea*, this study aimed to verify the occurrence of that species in a gallery forest located between the Cerrado, Pantanal and Araguaia regions, in Mato Grosso state.

The present study was conducted in a gallery forest located at the Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso (IFMT), São Vicente Range (15°49'21.42" S; 55°25'06.36" W), in the Santo Antônio do Leverger municipality, Mato Grosso, Brazil (Fig 1). The region is characterized by

a Tropical Savanna climate, Aw type on the Köppen-Geiger climate classification system (Peel et al. 2007).

To check the occurrence or not of *A. caerulea* males in the study area, two plastic bottle traps containing methyl cinnamate were made available in the area from 28 May to 6 July. The trap consisted of a 500 ml plastic bottle with two side openings and a cotton pad containing methyl cinnamate hanging inside. Since these traps were not inspected daily, the bottom of the bottle was filled with 250 ml of 96% ethyl alcohol to avoid the decomposition of specimens that could be attracted. The first inspection was made on 26 June, and the second occurred on 6 July when the study was finished. The males caught in the traps were removed, pinned, and housed in the Universidade do Estado de Mato Grosso UNEMAT Bee Collection (EJAS 90.002 - 90.013) of the Laboratory of Neotropical Bees and Wasps (LABEVE), Cáceres municipality, Mato Grosso state, Brazil.

The geographical distribution data of *A. caerulea* presented in this study are based on the recent revision of occurrence records for this species (Anjos-Silva, 2019a,b), together with the specimens housed in the UNEMAT Bee Collection. Besides, the data made available from the Global Biodiversity Information Facility (GBIF) (www.gbif.org), Discover Life Bee Species Guide and World Checklist (Ascher & Pickering, 2018) (http://www.discoverlife.org), Moure's Bee Catalogue (Moure et al., 2012), and CRIA's Species Link (www.splink.org.br) were also used (Supplementary Material 1).

Eleven *A. caerulea* males were caught at the beginning of the dry season in the Paraguay-Araguaia-Tocantins divide at the northeast border of the Pantanal (Fig 1). Of the collected males, eight males were removed from the traps during the first inspection of them, and the three remaining males were found when the traps were removed from the field. This study adds new occurrence points for *A. caerulea* in the Neotropics (see Supplementary Material). Considering that cleptoparasitic species have extraordinary dispersal ability and travel several kilometers in forests in a single day (Wikelski et al., 2010; Pokorny et al., 2015), it seems reasonable to assume that *A. caerulea* could be found in the southern portion of the Pantanal sub-regions.

Concerning literature reviews, the results lead us to conclude that the São Vicente Range is the second most abundant area in the Neotropics for *A. caerulea* (Table 1), an area situated precisely between the Amazon, Paraguay, and Araguaia-Tocantins divide. Reports of this species for the Pantanal, therefore, may be influenced by (1) vegetation types and microclimates similar to Amazon and Atlantic Forests (Oliveira-Filho & Ratter, 1995; Sobral-Souza et al., 2015), (2) the formation of ecological corridors of gallery forests throughout the São Vicente Range region, situated in the same complex of parallel mountain ranges that also reaches the Parque Nacional da Chapada dos Guimarães, the location of the first record of this species for the Cerrado domain (Anjos-Silva et al., 2006), (3) the proximity to the flooded areas by

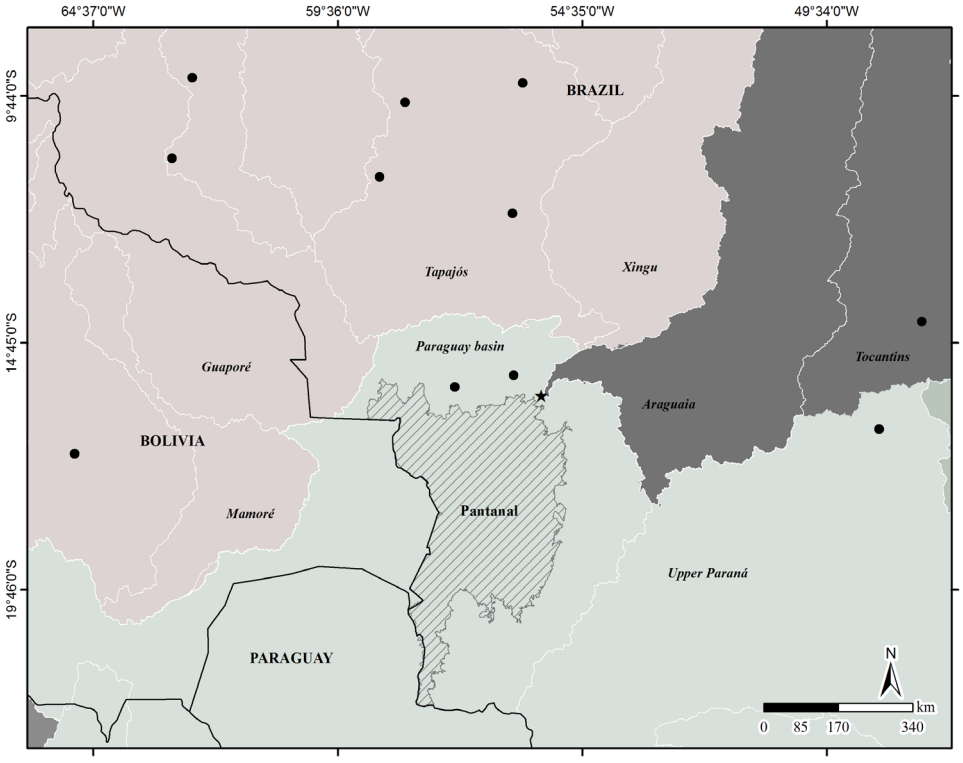

Fig 1. Map of the Amazon-Paraguay divide, with locations of the previous records of *A. caerulea* (black circle) and the first *A. caerulea* record point in Pantanal (black star), exactly between the sub-basin drainages of the Paraguay river (Hydrographic basin of Rio da Prata) and Araguaia river (Hydrographic basin of Rio Tocantins (IBGE, 2000). The physiographic limits of the Pantanal are indicated in hachured lines.

Table 1. Occurrence records for *Aglae caerulea* Lepeletier de Saint-Fargeau & Audinet-Serville, according to altitude (elevation, m), habitat associations, chemical attractants, and data relative to the abundance of these cleptoparasitic species.

Study Areas	Country	Long.	Lat.	Alt.	Attractants	*A. caerulea*	Habitat	References
Alto Paraíso de Goiás	BR	-47.6088	-14.3152	1230	MC	1	CE	Silva et al., 2013
Aragua, Portachuelo	VE	-61.2547	9.0516	1200	Flight	1	DF	González, 1996
Aragua, Guamita	VE	-60.3613	9.0080	725	Flight	1	DF	González, 1996
Aragua, El Limón	VE	-67.5722	10.06	450	Flight	1	DF	González, 1996
Aragua, Via Choroni	VE	-67.0581	10.5611	200	Flight	1	DF	González, 1996
Aragua, Moyobamba	PE	-76.5830	-6.0430	954	*	1	AF	Abrahamczyk et al., 2011
Silvânia	BR	-48.4917	-16.498	920	MC	1	CE	Silva et al., 2013
Santo Antônio do Leverger, São Vicente Range	BR	-55.4058	-15.8297	750	MC	11	GF	This study
Aragua, Guamita	VE	-60.3613	9.0080	725	Flight	1	DF	González, 1996
Pq. Nacional Chapada dos Guimarães	BR	-55.9867	-15.405	598	MC	8	GF	Anjos-Silva et al., 2006
Buena Vista	BO	-63.6360	-17.516	424	*	1	DF	Abrahamczyk et al., 2011
Parque Estadual do Mirador	BR	-45.8891	-6.6167	313	MC	2	GF	Martins et al., 2016
Parque Estadual Cristalino	BR	-55.8067	-9.4667	278	MC, BB	18	AF	Figueiredo et al., 2015
Parque Nacional da Serra do Divisor	BR	-73.7186	-7.4519	266	MC	1	AF	Morato, 2001
Parque Nacional da Serra do Divisor	BR	-73.6577	-7.4408	244	MC	1	AF	Morato, 2001
Cotriguaçu, São Nicolau Farm	BR	-58.2161	-9.8623	235	MC	1	AF	Schorn de Souza (unpublished data)
Estação Ecológica de Serra das Araras	BR	-57.2000	-15.650	225	Flight	1♀	CE	Anjos-Silva, 2019a,b
Parque Nacional da Serra do Divisor	BR	-72.8577	-8.4052	207	MC	1	AF	Morato, 2001
Pijuayal	PE	-74.1920	-8.0900	159	*	1	AF	Abrahamczyk et al., 2011
Inselberg-station Les Nouragues	FG	-52.6833	4.0833	120	Flight[1]	1	AF	Hentrich et al., 2007
Porto Velho, Teotônio Waterfall	BR	-64.0530	-8.8750	83	MS, EG	2	AF	Santos Junior et al., 2014
Guaimía, Anchicayá River	CO	-76.9500	3.7667	73	CI, MS, SK	2	AF	Otero & Sandino, 2003
Dawa, Dawa Field Station	GY	-58.6597	6.3038	35	MC	3	AF	Williams & Dodson, 1972

MC: Methyl Cinnamate; BB: Benzyl Benzoate; CI: 1,8 Cineole; MS: Methyl Salicylate; SK: Skatole; EG: Eugenol. AF: Amazon forest; GF: Gallery Forest; CE: Cerrado; DF: Decidual Forest; *no data; 1♂ observed after collecting floral scent on flowers of *Anthurium rubrinervium* (Link.) G. Don 1839 (Araceae)

the Cuiabá river and tributaries in the Pantanal of Barão de Melgaço, less than 30 km from the flooded plain, (4) by the presence of its hostess species *Eulaema nigrita* Lepeletier, 1846, considered abundant when compared to other occurrence data for hostess and their parasites in studied orchid bee assemblages (Williams & Dodson, 1972; Otero & Sandino, 2003; Anjos-Silva et al., 2006; Hentrich et al., 2007; Abrahamczyk et al., 2011; Silva et al., 2013; Santos Junior et al., 2014; Figueiredo et al., 2015; Martins et al., 2016, Anjos-Silva et al., 2019a,b).

The register of *A. caerulea* exactly between the sub-basins of the Paraguay and Araguaia rivers (IBGE, 2000) reinforces the link between the *A. caerulea* populations in two of the largest Brazilian river basins with populations in the western part of the northeast coastal basins. The results presented here demonstrate the need for further research to understand better the distributional range limits of *A. caerulea* in southern South America, now that the species has been recorded for the second time (Anjos-Silva, 2019a,b) almost 30 km from the flooded plains of the Pantanal.

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Authors' Contributions

EJAS and MHSS conceived and designed the research; MHSS, JDSF, JCC, SOP, FAL, and EJAS collected, organized, and analysed the data; EJAS, MHSS and CAG interpreted the data and wrote the manuscript. All authors read and approved the final manuscript.

References

Abrahamczyk, S., Gottleuber, P., Matauschek, C. & Kessler, M. (2011). Diversity and community composition of Euglossine bee assemblages (Hymenoptera: Apidae) in western Amazonia. Biodiversity Conservation, 20: 2981-3001. doi: 10.1007/s10531-011-0105-1

Anjos-Silva, E.J. (2019a). Unpredicted occurrence of *Aglae caerulea* in the Pantanal wetland biome and its implications (Apidae: Euglossini). Apidologie, 50: 288-292. doi: 10.1007/s13592-019-00640-9

Anjos-Silva, E.J. (2019b). Correction to: Unpredicted occurrence of *Aglae caerulea* in the Pantanal wetland biome and its implications Apidae: Euglossini). Apidologie, 50: 293-294. doi: 10.1007/s13592-019-00665-0

Anjos-Silva, E.J., Camillo, E. & Garófalo, C.A. (2006). Occurrence of *Aglae caerulea* Lepeletier & Serville (Hymenoptera: Apidae: Euglossini) in the Parque Nacional da Chapada dos Guimarães, Mato Grosso state, Brazil. Neotropical Entomology, 35: 868-870. doi: 10.1590/S1519-566X2006000600024

Ascher, J. & Pickering, J. (2018). Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). http://www.discoverlife.org/mp/20q?guide=Apoidea_species. (accessed date: 19 February, 2019).

Batalha-Filho, H. Fjeldså, J. Fabre, P.H. Miyaki, C.Y. (2013). Connections between the Atlantic and the Amazonian forest avifaunas represent distinct historical events. Journal of Ornithology, 154: 41-50. doi: 10.1007/s10336-012-0866-7

Costa, L.P. (2003). The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals. Journal of Biogeography, 30: 71-86.

CRIA (2019). Collaborative databasing of North American bee collections within a global informatics network project (AMNH-Bee), Coleção de Hymenoptera INPA (INPA-Hymenoptera), Snow Entomological Museum Collection (KU-SEMC). http://www.splink.org.br. (accessed date: 1 May, 2019).

Dodson, C.H., Dressler, R.L., Hills, H.G., Adams, R.M. & Williams, N. (1969). Biologically active compounds in orchid fragrances. Science, 164: 1243-1249. doi: 10.1126/science.164.3885.1243

Figueiredo, J.D.S., Schorn de Souza, M.H. & Anjos-Silva, E.J. (2015). Abelhas-das-orquídeas (Hymenoptera: Apidae: Euglossini). In: D. J. Rodrigues, J. C. Noronha, V. F. Vindica, F. R. Barbosa (Eds.), Biodiversidade do Parque Estadual do Cristalino (pp. 97-109). Sinop: Áttema Editorial.

Fouquet, A. Loebmann, D. Castroviejo-Fisher, S. Padial, J.M. Orrico, V.G.D. Lyra, M.L. Roberto, I.J. Kok, P.J.R. Haddad, C.F.B. Rodrigues, M.T. (2012). From Amazonia to the Atlantic forest: Molecular phylogeny of Phyzelaphryninae frogs reveals unexpected diversity and a striking biogeographic pattern emphasizing conservation challenges. Molecular Phylogenetics and Evolution, 65: 547-561. doi: 10.1016/j.ympev.2012.07.012

GBIF.org (2019). GBIF Occurrence download. doi: 10.15468/dl.j5bo7c. (accessed date: 27 May, 2019).

González, J.M. (1996). Fauna del Parque Nacional "Henri Pittier": Euglossini (Hymenoptera: Apidae: Bombinae). Claves y lista preliminar. Sociedad de Ciências Naturales La Salle, 145: 45-54.

Hentrich, H., Kaiser, R. & Gottsberger, G. (2007). Floral scent collection at the perfume flowers of *Anthurium rubrinervium* (Araceae) by the kleptoparasitic orchid bee *Aglae caerulea* (Euglossini). Ecotropica, 13: 149-155.

IBGE (2000). Bacia hidrográfica. In: Atlas Nacional do Brasil (p. 99). 3. ed. Rio de Janeiro.

Martins, D.C., Albuquerque, P.M.C., Silva, F.S. & Rebêlo, J. M.M. (2016). First record of *Aglae caerulea* (Hymenoptera, Apidae, Euglossini) in Brazilian Cerrado east of the Amazon Region, Maranhão State, Brazil. Brazilian Journal of Biology, 76: 554-556. doi: 10.1590/1519-6984.06415

Morato, E.F. (2001). Ocorrência de *Aglae caerulea* Lepeletier & Serville (Hymenoptera, Apidae, Apini, Euglossina) no estado do Acre, Brasil. Revista Brasileira de Zoologia, 18: 1031-1033. doi: 10.1590/S0101-81752001000300034

Moura, D.C., Schlindwein, C. (2009) Mata ciliar do Rio São Francisco como biocorredor para Euglossini (Hymenoptera: Apidae) de florestas tropicais úmidas. Neotropical Entomology, 38: 281-284.

Moure, J.S., Melo, G.A.R. & Faria Jr., L.R.R. (2012). Euglossini Latreille, 1802. In: J. S. Moure, D. Urban, & G. R. A. Melo (Orgs). Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region – online version. http://www.moure.cria.org.br/catalogue. (Accessed date: 27 May, 2019)

Oliveira-Filho, A.T. Ratter, J.A. (1995). A study of the origin of Central Brazilian Forests by the analysis of plant species distribution patterns. Edinburgh Journal of Botany, 52: 141-194.

Otero, J. T. & Sandino, J. C. (2003). Capture rates of male Euglossine bees across a human intervention gradient, Chocó Region, Colombia. Biotropica, 35: 520-529. doi: 10.1111/j.1744-7429.2003.tb00608.x

Peel, M.C., Finlayson, B.L., & Mcmahon, T.A. (2007). Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences, 4: 439-493. doi: 10.5194/hess-11-1633-2007

Pokorny T, Loose D., Dyker, G., Quezada-Euán, J.J. G. & Eltz, T. (2015). Dispersal ability of male orchid bees and direct evidence for long-range flights. Apidologie, 46: 224-237. doi: 10.1007/s13592-014-0317-y

Santos Júnior, J.E., Ferrari, R.R. & Nemésio, A. (2014). The orchid-bee fauna (Hymenoptera: Apidae) of a forest remnant in the southern portion of the Brazilian Amazon. Brazilian Journal of Biology, 74: 184-190. doi: 10.1590/1519-6984.25712

Sick, H. 1966. As aves do cerrado como fauna arborícola. Anais da Academia Brasileira de Ciências, 38, 355-363.

Silva, D.P., Aguiar, A.J.C., Anjos-Silva, E. J. & De Marco Jr., P. (2013). Amazonian species within the Cerrado savanna: new records and potential distribution for *Aglae caerulea* (Apidae: Euglossini). Apidologie, 44: 673-683. doi: 10.1007/s13592-013-0216-7

Sobral-Souza, T. Lima-Ribeiro, M. S. Solferini, V.S. (2015). Biogeography of Neotropical Rainforests: past connections between Amazon and Atlantic Forest detected by ecological niche modeling. Evolution and Ecology, 29, 643-655. doi: 10.1007/s10682-015-9780-9

Wang, X. Auler, A.S. Edwards, R.L. Cheng, H. Cristalli, P.S. Smart, P.L. Richards. D.A. Shen, C. C. (2004). Wet periods in northeastern Brazil over the past 210 kyr linked to distant climate anomalies. Nature, 432: 740-743.

Wikelski, M., Moxley, J., Eaton-Mordas, A., López-Uribe, M.M., Holland, R., Moskowitz, Roubik, D.W. & Kays, R. (2010). Large-Range movements of Neotropical orchid bees observed via radio telemetry. Plos One, 5(5): 1-6. doi: 10.1371/journal.pone.0010738

Williams, N. H. & Dodson, C. H. (1972). Selective attraction of male euglossine bees to orchid floral fragrances and its importance in long distance pollen flow. Evolution, 26: 84-95. doi: 10.1111/j.1558-5646.1972.tb00176.x

Williams, N.H. & Whitten, W.H. (1983). Orchid floral fragrances and male euglossine bees: methods and advances in last sesquidecade. Biological Bulletin, 164: 355-395. doi: 10.2307/1541248

Willis, E.O. (1992). Zoogeographical origins of eastern Brazilian birds. Ornitologia Neotropical, 3, 1-15.

Supplementary Material

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http://periodicos.uefs.br/index.php/sociobiology/rt/suppFiles/4581/0

S1. Distribution of 74 occurrences for *Aglae caerulea* for the Neotropical region, considered in the present research.