www.biotaxa.org/rce. ISSN 0718-8994 (online) Revista Chilena de Entomología (2020) 46 (3): 365-371.

Scientific Note

Notes on the nest architecture of *Centris* (*Centris*) *caxiensis* Ducke (Hymenoptera: Apidae) in an urban dry forest fragment in northeastern Brazil

Notas sobre la arquitectura del nido de *Centris* (*Centris*) *caxiensis* Ducke (Hymenoptera: Apidae) en un fragmento urbano de bosque seco en el noreste de Brasil

Herbeson Ovidio de Jesus Martins[1,2], Felipe Vivallo[3] and Vinina Silva Ferreira[1]

[1]*Universidade Federal do Vale do São Francisco, Colegiado de Ciências Biológicas, Petrolina, Brazil. E-mail: vinina.ferreira@univasf.edu.br*
[2]*Programa de Pós-Graduação em Entomologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, Brazil. E-mail: herbeson.bio@hotmail.com*
[3]*HYMN Laboratório de Hymenoptera, Departamento de Entomologia, Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, São Cristóvão 20940–040 Rio de Janeiro, RJ, Brazil. E-mail: fvivallo@yahoo.com*

ZooBank: urn:lsid:zoobank.org:pub: 05651A97-502D-4DC1-B11E-D27D2312009D
https://doi.org/10.35249/rche.46.3.20.02

Abstract. We described the nest architecture and the brood cell morphology of the oil-collecting bee *Centris caxiensis*. The nest is a single and unbranched tunnel measuring between 37 and 49 cm in length slant obliquely into the ground. There were one or two brood cells at the end of the gallery oriented vertically. The brood cells are urn-shaped with a plug containing a central hollow process. The nest morphology and the brood cells followed a similar pattern to the other ones reported for species of the subgenus *Centris s. str.*

Key words: Caatinga, ground-nesting, oil-collecting bee, solitary bee.

Resumen. Describimos la arquitectura del nido y la morfología de las celdillas de cría de la abeja recolectora de aceite *Centris caxiensis.* El nido corresponde a un túnel único no ramificado que mide entre 37 y 49 centímetros de largo dispuesto oblicuamente en el suelo. Al final del túnel se encuentran una o dos celdillas de cría orientadas verticalmente. Las celdillas de cría tienen forma de barril con una proyección central en forma de chimenea. La morfología, tanto del nido como de las celdillas de cría, siguen un patrón similar a otros encontrados en especies del subgénero *Centris s. str.*

Palabras clave: Abeja recolectora de aceite, abeja solitaria, Caatinga, nidificación en suelo.

The solitary bee genus *Centris* Fabricius, 1804 consists of approximately 230 species, grouped in 12 subgenera (Moure *et al.* 2007; Vivallo 2019). These oil-collecting bees have a mutualistic relationship with plants that offer oil from specialized glands (elaiophores) (*e.g.* Malpighiaceae, Krameriaceae, Plantaginaceae, etc.) (Buchmann 1987; Neff and Simpson 2017). Most females of *Centris* have morphological structures, elaiospathes, that allow them to collect this floral resource promoting the plant pollination (Vogel 1974; Neff and Simpson 2017). Females use this floral oil to feeding their offspring and/or to waterproof their brood cells (Vogel 1974; Neff and Simpson 2017).

Received 13 June 2020 / Accepted 6 July 2020 / Published online 24 July 2020
Responsible Editor: José Mondaca E.

Bees of the genus *Centris* have different nesting habits (Coville *et al.* 1983). Species of the subgenera *Centris s. str.* Fabricius, *C.* (*Melanocentris*) Friese, *C.* (*Paracentris*) Cameron, *C.* (*Penthemisia*) Moure, *C.* (*Trachina*) Klug, and *C.* (*Wagenknechtia*) Moure construct their nests in the flat ground or earth banks (Coville *et al.* 1983; Aguiar and Gaglianone 2003; Sabino *et al.* 2020). On the other hand, species of *C.* (*Ptilotopus*) Klug nest in termitaria (Gaglianone 2001), and those of the subgenera *C.* (*Hemisiella*) Moure, *C.* (*Heterocentris*) Cockerell and *C.* (*Xanthemisia*) Moure build their nests in pre-existing cavities such as wooden galleries made by other insects or abandoned nests of other bee and wasp species (Frankie *et al.* 1993; Camillo *et al.* 1995; Aguiar *et al.* 2005). The nesting habits of the species of *C.* (*Aphemisia*) Ayala and *C.* (*Ptilocentris*) Snelling remain unknown. Despite the advances in the researches on cavity-nesting bees (Costa and Gonçalves 2019), the studies on the nesting biology of most *Centris* species remain unknown, mainly those ground nesting due to the difficulty in finding their nests.

Centris (*Centris*) *caxiensis* Ducke, 1907 is a Neotropical species found mainly in the Brazilian coastal sand dune (Restinga) (Madeira-da-Silva and Martins 2003). It was also recorded in the dry forest (Caatinga) (Aguiar and Zanella 2005) and in the Brazilian Cerrado (Albuquerque and Mendonça 1996). As far as we know, there is only one study that mentions the nest excavation of *C. caxiensis* to study trophic ecology, but it did not report the nest architecture (Ribeiro *et al.* 2008). Here we described the nest architecture and the morphology of the brood cells of *C. caxiensis*, providing additional information about its reproductive nesting biology.

We carried out this study at the Campus de Ciências Agrárias of the Universidade Federal do Vale do São Francisco (CCA / UNIVASF) (9°19’44.2”S, 40°33’30.1”W), in Petrolina, Pernambuco state, northeastern Brazil. The climate of the region is dry and hot semi-arid (BShw) according to the Köpen classification (1948), with the annual average temperature of 24.8°C (Alvares *et al.* 2013).

In May 2017, we recorded five females of *C. caxiensis* digging nests in an earth bank under shrubs (Fig. 1a). We discovered the other seven old nests, but four of them were abandoned by the females before their completion. We excavated five nests and used three for the architecture description. We used a liquid plaster to filling the burrow while we excavated (Fig. 1b). We took the brood cells to the laboratory and measured it using a caliper rule. In addition, we did the chemical and physical analyzes of the soil from the nesting sites. We removed the nest structures and took them to the Laboratório de Entomologia of the Universidade Federal do Vale do São Francisco (UNIVASF), Petrolina, Pernambuco state, Brazil. Voucher specimens are deposited in the Coleção Entomológica of the Museu Nacional Rio de Janeiro, Brazil (MNRJ).

The nests were not aggregated, with their entrances from seven to 30 meters away, approximately. The soil was classified as quartzarenic neossol, with two defined layers. The upper part consisted of earth banks, composed of loose soil deposited artificially, being the layer where we found the nests. The lower part contained a vertical soil (ravine type), which was exposed through excavation. The sand content of the composite nest substrate was high (87.95%) followed by silt (8.15%) and clay (3.90%). In addition, the upper layer was classified as acid (pH = 5.20).

The nests had an entrance ranging from circular to oval measuring between 1 cm and 1.5 cm (n= 5). When females were active, we observed the sand tumuli as a result of the excavation processes. The nest entrance was closed by the females upon completion (Fig. 2a). Following the entrance, we identified a simple gallery measuring between 37 cm and 49 cm in length (from the entrance to the first brood cell). The main tunnel descended vertically to a maximum depth from 21 cm to 28 cm below the surface. At the end we found one (Fig. 2a) or two (Fig. 2c) brood cells oriented vertically. We visualized some nests with the brood cells opened and/or partially provisioned, which suggest that these nests were abandoned (Fig. 2b). Two nests showed a curvature in the tunnel, probably formed to deflect a rock (Fig. 2b-2c). The brood cells were urn-shaped with a plug containing a central hollow process (Fig. 2d). This orifice connected the inner side of the brood cell with the external environment. The brood cells measured 16.78-18.83 mm in length, 10.86-12.16 in maximum diameter, and 10.32-11.03 in minimum diameter.

We also observed the female's activities to build their nests. The first day was intended for excavation of the nest (Fig. 1d). The second day the female transported pollen what means that she was provisioning her brood cells. The third day the female ended her activities in the morning, suggesting that these bees take just a couple of days to build, provisioning and laying their eggs. Moreover only one male emerged after 58 days from the brood cells that we took to the laboratory. The other two brood cells contained a dead larva and a mass of dry pollen.

Figure 1. Main characteristics of the nesting habits of *Centris caxiensis.* (a) General view of nest site; (b) Excavated nest; (c) Females cleaning nest entrance; (d) Females digging the nest (arrow 1: brood cell; arrow 2: nest entrance).

The ground-nesting habit is considered plesiomorphic for the centridine bees, occurring in most species of the genus (Coville *et al.* 1983). In addition, most species of *Centris* have the habit of digging their nests on flat surfaces (see Coville *et al.* 1993). The females of *C. caxiensis* nested in sandy soil, which might have facilitated the excavation of the tunnel. Excluding *C. aenea* Lepeletier that nests in clay soil (Aguiar and Gaglianone

2003), species of the subgenus *Centris s. str.* seem to prefer to dig their nests in sandy surfaces (see Coville *et al.* 1983). Ribeiro *et al.* (2008) reported the presence of nests of *C. caxiensis* in sand dunes, which strengthens the hypothesis that the species nests in areas with earth banks.

The shape of the brood cells of *C. caxiensis* was similar to that observed for other species of *Centris*, being urn-shaped and with a rounded base (see Coville *et al.* 1983; Rozen and Buchmann 1990; Aguiar and Gaglianone 2003). In addition, the brood cell closure of *C. caxiensis* had a central process in the operculum such as other species of the subgenus. In spite of connecting the inner side of the brood cell with the external environment, it is unlikely that external materials such as dust or water will enter the brood cell. The central process morphology, with the upper part usually folded at the base or at its end, may acts as a barrier protecting the inner of the cell. Similar observations were made by Coville *et al.* (1983) in *C. varia* (Erichson), cited as *C. segregata* Crawford one of its junior synonyms. Furthermore, Rozen and Buchmann (1990) suggested that the presence of a hollow central process probably facilitates the exchange of gases between the internal and external environment since the brood cells of these species are lined at the beginning of construction and the waterproofing layer would probably make it difficult to exchange gases through the brood cell wall. However, different brood cell shapes have been reported for *C. pallida* Fox (Alcock *et al.* 1976; Rozen and Buchmann 1990) and *C. burgdorfi* Friese (Sabino *et al.* 2020), in which the top of the operculum does not have a hollow central process.

Nests of *C. caxiensis* are deep when compared to other species of *Centris* that generally have shallow nests [*e.g.*, at depths of 11.8 cm in *C. rhodopus* Cockerell; 8.3 in *C. cockerelli* Fox; 10.5 in *C. pallida* (Alcock *et al.* 1976); 12 cm in *C. collaris* Lepeletier; 3.8-4.9 in *C. fuscata* Lepeletier (Camillo *et al.* 1993); 5.0-9.5 in *C. heithausi* Snelling (Coville *et al.* 1986); and 8.4-14.5 in *C. aethyctera* Snelling (Vinson and Frankie 1977)]. Nests with similar depth to those observed for *C. caxiensis* were also observed in other species of the subgenus, such as *C. flavofasciata* Friese (Vinson and Frankie 1999; Rozen *et al.* 2011) and *C. flavifrons* (Fabricius) (Vinson and Frankie 1988; Rêgo *et al.* 2006; Martins *et al.* 2014). In addition, the nests of *C. caxiensis* were formed by a simple tunnel ending in one or two brood cells. Coville *et al.* (1983) suggested that this type of structure is plesiomorphic for *Centris* species, being reported in *C. pallida* (Alcock *et al.* 1976; Rozen and Buchmann 1990), *C. cockerelli, C. rhodopus* (Alcock *et al.* 1976), *C. flavifrons* (Vinson and Frankie 1988; Rêgo *et al.* 2006), *C. flavofasciata* (Vinson and Frankie 1999; Rozen *et al.* 2011), and *C. aethiocesta* Snelling (Vinson and Frankie 1988). The construction of nests with a single brood cell, although uncommon in *Centris,* is frequently seen in *Epicharis* Klug, 1807 species, such as *E. nigrita* Friese (Gaglianone 2005), *E. bicolor* Smith (Rocha-Filho *et al.* 2008), and *E. dejeanii* Lepeletier (Dec and Vivallo 2019). This type of architecture appears to be energetically inefficient when compared to a multicelled nest since females spent a lot of energy in the digging process to construct a single brood cell. However, Coville *et al.* (1983) suggested that this type of architecture is associated with the soil composition, which is generally sandy and easy to excavate, and the presence of natural enemies. In this sense, the construction of nests containing a single brood cell would spread the pressure of these natural enemies that have the capacity to memorize the entrance of the nests. Despite this, no natural enemies were observed visiting the nest sites during the development of the study.

This study allows understanding the structural aspects related to the nests of *C. caxiensis*, an important species to the maintenance of plant populations from sand dunes, dry forest, cerrado, and agrosystems. Also, it can increase the knowledge of bionomic aspects of ground-nesting *Centris* due to the difficulty of finding nests in natural areas.

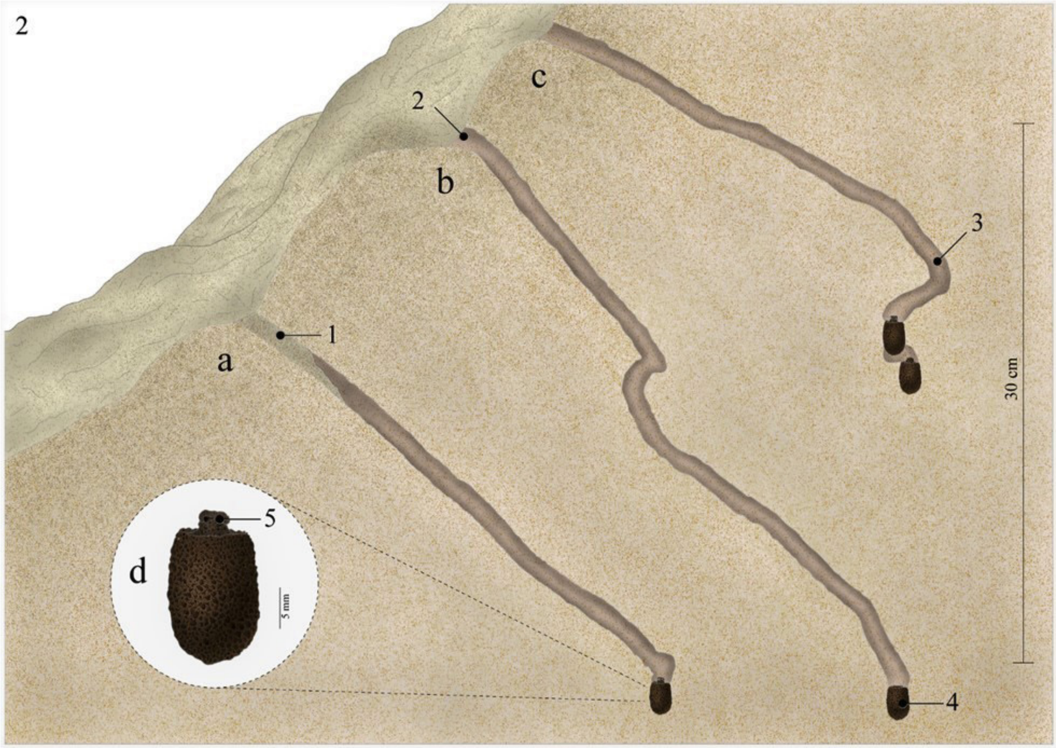

Figure 2. Nest features of *Centris caxiensis.* (a) Nest with a single brood cell; (b), Unfinished nest; (c) Nest with two brood cells; (d) Brood cell: 1-sand filling tunnel; 2- nest entrance; 3-curvature in the tunnel; 4-unfinished cell; 5- central process.

Acknowledgements

We thank Dr. José Jorge Sousa Carvalho and Mirelly Ferreira Tenório for carrying out soil analysis. The first author thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for granting the scholarship 134121/2019-8. This paper is part of the SIGMA project Nº21565 MN/UFRJ and the contribution number 46 from the HYMN.

Literature Cited

Aguiar, C.M.L. and Gaglianone, M.C. (2003) Nesting biology of *Centris* (*Centris*) *aenea* Lepeletier (Hymenoptera, Apidae, Centridini). *Revista Brasileira de Zoologia, 20*(4): 601-606.

Aguiar, C.M. and Zanella, F.C.V. (2005) The bee community (Hymenoptera: Apoidea: Apiformis) of an area in the border of the Caatinga Domain (Itatim, BA, Brazil). *Neotropical Entomology, 34*(1): 15-24.

Aguiar, C.M., Garófalo, C.A. and Almeida, G.F. (2005) Trap-nesting bees (Hymenoptera, Apoidea) in areas of dry semideciduous forest and caatinga, Bahia, Brazil. *Revista Brasileira de Zoologia, 22*(4): 1030-1038.

Albuquerque, P. and Mendonça, J.A.C. (1996) Anthophoridae (Hymenoptera; Apoidea) e flora associada em uma formação de cerrado no município de Barreirinhas, MA, Brasil. *Acta Amazonica, 26*(1-2): 45-54.

Alcock, J., Jones, C. and Buchmann, S. (1976) The nesting behavior of three species of *Centris* bees (Hymenoptera: Anthophoridae). *Journal of the Kansas Entomological Society, 49*(4): 469-474.

Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.L.M. and Sparovek, G. (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift, 22*(6): 711-728.

Camillo, E., Garófalo, C.A., and Serrano, J.C. (1993) Hábitos de nidificação de *Melitoma segmentaria, Centris collaris, Centris fuscata* e *Paratetrapedia gigantea* (Hymenoptera, Anthophoridae). *Revista Brasileira de Entomologia, 37*(1): 145-156.

Camillo, E., Garófalo, C.A., Serrano, J.C. and Muccillo, G. (1995) Diversidade e abundância sazonal de abelhas e vespas solitárias em ninhos armadilhas (Hymenoptera, Apocrita, Aculeata). *Revista Brasileira de Entomologia, 39*(2): 459-470.

Costa, C.C.F.D. and Gonçalves, R.B. (2019) What do we know about Neotropical trap-nesting bees? Synopsis about their nest biology and taxonomy. *Papéis Avulsos de Zoologia, 59*: e20195926.

Coville, R.E., Frankie, G.W. and Vinson, S.B. (1983) Nests of *Centris segregata* (Hymenoptera: Anthoporidae) with a review of the nesting habits of the genus. *Journal of the Kansas Entomological Society, 56*(2): 109-122.

Coville, R.E., Frankie, G.W., Buchmann, S.L., Vinson, S.B. and Williams, H.J. (1986) Nesting and male behavior of *Centris heithausi* (Hymenoptera: Anthophoridae) in Costa Rica with chemical analysis of the hindleg glands of males. *Journal of the Kansas Entomological Society, 59*(2): 325-336.

Dec, E. and Vivallo, F. (2019) Nesting biology and immature stages of the oil-collecting bee *Epicharis dejeanii* (Apidae: Centridini). *Apidologie, 50*(5): 606-615.

Frankie, G.W., Newstrom, L., Vinson, S.B. and Barthell, J.F. (1993) Nesting-habitat preferences of selected *Centris* bee species in Costa Rican dry forest. *Biotropica, 25*(3): 322-333.

Gaglianone, M.C. (2005) Nesting biology, seasonality, and flower hosts of *Epicharis nigrita* (Friese, 1900) (Hymenoptera: Apidae: Centridini), with a comparative analysis for the genus. *Studies on Neotropical Fauna and Environment, 40*(3): 191-200.

Madeira-da-Silva, M.C. and Martins, C.F. (2003) Abelhas (Hymenoptera, Apoidea Apiformes) de uma área de restinga, Paraíba, Nordeste do Brasil: Abundância, diversidade e sazonalidade. *Revista Nordestina de Biologia, 17*(1): 75-90.

Moure, J.S., Melo, G.A.R. and Vivallo, F. (2007) Centridini Cockerell & Cockerell, 1901. *In:* Moure, J.S., Urban, D. & Melo, G.A.R. (Eds.), Catalogue of bees (Hymenoptera, Apoidea) in the Neotropical region, Sociedade Brasileira de Entomologia, Curitiba (Paraná), pp. 83-142

Neff, J.L. and Simpson, B.B. (2017) Vogel's great legacy: The oil flower and oil-collecting bee syndrome. *Flora, 232*: 104-116.

Ramos, M., Albuquerque, P.D. and Rêgo, M. (2010) Nesting behavior of *Centris* (*Hemisiella*) *vittata* Lepeletier (Hymenoptera: Apidae) in an area of the Cerrado in the northeast of the state of Maranhão, Brazil. *Neotropical Entomology, 39*(3): 379-383.

Ramos, M., Mendes, F., Albuquerque, P. and Rêgo, M. (2007) Nidificação e forrageamento de *Centris* (*Ptilotopus*) *maranhensis* Ducke (Hymenoptera, Apidae, Centridini). *Revista Brasileira de Zoologia, 24*(4): 1006-1010.

Rêgo, M.M.C., Albuquerque, P.M.C., Ramos, M. C. and Carreira, L.M. (2006) Aspectos da biologia de nidificação de *Centris flavifrons* (Friese) (Hymenoptera: Apidae, Centridini), um dos principais polinizadores do murici (*Byrsonima crassifolia* L. Kunth, Malpighiaceae), no Maranhão. *Neotropical Entomology, 35*(5): 579-587.

Ribeiro, É.K.M.D., Rêgo, M.M.C. and Machado, I.C.S. (2008) Cargas polínicas de abelhas polinizadoras de *Byrsonima chrysophylla* Kunth. (Malpighiaceae): fidelidade e fontes alternativas de recursos florais. *Acta Botanica Brasilica, 22*(1): 165-171.

Rocha-Filho, L.C., Silva, C.I., Gaglianone, M.C. and Augusto, S.C. (2008) Nesting behavior and natural enemies of *Epicharis* (*Epicharis*) *bicolor* Smith 1854 (Hymenoptera Apidae). *Tropical Zoology, 21*(2): 227-242.

Rozen, J.G. and Buchmann, S.L. (1990) Nesting biology and immature stages of the bees *Centris caesalpiniae, C. pallida,* and the cleptoparasite *Ericrocis lata* (Hymenoptera: Apoidea: Anthophoridae). *American Museum Novitates, 2985*: 1-30.

Rozen, J.G., Vinson, S.B., Coville, R. and Frankie, G. (2011) Biology of the cleptoparasitic bee *Mesoplia sapphirina* (Ericrocidini) and its host *Centris flavofasciata (*Centridini) (Apidae: Apinae). *American Museum Novitates, 2011*(3723): 1-37.

Sabino, W.O., Alves-dos-Santos, I., Queiroz, E.P., Faria, L.B., Papaj, D.R., Buchmann, S.L. and Silva, C.I. (2020) Nesting biology of *Centris* (*Paracentris*) *burgdorfi* (Apidae: Centridini). *Journal of Apicultural Research, 1-11.* https://doi.org/10.1080/00218839.2020.1717760

Vinson, S.B. and Frankie, G. (1977) Nest of *Centris aethyctera* (Hymenoptera: Apoidea: Anthophoridae) in the dry forest of Costa Rica. *Journal of the Kansas Entomological Society, 50*(2): 301-311.

Vinson, S.B. and Frankie, G. W. (1988) A comparative study of the ground nests of *Centris flavifrons* and *Centris aethiocesta* (Hymenoptera: Anthophoridae). *Entomologia Experimentalis et Applicata, 49*(1-2): 181-187.

Vinson, S.B., Frankie, G.W. and Coville, R.E. (1987) Nesting habits of *Centris flavofasciata* Friese (Hymenoptera: Apoidea: Anthophoridae) in Costa Rica. *Journal of the Kansas Entomological Society, 60*(2): 249-263.

Vivallo, F. (2019) Lectotype designations, taxonomic notes and new synonymies in some species of the bee genus *Centris* Fabricius, 1804 described by Amédée Lepeletier de Saint-Fargeau (Hymenoptera: Apidae). *Zootaxa, 4624*(1): 23-40.

Vogel, S. (1974) Ölblumen und ölsammelnde Bienen. *Tropische und Subtropische Pflanzenwelt, 7*: 285-547.