

OCCURRENCE OF THE LEAF-CUTTING ANT *Atta sexdens* (L.) (HYMENOPTERA: FORMICIDAE) RELATED TO UNPAVED ROADS IN TWO BRAZILIAN SEMIARID AREAS WITH CONTRASTING DISTURBANCE DEGREES

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ABSTRACT

In the semiarid Brazilian Caatinga, we compared the occurrence of leaf-cutting ant nests (*Atta sexdens*) at two areas in Contendas do Sincorá, Bahia State: one single disturbed area subjected to cattle overgrazing (Fazenda Lagoa das Covas: FLC) and one protected area characterized by well-preserved patches of caatinga (Floresta Nacional Contendas do Sincorá: FNCS). We also tested if *A. sexdens* nests were more abundant near roads. No nest was observed in the FNCS, whereas 35 nests were recorded in the FLC (3.6 colonies ha⁻¹). The number of *A. sexdens* nests clearly decreased with increasing road distance, which varied from zero to about 140 m. Nests were also observed on roads outside FLC and FNCS. We suggest that roads may be facilitating the expansion of *A. sexdens* range in the Caatinga vegetation at Contendas do Sincorá. We expect that *A. sexdens* presence will maintain or even increase the disturbing effects of cattle overgrazing on FLC vegetation. If *A. sexdens* also succeed to establish in FNCS, this protected area will experience a possible process of flora homogenization and impoverishment, favoring the establishment of plant species associated to anthropogenic disturbances. It is possible that other Caatinga areas are being subjected to the same process of *Atta* invasion favored by the establishment of paved and unpaved roads.

Keywords: Anthropogenic Disturbance; *Atta* Nest Foundation; Biotic Homogenization; Caatinga.

RESUMO

Ocorrência da formiga cortadeira *Atta sexdens* (L.) (Hymenoptera: Formicidae) relacionada a estradas não pavimentadas em duas áreas de semiárido brasileiro com condições de perturbação contrastantes. Na Fazenda Lagoa das Covas (FLC), uma área perturbada por pecuária, foram registradas 35 colônias de *Atta sexdens* (3,6 colônias ha⁻¹). Nenhum ninho foi registrado na Floresta Nacional Contendas do Sincorá (FNCS). O número de ninhos de *A. sexdens* diminuiu claramente com o aumento da distância das estradas, que variou de zero a cerca de 140 m. Os ninhos também foram observados em estradas fora da FLC e da FNCS. Sugerimos que as estradas podem estar facilitando a expansão do alcance da *A. sexdens* na vegetação de Caatinga em Contendas do Sincorá. Esperamos que a presença de *A. sexdens* mantenha ou até mesmo aumente os efeitos perturbadores da superpastejo na vegetação da FLC. Se a *A. sexdens* também conseguir estabelecer na FNCS, esta área protegida sofrerá um possível processo de homogeneização da flora e empobrecimento, favorecendo o estabelecimento de espécies de plantas associadas a perturbações antropogênicas. É possível que outras áreas de Caatinga estejam sendo submetidas ao mesmo processo de invasão de *Atta* favorecido pelo estabelecimento de estradas pavimentadas e não pavimentadas. Nenhum ninho foi registrado na FNCS, em

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contraste, 35 ninhos foram registrados na FLC (3,6 colônias ha⁻¹). O número de ninhos de *A. sexdens* claramente diminuiu com o aumento da distância da estrada, que variou de 0 a 140 m. Ninhos também foram observados nas estradas do lado de fora da FLC e da FNCS. Nós sugerimos que estradas podem estar facilitando a expansão de *A. sexdens* nas áreas de caatinga do município de Contendas do Sincorá. Nós esperamos que a presença de *A. sexdens* irá manter ou mesmo aumentar os efeitos dos distúrbios promovidos pelo gado na vegetação da FLC. Se o estabelecimento de *A. sexdens* na FNCS também for bem sucedido, nesta área protegida poderá ocorrer um processo de homogeneização e empobrecimento, favorecendo o estabelecimento de espécies de plantas associadas a perturbações antrópicas. É possível que outras áreas da Caatinga estejam sendo submetidas ao mesmo processo de invasão por *Atta* favorecido por estradas pavimentadas e não-pavimentadas.

Palavras-chave: Caatinga; Distúrbios Antrópicos; Fundação de Ninhos de *Atta*; Homogeneização Biótica.

INTRODUCTION

Human-induced disturbances may expand the original distribution and density of certain native species, which become hyper-abundant as well as invasive, if they also spread into areas where they historically did not occur (e.g., Shackelford et al., 2015). This seems to be the case for some leaf-cutting ants (*Atta* and *Acromyrmex* spp.; hereafter LCAs) in the Neotropics. It is notable the proliferation of LCA species along artificial forest edges, created through habitat fragmentation (Meyer et al., 2009; Dohm et al., 2011; Leal et al., 2014), and in regenerating forests after the abandonment of agricultural activities and/or pastures (Vasconcelos and Cherrett, 1995; Silva et al., 2009). Besides, the disturbance caused by the opening of roads also facilitates *Atta* colonies establishment and dissemination such as in the Brazilian Cerrado (but see Vasconcelos et al., 2006; Vieira-Neto et al., 2016). *Atta* proliferation is often associated to the higher availability of preferred plants, such as fast-growing plant species, recorded in anthropogenic disturbed areas (Farji-Brener, 2001; Silva et al., 2009; Vasconcelos et al., 2006). Although LCAs' ecology and distribution have been relatively well studied in rainforests (Leal et al., 2014), they remain poorly studied in savannas (Vasconcelos et al., 2006; Vieira-Neto et al., 2016) and semiarid vegetations, especially in the semiarid Brazilian Caatinga (Siqueira et al., 2018).

Particularly, the species *Atta sexdens* is considered as a habitat generalist (Fowler et al., 1989) and an opportunistic leaf-cutting ant species (Silva et al., 2007). This species exploits a broad array of plant resources, not only leaves (Câmara et al., 2020). For example, *A. sexdens* eventually disperses seeds of non-myrmecochorous plants as described by Silva et al. (2007) for seeds of *Protium heptaphyllum* (Burseraceae), a plant species that became extremely abundant in an Atlantic forest fragment. Besides, *A. sexdens* is able to adjust its foraging trail network to profit rapidly from the continuous emergence/recruitment of new resources (Silva et al., 2012a; Silva et al., 2013). Thus, *A. sexdens* profoundly benefits from human-disturbed forest areas, becoming hyper-abundant and persisting in time, for example, at the edge of an old-growth Atlantic Forest fragment (Meyer et al., 2009).

Here, we report on a study in the semiarid Caatinga which compared the occurrence of leaf-cutting ant nests (*Atta sexdens*) between two areas with contrasting disturbance degrees: one disturbed area subjected to cattle overgrazing (Fazenda Lagoa das Covas; hereafter FLC), and one protected area characterized by well-preserved patches of *caatinga* vegetation (Floresta Nacional Contendas do Sincorá (hereafter FNCS). Considering that the LCAs proliferate at artificial edges and/or disturbed habitats (e.g.,

Meyer et al., 2009) and usually nest on/near roads (Vasconcelos et al., 2006 and Vieira-Neto et al., 2016), we tested (1) if the number of *A. sexdens* nests differed between the disturbed (FLC) and protected (FNCS) areas, and (2) if *A. sexdens* nests were more abundant near roads. Based on our results, we discuss about LCAs' probable foraging effects on local plant assemblages. Finally, we also discuss about the potential establishment of *A. sexdens* in FNCS, aiming to encourage future research directed to monitor and manage leaf-cutting ant colonies at this site.

MATERIAL AND METHODS

The occurrence of *A. sexdens* nests was investigated in two distinct caatinga areas, in the municipality of Contendas do Sincorá, Bahia State, Brazil (Figure 1A). Both areas are crossed by unpaved roads. In FLC (13°54'S, 41°07'W), loose-housed cattle promoted land degradation due to inappropriate grazing (*i.e.* overgrazing) for a long period. Its vegetation is characterized by numerous small patches of scattered trees and shrubs, with few or any litter cover. Adjacent to it, FNCS (13°55'S, 41°06'W; with 11,215.78 hectares) is a protected preserve established by the Brazilian National System of Conservation Units (Sistema Nacional de Unidades de Conservação - SNUC), covered by patches of well-preserved dry vegetation, mainly composed by closed shrub and small trees with more than six meters high (IBAMA, 2006). According to Cruz (2015), woody plant density in FNCS is 3.25 times higher than in FLC (data collected at the same time as *Atta* nests survey, based on 24 plots of 20 x 10 m, 12 in each area). For details about soil, vegetation and climate, see IBAMA (2006).

To investigate *Atta* nest occurrence in both areas, we departed from unpaved roads. In FLC, two unpaved roads were used and the whole area used for cattle grazing was surveyed (9.75 hectares). In FNCS, the inventory was done using eight abandoned foot trails, all of them departing perpendicularly from three unpaved roads that cross this reserve. Distances between the surveyed trails were at least one kilometer, counting from their respective starting point at the unpaved roads. For estimating the total area covered by us, we considered 10 m to each side of the walked trails as being the area where we could visually detect an *Atta* mound or foraging trails (following Dohm et al., 2011; and other references therein). The eight areas varied in size from 0.11 to 19.41 ha, totalizing 36.94 ha investigated at FNCS. To test the hypothesis that nest distribution is associated to roads, we measured nest distances to the nearest unpaved road. For data analysis, we classified these distances into categories of 10 m (*e.g.*, 0-10 m, 10.1-20 m, and so forth) and counted how many nests were encountered in each distance category. A simple linear regression was performed for verifying if distance to the nearest road explained the number of nests found. To do this, we used the median of each distance category.

RESULTS

At FLC, a total of 35 nests of *A. sexdens* were recorded (3.6 colonies ha⁻¹; Figure 1B). Nests number clearly decreased with increasing road distance ($R^2 = 0.26$, $p = 0.037$; Figure 1C), which varied from 0 to 138.28 m. In FLC, most nests (19) were found around less than 50 m from the nearest road. Out of those nests, six were located less than 10 meters from the nearest road. Outside FNCS and FLC, seven more colonies were

found, whose distances to the nearest roads were: zero (four colonies), 28, 36 and 100 m. On the other hand, at FNCS, no nest was observed in the eight studied transects (although a much larger area was inspected, \approx 37 ha), as well as along the margins of the 23.2 kilometers of the three unpaved roads that cross this preserve.

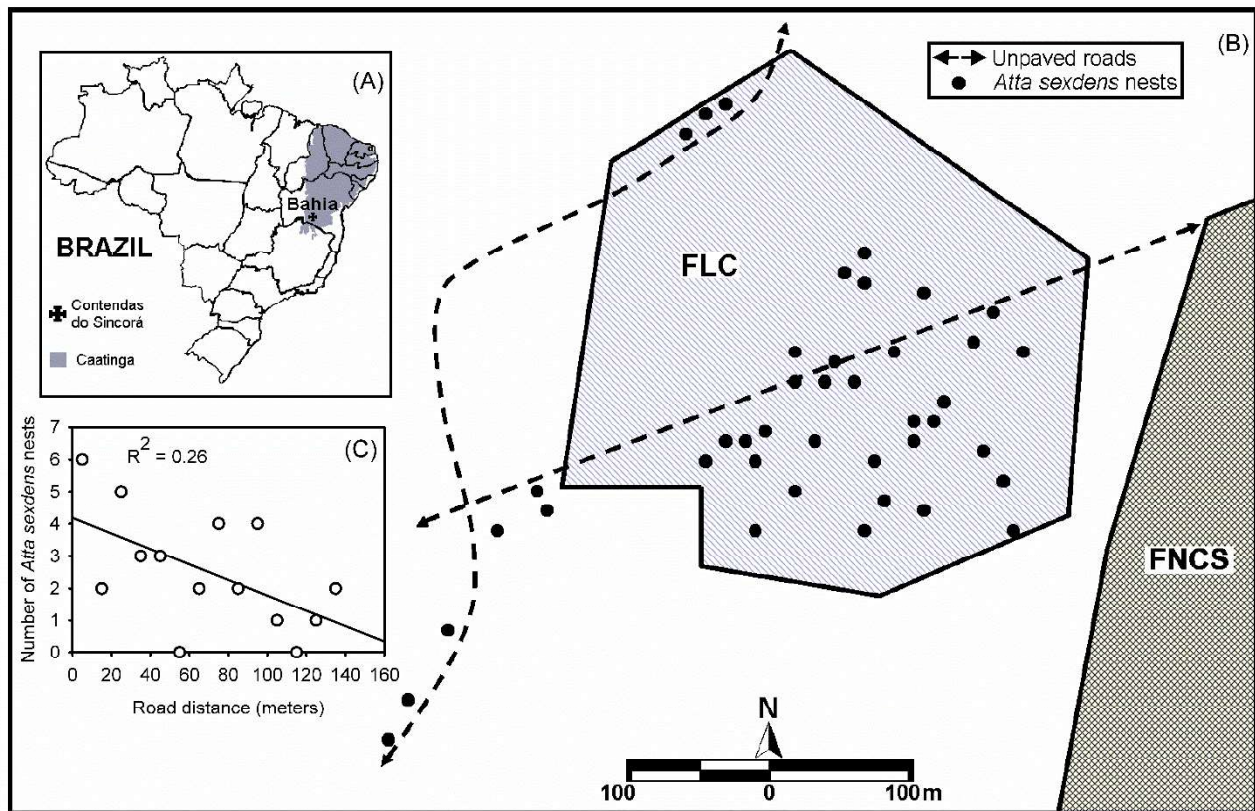


Figure 1. (A) Map showing the location of the municipality of Contendas do Sincorá, Bahia State, as well as the abrangeance of the semiarid Caatinga vegetation in Brazil. (B) Distribution of *Atta sexdens* colonies in the Fazenda Lagoa das Covas (FLC), a privately-owned farm subjected to overgrazing caused by loose housed cattle, near the preserve Floresta Nacional Contendas do Sincorá (FNCS). The light-dashed polygon represents the surveyed area inside FLC. For convenience, one colony located outside FLC and along the road is not shown in the figure. (C) Linear regression between the distance to the nearest road and the number of *A. sexdens* nests encountered at FLC and nearby.

DISCUSSION

The high density of *A. sexdens* nests at the disturbed FLC together with the absence of records inside a much larger area at the protected FNCS support the idea that in this part of Caatinga, the species *A. sexdens* should be considered as invasive. Reinforcing the idea that this species is allochthonous in the studied area, a local resident, who lived and worked (mainly fieldwork) in FNCS area for more than 40 years (A.C. Freire, pers. com.), confirmed that no *Atta* nest was ever recorded inside FNCS. Moreover, as observed here, nests tend to occur in or near unpaved roads. Thus, roads seem to have facilitated *A. sexdens* colony foundation and establishment at this *caatinga* disturbed area (FLC) in Contendas do Sincorá, confirming our hypothesis. As previously mentioned, the opening of roads clearly facilitated the establishment of *A. laevigata* colonies in the Brazilian Cerrado savanna (Vasconcelos et al., 2006; Vieira-Neto et al., 2016), and probably also explains its occurrence in remote areas in the Amazon Forest (Vasconcelos and Cherrett, 1995).

Despite no *A. sexdens* nest was yet observed in FNCS, some nests are located very close (ca. 100 m) to FNCS borders. Considering that winged LCAs are able to fly for several kilometers (e.g., about 11 km; Jutsum and Quinlan, 1978), it seems possible that, in this *caatinga* area, *A. sexdens* range may in the near future reach the FNCS, either through the boundary of this preserve with farms such as FLC or, most probably, through roads. The reason why *A. sexdens* has not yet established its nests in FNCS remains unknown, but some hypotheses are considered here. Firstly, the mortality of alates and young queens are known to be elevated during their attempt to found a new colony (e.g., Moser, 1967). For example, in the first year after nest foundation, the survival of insipient *A. sexdens* colonies may be extremely low (<5 %; Autuori, 1950). Second, it is possible that *A. sexdens* founding-queens prefer to start a new colony in FLC, once they prefer (1) to nest in vegetation clearings (i.e., open habitats; Vasconcelos, 1990), as well as (2) queens of the congener species, *A. laevigata*, significantly prefer to nest on bare soil than on soil covered with leaf litter (Vasconcelos et al., 2006). In this sense, FLC presents a woody plant density much smaller than FNCS (Cruz, 2015) and do not possess a thick litter cover (P. S. D. Silva, pers. obs.). Finally, *A. sexdens*' most foraged plant species in this site (*Senna acuruensis* - Fabaceae, *Croton argyrophyllus* - Euphorbiaceae, and *Thiloua glaucocarpa* - Combretaceae) are also amongst the most common woody plant species in FLC (M. M. Corrêa, unpublished data).

The restoration and/or conservation of the *caatinga* flora in this region, particularly at FLC and FNCS, may depend on the development of a project aiming to monitor and manage LCAs colonies. We expect that *A. sexdens* herbivore activity will not only maintain the disturbance caused by past cattle overgrazing at FLC, but also amplify the environmental homogeneity and favor the maintenance of early successional and/or degraded ecosystems as suggested by Leal et al. (2014) and Siqueira et al. (2018). In the Atlantic forest, Leal et al. (2012) showed that the herbivory caused by *A. cephalotes* and *A. sexdens* reduced the production of flower and/or fruits in no less than seven species (compared to plants free from LCAs herbivory; Leal et al., 2012). By using a complex foraging trail network (Silva et al., 2013), workers constantly remove leaves within/on canopies via trunk trails (Leal et al., 2014). They also clear the vegetation above and immediately around their nests making "bottom-up" gaps (Leal et al., 2014). Moreover, workers harvest leaves and clear the vegetation (e.g. seedlings, juveniles, small understory plants) along and/or besides their foraging trails (Vasconcelos and Cherrett, 1997; Silva et al., 2007; Silva et al., 2012a; Sánchez-Restrepo et al., 2019). Thus, leaf-cutting ants cause drastic changes on canopy openness and light availability on the forest floor (see Leal et al., 2014 for a recent review about the multiple impacts of leaf-cutting ants; Corrêa et al., 2016), at the same time that they affect plant abundance and assemblage and interfere with successional trajectories (Silva et al., 2012a; Leal et al., 2014; Câmara et al., 2020). If *A. sexdens* succeeds in founding colonies also in FNCS, this preserved area will experience an increase in total herbivory possibly resulting in a process of flora homogenization and impoverishment, which favors directly and indirectly the establishment of plant species associated to anthropogenic disturbances (Silva et al., 2012b; Leal et al., 2014).

In this way, future studies should try to elucidate: (1) the reason why *A. sexdens* has not yet established nests in FNCS (including comparisons of plant assemblage and edaphoclimatic conditions between these two areas); (2) if there are other farms bordering FNCS with *A. sexdens* nests; (3) if workers of *A. sexdens* colonies located near FNCS already harvest plant material inside FNCS; and (4) what are *A. sexdens* multiple effects on vegetation in FLC, regarding their activities of nest building/maintenance as well as the

foraging activity around nests and along trails. Besides, it is essential to monitor their nuptial flight events to control or prevent the establishment of new colonies in FNCS and its borders. Finally, it is of uppermost importance to investigate if this situation is being repeated around other protected Caatinga areas, which are often located near roads and/or neighbor to privately-owned farms (such as FLC) subjected to chronic disturbances (*e.g.*, cattle overgrazing and harvesting for firewood).

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