

## New records for the western range of *Cabassous tatouay* (Cingulata: Chlamyphoridae) and the first record for the Pantanal wetland biome

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**Abstract** The greater naked-tailed armadillo (*Cabassous tatouay*) is the largest armadillo in the *Cabassous* genus. It can be distinguished from other species in the genus by its large body size and large ears with granular edges that extend above the top of the head. The presence of *C. tatouay* in some regions of Brazil and in some Brazilian biomes, such as the Pantanal wetland, was not previously confirmed. This paper presents 12 new records of *C. tatouay* obtained by camera traps (n=7), direct observations (n=1), and roadkills (n=4) in Mato Grosso do Sul (MS), Brazil. However, two camera trap records were only 14 minutes apart and could potentially represent the same individual. Photographic records are compared with *C. squamicaudis* to highlight important characteristics that differentiate the species. Finally, these records of *C. tatouay* extend its range to western Brazil and for the first time into the Pantanal wetland near the transition to the Cerrado savanna.

**Keywords:** roadkill, Cerrado savanna, greater naked-tailed armadillo, photograph record, transition environment, Xenarthra

### Novos registros da distribuição ocidental de *Cabassous tatouay* (Cingulata: Chlamyphoridae) e o primeiro registro de ocorrência para o bioma Pantanal

**Resumo** O tatu-de-rabo-mole grande (*Cabassous tatouay*) é o maior tatu do gênero *Cabassous*. Ele pode ser distinguido de outras espécies do gênero pelo tamanho corporal e pelas grandes orelhas granulares que se estendem acima do topo da cabeça. A ocorrência de *C. tatouay* em algumas regiões do Brasil e em alguns biomas brasileiros, como o Pantanal, ainda é incerta. Este trabalho apresenta 12 registros de *C. tatouay* obtidos por armadilhas fotográficas (n=7), observações diretas (n=1) e atropelamentos (n=4) em Mato Grosso do Sul (MS), Brasil. No entanto, dois registros de armadilhas fotográficas tiveram apenas 14 minutos de diferença e poderiam representar o mesmo indivíduo. Foi comparado alguns registros fotográficos com *C. squamicaudis* para evidenciar algumas características importantes que diferenciam ambas espécies. Por fim, a ocorrência de *C. tatouay* foi confirmada nos limites ocidentais de sua distribuição e os primeiros registros no Pantanal são relatados próximo aos limites de transição com o Cerrado.

**Palavras-chave:** ambiente de transição, Cerrado, registro fotográfico, tatu-de-rabo-mole, atropelamentos, Xenarthra

## INTRODUCTION

The greater naked-tailed armadillo, *Cabassous tatouay* (Desmarest, 1804), is a poorly known mammal of the order Cingulata. This genus includes four other species: *C. chacoensis* (Wetzel, 1980), *C. centralis* (Miller, 1899), *C. uncinatus* (Linnaeus, 1758), and *C. squamicaudis* (Lund, 1845). *Cabassous tatouay* is the largest species of the genus and on average measures 47.9 cm in head-body length and weighs 4.8 kg. In addition to its size, this species can be differentiated from its congeners by the presence of 35 to 57 small cephalic scutes regularly organized around a large central hexagonal scute over its head. Moreover, it has larger ears, on average 4.1 cm long, that extend above the top of its head and bear characteristic granular edges that extend above the top of its head (Feijó & Anacleto, 2021).

Other species of the genus *Cabassous* reach a maximum head-body length of 46.4 cm and weigh up to 3.8 kg (Desbiez *et al.*, 2018; Feijó & Anacleto, 2021). They have a different pattern of the cephalic scutes and smaller ears compared to *C. tatouay* (Feijó & Anacleto, 2021). In general, the main morphological characteristic of the *Cabassous* species is a tail lacking a full osteoderm cover. They are also characterized by having from 11 to 14 movable bands on the carapace and by the forefeet that exhibit robust claws on the third and fourth digits (Feijó & Anacleto, 2021).

The species of the genus *Cabassous* are still poorly known, especially *C. tatouay* (Ubaid *et al.*, 2010; Superina *et al.*, 2014). Field records of *C. tatouay* are rare and may be false due to external morphological similarities with other species of the genus (Oliveira *et al.*, 2015; Massocato & Desbiez, 2017; Desbiez *et al.*, 2018; Feijó & Anacleto, 2021). *Cabassous tatouay* is a cryptic, solitary species with a specialist insectivorous diet (Redford, 1985; Anacleto, 2007). The few records of the species in the literature suggest that it can be nocturnal and/or diurnal (Meritt, 1985; Encarnação, 1987; Ubaid *et al.*, 2010; Massocato & Desbiez, 2017). It is believed that *C. tatouay* can use both forested and open areas, but prefers forested habitats (Gonzalez & Abba, 2014; Feijó & Anacleto, 2021). Others report that it uses primary and secondary forest habitats, but is rare in areas that are largely degraded or with agricultural activities (Mikich & Bérnils, 2004; Anacleto, 2006; Aguiar & Fonseca, 2008; Oliveira *et al.*, 2015).

*Cabassous tatouay* occurs in northeastern, eastern, central western and southern Brazil, northeastern Uruguay, northeastern Argentina, and southeastern Paraguay (Gonzalez & Abba, 2014; Feijó & Anacleto, 2021). In Brazil, records of the species come from the states of Espírito Santo, Goiás, Mato Grosso, Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São

Paulo, Paraíba, Pernambuco, Ceará, Piauí, Pará, and Mato Grosso do Sul (Ubaid *et al.*, 2010; Gonzalez & Abba, 2014; Feijó & Anacleto, 2021). Moreover, the species is reported from the Atlantic forest, Caatinga, Cerrado savanna, and Pampa biomes (Feijó & Langguth, 2013; Anacleto *et al.*, 2015; Oliveira *et al.*, 2015). The occurrence of *C. tatouay* in the Pantanal wetland was predicted by some authors (Anacleto *et al.*, 2006; Paglia *et al.*, 2012; Hayssen, 2014). However, a recent study indicated low suitability for *C. tatouay* in the Pantanal wetland and Amazonia (Rocha *et al.*, 2022).

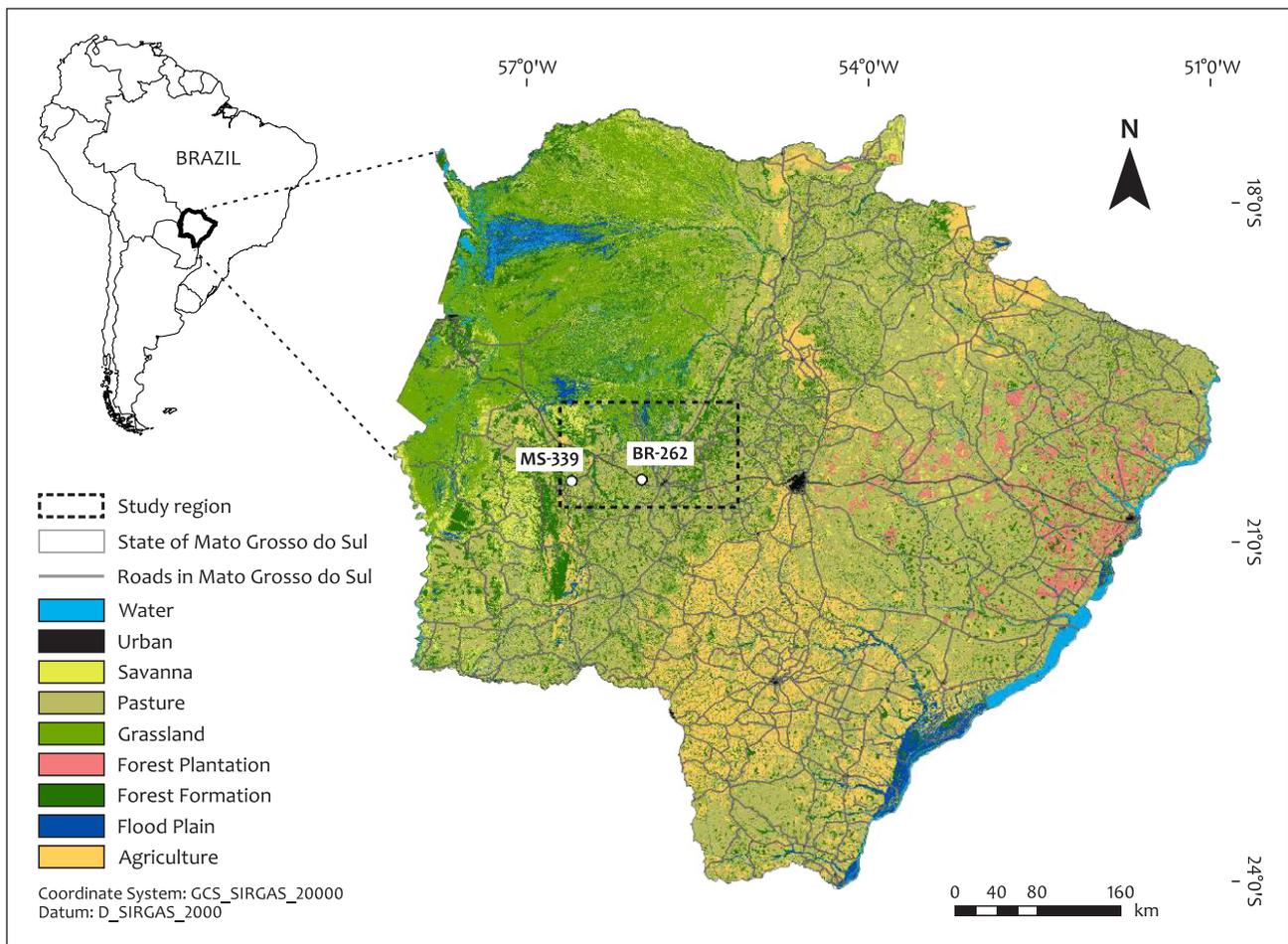
The state of Mato Grosso do Sul (MS) includes three biomes: Atlantic forest, Cerrado savanna, and Pantanal wetland (Silva *et al.*, 2010). The most recent list of mammals in the state reported 166 species, including six armadillos: *Cabassous squamicaudis*, *Dasypus novemcinctus*, *Dasypus septemcinctus*, *Euphractus sexcinctus*, *Tolypeutes matacus*, and *Priodontes maximus* (Tomas *et al.*, 2017). Although *C. tatouay* was not included in this list, its presence in MS had already been confirmed (Massocato & Desbiez, 2017) and published in a Xenarthran data set (Santos *et al.*, 2019). Most of these records were from the Cerrado savanna of MS: two camera trap records from the municipality of Brasilândia (Massocato & Desbiez, 2017), two roadkills from the municipality of Inocência, and one specimen in Brasilândia (Santos *et al.*, 2019).

Although the current distribution of *C. tatouay* encompasses the Pantanal wetland (Feijó & Anacleto, 2021), its presence in this biome seemed doubtful, with no confirmed records (Rocha *et al.*, 2022). Only one unconfirmed camera trap record was reported on a farm in the municipality of Miranda (Santos *et al.*, 2019). *Cabassous squamicaudis* has been widely registered and confirmed in the Pantanal wetland and identification errors between both species are common due to morphological similarities between them (Desbiez *et al.*, 2018). This paper presents new records of *C. tatouay* in MS, confirming the species in the Cerrado savanna and Pantanal wetland biomes.

## MATERIALS AND METHODS

We compiled records of free-living animals made by field researchers between 2013 and 2021 in the western region of MS state (FIG. 1). The study region covers 16,800 km<sup>2</sup> and is composed of both dry and seasonally flooded savannas. The savannas are a mosaic of pastures, natural grasslands, forest fragments, and savanna/scrubland (FIG. 1). Records of the species were obtained through three complementary methods: survey of animal carcasses on roads, camera traps, and direct observation.

Roadkill data were obtained from a long-term monitoring effort of wildlife-vehicle collisions on



**FIGURE 1.** Main land cover classes (from <https://mapbiomas.org> in Collection 6) and road network, especially BR-262 and MS-339, in the study region in Mato Grosso do Sul, Brazil.

MS highways BR-262 and MS-339 (Ascensão *et al.*, 2017, 2021; **FIG. 1**). The monitoring has been carried out since 2013 by Instituto de Conservação de Animais Silvestres (ICAS, <https://www.icasconservacion.org.br>). Carcasses of *Cabassous* spp. that could not be identified ( $n=9$ ) were sampled for genetic species identification (Schetino, 2017).

Camera trap records were obtained on ranches in the study region during mammal surveys. Camera traps (Bushnell, Leneka, USA; Cuddeback, De Pere, USA; and Stealth, Irving, USA) were programmed to take photos or videos. They were placed along fences, riverbanks, roads, trails, and open areas with the objective of recording medium and large mammals. In addition, live animals were photographed by ranch employees or researchers and given to ICAS for identification. All records obtained from camera traps that were not in the same action sequence were considered.

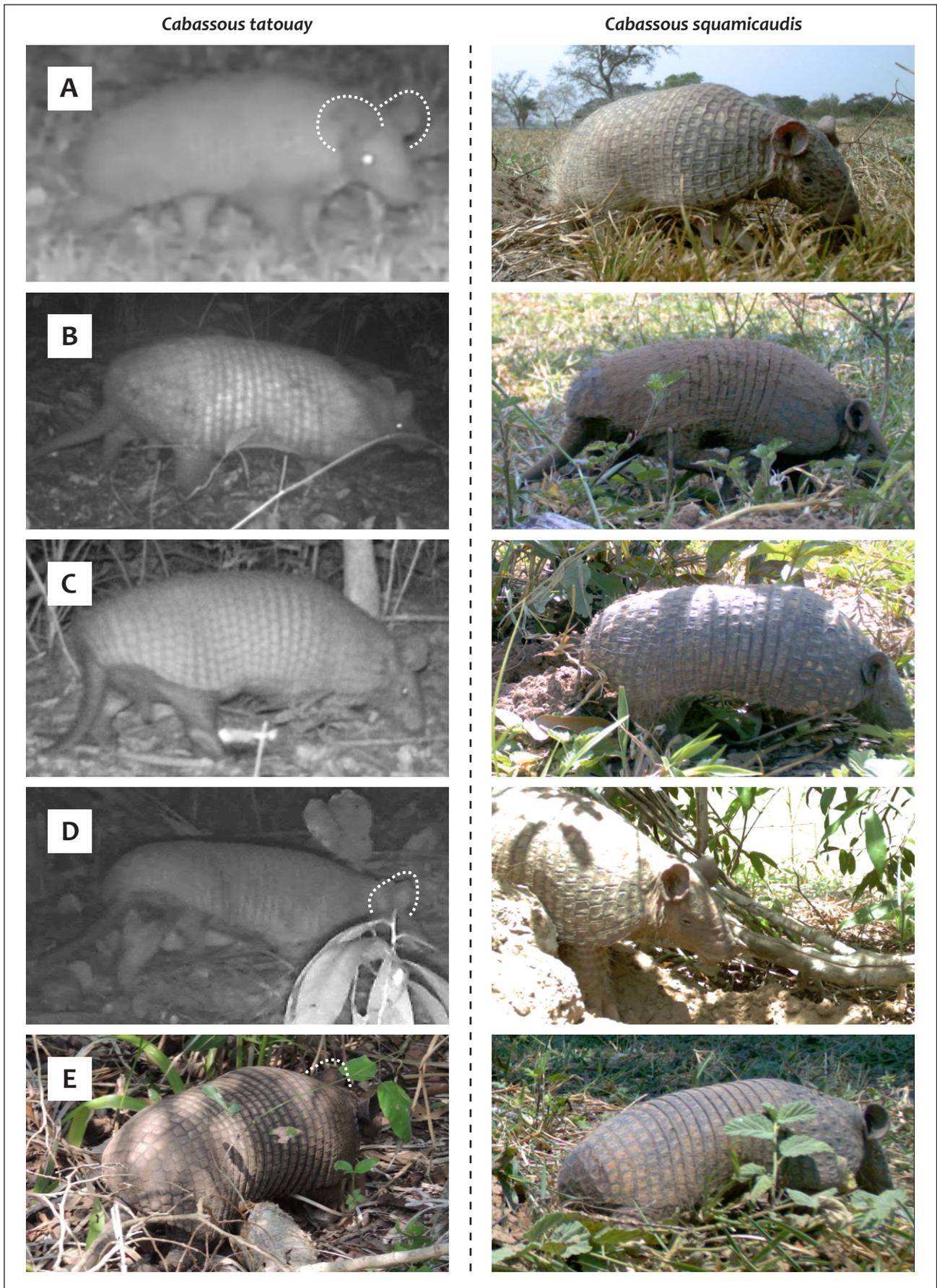
In the study area two species of naked-tailed armadillos, *C. tatouay* and *C. squamicaudis*, occur; they can sometimes be mistaken for each other (Massocato & Desbiez, 2017; Desbiez *et al.*, 2018). The main characteristic that we used in camera trap records for differentiating species was the size of

the ears, which are proportionally larger in *C. tatouay* (**FIG. 2**). In addition, *C. tatouay* is more robust and has a larger body size with well-developed scales on the carapace (**FIG. 2E**). Finally, nocturnal records can be an indication of *C. tatouay* because in the study region *C. squamicaudis* is strictly diurnal (Hayssen, 2014; Desbiez *et al.*, 2018; Feijó & Anacleto, 2021).

Camera trap records and direct observation were also used to document the activity period of *C. tatouay* in the study region. The new records of *C. tatouay* were georeferenced and compared with the species distribution map proposed by Feijó & Anacleto (2021). All points were imported to a GIS platform (ArcMap; ESRI, 2021) to generate a map with the new occurrence points of *C. tatouay* (**FIG. 3**). A land cover map of MapBiomas available in Collection 6 (<https://mapbiomas.org>) was also used to describe the vegetation types of the study area (**FIG. 1**).

## RESULTS AND DISCUSSION

We obtained 12 new records (**TABLE 1, FIG. 3**) for *C. tatouay* in four MS municipalities: Aquidauana



**FIGURE 2.** External morphological traits to differentiate *C. tatouay* (left) from *C. squamicaudis* (right) in photographs and direct observation; large ears of *C. tatouay* extending above the top of their heads are highlighted in pictures **A** and **D**, and the larger ears and body size in pictures **B** and **C** on the left side. Note the size of the body, the larger ears that extend above the top of the head, and the well-developed scales on the carapace in picture **E**.

(n=4), Bodoquena (n=3), Corguinho (n=1), and Miranda (n=4). Records were from camera trap surveys (n=7), roadkills (n=4), and direct observation (n=1) (TABLE 1).

During road surveys, two of the carcasses could be identified as *C. tatouay* through external morphological features. The carcasses were found in 2015 on MS-339 in the municipality of Bodoquena (TABLE 1, FIG. 3) and in 2020 on BR-262 in Miranda municipality, respectively (TABLE 1, FIG. 3). In addition, nine carcasses could not be identified to species level and were classified as *Cabassous* sp. Samples of these carcasses were collected and genetic analysis revealed that two of them were *C. tatouay* (Ascensão *et al.*, 2017; Schetino, 2017). Both had been collected in 2013 near Miranda (TABLE 1, FIG. 2).

The vegetation found on both sides of the road from the collected specimens was predominantly pasture with patches of forest. The presence of *C. tatouay* in this type of habitat was not expected, as the species tends to avoid degraded habitats or areas with intense agricultural activity (Mikich & Bérnils, 2004; Aguiar & Fonseca, 2008; Oliveira *et al.*, 2015). However, *C. tatouay* may use this type of habitat to move between forest fragments in search of shelter and resources. These records also demonstrate that highways and vehicle collisions can be a threat to species of the genus *Cabassous*.

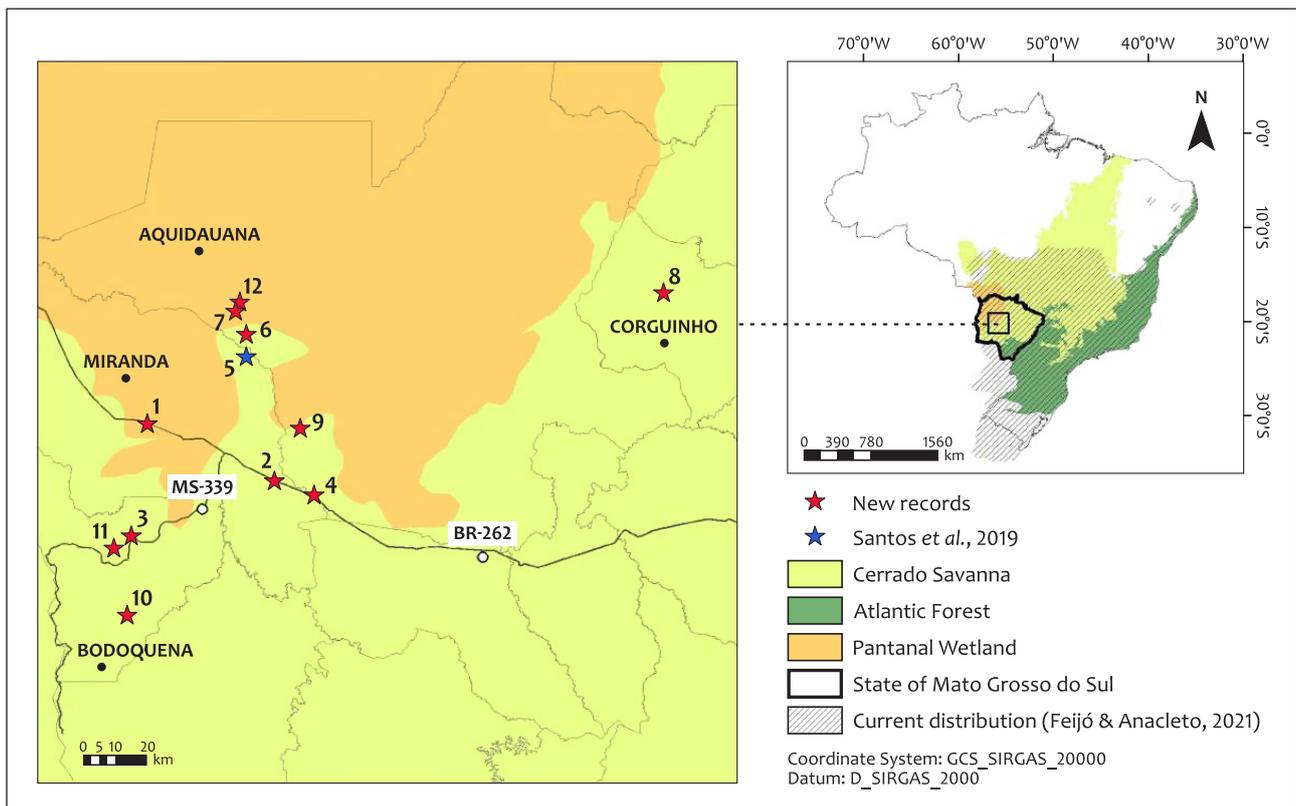
Camera trap photographs were clear enough to distinguish the unique characteristics of *C. tatouay* (FIG. 2). One individual of *C. tatouay* was recorded in the municipality of Aquidauana on 18 August 2020, and two other records were made on 29 August 2020 on the same night (TABLE 1). The latter two records were only 14 minutes apart and could potentially represent the same individual. Two individuals were recorded in the municipalities of Corguinho and Miranda in 2014 and 2015, respectively (TABLE 1). Two other individuals were recorded in Bodoquena in 2018 and 2021, respectively (TABLE 1). All camera trap records occurred on cattle ranches near or in native forest habitats of the study region.

We recorded only one direct observation, in Aquidauana (FIG. 2E, TABLE 1) in 2020. In a study on *C. squamicaudis* in the Pantanal wetland, the animals spent on average 0.75% (10.8 minutes) of their time above ground and the species was therefore classified as subterranean (Desbiez *et al.*, 2018). Although we do not know if *C. tatouay* behaves similarly to *C. squamicaudis*, direct observations are very rare and its behavior may explain why there is so little information about the species.

Our camera trap and direct observation records were at night (n=6) and in the morning (n=2); no records were obtained during the afternoon. However, the low number of records presented in this

**TABLE 1.** New records of *Cabassous tatouay* in Mato Grosso do Sul, Brazil, obtained during field surveys between 2013 and 2021. Record numbers correspond to those indicated in FIG. 3.

Record	Record type	Biome	Municipality	Date	Time	Latitude (S)	Longitude (W)
1	Carcass/BR 262	Pantanal wetland	Miranda	18 May 2013	11:30	20°08'46"S	56°36'41"W
2	Carcass/BR 262	Cerrado savanna	Miranda	24 August 2013	10:14	20°18'33"S	56°14'53"W
3	Carcass/MS 339	Cerrado savanna	Bodoquena	14 February 2015	07:12	20°28'06"S	56°39'24"W
4	Carcass/BR 262	Cerrado savanna	Miranda	8 December 2020	13:18	20°21'04"S	56°08'07"W
5	Camera Trap	Cerrado savanna	Aquidauana	18 August 2020	00:08	19°53'21"S	56°19'46"W
6	Camera Trap	Pantanal wetland	Aquidauana	29 August 2020	04:36	19°49'21"S	56°21'37"W
7	Camera Trap	Pantanal wetland	Aquidauana	29 August 2020	04:50	19°49'21"S	56°21'37"W
8	Camera Trap	Cerrado savanna	Corguinho	23 May 2014	03:13	19°46'02"S	55°08'27"W
9	Camera Trap	Cerrado savanna	Miranda	19 November 2015	04:12	20°09'32"S	56°10'34"W
10	Camera Trap	Cerrado savanna	Bodoquena	24 September 2018	09:14	20°41'41"S	56°40'08"W
11	Camera Trap	Cerrado savanna	Bodoquena	23 September 2021	21:37	20°30'09"S	56°42'22"W
12	Direct observation	Pantanal wetland	Aquidauana	25 October 2020	09:35	19°47'45"S	56°20'54"W



**FIGURE 3.** Study region with the location of new records of greater naked-tailed armadillo (*Cabassous tatouay*) in Mato Grosso do Sul, Brazil.

study does not allow us to confirm the activity pattern of *C. tatouay*. There are few studies on the activity pattern of *C. tatouay* (Meritt, 1985; Encarnaç o, 1987). Some authors consider the species to be nocturnal (Meritt, 1985; Encarnaç o, 1987; Ribeiro *et al.*, 2013; Monteiro *et al.*, 2019) while others consider it to be diurnal (Ubaid *et al.*, 2010). Other Cingulata species are known to change their activity depending on habitat structure (Norris *et al.*, 2010), prey availability (Bonato *et al.*, 2008), hunting pressure (Loughry & McDonough, 1998), and ambient temperature (Maccarini *et al.*, 2015; Attias *et al.*, 2018). Hence, to better understand its behavior, we suggest that future research should explicitly evaluate the relationship between the behavior of this species and environmental conditions, thereby increasing the knowledge on this cryptic and poorly known species.

In this study, a total of eight records were obtained in the Cerrado savanna and four in the Pantanal wetland. Our records have been categorized according to the boundaries of Brazilian biomes defined by IBGE (2004; FIG. 3). We consider the region to be a transition between the Pantanal wetland and Cerrado savanna locations: it presents differences in altitude between the Pantanal wetland and Cerrado savanna (115 to 156 m asl), but similarities in vegetation mosaics, both composed of several types of seasonal savanna, semi-deciduous

forests, gallery forests, grasslands, and open areas, and some parts are subject to seasonal flooding (Eiten, 1991; Harris *et al.*, 2005). The only previously published record of *C. tatouay* in the Pantanal wetland (Santos *et al.*, 2019, FIG. 3) is not within the boundaries of the biome according to IBGE maps. The transition zones may generate confusion in the classification of field records. Our data present the first records for this species in the Pantanal wetland biome, and we recommend the inclusion of *C. tatouay* in the species list of this biome. However, the presence of this species in central regions of the Pantanal wetland remains unconfirmed due to the lack of records and the low suitability of this biome for the species according to Rocha *et al.* (2022).

The new records presented here extend the confirmed range of *C. tatouay* in MS to the west. These results highlight the need for further surveys in this region to understand the distribution, habitat associations, and ecology of this cryptic mammal.

## CONCLUSION

This work presents 12 new records of *C. tatouay* in Mato Grosso do Sul. We show that photographic records can be effective in identifying this species and that it can be active both during the day and night in this region. Our data also suggest that highways may be a threat to this species. Furthermore,

we confirmed for the first time the presence of *C. tatouay* in the Pantanal wetland, with records in the transitional environments between the Cerrado savanna and Pantanal. We highlight the importance of studies in the core zone of the Pantanal wetland to confirm the range of the species in this biome. Further research in this region and in other parts of its range may help to understand habitat use, distribution, and activity patterns of *C. tatouay*. We reinforce the importance of transition areas for biodiversity and the importance of developing conservation strategies in these regions, especially for areas that suffer from the conversion of native vegetation to pasture and agriculture.

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