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# Snakes of Campo Grande municipality, Mato Grosso do Sul state, Central Brazil

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**Abstract.** The Cerrado biome harbours one of the highest levels of squamate species richness globally. In the past few years, several new localities have been sampled, providing important data regarding snake diversity within this biome. Few reptile and/or snake inventories have been performed in the state of Mato Grosso do Sul, Brazil, and none have been carried out in the municipality of Campo Grande, the capital of this state. In this paper, we present the first list of snake species in the municipality of Campo Grande based on specimens housed in the Zoological Collection of the Universidade Federal de Mato Grosso do Sul. We recorded 38 species distributed in the families Dipsadidae (21), Colubridae (6), Viperidae (5), Elapidae (2); Anomalepididae, Boidae, Leptotyphlopidae and Typhlopidae (1 species each). The snake fauna of Campo Grande is characterized by species typical of open habitats, some of which are Cerrado endemics (e.g. *Trilepida koppesi*, *Chironius flavolineatus*, *Chironius quadricarinatus*, *Simophis rhinostoma*, *Erythrolamprus frenatus*, *Phalotris matogrossensis*, *Bothrops moojeni* and *Bothrops pauloensis*). Despite the number of species found, our accumulation curve shows that the richness in the municipality is higher, and more sampling efforts are needed.

**Keywords:** hotspot, savannah, open formations, zoological collection, Serpentes, Cerrado, inventory

## Introduction

The Brazilian Cerrado hotspot is the second largest Neotropical morphoclimatic savannah domain (Ab'Saber, 1977) with high environmental heterogeneity, from grasslands to forested formations (Oliveira-Filho and Ratter, 2002). This, in turn, promotes a strong horizontal stratification driving the herpetofaunal diversity (Colli et al., 2002; Nogueira et al., 2011).

In the last two decades, several studies have been published about the diversity and distribution of Cerrado squamates (e.g. Colli et al., 2002; Costa et al., 2007; Nogueira et al., 2011; Azevedo et al., 2016). Such knowledge has increased due to sampling in previously unsearched areas as well as from data from museum collections. Colli et al. (2002) revised the distribution of squamates in the Cerrado and provided a checklist of 170 species. Only nine years later, Nogueira et al. (2011) increased this richness by ~60% to 267 species. Snakes account for ~60% of these squamates (158 species), with 51 snake species considered endemic to this area (Nogueira et al., 2011).

Despite this progress, there are several gaps regarding the geographical distribution of Cerrado snakes (Colli et al., 2002; Costa et al., 2007; Nogueira et al., 2010), including the state of Mato Grosso do Sul, Central Brazil (Ferreira et al., 2017). In the present study we provide the first checklist of snakes for Campo Grande municipality, the capital of Mato Grosso do Sul, using specimens deposited in the most representative zoological collection of the region, the zoological collection of the Universidade Federal do Mato Grosso do Sul (ZUFMS).

## Material and Methods

*Study area.*—Campo Grande municipality is the capital and largest city of the state of Mato Grosso

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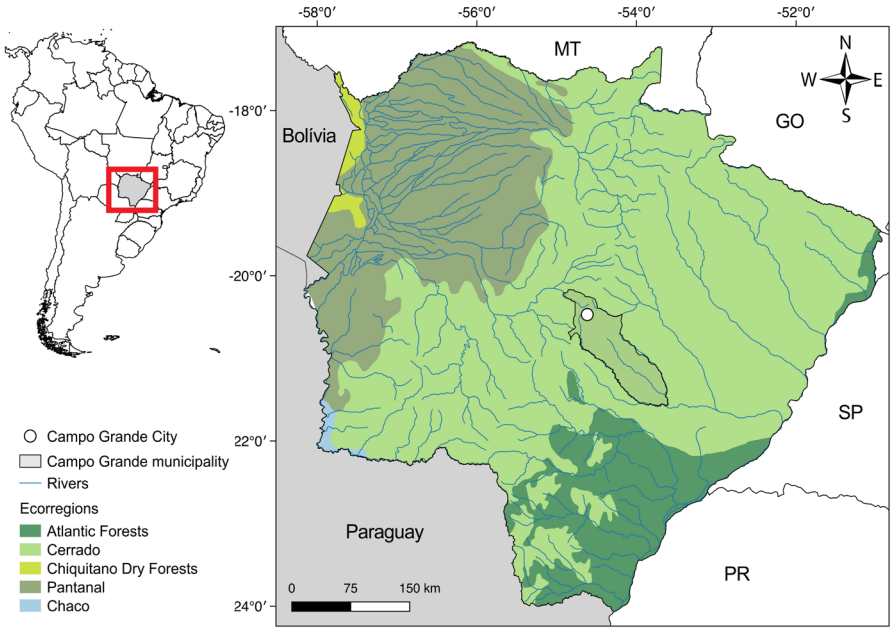


**Figure 1.** Map of the state of Mato Grosso do Sul, highlighting the municipality of Campo Grande, Mato Grosso do Sul State, Brazil.

do Sul, located in a plateau region in the centre of the state, with a plain landscape (around 590 m above sea level) covering around 8,096 km² (Figure 1; Instituto Municipal de Planejamento Urbano, 2007), and 33.4% of its area is urbanized, with less than 1% of the municipality area within conservation units. It has a population of about 850,000 people. Cerrado vegetation characterizes all of the rural territory in the municipality and several phytophysiognomies can be found in this area, such as grasslands, "*cerradão*", "*veredas*", and riparian forests. The climate is equatorial with two well-defined seasons, a dry winter (April to August) and a wet summer (September to March; Aw; Kottek et al., 2006). The average temperature is 22.8ºC and the average annual precipitation is 1,533 mm (INMET, 2005). Two hydrographic basins have their headwaters in the city, the Parana River basin, running to the east, and the Paraguay River basin, running to the west.

*Sampling and data analysis.*—We analysed all snake specimens collected in Campo Grande and housed in ZUFMS since 1982 until 2017. Accuracy of identification was confirmed using morphological analysis (morphometrics, pholidosis, and coloration) based on specific literature (e.g. Lema et al., 2005; Silva and Rodrigues, 2008; Costa et al., 2016). We follow Zaher et al. (2009) and Costa and Bérnils (2014) for nomenclature and classification. The patterns of distribution of each species within the Cerrado was classified based on Nogueira et al. (2011). Additionally, we verified the presence of endangered species by consulting the IUCN Red List (IUCN, 2016) and the Brazilian Red List (ICMBio, 2014).

We constructed a species accumulation curve (Gotelli and Colwell, 2001), using 1000 randomizations of an abundance matrix where each column represents a species and each row represents one year, using abundance data (individuals). The graphic representation is provided by species x individuals. We used the species richness estimator Jacknife1 to determine the expected richness of snakes (Colwell and Coddington, 1994). We performed this analysis using EstimateS v.9.0.0 (Gotelli and Colwell, 2001).

## Results

We analysed 212 snake specimens from Campo Grande municipality in the ZUFMS collection, comprising 38 species, 21 genera and eight families (Figure 2, Table 1). The most speciose family was Dipsadidae (21 species),


**Figure 2.** Live individuals of some of the species of snakes known from Campo Grande municipality, Mato Grosso do Sul State, Brazil: (a) *Oxyrhopus guibei*; (b) *Phalotris matogrossensis*; (c) *Philodryas mattogrossensis*; (d) *Thamnodynastes hypoconia*; (e) *Bothrops alternatus*; (f) *Bothrops moojeni*.

followed by Colubridae (6), Viperidae (5), Elapidae (2), Anomalepididae (1), Boidae (1), Leptotyphlopidae (1) and Typhlopidae (1). The most abundant species in the collection were *Oxyrhopus guibei* (28), *Sibynomorphus ventrimaculatus* (22), *S. mikanii* (16) and *Crotalus durissus* (14). From the 38 recorded species, only three (*Liotyphlops beui*, *O. guibei*, *C. durissus*) were evaluated by IUCN, all of which are categorized as Least Concern (LC), and in the Brazilian Red List from ICMBio, all species registered in this study are categorized as LC as well. We examined specimens of eight Cerrado endemic species: *Trilepida koppesi*, *Chironius flavolineatus*, *Chironius quadricarinatus*, *Simophis rhinostoma*, *Erythrolamprus frenatus, Phalotris matogrossensis, Bothrops moojeni* and *Bothrops pauloensis*. The accumulation curve did not reach an asymptote, and the Jackknife estimator predicted that there are probably about 44 species total in this assemblage (Figure 3).

We found three distribution patterns among the snakes species recorded herein: (a) Cerrado endemic species, (b) widespread species and (c) species shared among Cerrado and neighbouring domains, especially Atlantic rain forest (Table 1).

## Discussion

Our checklist shows that Campo Grande municipality has a high level of snake species richness (Table 1) compared to other Cerrado localities (e.g. Recoder and

**Table 1**. Species of snakes known from Campo Grande municipality, Mato Grosso do Sul state, Brazil, deposited in the ZUFMS. Distribution: **W** = widely distributed in Brazil; **End** = Cerrado endemic; **Ce =** Cerrado; **Af** = Atlantic Forest; **Ca** = Caatinga; **Ch** = Chaco; **Am** = Amazon Forest; **Pn** = Pantanal; **Pp** = Pampas. Distribution based on Nogueira et al. (2011).

| Taxa | Distribution | Sample |
|---|---|---|
| **Anomalepididae (1)** | | |
| *Liotyphlops beui* (Amaral, 1924) | Af, Ce | 1 |
| **Leptotyphlopidae (1)** | | |
| *Trilepida koppesi* (Amaral, 1955) | End | 1 |
| **Typhlopidae (1)** | | |
| *Amerotyphlops brongersmianus* (Vanzolini, 1976) | W | 7 |
| **Boidae (1)** | | |
| *Boa constrictor* Linnaeus, 1758 | W | 4 |
| **Viperidae (5)** | | |
| *Bothrops alternatus* Duméril, Bibron & Duméril, 1854 | Pp, Ce | 1 |
| *Bothrops mattogrossensis* Amaral, 1925 | Ch, Ce | 3 |
| *Bothrops moojeni* Hoge, 1966 | End | 2 |
| *Bothrops pauloensis* Amaral 1925 | End | 5 |
| *Crotalus durissus* Amaral, 1926 | Ca, Am, Ce | 14 |
| **Elapidae (2)** | | |
| *Micrurus frontalis* (Duméril, Bibron, Duméril, 1854) | Ch, Af, Pp, Ce | 11 |
| *Micrurus lemniscatus* (Linnaeus, 1758) | Af, Ca, Am, Ce | 3 |
| **Colubridae (6)** | | |
| *Chironius flavolineatus* (Jan, 1863) | End | 10 |
| *Chironius quadricarinatus* (Boie, 1827) | End | 1 |
| *Leptophis ahaetulla* (Linnaeus, 1758) | Am, Ch, Pn, Ce | 1 |
| *Mastigodryas bifossatus* (Raddi, 1820) | W | 1 |
| *Simophis rhinostoma* (Schlegel, 1837) | End | 3 |
| *Tantilla melanocephala* (Linnaeus, 1758) | Am, Ce | 2 |
| **Dipsadidae (21)** | | |
| *Apostolepis assimilis* (Reinhardt, 1861) | Af, Ch, Ce | 6 |
| *Erythrolamprus frenatus* (Werner, 1909) | End | 4 |
| *Erythrolamprus poecilogyrus* (Wied, 1825) | W | 13 |
| *Erythrolamprus reginae* (Amaral, 1935) | W | 3 |
| *Erythrolamprus typhlus* (Linnaeus, 1758) | Am, Af, Ca, Ce | 1 |
| *Helicops infrataeniatus* (Jan, 1865) | Pp, Af, Ce | 2 |
| *Helicops leopardinus* (Schlegel, 1837) | Am, Pn, Ce | 2 |
| *Leptodeira annulata* (Linnaeus, 1758) | Am, Af, Ce | 2 |
| *Oxyrhopus guibei* Hoge & Romano, 1978 | Af, Ce | 31 |
| *Oxyrhopus petolarius* (Reuss, 1834) | Am, Af, Ce | 3 |
| *Oxyrhopus trigeminus* Duméril, Bibron & Duméril, 1854 | Ca, Ch, Ce | 2 |
| *Phalotris matogrossensis* Lema, D'Agostini & Cappellari, 2005 | End | 8 |
| *Phalotris mertensi* (Hoge, 1955) | Af, Ce | 3 |
| *Philodryas mattogrossensis* Koslowsky, 1898 | Ch, Ce | 3 |
| *Philodryas olfersii* (Liechtenstein, 1823) | W | 10 |
| *Philodryas patagoniensis* (Girard, 1858) | Af, Pp, Ca, Ce | 3 |
| *Sibynomorphus mikanii* (Schlegel, 1837) | Pp, Af, Ce | 16 |
| *Sibynomorphus turgidus* (Cope, 1868) | W | 2 |
| *Sibynomorphus ventrimaculatus* (Boulenger, 1885) | W | 22 |
| *Thamnodynastes hypoconia* (Cope, 1860) | Ch, Ca, Ce, Af | 2 |
| *Xenodon merremii* (Wagler in Spix, 1824) | Ch, Ca, Ce | 6 |

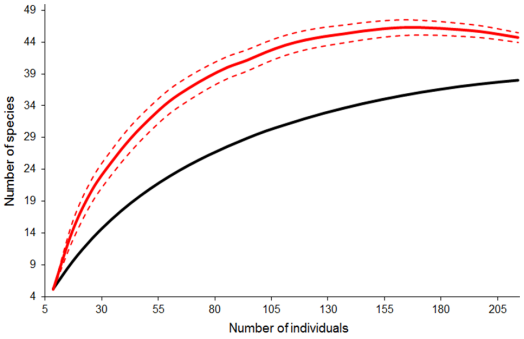


**Figure 3.** Accumulation curve for snakes sampled at the Campo Grande municipality, Mato Grosso do Sul State, Brazil (period of sampling from 1982 to 2017). Black line represents the accumulation curves, red line represents species estimates based on Jacknife1 and red dashed lines represents the confidence interval of 95%.

Nogueira, 2007, 22 species in Parque Nacional Grande Sertão Veredas, Minas Gerais; Recoder et al., 2011, 21 species in Estação Ecológica Serra Geral do Tocantins, Tocantins), and comparable to others (e.g. Carvalho and Nogueira, 1998, 37 species in Cuiabá, MT; Sawaya et al., 2008, 36 species in Itirapina, São Paulo), especially for such an urbanized area. However, this list remains underestimated, because the accumulation curve did not reach an asymptote (Figure 3). Continuing long-term surveys is important to overcome this situation, especially because many species of snakes have cryptic habits and some are naturally low in abundance (Steen, 2010; Durso et al., 2011; Bernarde et al., 2011, 2012). We highlight that even in some intensively studied areas, new records of species of snakes are sometimes added to checklists after multiple decades (Gibbons et al., 1997; Bernarde et al., 2011, 2012).

Most of the snake species recorded in this study are considered common in open areas of Cerrado (Nogueira et al., 2011). Furthermore, some species are widely distributed in Brazil, and can be found in three or more biomes (Table 1; Cunha and Nascimento, 1993; Nogueira et al., 2011; Bernarde et al., 2012; Guedes et al., 2014). The geographical distribution patterns of the species that occur in Campo Grande reveal an important faunistic interchange with adjacent regions, which increases the regional richness. Despite the predominance of Cerrado species, there is an important contribution of species typical from adjacent domains, mainly Atlantic Forest species. Regarding local comparisons, Ferreira et al. (2017) provided an extensive check list for the reptiles of the state of Mato Grosso do Sul. They provide a list classifying species that occur in the Pantanal floodplain and in the Plateaus. We found 38% of the snake species they mentioned that possible occur in Plateaus with Cerrado physiognomies (the same type as Campo Grande). We predict that most of the widespread, common species recorded by Ferreira et al. (2017) list (e.g. *Spilotes pullatus*, *Helicops modestus*) should also be found in Campo Grande.

The two protected areas (conservation units) within Campo Grande municipality are poorly sampled, with only one common and widespread fossorial snake (*Amerotyphlops brongersmianus*) recorded at Prosa State Park and Mata dos Segredos State Park. Unfortunately, there are no systematic snake surveys in either conservation unit, which hampers our ability to evaluate how much these areas help protect the snake fauna of the region. Many species can also be found in urban areas, even in highly urbanized areas, reflecting the high behavioural plasticity of reptiles in dealing with anthropogenic habitats (e.g. Ackley et al., 2015).

The present inventory is the first for the region, and we highlight the need of more intensive samplings. The precise geographical coordinates of most records were poorly determined, and accurate collection locality data could be determined for few Campo Grande specimens in the ZUFMS collection. These conditions highlight two issues common to many specimens collections: the low precision of the locality data collected and the insufficient and inconsistent sampling effort. Most of these specimens were collected by non-biologists, often as road-killed specimens or in rural zones. Many of these collectors provide little detailed information about the collection locality. However, as in many areas, this museum collection is the only permanent record of snake diversity in Campo Grande that exists. Future efforts should aim to supplement the collection, encourage the collection of precise, georeferenced locality data for all future specimens, and incorporate digital specimen data collected by citizen scientists (O'Donnell and Durso, 2014).

The main purpose of biological collections is store information about the diversity of different groups of organisms (Zaher and Young, 2003). Their records complement zoological studies (e.g. Recoder and Nogueira, 2007; Costa et al., 2007; Sawaya et al., 2008; Valdujo et al., 2009; Costa et al., 2010; Guedes et al., 2014; Vasconcelos and Nascimento, 2014) and provide important data for medical, pharmaceutical and agronomical research (Zaher and Young, 2003). Brazil harbours a huge diversity of birds (Silva and Bates,

2002), mammals (Carmignotto et al., 2012), amphibians and squamates (Azevedo et al., 2016), and is home to the most representative zoological collections in the Neotropics (Zaher and Young, 2003). Nevertheless, these collections have paradoxically outdated infrastructure and receive inadequate maintenance, which has already caused the unfortunate loss of biological information collected through many decades over extensive geographic areas (Sant'anna, 2010; De Lima, 2010; Warrell et al., 2010; Franco, 2012). Given the scope of anthropogenic activities in the Cerrado landscape (Sano et al., 2010) and elsewhere, it is more imperative than ever to maintain zoological collections and the data they contain about biodiversity.

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**Appendix 1**. Specimen numbers of snakes examined from Campo Grande municipality, Mato Grosso do Sul, Brazil in the collection of the Coleção Zoológica da Universidade Federal do Mato Grosso do Sul (ZUFMS).

*Amerotyphlops brongersmianus*: ZUFMS-REP 194–196, 2181–2182, 2188–2189; *Apostolepis assimilis*: ZUFMS-REP 94–95, 233–234, 256, 1732; *Boa constrictor*: ZUFMS-REP 951, 952, 987, 1854; *Bothrops alternatus:* ZUFMS-REP 2446; *Bothrops mattogrossensis*: ZUFMS-REP 1333, 1348, 1571; *Bothrops moojeni*: ZUFMS-REP 1362, 2388; *Bothrops pauloensis:* ZUFMS-REP 1334, 1347, 1349–1350, 1367; *Chironius flavolineatus*: ZUFMS-REP 347, 983, 1376–1380, 1534, 1549, 1835; *Chironius quadricarinatus*: ZUFMS-REP 1581; *Crotalus durissus*: ZUFMS-REP 02, 344, 346, 362–365, 1363, 1370–1371, 1586, 1881–1882, 1891; *Erythrolamprus frenatus*: ZUFMS-REP 242, 1398, 1578, 1703, *Erythrolamprus poecilogyrus:* ZUFMS-REP 282, 293, 1271–1276, 1279, 1281, 1552, 1966, 1975; *Erythrolamprus reginae*: ZUFMS-REP 236, 1400, 1505; *Erythrolamprus typhlus*: ZUFMS-REP 1282; *Helicops infrataeniatus:* ZUFMS-REP 1584, 1900; *Helicops leopardinus*: ZUFMS-REP 1321, 1323; *Leptodeira annulata:* ZUFMS-REP 1531, 1912; *Leptophis ahaetulla*: ZUFMS-REP 1639; *Liotyphlops beui*.: ZUFMS-REP 107; *Mastigodryas bifossatus:* ZUFMS-REP 283; *Micrurus frontalis*: ZUFMS-REP 06, 08, 1412–1416, 1507, 1836, 2016, 2020; *Micrurus lemniscatus:* ZUFMS-REP 131, 2017–2018; *Oxyrhopus guibei*: ZUFMS-REP 132, 241, 244–245, 251–255, 258–259, 261, 265–268, 271, 278, 320, 1294, 1300–1304, 1423, 2384–2385; 2484–2486; *Oxyrhopus petolarius*: ZUFMS-REP 1420–1421, 2391; *Oxyrhopus trigeminus*: ZUFMS–REP, 270, 1424; *Phalotris matogrossensis*: ZUFMS-REP 260, 1426–1427, 2027, 2110, 2169; 2487–2488; *Phalotris mertensi*: ZUFMS-REP 191, 1132, 2386; *Philodryas mattogrossensis*: ZUFMS-REP 269, 1588, 2447; *Philodryas olfersii*: ZUFMS-REP 281, 348,1429–1433, 1617, 1645, 2033; *Philodryas patagoniensis*: ZUFMS-REP 1308, 1311, 2039; *Sibynomorphus mikanii*: ZUFMS-REP 349, 366–370, 1445–1446, 1448, 1635, 2049–2052, 2054, 2390; *Sibynomorphus turgidus*: ZUFMS-REP 1540, 2064; *Sibynomorphus ventrimaculatus*: ZUFMS-REP 239–240, 275, 277, 279, 957–962, 980, 1447, 1503, 1529, 2058, 2063, 2086–2087, 2089, 2119, 2122; *Simophis rhinostoma*: ZUFMS-REP 1451–1452, 2043; *Tantilla melanocephala*: ZUFMS-REP 247, 1454; *Thamnodynastes hypoconia:* ZUFMS-REP 2387, 2477; *Trilepida kopessi*: ZUFMS-REP 238; *Xenodon merremii*: ZUFMS-REP 299, 1488–1490, 2096, 2101.

*Accepted by Andrew Durso*