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Distribution and Abundance of *Caiman latirostris* and *Paleosuchus palpebrosus* at Grande Sertão Veredas National Park, Central Brazil

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***Abstract.*—We surveyed Grande Sertão Veredas National Park in the Cerrado of Central Brazil to evaluate the distribution and abundance of the Broad-snouted Caiman (*Caiman latirostris*) and Cuvier's Smooth-fronted Caiman (*Paleosuchus palpebrosus*) populations in the park. We conducted nocturnal spotlight surveys at 35 different sites in 2009 and 2010, and found differences in habitat use and distribution between the two species: *Caiman latirostris* was more common in oxbow lakes associated with the low valleys of large rivers, while *P. palpebrosus* was typically found in swift-flowing headwater streams or in their associated dams. We conducted additional spotlight sampling in 2011 at 40 selected oxbow lakes which revealed low site occupancy and small population sizes for *C. latirostris*, while intensive trapping for *P. palpebrosus* in a 3.5 km section of a selected headwater stream suggests that the species may be more common than it appears at first sight, based on conventional spotlight sampling. A sample of captured *C. latirostris* was dominated by hatchlings and juveniles, in contrast to *P. palpebrosus*, which had proportionally more adults in the sample, but these differences were not statistically significant. Further studies are needed to better elucidate the conservation status of caiman populations in the park and factors affecting their abundance and distribution.**

Key Words.—Broad-snouted Caiman; Cerrado; Cuvier's Smooth-fronted Caiman; habitat use; population structure; reptiles

Introduction

The Cerrado is a floristic province comprising xeromorphic woodlands, savannas, and grasslands in central Brazil (Oliveira and Marquis 2002). It is considered a biodiversity hotspot, with almost 60% of its natural cover lost, and it is still under pressure (Klink and Machado 2005). Five species of alligatorids (caimans) are known to occur in the Cerrado, but studies on their ecology, distribution, and conservation status in the biome are still rare (Colli et al. 2002). With few exceptions, most studies on alligatorids in Brazil have been conducted in Amazonia or in the Pantanal, where populations are relatively abundant and more amenable to study (e.g., Magnusson et al. 1987; Magnusson and Lima 1991; Da Silveira et al. 1999; Campos et al. 2010).

Grande Sertão Veredas National Park (GSVNP) is the largest national park in the Cerrado biome, and is located inside one of the largest continuous blocks of remaining Cerrado in Brazil (IBAMA. 2003. Plano de Manejo do Parque Nacional Grande Sertão Veredas. Available from http://www.icmbio.gov.br/portal/biodiversidade/unidades-de-conservacao/biomas-brasileiros/cerrado/unidades-de-conservacao-cerrado/2099-parna-grande-sertao-veredas.html [Accessed 06 May 2013]). Two alligatorid species occur inside the Park, the Broad-snouted Caiman (*Caiman latirostris*) and Cuvier's Smooth-fronted Caiman (*Paleosuchus palpebrosus*). Studies on the distribution, conservation status, ecology, and population biology of these species are considered priority by the International Union for the Conservation of Nature (IUCN; Magnusson and Campos 2010; Verdade et al. 2010). The occurrence of these species in the Park represents an opportunity to study their biology in relatively pristine Cerrado environment. In this study, we evaluate patterns of distribution, abundance, and population structure of *C. latirostris* and *P. palpebrosus* at GSVNP.

Materials and Methods

Study site.—Grande Sertão Veredas National Park (Fig. 1) is the largest (> 230,000 ha) National Park in the Cerrado biome of Brazil. The park is located in the borders of the Brazilian States of Bahia and Minas Gerais, on a sandy sedimentary plateau with flat to rolling terrain and with altitudes ranging from 600 to 850 m (Recoder and Nogueira 2007). The climate is seasonal, with most of the annual rains (1,400 mm) falling from November to March. Vegetation cover consists of a mosaic of savannas with different levels of arboreal cover, with patches of forests and grassy fields.

Figure 1. Top: Map of Brazil showing the location of Grande Sertão Veredas National Park (GSVNP); Bottom: Map of GSVNP, showing major rivers systems and distribution of sampling sites (stars).

GSVNP is inserted in the western side of the São Francisco River Basin and is relatively well-drained (IBAMA. 2003. *op. cit.*). The park has two main groups of aquatic habitats, the first comprising headwater tributary streams and their associated dams (natural or artificial); these habitats are typically surrounded by dense vegetation and have colder, oligotrophic waters. The second group is related to the low valleys of larger rivers, including the rivers themselves and the marsh areas and oxbow lakes; these habitats are characterized by open water and a grassy floodplain (pers. obs.). The GSVNP buffer zone is under pressure from agricultural development, such as soybean and pastures, but the impact of these activities on the park and its river systems are little understood. Because the sources of most GSVNP rivers are located inside the park (IBAMA. 2003. *op. cit.*), impacts on wetland habitat and on caimans are likely to be indirect.

Caiman distribution.—We surveyed the park from July 2009 to December 2010 to evaluate the distribution of *C. latirostris* and *P. palpebrosus*. We sampled caiman along transects on the margins of rivers, streams, oxbow lakes and dams, distributed to cover the most important river basins and aquatic habitats of the park. Transects were surveyed at night, mostly on foot, but occasionally by boat, and we located caiman by their reflecting eyeshine using a handheld spotlight (Da Silveira et al. 1999). We counted all caiman we sighted and, whenever possible, we captured caiman by hand or using snares. For caiman we captured, we measured snout-vent length (SVL), determined sex (Ziegler and Olbort 2007), marked them using a combination of notches in tail scutes (Jennings

et al. 1991), and released caiman at the site of capture. We assigned individuals to the following size classes: < 25 cm SVL, 25–49 cm SVL, 50–74 cm SVL, and 75–100 cm SVL (we included only captured individuals in size-structure analysis). Sampling effort per site varied depending on site size and accessibility. For example, we could survey large rivers for up to 10 km by boat, we sampled headwater streams by walking along their margins for distances of up to 2 km, and we typically sampled oxbow lakes from a fixed spot because of their small size (50–500 m length).

Caiman abundance.—In 2011, we conducted intensive surveys at selected sites to evaluate relative abundance of caimans. We counted *Caiman latirostris* during nocturnal spotlight surveys in 40 oxbow lakes located along a 10 km section (measured with a GPS device) of the Preto River floodplain (15° 09' S; 45° 44' W). We sampled all oxbows on two occasions, the first in February-March, and the second in November-December 2011. Because most oxbows were small (< 100 m length in the longest axis), we considered that all oxbow shorelines were surveyed, and we used the total number of individuals encountered per site as a measure of relative abundance for this species. We sampled *Paleosuchus palpebrosus* by systematic snare-trapping along a 3.5 km section (measured with a GPS device) of Santa Rita headwater stream (15° 14' S; 45° 39' W). We installed 35 snares at regular intervals in two different trapping occasions, the first in April-May, and the second in October-November 2011. Snares were built after Kofron (1989), set as baited walk-through traps on stream margins, and checked daily in the morning through seven consecutive days. We used the total number of individuals recorded per km of stream as a measure of relative abundance of this species. To compare the distribution of sizes of the two species, we used the Kolmogorov-Smirnov two sample test ($\alpha = 0.05$).

Results

In 2009 and 2010, we conducted 64 surveys at 35 different sites, representing four different habitat types: headwater streams, headwater stream dams, large rivers, and oxbow lakes (Table 1). We recorded 44 *Caiman latirostris*, 13 *Paleosuchus palpebrosus*, and five "eyeshine-only" (unidentified individuals). We captured 21 *C. latirostris* and recaptured four; we captured four *P. palpebrosus* with one recapture. Overall, the number of individuals found per site was low, ranging from zero to seven. In rivers, the number of individuals found in surveys was always < 1/km of margin.

We recorded *Caiman latirostris* in 37% (n = 13) of sampled sites. The species was typically found in oxbow lakes associated with the low valleys of larger rivers, such as Preto and Carinhanha, as well as in the rivers themselves (Table 1). We found *P. palpebrosus* in only 25% (n = 9) of sites, typically in upstream sites such as streams and stream dams (Table 1). In the few cases when it was found in a large river or oxbow (n = 3), it was always near the mouth of a headwater stream.

During the 2011 sampling along the Preto River oxbows, we recorded 26 *C. latirostris* and captured 10 individuals. The species was concentrated at few sites: in the first sampling occasion, we recorded the species in one of 40 oxbows, and in the second occasion, in six of 40 oxbows. The number of individuals per site ranged from one to 11. Our intensive trapping effort for *P. palpebrosus* along Santa Rita Stream produced 10 captures, representing six different adult individuals. Assuming that these individuals are all residents, we estimate a

Table 1. Total counts and means (in parentheses) of Broad-snouted Caimans (*Caiman latirostris*) and Cuvier's Smooth-fronted Caimans (*Paleosuchus palpebrosus*) by habitat type in the Grande Sertão Veredas National Park of Brazil during nocturnal sight surveys in 2009 and 2010. The number of sites surveyed for each habitat is n and unidentified individuals are listed as eyeshine only.

Habitat type		n	*C. latirostris*	*P. palpebrosus*	Eyeshine Only
Headwater	Stream	6	0 (0)	5 (0.83)	0
	Dam	8	4 (0.50)	5 (0.63)	0
Low valley	River	7	8 (1.14)	2 (0.29)	3
	Oxbow	14	32 (2.29)	1 (0.07)	2

Table 2. Number of captured Broad-snouted Caimans (*Caiman latirostris*) and Cuvier's Smooth-fronted Caimans (*Paleosuchus palpebrosus*) by size class (snout-vent length) at Grande Sertão Veredas National Park, Brazil, 2009 to 2011.

Size class (cm)	*Caiman latirostris*	*Paleosuchus palpebrosus*
< 25	9	0
25–49	16	4
50–74	4	2
75–100	2	3

minimum density of 1.7 individuals per km of stream.

Juveniles comprised most of the 31 *C. latirostris* we captured (Table 2). The female to male ratio for six individuals with SVL > 50 cm was 2:1. In the case of *P. palpebrosus*, adults were better represented in the sample of nine captured individuals (Table 2), and the sex ratio of six individuals with SVL > 40 cm was 1:1. There was no significant difference in size distribution between species (D = 0.5, P = 0.699).

Discussion

In this study, we provide baseline data on the distribution, abundance, and population structure of *C. latirostris* and *P. palpebrosus* in a Cerrado area in central Brazil. *Caiman latirostris* was more common in oxbow lakes in the floodplains of larger rivers, particularly the Carinhanha and Preto Rivers, occasionally using the rivers, probably as dispersal corridors. This agrees with previous studies, which also reported a preference for quiet and densely vegetated waters (Filogonio et al. 2010; Verdade et al. 2010). Densities and site occupancy rates seem to be very small for *C. latirostris* in the study area, even considering imperfect detection of night-counts and bias introduced by unequal sampling effort (Sarkis-Gonçalves et al. 2004; Da Silveira et al. 2008). Populations of this species in the São Francisco basin are scattered and typically have low numbers of individuals (Verdade 2001; Filogonio et al. 2010) and low dispersal rates (Verdade et al. 2002).

The reasons for such low abundances are unclear. At other sites of the basin, the species may be limited by direct persecution and wetland degradation (Filogonio et al. 2010). However, these threats seem to be of limited magnitude within GSVNP. It may be possible that the local population is still recovering from pressures occurred two decades ago before the decree of the park. Alternatively, the population may be naturally limited by the decrease in habitat availability that occurs in the dry season, when most oxbow lakes become completely dry. A third possibility is that the population is suffering indirect impacts from agricultural development around the park, such as high water demand for irrigation, erosion, or pesticide runoff. More studies are needed to elucidate if the low densities of Broad-snouted Caiman are caused by natural or anthropogenic factors. For example, surveying sites under different levels of anthropogenic impact may help to elucidate how caiman abundance is affected by these factors (Shirley et al. 2009; Filogonio et al. 2010), long-term monitoring can reveal if the population is stable or if it is recovering from previous disturbances (Fukuda et al. 2011), and molecular studies can help understanding how micro and macrogeographic variation relates to environmental and anthropogenic factors (Verdade et al. 2002; Villela et al. 2008).

Paleosuchus palpebrosus, on the other hand, was more frequently found in closed-canopy, swiftly-flowing headwater streams, as well as in their associated dams. This is the typical habitat reported for the species (Medem 1967; Campos et al. 2004; Campos and Mourão 2006, Magnusson and Campos 2010). Although a few juveniles were found at large rivers and oxbows, these may represent dispersing individuals. Juveniles of the congeneric *P. trigonatus* are known to disperse for the first 10 to 20 years of life (Magnusson and Lima 1991). Despite the low number of records obtained during spotlight surveys, the species seems to be more abundant than it appears. Our intensive trapping effort at a selected stream resulted in 10 captures of six different adult individuals, while two conventional spotlight surveys conducted at this same site produced only one "eyeshine-only" record. Unfortunately, we could not perform statistical tests for this hypothesis because we conducted intensive trapping at only one site.

The density of 1.7 adult individuals per linear km of stream is within the range reported for the species at other sites (Magnusson and Campos 2010). Though preliminary, our result suggests that conventional spotlight sampling is not the best alternative to study this species, at least at our Cerrado study site. Besides the difficulty posed by the cryptic habits of the species, the logistic effort required to traverse and sample the closed habitats favored by the species is daunting (Campos et al. 2010).

The small number of captures for both species makes it difficult to draw conclusions on their population structure. The predominance of hatchlings and juveniles for *C. latirostris* suggests that the population is growing, but reliable inferences will require long-term data collection and larger sample sizes. The predominance of adult individuals in the *P. palpebrosus* sample may be attributed to two factors: first, trapping is selective for large individuals (Kofron 1989), in contrast to spotlighting that tends to record smaller individuals (Campos et al. 2004); second, upstream sites may be dominated by territorial adults, which may be forcing juveniles and even hatchlings to disperse from these sites at an early stage, as reported for the congeneric *P. trigonatus* in Amazonia (Magnusson and Lima 1991). However, since there was no statistically significant difference in size distribution between species, the considerations above should be viewed with caution.

Besides previous work by Filogonio et al. (2010), this is the first study evaluating the distribution and abundance of caimans in the Cerrado wetlands of the São Francisco basin. Our results seem to confirm that *C. latirostris* is widely distributed, albeit at relatively low population density, in the basin (Filogonio et al. 2010). It also provides relevant data to our current knowledge of the distribution and conservation status of *P. palpebrosus*. Our data suggests that this species may be more abundant that it appears based on conventional spotlight sampling data, and that it may require methodologies designed specifically to deal with its cryptic habits and unreceptive habitat. We recommend more studies to evaluate the comparative efficiency of sampling methods, natural and anthropogenic factors affecting the distribution and abundance of caimans in the region, as well as their conservation status.

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Literature Cited

Campos, Z., and G. Mourão. 2006. Conservation status of the Dwarf Caiman, *Paleosuchus palpebrosus*, in the region surrounding Pantanal. Crocodile Specialist Group Newsletter 25:9–10.

Campos, Z.M.S., M.E. Coutinho, and C. Abercrombie. 2004. Ecologia e status de conservação do jacaré-paguá nas montanhas do Amolar, Pantanal Sul. Embrapa Pantanal Comunicado Técnico 31. Corumbá, Mato Grosso do Sul.

Campos, Z., T. Sanaiotti, and W.E. Magnusson. 2010. Maximum size of Cuvier's Smooth-fronted Caiman, *Paleosuchus palpebrosus* (Cuvier, 1807), in the Amazon and habitats surrounding the Pantanal, Brazil. Amphibia-Reptilia 31:439–442.

Colli, G.R., R.P. Bastos, and A.F.B. Araujo. 2002. The character and dynamics of the Cerrado herpetofauna. Pp. 223–241 *In* The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna. Oliveira, P.S., and R.J. Marquis. (Eds.). Columbia University Press, New York, New York, USA.

Da Silveira, R., W.E. Magnusson, and Z. Campos. 1999. Monitoring the distribution, abundance and breeding areas of *Caiman crocodilus* and *Melanosuchus niger* in the Anavilhanas Archipelago, Central Amazonia, Brazil. Journal of Herpetology 31:514–520.

Da Silveira, R., W.E. Magnusson, and J.B. Thorbjarnarson. 2008. Factors affecting the number of Caimans seen during spotlight surveys in the Mamirauá Reserve, Brazilian Amazonia. Copeia 2008:425–430.

Filogonio, R., V.B. Assis, L.F. Passos, and M.E. Coutinho. 2010. Distribution of populations of

Broad-snouted Caimans (*Caiman latirostris*, Daudin 1802, Alligatoridae) in the São Francisco River basin, Brazil. Brazilian Journal of Biology 70:960–968.

Fukuda, Y., G. Webb, C. Manolis, R. Delaney, M. Letnic, G. Lindner, and P. Whitehead. 2011. Recovery of Saltwater Crocodiles following unregulated hunting in tidal rivers of the Northern Territory, Australia. Journal of Wildlife Management 75:1253–1266.

Jennings, M.L., D.N. David, and K.M. Portier. 1991. Effect of marking techniques on growth and survivorship of hatchling alligators. Wildlife Society Bulletin 19:204–207.

Klink, C.A., and R.B. Machado. 2005. Conservation of the Brazilian Cerrado. Conservation Biology 19:703–713.

Kofron, C.P. 1989. A simple method for capturing large Nile Crocodiles. African Journal of Ecology 27:183–189.

Magnusson, W.E., and Z. Campos. 2010. *Paleosuchus palpebrosus*. Pp. 40–42 *In* Crocodiles. Status Survey and Conservation Action Plan. Manolis, S.C., and C. Stevenson (Eds.). IUCN Crocodile Specialist Group, Darwin, Australia.

Magnusson, W.E., and A.P. Lima. 1991. The ecology of a cryptic predator, *Paleosuchus trigonatus*, in a tropical rainforest. Journal of Herpetology 25:41–48.

Magnusson, W.E., E.V. Silva, and A.P. Lima. 1987. Diets of Amazonian crocodilians. Journal of Herpetology 21:85–95.

Medem, F. 1967. El Género "*Paleosuchus*" em Amazonia. Atas do Simpósio sobre a Biota Amazônica 3:141–162.

Oliveira, P.S., and R.J. Marquis. 2002. The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna. Columbia University Press, New York, New York, USA.

Recoder, R., and C. Nogueira. 2007. Composição e diversidade de Répteis Squamata na região sul do Parque Nacional Grande Sertão Veredas, Brasil Central. Biota Neotropica 7:267–278.

Sarkis-Gonçalves, F., A.M.V. Castro, and L.M. Verdade. 2004. The influence of weather conditions on caiman night-counts. Pp.387–393 *In* Crocodiles - Proceedings of the 17th Working Meeting of the Crocodile Specialist Group. IUCN, Gland, Switzerland.

Shirley, M.H., W. Oduro, and H.Y. Beibro. 2009. Conservation status of crocodiles in Ghana and Côte-d'Ivoire, west Africa. Oryx 43:136–145.

Verdade, L.M. 2001. The São Francisco River 'codfish': the northernmost populations of the Broad-snouted Caiman (*Caiman latirostris*). Crocodile Specialist Group 20:80–82.

Verdade, L.M., A. Larriera, and C.J. Piña. 2010. Broad-snouted Caiman *Caiman latirostris*. Pp. 18–22 *In* Crocodiles. Status Survey and Conservation Action Plan. Manolis, S.C., and C. Stevenson (Eds.). IUCN Crocodile Specialist Group, Darwin, Australia.

Verdade, L.M., R.B. Zucoloto, and L.L. Coutinho. 2002. Microgeographic variation in *Caiman latirostris.* Journal of Experimental Zoology 294:387–396.

Villela, P.M.S., L.L. Coutinho, C.I. Piña, and L.M. Verdade. 2008. Macrogeographic genetic variation in Broad-snouted Caiman (*Caiman latirostris*). Journal of Experimental Zoology 309:1–9.

Ziegler, T., and S. Olbort. 2007. Genital structures and sex identification in crocodiles. Crocodile Specialist Group Newsletter 26:16–17.

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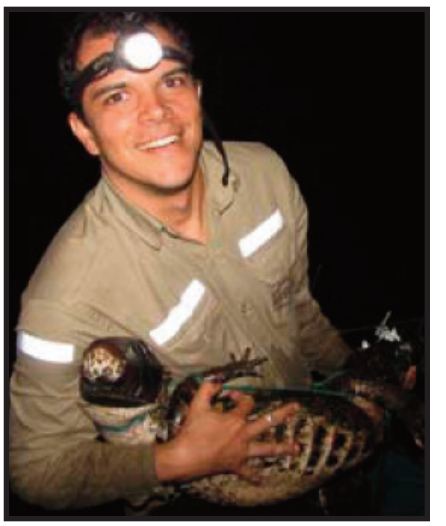

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