

Where are the black caimans, *Melanosuchus niger* (Crocodylia: Alligatoridae), in the Xingu River basin, Brazil?

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The black caiman, *Melanosuchus niger* (Spix, 1825), which can reach a length of 6 meters (Medem, 1981), was considered endangered due to intense hunting for its skin in the 1970s (Rebello and Magnusson, 1983), but densities in several areas have recovered after the implementation of environmental laws and conservation programs (Da Silveira and Thorbjarnason, 1999), as well as changes in contraband routes.

The historical distribution of the species is based on museum locations, literature reports and sightings by reliable researchers (Plotkin et al., 1983), and includes the Amazonian areas of Bolivia, Peru, Colombia, Ecuador, Guyana, French Guiana, and Brazil. The main habitat of the species consists of slow-flowing rivers, lakes and streams, in addition to seasonal savannahs, but the species can sometimes be found in fast-flowing rivers (Medem, 1983). Both the historical distribution recognized by the Interantional Union for Conservation of Nature (IUCN: Thorbjarnason, 2010) and the recent review conducted by the Brazilian government authorities (Marioni et al., 2013) are based on the assumption that the species occurs throughout the Xingu River basin.

The Xingu River is one of the main tributaries of the Amazon River and is about 1,800 km in length (Radam-Brazil, 1978). Its source is in the state of Mato Grosso, and it flows across the Brazilian Shield to the Amazon

River, in the state of Pará. The upper and middle portions of the Xingu River are located in the highlands region of the Brazilian shield, and have rocky substrates and swift running water. In the mid reaches, close to the city of Altamira, the river makes a sharp bend, forming the so-called Volta Grande do Xingu, with an 85 meters high waterfall and smaller falls extending over 160 km, as well as various anastomotic channels (Sioli, 1975). After entering the Amazonian sedimentary plain, the river has sedimentary substrate, calm waters, floods extensive areas of forest, and may be subject to the effect of tides. The Volta Grande do Xingu also represents a biogeographic barrier for aquatic vertebrates, limiting the historical distribution of several species that occur exclusively above or below this geological barrier (Camargo et al., 2004).

This study investigated the presence of *Melanosuchus niger* along the Xingu River, aiming to delimit the occurrence of the species and propose a new map of its geographical distribution.

Material and Methods

We carried out exhaustive nocturnal surveys for black caimans in the Xingu River basin in April, July, and October in 2013, January, April, July and October in 2014 and 2015, and April and October in 2016 and 2017. The surveys were undertaken from the mouth of the Iriri River where it meets the Xingu, in the municipality of Altamira, Pará (PA) to below the Xingu Volta Grande waterfall, between the municipalities of Vitória do Xingu and Senador Porfírio, PA, an area direct and indirect of the Belo Monte dam (Datum WCS 84; 3.23689°S, 51.58853°W). In September 2015, we surveyed the Alto Xingu region in the state of Mato Grosso (MT), along the Culuene River, Paranatinga Municipality, Sete de Setembro River in Canarana Municipality, Batovi River in Salto Alegre Municipality, Rio Ronuro in Água Limpa Municipality, Fontoura River in São

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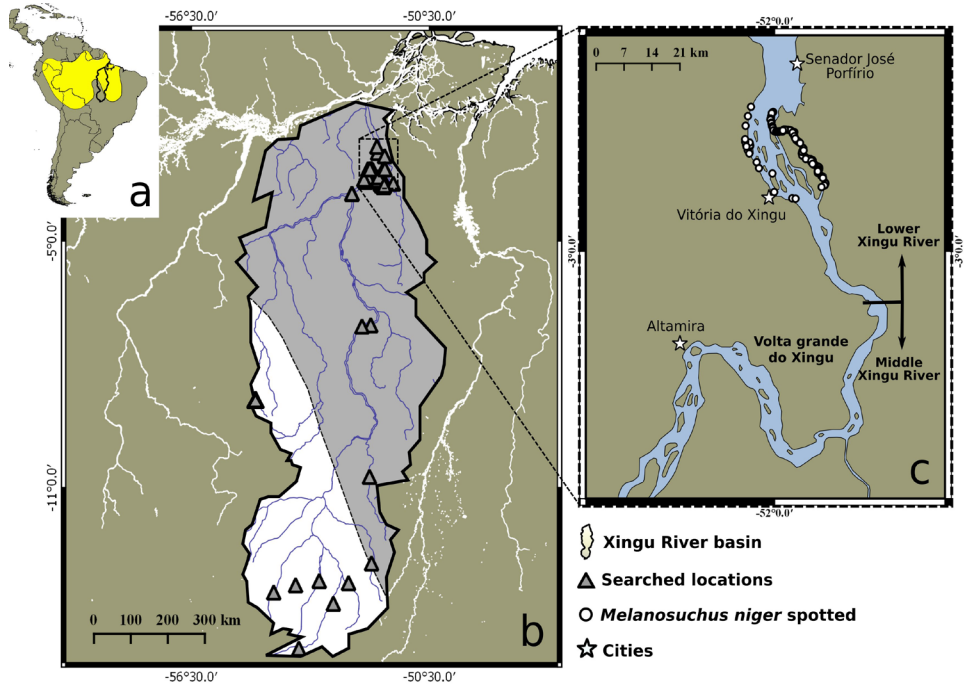


Figure 1. Map of the historical range of *Melanosuchus niger* given in the literature (a), highlighting the Xingu River basin with sampling points (triangle) and extending to the lower and middle Xingu region, in the Volta Grande do Xingu (b). The locations of the black caimans seen during this study were plotted on the map (c).

José do Fontoura Municipality, and Curizevo River in Gaúcha do Norte Municipality. In December 2017, surveys were carried out in the Xingu region, in the area of the Suiá-Miçu River, Querência Municipality, MT, the Curuá and 13 de Maio Rivers, Cachoeira da Serra Municipality, MT, and the Xingu River, São Félix do Xingu Municipality, PA (Fig 1.)

Individuals of crocodylian species were identified after approaching them by motorboat at speeds ranging from 15 to 60 km/h, according to the limitations of the rivers, and each individual was georeferenced using a GPS receiver (Garmin® model GPS map 62). Some individuals were captured and their snout-vent length (SVL, in cm) and body mass (kg) were recorded.

The new distribution map was made using the original shapefile map provided by the IUCN-SSC Crocodile Specialist Group (CSG), with adjustments made to exclude the middle Xingu region in the program QGIS version 2.18.15. The new black caiman distribution area was estimated using the SPRING 4.3.3./INPE program.

Results

The surveys covered approximately 2,120 km of river in different sections of the basin, including the lower, middle and upper Xingu. Above the Volta Grande waterfall, considered to be a region of the middle Xingu, only two species were observed, *Caiman crocodilus* and *Paleosuchus trigonatus*, after an effort of 503 hours during 162 nights of surveys. In the upper Xingu, *C. crocodilus* and *P. palpebrosus* were found in 23.3 hours of survey during 9 nights. In the lower Xingu, below the Volta Grande waterfall, *C. crocodilus*, *P. trigonatus*, *P. palpebrosus* and *Melanosuchus niger* were found in 110 hours of surveys conducted during 34 nights. In this region, between the municipalities of Vitória do Xingu and Senador José Porfírio, 365 individuals of *M. niger* were observed in a stretch of 715 km along the Xingu River, with an observed density of 0.51 *M. niger* per kilometer (Fig. 1). In addition, we captured 29 individuals (20-81.5 cm SVL, 0.15-11.6 kg body mass). *Melanosuchus niger* was sighted at 10 locations below the Xingu Volta Grande waterfall (Table 1). Above the high waterfall, the predominant environment consists of

Table 1. Geographic positions of the 10 individuals Black caiman, *Melanosuchus niger*, counted during surveys, between 2013 to 2017, Lower Volta Grande Xingu, waterfall, Pará, Brazil.

Date	Latitude	Longitude
14/04/2013	2°49.173'S	51°59.126'O
15/04/2013	2°48.219'S	51°59.559'O
17/07/2013	2°48.228'S	51°59.790'O
20/07/2014	2°55.276'S	51°51.844'O
19/07/2015	2°44.227'S	52°0.001'O
04/11/2016	2°46.722'S	52°3.632'O
05/11/2016	2°50.104'S	51°55.652'O
19/10/2017	2°49.066'S	51°53.945'O
19/10/2017	2°44.249'S	51°58.885'O
19/10/2017	2°45.440'S	51°56.985'O

rocky substrate and fast flowing waters (Fig. 2), while that below is mainly slow-moving water and sandy substrate interspersed with vegetated islands (Fig. 3) between rocky banks.

Discussion

Literature reports of the species' distribution include the whole Xingu River Basin, except for part of the Upper Xingu, in the state of Mato Grosso, and the region of Serra do Cachimbo, in Pará, covering a total of 5,981,145 km². Excluding the middle Xingu up to the



Figure 2. Rocky substrates and fast running water are characteristic of the middle and upper Xingu River above the Volta Grande waterfall.

Volta Grande waterfall, reduces the distribution of *M. niger* to 5,704,203 km² (Fig. 4). This is a proportionally small reduction, but the area is very large; in fact, it is larger than or similar in magnitude to the present distributions of several crocodylian species, such as *Crocodylus intermedius*, *C. siamensis*, *C. mindorensis*, and *Alligator sinensis* (Seijas et al., 2010; Simpson and Beuijien, 2010; Van Weerd, 2010; Jiang, 2010).

The geographical distribution of crocodylians is an important tool for establishing conservation actions by region or river basin. This study provided a detailed picture of the occurrence of *M. niger* in the Xingu River basin, based on exhaustive nocturnal surveys along the Xingu River and its tributaries, especially in areas that are directly and indirectly influenced by the Belo Monte hydroelectric dam. There is no historical record of the species in the Xingu River above Volta Grande, and it is our belief that the species never occurred there. The restriction of the distribution of *M. niger* in the Xingu basin to the region below the Volta Grande waterfall in the Xingu River may be explained by the geological barrier that prevented the species from colonizing areas the above the large waterfall in Volta Grande do Xingu, as is the case of other large vertebrates such as turtles, dolphins and manatees (Domming, 1981). In any case, the fast-flowing river with rocky substrate above the waterfall is probably not adequate habitat for the species.

In 2016, as a conservation action two areas were created encompassing the Refúgio de Vida Silvestre Tabuleiro do Embaubal and the Reserva de Desenvolvimento Sustentável de Souzel (RDS), covering 22,950 ha,



Figure 3. Slow moving water in drainage channels between islands with vegetation and sandy substrate are typical of the Xingu River below the Volta Grande waterfall.



Figure 4. *Melanosuchus niger* distribution map showing the reduction in area in the Xingu River basin.

including all the vegetated islands below the great waterfall of the Volta Grande do Xingu, in order to protect aquatic vertebrates such as turtles, crocodylians, dolphins and manatees. These areas will likely protect *M. niger* from hunters and other human actions, but, they may be impacted by reductions in river flow due to the Belo Monte dam, which now represents the geographical limit of the species in the Xingu River.

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