SRAS final report
Pathological, parasitological, hematological and biometrical findings of wild caimans (*Caiman yacare*) in the Brazilian Pantanal

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Abstract

The Pantanal is one of the largest wetlands in the world, with a great diversity of wildlife. Climatic changes recorded in the Pantanal over recent decades represent an abiotic factor that interferes with the entire habitat, including the dynamic population of wildlife. Wild populations of yacare caiman (*Caiman yacare*) are extensively distributed throughout the floodplain. Studies focusing on ecology, feeding, and reproduction are common. However, studies on climatic changes that affect wild populations of caiman in the Pantanal are scarce. This study aimed to investigate the possible effects of prolonged drought periods on the health of wild caimans in the Brazilian Pantanal. The study was conducted along the Transpantaneira highway (MT-060), in the Northern Pantanal, during an extreme drought period (October 2021) and a flood period (October 2022). Necropsies were made during both periods in the field opportunistically. Blood samples, and biometric data were collected from caimans, randomly captured during the study. All animals were weighed, measured and sexed. A total of 170 caimans were sampled across both periods. 13 animals were necropsied, and granulomatous pneumonia, granulomatous tracheitis, intestinal hemorrhage, and intestinal granuloma were some of the anatomopathological findings. Furthermore, five species of helminths were also identified. Blood samples were taken from the other 157 caimans. Statistical analyses indicated that hematological and biometric parameters were significantly better in caimans sampled in 2022 (flood period) compared to 2021 (drought period). This study protocol demonstrates significant potential for monitoring the health and conservation of wild yacare caimans, providing a framework to prevent and mitigate the future effects of climate change on these populations.

Introduction

The Pantanal is situated in the upper Paraguay River basin and is recognized as one of the most extensive seasonal wetlands in the world, comprising a diverse natural habitat for several species (Coutinho and Campos, 2007). The yacare caiman (*Caiman yacare*) is the most abundant crocodilian species in this region, and the high density of its wild populations are attributed to the high-water availability (Mourão et al., 1999). The Pantanal climate is characterized by an annual variation between flood and drought periods, resulting in fluctuations in temperature, rainfall, water levels, and the extent of the flooded area. Prolonged drought periods have been recorded in the Pantanal region since the 1960s. These periods are characterized by a rainfall deficit, lower river water levels, fires, and vegetation modifications (Marengo et al., 2021). Studies have demonstrated that drought periods affect several aspects of the biology and ecology of wild caiman populations in this region, including feeding, thermoregulation, and reproduction (Campos and Magnusson, 1995; Santos et al., 1996; Campos et al., 2003). However, studies about the impact of these drought periods on the health of wild caimans are scarce (Gorza et al., 2025).

Body condition can be defined as an individual's fat or protein reserves and is considered one of the most accessible markers of crocodilian health, where it is possible to relate the length and weight of the animal as a relative indicator of health. Previously, correlations between the body condition of caimans and seasonal changes, dietary composition, male reproduction, and parasite load have been demonstrated (Coutinho, 2000). Hematological studies are essential for evaluating the health status of a species (Lopes et al., 2021). In wild crocodilians, hematological parameters contribute to conservation efforts by providing critical physiological baseline data (Oliveira et al.,

2026). Nevertheless, studies on the hematological parameters of wild caiman populations remain scarce, especially those comparing these parameters across different seasonal periods (flood and drought). The present study goal to investigate the possible effects of prolonged drought periods on the health of wild caimans in the Brazilian Pantanal.

Material and Methods

The study area comprised 128 km along the unpaved Transpantaneira road (MT-060) extending from the urban zone of Poconé (16°15′26″S, 56°37′29″W) to Porto Jofre community (17°19'60.00"S 56°47'59.99"W) municipalities. Sampling was performed from October 5th to 25th in 2021 (drought period) and October 9th to 27th in 2022 (flood period) (Figure 1).

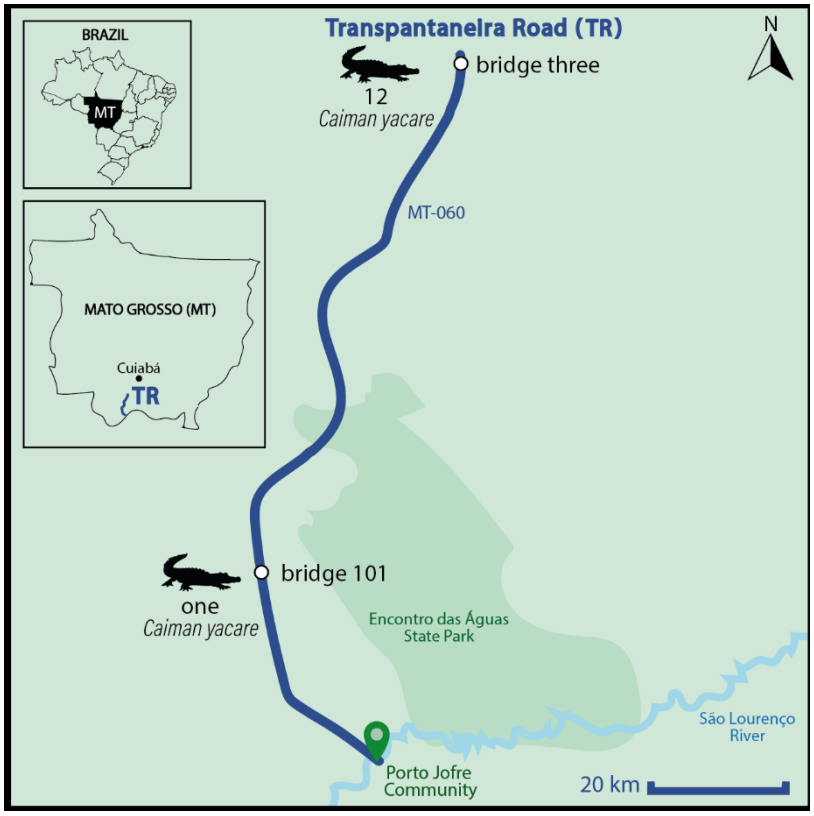


Figure 1. Map of the Transpantaneira road, located in the Brazilian Pantanal (Mato Grosso state, Brazil). Route from bridge three to bridge 101, with the total number of necropsied wild caimans per site. Figure made by Canva.

Necropsies were performed during both periods in the field opportunistically following notification of caiman mortality from governmental entities. All carcasses were weighed, measured (snout-vent length, SVL), sexed (through digital manipulation of the cloaca), and assessed for postmortem and body condition. During necropsy, samples of viscera, including the heart, lung, trachea, eyes, brain, kidney, spleen, liver, esophagus, stomach, and small and large intestine were collected and fixed in 10% neutral buffered formalin. The tissues were processed with routine techniques and sections were cut at 5 µm and stained with hematoxylin and eosin. Parasites found during necropsy were initially preserved in 4% warm formalin for 2 days and then transferred to 70% ethanol. Parasites were identified morphologically using taxonomic keys and previously published descriptive works according to the following taxonomic groups: Acanthocephala; Nematoda; or Pentastomida.

Caimans were randomly captured and appropriately restrained. All animals were weighed, measured, and sexed. Body condition score (BCS) was calculated based on biometric measurements (Fulton's Index- K). The BCS of the captured caimans was also compared to necropsied animals, found at the same location. Blood samples were taken from the occipital venous sinus after a local antisepsis. Heparin tubes and tubes with clot-activating substances were used for blood collection, manually homogenized, and stored in a thermal box. The complete blood count included hematocrit (Ht), hemoglobin (Hb), total red blood cell counts (RBC), total white blood cell counts (WBC), and total thrombocyte counts (Thromb).

The descriptive analysis encompassed the means, ranges, and standard deviations of the biometric and hematological parameters. Normal distribution of data was assessed with the D´Agostino and Shapiro-Wilk tests. The univariate inferential analysis included tests for comparing means or medians, according to the fulfillment of the assumptions of normality of the obtained data. General Linear Models were used to investigate the influence of the independent variables (period and collection location) on the body condition score and on the matrices of hematological parameters by Multivariate Analysis of Variance. The correlation between categorical and quantitative body condition score measures was evaluated using the Spearman's Rank Correlation Test. Differences were considered significant when $p < 0.05$. The Fulton's Index was used to describe the quotient between body mass and the SVL, and was also used as a quantitative marker of BCS. In order to investigate the inter annual differences in individual BCS, including those that were necropsied in the same period, we used the residual of the allometric relationship between body mass and size, given in SVL. The analysis of residuals in allometric relationships examines the differences between observed and predicted values (log transformed) in the body mass*size model. The residuals, with positive or negative values, provide information on whether each individual is under or above its expected value, which was used to infer individual BCS. The statistical analysis was performed using R software version 4.3.0 (R Core Team, 2023). Results are presented as mean ± standard deviation (SD).

Results

A total of 170 caimans were sampled across both periods.

Thirteen caimans were necropsied: twelve in 2021, and one caiman in 2022. The average SVL of the necropsied caimans in 2021 were 1.14 ± 0.13 m, ranging from 0.78 m to 1.33m, and the average weight was 23.64 ± 5.38 kg, ranging from 31.5 kg to 10.10 kg. The necropsied caiman in 2022 presented SVL of 0.66 m and weight of 9.0 kg. The cohort was composed of 12 males and one female.

According to the classification proposed by Coutinho (2000), eleven caimans were adults, one sub-adult and one young-adult. Pulmonary granulomas were present in ten caimans as characterized by large areas of parenchymal effacement by variable numbers of epithelioid macrophages and fewer multinucleated giant cells and granulocytes arranged concentrically, frequently surrounding aggregates of abundant eosinophilic amorphous material. In seven of these caimans, granulomatous inflammation was associated with pentastome nymphs and ova. Adult pentastomes were also observed in the lung without an associated inflammatory response. No microorganisms were identified in this inflammation with histochemical stains. Mixed interstitial pneumonia (composed of mononuclear cells and granulocytes) as well as pulmonary edema were each observed in a single caiman. Granulomas were also present in the trachea of a subset of caimans and were sometimes associated with pentastome fragments. Granulomatous gastritis was observed in three caimans. Small spherical and operculated endoparasite ova were found in the gastric lumen in three animals. Different larval stages were also present in the gastric mucosa of one animal. Intestinal granulomas were identified in five caimans, mainly in the muscular layer. In a single caiman, an adult acanthocephalan was noted within the submucosal/mucosal layers but was not associated with appreciable inflammation. Lymphocytic and granulocytic hepatitis was noted in a single caiman. In the cardiovascular system, the heart of one caiman contained

both granulomas and granulocytic endocardial inflammation (endocarditis) associated with numerous aggregates of coccoid bacteria. A single caiman possessed renal intratubular helminths, morphologically suggestive of trematodes. A total of five species of parasites were found; and the species *Polyacanthorhynchus rhopalorhynchus* (Acanthocephala: Polyacanthorhynchidae), *Leiperia gracilis* (Pentastomida: Sebekidae), and *Alofia platycephala* (Pentastomida: Sebekidae) were the most frequent.

Blood samples were collected from the remaining 157 caimans: 72 in 2021 (36 females and 36 males) and 85 in 2022 (45 females and 40 males). The SVL ranged from 45.0 to 144.0 cm in 2021 and 37.5 to 107.0 cm in 2022. Body mass ranged from 2.0 to 50.0 kg in 2021 and 1.8 to 35.0 kg in 2022, and showed a significant difference between the two time frames. However, the SVL did not.

Despite this, the distribution of age groups based on the SVL was significantly different (X2 = 8.5651, df = 3, p-value = 0.03567) between the two studied periods. The Mann-Whitney U Test found a significant difference in K values between the two periods (U =1129, p <0.000). Moreover, Spearman´s Test showed a significant and moderate correlation between visual BCS and Fulton´s Index values (S = 426961, p-value = 1.495e-05, rho =0.3380003), corroborating the sensibility of the visual scores as an evaluation method in 2021 (Figure 2).

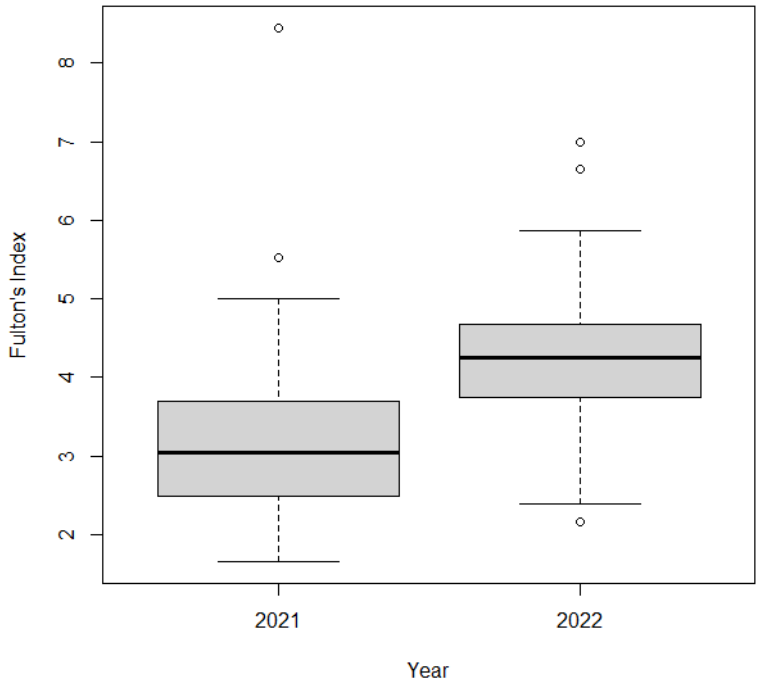


Figure 2. Caiman assessment during an extended drought in the Brazilian Pantanal. Boxplot of body condition score (BCS) by FI, indicating a significant median difference between sampling periods (U = 1129, p < 0,000).

The mean residuals of all caimans' relationships was 0.0±0.025, whereas the mean residuals of the 13 necropsied animals was -0.176±0.049. The mean residuals of viable yacare caiman captured in 2021 was -0.158±0.030, whereas the mean residuals of the ones captured in 2022 was 0.188±0.029. Data about hematologic values are presented at Table 1. MANOVA results indicated that higher water depth positively influenced the matrix of hematological parameters (Df=1, Sum of squares=1086764050, R2= 0.19635, F=31.029, p= 0.001).

Table 1. Hematologic values (mean ± SD) registered in wild yacare caiman, during a drought (2021) and flood (2022) periods.

		Year	
	Units	**2021**	**2022**
Hematocrit	%	19.71 ± 5	23.8 ± 6.8
Hemoglobin	g/dL	0.18 ± 0.04	0.20 ± 0.03
Total red blood cell counts	$x10^4$cells/µL	86.5 ± 31	150 ± 31
Total white blood cell counts	$x10^4$cells/µL	30.55 ± 14.7	52.9 ± 27.7
Total thrombocyte	$x10^3$cells/µL	48.05 ± 50.4	53.2 ± 25

Discussion

The annual drought and flooding periods represent one of the most important natural characteristics of the Pantanal, and the occurrence of each season is dependent on rainfalls and water levels in the Paraguay river (Alho and Silva, 2012; Marengo et al., 2012). The extreme drought period in the Brazilian Pantanal occurred as a consequence of low rainfall periods and high environmental temperatures during the summer of 2019 and 2020 (Marengo et al., 2021).

The most frequent lesion diagnosed in the respiratory system of necropsied caimans was granulomatous pneumonia, often associated with eggs and pentastome fragments presumed to represent *Alofia platycephala* (Sebekidae). Other pentastomes of the family Sebekidae have been documented as an important cause of pulmonary damage in crocodilians (Adams et al. 2001; Cardoso et al. 2014; Woodyard et al. 2019). Granulomatous tracheitis, associated with another Sebekidae pentastome, *Leiperia gracilis*, was another important finding. While tracheal helminths of crocodilians have been previously reported (Junker et al. 2016), only parasites were documented and not the host tissue response associated with them. This report is the first to document potential tissue damage and reaction in response to *L. gracili*s in free-ranging crocodilians. Intestinal nematodes (*M. vazi* and *O. alata*) and acanthocephalans (*P. rhopalorhynchus*) were frequently found in necropsied caimans. These species of helminths are well described in free-ranging yacare caiman; however, prior reports did not document the tissue reaction in the caiman (Catto and Amato, 1994; Lopes et al. 2019). In our study, intestinal hemorrhage associated with *P. rhopalorhynchus* was observed in a small proportion of caimans. This acanthocephalan has a proboscis with several hooks, which facilitate its blood feeding habit (Núñez and Drago, 2017), and may explain the hemorrhagic lesions. Intestinal granulomas were also observed and although we did not detect associated parasites, we cannot rule out that these granulomas may also be related to mechanical trauma caused by the proboscis of *P. rhopalorhynchus* (Núñez and Drago, 2017).

Regarding the 157 analyzed caimans, statistical difference in the BCS was observed between the two seasons. This date demonstrated a difference between the body mass in the two seasons in caimans with the same average size, demonstrating a positive influence of the water depth at Ladário gauge. The GLM results indicated a positive influence of higher water levels in the K values observed in 2022. The hematological parameters showed significantly higher in 2022. In adult caiman congeners, the reference blood values were Ht 20-30% and Hb 6.3-10.3 g/dL, which confirmed anemia during the dry season (Lopes et al., 2021). Also, based on these authors, RBC and WBC in the 2021 sample would be below the reference values or close to their lower limits, reaching normality in 2022. The MANOVA results demonstrated a positive influence of the 2022

floods on the hematological matrix. The floods increased water and food supplies, which corrected dehydration, protein, and vitamin deficits in the sampled individuals.

Conclusions

The present study showed that wild caiman in the Brazilian Pantanal can be susceptible to different pathogens, mostly represented by pulmonary parasites. Wild caimans had significantly higher body scores and better hematological parameters in flood period compared to drought period. Prolonged drought is an abiotic factor that affects wild caiman health.

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