

Emergence behaviour of yacare caimans (*Caiman crocodilus yacare*) in the Brazilian Pantanal

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We studied the emergence and basking behaviour of Pantanal caimans (*Caiman crocodilus yacare*) in relation to temperature. In the cold season, caimans were exposed to the sun, and air temperatures higher than water temperatures suggest that emergence behaviour may be due to thermoregulation. In the dry season, most (66%) emergent caimans were found in the shade between 1000 and 1500, and body temperatures rarely exceeded water temperatures. Caimans also emerged at night, although body temperatures were highly correlated ($r=0.974$, $P<0.001$) with water temperatures, suggesting that emergence is related to factors other than thermoregulation.

Key words: basking, conservation, Pantanal caiman, social behaviour

Crocodilians are aquatic ectotherms with low metabolism that use behavioural and physiological mechanisms to thermoregulate (Smith, 1976). Evidence exists that climatic conditions, social interactions and reproductive status influence their thermal behaviour (Lang, 1987). Basking behaviour has been described for crocodiles (Loveridge, 1984; Downs et al., 2008) and caimans (Thorbjarnarson, 1995; Campos et al., 2005). Water plays an important role in crocodilian thermoregulation by minimizing ambient fluctuations that could result in extreme body temperature (Smith, 1979). Basking and shuttling behaviour of crocodilians between air and water and between places exposed to sun and shade may serve for thermoregulation (Seebacher et al., 1999), but can also occur for reasons such as retarding the growth of epiphytes and fungi on the skin (Moll & Legler, 1971), social behaviour that results in movements between land and water (Lang, 1987), or a strategy for vitamin D synthesis (Pritchard & Greenwood, 1968).

Campos et al. (2005) reported that the Pantanal caiman, *Caiman crocodilus yacare*, appeared to vary from thermoconformity in the warm season to active thermoregulation when water temperatures were below 28 °C, yet emergence behaviour occurred in both seasons. Thus, the thermoregulatory significance of emergence for wild caiman is unclear. This ambiguity led us to investigate the emergence patterns of hatchling and adult caimans in lakes and intermittent rivers in the Brazilian Pantanal.

The study was undertaken in the Taquari River alluvial fan, Nhecolândia region, southwestern Brazilian Pantanal. The climate is seasonal, with a warm, rainy season from October to April. The period from May to September is dry, and cold fronts from the south cause abrupt falls in air temperature. Campo Dora Ranch (18°55'S, 56°40'W; elevation 60 m) consists of a mosaic of open pastures used for livestock grazing and gallery forest, drained by intermittent rivers, and containing a few lakes. Nhimirim Ranch (18°59'S, 56°39'W; elevation 60 m) is characterized by small, shallow (<2.0 m) lakes surrounded by open pastures and forest patches. Pastures are flooded during the wet (warm) season, but during the dry (warm or cold) season water remains only in the larger lakes and in pools formed in the intermittent river channels.

We studied the basking behaviour of two clutches of hatchling caimans by direct observation from a distance of more than 10 m. Hatchlings were approached carefully and showed no response to the presence of the researcher. One clutch of 28 hatchlings in Nhimirim Ranch was studied in the wild, and a clutch of 25 individuals was observed in captivity. Individuals were considered to be emergent when they were partly or completely out of water. Observations were made between 0600 and 1800 over two and three days in August 1997 (see below) for wild and captive hatchlings, respectively. The number and location of hatchling exposed to the sun were recorded at hourly intervals. We measured air (T_{air}) and water temperature (T_{water}) with a digital thermometer during observations, and additionally recorded T_{air} (shady places on the margins of lakes and rivers at 1 m above ground) and T_{water} (10–15 cm below the surface) with StowAway™ dataloggers (Onset Computer, 470 MacArthur Blvd, Bourne, MA 02532, USA). The 25 captive hatchlings were observed in a 2 × 5 m area of a natural lake that had a small artificial sand beach and was fenced with wire mesh. We recorded the total number of caimans observed, the positions of caimans (on land or in water, and in sun or in shade) and the number of caimans vocalizing every hour. We scored the position of each caiman by the location of the trunk. Aggressive interactions among individuals were also recorded. In one lake on Nhimirim Ranch, we observed the sun exposure of adult caimans in the cold season on eight days in June and July 1998, and on three consecutive days in October 1998 (see below). The proportion of caimans in the sun at each hourly interval was obtained from the number of caimans known to occur in the lake (Campos et al., 1995).

In Campo Dora Ranch, which had water bodies with unvegetated margins, adult caimans could be directly observed in water and on land. We made observations of emergence behaviour over a 3 km river stretch in Campo Dora on nine days during June and July 1999, six consecutive days in October 1999 and seven consecutive days in November 1999. T_{water} and T_{air} were measured at one-hour intervals with StowAway™ data loggers using the same protocols as described above. We lacked data loggers in the river area in October–November 1999, and T_{air} data

were obtained from the Nhumirim Meteorological Station at 0800, 1400 and 2000 on each day.

We obtained further data from caimans that we hand- or noose-captured at night in the river at Campo Dora between August 1996 and September 1999. Within 5 min of each capture, we measured air (in the boat), water (depth about 30 cm) and cloacal temperatures (introduced about 3 cm into the cloaca) with a digital thermometer. Only caiman captured at least 30 min after sunset were used in night analyses. Statistical analyses were done using SYSTAT 8.0. We summarize data as means and standard deviations.

Activity of hatchling caimans in the wild clutch were marginally but significantly different between the two days of observation (Wilcoxon signed-rank test, $P=0.051$). On 27 August, peaks of activity in the sun occurred in the morning and evening (Fig. 1A), whereas on 28 August most individuals were exposed to the sun in the middle of the day (Fig. 1B). Hatchlings in the enclosure also varied greatly in their pattern of exposure. On 28 July, most hatchlings were exposed to the sun in the afternoon (Fig. 1C), whereas on 16 August most hatchlings were exposed to the sun in the morning (Fig. 1D). On 17 August, peaks in emergence occurred in the morning and evening (Fig. 1E). Despite differences in behaviour between days, variations in T_{air} and T_{water} were similar among sites and days (Fig. 1F–J).

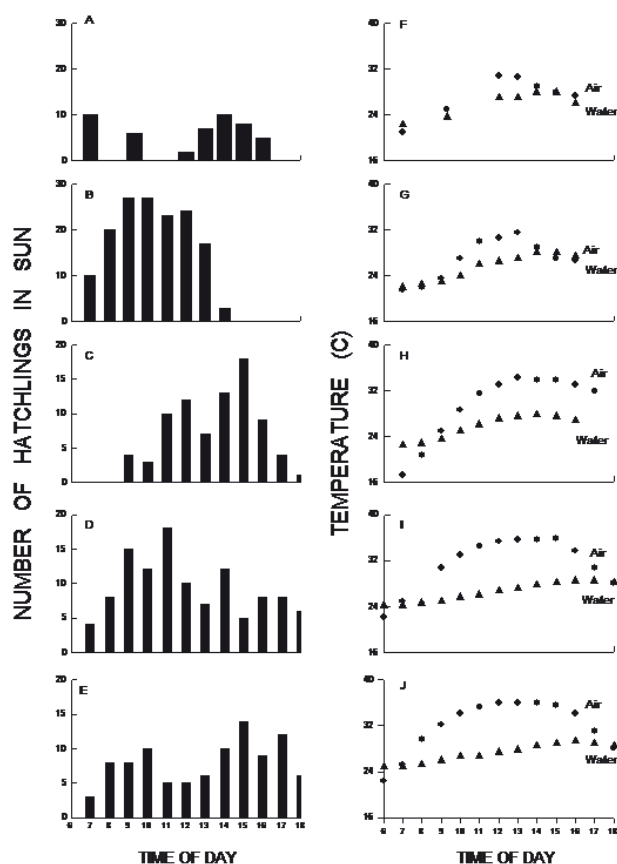


Fig. 1. Basking activity of hatchlings in the field (A, B) and in captivity (C, D, E), with air (\bullet) and water (\blacktriangle) temperatures on the days of observation during the cold season.

In the lake area, the proportion of emergent adults exposed to the sun varied across the day (Fig. 2A). Most individuals remained in floating vegetation during the warmest period (1100–1300). Terrestrial activity varied across the day in both seasons (Fig. 2B,E). During the cold season, more than half of the caimans remained exposed to the sun (Fig. 2G,H), whereas they showed distinct peaks in exposure to the sun in the mornings and evenings in the warm season. At midday, when air and water temperatures were high, caimans used shady areas (Fig. 2L).

Vocalizations and aggressive interactions occurred in the early mornings in the warm season, coinciding with the lowest daytime temperatures. The peaks in these behaviours occurred between 0700 and 0800 ($S=1.03$) and between 0800 and 0900 ($S=1.25$), respectively. There was also a peak in emergence at this time (Fig. 2K). No aggressive interactions were recorded in the afternoon. Males communicated through strident sounds that anticipated aggressive acts, and vocalizations were often made in duets. When an adult male (>90 cm SVL) vocalized, another individual would vocalize almost immediately. Most aggressive interactions were chases; typically large males (approximately 90–120 cm SVL) chased smaller animals (approximately 60–70 cm SVL) on pool margins. The pursuit generally continued until the smaller animal entered deep water.

We obtained body temperatures for 739 caimans of different sizes (SVL 74.0 ± 20.4 cm, range 14.5–120 cm; mass 10.7 ± 6.9 kg, range 0.04–43.0 kg) at night. Air temperatures fluctuated widely in the period from May to September, and warm days often alternated with cold days. Mean daily air temperatures varied between 20.4 °C (May 1998) and 30 °C in September 1999 (Fig. 5A). No cold fronts were recorded in April or September 1998. During the remaining months, mean air temperatures remained around 30 °C. Mean body temperature at night varied from 24.9 °C to 33 °C (Fig. 5B). Over the 28 months of this study, mean monthly temperatures of caimans recorded at night were strongly correlated with mean monthly air ($r=0.832$, $P<0.001$) and water temperatures ($r=0.974$, $P<0.001$).

Captive and wild hatchling *C. c. yacare* showed different daily patterns of sun exposure on different days, despite similar environmental temperatures. Crocodilian hatchlings group to avoid predation and increase feeding efficiency independent of thermoregulation (Lang, 1987). As body temperatures of hatchlings were not measured, we could not determine the effect of sun exposure. However, hatchlings of thermophilic crocodilians tend to reduce their body temperatures after one month (Lang, 1982, 1985). Grigg & Gans (1993) considered crocodilians to be primarily thermoconformers, similar to small marine turtles (Read et al., 1996).

Crocodilians utilize aquatic and terrestrial habitats differently across the daily cycle (Lang, 1976). In the warm season, caimans spent more time in the shade than exposed to sunlight irrespective of habitat. Radio-telemetry data showed that, in the warm season, caiman body temperatures are similar to water temperatures irrespective of whether caimans are on land or in water and whether

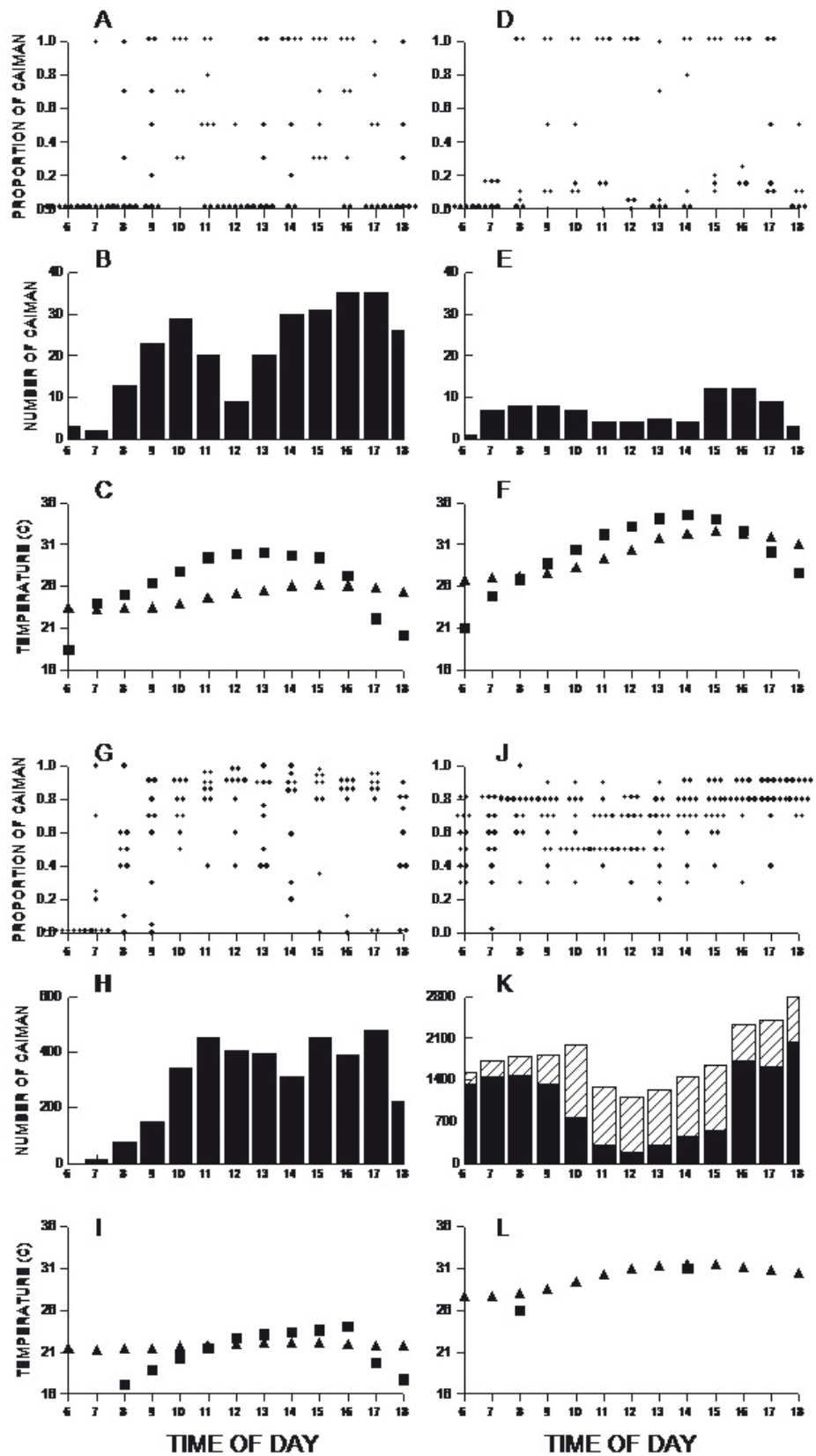


Fig. 2. Proportion of caimans exposed to direct sunlight during each day of observation in the lake area in cold (A) and warm (D) seasons. Diurnal pattern of basking in cold (B) and warm (E) seasons in areas with floating vegetation. Variation in air (■) and water (▲) temperatures in cold (C) and warm (F) seasons. Data presented are daily means for 8 days during the cold season and 3 days during the warm season. Proportion of caimans exposed to direct sunlight each day of observation in the river area in cold (G) and warm (J) seasons. Diurnal pattern of exposure on land in cold (H) and warm (K) seasons in sun (black bars) and shade (striped bars) and variation in air (■) and water (▲) temperatures in cold (I) and warm (L) seasons. Data presented are daily means for 9 days during the cold season and 6 days during the warm season.

they are exposed to the sun or not (Campos et al., 2005), and the thermal effects of shuttling are unclear. In the cold season, body temperatures on land can be up to 15 °C higher than water temperature, but rarely exceed air temperatures (Campos et al., 2005). On warmer days in the cold season, caimans remained exposed to the sun (on land or in water), and on cold days they remained in the water. Therefore, shuttling between land and water in the cold season may be related to thermoregulation, but the role of insolation as opposed to thigmothermy is unclear.

Social interactions among caimans during the warm season occurred mainly in the morning, when most caimans were in water and air and water temperatures were low. Vocalizations were often made in duets and chases occurred in this period. High frequencies of social activities at low body temperatures in the morning are characteristic for other crocodilians. Lang (1987), Grigg et al. (1998) and Seebacher & Grigg (1997) also observed aggressive behaviour in *Crocodylus johnstoni* during putative basking. This may be because higher temperatures are not required during social interactions, or because social interactions generally have lower priority than, for example, feeding when body temperatures are high.

Environmental temperatures during the study reflected the seasonally unpredictable temperatures in the Pantanal. The mean body temperature of caimans after dusk varied seasonally, and it is likely that caimans did not attempt to or were unable to thermoregulate. It is likely that shuttling and apparent basking behaviour have thermoregulatory significance for caimans in cold periods during the day in the dry season. However, similar behaviours occur during warm periods as well as at night, when there is apparently no thermoregulatory advantage to leaving the water. At night, when caimans are presumably hunting, body temperatures are strongly correlated with water temperatures, indicating that shuttling has little effect on thermoregulation. Therefore, much of the shuttling between land and water by Pantanal caimans appears to have little to do with thermoregulation, and other factors such as the avoidance of aquatic pathogens should be investigated (Campos et al., 2005).

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