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Observations on breeding site, bioacoustics and biometry of hatchlings of *Paleosuchus trigonatus* (Schneider, 1801) from French Guiana (Crocodylia: Alligatoridae)

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Dwarf forest crocodilians are difficult to study in the field on account of their very secretive habits, which makes it very hard to find and follow in dense tropical forests. Consequently, their biology and ecology remain largely unknown (Magnusson et al., 2010). *Paleosuchus trigonatus* is the least known of the two species of the genus, with only few studies conducted in the field, often with a small sample size, and mostly focusing on the Amazon Basin populations (e.g., Magnusson et al., 1985; Magnusson and Lima, 1991; Magnusson et al., 1997; Morato et al., 2011). Despite being widespread and locally common in preserved habitats in French Guiana, there are still few data on the populations of the Guiana Shield (e.g., Lemaire et al. 2018). In other parts of its distribution, the species suffers from forest fragmentation and habitat degradation (Magnusson and Campos, 2010).

This note reports a field observation of a breeding site of *Paleosuchus trigonatus* in the protected area "*Réserve Naturelle Nationale des Nouragues*" in French Guiana. It includes a description of its nest, hatchlings and habitat, with an emphasis on hatchlings' vocal signal. It also reports the result of a playback experiment on an adult. The observations were made during a research mission to the northeast quarter of the reserve (9,500 ha far from any human disturbance), at an international research station managed by the French National Centre for Scientific Research (CNRS). The observations focused on the "*Crique Cascade*", a stream about 100 km southwest of the town of Cayenne, running 1 km through the "Inselberg Camp".

On the 15th of November 2017, at approximately 2130 h, 15 young caimans were located in the creek, in an area of approximately 70m^2 (4.0667°N, 52.6833°W; Datum WGS84; 20 m elevation), partially hidden in the aquatic vegetation dominated by *Thurnia sphaerocephala*. Despite of the shape irregularity of the banks, we measured this part of the creek to be approximately 6 m wide in its wider part and 40 cm deep in its deepest section (measured with a tape to the nearest cm). The water was running at approximately 0.25 m/s (calculated by the time spent to a 5 cm piece of wood to float 1 m in the water) and its temperature was 26.0°C (measured with a digital thermometer to the nearest 0.1°C). The animals were captured by hand and identified as *Paleosuchus trigonatus* based on dorsal scalation between the posterior limbs (Dewynter et al., 2016). We recorded calls from 11 of the 15 young caimans while holding them with the recorder positioned at 20 cm from the animal's snout (digital recorder: ZOOM H4N with built-in microphones; sampling frequency = 44.1 kHz, 16 bits of dynamic).

Animals were brought to the basecamp for biometric data collection. Their weight was determined with an electronic scale (precision ± 0.01 g). A measuring tape was used to take the snout-vent length (SVL) and the total length (TL) to the nearest mm. Mean weight of the 15 animals was 49.45 g ± 1.98 g (min = 44.98g, max = 52.26g). Mean SVL was 12.5 cm ± 0.3 cm (min = 12.0

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cm, max = 13.0 cm) and mean TL was 23.6 cm ± 0.5 cm (min = 22.7cm, max = 24.3cm). These values indicate that the individuals were neonates comparing with the values taken from five 3-month-old animals by Rivas et al. (2001). All animals were released exactly where they had been captured.

Near this site, two adult individuals were observed. The first one was located in a cave approximately 10 m upstream from the site where the young were found. We were not able to catch this individual, but we suspected it to be a female and possibly the mother of the neonates (see the playback experiment paragraph). The second one had been found approximately 140 m downstream from the neonates' location. It was captured and identified as a male of 143 cm (TL), weighting approximately 17 kg.

On the 16th of November 2017, five meters from the bank where the neonates had been discovered, the remnant eggshells of a recent nest were found. We believe that nest to be the neonates' origin. It was made out of dead vegetation and measured about 140 cm of diameter and nearly 60 cm of height (measured with a tape to the nearest centimetre) and was located adjacent to a big tree (Figure 1). One eggshell was found nearly intact measuring 67.1 mm of length and 41.2 mm of diameter (measured with a calliper to the nearest 0.1 millimetre).

Figure 1. Nest of *Paleosuchus trigonatus* in the Nouragues natural reserve, French Guiana (4.0667°N, 52.6833°W; Datum WGS84; 20 m elevation). Position indicated by the red circle. Arrows indicate remains of the eggshells.

We used the PRAAT signal analysis software (Boersma 2001) and Seewave R package (Sueur et al., 2008) (see Chabert et al., 2015 for details on the acoustic analysis method and parameters). The calls' structure was analysed using a set of 14 variables describing the distribution of energy among the frequency spectrum, call pitch, and call duration. We followed Chabert et al. (2015) to choose the most explanatory variables related to the spectral content of the call. Except for call duration, no other measurements were taken on the oscillogram, since variations in amplitude are highly dependent on recordings conditions (Gerhardt 1998). We did not describe the emission rate of the calls because, according to our experience, it is a feature that shows high variation depending on the recording context, which in this study included handling the specimens. There is no published paper on this aspect, but we know by experience that the "emission rate" of distress calls depends on factors that are either independent of the animal (for instance, how long you handle the crocodile and how you do it) or dependent on its motivation state. Also, we believe the emission rate is highly variable between individuals. Some individuals are very talkative, and produce many distress calls easily, while others are more reluctant to produce these calls. We have observed this differential behaviour in all the crocodilian species that we have studied.

The call shows the typical, complex structure of a juvenile crocodilian distress call (Vergne et al., 2009). It is a modulated harmonic series spreading over a large frequency bandwidth, from 200 to 3,000 Hz. The frequency modulation is pronounced, with a short upward at the beginning of the call and then a downward part. The energy is mostly concentrated on a 500-1,500 Hz bandwidth. Call duration is around 160 ms (Table 1; Figure 2). Although most of the acoustic parameters are within the range described for other crocodilian newborn distress calls, pitch values are somewhat low (Table 1) when compared to other crocodilian species. For example, Chabert et al. (2015) report a mean pitch of, respectively, 376, 432, 456 and 593 Hz for juveniles of *Caiman crocodilus* (Linnaeus, 1758), *Crocodylus intermedius* (Graves, 1819), *Crocodylus niloticus* Laurenti, 1768, and *Alligator mississippiensis* (Daudin, 1802). Lower pitch values are often related to greater body sizes, however, once the newborns we recorded are in the same range of body size (20-40 cm) as the specimens recorded by Chabert et al. (2015), we suggest that a lower pitch could be a specific feature of the vocalizations of *P. trigonatus neonates*.

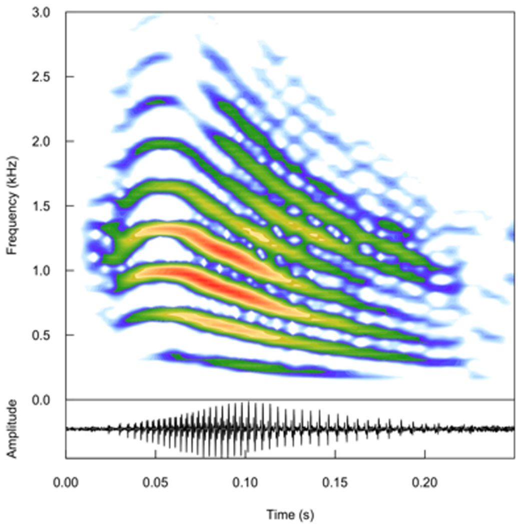

Figure 2. Spectrogram (top) and oscillogram (bottom) of single call of a representative neonate of *Paleosuchus trigonatus* from French Guiana (graphical representation produced with the R package Seewave [Sueur et al., 2008]).

To test for the adult responsiveness to neonates' distress calls, we played back a mix of calls from a remote-controlled loudspeaker (FoxPro Fury©). All played back calls were previously recorded from the neonates described here (including calls from different individuals). The total duration of the playback was 2.5 minutes nonstop, with a call rhythm of 40-50 calls/minutes. This rate was similar to the calling rate of newborns during the recordings. Prior to the playback, the loudspeaker was placed near some neonates, approximately 20 meters from the adult in the cavern. The adult responded immediately and strongly as soon as the playback started, hissing and getting out of its cavern. Due to that behaviour, we suspected it to be a female protecting its offspring. However, it might have noticed our presence since it retreated rapidly and did not respond again. The newborns did not move and remain silent during the playback. Such immobility in newborns during playback of distress calls has already been reported during field experiments in the black caiman *Melanosuchus niger* (Spix, 1825) (Vergne et al. 2011).

Given our observations, this area seems to be a potential nursery site for *Paleosuchus trigonatus*, with a small stream and aquatic vegetation, which is essential to allow neonates to hide from predators. The presence of a cave offers the adult caiman a position to monitor the nursery area while remaining safe from predators. Moreover, the adult behavioural response to played back calls of newborns suggests that this species may have parental care.

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Table 1. Acoustic variables of the calls of *Paleosuchus trigonatus* neonates (11 individuals, 7 calls per individual). MP = mean pitch; SP = start pitch; MXP = max pitch; MIP = min pitch; EP = end pitch; MF = maximal frequency; Q25 = first quartile of energy (frequency value corresponding to 25% of the total energy spectrum); Q75 = third quartile of energy (frequency value corresponding to 75% of the total energy spectrum); IQR = interquartile range (difference between Q75 and Q25); CENT = centroid of the frequency spectrum; SK = skewness; KURTOSIS = measure of spectrum peakedness; SFM = spectral flatness (ratio between the geometric mean and the arithmetic mean of the spectrum); SD = Standard Deviation.

Acoustic variables	MP (Hz)	SP (Hz)	MXP (Hz)	MIP (Hz)	EP (Hz)	MF (Hz)	Q25 (Hz)	Q75 (Hz)	IQR (Hz)	Cent (Hz)	SK	Kurtosis	SFM	Duration (s)
Mean	223	244	296	113	113	854	786	2263	1478	1660	1.55	4.92	0.652	0.164
Min.	135	98	164	77	77	435	652	1435	739	1322	0.58	2.08	0.484	0.135
Max.	282	384	388	208	208	1130	1043	3783	2870	2579	2.89	12.8	0.840	0.296
SD	39	78	56	29	29	163	91	674	602	296	0.40	1.85	0.102	0.04

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