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Clutch size of *Caiman latirostris* (Crocodylia: Alligatoridae) varies on a latitudinal gradient

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Abstract. The distribution of the Broad-Snouted Caiman (*Caiman latirostris*) ranges from 5°S to 32°S. Thus, caiman populations are exposed to different climatic conditions, and this latitudinal gradient could affect aspects of their reproduction. In this study we present evidence that there is a positive relationship between clutch size and latitude. A possible effect of smaller clutch size on populations from low latitudes could be increased nesting frequency, thus improving female fitness.

Key-words: Broad Snouted Caiman, Latitude, Reproductive frequency, Crocodilian reproduction, Fitness

Caiman latirostris (Broad-Snouted Caiman) has a broad latitudinal distribution in South America from 5°S to 32°S. This species is found in Argentina, Bolivia, Brazil, Paraguay, and Uruguay (Verdade et al. in press). In Argentina, the northernmost populations of *Caiman latirostris* are located in Formosa province; on the other hand, the southernmost distribution of the species is Santa Fe province (31ºS; Piña et al. 2004) (Fig. 1). Caiman populations inhabitating this latitudinal range are exposed to different weather conditions (Table 1). From Santa Fe city (31° 35'S, 60° 11'W) to Formosa city (26° 11'S, 58° 10'W) there are 650 Km in a South – North direction. Thus, Broad-Snouted Caiman populations are exposed to differences in winter intensity in this latitudinal gradient. Moreover, it is possible that this decrease in temperatures could be the cause of the southern distribution limit of the species in Argentina (Siroski 2004), reducing the length of the high temperature period for reproduction or somatic growth, as reported by Lance (2003) for American alligators *Alligator mississippiensis*.

Larriera (1991, 1994) and Verdade (1995, 1997) have reported differences in clutch size of *C. latirostris*, in different geographical areas (Santa Fe province, Argentina; and São Paulo state, Brazil). Clutch sizes from Santa Fe were larger, but the origin of the studied nests was not similar; the ones from Argentina came from wild populations, and the Brazilian ones were collected in captivity. However, variation in clutch size within a latitudinal range in crocodilians was previously described for *Alligator*

mississippiensis (Wilkinson 1983). In the present study, we evaluated the effects of latitude on *C. latirostris* clutch size from wild populations in Argentina.

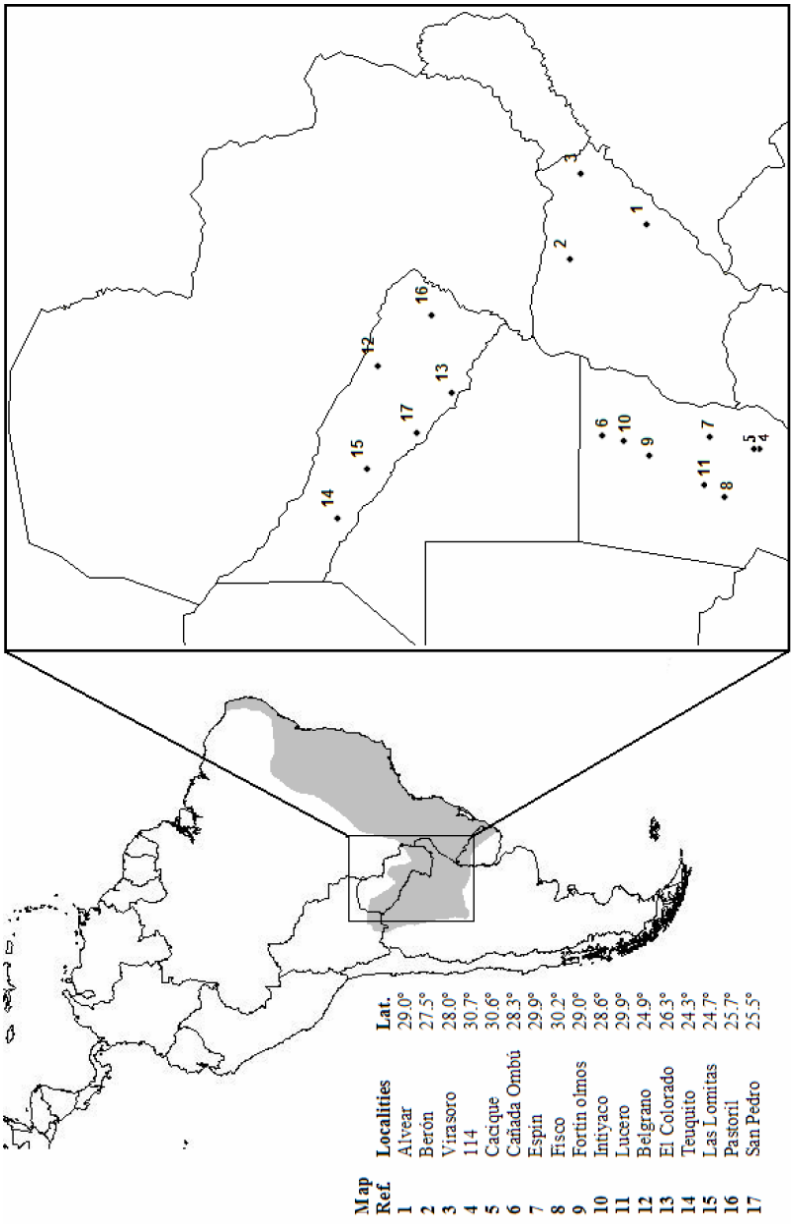

Figure 1. Map with the distribution of *Caiman latirostris* (grey) and the 17 localities included in the study.

Table 1. Table of weather caracteristics of Formosa, Corrientes and Santa Fe province (data was obtained from Servicio Meteorológico Nacional Web page: www.smn.gov.ar).

Province	Weather	Mean Annual Temperatures	Annual Rainfall
Formosa	Continental subtropical	29.5ºC to 16.6ºC	940mm (concentrated in the winter)
Corrientes	Warm and wet	25.7ºC to 17.1ºC few colds days	1600mm (rains occurs througout the year)
Santa Fe	Subtropical	25.6ºC to 14.9ºC high temperatures during summer and periods of frost during winter	1380mm (mostly during summer)

For this study, we used a database on 587 natural nests of *C. latirostris* collected between December 2004 and February 2005, by the ranching programs "Caimanes de Formosa" (n = 177 nests, from 6 localities of Formosa province), "Yacaré Porá" (n = 153 nests, from 3 localities of Corrientes province) and "Proyecto Yacaré" (n = 257 nests, from 8 localities of Santa Fe province) (Fig. 1). In the database we included all the nests that presented no signs of depredation in order to avoid clutch size underestimation.

In order to check for a connection between clutch size (number of eggs per clutch) and latitude we used a simple regression model. As independent variable we used latitude (expressed as degree with decimals) of each one of the 17 localities from where we have collected nests. Clutch size was calculated as the average from all the nests harvested in each location. Our alpha value for significance was 0.05.

As expected, clutch size in "Teuquito" locality (lower latitude, Formosa province) was 30.0 eggs/nest (SD: 6.7; CI: 16-41), whereas in locality "114" (higher latitude, Santa Fe province) was 37.7 eggs/nest (SD: 4.9; CI: 32-45). We found a positive linear relationship between latitude and clutch size (P = 0.0048; R^2= 0.42; b= 0.99; Fig. 2). If we consider the average for each province, we obtained for Santa Fe province 33.1 eggs/nest (SD: 5.9; CI: 16-45), Corrientes province 30.6 eggs/nest (SD: 6.3; CI: 14-44) and Formosa province 29.6 eggs/nest (SD: 6.4; CI: 14-43).

Clutch size from higher latitude localities was larger than for the lower latitude ones (Fig. 2), even considering that mean clutch size from the eight localities within Santa Fe province were smaller than clutch sizes previously reported in other works (37 eggs/nest; Larriera 1991). Considering previous works in the same habitats in Santa Fe province, we have found an historical reduction on *C. latirostris* clutch size (37 eggs/nest in 1991, n= 12, Larriera 1991; 34,9 eggs/nest in 2001/2, n= 154, Montini et al. 2006; and 33.3 eggs/nest in 2005, n= 257), this could be explained by the reintroduction work done by the ranching program "Proyecto Yacaré", resulting in the increase of young females in the breeding stock of wild populations in Santa Fe. Larriera et al. (2006) reported the capture of females of nine and ten years old, reintroduced in the wild by Proyecto Yacaré

(MUPCN/Gobierno de la provincia de Santa Fe), attending nests. There are reports that in some crocodilians, female size is related to clutch size, larger females producing greater clutch sizes (Thorbjarnarson 1996; Larriera et al. 2004). Therefore we assumed that the differences related to the latitudinal gradient found in this work, could be even larger if we compare a population where no animals have been reintroduced.

In our study we found a relationship between the variables clutch size and latitude; the model explained 42% of clutch size variation. Previous studies mentioned that population density, female nutritional status, age and size, weather variables like rainfall and toxic contaminant levels could affect clutch size (Woodward et al. 1993; Larriera et al. 2004; Simoncini et al. 2008) in crocodilians. But our results showed a latitudinal effect on clutch size of *C. latirostris*, as reported for *Alligator mississippiensis* (Wilkinson 1983), the spotted turtle (*Clemmys guttata*; Litzgus & Mousseau 2006), and birds (Symonds et al. 2006). Population density, adult nutritional status or toxic contaminant levels were not measured in this work, we consider these effects to be randomly distributed because we worked with many sampling areas in the three provinces.

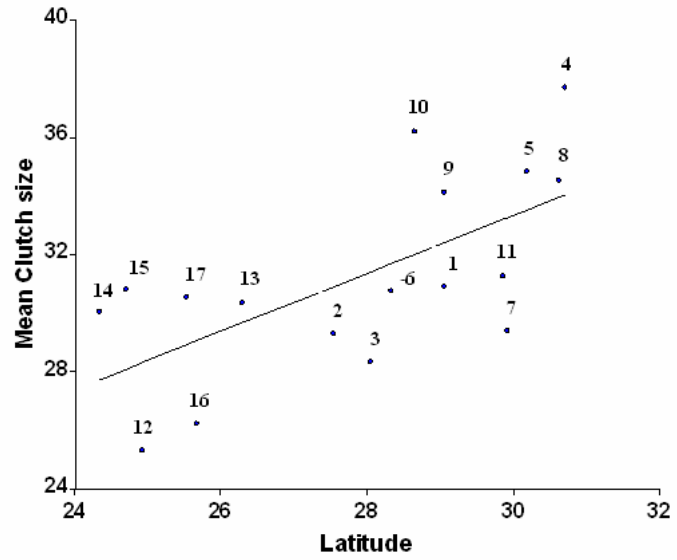

Figure 2. Relationship between clutch size of *Caiman latirostris* and latitude. Numbers 1 to 3 represent localities within Corrientes province; 4 to 11 localities within Santa Fe province; 12 to 17 localities within Formosa province.

In conclusion, clutch size in *C. latirostris* increases with latitude. *C. latirostris* females from lower latitudes, with smaller clutches but similar-sized eggs as higher latitudes females (A. Larriera pers. comm.) could have the same reproductive output by increasing nesting frequency (Litzgus & Brooks 1998). This would be an advantage in females' fitness and for the surviving cohorts since a higher nesting frequency would increase the chances of laying eggs during good years (Madsen & Shine 1998).

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