REVIEW ARTICLE

Camera traps capture images of predators of *Caiman crocodilus yacare* eggs (Reptilia: Crocodylia) in Brazil's Pantanal wetlands

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Camera traps were set up in forest nests in 2009, 2010 and 2012 to capture images of possible predators eating eggs of the Pantanal caiman, *Caiman crocodilus yacare*. We monitored 57 caiman nests; 42 nests were opened and the eggs were counted (mean = 25 eggs/nest, SD = 4.3). Females were present and captured at 38 of those nests. The remaining 15 nests were used as controls, and we did not capture the females or open the egg cavities of these nests. Most of the nests had the eggs eaten by predators, in both the disturbed group (38 nests) and the control group (13 nests). The main predators were carnivorous mammals, such as crab-eating foxes (*Cerdocyon thous*), coatis (*Nasua nasua*) and tayras (*Eira barbara*), although feral pigs (*Sus scrofa*) and armadillos (*Dasypus novemcinctus*) were also photographed eating caiman eggs. The lizard *Salvator merianae* was photographed eating eggs of two nests.

Keywords: Crocodylia; caiman; nests; camera traps; Pantanal

Introduction

Mortality rate of crocodile eggs is a key parameter in models of crocodilian population dynamics (Bayliss 1987). The main reported causes of egg mortality in crocodilians are flooding and predation, and the intensity of the effects of these causes on nests depends on nesting habitats and the weather conditions prevailing during the incubation period (Magnusson 1979). Female crocodilians often remain near nest sites to protect their nest, which is known to minimize the frequency of predatory attacks (Lang 1987). The presence of researchers at nesting sites has been reported to lead to increased predation rates on many species of crocodilians (Deitz and Hines 1980; Magnusson 1982; Campos 1993). Traditionally, egg predators have been identified by indirect observations, such as by the tracks and signs they leave at nests and marks on eggshells (Webb et al. 1983), or by time-lapse photography (Magnusson 1982). Recently, camera traps have started to be used to reliably identify the predators of crocodilian eggs and nest-site visitors. In Australia, dingoes, *Canis lupus dingo*, and yellow spotted goannas, *Varanus panoptes*, have been recorded preying on the nests of the freshwater crocodile, *Crocodylus johnstoni* (Somaweera et al. 2011). In the Amazon, initial studies, which used relatively few camera traps, revealed lizards (*Tupinambis teguixin*) and jaguars (*Panthera onca*) preying on or visiting the nests of black caimans (*Melanosuchus niger*) and spectacled caimans

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(*Caiman crocodilus*) (Villamarín-Jurado and Suárez 2007; Da Silveira et al. 2010). Camera traps were also used to document maternal care provided by *Crocodylus acutus* females in Mexico (Charruau and Hénaut 2012).

Caiman crocodilus yacare is abundant and widespread in the Pantanal wetlands (Mourão et al. 2000). The subspecies nests in a variety of habitats early in the rainy season (Cintra 1988; Campos and Magnusson 1995). In the Pantanal wetlands, indirect observations (tracks) indicated that the potential predators of caiman nests in forests are coatis, *Nasua nasua*, crab-eating foxes, *Cerdocyon thous*, and feral pigs, *Sus scrofa* (Crawshaw and Schaller 1980; Cintra 1988; Campos 1993). The aim of the present study was to identify predators through use of camera traps, and evaluate the effect of researcher-induced disturbance of nests on egg mortality in the Pantanal region of Brazil.

Material and methods

We searched for caiman nests in forests on horseback and on foot in February 2009, 2010 and 2012 on Nhumirim Ranch (18°59' S, 56°39' W) and Campo Dora Ranch (18°55' S, 56° 39' W). The nesting area is predominantly forested, with an understorey of spiny bromelias, *Bromelia balansae*. We found 30 nests in 2009, 11 in 2010 and 16 in 2012. Beside each nest, we installed a digital camera trap (Tigrinus Equipamentos 6.0 D®, Timbó, Espírito Santo, Brazil and Bushnell® Kansas City, MO, USA) to capture images of egg predators (Figure 1). Camera traps were set to operate on 24-h

Figure 1. Camera trap installed next to a Pantanal caiman (*Caiman crocodilus yacare*) nest, Brazil.

cycles until the eggs were lost to predation. We opened the nest cavities of 42 of these nests to count and measure the eggs. One egg overall was collected to estimate the age of the embryo. Adult females were present at 38 of these nests, which were captured, measured and marked. We did not attempt to capture the females nor open the egg cavities of 15 nests, which were used as controls for the effects of severe disturbance. The control nests were chosen haphazardly, three in 2009, four in 2010 and eight in 2012.

Results

The mean clutch size was 25.0 eggs (range 17–37, $n = 42$, $SD = 4.3$) and females attending nests varied in snout–vent length from 76.0 to 90.0 cm (mean = 82.3, $SD = 3.67$, $n = 38$). The timing of nest depredation was between 5 and 55 days of incubation (mean = 21 days, $SD = 10.7$, $n = 22$). Most of the nests had the eggs eaten by predators, both in the disturbed group (38 nests) and the control group (13 nests), and there was no difference in predation rate between these groups ($\chi^2 = 0.17$, $p = 0.68$). Females were present at 38 of the disturbed nests, and at five of the control nests. Eggs were depredated in 34 of the disturbed nests at which females had been present, and in three of the control nests at which females were present. Pooling both groups together, the predation rate was not affected by the presence of the female ($\chi^2 = 0.226$, $p = 0.635$).

The 57 camera traps recorded a total of 870 photos, including attending females and predators. The photographs indicated that three of the 38 females captured at nests continued to attend the nest after capture. Females were photographed two to five times in three nests of the control group and one to three times in three nests of the disturbed group. Crab-eating foxes (*Cerdocyon thous*) were photographed eating caiman eggs on 24 occasions, and coatis (*Nasua nasua*, $n = 19$), tayras (*Eira barbara*, $n = 15$), feral pigs (*Sus scrofa*, $n = 2$, [Figure 2](#)), armadillos (*Dasypus novemcinctus*, $n = 2$), and the tegu lizard, *Salvator merianae* ($n = 2$) were also recorded taking eggs. Other mammals, such as the giant anteater (*Myrmecophaga tridactyla*), lesser anteater (*Tamandua tetradactyla*), white-lipped peccary (*Tayassu pecari*), banded armadillo (*Euphractus sexcinctus*), ocelot (*Felis pardalis*) and puma (*Felis concolor*) were photographed near nests, but not eating eggs.

Discussion

Camera traps have proved to be useful tools for documenting and studying the behaviour of predators of the eggs of various species of birds (Felege-Ellis et al. 2008), turtles (Bieber-Ham 2010) and crocodilians (Hunt and Ogden 1991). Most of the information about potential crocodilian egg predators has been obtained only through indirect evidence (Deitz and Hines 1980; Webb et al. 1983; Cintra 1988). The presence of humans in nesting areas has reportedly increased the predation rate of nests (Deitz and Hines 1980; Campos 1993). This study showed that carnivorous mammals were the main predators of eggs of Pantanal caimans. Numerous images were captured of crab-eating foxes, coatis and tayras eating caiman eggs in various forest nests. These mammals have been considered threats to the survival of hatchling marine turtles, *Caretta caretta*, in the USA (Stancyk 1982), and methods for protecting nests from predators, especially raccoons, red foxes, feral pigs and armadillos,

Figure 2. Mammalian predators of the eggs of the Pantanal caiman (*Caiman crocodilus yacare*) – (A) crab-eating fox (*Cerdocyon thous*); (B) coati (*Nasua nasua*); (C) tayra (*Eira barbara*); (D) feral pig (*Sus scrofa*).

have been suggested (Kurtz et al. 2011). Mammals may be serious threats to the survival of caiman eggs in the Pantanal wetlands in other areas. Campos (1993) considered feral pigs *Sus scrofa* to be major predators of eggs in regions of intermittent rivers where caiman nest densities are higher than in this study. In the USA, *Sus scrofa* has been reported to cause nest loss and other effects on the wetland habitats of *Alligator mississippiensis* (Elsey et al. 2012).

Female caimans defend their nests (Campos 1993; Campos et al. 2008), but not always effectively. The incubation period of caimans varies from 60 to 70 days (Cintra 1988), and during this period the females may leave the nest for variable periods. Predators can take advantage of this to take the eggs. Therefore, the frequency of the nest attendance may affect the chances of nest success. Even in the group controlled for strong disturbances, the research visit could have left scents and visual trails that could increase the chances of predators locating the nests.

Most predation occurred mid-way through the incubation (from 21 days). In some cases, predation may occur near the end of the incubation. In this study, a nine-banded armadillo (*Dasypus novemcinctus*), was photographed eating an egg from a nest when the eggs were hatching on 1 April 2012.

The magnitude of predation depends on the density of mammal populations in the nesting areas. The densities of the main predators in our study area are reportedly high, varying from 16.7 to 10.5 coatIs/km², 0.41 to 0.55 crab-eating foxes/km² and

0.37 to 0.48 tayras/km² in forest and cerrado environments (Alho et al. 1987; Desbiez et al. 2010). In Australia, dingoes were responsible for 98% of all predator visits to the nests of freshwater crocodiles (*Crocodylus johnstoni*) and Somaweera et al. (2011) suggested that dingoes pinpoint the location of nests by odour, visual evidence and through the calls of hatchlings.

In the central Pantanal region, predation by crab-eating foxes, coatis, tayras and other predators was high. We detected the presence of three predator species at the same nest at different times of day. Undisturbed female crocodilians can prevent many predator attacks and therefore limit predation (Lang 1987), but we did not find evidence of this.

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References

- Alho CJR, Lacher Jr TE, Campos ZM, Gonçalves HC. 1987. Mamíferos da Fazenda Nhumirim, sub-região de Nhecolândia, Pantanal do Mato Grosso do Sul: I - levantamento preliminar de espécies. *Rev Bras Zool.* 4:139–149.
- Bayliss P. 1987. Survey methods and monitoring within crocodile management programmers. In: Webb GJW, Manolis SC, Whitehead PJ, editors. *Wildlife management: crocodiles and alligators*. Chipping Norton (NSW): Surrey Beatty and Sons PTY Limited; p. 157–175.
- Bieber-Ham LM. 2010. Population and nesting ecology of painted turtles (*Chrysemys picta*) in Pennsylvania [M.S. thesis]. Carlisle (PA): Dickinson College; 35p.
- Campos Z. 1993. Effect of habitat on survival of eggs and sex ratio of hatchlings of *Caiman crocodilus yacare* in the Pantanal, Brazil. *J Herpetol.* 27:127–132.
- Campos Z, Magnusson W, Sanaiotti T, Coutinho M. 2008. Reproductive trade-offs in *Caiman crocodilus crocodilus* and *Caiman crocodilus yacare*: implications for size-related management quotas. *Herpetol J.* 18:91–96.
- Campos Z, Magnusson WE. 1995. Relationships between rainfall, nesting habitat and fecundity of *Caiman crocodilus yacare* in the Pantanal, Brazil. *J Trop Ecol.* 11:353–358.
- Charruau P, Hénaut Y. 2012. Nest attendance and hatchling care in wild American crocodiles (*Crocodylus acutus*) in Quintana Roo, Mexico. *Anim Biology.* 62:29–51.
- Cintra R. 1988. Nesting ecology of the Paraguayan Caiman (*Caiman yacare*) in the Brazilian Pantanal. *J Herpetol.* 22:219–222.
- Crawshaw PG, Schaller GB. 1980. Nesting of Paraguayan caiman, *Caiman yacare*, in Brazil. *Pap Avulsos Zoologia.* 33:283–292.
- Da Silveira R, Ramalho EE, Thorbjarnarson JB, Magnusson WE. 2010. Depredation by jaguars on caimans and importance of Reptiles in the diet of jaguar. *J Herpetol.* 44:418–424.
- Deitz DC, Hines TC. 1980. Alligator nesting in North-Central Florida. *Copeia.* 1980:249–258.
- Desbiez ALJ, Bodmer RE, Tomas WM. 2010. Mammalian densities in a Neotropical Wetland subject to extreme climatic events. *Biotropica.* 42:372–378.
- Elsley R, Mouton Jr EC, Kinler N. 2012. Effects of feral swine (*Sus scrofa*) on alligator (*Alligator mississippiensis*) nests in Louisiana. *Southwest Nat.* 11:205–218.

- Felege-Ellis SN, Burnam JS, Palmer WE, Sisson DC, Wellendorf SD, Thornton RP, Stribling HL, Carroll JP. 2008. Cameras identify white-tailed deer depredating Northern Bobwhite nests. *Notes Southwest Nat Issue*. 7/3:562–564.
- Hunt RH, Ogden JJ. 1991. Selected aspects of the nesting ecology of American alligators in the Okefenokee Swamp. *J Herpetol*. 25:448–453.
- Kurtz D, Straley KM, DeGregorio BA. 2011. Out-foxing the red fox: how best to protect the nests of the endangered loggerhead marine turtle *Caretta caretta* from mammalian predation. *Oryx*. 46:223–228.
- Lang JW. 1987. Crocodilian behavior: implications for management. In: Webb GJW, Manolis SC, Whitehead PJ, editors. *Wildlife management: crocodiles and alligator*. Chipping Norton (NSW): Surrey Beatty and Sons PTY Limited; p. 273–294.
- Magnusson WE. 1979. Dispersal of hatchling crocodiles (*Crocodylus porosus*) (Reptilia, Crocodylidae). *J Herpetol*. 13:227–231.
- Magnusson WE. 1982. Mortality of eggs of the crocodile *Crocodylus porosus* in Northern Australia. *J Herpetol*. 16:121–130.
- Mourão G, Coutinho M, Mauro R, Campos Z, Tomás W, Magnusson W. 2000. Aerial surveys of caiman, marsh deer and pampas deer in the Pantanal Wetland of Brazil. *Biol Conserv*. 92:175–183.
- Somaweera R, Webb JK, Shine R. 2011. It's a dog-eat-croc world: dingo predation on the nests of freshwater crocodiles in tropical Australia. *Ecol Res*. 26:957–967. doi: [10.1007/s11284-011-0853-0](https://doi.org/10.1007/s11284-011-0853-0).
- Stancyk SE. 1982. Non-human predators of sea turtles and their control. In: Bjorndal KA, editor. *Biology and conservation of sea turtles*. Washington (DC): Smithsonian Institution Press; p. 139–152.
- Villamarín-Jurado F, Suárez E. 2007. Nesting of the black caiman (*Melanosuchus niger*) in Northeastern Ecuador. *J Herpetol*. 41:164–167.
- Webb GJW, Manolis SC, Buckworth R. 1983. *Crocodylus johnstoni* in the McKinlay River area N. T, III.* Growth, movement and the population age structure. *Aust Wildlife Res*. 10:383–401.