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Capture methods of *Caiman latirostris* Daudin, 1802 (Crocodylia, Alligatoridae) in northern Uruguay, with notes of defensive and feeding behaviours

Claudio Borteiro

Museo Nacional de Historia Natural (MNHN), Miguelete 1825, 11800, Montevideo, Uruguay, borteiro@gmail.com

Francisco Gutiérrez

Zoológico Villa Dolores, Intendencia Municipal de Montevideo, Av. Gral. Rivera, 3245, 11300, Montevideo, Uruguay.

Marcelo Tedros

Clínica Veterinaria del Cerro, Av. Cibils, 4303, 12800, Montevideo, Uruguay.

Francisco Kolenc

Museo Nacional de Historia Natural (MNHN), Miguelete 1825, 11800, Montevideo, Uruguay.

Luciano Martins Verdade

Universidade de São Paulo, CENA/Lab. de Ecologia Evolutiva Aplicada de Vertebrados (LE²AVe), Avenida Centenário, 303, São Dimas, 13416-000, Piracicaba, São Paulo, Brazil.

Abstract: *Caiman latirostris* is a Neotropical crocodilian for which there is scarce natural history information in regard to other species, as also about survey methods used by field researchers. In this work we report the capture methodology implemented during population monitoring in northern Uruguay and some observations about defensive and feeding behaviours. We found the use of a metallic clamp as very useful for capturing juveniles and subadult individuals (< 120 cm total length) in vegetated habitats, while a wire snare was used for adults. Regardless locomotor escape, we provide a reappraisal of defensive behaviours in the presence of humans, with comments on tonic immobility. In addition, we suggest an apparent case of carcass consumption (scavenging) for the species, a presumably common behaviour but sometimes hard to observe in wild crocodilians.

Keywords: caiman surveys, carcass consumption, crocodiles, freezing, tonic immobility.

Métodos de captura de *Caiman latirostris* Daudin, 1802 (Crocodylia, Alligatoridae) no norte do Uruguai, com notas de comportamentos defensivo e alimentar

Resumo: *Caiman latirostris* é um crocodilo Neotropical cuja história natural é pouco compreendida em relação às outras espécies, assim como seus métodos amostrais utilizados por pesquisadores de campo. Neste trabalho, indicamos os métodos de captura utilizados no norte do Uruguai, durante o

monitoramento populacional e algumas observações sobre o comportamento defensivo e alimentar. O uso de pinça de metal foi muito útil para a captura de juvenis e subadultos (< 120 cm de comprimento total) em ambientes vegetados, enquanto o uso de laço foi o método de escolha para adultos. Além da fuga ativa, apresentamos um repertório de comportamentos defensivos da espécie na presença de humanos, com especial atenção à imobilidade tônica. Por fim, sugerimos um caso aparente de consumo de carniça por esta espécie, um comportamento presumivelmente comum, mas difícil de observar em crocodilos na natureza.

Palavras-chave: amostragem de caimans, crocodilos, consumo de carniça, freezing, imobilidade tônica.

Introduction

The information about field methods used for the study of *Caiman latirostris* (Daudin, 1802; Alligatoridae) is still scarce (see Filho et al., 2021), as compared with other crocodilians for which long-term sustainable management programmes have been implemented (Walsh, 1987). Similarly, those works dealing with behaviour on this species are a few ones mainly based on captive colonies. For instance, there are some published reports about feeding, including management in farming operations (Diefenbach, 1979; 1988; Sarkis-Gonçalves et al., 2001; Sarkis-Gonçalves et al., 2002), thermoregulation (Bassetti et al., 2014; Verdade et al., 1994), agonistic social interactions (Verdade, 1992), courtship (Piffer & Verdade, 2002), and parental care (Carl & Darlington, 2017). Publications related to specific behaviours of *C. latirostris* in wild specimens are related to feeding (Borteiro et al., 2009; Piña & Larriera, 2003), nesting (Rodrigues et al., 2021), and maternal nest attendance (Larriera & Piña, 2000; Parachú Marcó et al., 2015).

The Broad-snouted caiman, *C. latirostris*, is a medium sized alligatorid crocodilian native to central-eastern South America throughout a large latitudinal gradient from north-eastern Brazil to south-eastern Uruguay (Borteiro et al., 2006; Verdade & Piña, 2006; Verdade et al., 2010). This caiman is a generalist species regarding the wetland habitats it occupies, preferring lentic water bodies as marshes and lagoons (Yanosky, 1990; Borteiro et al., 2006; Coutinho et al., 2013). The knowledge about this crocodilian has significantly increased in the last decades, and particularly in Uruguay first population surveys become available recently (Borteiro et al., 2006; 2008).

In this regard, we communicate herein the capture methods used to study wild *C. latirostris* in north-western (NW) Uruguay, where populations are present in agriculture areas mainly of natural grasslands for cattle grazing and crops, mainly sugar cane and rice (Borteiro et al., 2006). In addition, we provide some observations on the defensive behaviour of wild specimens during capture sessions of surveys, and we report the occurrence of scavenging in the wild for the first time.

Material and Methods

Study area and surveys

Populations of *C. latirostris* from northern Uruguay are present in areas of agricultural landscapes (Borteiro et al., 2006), which require the construction of large impoundments for irrigation, by damming creeks and streams (DNH, 2000). We collected data on caimans' capture and their defensive and feeding behaviour, between 2000 and 2004. The study area extended between 30.39°/30.57° S and 57.83°/57.49° W, close to the Uruguay River, at 40-100 m altitude (Fig. 1). The climate is temperate wet, with average annual temperature and precipitation of 19 ºC and 1400 mm respectively (https://www.inumet.gub.uy/clima/estadisticas-climatologicas/caracteristicas-climaticas).

We implemented spotlight monitoring sessions in 33 agriculture impoundments of the Lenguazo, Mandiyú and Ñaquiñá streams (see Fig. 1). These man-made habitats presented a mean surface area of 27 ha (2-116) and mean maximum depth of 6 m (2.5-10) (Borteiro et al., 2008; 2009). For a subsample of individuals (n = 32), we measured water depth at the capture site.

Capture techniques

Surveys were made with a 4.5 m rowing canoe of 0.95 m width provided with lateral floats to prevent twisting when standing during spotlighting and capture (Fig. 2A). We searched for caimans close to the shores (ca. 10 m) using a sealed beam spotlight lamp connected to a motorbike battery (12 v, 30 A). The crew consisted of at least four people, two at the back in charge of rowing, two at the front detecting and capturing caimans. Occasionally, a fifth member (local) helped with records, captures and restraint. Caimans were approached in a frontal direction and when close enough, we obtained an

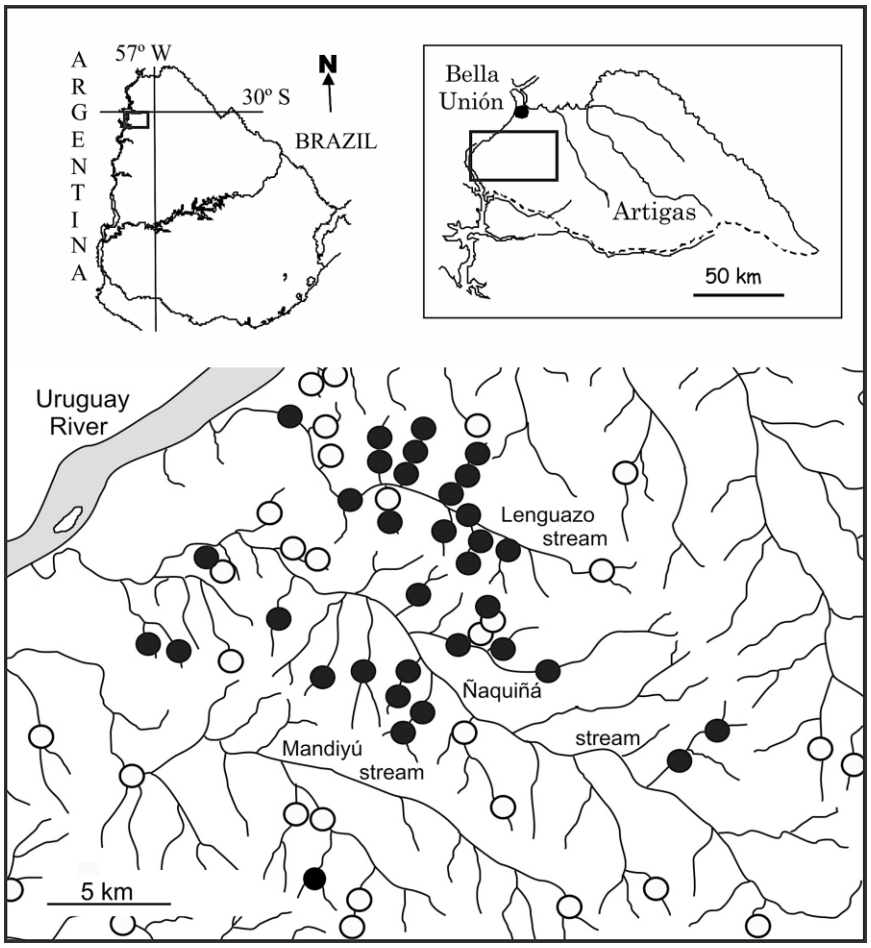

Fig. 1. Study area in north-western Uruguay, Department of Artigas, south to the city of Bella Unión. Circles correspond to artificial impoundments for irrigation of cultures; solid ones are those surveyed for the present study (2001-2004).

eye estimation of total size from the head aspect (Magnusson, 1983), always made by the same observer (CB), from 1-6 m distance. The capture technique was an immediate choice of the researcher based on size estimation, and the boat was usually turned in an oblique position to facilitate its implementation.

We considered three size classes of total length: juveniles (≤49 cm), subadults (50-119 cm), and adults (≥120 cm) (Borteiro et al., 2008). Three capture techniques were implemented, targeting a restraint from the neck: hand catching (Walsh, 1987; Fig. 2B); restraint with a handmade curved metallic clamp of approximately 15 cm maximum amplitude fixed onto a 3.0 m square aluminum pole (2.5 cm side) covered with black tape to diminish shinning, that closed upon continued tension of a rope attached to one of its arms (Fig. 2C); and snaring with a steel wire loop tied to a rope, loosely attached with a metallic clip on a 2.5 m cane stick that gets free when strongly pulled, after being properly positioned on the caiman neck (following Chabreck, 1963; Fig. 2D).

Juveniles were caught manually, or with the clamp when hidden among vegetation. For subadults we used the clamp, and eventually the snare in apparently more robust individuals. All capture attempts of adults were made with the snare as the clamp was not useful in preliminary surveys due to the vigorous writhing behavior that large specimens exhibit once restrained (>120 cm length).

Almost all individuals captured from the boat were pulled up. When juveniles and subadults were captured with the clamp (at the front of the boat) the researcher must made continuous tension at the rope that closes it. Given the pole length, the caiman was turned towards the crew on the back to gain further control. The mouth and limbs were secured with duct tape to prevent accidents and escapes and caimans were put in the center of the canoe for the rest of the session. Larger individuals of total length >180 cm (big males) were pulled out to the shoreline and handled on land. First, we covered the eyes with a small towel and one researcher mounted the specimen from the back,

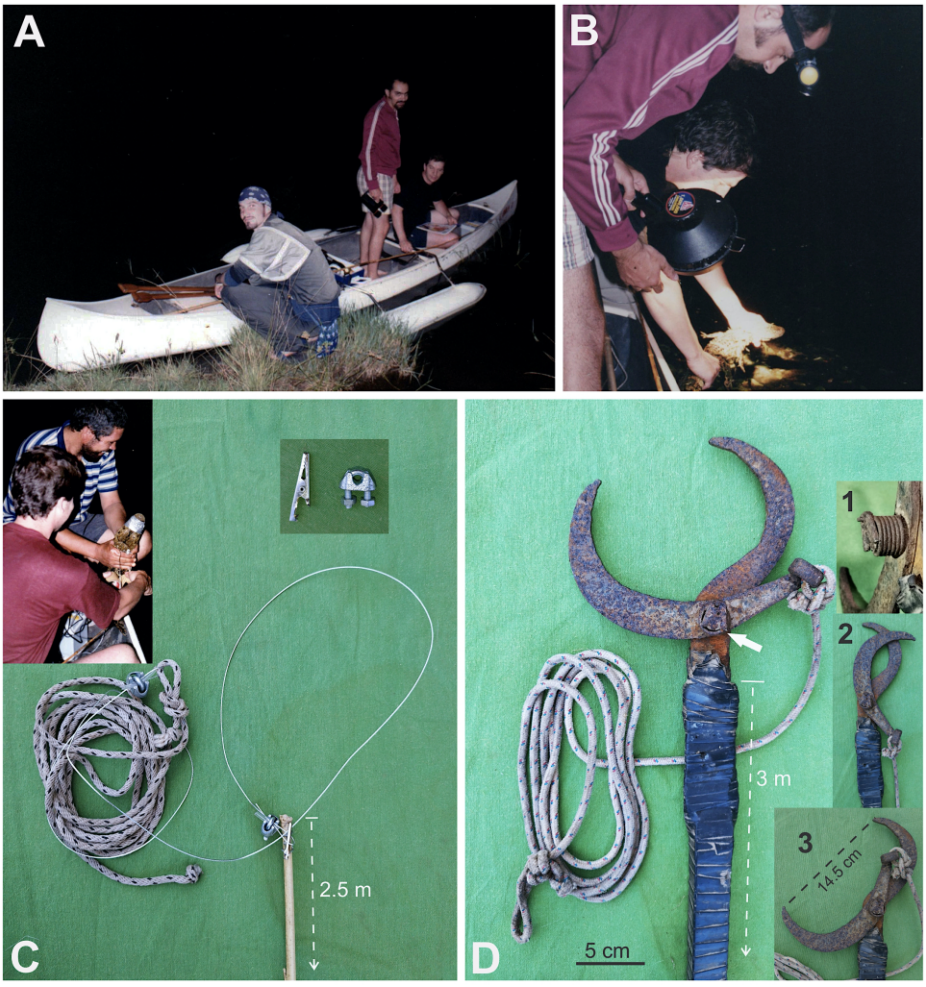

Fig. 2. Capture devices for *Caiman latirostris* (Daudin, 1802) used in northern Uruguay. A. Rowing canoe (4.5 m) with lateral floats for 4-5 people (crew from left to right FG, MT, CB; photo F. Kolenc). B. Hand-catching of a juvenile from the boat. C. Steel wire snare (above 1 mm) secured to a rope and fixed with a clip onto a 2.5 m cane stick, for the capture of subadult and adult caiman. Insets: left, snared subadult being restrained on the boat with the aid of local guide (Sergio Ripoll, back); right, detail of metallic attachments. D. Hand-made metallic clamp attached to an aluminum pole for restraint from the neck of juvenile and subadult caimans up to approximately 120 cm total length. The mobile branch attached to the rope is permanently opened by a spring (arrow). Insets: 1, spring in oblique view; 2, device fully closed; 3, maximum opening.

holding the neck and pressuring against the floor, then slowly advancing to secure the mandibles manually. At this point another researcher secured the mouth and limbs.

Because size estimation may influence the choice of the capture method and thus bias efficiency (i.e., use of clamp with an adult), we checked for its accuracy in a subsample of captured individuals. Precision of size estimates contrasted to actual caiman size, considered as r^2, was accurate during consecutive survey sessions: 0.90 ($n = 11$, $P < 0.0001$), 0.92 ($n = 28$, $P < 0.000001$), 0.93 ($n = 25$, $P < 0.000001$), and 0.79 ($n = 11$, $P < 0.001$).

Some individuals were measured, weighed, and sexed manually by internal palpation of the cloaca (Yanosky, 1990).

Results

Capture methods

We obtained an estimation of total size for 319 (69 %) among 462 caimans detected. Estimates assigned to the size categories resulted in 31 juveniles, 199 subadults, and 89 adults. Most individuals were captured while floating, usually from the boat.

Juveniles were captured from the boat as they allowed a closer approach. We captured them mostly with the clamp because the majority were hidden among vegetation. Smaller individuals sometimes escaped as the clamp did not provide a secure restraint from the neck

when closed. However, some amount of vegetation did not impede capture attempts with this method if implemented with a sudden strike.

We captured with the clamp a total of 82 individuals, which accounted for 61.2% of total captures (11/31 juveniles, 71/92 subadults). When the vegetation stuck the boat, the attempt to capture juveniles and subadults was continued on foot from the shore.

All adult caiman except one that escaped on land (see next section), could only be captured from the boat as they were in deeper waters. Mean water depth at 32 capture point sites was 78 ± 49 cm (10-205), presenting a significant positive association with caiman measured total length (45-165 cm, n = 32): $r^2 = 0.12$, p = 0.05. Two large subadults and one adult that submerged in shallow areas (0,5-1 m) were captured underwater, with the clamp and snare respectively. The snare technique was implemented with individuals up to 216 cm total length and > 50 kg.

A silent and rapid approach of the boat seemed to be more effective. Statistical comparisons between size classes when using common methods was only possible in the case of juveniles and subadults, for manual restraint and clamping: 5/2 and 11/71 respectively, Chi Square ($\chi 2$) = 14.7, p = 0.0001. Among 90 subadults captured with the clamp (n = 71) and the snare (n = 19), there was an empirical preference for the first technique at the moment of capture. This bias was significant when contrasted to a balanced choice of n = 45 for each method: $\chi 2$ = 16.4, p = 0.00005. Results of captures by the different methods are summarized in Tab. 1 and Fig. 3.

Behavioural observations

The most common defensive behaviours detected during capture sessions were escape by submersion and hiding among emergent or floating vegetation, in all size classes. Submersion in subadults and adults was usually followed by underwater displacement prior to the next emergence, gaining distance from the observers, but sometimes they were detected immobile at the same site (see Tab. 1, captures while submerged). In more vegetated areas we also observed swimming escape on surface, looking for shelter without submersion. This behavior was mostly exhibited by juveniles.

Once snared, subadult and mainly adult caiman commonly performed writhing, entangling the rope and surrounding vegetation, which sometimes complicated safe physical restraint and pulling. Biting the snare cable was also common. On one occasion a large adult male that was snared and pulled close to the boat (ca. 1,5 m) exhibited writhing, opened the mouth, and made a strike, repeatedly biting the boat and one of the paddles. Distress vocalization following capture was common, mainly in juveniles and subadults.

As additional unusual observations, we spotlighted a caiman in a slow running and clear water pool of a creek approximately 1.5 m wide, 3 m long, and 0.2 m deep, flanked with clumps of tall grasses, at Ñaquiñá stream basin (30.500º S, 57.633º W; elevation 59 m), on 30 November 2000, ca. 10 pm, 22.0 and 14.5 ºC air and surface water temperature respectively. When spotted, it submerged and remained immobile keeping the eyes closed (Fig. 4A). We captured it by holding the neck (Fig. 4B), it opened the eyes and unexpectedly did not display any active defensive behavior during ca. 20 min of manual restraint and handling. The caiman remained noticeably relaxed, even when placed on the ground in dorsal recumbency for

Tab. 1. Capture of *Caiman latirostris* (Daudin, 1802) during population monitoring in northern Uruguay (2001-2004), according to caiman size: juveniles (up to 49 cm; n = 31), subadults (50-119 cm; n = 199), and adults (≥ 120; n = 89 cm).

Capture	Juveniles	Subadults	Adults
Manual from boat	5	---	---
Manual from shoreline	---	2	---
Clamp from boat	11	58	---
Clamp from boat while submerged	---	2	---
Clamp from shoreline	---	11	---
Snare from boat	---	19	24
Snare from boat while submerged	---	---	1
Snare on land	---	---	1
Total captured (%)	16 (51.6)	92 (46.2)	26 (29.2)

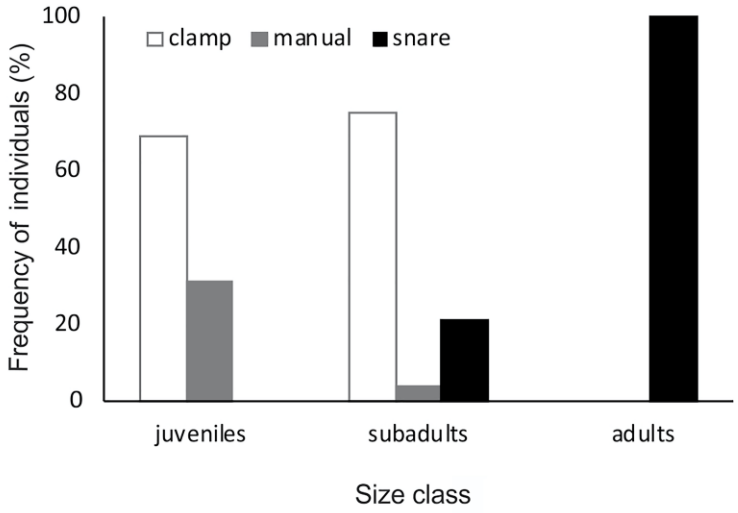

Fig. 3. Relative importance of the capture methods implemented for *Caiman latirostris* (Daudin, 1802) during population monitoring in north-western Uruguay (2001-2004), according to caiman size classes: (A) direct manual restraint, (B) metallic clamp, and (C) snaring (see text for detail). Juveniles (up to 49 cm; n = 16), subadults (50-119 cm; n = 92), and adults (≥ 120 cm; n = 26).

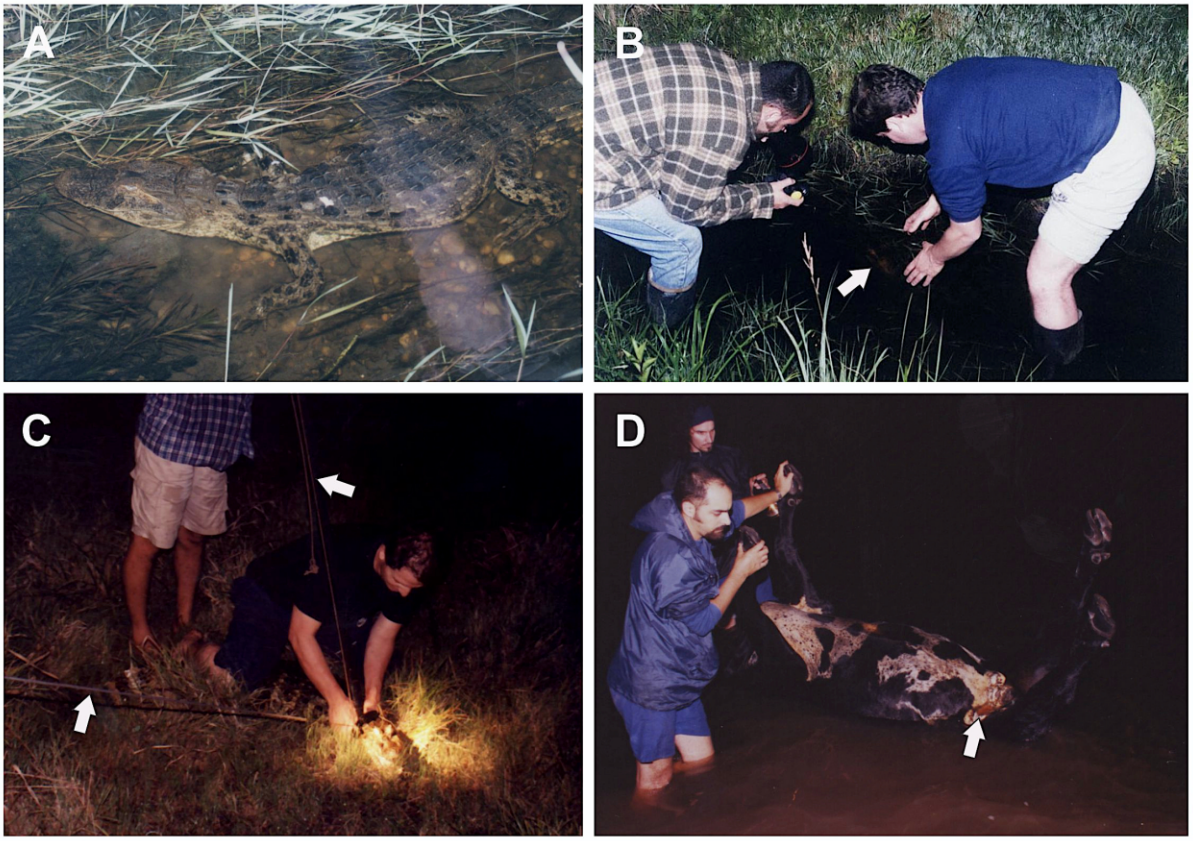

Fig. 4. Capture and behaviour of *Caiman latirostris* (Daudin, 1802) in north-western Uruguay. A. Young adult female displaying passive defensive posture in shallow water after being spotlighted, being "freezing" (immobility) underwater, with the eyes closed. B. Manual capture of same specimen; arrow indicates the caiman´s head. C. Capture of an adult female on land after locomotor escape from water, using a snare (left arrow), aided by pressure with a metallic clamp on the neck (right arrow) by the assistant backwards, and further manual restraint. Notice that the specimen exhibited mouth gaping, that was accompanied by hissing. D. cow carcass with apparent signs of scavenging on the udder (arrow) by the same specimen.

cloacal sexing. It was a young adult female of approximately 120 cm of total length (not measured), with no external morphological anomalies. When released into the pool it gently accommodated the body underwater, closed the eyes, and remained still.

Another caiman observed during a night boat survey in a shallow shore area (0.5 m deep) of clear water at a dammed portion of the Lenguazo stream (ca. 100 ha; 30.2548º S, 57.3915º W; elevation 50 m); on 15 January 2003 by midnight, 23 and 26 ºC air and water surface temperature respectively), performed an unusual escape behaviour. It was with the head above water surface by the side of a semi submerged dead cow in lateral recumbency with the back to the shore. An attempt of snaring the caiman from the boat at about 1.5 m failed as it submerged trying to escape underwater but hitting the ravine of the shore. It immediately raised the head from the surface, and suddenly came out of water body running for shelter among the surrounding grasslands, where we could snare it on land about 50 m away (Fig. 4C). It was an adult female of 86.8 cm snout-vent length, and 169.8 cm of total length considering the lost tail tip. Once immobilized with duct tape, we performed the stomach flushing technique (see Taylor et al., 1978). Recovered food items were insect exoskeletons, partially digested snails, and shell fragments (*Pomacea canaliculata* Lamarck, 1822), plant material, and partially digested vertebrate prey remains including unidentified fish and bird. The cow carcass showed lacerations on the udder (underwater), with tissue sloughing (Fig. 4D). Fishes feeding on the carcass were not detected (i.e. "Piraña", *Serrasalmus* sp.).

Discussion

Capture methods

Different capture methods have been used by field researchers working with crocodilians and may vary according to the particular behaviours of the species of concern (Lang, 1987). For Neotropical species manual capture and snaring are commonly used, but also passive techniques like net traps (Filho et al., 2021). The variations we implemented for *C. latirostris* with a rowing boat were adapted for agriculture impoundments, in which caimans are not always easily approachable because of marginal and floating vegetation.

Our methodology required a crew of at least 4 people, and even being time consuming, silent boat surveys at night produced minimal disturbance for cattle and local people living at the study sites. The attachment of vegetation on the lateral floats sometimes lowered speed and made maneuvering more difficult but provided stability facilitating the movement of researchers for spotlighting and capturing animals.

Wariness was particularly noticeable for larger individuals as tolerance to human presence diminish with increasing caiman size in the study area (Borteiro et al., 2008). Consequently, our capture efficiency tended to be lower at larger sizes as we captured approximately half of non-adults (46.9%), but almost a third of the adults we detected (29.2%). This body size related wariness of crocodilians may be enhanced by individual experience, and also human disturbance (Bayliss, 1987; Pacheco, 1996; Webb & Messel, 1979) like it occurs in northern Uruguay (Borteiro et al., 2006). Melo (1990) used an aluminum boat with a 9.8 HP engine to capture *C. latirostris* in large wetlands of southern Brazil, but when detecting a caiman, she propelled the boat with a stick.

The manual capture of *C. latirostris* during boat surveys was mainly limited to the juvenile class, due to both wariness and robustness of larger specimens. Manual capture of juvenile *C. latirostris* from boats using head lamps was presented by Filho et al. (2013) for Brazilian populations. Similarly, Chabreck (1963) found it effective for the capture of the ecologically similar alligatorid *Alligator mississippiensis* (Daudin, 1801) measuring less than 3 feet of total length (< 92 cm).

Maybe the most particular feature of our capture techniques was the use of a metallic clamp. It proved useful for capturing small and medium-sized caimans when the manual capture from the boat or snaring was hampered by the vegetation. It was the method of choice for subadults and did not cause injuries even in small specimens.

Snaring was recommended as a capture and restraint method by Filho et al. (2013) for the study of large Neotropical caimans. Even when effective with relatively larger alligatorids like *A. mississippiensis* (Chabreck, 1963), it is not implemented for large crocodiles as other methods like baited traps and harpoons are more useful (Hutton et al., 1987; Walsh, 1987). A steel wire snare attached to a cane stick was the only method reported by Melo (1990) for the capture of 86 *C. latirostris* from 50 to 241 cm total length.

In summary, silent boat surveys are adequate to study shy crocodilians like *C. latirostris*. Besides, the use of a metallic clamp should be considered when capturing non-adults of this species in vegetated sites.

Defensive behaviours

Predation is a significant selective pressure on the defensive strategies of crocodilians (Somaweera et al., 2013), which include locomotor escape, vanishing underwater, attacking, hissing, vocalizing, cloacal discharge, gaping,

and writhing, among others (Greene, 1988). Swimming away is likely the most common locomotor escape (Greene, 1988), as we observed in wild *C. latirostris*. The submersion followed by immobility exhibited by this species during human approach is probably much more frequent than observed, because of the low visibility at vegetated sites. The underwater immobility qualifies as a "freezing" response to pass unnoticed in the environment (crypsis) when facing a predator, and allows preparation for attacking or fleeing (Hagenaars et al., 2014).

On the other hand, the immobility with generalized flaccidity and unresponsiveness we induced by manual restraint in a young female corresponds to "tonic immobility", "thanatosis" or "death feigning" (Gallup, 1974). With reduced possibilities to escape, restraint from the neck while freezing would have led to tonic immobility (Hagenaars et al., 2014). This may inhibit further attack or subjugation by predators (Humphreys & Ruxton, 2018), and was infrequently reported as a crocodilian behaviour: tonic immobility can be induced in American alligators (*A. mississippiensis*) when inverted, being the mechanism a fear vasovagal syncope (Young et al., 2018), and hatchling *Caiman crocodilus* (Linnaeus, 1758) handled underwater were observed "playing dead" (Gorzula, 1978), as reported for young crocodiles (unspecified species) from central Africa (Schmidt, 1919).

The unusual escape on land we observed in an adult female was performed as an "explosive belly run" (see Cott, 1961). The robustness of adult *C. latirostris* may allow locomotor escape through the aquatic vegetation and on land. Fast escape by galloping was reported in immature *Crocodylus porosus* (Schneider, 1801), but with the body elevated from the ground (Zug, 1974). Finally, attacking towards humans as a defensive behaviour in wild *C. latirostris* are rare, and the few reports were associated to territoriality and nest defense (Verdade, 1999; Yanosky, 1990). A repertoire of the defensive behaviour of the species in the presence of humans is presented in Tab. 2. Further systematized studies may provide insights into the relative importance of the different behaviours during the ontogeny of *C. latirostris*.

Scavenging

Carrion consumption is long-time known in the Order Crocodylia (Tenney, 1877), and was also proposed for extinct forms (Erickson, 1990; Forrest, 2003). Widely assumed as a common crocodilian behaviour (Lang, 1987), its role in feeding ecology is almost unknown except for

Tab. 2. Known defensive behaviours for *Caiman latirostris* (Daudin, 1802) in the presence of humans. Categorization adapted from Greene (1988).

Defensive behaviour	Size class			Observations
	Juveniles	Subadults	Adults	
Vocalization	X			Present study
Locomotor escape (surface or underwater swimming)	X	X	X	Present study
Inaccessibility (immersion; hide in vegetation)	X	X	X	Present study
Gaping	X	X	X	Present study
Biting	X	X	X	Present study; Yanosky (1990)
Writhing		X	X	Present study
"Freezing" underwater		X	X	Present study
Hissing		X	X	Present study
Tonic immobility after captured?			X	Present study
Locomotor escape on land			X	Present study
Tail strike			X	Present study
Display or threat with the tail			X	Verdade (1999)
Frontal attack			X	Verdade (1999)
Frontal attack and biting			X	Present study
Unspecified attack to humans			X	Brito del Pino (1956); Yanosky (1990)

some studies on *Crocodylus niloticus* (Laurenti, 1768) [Handler et al., 2021; Subalusky et al., 2017]. Additional field data are anecdotal, for instance in *A. mississippiensis* (Nifong et al., 2011), *C. acutus* (Cuvier, 1807) [Cupul-Magaña et al., 2005; Escobar-Lasso et al., 2016], *C. niloticus* [Cott, 1961; Moleón et al., 2015], *C. palustris* (Lesson, 1831) [Murugan et al., 2020; Vyas, 2012], and *C. porosus* [Lim, 2015; Gallagher et al., 2018].

Unusual prey remains recovered from stomach contents cannot be easily assigned either to predation or scavenging events (Marioni et al., 2019). Borteiro et al. (2009) suggested the consumption of carrion in *C. latirostris* because of the identification of fly larvae (Cochliomyia) in stomach contents, a frequent finding in vertebrate carcasses. However, live animals may carry these parasitic or parasitoid immature dipterans (Francesconi & Lupi, 2012). Recently, Dantas et al. (2020) proposed that *C. latirostris* may behaved as a scavenger of meso and megahervibores during the late Pleistocene in open areas of northeastern Brazil. Furthermore, this caiman accepts dead animal foods in captivity (i.e., Sarkis-Gonçalves et al., 2001; Piña & Larriera, 2002; Sarkis-Gonçalves et al., 2002). Although we did not directly observe scavenging by *C. latirostris*, it likely occurs as an opportunistic feeding behavior.

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